Volume 1

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Series A

Semiconductor Data Library

Data Sheets For:

- EIA Registered Type Numbers to 1N5000 and 2N5000

MOTOROLA Semiconductor Products Inc.

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SERIES A
VOLUME I

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VOLUME I

This volume contains complete data sheets for Motorola-manufactured devices with EIA registered type numbers up to 1N4999 and 2N4999. Data sheets are in numerical sequence according to device type number except for those data sheets that cover several devices with different type numbers. The numerical index in front of the book permits the user to quickly locate the page number of the data sheet for any device characterized in the book.

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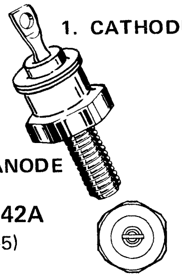
2N4931S,JAN,JTX	2-884
2N4937	2-886
2N4938	
2N4939	
2N4940	
2N4941	
2N4942	2-886
2N4948	2-888
2N4949	2-888
2N4957	2-890
2N4958	2-890
2N4959	2-890
2N4993	2-899

1N... JEDEC REGISTERED DEVICE SPECIFICATIONS

1N248B,C thru 1N250B,C

1N1191 thru 1N1198
1N1195A thru 1N1198A
1N3213,1N3214



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N248BR.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	V_{RRM} V_R		Volts
1N248B, 1N1191		50	
1N248C		55	
1N249B, 1N1192		100	
1N249C		110	
1N1193		150	
1N250B, 1N1194		200	
1N250C		220	
1N1195, 1N1195A		300	
1N1196, 1N1196A		400	
1N1197, 1N1197A, 1N3213		500	
1N1198, 1N1198A, 1N3214		600	
RMS Reverse Voltage	$V_{R(RMS)}$		Volts
1N248B, 1N1191		35	
1N248C		38.5	
1N249B, 1N1192		70	
1N249C		77	
1N1193		105	
1N250B, 1N1194		140	
1N250C		154	
1N1195, 1N1195A		210	
1N1196, 1N1196A		280	
1N1197, 1N1197A, 1N3213		350	
1N1198, 1N1198A, 1N3214		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, $T_C = 150^oC$)	I_O	20	Amp
Peak Repetitive Forward Current ($T_C = 150^oC$)	I_{FRM}	90	Amp
Peak Surge Current ($T_C = 150^oC$, superimposed on Rated Current at Rated Voltage, 1/2-Cycle, 1/120 sec)	I_{FSM}	350	Amp

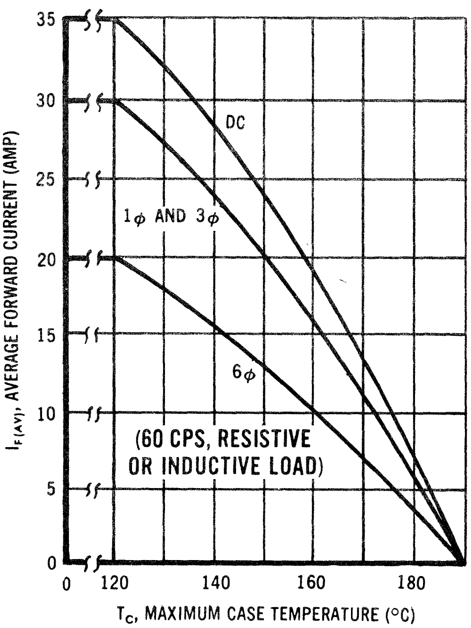
THERMAL CHARACTERISTICS

Maximum Operating and Storage Temperature: −65 to + 190°C
Maximum Thermal Impedance, Junction to Case: θ_{JC} = 1.50°C/W DC

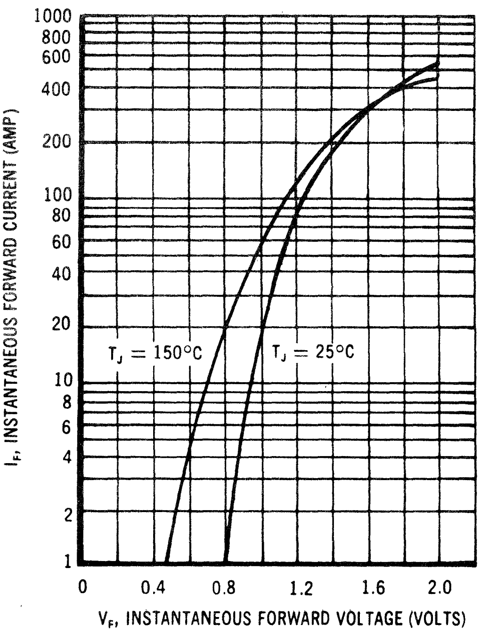
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop (I_F = 100 Amps, T_J = 25°C)	V_F	1.5	Volts
Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$I_{R(AV)}$		mA
1N248B thru 1N250B, 1N1191 thru 1N1198		5.0	
1N248C		3.8	
1N249C		3.6	
1N250C		3.4	
1N1195A		3.2	
1N1196A		2.5	
1N1197A		2.2	
1N1198A		1.5	
1N3213 and 1N3214		10.0	
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	1.0	mA

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE



TYPICAL FORWARD CHARACTERISTICS



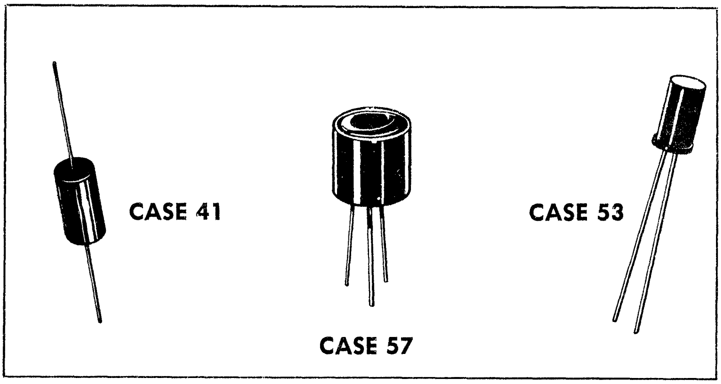
1N429

1N1530 series

1N1735 series

1N4057 series

Temperature compensated zener reference diodes designed for reference sources utilizing an oxide-passivated junction for long-term voltage stability, high uniformity and reliable operation.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	-55 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C
Power Dissipation*	P_D	See Tables 1 & 2*	W

*The devices are designed for operation at the specified I_{ZT}. Operation above or below this current is not recommended, since the temperature coefficient is no longer valid. See Note 2 and Figure 4.

MECHANICAL CHARACTERISTICS

Case:	Discrete glass package devices encapsulated in a transfer molded plastic package
Polarity:	Indicated by diode symbol except 1N429, 1N1530, 1N1530A where cathode indicated by polarity dot of contrasting color
Weight:	Varies according to device 0.5 grams (min) 12 grams (max)
Finish:	All external surfaces corrosion resistant and leads readily solderable.

TABLE 1 – ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

TYPE	CASE	Zener Voltage ±5% V_Z Volts	@ I_{ZT} mA	Z_{ZT} Ohms (Note 3)	Temperature Coefficient %/°C (Note 2)	ΔV_Z @ I_{ZT} (+25 to +100°C) Volts (Note 2)	ΔV_Z (–55 to + 25°C) Volts (Note 2)	P_D* T_A = 25°C W
1N4057	41-8	12.4	10	25	0.005	0.047	0.050	1.5
1N4057A		12.4		25	0.002	0.019	0.020	
1N4058		14.6		30	0.005	0.055	0.058	
1N4058A		14.6			0.002	0.022	0.023	
1N4059		16.8			0.005	0.063	0.067	
1N4059A		16.8			0.002	0.025	0.027	
1N4060		18.5			0.005	0.069	0.074	
1N4060A		18.5			0.002	0.028	0.030	
1N4061		21		35	0.005	0.079	0.084	
1N4061A		21		35	0.002	0.032	0.034	
1N4062		23		40	0.005	0.086	0.092	
1N4062A		23		40	0.002	0.035	0.037	
1N4063		27		45	0.005	0.101	0.108	
1N4063A		27		45	0.002	0.041	0.043	
1N4064		30		50	0.005	0.113	0.120	
1N4064A		30		50	0.002	0.045	0.048	
1N4065		33		55	0.005	0.124	0.132	
1N4065A		33		55	0.002	0.050	0.053	
1N4066		37	7.5	80	0.005	0.139	0.148	
1N4066A		37		80	0.002	0.056	0.059	
1N4067		43		90	0.005	0.161	0.172	
1N4067A		43		90	0.002	0.065	0.069	
1N4068		47		100	0.005	0.176	0.188	
1N4068A		47		100	0.002	0.071	0.075	
1N4069	41-9	51		110	0.005	0.191	0.204	2.0
1N4069A		51		110	0.002	0.077	0.082	
1N4070		56		120	0.005	0.210	0.224	
1N4070A		56		120	0.002	0.084	0.090	
1N4071		62		135	0.005	0.232	0.248	
1N4071A		62		135	0.002	0.093	0.099	
1N4072		68	5.0	230	0.005	0.255	0.272	
1N4072A		68		230	0.002	0.102	0.109	
1N4073		75		250	0.005	0.281	0.300	
1N4073A		75		250	0.002	0.113	0.120	
1N4074		82		270	0.005	0.307	0.328	
1N4074A		82		270	0.002	0.123	0.131	
1N4075		87		290	0.005	0.326	0.348	
1N4075A		87		290	0.002	0.131	0.139	
1N4076		91		310	0.005	0.341	0.364	
1N4076A		91		310	0.002	0.137	0.146	
1N4077		100		340	0.005	0.375	0.400	
1N4077A		100		340	0.002	0.150	0.160	
1N4078		105	2.5	700	0.005	0.394	0.420	
1N4078A		105		700	0.002	0.158	0.168	
1N4079		110		740	0.005	0.413	0.440	
1N4079A		110		740	0.002	0.165	0.176	
1N4080		120		800	0.005	0.450	0.480	
1N4080A		120		800	0.002	0.180	0.192	
1N4081	41-10	130		840	0.005	0.488	0.520	2.5
1N4081A		130		840	0.002	0.195	0.208	
1N4082		140		960	0.005	0.525	0.560	
1N4082A		140		960	0.002	0.210	0.224	
1N4083		150		1020	0.005	0.563	0.600	
1N4083A		150		1020	0.002	0.225	0.240	
1N4084		175		1150	0.005	0.656	0.700	
1N4084A		175		1150	0.002	0.263	0.280	
1N4085		200		1350	0.005	0.750	0.800	
1N4085A		200		1350	0.002	0.300	0.320	

*Derate linearly from 25°C to 175°C.

TABLE 2 – ELECTRICAL CHARACTERISTICS (I_{ZT} = 7.5 mA, T_A = 25°C unless otherwise noted)

Type Number	Zener Voltage V_Z ± 5% (Volts)	Max Voltage Change @ –55, +25, +100°C ΔV_Z (Volts) (Note 2)	Max Dynamic Impedance (Note 3) Z_{ZT} (Ohms)	Temperature Coefficient (Note 2) (%/°C)	Power* Dissipation P_D (mW)	Case Number	Figure Number
1N429 ①	6.2	0.050	20	0.01	200	53	1
1N1735	6.2	0.050	20	0.01	200	41-6	2
1N1530** 1N1530A** ②	8.4	0.014 0.007	15	0.002 0.001	250	57	3
1N1736 1N1736A	12.4	0.100 0.050	40	0.01 0.005	400	41-3	2
1N1737 1N1737A	18.6	0.150 0.075	60	0.01 0.005	600	41-5	2
1N1738 1N1738A	24.8	0.200 0.100	80	0.01 0.005	800	41-5	2
1N1739 1N1739A	31.0	0.250 0.125	100	0.01 0.005	1000	41-4	2
1N1740 1N1740A	37.2	0.300 0.150	120	0.01 0.005	1200	41-4	2
1N1741 1N1741A	43.4	0.350 0.175	140	0.01 0.005	1400	41-4	2
1N1742 1N1742A ③	49.6	0.400 0.200	180	0.01 0.005	1600	41-4	2

*Derate linearly from 25°C to 175°C

**I_{ZT} = 10 mA

① Available to MIL-S-19500/299 Specifications.

② Available to MIL-S-19500/320 Specifications.

③ Available to MIL-S-19500/298 Specifications.

TEMPERATURE-COMPENSATED REFERENCE DIODES

Temperature compensated reference diodes are made possible by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device which shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum (Figure 4)

Further information, including a method of effective impedance cancellation in a bridge circuit for ultra-stable reference supplies, is contained in the Zener Diode Handbook. The handbook, containing valuable theory, design, and application information, is available from your distributor.

NOTE 1 — Voltage-Current Characteristics

Figure 4 shows the voltage-current characteristics of a typical temperature compensated unit at three different temperatures. The exploded view illustrates the cross-over area (optimum temperature stability point), the non-linearity of the temperature-voltage relationship, and the maximum voltage variation (ΔV_Z) for the three temperatures shown.

Because of device impedance, the reference voltage will vary with changes in zener current. These variations can be minimized by driving the device from a constant current source.

NOTE 2 — Voltage Variation (ΔV_Z) and Temperature Coefficient

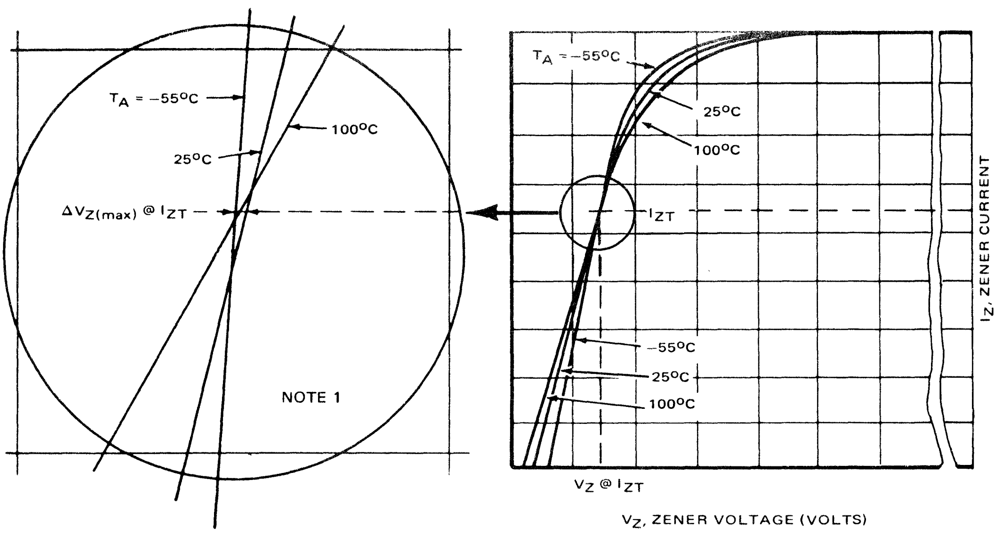
All reference diodes are characterized by the "box" method. This method provides for a guaranteed maximum voltage variation (ΔV_Z in mV) over a specified temperature range at the specified I_{ZT} verified by tests at several points within the range. (Maximum voltage variations over the specified temperature ranges are given in Tables 1 and 2.) The design engineer now has a number (without any calculations) telling him the stability of the voltage over the temperature range of interest thus giving him the maximum flexibility as well as economy in selecting the temperature stability required. The referenced military specifications use this approach to characterize these devices.

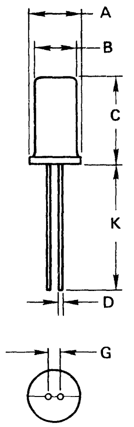
Since reference diodes have a non-linear voltage-temperature relationship (illustrated in exploded view, Figure 4) the temperature coefficients in %/°C are tabulated primarily for reference purposes and are guaranteed only at the end points of the temperature range.

NOTE 3 — Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60 Hz ac voltage which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

FIGURE 4 — TYPICAL OPERATING CHARACTERISTICS

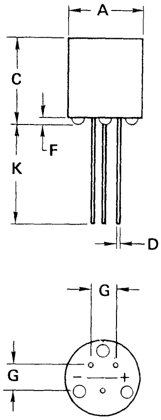




DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.33	5.84	0.210	0.230
B	4.57	5.08	0.180	0.200
C	8.89	9.40	0.350	0.370
D	0.48	0.56	0.019	0.022
G	1.14	1.40	0.045	0.055
K	26.97	–	1.062	–

NOTE:
1. POLARITY INDICATED BY CATHODE DOT ON BODY ADJACENT TO CATHODE LEAD.

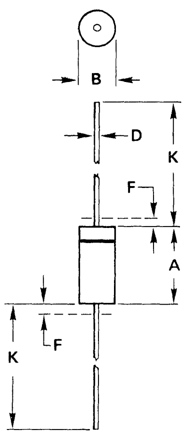
CASE 53



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	14.22	–	0.560
C	–	16.26	–	0.640
D	0.74	0.89	0.029	0.035
F	–	1.02	–	0.040
G	5.08 BSC		0.200 BSC	
K	19.05	–	0.750	–

CASE 57

CASE 41



NOTE:
1. LEAD FINISH & DIA UNCONTROLLED IN AREA "F".

-01

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	25.40	–	1.000
B	–	12.70	–	0.500
D	0.76	0.86	0.030	0.034
F	–	1.27	–	0.050
K	31.75	–	1.250	–

-03

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	26.16	–	1.030
B	–	9.60	–	0.378
D	0.76	0.86	0.030	0.034
F	–	1.27	–	0.050
K	31.75	–	1.250	–

-04

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	30.99	–	1.220
B	–	16.28	–	0.641
D	0.76	0.86	0.030	0.034
F	–	1.27	–	0.050
K	44.45	–	1.750	–

-05

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	16.64	–	0.655
B	–	16.28	–	0.641
D	0.76	0.86	0.030	0.034
F	–	1.27	–	0.050
K	31.75	–	1.250	–

-06

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	13.21	–	0.520
B	–	6.98	–	0.275
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	31.75	–	1.250	–

-08

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	13.21	–	0.520
B	6.10	6.60	0.240	0.260
D	0.71	0.81	0.028	0.032
F	–	1.27	–	0.050
K	25.40	–	1.000	–

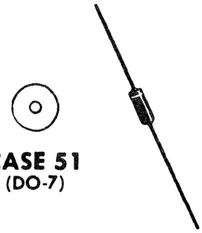
-09

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	19.81	–	0.780
B	6.10	6.60	0.240	0.260
D	0.58	0.81	0.023	0.032
F	–	1.27	–	0.050
K	25.40	–	1.000	–

-10

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	29.34	–	1.155
B	7.70	8.20	0.303	0.323
D	0.71	0.81	0.028	0.032
F	–	1.27		0.050
K	25.40	–	1.000	–

1N702 thru 1N745 (ZENER DIODES)



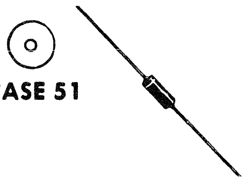
CASE 51
(DO-7)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N5221 series.

1/4 watt, 2-200 volts

Polarity Indicated by Cathode Band

1N746 thru 1N759 1N746A thru 1N759A (ZENER DIODES)
1N4370 thru 1N4372 1N4370A thru 1N4372A



CASE 51

Hermetically sealed, all-glass case with all external surfaces corrosion resistant.

Polarity Indicated by Cathode Band

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50°C Ambient)

TOLERANCE DESIGNATIONS

The type numbers shown have tolerance designations as follows:
1N4370 series: ±10%, suffix A for ±5% units.
1N746 series: ±10%, suffix A for ±5% units.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

TYPE NUMBER	NOMINAL ZENER VOLTAGE V_Z @ I_{ZT} VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE Z_{ZT} @ I_{ZT} Ohms	MAXIMUM DC ZENER CURRENT I_{ZM} mA	MAXIMUM REVERSE LEAKAGE CURRENT T_A = 25°C I_R @ V_R = 1 V μA	MAXIMUM REVERSE LEAKAGE CURRENT T_A = 150°C I_R @ V_R = 1 V μA
1N4370	2.4	20	30	150	100	200
1N4371	2.7	20	30	135	75	150
1N4372	3.0	20	29	120	50	100
1N746	3.3	20	28	110	10	30
1N747	3.6	20	24	100	10	30
1N748	3.9	20	23	95	10	30
1N749	4.3	20	22	85	2	30
1N750	4.7	20	19	75	2	30
1N751	5.1	20	17	70	1	20
1N752	5.6	20	11	65	1	20
1N753	6.2	20	7	60	0.1	20
1N754	6.8	20	5	55	0.1	20
1N755	7.5	20	6	50	0.1	20
1N756	8.2	20	8	45	0.1	20
1N757	9.1	20	10	40	0.1	20
1N758	10.0	20	17	35	0.1	20
1N759	12.0	20	30	30	0.1	20

POLARITY: Cathode End, Indicated by Color Band, Will Be Positive When Operate Operated In The Zener Region.

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
a Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

To designate units with zener voltages other than those listed, the Motorola type number should be modified as shown below. Unless otherwise specified, the electrical characteristics other than the nominal voltage (V_Z) and test voltage for leakage current will conform to the characteristics of the next higher voltage type shown in the table.

EXAMPLE: 1N746 series, 1N4370 series

.4	M	3.7	A	Z	5
Power Rating	Motorola	Nominal Voltage	Alloy	Zener Diode	Tolerance (±%)

1N761 thru 1N769

Recommended for applications requiring an exact replacement only. For new designs see 1N5221 series.

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2360
MZ2361
MZ2362

CONSTANT-VOLTAGE REFERENCE DIODES FOR LOW-VOLTAGE APPLICATIONS

. . . high-conductance silicon diodes designed as a stable forward reference source for biasing transistor amplifiers and similar applications.

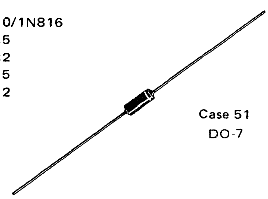
- Guaranteed Forward Voltage Range
- Choice of Package
- Temperature Effects Provided

FORWARD REFERENCE DIODES – STABISTORS –

MAXIMUM RATINGS

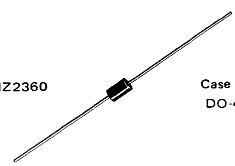
Rating	Symbol	Value	Unit
DC Power Dissipation @ T_L = 30°C ±3°C, Lead Length = 3/8″	P_D	400	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2361
MZ2362



Case 51
DO-7

MZ2360



Case 59
DO-41

MECHANICAL CHARACTERISTICS

Case: Choice of package, either Glass or Surmetic
Dimensions: See outline drawings
Finish: All external surfaces are corrosion resistant and leads are readily solderable and weldable
Polarity: Cathode indicated by polarity band. Cathode negative for forward reference application.
Weight: 0.2 Gram (approximate)
Mounting Positions: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

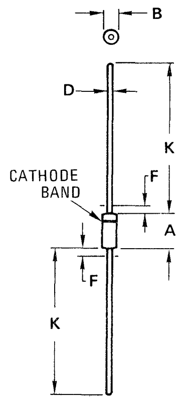
Type Number	Forward Reference Voltage (1) V_F Volts Min/Max	@ I_F mA	Reverse Leakage Current (Max) I_R µA	@ V_R Volts	Package	Case
.4M.64FR10/ 1N816* (2)	0.58/0.70	1.0	0.1	4.0	Glass	51
.4M1.36FR5	1.29/1.43	10	0.1	4.0	Glass	51
.4M1.36FR2	1.33/1.39	10	0.1	4.0	Glass	51
.4M2.04FR5	1.94/2.14	10	0.1	4.0	Glass	51
.4M2.04FR2	2.00/2.08	10	0.1	4.0	Glass	51
MZ2360	0.63/0.71	10	10	5.0	Surmetic	59
MZ2361	1.24/1.38	10	10	5.0	Surmetic	51
MZ2362	1.90/2.10	10	10	5.0	Glass	51

*Indicates JEDEC Registered Data for 1N816

(1) Motorola guarantees the forward reference voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at 30°C ± 1°C, 3/8" from the diode body.

(2) Minimum Saturation Voltage for 1N816 = 40 V @ 100 µA.

.4M.64FR10/1N816
.4M1.36FR5
.4M1.36FR2
.4M2.04FR5
.4M2.04FR2
MZ2361
MZ2362

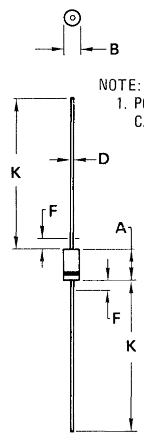


CASE 51-02
DO-7

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

MZ2360



NOTE:
1. POLARITY DENOTED BY CATHODE BAND

CASE 59-03
DO-41

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

All JEDEC dimensions and notes apply.

.4M.64FR10/1N816, .4M1.36FR5, .4M1.36FR2, .4M2.04FR5, .4M2.04FR2, MZ2360, MZ2361, MZ2362 (continued)

TYPICAL FORWARD VOLTAGE CHARACTERISTICS

FIGURE 1 — .4M.64FR10/1N816

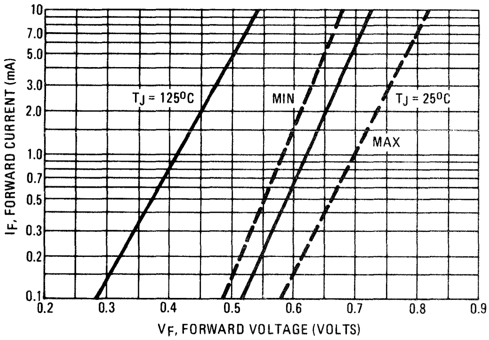


FIGURE 2 — .4M1.36FR5

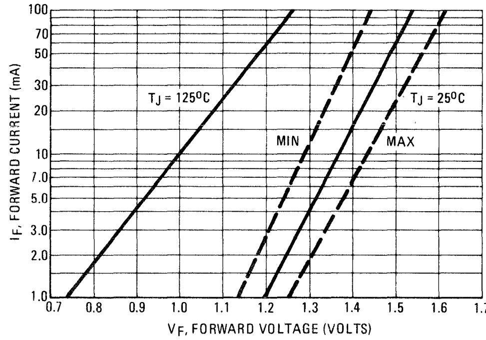


FIGURE 3 — .4M2.04FR5

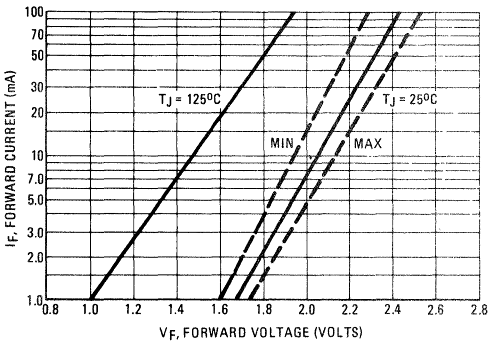


FIGURE 4 — MZ2360

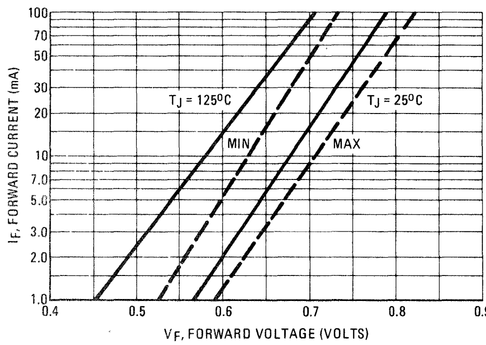


FIGURE 5 — MZ2361

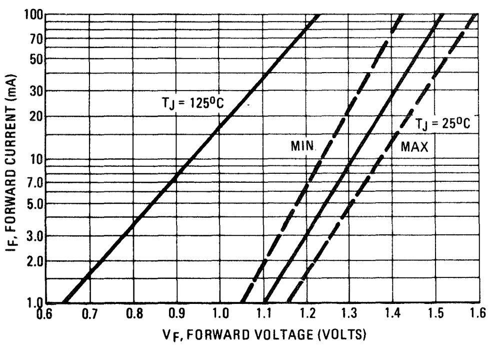
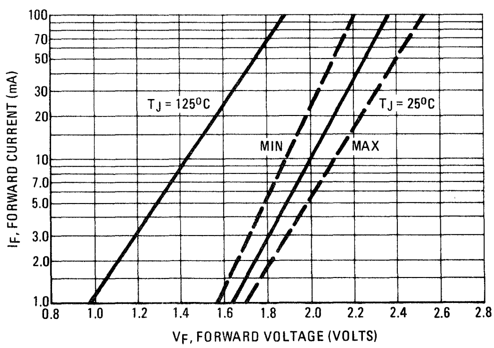


FIGURE 6 — MZ2362



TYPICAL TEMPERATURE COEFFICIENT

FIGURE 7 – .4M.64FR10/1N816

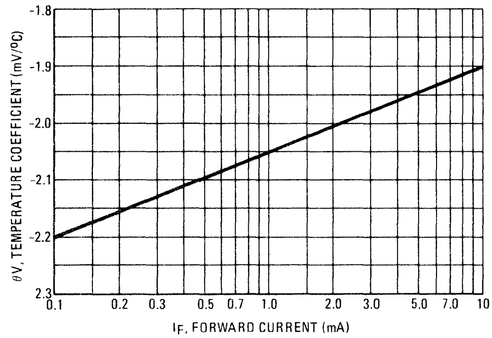


FIGURE 8 – MZ2360

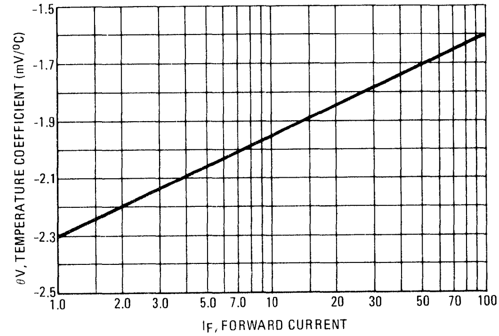


FIGURE 9 – .4M1.36FR5/MZ2361

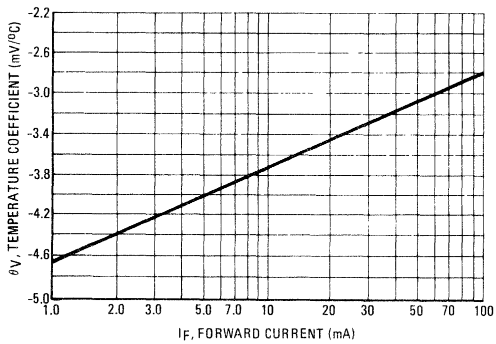
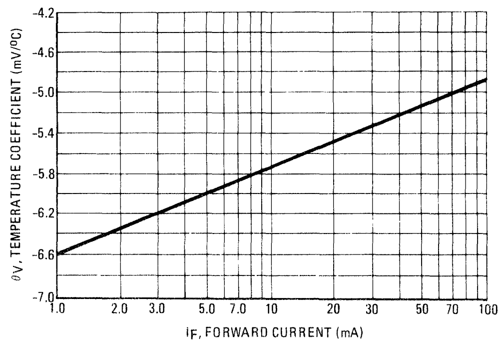
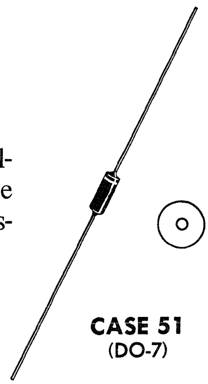


FIGURE 10 – .4M2.04FR5/MZ2362



1N821, A, 1N823, A (SILICON)
1N825, A, 1N827, A
1N829, A



CASE 51
(DO-7)

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 400 mW @ T_A = 50°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

V_Z = 6.2 V ±5.0%* @ I_{ZT} = 7.5 mA

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature °C ±1°C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} Ohms (Note 3)
1N821	0.096	-55, 0, +25, +75, +100	0.01	15
1N823	0.048		0.005	
1N825	0.019		0.002	
1N827	0.009		0.001	
1N829	0.005		0.0005	
1N821A	0.096		0.01	10
1N823A	0.048		0.005	
1N825A	0.019		0.002	
1N827A	0.009		0.001	
1N829A	0.005		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 30 to 400 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 15 to 400 V

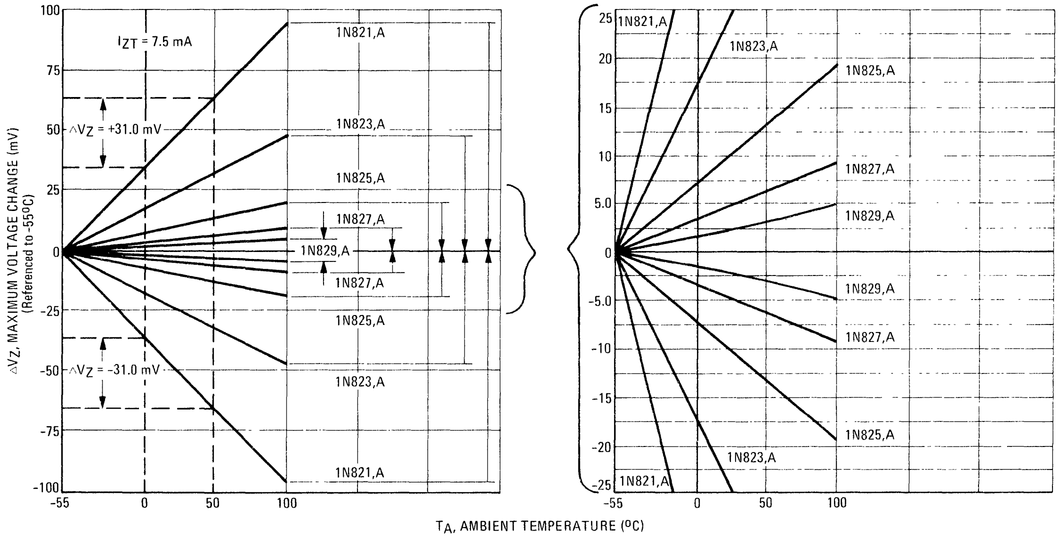
MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N821 thru 1N829

FIGURE 1a

FIGURE 1b



ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE

(At Specified Temperatures)
(See Note 5)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 2 — 1N821 SERIES

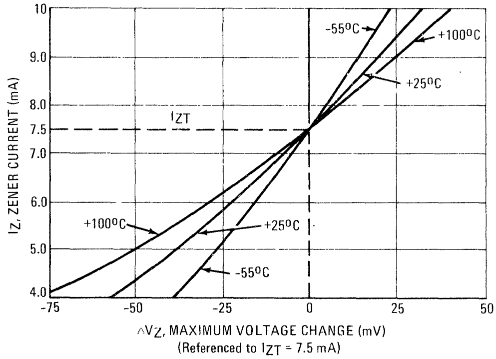
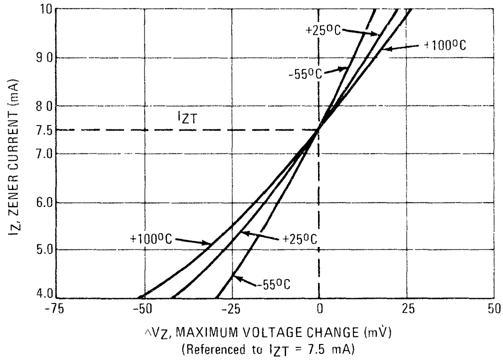


FIGURE 3 — 1N821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES.

FIGURE 4 – 1N821 SERIES

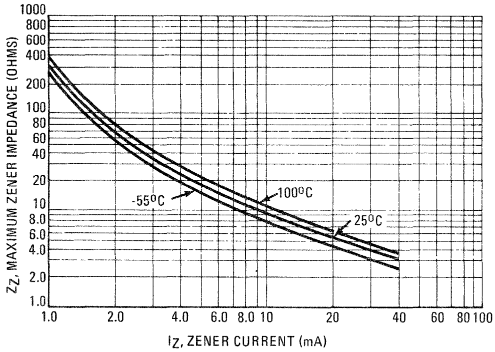


FIGURE 5 – 1N821A SERIES

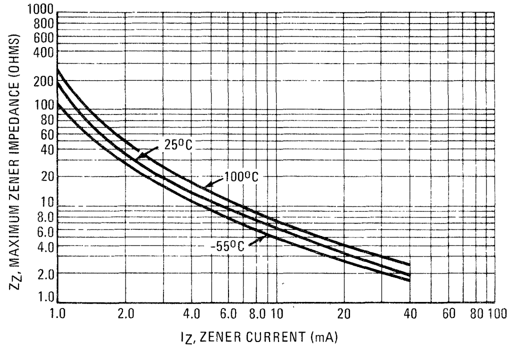
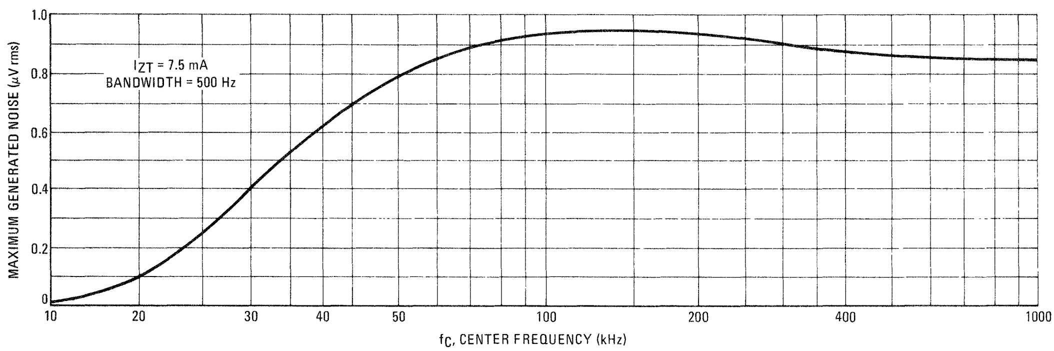


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N821, 1N823, 1N825, 1N827, and 1N829 are available to MIL-S-19500/159.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figures 4 and 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

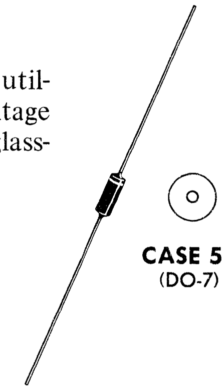
NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +31 mV or -31 mV for 1N821 or 1N821A, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, an expanded view of the shaded area in Figure 1a is shown in Figure 1b.

NOTE 5:

The maximum voltage change, ΔV_Z, Figures 2 and 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by graphically adding ΔV_Z in Figure 2 or 3 to the ΔV_Z in Figure 1 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 2 or 3 on Figure 1. For a more detailed explanation see AN-437 (Application Note).

1N935, A, B (SILICON)
thru
1N939, A, B



CASE 51
(DO-7)

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature °C ±1°C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 9.0 V ±5.0%* @ I_{ZT} = 7.5 mA				
1N935	0.067		0.01	
1N936	0.033		0.005	
1N937	0.013	0, +25, +75	0.002	20
1N938	0.006		0.001	
1N939	0.003		0.0005	
1N935A	0.139		0.01	
1N936A	0.069		0.005	
1N937A	0.027	-55, 0, +25, +75, +100	0.002	20
1N938A	0.013		0.001	
1N939A	0.007		0.0005	
1N935B	0.184		0.01	
1N936B	0.092		0.005	
1N937B	0.037	-55, 0, +25, +75, +100, +150	0.002	20
1N938B	0.018		0.001	
1N939B	0.009		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935 thru 1N939

FIGURE 1a

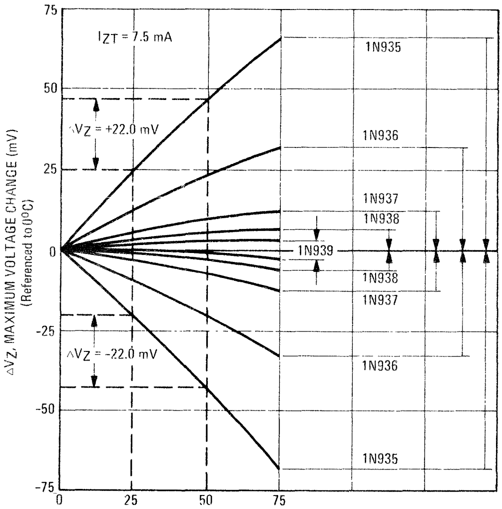
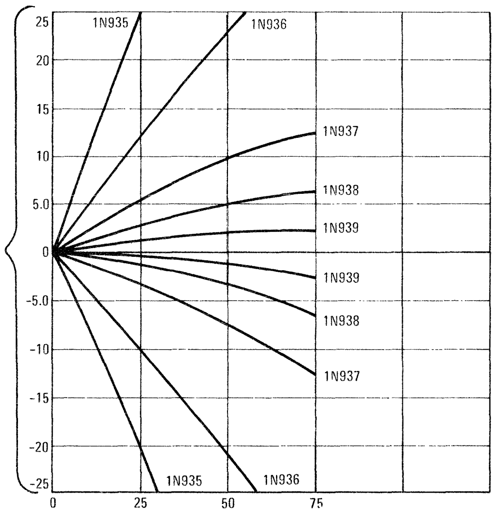


FIGURE 1b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935A thru 1N939A

FIGURE 2a

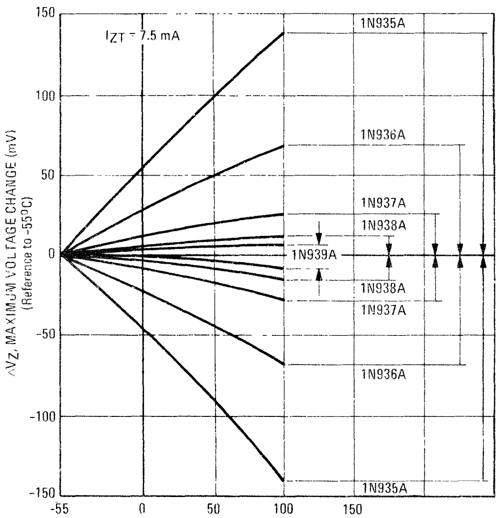
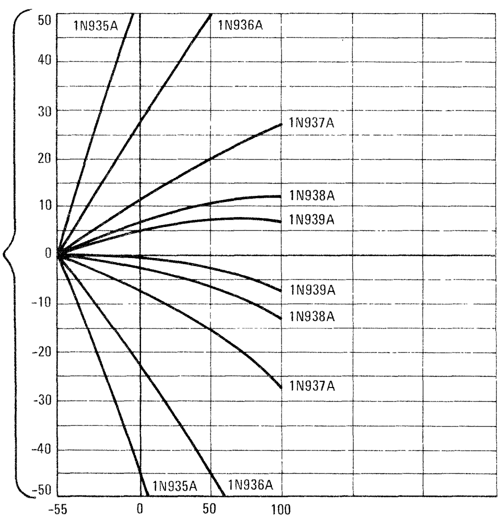


FIGURE 2b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N935B thru 1N939B

FIGURE 3a **FIGURE 3b**

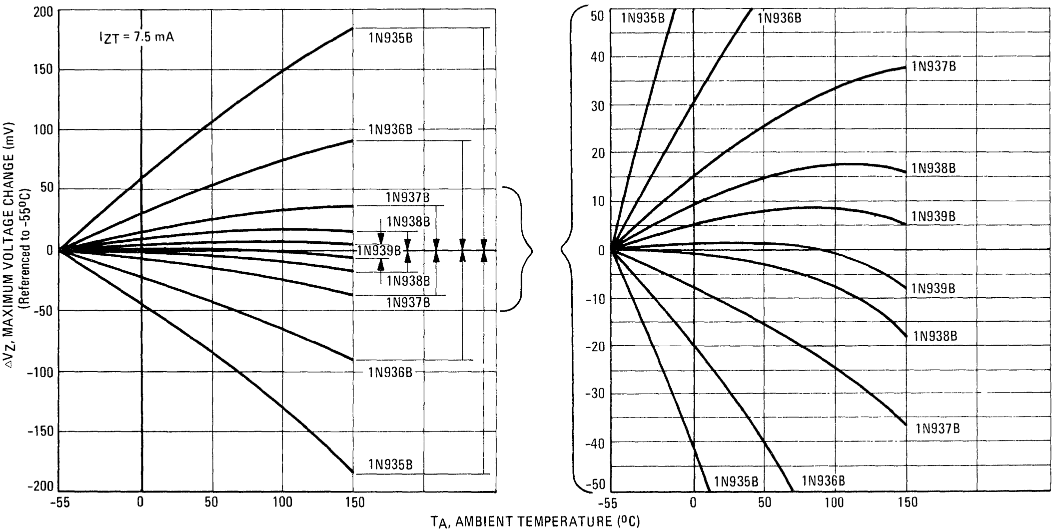


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)

(See Note 5)

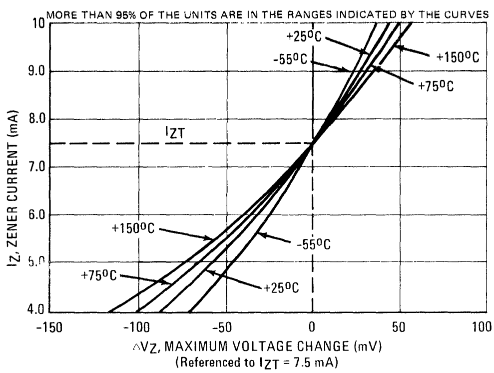


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

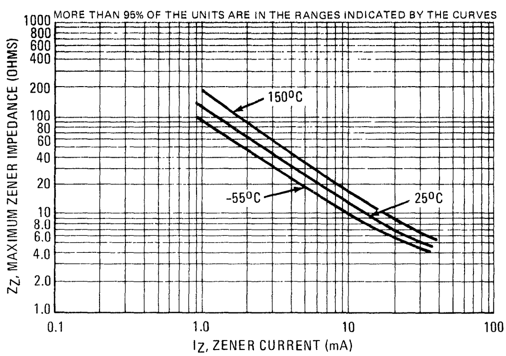
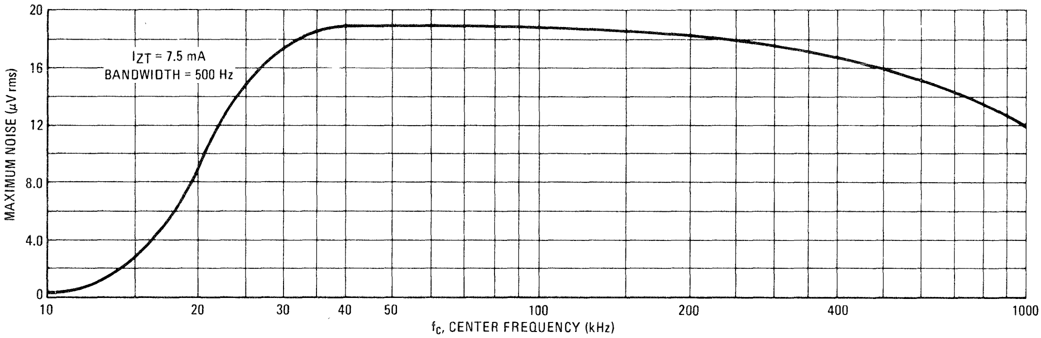


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N935B, 1N937B, and 1N939B are available to MIL-S-19500/156.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

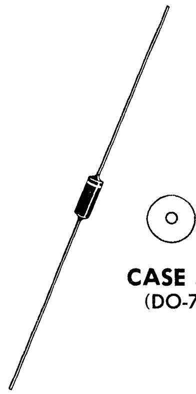
These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +22 mV or −22 mV for 1N935, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, ΔV_Z, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N941, A, B (SILICON)
thru
1N945, A, B

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature °C ±1°C	Temperature Coefficient %/°C (Note 2)	Maximum Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 11.7 V ±5.0%* @ I_{ZT} = 7.5 mA				
1N941	0.088	0, +25, +75	0.01	30
1N942	0.044		0.005	
1N943	0.018		0.002	
1N944	0.009		0.001	
1N945	0.004		0.0005	
1N941A	0.181	-55, 0, +25, +75, +100	0.01	30
1N942A	0.090		0.005	
1N943A	0.036		0.002	
1N944A	0.018		0.001	
1N945A	0.009		0.0005	
1N941B	0.239	-55, 0, +25, +75, +100, +150	0.01	30
1N942B	0.120		0.005	
1N943B	0.047		0.002	
1N944B	0.024		0.001	
1N945B	0.012		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 14 to 35 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 150 to 1200 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941 thru 1N945

FIGURE 1a

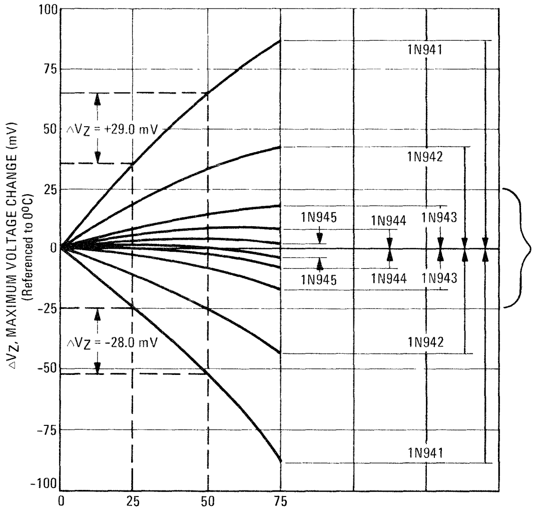
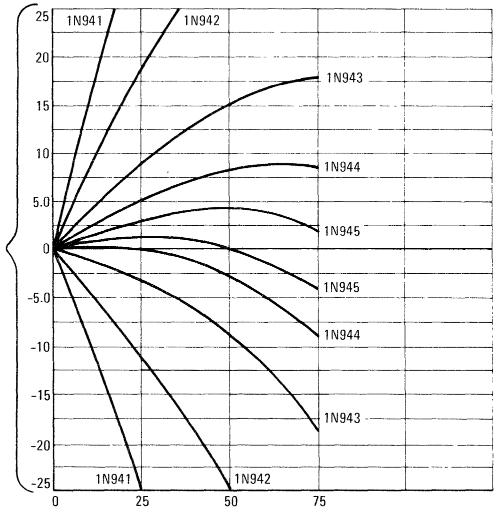


FIGURE 1b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941A thru 1N945A

FIGURE 2a

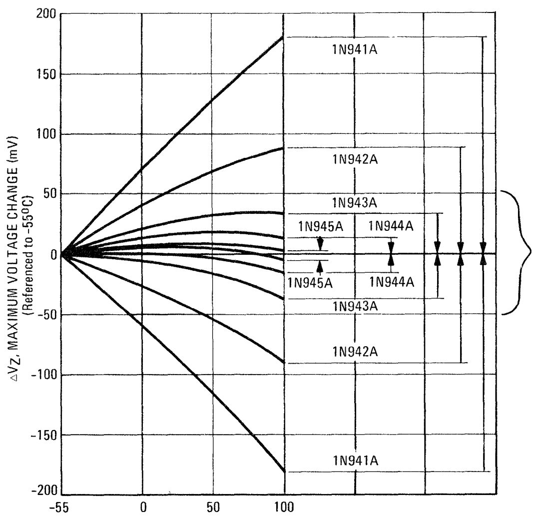
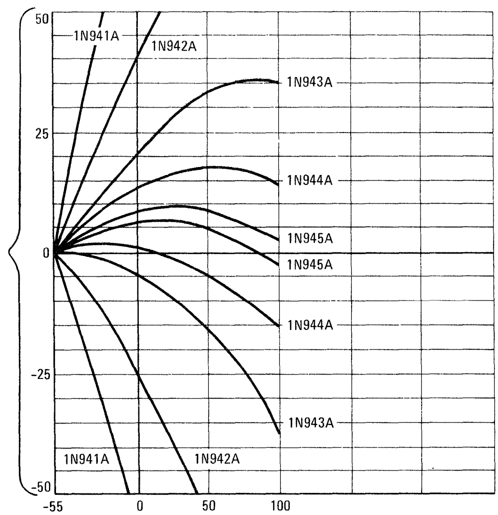


FIGURE 2b



T_A, AMBIENT TEMPERATURE (°C)

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 4)

1N941B thru 1N945B

FIGURE 3a

FIGURE 3b

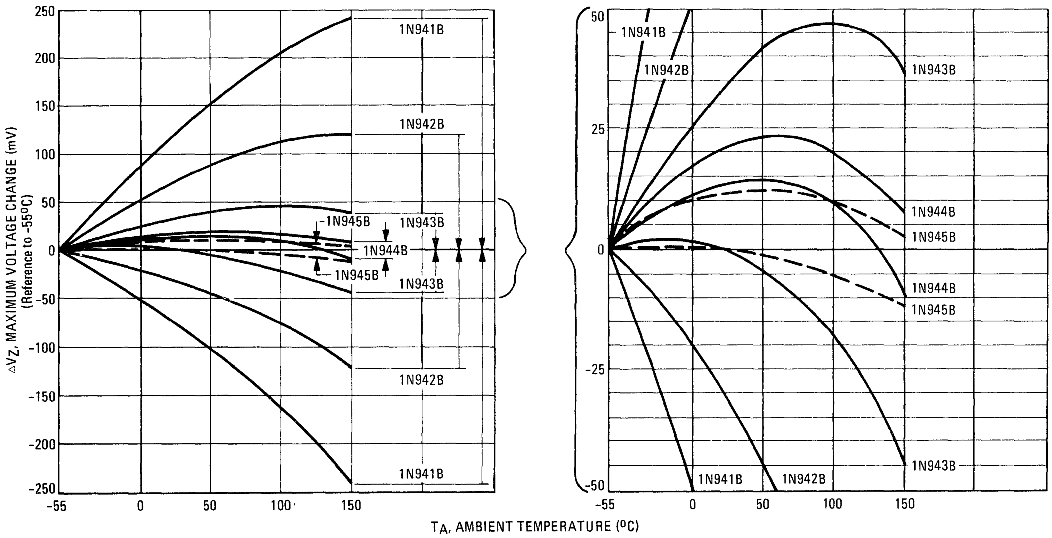


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures)

(See Note 5)

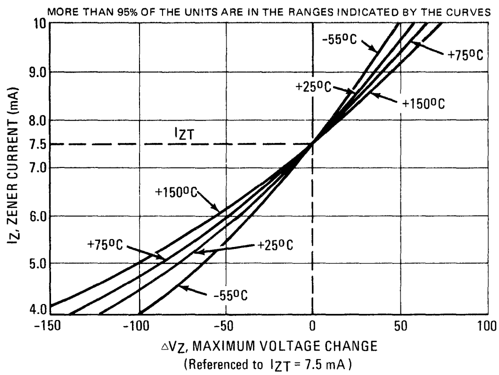


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

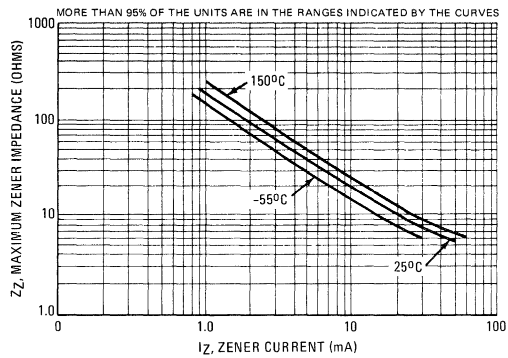
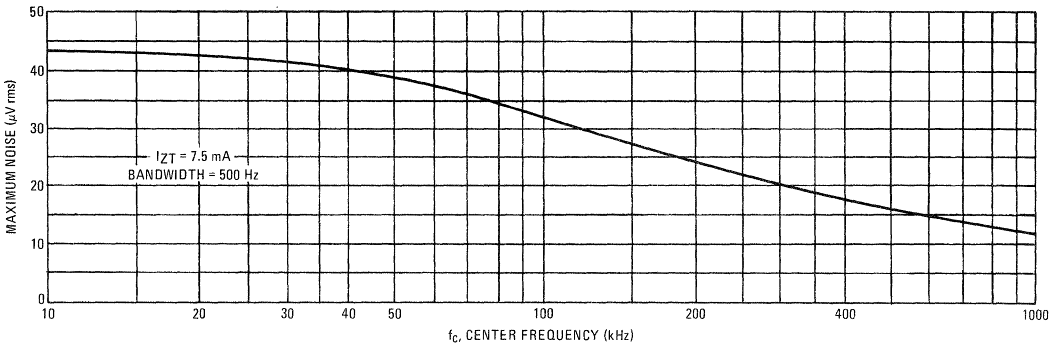


FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N941B, 1N943B, and 1N944B are available to MIL-S-19500/157.

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

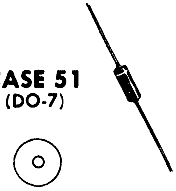
These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +29 mV or -28 mV for 1N941, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 5:

The maximum voltage change, ΔV_Z, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N957 thru 1N992

CASE 51
(DO-7)



Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50°C Ambient)

TOLERANCE DESIGNATIONS

With no suffix, tolerance is ±20%, for ±10% units, add suffix A, for ±5% units, add suffix B.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Motorola Guarantees the Zener Voltage at 90 Seconds with Lead Temperature of 30°C±1°C, 3/8" from Unit Body.

TYPE NUMBER	NOMINAL ZENER VOLTAGE V_Z VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE			MAXIMUM DC ZENER CURRENT I_{ZM} mA	REVERSE LEAKAGE CURRENT		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R MAXIMUM (µA)	TEST VOLTAGE Vdc * V_{R1}	V_{R2}
1N957	6.8	18.5	4.5	700	1.0	47	150	5.2	4.9
1N958	7.5	16.5	5.5	700	0.5	42	75	5.7	5.4
1N959	8.2	15	6.5	700	0.5	38	50	6.2	5.9
1N960	9.1	14	7.5	700	0.5	35	25	6 9	6.6
1N961	10	12.5	8.5	700	0.25	32	10	7.6	7.2
1N962	11	11.5	9.5	700	0.25	28	5	8.4	8.0
1N963	12	10.5	11.5	700	0.25	26	5	9.1	8.6
1N964	13	9.5	13	700	0.25	24	5	9.9	9.4
1N965	15	8.5	16	700	0.25	21	5	11.4	10.8
1N966	16	7.8	17	700	0.25	19	5	12.2	11.5
1N967	18	7.0	21	750	0.25	17	5	13.7	13.0
1N968	20	6.2	25	750	0.25	15	5	15.2	14.4
1N969	22	5.6	29	750	0.25	14	5	16.7	15.8
1N970	24	5.2	33	750	0.25	13	5	18.2	17.3
1N971	27	4.6	41	750	0.25	11	5	20.6	19.4
1N972	30	4.2	49	1000	0.25	10	5	22.8	21.6
1N973	33	3.8	58	1000	0.25	9.2	5	25.1	23.8
1N974	36	3.4	70	1000	0.25	8.5	5	27.4	25.9
1N975	39	3.2	80	1000	0.25	7.8	5	29.7	28.1
1N976	43	3.0	93	1500	0.25	7.0	5	32.7	31.0
1N977	47	2.7	105	1500	0.25	6.4	5	35.8	33.8
1N978	51	2.5	125	1500	0.25	5.9	5	38.8	36.7
1N979	56	2.2	150	2000	0.25	5.4	5	42.6	40.3
1N980	62	2.0	185	2000	0.25	4.9	5	47.1	44.6
1N981	68	1.8	230	2000	0.25	4.5	5	51.7	49.0
1N982	75	1.7	270	2000	0.25	4.0	5	56.0	54.0
1N983	82	1.5	330	3000	0.25	3.7	5	62.2	59.0
1N984	91	1.4	400	3000	0.25	3.3	5	69.2	65.5
1N985	100	1.3	500	3000	0.25	3.0	5	76.0	72.0
1N986	110	1.1	750	4000	0.25	2.7	5	83.6	79.2
1N987	120	1.0	900	4500	0.25	2.5	5	91.2	86.4
1N988	130	0.95	1100	5000	0.25	2.3	5	98.8	93.6
1N989	150	0.85	1500	6000	0.25	2.0	5	114.0	108.0
1N990	160	0.80	1700	6500	0.25	1.9	5	121.6	115.2
1N991	180	0.68	2200	7100	0.25	1.7	5	136.8	129.6
1N992	200	0.65	2500	8000	0.25	1.5	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
  a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
  b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

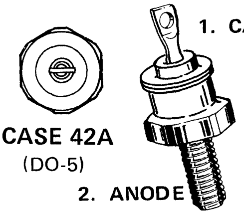
$^*V_{R1}$ — Test Voltage for 5% Tolerance Device
V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

To designate units with zener voltages other than those listed, the Motorola type number should be modified as shown below. Unless otherwise specified, the electrical characteristics other than the nominal voltage (V_Z) and test voltage for leakage current will conform to the characteristics of the next higher voltage type shown in the table.

EXAMPLE: 1N957 series

.4	M	115	Z	3
Power Rating	Motorola	Nominal Voltage	Zener Diode	Tolerance (±%)

1N1183 thru 1N1190 (SILICON)



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183R.

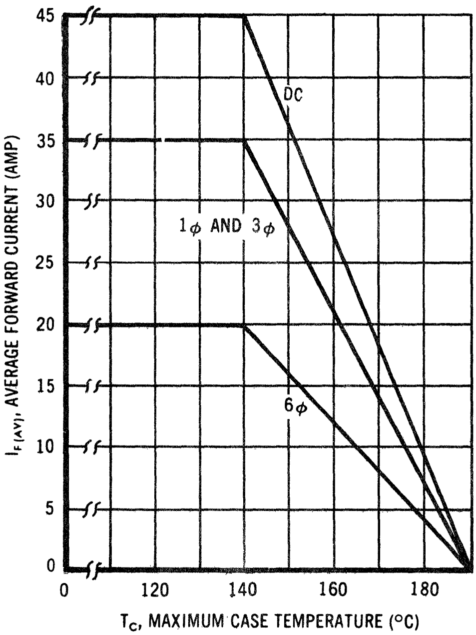
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	V_{RRM} V_R		Volts
1N1183		50	
1N1184		100	
1N1185		150	
1N1186		200	
1N1187		300	
1N1188		400	
1N1189		500	
1N1190		600	
RMS Reverse Voltage	$V_{R(RMS)}$		Volts
1N1183		35	
1N1184		70	
1N1185		105	
1N1186		140	
1N1187		210	
1N1188		280	
1N1189		350	
1N1190		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, T_C = 140°C)	I_O	35	Amp
Peak Repetitive Forward Current (T_C = 140°C)	I_{FRM}	150	Amp
Peak Surge Current (T_C = 140°C, superimposed on Rated Current at Rated Voltage)	I_{FSM}	400	Amp
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190	°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

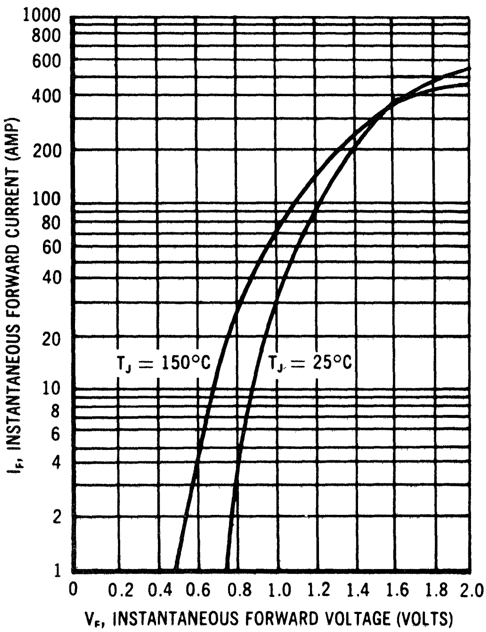
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Max Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 Hz, T_C = 140°C)	$V_{F(AV)}$	0.6	Volts
Max Instantaneous Forward Voltage Drop (I_F = 100 Amps, T_J = 25°C)	V_F	1.3	Volts
Max Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 Hz, T_C = 140°C)	$I_{R(AV)}$	10.0	mA
Max DC Reverse Current (Rated V_R, T_C = 25°)	I_R	1.0	mA

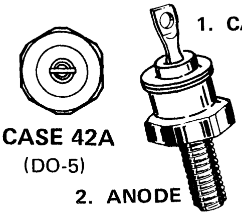
MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE (60 CPS, RESISTIVE OR INDUCTIVE LOAD)



TYPICAL FORWARD CHARACTERISTICS



1N1183A thru 1N1189A (SILICON)



Medium current silicon rectifiers. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183RA.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	V_{RRM} V_R		Volts
1N1183A		50	
1N1184A		100	
1N1185A		150	
1N1186A		200	
1N1187A		300	
1N1188A		400	
1N1189A		500	
RMS Reverse Voltage	$V_{R(RMS)}$		Volts
1N1183A		35	
1N1184A		70	
1N1185A		105	
1N1186A		140	
1N1187A		210	
1N1188A		280	
1N1189A		350	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 Hz, $T_C = 150^oC$)	I_O	40	Amp
Peak Surge Current ($T_C = 150°C$, superimposed on Rated Current at Rated Voltage)	I_{FSM}	800	Amp
Operating and Storage Temperature	T_J, T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Max Instantaneous Forward Voltage ($I_{O(max)}$, rated V_r, 60 Hz, $T_C = 150^oC$)	v_{pk}	1.3	Volts
Max Instantaneous Forward Voltage Drop (I_F = 100 Amps, $T_C = 25^oC$)	v_F	1.1	Volts
Max Full Cycle Average Reverse Current ($I_{O(max)}$, rated V_r, 60 Hz, $T_C = 150^oC$)	$I_{R(AV)}$	2.5	mA
Max DC Reverse Current (Rated V_R, $T_C = 150^oC$)	I_R	5.0	mA

1N1191 thru 1N1198
1N1195A thru 1N1198A

For Specifications, See **1N248B** Data.

1N1313 thru 1N1327

CASE 53

Very low power zener diodes with standard ±10% tolerances. Available with ±5.0% tolerance by adding suffix "A" to type number.

Standard cathode-to-case polarity.

For new designs and for industry preferred replacement devices, see 1N5837A series.

MAXIMUM RATINGS

Junction and Storage Temperature Range: -65 to +175°C (Derate 1 mW/°C above 25°C).

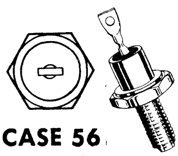
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Type	Nominal Voltage V_Z @ I_{ZT} = 200 μA volts	Max Reverse Current T_A = 25°C I_R @ V_R μA	Max Reverse Current T_A = 100°C I_A @ V_R μA	Test Voltage V_R volts
1N1313	8.75	0.5	5	6.8
1N1314	10.50	0.5	5	8.2
1N1315	12.75	0.5	5	10
1N1316	15.75	0.5	5	12
1N1317	19.00	0.5	5	15

Type	Nominal Voltage V_Z @ I_{ZT} = 200 μA volts	Max Reverse Current T_A = 25 C I_R @ V_R μA	Max Reverse Current T_A = 100 C I_A @ V_R μA	Test Voltage V_R volts
1N1318	23.50	0.1	10	18
1N1319	28.50	0.1	10	22
1N1320	34.50	0.1	10	27
1N1321	41.00	0.1	10	33
1N1322	48.50	0.1	10	39

Type	Nominal Voltage V_Z @ I_{ZT} = 200 μA volts	Max Reverse Current T_A = 25°C I_R @ V_R μA	Max Reverse Current T_A = 100°C I_A @ V_R μA	Test Voltage V_R volts
1N1323	58.00	0.1	10	47
1N1324	71.00	1.0	50	56
1N1325	87.50	1.0	50	68
1N1326	105.0	1.0	50	82
1N1327	127.5	1.0	50	100

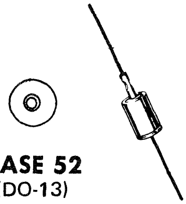
1N1351 thru 1N1375



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

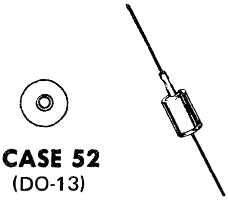
1N1507 thru 1N1517



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1.0-watt, 1N4728 series.

1N1518 thru 1N1528



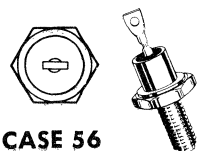
CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1530, A

For Specifications, See 1N429 Data.

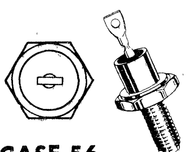
1N1588 thru 1N1598



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N1599 thru 1N1609



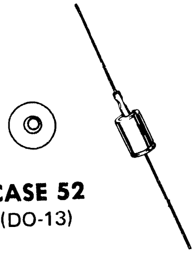
CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N1735 thru 1N1742 (REFERENCE DIODES)
1N1736A thru 1N1742A

For Specifications, See 1N429 Data.

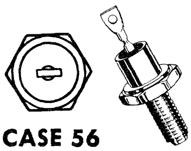
1N1765 thru 1N1802 (ZENER DIODES)



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N1803 thru 1N1836 (ZENER DIODES)

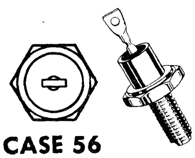


CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series, and 1N2970 series.

1N1816 thru 1N1836 are available as clipper devices. To order, add suffix "C" for ±10%, suffix "CA" for ±5%.

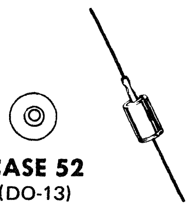
1N2008 thru 1N2012 (ZENER DIODES)



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

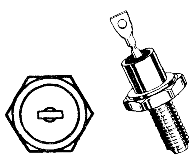
1N2032 thru 1N2040 (ZENER DIODES)



CASE 52
(DO-13)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N4728 series.

1N2041 thru 1N2049 (ZENER DIODES)



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 series.

1N2163 thru 1N2171 (SILICON)

1N2163A thru 1N2171A

1N3580, A, B thru 1N3583, A, B

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.

- Low Dynamic Impedance
- Choice of Three Temperature Ranges
- "Box Method" Specifications Guarantee Maximum Voltage Deviation.

Temperature compensated reference diodes are made by taking advantage of the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/°C. Reverse biased junctions above 5.0 volts have a positive temperature coefficient and therefore it is possible by judicious selection of combinations of forward and reverse biased junctions to obtain a device that shows a very low temperature coefficient due to cancellation. Because of the differing impedance versus temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum.

MAXIMUM RATINGS

Junction Temperature: -55 to +200°C

Storage Temperature: -65 to +200°C

DC Power Dissipation: 750 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal glass

DIMENSIONS: See outline drawing.

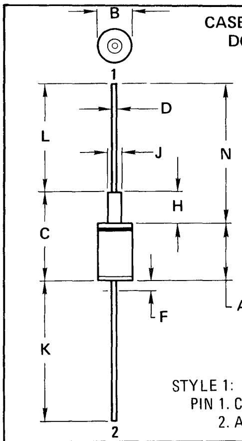
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES



CASE 52-03
DO-13

STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.44	9.07	0.293	0.357
B	5.46	5.97	0.215	0.235
C	–	14.48	–	0.570
D	0.64	0.89	0.025	0.035
F	–	4.78	–	0.188
J	1.14	2.54	0.045	0.100
K	25.40	41.28	1.000	1.625
L	25.40	41.28	1.009	1.625

All JEDEC dimensions and notes apply

ELECTRICAL CHARACTERISTICS

V_Z = 9.4 Volts ± 0.4 V (± 0.2 V Suffix "A") @ (I_{ZT} = 10 mA)

Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures °C	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
1N2163,A	0.033	0, +25, +70	0.005	
1N2164,A	0.086	-55, 0, +25, +75, +125	0.005	15
1N2165,A	0.115	-55, 0, +25, +75, +125, +185	0.005	
1N2166,A	0.007	0, +25, +70	0.001	
1N2167,A	0.017	-55, 0, +25, +75, +125	0.001	15
1N2168,A	0.023	-55, 0, +25, +75, +125, +185	0.001	
1N2169,A	0.004	0, +25, +70	0.0005	
1N2170,A	0.009	-55, 0, +25, +75, +125	0.0005	15
1N2171,A	0.012	-55, 0, +25, +75, +125, +185	0.0005	

NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the maximum ΔV_Z given.

This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

ELECTRICAL CHARACTERISTICS

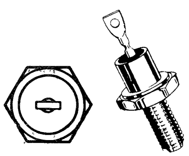
V_Z = 11.7 Volts ± 5.0% (I_{ZT} = 7.5 mA)

Type Number	Max Voltage Change (Note 1) ΔV_Z (Volts)	Test Temperatures °C	Temperature Coefficient (Note 1) %/°C	Max Dynamic Impedance (Note 2) Z_{ZT} (Ohms)
1N3580	0.088		0.01	
1N3581	0.044	0, +25, +75	0.005	25
1N3582	0 018		0.002	
1N3583	0.009		0.001	
1N3580A	0.181		0.01	
1N3581A	0.090	-55, 0, +25, +75, +100	0.005	25
1N3582A	0.036		0.002	
1N3583A	0.018		0.001	
1N3580B	0.239		0.01	
1N3581B	0.120	-55, 0, +25 +75, +100, +150	0.005	25
1N3582B	0.048		0.002	
1N3583B	0.024		0.001	

NOTE 2:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N2498 thru 1N2500



CASE 56
(DO-4)

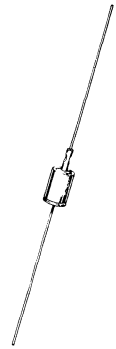
Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N2609 thru 1N2617

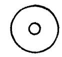
Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N2620, A, B (SILICON)
thru
1N2624, A, B

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. Construction consists of welded hermetically sealed metal and glass case.



CASE 52
(DO-13)



MAXIMUM RATINGS

Junction Temperature: –55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 750 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, welded metal and glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode to case

WEIGHT: 1.5 Grams (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No.	Maximum Voltage Change ΔV_Z (Volts) (Note 1)	Ambient Test Temperature °C ±1°C	Temperature Coefficient %/°C (Note 1)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 2)
V_Z = 9.3 V ±5.0%* @ I_{ZT} = 10 mA				
1N2620	0.070	0, +25, +75	0.01	15
1N2621	0.035		0.005	
1N2622	0.014		0.002	
1N2623	0.007		0.001	
1N2624	0.003		0.0005	
1N2620A	0.144	-55, 0, +25, +75, +100	0.01	15
1N2621A	0.072		0.005	
1N2622A	0.029		0.002	
1N2623A	0.014		0.001	
1N2624A	0.007		0.0005	
1N2620B	0.191	-55, 0, +25, +75, +100, +150	0.01	15
1N2621B	0.095		0.005	
1N2622B	0.038		0.002	
1N2623B	0.019		0.001	
1N2624B	0.010		0.0005	

*Tighter-tolerance units available on special request.

CAPACITANCE (C) = 75 to 200 pF @ 90% of V_Z

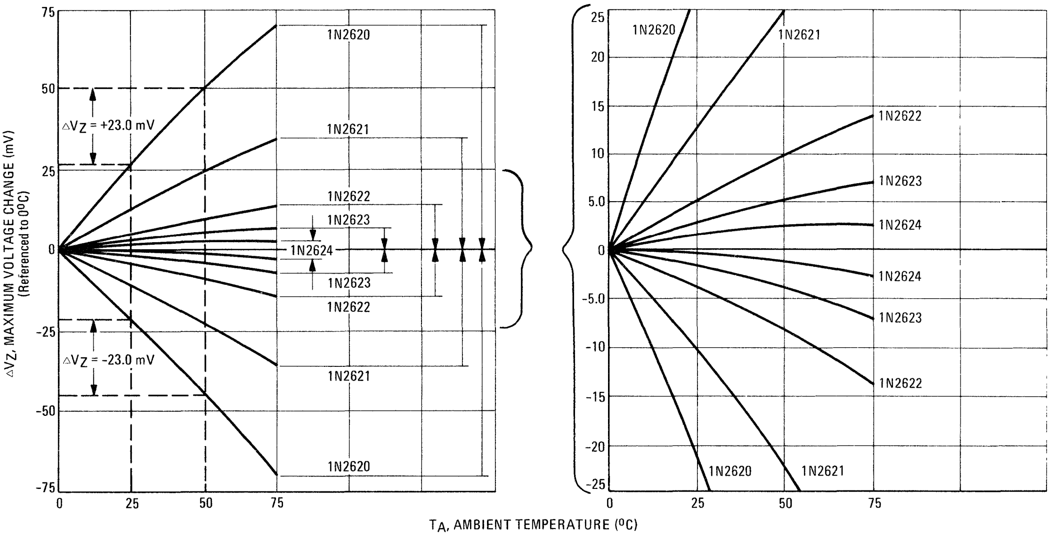
FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 10 mA ±0.01 mA) (See Note 3)

1N2620 thru 1N2624

FIGURE 1a **FIGURE 1b**

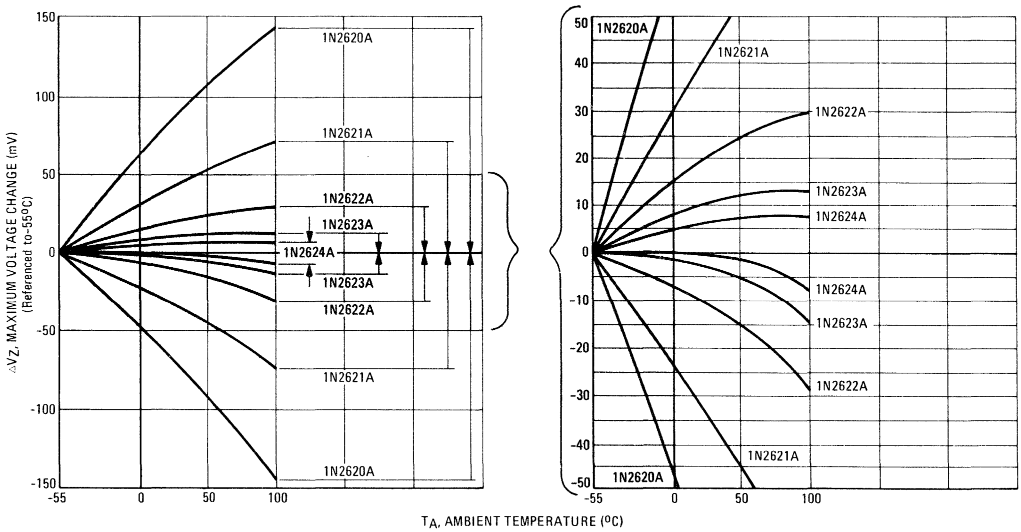


MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(With I_{ZT} = 10 mA ±0.01 mA) (See Note 3)

1N2620A thru 1N2624A

FIGURE 2a **FIGURE 2b**



MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N2620B thru 1N2624B

FIGURE 3a

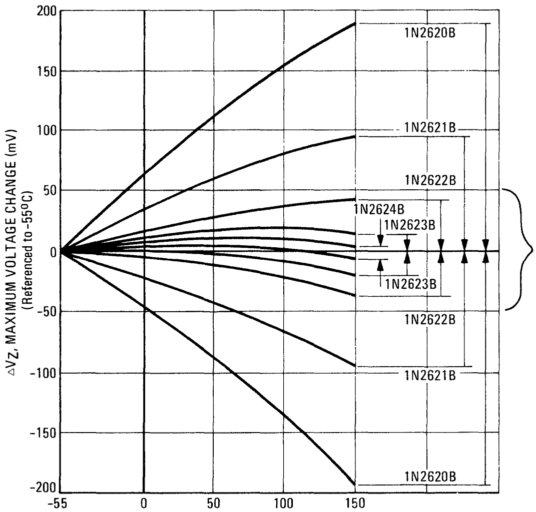
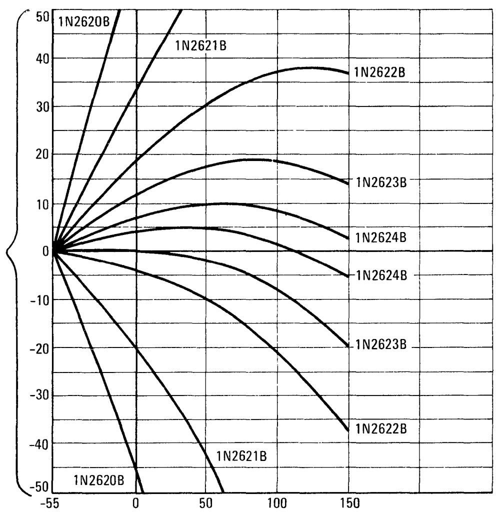


FIGURE 3b

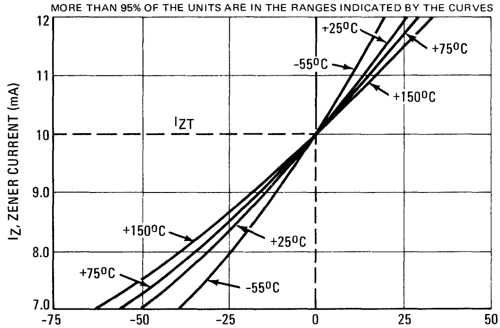


T_A, AMBIENT TEMPERATURE (°C)

FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)

(See Note 4)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES

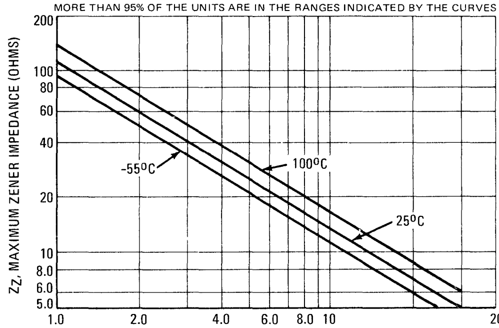


ΔVZ, MAXIMUM VOLTAGE CHANGE (mV)
(Referenced to I_{ZT} = 10 mA)

FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

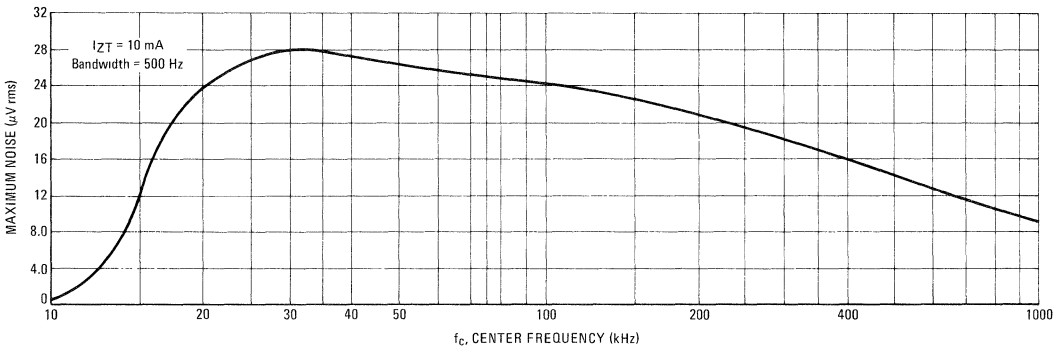
(See Note 2)

MORE THAN 95% OF THE UNITS ARE IN THE RANGES INDICATED BY THE CURVES



I_Z, ZENER CURRENT (mA)

FIGURE 6 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 5. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 3:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from +25 to +50°C will cause a voltage change no greater than +23 mV or −23 mV for 1N2620, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution, expanded views of the shaded areas in Figures 1a, 2a, and 3a are shown in Figures 1b, 2b, and 3b respectively.

NOTE 4:

The maximum voltage change, ΔV_Z, in Figure 4 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 4 to the ΔV_Z in Figure 1, 2, or 3 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 4 on Figure 1, 2, or 3.

1N2804 thru 1N2846 (ZENER DIODES)

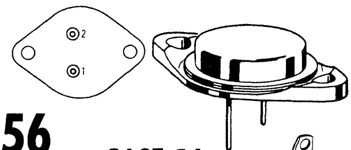
6.8V thru 200V (Case 54)

1N4557 thru 1N4564 1N4549 thru 1N4556

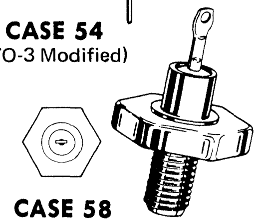
3.9V thru 7.5V (Case 54) 3.9V thru 7.5V (Case 58)

1N3305 thru 1N3350

6.8V thru 200V (Case 58)



CASE 54
(TO-3 Modified)



CASE 58
(stud package)

Units are available with anode-to-case and cathode-to-case connections (standard and reverse polarity). For reverse polarity, add suffix "R" to type number.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.

D C Power Dissipation: 50 Watts. (Derate 0.5 W/°C above 75°C).

TOLERANCE DESIGNATION

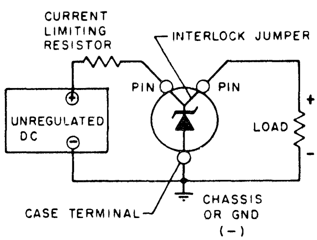
The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available.

CASE 54 APPLICATIONS INFORMATION

If these units are used with a socket, the unregulated line should be connected to one pin through a suitable current limiting resistor and the load should be connected to the other pin. The load will now be disconnected from the line if the unit is removed from the socket.

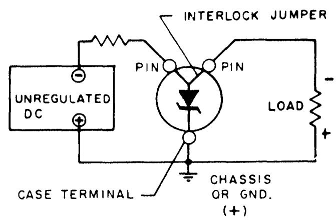
Typical circuit connections for anode-to-case and cathode-to-case polarities (standard and reverse polarities, respectively) are shown below

CIRCUIT CONNECTIONS



STANDARD POLARITY
(ANODE TO CASE)

REVERSE POLARITY
(CATHODE TO CASE)
(RED DOT ON CASE AND "R" SUFFIX ON TYPE NO)



(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Motorola type number should be used.

50	M	90	S	Z	3
Device Description	Motorola	Nominal Voltage	Stud	Zener Diode	Tolerance (±%)

Example: 50M90ZS3

(B) MATCHED SETS: (Standard Tolerances are ±5.0% ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number which is different for each set being ordered.

50	M	51	S	Z	5	B	1
Device Description	Motorola	51 Volts (each device)	Stud	Zener Diodes	Tolerance per device (±5%) (omit for ±20% units)	Code* (A-Not used)	Overall Tolerance of set (±1%)

*Code:
B – Two devices in series
C – Three devices in series
D – Four devices in series

Example: 50M51SZ5B1

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

50	M	20,	S	Z	Z	10
Device Description	Motorola	Nominal Voltage	Stud	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 50M20SZZ10

ELECTRICAL CHARACTERISTICS

(T_C = 30°C unless otherwise specified) V_F = 1.5 V max @ 10 A on all types.

50 Watt CASE 54	50 Watt CASE 58	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance		Max DC Zener Current 75°C Case Temp (I_{ZM}) mA	REVERSE * LEAKAGE CURRENT			Typical Zener Voltage Temp. Coeff. %/°C
				Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ I_{ZK} = 5mA ohms		I_R MAX (μA)	V_{R1}	V_{R2}	
1N4557	1N4549	3.9	3200	0.16	400	11900	150	0.5	0.5	-.025
1N4558	1N4550	4.3	2900	0.16	500	10650	150	0.5	0.5	-.025
1N4559	1N4551	4.7	2650	0.12	600	9700	100	1.0	1.0	.010
1N4560	1N4552	5.1	2450	0.12	650	8900	20	1.0	1.0	.015
1N4561	1N4553	5.6	2250	0.12	900	8100	20	1.0	1.0	.030
1N4562	1N4554	6.2	2000	0.14	1000	7300	20	2.0	2.0	.040
1N2804	1N3305	6.8	1850	0.2	70	6600	150	4.5	4.3	.040
1N4563	1N4555	6.8	1850	0.16	200	6650	10	2.0	2.0	.045
1N2805	1N3306	7.5	1700	0.3	70	5900	75	5.0	4.7	.045
1N4564	1N4556	7.5	1650	0.24	100	6050	10	3.0	3.0	.053
1N2806	1N3307	8.2	1500	0.4	70	5200	50	5.4	5.2	.048
1N2807	1N3308	9.1	1370	0.5	70	4800	25	6.1	5.7	.051
1N2808	1N3309	10	1200	0.6	80	4300	10	6.7	6.3	.055
1N2809	1N3310	11	1100	0.8	80	3900	5	8.4	8.0	.060
1N2810	1N3311	12	1000	1.0	80	3600	5	9.1	8.6	.065
1N2811	1N3312	13	960	1.1	80	3300	5	9.9	9.4	.065
1N2812	1N3313	14	890	1.2	80	3000	5	10.6	10.1	.070
1N2813	1N3314	15	830	1.4	80	2800	5	11.4	10.8	.070
1N2814	1N3315	16	780	1.6	80	2650	5	12.2	11.5	.070
1N2815	1N3316	17	740	1.8	80	2500	5	13.0	12.2	.075
1N2816	1N3317	18	700	2.0	80	2300	5	13.7	13.0	.075
1N2817	1N3318	19	660	2.2	80	2200	5	14.4	13.7	.075
1N2818	1N3319	20	630	2.4	80	2100	5	15.2	14.4	.075
1N2819	1N3320	22	570	2.5	80	1900	5	16.7	15.8	.080
1N2820	1N3321	24	520	2.6	80	1750	5	18.2	17.3	.080
1N2821	1N3322	25	500	2.7	90	1550	5	19.0	18.0	.080
1N2822	1N3323	27	460	2.8	90	1500	5	20.6	19.4	.085
1N2823	1N3324	30	420	3.0	90	1400	5	22.8	21.6	.085
1N2824	1N3325	33	380	3.2	90	1300	5	25.1	23.8	.085
1N2825	1N3326	36	350	3.5	90	1150	5	27.4	25.9	.085
1N2826	1N3327	39	320	4.0	90	1050	5	29.7	28.1	.090
1N2827	1N3328	43	290	4.5	90	975	5	32.7	31.0	.090
1N2828	1N3329	45	280	4.5	100	930	5	34.2	32.4	.090
1N2829	1N3330	47	270	5.0	100	880	5	35.8	33.8	.090
1N2830	1N3331	50	250	5.0	100	830	5	38.0	36.0	.090
1N2831	1N3332	51	245	5.2	100	810	5	38.8	36.7	.090
-	1N3333	52	240	5.5	100	790	5	39.5	37.4	.090
1N2832	1N3334	56	220	6	110	740	5	42.6	40.3	.090
1N2833	1N3335	62	200	7	120	660	5	47.1	44.6	.090
1N2834	1N3336	68	180	8	140	600	5	51.7	49.0	.090
1N2835	1N3337	75	170	9	150	540	5	56.0	54.0	.090
1N2836	1N3338	82	150	11	160	490	5	62.2	59.0	.090
1N2837	1N3339	91	140	15	180	420	5	69.2	65.5	.090
1N2838	1N3340	100	120	20	200	400	5	76.0	72.0	.090
1N2839	1N3341	105	120	25	210	380	5	79.8	75.6	.095
1N2840	1N3342	110	110	30	220	365	5	83.6	79.2	.095
1N2841	1N3343	120	100	40	240	335	5	91.2	86.4	.095
1N2842	1N3344	130	95	50	275	310	5	98.8	93.6	.095
-	1N3345	140	90	60	325	290	5	106.4	100.8	.095
1N2843	1N3346	150	85	75	400	270	5	114.0	108.0	.095
1N2844	1N3347	160	80	80	450	250	5	121.6	115.2	.095
-	1N3348	175	70	85	500	230	5	133.0	126.0	.095
1N2845	1N3349	180	68	90	525	220	5	136.8	129.6	.095
1N2846	1N3350	200	65	100	600	200	5	152.0	144.0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

*V_{R1} — Test Voltage for 5% Tolerance Device

V_{R2} — Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

FIGURE 1 — TEMPERATURE CHARACTERISTICS

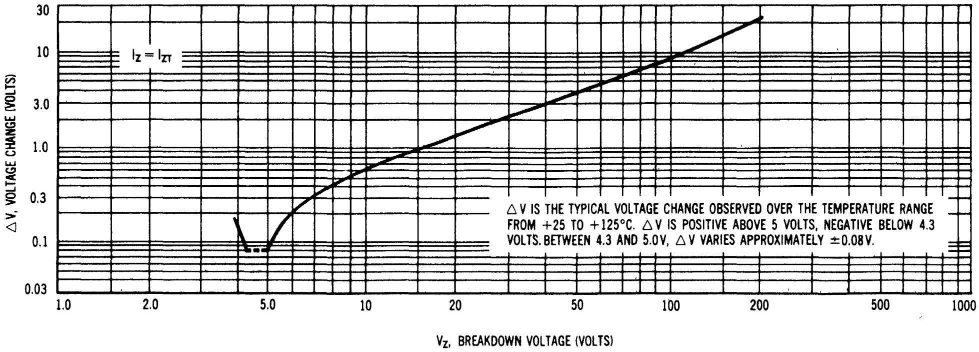


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE

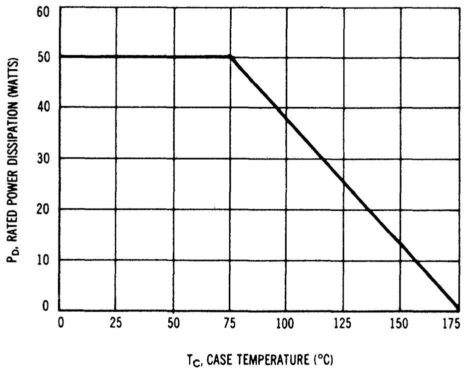


FIGURE 3 — LEAKAGE CURRENT

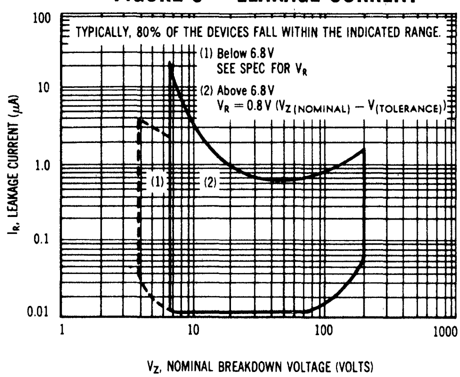
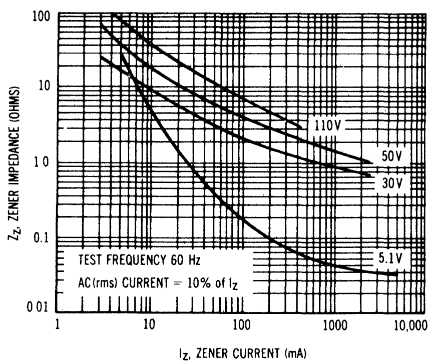
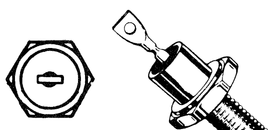


FIGURE 4 — ZENER IMPEDANCE versus ZENER CURRENT



1N2970 thru 1N3015 (ZENER DIODES)



CASE 56
(DO-4)

Diffused-junction zener diodes for both military and high-reliability industrial applications. Available with anode-to-case and cathode-to-case connections (standard and reverse polarity), i.e., 1N2970 and 1N2970R. Supplied with mounting hardware.

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available.)

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

ELECTRICAL CHARACTERISTICS

(T_C = 25°C unless otherwise noted) **V_F = 1.5 V max @ I_F = 2 amp on all types.**

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}
1N2970	6.8	370	1.2	500	1.0	1,320	150	5.2	4.9
1N2971	7.5	335	1.3	250	1.0	1,180	75	5.7	5.4
1N2972	8.2	305	1.5	250	1.0	1,040	50	6.2	5.9
1N2973	9.1	275	2.0	250	1.0	960	25	6.9	6.6
1N2974	10	250	3	250	1.0	860	10	7.6	7.2
1N2975	11	230	3	250	1.0	780	5	8.4	8.0
1N2976	12	210	3	250	1.0	720	5	9.1	8.6
1N2977	13	190	3	250	1.0	660	5	9.9	9.4
1N2978	14	180	3	250	1.0	600	5	10.6	10.1
1N2979	15	170	3	250	1.0	560	5	11.4	10.8
1N2980	16	155	4	250	1.0	530	5	12.2	11.5
1N2982	18	140	4	250	1.0	460	5	13.7	13.0
1N2983	19	130	4	250	1.0	440	5	14.4	13.7
1N2984	20	125	4	250	1.0	420	5	15.2	14.4
1N2985	22	115	5	250	1.0	380	5	16.7	15.8
1N2986	24	105	5	250	1.0	350	5	18.2	17.3
1N2988	27	95	7	250	1.0	300	5	20.6	19.4
1N2989	30	85	8	300	1.0	280	5	22.8	21.6
1N2990	33	75	9	300	1.0	260	5	25.1	23.8
1N2991	36	70	10	300	1.0	230	5	27.4	25.9

*V_{R1} – Test Voltage for 5% Tolerance Device. V_{R2} – Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Motorola type number should be used.

10 M 90 Z 3

- 10 – Device Description
- M – Motorola
- 90 – Nominal Voltage
- Z – Zener Diode
- 3 – Tolerance (±%)

Example: 10M90Z3

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.

10 M 51 Z 5 B 1

- 10 – Device Description
- M – Motorola
- 51 – 51 Volts (each device)
- Z – Zener Diodes
- 5 – Tolerance per device (±5%) (omit for ±20% units)
- B – Code* (A-Not used)
- 1 – Overall Tolerance of set (±1%)

*Code:
- B – Two devices in series
- C – Three devices in series
- D – Four devices in series

Example: 10M515B1

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

10 M 20, Z Z 10

- 10 – Device Description
- M – Motorola
- 20, – Nominal Voltage
- Z – Zener Diodes
- Z – Clipper
- 10 – Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 10M20ZZ10

ELECTRICAL CHARACTERISTICS

(T_C = 25°C unless otherwise noted) V_F = 1.5 V max @ I_F = 2 amp on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance			Max DC Zener Current I_{ZM} mA	Max. Reverse Current *		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Max (μA)	V_{R1}	V_{R2}
1N2992	39	65	11	300	1.0	210	5	29.7	28.1
1N2993	43	60	12	400	1.0	195	5	32.7	31.0
1N2995	47	55	14	400	1.0	175	5	35.8	33.8
1N2996	50	50	15	500	1.0	165	5	38.0	36.0
1N2997	51	50	15	500	1.0	163	5	38.8	36.7
1N2998	52	50	15	500	1.0	160	5	39.5	37.4
1N2999	56	45	16	500	1.0	150	5	42.6	40.3
1N3000	62	40	17	600	1.0	130	5	47.1	44.6
1N3001	68	37	18	600	1.0	120	5	51.7	49.0
1N3002	75	33	22	600	1.0	110	5	56.0	54.0
1N3003	82	30	25	700	1.0	100	5	62.2	59.0
1N3004	91	28	35	800	1.0	85	5	69.2	65.5
1N3005	100	25	40	900	1.0	80	5	76.0	72.0
1N3006	105	25	45	1,000	1.0	75	5	79.8	75.6
1N3007	110	23	55	1,100	1.0	72	5	83.6	79.2
1N3008	120	20	75	1,200	1.0	67	5	91.2	86.4
1N3009	130	19	100	1,300	1.0	62	5	98.8	93.6
1N3010	140	18	125	1,400	1.0	58	5	106.4	100.8
1N3011	150	17	175	1,500	1.0	54	5	114.0	108.0
1N3012	160	16	200	1,600	1.0	50	5	121.6	115.2
1N3014	180	14	260	1,850	1.0	45	5	136.8	129.6
1N3015	200	12	300	2,000	1.0	40	5	152.0	144.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

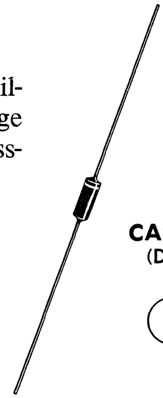
*V_{R1} – Test Voltage for 5% Tolerance Device. V_{R2} – Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3016 thru 1N3051

For Specifications, See 1N3821 Data.

1N3154, A (SILICON)
thru
1N3157, A

Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

O

MAXIMUM RATINGS

Junction Temperature: -55 to +175°C

Storage Temperature: -65 to +175°C

DC Power Dissipation: 500 mW @ T_A = 25°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

JEDEC Type No. (Note 1)	Maximum Voltage Change ΔV_Z (Volts) (Note 2)	Ambient Test Temperature °C ±1°C	Temperature Coefficient %/°C (Note 2)	Maximum Dynamic Impedance Z_{ZT} (Ohms) (Note 3)
V_Z = 8.4 V ±5.0%* @ I_{ZT} = 10 mA				
1N3154	0.130	-55, 0, +25, +75, +100	0.01	15
1N3155	0.065		0.005	
1N3156	0.026		0.002	
1N3157	0.013		0.001	
1N3154A	0.172	-55, 0, +25, +75, +100, +150	0.01	15
1N3155A	0.086		0.005	
1N3156A	0.034		0.002	
1N3157A	0.017		0.001	

*Tighter-tolerance units available on special request.

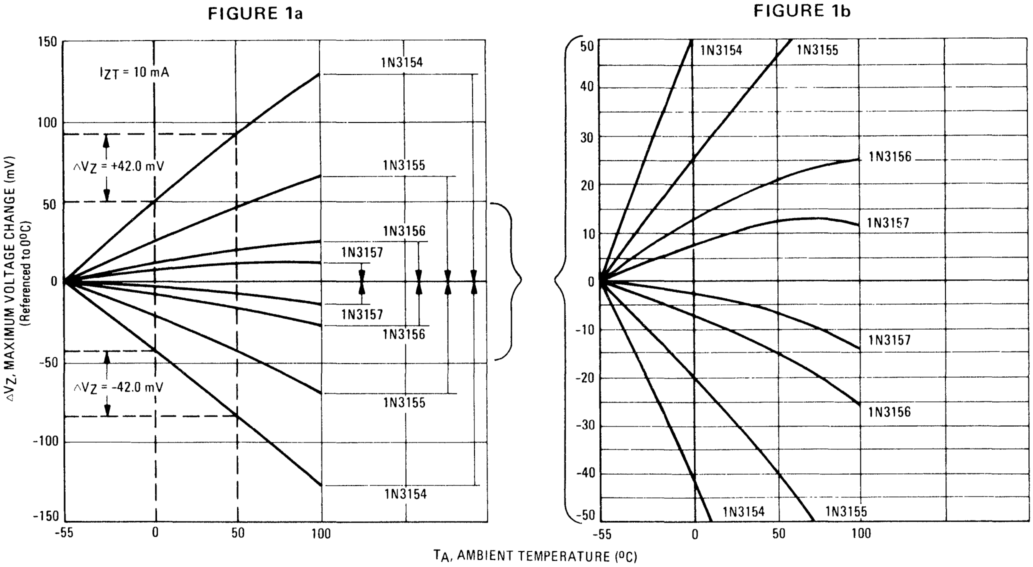
CAPACITANCE (C) = 20 to 180 pF @ 90% of V_Z

FORWARD BREAKDOWN VOLTAGE (V_f) = 100 to 800 V

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N3154 thru 1N3157



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 10 mA ±0.01 mA) (See Note 4)

1N3154A thru 1N3157A

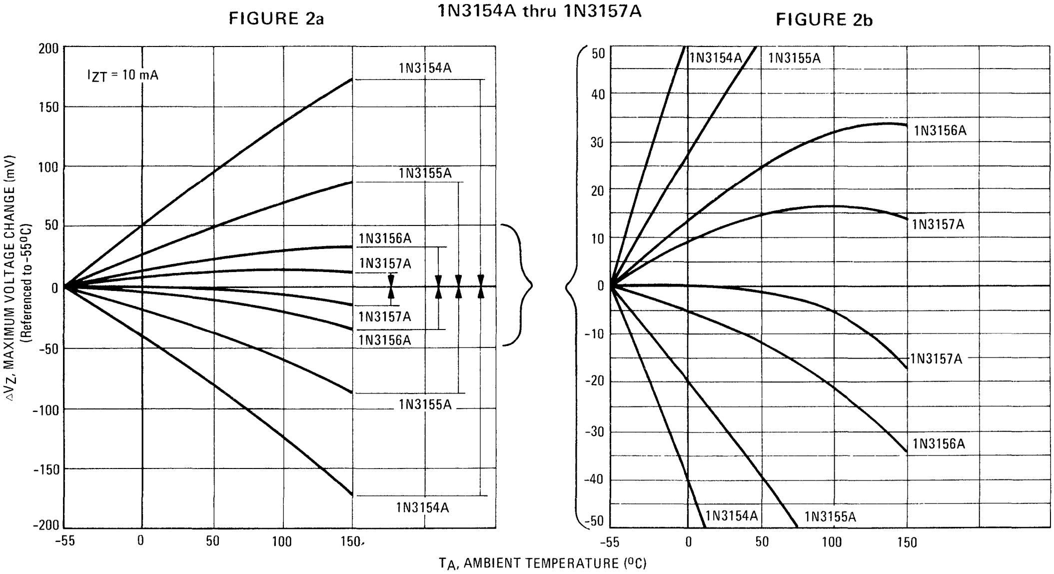


FIGURE 3 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 5)

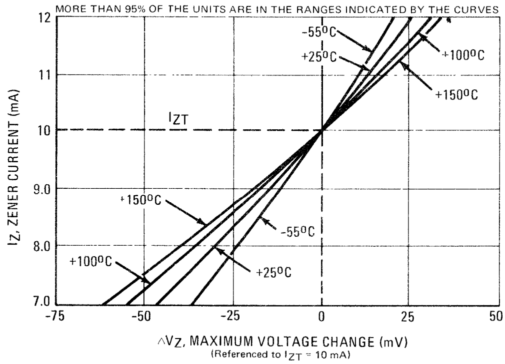


FIGURE 4 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

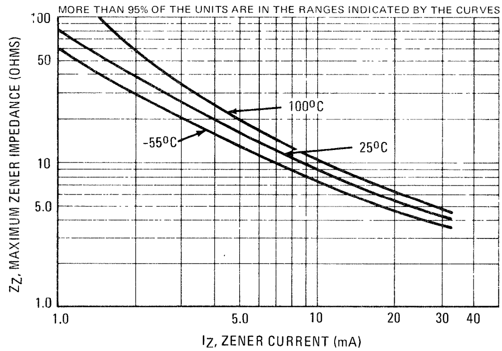
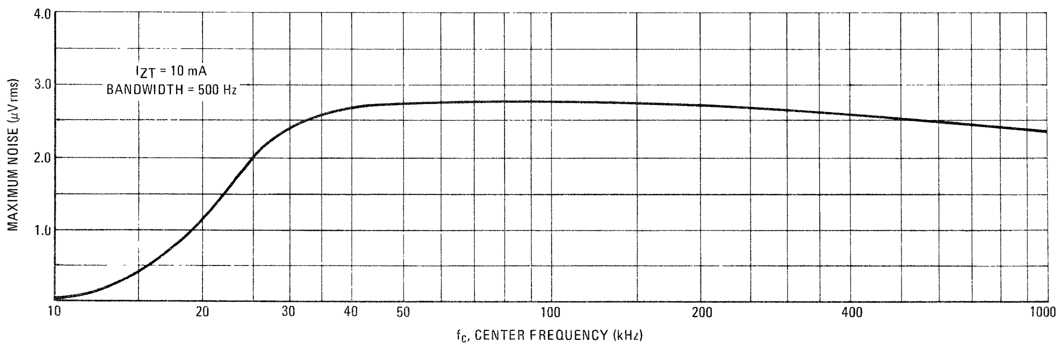


FIGURE 5 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N3154 thru 1N3157 are available to MIL-S-19500/158

NOTE 2:

Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability – by means of temperature coefficient – accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 3:

Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. Curves showing the variation of zener impedance with zener current for each series are given in Figure 4. A cathode-ray tube curve-trace test on a sample basis is used to ensure that each zener characteristic has a sharp and stable knee region.

NOTE 4:

These graphs can be used to determine the maximum voltage change of any device in the series over any specific temperature range. For example, a temperature change from 0 to +50°C will cause a voltage change no greater than +42 mV or -42 mV for 1N3154, as illustrated by the dashed lines in Figure 1. The boundaries given are maximum values. For greater resolution,. expanded views of the shaded areas in Figures 1a and 2a are shown in Figures 1b and 2b respectively.

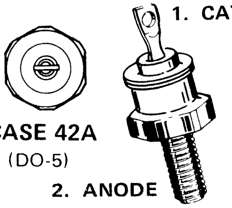
NOTE 5:

The maximum voltage change, ΔV_Z, in Figure 3 is due entirely to the impedance of the device. If both temperature and I_{ZT} are varied, then the total voltage change may be obtained by adding ΔV_Z in Figure 3 to the ΔV_Z in Figure 1 or 2 for the device under consideration. If the device is to be operated at some stable current other than the specified test current, a new set of characteristics may be plotted by superimposing the data in Figure 3 on Figure 1 or 2.

1N3189 thru 1N3191

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N3208 thru 1N3212 (SILICON)



Medium-current silicon rectifiers. Cathode connected to case, but reverse polarity (anode-to-case connection) also available by adding suffix "R" to type number, e.g. 1N3208R.

MAXIMUM RATINGS

Rating	Symbol	1N3208 1N3208R	1N3209 1N3209R	1N3210 1N3210R	1N3211 1N3211R	1N3212 1N3212R	Unit
D C Blocking Voltage	V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current With Resistive Load	I_O*	15	15	15	15	15	Amp
Peak One Cycle Surge Current (60 cps & 25°C Case Temp)	I_{FSM}	250	250	250	250	250	Amp
Operating Junction Temperature	T_J	-65 to + 175					°C
Storage Temperature	T_{stg}	-65 to + 175					°C

*T_C = 150°C

ELECTRICAL CHARACTERISTICS (All Types) at 25°C Case Temp.

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage at 40 Amp D-C Forward Current	V_F	1.5	Volts
Maximum Reverse Current at Rated D-C Reverse Voltage	I_R	1.0	mAdc
Typical Thermal Resistance, Junction To Case	$R_{\theta JC}$	1.7	C/W

1N3213, 1N3214

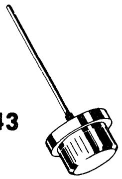
For Specifications, See **1N248B** Data.

1N3305 thru 1N3350

For Specifications, see 1N2804 Data.

1N3491 thru 1N3495 (SILICON)
MR327, MR328, MR330, MR331

CASE 43
(DO-21)



Medium-current silicon rectifiers – compact, highly efficient silicon rectifiers for medium-current applications.

MAXIMUM RATINGS

Rating	Symbol	1N3491	1N3492	1N3493	1N3494	1N3495	MR327	MR328	MR330	MR331	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz , see Figure 3) T_C = 130°C	I_O	25									Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	I_{FSM}	300 (for 1/2 cycle)									Amp
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	375									$A_{(rms)}^2$ sec
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175									°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable.

POLARITY: CATHODE TO CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR327R or 1N3491R).

MOUNTING POSITIONS: Any.

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop (i_F = 100 Amps, T_J = 25°C)	v_F	1.5	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 Hz, T_C = 150°C)	$I_{R(AV)}$		mA
1N3491		10	
1N3492		10	
1N3493		8.0	
1N3494		6.0	
1N3495		4.0	
MR327		3.0	
MR328		2.5	
MR330		2.0	
MR331		1.5	
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	1.0	mA

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

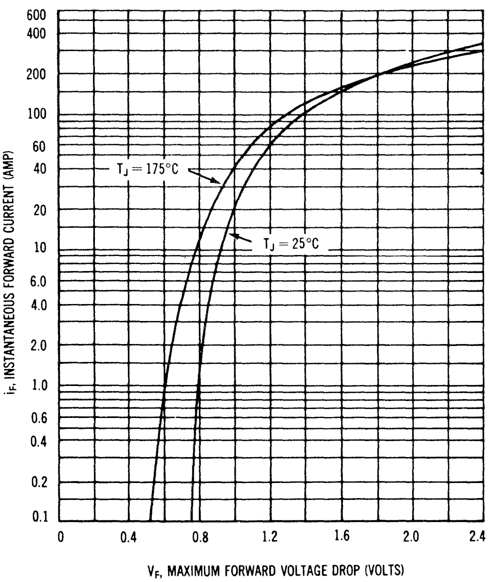


FIGURE 2 — MAXIMUM FORWARD POWER DISSIPATION

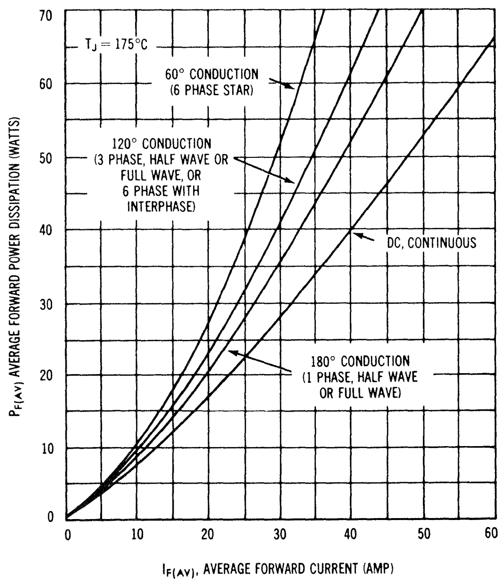


FIGURE 3 — MAXIMUM CURRENT RATINGS

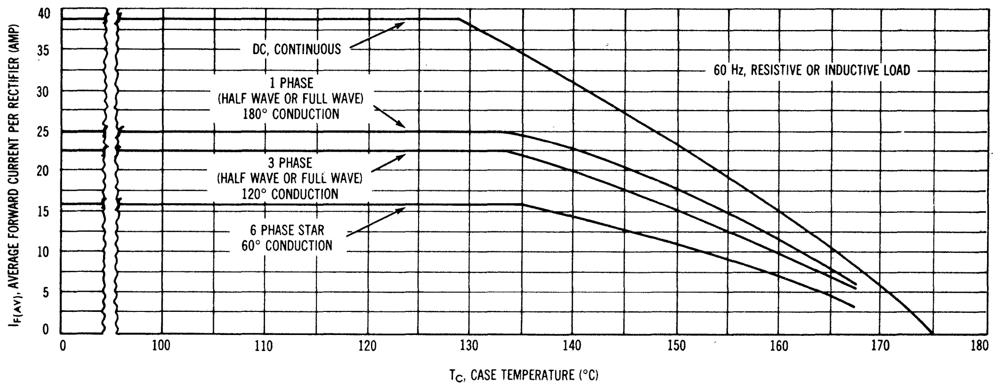


FIGURE 4 — MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE

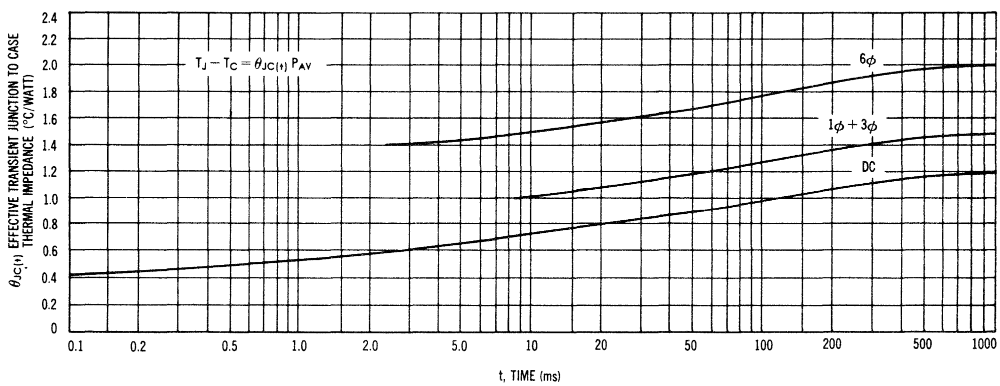
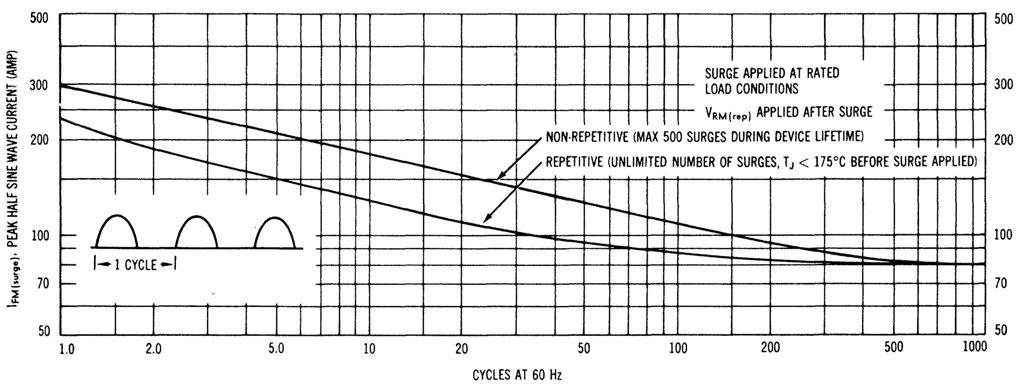


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 — RECTIFICATION EFFICIENCY

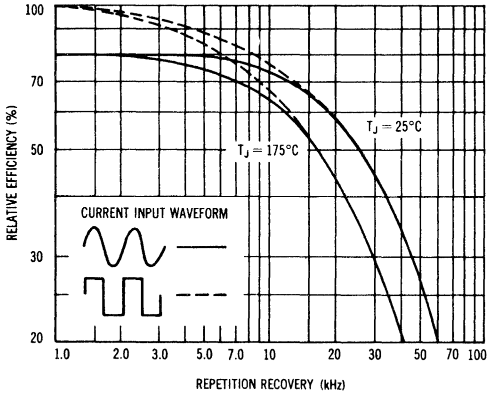


FIGURE 7 — REVERSE RECOVERY TIME

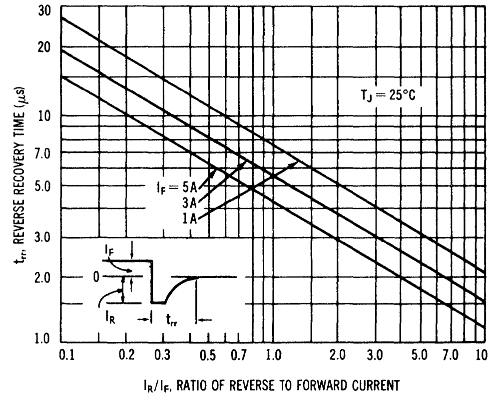


FIGURE 8 — JUNCTION CAPACITANCE

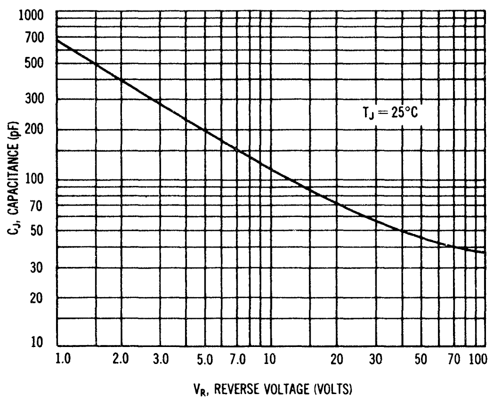
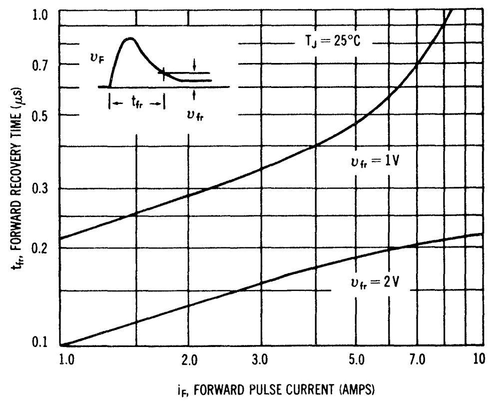
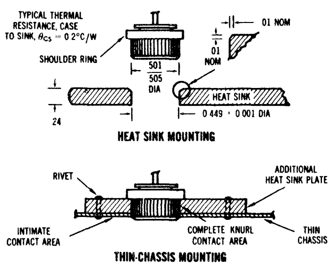


FIGURE 9 — FORWARD RECOVERY TIME





MOUNTING PROCEDURES

MR327-MR331 and 1N3491-1N3495 rectifiers are designed to be press-fitted in a heat sink in order to attain full device ratings. Recommended procedures for this type of mounting are as follows:

1. **Drill a hole in the heat sink 0.499 ± .001 inch in diameter.**
2. **Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.**
3. **The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.**
4. **To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown in the figure.**
5. **The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a light industrial lubricant will be of considerable aid.**

1N3580, A, B thru 1N3583, A, B

For Specifications, See 1N2163 Data.

1N3649, 1N3650

Obsolete, discontinued types, replace with devices from the MR1120 series.

1N3659 thru 1N3663 (SILICON)

CASE 43
(DO-21)

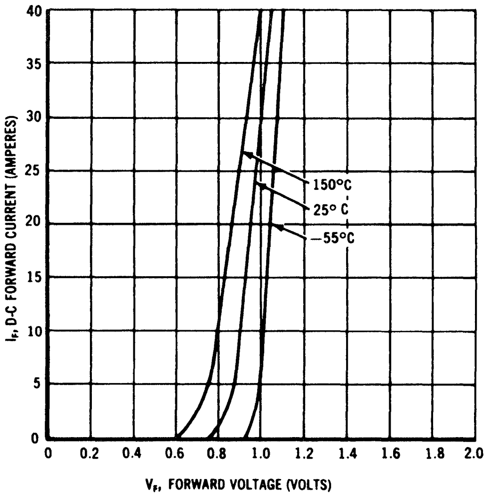
Low-cost silicon rectifiers in hermetically sealed, press-fit case, designed for operation under severe environmental conditions. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

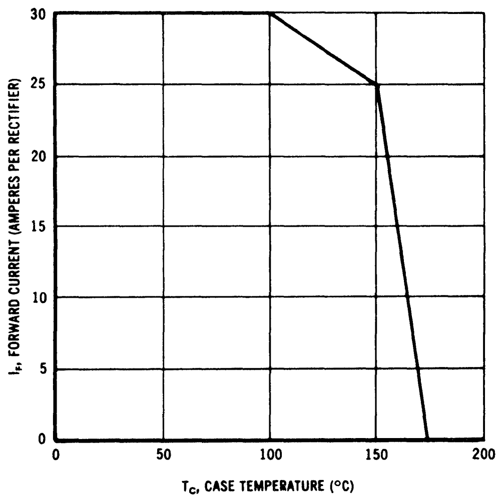
MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Units
Peak Repetitive Reverse Voltage DC Blocking Voltage	V_{RRM} V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current with Resistive Load @ 100°C case @ 150°C case	I_O			30 25			Amp Amp
Peak One Cycle Surge Current (150°C case temp, 60 Hz)	I_{FSM}			400			Amp
Operating Junction Temperature	T_J			−65 to +175			°C
Storage Temperature	T_{stg}			−65 to +200			°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Unit
Maximum Forward Voltage at 25 Amp DC Forward Current	V_F	1.2	1.2	1.2	1.2	1.2	Volts
Maximum Full Cycle Average Forward Voltage Drop @ Rated PIV and Current	$V_{F(AV)}$	0.7	0.7	0.7	0.7	0.7	Volts
Maximum Full Cycle Average Reverse Current @ Rated PIV and Current (as half-wave rectifier, resistive load, 150°C)	$I_{R(AV)}$	5.0	4.5	4.0	3.5	3.0	mA
Thermal Resistance, Junction to Case	$R_{\theta JC}$			1.0			°C/W



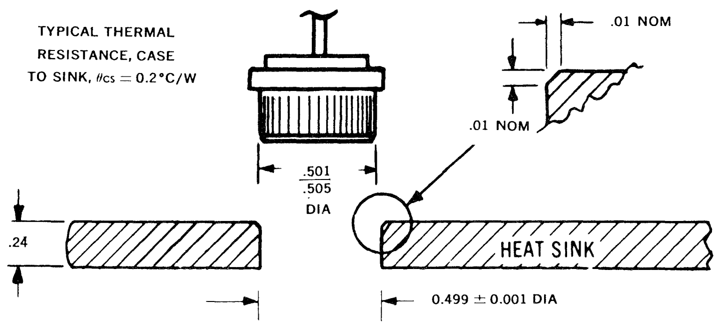


1N3659-1N3663 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

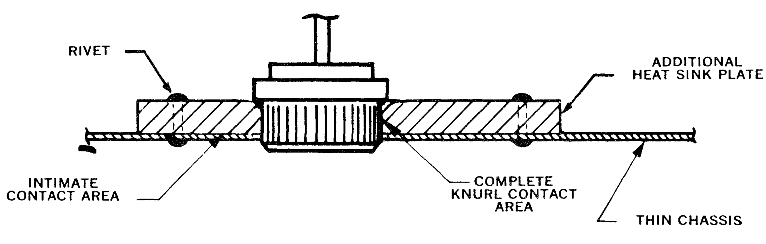
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat sink surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier- heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.

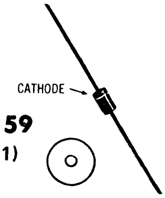


HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

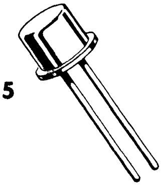
1N3675 thru 1N3703 (SILICON)



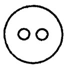
CASE 59
(DO-41)

Recommended for applications requiring an exact replacement only. For new designs and industry preferred replacement devices, see 1N4728 series.

1N3785 thru 1N3820



CASE 55



Low silhouette single-ended package for printed circuit or socket mounting. Cathode connected to case.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 1.5 Watts at 25°C Ambient. (Derate 10 mW/°C).

The type numbers shown have a standard tolerance of ±20% on the zener voltage. Standard tolerances of ±10% and ±5% on individual units are also available and are indicated by suffixing "A" for ±10% and "B" for ±5% units to the standard type number.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

V_F = 1.5 V max @ 300 mA

Type No.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ I_{ZK} ohms	I_{ZK} mA	Max DC Zener Current (I_{ZM}) mA	Reverse Leakage Current* I_R Max (μA)	V_{R1}	V_{R2}	Typical Zener Voltage Temp. Coeff. %/°C
1N3785	6.8	55	2.7	700	1.0	195	150	5.2	4.9	.040
1N3786	7.5	50	3.0	700	0.5	175	75	5.7	5.4	.045
1N3787	8.2	46	3.5	700	0.5	155	50	6.2	5.9	.048
1N3788	9.1	41	4.0	700	0.5	140	25	6.9	6.6	.051
1N3789	10	37	5	700	0.25	125	10	7.6	7.2	.055
1N3790	11	34	6	700	0.25	115	5	8.4	8.0	.060
1N3791	12	31	7	700	0.25	105	5	9.1	8.6	.065
1N3792	13	29	8	700	0.25	98	5	9.9	9.4	.065
1N3793	15	25	10	700	0.25	85	5	11.4	10.8	.070
1N3794	16	23	11	700	0.25	80	5	12.2	11.5	.070
1N3795	18	21	13	750	0.25	70	5	13.7	13.0	.075
1N3796	20	19	15	750	0.25	62	5	15.2	14.4	.075
1N3797	22	17	16	750	0.25	56	5	16.7	15.8	.080
1N3798	24	16	17	750	0.25	51	5	18.2	17.3	.080
1N3799	27	14	20	750	0.25	46	5	20.6	19.4	.085
1N3800	30	12	25	1,000	0.25	41	5	22.8	21.6	.085
1N3801	33	11	30	1,000	0.25	38	5	25.1	23.8	.085
1N3802	36	10	35	1,000	0.25	35	5	27.4	25.9	.085
1N3803	39	10	40	1,000	0.25	31	5	29.7	28.1	.090
1N3804	43	9.0	45	1,500	0.25	28	5	32.7	31.0	.090
1N3805	47	8.0	55	1,500	0.25	26	5	35.8	33.8	.090
1N3806	51	7.4	65	2,000	0.25	24	5	38.8	36.6	.090
1N3807	56	6.7	75	2,000	0.25	22	5	42.6	40.3	.090
1N3808	62	6.0	85	2,000	0.25	20	5	47.1	44.6	.090
1N3809	68	5.5	95	2,000	0.25	18	5	51.7	49.0	.090
1N3810	75	5.0	110	2,000	0.25	16	5	56.0	54.0	.090
1N3811	82	4.5	130	3,000	0.25	14	5	62.0	59.0	.090
1N3812	91	4.1	150	3,000	0.25	13	5	69.2	65.5	.090
1N3813	100	3.7	200	3,000	0.25	12.0	5	76.0	72.0	.090
1N3814	110	3.4	300	4,000	0.25	11.0	5	83.6	79.2	.095
1N3815	120	3.1	350	4,500	0.25	10.5	5	91.2	86.4	.095
1N3816	130	2.9	400	5,000	0.25	9.0	5	98.8	93.6	.095
1N3817	150	2.5	700	6,000	0.25	8.0	5	114.0	108.0	.095
1N3818	160	2.3	750	6,500	0.25	8.0	5	121.8	115.0	.095
1N3819	180	2.1	800	7,000	0.25	7.0	5	137.0	130.0	.095
1N3820	200	1.9	1,000	8,000	0.25	6.0	5	152.0	144 0	.100

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)
1 — Nominal zener voltages between those shown.
2 — Matched sets: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%) depending on voltage per device.
  a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make possible higher zener voltages and provide lower temperature coefficients, lower dynamic impedance and greater power handling ability.
  b. Two or more units matched to one another with any specified tolerance.
3 — Tight voltage tolerances: 1.0%, 2.0%, 3.0%.

*V_{R1} — Test Voltage for 5% Tolerance Device. V_{R2} — Test Voltage for 10% Tolerance Device. No Leakage Specified as 20% Tolerance Device.

1N3821 thru 1N3830 (SILICON)
SERIES
(1M3.3AZ10 thru 1M7.5AZ10)
1N3016 thru 1N3051
SERIES
(1M6.8Z thru 1M200Z)

Designers Data Sheet

1.0 WATT METAL SILICON ZENER DIODES

. . . a complete series of 1.0 Watt Zener Diodes with limits and operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, metal package offering protection in all common environmental conditions.

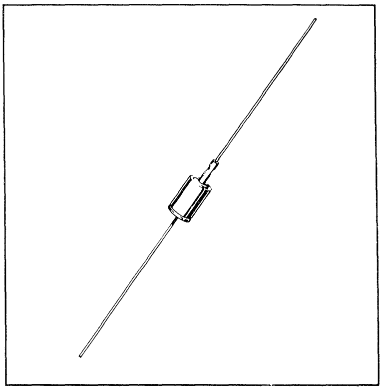
- To 100 Watts Surge Rating @ 10 ms
- Maximum Limits Guaranteed on Five Electrical Parameters
- Power Capability to MIL-S-19500 Specifications

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

1.0 WATT
ZENER REGULATOR DIODES

3.3–200 VOLTS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 25°C Derate above 25°C (See Figure 1)	P_D	1.0 6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C
Lead Temperature 230°C at a distance not less than 1/16" from the case for 10 seconds.			

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed metal and glass.

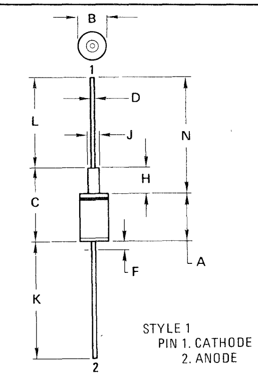
DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion-resistant and leads are readily solderable and weldable.

POLARITY: Cathode connected to the case. When operated in zener mode, cathode will be positive with respect to anode.

WEIGHT: 1.4 Grams (approx)

MOUNTING POSITION: Any

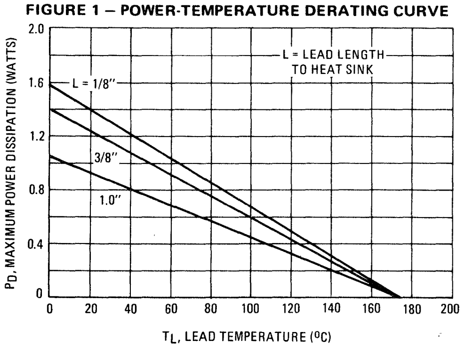


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	7.44	9.07	0.293	0.357
B	5.46	5.97	0.215	0.235
C	–	14.48	-	0.570
D	0.64	0.89	0.025	0.035
F	–	4.78	-	0.188
J	1.14	2.54	0.045	0.100
K	25.40	41.28	1.000	1.625
L	25.40	41.28	1.009	1.625

All JEDEC dimensions and notes apply

CASE 52-03
DO-13

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)
V_F = 1.5 V max @ I_F = 200 mA for all types

JEDEC Type No. (Flangeless) (Note 1 & 2)	*Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 3)	*Test Current I_{ZT} mA	*Max Zener Impedance (Note 4)			Max Reverse Current (Note 5)			*Max DC Zener Current I_{ZM} mA (Note 6)
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	I_R Max (μA)	V_{R1} 5%	V_{R2} 10%	
1N3821	3.3	76	10	400	1.0	*100	*1.0	1.0	276
1N3822	3.6	69	10	400	1.0	*100	*1.0	1.0	252
1N3823	3.9	64	9.0	400	1.0	*50	*1.0	1.0	238
1N3824	4.3	58	9.0	400	1.0	*10	*1.0	1.0	213
1N3825	4.7	53	8.0	500	1.0	*10	*1.0	1.0	194
1N3826	5.1	49	7.0	550	1.0	*10	*1.0	1.0	178
1N3827	5.6	45	5.0	600	1.0	*10	*2.0	2.0	162
1N3828	6.2	41	2.0	700	1.0	*10	*3.0	3.0	146
1N3829	6.8	37	1.5	500	1.0	*10	*3.0	3.0	133
1N3830	7.5	34	1.5	250	1.0	*10	*3.0	3.0	121
1N3016	6.8	37	3.5	700	1.0	10	5.2	4.9	140
1N3017	7.5	34	4.0	700	0.5	10	5.7	5.4	125
1N3018	8.2	31	4.5	700	0.5	10	6.2	5.9	115
1N3019	9.1	28	5.0	700	0.5	7 5	6.9	6.6	105
1N3020	10	25	7.0	700	0.25	5 0	7.6	7.2	95
1N3021	11	23	8.0	700	0.25	5 0	8.4	8.0	85
1N3022	12	21	9.0	700	0.25	2.0	9.1	8 6	80
1N3023	13	19	10	700	0.25	1.0	9.9	9.4	74
1N3024	15	17	14	700	0.25	1.0	11.4	10.8	63
1N3025	16	15.5	16	700	0.25	1.0	12.2	11.5	60
1N3026	18	14	20	750	0 25	0.5	13.7	13.0	52
1N3027	20	12.5	22	750	0.25	0.5	15.2	14.4	47
1N3028	22	11.5	23	750	0.25	0 5	16.7	15.8	43
1N3029	24	10.5	25	750	0.25	0.5	18 2	17.3	40
1N3030	27	9.5	35	750	0.25	0.5	20.6	19.4	34
1N3031	30	8.5	40	1000	0.25	0.5	22.8	21.6	31
1N3032	33	7.5	45	1000	0.25	0 5	25.1	23.8	28
1N3033	36	7.0	50	1000	0.25	0.5	27.4	25.9	26
1N3034	39	6.5	60	1000	0.25	0.5	29.7	28.1	23
1N3035	43	6.0	70	1500	0.25	0.5	32.7	31.0	21
1N3036	47	5.5	80	1500	0.25	0.5	35.8	33.8	19
1N3037	51	5.0	95	1500	0.25	0.5	38.8	36.7	18
1N3038	56	4.5	110	2000	0.25	0.5	42.6	40.3	17
1N3039	62	4.0	125	2000	0.25	0.5	47.1	44.6	15
1N3040	68	3.7	150	2000	0.25	0.5	51.7	49.0	14
1N3041	75	3.3	175	2000	0.25	0.5	56.0	54.0	12
1N3042	82	3.0	200	3000	0.25	0.5	62.2	59.0	11
1N3043	91	2.8	250	3000	0.25	0.5	69.2	65.5	10
1N3044	100	2.5	350	3000	0.25	0.5	76.0	72.0	9 0
1N3045	110	2.3	450	4000	0.25	0.5	83.6	79.2	8.3
1N3046	120	2.0	550	4500	0.25	0.5	91.2	86.4	8.0
1N3047	130	1.9	700	5000	0.25	0.5	98.8	93.6	6.9
1N3048	150	1.7	1000	6000	0.25	0.5	114.0	108.0	5 7
1N3049	160	1.6	1100	6500	0.25	0.5	121.6	115.2	5.4
1N3050	180	1.4	1200	7000	0.25	0.5	136.8	129.6	4.9
1N3051	200	1.2	1500	8000	0.25	0.5	152.0	144.0	4.6

* JEDEC Registered Data on 1N3821 thru 1N3830 and 1N3016 thru 1N3051

NOTE 1 – TOLERANCE AND TYPE NUMBER DESIGNATION

1N3821 thru 1N3830 – The JEDEC type numbers shown have a standard tolerance for the nominal zener voltage of ±10%. A standard tolerance of ±5% for individual units is also available and is indicated by adding suffix "A" to the standard type number.

1N3016 thru 1N3051 – The JEDEC type numbers shown have a standard tolerance of ±20% for the nominal zener voltage. Suffix "A" for ±10% units or "B" for ±5% units.

NOTE 2 – SPECIALS AVAILABLE INCLUDE:

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES: To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Motorola type number should be used.

1 M 5.1 A Z 3

- 1 – Device Description
- M – Motorola
- 5.1 – Nominal Voltage
- A – 1N3821 thru 1N3830 only
- Z – Zener Diode
- 3 – Tolerance (±%)

EXAMPLE **1M5.1AZ3**

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).

Zener diodes are available in sets consisting of two or more matched devices. The method for specifying matched sets is similar to the one described in (A) except that two additional suffixes are added to the code number described.

These devices are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set ordered.

1 M 51 A 5 B 1

- 1 – Device Description
- M – Motorola
- 51 – 51 Volts (each device)
- A – 1N3821 thru 1N3830 only
- 5 – Tolerance per device ±5% (omit for ±20% units)
- B – Code
  - A – Not used
  - B – Two devices in series
  - C – Three devices in series
  - D – Four devices in series
- 1 – Overall Tolerance of set (±1%)

EXAMPLE **1M51Z5B1**

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

1	M	7.5	A	Z	Z	10
Device Description	Motorola	Nominal Voltage	1N3821 thru 1N3830 only	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: **1M7.5AZZ10**

NOTE 3 – ZENER VOLTAGE (V_Z) MEASUREMENT

Motorola guarantees the zener voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at 30°C ± 1°C, 3/8" from the diode body.

NOTE 4 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}.

NOTE 5 – REVERSE LEAKAGE CURRENT I_R

Reverse leakage currents are guaranteed only for 5% and 10% zener diodes and are measured at V_R as shown in the Electrical Characteristics Table.

NOTE 6 – MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

1N3821 thru 1N3830 — Maximum zener current ratings are based on maximum voltage of 10% tolerance units.

1N3016 thru 1N3051 — Maximum zener current ratings are based on maximum voltage of 5% tolerance units.

NOTE 7 – SURGE CURRENT (i_r)

Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a specified pulse width, PW. The data presented in Figures 8 and 9 may be used to find the maximum surge current for a square wave of any pulse width between 0.01 ms and 1000 ms.

APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance (°C/W) and P_D is the power dissipation. The value for θ_{LA} will vary and depends on the device mounting method. θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the lead can also be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 6 for a train of power pulses (L = 3/8 inch) or from Figure 7 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of $T_J(\Delta T_J)$ may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 2 and 3.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 6 should not be used to compute surge capability. Surge limitations are given in Figure 8. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 8 be exceeded.

TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% OF THE UNITS ARE IN THE RANGES INDICATED)

FIGURE 2 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS TO 12 VOLTS

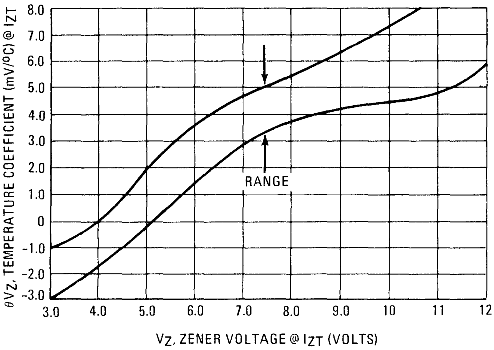


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

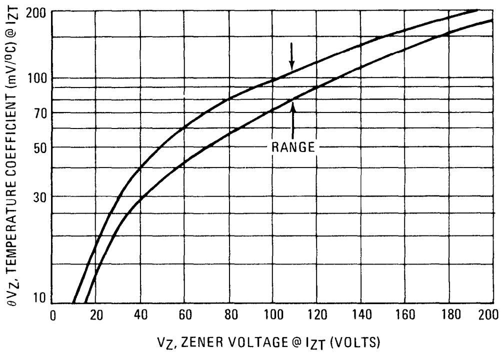


FIGURE 4 – TYPICAL VOLTAGE REGULATION

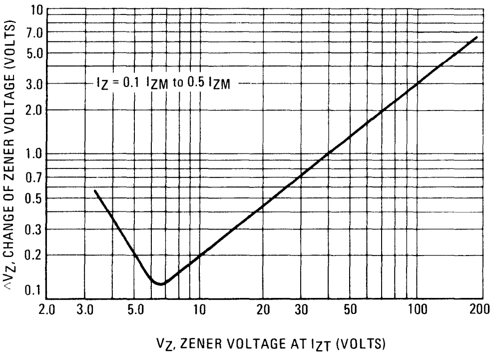


FIGURE 5 – MAXIMUM REVERSE LEAKAGE
(95% OF THE UNITS ARE BELOW THE VALUES SHOWN)

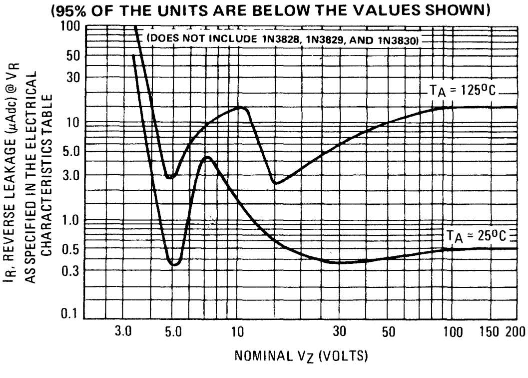


FIGURE 6 — TYPICAL THERMAL RESPONSE L, LEAD LENGTH = 3/8 INCH

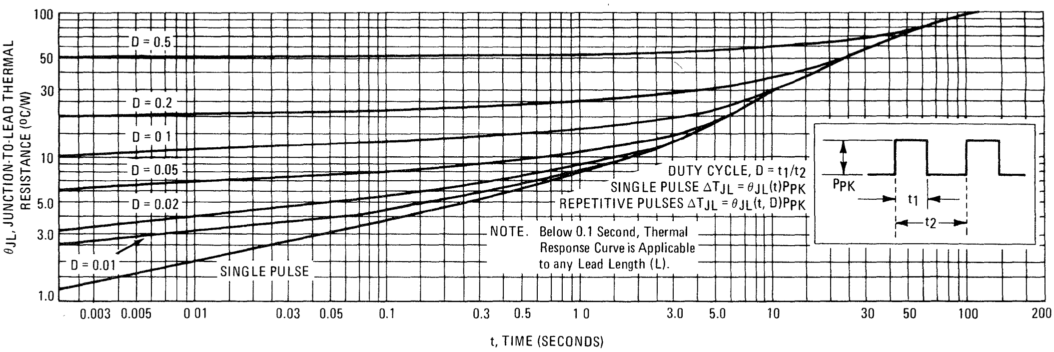


FIGURE 7 — TYPICAL THERMAL RESISTANCE

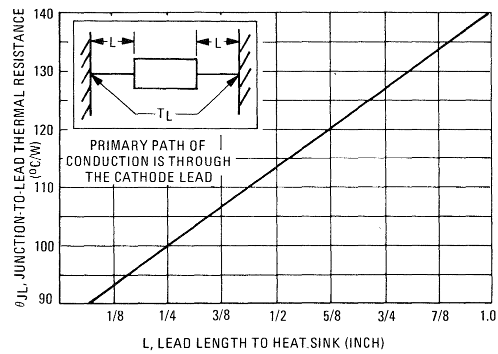


FIGURE 8 — MAXIMUM NON-REPETITIVE SURGE CURRENT

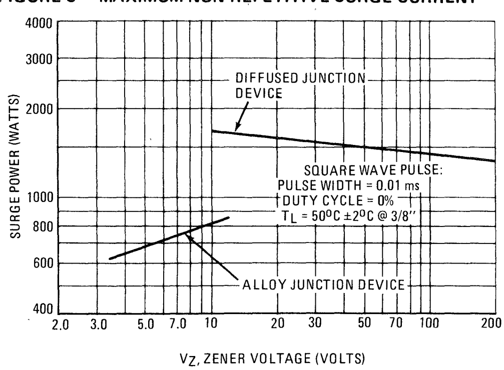


FIGURE 9 — SURGE POWER FACTOR

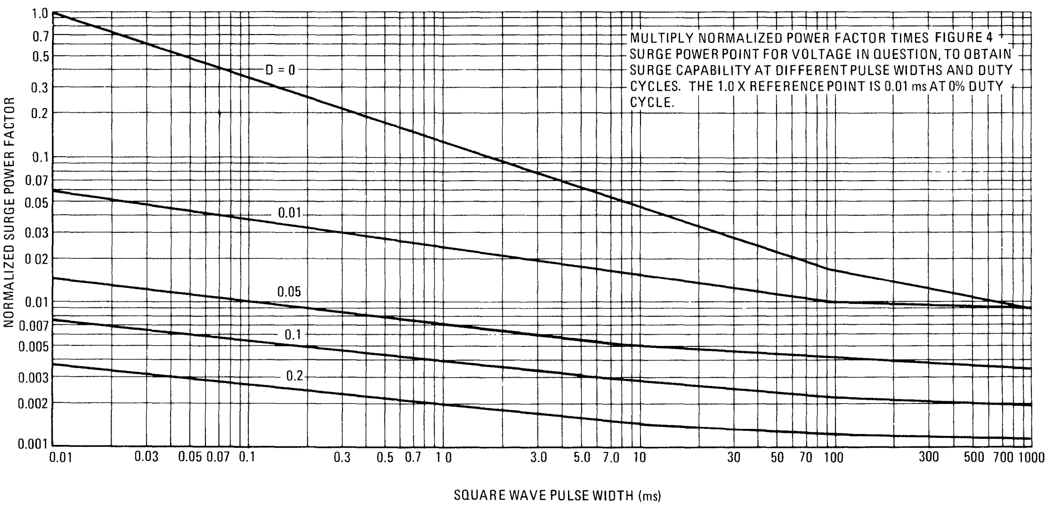
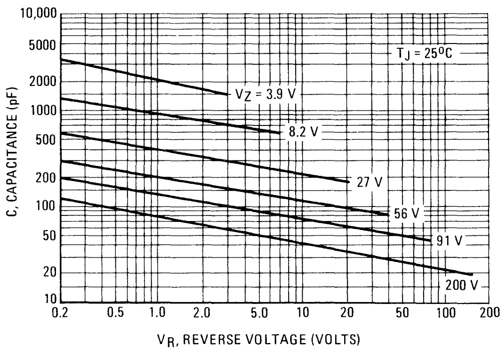


FIGURE 10 — TYPICAL CAPACITANCE



1N3879 thru 1N3883
MR1366

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

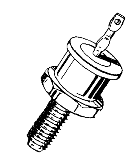
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
6 AMPERES



***MAXIMUM RATINGS**

Rating	Symbol	1N3879	1N3880	1N3881	1N3882	1N3883	MR1366	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 100°C)	I_O	← 6 0 →						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load continuous)	I_{FSM}	← 150 (one cycle) →						Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →						°C
Storage Temperature Range	T_{stg}	← -65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3 0	°C/W

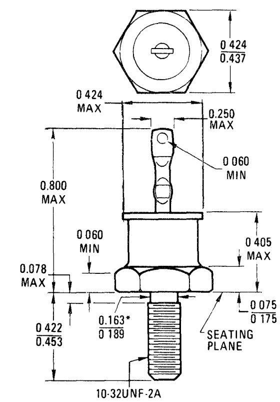
Motorola guarantees the listed value, although parts having higher values of thermal resistance will meet the current rating
Thermal resistance is not required by the JEDEC registration

***ELECTRICAL CHARACTERISTICS**

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 19 Amp, T_J = 150°C)	v_F	–	1 2	1 5	Volts
Forward Voltage (I_F = 6.0 Amp, T_C = 25°C)	V_F	–	1 0	1.4	Volts
Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	– –	10 0 5	15 1 0	μA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time *(I_{FM} = 1.0 Amp to V_R = 30 Vdc, Figure 16) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	 – –	 100 200	 200 400	ns
Reverse Recovery Current *(I_F = 1 0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	–	2 0	Amp



*Dimension is a diameter
All JEDEC dimensions and notes apply

CASE 56B
DO-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 5.6 Grams (approximately)

*Indicates JEDEC Registered Data for 1N3879 Series.

FIGURE 1 – FORWARD VOLTAGE

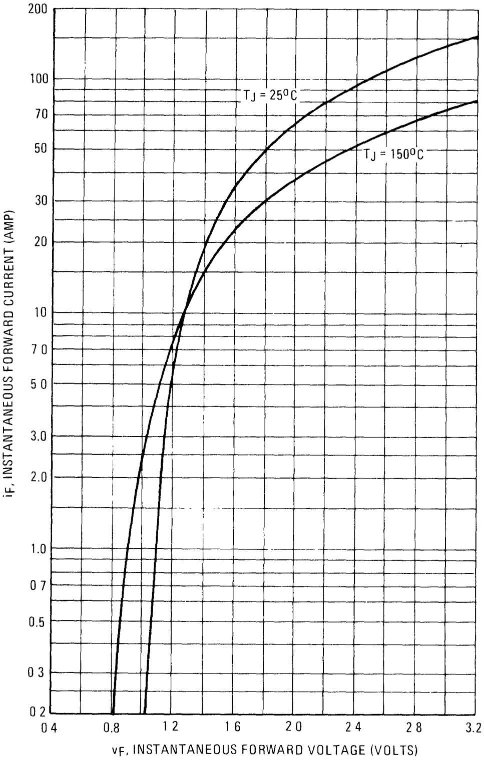
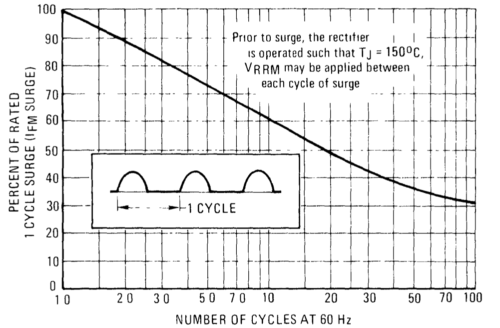
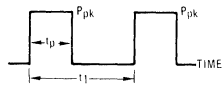


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p\ t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3) The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved Using the measured value of T_C, the junction temperature may be determined by

$$T_J = T_C + \quad T_{JC}$$

where T_{JC} is the increase in junction temperature above the case temperature It may be determined by

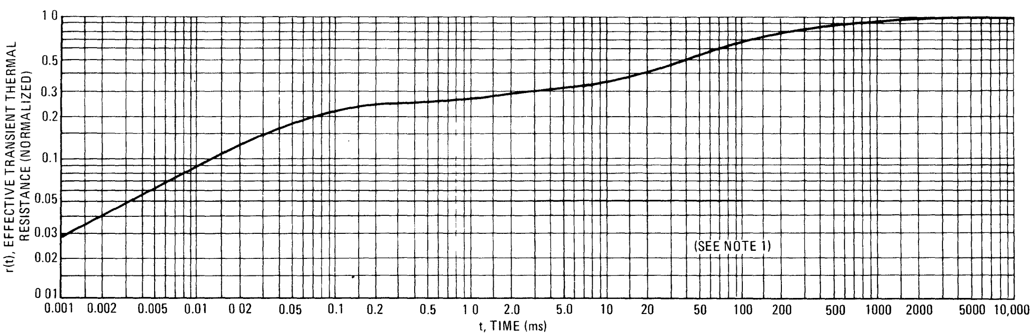
$$\therefore T_{JC} = P_{pk} \quad R_{\theta JC} [D + (1 - D) \quad r(t_1 + t_p) + r(t_p) \quad r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i e

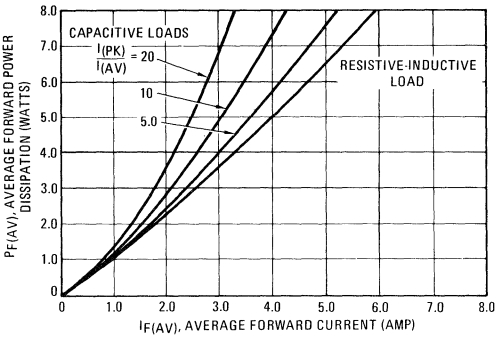
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

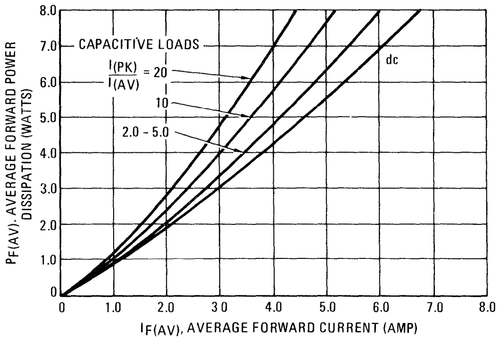


FIGURE 6 – CURRENT DERATING

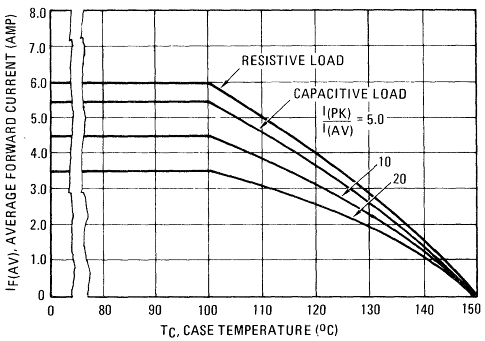


FIGURE 7 – CURRENT DERATING

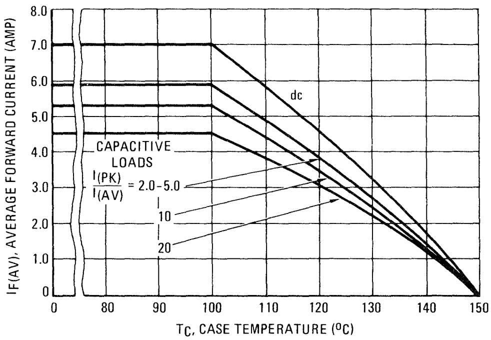


FIGURE 8 – TYPICAL REVERSE CURRENT

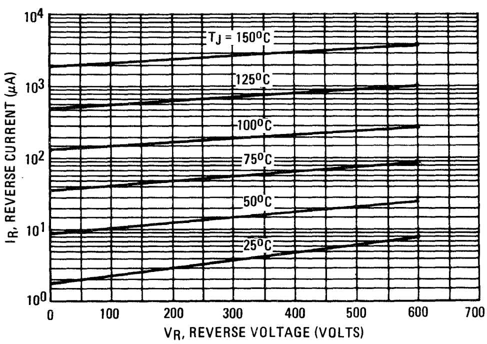
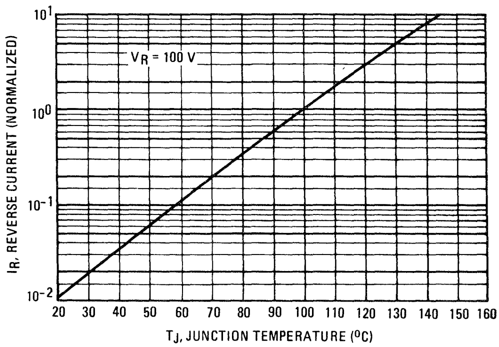


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

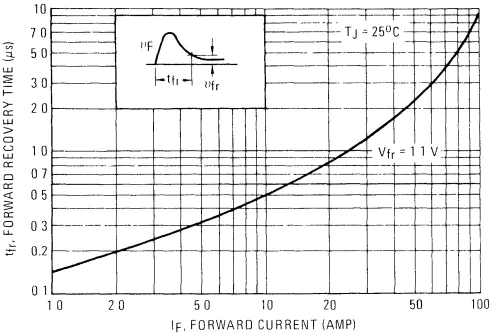
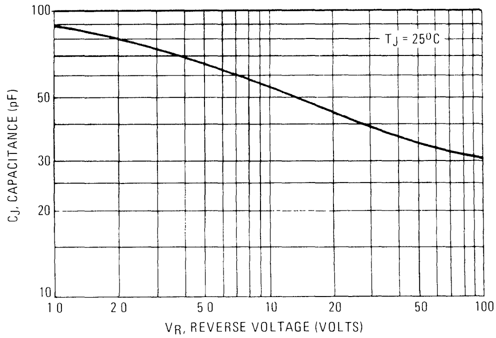


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(SEE NOTE 2)

FIGURE 12 – T_J = 25°C

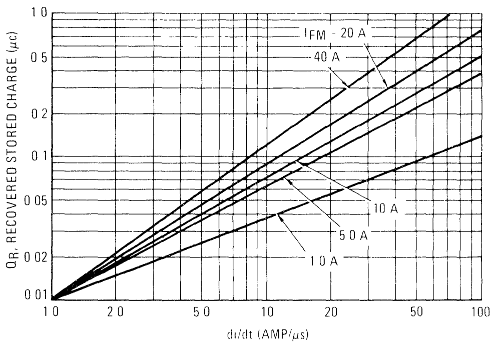


FIGURE 13 – T_J = 75°C

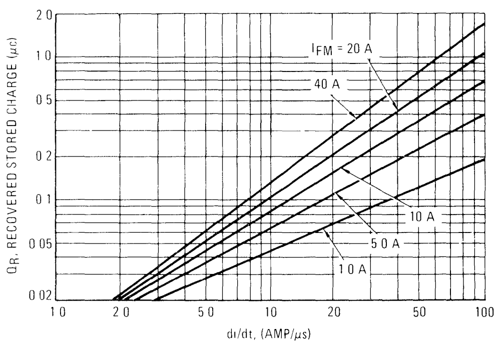


FIGURE 14 – T_J = 100°C

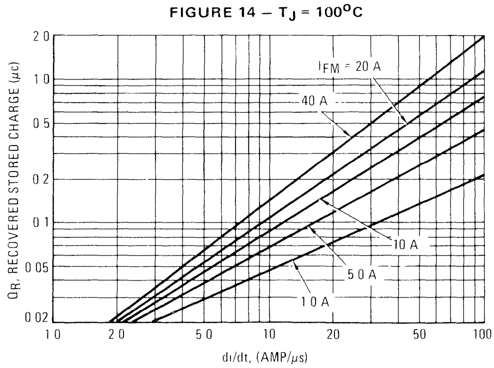


FIGURE 15 – T_J = 150°C

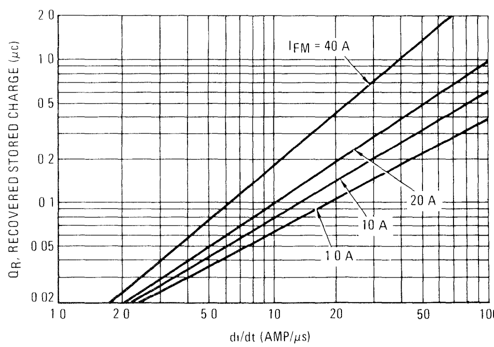
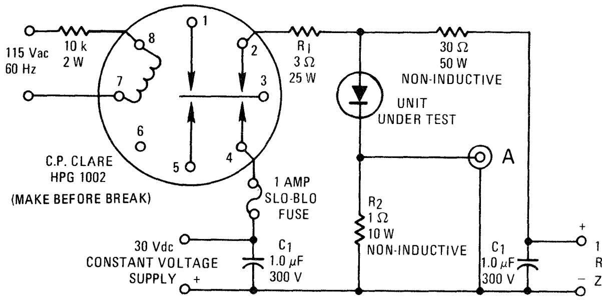


FIGURE 16 – REVERSE RECOVERY CIRCUIT



A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

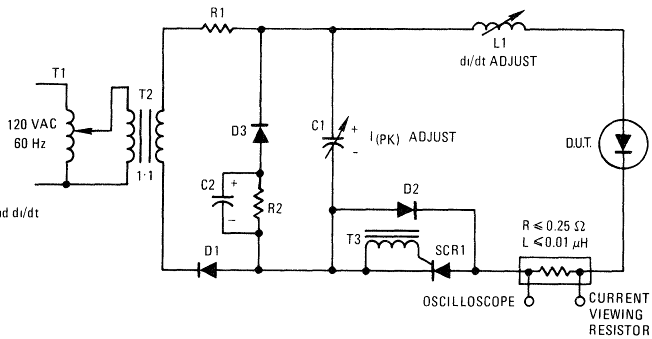
R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

$T_A = 25 ^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)



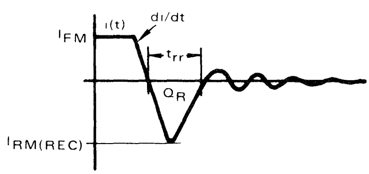
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

1N3889 thru 1N3893
MR1376

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

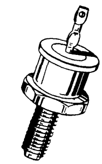
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

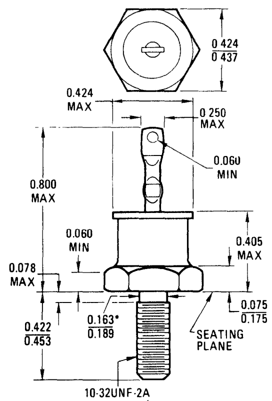
Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
12 AMPERES





*Dimension is a diameter
All JEDEC dimensions and notes apply

CASE 56B
DO-4

*MAXIMUM RATINGS

Rating	Symbol	1N3889	1N3890	1N3891	1N3892	1N3893	MR1376	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^oC$)	I_O	← 12 →						Amps
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 200 → (one cycle)						Amp
Operating Junction Temperature Range	T_J	← -65 to +150 →						^oC
Storage Temperature Range	T_{stg}	← -65 to +175 →						^oC

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	$^oC/W$

Motorola guarantees the listed value, although parts having higher values of thermal resistance will meet the current rating. Thermal resistance is not required by the JEDEC registration.

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 38 Amp, $T_J = 150^oC$)	v_F	–	1.2	1.5	Volts
Forward Voltage (I_F = 12 Amp, $T_C = 25^oC$)	V_F	–	1.0	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^oC$ $T_C = 100^oC$	I_R	– –	10 0.5	25 3.0	μA mA

*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	 – –	 100 200	 200 400	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	–	2.0	Amp

*Indicates JEDEC Registered Data for 1N3889 Series.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 5.6 grams (approximately)

FIGURE 1 — FORWARD VOLTAGE

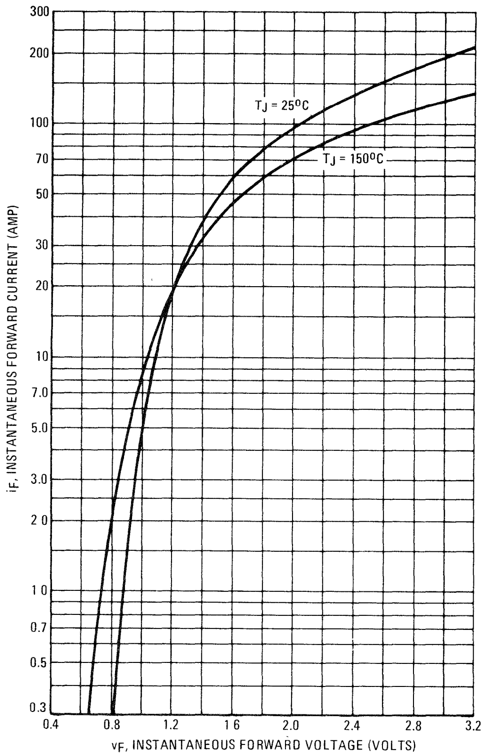
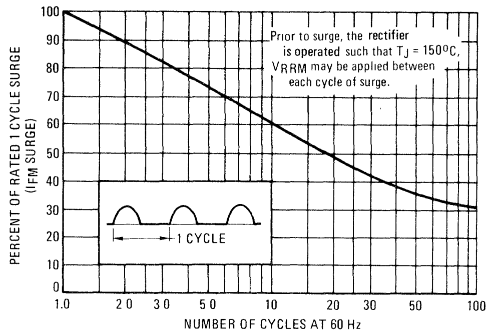
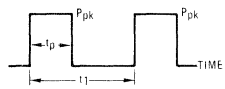


FIGURE 2 — MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3) The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady state conditions are achieved Using the measured value of T_C, the junction temperature may be determined by

$$T_J = T_C + \quad T_{JC}$$

where $\quad T_{JC}$ is the increase in junction temperature above the case temperature It may be determined by

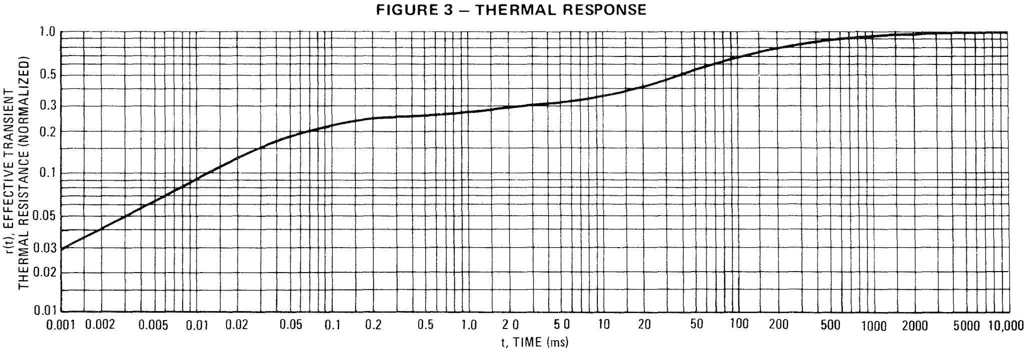
$$\Delta T_{JC} = P_{pk} \quad R_{\theta JC} \, [D + (1 - D) \quad r(t_1 + t_p) + r(t_p) \; - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i e

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

FIGURE 3 — THERMAL RESPONSE



SINE WAVE INPUT

SQUARE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION

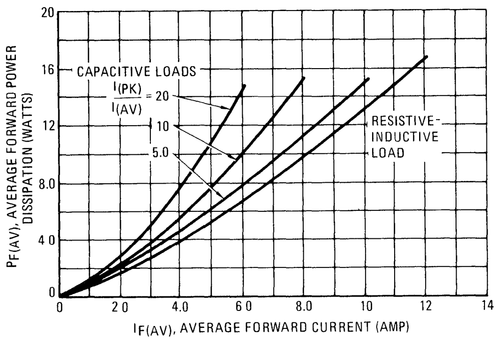


FIGURE 5 — FORWARD POWER DISSIPATION

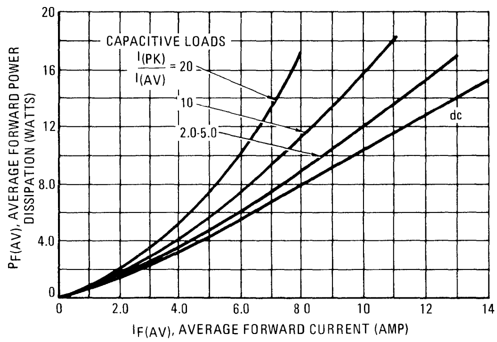


FIGURE 6 — CURRENT DERATING

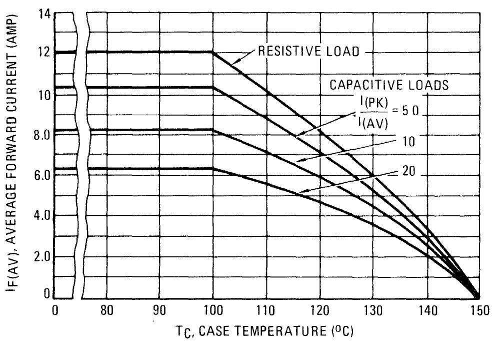


FIGURE 7 — CURRENT DERATING

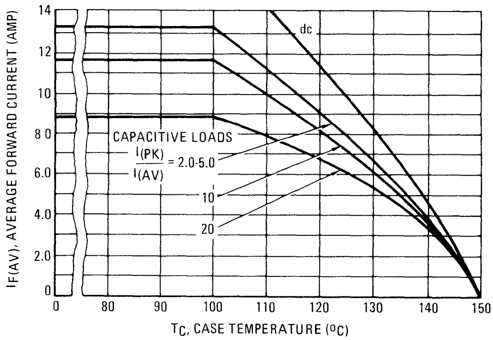


FIGURE 8 — TYPICAL REVERSE CURRENT

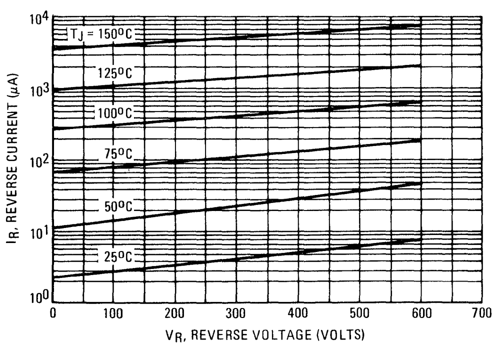
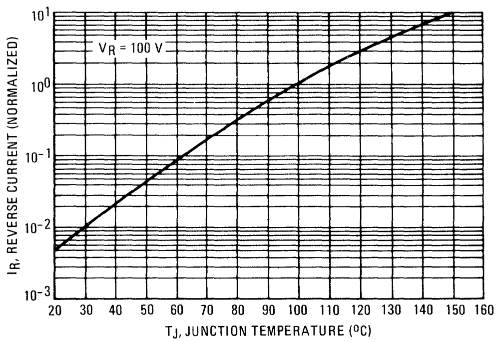


FIGURE 9 — NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

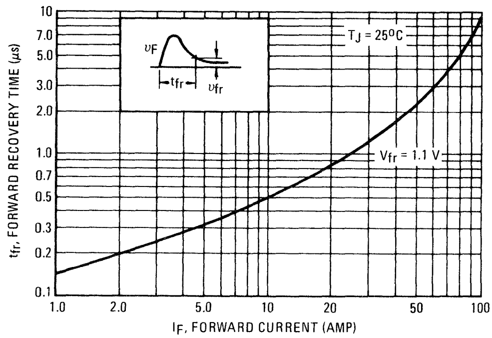
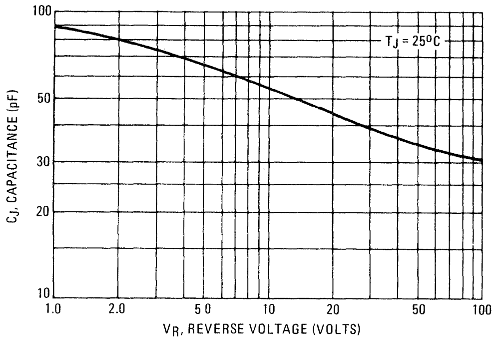


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – T_J = 25°C

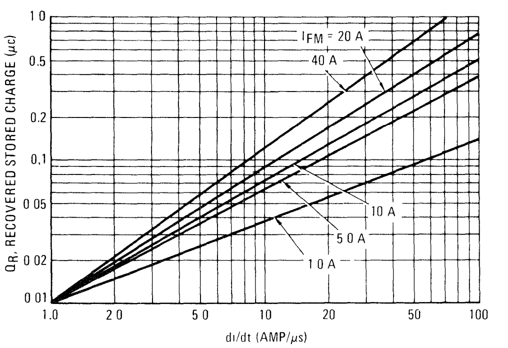


FIGURE 13 – T_J = 75°C

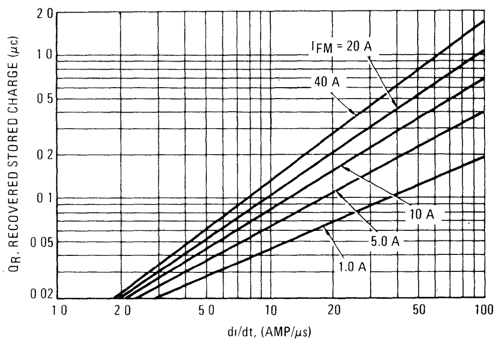


FIGURE 14 – T_J = 100°C

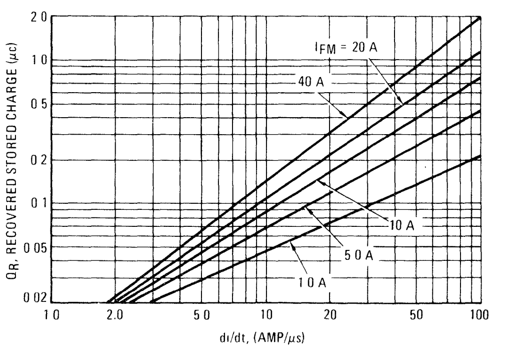


FIGURE 15 – T_J = 150°C

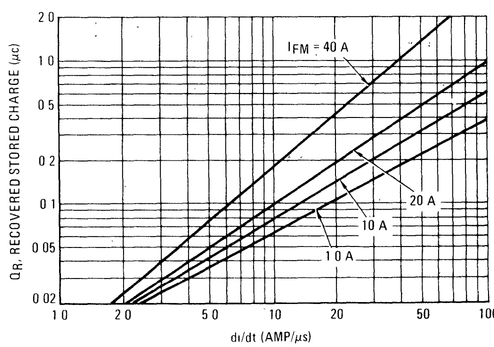
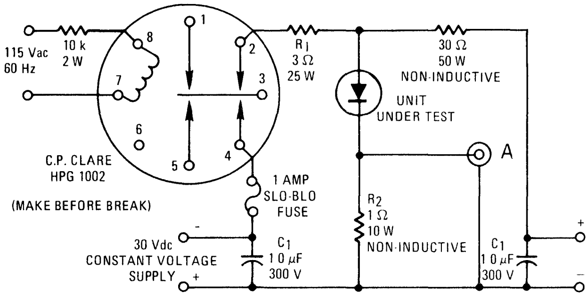


FIGURE 16 — REVERSE RECOVERY CIRCUIT



A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1 4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

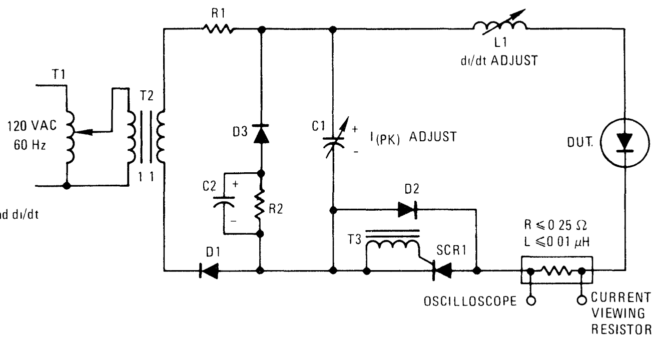
$T_A = 25\,^{+10}_{-0}\,^{\circ}C$ FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1 0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

FIGURE 17 — JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1.1
T3 = 1.1 (to trigger circuit)



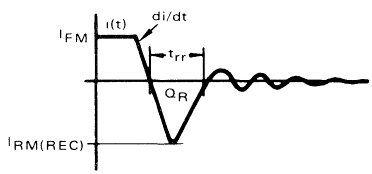
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

1N3899 thru 1N3903
MR1386

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

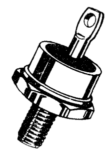
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

Designers Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
20 AMPERES



*MAXIMUM RATINGS

Rating	Symbol	1N3899	1N3900	1N3901	1N3902	1N3903	MR1386	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 100°C)	I_O	← 20 →						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 250 → (one cycle)						Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →						°C
Storage Temperature Range	T_{stg}	← -65 to +175 →						°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1 8	°C/W

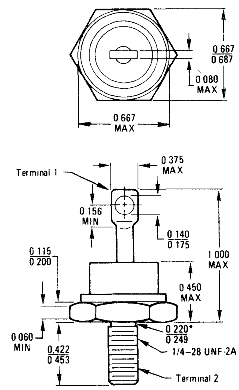
*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 63 Amp, T_J = 150°C)	v_F	–	1 2	1 5	Volts
Forward Voltage (I_F = 20 Amp, T_C = 25°C)	V_F	–	1 1	1 4	Volts
Reverse Current (rated dc voltage) T_C = 25°C	I_R	–	10	5υ	μA
T_C = 100°C		–	0.5	6.0	mA

*REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time	t_{rr}				ns
(I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)		–	100	200	
(I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)		–	200	400	
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	–	3 0	Amp

*Indicates JEDEC Registered Data for 1N3899 Series



*Dimension is a diameter

All JEDEC dimensions and notes apply

CASE 257
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity available by adding Suffix "R" to type number.

WEIGHT: 17 Grams (Approximately)

FIGURE 1 — FORWARD VOLTAGE

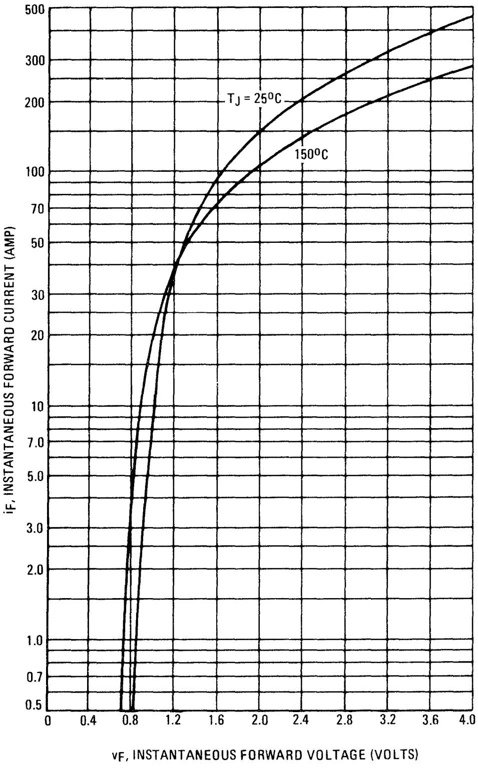
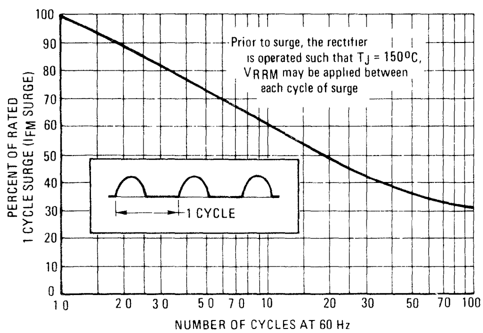
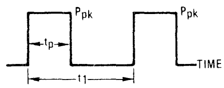


FIGURE 2 — MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3) The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved Using the measured value of T_C, the junction temperature may be determined by

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature It may be determined by

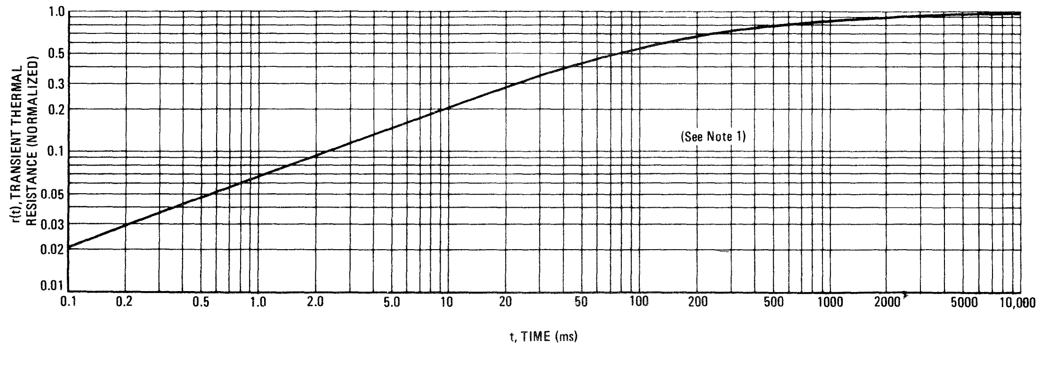
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i e

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

FIGURE 3 — THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION

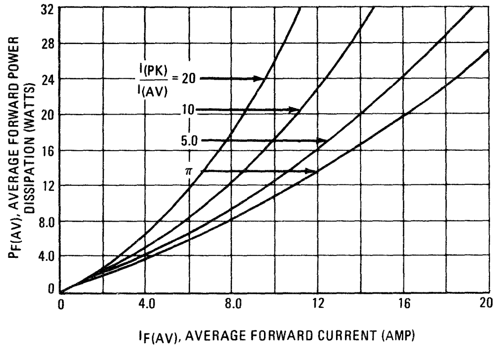


FIGURE 6 — CURRENT DERATING

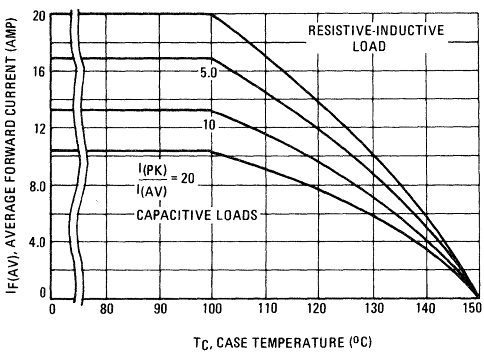
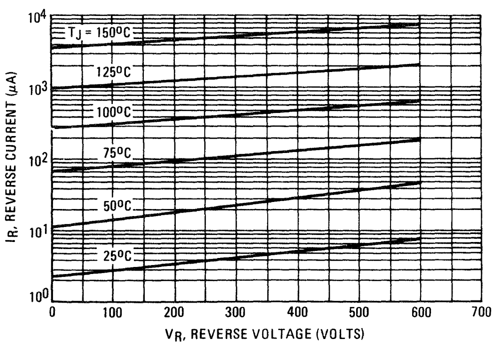


FIGURE 8 — TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 — FORWARD POWER DISSIPATION

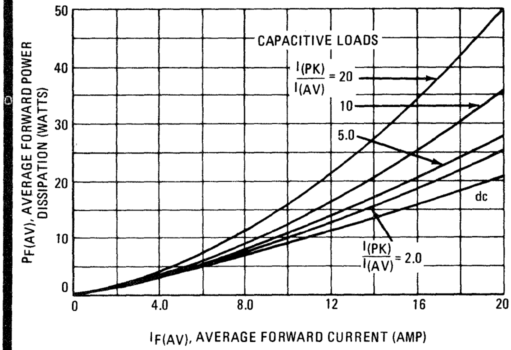


FIGURE 7 — CURRENT DERATING

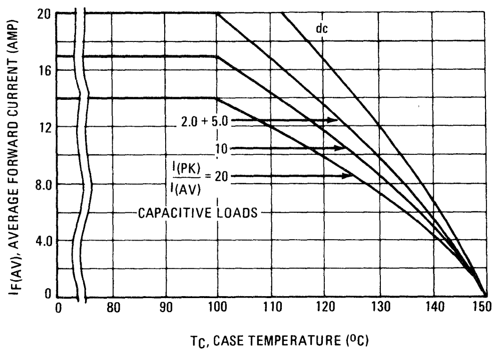


FIGURE 9 — NORMALIZED REVERSE CURRENT

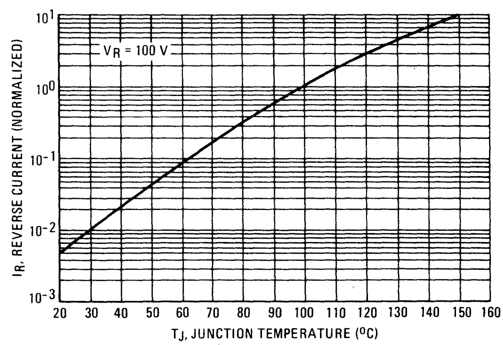
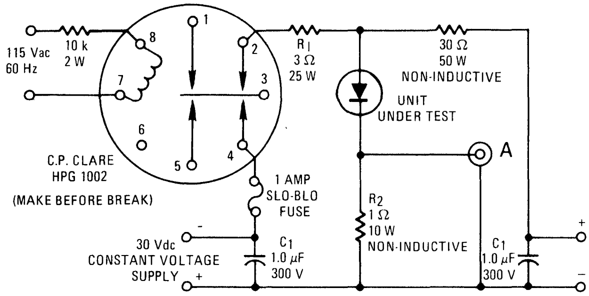


FIGURE 16 — REVERSE RECOVERY CIRCUIT



A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

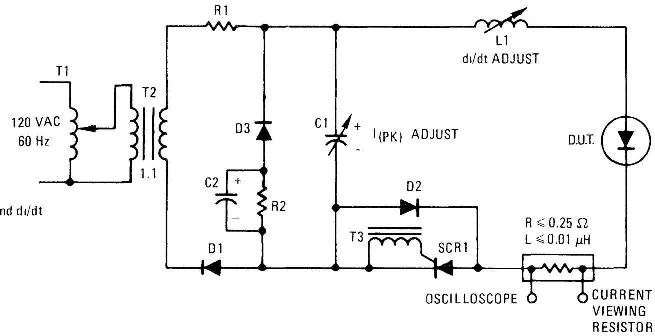
$T_A = 25\,^{+10}_{-0}\,^\circ C$ FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

FIGURE 17 — JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1:1
T3 = 1:1 (to trigger circuit)



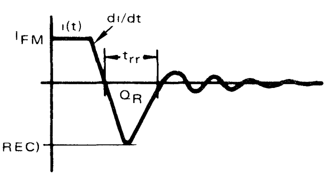
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

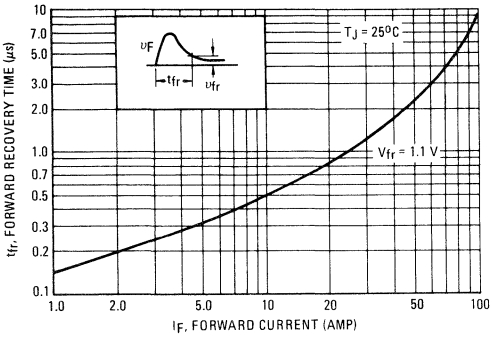
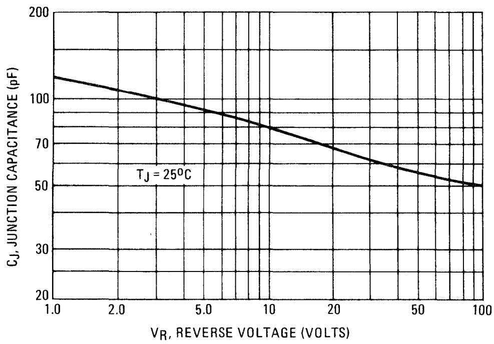


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25°C$

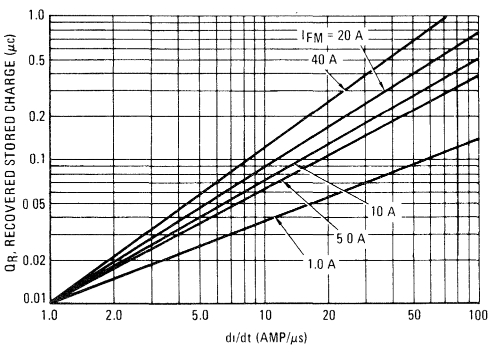
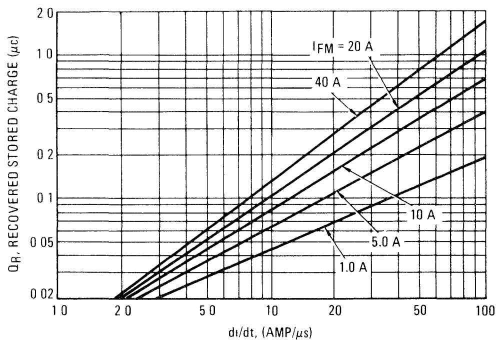


FIGURE 13 – $T_J = 75°C$



STORED CHARGE DATA

FIGURE 14 – $T_J = 100°C$

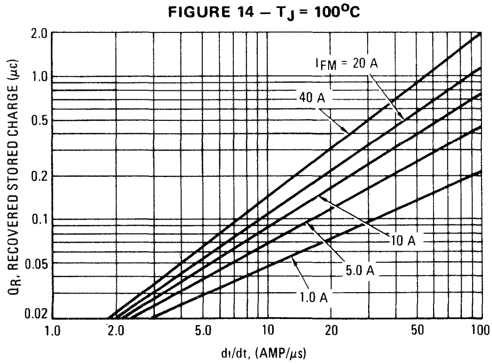
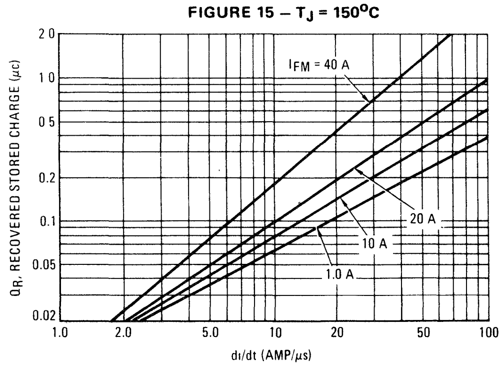


FIGURE 15 – $T_J = 150°C$



1N3909 thru 1N3913
MR1396

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

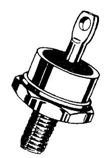
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

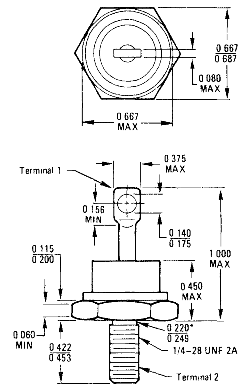
Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

FAST RECOVERY
POWER RECTIFIERS

50-600 VOLTS
30 AMPERES





*Dimension is a diameter
All JEDEC dimensions and notes apply

CASE 257
DO-5

***MAXIMUM RATINGS**

Rating	Symbol	1N3909	1N3910	1N3911	1N3912	1N3913	MR1396	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^oC$)	I_O	← 30 →						Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 300 →						Amp
Operating Junction Temperature Range	T_J	← -65 to +150 →						^oC
Storage Temperature Range	T_{stg}	← -65 to +175 →						^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.2	$^oC/W$

***ELECTRICAL CHARACTERISTICS**

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (I_F = 93 Amp, $T_J = 150^oC$)	v_F	–	1.2	1.5	Volts
Forward Voltage (I_F = 30 Amp, $T_C = 25^oC$)	V_F	–	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25^oC$ $T_C = 100^oC$	I_R	– –	10 0.5	80 10	μA mA

***REVERSE RECOVERY CHARACTERISTICS**

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 17)	t_{rr}	 – –	 100 200	 200 400	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 16)	$I_{RM(REC)}$	–	1.5	3.0	Amp

*Indicates JEDEC Registered Data for 1N3909 Series

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case. Reverse Polarity type available by adding Suffix "R" to type number.

WEIGHT: 17 Grams (Approximately)

FIGURE 1 – FORWARD VOLTAGE

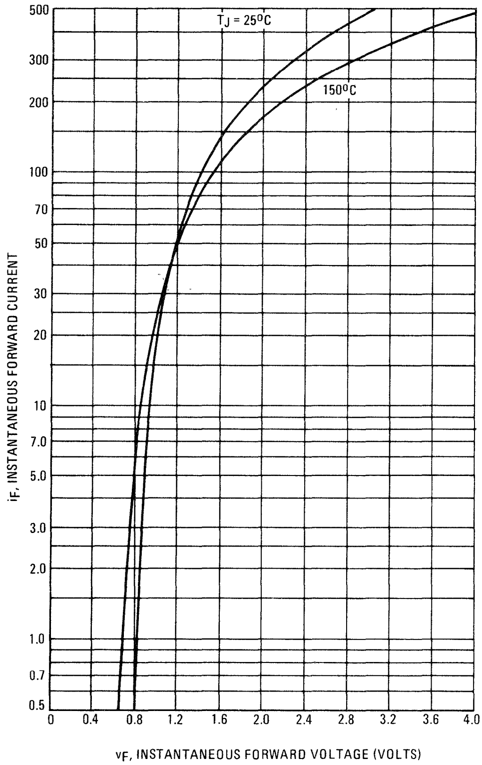
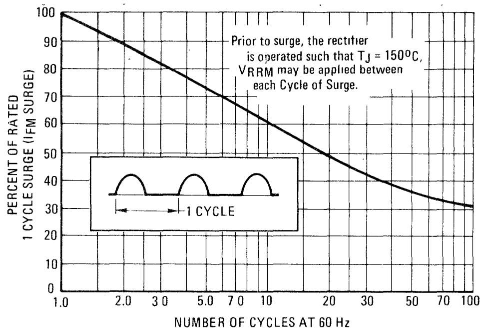
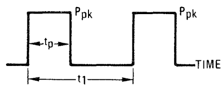


FIGURE 2 – MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended:

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3). The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature. It may be determined by

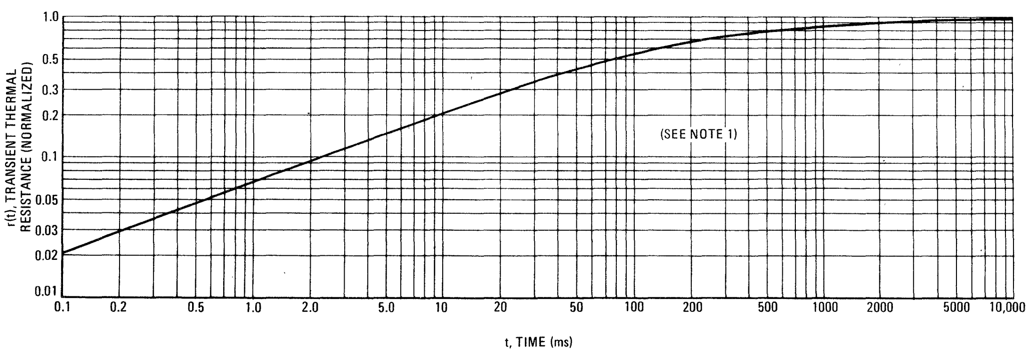
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i.e.

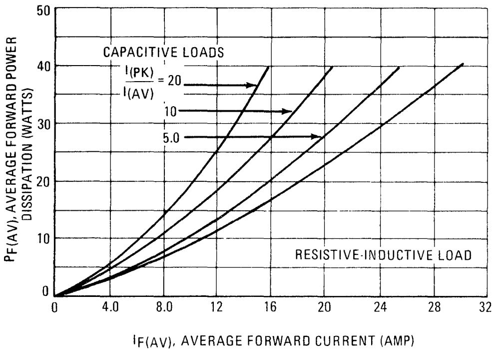
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

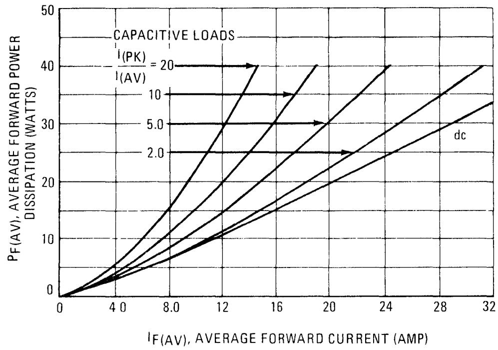


FIGURE 6 – CURRENT DERATING

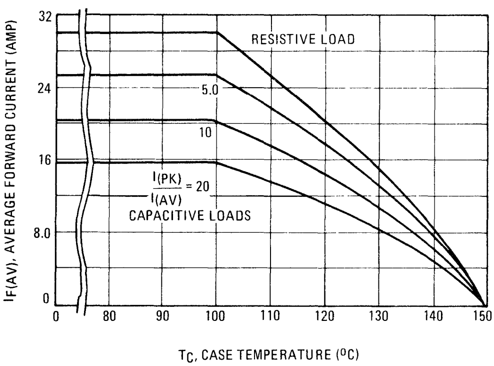


FIGURE 7 – CURRENT DERATING

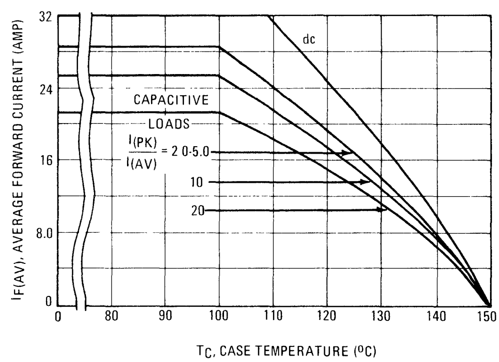


FIGURE 8 – TYPICAL REVERSE CURRENT

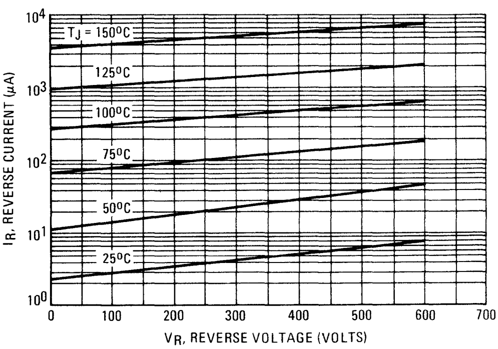
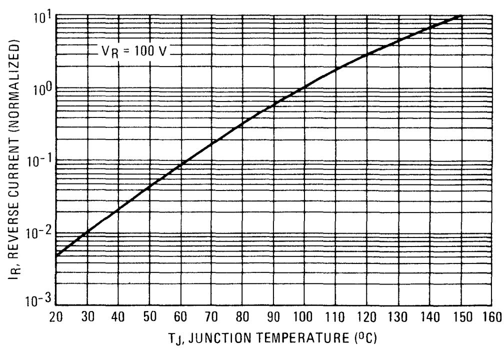


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

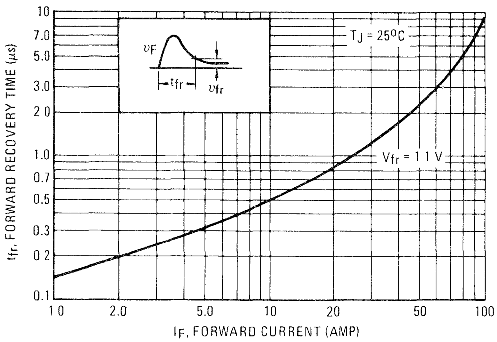
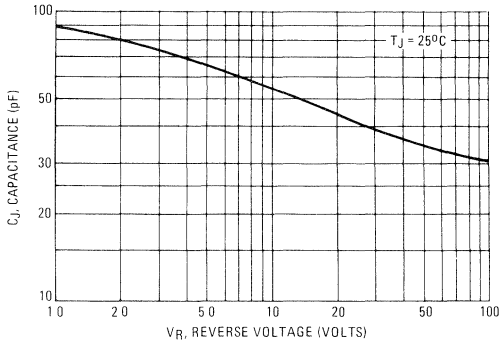


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25°C$

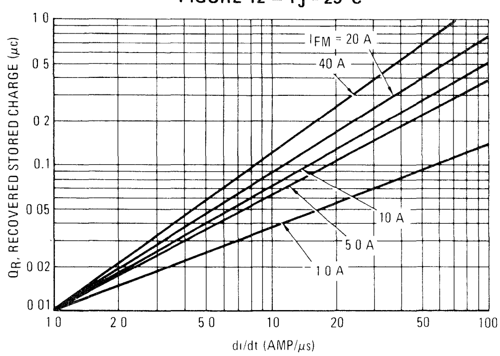


FIGURE 13 – $T_J = 75°C$

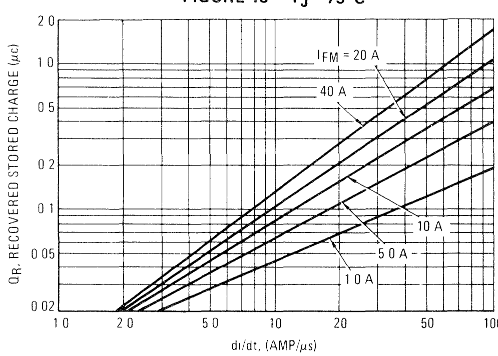


FIGURE 14 – $T_J = 100°C$

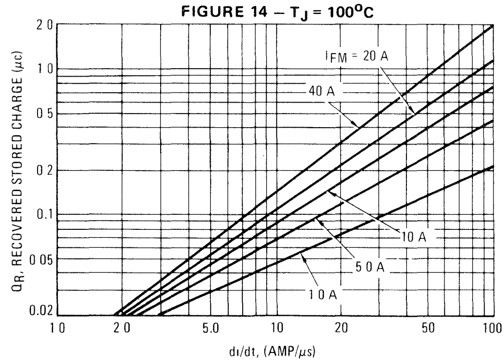


FIGURE 15 – $T_J = 150°C$

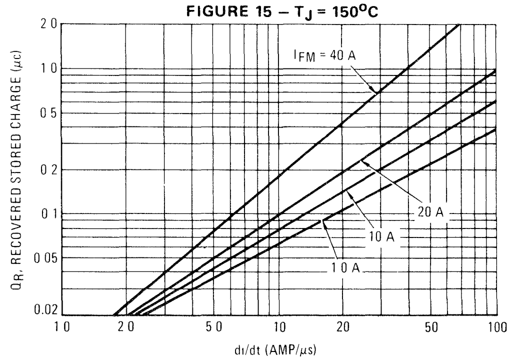
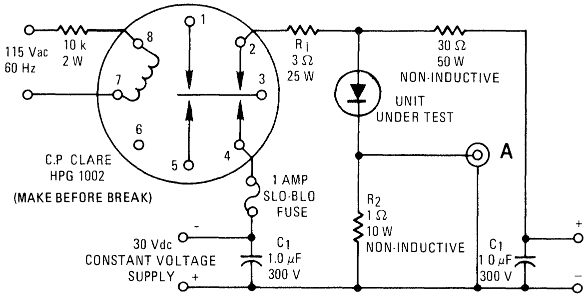


FIGURE 16 – REVERSE RECOVERY CIRCUIT



A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

R_1 – ADJUSTED FOR 1 4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 μH

R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

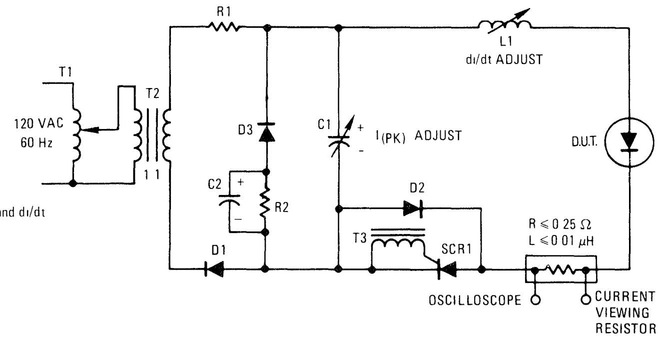
$T_A = 25\,^{+10}_{-0}$ °C FOR RECTIFIER

MINIMIZE ALL LEAD LENGTHS

1 0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

FIGURE 17 – JEDEC REVERSE RECOVERY CIRCUIT

R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4933
SCR1 = MCR729-10
C1 = 0.5 to 50 μF
C2 ≈ 4000 μF
L1 = 1.0 - 27 μH
T1 = Variac Adjusts $I_{(PK)}$ and di/dt
T2 = 1 1
T3 = 1:1 (to trigger circuit)



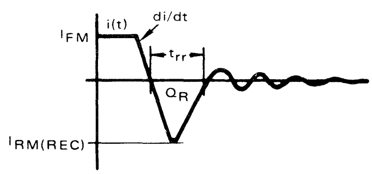
NOTE 2

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.

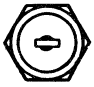
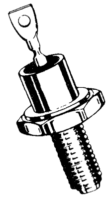


From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

1N3993 thru 1N4000 (ZENER DIODES)

CASE 56
(DO-4)

Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected to case. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

The type numbers shown in the table have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS

(T_B = 30°C ± 3, V_F = 1.5 max @ I_F = 2 amp for all units)

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance		Max DC Zener Current I_{ZM} mA	Reverse Leakage Current	
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 1.0 mA Ohms		I_R µA	V_R Volts
1N3993	3.9	640	2.0	400	2380	100	0.5
1N3994	4.3	580	1.5	400	2130	100	0.5
1N3995	4.7	530	1.2	500	1940	50	1.0
1N3996	5.1	490	1.1	550	1780	10	1.0
1N3997	5.6	445	1.0	600	1620	10	1.0
1N3998	6.2	405	1.1	750	1460	10	2.0
1N3999	6.8	370	1.2	500	1330	10	2.0
1N4000	7.5	335	1.3	250	1210	10	3.0

SPECIAL SELECTIONS AVAILABLE INCLUDE: (See Selector Guide for details)

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES:

To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±3%, ±2%, ±1%), the Motorola type number should be used.

10 M 5.0 A Z 3

10 — Device Description; M — Motorola; 5.0 — Nominal Voltage; A — Alloy; Z — Zener Diode; 3 — Tolerance (±%)

Example: 10M5.0AZ3

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A) for specifying units with a special voltage and/or tolerance except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.

10 M 5.1 A Z 5 B 1

10 — Device Description; M — Motorola; 5.1 — 5.1 Volts (each device); A — Alloy; Z — Zener Diodes; 5 — Tolerance per device (±5%) (omit for ±20% units); B — Code*; 1 — Overall Tolerance of set (±1%) (A-Not used)

*Code:
B – Two devices in series
C – Three devices in series
D – Four devices in series

Example: 10M5.1AZ5B1

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

10 M 4.7 A Z Z 10

10 — Device Description; M — Motorola; 4.7 — Nominal Voltage; A — Alloy; Z — Zener Diodes; Z — Clipper; 10 — Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 10M4.7AZZ10

1N4001 (SILICON)
thru
1N4007

Designers Data Sheet

"SURMETIC" RECTIFIERS

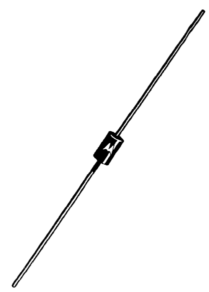
. . . subminiature size, axial lead mounted rectifiers for general-purpose low-power applications.

Designers Data for "Worst Case" Conditions

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

LEAD MOUNTED SILICON RECTIFIERS

50-1000 VOLTS DIFFUSED JUNCTION



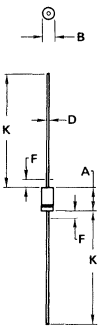
*MAXIMUM RATINGS

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	720	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 8, T_A = 75°C)	I_O	1.0							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 2)	I_{FSM}	30 (for 1 cycle)							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175							°C

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop (i_F = 1.0 Amp, T_J = 25°C) Figure 1	v_F	0.93	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads)	$V_{F(AV)}$	–	0.8	Volts
Maximum Reverse Current (rated dc voltage)	I_R			μA
T_J = 25°C		0.05	10	
T_J = 100°C		1.0	50	
Maximum Full-Cycle Average Reverse Current (I_O = 1.0 Amp, T_L = 75°C, 1 inch leads	$I_{R(AV)}$	–	30	μA

*Indicates JEDEC Registered Data.



NOTE.
1. POLARITY DENOTED BY CATHODE BAND

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

All JEDEC dimensions and notes apply.

CASE 59-03
DO-41

MECHANICAL CHARACTERISTICS

CASE: Void free, Transfer Molded
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds at 5 lbs. tension
FINISH: All external surfaces are corrosion-resistant, leads are readily solderable
POLARITY: Cathode indicated by color band
WEIGHT: 0.40 Grams (approximately)

FIGURE 1 — FORWARD VOLTAGE

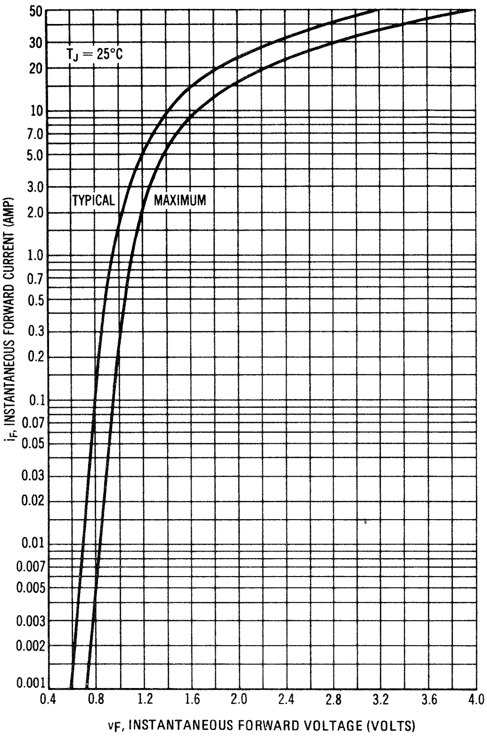


FIGURE 2 — NON-REPETITIVE SURGE CAPABILITY

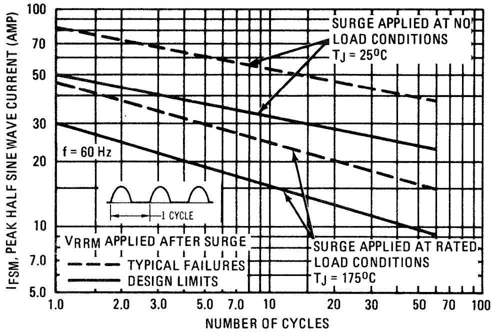


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

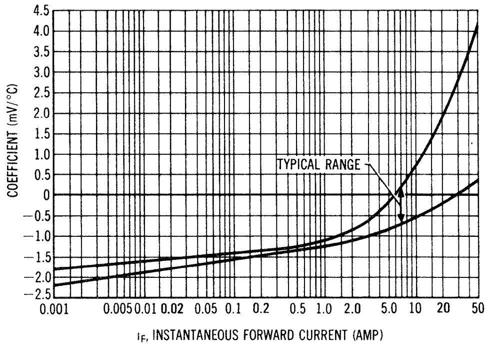
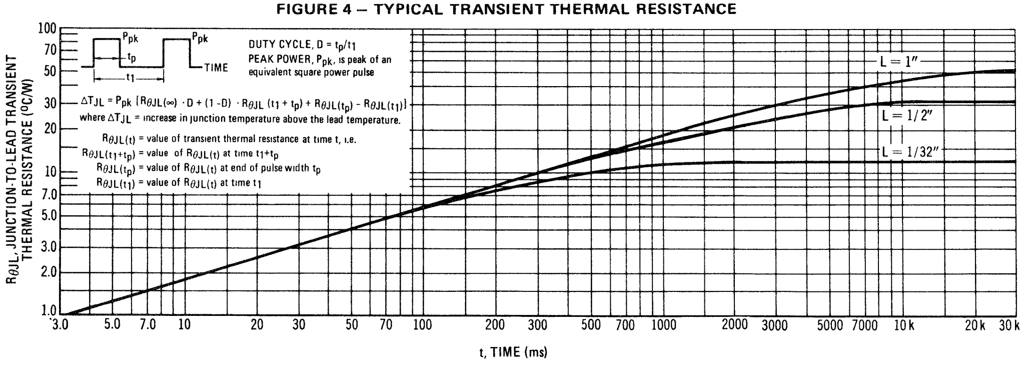


FIGURE 4 — TYPICAL TRANSIENT THERMAL RESISTANCE



The temperature of the lead should be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}.$$

CURRENT DERATING DATA

FIGURE 5 — FORWARD POWER DISSIPATION

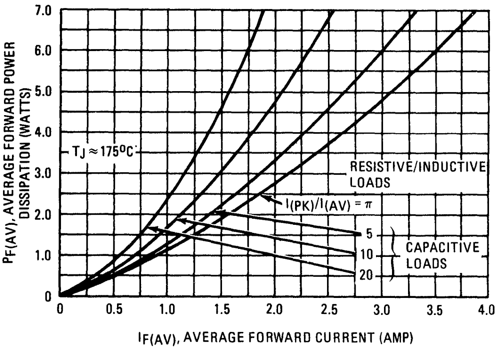


FIGURE 6 — EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

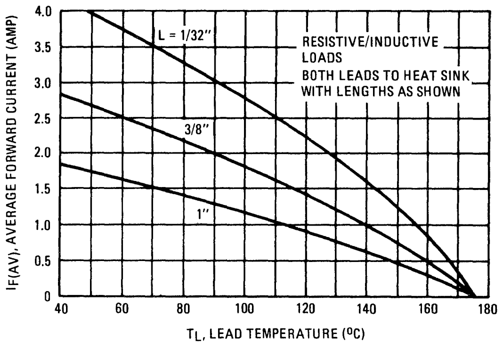


FIGURE 7 — 3/8" LEAD LENGTH, VARIOUS LOADS

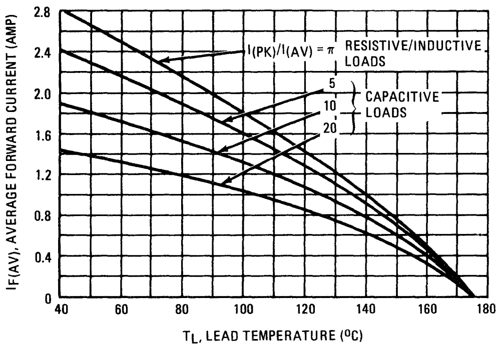


FIGURE 8 — PRINTED CIRCUIT BOARD MOUNTING — VARIOUS LOADS

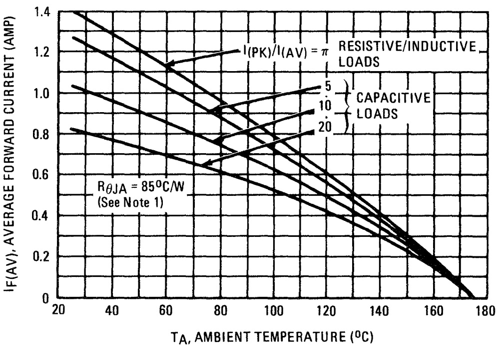
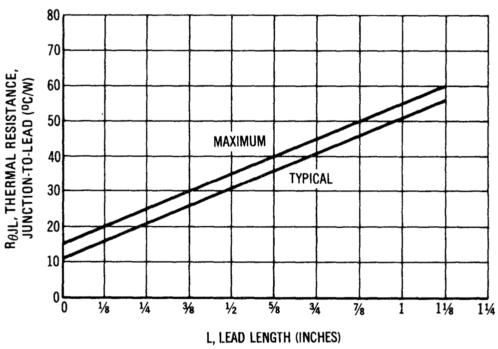


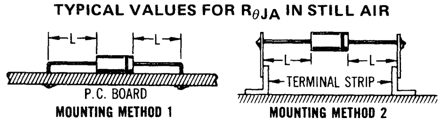
FIGURE 9 — STEADY-STATE THERMAL RESISTANCE



NOTE 1

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guide-line values for preliminary engineering or in case the tie point temperature cannot be measured

TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR



MOUNTING METHOD	LEAD LENGTH, L (IN)			$R_{\theta JA}$
	1/32	3/8	1	
1	—	75	85	°C/W
2	55	72	85	°C/W

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

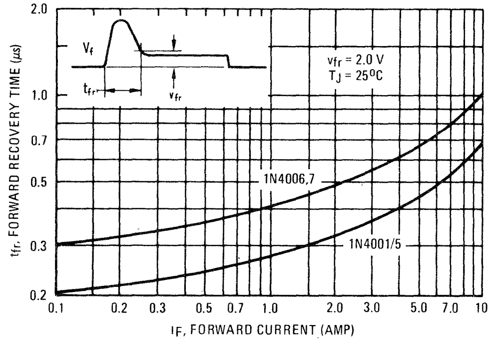


FIGURE 11 – REVERSE RECOVERY TIME

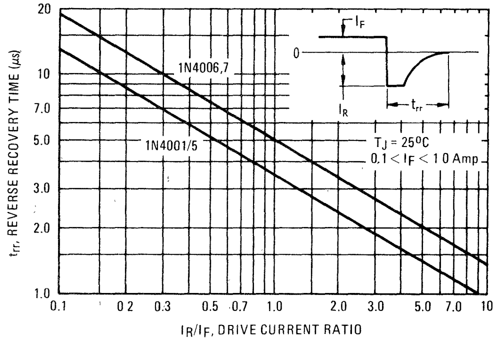


FIGURE 12 – JUNCTION CAPACITANCE

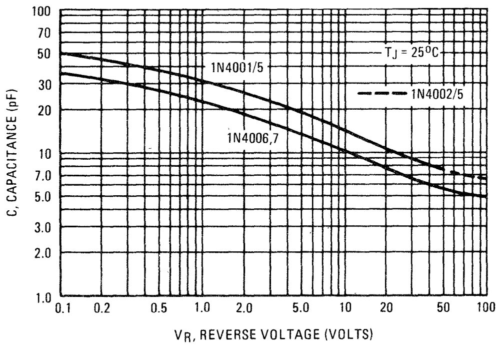


FIGURE 13 – RECTIFICATION WAVEFORM EFFICIENCY FOR SINE WAVE

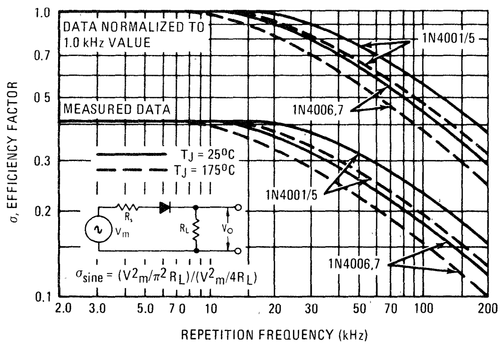
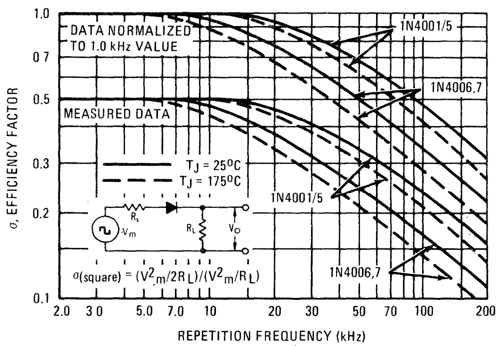


FIGURE 14 – RECTIFICATION WAVEFORM EFFICIENCY FOR SQUARE WAVE



RECTIFIER EFFICIENCY NOTE

The rectification efficiency factor σ shown in Figures 13 and 14 was calculated using the formula:

$$\sigma = \frac{P_{dc}}{P_{rms}} = \frac{\frac{V^2{}_{O(dc)}}{R_L}}{\frac{V^2{}_{O(rms)}}{R_L}} \bullet 100\% = \frac{V^2{}_{O(dc)}}{V^2{}_{O(ac)} + V^2{}_{O(dc)}} \bullet 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes 40%; for a square wave input of amplitude V_m, the efficiency factor becomes 50%. (A full wave circuit has twice these efficiencies).

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 11) becomes significant, resulting in an increasing ac voltage component across R_L which is opposite in polarity to the forward current thereby reducing the value of the efficiency factor σ, as shown in Figures 13 and 14.

It should be emphasized that Figures 13 and 14 show waveform efficiency only; they do not account for diode losses. Data was obtained by measuring the ac component of V_O with a true rms voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the Figures.

1N4057 (Series)

For Specifications, See 1N429 Data

1N4099 thru 1N4135 (SILICON)
(MZ4614 thru MZ4627) *

LOW-LEVEL SILICON PASSIVATED ZENER DIODES

. . . designed for 250 mW applications requiring low leakage, low impedance, and low noise.

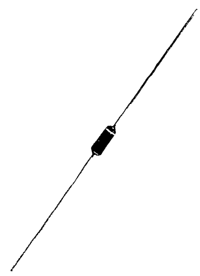
- Voltage Range from 1.8 to 100 Volts
- First Zener Diode Series to Specify Noise—50% Lower than Conventional Diffused Zeners
- Zener Impedance and Zener Voltage Specified for Low-Level Operation at I_{ZT} = 250 μA
- Low Leakage Current — I_R from 0.01 to 10 μA over Voltage Range
- Expanded Temperature Range — T_J = -65 to +200°C

SILICON ZENER DIODES

(±5.0% TOLERANCE)

250 MILLIWATTS
1.8–100 VOLTS

SILICON OXIDE PASSIVATED JUNCTION



MAXIMUM RATINGS

Rating	Value	Unit
DC Power Dissipation, 25°C Ambient	250	mW
Derating Factor	1.43	mW/°C
Junction and Storage Temperature	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass.

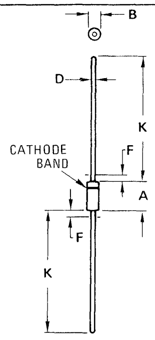
DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 gram (approx)

MOUNTING POSITION: Any

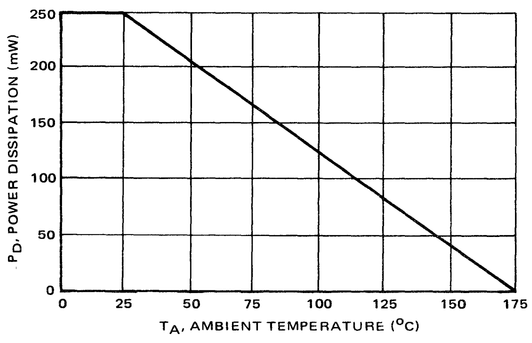


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	–	1.000	–

All JEDEC dimensions and notes apply

CASE 51-02
DO-7

POWER TEMPERATURE DERATING CURVE



*Identical to 1N4614 registration, except registration has a minimum package diameter of 0.115 inches.

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted) I_{ZT} = 250 μA and V_F = 1.0 V max @ I_F = 200 mA on all Types

Type Number (Note 1)	Nominal Zener Voltage V_Z (Note 1) (Volts)	Max Zener Impedance Z_{ZT} (Note 2) (Ohms)	Max Reverse Current I_R (μA) @ (Note 4)	Test Voltage V_R (Volts)	Max Noise Density At I_{ZT} = 250 μA N_D (Fig 1) (micro-volts per Square Root Cycle)	Max Zener Current I_{ZM} (Note 3) (mA)
MZ4614	1.8	1200	7.5	1.0	1.0	120
MZ4615	2.0	1250	5.0	1.0	1.0	110
MZ4616	2.2	1300	4.0	1.0	1.0	100
MZ4617	2.4	1400	2.0	1.0	1.0	95
MZ4618	2.7	1500	1.0	1.0	1.0	90
MZ4619	3.0	1600	0.8	1.0	1.0	85
MZ4620	3.3	1650	7.5	1.5	1.0	80
MZ4621	3.6	1700	7.5	2.0	1.0	75
MZ4622	3.9	1650	5.0	2.0	1.0	70
MZ4623	4.3	1600	4.0	2.0	1.0	65
MZ4624	4.7	1550	10	3.0	1.0	60
MZ4625	5.1	1500	10	3.0	2.0	55
MZ4626	5.6	1400	10	4.0	4.0	50
MZ4627	6.2	1200	10	5.0	5.0	45
1N4099	6.8	200	10	5.2	40	35
1N4100	7.5	200	10	5.7	40	31.8
1N4101	8.2	200	1.0	6.3	40	29.0
1N4102	8.7	200	1.0	6.7	40	27.4
1N4103	9.1	200	1.0	7.0	40	26.2
1N4104	10	200	1.0	7.6	40	24.8
1N4105	11	200	0.05	8.5	40	21.6
1N4106	12	200	0.05	9.2	40	20.4
1N4107	13	200	0.05	9.9	40	19.0
1N4108	14	200	0.05	10.7	40	17.5
1N4109	15	100	0.05	11.4	40	16.3
1N4110	16	100	0.05	12.2	40	15.4
1N4111	17	100	0.05	13.0	40	14.5
1N4112	18	100	0.05	13.7	40	13.2
1N4113	19	150	0.05	14.5	40	12.5
1N4114	20	150	0.01	15.2	40	11.9
1N4115	22	150	0.01	16.8	40	10.8
1N4116	24	150	0.01	18.3	40	9.9
1N4117	25	150	0.01	19.0	40	9.5
1N4118	27	150	0.01	20.5	40	8.8
1N4119	28	200	0.01	21.3	40	8.5
1N4120	30	200	0.01	22.8	40	7.9
1N4121	33	200	0.01	25.1	40	7.2
1N4122	36	200	0.01	27.4	40	6.6
1N4123	39	200	0.01	29.7	40	6.1
1N4124	43	250	0.01	32.7	40	5.5
1N4125	47	250	0.01	35.8	40	5.1
1N4126	51	300	0.01	38.8	40	4.6
1N4127	56	300	0.01	42.6	40	4.2
1N4128	60	400	0.01	45.6	40	4.0
1N4129	62	500	0.01	47.1	40	3.8
1N4130	68	700	0.01	51.7	40	3.5
1N4131	75	700	0.01	57.0	40	3.1
1N4132	82	800	0.01	62.4	40	2.9
1N4133	87	1000	0.01	66.2	40	2.7
1N4134	91	1200	0.01	69.2	40	2.6
1N4135	100	1500	0.01	76.0	40	2.3

NOTE 1: TOLERANCE AND VOLTAGE DESIGNATION

The type numbers shown have a standard tolerance of ±5.0% on the nominal zener voltage.

NOTE 2: ZENER IMPEDANCE (Z_{ZT}) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT}) is superimposed on I_{ZT}.

NOTE 3: MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

Maximum zener current ratings are based on maximum zener voltage of the individual units.

NOTE 4: REVERSE LEAKAGE CURRENT I_R

Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

ZENER NOISE DENSITY

A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. This microplasma noise is generally considered "white" noise with equal amplitude for all frequencies from about zero cycles to approximately 200,000 cycles. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

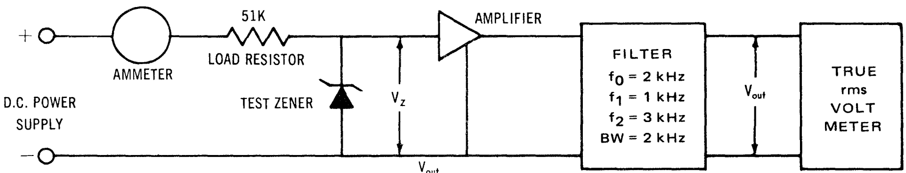
Motorola is rating this series with a maximum noise density at 250 microamperes. The rating of microvolts RMS per square root cycle enables calculation of the maximum RMS noise for any bandwidth.

Noise density decreases as zener current increases. This can be seen by the graph in Figure 2 where a typical noise density is plotted as a function of zener current.

The junction temperature will also change the zener noise levels. Thus the noise rating must indicate bandwidth, current level and temperature.

The block diagram given in Figure 1 shows the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 1 — NOISE DENSITY MEASUREMENT METHOD



NOISE DENSITY (VOLTS PER SQUARE ROOT CYCLE) $= \dfrac{V_{out}}{\text{OVERALL GAIN} \sqrt{BW}}$

WHERE: BW = FILTER BANDWIDTH (CYCLES)

V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 2 — TYPICAL NOISE DENSITY versus ZENER CURRENT

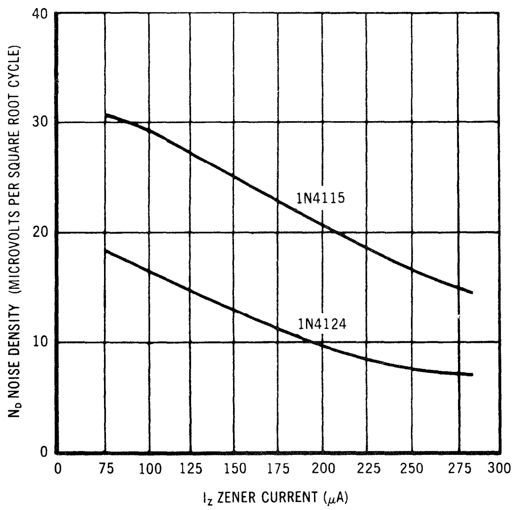


FIGURE 3 – TYPICAL CAPACITANCE

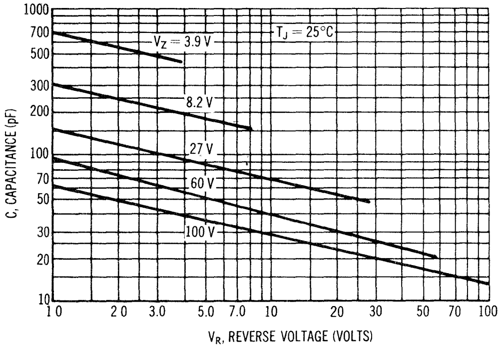
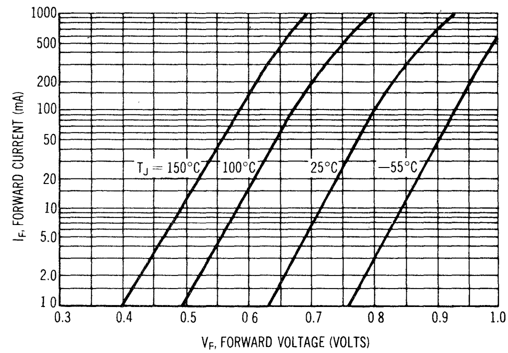


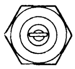
FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS

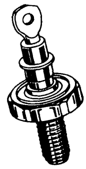


1N4370 thru 1N4372
1N4370A thru 1N4372A

For Specifications, see 1N746 Data.

1N4387 (SILICON)





CASE 44
(DO-4)

Silicon varactor diode for high-power frequency multiplication applications.

cathode connected to stud

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	150	Vdc
RF Power Input	P_{in}	40	Watts
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	20 200	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

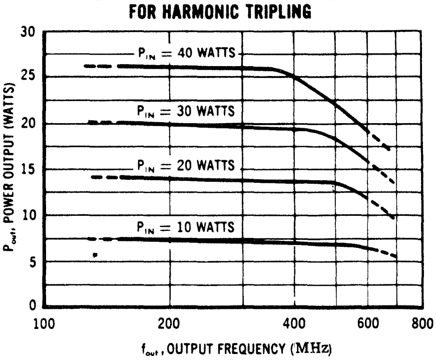
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	150	200	-	Vdc
Series Resistance (V_R = 6.0 Vdc, f = 50 MHz)	R_S	-	1.0	1.5	Ohms
Junction Capacitance * (V_R = 6.0 Vdc, f = 1.0 MHz)	C_T	-	25	35	pF
Figure of Merit (V_R = 10 Vdc, f = 50 MHz)	Q	150	200	-	-

FUNCTIONAL TESTS

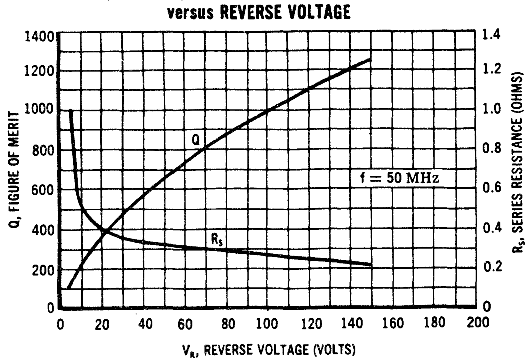
Power Output	Tripler Circuit P_{in} = 30 W, f_{in} = 150 MHz, f_{out} = 450 MHz	P_{out}	15	18	-	Watts
Efficiency		η	50	60	-	%

$*C_T = C_J + C_c$

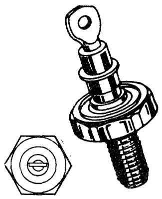
POWER OUTPUT versus OUTPUT FREQUENCY FOR HARMONIC TRIPLING



SERIES RESISTANCE AND FIGURE OF MERIT versus REVERSE VOLTAGE



1N4388 (SILICON)



CASE 44
(DO-4)

Silicon varactor diode for high-frequency harmonic generation applications.

cathode connected to stud

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Vdc
Forward Current	I_F	1.0	Amp
RF Power Input	P_{in}	25	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	10 0.10	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

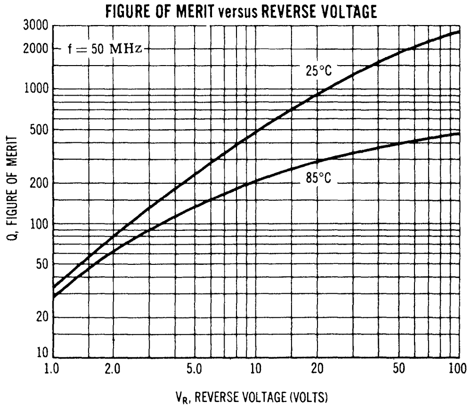
Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	100	150	-	Vdc
Reverse Current (V_R = 75 Vdc) (V_R = 75 Vdc, T_A = 150°C)	I_R	 - -	 0.5 -	 2.0 100	μAdc
Diode Capacitance (V_R = 6.0 Vdc, f = 1.0 MHz) (V_R = 90 Vdc, f = 1.0 MHz)	C_T*	 - -	 10 5.0	 20 10	pF
Series Resistance (V_R = 6.0 Vdc, f = 50 MHz)	R_S	-	1.2	2.0	Ohms
Figure of Merit **(V_R = 10 Vdc, f = 50 MHz)** (V_R = 90 Vdc, f = 50 MHz)	Q	 200 1000	 300 -	 - -	-

FUNCTIONAL TESTS

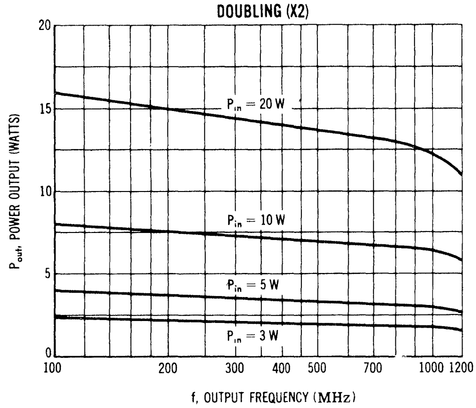
		Symbol	Min	Typ	Max	Unit
Power Output	**Doubler Circuit** (Figure 1) P_{in} = 20 W, f_{in} = 500 MHz, f_{out} = 1000 MHz	P_{out}	11.0	12.0	-	Watts
Efficiency		η	55	60	-	%

$*C_T = C_J + C_C$

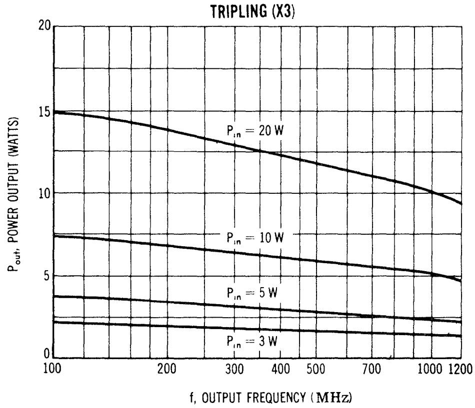
FIGURE OF MERIT versus REVERSE VOLTAGE



POWER OUTPUT versus OUTPUT FREQUENCY
DOUBLING (X2)



TRIPLING (X3)



QUADRUPLING (X4)

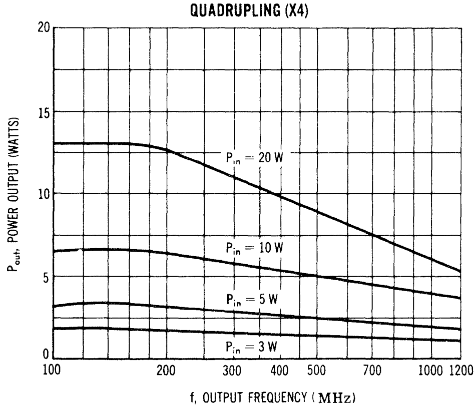
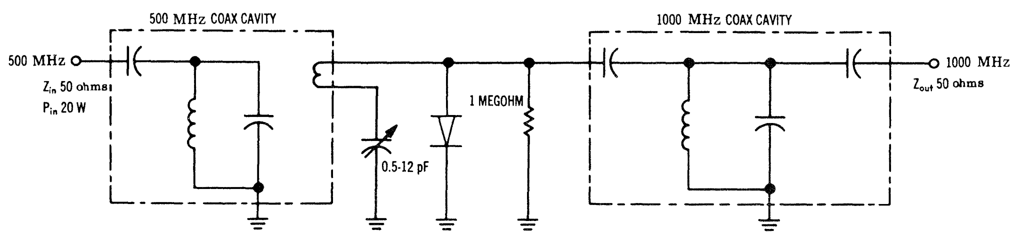


FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT



1N4549 thru 1N4556
1N4557 thru 1N4564

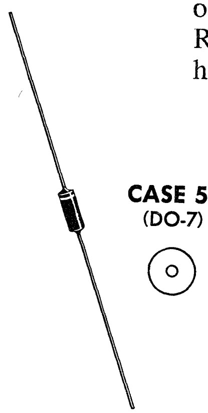
For Specifications, See 1N2804 Data

1N4565-1N4584

1N4775-1N4784

1N4765-1N4774

Low level temperature-compensated zener reference diodes—highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.



CASE 51
(DO-7)

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C

DC Power Dissipation: 400 Milliwatts at 50°C Ambient
(Derate 3.2 mW/°C Above 50°C)

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

TYPE	ΔV_Z (Note 1) Volts Max	@ Test Temperature °C	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
V_Z = 6.4 Volts ±5% (I_{ZT} = 0.5 mA)				
1N4565	0.048		0.01	
1N4566	0.024		0.005	
1N4567	0.010	0, +25,	0.002	200
1N4568	0.005	+75	0.001	
1N4569	0.002		0.0005	
1N4565A	0.099		0.01	
1N4566A	0.050	−55, 0,	0.005	
1N4567A	0.020	+25, +75,	0.002	200
1N4568A	0.010	+100	0.001	
1N4569A	0.005		0.0005	
V_Z = 6.4 Volts ±5% (I_{ZT} = 1.0 mA)				
1N4570	0.048		0.01	
1N4571	0.024		0.005	
1N4572	0.010	0, +25,	0.002	100
1N4573	0.005	+75	0.001	
1N4574	0.002		0.0005	
1N4570A	0.099		0.01	
1N4571A	0.050	−55, 0,	0.005	
1N4572A	0.020	+25, +75,	0.002	100
1N4573A	0.010	+100	0.001	
1N4574A	0.005		0.0005	
V_Z = 6.4 Volts ±5% (I_{ZT} = 2.0 mA)				
1N4575	0.048		0.01	
1N4576	0.024		0.005	
1N4577	0.010	0, +25,	0.002	50
1N4578	0.005	+75	0.001	
1N4579	0.002		0.0005	
1N4575A	0.099		0.01	
1N4576A	0.050	−55, 0,	0.005	
1N4577A	0.020	+25, +75,	0.002	50
1N4578A	0.010	+100	0.001	
1N4579A	0.005		0.0005	
V_Z = 6.4 Volts ±5% (I_{ZT} = 4.0 mA)				
1N4580	0.048		0.01	
1N4581	0.024		0.005	
1N4582	0.010	0, +25,	0.002	25
1N4583	0.005	+75	0.001	
1N4584	0.002		0.0005	
1N4580A	0.099		0.01	
1N4581A	0.050	−55, 0,	0.005	
1N4582A	0.020	+25, +75,	0.002	25
1N4583A	0.010	+100	0.001	
1N4584A	0.005		0.0005	

TYPE	ΔV_Z (Note 1) Volts Max	@ Test Temperature °C	Temperature Coefficient for Reference %/°C (Note 1)	Dynamic Imped. Ohms Max (Note 2)
V_Z = 8.5 Volts ±5% (I_{ZT} = 0.5 mA)				
1N4775	0.064		0.01	
1N4776	0.032		0.005	
1N4777	0.013	0, +25,	0.002	200
1N4778	0.006	+75	0.001	
1N4779	0.003		0.0005	
1N4775A	0.132		0.01	
1N4776A	0.066	−55, 0,	0.005	
1N4777A	0.026	+25, +75,	0.002	200
1N4778A	0.013	+100	0.001	
1N4779A	0.007		0.0005	
V_Z = 8.5 Volts ±5% (I_{ZT} = 1.0 mA)				
1N4780	0.064		0.01	
1N4781	0.032		0.005	
1N4782	0.013	0, +25,	0.002	100
1N4783	0.006	+75	0.001	
1N4784	0.003		0.0005	
1N4780A	0.132		0.01	
1N4781A	0.066	−55, 0,	0.005	
1N4782A	0.026	+25, +75,	0.002	100
1N4783A	0.013	+100	0.001	
1N4784A	0.007		0.0005	
V_Z = 9.1 Volts ±5% (I_{ZT} = 0.5 mA)				
1N4765	0.068		0.01	
1N4766	0.034		0.005	
1N4767	0.014	0, +25,	0.002	350
1N4768	0.007	+75	0.001	
1N4769	0.003		0.0005	
1N4765A	0.141		0.01	
1N4766A	0.070	−55, 0,	0.005	
1N4767A	0.028	+25, +75,	0.002	350
1N4768A	0.014	+100	0.001	
1N4769A	0.007		0.0005	
V_Z = 9.1 Volts ±5% (I_{ZT} = 1.0 mA)				
1N4770	0.068		0.01	
1N4771	0.034		0.005	
1N4772	0.014	0, +25,	0.002	200
1N4773	0.007	+75	0.001	
1N4774	0.003		0.0005	
1N4770A	0.141		0.01	
1N4771A	0.070	−55, 0,	0.005	
1N4772A	0.028	+25, +75,	0.002	200
1N4773A	0.014	+100	0.001	
1N4774A	0.007		0.0005	

NOTE 1:

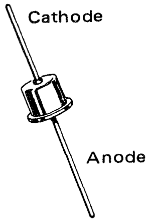
Voltage Variation (ΔV_Z) and Temperature Coefficient.

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

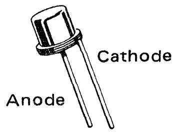
NOTE 2:

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

1N4719 thru 1N4725 (SILICON)
1N4997 thru 1N5003



CASE 60
1N4719 THRU 1N4725



CASE 70
1N4997 thru 1N5003

Silicon high-conductance rectifiers available in either axial-lead or single-ended packages. Type numbers shown have cathode connected to case. For anode-to-case connection, add suffix "R" to type number, i. e. 1N4719R

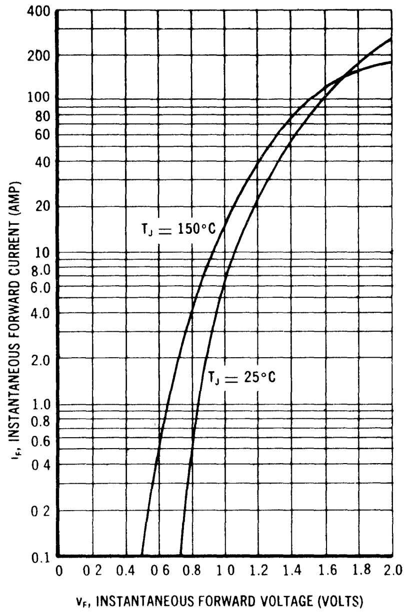
MAXIMUM RATINGS (Both Package Types) $T_A = 25^oC$ unless otherwise noted.

Rating	Symbol	1N 4719 1N 4997	1N 4720 1N 4998	1N 4721 1N 4999	1N 4722 1N 5000	1N 4723 1N 5001	1N 4724 1N 5002	1N 4725 1N 5003	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	500	720	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75^oC$) see figure 4	I_O	3.0							Amp
Peak Repetitive Forward Current ($T_A = 75^oC$)	I_{FRM}	25							Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75^oC$) see figure 1	I_{FSM}	300 (for 1/2 cycle)							Amp
I^2t Rating (non-repetitive, 1 ms $<$ t $<$ 8.3 ms)	I^2t	185							$A_{(rms)}^2s$
Operating and Case Temperature	T_J, T_{stg}	-65 to +175							^oC
Thermal Resistance, Junction to Case (note 1)	$R_{\theta JA}$	30							$^oC/W$

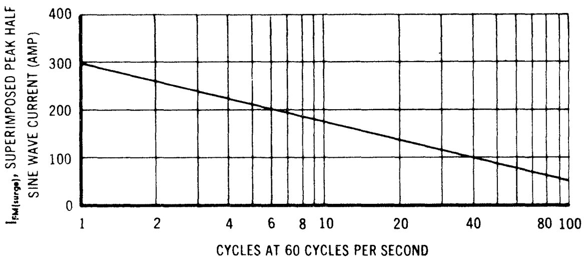
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
Instantaneous Forward Voltage (i_F = 9.4 A, T_J = 175°C, Half Wave Rectifier)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 3.0 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.5	mA

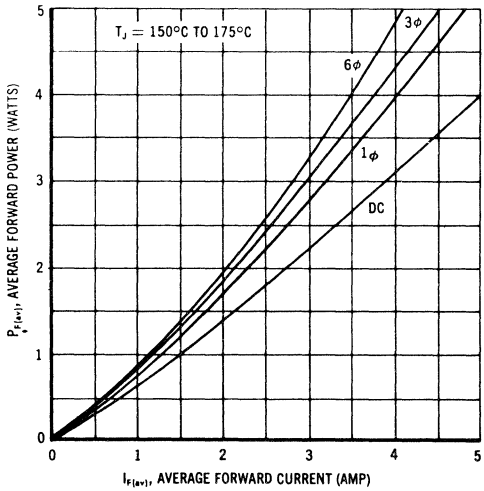
FORWARD VOLTAGE CHARACTERISTICS



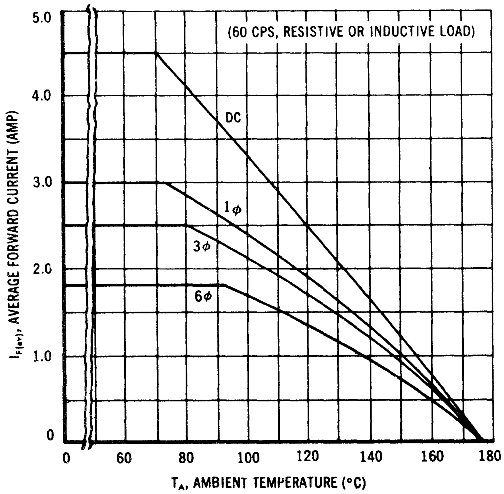
MAXIMUM SURGE CURRENT T_A = 75°C)



MAXIMUM FORWARD POWER DISSIPATION versus AVERAGE FORWARD CURRENT



MAXIMUM FORWARD CURRENT versus AMBIENT TEMPERATURE



1N4728 thru 1N4764 (SILICON)
1M3.3ZS10 thru 1M200ZS10

Designers Data Sheet

1.0 WATT SURMETIC 30 SILICON ZENER DIODES

. . . a complete series of 1.0 Watt Zener Diodes with limits and operating characteristics that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

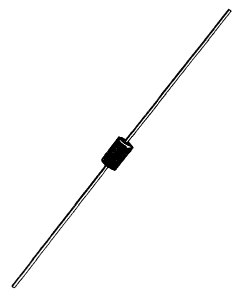
- To 80 Watts Surge Rating @ 1.0 ms
- Maximum Limits Guaranteed on Six Electrical Parameters
- Package No Larger Than the Conventional 400 mW Package

Designer's Data for "Worst Case" Conditions

The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

1.0 WATT ZENER REGULATOR DIODES

3.3–200 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*DC Power Dissipation @ $T_A = 50^oC$ Derate above 50^oC	P_D	1.0 6.67	Watt $mW/^oC$
DC Power Dissipation @ $T_L = 75^oC$ Lead Length = 3/8" Derate above 75^oC	P_D	3.0 24	Watts $mW/^oC$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

MECHANICAL CHARACTERISTICS

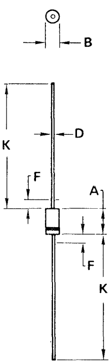
CASE: Void-free, transfer-molded, thermosetting plastic

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable

POLARITY: Cathode indicated by polarity band. When operated in zener mode, cathode will be positive with respect to anode

MOUNTING POSITION: Any

WEIGHT: 0.4 gram (approx)



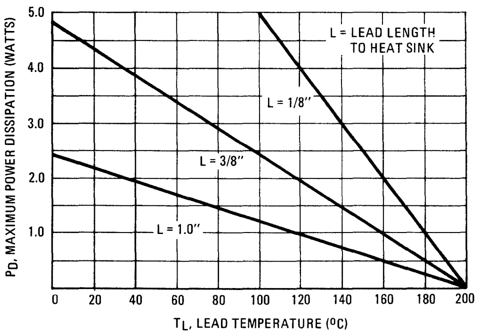
NOTE
1. POLARITY DENOTED BY CATHODE BAND

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

All JEDEC dimensions and notes apply

CASE 59-03
DO-41

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) *V_F = 1.5 V max, I_F = 200 mA for all types

JEDEC Type No. (Note 1)	Motorola Type No. (Note 2)	*Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2 & 3)	*Test Current I_{ZT} mA	*Max Zener Impedance (Note 4) Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	*Leakage Current I_R μA Max	V_R @ Volts	*Surge Current @ T_A = 25°C i_r – mA (Note 5)
1N4728	1M3.3ZS10	3.3	76	10	400	1.0	100	1.0	1380
1N4729	1M3.6ZS10	3.6	69	10	400	1.0	100	1.0	1260
1N4730	1M3.9ZS10	3.9	64	9.0	400	1.0	50	1.0	1190
1N4731	1M4.3ZS10	4.3	58	9.0	400	1.0	10	1.0	1070
1N4732	1M4.7ZS10	4.7	53	8.0	500	1.0	10	1.0	970
1N4733	1M5.1ZS10	5.1	49	7.0	550	1.0	10	1.0	890
1N4734	1M5.6ZS10	5.6	45	5.0	600	1.0	10	2.0	810
1N4735	1M6.2ZS10	6.2	41	2.0	700	1.0	10	3.0	730
1N4736	1M6.8ZS10	6.8	37	3.5	700	1.0	10	4.0	660
1N4737	1M7.5ZS10	7.5	34	4.0	700	0.5	10	5.0	605
1N4738	1M8.2ZS10	8.2	31	4.5	700	0.5	10	6.0	550
1N4739	1M9.1ZS10	9.1	28	5.0	700	0.5	10	7.0	500
1N4740	1M10ZS10	10	25	7.0	700	0.25	10	7.6	454
1N4741	1M11ZS10	11	23	8.0	700	0.25	5.0	8.4	414
1N4742	1M12ZS10	12	21	9.0	700	0.25	5.0	9.1	380
1N4743	1M13ZS10	13	19	10	700	0.25	5.0	9.9	344
1N4744	1M15ZS10	15	17	14	700	0.25	5.0	11.4	304
1N4745	1M16ZS10	16	15.5	16	700	0.25	5.0	12.2	285
1N4746	1M18ZS10	18	14	20	750	0.25	5.0	13.7	250
1N4747	1M20ZS10	20	12.5	22	750	0.25	5.0	15.2	225
1N4748	1M22ZS10	22	11.5	23	750	0.25	5.0	16.7	205
1N4749	1M24ZS10	24	10.5	25	750	0.25	5.0	18.2	190
1N4750	1M27ZS10	27	9.5	35	750	0.25	5.0	20.6	170
1N4751	1M30ZS10	30	8.5	40	1000	0.25	5.0	22.8	150
1N4752	1M33ZS10	33	7.5	45	1000	0.25	5.0	25.1	135
1N4753	1M36ZS10	36	7.0	50	1000	0.25	5.0	27.4	125
1N4754	1M39ZS10	39	6.5	60	1000	0.25	5.0	29.7	115
1N4755	1M43ZS10	43	6.0	70	1500	0.25	5.0	32.7	110
1N4756	1M47ZS10	47	5.5	80	1500	0.25	5.0	35.8	95
1N4757	1M51ZS10	51	5.0	95	1500	0.25	5.0	38.8	90
1N4758	1M56ZS10	56	4.5	110	2000	0.25	5.0	42.6	80
1N4759	1M62ZS10	62	4.0	125	2000	0.25	5.0	47.1	70
1N4760	1M68ZS10	68	3.7	150	2000	0.25	5.0	51.7	65
1N4761	1M75ZS10	75	3.3	175	2000	0.25	5.0	56.0	60
1N4762	1M82ZS10	82	3.0	200	3000	0.25	5.0	62.2	55
1N4763	1M91ZS10	91	2.8	250	3000	0.25	5.0	69.2	50
1N4764	1M100ZS10	100	2.5	350	3000	0.25	5.0	76.0	45
–	1M110ZS10	110	2.3	450	4000	0.25	5.0	83.6	–
–	1M120ZS10	120	2.0	550	4500	0.25	5.0	91.2	–
–	1M130ZS10	130	1.9	700	5000	0.25	5.0	98.8	–
–	1M150ZS10	150	1.7	1000	6000	0.25	5.0	114.0	–
–	1M160ZS10	160	1.6	1100	6500	0.25	5.0	121.6	–
–	1M180ZS10	180	1.4	1200	7000	0.25	5.0	136.8	–
–	1M200ZS10	200	1.2	1500	8000	0.25	5.0	152.0	–

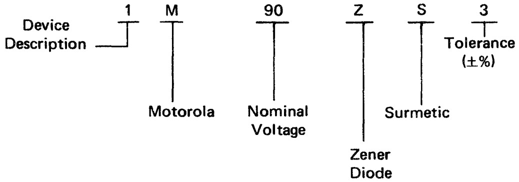
*Indicates JEDEC Registered Data

NOTE 1 – TOLERANCE AND TYPE NUMBER DESIGNATION

The JEDEC type numbers listed have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

NOTE 2 – SPECIALS AVAILABLE INCLUDE:

(A) NOMINAL ZENER VOLTAGES BETWEEN THE VOLTAGES SHOWN AND TIGHTER VOLTAGE TOLERANCES: To designate units with zener voltages other than those assigned JEDEC numbers and/or tight voltage tolerances (±5%, ±3%, ±2%, ±1%), the Motorola type number should be used.

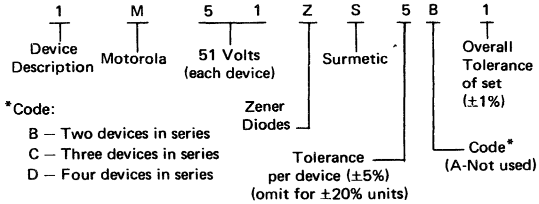


Example: **1M90ZS3**

(B) MATCHED SETS: (Standard Tolerances are ±5.0%, ±3.0%, ±2.0%, ±1.0%).

Zener diodes can be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to the one described in (A), except that two extra suffixes are added to the code number described.

These units are marked with code letters to identify the matched sets and, in addition, each unit in a set is marked with the same serial number, which is different for each set being ordered.



Example: **1M51ZS5B1**

(C) ZENER CLIPPERS: (Standard Tolerance ±10% and ±5%).

Special clipper diodes with opposing Zener junctions built into the device are available by using the following nomenclature:

1 M 20 Z Z S 10

- 1 — Device Description
- M — Motorola
- 20 — Nominal Voltage
- Z — Zener Diode
- Z — Clipper
- S — Surmetic
- 10 — Tolerance for each of the two Zener voltages (not a matching requirement)

Example: **1M20ZZS10**

NOTE 3 – ZENER VOLTAGE (V_Z) MEASUREMENT

Motorola guarantees the zener voltage when measured at 90 seconds while maintaining the lead temperature (T_L) at 30°C ± 1°C, 3/8″ from the diode body.

NOTE 4 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 cycle ac voltage, which results when an ac current having an rms value equal to 10% of the dc zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}.

NOTE 5 – SURGE CURRENT (i_r) NON-REPETITIVE

The rating listed in the electrical characteristics table is maximum peak, non-repetitive, reverse surge current of 1/2 square wave or equivalent sine wave pulse of 1/120 second duration superimposed on the test current, I_{ZT}, per JEDEC registration, however, actual device capability is as described in Figures 4 and 5.

APPLICATION NOTE

Since the actual voltage available from a given zener diode is temperature dependent, it is necessary to determine junction temperature under any set of operating conditions in order to calculate its value. The following procedure is recommended:

Lead Temperature, T_L, should be determined from:

$$T_L = \theta_{LA} P_D + T_A$$

θ_{LA} is the lead-to-ambient thermal resistance (°C/W) and P_D is the power dissipation. The value for θ_{LA} will vary and depends on the device mounting method. θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use and for printed circuit board wiring

The temperature of the lead can also be measured using a thermocouple placed on the lead as close as possible to the tie point. The thermal mass connected to the tie point is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_L, the junction temperature may be determined by:

$$T_J = T_L + \Delta T_{JL}$$

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 2 for a train of power pulses (L = 3/8 inch) or from Figure 3 for dc power.

$$\Delta T_{JL} = \theta_{JL} P_D$$

For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of $T_J(\Delta T_J)$ may be estimated. Changes in voltage, V_Z, can then be found from:

$$\Delta V = \theta_{VZ} \Delta T_J$$

θ_{VZ}, the zener voltage temperature coefficient, is found from Figures 6 and 7.

Under high power-pulse operation, the zener voltage will vary with time and may also be affected significantly by the zener resistance. For best regulation, keep current excursions as low as possible.

Data of Figure 2 should not be used to compute surge capability. Surge limitations are given in Figure 4. They are lower than would be expected by considering only junction temperature, as current crowding effects cause temperatures to be extremely high in small spots resulting in device degradation should the limits of Figure 4 be exceeded.

FIGURE 2 — TYPICAL THERMAL RESPONSE, LEAD LENGTH L = 3/8 INCH

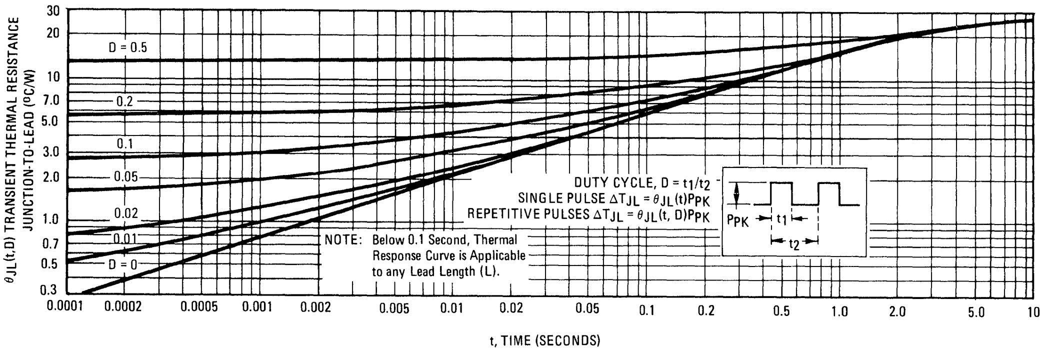


FIGURE 3 — TYPICAL THERMAL RESISTANCE

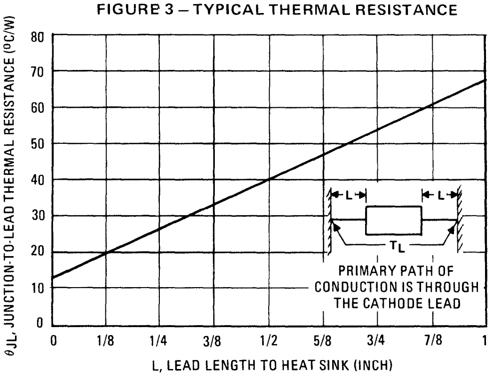


FIGURE 4 — MAXIMUM NON-REPETITIVE SURGE POWER

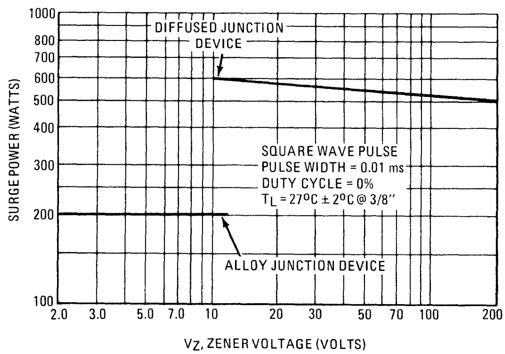
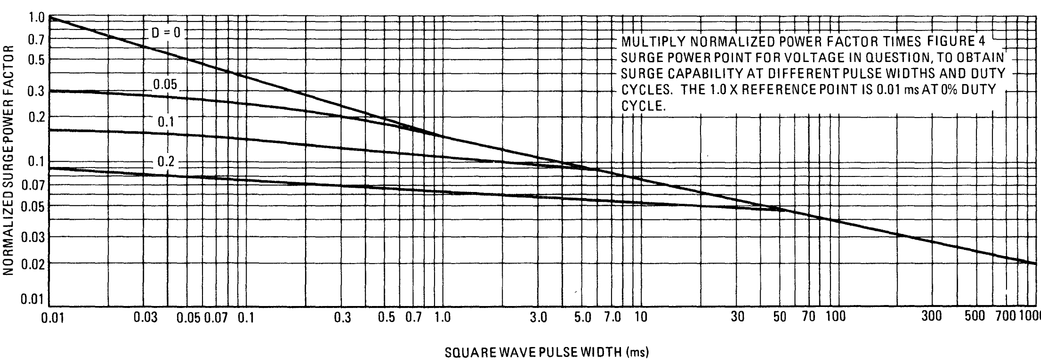


FIGURE 5 — SURGE POWER FACTOR



TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

(90% OF THE UNITS ARE IN THE RANGES INDICATED)

FIGURE 6 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS TO 12 VOLTS

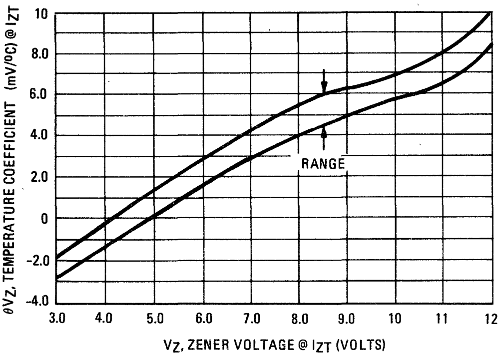


FIGURE 7 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 200 VOLTS

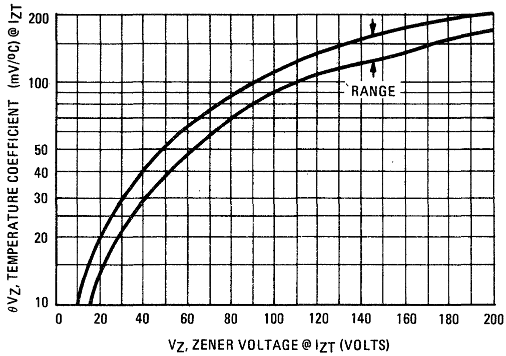


FIGURE 8 – VOLTAGE REGULATION

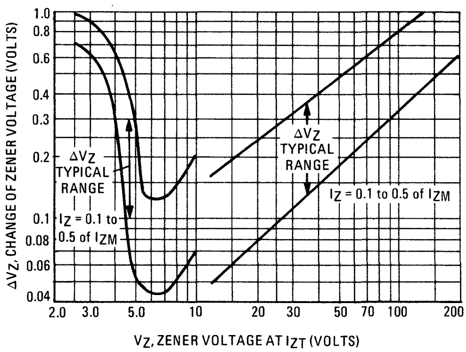
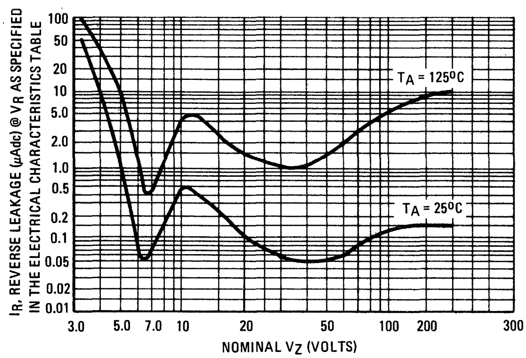


FIGURE 9 – MAXIMUM REVERSE LEAKAGE

(95% OF THE UNITS ARE BELOW THE VALUES SHOWN)



1N4765 thru 1N4774
1N4775 thru 1N4784

For Specifications, See 1N4565 Data.

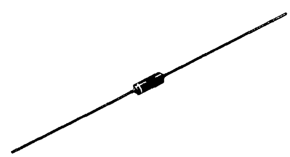
1N4896, A thru 1N4915, A
1N4916, A thru 1N4932, A

LOW NOISE TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing an oxide-passivated junction for long-term voltage stability. RamRod construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Noise Density Specified for Critical Applications
- Low Power Drain
  Devices Specified @ 0.5 mA, 1.0 mA, 2.0 mA, 4.0 mA, and 7.5 mA
- Maximum Voltage Change Specified over Test Temperature Range
- Temperature Compensation Guaranteed over Two Standard Operating Temperature Ranges:
  +25 to +100°C
  -55 to +100°C

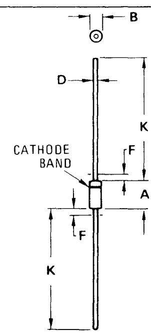
LOW NOISE
TEMPERATURE-COMPENSATED
ZENER
REFERENCE DIODES



MAXIMUM RATINGS

Junction and Storage Temperature. -65°C to +175°C

DC Power Dissipation· 400 Milliwatts at 50°C Ambient
(Derate 3 2 mW/°C Above 50°C)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7 62	0.230	0.300
B	2.16	2 72	0.085	0.107
D	0.46	0.56	0 018	0 022
F	–	1 27	–	0.050
K	25.40	–	1.000	–

CASE 51
DO-7

MECHANICAL CHARACTERISTICS

CASE· Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

POLARITY. Cathode indicated by polarity band.

WEIGHT 0.2 Gram (approx)

MOUNTING POSITION. Any

V_Z = 12.8 V

TEMPERATURE RANGE:

STANDARD DEVICES
*+25, +75, +100°C

"A" SUFFIX
* -55, 0 + 25, +75, +100°C

Type Number	*ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. %/°C (Note 1)	*Dynamic Imped. Ohms Max (Note 2)
*I_{ZT} = 0.5 mA(1) N_D = 0.8 $\frac{\mu V}{\sqrt{Hz}}$			
1N4896	0 096	0 01	400
1N4896A	0 198	0.01	
1N4897	0 048	0 005	
1N4897A	0 099	0 005	
1N4898	0 019	0 002	
1N4898A	0 040	0 002	
1N4899	0.010	0 001	
1N4899A	0 020	0 001	
*I_{ZT} = 1.0 mA(1) N_D = 0.4 $\frac{\mu V}{\sqrt{Hz}}$			
1N4900	0 096	0 01	200
1N4900A	0 198	0 01	
1N4901	0 048	0 005	
1N4901A	0.099	0.005	
1N4902	0 019	0 002	
1N4902A	0.040	0 002	
1N4903	0 010	0 001	
1N4903A	0 020	0 001	
*I_{ZT} = 2.0 mA(1) N_D = 0.25 $\frac{\mu V}{\sqrt{Hz}}$			
1N4904	0 096	0 01	100
1N4904A	0 198	0 01	
1N4905	0 048	0 005	
1N4905A	0 099	0 005	
1N4906	0 019	0 002	
1N4906A	0 040	0 002	
1N4907	0 010	0 001	
1N4907A	0 020	0 001	
*I_{ZT} = 4.0 mA(1) N_D = 0.22 $\frac{\mu V}{\sqrt{Hz}}$			
1N4908	0 096	0 01	50
1N4908A	0 198	0 01	
1N4909	0 048	0 005	
1N4909A	0 099	0 005	
1N4910	0 019	0 002	
1N4910A	0 040	0 002	
1N4911	0 010	0 001	
1N4911A	0 020	0 001	
*I_{ZT} = 7.5 mA(1) N_D = 0.20 $\frac{\mu V}{\sqrt{Hz}}$			
1N4912	0 096	0 01	25
1N4912A	0 198	0 01	
1N4913	0 048	0 005	
1N4913A	0 099	0 005	
1N4914	0 019	0 002	
1N4914A	0 040	0 002	
1N4915	0 010	0 001	
1N4915A	0 020	0 001	

V_Z = 19.2 V

TEMPERATURE RANGE:

STANDARD DEVICES
*+25, +75, +100°C

"A" SUFFIX
*-55, 0, +25, +75, +100°C

Type Number	*ΔV_Z Volts (Note 1)	Temp. Coeff. for Ref. %/°C (Note 1)	*Dynamic Imped. Ohms Max (Note 2)
*I_{ZT} = 0.5 mA(1) N_D = 1.0 $\frac{\mu V}{\sqrt{Hz}}$			
1N4916	0 144	0 01	600
1N4916A	0 298	0 01	
1N4917	0 072	0 005	
1N4917A	0.149	0 005	
1N4918	0 029	0 002	
1N4918A	0.060	0 002	
*I_{ZT} = 1.0 mA(1) N_D = 0.5 $\frac{\mu V}{\sqrt{Hz}}$			
1N4919	0 144	0 01	300
1N4919A	0 298	0 01	
1N4920	0 072	0 005	
1N4920A	0 149	0 005	
1N4921	0 029	0 002	
1N4921A	0 060	0 002	
*I_{ZT} = 2.0 mA(1) N_D = 0.25 $\frac{\mu V}{\sqrt{Hz}}$			
1N4922	0 144	0 01	150
1N4922A	0 298	0 01	
1N4923	0 072	0 005	
1N4923A	0 149	0 005	
1N4924	0 029	0 002	
1N4924A	0 060	0 002	
*I_{ZT} = 4.0 mA(1) N_D = 0.22 $\frac{\mu V}{\sqrt{Hz}}$			
1N4925	0 144	0 01	75
1N4925A	0 298	0 01	
1N4926	0 072	0 005	
1N4926A	0 149	0 005	
1N4927	0 029	0 002	
1N4927A	0 060	0 002	
1N4928	0 014	0 001	
1N4928A	0 030	0 001	
*I_{ZT} = 7.5 mA(1) N_D = 0.20 $\frac{\mu V}{\sqrt{Hz}}$			
1N4929	0 144	0 01	36
1N4929A	0 298	0 01	
1N4930	0 072	0 005	
1N4930A	Q 149	0 005	
1N4931	0 029	0 002	
1N4931A	0 060	0 002	
1N4932	0 014	0 001	
1N4932A	0 030	0 001	

*Indicates JEDEC Registered Data.

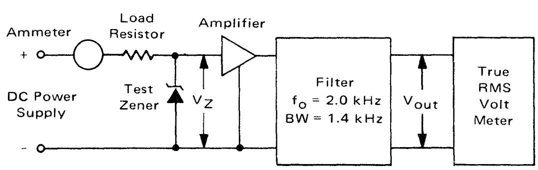
NOTE 1
Voltage Variation (ΔV_Z) and Temperature Coefficient

All reference diodes are characterized by the "box method". This guarantees a maximum voltage variation (ΔV_Z) over the specified temperature range, at the specified test current (I_{ZT}), verified by tests at indicated temperature points within the range. V_Z is measured and recorded at each temperature specified. The ΔV_Z between the highest and lowest values must not exceed the max ΔV_Z given. This method of indicating voltage stability is now used for JEDEC registration as well as for military qualification. The former method of indicating voltage stability — by means of temperature coefficient — accurately reflects the voltage deviation at the temperature extremes, but is not necessarily accurate within the temperature range because reference diodes have a nonlinear temperature relationship. The temperature coefficient, therefore, is given only as a reference.

NOTE 2: Zener Impedance Derivation

The dynamic zener impedance, Z_{ZT}, is derived from the 60-Hz ac voltage drop which results when an ac current with an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A cathode-ray tube curve-trace test on a sample basis is used to ensure that the zener has a sharp and stable knee region.

(1)NOISE DENSITY MEASUREMENT METHOD



$$\text{Noise Density (Volts per Square Root Bandwidth)} = \frac{V_{out}}{\text{Overall Gain} \quad \text{BW}}$$

Where BW = Filter Bandwidth (Hz)
V_{out} Output Noise (Volts RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The amplifier is low noise so that the amplifier noise is negligible compared to that of the test TC zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

1N4933 thru 1N4937
MR2271

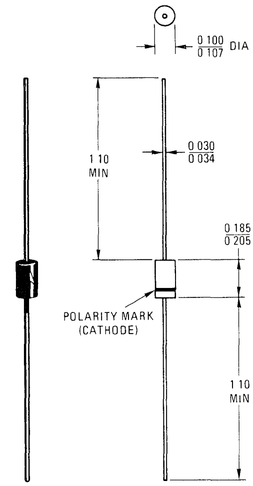
Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY RECTIFIERS

. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 100 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY RECTIFIERS

50-600 VOLTS
1 AMPERE



All JEDEC dimensions and notes apply

CASE 59
DO-41

Designer's Data for "Worst Case" Conditions

The Designers Data Sheet permits the design of most circuits entirely from the information presented. Limit curves — representing device characteristics boundaries — are given to facilitate "worst case" design.

***MAXIMUM RATINGS**

Rating	Symbol	1N4933	1N4934	1N4935	MR2271	1N4936	1N4937	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	350	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, T_A = 75°C)	I_O	← 1.0 →						Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 30 →						Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →						°C
Storage Temperature Range	T_{stg}	← -65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Typical Printed Circuit Board Mounting)	$R_{\theta JA}$	65	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
*Instantaneous Forward Voltage (I_F = 3.14 Amp, T_J = 150°C)	V_F	–	1.0	1.2	Volts
Forward Voltage (I_F = 1.0 Amp, T_A = 25°C)	V_F	–	1.0	1.1	Volts
*Reverse Current (rated dc voltage) T_A = 25°C	I_R	–	1.0	5.0	µA
T_A = 100°C		–	50	100	

***REVERSE RECOVERY CHARACTERISTICS**

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc) (Figure 21)	t_{rr}	–	100	200	ns
(I_{FM} = 15 Amp, di/dt = 10 A/µs) (Figure 22)		–	150	300	
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc) (Figure 21)	$I_{RM(REC)}$	–	1.0	2.0	Amp

*Indicates JEDEC Registered Data for 1N4933 Series

MECHANICAL CHARACTERISTICS

CASE: Void Free, Transfer Molded
FINISH: External leads are plated, leads are readily solderable

POLARITY: Cathode indicated by Polarity band.
WEIGHT: 0.4 Gram (Approximately)

FIGURE 1 – FORWARD VOLTAGE

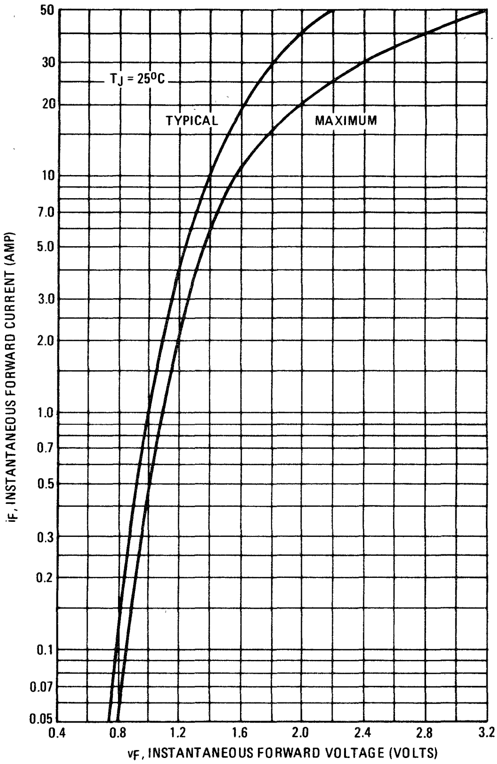


FIGURE 2 – MAXIMUM SURGE CAPABILITY

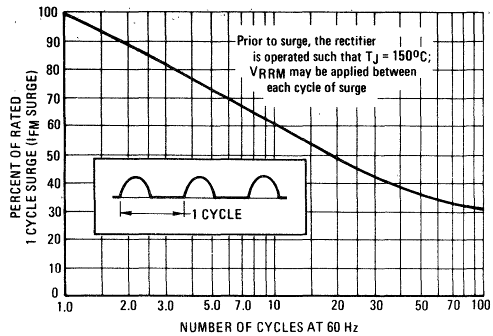
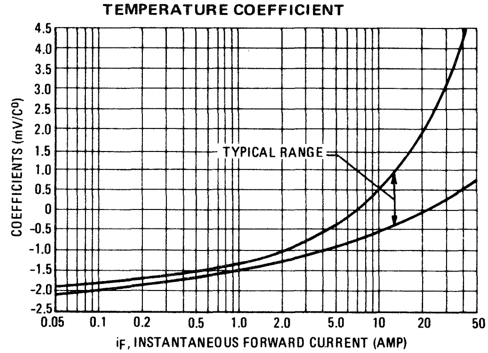
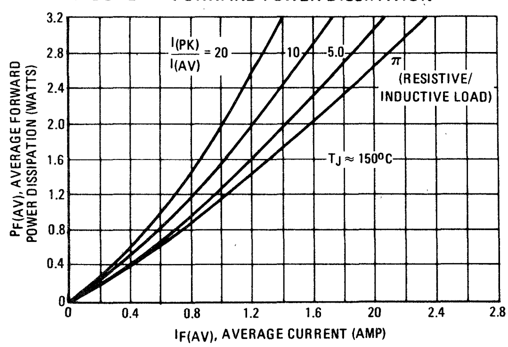


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



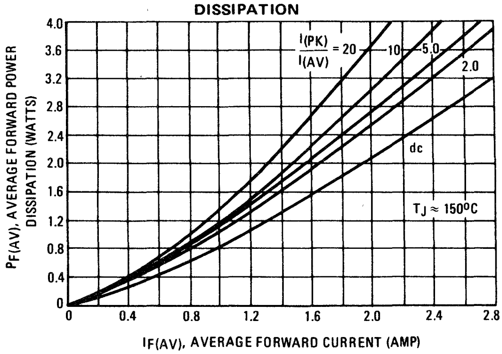
SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

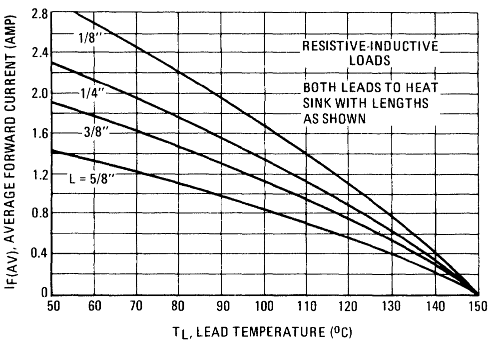
FIGURE 5 – FORWARD POWER DISSIPATION



MAXIMUM CURRENT RATINGS

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

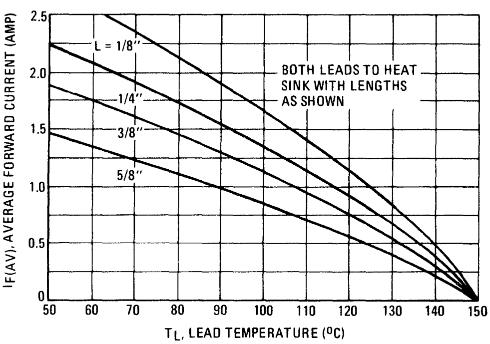


FIGURE 8 – 1/8″ LEAD LENGTH, VARIOUS LOADS

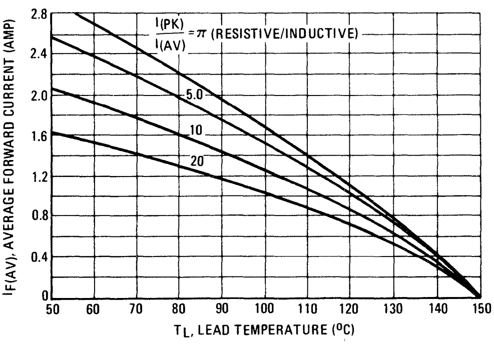


FIGURE 9 – 1/8″ LEAD LENGTHS, VARIOUS LOADS

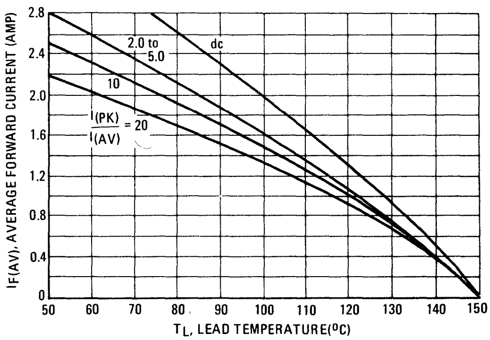


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

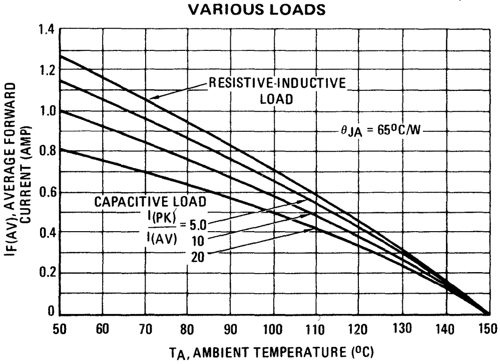


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

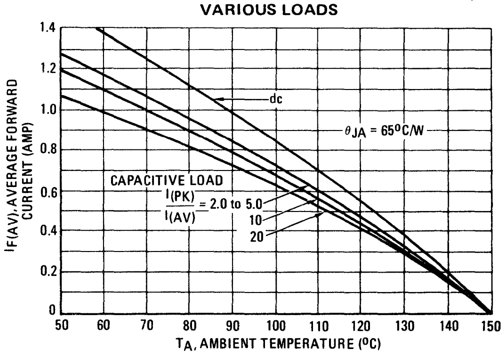


FIGURE 12 – THERMAL RESPONSE

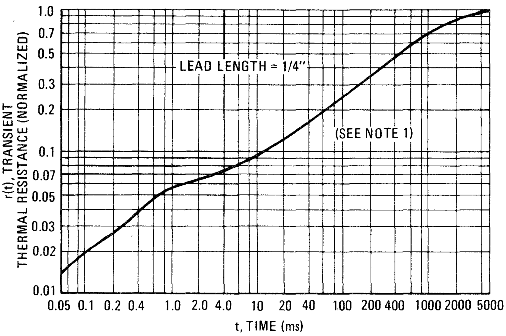
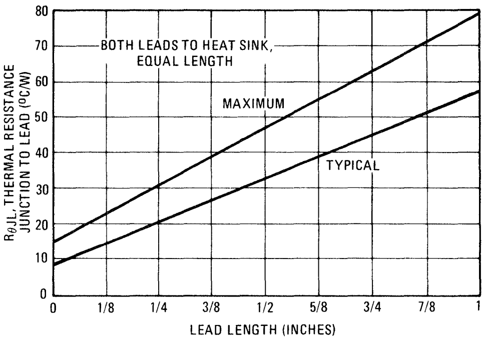
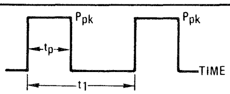


FIGURE 13 – THERMAL RESISTANCE



NOTE 1



DUTY CYCLE, $D = t_p/t_1$
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse

To determine maximum junction temperature of the diode in a given situation, the following procedure is recommended

The temperature of the case should be measured using a thermocouple placed on the case at the temperature reference point (see Note 3) The thermal mass connected to the case is normally large enough so that it will not significantly respond to heat surges generated in the diode as a result of pulsed operation once steady-state conditions are achieved. Using the measured value of T_C, the junction temperature may be determined by

$$T_J = T_C + \Delta T_{JC}$$

where ΔT_{JC} is the increase in junction temperature above the case temperature It may be determined by

$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 3, i e.

$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$

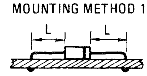
NOTE 2

Data shown for thermal resistance junction-to-ambient (θ_{JA}) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

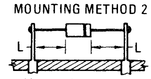
TYPICAL VALUES FOR θ_{JA} IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	65	72	82	92	°C/W
2	74	81	91	101	°C/W
3		40			°C/W

MOUNTING METHOD 1



MOUNTING METHOD 2



Vector pin mounting

MOUNTING METHOD 3

P. C. Board with 1-1/2" x 1-1/2" copper surface

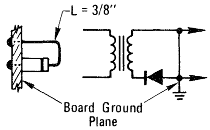
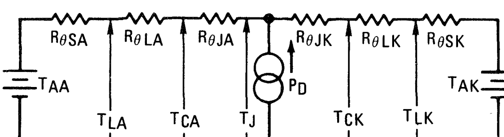


FIGURE 14 – THERMAL CIRCUIT MODEL
(For Heat Conduction Through The Leads)



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. For a given total lead length, lowest values occur when one side of the rectifier is brought as close as possible to the heat sink. Terms in the model signify:

T_A = Ambient Temperature $R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
T_L = Lead Temperature $R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
T_C = Case Temperature $R_{\theta J}$ = Thermal Resistance, Junction to Case
T_J = Junction Temperature P_D = Power Dissipation
(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are
$R_{\theta L}$ = 112°C/W/IN. Typically and 128°C/W/IN Maximum
$R_{\theta J}$ = 18°C/W Typically and 30°C/W Maximum

The maximum lead temperature may be calculated as follows:

$$T_L = 150^\circ - \Delta T_{JL}$$

ΔT_{JL} can be calculated as shown in NOTE 1 or it may be approximated as follows.

$\Delta T_{JL} \approx R_{\theta JL} \bullet P_F$; P_F may be formulated for sine-wave operation from Figure 3 or from Figure 4 for square-wave operation.

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 – FORWARD RECOVERY TIME

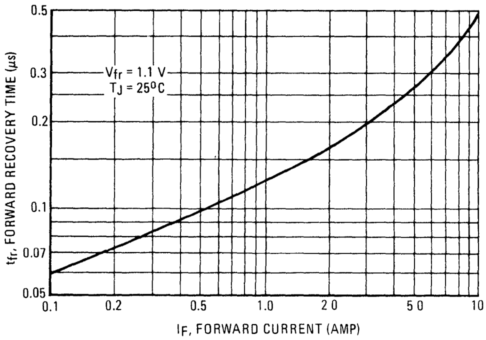
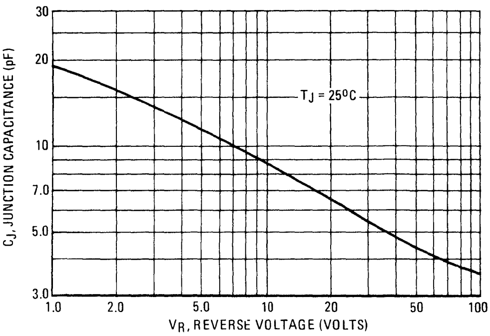


FIGURE 16 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGED DATA

FIGURE 17 – T_J = 25°C

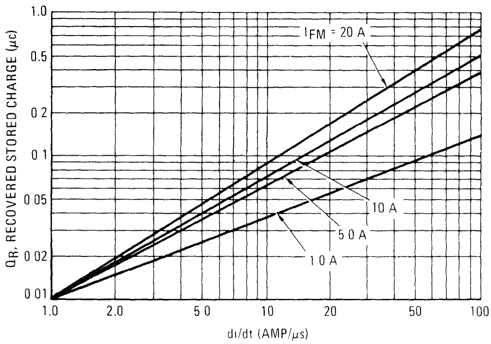


FIGURE 18 – T_J = 75°C

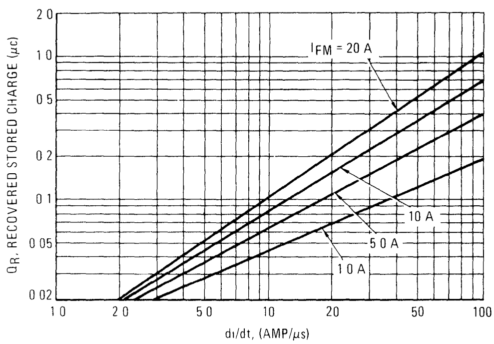


FIGURE 19 – T_J = 100°C

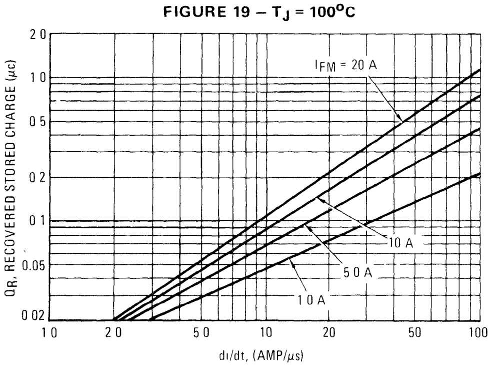
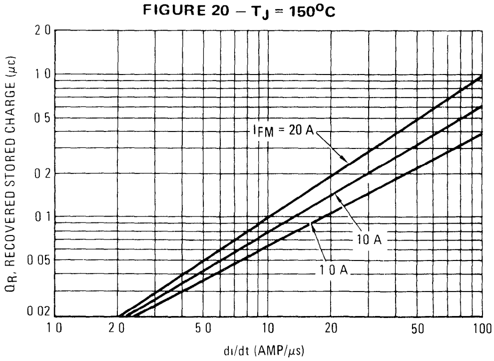


FIGURE 20 – T_J = 150°C



RECOVERY TIME

FIGURE 21 – REVERSE RECOVERY CIRCUIT

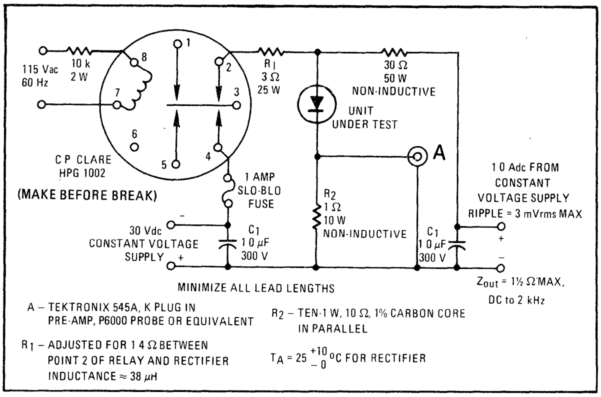
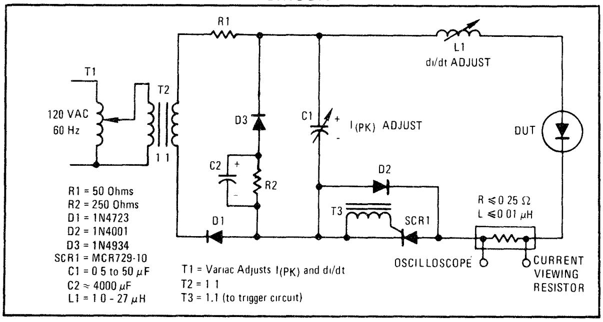


FIGURE 22 – JEDEC REVERSE RECOVERY CIRCUIT



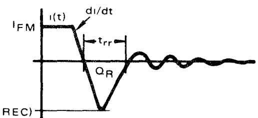
NOTE 3

Reverse recovery time is the period which elapses from the time that the current, thru a previously forward biased rectifier diode, passes thru zero going negatively until the reverse current recovers to a point which is less than 10% peak reverse current.

Reverse recovery time is a direct function of the forward current prior to the application of reverse voltage.

For any given rectifier, recovery time is very circuit dependent. Typical and maximum recovery time of all Motorola fast recovery power rectifiers are rated under a fixed set of conditions using I_F = 1.0 A, V_R = 30 V. In order to cover all circuit conditions, curves are given for typical recovered stored charge versus commutation di/dt for various levels of forward current and for junction temperatures of 25°C, 75°C, 100°C, and 150°C.

To use these curves, it is necessary to know the forward current level just before commutation, the circuit commutation di/dt, and the operating junction temperature. The reverse recovery test current waveform for all Motorola fast recovery rectifiers is shown.



From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas

$$t_{rr} = 1.41 \times \left[\frac{Q_R}{di/dt}\right]^{1/2}$$

$$I_{RM(REC)} = 1.41 \times \left[Q_R \times di/dt\right]^{1/2}$$

FIGURE 23 – TYPICAL REVERSE LEAKAGE

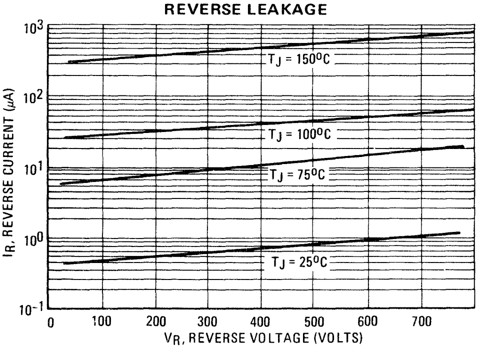
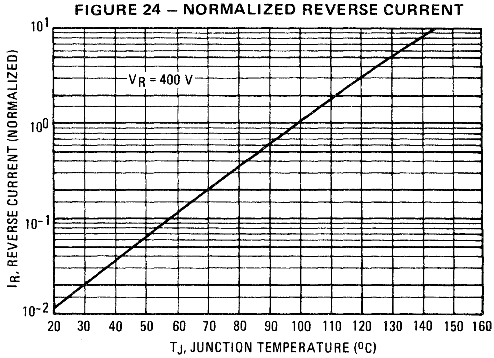


FIGURE 24 – NORMALIZED REVERSE CURRENT



1N4997 thru 1N5003

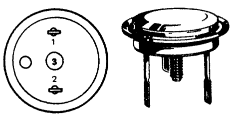
For Specifications, See 1N4719 Data.

2N... JEDEC REGISTERED DEVICE SPECIFICATIONS

2N173 (GERMANIUM)

For Specifications, See 2N277 Data.

2N174 (GERMANIUM)
2N1100
2N1358,A



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5
(TO-36)

PNP germanium power transistors. Power dissipation and junction temperature ratings exceed those of EIA registration.

MAXIMUM RATINGS

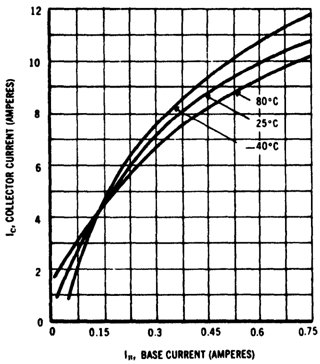
Rating	Symbol	2N174	2N1100	2N1358	Unit
Collector-Base Voltage	V_{CB}	80	100	80	Vdc
Emitter-Base Voltage	V_{EB}	60	80	60	Vdc
Emitter Current (Continuous)	I_E	15	15	15	Amp
Base Current (Continuous)	I_B	4.0	4.0	4.0	Amp
Junction and Storage Temperature	T_J, T_{stg}	-65 to +110			°C
Thermal Resistance, Junction to Case	θ_{JC}	0.5			°C/W

ELECTRICAL CHARACTERISTICS

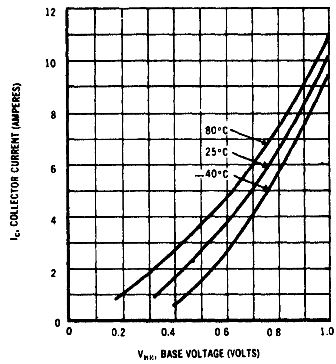
Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				μA
(V_{CB} = 2 volts)	2N174		-	100	-	
	2N1100		-	100	-	
	2N1358		-	100	200	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{EB} = 1.5 volts, V_{CB} = 80 volts)	2N174		-	2.0	8.0	
100	2N1100		-	2.0	8.0	
80	2N1358		-	2.0	8.0	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = 60 volts)	2N174		-	1.0	8.0	
80	2N1100		-	1.0	8.0	
60	2N1358		-	1.0	8.0	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{CB} = 80 volts, 71°C)	2N174		-	-	15	
100	2N1100		-	-	15	
60	2N1358		-	4.0	6.0	
Emitter-Base Cutoff Current (V_{EB} = 30 volts, 71°C)	2N1358	I_{EBO}	-	4.0	6.0	mA
Collector-Emitter Voltage		BV_{CES}*				Vdc
(I_C = 300 mA, V_{EB} = 0)	2N174		70	-	-	
	2N1100		80	-	-	
	2N1358		70	-	-	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
(I_C = 1.0 amp, I_B = 0)	2N174		55	-	-	
1.0 amp, I_B = 0	2N1100		65	-	-	
300 mA, I_B = 0	2N1358		40	-	-	
Floating Potential		V_{EBF}				volt
(I_E = 0, V_{CB} = 80 volts)	2N174		-	-	1.0	
100	2N1100		-	-	1.0	
80	2N1358		-	0.15	1.0	
Current Gain		h_{FE}				-
(I_C = 1.2 amp, V_{CB} = 2 volts)	2N1358		40	55	80	
(I_C = 5 amp, V_{CB} = 2 volts)	2N174		25	-	50	
	2N1100		25	-	50	
	2N1358		25	35	-	
(I_C = 12 amp, V_{CB} = 2 volts)	2N174		-	20	-	
	2N1100		-	20	-	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 1.2 amp, V_{CB} = 2 volts)	2N1358		-	0.35	0.5	
(I_C = 5 amp, V_{CB} = 2 volts)	2N174		-	0.65	0.9	
	2N1100		-	0.65	0.9	
	2N1358		-	0.65	0.9	
Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 12 amp, I_B = 2 amp)	2N174		-	0.3	0.9	
	2N1100		-	0.3	0.7	
	2N1358		-	0.3	0.7	
Common-Emitter Cutoff Frequency		$f_{\alpha e}$				kHz
(I_C = 5 amp, V_{CE} = 6 volts)	2N174		-	10	-	
	2N1100					
Common-Base Cutoff Frequency (I_E = 1 amp, V_{CB} = 12 volts)	2N1358	$f_{\alpha b}$	100	-	-	kHz
Rise Time ("on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = 12 volts)		t_r	-	15	-	μs
Fall Time ("off" I_C = 0, V_{EB} = -6 volts, R_{EB} = 10 ohms)		t_f	-	15	-	μs

* In order to avoid excessive heating of the collector junction, perform test by the sweep method.

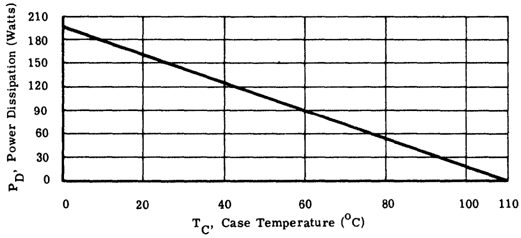
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



POWER-TEMPERATURE DERATING CURVE

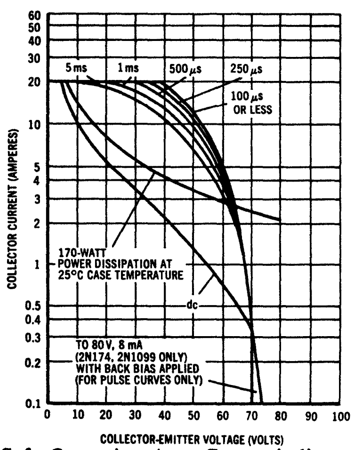


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

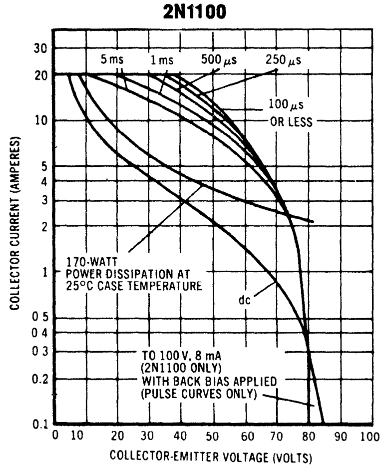
This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

2N174 AND 1358

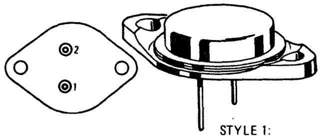


2N1100



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N176 (GERMANIUM)
2N669



CASE 11

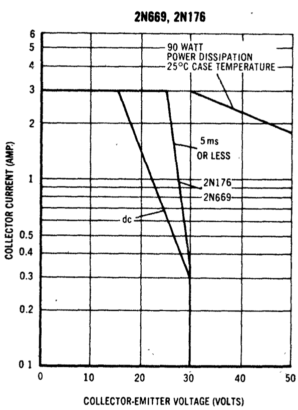
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

Collector connected to case

PNP germanium power transistors for economical power switching circuits and commercial grade power amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector Current (Continuous)	I_C	3.0	Amp
Storage and Junction Temperature	T_J, T_{stg}	−65 to +100	°C
Total Device Dissipation (At 25°C Case Temperature)	P_D	90	Watts
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W



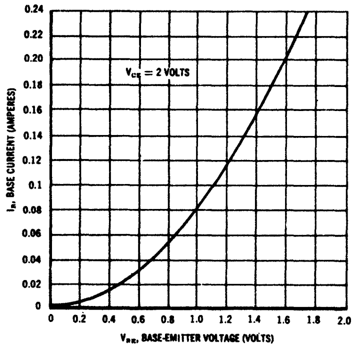
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

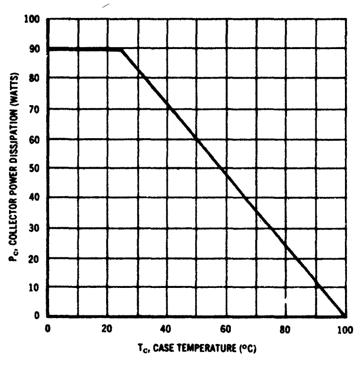
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				
V_{CB} = 30 V, I_E = 0			—	—	3.0	mA
V_{CB} = 2.0 V, I_E = 0			—	50	—	μA
V_{CB} = 30 V, I_E = 0, T_C = 90°C			—	—	20	mA
Emitter-Base Cutoff Current V_{EB} = 10 V, I_C = 0		I_{EBO}	—	—	2.0	mA
Collector-Emitter Breakdown Voltage I_C = 330 mA, R_{BE} = 10 Ohms	2N176	BV_{CER}	30	—	—	Vdc
	2N669	BV_{CES}	30	—	—	
Collector-Emitter Saturation Voltage I_C = 3 A, I_B = 300 mA		$V_{CE(SAT)}$	—	—	0.4	Vdc
DC Forward Current Transfer Ratio V_{CE} = 2.0 V, I_C = 0.5 A	2N176	h_{FE}	25	—	—	—
	2N669		75	—	250	
Power Gain P_{out} = 2 Watts, V_{CE} = 12 V, I_C = 0.5 Amp, f = 1 kHz, R_S = 10 Ohms, R_L = 26.6 Ohms	2N176	G_{PE}	34	—	37	dB
	2N669		38	—	—	
Total Harmonic Distortion (under same conditions of power gain)			—	—	5.0	%
Small-Signal Current Gain Cutoff Frequency V_{CE} = 12 V, I_C = 0.5 Amp, f = 1 kHz ref	2N176	$f_{\alpha e}$	4.0	7.0	—	kHz
	2N669		3.0	5.0	—	
Small-Signal Forward-Current Transfer Ratio V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kHz	2N176	h_{fe}	—	45	—	—
	2N669		—	90	—	
Small-Signal Input Impedance V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kHz	2N176	h_{ie}	7.0	—	25	Ohms
	2N669		10	—	50	

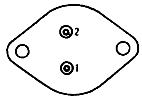
INPUT CURRENT versus EMITTER DRIVE VOLTAGE
(Both Types)



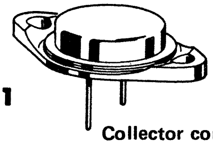
POWER-TEMPERATURE DERATING CURVE
(Both Types)



2N178 (GERMANIUM)
2N554
2N555



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR



CASE 11

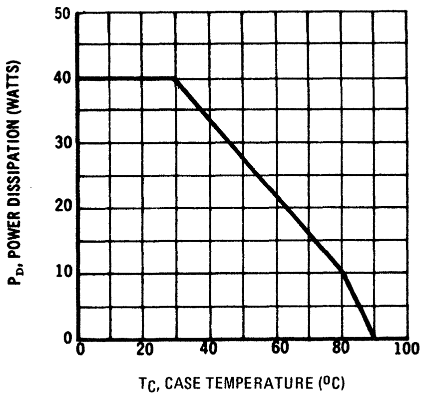
Collector connected to case

PNP germanium power transistor for non-critical power amplifier and power switching applications requiring economical components.

MAXIMUM RATINGS

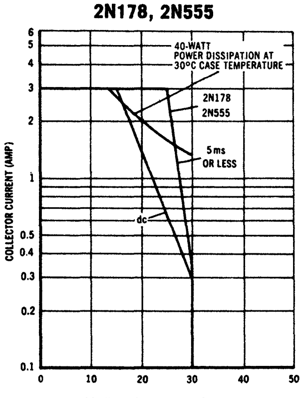
Rating	Symbol	2N178	2N554	2N555	Unit
Collector-Emitter Voltage	V_{CER}	30	16	30	Vdc
Collector-Base Voltage	V_{CB}	30	15	30	Vdc
Emitter-Base Voltage	V_{EB}	20	15	15	Vdc
Collector Current	I_C	3.0			Adc
Total Device Dissipation @ T_C = 80°C	P_D	10			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-40 to +90			°C

POWER-TEMPERATURE DERATING CURVE

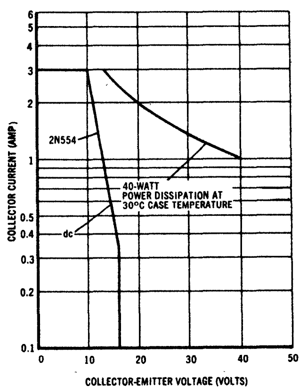


SAFE OPERATING AREAS

2N178, 2N555



2N554



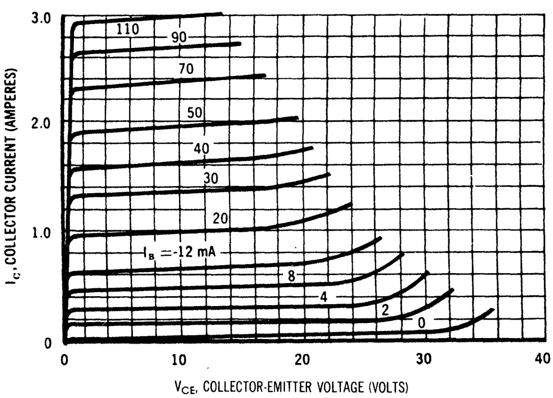
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N178, 2N554, 2N555 (continued)

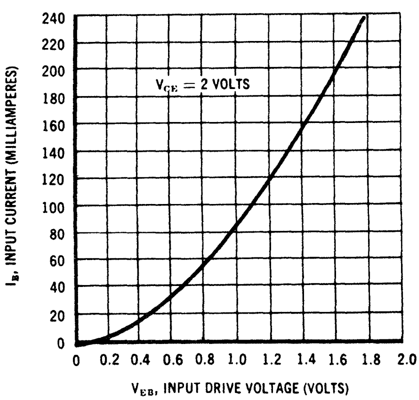
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 330 mAdc, R_{BE} = 10Ω)	2N178	BV_{CER}	30	-	-	Vdc
	2N554		16	-	-	
	2N555		30	-	-	
Collector-Base Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	2N178	I_{CBO}	-	0.05	-	mA
(V_{VB} = 30 Vdc, I_E = 0)	2N178		-	-	3.0	
(V_{CB} = 15 Vdc, I_E = 0)	2N554		-	-	10.0	
(V_{CB} = 30 Vdc, I_E = 0)	2N555		-	-	20.0	
(V_{CB} = 30 Vdc, I_E = 0, T_C = 90°C)	2N178		-	-	20.0	
Emitter-Base Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	2N178	I_{EBO}	-	-	2.0	mA
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)	2N178	h_{FE}	15	-	45	-
	2N554		-	50	-	
	2N555		-	50		
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)		$V_{CE(sat)}$	-	0.6	-	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 1.0 kHz ref)	2N178	$f_{\alpha e}$	5.0	-	-	kHz
	2N554		-	6.0	-	
	2N555		-	6.0	-	
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc, f = 1.0 kHz ref)	2N178	h_{fe}	-	30	-	-
	2N554		-	55	-	
	2N555		-	55	-	
Input Impedance (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc, f = 1.0 kHz)	2N178	h_{ie}	8.0	25	-	Ohms
	2N554		-	25	-	
	2N555		-	25	-	
FUNCTIONAL TESTS						
Power Gain (V_{CE} = 12 Vdc, I_C = 0.5 Adc, P_{out} = 2.0 Watts, f = 1.0 kHz, R_S = 10 Ohms, R_L = 26.6 Ohms)	2N178	G_{PE}	28	-	33	dB
	2N554		20	35	-	
	2N555		25	35	-	
Total Harmonic Distortion (Under same conditions as power gain)	2N178		-	-	5.0	%

COLLECTOR CHARACTERISTICS

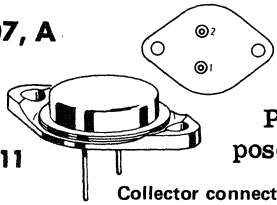


INPUT CURRENT versus INPUT DRIVE VOLTAGE



2N242 (GERMANIUM)

2N307, A



STYLE 1
PIN 1 BASE
2. EMITTER
CASE-COLLECTOR

CASE 11

Collector connected to case

PNP germanium power transistors for general purpose power amplifier and switching applications.

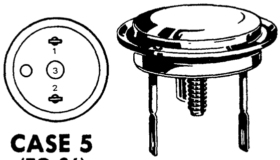
MAXIMUM RATINGS

Rating	Symbol	2N242	2N307, 307A	Unit
Collector-Base Voltage	V_{CB}	45	35	Volts
Collector-Emitter Voltage (R_{BE} = 30 Ω)	V_{CER}	45	—	Volts
Collector-Emitter Voltage	V_{CEO}	—	35	Volts
Emitter-Base Voltage	V_{EB}	—	10	Volts
Collector Current	I_C	5.0	5.0	Amp
Junction Temperature Range	T_J	-65 to + 110	-65 to +110	°C
Collector Dissipation (at T_C = 25°C)	P_D	106	106	Watts

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 2 Vdc) (V_{CB} = 25 Vdc) (V_{CB} = 1 Vdc, I_E = 0, T_C = 85°C)	 2N307 2N307 2N307A 2N242	I_{CBO}	 — — — —	 0.5 5.0 2.0 5.0	mAdc
Emitter-Base Cutoff Current (V_{EB} = 10 Vdc)		I_{EBO}	 —	 2.0	mAdc
Collector-Emitter Cutoff Current (V_{CE} = 45 Vdc, R_{BE} = 30 Ω) (V_{CE} = 25 Vdc, R_{BE} = 30 Ω) (V_{CE} = 35 Vdc, R_{BE} = 30 Ω)	 2N242 2N242 2N307 2N307A	I_{CER}	 — — — —	 5.0 1.0 15 7.0	mAdc
Base-Emitter Voltage (V_{CE} = 1.5 Vdc, I_C = 1.0 Adc)	 2N242	V_{BE}	 0.3	 0.8	Vdc
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc) (I_C = 0.2 Adc, I_B = 20 mAdc) (I_C = 1.0 Adc, I_B = 100 mAdc)	 2N242 2N307 2N307A	$V_{CE(sat)}$	 — — —	 0.8 1.0 0.8	Vdc
DC Current Gain (V_{CE} = 12 Vdc, I_C = 500 mAdc) (V_{CE} = 1 Vdc, I_C = 200 mAdc)	 2N242 2N307 2N307A	h_{FE}	 30 20 30	 120 — —	—
Common Emitter Cutoff Frequency (V_{CE} = 12 V, I_C = 0.5 A) (V_{CE} = 6 V, I_C = 1 A)	 2N242 2N307A 2N307	$f_{\alpha e}$	 5.0 3.5 3.0	 — — —	kHz
Power Gain (I_C = 0.5 A, V_{CE} = -14 V, R_L = 30 Ω, R_g = 10 Ω)	 2N242	G_e	 30		dB

2N277 (GERMANIUM)
2N278
2N173
2N1099



CASE 5
(TO-36)

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Collector connected to case

PNP germanium power transistors for general purpose power amplifier and switching applications. Power and temperature ratings exceed EIA registration.

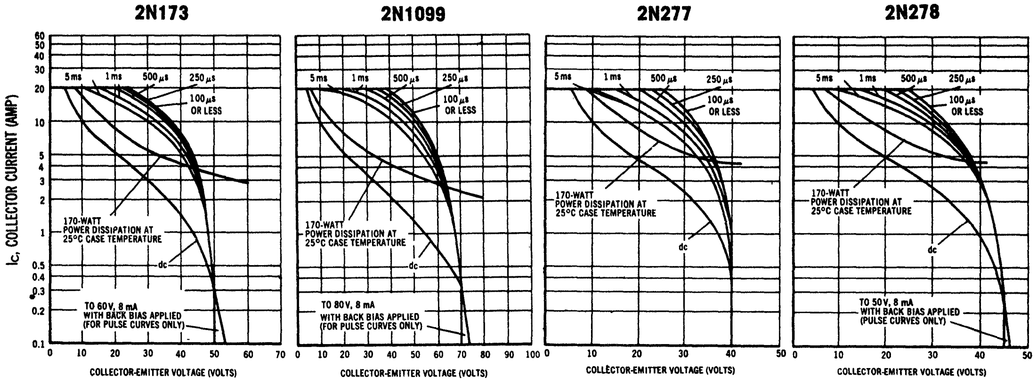
MAXIMUM RATINGS

Rating	Symbol	2N277	2N278	2N173	2N1099	Unit
Collector-Base Voltage	V_{CB}	40	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	40	Vdc
Emitter Current-Continuous	I_E	15				Adc
Base Current	I_B	4.0				Adc
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	170 2.0				Watts W/$^{\circ}$C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				$^{\circ}$C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^{\circ}$C/W

SAFE OPERATING AREAS



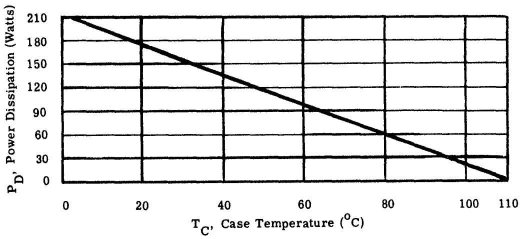
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current V_{CBO} = 2 V		I_{CBO}	—	100	—	μA
Collector-Base Cutoff Current		I_{CBX}				mA
V_{EB} = 1.5 V, V_{CB} = 40 V	2N277		—	2.0	8.0	
50	2N278		—	2.0	8.0	
60	2N173		—	2.0	8.0	
80	2N1099		—	2.0	8.0	
Emitter-Base Cutoff Current		I_{EBO}				mA
V_{EBO} = 20 V	2N277		—	1.0	8.0	
30	2N278		—	1.0	8.0	
40	2N173		—	1.0	8.0	
40	2N1099		—	1.0	8.0	
Collector-Base Cutoff Current		I_{CBO}				mA
V_{CBO} = 40 V, 71°C	2N277		—	—	15	
50	2N278		—	—	15	
60	2N173		—	—	15	
80	2N1099		—	—	15	
Collector-Emitter Voltage		BV_{CES}*				Vdc
I_C = 300 mA, V_{EB} = 0	2N277		40	—	—	
	2N278		45	—	—	
	2N173		50	—	—	
	2N1099		70	—	—	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
I_C = 1 Amp, I_B = 0	2N277		25	—	—	
	2N278		30	—	—	
	2N173		45	—	—	
	2N1099		55	—	—	
Floating Potential		V_{fl}				volt
I_E = 0, V_{CB} = 40 V	2N277		—	0.15	1.0	
50	2N278		—	0.15	1.0	
60	2N173		—	0.15	1.0	
80	2N1099		—	0.15	1.0	
Current Gain		h_{FE}				—
I_C = 5 Amp, V_{CB} = 2 V			35	—	70	
I_C = 12 Amp, V_{CB} = 2 V			—	25	—	
Base-Emitter Voltage		V_{BE}				Vdc
I_C = 5 Amp, V_{CB} = 2 V	2N277		—	0.65	—	
	2N278		—	0.65	—	
	2N173		—	0.65	—	
	2N1099		—	0.65	0.9	
Saturation Voltage		$V_{CE(SAT)}$				Vdc
I_C = 12 Amp, I_B = 2 Amp	2N277		—	0.3	—	
	2N278		—	0.3	1.0	
	2N173		—	0.3	1.0	
	2N1099		—	0.3	0.7	
Common-Emitter Current Amplification Cutoff Frequency I_C = 5 Amp, V_{CE} = 6 V		$f_{\alpha e}$	0.3	10	—	kHz
Rise Time "on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = 12 V		t_r	—	15	—	μs
Fall Time "off" I_C = 0, V_{EB} = 6 V, R_{EB} = 10 Ohms		t_f	—	15	—	μs

* To avoid excessive heating of the collector junction, perform these tests with the sweep method.

POWER-TEMPERATURE DERATING CURVE

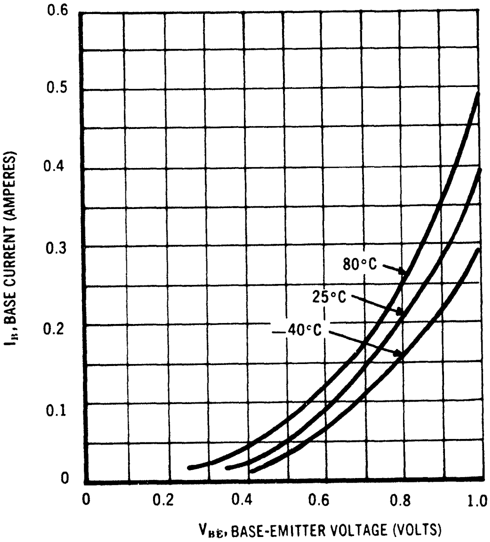


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

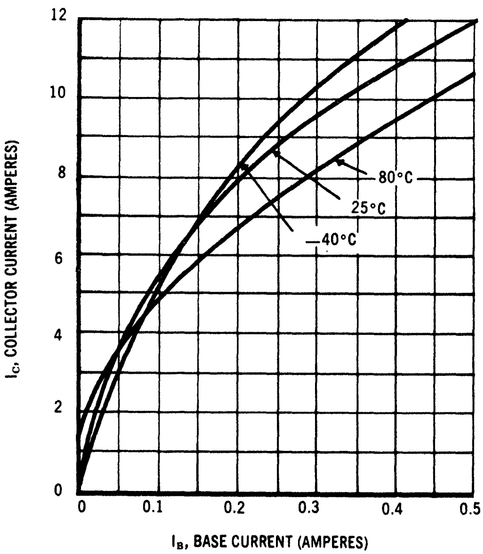
This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

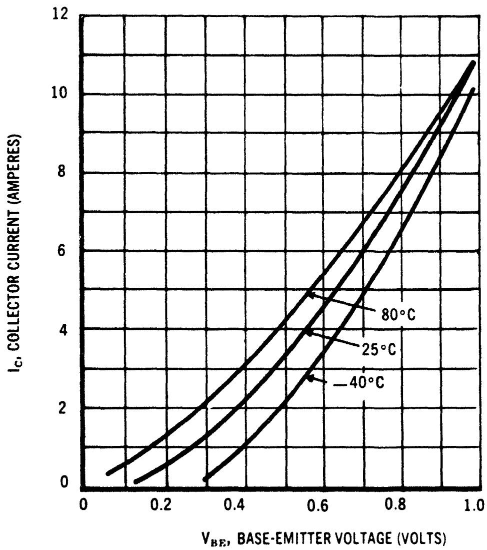
INPUT CHARACTERISTICS



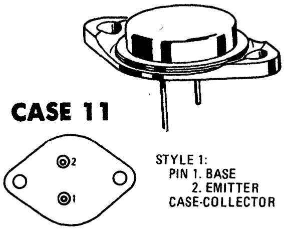
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



2N297A (GERMANIUM)

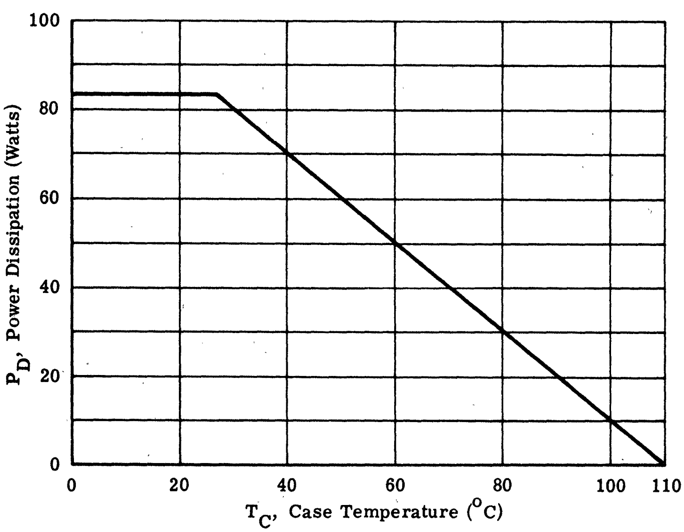


PNP germanium power transistor for military and industrial power switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	5.0	Amp
Operating Temperature Range	T_J	−65 to +110	°C
Collector Dissipation at 25°C Case Temperature (θ_{JC} = 1°C/W max)	P_D	85	Watts

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

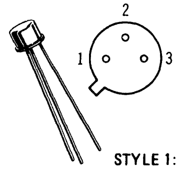
Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 0.5 Adc	h_{FE}	40	100	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 2.0 Adc	h_{FE}	20	—	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 14 Vdc I_C = 0.5 Amp	$f_{\alpha e}$	5.0	—	kHz
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 60 Vdc I_E = 0	I_{CBO}	—	3.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 0.5 Adc	I_B	5.0	12.5	mAdc
Base Current V_{CE} = 2 Vdc I_C = 2 Adc	I_B	—	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 2 Adc	V_{EB}	—	1.5	Vdc
Floating Potential V_{CB} = 60 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}		0.18	Vdc
Collector-Emitter Saturation Voltage I_C = 2 Adc I_B = 200 mAdc	$V_{CE(SAT)}$		1.0	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	50	—	Vdc
High-Temperature Operation T_C = +71°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	6.0	mAdc

2N307 (GERMANIUM)
2N307 A

For Specifications, See 2N242 Data.

2N319 thru 2N321 (Germanium)

CASE 31
(TO-5)



Base connected to case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistors for audio amplifier and low-frequency switching applications.

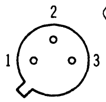
MAXIMUM RATINGS

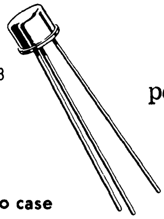
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -25 Vdc, I_E = 0	I_{CBO}	-	16	µAdc
Emitter Cutoff Current V_{EB} = -3.0Vdc, I_C = 0	I_{EBO}	-	10	µAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	20	-	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc 2N319 2N320 2N321	h_{FE}	 25 34 53	 42 65 121	-
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc 2N319 2N320 2N321	h_{FE}	 23 30 47	 - - -	-
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	-	35	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc 2N319 2N320 2N321	$f_{\alpha b}$	 1.0 1.5 2.0	 - - -	MHz

2N322 thru 2N324 (GERMANIUM)
2N508





CASE 31
(TO-5)
Base connected to case

PNP germanium transistors for audio driver and low power output service in entertainment equipment.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

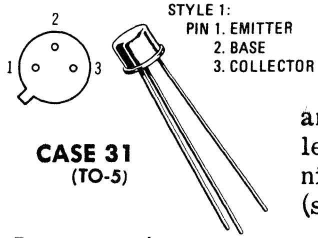
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J, T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -16 Vdc, I_E = 0	I_{CBO}	—	16	μAdc
Emitter Cutoff Current V_{EB} = -3 Vdc, I_C = 0	I_{EBO}	—	16	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 5 K	BV_{CER}	18	—	Vdc
DC Current Gain V_{CE} = -1 Vdc, I_C = 20 mAdc 2N322 2N323 2N324 2N508	h_{FE}	 34 53 72 99	 65 121 198 198	—
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	—	35	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc 2N322 2N323 2N324 2N508	$f_{\alpha b}$	 1.0 1.5 2.0 2.5	 — — — —	MHz

2N331 (Germanium)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistor for audio range amplifier and switching service in military equipment. Have collector dissipation and storage temperature ratings significantly higher than those of the military specification (see maximum ratings table below).

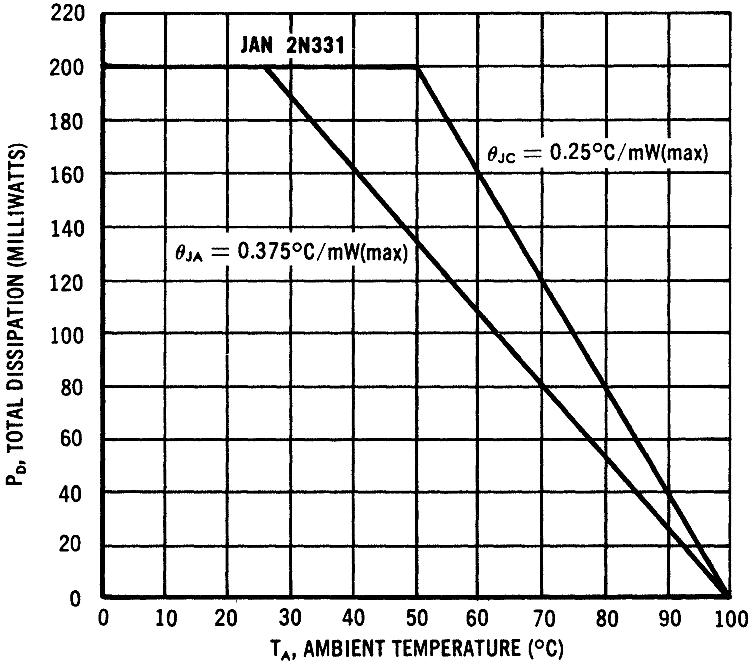
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Emitter-Base Voltage	V_{EB}	12	Volts
Storage Temperature	T_{stg}	-65 to + 85	°C
Storage Temperature	T_{stg}	-65 to + 100	°C
Collector Dissipation at T_A = 25°C (MIL-S-19500/4C (Derate 1.25 mW/°C above 25°C)	P_D	75	mW
Collector Dissipation at T_A = 25°C (JAN 2N331) (Derate 2.67 mW/°C above 25°C)	P_D	200	mW

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

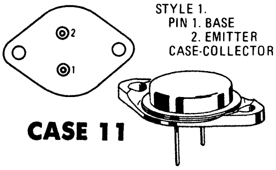
Characteristics	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{EB} = -12 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
Collector Cutoff Current (V_{CB} = -30 Vdc, I_E = 0)	I_{CBO}	—	10	μAdc
Small-Signal Open-Circuit Output Admittance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	h_{ob}	—	1.0	μmho
Small-Signal Short-Circuit Input Impedance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	h_{ib}	—	50	Ohms
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = -6 Vdc, I_C = 1.0 mAdc, f = 1 kHz)	h_{fe}	30	70	—
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency (V_{CB} = -6 Vdc, I_E = 1 mAdc)	$f_{\alpha b}$	0.4	—	MHz
Output Capacitance (V_{CB} = -6 Vdc, I_E = 1 mAdc)	C_{ob}	—	50	pF
Noise Figure (V_{CB} = -6 Vdc, I_E = 1 mAdc, R_S = 1000, ohms, f = 1 kHz , f=Δ1 Hz)	NF	—	20	dB

POWER-TEMPERATURE DERATING CURVE



2N350A (GERMANIUM)
2N351A

2N376A



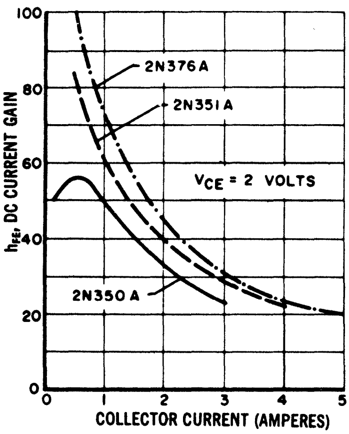
CASE 11

PNP germanium power transistors for economical power switching applications and for power amplifiers requiring up to 4 watts of output power at relatively low distortion.

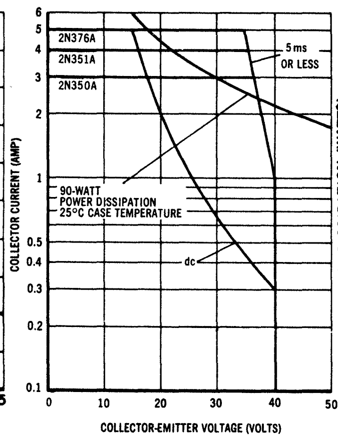
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector Dissipation at 25°C mounting base temperature	P_D	90	Watts
Collector Junction Temperature	T_J	−65 to +100	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W

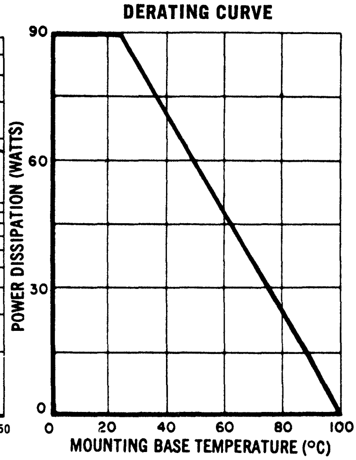
CURRENT GAIN versus COLLECTOR CURRENT (COMMON EMITTER)



SAFE OPERATING AREAS



POWER TEMPERATURE DERATING CURVE



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

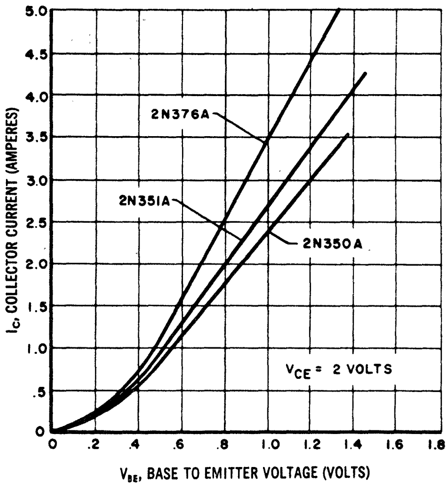
ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

GENERAL	Symbol	Minimum	Typical	Maximum	Unit
Collector Cutoff Current	I_{CBO}				
V_{CB} = 30 V		—	—	3.0	mA
V_{CB} = 2 V		—	50	—	μA
V_{CB} = 30 V, T = 100°C		—	—	30	mA
Emitter Cutoff Current V_{EB} = 10 V	I_{EBO}	—	—	2.0	mA
Collector Breakdown Voltage I_C = 1 A (R_{BE} = 10 Ω) I_C = 330 mA, R_{BE} = 0 (This test should be made under dynamic conditions only)	BV_{CES}	40	—	—	Vdc

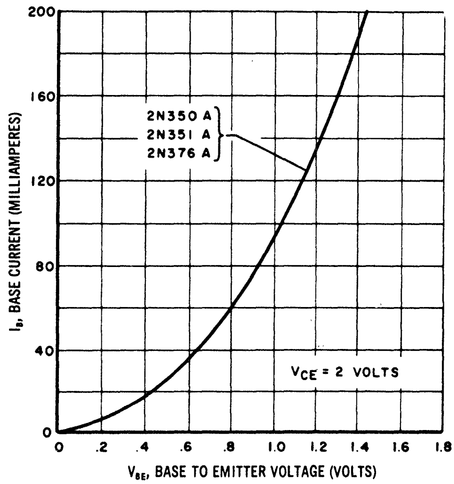
ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

COMMON EMITTER		2N350A			2N351A			2N376A			Unit
	Sym	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Gain (± 0.5 db) P_{out} = 4 Watts, V_{CE} = 12 V, I_C = 0.7 A, f = 1 kHz	G_{PE}	30	—	33	32	—	35	34	—	37	dB
Total Harmonic Distortion under same conditions as power gain		—	—	7.0	—	—	7.0	—	—	7.0	%
DC Forward Current Gain V_{CE} = 2 V, I_C = 0.7 A	h_{FE}	20	—	60	25	—	90	35	—	120	
Current Gain Frequency Cutoff V_{CE} = 12 V, I_C = 0.7 A, f = 1 kHz ref	$f_{\alpha e}$	5.0	—	—	5.0	—	—	5.0	—	—	kHz
Small-Signal Forward Current Gain f = 1 kHz , V_{CE} = 2 V, I_C = 0.7 A	h_{fe}	—	30	—	—	45	—	—	60	—	
Small-Signal Input Impedance f = 1 kHz , V_{CE} = 2 V, I_C = 0.7 A	h_{ie}	5.0	—	17	6.0	—	20	7.0	—	25	Ohms
Collector Saturation Voltage I_C = 3 A, I_B = 300 mA	$V_{CE(SAT)}$	—	0.8	1.75	—	—	—	—	—	—	Vdc
Base-Emitter Voltage I_C = 3 A, I_B = 300 mA	V_{BE}	—	1.0	2.00	—	—	—	—	—	—	Vdc
Collector Saturation Voltage I_C = 4 A, I_B = 400 mA	$V_{CE(SAT)}$	—	—	—	—	0.8	1.75	—	—	—	Vdc
Base-Emitter Voltage I_C = 4 A, I_B = 400 mA	V_{BE}	—	—	—	—	1.0	2.00	—	—	—	Vdc
Collector Saturation Voltage I_C = 5 A, I_B = 500 mA	$V_{CE(SAT)}$	—	—	—	—	—	—	—	0.8	1.75	Vdc
Base-Emitter Voltage I_C = 5 A, I_B = 500 mA	V_{BE}	—	—	—	—	—	—	—	1.0	2.00	Vdc

OUTPUT CURRENT versus EMITTER-DRIVE VOLTAGE

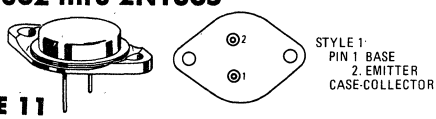


INPUT CURRENT versus EMITTER-DRIVE VOLTAGE



2N375 (GERMANIUM)
2N618
2N1359
2N1360
2N1362 thru 2N1365

PNP germanium power transistors for general purpose switching and amplifier applications.



CASE 11

MAXIMUM RATINGS

Rating	Symbol	2N1359 2N1360	2N375 2N618	2N1362 2N1363	2N1364 2N1365	Unit
Collector-Emitter Voltage	V_{CES}	40	60	75	100	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	60	Vdc
Collector Current-Continuous Peak	I_C	3.0 10				Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	106 1.25				Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				^oC

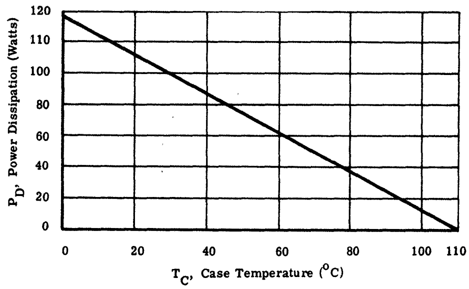
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Types	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current	2N1359, 2N1360	I_{CBO}				mA
(V_{CB} = 40 V, I_E = 0)			--	--	3.0	
(V_{CB} = 50 V, I_E = 0)			--	--	20.0	
(V_{CB} = 60 V, I_E = 0)	2N375, 2N618		--	--	3.0	
(V_{CB} = 80 V, I_E = 0)			--	--	20.0	
(V_{CB} = 75 V, I_E = 0)	2N1362, 2N1363		--	--	3.0	
(V_{CB} = 100 V, I_E = 0)			--	--	20.0	
(V_{CB} = 100 V, I_E = 0)	2N1364, 2N1365		--	--	3.0	
(V_{CB} = 120 V, I_E = 0)			--	--	20.0	
Collector-Base Cutoff Current at Tc = +90°C V_{CB} = 1/2 BV_{CES} rating		I_{CBO}	--	--	20	mA
Emitter-Base Cutoff Current (V_{EB} = 12 V, I_C = 0)		I_{EBO}	--	--	0.5	mA
(V_{EB} = 25 V, I_C = 0)	2N1359, 2N1360		--	--	20	
(V_{EB} = 50 V, I_C = 0)	2N1362, 2N1363		--	--	20	
(V_{EB} = 60 V, I_C = 0)	2N1364, 2N1365		--	--	20	
Collector-Emitter Breakdown Voltage						Vdc
I_C = 500 mA, V_{EB} = 0)	2N1359, 2N1360	BV_{CES}	40	--	--	
	2N375, 2N618		60	--	--	
	2N1362, 2N1363		75	--	--	
	2N1364, 2N1365		100	--	--	
DC Current Transfer Ratio		h_{FE}				--
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		35	55	90	
	2N1360, 618, 1363, 65		60	90	140	
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		15	22	--	
	2N1360, 618, 1363, 65		20	35	--	
Transconductance						mhos
(V_{CE} = 4 V, I_C = 1.0A)	2N375	g_{FE}	0.8	1.25	2.2	
	2N618		1.0	1.6	2.5	
	2N1359, 2N1362, 2N1364		0.8	1.25	--	
	2N1360, 2N1363, 2N1365		1.0	1.6	--	
Frequency Cutoff		$f_{\alpha e}$				kHz
(V_{CE} = 4 V, I_C = 1 A)	2N375		5.0	8.5	--	
(V_{CE} = 4 V, I_C = 1 A)	2N618		5.0	8.5	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1359, 2N1362, 2N1364		7.0	10	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1360, 2N1363, 2N1365		5.0	8.5	--	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 2.0 A, I_B = 200mA)	2N1359, 375, 1362, 64		--	0.4	1.0	
	2N1360, 618, 1363, 65		--	0.3	0.8	
Base-Emitter Drive Voltage		V_{BE}				Vdc
(I_C = 2.0A, I_B = 200 mA)	2N1359, 375, 1362, 64		--	0.7	--	
	2N1360, 618, 1363, 65		--	0.6	--	
Collector-Emitter Punch-Through Voltage		V_{EBF}				Vdc
(V_{CB} = 50 V, I_C = 0)	2N1359, 2N1360		--	--	1.25	
(V_{CB} = 100 V, I_C = 0)	2N1362, 2N1363		--	--	1.25	
(V_{CB} = 120 V, I_C = 0)	2N1364, 2N1365		--	--	1.25	

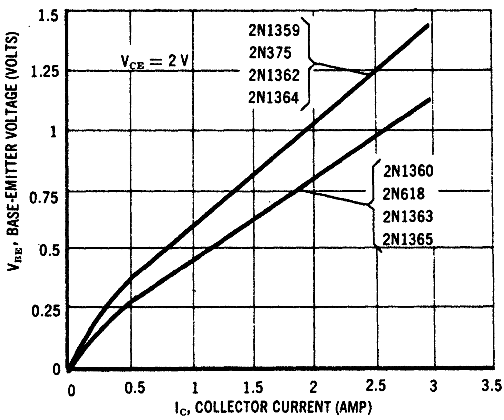
POWER-TEMPERATURE DERATING CURVE



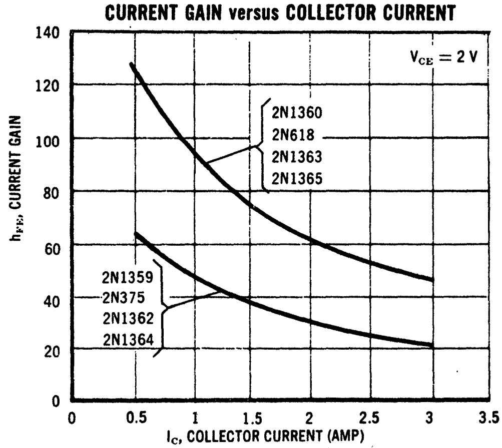
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = Vc \times Ic$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^o - Tc}{0.8}$$

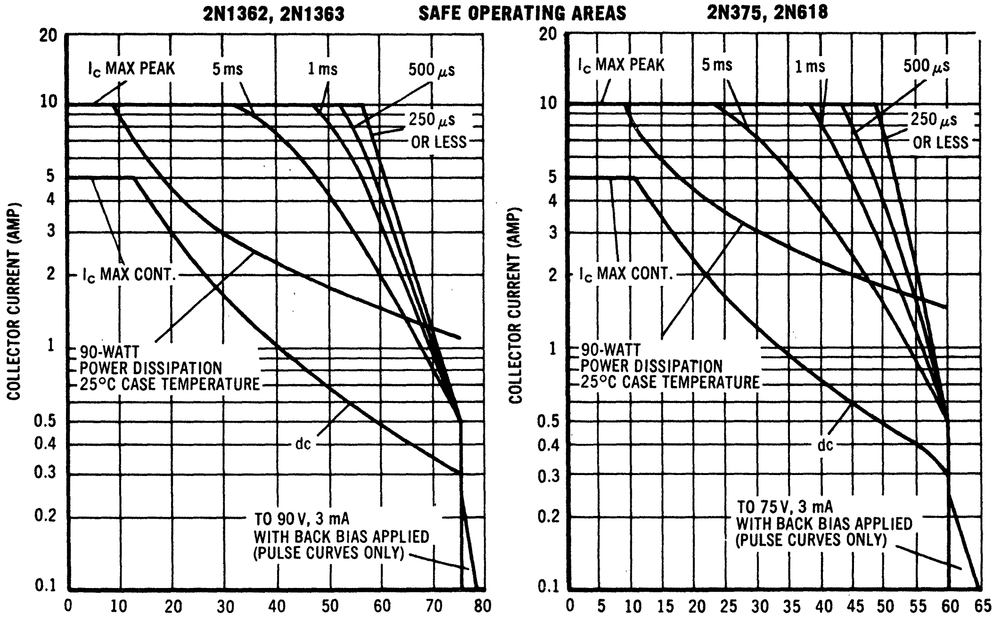
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



CURRENT GAIN versus COLLECTOR CURRENT



2N1362, 2N1363 SAFE OPERATING AREAS 2N375, 2N618



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N376A (GERMANIUM)

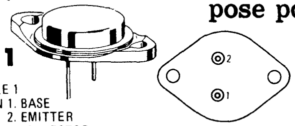
For Specifications, See 2N350A Data.

2N378 thru 2N380 (GERMANIUM)

2N459,A

PNP germanium power transistors for general purpose power amplifier and switching applications.

CASE 11



STYLE 1
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	2N378	2N379	2N380	2N459	2N459A	Unit
Collector-Emitter Voltage	V_{CEO}	20	40	30	60	60	Vdc
Collector-Emitter Voltage	V_{CEX}						Vdc
(V_{BE} = 1.5 V)		40	80	60	-	-	
(V_{BE} = 1.0 V)		-	-	-	105	105	
Collector-Emitter Voltage	V_{CES}	-	-	-	70	70	Vdc
Collector-Base Voltage	V_{CB}	-	-	-	-	105	Vdc
Emitter-Base Voltage	V_{EB}	-	-	-	10	25	Vdc
Collector Current	I_C	5.0					Adc
Operating Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation @ T_C = 25°C	P_D	106					Watts

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

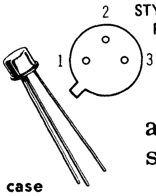
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 100 mAdc)	2N378		20	-	
	2N379		40	-	
	2N380		30	-	
	2N459, 2N459A		60	-	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N378		-	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N380		-	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N379		-	10	
(V_{CE} = 105 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N459		-	10	
(V_{CE} = 105 Vdc, $V_{BE(off)}$ = 1.0 Vdc)	2N459A		-	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 25 Vdc)			-	0.5	
(V_{CB} = 25 Vdc, T_C = 85°C)			-	7.5	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 10 Vdc)	2N380		-	1.5	
	2N459		-	2.0	
(V_{BE} = 25 Vdc)	2N459A		-	2.0	

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N378		40	80	
	2N379, 2N459		20	70	
	2N380		30	70	
	2N459A		40	70	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N459A		20	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 0.2 Adc)	2N378-2N380, 2N459		-	1.0	
	2N459A		-	0.3	
Base-Emitter Voltage		$V_{BE(on)}$			Vdc
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N378		-	1.6	
	2N379, 2N459, 2N459A		-	1.3	
	2N380		-	1.0	
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency		$f_{\alpha e}$			kHz
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	2N378-2N380, 2N459		5.0	-	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N459A		5.0	-	

2N381 thru 2N383 (GERMANIUM)

2N2171



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

Base connected to case

PNP germanium transistors for small-signal audio amplifiers, Class B push-pull output stages and medium-speed switching circuits.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Volts
Collector-Emitter Voltage (R_{BE} = 10K)	V_{CER}	25	Volts
Emitter-Base Voltage	V_{EB}	20	Volts
Collector Current	I_C	400	mA
Junction Temperature	T_J	-65 to +100	°C
Collector Dissipation	P_D		
T_A = 25°C		225	mW
derate		3.0	mW/°C
T_C = 25°C		500	mW
derate		6.7	mW/°C

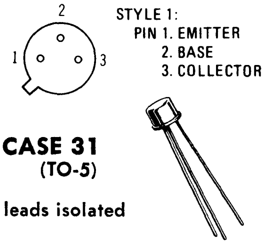
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -25 Vdc)	I_{CBO}	---	6.0	10	μAdc
Emitter-Base cutoff Current (V_{EB} = -20 Vdc)	I_{EBO}	---	5.0	10	μAdc
Collector-Emitter Voltage (I_C = 500 μAdc, R_{BE} = 10K)	BV_{CER}	25	---	---	Vdc
Collector-Emitter Voltage (I_C = 50 μAdc, V_{BE} = 1.0 Vdc) 2N381	BV_{CER}	---	50	---	Vdc
2N382, 2N383, 2N2171		---	45	---	
DC Current Gain (I_C = 20 mAdc, V_{CE} = -1.0 Vdc) 2N381	h_{FE}	35	---	65	---
2N382		60	---	95	
2N383		75	---	120	
2N2171		110	---	250	
(I_C = 100 mAdc, V_{CE} = -1.0 Vdc) 2N381		30	---	---	
2N382		50	---	---	
2N383		65	---	---	
2N2171		90	---	---	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Typical	Max	Unit
Small Signal Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{fe}				- - -
	2N381		35	60	85	
	2N382		70	90	135	
	2N383		90	115	155	
	2N2171		120	210	310	
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)		h_{re}				$X10^{-3}$
	2N381		- - -	0.66	- - -	
	2N382		- - -	0.69	- - -	
	2N383		- - -	0.72	- - -	
	2N2171		- - -	0.75	- - -	
Input Impedance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{ie}				ohms
	2N381		- - -	300	- - -	
	2N382		- - -	450	- - -	
	2N382		- - -	550	- - -	
	2N2171		- - -	850	- - -	
Output Admittance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kHz)		h_{oe}				µmhos
	2N381		- - -	420	- - -	
	2N382		- - -	400	- - -	
	2N383		- - -	380	- - -	
	2N2171		- - -	500	- - -	
Transducer Gain		G_T				dB
(R_g = 300 Ω, R_L = 500 Ω)	2N381		- - -	36	- - -	
(R_g = 450 Ω, R_L = 500 Ω)	2N382		- - -	38	- - -	
(R_g = 550 Ω, R_L = 500 Ω)	2N383		- - -	39.5	- - -	
(R_g = 785 Ω, R_L = 500 Ω)	2N2171		- - -	42.5	- - -	
Output Capacitance (I_C = 1 mA, V_{CB} = -6V)		C_{ob}	- - -	20	- - -	pF
Noise Figure (I_C = 1 mA, V_{CE} = -6V, R_g = 1 kc, f = 1 kHz)		NF				dB
	2N381		- - -	6.0	- - -	
	2N382		- - -	5.5	- - -	
	2N383		- - -	5.0	- - -	
	2N2171		- - -	3.5	- - -	
Cutoff Frequency (I_C = 1 mA, V_{CB} = -6V)		$f_{\alpha b}$				MHz
	2N381		- - -	3.0	- - -	
	2N382		- - -	4.0	- - -	
	2N383		- - -	5.0	- - -	
	2N2171		- - -	7.5	- - -	

2N398, 2N398 A (GERMANIUM)



CASE 31
(TO-5)

All leads isolated

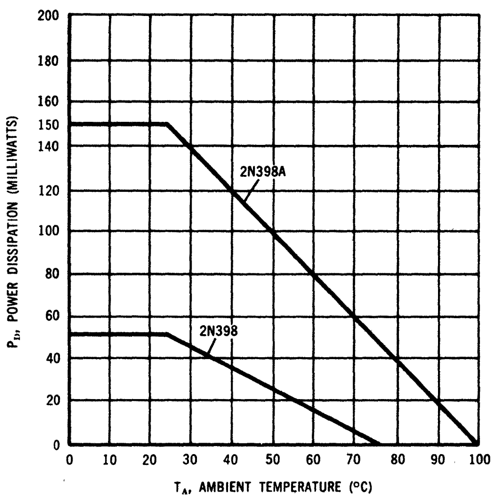
PNP germanium transistor for high-voltage, audio-frequency applications.

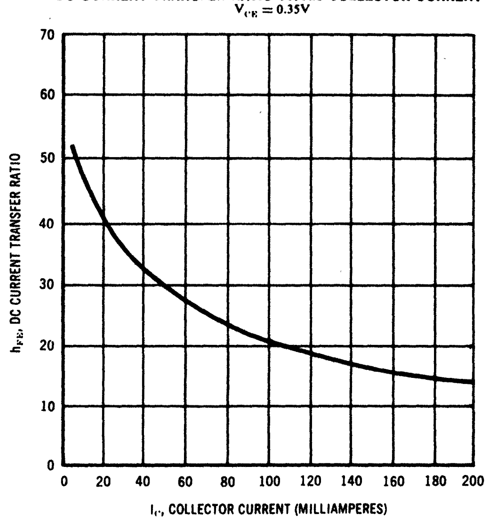
MAXIMUM RATINGS

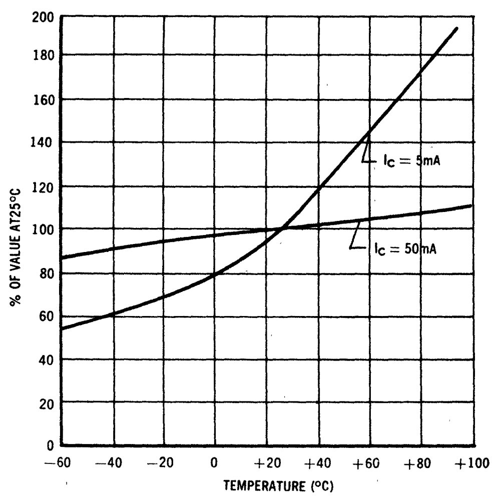
Rating	Symbol	2N398A	2N398	Unit
Collector-Base Voltage	V_{CB}	105	105	Vdc
Collector-Emitter Voltage	V_{CEO}	105	105	Vdc
Emitter-Base Voltage	V_{EB}	50	50	Vdc
DC Collector Current	I_C	200	100	mA
Emitter Current	I_E	200	100	mA
Junction Temperature	T_J	-65 to +100	-65 to +85	°C
Storage Temperature	T_{stg}	-65 to +100	-65 to +85	°C
Collector Dissipation @ 25°C	P_D	150	50	mW
Thermal Resistance, Junction to Ambient	$\theta_{JA\ max}$	0.5	1.2	°C/mW

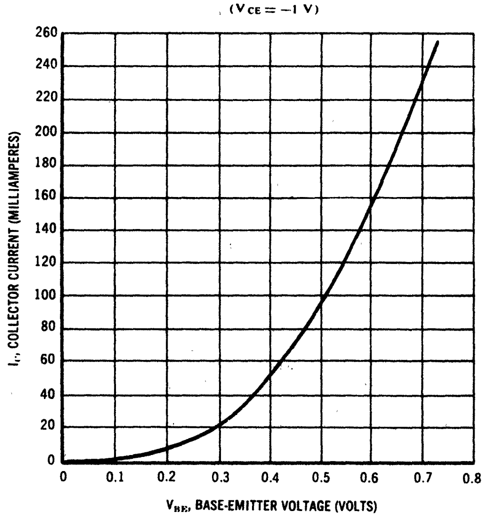
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 105 V, I_B = 0)	I_{CBO}	-	12.0	50	μA
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_B = 0)	I_{CBO}	-	5.0	14	μA
Emitter-Base Cutoff Current (V_{EB} = 50 V, I_C = 0)	I_{EBO}	-	3.0	50	μA
Collector-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{CE\ (SAT)}$	-	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{BE\ (SAT)}$	-	0.22	0.40	Vdc
DC Current Transfor Ratio (I_C = 5 mAdc; V_{CE} = 0.35 Vdc)	h_{FE}	20	65	-	-
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})	V_{PT}	105	160	-	Vdc
Small-Signal Short-Circuit, Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc; I_E = 1 mAdc)	$f_{\alpha b}$	-	1.0	-	MHz


POWER — TEMPERATURE DERATING CURVE
P_D, POWER DISSIPATION (MILLIWATTS)
T_A, AMBIENT TEMPERATURE (°C)
2N398A
2N398
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
150
160
180
200


DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT
$V_{CE} = 0.35V$
h_{FE}, DC CURRENT TRANSFER RATIO
I_C, COLLECTOR CURRENT (MILLIAMPERES)
0
20
40
60
80
100
120
140
160
180
200
0
10
20
30
40
50
60
70

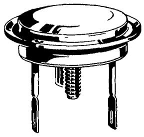

LARGE SIGNAL CURRENT GAIN (H_{FE}) versus TEMPERATURE
(Normalized to 25°C Value; $V_{CE} = 0.35V$)
% OF VALUE AT25°C
TEMPERATURE (°C)
$I_C = 5mA$
$I_C = 50mA$
−60
−40
−20
0
+20
+40
+60
+80
+100
0
20
40
60
80
100
120
140
160
180
200

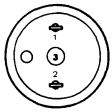

OUTPUT CURRENT versus BASE-DRIVE VOLTAGE
($V_{CE} = -1$ V)
I_C, COLLECTOR CURRENT (MILLIAMPERES)
V_{BE}, BASE-EMITTER VOLTAGE (VOLTS)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100
120
140
160
180
200
220
240
260

2N441 (GERMANIUM)
2N442
2N443

PNP germanium power transistors for power switching and amplifier applications. Power and temperature ratings exceed EIA registration.

CASE 5
(TO-36)





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Collector connected to case

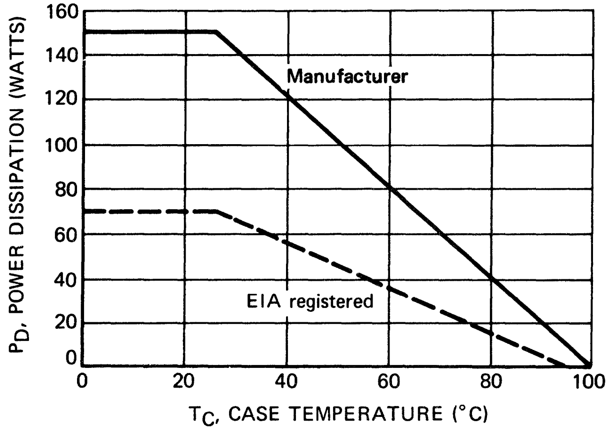
MAXIMUM RATINGS

Rating	Symbol	2N441	2N442	2N443	Unit
Collector-Emitter Voltage	V_{CES}	40	45	50	Vdc
Collector-Base Voltage	V_{CB}	40	50	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	Vdc
Base Current — Continuous	I_B	4.0			Adc
Emitter Current — Continuous	I_E	15			Adc
Total Device Dissipation @ T_C = 25°C	P_D	150			Watts
Operating Junction Temperature Range (EIA Registered)	T_J	-65 to +95			°C
Operating Junction Temperature Range	T_J	-65 to +100			°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case (EIA Registered)	θ_{JC}	1.0	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{100° - T_C}{0.5}.$$

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 Adc, I_B = 0)	2N441	BV_{CEO}*	25	-	-	Vdc
	2N442		30	-	-	
	2N443		45	-	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N441	BV_{CES}*	40	-	-	Vdc
	2N442		45	-	-	
	2N443		50	-	-	
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	2N441	V_{EBF}	-	-	1.0	Vdc
(V_{CB} = 50 Vdc, I_E = 0)	2N442		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N443		-	-	1.0	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.1	-	mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N441		-	2.0	8.0	
(V_{CB} = 50 Vdc, I_E = 0)	2N442		-	2.0	8.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N443		-	2.0	8.0	
(V_{CB} = 40 Vdc, I_E = 0, T_B = 71°C)	2N441		-	-	15	
(V_{CB} = 50 Vdc, I_E = 0, T_B = 71°C)	2N442		-	-	15	
(V_{CB} = 50 Vdc, I_E = 0, T_B = 71°C)	2N443		-	-	15	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	2N441	I_{EBO}	-	1.0	8.0	mAdc
(V_{BE} = 30 Vdc, I_C = 0)	2N442		-	1.0	8.0	
(V_{BE} = 40 Vdc, I_C = 0)	2N443		-	1.0	8.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	-	40	-
(I_C = 12 Adc, V_{CE} = 2.0 Vdc)			-	20	-	
Collector-Emitter Saturation Voltage (I_C = 12 Adc, I_B = 2.0 Adc)	2N441	$V_{CE(sat)}$	-	0.3	-	Vdc
	2N442		-	0.3	-	
	2N443		-	0.3	1.0	
Base-Emitter Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N441	V_{BE}	-	0.65	-	Vdc
	2N442		-	0.65	-	
	2N443		-	0.65	0.9	
DYNAMIC CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	-	10	-	kHz
SWITCHING CHARACTERISTICS						
Rise Time (V_{CE} = 12 Vdc, I_C = 12 Adc, I_B = 2.0 Adc)		t_r	-	15	-	μs
Fall Time (I_C = 0, V_{BE} = 6.0 Vdc, R_{BE} = 10 ohms)		t_f	-	15	-	μs

* Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

TYPICAL COMMON-EMITTER CHARACTERISTICS

FIGURE 2 – OUTPUT CHARACTERISTICS

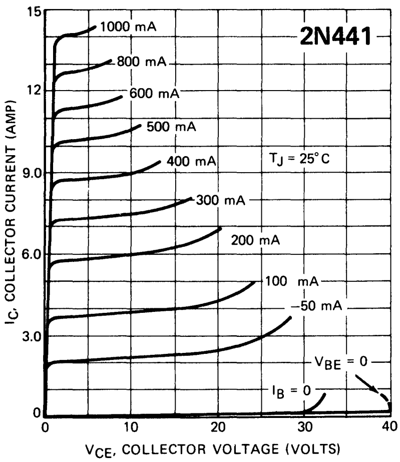


FIGURE 3 – OUTPUT CHARACTERISTICS

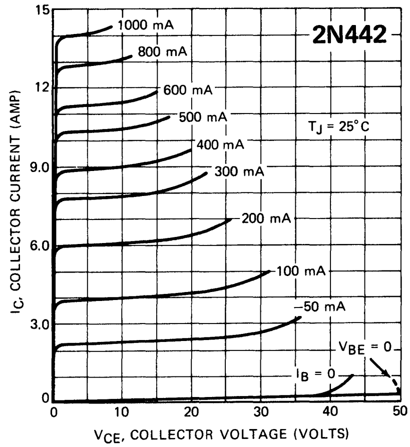


FIGURE 4 – OUTPUT CHARACTERISTICS

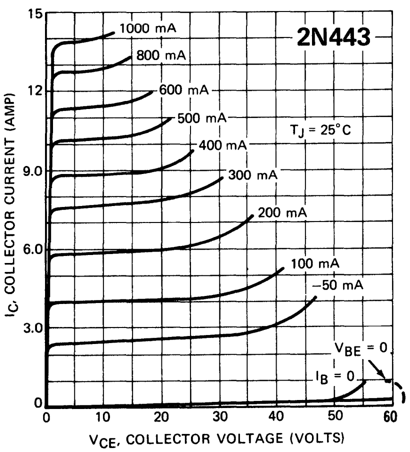


FIGURE 5 – INPUT CHARACTERISTICS

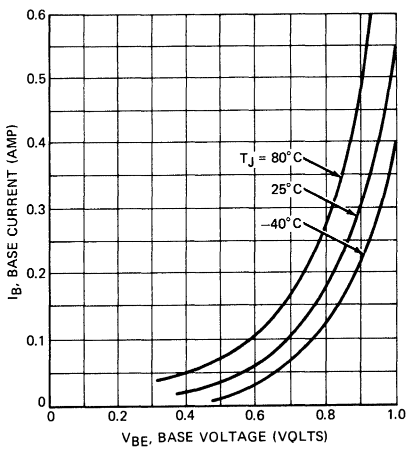


FIGURE 6 – DC CURRENT GAIN TRANSFER CHARACTERISTICS

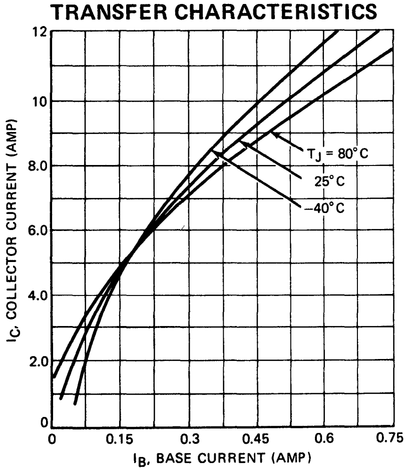
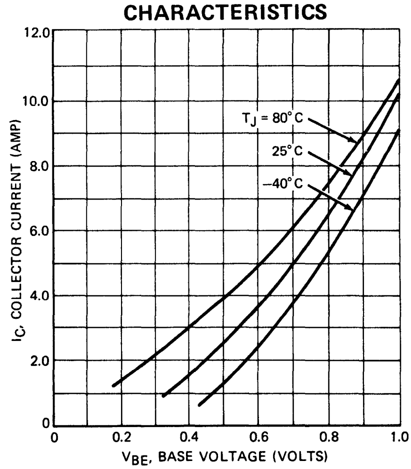


FIGURE 7 – TRANSCONDUCTANCE CHARACTERISTICS



2N456A (GERMANIUM)
2N457A
2N458A

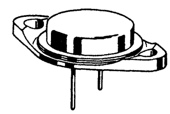
PNP GERMANIUM POWER TRANSISTORS

. . . designed for general-purpose power amplifier and switching applications.

- High DC Current Gain – h_{FE} = 30-90 @ I_C = 5.0 Adc
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 5.0 Adc

7 AMPERE POWER TRANSISTORS PNP GERMANIUM

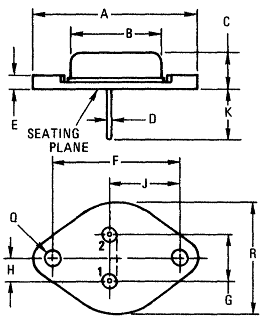
40-60-80 VOLTS
85 WATTS



*MAXIMUM RATINGS

Rating	Symbol	2N456A	2N457A	2N458A	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Collector-Base Voltage	V_{CB}	40	60	80	Volts
Emitter-Base Voltage	V_{EB}	←	20	→	Volts
Collector Current	I_C	←	7.0	→	Adc
Base Current	I_B	←	3.0	→	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	←	85 1.0	→	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←	-65 to +110	→	°C

*Indicates JEDEC Registered Data.

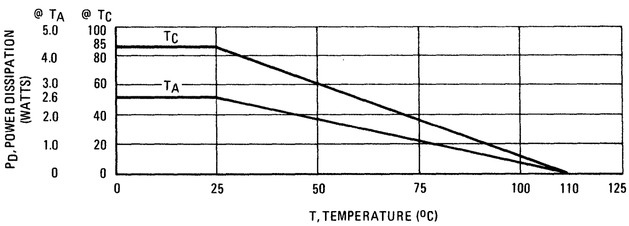


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	--	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

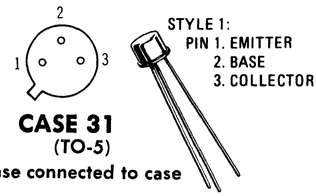
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 200 mAdc, I_B = 0)	2N456A		20	–	
	2N457A		30	–	
	2N458A		40	–	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 20 Vdc, I_E = 0)	2N456A		–	0.5	
(V_{CB} = 30 Vdc, I_E = 0)	2N457A		–	0.5	
(V_{CB} = 40 Vdc, I_E = 0)	2N458A		–	0.5	
(V_{CB} = 40 Vdc, I_E = 0)	2N456A		–	2.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N457A		–	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N458A		–	2.0	
(V_{CB} = 40 Vdc, I_E = 0, T_C = +71°C)	2N456A		–	10	
(V_{CB} = 60 Vdc, I_E = 0, T_C = +71°C)	2N457A		–	10	
(V_{CB} = 80 Vdc, I_E = 0, T_C = +71°C)	2N458A		–	10	
Emitter-Base Cutoff Current (V_{EB} = 20 Vdc, I_C = 0)		I_{EBO}	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)			40	–	
(I_C = 3.0 Adc, V_{CE} = 1.5 Vdc)			35	–	
(I_C = 5.0 Adc, V_{CE} = 1.5 Vdc)			30	90	
(I_C = 7.0 Adc, V_{CE} = 1.5 Vdc)			22	–	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	–	0.5	Vdc
Base-Emitter Voltage (I_C = 5.0 Adc, V_{CE} = 1.5 Vdc)		V_{BE}	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		f_T	200	–	kHz
Input Impedance (I_C = 5.0 Adc, V_{CE} = 1.5 Vdc)		h_{ie}	–	28	Ohms

*Indicates JEDEC Registered Data.

2N459,A (GERMANIUM)

For Specifications, See 2N378 Data.

2N460, 2N461 (GERMANIUM)



CASE 31
(TO-5)
Base connected to case

PNP germanium transistor for general purpose industrial applications.

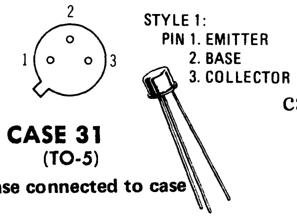
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Volts
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	35	Volts
Emitter-Base Voltage	V_{EB}	10	Volts
Collector Current	I_C	400	mA
Collector Dissipation at 25° C Case Temperature Derate above 25° C at 25° C Ambient Temperature Derate above 25° C	P_D	 500 6.7 225 3.0	 mW mW/° C mW mW/° C
Junction Temperature Range	T_J	-65 to +100	° C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 45 Vdc)		I_{CBO}	---	---	15	μAdc
Emitter-Base Cutoff Current (V_{EB} = -10 Vdc)		I_{EBO}	---	---	10	μAdc
Collector-Emitter Voltage (I_C = 1 mAdc, R_{BE} = 1 K)		BV_{CER}	35	---	---	Vdc
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{fb}	0.94 0.955	0.96 0.968	0.972 0.988	---
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{fe}	17 31	---	36 200	---
Reverse Voltage Ratio (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{rb}	--- ---	2.0 3.0	15 15	$X10^{-4}$
Input Resistance (V_{CB} - -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{ib}	25 25	30 ---	40 40	Ohms
Output Admittance (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N460 2N461	h_{ob}	--- ---	0.8 0.5	1.5 1.5	μmho
Frequency Cutoff (V_{CE} = -5 Vdc, I_E = 1 mAdc)	2N460 2N461	$f_{\alpha b}$	--- ---	1.2 4.0	--- ---	MHz
Output Capacitance (V_{CB} = -10 Vdc, I_E = 1 mAdc, f = 1 MHz)		C_{ob}	---	20	---	pF
Noise Figure (V_{CE} = -4.5 Vdc, I_E = 0.5 mAdc, R_g = 1 K, f = 1 kHz)	2N460 2N461	NF	--- ---	5.0 4.0	--- ---	dB

2N464 thru 2N467 (GERMANIUM)



CASE 31
(TO-5)
Base connected to case

PNP germanium transistor for general purpose applications in the audio-frequency range.

MAXIMUM RATINGS

Rating	Symbol	2N464	2N465	2N466	2N467	Unit
Collector-Base Voltage	V_{CB}	45	45	35	35	Volts
Collector-Emitter Voltage	V_{CER}	40	30	20	15	Volts
Emitter-Base Voltage	V_{EB}	12				Volts
DC Collector Current	I_C	500				mA
Max. Junction & Storage Temperature	T_J and T_{stg}	100				°C
Collector Dissipation, Ambient	P_D	200				mW
Derate above 25°C		2.67				mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375				°C/mW

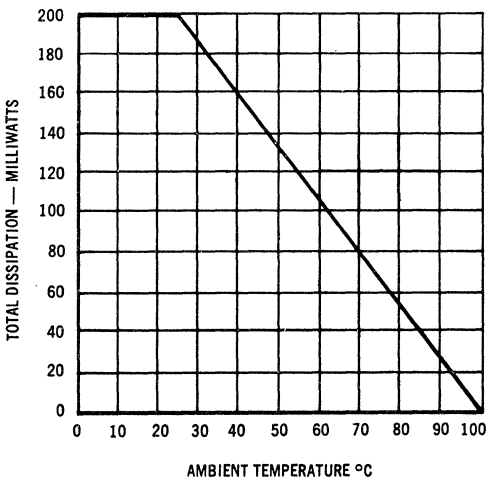
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10 K ohms)	2N464	BV_{CER}	40	–	–	Vdc
	2N465		30	–	–	
	2N466		20	–	–	
	2N467		15	–	–	
Collector-Base Cutoff Current (V_{CB} = 20 Vdc)		I_{CBO}	–	6.0	15	μAdc
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N464	$f_{\alpha b}$	–	0.7	–	MHz
	2N465		–	0.8	–	
	2N466		–	1.0	–	
	2N467		–	1.2	–	
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	2N464	h_{fe}	14	26	–	–
	2N465		27	45	–	
	2N466		56	90	–	
	2N467		112	180	–	

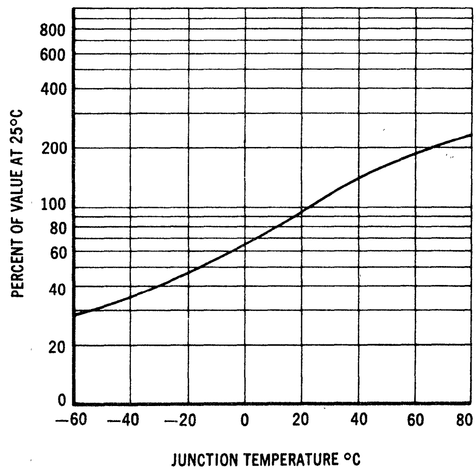
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Input Impedance (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz)	2N464	h_{ie}	–	900	–	Ohms
	2N465		–	1400	–	
	2N466		–	3000	–	
	2N467		–	5500	–	
Small Signal Power Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kHz, matched)	2N464	G_e	–	40	–	dB
	2N465		–	42	–	
	2N466		–	44	–	
	2N467		–	45	–	
Noise Figure (V_{CE} = 2.5 Vdc, I_E = 0.5 mAdc, f = 1 kHz, R_S = 10 Kohms, Δf = 1 Hz		NF	–	–	22	dB

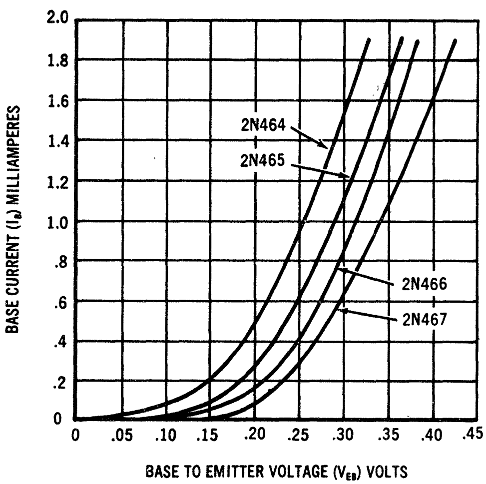
POWER-TEMPERATURE DERATING CURVE



SMALL SIGNAL CURRENT GAIN versus TEMPERATURE

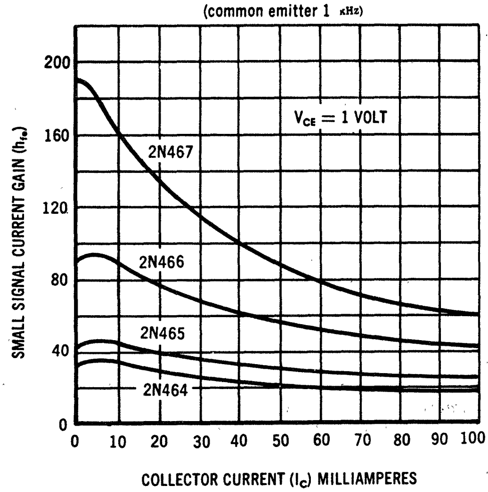


Input Current versus Emitter-Drive Voltage



Small Signal Current Gain versus Collector Current

(common emitter 1 kHz)



2N499 (Ge Mesa)
(2N499 JAN AVAILABLE)
2N499A
(2N499A JAN AVAILABLE)
2N502A JAN AVAILABLE
2N502B JAN AVAILABLE

PNP GERMANIUM AMPLIFIER TRANSISTORS

PNP GERMANIUM HIGH-FREQUENCY TRANSISTORS

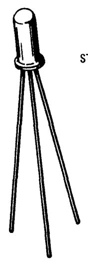
. . . designed for driver applications, small-signal amplification, wide band video amplifiers, and VHF/UHF oscillators.

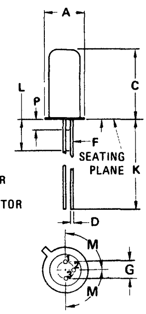
***MAXIMUM RATINGS**

Rating	Symbol	2N499 2N499JAN 2N499A 2N499AJAN	2N502AJAN 2N502BJAN	Unit
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current — Continuous	I_C	50		mAdc
Total Power Dissipation @ $T_A = 25°C$	P_D	60	75	mW
Operating Junction Temperature Range	T_J	100		°C

*Indicates JEDEC Registered Data.

2N499, 2N499A
2N499JAN, 2N499AJAN



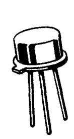


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

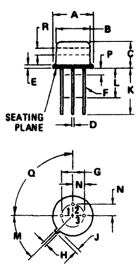
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	6.10	–	0.240
C	–	10.41	–	0.410
D	–	0.53	–	0.021
F	0.406	0.483	0.016	0.019
G	1.55	2.06	0.061	0.081
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	90° NOM		90° NOM	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 149-02
TO-1



2N502AJAN
2N502BJAN



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current	I_{CBO}			Adc
(V_{CB} = 10 Vdc, I_E = 0) 2N502A,BJAN		–	4.0	
(V_{CB} = 15 Vdc, I_E = 0) 2N499,A, 2N499,AJAN		–	10	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product	f_T			MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz) 2N499,A, 2N499,AJAN		120	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N502A,BJAN		150	600	
Output Capacitance	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 4.0 MHz) 2N499,A, 2N499,AJAN		–	2.5	
2N502A,BJAN		–	1.6	
Small-Signal Current Gain	h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 9.0 Vdc, f = 1.0 kHz) 2N499,A, 2N499,AJAN		20	80	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N502AJAN		15	200	
2N502BJAN		25	80	
Collector-Base Time Constant	$r_b'C_c$			ps
(I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 46 MHz) 2N499,AJAN		5.0	50	
2N499		–	250	
2N499A		5.0	250	
2N502A,BJAN		5.0	25	
Noise Figure	NF			dB
(I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 200 MHz) 2N502A,BJAN		–	7.0	
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain	G_{pe}			dB
(V_{CB} = 10 Vdc, I_E = 2.0 mAdc, f = 100 MHz) 2N499,A,2N499,AJAN		7.5	–	
(V_{CB} = 10 Vdc, I_E = 2.0 mAdc, f = 200 MHz) 2N502A,BJAN		10	20	

*Indicates JEDEC Registered Data.

2N508 (GERMANIUM)

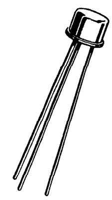
For Specifications, See 2N322 Data

2N508A (GERMANIUM)

PNP Germanium Milliwatt transistor designed for low noise audio and switching applications.

- Small-Signal Current Gain – h_{fe} = 180 (Max) @ I_E = 1.0 mAdc
- Low Noise Figure Applications – NF = 5.0 dB (Max) @ I_C = 1.0 mAdc

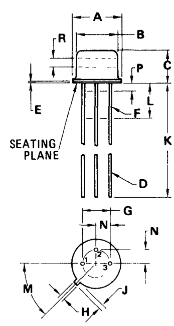
PNP GERMANIUM AUDIO AND SWITCHING TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage (R_{BE} = 10 kohms)	V_{CER}	25	Vdc
*Collector-Emitter Voltage	V_{CES}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	10	Vdc
*Collector Current	I_C	200	mAdc
*Total Device Dissipation @T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

*Indicates JEDEC Registered Data



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

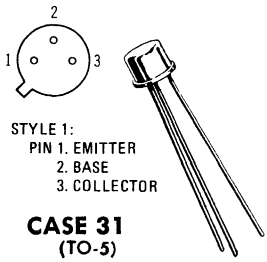
CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Breakdown Voltage (I_C = 600 μAdc, R_{BE} = 10 k ohms)	BV_{CER}	25	-	Vdc
*Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	-	7.0	μAdc
*Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	-	7.0	μAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	100	200	-
*Base-Emitter Voltage (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	V_{BE}	0.18	0.32	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	$f_{\alpha b}$	2.5	-	MHz
*Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 1.0 mAdc, f = 1.0 MHz)	C_{ob}	-	35	pF
*Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	26	31	Ohms
*Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	1×10^{-4}	17×10^{-4}	-
*Small-Signal Current Gain (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	75	180	-
*Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	0.1	0.9	μmhos
Noise Figure (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, R_S = 500 ohms, f = 1.0 kHz, Δf = 1.0 Hz)	NF	-	5.0	dB

*Indicates JEDEC Registered Data.

2N524 thru 2N527 (GERMANIUM)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current	I_C	500	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation @ 25°C Ambient	P_D	225	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.333	°C/mW
Thermal Resistance (infinite heat sink)	θ_{JC}	0.15	°C/mW

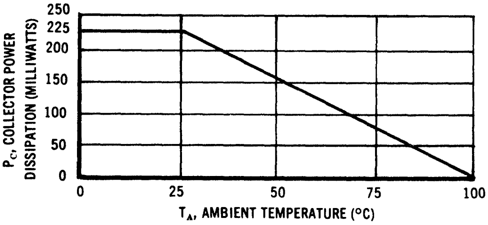
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristics		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10K)		BV_{CER}	30	-	Vdc
Collector-Emitter Reach Through (Punch-Thru) Voltage (V_{EB} = 1 Vdc, VTVM Z ≥ 1 Megohm)		V_{RT}	30	-	Vdc
Static Forward-Current Transfer Ratio (V_{CE} = 1 Vdc, I_C = 20 mAdc)	2N524	h_{FE}	25	42	-
	2N525		34	65	-
	2N526		53	90	-
	2N527		72	121	-
Small-Signal Short-Circuit Forward Current Transfer Ratio Frequency Cutoff (V_{CB} = 5 Vdc, I_E = 1 mAdc)	2N524	$f_{\alpha b}$	0.8	5.0	MHz
	2N525		1.0	5.5	
	2N526		1.3	6.5	
	2N527		1.5	7.0	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 MHz)		C_{ob}	5.0	40	pF
Small-Signal Open Circuit Output Admittance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524	h_{ob}	0.10	1.3	μmho
	2N525		0.10	1.2	
	2N526		0.10	1.0	
	2N527		0.10	0.9	
Small-Signal Open Circuit Reverse Transfer Voltage Ratio (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524	h_{rb}	1.0	10	$X10^{-4}$
	2N525		1.0	11	
	2N526		1.0	12	
	2N527		1.0	14	
Small-Signal Short Circuit Input Impedance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524	h_{ib}	26	36	ohms
	2N525		26	35	
	2N526		26	33	
	2N527		26	31	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$			
(I_B = 2 mAdc, I_C = 20 mAdc)	2N524				
(I_B = 1.33 mAdc, I_C = 20 mAdc)	2N525		-	130	mVdc
(I_B = 1.0 mAdc, I_C = 20 mAdc)	2N526		-	130	
(I_B = 0.67 mAdc, I_C = 20 mAdc)	2N527		-	130	
			-	130	
Base Input Voltage (V_{CE} = 1 Vdc, I_C = 20 mAdc)	2N524	V_{BE}	220	320	mVdc
	2N525		200	300	
	2N526		190	280	
	2N527		180	260	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Max	Unit
Noise Figure (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz, BW = 1 Hz		NF	-	15	dB
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N524	h_{fe}	18	41	-
	2N525		30	64	
	2N526		44	88	
	2N527		60	120	

POWER-TEMPERATURE DERATING CURVE

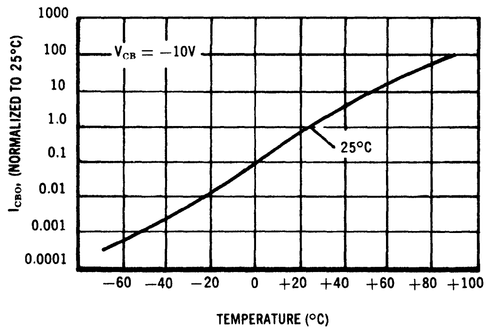


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

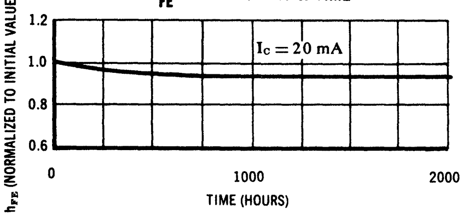
This curve has a value of 225mW at case temperatures of 25°C and is 0 mW at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_A}{0.333}$$

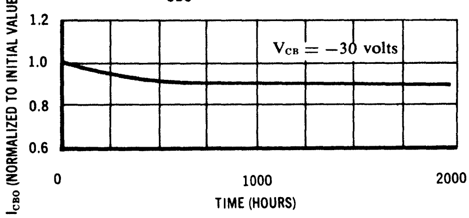
COLLECTOR CUTOFF CURRENT versus TEMPERATURE



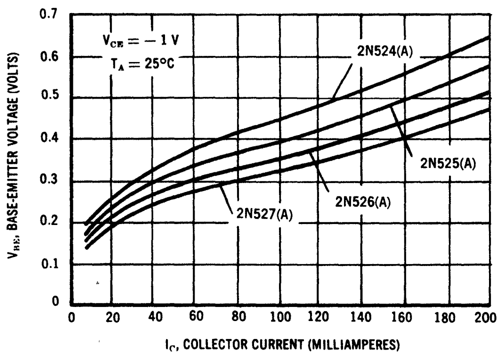
h_{FE} VARIATION WITH TIME



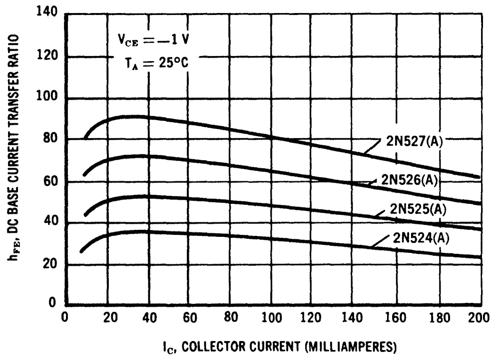
I_{CBO} VARIATION WITH TIME



COMMON EMITTER INPUT VOLTAGE versus COLLECTOR CURRENT



D-C BASE CURRENT GAIN versus COLLECTOR CURRENT



2N554 (GERMANIUM)
2N555

For Specifications, See 2N178 Data.

2N618 (GERMANIUM)

For Specifications, See 2N375 Data.

2N650A, 2N650 (GERMANIUM)
2N651A, 2N651
2N652A, 2N652

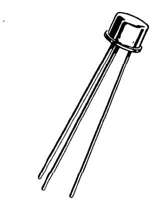
GERMANIUM PNP MILLIWATT TRANSISTORS

. . . designed primarily for low-power audio amplifier and medium-speed switching applications.

- Stabilization Bake at 100°C for 120 Hours for Greater Gain Stability
- Low Collector-Emitter Saturation Voltage — 0.2 Vdc Typ @ I_C = 200 mA

AUDIO TRANSISTORS
GERMANIUM PNP

45 VOLTS
200 MILLIWATTS



*MAXIMUM RATINGS

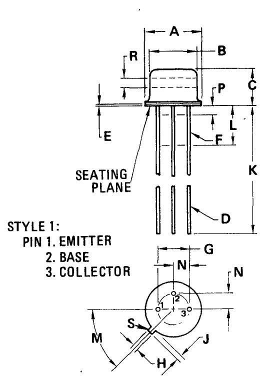
Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} = 10 k ohms)	V_{CER}	30	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current — Continuous (1)	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	°C

Maximum lead temperature is 250°C for 3.0 seconds, 1/16" ± 1/32" from case.
(1) Limited by power dissipation.

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.250	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	°C/mW

*Indicates JEDEC Registered Data.

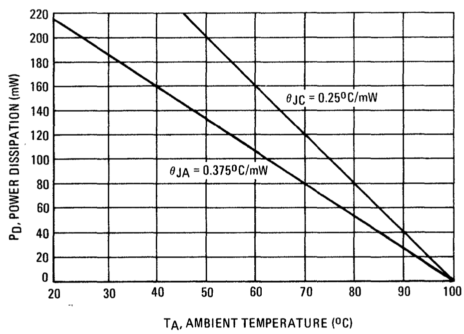


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

FIGURE 1 — POWER-TEMPERATURE DERATING



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Floating Potential (1) (V_{CB} = 45 Vdc, I_E = 0, voltmeter input resistance ≥ 10 megohms)		V_{EBF}	–	1.0	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, R_{BE} = 10 k ohms)		I_{CER}	–	600	μAdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)			–	10	
(V_{CB} = 45 Vdc, I_E = 0)			–	50	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C)			–	100	
Emitter Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N650		30	–	
	2N650A		33	–	
	2N651, A		45	–	
	2N652, A		80	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)	2N650, A		–	0.250	
(I_C = 50 mAdc, I_B = 1.67 mAdc)	2N651, A		–	0.250	
(I_C = 50 mAdc, I_B = 1.25 mAdc)	2N652, A		–	0.250	
(I_C = 100 mAdc, I_B = 5.0 mAdc)	2N650, A		–	0.500	
(I_C = 100 mAdc, I_B = 3.33 mAdc)	2N651, A		–	0.500	
(I_C = 100 mAdc, I_B = 2.5 mAdc)	2N652, A		–	0.500	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N650, A		–	0.270	
	2N651, A		–	0.260	
	2N652, A		–	0.250	
SMALL-SIGNAL CHARACTERISTICS					
Common-Base Cutoff Frequency		$f_{\alpha b}$			MHz
(I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)	2N650, A		0.75	–	
	2N651, A		1.0	–	
	2N652, A		1.25	–	
Output Capacitance (1) (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	–	25	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc, f = 1.0 kHz)		h_{ib}	27	37	Ohms
Small-Signal Current Gain		h_{fe}			–
(I_E = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	2N650, A		30	70	
	2N651, A		50	120	
	2N652, A		100	225	
Output Admittance (1) (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc, f = 1.0 kHz)		h_{ob}	0.15	1.0	μmhos
Noise Figure (I_E = 0.5 mAdc, V_{CE} = 4.5 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz, Δ f = 1.0 Hz)		NF	–	15	dB

(1) Applies only to 2N650A, 2N651A, and 2N652A Devices

*Indicates JEDEC Registered Data.

FIGURE 2 – DC CURRENT GAIN

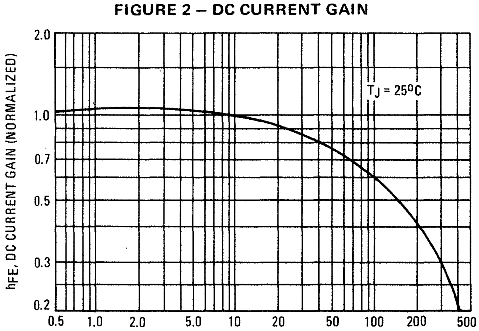
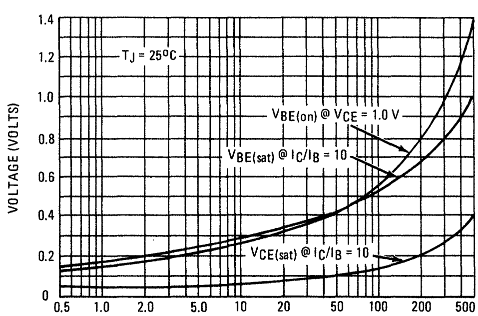


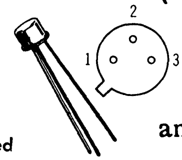
FIGURE 3 – "ON" VOLTAGES



2N653 thru 2N655 (GERMANIUM)

CASE 31
(TO-5)

All leads isolated



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium transistor, for high-gain amplifier and switching service in the audio frequency range.

MAXIMUM RATINGS

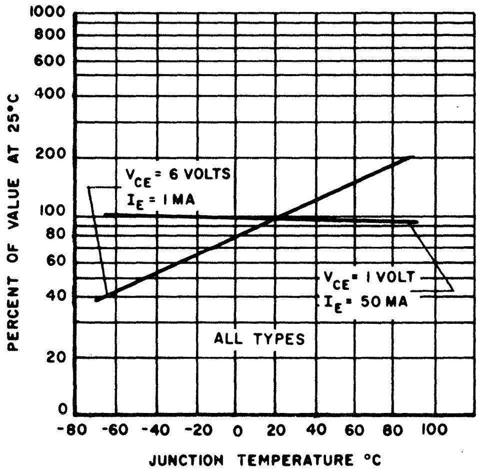
Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	30	Volts
Collector to Emitter Voltage	V_{CER}	25	Volts
Emitter to Base Voltage	V_{EB}	25	Volts
Collector D. C. Current *	I_C	250*	mA
Junction Temperature Limits	T_J	-65 to +100	°C
Storage Temperature Limits	T_{stg}	-65 to +100	°C
Collector Dissipation in, Ambient Derate 2.67 mW/°C above 25°C	P_D	200	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.375	°C/mW

*Limited by power dissipation.

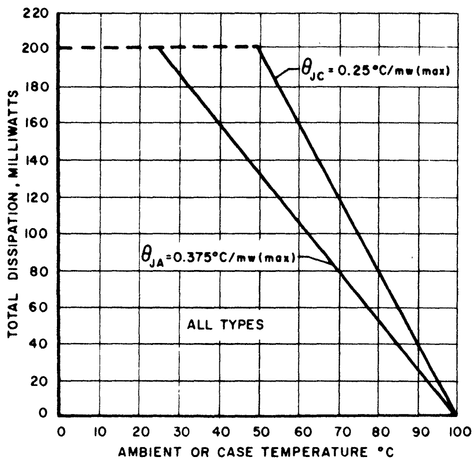
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	2N653			2N654			2N655			Unit
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Small Signal Current Gain V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz	h_{fe}	30	49	70	50	80	125	100	130	250	-
Small Signal Input Impedance V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz	h_{ie}	750	-	2900	1500	-	4700	3000	-	8500	ohms
Small Signal Current Gain Cutoff Frequency V_{CB} = 6 V, I_E = 1.0 mA	$f_{\alpha b}$		1.5			2.0			2.5		MHz
Output Capacity V_{CB} = 6 V, I_E = 0 mA, f = 1 MHz	C_{ob}		10			10			10		pF
Noise Figure V_{CE} = 4.5 V, I_E = 0.5 mA, Rs = 1, f = kHz Δf = 1 Hz	NF		10			10			10		dB
Collector Reverse Current V_{CB} = 25 V, I_E = 0	I_{CBO}		5.0	15		5.0	15		5,0	15	μA
Emitter Reverse Current V_{EB} = 25 V, I_C = 0	I_{EBO}		5.0	15		5.0	15		5.0	15	μA
Collector-Emitter Reverse Current V_{CE} = 25 V, R_{BE} = 10 k	I_{CER}			600			600			600	μA
Base-Emitter Input Voltage V_{CE} = 6 V, I_C = 1.0 mA	V_{BE}			0.3			0.3			0.3	Vdc

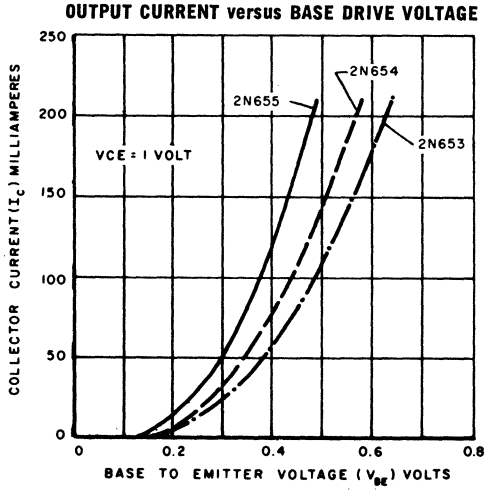
SMALL SIGNAL CURRENT GAIN (h_{fe}) versus TEMPERATURE



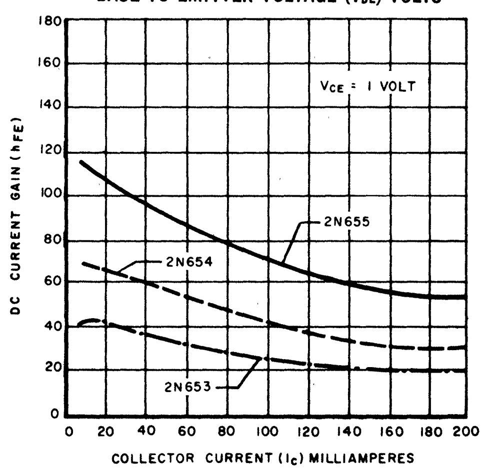
POWER-TEMPERATURE DERATING CURVE



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



LARGE SIGNAL CURRENT GAIN versus COLLECTOR CURRENT
BASE TO EMITTER VOLTAGE (V_{BE}) VOLTS



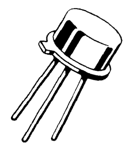
2N656S (SILICON)
2N657S

NPN SILICON ANNULAR TRANSISTORS

. . . NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 100 Vdc (Min) @ I_C = 250 μAdc — 2N657
- High Emitter-Base Breakdown Voltage — BV_{EBO} = 8.0 Vdc (Min) @ I_E = 250 μAdc

NPN SILICON ANNULAR TRANSISTORS



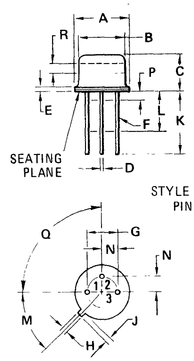
*MAXIMUM RATINGS

Rating	Symbol	2N656	2N657	Unit
Collector-Emitter Voltage	V_{CEO}	60	100	Vdc
Collector-Base Voltage	V_{CB}	60	100	Vdc
Emitter-Base Voltage	V_{EB}	8.0		Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.7		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	4.0 22.8		Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 250 μAdc, I_B = 0) 2N656 2N657	BV_{CEO}	60 100	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) 2N656 2N657	BV_{CBO}	60 100	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 250 μAdc, I_C = 0)	BV_{EBO}	8.0	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	—	10	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 200 mAdc, V_{CE} = 10 Vdc)	h_{FE}	30	90	—
Collector-Emitter Saturation Voltage(1) (I_C = 200 mAdc, I_B = 40 mAdc)	$V_{CE(sat)}$	—	4.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Input Impedance(1) (I_B = 8.0 mAdc, V_{CE} = 10 Vdc)	h_{ie}	—	0.5	k ohm

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	—	0.500	—
L	6.35	—	0.250	—
M	45^0 NOM		45^0 NOM	
P	—	1.27	—	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	—	0.100	—

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

2N665JAN (GERMANIUM)

GERMANIUM PNP POWER TRANSISTOR

. . . designed for driver, amplifier, and switching applications, with especially good high-temperature characteristics. These devices feature:

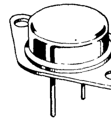
- Very Low Leakage Current — $I_{CBO} = 50\,\mu A$ at $V_{CBO} = 2V$
- High Frequency — 600 kc at $V_{CE} = 12V$, $I_C = 0.5A$

MIL-S-19500/58C

5 AMPERE POWER TRANSISTORS

PNP GERMANIUM

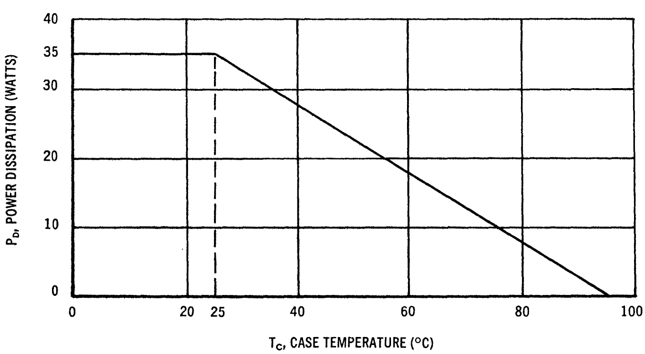
80 VOLTS
35 WATTS

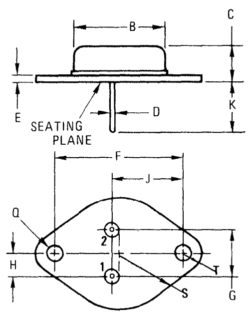


MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
DC Collector Current MIL-S-19500/58C Motorola Unit	I_C	 2 3	Amps
DC Emitter Current	I_E	5	Amps
Collector Junction Temperature	T_J	-65 to +95	°C
Collector Dissipation Derate above 25°C	P_C	35 0.5	Watts W/°C

FIGURE 1 — POWER DERATING CURVE





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	–	22.23	–	0.875
C	6.35	11 43	0 250	0.450
D	0.97	1.09	0 038	0 043
E	–	3.43	–	0 135
F	29.90	30.40	1.177	1 197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16:64	17.15	0.655	0 675
K	7.92	–	0.312	—
Q	3.84	4.09	0 151	0.161
S	–	13.34	–	0.525
T	–	4.78	–	0 188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

TABLE I — GROUP A INSPECTION

Examination or Test	Symbol	Limits Min	Limits Max	Unit	AQL (percent defective)	Inspection Level
SUBGROUP 1						
Visual and Mechanical Examination	—	—	—	—	Major = 1 Minor = 2.5	II
SUBGROUP 2						
Emitter Cutoff Current (V_{EBO} = -40 Vdc, I_C = 0)	I_{EBO}	—	-2	mAdc	1	II
Collector Cutoff Current	I_{CBO}			mAdc		
(V_{CBO} = -2 Vdc, I_E = 0)		—	-.05			
(V_{CBO} = -60 Vdc, I_E = 0)		—	-2			
(V_{CBO} = -80 Vdc, I_E = 0)		—	-10			
DC Current Gain	h_{FE}			—		
(V_{CE} = -2 Vdc, I_C = -0.5 Adc)		40	80			
(V_{CE} = -2 Vdc, I_C = -2 Adc)		20	—			
Emitter-Base Voltage (V_{CE} = -2 Vdc, I_C = -2 Adc)	V_{EB}	—	1.5	Vdc		
Floating Potential (V_{CB} = -80 Vdc, voltmeter input resistance = 10 megohms min, t ≈ 1 sec)	V_{EBF}	—	-1	Vdc		
Collector-Emitter Saturation Voltage (I_C = -3 Adc, I_B = -220 mAdc)	$V_{CE(sat)}$	—	-0.9	Vdc		
Collector-Emitter Voltage (I_C = -300 mAdc, I_B = 0)	V_{CEO}	-40	—	Vdc		
SUBGROUP 3						
Small-Signal Short-Circuit Forward-Current Transfer-Ratio Cutoff Frequency (V_{CE} - -14 Vdc, I_C = -2 Adc)	f_{hfe}	20	—	kc	4	II
Emitter Cutoff Current (V_{EBO} = -30 Vdc, I_C = 0, T_C = +71°C min)	I_{EBO}	—	-2	mAdc		
Collector Cutoff Current (V_{CBO} = -30 Vdc, I_E = 0, T_C = +71°C min)	I_{CBO}	—	-2	mAdc		

NOTE 1. Requirements shall be in accordance with Specification MIL-S-19500, and as specified herein.

NOTE 2. Sampling and inspection shall be in accordance with Specification MIL-S-19500, and as specified herein.

NOTE 3. In addition to the marking specified in Specification MIL-S-19500, transistors shall be marked with the type designation and date of manufacture. The date of manufacture shall be indicated as specified in Specification MIL-S-19500, except that the first number in the code shall consist of the last two digits of the number of the year (for example, 59, 60, etc.).

NOTE 4. Acceptance inspection shall consist of groups A and B, and inspection of preparation for delivery.

NOTE 5. An inspection lot shall be as specified in Standard MIL-STD-105 and as follows:

(a) Consist of transistors of one type designation manufactured by one manufacturer at one plant during a period of not longer than 31 consecutive calendar days, and offered for inspection at one time.

(b) Consist of not more than 10,000 transistors.

(c) Inspection lots consisting of less than 301 transistors shall be considered as consisting of 301 transistors for sampling purposes.

NOTE 6. The requirement that the transistor be subjected to the lead-fatigue test prior to cycling shall not apply.

NOTE 7. Operation-life and storage-life tests shall be conducted in accordance with method A of Specification MIL-S-19500.

NOTE 8. The transistor shall be examined only for legibility of marking before the specified measurements are made.

NOTE 9. The transistor shall be maintained at each end temperature until thermal equilibrium has been reached but for not less than 15 minutes. The transistor may be maintained at room ambient temperature for not more than 5 minutes between each period at the end temperature. This test may be started at any point in the cycle.

NOTE 10. In addition to the notes specified herein, the notes specified in Specification MIL-S-19500 are applicable to this specification.

TABLE II — GROUP B INSPECTION

Examination or Test	Symbol	Limits Min	Limits Max	Unit	AQL (percent defective)	Inspection Level
SUBGROUP 1						
Physical Dimensions	—	—	—	—	6.5	L7 Reduced: L5 Procedure R-1
SUBGROUP 2						
Emitter Current (I_E = 5 Adc, V_{CB} = 0, T_C = $25^o \pm 5^oC$, t ≈ 1 hr)	—	—	—	—	4	L4 Reduced: L2 Procedure R-1
Temperature Cycling (Note 9) (5 cycles, T = 95^omin)	—	—	—	—		
Moisture Resistance (Note 6)	—	—	—	—		
End Points: (Subgroups 2, 3, 4, 6, 7)						
Emitter Cutoff Current (V_{EBO} = -40 Vdc, I_C = 0)	I_{EBO}	—	-4	mAdc		
Collector Cutoff Current (V_{CBO} = -60 Vdc, I_E = 0)	I_{CBO}	—	-4	mAdc		
DC Current Gain (V_{CE} = -2 Vdc, I_C = -2 Adc)	h_{FE}	13	—	—		
SUBGROUP 3						
Shock * † (500G, t ≈ 1 msec, 5 blows each in orientations X_1, Y_1, Y_2, and Z_1, total of 20 blows)	—	—	—	—	4	L4 Reduced: L2 Procedure R-1
Constant Acceleration* (10,000G)	—	—	—	—		
Vibration Fatigue * † (10G)	—	—	—	—		
Vibration, Variable Frequency (10G, 100 to 1000 cps)	—	—	—	—		
End Points: Same as Subgroup 2						
SUBGROUP 4						
Barometric Pressure, Reduced (Altitude Operation) (V_{CBO} = -60 Vdc, I_{CBO} = -2 mAdc max, I_E = 0, 15 mm Hg, t ≈ 60 sec)	—	—	—	—	4	L4 Reduced: L2 Procedure R-1
Salt Spray (Corrosion) (Note 8) * (Test Condition A)	—	—	—	—		
End Points: Same as Subgroup 2						
SUBGROUP 5						
Thermal Resistance	θ_{J-C}	—	2	$^oC/W$	4	L4 Reduced: L2 Procedure R-1

Examination or Test	Symbol	Limits Min	Limits Max	Unit	AQL (percent defective) 1,000-Hour Life Test 250 hr	1,000-Hour Life Test 500 hr	1,000-Hour Life Test 1,000 hr	Reduce-Hours Life-Test 500 hr	Reduce-Hours Life-Test 250 hr	Inspection Level 1,000-hr Life Test	Reduce-Hours Life-Test 500 hr	Reduce-Hours Life-Test 250 hr
SUBGROUP 6												
Storage Life (Note 7) (T_{stg} = +95°C min)	—	—	—	—	4	4	4	2.5	1.5	L8	I	II
End Points: Same as Subgroup 2												
SUBGROUP 7												
Operation Life (Note 7) (T_C = +75°C min, P_C = 10^{+0}_{-1} W)	—	—	—	—	4	4	4	2.5	1.5	L8	I	II
End Points: Same as Subgroup 2												

* Destructive tests

† No biases shall be applied during these tests.

FIGURE 2 — SAFE OPERATING AREA

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

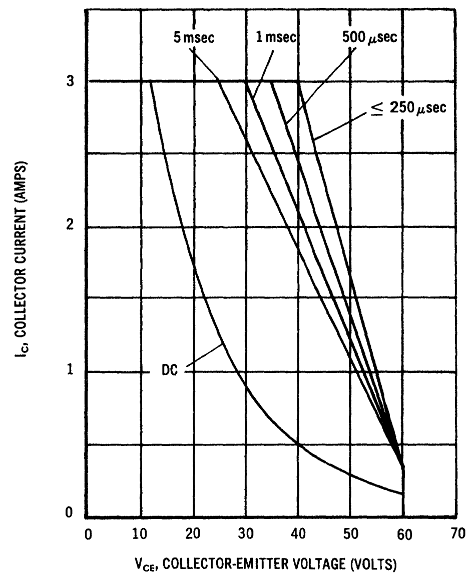


FIGURE 3 — h_{FE} versus TEMPERATURE

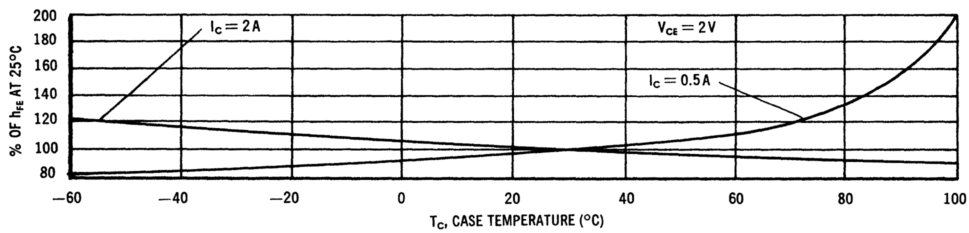
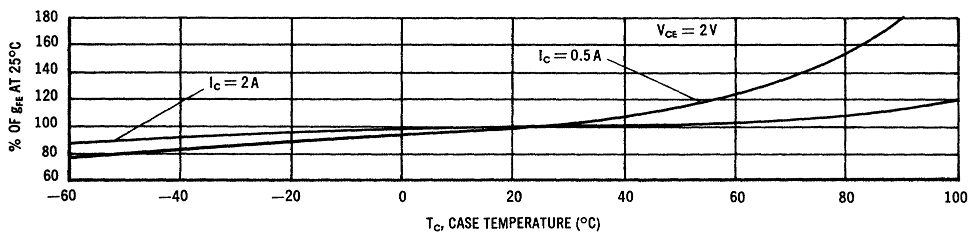


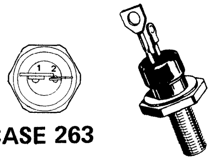
FIGURE 4 — g_{FE} versus TEMPERATURE



2N669 (GERMANIUM)

For Specifications, See 2N176 Data.

2N681 thru 2N689 (SILICON)



CASE 263

STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 25 amperes at junction temperatures to 125°C. MCR equivalents available in TO-48 package – i.e. – 2N681 available in TO-48 package as MCR681.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage* †		$V_{RSM(rep)}$* †		Volts
	2N681		25	
	2N682		50	
	2N683		100	
	2N684		150	
	2N685		200	
	2N686		250	
	2N687		300	
	2N688		400	
	2N689		500	
Peak Reverse Blocking Voltage*		$V_{RSM(non\text{-}rep)}$*		Volts
(Transient)	2N681		35	
(non-recurrent t = 5 ms max.)	2N682		75	
	2N683		150	
	2N684		225	
	2N685		300	
	2N686		350	
	2N687		400	
	2N688		500	
	2N689		600	
Forward Current RMS (all conduction angles)		I_T	25	Amp
Peak Forward Surge Current (One cycle, 60 Hz, T_J = -65 to +125°C)		T_{TSM}	200	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)		I^2t	165	A^2s
Peak Gate Power-Forward		P_{GM}	5.0	Watts
Average Gate Power-Forward		$P_{G(AV)}$	0.5	Watt
Peak Gate Current-Forward		I_{GM}	2.0	Amp
Peak Gate Voltage-Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-65 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Stud Torque		—	30	in. lb.

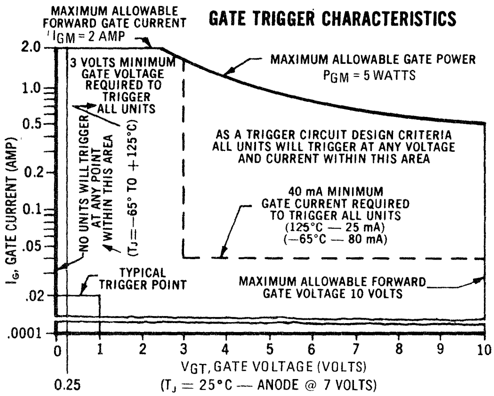
† V_{RSM} for all types can be applied on a continuous dc basis without incurring change.

* $V_{RSM(rep)}$ ratings apply for zero or negative gate voltage.

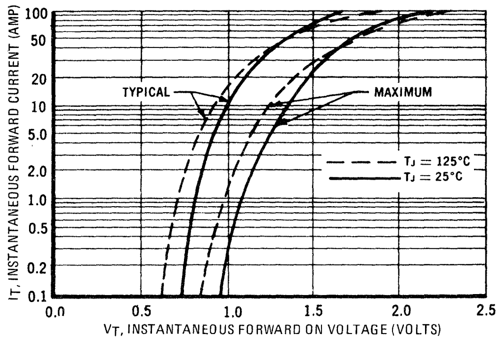
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 125°C)	2N681	V_{DRM}	25	—	—	Volts
	2N682		50	—	—	
	2N683		100	—	—	
	2N684		150	—	—	
	2N685		200	—	—	
	2N686		250	—	—	
	2N687		300	—	—	
	2N688		400	—	—	
	2N689		500	—	—	
Peak Forward or Reverse Blocking Current (T_J = 125°C)	2N681 - 2N684	I_{DRM} I_{RRM}	—	—	10.0	mA
	2N685		—	—	10.0	
	2N686		—	—	10.0	
	2N687		—	—	10.0	
	2N688		—	—	8.0	
	2N689		—	—	6.0	
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	10	25	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	0.25	—	3.0	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_H	—	20	—	mA
Forward On Voltage (I_T = 20 Adc)		V_{TM}	—	1.1	1.5	Volts
Turn-On Time (I_T = 10A, I_G = 200 mA)		t_{gt}	—	1.0	—	μs
Turn-Off Time (I_T = 10 A; I_R = 10 A, dv/dt = 30 V/μs min, T_J = 125°C) (V_{DRM} = rated voltage)		t_q	—	30	—	μs
Forward Voltage Application Rate (Gate open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

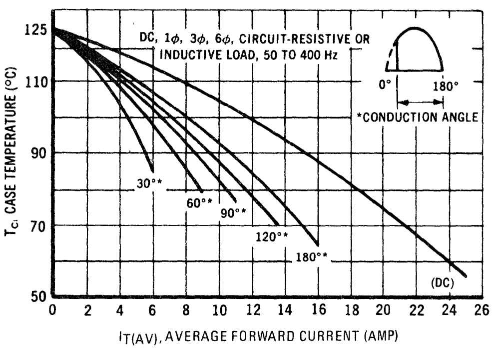
GATE TRIGGER CHARACTERISTICS



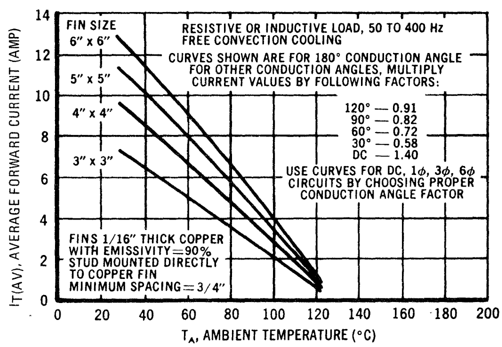
FORWARD CONDUCTING CHARACTERISTICS



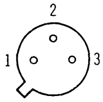
CURRENT DERATING



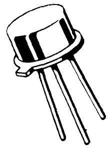
SUGGESTED FIN SIZES



2N696S (SILICON)
2N697S



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



CASE 79
(TO-39)

NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 13.3	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

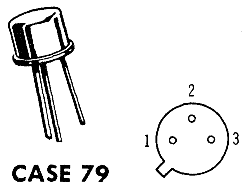
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)		BV_{CER}	40		Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	60		Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0		Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	- -	1.0 100	μAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N696 2N697	h_{FE}	20 40	60 120	-
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	-	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N696 2N697	f_T	40 50	- -	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)		C_{ob}	-	35	pF

* Indicates JEDEC Registered Data

* Pulse Test: Pulse Length ≦ 12 ms, Duty Cycle ≦ 2.0%.

2N699 (SILICON)

NPN silicon annular transistor designed for medium-current switching and amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)
Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	75	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	250	°C/W

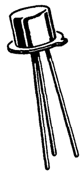
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 100 mAdc, R_{BE} ≦ 10 ohms)	BV_{CER}*	80	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	-	2.0	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		-	200	
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	40	120	-
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$*	-	5.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$*	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	20	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	2.5	X 10^{-4}
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	3.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	35	100	-
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		45	-	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	0.1	0.5	μmhos
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	1.0	

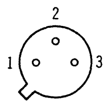
* Pulse Test: Pulse Width ≦ 300 μs; Duty Cycle ≦ 2%.

2N702 (SILICON)
2N703
2N703 JAN AVAILABLE

NPN silicon annular transistors designed for low-level, high-speed switching applications.



CASE 22
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

***MAXIMUM RATINGS** (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	600 4.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_{stg}	-65 to +175	°C

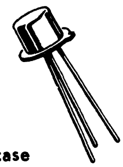
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 2.0 mAdc, I_B = 0)		BV_{CEO}	25	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 μAdc, I_E = 0)		BV_{CBO}	25	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)		I_{CEO}	-	-	10	μAdc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = +150°C)		I_{CBO}	- -	- -	0.5 50	μAdc
ON CHARACTERISTICS						
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N702 2N703 2N702 2N703	h_{FE}	20 40 12 20	- - - -	60 100 - -	-
Collector-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter On Voltage(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.7	-	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product (I_E = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		f_T	70	150		MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	3.0	6.0	pF

* Indicates JEDEC Registered Data
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

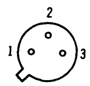
2N705 (Ge Mesa)
2N705 JAN AVAILABLE

CASE 22-03
(TO-18)



Collector connected to case

PNP germanium mesa transistor for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CES}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current - Continuous	I_C	50	mAdc
Emitter Current	I_E	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65°C to +100	°C
Collector Dissipation @ T_C = 25°C Derate above 25°C	P_C	300 4.0	mW mW/°C
Collector Dissipation @T_A = 25°C	P_C	150	mW

*Indicates JEDEC Registered Data

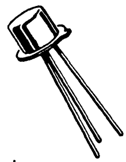
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Collector-Emitter Breakdown Voltage (I_{CE} = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	–	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	–	3.0	μAdc
DC Forward Current Transfer Ratio (V_{CE} = .3 Vdc, I_C = 10 mAdc)	h_{FE}	25	–	–
Collector Saturation Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
Base-Emitter Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	V_{BE}	0.34	0.44	Vdc
Delay + Rise Time (I_C = 10 mAdc, I_B = 1 mAdc)	$t_d + t_r$	–	75	ns
Storage Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_s	–	100	ns
Fall Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_f	–	100	ns

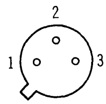
*Indicates JEDEC Registered Data

2N706, A, B (SILICON)
(2N706JAN AVAILABLE)

NPN silicon annular switching transistors for high-speed switching applications.



CASE 22
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage (1)	V_{CER}	20	Volts
Emitter-Base Voltage 2N706 2N706A 2N706B	V_{EB}	3.0 5.0 5.0	Volts
Junction Temperature	T_J	175	°C
Storage Temperature	T_{stg}	-65 to +175	°C
Total Device Dissipation at 25°C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25° C Ambient Temperature (Derate 2 mW/°C above 25°C)	P_D	0.3	Watt
Total Device Dissipation at 100°C Case Temperature (Derate 6.67 mW/°C above 100°C)	P_D	0.5	Watt

* Indicates JEDEC Registered Data

(1) *Refers to collector breakdown voltage in the high current region when* $R_{be} = 10\Omega$

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

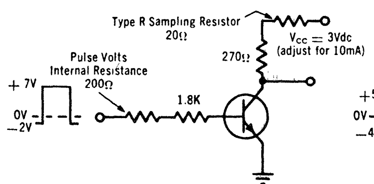
Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 15Vdc, I_E = 0) (V_{CB} = 15Vdc, I_E = 0, T_A = 150 °C) (V_{CB} = 25Vdc, I_E = 0)	 All Types All Types 2N706A, 2N706B,	I_{CBO}	 - - -	 0.005 3.0 -	 0.5 30 10	µAdc
Collector-Emitter Cutoff Current (V_{CE} = 20Vdc, R_{be} = 100k)	2N706A, 2N706B,	I_{CER}	-	-	10	µAdc
Emitter Cutoff Current (V_{EB} = 3Vdc, I_C = 0) (V_{EB} = 5Vdc, I_C = 0)	 2N706 2N706A, 2N706B,	I_{EBO}	 - -	 - -	 10 10	µAdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10mAdc,I_B = 0)		BV_{CEO}	15		-	Vdc
Collector-Emitter Breakdown Voltage(1) (R = 10 ohms, I_C = 10mAdc)		BV_{CER}	20		-	Vdc
Forward-Current Transfer Ratio(1) (I_C = 10mAdc, V_{CE} = 1Vdc)	2N706 2N706A, 2N706B,	h_{FE}	20 20	40 40	- 60	
Base-Emitter Voltage(1) (I_C = 10mAdc, I_B = 1mAdc)	2N706 2N706A, 2N706B,	V_{BE}(sat)	- 0.7	0.75 0.75	0.9 0.9	Vdc
Collector Saturation Voltage(1) (I_C = 10mAdc, I_B = 1mAdc)	2N706, 2N706A 2N706B	V_{CE}(sat)	- -	0.3 0.3	0.6 0.4	Vdc
Collector Capacitance (V_{CB} = 5Vdc, I_E = 0 (V_{CB} = 10Vdc, I_E = 0)	2N706A, 2N706B, 2N706	C_{ob}	 -	 5.0	 6.0	pF
Small-Signal Forward Current Transfer Ratio (V_{CE} = 15Vdc, I_E = 10mAdc, f = 100MHz)		h_{fe}	2.0	4.0	-	-
Current Gain-Bandwidth Product (V_{CE} = 15Vdc, I_E = 10mAdc, f = 100 MHz)		f_T	-	400	-	MHz
Base Resistance (V_{CE} = 15Vdc, I_E = 10mAdc, f = 300 MHz)		r_b'	-	39	50	ohms
Charge Storage Time Constant(2)	2N706 2N706A 2N753	τ_s	- - -	16 16 19	60 25 35	ns
Storage Time	2N706B	t_s	-	19	25	ns
Turn-On Time		t_{on}	-	30	40	ns
Turn-Off Time		t_{off}	-	50	75	ns

* Indicates JEDEC Registered Data

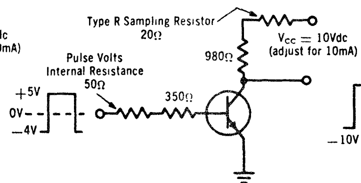
(1) Pulse Test: PW ≤ 12 ms, Duty Cycle ≤ 2%

(2) Switching Times Measured with Tektronix Type R Plug-In (50Ω Internal Impedance) and Circuits Shown Below.

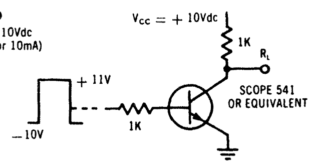
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT



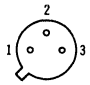
MEASUREMENT CIRCUIT



2N708 (SILICON)

2N708
JAN, JTX AVAILABLE

NPN silicon annular transistor for high-speed switching applications.



CASE 22
(TO-18)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	360 2.0	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ $T_C = 100°C$ Derate above 25°C Derate above 100°C	P_D	1.2 680 6.9 6.9	Watts mW mW/°C mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

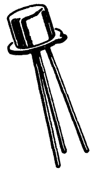
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, $R_{BE} \leq$ 10 ohms)	BV_{CER}	20	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0.25 Vdc, T_A = +125°C)	I_{CEX}	-	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 - -	 0.005 -	 0.025 15	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	-	0.08	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (1)	h_{FE}	 15 30 15	 - - -	 - 120 -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C to +125°C)	$V_{CE(sat)}$	 - -	 0.2 -	 0.4 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C)	$V_{BE(sat)}$	 0.72 -	 - -	 0.80 0.90	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	450	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)	C_{ob}	-	3.0	6.0	pF
Extrinsic Base Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	r_b'	-	-	50	ohms
Storage Time ($I_C = I_{B1} = I_{B2}$ = 10 mAdc)	t_s	-	15	25	ns

* Indicates JEDEC Registered Data

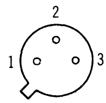
(1) Pulse Test: Pulse Width ≤ 300μs, Duty Cycle = 2.0 %.

2N711A,B (Ge Mesa)

CASE 22-03
(TO-18)
Collector
connected to case



PNP germanium mesa transistors for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N711A	2N711B	Unit
Collector-Base Voltage	V_{CB}	15	18	Vdc
Collector-Emitter Voltage	V_{CES}	14	15	Vdc
Collector-Emitter Voltage	V_{CEO}	7.0	7.0	Vdc
Emitter-Base Voltage	V_{EB}	1.5	2.0	Vdc
Collector Current-Continuous	I_C	100	100	mAdc
Emitter Current-Continuous	I_E	100	100	mAdc
Junction Temperature	T_J	← 100 →		°C
Storage Temperature	T_{stg}	← -65 to +100 →		°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 300 → ← 4.0 →		mW mW/°C
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 150 → ← 2.0 →		mW mW/°C

*Indicates JEDEC Registered Data

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Sym	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N711A	BV_{CBO}	15	—	Vdc
(I_C = 20 μAdc, I_E = 0)	2N711B		18	—	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc)	2N711A	BV_{CES}	14	—	Vdc
(I_C = 20 μAdc)	2N711B		15	—	
Collector-Emitter Breakdown Voltage (I_C = 5 mAdc, I_B = 0)	2N711A, 2N711B	BV_{CEO}	7.0	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	2N711A	BV_{EBO}	1.5	—	Vdc
	2N711B		2.0	—	
Collector-Base Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	2N711A	I_{CBO}	—	1.5	μAdc
(V_{CB} = 10 Vdc, I_E = 0)	2N711B		—	1.5	
Emitter-Base Cutoff Current (V_{EB} = 1 Vdc)	2N711A	I_{EBO}	—	100	μAdc
	2N711B		—	20	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N711A	h_{FE}	25	150	—
	2N711B		30	150	
(I_C = 50 mAdc, V_{CE} = 0.7 Vdc)	2N711A, 2N711B		40	—	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N711A	$V_{CE(sat)}$	—	0.30	Vdc
(I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711B		—	0.25	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		—	0.55	
	2N711B		—	0.45	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	2N711A, 2N711B	h_{fe}	1.5	—	—
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, f = 100 MHz)	2N711A		1.1	—	
	2N711B		1.2	—	
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711A	V_{BE}	0.30	0.44	Vdc
	2N711B		0.30	0.44	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		0.40	0.65	
	2N711B		0.40	0.65	
Collector Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	2N711A, 2N711B	C_{ob}	—	6.0	pF
Fall Time	Figure 1: 2N711A	t_f	—	150	ns
	Figure 1: 2N711B		—	110	
	Figure 2: 2N711A		—	110	
	Figure 2: 2N711B		—	100	
Minority Carrier Storage Time	Figure 1: 2N711A	t_s	—	150	ns
	Figure 1: 2N711B		—	140	
	Figure 2: 2N711A		—	120	
	Figure 2: 2N711B		—	100	
Delay Plus Rise Time	Figure 1: 2N711A, 2N711B	$t_d + t_r$	—	100	ns
	Figure 2: 2N711A, 2N711B		—	75	

*Indicates JEDEC Registered Data

SWITCHING CIRCUITS

FIGURE 1

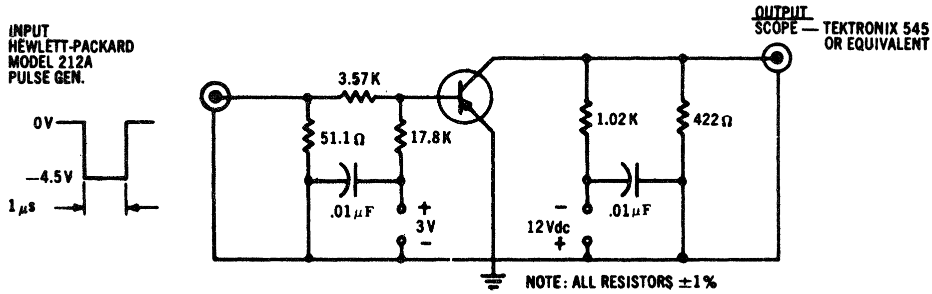
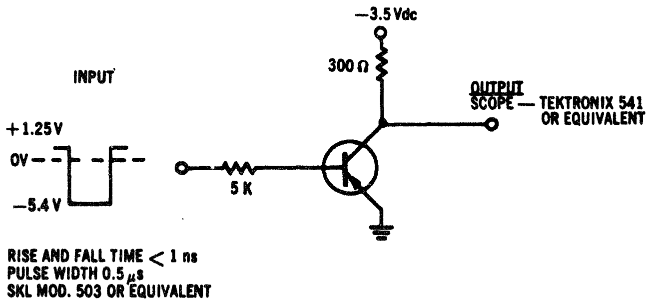


FIGURE 2



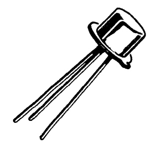
2N717 (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use as a general-purpose amplifier transistor in medium-voltage applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CER} = 40 Vdc (Min) @ I_C = 100 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 300 MHz (Typ) @ I_C = 50 mAdc

NPN SILICON AMPLIFIER TRANSISTOR



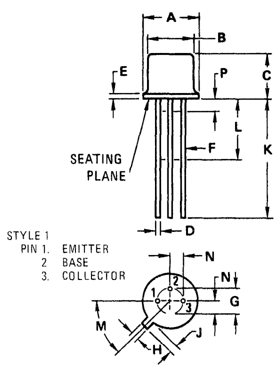
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage ($R_{BE} \leqslant 10$ Ohms)	V_{CER}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.66	mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.5 10	Watts mW/^oC
Operating Junction Temperature Range	T_J	-65 to +175	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	376	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	100	$^oC/W$

*Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

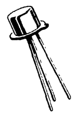
CASE 22
TO-18

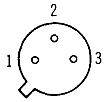
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, $R_{BE} \leqslant$ 10 Ohms)	BV_{CER}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		–	–	100	
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	55	60	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.15	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.85	1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	300	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	5.6	35	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	20	80	pF

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

2N718 (SILICON)





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)
Collector connected to case

NPN silicon annular transistors for medium-current switching and amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation at 25°C Case Temperature Derating Factor Above 25°C	P_D	1.5 10	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperatures Derating Factor Above 25°C	P_D	0.4 2.66	Watts mW/°C
Junction Temperature	T_J	+ 175	°C
Storage Temperature range	T_{stg}	-65 to + 200	°C

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	.001 –	1.0 100	μAdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_B \leqq$ 10 Ohms)	BV_{CER}	40	-	–	Vdc
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	–	1.3	Vdc

* Indicates JEDEC Registered Data
(1)**Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2%**

*ELECTRICAL CHARACTERISTICS (continued)

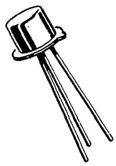
Characteristic	Symbol	Min	Typ	Max	Unit
DC Forward Current Transfer Ratio(1)	h_{FE}				–
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		–	20	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	–	120	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		–	20	–	
Small Signal Forward Current Transfer Ratio (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.5	15	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	–	5.0	35	pF

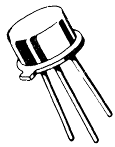
* Indicates JEDEC Registered Data

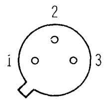
(1) **Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2%**

2N718A (SILICON)

2N718A JAN, JTX AVAILABLE
2N956
2N1711S







STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)
2N718A
2N956

CASE 79
(TO-39)
2N1711

Collector connected to case

NPN silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	2N718A 2N956	2N1711	Unit
Collector-Emitter Voltage	V_{CER}	50		Vdc
Collector-Base Voltage	V_{CB}	75		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	800 4.57	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	3.0 17.1	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

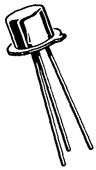
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_{BE} \leq$ 10 ohms)		BV_{CER}	50	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	75	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	0.001	0.01	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			-	-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N718A,	I_{EBO}	-	-	0.010	μAdc
	2N956, 2N1711		-	-	0.005	
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.01 mAdc, V_{CE} = 10 Vdc)	2N956, 2N1711	h_{FE}	20	-	-	-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N718A,		20	-	-	
	2N956, 2N1711		35	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N718A,		35	-	-	
	2N956, 2N1711		75	-	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N718A,		20	-	-	
	2N956, 2N1711		35	-	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N718A,		40	-	120	
	2N956, 2N1711		100	-	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N718A,		20	-	-	
	2N956, 2N1711		40	-	-	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	-	0.24	1.5	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	-	1.0	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N718A,	f_T	60	300	-	MHz
	2N956, 2N1711		70	300		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	20	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	24	-	34	ohms
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			4.0	-	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N718A,	h_{rb}	-	-	3.0	$X 10^{-4}$
	2N956, 2N1711		-	-	5.0	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N718A,		-	-	3.0	
	2N956, 2N1711		-	-	5.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N718A,	h_{fe}	30	-	100	-
	2N956, 2N1711		50	-	200	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,		35	-	150	
	2N956, 2N1711		70	-	300	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	0.1	-	0.5	μmho
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			0.1	-	1.0	
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N718A,	NF	-	-	12	dB
	2N956, 2N1711		-	-	8.0	

* Indicates JEDEC Registered Data

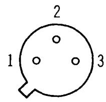
(1)Pulse Test: Pulse Width $\leq$ 300 μs, Duty Cycle $\leq$ 2.0%.

2N720A (SILICON)



NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.

CASE 22
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Emitter Voltage	V_{CER}	100	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	97	°C/W

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	80	-	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	$BV_{CER(sus)}$	100	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 90 Vdc, I_E = 0)		-	.010	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)		-	15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	.010	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		20	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)(1)		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)		40	120	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	1.2	
(I_C = 150 mAdc, I_B = 15 mAdc)		-	5.0	
Base-Emitter Saturation Voltage (1)	$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		-	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.3	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	50	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	85	pF
Input Impedance	h_{ib}			Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		20	30	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		4.0	8.0	
Voltage Feedback Ratio	h_{rb}			$X 10^{-4}$
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		-	1.25	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	1.50	
Small-Signal Current Gain	h_{fe}			-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		30	100	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		45	-	
Output Admittance	h_{ob}			μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		-	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		-	0.5	

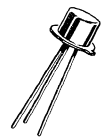
*Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general purpose audio amplifier applications.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 20 Vdc (Min) @ I_C = 10 mAdc
- Low Output Capacitance –
  C_{ob} = 5.0 pF (Max) @ V_{CB} = 5.0 Vdc

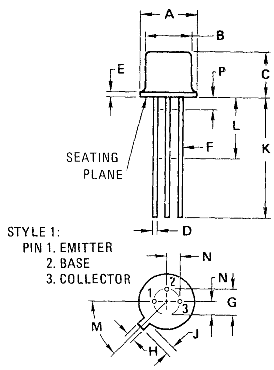
PNP SILICON AMPLIFIER TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current – Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

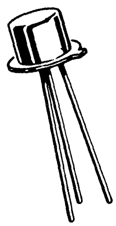
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–	5.0	μAdc
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0) (V_{CB} = 25 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	1.0 25	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	0.5	μAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	h_{FE}	30 12	120 –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	140	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	30	240	–

*Indicates JEDEC Registered Data.

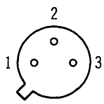
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N736 (SILICON)
2N739
2N740



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)
Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N736	2N739 2N740	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	125	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	500 2.86		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data
Lead Temperature, 1/16" ± 1/32" from case for 10 s.

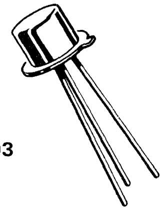
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N736	BV_{CEO}	60	-	Vdc
	2N739, 2N740		80	-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N736	BV_{CBO}	80	-	Vdc
	2N739, 2N740		125	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	-	1.0	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N739	h_{FE}	30	100	-
	2N736, 2N740		60	200	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.0 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 2.0 mAdc)		V_{BE}	0.35	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	10	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N739	h_{ie}	-	1500	Ohm
	2N736, 2N740		-	1800	
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 Hz)	2N739	h_{fe}	40	100	-
	2N736, 2N740		80	200	

* Indicates JEDEC Registered Data

(1)Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

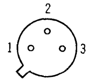
2N741,A (Ge Mesa)



CASE 22-03
(TO-18)

Collector connected to case

PNP germanium mesa transistors for oscillator, frequency multiplier and amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N741	2N741A	Unit
Collector-Emitter Voltage	V_{CE}	15	20	Vdc
Collector-Base Voltage	V_{CB}	15	20	Vdc
Emitter-Base Voltage	V_{EB}	1.0		Vdc
Collector Current - Continuous	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0		mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4.0		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

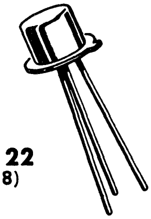
*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N741 2N741A	BV_{CBO}	15 20	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1.0	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0) (V_{CE} = 20 Vdc, V_{BE} = 0)	2N741 2N741A	I_{CES}	- -	100 100	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	3.0	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc)		h_{FE}	10	-	-
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 100 MHz)	2N741 2N741A	f_T	- 300	- -	MHz
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	10	pF
Small-Signal Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc, f = 1 kHz)		h_{fe}	20	-	-
Input Impedance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 1 kHz)		h_{ib}	-	15	Ohms
Power Gain, Matched, Neutralized (V_{CB} = 6 Vdc, I_E = 5 mAdc, f = 30 MHz)		G_{pe}	16	-	dB

*Indicates JEDEC Registered Data

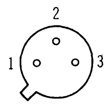
2N744 (SILICON)



CASE 22
(TO-18)

Collector connected to case

NPN silicon annular transistor for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

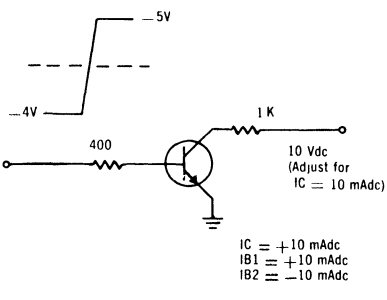
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage(1)	V_{CEO}	12*	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector DC Current	I_C	200	mAdc
Total Device Dissipation at 25°C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25°C Ambient Temperature Derate above 25°C	P_D	0.3 2.0	Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +200	°C

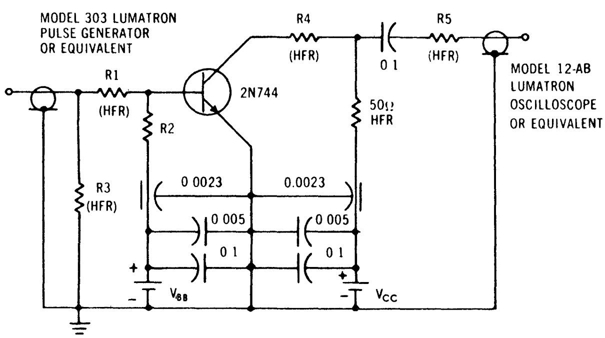
* Indicates JEDEC Registered Data

(1)Refers to the voltage at which the magnitude of h_{FE} approaches one when the emitter-base diode is open-circuited.

SWITCHING TIME TEST CIRCUIT



CHARGE STORAGE TEST CIRCUIT



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CE} = 20 Vdc, I_E = 0) (V_{CE} = 20 Vdc, I_B = 0, T_A = 170°C)	I_{CES}	 – –	 .005 –	 1.0 100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.35 Vdc, T_A = 100°C)	I_{CEX}	–	–	30	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	–	–	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)*	BV_{CEO}	12	30	–	Vdc
Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 0.25 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)(1)	h_{FE}	 20 40 20 20	 – – – –	 – 120 – –	–
Small Signal Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	2.8	4.5	–	–
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 10 mAdc, I_B = 1 mAdc, T_A = -55°C) (I_C = 100 mAdc, I_B = 10 mAdc)(1) (I_C = 100 mAdc, I_B = 10 mAdc, T_A = -55°C)(1)	V_{BE}	 0.7 – – –	 – – – –	 0.85 1.1 1.5 1.6	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc, T_A = 170°C) (I_C = 100 mAdc, I_B = 10 mAdc, T_A = 170°C)(1)	$V_{CE(sat)}$	 – –	 – –	 0.35 1.0	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0)	C_{ob}	–	3.0	5.0	pF
Turn-on Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{on}	 – – – –	 26 10 7.0 6.0	 – 16 – 12	ns
Turn-off Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{off}	 – – – –	 30 17 18 23	 – 24 – 45	ns
Charge Storage Time Constant (I_C = 10 mAdc, I_{B1} = $-I_{B2}$ = 10 mAdc)	τ_s	–	–	18	ns

(1) Pulse Test: Pulse width ≦ 300 μs, duty cycle ≦ 2%

CONDITION	I_C mA	I_{B1} mA	I_{B2} mA	$V_{BE(off)}$ Vdc	V_{CC} Vdc	$R_1 = R_2$ Ω	R_3 Ω	R_4 Ω	R_5 Ω	t_{on} V_{BB} V	t_{on} V_{IN} V	t_{off} V_{BB} V	t_{off} V_{IN} V
1	3	1	-0.5	-0.9	3.4	6.8 K	50	1 K	0	-1.8	10.2	8.4	-10.2
2	10	3	-1.5	-1.5	3.0	3.3 K	50	220	0	-3.0	15.0	12.0	-15.0
3	50	15	-7.5	-1.8	4.0	680	50	18	1 K	-3.5	15.3	** 1.7	-15.3
4	100	40	-20.0	-2.4	6.0	330	56	0	1 K	-4.5	20.0	** 5.3	-20.0

* Indicates JEDEC Registered Data

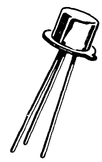
** V_{BB} is pulsed for 1.5 s @ less than 10% duty cycle

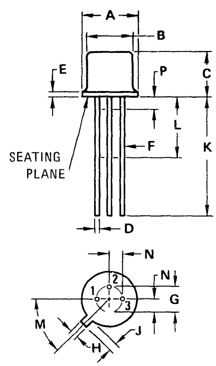
NPN SILICON SWITCHING TRANSISTOR

NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in high-speed saturated switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CER} = 20 Vdc (Min) @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 10 mAdc
- High Current-Gain—Bandwidth Product — f_T = 400 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Times — t_{on} = 40 ns (Max) t_{off} = 75 ns (Max)





STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	150	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	500	°C/W

* Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, R_{BE} = 10 Ohms)	BV_{CER}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)		–	–	0.5	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		–	–	30	
(V_{CB} = 25 Vdc, I_E = 0)		–	–	10	
Collector-Emitter Cutoff Current (V_{CE} = 20 Vdc, R_{BE} = 100 k Ohms)	I_{CER}	–	–	10	μAdc
Emitter-Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	70	120	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	0.3	0.6	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	0.3	–	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.8	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	4.0	5.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, $V_{BE(off)}$ = 2.0 Vdc, I_{B1} = 1.2 mAdc)	t_{on}	–	30	40	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 1.2 mAdc, I_{B2} = 0.5 mAdc)	t_{off}	–	60	75	ns
Storage Time (Figure 2) (V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	–	19	35	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

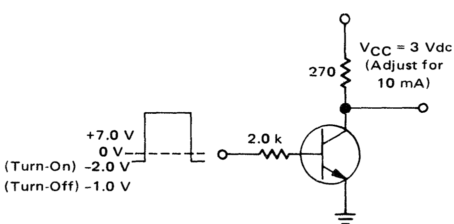
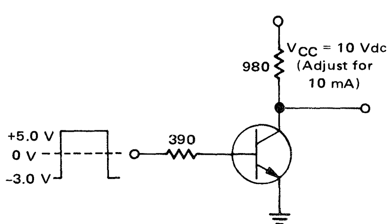
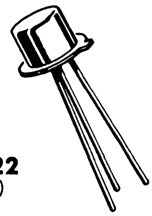


FIGURE 2 — STORAGE TIME TEST CIRCUIT



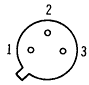
2N827 (Ge Mesa)



CASE 22
(TO-18)

Collector connected to case

PNP germanium mesa transistor for high-speed switching applications.



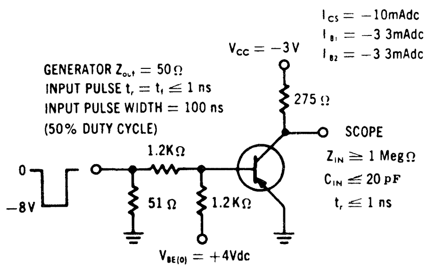
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage	V_{CES}	20	Vdc
Collector-Emitter Voltage	V_{CEX}	10	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to + 100	°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C

*Indicates JEDEC Registered Data

FIGURE 1 - SWITCHING TIME TEST CIRCUIT

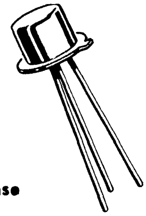


* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4	---	Vdc
Collector Latch-up Voltage	LV_{CEX}	10	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	---	5.0	μAdc
Collector-Base Cutoff Current (V_{CB} = 15 Vdc)	I_{CBO}	---	5.0	μAdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	100	---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.25	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1 V, f = 100 MHz)	h_{fe}	2.5	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	---	9.0	pF
Delay Time (Figure 1)	t_d	---	15	ns
Rise Time (Figure 1)	t_r	---	20	ns
Storage Time (Figure 1)	t_s	---	30	ns
Fall Time (Figure 1)	t_f	---	30	ns

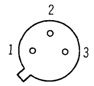
*Indicates JEDEC Registered Data

2N828 (Ge Mesa)



CASE 22-03
(TO-18)
Collector
connected to case

PNP germanium epitaxial mesa transistor for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4.0	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

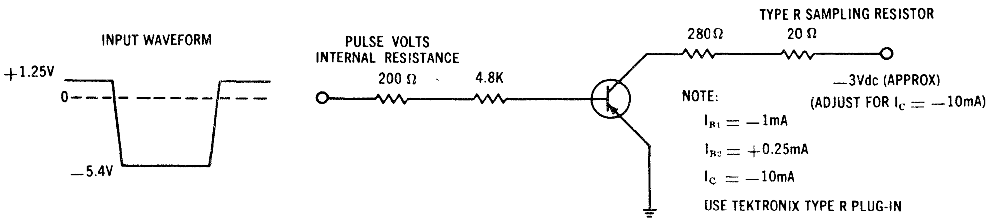
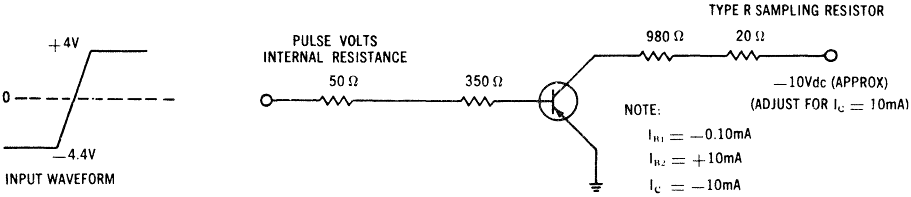


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT

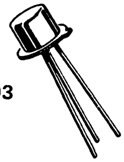


*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	–	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	I_{CBO}	–	3.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	25	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	 – –	 0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.34	0.44	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	300	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	–	–	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	h_{fe}	3.0	–	–
Delay Plus Rise Time (Figure 1)	$t_d + t_r$	–	70	ns
Storage Time (Figure 1)	t_s	–	50	ns
Fall Time (Figure 1)	t_f	–	50	ns
Charge Storage Time Constant (Figure 2)	τ_s	–	25	ns
Rise Time	t_r	–	–	ns
Storage Time	t_s	–	–	ns
Fall Time	t_f	–	–	ns

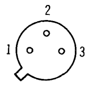
*Indicates JEDEC Registered Data.

2N828A (Ge Mesa)



CASE 22-03
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistors for high- speed switching applications

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector to Base Voltage	V_{CB}	15	Vdc
Collector to Emitter Voltage	V_{CES}	15	Vdc
Emitter to Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to +100	°C

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector to Base Breakdown Voltage $I_E = 0$, $I_C = 100\mu Adc$	BV_{CBO}	15	--	Vdc
Collector to Emitter Breakdown Voltage $V_{EB} = 0$, $I_C = 100\mu Adc$	BV_{CES}	15	--	Vdc
Emitter to Base Breakdown Voltage $I_C = 0$, $I_E = 100\mu Adc$	BV_{EBO}	2.5	--	Vdc
Collector Cutoff Current $I_E = 0$, $V_{CB} = 6Vdc$	I_{CBO}	--	3.0	μAdc
Forward Current Transfer Ratio $I_C = 10mAdc$, $V_{CE} = 0.3Vdc$	h_{FE}	25	--	--
Forward Current Transfer Ratio $I_C = 150mAdc$, $V_{CE} = 1Vdc$	h_{fe}	25	--	--
Collector Saturation Voltage $I_C = 10mAdc$, $I_B = 1.0\ mAdc$	$V_{CE(sat)}$	--	0.20	Vdc
Collector Saturation Voltage $I_C = 50mAdc$, $I_B = 5.0mAdc$	$V_{CE(sat)}$	--	0.25	Vdc
Collector Saturation Voltage $I_C = 150mAdc$, $I_B = 15mAdc$	$V_{CE(sat)}$	--	0.50	Vdc
Base to Emitter Voltage $I_C = 10mAdc$, $I_B = 1mAdc$	V_{BE}	0.34	0.44	Vdc
Base to Emitter Voltage $I_C = 150mAdc$, $I_B = 15mAdc$	V_{BE}	--	0.85	Vdc
Collector Capacitance $I_E = 0$, $V_{CB} = 6Vdc$, f = 100 kHz)	C_{ob}	--	4.0	pF

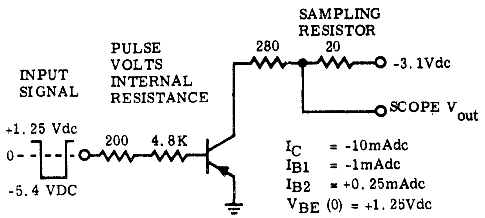
*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance V_{BE} = 1Vdc, I_E = 0, f = 100 kHz)	C_{ib}	--	3.5	pF
Small Signal Forward Current Transfer Ratio I_C = 10mAdc, V_{CE} = -1Vdc, f = 100 MHz	h_{fe}	3.0	--	--
Current Gain Bandwidth Product V_{CE} = 1Vdc, I_C = -10mAdc, f = 100 MHz	f_T	300	--	MHz
Delay Plus Rise Time (Fig. 1) I_C = 10mAdc	t_{on}	--	50	ns
Storage Time (Fig. 1) I_C = 10mAdc	ts	--	50	ns
Fall Time (Fig. 1) I_C = 10mAdc	tf	--	50	ns
Total Control Charge (Fig. 3) I_C = 10mAdc	Q_T	--	80	pC
Delay Plus Rise Time (Fig. 2) I_C = 150mAdc	t_{on}	--	50	ns
Turn Off Time (Fig. 2) I_C = 150mAdc	t_{off}	--	100	ns
Total Control Charge (Fig. 4) I_C = 150mAdc	Q_T	--	175	pC

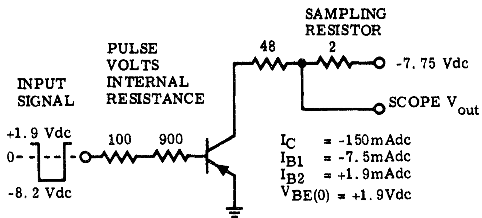
*Indicates JEDEC Registered Data

FIGURE 1 — 10mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20 pF
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE t_r = t_f = 2ns

FIGURE 2 — 150mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20 pF
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE t_r = t_f = 2ns

FIGURE 3 — 10mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -5.4 VOLT PULSE AT POINT A

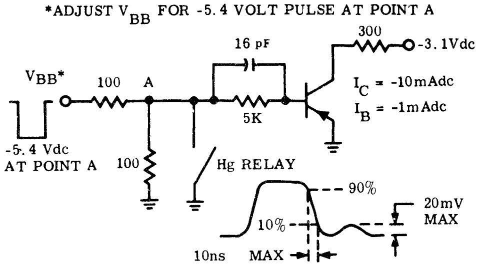
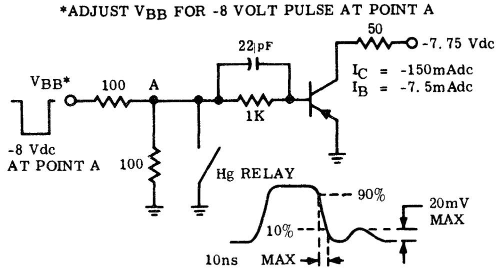
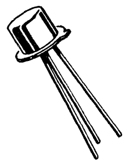


FIGURE 4 — 150mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -8 VOLT PULSE AT POINT A



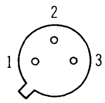
2N834 (SILICON)
2N835



NPN silicon epitaxial transistors for high- speed switching applications.

CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N834	2N835	Unit
Collector-Emitter Voltage	V_{CES}	30	20	Vdc
Collector-Base Voltage	V_{CB}	40	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	3.0	Vdc
Collector Current-Continuous Peak	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2.0		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67		Watt mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5 6.67		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT

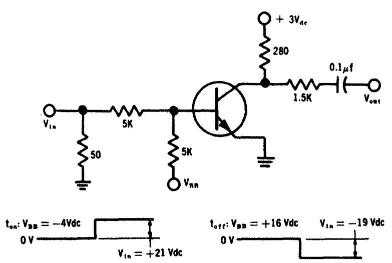
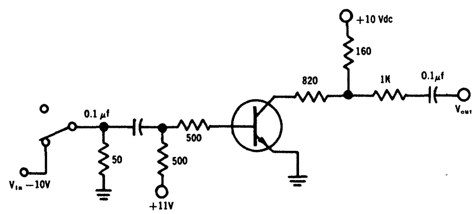


FIGURE 2 — CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

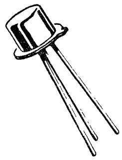
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N834	BV_{CBO}	40	-	Vdc
	2N835		25	-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N834	BV_{EBO}	5.0	-	Vdc
	2N835		3.0	-	
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	2N834	I_{CES}	-	10	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N835		-	10	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	0.5	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			-	30	
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N834	h_{FE}	25	-	-
	2N835		20	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N834	($V_{CE(sat)}$	-	0.25	Vdc
	2N835		-	0.30	
(I_C = 50 mAdc, I_B = 5 mAdc)(1)	2N834		-	0.4	
	2N835		-	-	
Base-Emitter Saturation Voltage(1) (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	f_T	350	-	MHz
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		300	-	
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	$\|h_{fe}\|$	3.5	-	-
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		3.0	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	pF
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	2N834	t_s	-	25	ns
	2N835		-	35	
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834	t_{on}	-	33	ns
	2N835		-	20	
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834	t_{off}	-	75	ns
	2N835		-	35	

* Indicates JEDEC Registered Data

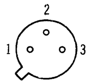
(1)Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2%

2N838 (Ge Mesa)



CASE 22-03
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP germanium mesa transistor for high-speed switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Emitter Voltage	V_{CEX}	15	Vdc
Emitter-Base Boltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	^oC
Storage Temperature	T_{stg}	-65 to+ 100	^oC
Device Dissipation @ $T_A = 25^oC$ (Derate 2mW/^oC above 25^oC)	P_D	150 2.0	mW mW/^oC

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

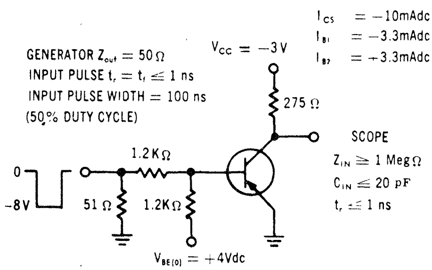
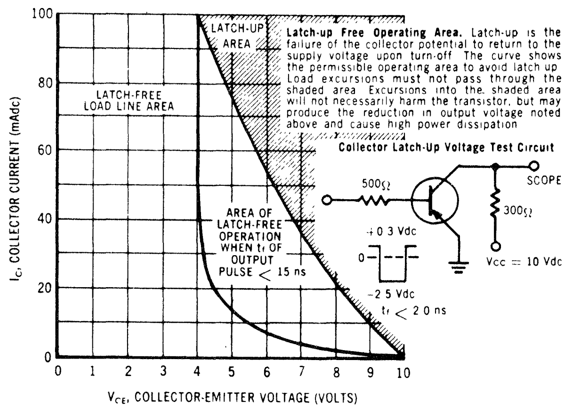


FIGURE 2 — AREA OF PERMISSIBLE LOAD LOCI

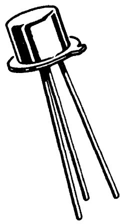


*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

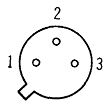
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	30	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	---	Vdc
Collector Latch-up Voltage (see Figure 2)	LV_{CEX}	15	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	---	10	μAdc
Collector-Base Cutoff Current (V_{CB} = 15 V, I_E = 0)	I_{CBO}	---	10	μAdc
DC Forward Current Transfer Ratio (I_C = 10mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	30	---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.18	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1V, f = 100 MHz)	h_{fe}	3.0	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	C_{ob}	---	4.0	pF
Delay Time (Figure 1)	t_d	---	15	ns
Rise Time (Figure 1)	t_r	---	15	ns
Storage Time (Figure 1)	t_s	---	20	ns
Fall Time (Figure 1)	t_f	---	20	ns

*Indicates JEDEC Registered Data

2N841 (SILICON)



NPN silicon annular transistor designed for small-signal amplifier and general purpose switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage	V_{CES}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	2.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.0	-	Vdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0, R_{BE} = 5.0 k ohms)	I_{CER}	-	20	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	I_{CBO}	-	1.0	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)		-	50	
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	50	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	60	400	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.2 mAdc)	$V_{CE(sat)}$	-	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)	f_T	2.0	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	15	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	80	330	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz, T_A = -55°C)		25	-	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	-	1.2	μmhos
Input Resistance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	-	80	Ohms
Output Conductance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	1.2	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	$Re(h_{ie})$	-	500	Ohms

*Indicates JEDEC Registered Data

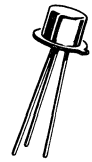
2N843 (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in general-purpose amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 45 Vdc (Min) @ I_C = 10 mAdc
- High Current-Gain—Bandwidth Product — f_T = 250 MHz (Typ) @ I_C = 10 mAdc

NPN SILICON AMPLIFIER TRANSISTOR



MAXIMUM RATINGS

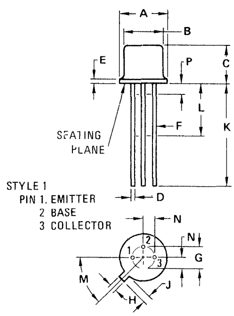
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	45	Vdc
*Collector-Base Voltage	V_{CB}	45	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current — Continuous	I_C	800	mAdc
*Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	300 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	1.3 8.7	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	115	°C/W

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5 31	5 84	0 209	0 230
B	4 52	4 95	0 178	0 195
C	4 32	5 33	0 170	0 210
D	0 406	0 533	0 016	0 021
E	–	0.762	–	0.030
F	0 406	0 483	0 016	0 019
G	2 54 BSC		0 100 BSC	
H	0.914	1.17	0 036	0 046
J	0 711	1 22	0 028	0 048
K	12 70	–	0.500	–
L	6 35	–	0 250	–
M	45° BSC		45° BSC	
N	1 27 BSC		0 050 BSC	
P	–	1.27	–	0 050

All JEDEC notes and dimensions apply

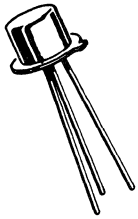
CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 – –	 1.0 50	μAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, $R_{BE} \leqslant$ 5.0 kΩ)	I_{CER}	–	–	20	μAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	45	100	150	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.2 mAdc)	$V_{CE(sat)}$	–	0.3	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 2.2 mAdc)	$V_{BE(sat)}$	–	0.78	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	4.0	10	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	40	–	–	–

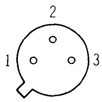
*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

2N869 (SILICON)



CASE 22
(TO-18)

Collector connected to case



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

PNP silicon annular transistor for high-frequency general-purpose amplifier applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation at 25°C Case Temperature at 100°C Case Temperature Derate above 25°C	P_D	 1.2 0.68 6.86	 Watts Watt mW/°C
Total Device Dissipation at 25°C Ambient Temperature Derate above 25°C	P_D	 0.36 2.06	 Watt mW/°C
Storage Temperature	T_{stg}	-65 to +200	°C
Junction Temperature	T_J	+200	°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	---	---	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sust)}$	18	---	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	---	---	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	---	---	010	μ Adc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		---	---	25	
Emitter Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	---	---	10	μ Adc
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	V_{CE} (sat)	---	0.17	1.0	Vdc
Base Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	V_{BE} (sat)	---	0.78	1.0	Vdc
DC Forward-Current Transfer Ratio(1) (I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	20	---	120	---
Open-Circuit Output Capacitance (V_{CB} = 10 V, I_E = 0)	C_{ob}	---	3.0	9	pF
Open-Circuit Input Capacitance (V_{BE} = 0.5 V, I_C = 0) Both Types	C_{ib}	---	7.0	11	pF
Small-Signal Forward-Current Transfer Ratio (I_C = 10 mA, V_{CE} = 15 V, f = 100 MHz)	h_{fe}	1.0	3.0	---	---

* Indicates JEDEC Registered Data

(1) Pulse Note: Pulse Width = 300 μs, Duty Cycle = 1%

2N869A (SILICON)
2N4453

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high speed, low power, saturated switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 18 Vdc (Min) – 2N869A, 2N4453
- JAN/JANTX/JANTXV Available for 2N869A and 2N4453
- Glass Passivated Die
- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 30 Vdc – Available as a Special
- Switching Times @ I_C = 30 mAdc, I_C/I_B = 10
  t_{on} = 9.0 ns (Typ)
  t_{off} = 44 ns (Typ)

SWITCHING TRANSISTORS

PNP SILICON

MAXIMUM RATINGS

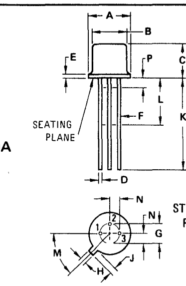
Rating	Symbol	2N869A	2N4453	Unit
*Collector-Emitter Voltage	V_{CEO}	18	18	Vdc
*Collector-Base Voltage	V_{CB}	25	25	Vdc
*Emitter-Base Voltage	V_{EB}	← 5.0 →		Vdc
*Collector Current — Continuous	I_C	← 200 →		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	360* 2.06	300* 1.71	mW mW/°C
Total Power Dissipation @ T_C = 25°C T_C = 100°C Derate above 25°C	P_D	1.2* 0.686* 6.86	1.8* 1.03 10.3	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N869A	2N4453	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	486	585	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	146	97.5	°C/W

*Indicates JEDEC Registered Data.

2N869A



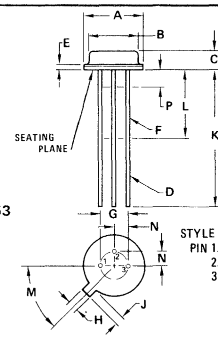
STYLE 1.
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22-03 (TO-18)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5 31	5 84	0.209	0.230
B	4.52	4 95	0.178	0.195
C	4 32	5 33	0.170	0 210
D	0.406	0 533	0.016	0.021
E	–	0 762	–	0 030
F	0 406	0.483	0 016	0.019
G	2 54 BSC		0 100 BSC	
H	0.914	1 17	0.036	0 046
J	0.711	1 22	0 028	0.048
K	12 70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1 27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply

2N4453



STYLE 1.
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 26-03 TO-46

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5 31	5.84	0.209	0 230
B	4 52	4.95	0.178	0.195
C	1 65	2.16	0.065	0 085
D	0 406	0 533	0.016	0.021
E	–	1.02	–	0 040
F	0 305	0.483	0.012	0.019
G	2.54 BSC		0 100 BSC	
H	0 914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12 70	–	0 500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1 27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N869A, 2N4453	$V_{CEO(sus)}$	18	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	2N869A, 2N4453	BV_{CES}	25	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N869A	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	–	–	10	nAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N869A	I_{CBO}	–	–	25	μAdc
Emitter Cutoff Current (V_{EB} = 4.5 Vdc, I_C = 0)	2N4453	I_{EBO}	–	–	10	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N869A	I_B	–	–	10	nAdc
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N869A		30	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N869A		40	–	120	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)	2N869A		40	–	120	
	2N4453		40	–	–	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = −55°C)	2N869A		17	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N869A		25	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A		–	–	0.15	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		–	–	0.25	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A		–	–	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A		–	–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	2N869A		0.78	–	0.98	
(I_C = 30 mAdc, I_B = 1.5 mAdc)	2N4453		0.8	–	1.1	
(I_C = 30 mAdc, I_B = 3.0 mAdc)	2N869A		0.85	–	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N869A		–	–	1.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product (1),(2) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	400	–	–	MHz
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N4453	C_{eb}	–	–	6.0	pF
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N4453	C_{cb}	–	–	6.0	pF
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	2N869A	C_{ob}	–	–	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 150 kHz)	2N869A	C_{ib}	–	–	6.0	pF

SWITCHING CHARACTERISTICS (Figure 3)

Characteristic	Conditions		Symbol	Min	Typ	Max	Unit
Turn-On Time		V_{CC} = 2.0 Vdc, 2N869A	t_{on}	–	30	50	ns
Delay Time	I_C = 30 mAdc,	V_{CC} = 3.0 Vdc 2N4453	t_d	–	13	35	ns
Rise Time	I_{B1} = 1.5 mAdc	V_{CC} = 3.0 Vdc 2N4453	t_r	–	17	20	ns
Turn-Off Time	I_C = 30 mAdc,	V_{CC} = 2.0 Vdc 2N869A	t_{off}	–	60	80	ns
Storage Time	I_{B1} = I_{B2} =	V_{CC} = 3.0 Vdc 2N4453	t_s	–	43	65	ns
Fall Time	1.5 mAdc	V_{CC} = 3.0 Vdc 2N4453	t_f	–	17	20	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle = 1.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 1 – TURN-ON TIME

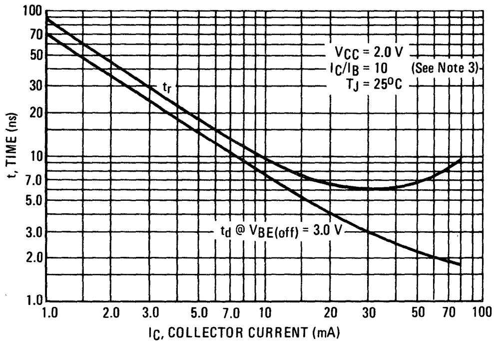


FIGURE 2 – TURN-OFF TIME

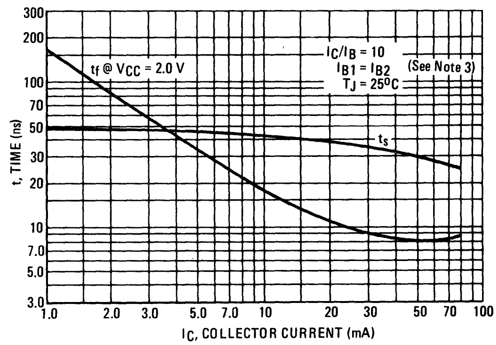


FIGURE 3 – SWITCHING TIME TEST CIRCUIT

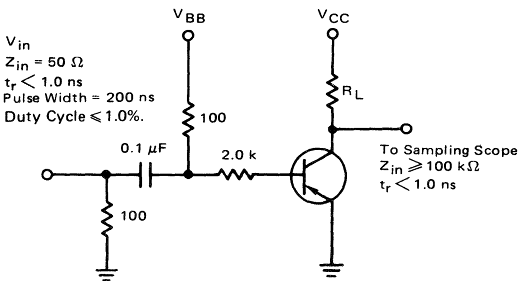


FIGURE 4 – CAPACITANCE

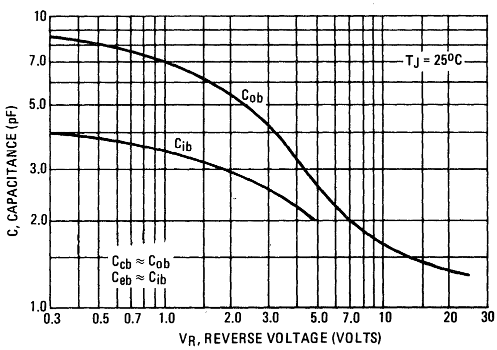


FIGURE 5 – SWITCHING TEST CIRCUIT VALUES

		V_{in} Volts	V_{BB} Volts	V_{CC} Volts	R_L Ohms	I_C mA	I_{B1}(4) mA	I_{B2}(4) mA
t_{on}, t_r, t_d	2N869A	-7.0	3.0	2.0	62	30	1.5	–
	2N4453	-7.0	3.0	3.0	91	30	1.5	–
t_{off}, t_s, t_f	2N869A	+6.0	-4.0	2.0	62	30	1.5	1.5
	2N4453	+6.0	-4.0	3.0	91	30	1.5	1.5

(3) I_C/I_B = 10. Switching is shown to reflect current industry practices. Compare the values shown in Figures 1 and 2 @ I_C = 30 mA to the typical values in the Electrical Characteristics table @ I_C/I_B = 20.

(4) $I_{B1} = I_{B2}$ = 3.0 mA @ I_C/I_B = 10

FIGURE 6 – DC CURRENT GAIN

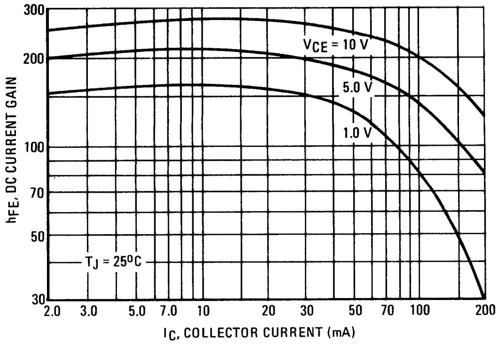


FIGURE 7 – "ON" VOLTAGES

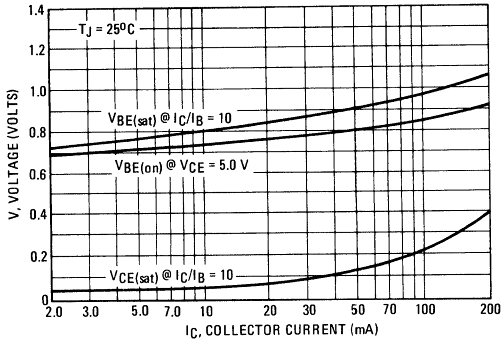
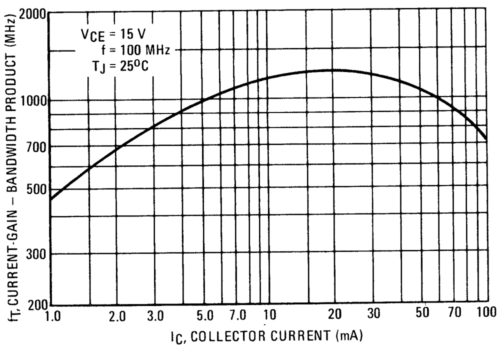


FIGURE 8 – CURRENT-GAIN – BANDWIDTH PRODUCT

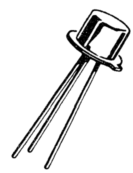


NPN SILICON ANNULAR TRANSISTOR

. . . designed for small-signal amplifier applications.

- High Collector-Emitter Sustaining Voltage — $V_{CEO(sus)} \geqslant 60$ Vdc (Min) @ $I_C = 30$ mAdc

NPN SILICON AMPLIFIER TRANSISTOR



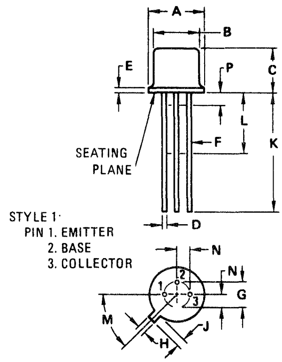
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	60	Vdc
*Collector-Emitter Voltage (R_{BE} = 10 Ohms)	V_{CER}	80	Vdc
*Collector-Base Voltage	V_{CB}	100	Vdc
*Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
*Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
*Total Power Dissipation @ $T_C = 25°C$ $T_C = 100°C$ Derate above 25°C	P_D	1.8 1.0 10.3	Watt mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	350	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	97.4	°C/W

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03 (TO-18)

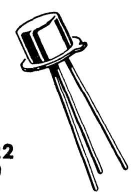
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, $R_{BE} \leqslant$ 10 ohms)	$V_{CER(sus)}$	80	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 75 Vdc, I_E = 0)		–	25	nAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		–	15	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	25	nAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		35	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = −55°C)		30	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	0.4	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.6	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	0.9	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	85	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} · 5.0 Vdc, f = 1.0 kHz)	h_{ie}	–	1800	Ohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	76	200	–
Output Admittance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	–	100	μmhos
Input Resistance	h_{ib}			Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		20	30	
(I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		4.0	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	–	3.0	$\times 10^{-4}$
Output Conductance	h_{ob}			μmho
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		–	0.5	
(I_C = 5.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		–	1.0	
Noise Figure (I_C = 0.3 mAdc, V_{CB} = 10 Vdc, R_G = 510 ohms, f = 1.0 kHz, B. W. = 200 Hz)	NF	–	12	dB

*Indicates JEDEC Registered Data.

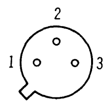
(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle = 2.0%.

2N914 (SILICON)
2N914 JAN, JTX Available



CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

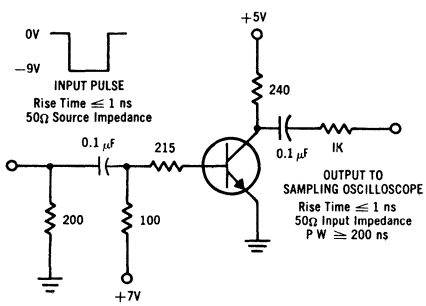
NPN silicon annular transistor for high-speed switching applications.

*MAXIMUM RATINGS

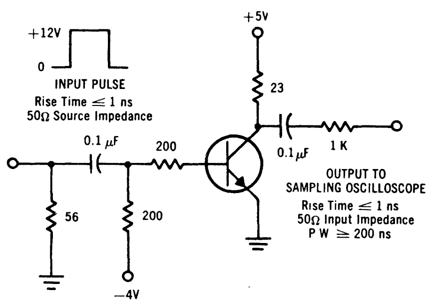
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current (Note 1)	I_C	150	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	360 2.06	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.2 6.9	Watts $mW/^oC$
Total Device Dissipation @ $T_C = 100^oC$	P_D	0.68	Watt
Operating Junction Temperature Range	T_J	200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.
Note 1: Limited by Power Dissipation

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



t_{on} and t_{off} TEST CIRCUIT



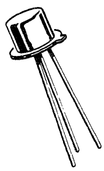
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage **(Note 1)** (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	15	-	Vdc
Collector-Emitter Sustaining Voltage **(Note 1)** (I_C = 30 mAdc, $R_{BE} \le$ 10 ohms)	$BV_{CER(sus)}$	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		-	15	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain **(Note 1)** (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	120	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	-	
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)		10	-	
Collector-Emitter Saturation Voltage **(Note 1)** (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	-	0.70	Vdc
(I_C = 10 mAdc, I_B = 1.0 thru 20 mAdc, T_A = -55 to +125°C)		-	0.25	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.70	0.80	Vdc
DYNAMIC CHARACTERISTICS				
†Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	9.0	pF
Charge Storage Time Constant **(Note 2)** ($I_C = I_{B1} = I_{B2}$ = 20 mAdc)	τ_s	-	20	ns
Turn-On Time **(Note 2)** (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{on}	-	40	ns
Turn-Off Time **(Note 2)** (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{off}	-	40	ns

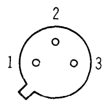
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤1.0%.
Note 2: Measured on Sampling Scope: Pulse Width ≥ 200 ns.
*Indicates JEDEC Registered Data.
†JEDEC Registration Defined as h_{fe}.

2N915 (SILICON)

CASE 22
(TO-18)



Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.9	 W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 0.36 2.06	 W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25^o$ C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		10	nA
Collector Cutoff Current @ 150°C $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		30	μ A
Collector Breakdown Voltage $I_C = 100\ \mu A$ $I_E = 0$	BV_{CBO}	70		Volts
Collector to Emitter Sustaining Voltage(1) $I_C = 10mA$ $I_B = 0$	V_{CEO}	50		Volts
Emitter Breakdown Voltage $I_C = 0$ $I_E = 100\ \mu A$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Volts
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		1.0	Volts
DC Pulse Current Gain $I_C = 10mA$ $V_{CE} = 5.0V$	h_{FE}	50	200	
Output Capacitance $I_E = 0$ $V_{CB} = 10V$	C_{ob}		3.5	pF
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pF
High Frequency Current Gain f = 100 MHz $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	2.5		
Small Signal Current Gain f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	μmho μmho

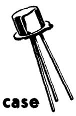
* Indicates JEDEC Registered Data

(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 1.0%

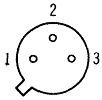
2N916 (SILICON)

2N916 JAN Available

CASE 22
(TO-18)



Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.9	 W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 .36 2.06	 W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +300	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	nAdc
Collector Cutoff Current @150° C $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	µAdc
Collector Breakdown Voltage $I_C = 10\mu A$ $I_E = 0$	BV_{CBO}	45		Vdc
Collector to Emitter Sustaining Voltage (1) $I_C = 30mA$ $I_B = 0$	V_{CEO}	25		Vdc
Emitter Breakdown Voltage $I_C = 0$ $I_E = 10\ \mu A$	BV_{EBO}	5.0		Vdc
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Vdc
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		0.5	Vdc
DC Pulse Current Gain (1) $I_C = 10mA$ $V_{CE} = 1.0V$	h_{FE}	50	200	—
Output Capacitance $I_E = 0$ $V_{CB} = 5.0V$	C_{ob}		6.0	pF
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pF
High Frequency Current Gain f = 100 MHz $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	3.0		—
Small Signal Current Gain f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1 kHz $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	µmho µmho

* Indicates JEDEC Registered Data

(1) **Pulse Test: Pulse Width ≦ 300 µs, Duty Cycle ≦ 1.0%**

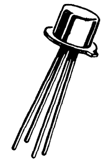
2N917 (SILICON)

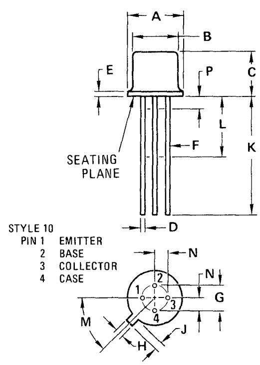
NPN SILICON ANNULAR VHF/UHF OSCILLATOR AMPLIFIER TRANSISTOR

. . . designed for use as both oscillator and amplifier at UHF and VHF frequencies.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 15 Vdc (Min) @ I_C = 3.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 900 MHz (Typ) @ I_C = 4.0 mAdc
- Low Output Capacitance — C_{ob} = 0.8 pF (Typ) @ V_{CB} = 10 Vdc
- Excellent Noise Figure — NF = 3.0 dB (Typ) @ I_C = 1.0 mAdc, f = 60 MHz
- High Power Output — P_{out} = 10 mW @ V_{CE} = 15 Volts

NPN SILICON VHF/UHF OSCILLATOR AMPLIFIER TRANSISTOR





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	15	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector-Current — Continuous	I_C	50	mAdc
*Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
*Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	875	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	583	°C/W
Lead Temperature 1/16″ From Case for 60 Seconds	T_L	300	°C

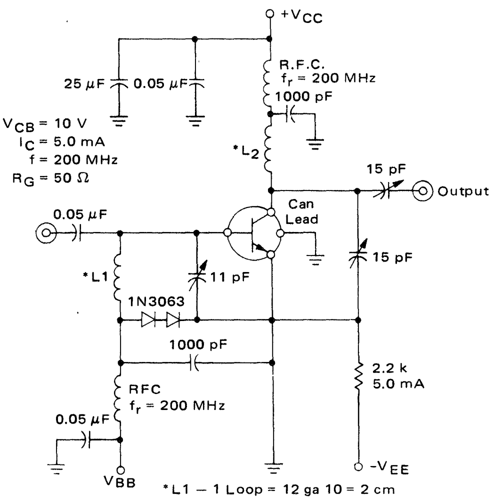
*Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 3.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				nAdc
(V_{CB} = 15 Vdc, I_E = 0)		–	–	1.0	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		–	–	100	
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	125	200	–
Collector-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)	$V_{CE(sat)}$	–	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 mAdc, I_B = 0.15 mAdc)	$V_{BE(sat)}$	–	0.78	0.87	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	500	900	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	0.8	1.7	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	0.9	1.6	pF
Collector-Base Time Constant (I_C = 4.0 mAdc, V_{CB} = 10 Vdc, f = 40 MHz)	$r_b'C_c$	–	–	75	ps
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 400 Ohms, f = 60 MHz)	NF	–	3.0	6.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1) (V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	9.0	–	–	dB
Power Output (Figure 2) (V_{CE} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_{out}	10	–	–	mW

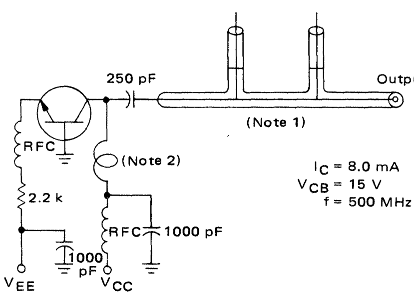
(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN



*L1 — 1 Loop = 12 ga 10 = 2 cm
L2 — 1/2 Loop = 12 ga 10 = 3 cm

FIGURE 2 – 500 MHz OUTPUT POWER OSCILLATOR



Notes:

1. Coax plumbing consists of the following GR air lines:*
   - 2 Type 874 TEE
   - 1 Type 874-D20 Adjustable Stub
   - 1 Type 874-LA Adjustable Line
   - 1 Type 874-WN3 Short-Circuit Termination
2. 2 turns #16 AWG wire, 3/8 inch OD, 1-1/4 inch long

*(or the equivalent)

2N918 (SILICON)

2N918 JAN, JTX AVAILABLE

NPN SILICON ANNULAR TRANSISTORS

. . . designed for use in VHF and UHF amplifier, mixer and oscillator applications.

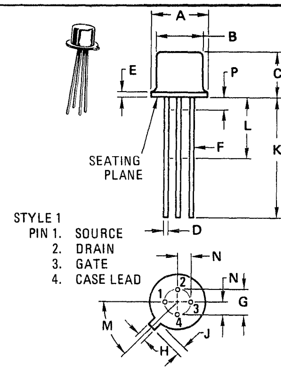
- High Current-Gain — Bandwidth Product —
  f_T = 600 MHz (Min) @ f = 100 MHz
- Low Output Capacitance —
  C_{ob} = 1.7 pF (Max) @ V_{CB} = 10 Vdc
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 15 Vdc (Min) @ I_C = 3.0 mAdc
- JAN/JANTX Also Available

NPN SILICON AMPLIFIER TRANSISTORS

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

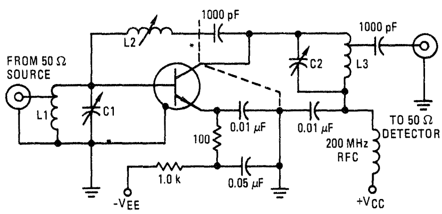


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

FIGURE 1 — NEUTRALIZED 200 MHz POWER AMPLIFIER GAIN TEST CIRCUIT

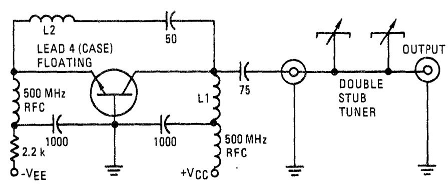


CIRCUIT COMPONENT INFORMATION:

C1: 3.0-12 pF
C2: 1.5-7.5 pF
L1: 3 1/2 turns #16 AWG 5/16" ID, 7/16" length, turns ratio -2 to 1
L2: 0.4-0.65 µH Miller #4303 (or equal)
L3: 8 turns #16 AWG 1/8" ID, 7/8" length, turns ratio – 8 to 1

*External interlead shield to isolate collector lead from emitter and base leads.

FIGURE 2 — 500 MHz OSCILLATOR TEST CIRCUIT



CIRCUIT COMPONENT INFORMATION:

L1: 2 turns #16 AWG, 3/8" OD, 1 1/4" length
L2: 9 turns #22 AWG, 3/16" OD, 1/2" length

Capacitance values are in pF.

Double Stub Tuner consists of the following commercially available components.

2 GR Type 874 TEE
1 GR Type 874-D20 Adjustable Stub
1 GR Type 874-LA Adjustable Line
1 GR Type 874-WN3 Short-Circuit Termination
(or equivalents)

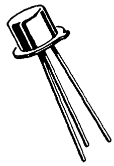
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 15 Vdc, I_E = 0)		–	.010	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (1) (I_C = 4.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	600	–	MHz
Output Capacitance	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		–	1.7	
(V_{CB} = 0, I_E = 0, f = 140 kHz)		–	3.0	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	2.0	pF
Noise Figure (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_G = 400 Ohms, f = 60 MHz)	NF	–	6.0	dB
FUNCTIONAL TEST				
Amplifier Power Gain (Figure 1) (V_{CB} = 12 Vdc, I_C = 6.0 mAdc, f = 200 MHz)	G_{pe}	15	–	dB
Power Output (Figure 2) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	P_{out}	30	–	mW
Collector Efficiency (Figure 2) (V_{CB} = 15 Vdc, I_C = 8.0 mAdc, f = 500 MHz)	η	25	–	%

*Indicates JEDEC Registered Data.

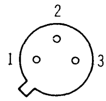
(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

2N929, A (SILICON)
2N930, A
2N929 JAN,JTX AVAILABLE
2N930 JAN,JTX AVAILABLE



NPN silicon annular transistors for low-level, low-noise amplifier applications.

CASE 22
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N929 2N930	2N929A 2N930A	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current	I_C	30		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33		W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 12		Watt mW/°C
Operating Junction Temperature Range	T_J	-65to + 175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

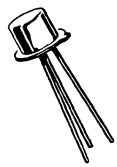
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N929A, 2N930A	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N929, 2N930	BV_{EBO}	5.0	-	Vdc
	2N929A, 2N930A		6.0	-	
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	-	2.0	nAdc
Collector Cutoff Current (V_{CE} = 45 Vdc, V_{BE} = 0)	2N929, 2N930	I_{CES}	-	10	nAdc
	2N929A, 2N930A		-	2.0	
(V_{CE} = 45 Vdc, V_{BE} = 0, T_A = 170°C)	2N929, 2N930		-	10	μAdc
	2N929A, 2N930A		-	2.0	
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N929, 2N930	I_{CBO}	-	10	nAdc
	2N929A, 2N930A		-	2.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N929, 2N930	I_{EBO}	-	10	nAdc
	2N929A, 2N930A		-	2.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N929A	h_{FE}	25	-	-
	2N930A		60	-	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N929, 2N929A		40	120	
	2N930, 2N930A		100	300	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N929		10	-	
	2N929A		15	-	
	2N930		20	-	
	2N930A		30	-	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N929, 2N929A		60	-	
	2N930, 2N930A		150	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (1)	2N929, 2N929A		-	350	
	2N930, 2N930A		-	600	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N929, 2N930	$V_{CE(sat)}$	-	1.0	Vdc
	2N929A, 2N930A		-	0.5	
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 0.5 mAdc)	2N929, 2N930 2N929A, 2N930A	$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)	2N929, 2N930	f_T	30	-	MHz
	2N929A, 2N930A		45	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	2N929, 2N930	C_{ob}	-	8.0	pF
	2N929A, 2N930A		-	6.0	
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{rb}	-	600	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N929, 2N929A	h_{fe}	60	350	-
	2N930, 2N930A		150	600	
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	2N929, 2N929A	NF	-	4.0	dB
	2N930, 2N930A		-	3.0	

* Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

2N956

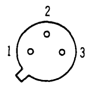
For Specifications, See 2N718A Data

2N960 (Ge Mesa)
2N961
2N962
2N962JAN AVAILABLE
2N964
2N964JAN AVAILABLE
2N965
2N966



PNP germanium mesa transistors for high-speed switching applications.

CASE 22-03
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Characteristic	Symbol	2N960 2N964	2N961 2N965	2N962 2N966	Unit
Collector-Emitter Voltage	V_{CE}	15	12	12	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D		150 2.0		mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D		300 4.0		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}		-65 to +100		^oC

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N960, 2N964	BV_{CBO}	15	-	Vdc
	2N961, 2N962, 2N965, 2N966		12	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N960, 2N964	BV_{EBO}	2.5	-	Vdc
	2N961, 2N965		2.0	-	
	2N962, 2N966		1.25	-	
Collector-Latch-up Voltage V_{CC} = 11.5 Vdc		LV_{CEX}	11.5	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc)	2N960, 2N964	I_{CES}	-	100	μAdc
(V_{CE} = 12 Vdc)	2N961, 2N962, 2N965, 2N966		-	100	
Collector-Base Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	3.0	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N960, 2N961, 2N962	h_{FE}	20	-	-
	2N964, 2N965, 2N966		40	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	-	
	2N964, 2N965, 2N966		40	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	-	
	2N964, 2N965, 2N966		40	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N964, 2N965, 2N966	$V_{CE(sat)}$	-	0.18	Vdc
	2N960, 2N961, 2N962		-	0.20	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N964, 2N965, 2N966		-	0.35	
	2N960, 2N961, 2N962		-	0.40	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N964, 2N965, 2N966		-	0.60	
	2N960, 2N961, 2N962		-	0.70	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	All Types	$V_{BE(sat)}$	0.30	0.50	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types		0.40	0.75	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N960, 2N961, 2N964, 2N965		0.40	1.00	
	2N962, 2N966		0.40	1.25	
Current-Gain – Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1.0 Vdc, f = 100 MHz)		f_T	300	-	MHz

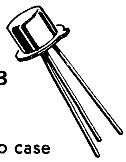
*Indicates JEDEC Registered Data

* ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	-	4.0	pF
Emitter Transition Capacitance (V_{EB} = 1 Vdc)	C_{Te}	-	3.5	pF
Turn-On Time	t_{on}			ns
(I_C = 10 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)		-	50	
(I_C = 100 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)		-	50	
Turn-Off Time	t_{off}			ns
(I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc) 2N960, 2N961, 2N964, 2N965		-	85	
2N962, 2N966		-	100	
(I_C = 100 mAdc, I_{B1} = 5 mAdc, I_{B2} = 1.25 mAdc) 2N960, 2N961, 2N964, 2N965		-	85	
2N962, 2N966		-	100	
Total Control Charge	Q_T			pC
(I_C = 10 mAdc, I_B = 1 mAdc) 2N960, 2N961, 2N964, 2N965		-	80	
2N962, 2N966		-	90	
(I_C = 100 mAdc, I_B = 5 mAdc) 2N960, 2N961, 2N964, 2N965		-	125	
2N962, 2N966		-	150	

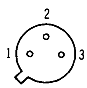
*Indicates JEDEC Registered Data

2N963 (Ge Mesa)
2N967



CASE 22-03
(TO-18)
Collector
connected to case

PNP germanium epitaxial mesa transistors for high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	100	°C

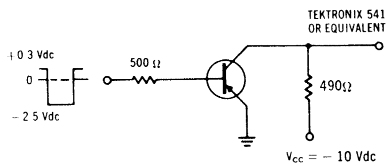
*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

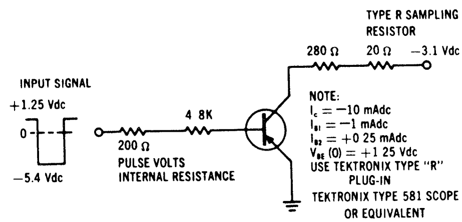
Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2.0	-	Vdc
Collector-Latch-up Voltage (V_{CC} = 10 Vdc)		LV_{CEX}	10	-	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, V_{BE} = 0)		I_{CES}	-	100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, $T_A = 55^oC$)		I_{CEX}	-	20	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	5.0	μAdc
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, $T_A = 55^oC$)		I_{BL}	-	20	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N963 2N967	h_{FE}	20 40	- -	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc		$V_{CE(sat)}$	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	0.3	0.5	Vdc
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	4.0	pF
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, $V_{BE(off)}$ = 1.25 Vdc)		t_{on}	-	60	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 1.25 mAdc)		t_{off}	-	120	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)		Q_T	-	120	pC

*Indicates JEDEC Registered Data

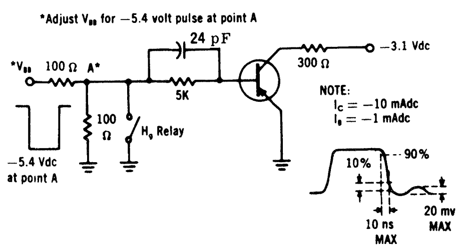
COLLECTOR LATCH-UP VOLTAGE TEST CIRCUIT



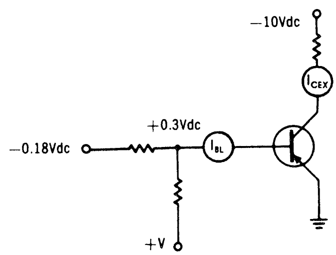
10-mA (I_C) SWITCHING TIME TEST CIRCUIT



BASE AND COLLECTOR CUTOFF CURRENT TEST CIRCUIT



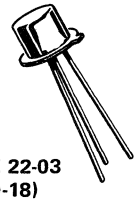
10-mA (I_C) TOTAL CONTROL CHARGE TEST CIRCUIT



2N964 (Ge Mesa)

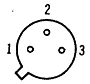
For Specifications, See 2N960 Data.

2N964A (Ge Mesa)



CASE 22-03
(TO-18)
Collector Connected to Case

PNP germanium mesa transistor for high- speed switching applications.



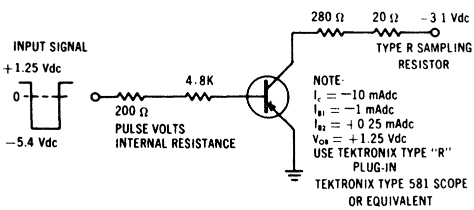
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4.0	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

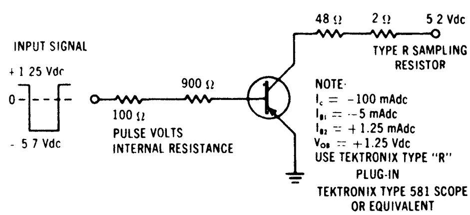
*Indicates JEDEC Registered Data

FIGURE 1



10-mA (I_C) SWITCHING TIME TEST CIRCUIT

FIGURE 2



100-mA (I_C) SWITCHING TIME TEST CIRCUIT

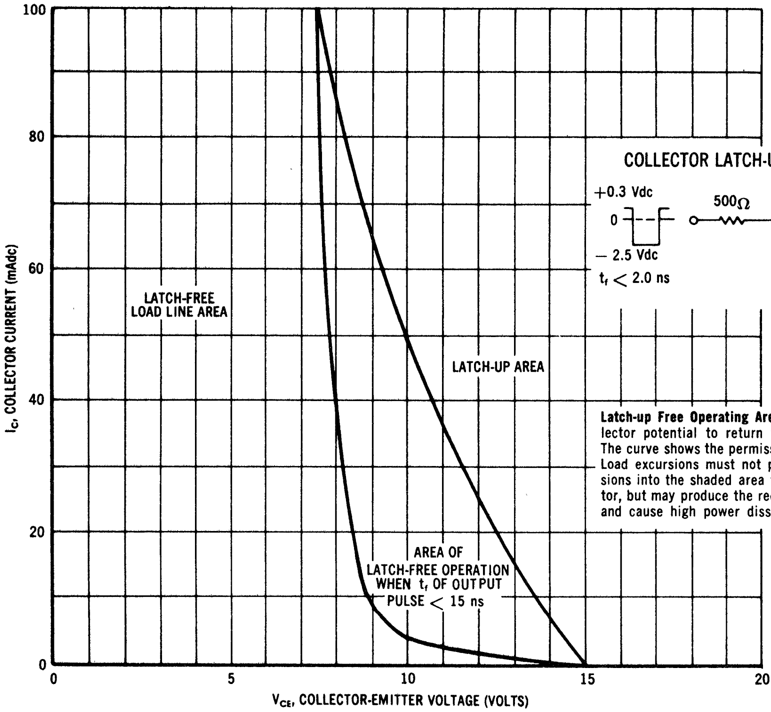
* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	7.0	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	-	Vdc
Collector Latch-up Voltage	LV_{CEX}	11.5	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	100	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	I_{CBO}	-	3.0	μAdc
Base Leakage Current	I_{BL}			μAdc
(V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		-	4.0	
(V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_J = 85°C)		-	140	
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		40	-	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_J = -55°C)		20	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)		48	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)		40	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc, T_J = 85°C)		35	-	
Collector Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.18	
(I_C = 50 mAdc, I_B = 5 mAdc)		-	0.28	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.4	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		0.3	0.44	
(I_C = 50 mAdc, I_B = 5 mAdc)		0.4	0.58	
(I_C = 100 mAdc, I_B = 10 mAdc)		0.4	0.72	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1 Vdc, f = 100 MHz)	f_T	300	-	MHz
High-Frequency Current Gain (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	h_{fe}	3.0	-	-
Output Capacitance	C_{ob}			pF
(V_{CB} = 1 Vdc, I_E = 0, f = 1 MHz)		-	5.0	
(V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		-	4.0	
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	3.5	pF
Delay Time Plus Rise Time	$t_d + t_r$			ns
(I_C = 10 mAdc)		-	50	
(I_C = 100 mAdc)		-	50	
Storage Time Plus Fall Time	$t_s + t_f$			ns
(I_C = 10 mAdc)		-	85	
(I_C = 100 mAdc)		-	85	
Active Region Time Constant (I_C = 10 mAdc)	τ_A	-	1.5	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	Q_T	-	75	pC

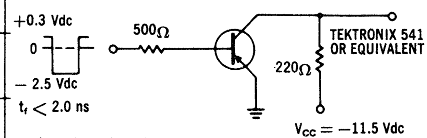
*Indicates JEDEC Registered Data

2N964A LIMIT CURVES

FIGURE 3—AREA OF PERMISSIBLE LOAD LOCI



COLLECTOR LATCH-UP VOLTAGE TEST CIRCUIT



Latch-up Free Operating Area. Latch-up is the failure of the collector potential to return to the supply voltage upon turn-off. The curve shows the permissible operating area to avoid latch-up. Load excursions must not pass through the shaded area. Excursions into the shaded area will not necessarily harm the transistor, but may produce the reduction in output voltage noted above and cause high power dissipation.

2N965 (Ge Mesa)
2N966

For Specifications, See 2N960 Data.

2N967 (Ge Mesa)

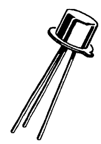
For Specifications, See 2N963 Data.

PNP SILICON AMPLIFIER TRANSISTOR

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose amplifier applications.

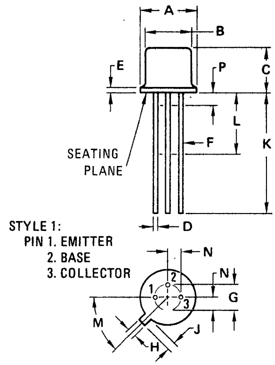
- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 20 Vdc (Min) @ I_C = 100 mAdc



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltate	V_{EB}	5.0	Vdc
Collector Current	I_C	600	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25°C	P_D	0.33 2.64	Watt mW/°C
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	1.25 10	Watts mW/°C
Operating Junction Temperature	T_J	150	°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 200	°C

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

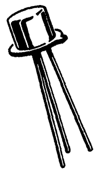
CASE 22-03
(TO-18)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

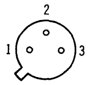
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	30	–	Vdc
Collector Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 10 Vdc, I_E = 0		–	5.0	
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		–	200	
Emitter Cutoff Current (V_{EB} = 1.0 Vdc, I_C = 0)	I_{EBO}	–	200	μAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		15	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		15	60	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	45	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	h_{fe}	2.0	–	–

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

2N985 (Ge Mesa)



CASE 22-03
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

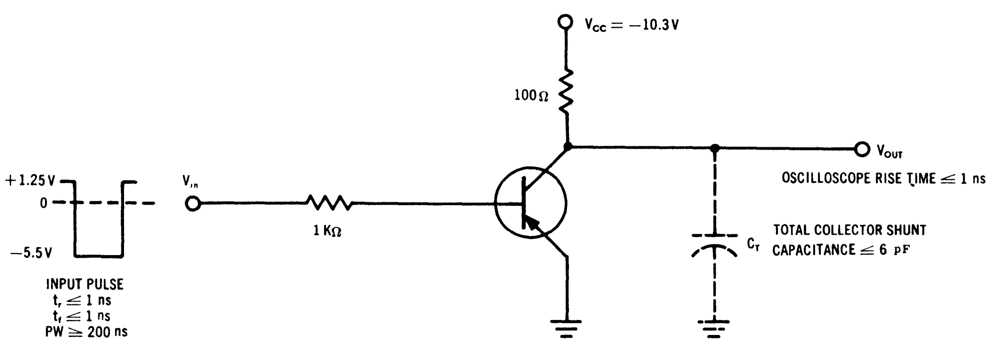
PNP germanium mesa transistor for high-speed switching applications.

* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	200	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C

*Indicates JEDEC Registered Data

SWITCHING TIME TEST CIRCUIT



*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 5 mAdc, I_B = 0)	BV_{CEO}	7.0	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, R_{BE} = 0)	BV_{CES}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	—	3.0	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.25 Vdc) (I_C = 100 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	 40 60	 — —	—
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 100 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	 — —	 0.15 0.30	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc) (I_C = 100 mAdc, I_B = 5 mAdc)	V_{BE}	 0.28 0.40	 0.40 0.60	Vdc
Small Signal Current Gain (V_{CE} = 2 Vdc, I_C = 30 mAdc, f = 100 MHz)	$\|h_{fe}\|$	3.0	—	—
Collector Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	6.0	pF
Turn-on Time (I_C = 10 mAdc, I_{B1} = 5 mAdc, $V_{BE(0)}$ = 1.25 Vdc)	t_{on}	—	35	ns
Turn-off Time (I_C = 10 mAdc, I_{B1} = 5 mAdc, I_{B2} = 1.25 mA)	t_{off}	—	80	ns

*Indicates JEDEC Registered Data

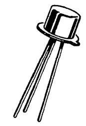
2N996 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage — $V_{CEO(sus)}$ = 12 Vdc (Min) @ I_C = 10 mAdc
- Collector-Base Breakdown Voltage — BV_{CBO} = 15 Vdc (Min) @ I_C = 10 μAdc
- Emitter-Base Breakdown Voltage — BV_{EBO} = 4.0 Vdc (Min) @ I_E = 10 μAdc

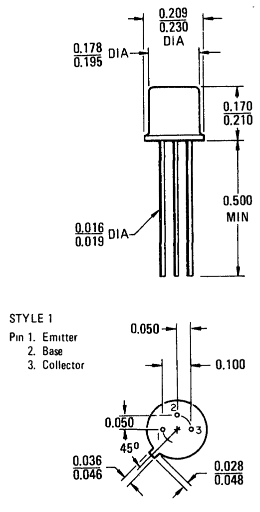
PNP SILICON TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	360 2.06	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.2 6.86	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



Collector Connected to Case
CASE 22(1)
(TO-18)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 10 Vdc, I_E = 0)		–	0.005	μAdc
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)		–	15	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 20 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	35	–	–
Collector-Emitter Saturation Voltage (I_C = 60 mAdc, I_B = 2.0 mAdc)	$V_{CE(sat)}$	–	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc)	$V_{BE(sat)}$	–	0.95	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz to 1.0 MHz)	C_{ob}	–	10	pF

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

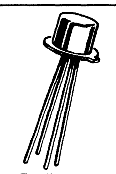
2N998 (SILICON)

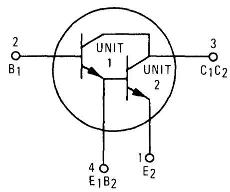
NPN SILICON ANNULAR DARLINGTON TRANSISTORS

. . . containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

- High DC Current Gain –
  h_{FE} = 2000 (Min) @ I_C = 100 mAdc
- Guaranteed DC Current Gain from 1.0 mAdc to 100 mAdc
- Low Noise Figure –
  NF = 6.0 dB (Max) @ I_C = 0.1 mAdc
- Low Leakage Current –
  I_{CBO} = 0.01 μAdc (Max) @ V_{CB} = 90 Vdc
  I_{EBO} = 0.01 μAdc (Max) @ V_{BE} = 10 Vdc

NPN SILICON DARLINGTON TRANSISTORS



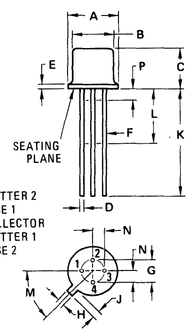


The input unit is identified as Unit 1 regardless of terminal numbering.

***MAXIMUM RATINGS** (Numerical subscripts refer to unit number.)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current – Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.86	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data



STYLE 8
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1
BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

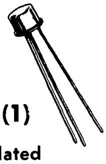
CASE 20-03
TO-72

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage [1] (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	15	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	I_{CBO}	—	0.01	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)		—	15	
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)	I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	800	—	—
(I_C = 10 mAdc, V_{CE} = 5 Vdc)		1,600	8,000	
(I_C = 100 mAdc, V_{CE} = 5 Vdc)		2,000	—	
(I_C = 10 mAdc, V_{CE} = 5 Vdc, measured across each transistor within the device)		25	—	
DYNAMIC CHARACTERISTICS				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	30	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	50	pF
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	h_{fe}	1,000	—	—
Noise Figure** (I_C = 0.1 mAdc, V_{CE} = 10 Vdc, R_S = 5 kohms, f = 1 kHz, Bandwidth = 200 Hz)	NF**	—	6.0	dB

* Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%
**Measured with constant current supply of 20 μAdc connected to the emitter of the input transistor. (See Figure 1)

2N1008, A, B (GERMANIUM)
2N1008B JAN AVAILABLE



CASE 31(1)
(TO-5)
All leads isolated

PNP germanium transistor for audio driver and medium speed switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1008	2N1008A	2N1008B	Unit
Collector-Base Voltage	V_{CB}	20	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	40	60	Vdc
Emitter-Base Voltage	V_{EB}		15		Vdc
Collector Current	I_C		300		mAdc
Base Current	I_B		30		mAdc
Collector Dissipation $T_A = 25^oC$ derate $T_C = 25^oC$ derate	P_D		200 2.78 300 4.0		mW mW/^oC mW mW/^oC
Junction and Storage Temperature Range	T_J, T_{stg}		-65 to +100		^oC

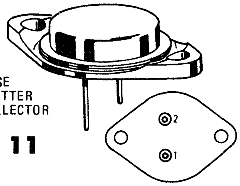
ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	UNIT
Collector Leakage Current	I_{CBO}				μAdc
(V_{CB} = 10 Vdc) 2N1008		---	5.0	10	
(V_{CB} = 10 Vdc, T_A = 85^oC) 2N1008		---	---	500	
(V_{CB} = 25 Vdc) 2N1008A		---	5.0	10	
(V_{CB} = 25 Vdc, T_A = 85^oC) 2N1008A		---	---	500	
(V_{CB} = 45 Vdc) 2N1008B		---	7.0	15	
(V_{CB} = 45 Vdc, T_A = 85^oC) 2N1008B		---	---	750	
Emitter Leakage Current	I_{EBO}				μAdc
(V_{EB} = 10 Vdc) 2N1008		---	5.0	10	
2N1008A		---	---	10	
2N1008B		---	---	10	
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, R_{BE} = 10 K)	BV_{CER}				Vdc
2N1008		15	---	---	
2N1008A		35	---	---	
2N1008B		55	---	---	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	V_{CE} (sat)	---	---	0.25	Vdc
Small Signal Current Gain (I_C = -10 mAdc, V_{CE} = 5.0 Vdc, f = 1 kHz)	h_{fe}	40	---	150	---
Input Resistance (V_{CB} = 6 V, I_E = 1 mA)	h_{ie}	200	---	1000	ohms

2N1011 (GERMANIUM)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 11



Collector connected to case

PNP germanium power transistor for general purpose power amplifier and switching applications in military and industrial equipment. Operating temperature range and power dissipation exceed military specifications.

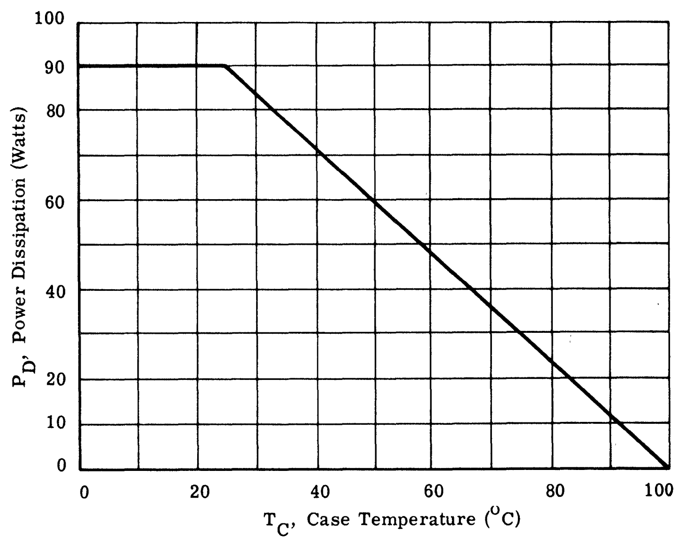
MAXIMUM RATINGS

Rating	Symbol	2N1011	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Collector Current	I_C	5.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 1.2	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

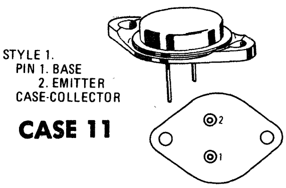
POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted).

Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 1.0 Adc	h_{FE}	—	150	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 3.0 Adc	h_{FE}	30	75	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 2 Vdc I_C = 3 Amp	$f_{\alpha e}$	5.0	—	kHz
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 80 Vdc I_E = 0	I_{CBO}	—	15.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 1 Adc	I_B	6.7	—	mAdc
Base Current V_{CE} = 2 Vdc I_C = 3 Adc	I_B	40	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 3 Adc	V_{EB}	—	2.0	Vdc
Floating Potential V_{CB} = 50 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage I_C = 3 Adc I_B = 200 mAdc	$V_{CE(SAT)}$	—	1.5	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	80	—	Vdc
High-Temperature Operation T_C = +90°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	20	mAdc

2N1021 (GERMANIUM)
2N1022



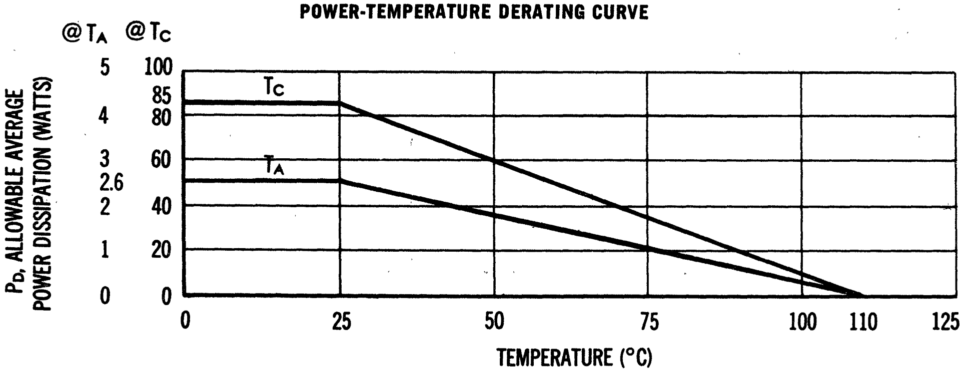
Collector connected to case

PNP germanium power transistors for industrial and general purpose power amplifier and switching applications.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Rating	Symbol	2N1021	2N1022	Unit
Collector-Base Voltage	V_{CB}	100	120	Volts
Collector-Emitter Voltage	V_{CEX}	100	120	Volts
Collector-Emitter Voltage	V_{CEO}	50		Volts
Emitter-Base Voltage	V_{EB}	30		Volts
Collector Current	I_C	5.0		Amp
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +110		°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1.0		Watts W/°C

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc)	2N1021		—	0.5	
(V_{CB} = 60 Vdc)	2N1022		—	0.5	
(V_{CB} = 100 Vdc)	2N1021		—	2.0	
(V_{CB} = 120 Vdc)	2N1022		—	2.0	
(V_{CB} = 50 Vdc, T_C = +55°C)	2N1021		—	8.0	
(V_{CB} = 60 Vdc, T_C = +55°C)	2N1022		—	8.0	
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc)		BV_{CEO}*	50	—	Vdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 10 Vdc)			—	0.5	
(V_{EB} = 30 Vdc)			—	2.0	
Base-Emitter Voltage (V_{CE} = -1.5 Vdc, I_C = 1.0 Adc)		V_{BE}	—	3.0	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)			40	—	
(I_C = 3 Adc, V_{CE} = 1.5 Vdc)			35	—	
(I_C = 5 Adc, V_{CE} = 1.5 Vdc)			30	90	
(I_C = 7 Adc, V_{CE} = 1.5 Vdc)			22	—	
Input Impedance (I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)		h_{ie}	—	28	ohms
Current Gain-Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2 Vdc)		f_T	200	—	kHz

*Sweep Test: 1/2 sine wave, 60 Hz .

2N1038 thru 2N1041 (GERMANIUM)
2N2552 thru 2N2559

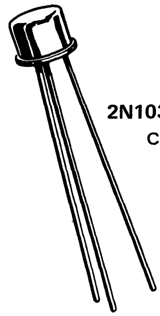
PNP GERMANIUM MEDIUM POWER TRANSISTORS

. . . designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

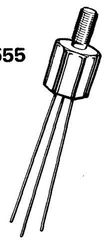
- High Current Capability — I_C = 3.0 Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

PNP GERMANIUM POWER TRANSISTORS

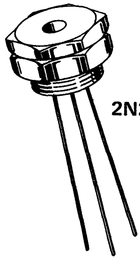
40–100 VOLTS
20 WATTS



2N1038 - 2N1041
CASE 180



2N2552 - 2N2555
CASE 183



2N2556 - 2N2559
CASE 184

*MAXIMUM RATINGS

Rating	Symbol	2N1038 2N2552 2N2556	2N1039 2N2553 2N2557	2N1040 2N2554 2N2558	2N1041 2N2555 2N2559	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	← 20 →				Vdc
Collector Current — Continuous	I_C	← 3.0 →				Adc
Base Current — Continuous	I_B	← 1.0 →				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 450 → ← 6.0 →				mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Note 1)	P_D	← 20 → ← 0.267 →				Watts W/°C
**Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +100 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

*Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

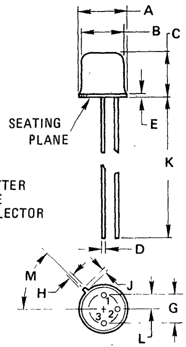
**Motorola guarantees this data in addition to the JEDEC Registered Data shown.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0)	2N1038, 2N2552, 2N2556	$V_{CEO(sus)}$	30	-	Vdc
	2N1039, 2N2553, 2N2557		40	-	
	2N1040, 2N2554, 2N2558		50	-	
	2N1041, 2N2555, 2N2559		60	-	
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	2N1038, 2N2552, 2N2556	I_{CEO}	-	25	mAdc
(V_{CE} = 20 Vdc, I_B = 0)	2N1039, 2N2553, 2N2557		-	20	
(V_{CE} = 25 Vdc, I_B = 0)	2N1040, 2N2554, 2N2558		-	20	
(V_{CE} = 30 Vdc, I_B = 0)	2N1041, 2N2555, 2N2559		-	20	
Collector-Emitter Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1038, 2N2552, 2N2556	I_{CEX}	-	0.65	mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1039, 2N2553, 2N2557		-	0.65	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1040, 2N2554, 2N2558		-	0.65	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1041, 2N2555, 2N2559		-	0.65	
(V_{CE} = 20 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1038, 2N2552, 2N2556		-	5.0	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1039, 2N2553, 2N2557		-	5.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1040, 2N2554, 2N2558		-	5.0	
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1041, 2N2555, 2N2559		-	5.0	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	2N1038, 2N2552, 2N2556	I_{CBO}	-	125	μAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N1039, 2N2553, 2N2557		-	125	
(V_{CB} = 40 Vdc, I_E = 0)	2N1040, 2N2554, 2N2558		-	125	
(V_{CB} = 50 Vdc, I_E = 0)	2N1041, 2N2555, 2N2559		-	125	
**(V_{CB} = 40 Vdc, I_E = 0)	2N1038, 2N2552, 2N2556		-	750	
**(V_{CB} = 60 Vdc, I_E = 0)	2N1039, 2N2553, 2N2557		-	750	
**(V_{CB} = 80 Vdc, I_E = 0)	2N1040, 2N2554, 2N2558		-	750	
**(V_{CB} = 100 Vdc, I_E = 0)	2N1041, 2N2555, 2N2559		-	750	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)		I_{EBO}	-	650	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 0.5 Vdc)		h_{FE}	33	200	-
(I_C = 1.0 Adc, V_{CE} = 0.5 Vdc)			20	60	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Input Voltage (I_C = 1.0 Adc, V_{CE} = 0.5 Vdc)		V_{BE}	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	18	72	-
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 112.5 kHz)		$\|h_{fe}\|$	2.0	-	-

*Indicates JEDEC Registered Data.
**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

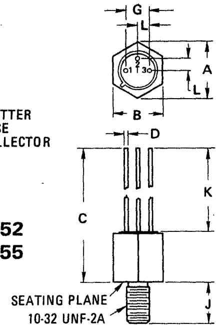


2N1038
2N1041

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.87	8.64	0.310	0.340
C	6.10	9.91	0.240	0.390
D	0.56	0.71	0.022	0.028
E	0.23	3.18	0.009	0.125
G	5.08 BSC		0.200 BSC	
H	0.64	0.89	0.025	0.035
J	0.74	1.14	0.029	0.045
K	38.10		1.500	
L	2.54 BSC		0.100 BSC	
M	45° BSC		45° BSC	

CASE 180

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



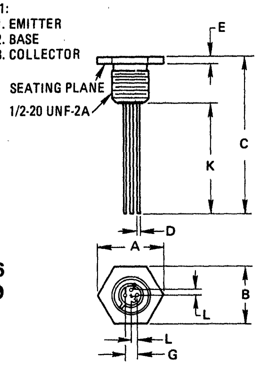
2N2552
2N2555

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12.45	12.95	0.490	0.510
B	10.85	11.35	0.427	0.447
C	49.35	–	1.943	–
D	0.56	0.71	0.022	0.028
G	4.83	5.33	0.190	0.210
J	8.76	9.27	0.345	0.365
K	38.10	–	1.500	–
L	2.41	2.67	0.095	0.105

NOTE:
1. COLLECTOR CONNECTED TO CASE

CASE 183

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



2N2556
2N2559

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	22.23	–	0.875
B	18.80	19.30	0.740	0.760
C	52.53	–	2.068	–
D	0.56	0.71	0.022	0.028
E	2.11	2.62	0.083	0.103
G	4.57	5.59	0.180	0.220
K	38.10	–	1.500	–
L	2.29	2.79	0.090	0.110

CASE 184

2N1042 thru 2N1045 (GERMANIUM)
2N2560 thru 2N2567

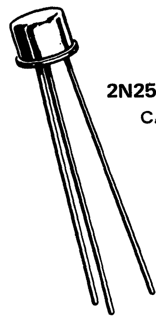
PNP GERMANIUM MEDIUM POWER TRANSISTORS

. . . designed for relay drivers, pulse amplifiers, audio amplifiers and high-current switching applications.

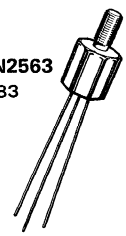
- High Current Capability — I_C = 3.5 Amperes
- Guaranteed Excellent Collector-Emitter Sustaining Voltage
- 20-Watt Power Dissipation at 25°C Case Temperature
- 100°C Maximum Junction Temperature

PNP GERMANIUM POWER TRANSISTORS

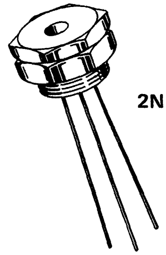
40–100 VOLTS
20 WATTS



2N2564 - 2N2567
CASE 180



2N2560 - 2N2563
CASE 183



2N1042 - 2N1045
CASE 184

*MAXIMUM RATINGS

Rating	Symbol	2N1042 2N2560 2N2564	2N1043 2N2561 2N2565	2N1044 2N2562 2N2566	2N1045 2N2563 2N2567	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	← 20 →				Vdc
Collector Current — Continuous	I_C	← 3.5 →				Adc
Base Current — Continuous	I_B	← 1.0 →				Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 450 → ← 6.0 →				mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C (Note 1)	P_D	← 20 → ← 0.267 →				Watts W/°C
**Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +100 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	3.75	°C/W

*Indicates JEDEC Registered Data.

Note 1: Case Temperature shall be measured 0.100 ± 0.010 inches above the seating plane.

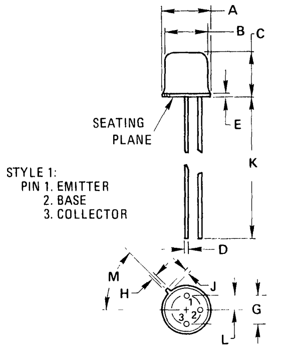
**Motorola guarantees this data in addition to the JEDEC Registered Data shown.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N1042,2N2560,2N2564		30	–	
	2N1043,2N2561,2N2565		40	–	
	2N1044,2N2562,2N2566		50	–	
	2N1045,2N2563,2N2567		60	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 15 Vdc, I_B = 0)	2N1042,2N2560,2N2564		–	25	
(V_{CE} = 20 Vdc, I_B = 0)	2N1043,2N2561,2N2565		–	20	
(V_{CE} = 25 Vdc, I_B = 0)	2N1044,2N2562,2N2566		–	20	
(V_{CE} = 30 Vdc, I_B = 0)	2N1045,2N2563,2N2567		–	20	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1042,2N2560,2N2564		–	0.65	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1043,2N2561,2N2565		–	0.65	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1044,2N2562,2N2566		–	0.65	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N1045,2N2563,2N2567		–	0.65	
(V_{CE} = 20 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1042,2N2560,2N2564		–	5.0	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1043,2N2561,2N2565		–	5.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1044,2N2562,2N2566		–	5.0	
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	2N1045,2N2563,2N2567		–	5.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 20 Vdc, I_E = 0)	2N1042,2N2560,2N2564		–	125	
(V_{CB} = 30 Vdc, I_E = 0)	2N1043,2N2561,2N2565		–	125	
(V_{CB} = 40 Vdc, I_E = 0)	2N1044,2N2562,2N2566		–	125	
(V_{CB} = 50 Vdc, I_E = 0)	2N1045,2N2563,2N2567		–	125	
**(V_{CB} = 40 Vdc, I_E = 0)	2N1042,2N2560,2N2564		–	750	
**(V_{CB} = 60 Vdc, I_E = 0)	2N1043,2N2561,2N2565		–	750	
**(V_{CB} = 80 Vdc, I_E = 0)	2N1044,2N2562,2N2566		–	750	
**(V_{CB} = 100 Vdc, I_E = 0)	2N1045,2N2563,2N2567		–	750	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)		I_{EBO}	–	650	μAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 0.5 Vdc)			50	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			–	150	
(I_C = 3.0 Adc, V_{CE} = 1.0 Vdc)			20	60	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	0.25	
(I_C = 3.0 Adc, I_B = 300 mAdc)			–	0.75	
Base-Emitter Input Voltage (I_C = 3.0 Adc, V_{CE} = 1.0 Vdc)		V_{BE}	–	1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 1.0 kHz)		h_{fe}	25	100	–
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 1.5 Vdc, f = 125 kHz)		$\|h_{fe}\|$	2.0	–	–

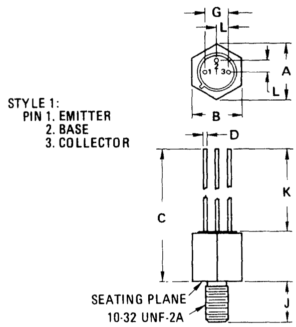
*Indicates JEDEC Registered Data.

**Motorola Guarantees this data in addition to the JEDEC Registered Data Shown.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.87	8.64	0.310	0.340
C	6.10	9.91	0.240	0.390
D	0.56	0.71	0.022	0.028
E	0.23	3.18	0.009	0.125
G	5.08 BSC		0.200 BSC	
H	0.64	0.89	0.025	0.035
J	0.74	1.14	0.029	0.045
K	38.10		1.500	
L	2.54 BSC		0.100 BSC	
M	45° BSC		45° BSC	

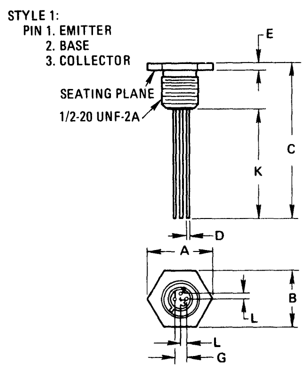
CASE 180



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.45	12.95	0.490	0.510
B	10.85	11.35	0.427	0.447
C	49.35	–	1.943	–
D	0.56	0.71	0.022	0.028
G	4.83	5.33	0.190	0.210
J	8.76	9.27	0.345	0.365
K	38.10	–	1.500	–
L	2.41	2.67	0.095	0.105

NOTE:
1. COLLECTOR CONNECTED TO CASE

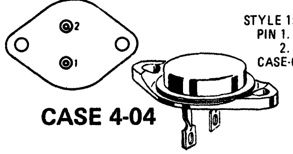
CASE 183



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	22.23	–	0.875
B	18.80	19.30	0.740	0.760
C	52.53	–	2.068	–
D	0.56	0.71	0.022	0.028
E	2.11	2.62	0.083	0.103
G	4.57	5.59	0.180	0.220
K	38.10	–	1.500	–
L	2.29	2.79	0.090	0.110

CASE 184

2N1073, A, B (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

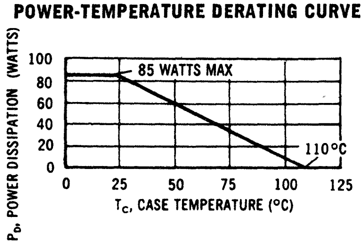
CASE 4-04

PNP germanium power transistors for high-voltage power switching applications.

MAXIMUM RATINGS

Rating	Symbol	2N1073	2N1073A	2N1073B	Unit
Collector-Emitter Voltage	V_{CER}	40	80	120	Vdc
Collector-Base Voltage	V_{CB}	40	80	120	Vdc
Emitter-Base Voltage	V_{EB}	1.5	1.5	1.5	Vdc
Collector Current (Cont)	I_C	10	10	10	Amp
Base Current (Cont)	I_B		5.0		Amp
Emitter Reverse Current (Surge 60 cps Recurrent)	I_E		1.5		Amp
Storage and Operating Temperature	T_{stg} T_J		-65 to +110		°C
Collector Dissipation (25°C Mtg. Case Temp.)	P_D		85		Watts

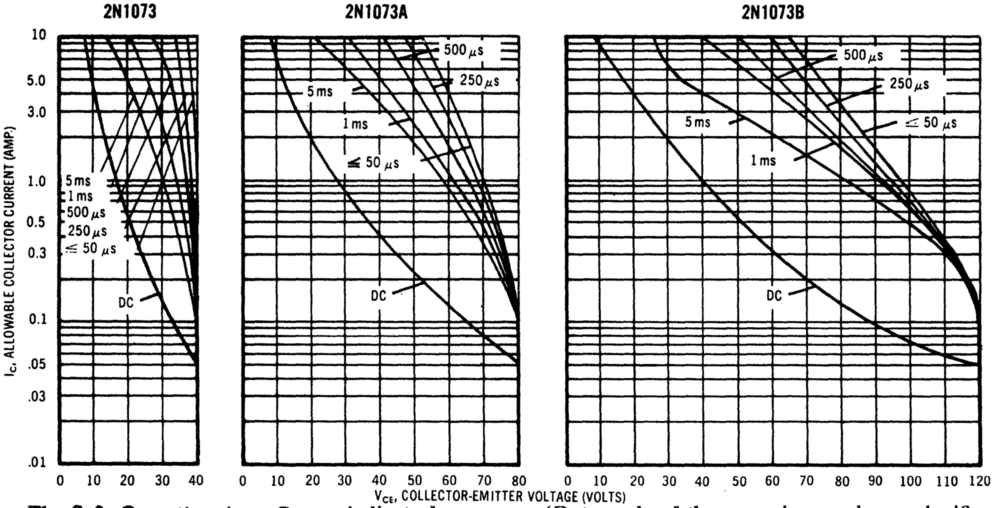
POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110° - T_C}{1.0} \text{ Watts}$$

SAFE OPERATING AREAS — PULSE CONDITIONS



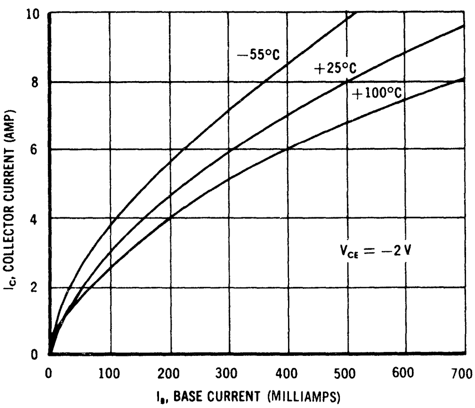
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

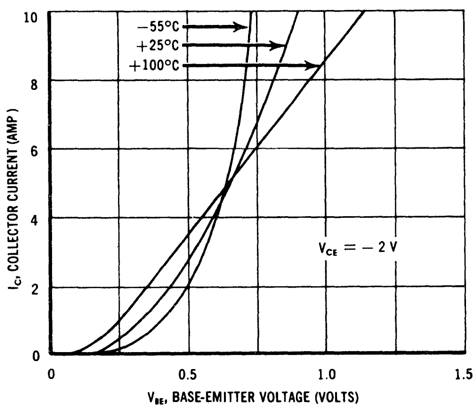
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N1073		-	-	1.0	
(V_{CB} = 25 Vdc, I_E = 0, T_C = 85°C)	2N1073		-	-	15	
(V_{CB} = 40 Vdc, I_E = 0)	2N1073		-	-	20	
(V_{CB} = 60 Vdc, I_E = 0)	2N1073A		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 85°C)	2N1073A		-	-	15	
(V_{CB} = 80 Vdc, I_E = 0)	2N1073A		-	-	20	
(V_{CB} = 100 Vdc, I_E = 0)	2N1073B		-	-	2.0	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 85°C)	2N1073B		-	-	20	
(V_{CB} = 120 Vdc, I_E = 0)	2N1073B		-	-	20	
(V_{CB} = 2.0 Vdc, I_E = 0)			-	-	0.3	
Emitter-Base Leakage Current (V_{EB} = 0.75 Vdc)		I_{EBO}	-	-	50	mAdc
Emitter Floating Potential		V_{EBF}				Vdc
(V_{CE} = 40 Vdc)	2N1073		-	-	1.0	
(V_{CE} = 80 Vdc)	2N1073A		-	-	1.0	
(V_{CE} = 120 Vdc)	2N1073B		-	-	1.0	
Collector-Emitter Breakdown Voltage* (I_C = 50 mAdc, R_{BE} = 100Ω)	2N1073	BV_{CER}*	40	-	-	Vdc
	2N1073A		80	-	-	
	2N1073B		120	-	-	
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	-	60	-
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 30 kHz)		h_{fe}	-	15	-	-
Base Input Voltage (V_{CE} = 2.0 Vdc, I_C = 5.0 Adc)		V_{BE}	-	-	1.0	Vdc
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	1.0	Vdc
Rise Time		t_r	-	5.5	-	μs
Storage Time		t_s	-	1.2	-	μs
Fall Time		t_f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

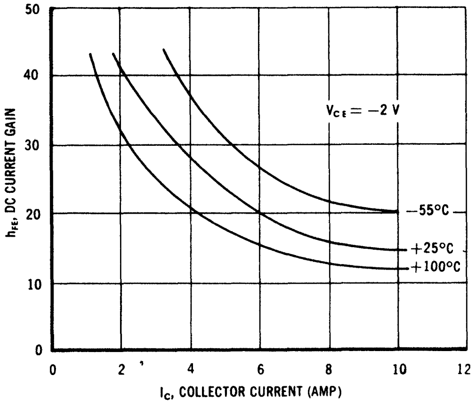
COLLECTOR CURRENT versus BASE CURRENT



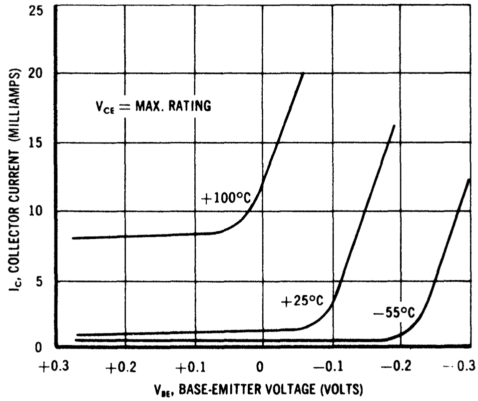
COLLECTOR CURRENT versus DRIVE VOLTAGE



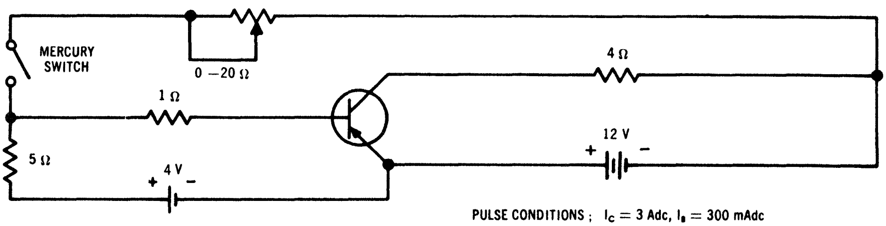
DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus DRIVE VOLTAGE



SWITCHING TEST CIRCUIT



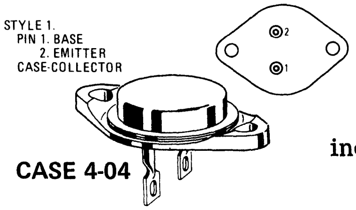
2N1099 (GERMANIUM)

For Specifications, See 2N277 Data.

2N1100 (GERMANIUM)

For Specifications, See 2N174 Data.

2N1120 (GERMANIUM)



CASE 4-04

PNP germanium power transistor for military and industrial power applications.

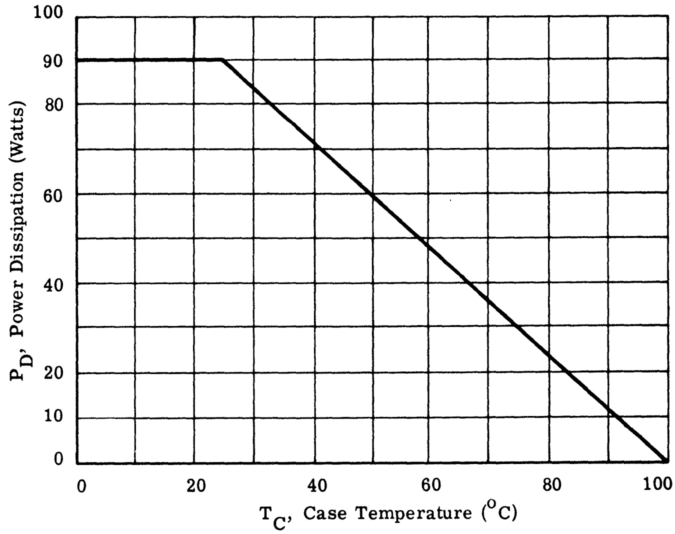
MAXIMUM RATINGS

Rating	Symbol	2N1120	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	15	Adc
Total Device Dissipation @ $T_C = 25^\circ C$ Derate above $25^\circ C$	P_D	90 1.2	Watts $W/^\circ C$
Operating Junction Temperature Range	T_J	-65 to +100	$^\circ C$

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^\circ C/W$

POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	BV_{CES}	70	-	Vdc
Floating Potential (V_{CB} = 80 Vdc, I_E = 0) (Voltmeter Input Resistance = 10 meg. min.)	V_{EBF}	-	1.0	Vdc
Collector Cutoff Current (V_{CB} = 2 Vdc, I_E = 0)	I_{CBO}	-	0.3	mAdc
(V_{CB} = 30 Vdc, I_E = 0)			20	
(V_{CB} = 80 Vdc, I_E = 0)		-	15	
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
Base Current (V_{CE} = 2 Vdc, I_C = 5 Adc)	I_B	50	-	mAdc
(V_{CE} = 2 Vdc, I_C = 10 Adc)		200	500	
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	-	100	-
(I_C = 10.0 Adc, V_{CE} = 2.0 Vdc)		20	50	
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage (I_C = 10 Adc, V_{CE} = 2 Vdc)	$V_{BE(on)}$	-	2.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$f_{\alpha e}$	3.0	-	kHz

2N1131S (SILICON)

2N1131 JAN AVAILABLE

2N1131AS

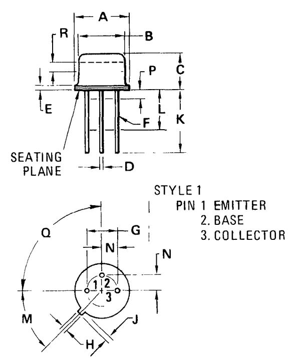
2N1991S

PNP SILICON ANNULAR TRANSISTORS

. . . designed for medium-speed switching and amplifier applications where low DC current gain is essential.

- Low DC Current Gain –
  h_{FE} = 45 (Max) @ I_C = 150 mAdc – 2N1131,A
- Turn-On Time – t_{on} = 45 ns (Max) – 2N1131A
- Turn-Off Time – t_{off} = 35 ns (Max) – 2N1131A

PNP SILICON AMPLIFIER AND SWITCHING TRANSISTORS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

*MAXIMUM RATINGS

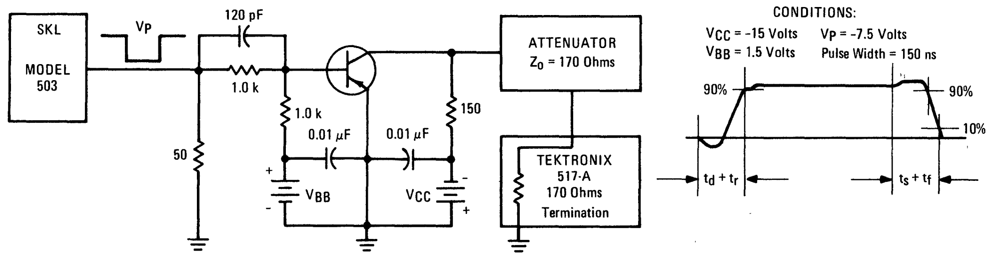
Rating	Symbol	2N1131	2N1131A	2N1991	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	20	Vdc
Collector-Emitter Voltage	V_{CER}	50	50	–	Vdc
Collector-Base Voltage	V_{CB}	50	60	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	5.0	Vdc
Collector Current – Continuous	I_C	600	600	600	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	0.6 4.0	0.6 4.8	Watt mW/°C
Total Device Dissipation @ T_C = 25°C @ T_C = 100°C Derate above 25°C	P_D	2.0 1.0 13.3	2.0 1.0 13.3	2.0 1.0 16	Watts Watt mW/°C
Operating Junction Temperature Range	T_J	175	175	150	°C
Storage Temperature Range	T_{stg}	-65 to +200		-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N1131,A	2N1991	Unit
Thermal Resistance, Junction to Case	θ_{JC}	75	62.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	250	208	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT – 2N1131A



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

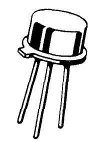
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0)	2N1131 2N1131A 2N1991	$V_{CEO(sus)}$	35 40 20	– – –	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, $R_{BE} \leq 10$ ohms)	2N1131, 2N1131A	$V_{CER(sus)}$	50	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) (I_C = 1.0 mAdc, I_E = 0)	2N1131A 2N1991	BV_{CBO}	60 30	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	2N1131A	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = +150°C) (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0) (V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C) (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = +150°C)	 2N1131 2N1131 2N1131 2N1131A 2N1131A 2N1991 2N1991	I_{CBO}	 – – – – – – –	 1.0 100 100 0.5 50 5.0 200	μAdc
Emitter Cutoff Current (V_{BE} = 2.0 Vdc, I_C = 0) (V_{BE} = 5.0 Vdc, I_C = 0) (V_{BE} = 1.0 Vdc, I_C = 0)	 2N1131 2N1131A 2N1991	I_{EBO}	 – – –	 100 100 200	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 2N1131, 2N1131A 2N1991 2N1131, 2N1131A 2N1991	h_{FE}	 15 15 20 15	 – – 45 60	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N1131, 2N1131A 2N1991	$V_{BE(sat)}$	– –	1.3 1.5	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N1131, 2N1131A 2N1991	f_T	50 40	– –	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	 2N1131, 2N1991 2N1131A	C_{ob}	 – –	 45 30	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz) (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	 2N1131 2N1131A	C_{ib}	 – –	 80 80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 2N1131, 2N1131A 2N1131, 2N1131A	h_{ib}	 25 –	 35 10	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 2N1131, 2N1131A 2N1131, 2N1131A	h_{rb}	 – –	 8.0 8.0	$\times 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 2N1131, 2N1131A 2N1131, 2N1131A	h_{fe}	 15 20	 50 –	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	 2N1131, 2N1131A 2N1131, 2N1131A	h_{ob}	 – –	 1.0 5.0	μmhos
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time	2N1131A	t_{on}	–	45	ns
Turn-Off Time	2N1131A	t_{off}	–	35	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

PNP SILICON ANNULAR TRANSISTORS

. . . designed for medium-current switching and amplifier applications.

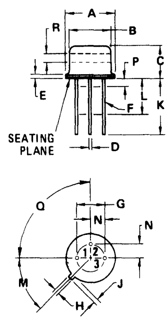
PNP SILICON SWITCHING TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	2N1132	2N1132A	Unit
Collector-Emitter Voltage	V_{CEO}	35	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leqslant 10$ Ohms)	V_{CER}	← 50 →		Vdc
Collector-Base Voltage	V_{CB}	50	60	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →		Vdc
Collector Current – Continuous	I_C	← 600 →		Vdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	← 600 → ← 4.0 →		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 2.0 → ← 13.3 →		Watts mW/^oC
Operating Junction Temperature Range	T_J	← -65 to +175 →		^oC
Storage Temperature Range	T_{stg}	← -65 to +200 →		^oC

*Indicates JEDEC Registered Data



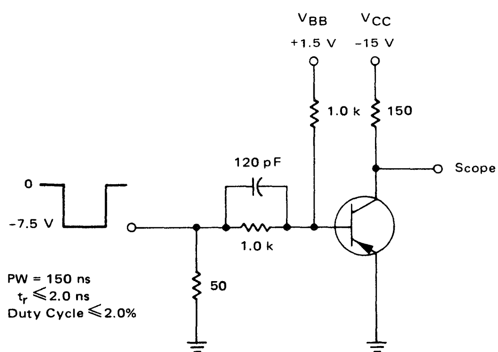
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

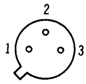
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 10 mAdc, I_B = 0)	2N1132,		35	–	
	2N1132A		40	–	
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, R_{BE} ⩽ 10 Ohms)		$V_{CER(sus)}$	50	–	Vdc
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N1132,		50	–	
	2N1132A		60	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 100 μAdc, I_C = 0)	2N1132,		5.0	–	
(I_C = 1.0 mAdc, I_C = 0)	2N1132A		5.0	–	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N1132		–	1.0	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N1132		–	100	
(V_{CB} = 45 Vdc, I_E = 0)	2N1132A		–	0.5	
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	2N1132A		–	50	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{BE} = 5.0 Vdc, I_C = 0)	2N1132A		–	100	
(V_{BE} = 2.0 Vdc, I_C = 0)	2N1132		–	100	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C - 5.0 mAdc, V_{CE} = 10 Vdc)			25	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			30	90	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	–	MHz
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	2N1132,		–	45	
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N1132A		–	30	
Input Capacitance		C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N1132,		–	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N1132A		–	80	
Input Resistance		h_{ib}			Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)			25	35	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)			–	10	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			–	8.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			–	8.0	
Small-Signal Current Gain		h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1132		25	100	
	2N1132A		25	75	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1132, 2N1132A		30	–	
Output Admittance		h_{ob}			μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			–	1.0	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			–	5.0	
SWITCHING CHARACTERISTICS (Figure 1)					
Turn-On Time	2N1132A	t_{on}	–	45	ns
Turn-Off Time	2N1132A	t_{off}	–	35	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%

2N1141 thru 2N1143 (Ge Mesa)
2N1142 JAN AVAILABLE
2N1195
2N1195 JAN AVAILABLE

PNP germanium mesa transistors for amplifier, driver, oscillator and doubler applications.

CASE 79-02
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

* MAXIMUM RATINGS

Rating	Symbol	2N1141	2N1142	2N1143	2N1195	Unit
Collector-Base Voltage	V_{CB}	35	30	25	30	Vdc
Emitter-Base Voltage	V_{EB}	1.0	0.7	0.5	1.0	Vdc
Collector Current-Continuous	I_C	100	100	100	40	mAdc
Base Current-Continuous	I_B	50	50	50	-	mAdc
Emitter Current-Continuous	I_E	100	100	100	-	mAdc
Total Device Dissipation @ $T_A = 25^{o}C$ Derate above $25^{o}C$	P_D	300 4.0	300 4.0	300 4.0	- -	mW $mW/^{o}C$
Total Device Dissipation @ $T_C = 25^{o}C$ Derate above $25^{o}C$	P_D	750 10	750 10	750 10	- -	mW $mW/^{o}C$
Collector Dissipation @ $T_A = 25^{o}C$ Derate above $25^{o}C$	P_C	- -	- -	- -	225 3.0	mW $mW/^{o}C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				^{o}C

*Indicates JEDEC Registered Data

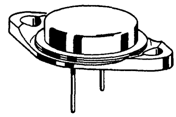
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

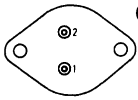
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N1141		35	–	
	2N1142		30	–	
	2N1143		25	–	
	2N1195		30	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 100 μAdc, I_C = 0)	2N1141		1.0	–	
	2N1142		0.7	–	
	2N1143		0.5	–	
	2N1195		1.0	–	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 15 Vdc, I_E = 0)			–	5.0	
(V_{CB} = 20 Vdc, I_E = 0)			–	5.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N1141, 2N1142, 2N1143	h_{FE}•	10	–	–
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 10 mAdc)	2N1141, 2N1142, 2N1143	$V_{CE(sat)}$	–	2.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T			MHz
	2N1141, 2N1195		1200	–	
	2N1142		1000	–	
	2N1143		800	–	
Collector Transition Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{Tc}	–	1.5	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1195	h_{ib}	–	10	k Ohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1195	h_{rb}	–	0.003	$X 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1195	h_{fb}	0.96	0.995	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1195	h_{ob}	–	20	μmhos
Extrinsic Base Resistance		r_b'			Ohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 250 MHz)	2N1141		–	70	
	2N1195		–	80	

*Indicates JEDEC Registered Data.

2N1162 thru 2N1167 (GERMANIUM)
2N1162A thru 2N1167A

PNP germanium power transistors for switching and amplifier applications in high reliability equipment.

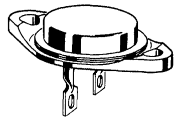


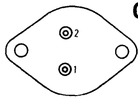


CASE 11A

STYLE 1
PIN 1 BASE
2 EMITTER
CASE COLLECTOR

2N1162, A
2N1164, A
2N1166, A





CASE 4-04

STYLE 1
PIN 1 BASE
2. EMITTER
CASE-COLLECTOR

2N1163, A
2N1165, A
2N1167, A

Collector connected to case

MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N1162A 2N1163A	2N1164A 2N1165A	2N1166A 2N1167A	Units
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Collector-Emitter Voltage	V_{CES}	35	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	Vdc
Total Device Dissipation @ 25°C Derate above 25°C	P_D	106 1.25			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

GROUP A ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = V_{CB}(max), I_E = 0)	I_{CBO1}	—	3.0	15	mA
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 2 V, I_E = 0)		—	125	225	µA
(V_{CB} = 15 V, I_E = 0, T_C = 90°C) 2N1162A-3A*		—	10	20	mA
(V_{CB} = 30 V, I_E = 0, T_C = 90°C) 2N1164A-7A*		—	10	20	mA
Collector-Emitter Breakdown Voltage** (I_C = 500 mA, V_{EB} = 0)	BV_{CES}**				Vdc
2N1162A-3A*		35	—	—	
2N1164A-5A*		60	—	—	
2N1166A-7A*		75	—	—	
Emitter Cutoff Current (V_{EB} = 12 V, I_C = 0)	I_{EBO}	—	0.5	1.2	mA
DC Forward Current Gain					—
(V_{CE} = 1 V, I_C = 25 A)	h_{FE1}	15	25	—	
(V_{CE} = 2 V, I_C = 5 A)	h_{FE}	—	65	125	
Collector-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	$V_{CE(sat)}$	—	0.3	0.8	volts
Base-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	$V_{BE(sat)}$	—	0.7	1.7	volts
Common Emitter-Cutoff Frequency (V_{CE} = 2 V, I_C = 2 A)	$f_{\alpha e}$	—	4.0	—	kHz

*Characteristics apply also to corresponding, non-A type numbers
**Sweep Method: 1/2 cycle sine wave, 60 Hz

SWITCHING CHARACTERISTICS (Typical)

Saturated Collector Current	Pulsed Drive Base Current		Response times in µs		
	On	Off	$t_d + t_r$	t_s	t_f
5 amp	330 mA	100 mA	11	5.0	17
10 amp	660 mA	200 mA	15	4.0	20
25 amp	1650 mA	500 mA	19	3.0	18

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

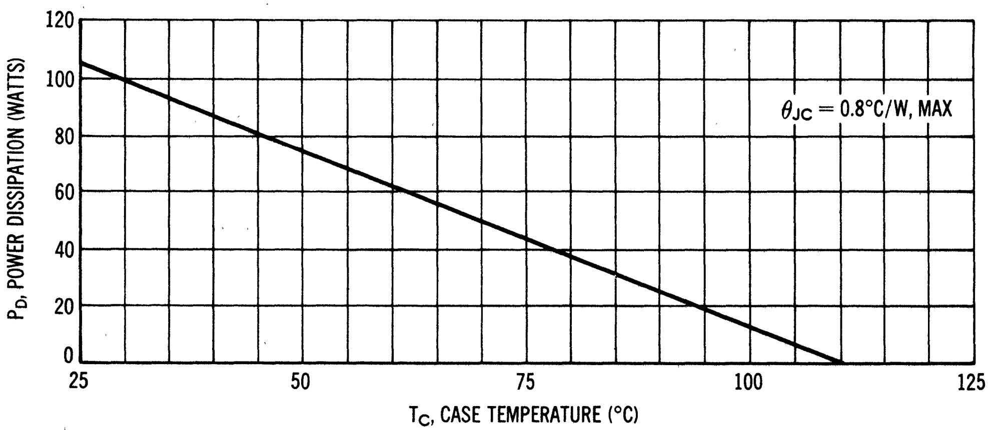
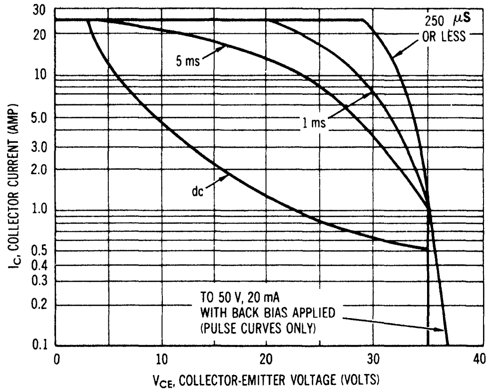
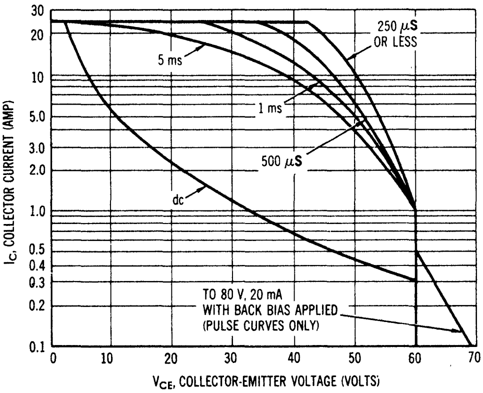
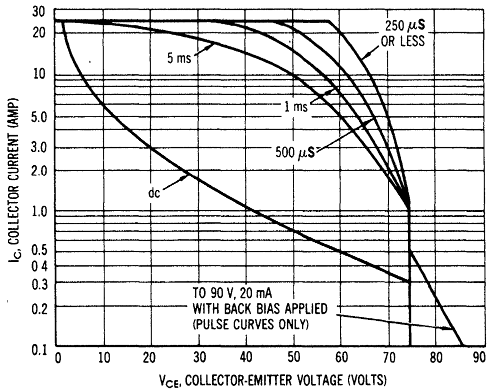


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.







LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

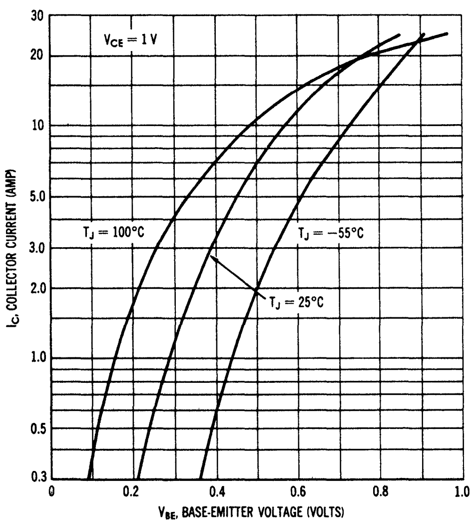


FIGURE 4 — INPUT ADMITTANCE

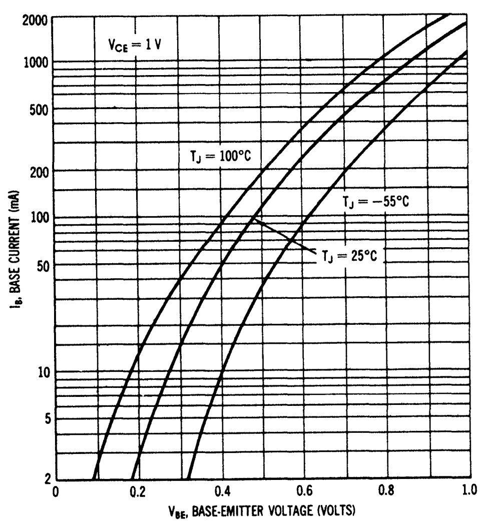


FIGURE 5 — CURRENT GAIN

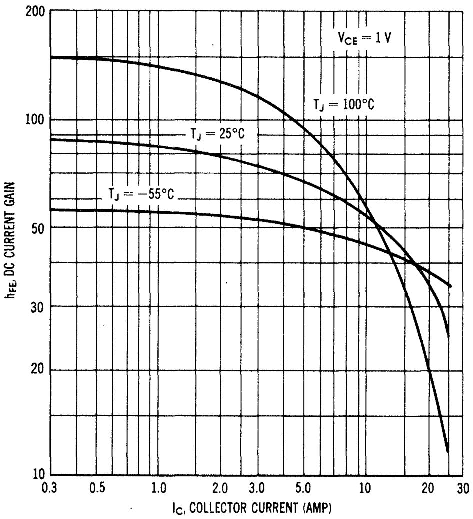
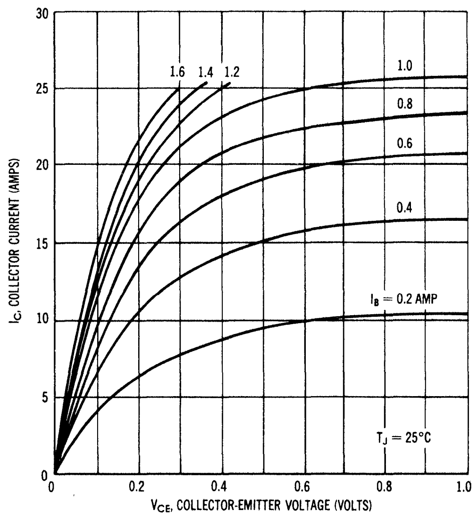
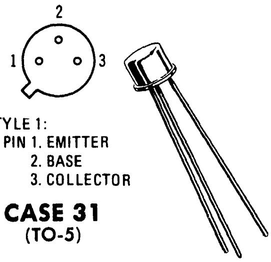


FIGURE 6 — SATURATION REGION



For Specifications, See 2N1413-2N1415 Data

2N1185 thru 2N1188 (GERMANIUM)



All leads isolated from case

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage 2N1185 2N1186-2N1188	V_{CB}	 45 60	Vdc
Collector-Emitter Voltage 2N1185 2N1186-2N1188	V_{CER}	 30 45	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current* (Continuous)	I_C	500*	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance Junction to Ambient	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

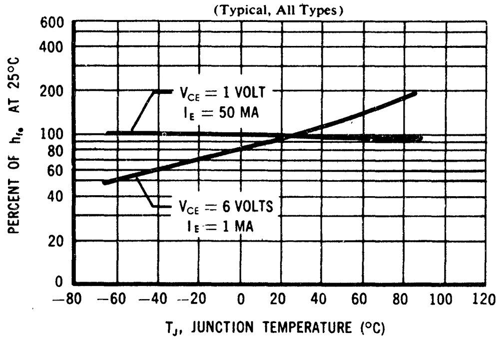
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 V, I_E = 0)	2N1185		-	3.0	10	
(V_{CB} = 45 V, I_E = 0)	2N1186 thru 2N1188		-	5.0	10	
(V_{CB} = 60 V, I_E = 0)	2N1186 thru 2N1188		-	-	50	
(V_{CB} = 10 V, I_E = 0, T_A = +71° C)	All Types		-	55	100	
Emitter-Base Cutoff Current (V_{EB} = 30 V, I_C = 0)		I_{EBO}	-	3.0	10	μAdc
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 30 V, R_{BE} = 10 K)	2N1185		-	-	600	
(V_{CE} = 45 V, R_{BE} = 10 K)	2N1186 thru 2N1188		-	-	600	
Collector-Emitter Punch-Thru Voltage (V_F = 1.0 V, VTVM Impedance ≥ 1 M ohm)	2N1185	V_{pt}	45	-	-	Vdc
	2N1186 thru 2N1188		60	-	-	
Output Capacitance (V_{CB} = 6 V, I_E = 0)		C_{ob}	-	10	25	pF
Noise Figure (V_{CE} = 4.5 V, I_E = 0.5 mA, R_g = 1 K, f = 1 kHz, Δf = 1 Hz)		NF	-	5.0	15	dB
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 V, I_E = 1 mA)	2N1185	$f_{\alpha b}$	1.75	3.0	-	MHz
	2N1186		0.75	1.5	-	
	2N1187		1.0	2.0	-	
	2N1188		1.25	2.5	-	
Input Impedance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185	h_{ib}	27	35	37	Ohms
	2N1186		27	31	37	
	2N1187		27	34	37	
	2N1188		27	35	37	
Output Admittance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185	h_{ob}	0.2	0.50	0.7	μmho
	2N1186		0.2	0.65	1.0	
	2N1187		0.2	0.60	0.9	
	2N1188		0.2	0.55	0.8	
Small Signal Current Gain (V_{CE} = 6 V, I_E = 1 mA, f = 1 kHz)	2N1185	h_{fe}	190	260	400	-
	2N1186		30	49	70	
	2N1187		50	80	120	
	2N1188		100	130	225	
DC Current Transfer Ratio (V_{CE} = 1.0 V, I_C = 10 mA)	2N1185	h_{FE}	130	170	-	-
	2N1186		33	44	-	
	2N1187		45	75	-	
	2N1188		80	115	-	

ELECTRICAL CHARACTERISTICS (continued)

Characteristics		Symbol	Min	Typ	Max	Unit
Base-Emitter Input Voltage (V_{CE} = 1.0 V, I_C = 10 mA)	2N1185	V_{BE}	-	0.215	0.240	Vdc
	2N1186		-	0.245	0.270	
	2N1187		-	0.235	0.260	
	2N1188		-	0.225	0.250	
Collector-Emitter Saturation Voltage (I_C = 50 mA, I_B = 1.0 mA)	2N1185	$V_{CE(sat)}$	-	0.175	0.250	Vdc
(I_C = 50 mA, I_B = 2.5 mA)	2N1186		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.67 mA)	2N1187		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.25 mA)	2N1188		-	0.175	0.250	
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 2.0 mA)	2N1185	$V_{CE(sat)}$	-	0.250	0.500	Vdc
(I_C = 100 mA, I_B = 5.0 mA)	2N1186		-	0.250	0.500	
(I_C = 100 mA, I_B = 3.33 mA)	2N1187		-	0.250	0.500	
(I_C = 100 mA, I_B = 2.5 mA)	2N1188		-	0.250	0.500	

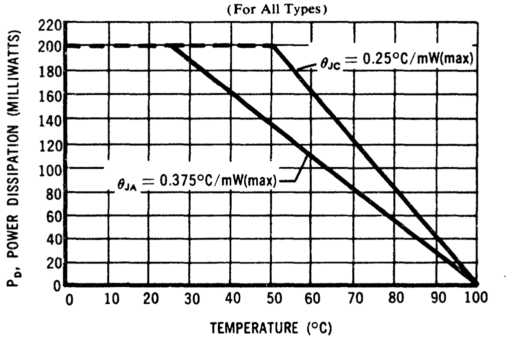
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE

(Typical, All Types)

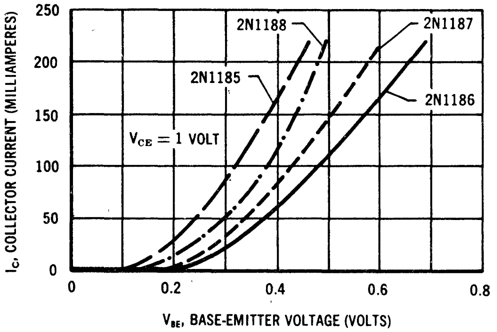


POWER-TEMPERATURE DERATING CURVE

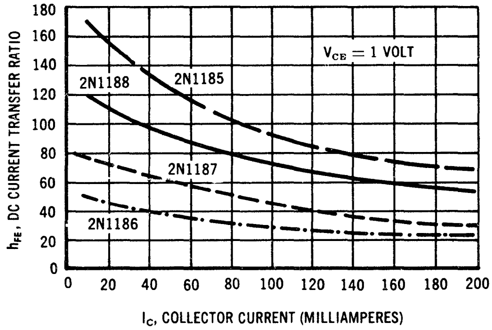
(For All Types)



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT

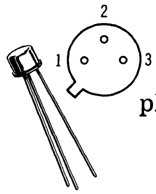


2N1189 2N1190 (GERMANIUM)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated



PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Junction, Storage Temperature	T_J, T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation.

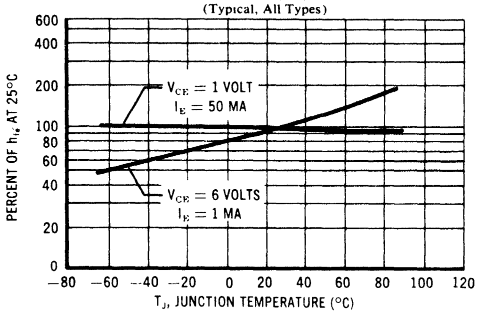
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)		—	3.0	10	
(V_{CB} = 45 Vdc, I_E = 0)		—	—	50	
(V_{CB} = 10 Vdc, I_E = 0, T_A = + 71°C)		—	55	100	
Emitter-Base Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	—	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 10K)	I_{CER}	—	—	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_{EB} = 1 Vdc, VTVM Impedance ≥ 1 M ohm	V_{pt}	45	—	—	Vdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	12.0	25	pF
Noise Figure (V_{CE} = 4.5 Vdc, I_E = 0.5 mAdc R_g = 1 K, f = 1 kHz Δf = 1 Hz)	NF	—	5.0	15	dB
Small-Signal Current-Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	$f_{\alpha b}$				MHz
2N1189		1.75	3.5	—	
2N1190		2.25	4.5	—	

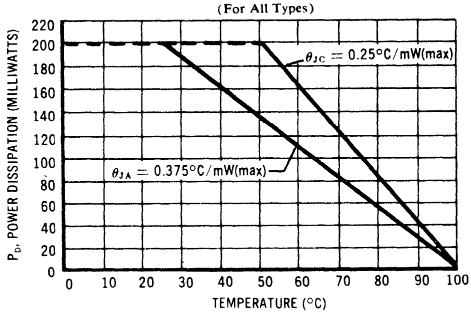
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ib}	27	31	37	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ob}	0.1	—	0.9	μmho
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{fe}				—
	2N1189		75	120	175	
	2N1190		125	190	300	
DC Current Transfer Ratio (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)		h_{FE}				—
	2N1189		60	115	—	
	2N1190		100	170	—	
Base-Emitter Drive Voltage (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)		V_{BE}				Vdc
	2N1189		—	0.24	0.26	
	2N1190		—	0.22	0.25	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 50 mAdc, I_B = 1.5 mA)	2N1189		—	0.14	0.22	
(I_C = 50 mAdc, I_B = 1.0 mA)	2N1190		—	0.15	0.22	
(I_C = 100 mAdc, I_B = 3.0 mA)	2N1189		—	0.17	0.3	
(I_C = 100 mAdc, I_B = 2.0 mA)	2N1190		—	0.19	0.3	

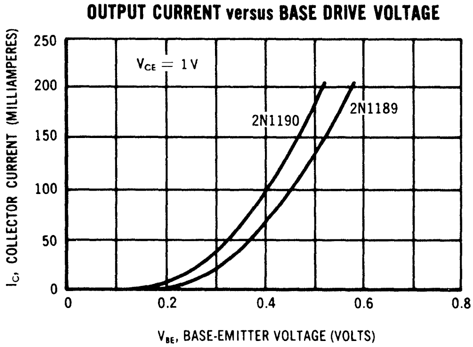
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE
(Typical, All Types)



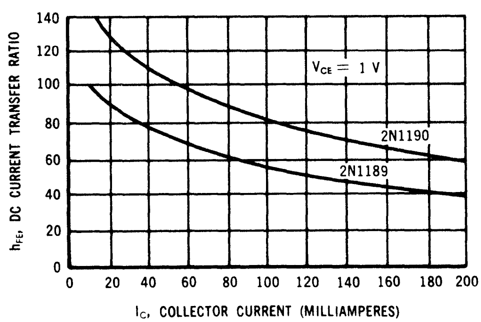
POWER-TEMPERATURE DERATING CURVE
(For All Types)



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT

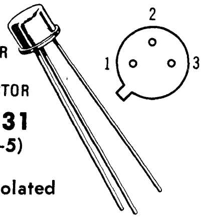


2N1191 thru 2N1194 (GERMANIUM)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated



PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CER}	25	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in, Ambient (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

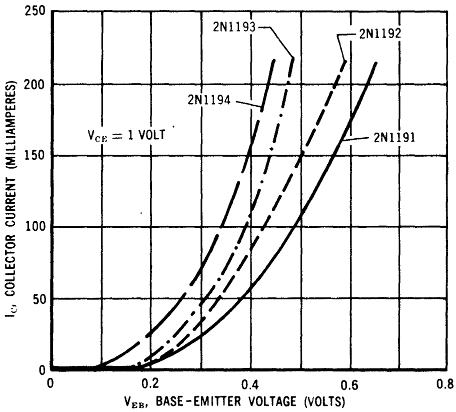
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 25 V, I_E = 0)		I_{CBO}	–	–	15	µAdc
(V_{CB} = 1.0 V, I_E = 0)			–	2.0	–	µAdc
Emitter-Base Cutoff Current (V_{EB} = 25 V, I_C = 0)		I_{EBO}	–	–	15	µAdc
Collector-Emitter Leakage Current (V_{CB} = 25 V, R_{BE} = 10 K)		I_{CER}	–	–	600	µAdc
Output Capacitance (V_{CE} = 6 V, I_E = 1.0 mA)		C_{ob}	–	20	–	pF
Noise Figure (V_{CE} = 4.5 V, I_E = 0.5 mA, f = 1 kHz, R_s = 100 ohms)		NF	–	10	–	dB
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 V, I_E = 1.0 mA)	2N1191	$f_{\alpha b}$	–	1.5	–	MHz
	2N1192		–	2.0	–	
	2N1193		–	2.5	–	
	2N1194		–	3.0	–	

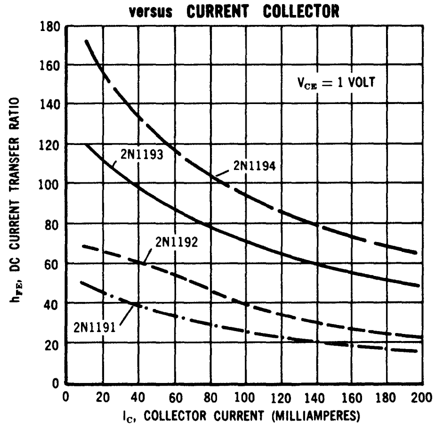
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Current Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz)	2N1191	h_{fe}	30	40	70	–
	2N1192		50	75	125	
	2N1193		100	160	250	
	2N1194		190	280	500	
DC Current Gain (V_{CE} = 1 V, I_C = 10 mA)	2N1191	h_{FE}	20	–	80	–
	2N1192		40	–	135	
	2N1193		70	–	300	
	2N1194		125	–	600	
Small Signal Power Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kHz, matched)	2N1191	G_e	–	42	–	dB
	2N1192		–	44	–	
	2N1193		–	46	–	
	2N1194		–	48	–	
Base-Emitter Input Voltage (V_{CE} = 6 V, I_C = 1.0 mA)		V_{BE}	–	–	0.3	Vdc

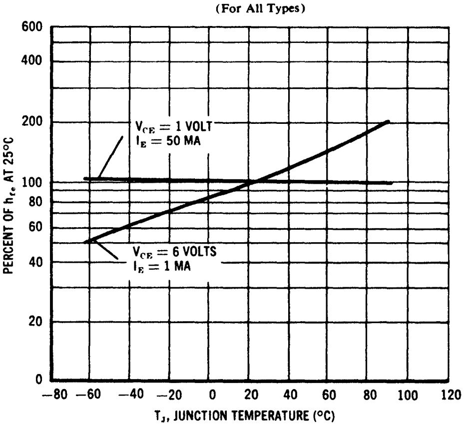
OUTPUT CURRENT versus BASE DRIVE VOLTAGE



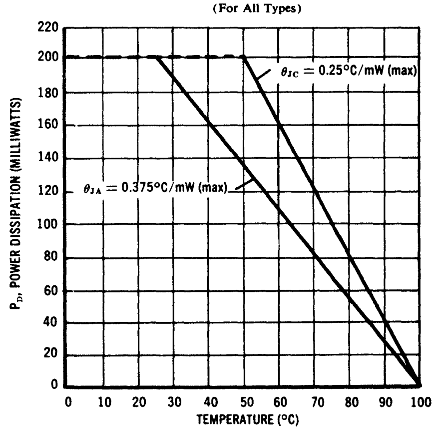
DC CURRENT TRANSFER RATIO versus CURRENT COLLECTOR



SMALL SIGNAL CURRENT GAIN versus TEMPERATURE
(For All Types)



POWER-TEMPERATURE DERATING CURVE
(For All Types)



2N1195, 2N1195JAN

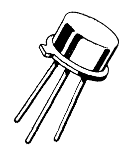
For Specifications, See 2N1141 Data

2N1204A (Ge Mesa)
2N1495

PNP GERMANIUM SWITCHING TRANSISTORS

. . . designed for high-speed, high-current switching applications.

PNP GERMANIUM SWITCHING TRANSISTORS



***MAXIMUM RATINGS**

Rating	Symbol	2N1204A	2N1495	Unit
Collector-Emitter Voltage	V_{CEO}	15	25	Vdc
Collector-Emitter Voltage	V_{CES}	20	40	Vdc
Collector-Base Voltage	V_{CB}	20	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 4.0		mW mW/^oC
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 10		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

*Indicates JEDEC Registered Data.

FIGURE 1 — CARRIER STORAGE TIME CONSTANT TEST CIRCUIT

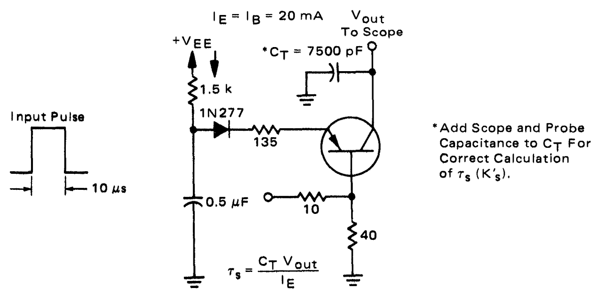
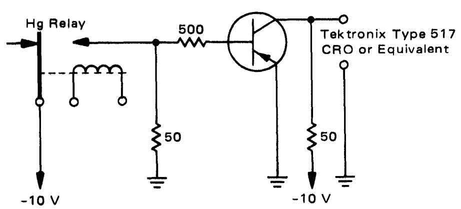
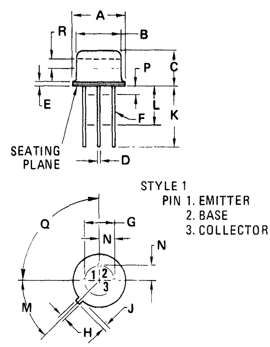


FIGURE 2 — RISE TIME TEST CIRCUIT





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 2.0 mAdc, I_B = 0)	2N1204A		15	–	
(I_C = 10 mAdc, I_B = 0)	2N1495		25	–	
Collector-Emitter Breakdown Voltage		BV_{CES}			Vdc
(I_C = 100 μAdc, V_{BE} = 0)	2N1204A		20	–	
	2N1495		40	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N1204A		20	–	
	2N1495		40	–	
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)		BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 5.0 Vdc, I_E = 0)		I_{CBO}	–	7.0	μAdc
Emitter-Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)	2N1495	I_{EBO}	–	50	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 0.5 Vdc)		h_{FE}	25	–	–
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 200 mAdc, I_B = 10 mAdc)	2N1204A		–	0.4	
(I_C = 200 mAdc, I_B = 20 mAdc)	2N1495		–	0.3	
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	0.40	0.72	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4.0 MHz)		C_{ob}	–	6.5	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 4.0 MHz)		C_{ib}	–	50	pF
Small-Signal Current Gain		h_{fe}			–
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N1204A		1.1	–	
	2N1495		1.5	–	
SWITCHING CHARACTERISTICS					
Rise Time (Figure 2)		t_r			ns
	2N1204A		–	35	
	2N1495		–	55	
Storage Time (Figure 1)		t_s			ns
	2N1204A		–	75	
	2N1495		–	90	

*Indicates JEDEC Registered Data.

2N1358JAN (GERMANIUM)

PNP GERMANIUM POWER TRANSISTOR

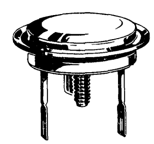
. . . designed for military applications requiring h_{FE} of 25-50 at I_C = 5 Amps.

- 0.5°C/Watt Maximum Thermal Resistance
- 150-Watt Power Dissipation at 25°C Case Temperature

15 AMPERE POWER TRANSISTOR

PNP GERMANIUM

80 VOLTS
150 WATTS

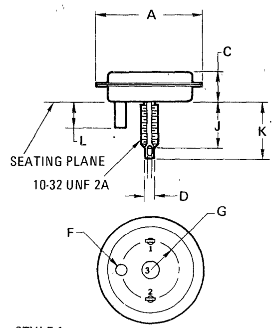


MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	80	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
Emitter Current (Continuous)	I_E	15	Amps
Base Current (Continuous)	I_B	4	Amps
Power Dissipation (per MIL-S-19500/122A Derate 1.25 W/°C above 25°C	P_C	94	Watts
Power Dissipation (MOTOROLA JAN 2N1358) Derate 2 W/°C above 25°C	P_C	150	Watts
Junction Temperature Range	T_J	-65 to +100	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case (per MIL-S-19500/122A)	θ_{JC}	—	0.8	°C/W
Actual Thermal Resistance, Junction to Case (MOTOROLA JAN 2N1358)	θ_{JC}	0.35	0.5	°C/W



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
(CONNECTED TO CASE)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	31.75	–	1.250
C	–	13.21	–	0.520
D	–	4.83	–	0.190
F	–	3.56	–	0.140
G	8.76 NOM		0.345 NOM	
J	9.53	12.70	0.375	0.500
K	15.49	18.03	0.610	0.710
L	–	7.92	–	0.312

All JEDEC dimensions and notes apply

CASE 5-03
TO-36

TABLE I — GROUP A INSPECTION

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD	Min Rej. Number
SUBGROUP 1							
Visual and Mechanical Examination	2071	—	—	—	—	10	5
SUBGROUP 2						5	4
Emitter-Base Cutoff Current	3061 Condition D	I_{EBO}			mAdc		
(V_{EB} = -2.0 Vdc, I_C = 0)			—	-0.2			
(V_{EB} = -40 Vdc, I_C = 0)			—	-4			
Collector-Base Cutoff Current	3036 Condition D	I_{CBO}			mAdc		
(V_{CB} = -2.0 Vdc, I_E = 0)			—	-0.2			
(V_{CB} = -80 Vdc, I_E = 0)			—	-4			
Collector-Emitter Breakdown Voltage* (I_C = -300 mAdc, I_B = 0)	3030	BV_{CEO}*	-40	—	Vdc		
Collector-Emitter Breakdown Voltage (I_C = -300 mAdc, V_{BE} = 0)	3030	BV_{CES}	-70	—	Vdc		
Emitter-Base Voltage	3066 Condition B	V_{EB}			Vdc		
(I_C = -1.2 Adc, V_{CE} = -2Vdc)			—	0.5			
(I_C = -5 Adc, V_{CE} = -2 Vdc)			—	0.9			
Floating Potential (V_{CB} = -80 Vdc, I_E = 0, voltmeter input resistance = 10 megohm min)	3020	V_{EBF}	—	-0.5	Vdc		
Collector-Emitter Saturation Voltage (I_C = 12 Adc, I_B = -2 Adc)	3071	V_{CE} (sat)	—	-0.7	Vdc		
DC Forward Current Transfer Ratio	3076	h_{FE}			—		
(I_C = -1.2 Adc, V_{CE} = -2 Vdc)			—	80			
(I_C = -5 Adc, V_{CE} = -2 Vdc)			25	50			
Base Current	3076	I_B			mAdc		
(I_C = -1.2 Adc, V_{CE} = -2 Vdc)			-15	—			
(I_C = -5 Adc, V_{CE} = -2 Vdc)			-100	-200			
SUBGROUP 3							
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency (V_{CE} = -6 Vdc, I_C = -5 Adc)	3301	f_{ae}	5	—	kc	5	4
SUBGROUP 4						10	5
Emitter-Base Cutoff Current (V_{EB} = -30 Vdc, T_C = 71°C)	3061 Condition D	I_{EBO}	—	-6	mAdc		
Collector-Base Cutoff Current (V_{CB} = -30 Vdc, T_C = 71°C)	3036 Condition D	I_{CBO}	—	-6	mAdc		

*Test by sweep method to avoid excessive heating.

TABLE II — GROUP B INSPECTION (Subgroups 2, 3, 5, 6, and 7 are destructive tests.)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD	Min Rej. Number
SUBGROUP 1							
Physical Dimensions	2066	—	—	—	—	20	4
SUBGROUP 2						15	5
Temperature Cycling	1051 Condition B, Except T (high) = 100°C	—	—	—	—		
Moisture Resistance	1021 omit initial conditioning	—	—	—	—		
End Points: (Subgroups 2, 3, 5)							
Emitter-Base Cutoff Current (V_{EB} = -40 Vdc)	3061 Condition D	I_{EBO}	—	-8	mAdc		
Collector-Base Cutoff Current (V_{CB}= -80 Vdc)	3036 Condition D	I_{CBO}	—	-8	mAdc		
Base Current (I_C = -5Adc, V_{CE} = -2 Vdc)	3076	I_B	-90	-250	mAdc		

TABLE II — GROUP B INSPECTION (Continued)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD	Min Rej. Number
SUBGROUP 3							
Shock (500G, 1 msec, 5 blows each in orientations X_1, X_2, Y_1, and Y_2, total of 20 blows)	2016 Non-operating	—	—	—	—	15	5
Vibration Fatigue	2046 Non-operating	—	—	—	—		
Vibration, Variable Frequency	2056 Non-operating	—	—	—	—		
Constant Acceleration (2000G)	2006	—	—	—	—		
End Points: Same as Subgroup 2							
SUBGROUP 4							
Terminal Strength (Tension) (10 lb ± 1 oz, 10 sec to each lead)	2036 Condition A	—	—	—	—	15	5
Terminal Strength (Torque) (lead torque = 24 oz-in., applied to flat of each lead; stud torque = 12 lb.-in)	2036 Condition D	—	—	—	—		
SUBGROUP 5							
Salt Spray (Corrosion)	1046 Condition A	—	—	—	—	20	4
End Points: Same as Subgroup 2	(See Note 4)						
SUBGROUP 6							
High Temperature Life (T_A = 100°C)	1031 Non-operating	—	—	—	—	λ = 10	—
End Points: (Subgroups 6, 7)							
Emitter-Base Cutoff Current (V_{EB} = -40 Vdc)	3061 Condition D	I_{EBO}	—	-10	mAdc		
Collector-Base Cutoff Current (V_{CB} = -80 Vdc)	3036 Condition D	I_{CBO}	—	-10	mAdc		
Base Current (I_C = -5 Adc, V_{CE} = -2 Vdc)	3076	I_B	-85	-250	mAdc		
SUBGROUP 7							
Steady State Operation Life (P_C = 18 W min, T_C = 80°C)	1026	—	—	—	—	λ = 15	—
End Points: Same as Subgroup 6							

TABLE III — GROUP C INSPECTION (See note 6)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD	Min Rej. Number
Thermal Resistance	3151	θ_{JC}	—	0.8	°C/W	20	4
Barometric Pressure, Reduced (15 ± 2 mm Hg, t = 60 sec min, V_{CB} = -80 Vdc)	1001 (See Note 5)	I_{CBO}	—	-5	mAdc		

NOTE 1. Sampling and inspection shall be in accordance with Specification MIL-S-19500, and as specified herein.

NOTE 2. Acceptance inspection shall consist of the examinations and tests specified in Tables I, II, and III.

NOTE 3. Marking shall be as specified in MIL-S-19500, except omit polarity and color band identification.

NOTE 4. The transistor shall be examined for legibility of marking before end-point measurements.

NOTE 5. The transistor shall operate satisfactorily without voltage derating.

NOTE 6. These tests shall be conducted on the initial lot, and thereafter once every 6 months.

NOTE 7. In addition to the notes specified herein, the notes specified in Specification MIL-S-19500 are applicable.

FIGURE 1 — INPUT CHARACTERISTICS

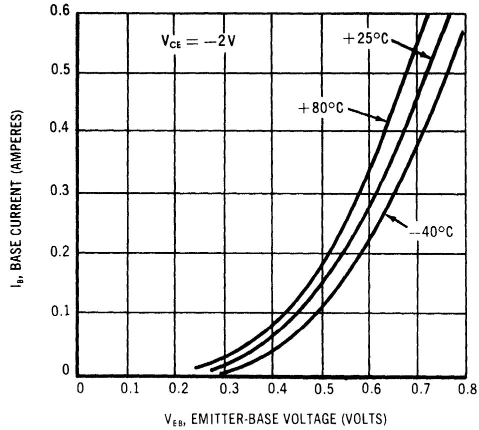


FIGURE 2 — OUTPUT CHARACTERISTICS

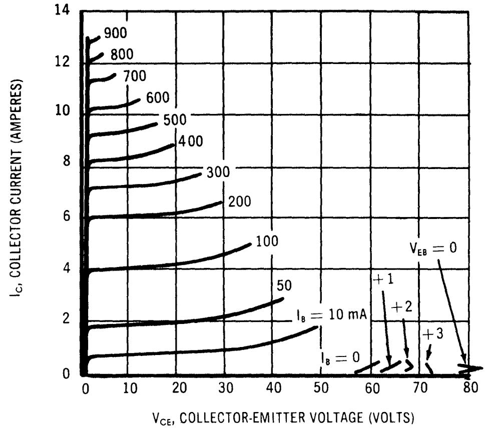


FIGURE 3 — CURRENT TRANSFER CHARACTERISTICS

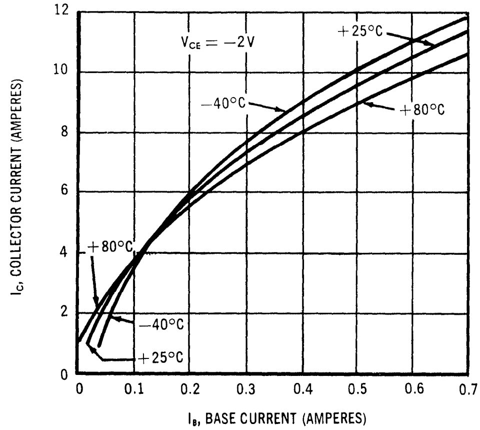


FIGURE 4 — TRANSCONDUCTANCE CHARACTERISTICS

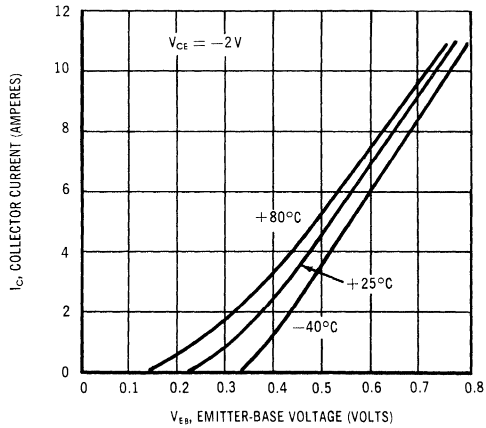
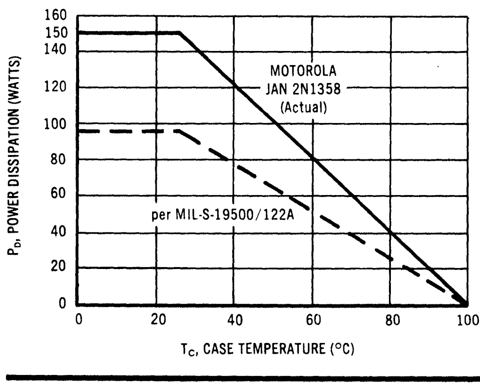


FIGURE 5 — POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that

$$\text{allowable } P_D = \frac{100^\circ - T\text{case}}{0.5}$$

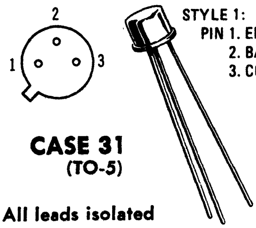
2N1358, A (GERMANIUM)

For Specifications, See 2N174 DATA.

2N1359 (GERMANIUM)
2N1360
2N1362 thru 2N1365

For Specifications, See 2N375 Data.

2N1408 (GERMANIUM)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated

PNP germanium transistor for high voltage neon driver, solenoid and relay driver circuits.

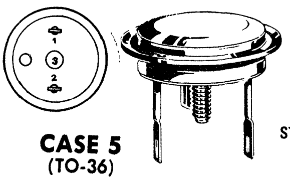
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CES}	50	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current	I_C	200	mA
Collector Dissipation at $T_A = 25°C$ derating factor	P_D	150 2.0	mW mW/°C
Junction Temperature Range	T_J	-65 to +100	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	---	7.0	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	---	7.0	μAdc
Collector-Emitter Leakage Current (V_{CB} = 50 Vdc, R_{BE} = 0)	I_{CES}	---	150	μAdc
Collector-Base Breakdown Voltage (I_C = 25 μAdc, I_E = 0)	BV_{CBO}	50	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 25 μAdc, I_C = 0)	BV_{EBO}	10	---	Vdc
Collector-Emitter Punch-Thru Voltage (I_E = 25 μAdc)	V_{pt}	50	---	Vdc
Base-Emitter Input Voltage (I_B = 1.0 mAdc, V_{CE} = 1.0 Vdc)	V_{BE}	---	0.6	Vdc
DC Current Gain (V_{CE} = 1 Vdc, I_B = 1 mAdc)	h_{FE}	10	---	---
Small Signal Current Gain (V_{CE} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kHz)	h_{fe}	10	---	---
Output Admittance (V_{CB} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kHz)	h_{ob}	---	2.0	μmhos

2N1412 (GERMANIUM)
2N1412A



CASE 5
(TO-36)
Collector connected to case

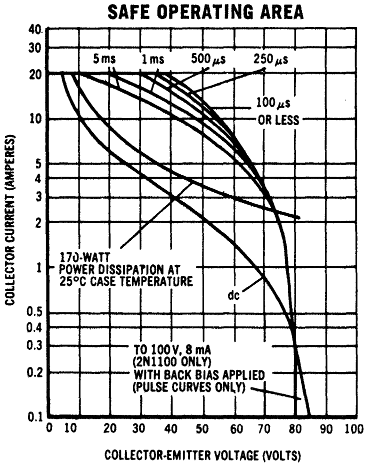
STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

PNP germanium power transistors for high-voltage power amplifier and switching applications in military and industrial equipment.

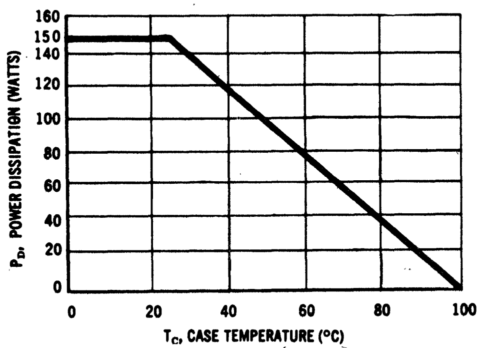
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EB}	60	Vdc
Emitter Current (Continuous)	I_E	15	Amp
Base Current (Continuous)	I_B	4.0	Amp
Junction & Storage Temperature	T_{stg}	-65 to +100	^{o}C
Thermal Resistance	θ_{JC}	0.5	$^{o}C/W$

SAFE OPERATING AREA



POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_C}{0.5}$$

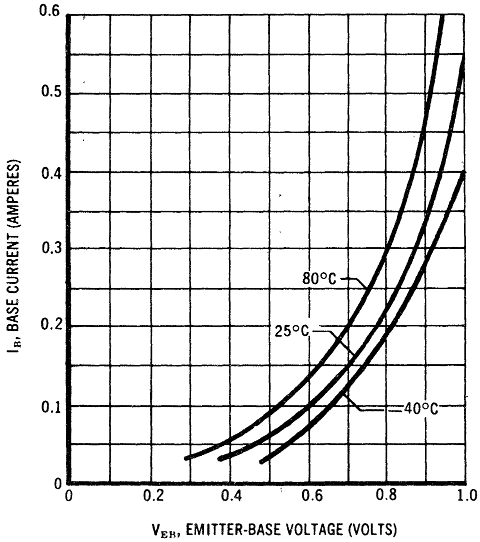
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS

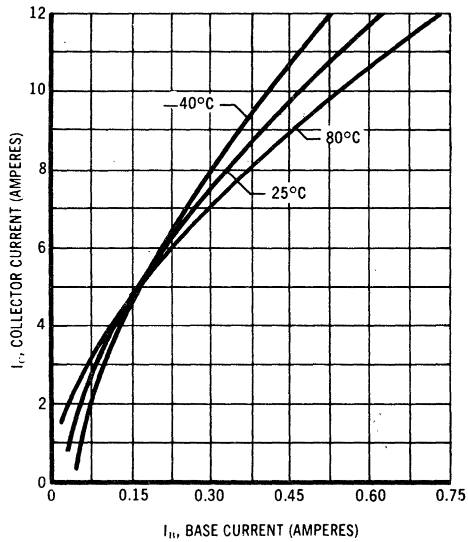
Characteristic	Symbol	Minimum	Maximum	Unit
Emitter Cutoff Current $V_{EB} = -2.0$ Vdc $I_C = 0$	I_{EBO}	—	200	μAdc
Emitter Cutoff Current $V_{EB} = -60$ Vdc $I_C = 0$	I_{EBO}	—	10	mAdc
Collector Cutoff Current $V_{CB} = -2.0$ Vdc $I_E = 0$	I_{CBO}	—	200	μAdc
Collector Cutoff Current $V_{CB} = -100$ Vdc $I_E = 0$	I_{CBO}	—	10	mAdc
Emitter-Base Voltage $V_{CE} = -2.0$ Vdc $I_C = -1.2$ Adc	V_{EB}	—	0.5	Vdc
Emitter-Base Voltage $V_{CE} = -2.0$ Vdc $I_C = -5.0$ Adc	V_{EB}	—	0.9	Vdc
Floating Potential $V_{CB} = -100$ Vdc $I_E = 0$ (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage $I_C = -12$ Adc $I_B = -2.0$ Adc	$V_{CE(SAT)}$	—	0.7	Vdc
Forward Current Transfer Ratio* $V_{CE} = -2.0$ Vdc $I_C = -15$ Adc	h_{FE}	10	—	—
Forward Current Transfer Ratio $V_{CE} = -2.0$ Vdc $I_C = -5.0$ Adc	h_{FE}	25	50	—
Collector-Emitter Breakdown Voltage* $I_C = -1$ Adc $I_B = 0$	BV_{CEO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* $V_{EB} = 0$ $I_C = 300$ mA	BV_{CES}	80	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency $V_{CE} = -12$ Vdc $I_C = -5.0$ Adc	$f_{\alpha e}$	5.0	—	kHz
High-Temperature Operation Emitter Cutoff Current $T_C = +71°C$ min $V_{EB} = -30$ Vdc	I_{EBO}	—	6.0	mAdc
Collector Cutoff Current $V_{CB} = -30$ Vdc $I_E = 0$	I_{CBO}	—	6.0	mAdc

*Test by sweep method with a short duty cycle (about 1%) to avoid excessive heating.

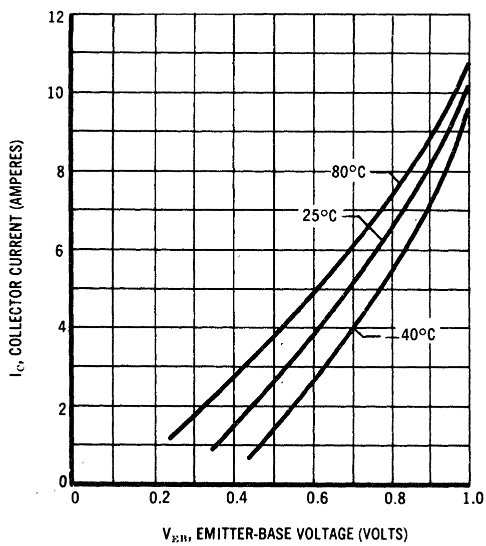
INPUT CHARACTERISTICS



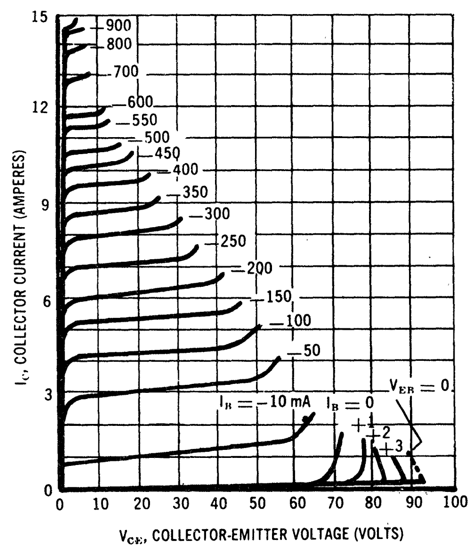
CURRENT TRANSFER CHARACTERISTICS



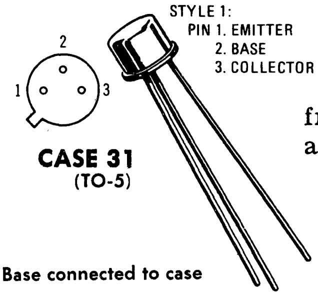
TRANSCONDUCTANCE CHARACTERISTICS



OUTPUT CHARACTERISTICS



2N1413 thru 2N1415 (GERMANIUM)
2N1175



Base connected to case

PNP germanium transistors for general-purpose low-frequency amplifier and switching applications. Characteristic curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 30 Vdc, I_E = 0	I_{CBO}	–	12	μAdc
Emitter Cutoff Current V_{EB} = 10 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	25	–	Vdc
Punch-Thru Voltage	V_{pt}	25	–	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = 1 Vdc 2N1413 2N1414 2N1415 2N1175	h_{FE}	 25 34 53 70	 42 65 90 140	 –

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain I_C = 100 mAdc, V_{CE} = 1 Vdc 2N1413 2N1414 2N1415 2N1175	h_{FE}	 23 30 47 62	 – – – –	 –
Base Input Voltage V_{CE} = 1 Vdc, I_C = 20 mAdc 2N1175	V_{BE}	 –	 260	 mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	–	40	pF
Frequency Cutoff V_{CE} = 5 Vdc, I_E = 1 mAdc 2N1413 2N1414 2N1415 2N1175	$f_{\alpha b}$	 0.8 1.0 1.3 1.5	 – – – –	 MHz
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1413 2N1414 2N1415 2N1175	h_{fe}	 20 30 44 60	 41 64 88 120	 –
Small-Signal Open Circuit Output Admittance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1413 2N1414 2N1415 2N1175	h_{ob}	 0.10 0.10 0.10 0.10	 1.3 1.2 1.0 0.9	 μmh
Small-Signal Open-Circuit Reverse-Transfer Voltate Ratio V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1413 2N1414 2N1415 2N1175	h_{rb}	 1.0 1.0 1.0 1.0	 10 11 12 14	 $X10^{-4}$
Small-Signal Short-Circuit Input Impedance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1413 2N1414 2N1415 2N1175	h_{ib}	 26 26 26 26	 36 35 33 31	 μmhos

2N1495

For Specifications, See 2N1204A Data

2N1518 thru 2N1523

PNP GERMANIUM HIGH POWER SWITCHING TRANSISTORS

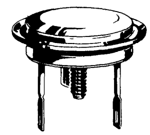
. . . designed featuring low saturation voltage capability for high efficiency performance in motor drive controls and low loss regulators.

- Collector-Base Voltage –
  V_{CB} = 50 Vdc (Min) – 2N1518, 2N1520, 2N1522
  = 80 Vdc (Min) – 2N1519, 2N1521, 2N1523
- Collector Current –
  I_C = 25 Adc – 2N1518, 2N1519
  = 35 Adc – 2N1520, 2N1521
  = 50 Adc – 2N1522, 2N1523

25, 35, 50 AMPERE POWER TRANSISTORS

PNP GERMANIUM

50, 80 VOLTS
87.5 WATTS



*MAXIMUM RATINGS

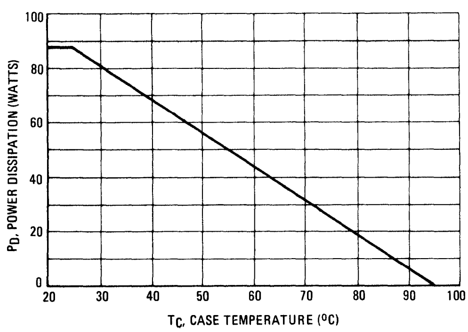
Rating	Symbol	2N1518 2N1520 2N1522		2N1519 2N1521 2N1523	Unit
Collector-Emitter Voltage	V_{CEO}	40		60	Vdc
Collector-Base Voltage	V_{CB}	50		80	Vdc
Emitter-Base Voltage	V_{EB}	30			Vdc
		2N1518 2N1519	2N1520 2N1521	2N1522 2N1523	
Collector Current – Continuous	I_C	25	35	50	Adc
Base Current – Continuous	I_B	4.0	6.0	8.0	Adc
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	← 87.5 → ← 1.17 →			Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +95 →			^oC

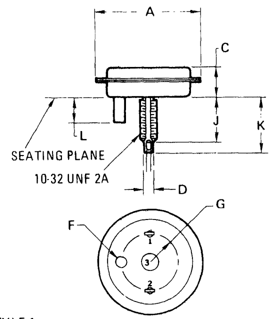
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	$^oC/W$

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR
(CONNECTED TO CASE)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	31.75	–	1.250
C	–	13.21	–	0.520
D	–	4.83	–	0.190
F	–	3.56	–	0.140
G	8.76 NOM		0.345 NOM	
J	9.53	12.70	0.375	0.500
K	15.49	18.03	0.610	0.710
L	–	7.92	–	0.312

All JEDEC dimensions and notes apply

CASE 5-03
TO-36

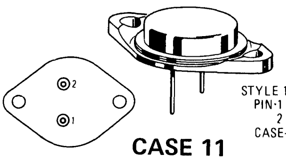
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
*Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 1.0 Adc, I_B = 0)	2N1518, 2N1520, 2N1522		40	–	–	
	2N1519, 2N1521, 2N1523		60	–	–	
*Floating Potential		V_{EBF}				Vdc
(V_{CB} = 50 Vdc, I_E = 0)	2N1518, 2N1520, 2N1522		–	–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N1519, 2N1521, 2N1523		–	–	1.0	
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 2.0 Vdc, I_E = 0)	All Devices		–	–	300	μAdc
*(V_{CB} = 50 Vdc, I_E = 0)	2N1518, 2N1520, 2N1522		–	–	4.0	mAdc
*(V_{CB} = 80 Vdc, I_E = 0)	2N1519, 2N1521, 2N1523		–	–	4.0	
*(V_{CB} = 50 Vdc, I_E = 0, T_C = 85°C)	2N1518, 2N1520, 2N1522		–	–	15	
*(V_{CB} = 80 Vdc, I_E = 0, T_C = 85°C)	2N1519, 2N1521, 2N1523		–	–	15	
*Emitter Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	–	8.0	mAdc
ON CHARACTERISTICS						
*DC Current Gain		h_{FE}				–
(I_C = 15 Adc, V_{CE} = 4.0 Vdc)	2N1518, 2N1519		15	–	60	
	2N1520, 2N1521		17	–	68	
	2N1522, 2N1523		25	–	100	
(I_C = 25 Adc, V_{CE} = 4.0 Vdc)	2N1518, 2N1519		12	–	–	
(I_C = 35 Adc, V_{CE} = 4.0 Vdc)	2N1520, 2N1521		12	–	–	
(I_C = 50 Adc, V_{CE} = 4.0 Vdc)	2N1522, 2N1523		12	17	–	
*Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 25 Adc, I_B = 4.0 Adc)	2N1518, 2N1519		–	–	0.7	
(I_C = 35 Adc, I_B = 4.0 Adc)	2N1520, 2N1521		–	–	0.6	
(I_C = 50 Adc, I_B = 5.0 Adc)	2N1522, 2N1523		–	–	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 25 Adc, I_B = 3.0 Adc)	2N1518, 2N1519		–	–	1.5	
(I_C = 35 Adc, I_B = 4.0 Adc)	2N1520, 2N1521		–	–	1.5	
(I_C = 50 Adc, I_B = 5.0 Adc)	2N1522, 2N1523		–	–	1.5	
SMALL-SIGNAL CHARACTERISTICS						
Common-Emitter Amplification Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		h_{hfe}	–	4.0	–	kHz

*Indicates JEDEC Registered Data.

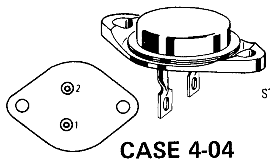
2N1529 thru 2N1538 (GERMANIUM)
2N1529A thru 2N1532A, 2N1534A thru 2N1537A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11

STYLE 1
PIN 1 BASE
2 EMITTER
CASE-COLLECTOR



CASE 4-04

STYLE 1
PIN 1 BASE
2. EMITTER
CASE-COLLECTOR

Collector connected to case

units with solder lugs attached, specify
ces MP1529, A etc. (Case 4-04)

MAXIMUM RATINGS

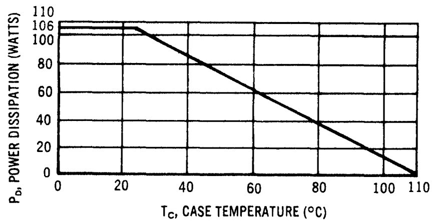
Rating	Symbol	2N1529 2N1534	2N1530 2N1535	2N1531 2N1536	2N1532 2N1537	2N1533 2N1538	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current (Continuous)	I_C	5.0					Amp
Collector Current (Peak)	I_C	10					Amp
Junction Temperature Range	T_J	-65 to +110					^oC
Total Device Dissipation (25°C Case Temperature)	P_D	106					Watts
Thermal Resistance	θ_{JC}	0.8					$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified.)

Characteristics apply to corresponding "A" type numbers also.

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}			mA
(V_{CB} = 25V)	2N1529, 2N1534		—	2.0	
(V_{CB} = 40V)	2N1530, 2N1535		—	2.0	
(V_{CB} = 55V)	2N1531, 2N1536		—	2.0	
(V_{CB} = 65V)	2N1532, 2N1537		—	2.0	
(V_{CB} = 80V)	2N1533, 2N1538		—	2.0	
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 2V)			—	0.2	
(V_{CB} = 1 2 BV_{CES} rating; T_C = +90°C)			—	20	
Emitter-Base Cutoff Current (V_{EB} = 12V)		I_{EBO}	—	0.5	mA
Collector-Emitter Breakdown Voltage		BV_{CES}			volts
(I_C = 500 mA, V_{EB} = 0)	2N1529, 2N1534		30	—	
	2N1530, 2N1535		45	—	
	2N1531, 2N1536		60	—	
	2N1532, 2N1537		75	—	
	2N1533, 2N1538		90	—	
Collector-Emitter Leakage Current (V_{BE} = 1V, V_{CE} @ rated BV_{CBO})		I_{CEX}	—	20	mA
Collector-Emitter Breakdown Voltage		BV_{CEO}			volts
(I_C = 500 mA, I_B = 0)	2N1529, 2N1534		20	—	
	2N1530, 2N1535		30	—	
	2N1531, 2N1536		40	—	
	2N1532, 2N1537		50	—	
	2N1533, 2N1538		60	—	
Collector-Base Breakdown Voltage		BV_{CBO}			volts
(I_C = 20 mA)	2N1529, 2N1534		40	—	
	2N1530, 2N1535		60	—	
	2N1531, 2N1536		80	—	
	2N1532, 2N1537		100	—	
	2N1533, 2N1538		120	—	
Current Gain		h_{FE1}			—
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1533		20	40	
	2N1534 - 2N1538		35	70	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1533		—	1.7	
	2N1534 - 2N1538		—	1.5	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1533		—	1.5	
	2N1534 - 2N1538		—	1.2	
Transconductance		g_{FE}			mhos
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1533		1.2	—	
	2N1534 - 2N1538		1.5	—	

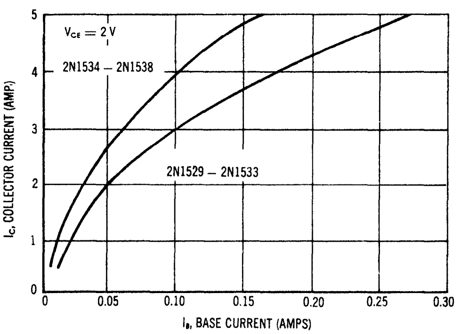
POWER-TEMPERATURE DERATING CURVE



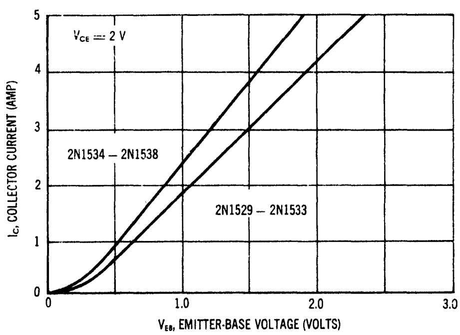
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - T_C}{0.8}$$

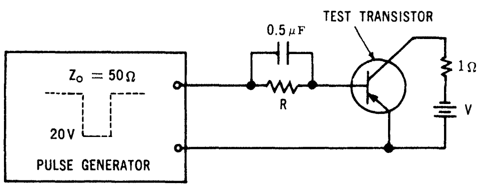
COLLECTOR CURRENT versus BASE CURRENT



COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



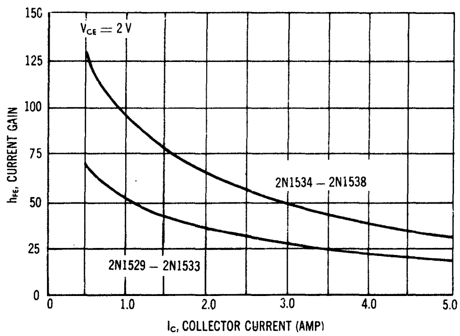
SWITCHING TIME MEASURING CIRCUIT



TYPICAL SWITCHING CHARACTERISTICS

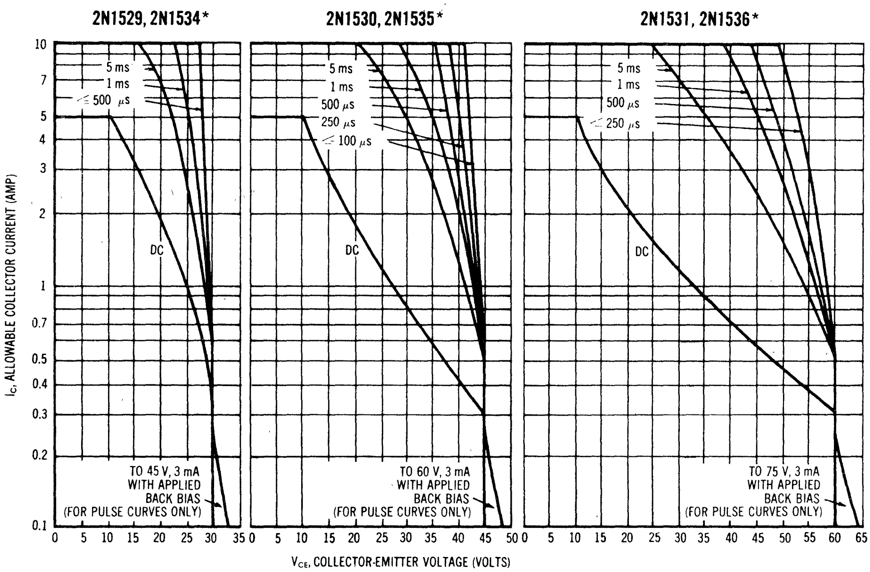
	I_C (AMP)	V (VOLTS)	R (ohms)	t_d+t_r (μS)	t_s (μS)	t_f (μS)
2N1529-33	3	3	65	10	2	5
2N1534-38	3	3	100	8	3	5

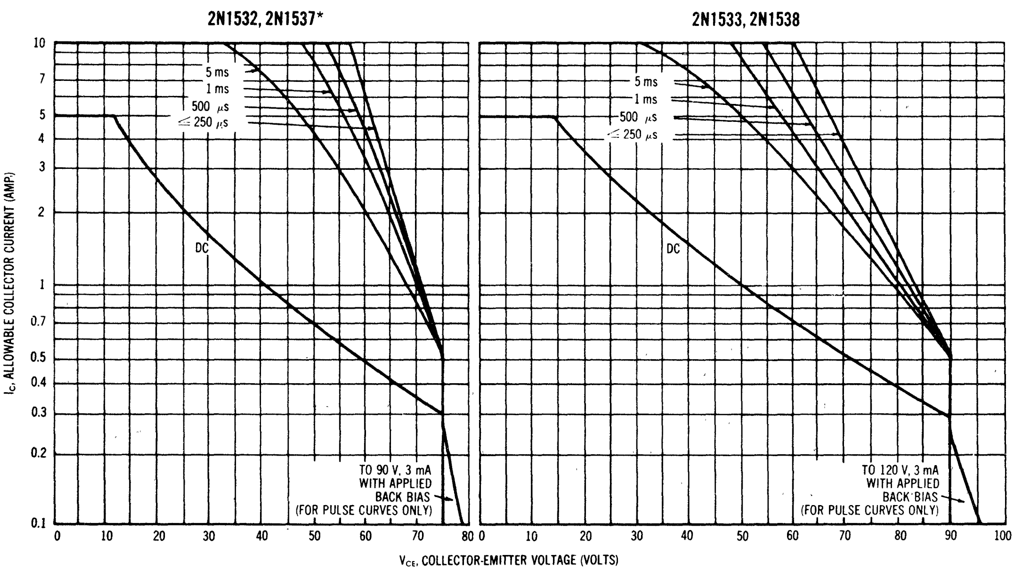
DC CURRENT GAIN versus COLLECTOR CURRENT



SAFE OPERATING AREAS — PULSE CONDITIONS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

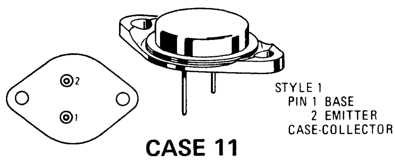




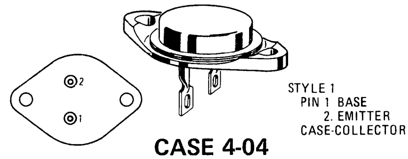
*Characteristics apply to corresponding "A" type numbers also.

2N1539 thru 2N1548 (GERMANIUM)
2N1539A thru 2N1542A, 2N1544A thru 2N1547A

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11



CASE 4-04

Collector connected to case

For units with solder lugs attached, specify devices MP1539, A etc. (Case 4-04)

MAXIMUM RATINGS

Rating	Symbol	2N1539 2N1544	2N1540 2N1545	2N1541 2N1546	2N1542 2N1547	2N1543 2N1548	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	60	Vdc
Collector Current-Continuous	I_C	5.0					Adc
Peak	I_C	10					Adc
Total Device Dissipation @T_C = 25° C	P_D	106					Watts
Operating Junction Temperature Range	T_J	-65 to +110					°C

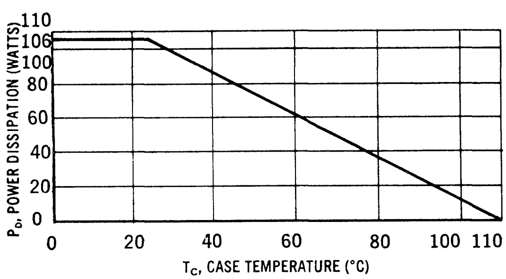
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d. c. or frequencies below 25 cps the transistor must be operated within the constant P_D = Vc x Ic hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25^{o}C and is 0 Watts at 110^{o}C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^o - Tc}{0.8}$$

POWER-TEMPERATURE DERATING CURVE

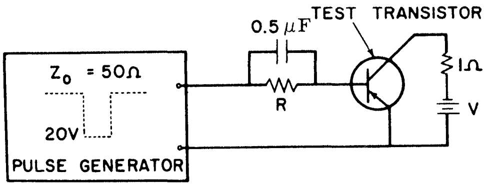


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage‡ (I_C = 500 mAdc, I_B = 0)	2N1539, 2N1544	BV_{CEO}‡	20	-	volts
	2N1540, 2N1545		30	-	
	2N1541, 2N1546		40	-	
	2N1542, 2N1547		50	-	
	2N1543, 2N1548		60	-	
Collector-Emitter Breakdown Voltage‡ (I_C = 500 mAdc, V_{BE} = 0)	2N1539, 2N1544	BV_{CES}‡	30	-	volts
	2N1540, 2N1545		45	-	
	2N1541, 2N1546		60	-	
	2N1542, 2N1547		75	-	
	2N1543, 2N1548		90	-	
Collector-Base Breakdown Voltage (I_C = 20 mAdc, I_E = 0)	2N1539, 2N1544	BV_{CBO}	40	-	volts
	2N1540, 2N1545		60	-	
	2N1541, 2N1546		80	-	
	2N1542, 2N1547		100	-	
	2N1543, 2N1548		120	-	
Collector Cutoff Current (V_{CE} @ rated V_{CB}, V_{BE} = 1.0 Vdc)		I_{CEX}	-	20	mA
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mA
(V_{CB} = 1/2 V_{CES} rating, T_C = 90°C)			-	20	
Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	2N1539, 2N1544	I_{CBO1}	-	2.0	mA
(V_{CB} = 40 Vdc, I_E = 0)	2N1540, 2N1545		-	2.0	
(V_{CB} = 55 Vdc, I_E = 0)	2N1541, 2N1546		-	2.0	
(V_{CB} = 65 Vdc, I_E = 0)	2N1542, 2N1547		-	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N1543, 2N1548		-	2.0	
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N1539-2N1543	h_{FE1}	50	100	-
	2N1544-2N1548		75	150	
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N1539-2N1543	g_{FE}	3.0	-	mhos
	2N1544-2N1548		5.0	-	
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	2N1539-2N1543	$V_{CE(sat)}$	-	0.3	volts
	2N1544-2N1548		-	0.2	
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)	2N1539-2N1543	$V_{BE(sat)}$	-	0.7	volts
	2N1544-2N1548		-	0.5	
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	Typ 4.0		kHz

Characteristics apply to corresponding A type numbers also.
‡To avoid excessive heating of collector junction, perform this test with a sweep method.

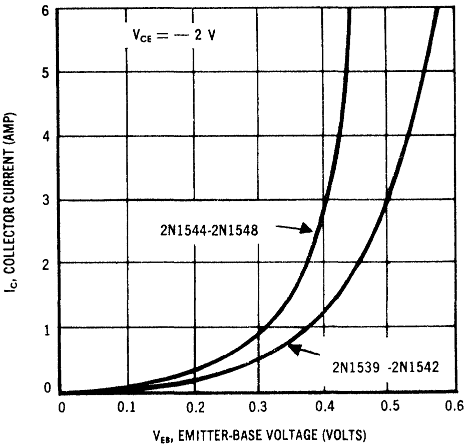
SWITCHING TIME MEASURING UNIT



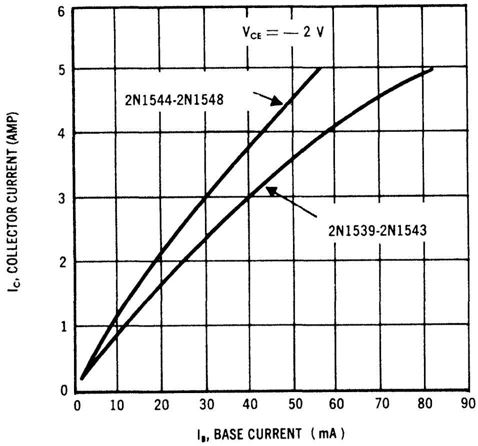
Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_d + t_r$ (μs)	t_s (μs)	t_f (μs)
2N1539-43	3	3	165	5	3	5
2N1544-48	3	3	250	5	3	8

*Input Pulse Repetition Rate = 2 kHz,
Pulse Width = 50 μs

COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



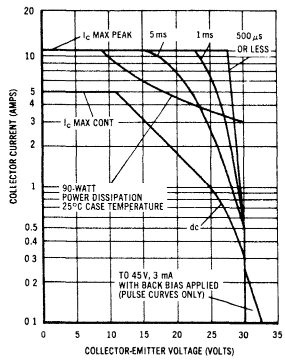
COLLECTOR CURRENT versus BASE CURRENT



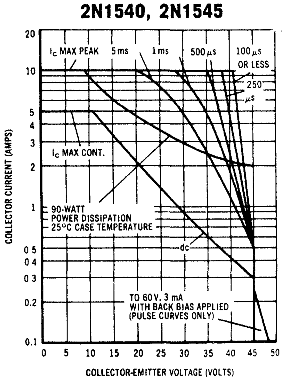
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

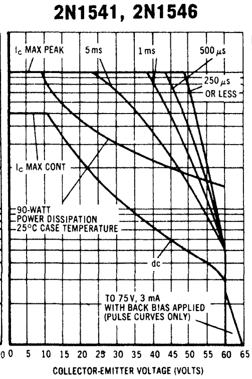
2N1539, 2N1544



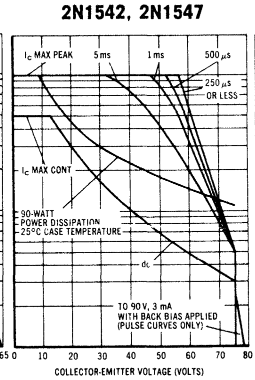
2N1540, 2N1545



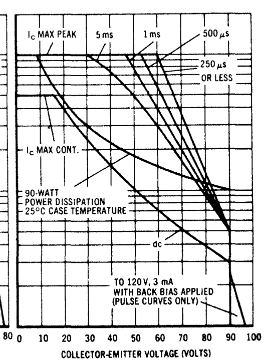
2N1541, 2N1546



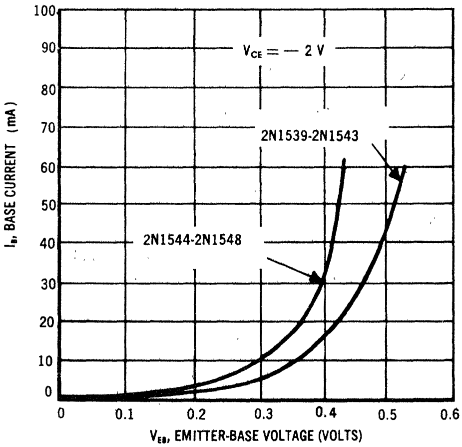
2N1542, 2N1547



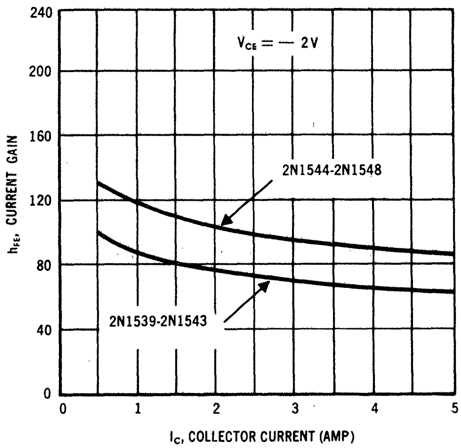
2N1543, 2N1548



BASE CURRENT versus EMITTER BASE VOLTAGE

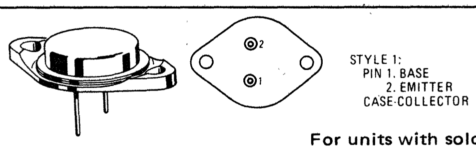


DC CURRENT GAIN versus COLLECTOR CURRENT

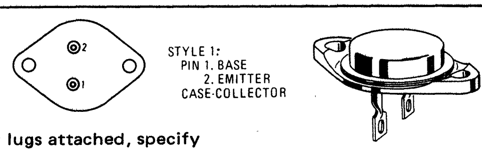


2N1549, A thru 2N1560, A (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.



CASE 11A



CASE 4-04

For units with solder lugs attached, specify devices MP1549, A etc. (Case 4-04).

Collector connected to case

MAXIMUM RATINGS Apply to corresponding "Hi-Rel" Series also

Rating	Symbol	2N1549 2N1553 2N1557	2N1550 2N1554 2N1558	2N1551 2N1555 2N1559	2N1552 2N1556 2N1560	Units
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	Vdc
Collector-Emitter Voltage	V_{CES}*	30	45	60	75	Vdc
Collector-Emitter Voltage	V_{CEO}*	20	30	40	50	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	50	Vdc
Collector Current (Continuous)	I_C	15				Amp
Collector Current (Peak)	I_C	20				Amp
Collector Junction Temperature	T_J	-65 to +110				^oC
Collector Dissipation (25°C Case Temp.)	P_D	106				Watts
Thermal Resistance	θ_{JC}	0.8				$^oC/W$

*To avoid excessive heating of collector junction, perform this test with a sweep method.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics apply to corresponding A type numbers also.

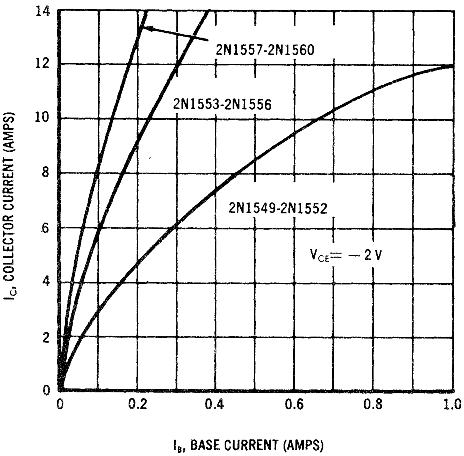
Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}			mA
(V_{CB} = 25 V)	2N1549, 2N1553, 2N1557		-	3.0	
(V_{CB} = 40 V)	2N1550, 2N1554, 2N1558		-	3.0	
(V_{CB} = 55 V)	2N1551, 2N1555, 2N1559		-	3.0	
(V_{CB} = 65 V)	2N1552, 2N1556, 2N1560		-	3.0	
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 2 V)			-	0.2	
(V_{CB} = 1/2 BV_{CES} rating; T_C = +90°C)			-	20	
Emitter-Base Cutoff Current		I_{EBO}			mA
(V_{EB} = 12 V)			-	0.5	
Collector-Emitter Breakdown Voltage		BV_{CES}			volts
(I_C = 300 mA)	2N1549, 2N1553, 2N1557		30	-	
	2N1550, 2N1554, 2N1558		45	-	
	2N1551, 2N1555, 2N1559		60	-	
	2N1552, 2N1556, 2N1560		75	-	
Collector-Emitter Leakage Current		I_{CEX}			mA
(V_{BE} = 1.0 V, V_{CE} @ rated BV_{CBO})			-	20	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			volts
(I_C = 300 mA, I_B = 0)	2N1549, 2N1553, 2N1557		20	-	
	2N1550, 2N1554, 2N1558		30	-	
	2N1551, 2N1555, 2N1559		40	-	
	2N1552, 2N1556, 2N1560		50	-	
Collector-Base Breakdown Voltage		BV_{CBO}			volts
(I_C = 20 mA)	2N1549, 2N1553, 2N1557		40	-	
	2N1550, 2N1554, 2N1558		60	-	
	2N1551, 2N1555, 2N1559		80	-	
	2N1552, 2N1556, 2N1560		100	-	
Current Gain		h_{FE1}			
(V_{CE} = 2.0 V, I_C = 10 A)	2N1549 - 2N1552		10	30	
	2N1553 - 2N1556		30	60	
	2N1557 - 2N1560		50	100	
Base-Emitter Drive Voltage		V_{BE}			volts
(I_C = 10 A, I_B = 1.0 A)	2N1549 - 2N1552		-	1.3	
	2N1553 - 2N1556		-	1.0	
	2N1557 - 2N1560		-	0.85	
Collector Saturation Voltage		$V_{CE(sat)}$			volts
(I_C = 10 A, I_B = 1.0 A)	2N1549 - 2N1552		-	1.0	
	2N1553 - 2N1556		-	0.7	
	2N1557 - 2N1560		-	0.5	

*To avoid excessive heating of collector junction, perform this test with a sweep method.

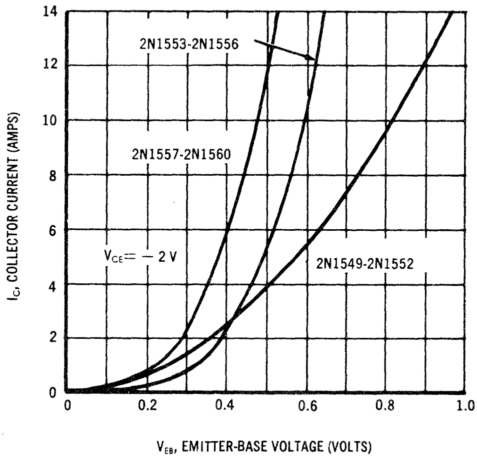
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Transconductance (V_{CE} = 2.0 V, I_C = 10 A)	g_{FE}			mhos
2N1549 - 2N1552		6.0	18	
2N1553 - 2N1556		8.0	30	
2N1557 - 2N1560		12	40	
Frequency Cutoff	f_{ae}	Typ		kHz
2N1549 - 2N1552		10		
2N1553 - 2N1556		6.0		
2N1557 - 2N1560		5.0		

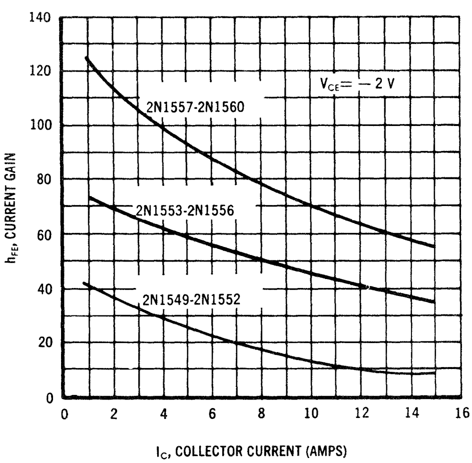
COLLECTOR CURRENT versus BASE CURRENT



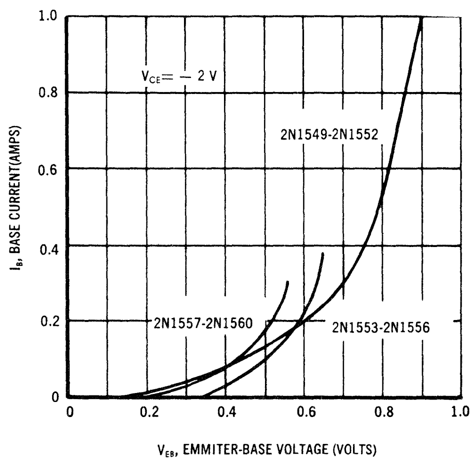
COLLECTOR CURRENT versus EMITTER-BASE VOLTAGE



CURRENT GAIN versus COLLECTOR CURRENT

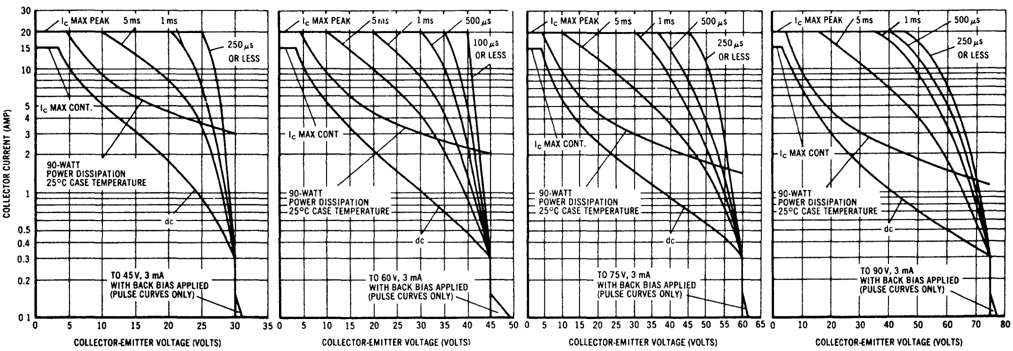


BASE CURRENT versus EMITTER-BASE VOLTAGE



SAFE OPERATING AREAS

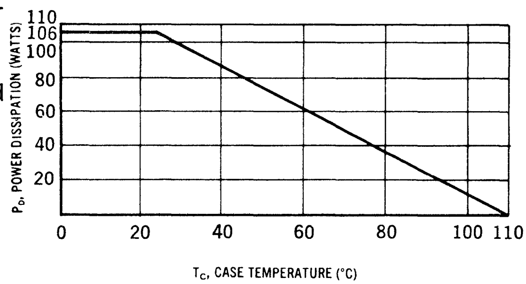
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.



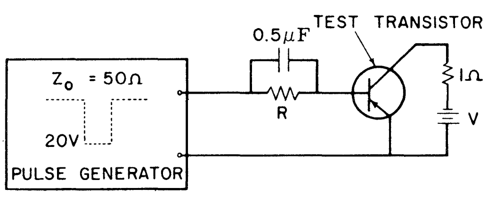
POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For dc or frequencies below 25 Hz the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 watts at case temperatures of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that P_D allowable

$$= \frac{110^{\circ} - T_C}{0.8}$$



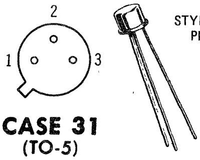
SWITCHING TIME MEASURING UNIT



Devices	Conditions*			Typical Switching Times		
	I_C (Amp)	V (Volts)	R (ohms)	$t_d + t_r$ (μs)	t_s (μs)	t_f (μs)
2N1549 -52	10	10	10	5	2	10
2N1553 -56	10	10	30	10	5	25
2N1557 -60	10	10	50	10	5	25

* Input Pulse Repetition Rate = 2 kHz, Pulse Width = 50 μs

2N1595 thru 2N1599 (SILICON)



STYLE 2:
PIN 1. CATHODE
2. GATE
3. ANODE

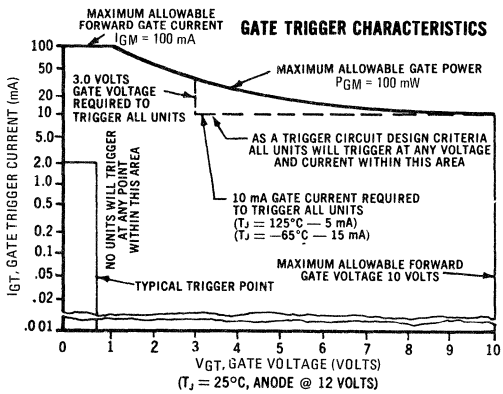
CASE 31
(TO-5)

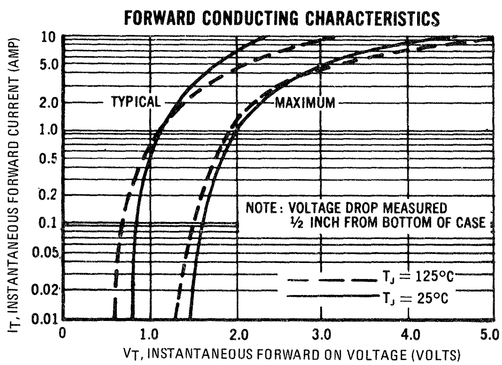
Industrial-type, low-current silicon controlled rectifiers in a three-lead package ideal for printed-circuit applications. Current handling capability of 1.6 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{RSM(rep)}$*		Volts
2N1595		50	
2N1596		100	
2N1597		200	
2N1598		300	
2N1599		400	
Forward Current RMS (All Conduction Angles)	$I_{T(RMS)}$	1.6	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	I_{TSM}	15	Amp
Peak Gate Power - Forward	P_{GM}	0.1	Watt
Average Gate Power - Forward	$P_{G(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{RSM} for all types can be applied on a continuous dc basis without incurring damage.



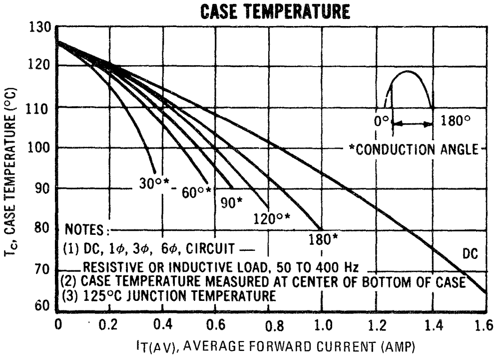


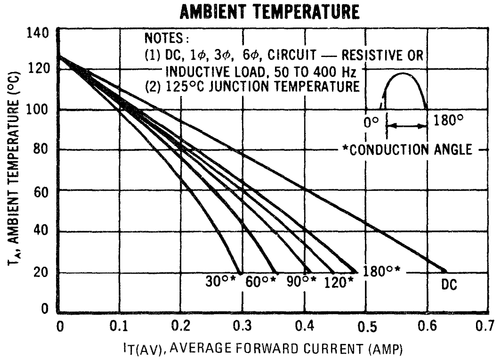
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) 2N1595	V_{DRM}*	50	—	—	Volts
2N1596		100	—	—	
2N1597		200	—	—	
2N1598		300	—	—	
2N1599		400	—	—	
Peak Forward Blocking Current (Rated V_{DRM} with gate open, T_J = 125°C)	I_{DRM}	—	—	1.0	mA
Peak Reverse Blocking Current (Rated V_{RSM}, T_J = 125°C)	I_{RRM}	—	—	1.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 12 Ω)	I_{GT}	—	2.0	10.0	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 12 Ω)	V_{GT}	—	0.7	3.0	Volts
(V_{DRM} = Rated, R_L = 12 Ω, T_J = 125°C)	V_{GNT}	0.2	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_H	—	5.0	—	mA
Forward On Voltage (I_T = 1 Adc)	V_{TM}	—	1.1	2.0	Volts
Turn-On Time (t_d + t_r) (I_{GT} = 10 mA, I_T = 1A)	t_{gt}	—	0.8	—	μs
Turn-Off Time (I_T = 1 A, I_R = 1 A, dv/dt = 20 V/μs, T_J = 125°C) (V_{DRM} = rated voltage)	t_q	—	10	—	μs

*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

CURRENT DERATING





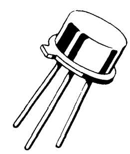
2N1613S (SILICON)
2N1613SJAN AVAILABLE

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in general purpose amplifier and switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CER} = 50 Vdc (Min) @ I_C = 100 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc

NPN SILICON AMPLIFIER TRANSISTOR



***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (R_{BE} ⩽ 10 Ohms)	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CB}	75	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

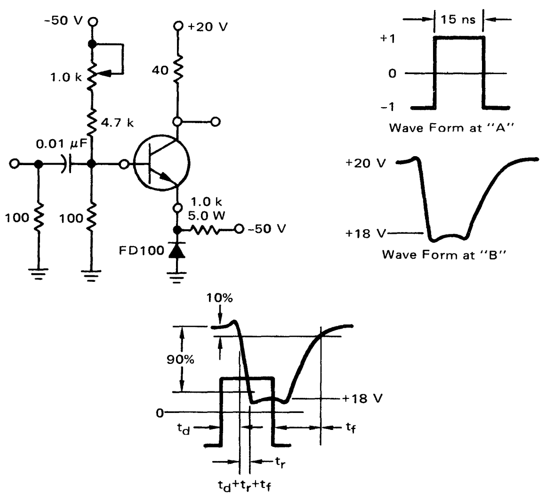
***THERMAL CHARACTERISTICS**

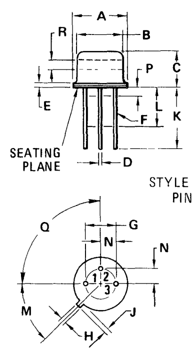
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)		°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT





STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

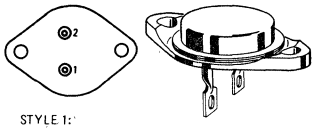
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted).

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, R_{BE} ≤ 10 Ohms)	$BV_{CER(sus)}$	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	75	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 60 Vdc, I_E = 0)		–	–	10	nAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		20	35	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		35	50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		20	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	80	120	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		20	30	–	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.78	1.3	Vdc
DYNAMIC CHARACTERISTICS/SMALL-SIGNAL CHARACTERISTICS					
Current-Gain – Bandwidth Product(1) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	50	80	pF
Input Impedance	h_{ib}				Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		24	–	34	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		4.0	–	8.0	
Voltage Feedback Ratio	h_{rb}				$X10^{-4}$
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		–	–	3.0	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		–	–	3.0	
Small-Signal Current Gain	h_{fe}				–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		30	–	100	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		35	–	150	
Output Admittance	h_{ob}				μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		0.05	–	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		0.1	–	1.0	
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 Ohms, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	–	–	12	dB
SWITCHING CHARACTERISTICS					
Switching Time (Figure 1)	$t_d+t_r+t_f$	–	–	30	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1651 thru 2N1653 (Germanium)

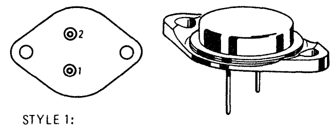
2N2285 thru 2N2287 (Germanium)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 161

2N1651 thru 2N1653



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 3-04

2N2285 thru 2N2287

PNP Germanium power transistors designed for high-current switching applications requiring low saturation voltages and fast switching times in addition to good safe operating area.

MAXIMUM RATINGS

Rating	Symbol	2N1651 2N2285	2N1652 2N2286	2N1653 2N2287	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	100	120	Vdc
Emitter-Base Voltage	V_{EB}	← 1.5 →			Vdc
Collector Current - Continuous	I_C	← 25 →			Adc
Base Current - Continuous	I_B	← 5.0 →			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 106 1.25 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

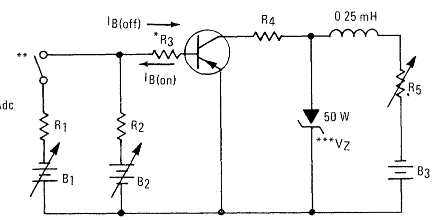
R_1 = 1.0 Ohm, 20 Watts
R_2 = 7.5 Ohms, 2.0 Watts
R_3 = 0.1 Ohm, 1.0%
$R_4 \leq$ 0.04 Ohm

R_5 I_C Adjust @ $V_{CE} = V_Z$

B_1 Adjust for $I_{B(on)} = \frac{I_C}{10}$

B_2 = 1.5 Vdc, Adjust for $I_{B(off)}$ = 0.2 Adc
B_3 = 12 Vdc

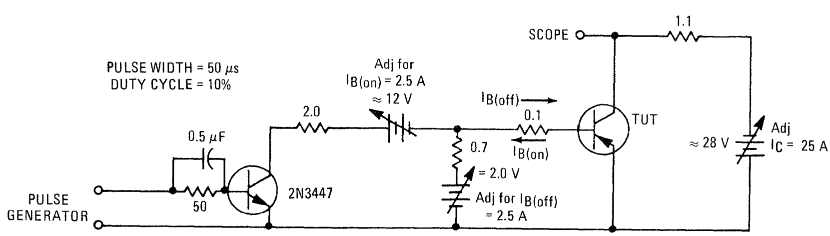
*Not required if current probe is used to read I_{B1}
**PRF ≈ 60 Hz
***Zener selected to establish Sustaining Voltage.
NOTE. Series impedance and inductance must be kept to a minimum.



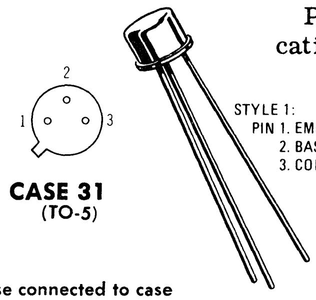
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N1651, 2N2285	BV_{CEO}	30	-	Vdc
	2N1652, 2N2286		60	-	
	2N1653, 2N2287		80	-	
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 25 Adc)	2N1651, 2N2285	$V_{CE(sus)}$	40	-	Vdc
	2N1652, 2N2286		45	-	
	2N1653, 2N2287		50	-	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO1}	-	200	μAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	2N1651, 2N2285	I_{CBO2}	-	5.0	mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N1652, 2N2286		-	5.0	
(V_{CB} = 100 Vdc, I_E = 0)	2N1653, 2N2287		-	5.0	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0, T_C = 100°C) (+0,-3.0°C)	2N1651, 2N2285	I_{CBO3}	-	35	mAdc
(V_{CB} = 80 Vdc, I_E = 0, T_C = 100°C) (+0,-3.0°C)	2N1652, 2N2286		-	35	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 100°C) (+0, -3.0°C)	2N1653, 2N2287		-	35	
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	2N1651, 2N2285	I_{CBO4}	-	20	mAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N1652, 2N2286		-	20	
(V_{CB} = 120 Vdc, I_E = 0)	2N1653, 2N2287		-	20	
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)		I_{EBO}	-	50	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	35	140	-
(I_C = 25 Adc, V_{CE} = 1.5 Vdc)			20	-	
Collector-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{CE(sat)}$	-	0.30	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	-	0.65	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)		h_{fe}	20	-	-
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 25 Adc, $I_{B(on)}$ = 2.5 Adc, $I_{B(off)}$ = 2.5 Adc) (See Figure 2)	t_r	-	12	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

FIGURE 2 — SWITCHING TIME TEST CIRCUIT



2N1705 thru 2N1707 (GERMANIUM)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistors for audio driver applications in transistorized radio receivers.

MAXIMUM RATINGS

Rating	Symbol	2N1705	2N1706	2N1707	Unit
Collector-Base Voltage	V_{CB}	18	25	30	Vdc
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	12	18	25	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	10	Vdc
Collector Current	I_C	400			mA
Collector Dissipation at T_C = 25°C	P_D	200			mW
Junction Temperature Range	T_J	-65 to +100			°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

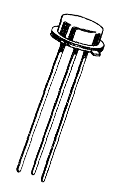
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = -10 Vdc)	2N1705		---	5 0	10	
	2N1706		---	---	10	
(V_{CB} = -25 Vdc)	2N1707		---	---	15	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = -5 Vdc)	2N1705		---	4.0	20	
	2N1706		---	---	20	
(V_{EB} = -10 Vdc)	2N1707		---	---	10	
Collector-Emitter Voltage		BV_{CER}				Vdc
(I_C = 1 mAdc, R_{BE} = 1 K)	2N1705		12	---	---	
	2N1706		18	---	---	
	2N1707		25	---	---	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 10 mA, V_{CE} = 5 V)	2N1706		0.15	---	0.35	
(I_C = 20 mA, V_{CE} = 1 V)	2N1705		0.2	---	0.4	
DC Current Gain		h_{FE}				---
(I_C = 10 mAdc, V_{CE} = -5 V)	2N1707		40	90	150	
(I_C = 20 mAdc, V_{CE} = -1 V)	2N1706		60	---	120	
Small Signal Current Gain		h_{fe}				---
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kHz)	2N1705		70	110	150	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706		50	90	150	
	2N1707		30	---	150	
Output Admittance Conductance		h_{ob}				μmhos
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kHz)	2N1705		---	0.5	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706, 2N1707		---	3.0	---	
Input Impedance		h_{ib}				ohms
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kHz)	2N1705		---	30	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kHz)	2N1706, 2N1707		---	4.0	---	
Voltage Feedback Ratio						
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kHz)	2N1705	h_{rb}	---	3.0	---	$X10^{-4}$
(I_C = 10 mA, V_C = -5 V, f = 1 kHz)	2N1706	h_{re}	---	0.69	---	$X10^{-3}$
	2N1707	h_{rb}	---	4.5	---	$X10^{-4}$
Frequency Cutoff		$f_{\alpha b}$				MHz
(I_C = 1 mA, V_C = -6 V)	2N1706, 2N1707		---	3.0	---	
	2N1705		---	4.0	---	
Output Capacitance		C_{ob}				pF
(I_C = 1 mA, V_{CB} = -6 V, f = 1 MHz)			---	20	---	
Noise Figure		NF				dB
(I_C = 1 mA, V_{CB} = -6 V, R_s = 1 K, f = 1 kHz)	2N1705		---	6.0	---	

NPN SILICON SWITCHING TRANSISTOR

. . . designed for high-speed, low-power saturated switching applications for computers in military and industrial service.

- Turn-On Time — t_{on} = 40 ns (Max) @ I_C = 10 mAdc
- Turn-Off Time — t_{off} = 75 ns (Max) @ I_C = 10 mAdc

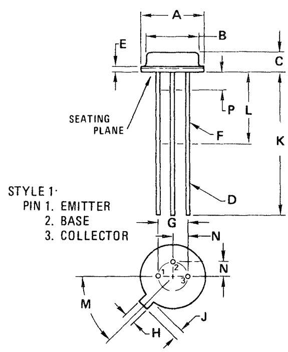
NPN SILICON SWITCHING TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	200	mAdc
**Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C
Lead Temperature 1/16" ± 1/32" from case, 10 s	T_L	+235	°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this data in addition to JEDEC Registered Data

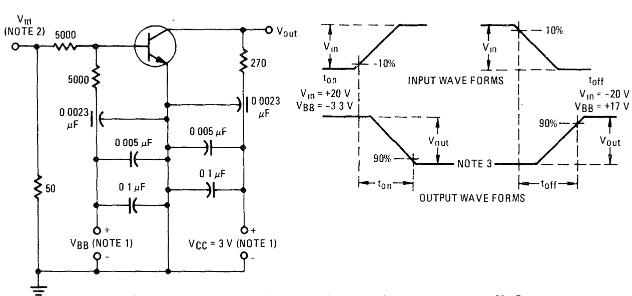


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26
TO-46

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



NOTE 1 With certain types of power supplies, it may be necessary to connect 25 µF decoupling capacitors across the power-supply terminals for V_{CC} and V_{BB}

NOTE 2 Input voltage (V_{in}) obtained from a pulse generator having an output impedance of 50 ohms V_{in} rise time ⩽ 1 0 ns, pulse duration ⩾ 300 ns, and duty factor ⩽ 2.0%

NOTE 3 Input and output waveforms, shown above, monitored by means of an oscilloscope having a rise time ⩽ 0 5 ns, input capacitance of probe ⩽ 2 5 pF with shunt resistance ⩾ 3000 ohms.

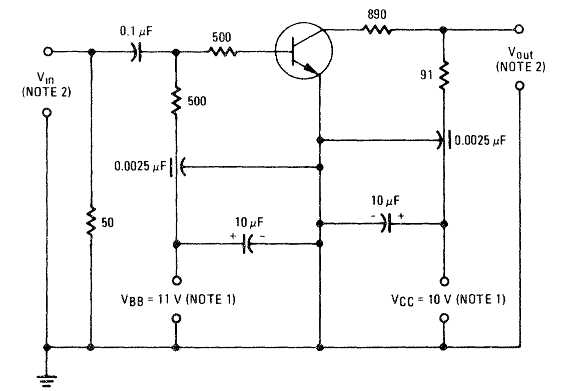
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

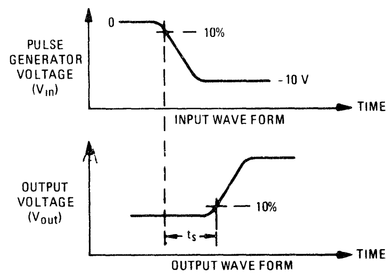
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	Vdc
Collector-Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.25 Vdc, T_A = 100°C)	I_{CEX}	–	15	μAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 0.025 15	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	20	–	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	 – –	 0.22 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	6.0	pF
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	–	40	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	–	75	ns
Storage Time (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	–	25	ns

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤ 1.0%.

FIGURE 2 — STORAGE TIME TEST CIRCUIT





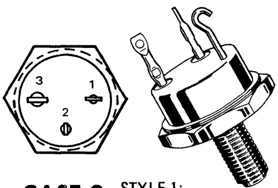
NOTE 1: Input voltage (V_{in}) obtained from pulse generator having an output impedance of 50 ohms. V_{in} rise time < 1 ns, pulse duration ≥ 300 ns, and duty factor ≤ 2.0%.

NOTE 2: Input and output wave forms monitored by means of an oscilloscope having a rise time ≤ 0.5 ns; input capacitance of probe ≤ 2.5 pF with shunt resistance ≥ 1000 ohms.

2N1711S

For Specifications, See 2N718A Data

2N1724 (SILICON)
2N1725



CASE 9
(TO-61)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon power transistors designed for switching and amplifier applications.

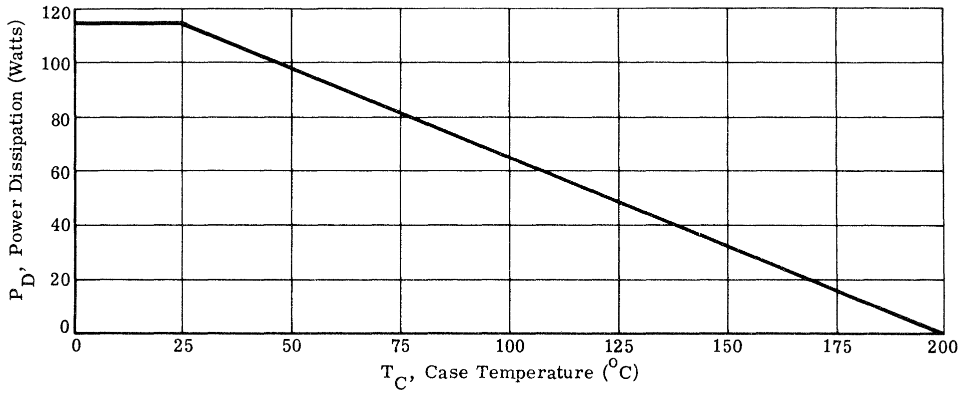
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	120	Vdc
Collector-Emitter Voltage	V_{CE}	80	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current (Continuous)	I_C	5.0	Adc
Power Dissipation	P_D	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$
Junction Operating Temperature Range	T_J	-65 to +200	^oC

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = 9 Vdc)	2N1725		-	-	0.5	
(V_{EB} = 10 Vdc)			-	-	10.0	
Collector-Emitter Cutoff Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)			-	-	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 0, T_C = 150°C)			-	-	2.0	
(V_{CE} = 120 Vdc, V_{BE} = 0, T_C = 150°C)			-	-	10.0	
Collector-Base Cutoff Current (V_{CB} = 3 Vdc, I_E = 0)		I_{CBO}	-	-	0.1	mAdc
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, I_B = 0)		$V_{CEO(sus)}$	80	-	-	Vdc
DC Current Gain		h_{FE}				
(V_{CE} = 15 Vdc, I_C = 2 Adc)	2N1724		20	40	90	
	2N1725		50	90	150	
(V_{CE} = 15 Vdc, I_C = 2 Adc, T_A = -55°C)	2N1724		12	-	-	
	2N1725		25	-	-	
(V_{CE} = 15 Vdc, I_C = 0.1 Adc)	2N1724		20	-	-	
	2N1725		50	-	-	
Collector-Emitter Saturation Voltage (I_C = 2 Adc, I_B = 200 mAdc)		$V_{CE(sat)}$		0.5	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 2 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$		1.2	2.0	Vdc
High Frequency Current Gain (V_{CE} = 15 Vdc, I_C = 0.5 Adc, f = 10 MHz)		h_{fe}	1.0	1.6	-	
Common Base Output Capacitance (V_{CB} = 10 Vdc, f = 0.1 MHz)		C_{ob}		260	550	pF
Switching Times (I_C = 2 Adc, I_{B1} = $-I_{B2}$ = 0.2 Adc)						µs
Delay time plus Rise time		$t_d + t_r$	-	0.15	-	
Storage time		t_s	-	1.3	-	
Fall time		t_f	-	0.14	-	

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREAS

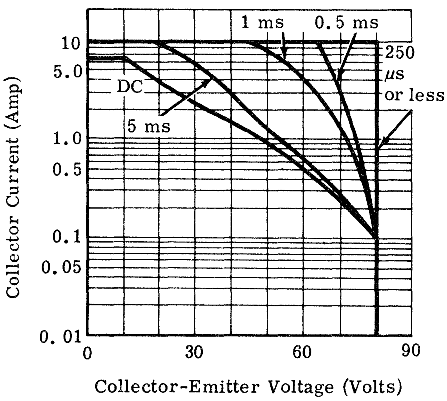
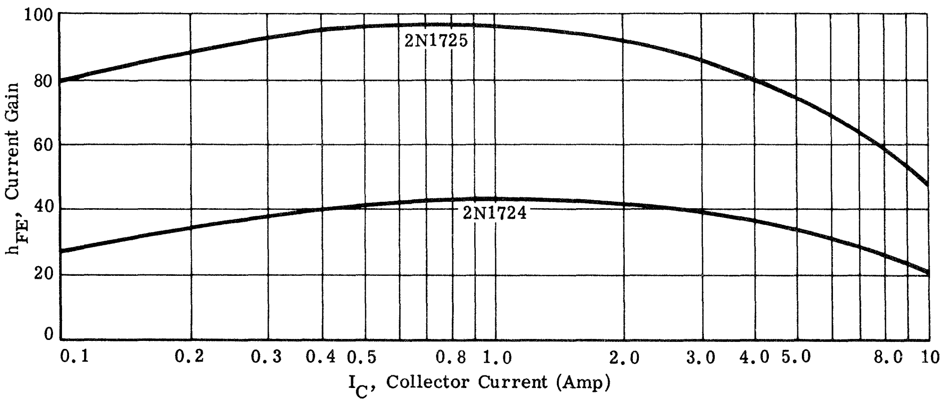


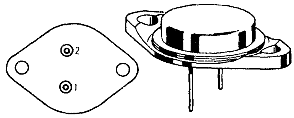
FIGURE 2 — 2N1724, 2N1725

In using these curves the average power derating curve (Fig. 1) must be observed to ensure operation below the maximum junction temperature.

FIGURE 3 — DC CURRENT GAIN versus COLLECTOR CURRENT



2N1751 (GERMANIUM)



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 3-04
(TO-3 modified)

PNP Germanium power transistor designed for high-current switching applications requiring low saturation voltages, short switching times and good sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)} = 0.3$ Vdc (Max) @ $I_C = 20$ Adc
  $V_{BE(sat)} = 0.7$ Vdc (Max) @ $I_C = 20$ Adc

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
*Collector-Base Voltage	V_{CB}	80	Vdc
*Emitter-Base Voltage	V_{EB}	2.5	Vdc
*Collector Current - Continuous	I_C	25	Adc
Base Current - Continuous	I_B	5.0	Adc
Total Device Dissipation @$T_C = 25°C$ Derate above 25°C	P_D	106 1.25	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

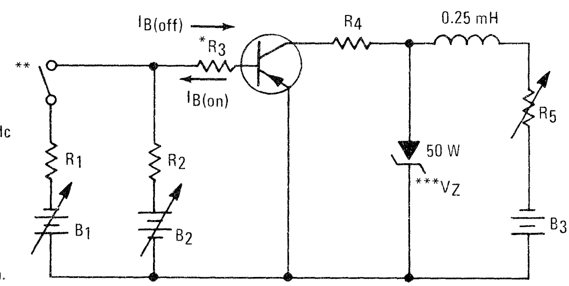
* Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT

R_1 = 1.0 Ohm, 20 Watts
R_2 = 10 Ohms, 2.0 Watts
R_3 = 0.1 Ohm, 1.0%
$R_4 \leq$ 0.04 Ohm

R_5: I_C Adjust @ $V_{CE} = V_Z$
B_1: Adjust for $I_{B(on)} = \frac{I_C}{10}$
B_2 = 2.0 Vdc, Adjust for $I_{B(off)}$ = 0.2 Adc
B_3 = 12 Vdc

*Not required if current probe is used to read I_B
**PRF ≈ 60 Hz
***Zener selected to establish Sustaining Voltage.
NOTE: Series impedance and inductance must be kept to a minimum.
Adjust input pulse width for I_C = 25 A condition.

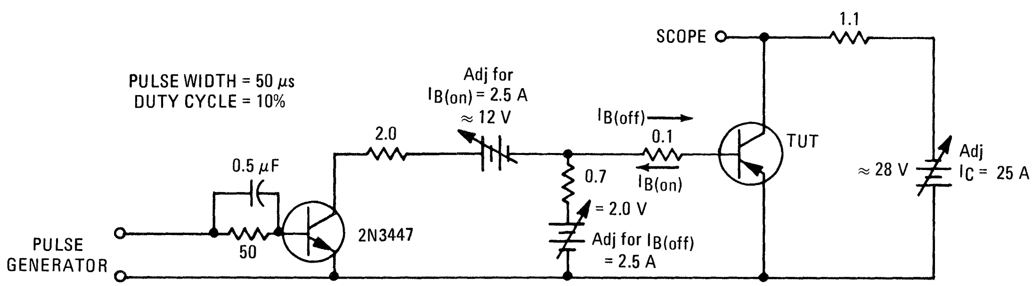


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

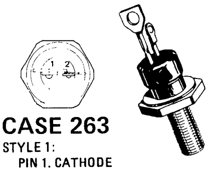
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 25 Adc)	$V_{CE(sus)}$	45	-	Vdc
*Floating Potential (V_{CB} = 80 Vdc, I_E = 0)	V_{EBF}	-	1.0	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 80 Vdc, R_{BE} = 50 Ohms)	I_{CER}	-	50	mAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 0)	I_{CES}	-	5.0	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO1}	-	200	μAdc
Collector Cutoff Current *(V_{CB} = 80 Vdc, I_E = 0)	I_{CBO2}	-	5.0	mAdc
(V_{CB} = 80 Vdc, I_E = 0, T_C = 100°C, +0, -3°C)		-	25	
*Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)	I_{EBO}	-	50	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 20 Adc, V_{CE} = 1.5 Vdc)	h_{FE}	30	90	-
Collector-Emitter Saturation Voltage (I_C = 20 Adc, I_B = 2.5 Adc)	$V_{CE(sat)}$	-	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 20 Adc, I_B = 2.5 Adc)	$V_{BE(sat)}$	-	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Common-Base Cutoff Frequency (I_C = 0.5 Adc, V_{CB} = 10 Vdc)	$f_{\alpha b}$	1.5	-	MHz
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)	h_{fe}	20	-	-
SWITCHING CHARACTERISTICS				
Rise Time (I_C = 25 Adc, $I_{B(on)}$ = 2.5 Adc, $I_{B(off)}$ = 2.5 Adc) (See Figure 2)	t_r	-	12	μs
Storage Time	t_s	-	10	μs
Fall Time	t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N1842 thru 2N1850 (SILICON)



CASE 263
STYLE 1:
PIN 1. CATHODE
2. GATE
3. ANODE

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 100°C. MCR equivalents available in TO-48 package – i.e. – 2N1842 available in TO-48 package as MCR1842.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Rating		Symbol	Value	Unit
Peak Reverse Blocking Voltage*		$V_{RSM(rep)}$*		Volts
	2N1842		25	
	2N1843		50	
	2N1844		100	
	2N1845		150	
	2N1846		200	
	2N1847		250	
	2N1848		300	
	2N1849		400	
	2N1850		500	
Peak Reverse Blocking Voltage		$V_{RSM(non-rep)}$		Volts
(Transient)	2N1842		35	
(Non-Recurrent 5 ms max.)	2N1843		75	
	2N1844		150	
	2N1845		225	
	2N1846		300	
	2N1847		350	
	2N1848		400	
	2N1849		500	
	2N1850		600	
Forward Current RMS (All Conduction Angles)		$I_{T(RMS)}$	16	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≦ 8.3 ms)		I^2t	60	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)		I_{TSM}	125	Amp
Peak Gate Power		P_{GM}	5.0	Watts
Average Gate Power		$P_{G(AV)}$	0.5	Watt
Peak Gate Current		I_{GM}	2.0	Amp
Peak Gate Voltage - Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +125	°C
Stud Torque		—	30	in. lb.

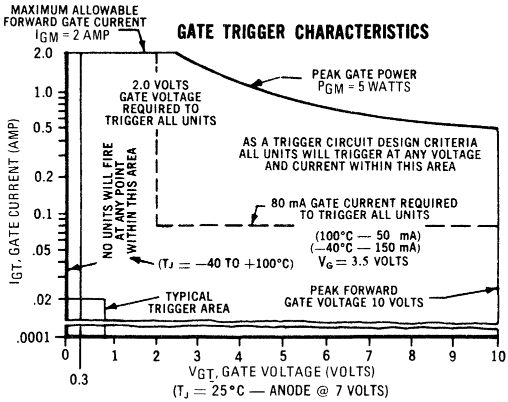
*$V_{RSM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage.
Ratings apply for zero or negative gate voltage.

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

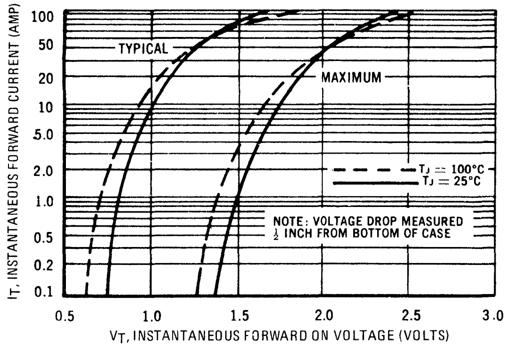
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* ($T_J = 100^oC$)		V_{DRM}*				Volts
	2N1842		25	—	—	
	2N1843		50	—	—	
	2N1844		100	—	—	
	2N1845		150	—	—	
	2N1846		200	—	—	
	2N1847		250	—	—	
	2N1848		300	—	—	
	2N1849		400	—	—	
	2N1850		500	—	—	
Peak Forward or Reverse Blocking Current (Rated V_{FOM} or V_{ROM} gate open, $T_J = 100^oC$)		I_{DRM} I_{RRM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 50\ \Omega$)		V_{GT}	—	0.8	2.0	Volts
(V_{DRM} = Rated V, $R_L = 50\ \Omega$, $T_J = 100^oC$)		V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_H	—	20	—	mA
Forward On Voltage (I_F = 16 Adc)		V_{TM}	—	1.1	1.8	Volts
Turn-On Time ($t_d + t_r$) (I_G = 50 mA, I_F = 10 A)		t_{gt}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A; dv/dt = 20 V/μs, $T_J = 100^oC$) (V_{DRM} = rated voltage)		t_q	—	25	—	μs
Forward Voltage Application Rate (Gate open, $T_J = 100^oC$)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	$^oC/W$

*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.
Ratings apply for zero or negative voltage.

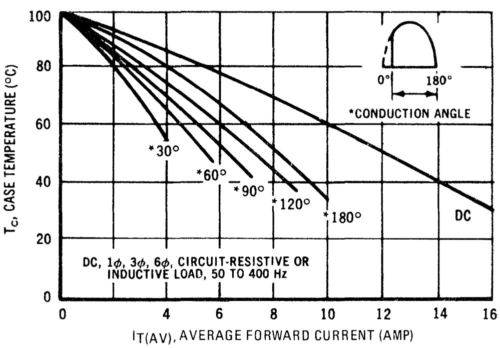
GATE TRIGGER CHARACTERISTICS



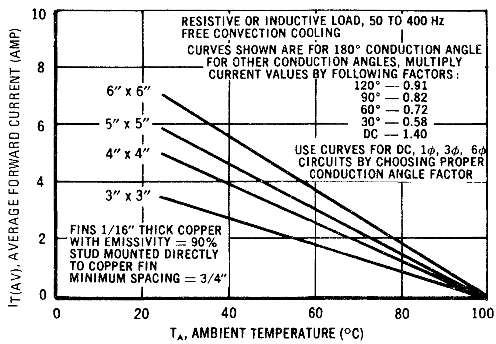
FORWARD CONDUCTING CHARACTERISTICS



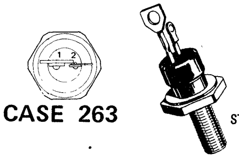
CURRENT DERATING



SUGGESTED HEAT SINK SIZES



2N1842A thru 2N1850A (SILICON)



Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{RSM(rep)}$*		Volts
2N1842A		25	
2N1843A		50	
2N1844A		100	
2N1845A		150	
2N1846A		200	
2N1847A		250	
2N1848A		300	
2N1849A		400	
2N1850A		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)	$V_{RSM(non-rep)}$		Volts
2N1842A		35	
2N1843A		75	
2N1844A		150	
2N1845A		225	
2N1846A		300	
2N1847A		350	
2N1848A		400	
2N1849A		500	
2N1850A		600	
Forward Current RMS	$I_{T(RMS)}$	16	Amp
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	I_{TSM}	125	Amp
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)	I^2t	60	A^2s
Peak Gate Power - Forward	P_{GM}	5.0	Watts
Average Gate Power - Forward	$P_{G(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in. lb.

*$V_{RSM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage.

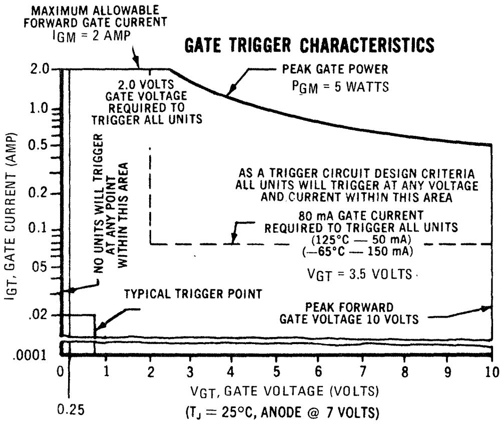
Ratings apply for zero or negative gate voltage.

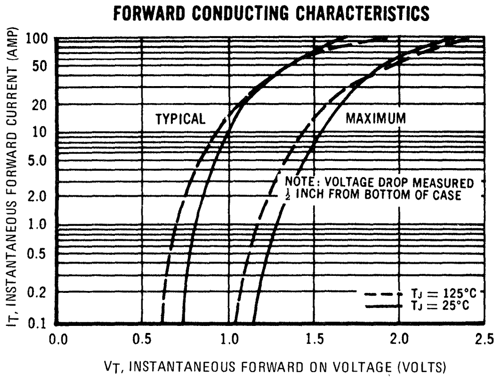
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

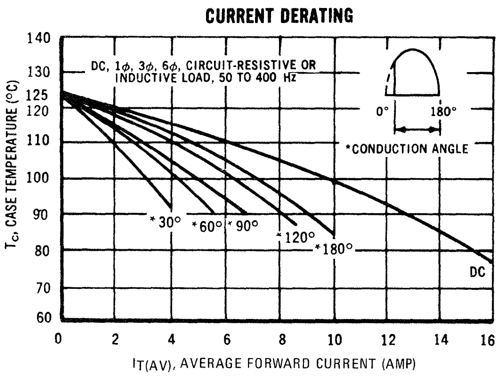
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage*		V_{DRM}*				Volts
(T_J = 125°C)	2N1842A		25	—	—	
	2N1843A		50	—	—	
	2N1844A		100	—	—	
	2N1845A		150	—	—	
	2N1846A		200	—	—	
	2N1847A		250	—	—	
	2N1848A		300	—	—	
	2N1849A		400	—	—	
	2N1850A		500	—	—	
Peak Forward or Reverse Blocking Current (V_{DRM}, OR V_{RSM}, gate open, T_J = 125°C)		I_{DRM} I_{RRM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	—	0.8	2.0	Volts
(V_{DRM} = Rated V, **R_L = 50 Ω, T_J = 125°C**)		V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_H	—	20	—	mA
Forward On Voltage (I_T = 16 Adc)		V_T	—	1.1	1.6	Volts
Turn-On Time ($t_d + t_r$) (I_{GT}= 50 mA, I_T = 10 A)		t_{gt}	—	1.0	—	μs
Turn-Off Time (I_T = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 125°C)		t_q	—	30	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

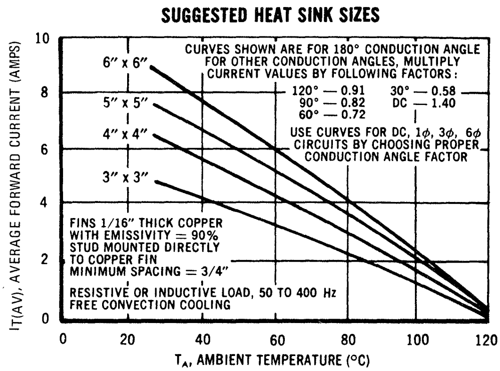
*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

Ratings apply for zero or negative gate voltage.


MAXIMUM ALLOWABLE FORWARD GATE CURRENT
IGM = 2 AMP
GATE TRIGGER CHARACTERISTICS
PEAK GATE POWER
PGM = 5 WATTS
2.0 VOLTS GATE VOLTAGE REQUIRED TO TRIGGER ALL UNITS
NO UNITS WILL TRIGGER AT ANY POINT WITHIN THIS AREA
AS A TRIGGER CIRCUIT DESIGN CRITERIA ALL UNITS WILL TRIGGER AT ANY VOLTAGE AND CURRENT WITHIN THIS AREA
80 mA GATE CURRENT REQUIRED TO TRIGGER ALL UNITS
(125°C — 50 mA)
(−65°C — 150 mA)
VGT = 3.5 VOLTS
TYPICAL TRIGGER POINT
PEAK FORWARD GATE VOLTAGE 10 VOLTS
IGT, GATE CURRENT (AMP)
VGT, GATE VOLTAGE (VOLTS)
(TJ = 25°C, ANODE @ 7 VOLTS)
0.25


FORWARD CONDUCTING CHARACTERISTICS
TYPICAL
MAXIMUM
NOTE: VOLTAGE DROP MEASURED ½ INCH FROM BOTTOM OF CASE
TJ = 125°C
TJ = 25°C
IT, INSTANTANEOUS FORWARD CURRENT (AMP)
VT, INSTANTANEOUS FORWARD ON VOLTAGE (VOLTS)


CURRENT DERATING
DC, 1φ, 3φ, 6φ, CIRCUIT-RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz
0°
180°
*CONDUCTION ANGLE
*30°
*60°
*90°
*120°
*180°
DC
TC, CASE TEMPERATURE (°C)
IT(AV), AVERAGE FORWARD CURRENT (AMP)


SUGGESTED HEAT SINK SIZES
6″ x 6″
5″ x 5″
4″ x 4″
3″ x 3″
CURVES SHOWN ARE FOR 180° CONDUCTION ANGLE FOR OTHER CONDUCTION ANGLES, MULTIPLY CURRENT VALUES BY FOLLOWING FACTORS:
120° — 0.91
90° — 0.82
60° — 0.72
30° — 0.58
DC — 1.40
USE CURVES FOR DC, 1φ, 3φ, 6φ CIRCUITS BY CHOOSING PROPER CONDUCTION ANGLE FACTOR
FINS 1/16″ THICK COPPER WITH EMISSIVITY = 90% STUD MOUNTED DIRECTLY TO COPPER FIN MINIMUM SPACING = 3/4″
RESISTIVE OR INDUCTIVE LOAD, 50 TO 400 Hz FREE CONVECTION COOLING
IT(AV), AVERAGE FORWARD CURRENT (AMPS)
TA, AMBIENT TEMPERATURE (°C)

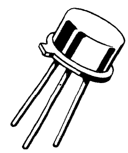
2N 1890S (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in medium-current, general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage — $BV_{CEO(sus)}$ = 60 Vdc (Min) @ I_C = 30 mAdc

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

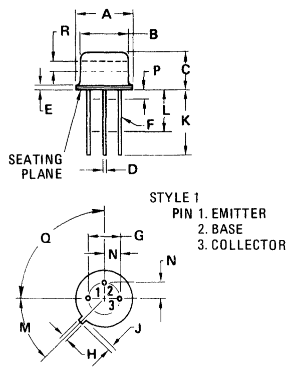
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage $R_{BE} \leqslant 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	800	mW
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$ (1)	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W
Lead Temperature 1/16″ from Case for 10 Seconds	T_L	80	Vdc

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

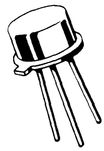
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 100 mAdc, I_B = 0, R_{BE} = 10 Ohms)	$BV_{CER(sus)}$	80	–	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	60	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	100	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 75 Vdc, I_E = 0)		–	–	10	nAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		–	–	15	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 10 Vdc)	h_{FE}	100	180	300	–
Collector-Emitter Saturation	$V_{CE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	0.4	1.2	
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.8	5.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)		–	0.78	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.9	1.3	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	–	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	55	85	pF
Input Impedance	h_{ib}				Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		20	–	30	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		4.0	–	8.0	
Voltage Feedback Ratio	h_{rb}				$X10^{-4}$
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		–	–	1.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		–	–	1.5	
Small-Signal Current Gain	h_{fe}				–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		50	–	200	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		70	–	300	
Output Admittance	h_{ob}				μmhos
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		–	–	0.3	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)		–	–	0.3	

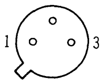
*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

2N1893S (SILICON)
2N2405S

NPN silicon annular transistors designed for medium-power amplifier and switching applications.



CASE 79
(TO-39)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N1893	2N2405	Unit
Collector-Emitter Voltage	V_{CEO}	80	90	Vdc
Collector-Emitter Voltage	V_{CER}	100	140	Vdc
Collector-Base Voltage	V_{CB}	120		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current	I_C	0.5	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.57	1.0 5.72	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17 2	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	2N1893	2N2405	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	219	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	35	°C/W

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0) (I_C = 100 mAdc, I_B = 0)	 2N1893 2N2405 2N2405	$BV_{CEO(sus)}$	 80 90 90	 - - -	Vdc
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, R_{BE} = 10 ohms)	 2N1893 2N2405	$BV_{CER(sus)}$	 100 140	 - -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	120	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0) (V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	 2N1893 2N2405	I_{CBO}	 - - -	 0.01 15 10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	0.01	μAdc

* Indicates JEDEC Registered Data

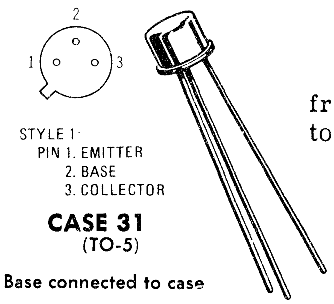
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N1893		20	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	Both Types		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N1893		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N1893		40	120	
	2N2405		60	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N1893		-	1.2	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N1893		-	5.0	
	2N2405		-	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N1893		-	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N1893		-	1.3	
	2N2405		-	1.1	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N1893		50	-	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, 100 kHz ≤ f ≤ 1.0 MHz)			-	15	
Input Capacitance		C_{ib}			pF
(V_{BE} = 0.5 Vdc, I_C = 0, 100 kHz ≤ f ≤ 1.0 MHz)	2N1893		-	85	
	2N2405		-	80	
Input Impedance		h_{ib}			ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		20	30	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893, 2N2405		4.0	8.0	
Voltage Feedback Ratio		h_{rb}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		-	1.25	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893		-	1.5	
	2N2405		-	3.0	
Small-Signal Current Gain		h_{fe}			-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1893		30	100	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2405		50	275	
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N1893		45	-	
Output Admittance		h_{ob}			μmho
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N1893		-	0.5	
(I_C = 5.0 mAdc, V_{CB} = 10 Vdc, f = 1.0 kHz)	2N1893, 2N2405		-	0.5	

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

2N1924 thru 2N1926 (GERMANIUM)



PNP germanium transistors for general purpose, low-frequency applications. Characteristics curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	25	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_J & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Ambient	P_D	225	mW

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

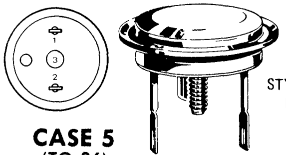
Characteristics	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = -45 Vdc, I_E = 0	I_{CBO}	–	10	μAdc
Emitter Cutoff Current V_{EB} = -25 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Base Voltage I_C = 200 μAdc, I_E = 0	V_{CBO}	60	–	Vdc
Collector-Emitter Voltage I_C = 50 μAdc, V_{BE} = +1.5 Vdc, R_{BE} = 10 K	V_{CEX}	50	–	Vdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	V_{CER}	40	–	Vdc
Punch-Thru Voltage **(V_{EB} = 1 Vdc, VTVM Z $\geq$ 1 Megohm)**	V_{pt}	50	–	Vdc

ELECTRICAL CHARACTERISTICS (continued)

Characteristics	Symbol	Min	Max	Unit
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc 2N1924 2N1925 2N1926	h_{FE}	 34 53 72	 65 90 121	–
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc 2N1924 2N1925 2N1926	h_{FE}	 30 47 65	 – – –	–
Collector-Emitter Saturation Voltage I_B = 1.33 mAdc, I_C = 20 mAdc 2N1924 I_B = 1.0 mAdc, I_C = 20 mAdc 2N1925 I_B = 0.67 mAdc, I_C = 20 mAdc 2N1926	$V_{CE(SAT)}$	 50 55 60	 110 110 110	mVdc
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc 2N1924 2N1925 2N1926	V_{BE}	 200 190 180	 300 290 280	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 MHz	C_{ob}	–	30	pF
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc 2N1924 2N1925 2N1926	$f_{\alpha b}$	 1.0 1.3 1.5	 – – –	MHz
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1924 2N1925 2N1926	h_{fe}	 30 44 60	 64 88 120	–
Small-Signal Open Circuit Output Admittance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1924 2N1925 2N1926	h_{oe}	 15 20 25	 60 65 70	μmho
Small-Signal Open-Circuit Reverse-Transfer Voltage Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1924 2N1925 2N1926	h_{re}	 2.0 3.0 4.0	 8.0 9.0 10	$X10^{-4}$
Small-Signal Short-Circuit Input Impedance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 kHz 2N1924 2N1925 2N1926	h_{ie}	 700 1200 1500	 2200 3200 4200	ohms

2N1970 (GERMANIUM)

2N1980 thru 2N1982



PNP germanium power transistors for general purpose amplifier and switching applications.

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5
(TO-36)
Collector connected to case

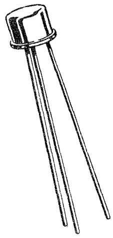
MAXIMUM RATINGS

Rating	Symbol	2N1970	2N1980	2N1981	2N1982	Unit
Collector-Base Voltage	V_{CB}	100	50	70	90	Volts
Collector-Emitter Voltage	V_{CEO}	50	30	40	50	Volts
Emitter-Base Voltage	V_{EB}	40	20	20	20	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^oC$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -100 Vdc)	2N1970		—	4.0	
(V_{CB} = -50 Vdc)	2N1980		—	6.0	
(V_{CB} = -70 Vdc)	2N1981		—	6.0	
(V_{CB} = -90 Vdc)	2N1982		—	6.0	
(V_{CB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N1970		—	4.0	
(V_{EB} = -20 Vdc)	2N1980-2N1982		—	5.0	
(V_{EB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 1 Adc, I_B = 0)	2N1970		50	—	
	2N1980		30	—	
	2N1981		40	—	
	2N1982		50	—	
Base-Emitter Voltage		V_{BE}			Vdc
(V_{CE} = -2 Vdc, I_C = 5 Adc)	2N1970		—	0.9	
Emitter Floating Potential		V_{EBF}			Vdc
(V_{CB} = -50 Vdc)	2N1980		—	1.0	
(V_{CB} = -70 Vdc)	2N1981		—	1.0	
(V_{CB} = -90 Vdc)	2N1982		—	1.0	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 Adc, I_B = 2 Adc)	2N1970		—	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N1980-2N1982		—	0.5	
DC Current Gain		h_{FE}			—
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N1970		17	40	
	2N1980-2N1982		50	100	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N1970		10	—	
Common Emitter Cutoff Frequency		$f_{\alpha e}$			kHz
(V_{CE} = -4 V, I_C = 5 A)	2N1970		5.0	—	
(V_{CE} = -5 V, I_C = 2 A)	2N1980-2N1982		3.0	—	

2N1983 (SILICON)
2N1984



NPN silicon annular small-signal transistor.

CASE 31
(TO-5)
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.8	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 16	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

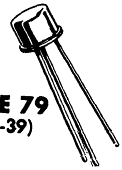
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	208	°C/W

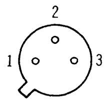
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)		$BV_{CEO(sus)}$	25	-	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, $R_{BE} \leq$ 10 ohms)		$BV_{CER(sus)}$	30	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	5.0	µAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)			-	200	
Emitter-Cutoff Current ($V_{EB(off)}$ = 2.0 Vdc, I_C = 0)		I_{EBO}	-	100	µAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	40	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)		C_{ob}	-	45	pF
Input Impedance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N1983	h_{ie}	-	2.0	k ohm
	2N1984		-	1.2	
Input Resistance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	30	ohm
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			4.0	8.0	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983	h_{rb}	-	7.0	$X\ 10^{-4}$
	2N1984		-	5.0	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983		-	7.0	
	2N1984		-	5.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983	h_{fe}	70	210	-
	2N1984		35	100	
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N1983		80	240	
	2N1984		40	120	
Output Admittance (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc)	2N1983	h_{oe}	-	200	-
	2N1984		-	100	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	1.0	µmho
(I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)			-	1.5	

(1) Pulse Test: Pulse Width ≦ 300 µs, Duty Cycle ≦ 2.0%.

2N1990S (SILICON)





CASE 79
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector Connected to Case

NPN silicon transistor designed for driving neon display tubes.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation $T_A = 25°C$ Derate above 25°C	P_D	0.6 4.8	W mW/°C
Total Device Dissipation $T_C = 2.5°C$ @ $T_C = 100°C$	P_D	2.0 1.0	W
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	62.5	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	208	°C/W

*ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector Cutoff Current ($V_{CE} = 75$ Vdc, $I_B = 10$ µAdc) ($V_{CE} = 75$ Vdc, $I_B = 250$ µAdc, $T_A = 150°C$	I_{CEX}	 - -	 10 250	µAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 30$ mAdc, $V_{CE} = 10$ Vdc)	h_{FE}	 20	 -	-
Collector-Emitter Saturation Voltage ($I_C = 2.0$ mAdc, $I_B = 0.2$ mAdc)	$V_{CE(sat)}$	 -	 0.5	Vdc
Base-Emitter Saturation Voltage ($I_C = 2.0$ mAdc, $I_B = 0.2$ mAdc)	$V_{BE(sat)}$	 -	 1.0	Vdc

* Indicates JEDEC Registered Data

2N1991S (SILICON)

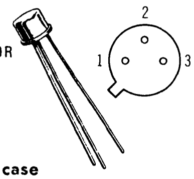
For Specifications, See 2N1131 Data.

2N2042, 2N2043 (GERMANIUM)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

All leads isolated from case



PNP germanium transistors suitable for high-voltage audio switching and amplifier applications. Suitable for high-reliability projects.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	105	Vdc
Collector-Emitter Voltage	V_{CES}	105	Vdc
Emitter-Base Voltage	V_{EB}	75	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation, Ambient Derate above 25°C	P_D	200 2.67	mW mW/°C
Thermal Resistance (Junction to Ambient)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

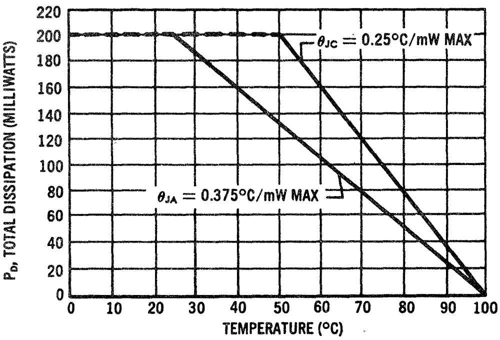
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 105 V, I_E = 0)		–	25	
(V_{CB} = 2.5 V, I_E = 0)		–	10	
(V_{CB} = 105 V, I_E = 0, T_A = +71°C)		–	500	
Emitter-Base Cutoff Current	I_{EBO}			μAdc
(V_{EB} = 75 V, I_C = 0)		–	50	
(V_{EB} = 2.5 V, I_C = 0)		–	10	
Collector-Emitter Cutoff Current (V_{CE} = 55 V, R_{BE} = 10 K)	I_{CER}	–	600	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 105 V, V_{BE} = 0)	I_{CES}	–	1.0	mAdc
DC Collector-Emitter Punch-Through Voltage (V_{fl} = 1.0 V, VTVM R_{in} 10-12 megohm)	V_{pt}	105	–	Vdc
DC Current Gain	h_{FE}			–
(I_C = 5 mA, V_{CE} = 0.35 V) 2N2042		20	50	
2N2043		40	100	
Common Base, Small-Signal Input Impedance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)	h_{ib}	30	50	Ohms

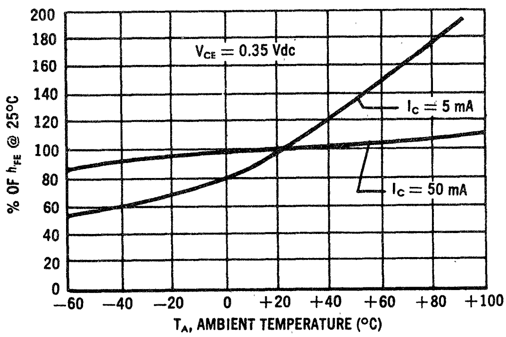
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Common Base, Small-Signal Output Admittance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kHz)		h_{ob}	0.1	1.0	μmho
Common Emitter, Small-Signal Current Transfer Ratio (V_{CE} = 6 V, I_C = 1 mA, f = 1 kHz)	2N2042	h_{fe}	20	80	–
	2N2043		45	180	
Base-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA)		$V_{BE(sat)}$	–	0.30	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA)		$V_{CE(sat)}$	–	0.25	Vdc
(I_C = 100 mA, I_B = 10 mA)			–	0.75	
Collector Output Capacitance (V_{CB} = 6 V, I_E = 0)		C_{ob}	–	25	pF
Common-Base, Small-Signal Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 V, I_E = 1 mA)	2N2042	$f_{\alpha b}$	0.50	–	MHz
	2N2043		0.75	–	

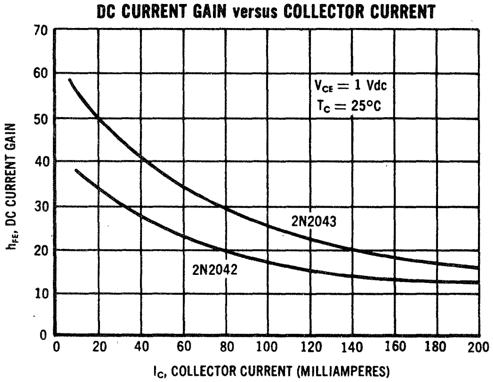
POWER-TEMPERATURE DERATING CURVE



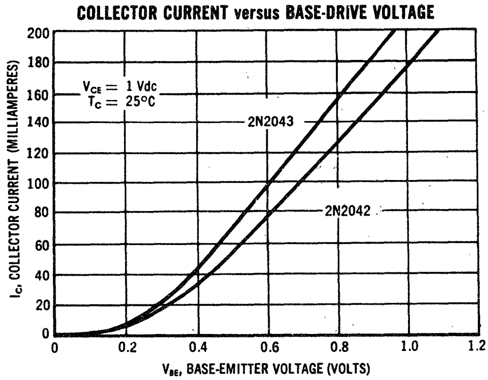
LARGE SIGNAL CURRENT GAIN versus TEMPERATURE



DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus BASE-DRIVE VOLTAGE



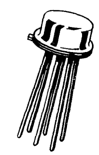
2N2060,A (SILICON)
2N2060 JAN,JTX,JTXV Available
2N2223,A
2N2480,A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N2223,A
  $\Delta|V_{BE1} - V_{BE2}| = 2.0$ mVdc (Max) @ -55 to +25°C
  = 2.5 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage – 2N2480
  $V_{CE(sat)} = 1.3$ Vdc (Max) @ $I_C = 50$ mAdc
- DC Current Gain Specified – 10 μAdc to 10 mAdc
- High Current-Gain–Bandwidth Product –
  $f_T = 60$ MHz @ $I_C = 50$ mAdc

NPN SILICON MULTIPLE TRANSISTORS



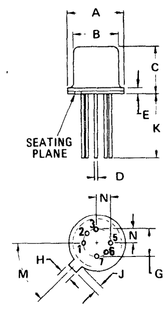
*MAXIMUM RATINGS

Rating	Symbol	2N2060,A 2N2223,A	2N2480	2N2480A	Unit
Collector-Emitter Voltage	V_{CEO}	60	35	40	Vdc
Collector-Emitter Voltage	V_{CER}	80	–	–	Vdc
Collector-Base Voltage	V_{CB}	100	75	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	5.0	5.0	Vdc
Collector Current – Continuous	I_C	← 500 →			mAdc

Rating	Symbol	One Die	All Die Equal Power	Unit
Total Power Dissipation @ $T_A = 25°C$	P_D			mW
2N2060,A		0.5	0.6	
2N2223,A		0.3	0.6	
2N2480,A		0.5	0.6	
Derate above 25°C				mW/°C
2N2060,A		2.86	3.43	
2N2223,A		1.72	3.43	
2N2480,A		2.86	3.43	
Total Power Dissipation @ $T_C = 25°C$	P_D			Watts
2N2060,A		1.5	3.0	
2N2223,A		1.0	2.0	
2N2480,A		1.6	3.0	
Derate above 25°C				mW/°C
2N2060,A		8.6	17.2	
2N2223,A		5.7	11.4	
2N2480,A		9.1	17.2	
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

STYLE 1
PIN 1 COLLECTOR 5. EMITTER
2 BASE 6. BASE
3. EMITTER 7. COLLECTOR
4. OMITTED 8 OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 51	9.40	0.335	0.370
B	7 75	8.51	0 305	0.335
C	3.81	4.70	0 150	0.185
D	0.41	0 53	0 016	0.021
G	5.08 BSC		0 200 BSC	
H	0.71	0.86	0 028	0.034
J	0 74	1.14	0 029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2 54 BSC		0.100 BSC	

CASE 654-07

* ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1)	2N2480	BV_{CEO}	35		Vdc
(I_C = 20 mAdc, I_B = 0)	2N2480A		40	-	
(I_C = 30 mAdc, I_B = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		60	-	
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, R_{BE} ≤ 10 ohms)	2N2060, 2N2060A, 2N2223, 2N2223A	BV_{CER}	80	-	Vdc
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		100	-	
	2N2480 (2)		75	-	
	2N2480A (2)		80	-	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 100 μAdc, I_C = 0)	2N2060, 2N2060A, 2N2223, 2N2223A		7.0	-	
	2N2480, 2N2480A		5.0	-	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2480, 2N2480A		-	15	
(V_{CB} = 60 Vdc, I_E = 0)	2N2480		-	0.050	
	2N2480A		-	0.020	
(V_{CB} = 80 Vdc, I_E = 0)	2N2060, 2N2060A		-	0.002	
	2N2223, 2N2223A		-	0.010	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)	2N2060, 2N2060A		-	10	
	2N2223, 2N2223A		-	15	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{BE} = 5.0 Vdc, I_C = 0)	2N2060, 2N2060A		-	2.0	
	2N2223, 2N2223A		-	10	
	2N2480		-	50	
	2N2480A		-	20	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		25	75	
	2N2223, 2N2223A		15	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		30	90	
	2N2223, 2N2223A		25	150	
	2N2480		20	-	
	2N2480A		35	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		40	120	
	2N2480		30	350	
	2N2480A		50	200	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)*	2N2060, 2N2060A		50	150	
	2N2223, 2N2223A		50	200	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060A		-	0.6	
	2N2060, 2N2223, 2N2223A, 2N2480A		-	1.2	
	2N2480		-	1.3	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A		-	0.9	
	2N2480		-	1.0	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain–Bandwidth Product		f_T			MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2223, 2N2223A, 2N2480, 2N2480A		50	-	
	2N2060, 2N2060A		60	-	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A		-	15	
	2N2480A		-	18	
	2N2480		-	20	

* Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.
(2) Motorola Guarantees this Data in Addition to JEDEC Registered Data.

* ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	C_{ib}	-	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A	h_{ie}	1000	4000	ohms
	2N2480A		1000	5000	
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2223, 2N2223A	h_{ib}	20	30	ohms
	2N2480A		20	35	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h_{rb}	-	3.0	$X 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A	h_{fe}	50	150	-
	2N2223, 2N2223A		40	200	
	2N2480A		50	300	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2060, 2N2060A, 2N2480A	h_{oe}	4.0	16	μmhos
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	2N2223, 2N2223A	h_{ob}	-	0.5	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, f = 1.0 kHz, BW = 1.0 Hz)	2N2480, 2N2480A	NF	-	8.0	dB
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, f = 1.0 kHz, BW = 200 Hz)	2N2060, 2N2060A		-	8.0	
(I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz, BW = 15.7 kHz)(3)			-	8.0	

MATCHING CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
DC Current Gain Ratio(4) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2223A	h_{FE1}/h_{FE2}	0.9	1.0	-
	2N2223, 2N2480, 2N2480A		0.8	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A		0.9	1.0	
	2N2480, 2N2480A		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2060A	$\|V_{BE1}-V_{BE2}\|$	-	3.0	mVdc
	2N2060, 2N2223A, 2N2480A		-	5.0	
	2N2480		-	10	
	2N2223		-	15	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2060, 2N2060A, 2N2480A		-	5.0	
	2N2480		-	10	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)	2N2060A	$\Delta(V_{BE1}-V_{BE2})$	-	0.4	mVdc
	2N2060		-	0.8	
	2N2223, 2N2223A		-	2.0	
	2N2480, 2N2480A		-	1.2	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N2060		-	1.0	
	2N2060A		-	0.5	
	2N2223, 2N2223A		-	2.5	
	2N2480, 2N2480A		-	1.5	

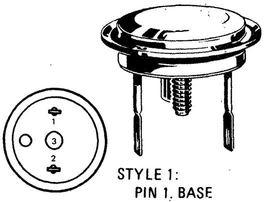
* Indicates JEDEC Registered Data

(3) Amplifier: 3.0 dB points at 25 Hz and 10 kHz with a roll-off of 6.0 dB per octave.

(4) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2075 thru 2N2082 (GERMANIUM)

2N2075A thru 2N2082A



STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5
(TO-36)

PNP germanium power transistors for high-power applications in high-reliability equipment.

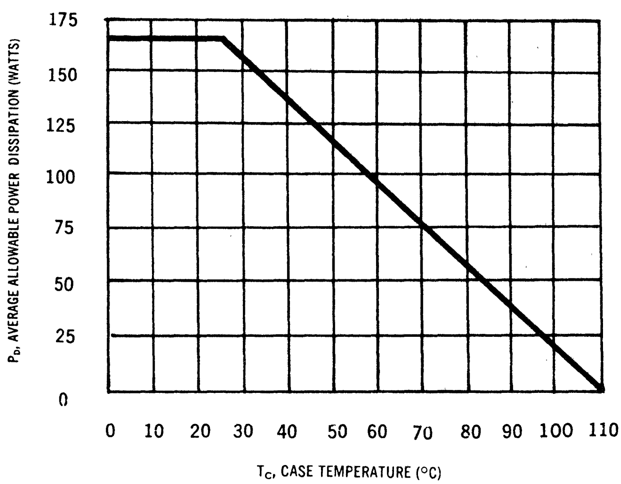
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N2078 2N2082	2N2077 2N2081	2N2076 2N2080	2N2075 2N2079	Unit
Collector-Emitter Voltage	V_{CEO}	25	45	55	65	Vdc
Collector-Emitter Voltage	V_{CES}	40	50	70	80	Vdc
Collector-Base Voltage	V_{CB}	40	50	70	80	Vdc
Emitter-Base Voltage	V_{EB}	20	25	35	40	Vdc
Collector Current	I_C	15				Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	170				Watts
Operating Junction Temperature Range	T_J	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W



POWER-TEMPERATURE DERATING CURVE

The maximum average power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

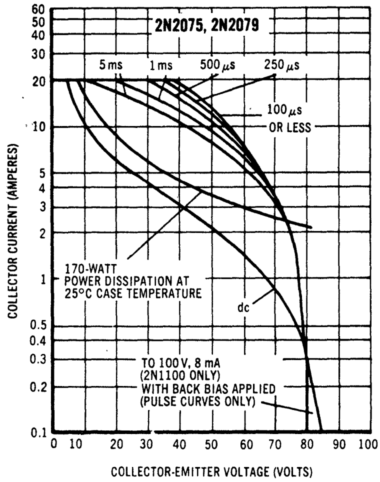
$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

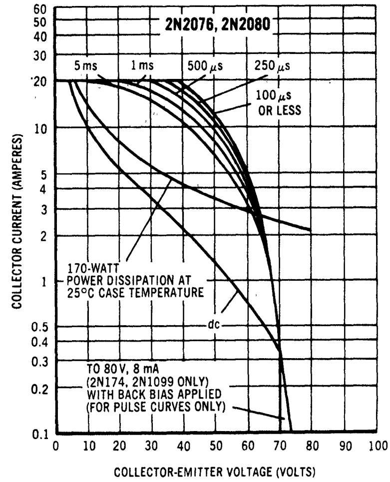
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

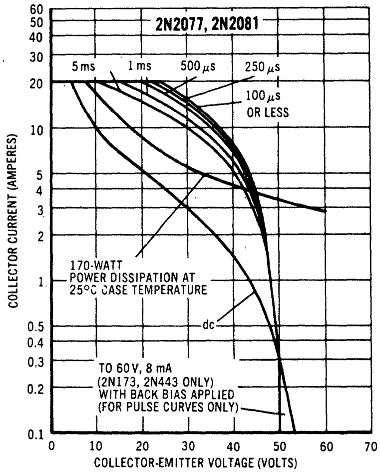
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 Adc, I_B = 0)	2N2078, 2N2082	BV_{CEO}	25	-	Vdc
	2N2077, 2N2081		45	-	
	2N2076, 2N2080		55	-	
	2N2075, 2N2079		65	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N2078, 2N2082	BV_{CES}	40	-	Vdc
	2N2077, 2N2081		50	-	
	2N2076, 2N2080		70	-	
	2N2075, 2N2079		80	-	
Floating Potential (V_{CB} = 40 Vdc, I_E = 0)	2N2078, 2N2082	V_{EBF}	-	1.0	Vdc
(V_{CB} = 50 Vdc, I_E = 0)	2N2077, 2N2081		-	1.0	
(V_{CB} = 70 Vdc, I_E = 0)	2N2076, 2N2080		-	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N2075, 2N2079		-	1.0	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = $V_{CB(max)}$, V_{EB} = 1.5 Vdc)			-	4.0	
(V_{CB} = $V_{CB(max)}$, I_E = 0, T_C = +71°C)			-	15	
Emitter Cutoff Current (V_{BE} = $V_{BE(max)}$, I_C = 0)		I_{EBO}	-	4.0	mAdc
(V_{BE} = $V_{BE(max)}$, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.2 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078	h_{FE}	25	100	-
	2N2079 thru 2N2082		40	160	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078		20	40	
	2N2079 thru 2N2082		35	70	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, T_C = -55°C)	2N2075 thru 2N2078		15	-	
	2N2079 thru 2N2082		25	-	
(I_C = 12 Adc, V_{CE} = 2.0 Vdc)	2N2075 thru 2N2078		8	-	
	2N2079 thru 2N2082		12	-	
Collector-Emitter Saturation Voltage (I_C = 13 Adc, I_B = 2.0 Adc)	2N2075 & 76, 2N2079 & 80	$V_{CE(sat)}$	-	0.7	Vdc
	2N2077 & 78, 2N2081 & 82		-	0.9	
Base-Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 12 Vdc)		$V_{BE(on)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	5.0	-	kHz
Rise Time (V_{CE} = 12 Vdc, $I_{C(on)}$ = 12 Adc, I_B = 2.0 Adc)	2N2075 thru 2N2078	t_r	Typ 9.0		μs
	2N2079 thru 2N2082		6.0		
Fall Time (V_{BE} = 6.0 Vdc, $I_{C(off)}$ = 0, R_{BE} = 10 ohms)	2N2075 thru 2N2078	t_f	12		μs
	2N2079 thru 2N2082		13		

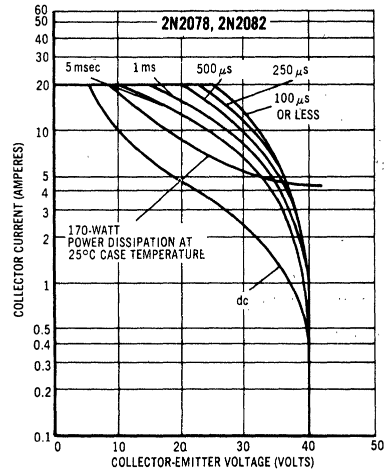
*To avoid excessive heating of collector junction, perform this test with a sweep method.

SAFE OPERATING AREAS





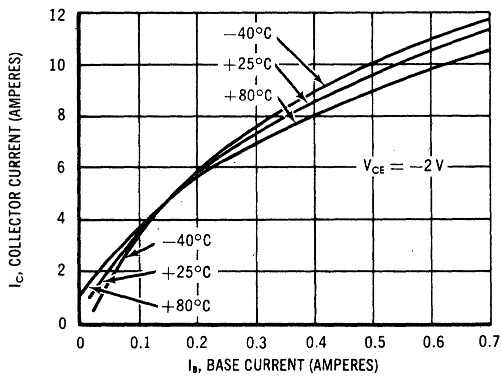




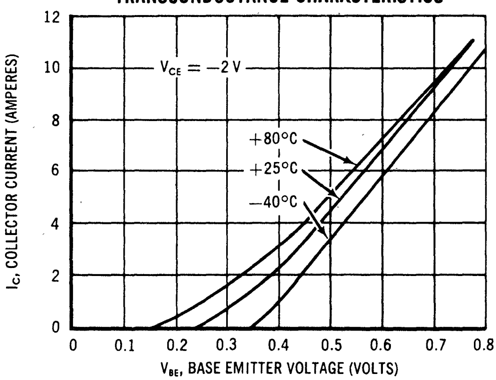
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2075-2N2078

CURRENT TRANSFER CHARACTERISTICS

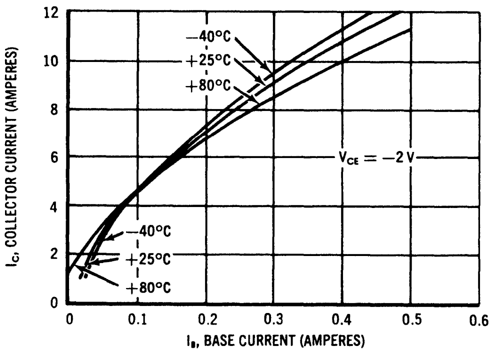


TRANSCONDUCTANCE CHARACTERISTICS

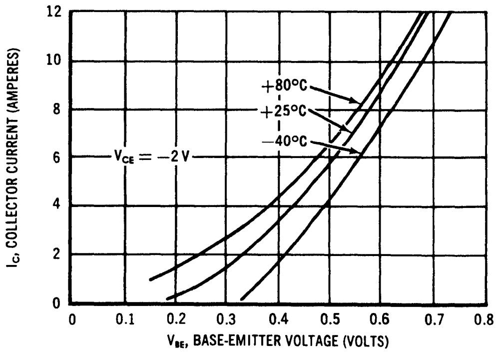


2N2079-2N2082

CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



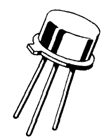
2N2102S (SILICON)

NPN SILICON ANNULAR AMPLIFIER TRANSISTOR

. . . designed for use in general-purpose amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 65 Vdc (Min) @ I_C = 100 mAdc
- DC Current Gain — 10 μAdc to 1.0 mAdc
- Low Noise Figure —
  NF = 4.0 dB (Typ) @ I_C = 300 μAdc

NPN SILICON AMPLIFIER TRANSISTOR



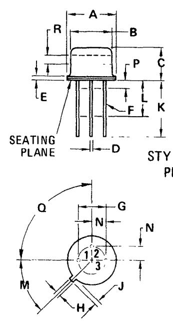
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Emitter Voltage, $R_{BE} \leqslant 10$ Ohms	V_{CER}	80	Vdc
Collector-Base Voltage	V_{CB}	120	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.71	Watt $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Stroage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^oC/W$

*Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1.
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0 737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0 250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

CASE 79-02

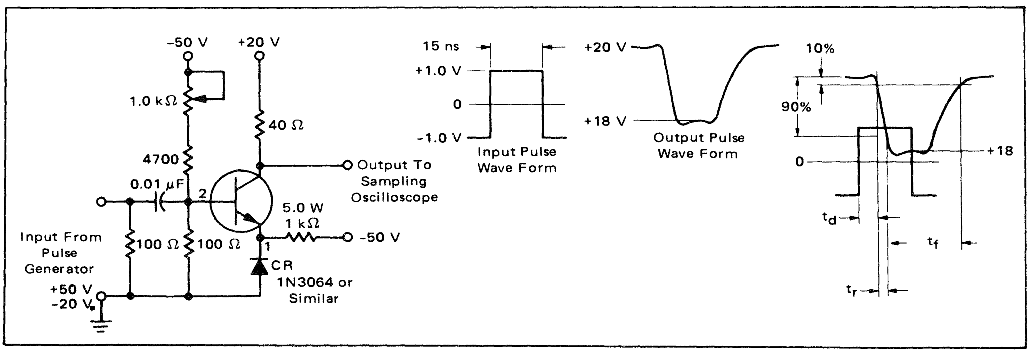
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	65	–	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, $R_{BE} \leqslant$ 100 Ohms)	$V_{CER(sus)}$	80	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 1.5 Vdc)	BV_{CEX}	120	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	120	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 – –	 2.0 2.0	 nAdc μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	2.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (1) (I_C = 500 mAdc, V_{CE} = 10 Vdc) (1) (I_C = 1.0 Adc, V_{CE} = 10 Vdc) (1)	h_{FE}	 10 20 35 20 40 25 10	 – – – – – – –	 – – – – 120 – –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.78	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	60	80	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ib}	 24 4.0	 – –	 34 8.0	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{rb}	 – –	 – –	 3.0 3.0	$\times 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	 30 35	 – –	 100 150	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz) (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ob}	 0.01 0.01	 – –	 0.5 1.0	μmho
Noise Figure (I_C = 300 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k Ohm, f = 1.0 kHz, Bandwidth = 1.0 Hz)	NF	–	4.0	6.0	dB
SWITCHING CHARACTERISTICS					
Switching Time (Figure 1)	$t_d + t_r + t_f$	–	–	30	ns

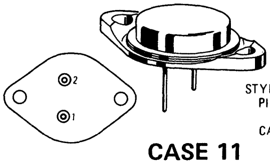
*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



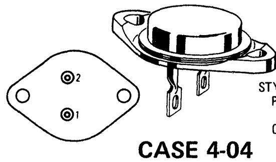
2N2137 thru 2N2146 (GERMANIUM)
2N2137A thru 2N2146A

PNP germanium industrial power transistors for driver applications in high reliability equipment.



STYLE 1
PIN 1 BASE
2 EMITTER
CASE-COLLECTOR

CASE 11



STYLE 1.
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

CASE 4-04

Collector connected to case

For units with solder lugs attached, specify devices MP2137,A etc. (Case 4-04)

MAXIMUM RATINGS

Apply also to standard, non-A series

Rating	Symbol	2N2137A 2N2142A	2N2138A 2N2143A	2N2139A 2N2144A	2N2140A 2N2145A	2N2141A 2N2146A	Unit
Collector-Base Voltage	V_{CB}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	65	Vdc
Emitter-Base Voltage	V_{EB}	15	25	30	40	45	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.833					Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110					°C

ELECTRICAL CHARACTERISTICS

*Characteristics apply also to corresponding, non-A type numbers.

OFF CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage**		BV_{CEO}**				Vdc
(I_C = 500 mAdc, I_B = 0)	2N2137A, 2N2142A*		20	-	-	
	2N2138A, 2N2143A*		30	-	-	
	2N2139A, 2N2144A*		45	-	-	
	2N2140A, 2N2145A*		60	-	-	
	2N2141A, 2N2146A*		65			
Collector-Emitter Breakdown Voltage**		BV_{CES}**				Vdc
(I_C = 300 mAdc, V_{BE} = 0)	2N2137A, 2N2142A*		30	-	-	
	2N2138A, 2N2143A*		45	-	-	
	2N2139A, 2N2144A*		60	-	-	
	2N2140A, 2N2145A*		75	-	-	
	2N2141A, 2N2146A*		90	-	-	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 30 Vdc, I_E = 0)	2N2137A, 2N2142A*		-	-	1.0	
(V_{CB} = 45 Vdc, I_E = 0)	2N2138A, 2N2143A*		-	-	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N2139A, 2N2144A*		-	-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2140A, 2N2145A*		-	-	1.0	
(V_{CB} = 90 Vdc, I_E = 0)	2N2141A, 2N2146A*		-	-	1.0	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	0.018	0.05	
(V_{CB} = $V_{CB(max)}$, I_C = 0, $T_C \geq +71°C$)			-	0.75	5.0	
Collector-Base Cutoff Current†		I_{CBO1}				mAdc
(V_{CB} = $V_{CB(max)}$, I_E = 0)			-	0.1	2.0	
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{BE} = $V_{BE(max)}$, I_C = 0)			-	0.08	2.0	
(V_{BE} = $V_{BE(max)}$, I_C = 0, T_C = +71°C)			-	0.5	5.0	

ON CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
DC Current Gain		h_{FE1}				-
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)†	2N2137A-2N2141A*		30	45	60	
	2N2142A-2N2146A*		50	70	100	
(I_C = 2.0 Adc, V_{CE} = 2.0 Vdc)	2N2137A-2N2141A*	h_{FE}	15	22	-	
	2N2142A-2N2146A*		25	33	-	
Collector-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{CE(sat)}$	-	0.12	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 Adc, I_B = 200 mAdc)		$V_{BE(sat)}$	-	0.75	1.2	Vdc

DYNAMIC CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Common Emitter Cutoff Frequency (I_C = 2.0 Adc, V_{CE} = 6.0 Vdc)	$f_{\alpha e}$	12	20	-	kHz

**Sweep method: 1/2 cycle sine wave, 60 Hz .

FIGURE 1 — POWER TEMPERATURE DERATING CURVE

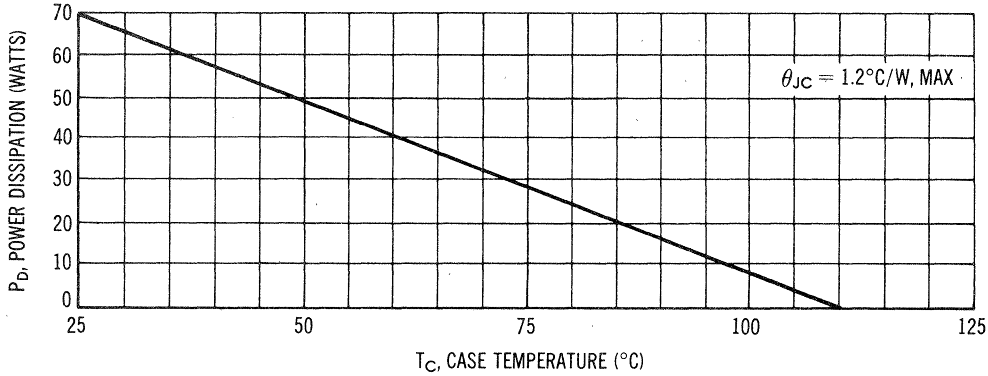
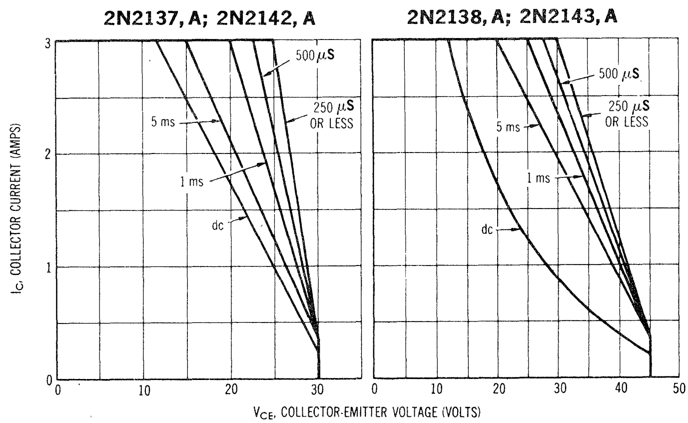
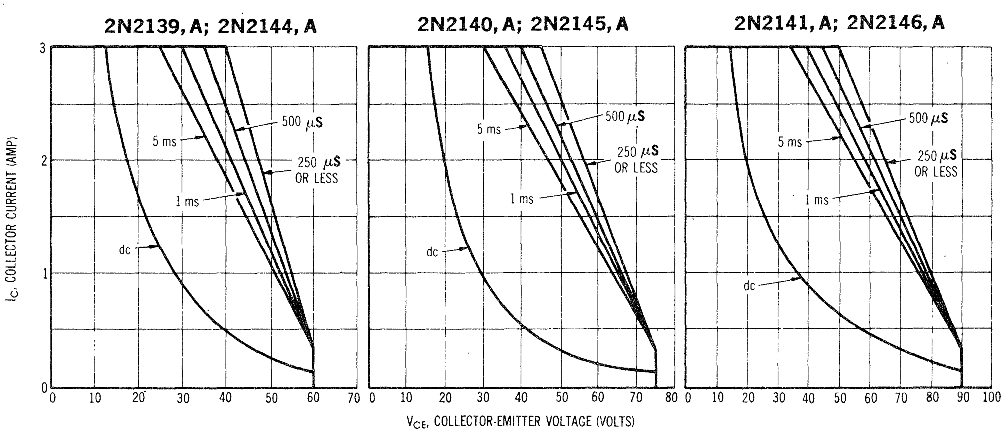


FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.





LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE (ALL TYPES)

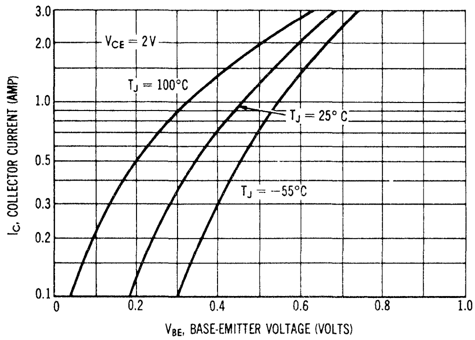


FIGURE 4 — INPUT ADMITTANCE (2N2137A-2N2141A, 2N2137-2N2141)

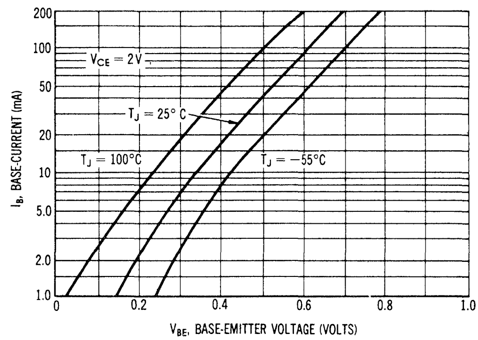


FIGURE 5 — INPUT ADMITTANCE (2N2142A-2N2146A, 2N2142-2N2146)

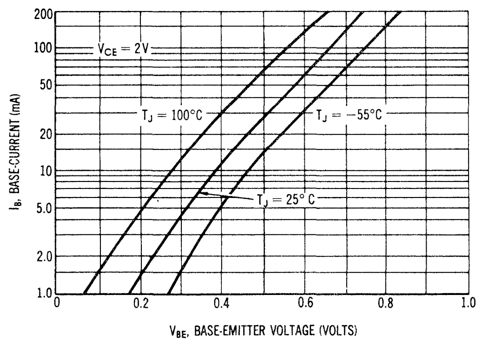


FIGURE 6 — NORMALIZED DC CURRENT GAIN (ALL TYPES)

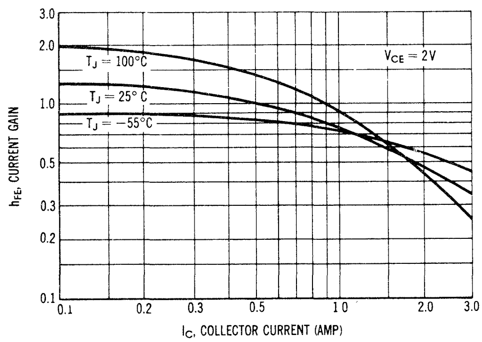


FIGURE 7 — SATURATION REGION (2N2137A-2N2141A, 2N2137-2N2141)

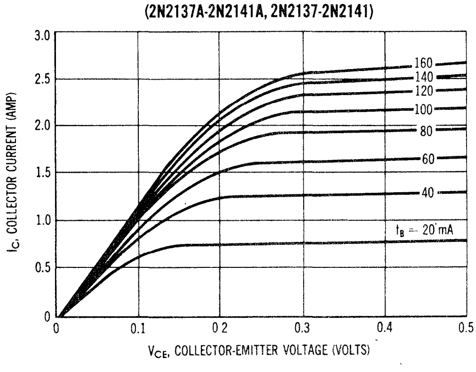
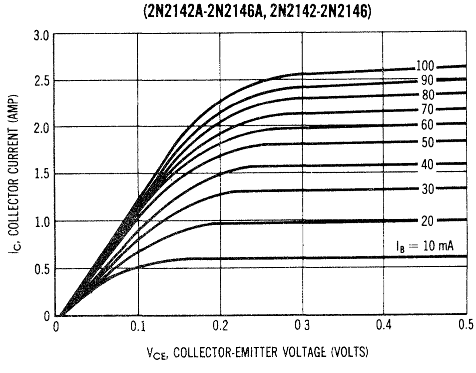
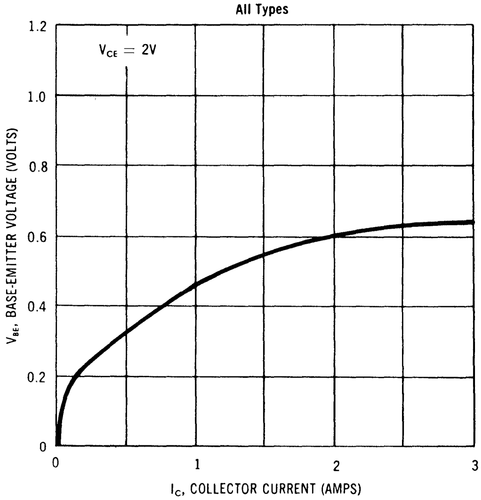


FIGURE 8 — SATURATION REGION (2N2142A-2N2146A, 2N2142-2N2146)

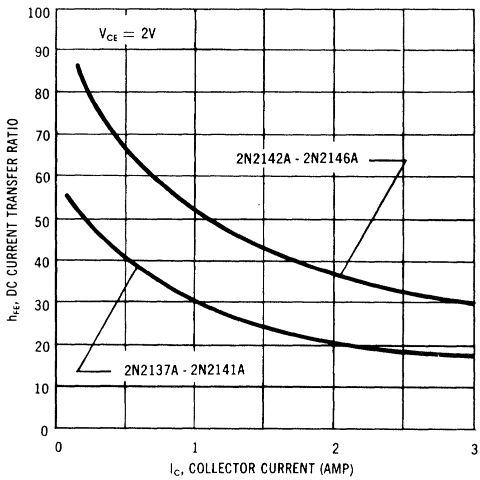


INPUT & TRANSFER CHARACTERISTICS

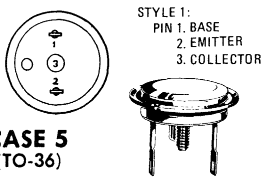
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT
All Types



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N2152 thru 2N2154 (GERMANIUM)
2N2156 thru 2N2158



CASE 5
(TO-36)
Collector connected to case

PNP germanium power transistors for high-power, high-gain applications in high-reliability industrial equipment.

MAXIMUM RATINGS

Rating	Symbol	2N2152 2N2156	2N2153 2N2157	2N2154 2N2158	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current	I_C		30		Adc
Total Device Dissipation @ $T_C = 25^{o}C$ Derate above $25^{o}C$	P_D		170 0.5		Watts $W/^{o}C$
Operating Junction Temperature Range	T_J		-65 to +110		^{o}C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^{o}C/W$

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

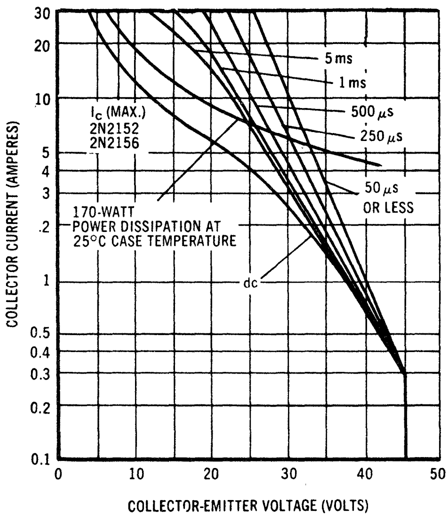
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 Adc, I_B = 0)	2N2152, 2N2156	BV_{CEO}*	30	-	-	Vdc
	2N2153, 2N2157		45	-	-	
	2N2154, 2N2158		60	-	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N2152, 2N2156	BV_{CES}*	45	-	-	Vdc
	2N2153, 2N2157		60	-	-	
	2N2154, 2N2158		75	-	-	
Floating Potential (V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156	V_{EBF}	-	-	1.0	Vdc
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	-	1.0	
Collector Cutoff Current (V_{CB} = 2V, I_E = 0)		I_{CBO}	-	0.08	0.2	mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156		-	0.9	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	0.9	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	0.9	4.0	
(V_{CB} = $V_{CB(max)}$, I_E = 0, T_C = 71°C)			-	4.0	15	
Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)		I_{EBO}	-	0.2	4.0	mAdc
(V_{BE} = 30 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = 40 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = $V_{EB(max)}$, I_C = 0, T_C = 71°C)			-	2.7	15	
ON CHARACTERISTICS						
DC Current Gain (I_C = 5.0 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154	h_{FE}	50	75	100	-
	2N2156, 2N2157, 2N2158		80	105	160	
(I_C = 15 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154		25	47	-	
	2N2156, 2N2157, 2N2158		40	63	-	
(I_C = 25 Adc, V_{CB} = 2 Vdc)			15	38	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)		$V_{CE(sat)}$	-	0.06	0.1	Vdc
(I_C = 25 Adc, I_B = 2 Adc)			-	0.2	0.3	
Base-Emitter On Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)		$V_{BE(on)}$	-	0.65	1.0	Vdc
(I_C = 25 Adc, I_B = 2 Adc)			-	1.0	2.0	
SMALL SIGNAL CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	2.0	2.7	-	kHz

*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

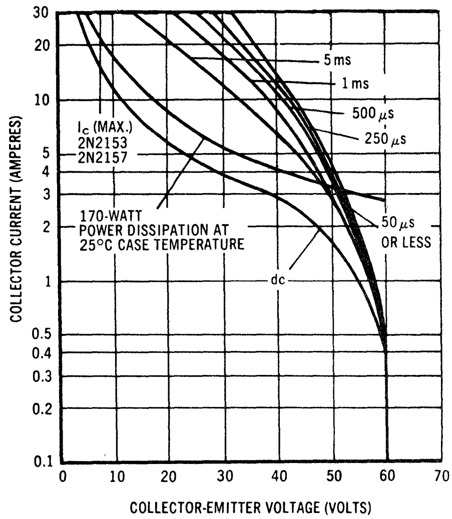
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

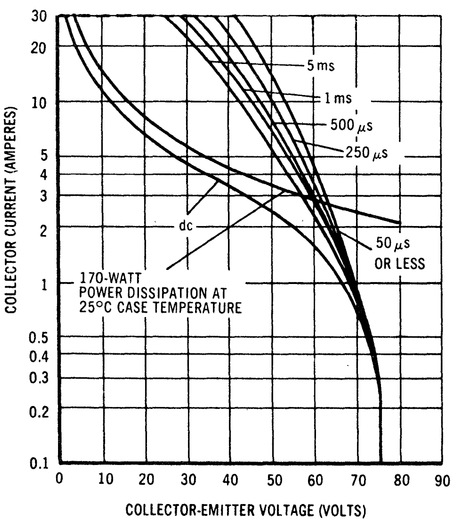
2N2152, 2N2156



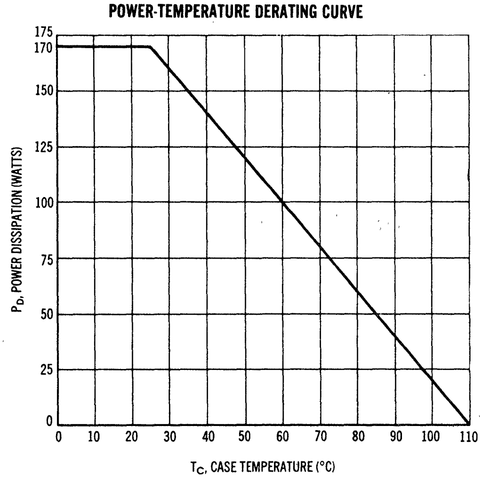
2N2153, 2N2157



2N2154, 2N2158



POWER-TEMPERATURE DERATING CURVE

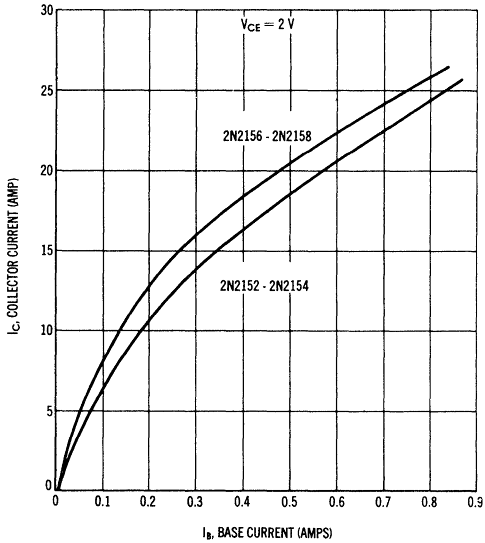


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

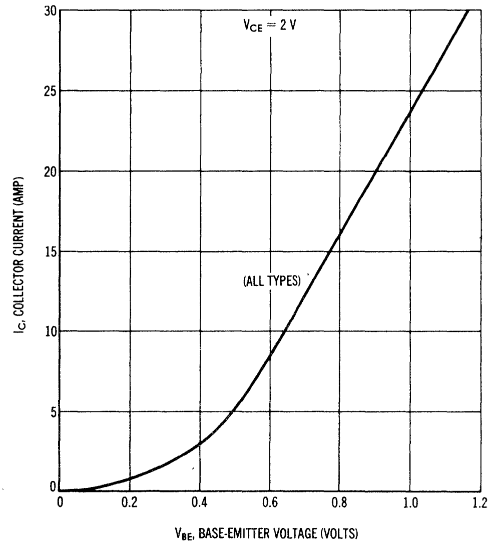
$$\text{allowable } P_D = \frac{110^{o} - T_C}{0.5}$$

TYPICAL INPUT AND TRANSFER CHARACTERISTICS

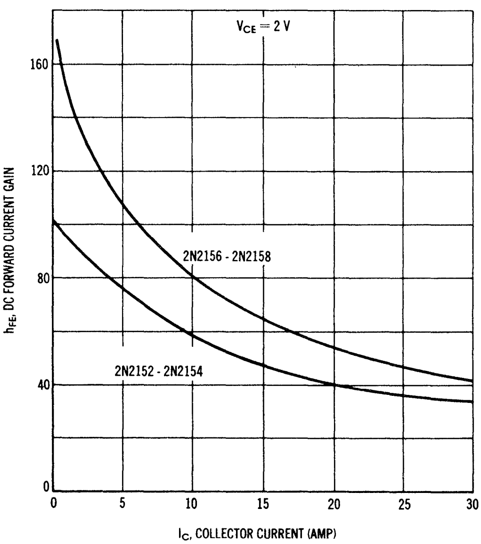
COLLECTOR CURRENT versus BASE CURRENT



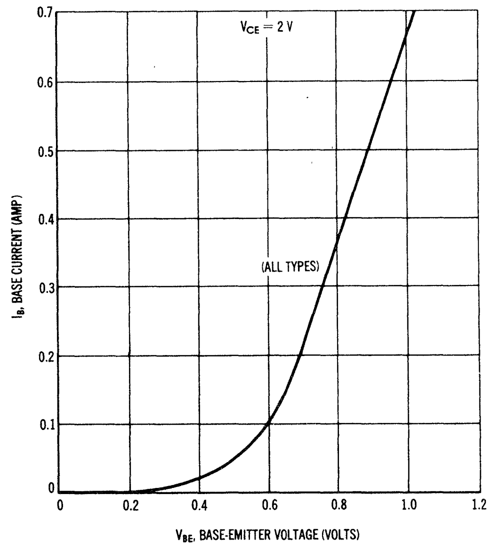
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



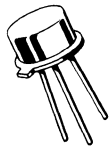
BASE CURRENT versus BASE-EMITTER VOLTAGE



2N2171

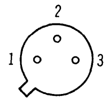
For Specifications, See 2N381 Data.

2N2193AS (SILICON)



NPN silicon annular transistors for high-current switching and amplifier applications.

CASE 79
(TO-39)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

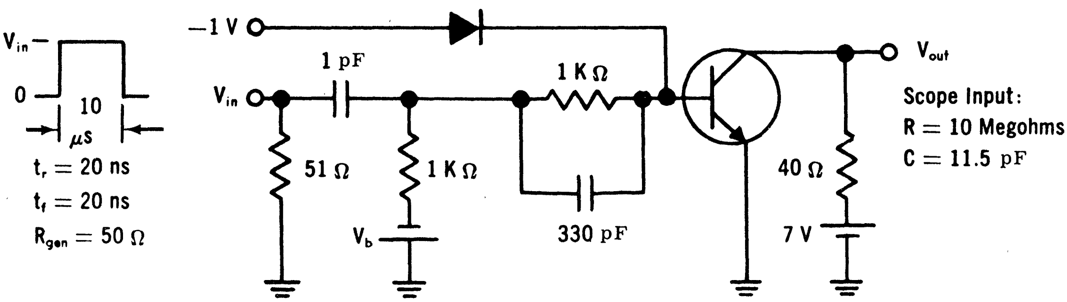
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EB}	8.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.8 4.56	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.8 16	Watts mW/°C
Junction Temperature, Operating	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

FIGURE 1

$V_{in} = 15$ V, $V_b = 15$ V



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 µAdc, I_E = 0)	BV_{CBO}	80	-	Vdc
Collector Emitter-Open Base Sustain Voltage [1] (I_C = 25 mA pulsed, I_B = 0)	$V_{CEO(sus)}$	50	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)	BV_{EBO}	8.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	-	0.010	µAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		-	25	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	-	0.050	µAdc
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DC Current Gain [1] (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}			-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		30	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		40	120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		30	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		20	-	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)				
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	20	pF
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)	h_{fe}	2.5	-	-
Rise Time	t_r	-	70	ns
Storage Time	t_s	-	150	ns
Fall Time	t_f	-	50	ns

* Indicates JEDEC Registered Data

[1] Pulse Test: PW ≤ 300 µs Duty Cycle ≤ 2%

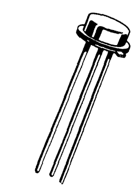
2N 2206 (SILICON)

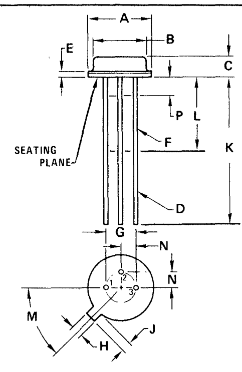
NPN SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications requiring TO-46 package configurations.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 12 Vdc (Min) @ I_C = 10 mAdc
- Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 50 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 250 MHz (Typ) @ I_C = 10 mAdc
- Fast Switching Time (Figure 2) @ I_C = 10 mAdc
  t_{on} = 35 ns (Typ)
  t_{off} = 60 ns (Typ)

NPN SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 0.66	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	150	°C/W
Lead Temperature 1/16" ±1/32" from Case for 10 seconds	T_L	235	°C

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.
*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 15 Vdc, I_E = 0)		–	–	25	nAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		–	–	15	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 250 mVdc, T_A = 100°C)	I_{CEV}	–	–	15	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	100	120	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				mVdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	150	220	
(I_C = 50 mAdc, I_B = 5.0 mAdc) (1)		–	200	350	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	700	800	900	mVdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	200	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	4.0	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc) (Figure 2)	t_{on}	–	35	40	ns
Turn-Off Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (Figure 2)	t_{off}	–	60	75	ns
Storage Time (V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	–	–	35	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 — STORAGE TIME TEST CIRCUIT

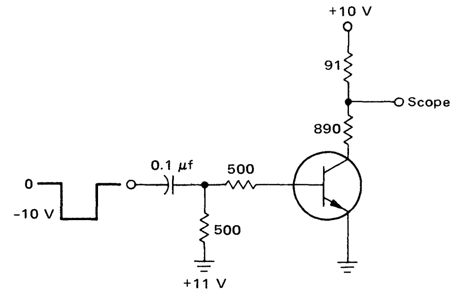
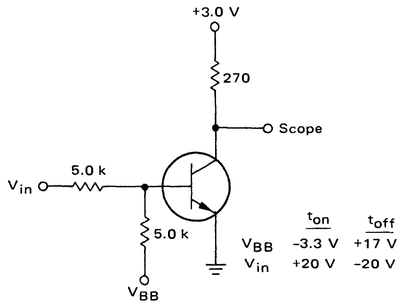


FIGURE 2 — TURN-ON AND TURN-OFF TIMES TEST CIRCUIT



2N2212 (GERMANIUM)

PNP GERMANIUM POWER TRANSISTORS

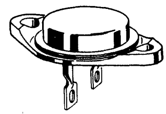
. . . designed for high-current switching applications requiring low saturation voltages, short switching times and good collector-emitter sustaining capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltage — $V_{CE(SAT)}$ = 0.5 Vdc (Max) @I_C = 5.0 Adc

10 AMPERE

PNP ADE GERMANIUM POWER TRANSISTORS

120 VOLTS
102 WATTS



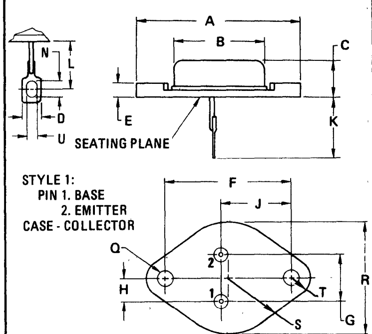
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CER}	120	Vdc
*Collector-Base Voltage	V_{CB}	120	Vdc
*Emitter-Base Voltage	V_{EB}	1.5	Vdc
*Collector Current - Continuous	I_C	10	Adc
*Base Current - Continuous	I_B	3.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	102 1.2	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.83	°C/W

*Indicates JEDEC Registered Data.

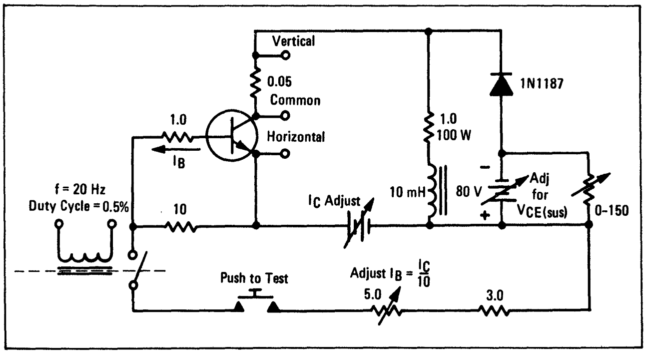


STYLE 1:
PIN 1. BASE
2. EMITTER
CASE - COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	4.32	4.83	0.170	0.190
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	–	17.27	–	0.680
N	3.30	4.32	0.130	0.170
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050
U	2.03	3.05	0.080	0.120

CASE 4-04

FIGURE 1 — SUSTAINING VOLTAGE TEST CIRCUIT

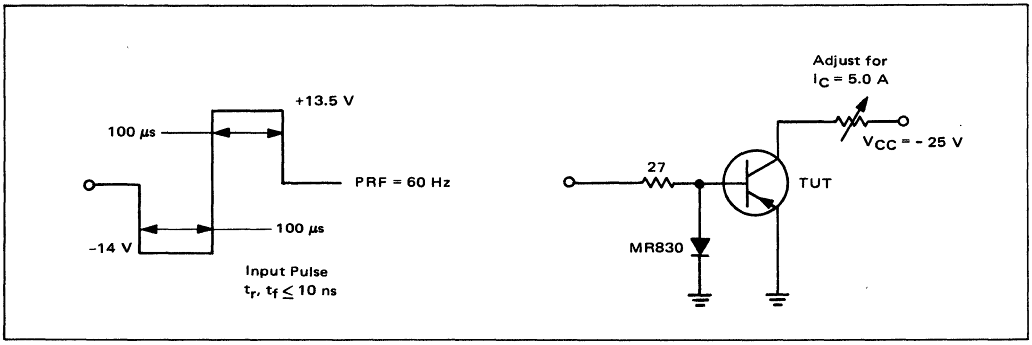


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	60	-	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc, I_B = 0)	$V_{CE(sus)}$	60	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 120 Vdc, R_{BE} = 100 Ohms)	I_{CER}	-	50	mAdc
*Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 85°C)	I_{CEX}	-	20	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)	I_{CBO}	-	200	μAdc
*(V_{CB} = 100 Vdc, I_E = 0)		-	2.0	mAdc
Emitter Cutoff Current (V_{EB} = 0.75 Vdc, I_C = 0)	I_{EBO}	-	25	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 0.6 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	50	200	-
(I_C = 1.2 Adc, V_{CE} = 1.0 Vdc)		60	200	
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		50	120	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)	$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter On Voltage (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$V_{BE(on)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)	h_{fe}	15	-	-
SWITCHING CHARACTERISTICS				
Rise Time — (I_C = 5.0 Adc, I_{B1} = 0.5 Adc, I_{B2} = 0.5 Adc) (See Figure 2)	t_r	-	7.0	μs
Storage Time	t_s	-	10	μs
Fall Time	t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 — SWITCHING TIME TEST CIRCUIT



2N2218S,AS, 2N2219S,AS, 2N2221,A(SILICON) 2N2222,A, 2N5581, 2N5582

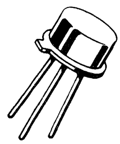
NPN SILICON ANNULAR HERMETIC TRANSISTORS

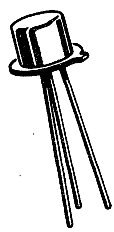
. . . widely used "Industry Standard" transistors for applications as medium-speed switches and as amplifiers from audio to VHF frequencies.

- DC Current Gain Specified — 1.0 to 500 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ @ I_C = 500 mAdc
  = 1.6 Vdc (Max) — Non-A Suffix
  = 1.0 Vdc (Max) — A-Suffix
- High Current-Gain—Bandwidth Product —
  f_T = 250 MHz (Min) @ I_C = 20 mAdc — All Types Except
  = 300 MHz (Min) @ I_C = 20 mAdc — 2N2219A, 2N2222A, 2N5582
- Complements to PNP 2N2904,A thru 2N2907,A
- JAN,JTX Available in all devices
- JTXV Available on 2N2222,A Series
- 2N2218 and 2N2219 available in TO-39 Package With 1/2" Leads (1)

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS

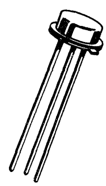
CASE 79-02
TO-39
2N2218,A
2N2219,A





CASE 22-03
TO-18
2N2221,A
2N2222,A

CASE 26-03
TO-46
2N5581
2N5582



SELECTION GUIDE

Device Type	Characteristic: BV_{CEO} I_C = 10 mAdc Volts	h_{FE} I_C = 150 mAdc Min/Max	h_{FE} I_C = 500 mAdc Min	Package
2N2218 2N2219	30	40/120 100/300	20 30	TO-5
2N2221 2N2222	30	40/120 100/300	20 30	TO-18
2N5581 2N5582	40	40/120 100/300	25 40	TO-46
2N2218A 2N2219A	40	40/120 100/300	25 40	TO-5
2N2221A 2N2222A	40	40/120 100/300	25 40	TO-18

*MAXIMUM RATINGS

Rating	Symbol	2N2218 2N2219 2N2221 2N2222	2N2218A 2N2219A 2N2221A 2N2222A	2N5581 2N5582	Unit
Collector-Emitter Voltage	V_{CEO}	30	40	40	Vdc
Collector-Base Voltage	V_{CB}	60	75	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	6.0	Vdc
Collector Current — Continuous	I_C	800	800	800**	mAdc
		2N2218,A 2N2219,A	2N2221,A 2N2222,A	2N5581 2N5582	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	0.5 3.33	0.5 3.33	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	1.8 12	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	Non-A Suffix		30	–	
	A-Suffix, 2N5581,2N5582		40	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	Non-A Suffix		60	–	
	A-Suffix, 2N5581,2N5582		75	–	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)	Non-A Suffix		5.0	–	
	A-Suffix, 2N5581,2N5582		6.0	–	
Collector Cutoff Current		I_{CEX}			nAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix, 2N5581,2N5582		–	10	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix		–	0.01	
(V_{CB} = 60 Vdc, I_E = 0)	A-Suffix, 2N5581,2N5582		–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix		–	10	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	A-Suffix, 2N5581,2N5582		–	10	
Emitter Cutoff Current		I_{EBO}			nAdc
(V_{EB} = 3.0 Vdc, I_C = 0)	A-Suffix, 2N5581,2N5582		–	10	
Base Cutoff Current		I_{BL}			nAdc
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	A-Suffix		–	20	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		20	–	
	2N2219,A,2N2222,A,2N5582(1)		35	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581		25	–	
	2N2219,A,2N2222,A,2N5582		50	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218,A,2N2221,A,2N5581(1)		35	–	
	2N2219,A,2N2222,A,2N5582(1)		75	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2218A,2N2221A,2N5581		15	–	
	2N2219A,2N2222A,2N5582		35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,A,2N2221,A,2N5581		40	120	
	2N2219,A,2N2222,A,2N5582		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)(1)	2N2218A,2N2221A,2N5581		20	–	
	2N2219A,2N2222A,2N5582		50	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2218,2N2221		20	–	
	2N2219,2N2222		30	–	
	2N2218A,2N2221A,2N5581		25	–	
	2N2219A,2N2222A,2N5582		40	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		–	0.4	
	A-Suffix, 2N5581,2N5582		–	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	1.6	
	A-Suffix, 2N5581,2N5582		–	1.0	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	Non-A Suffix		0.6	2.0	
	A-Suffix, 2N5581,2N5582		0.6	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)	Non-A Suffix		–	2.6	
	A-Suffix, 2N5581,2N5582		–	2.0	

* Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (Continued)

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	All Types, Except 2N2219A,2N2222A,2N5582	f_T	250 300	– –	MHz
Output Capacitance(3) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	8.0	pF
Input Capacitance(3) (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	Non-A Suffix A-Suffix, 2N5581,2N5582	C_{ib}	– –	30 25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{ie}	1.0 2.0	3.5 8.0	k ohms
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		0.2 0.25	1.0 1.25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{re}	– –	5.0 8.0	$X 10^{-4}$
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		– –	2.5 4.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{fe}	30 50	150 300	–
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		50 75	300 375	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582	h_{oe}	3.0 5.0	15 35	μmhos
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N2218A,2N2221A,2N5581 2N2219A,2N2222A,2N5582		10 25	100 200	
Collector-Base Time Constant (I_E = 20 mAdc, V_{CB} = 20 Vdc, f = 31.8 MHz)	A-Suffix, 2N5581,2N5582	$r_b'C_c$	–	150	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)	2N2219A,2N2222A	NF	–	4.0	dB
SWITCHING CHARACTERISTICS (A-Suffix, 2N5581 and 2N5582)					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 14)	t_d	–	10	ns
Rise Time		t_r	–	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 15)	t_s	–	225	ns
Fall Time		t_f	–	60	ns
Active Region Time Constant** (I_C = 150 mAdc, V_{CE} = 30 Vdc)		T_A	–	2.5	ns

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
(3)2N5581 and 2N5582 are Listed C_{cb} and C_{eb} for these conditions and values.

FIGURE 1 — NORMALIZED DC CURRENT GAIN

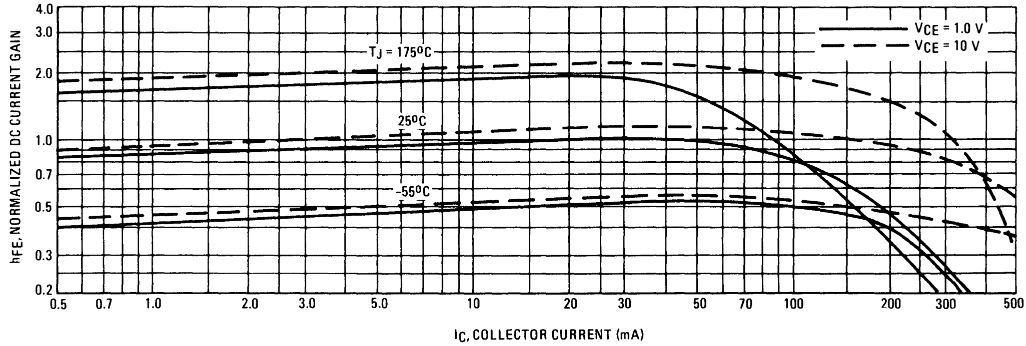
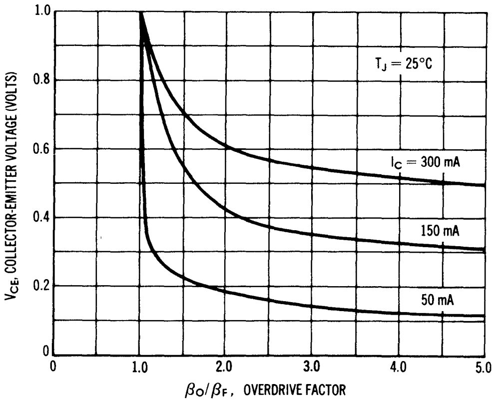


FIGURE 2 — COLLECTOR CHARACTERISTICS IN SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type 2N2219, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at $I_C = 150$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.62 of h_{FE} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, $\beta_o = 62$ and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_F} = \frac{h_{FE} @ 1.0\,V}{I_C/I_{BF}} \qquad 2.5 = \frac{62}{150/I_{BF}} \qquad I_{BF} \approx 6.0 \text{ mA}$$

FIGURE 3 — "ON" VOLTAGES

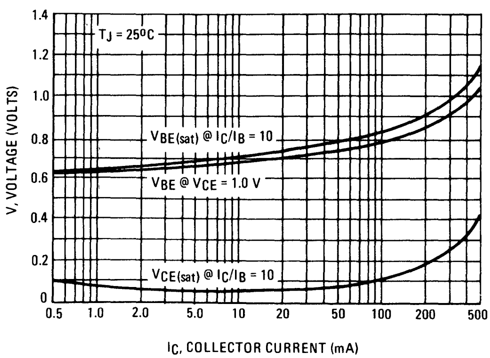
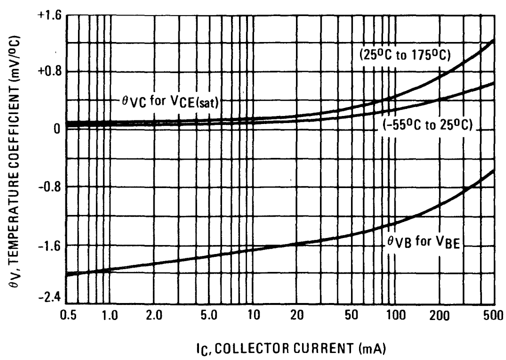


FIGURE 4 — TEMPERATURE COEFFICIENTS



NOISE FIGURE

V_{CE} = 10 V, T_A = 25°C

FIGURE 5 – FREQUENCY EFFECTS

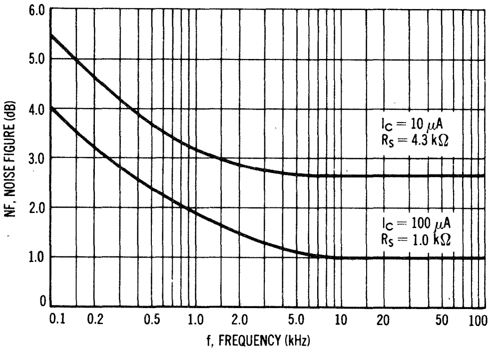
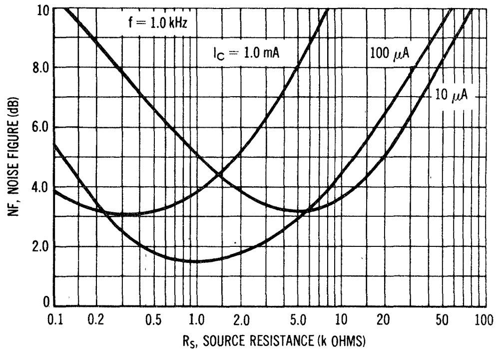


FIGURE 6 – SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 7 – INPUT IMPEDANCE

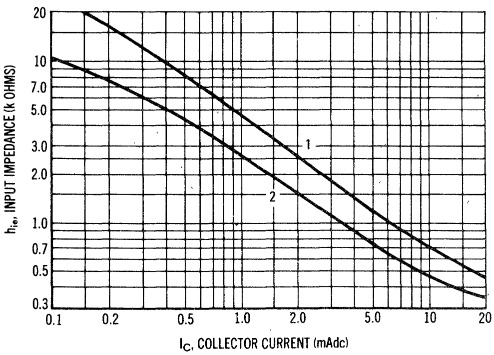


FIGURE 8 – VOLTAGE FEEDBACK RATIO

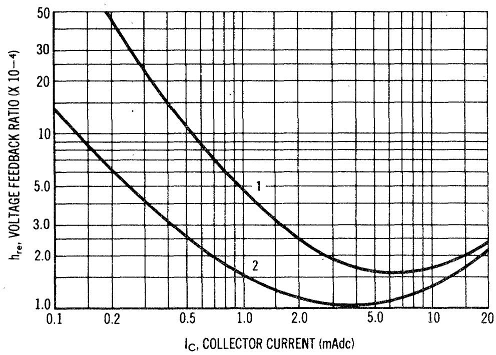


FIGURE 9 – CURRENT GAIN

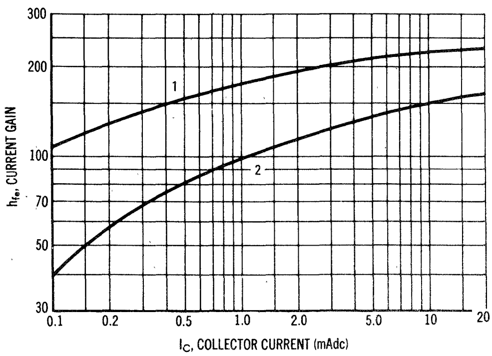
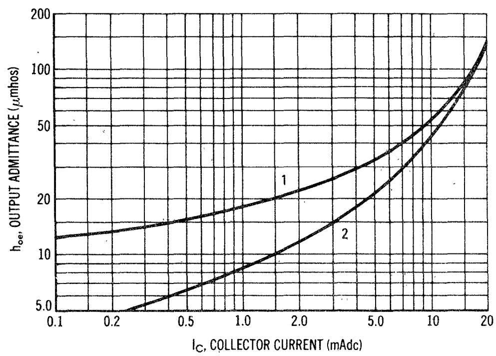


FIGURE 10 – OUTPUT ADMITTANCE



SWITCHING TIME CHARACTERISTICS

FIGURE 11 – TURN-ON TIME

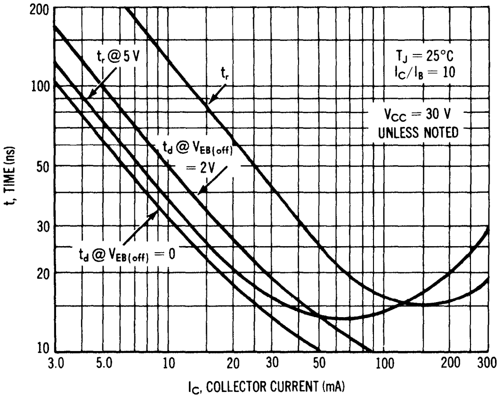


FIGURE 12 – CHARGE DATA

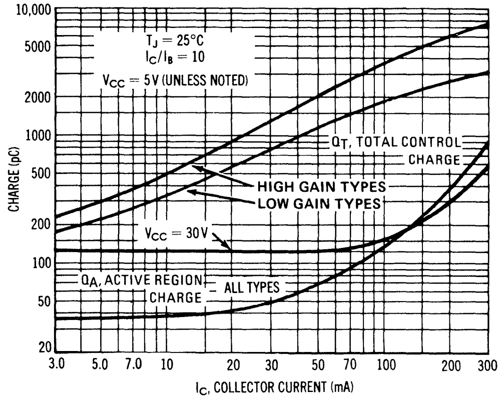


FIGURE 13 – TURN OFF BEHAVIOR

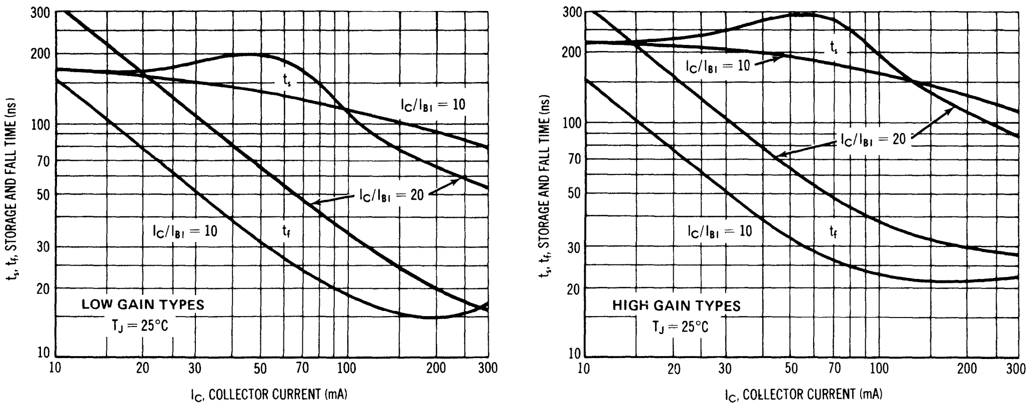


FIGURE 14 – DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

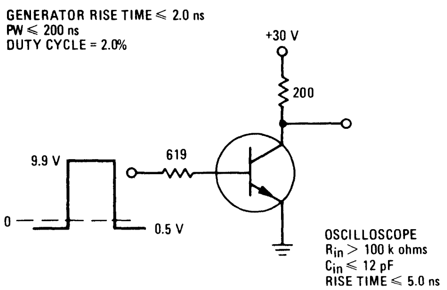


FIGURE 15 – STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT

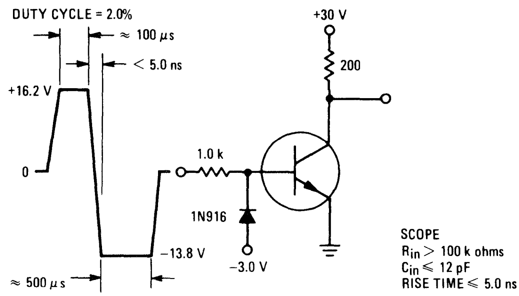


FIGURE 16 — CURRENT-GAIN—BANDWIDTH PRODUCT AND COLLECTOR-BASE TIME CONSTANT DATA

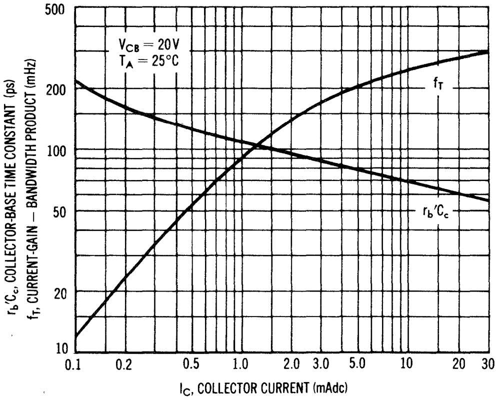


FIGURE 17 — CAPACITANCES

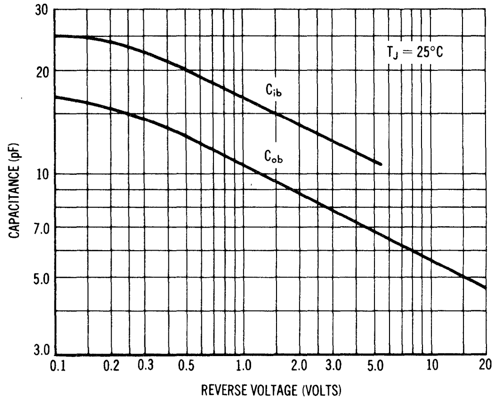
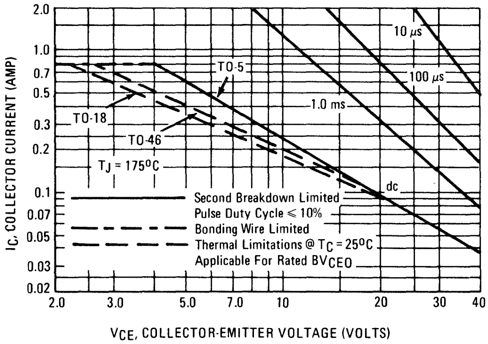


FIGURE 18 — ACTIVE-REGION SAFE OPERATING AREAS

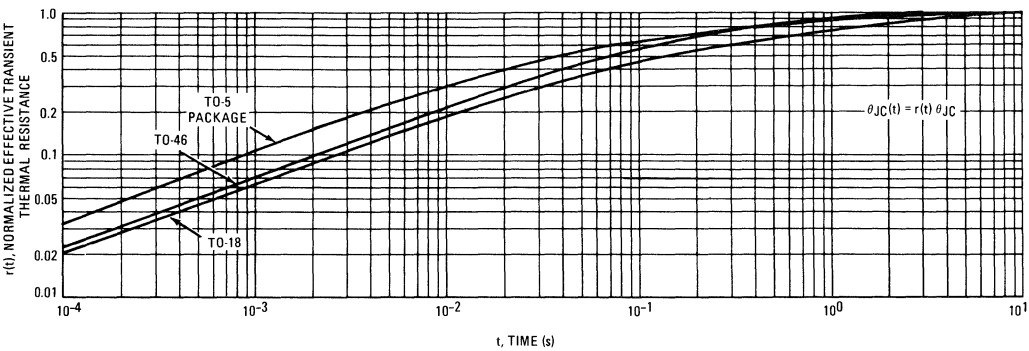


This graph shows the maximum I_C-V_{CE} limits of the device both from the standpoint of thermal dissipation (at 25°C case temperature), and secondary breakdown. For case temperatures other than 25°C, the thermal dissipation curve must be modified in accordance with the derating factor in the Maximum Ratings table.

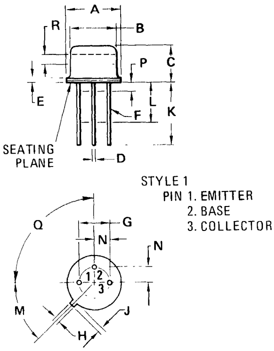
To avoid possible device failure, the collector load line must fall below the limits indicated by the applicable curve. Thus, for certain operating conditions the device is thermally limited, and for others it is limited by secondary breakdown.

For pulse applications, the maximum I_C-V_{CE} product indicated by the dc thermal limits can be exceeded. Pulse thermal limits may be calculated by using the transient thermal resistance curve of Figure 19.

FIGURE 19 — THERMAL RESPONSE



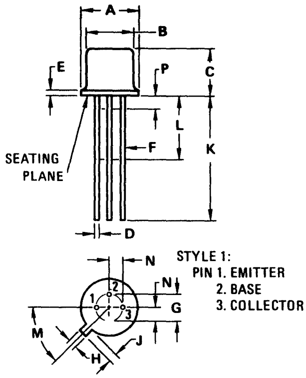
OUTLINE DIMENSIONS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9 40	0 350	0.370
B	8.00	8 51	0.315	0 335
C	6.10	6 60	0.240	0.260
D	0 406	0.533	0 016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0 016	0.019
G	4 83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12 70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

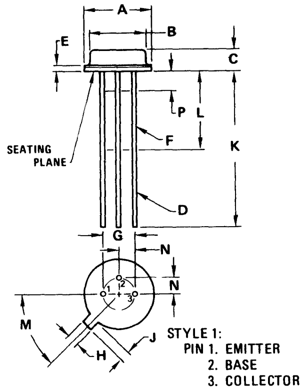
CASE 79-02
TO-39



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22
TO-18



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

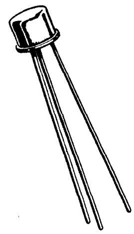
All JEDEC dimensions and notes apply

CASE 26
TO-46

2N2223, A

For Specifications, See 2N2060 Data.

2N2224 (SILICON)



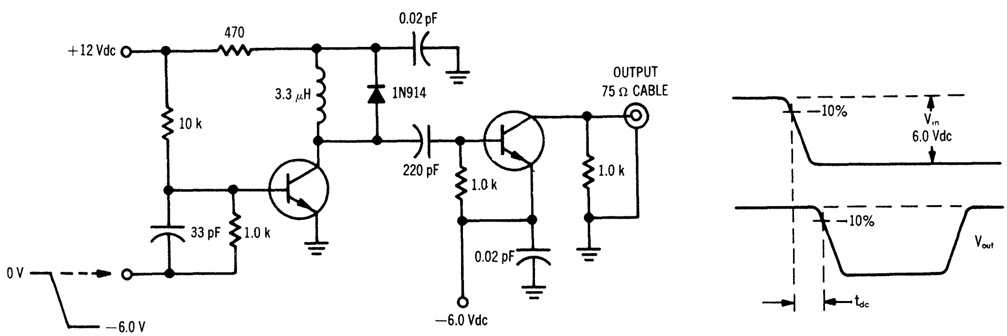
NPN silicon annular transistor designed primarily for high speed switching applications.

CASE 31
(TO-5)
Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	0.5	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	Watts mW/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

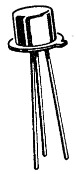
FIGURE 1



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

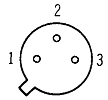
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	65	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector-Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	-	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)		-	10	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	-	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		25	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		35	115	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		40	120	
Collector-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	-	1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	-	MHz
(I_C = 80 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		160	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	-	8.0	pF
Circuit Delay (Figure 1) (T_A = 25°C)	t_{dc}	-	15	ns
Circuit Delay - Total Change (Figure 1) (T_A = +10°C to T_A = +25°C)	Δt_{dc}	-	15	ns

(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2.0%



NPN silicon annular transistor designed for high-speed, low-power saturated switching applications.

CASE 22
(TO-18)



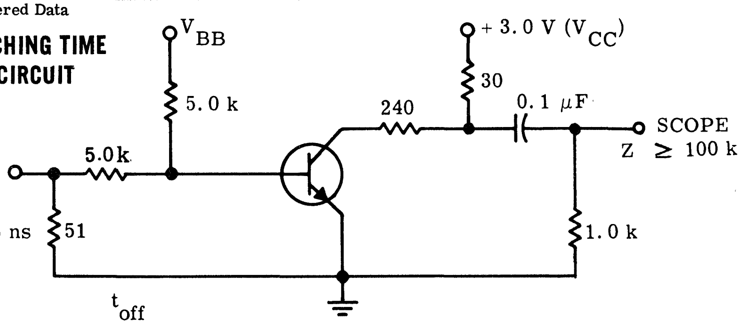
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	225	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mWatts mW/°C
Junction Temperature — Operating	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

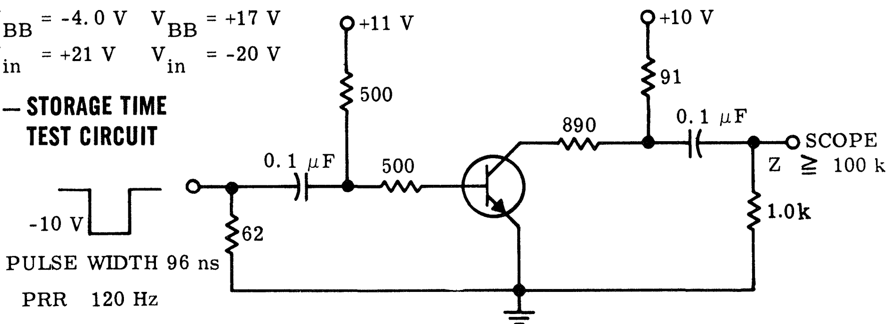
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



PULSE WIDTH 96 ns
PRR 120 Hz

	t_{on}	t_{off}
	V_{BB} = -4.0 V	V_{BB} = +17 V
	V_{in} = +21 V	V_{in} = -20 V

FIGURE 2 — STORAGE TIME TEST CIRCUIT



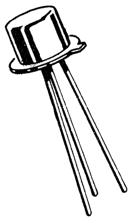
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 30 mAdc, I_E = 0)	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = 30 mAdc, R_{BE} = ≤ 10 ohms)	BV_{CER}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.1	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		-	15	
Emitter Cutoff Current ($V_{EB(off)}$ = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40	120	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		20	-	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	-	0.7	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55 to +125°C)		-	0.3	
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	-	1.5	Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 125°C)		-	0.8	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = +2.0 Vdc, I_{B1} = 3.0 mAdc, I_C = 10 mAdc)	t_{on}	-	30	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	50	ns
Storage Time (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	-	25	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Wdith = 300 μs; Duty Cycle = ≤ 2%

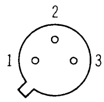
2N2256, 2N2257 (SILICON)



NPN silicon and PNP germanium mesa complementary transistors for high-speed non-saturated switching applications.

CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N2256 2N2257	Unit
Collector-Emitter Voltage	V_{CEO}	7.0	Vdc
Collector-Base Voltage	V_{CB}	7.0	Vdc
Emitter-Base Voltage	V_{EB}	1.0	Vdc
Collector Current-Continuous	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 2.0	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1000 6.67	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	^oC

* Indicates JEDEC Registered Data

TRANSISTOR SELECTION CHART

TYPE	TYPE		h_{FE} @ $I_C = 25$ mA	
	NPN	PNP	20	40
2N2256	X		X	
2N2257	X			X

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	7.0	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	7.0	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	3.0	10	μAdc
(V_{CB} = 6 Vdc, I_E = 0, T_A = 65°C)			-	30	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2256	h_{FE}	17	30	-	-
	2N2257		40	50	-	
(I_C = 25 mAdc, V_{CE} = 1 Vdc)	2N2256		20	35	-	
	2N2257		40	55	-	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 1 Vdc)		$V_{BE(on)}$	-	0.70	0.8	Vdc
(I_C = 25 mAdc, V_{CE} = 1 Vdc)			-	0.8	0.9	
Conduction Threshold Base-Emitter Voltage(1) (I_C = 200 μAdc, V_{CE} = 1 Vdc)		V_T	0.5	-	-	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)		f_T	250	320	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 4 MHz)		C_{ob}	-	4.0	5.0	pF
Base Resistance (I_E = 5 mAdc, V_{CB} = 2 Vdc, f = 300 MHz)		r'_b	-	50	100	Ohms
Turn-On Time (1)		t_{on}	-	3.0	7.0	ns
Turn-Off Time(1)		t_{off}	-	4.0	7.0	ns

(1)Base-to-emitter forward bias voltage at which transistor will be at the threshold of conduction; i.e. that base-to-emitter voltage at which the collector current is less than or equal to the specified amount under a given collector-to-emitter voltage condition.

* Indicates JEDEC Registered Data

FIGURE 1 — NPN SWITCHING TIME TEST CIRCUIT

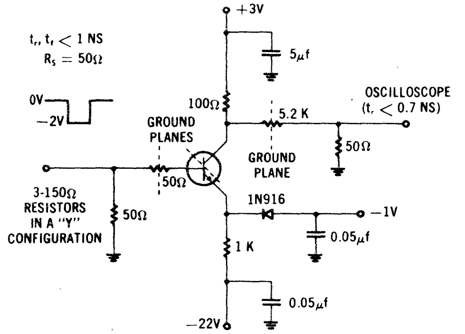


FIGURE 2 — CASCADE COMPLEMENTARY GATE

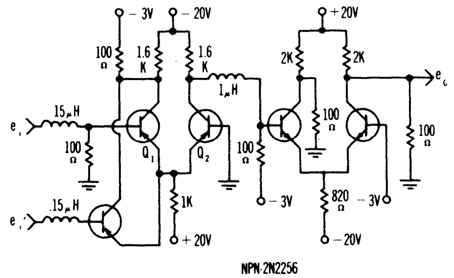


FIGURE 3 — CURRENT MODE INVERTER FOR USE WITH DIODE LOGIC PROPAGATION DELAY TIME 10 ns

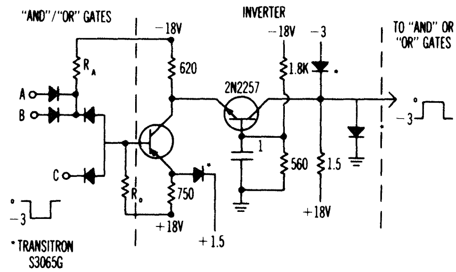


FIGURE 4 — CURRENT GAIN CHARACTERISTICS

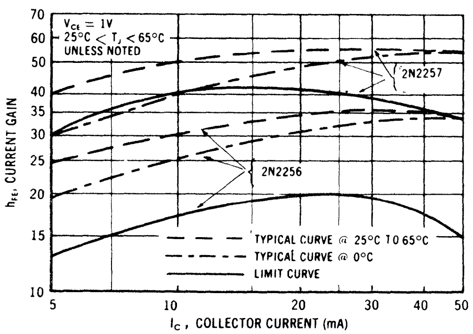
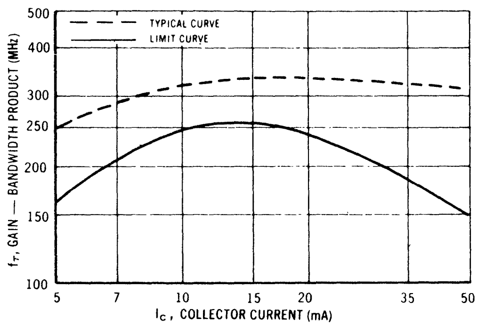


FIGURE 5 — CURRENT GAIN-BANDWITH PRODUCT CHARACTERISTICS



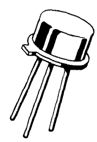
2N 2270S (SILICON)

NPN SILICON ANNULAR HIGH-CURRENT AMPLIFIER TRANSISTOR

. . . designed for use in amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $BV_{CEO(sus)}$ = 45 Vdc (Min) @ I_C = 100 mAdc
- High-Current-Gain—Bandwidth Product —
  f_T = 250 MHz (Typ) @ I_C = 50 mAdc

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

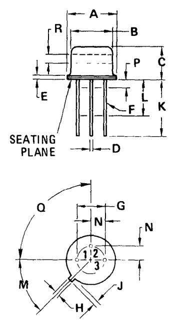
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Emitter Voltage, $R_{BE} \leqslant 10$ Ohms	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.71	Watt $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6	Watts $mW/^oC$
Operating and Stroage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	175	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^oC/W$

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9 40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12 70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

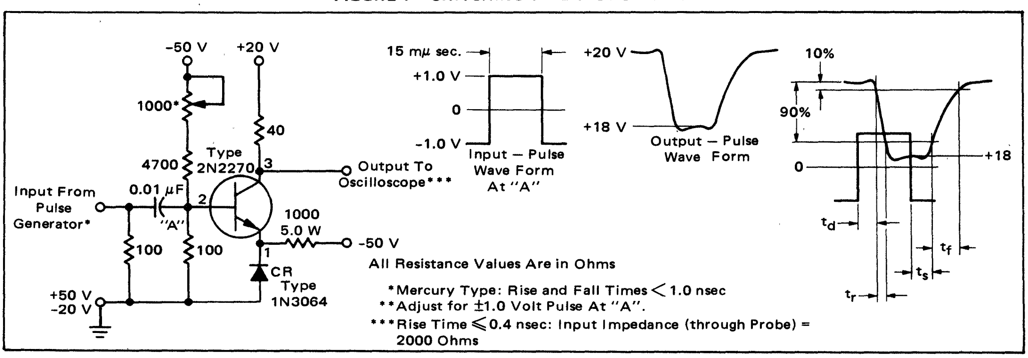
CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	45	–	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, $R_{BE} \leqslant$ 10 Ohms)	BV_{CER}	60	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.05 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_L = 25°C)		–	–	0.05	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)		–	–	50	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	nAdc
ON CHARACTERISTICS					
DC Current Gain (1)	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		30	90	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		50	135	200	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.3	0.9	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.75	1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	10	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	60	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	50	–	275	–
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k Ohm, f = 1.0 kHz, B.W. = 1.0 Hz)	NF	–	7.0	10	dB
SWITCHING CHARACTERISTICS					
Total Switching Time (Figure 1)	$t_{on} + t_{off}$	–	–	30	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width $\leqslant$300 μs, Duty Cycle $\leqslant$2.0%.

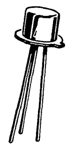
FIGURE 1 – SWITCHING TIME TEST CIRCUIT



PNP GERMANIUM AMPLIFIER TRANSISTOR

. . . designed for military VHF amplifier applications.

PNP GERMANIUM AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

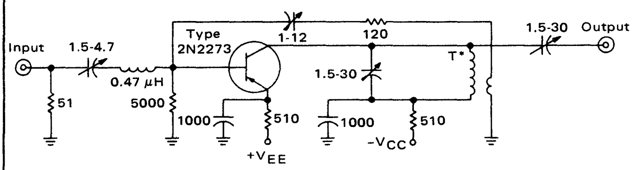
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	1.0	Vdc
Collector Current — Continuous	I_C	100	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2.0	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

*ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 200 μAdc, V_{BE} = 0)	BV_{CES}	25	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	1.0	–	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	75	–
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	250	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.5	pF
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 10 MHz)	h_{fe}	20	28	–
Extrinsic Base Resistance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 250 MHz)	r_b	–	250	Ohms
Noise Figure (I_C = 1.0 mAdc, V_{CB} = 10 Vdc, R_G = 50 Ohms, f = 10 MHz)	NF	–	12	dB

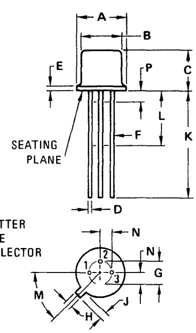
*Indicates JEDEC Registered Data.

FIGURE 1 — 30 MHz POWER GAIN TEST CIRCUIT



All Resistance Values in Ohms
All Capacitance Values in Picofarads

*Primary = 5½ Turns, 5/8" Long
Secondary = 1½ Turns
No. 22 Wire, O.D. = 1/4"



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0 046
J	0.711	1.22	0.028	0.048
K	12 70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 BSC		45^0 BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

2N2285 thru 2N2287

For Specifications, See 2N1651 Data.

2N2288, 2N2289 (GERMANIUM) 2N2290

PNP GERMANIUM POWER SWITCHING TRANSISTORS

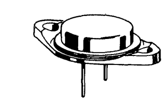
. . . designed for fast-switching applications requiring low saturation voltage and excellent collector-emitter sustaining voltage capability.

- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages —
  $V_{CE(sat)}$ = 0.5 Vdc (Max) @ I_C = 5.0 Adc
  $V_{BE(sat)}$ = 1.0 Vdc (Max) @ I_C = 5.0 Adc

10 AMPERE

POWER TRANSISTORS
PNP ADE GERMANIUM

40-120 VOLTS
70 WATTS



MAXIMUM RATINGS

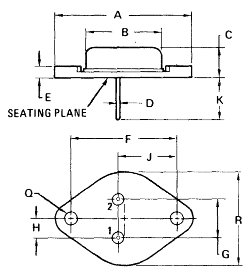
Rating	Symbol	2N2288	2N2289	2N2290	Unit
*Collector-Emitter Voltage (R_{BE} = 100 Ohms)	V_{CER}	40	80	120	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	← 0.75 →			Vdc
*Collector Current - Continuous	I_C	← 10 →			Adc
Base Current - Continuous	I_B	← 3.0 →			Adc
Total Device Dissipation @ T_C = 25°C *Derate above 25°C	P_D	← 70 0.833 →			Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/W

*Indicates JEDEC Registered Data.

STYLE 1
PIN 1 BASE
2. EMITTER
CASE COLLECTOR

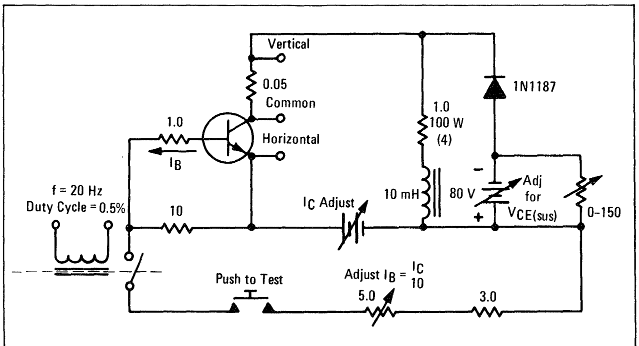


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case

CASE 11A

FIGURE 1 — SUSTAINING VOLTAGE TEST CIRCUIT

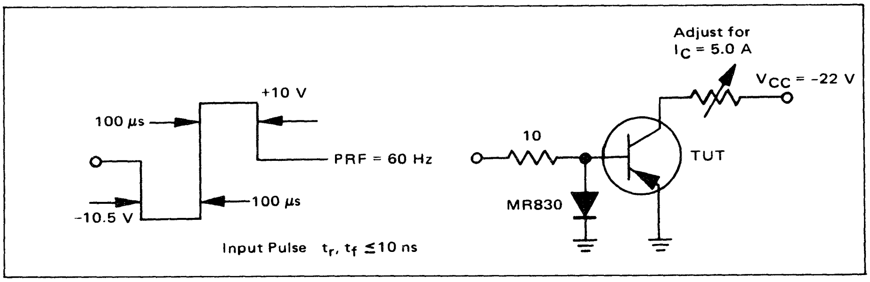


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2288 2N2289 2N2290	BV_{CEO}	30 50 70	- - -	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 5.0 Adc)	2N2288 2N2289 2N2290	$V_{CE(sus)}$	30 50 70	- - -	Vdc
*Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 Ohms)	2N2288 2N2289 2N2290	BV_{CER}	40 80 120	- - -	Vdc
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0) (V_{CE} = 25 Vdc, I_B = 0) (V_{CE} = 35 Vdc, I_B = 0)	2N2288 2N2289 2N2290	I_{CEO}	- - -	50 50 50	mAdc
*Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C) (V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C) (V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C, +0, -3.0°C)	2N2288 2N2289 2N2290	I_{CEX}	- - -	35 35 35	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0) *(V_{CB} = 40 Vdc, I_E = 0) *(V_{CB} = 80 Vdc, I_E = 0) *(V_{CB} = 120 Vdc, I_E = 0)	All Types 2N2288 2N2289 2N2290	I_{CBO}	- - - -	200 5.0 5.0 5.0	μAdc mAdc
Emitter Cutoff Current (V_{EB} = 0.75 Vdc, I_C = 0)		I_{EBO}	-	25	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20 20	- 60	-
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 14 Vdc, f = 1.0 kHz) (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)		h_{fe}	25 15	100 -	-
SWITCHING CHARACTERISTICS					
Rise Time	I_C = 5.0 Adc, I_{B1} = I_{B2} = 1.0 Adc) (See Figure 2)	t_r	-	5.0	μs
Storage Time		t_s	-	7.0	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



2N2291, 2N2292 (GERMANIUM)
2N2293

PNP GERMANIUM POWER SWITCHING TRANSISTORS

. . . designed for fast switching applications requiring low saturation voltage and excellent collector-emitter sustaining voltage capability.

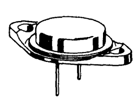
- Alloy-Diffused Epitaxial Construction
- Low Saturation Voltages –
  $V_{CE(sat)}$ = 0.5 Vdc @ I_C = 5.0 Adc
  $V_{BE(sat)}$ = 1.0 Vdc @ I_C = 5.0 Adc

10 AMPERE

POWER TRANSISTORS
PNP ADE GERMANIUM

40-120 VOLTS
70 WATTS

DS 85



MAXIMUM RATINGS

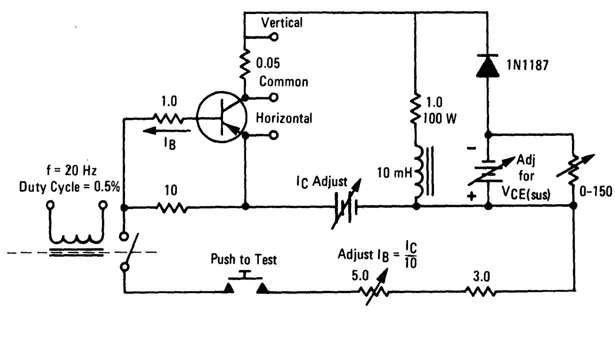
Rating	Symbol	2N2291	2N2292	2N2293	Unit
*Collector-Emitter Voltage	V_{CEO}	30	50	70	Vdc
*Collector-Base Voltage	V_{CB}	40	80	120	Vdc
*Emitter-Base Voltage	V_{EB}	←	1.5	→	Vdc
*Collector Current - Continuous	I_C	←	10	→	Adc
*Base Current - Continuous	I_B	←	3.0	→	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	←	70 0.83	→	Watts W/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	←	-65 to +110	→	°C

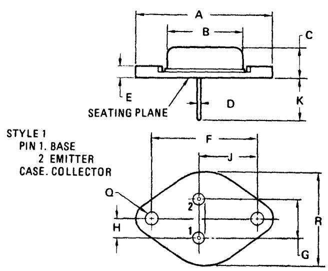
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.2	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – SUSTAINING VOLTAGE TEST CIRCUIT





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector Connected to Case

CASE 11A
(TO-3)

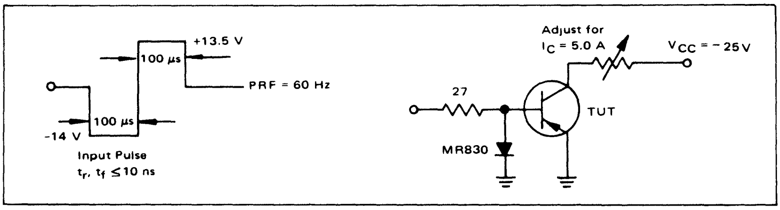
Except Pin Diameter

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2291	BV_{CEO}	30	-	Vdc
	2N2292		50	-	
	2N2293		70	-	
*Collector-Emitter Sustaining Voltage (See Figure 1) *(I_C = 500 mAdc)	2N2291	$V_{CE(sus)}$	30	-	Vdc
	2N2292		50	-	
	2N2293		70	-	
**(I_C = 5.0 Adc)	2N2291		25	-	
	2N2292		50	-	
	2N2293		70	-	
*Collector-Emitter Breakdown Voltage (I_C = 50 mAdc, R_{BE} = 100 ohms)	2N2291	BV_{CER}	40	-	Vdc
	2N2292		80	-	
	2N2293		120	-	
*Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	2N2291	I_{CEO}	-	50	mAdc
(V_{CE} = 25 Vdc, I_B = 0)	2N2292		-	50	
(V_{CE} = 35 Vdc, I_B = 0)	2N2293		-	50	
*Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2291	I_{CEX}	-	35	mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2292		-	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.1 Vdc, T_C = 100°C)	2N2293		-	35	
Collector Cutoff Current *(V_{CB} = -2.0 Vdc, I_E = 0)	All Types	I_{CBO}	-	200	μAdc
*(V_{CB} = 40 Vdc, I_E = 0)	2N2291		-	5.0	mAdc
*(V_{CB} = 80 Vdc, I_E = 0)	2N2292		-	5.0	
*(V_{CB} = 120 Vdc, I_E = 0)	2N2293		-	5.0	
Emitter Cutoff Current (V_{EB} = 1.5 Vdc, I_C = 0)		I_{EBO}	-	50	mAdc
ON CHARACTERISTICS					
*DC Current Gain (I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)		h_{FE}	40	-	-
(I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)			50	120	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{CE(sat)}$	-	0.5	Vdc
*Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc)		$V_{BE(sat)}$	-	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
*Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 14 Vdc, f = 1.0 kHz)		h_{fe}	50	200	-
(I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)			15	-	
SWITCHING CHARACTERISTICS					
Rise Time	(I_C = 5.0 Adc, I_{B1} = I_{B2} = 0.5 Adc) (See Figure 2)	t_r	-	7.0	μs
Storage Time		t_s	-	10	μs
Fall Time		t_f	-	8.0	μs

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to the JEDEC Registered Data Shown.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

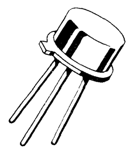


NPN SILICON ANNULAR HIGH-CURRENT AMPLIFIER TRANSISTOR

. . . designed for use in medium-current amplifier applications.

- Collector-Emitter Sustaining Voltage — $BV_{CEO(sus)}$ = 35 Vdc (Min) @ I_C = 30 mAdc
- Current-Gain — Bandwidth Product — f_T = 100 MHz (Typ) @ I_C = 50 mAdc
- DC Current Gain — 10 mAdc to 1.0 Adc

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

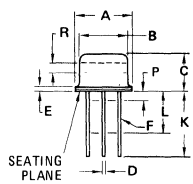
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

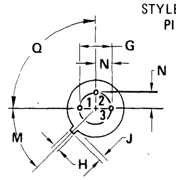
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	219	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Lead Temperature, 1/16" from Case for 10 seconds	T_L	300	°C

*Indicates JEDEC Registered Data.

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.





STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	35	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 60 Vdc, I_E = 0)		–	–	10	nAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		30	60	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc		40	80	120	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)		15	40	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.1	0.2	
(I_C = 1.0 Adc, I_B = 100 mAdc)		–	0.6	1.0	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)	$V_{BE(sat)}$	–	0.8	1.6	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	8.0	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	60	80	pF
Collector-Base Time Constant (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 4.0 MHz)	$r_b'C_c$	–	–	800	ps

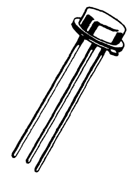
*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

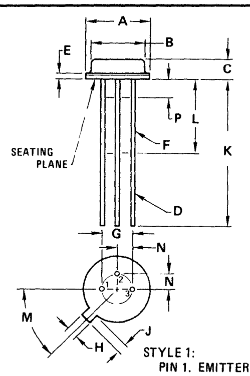
NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in high-speed low-current switching applications requiring TO-46 package configuration.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 15 Vdc (Min) @ I_C = 10 mAdc
- High-Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 10 mAdc
- DC Current Gain — 100 μAdc to 20 mAdc
- Fast Switching Time @ I_C = 20 mAdc (Figure 1)
  t_{on} = 45 μs (Typ)
  t_{off} = 40 μs (Typ)

NPN SILICON SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	15	Vdc
*Collector-Emitter Voltage	V_{CES}	30	Vdc
*Collector-Base Voltage	V_{CB}	30	Vdc
*Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
*Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	583	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	175	°C/W
*Lead Temperature 1/16" ±1/32" from Case for 15 seconds	T_L	300	°C

*Indicates JEDEC Registered Data
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
*Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
*Emitter-Base Breakdown Voltage (I_E = 1.0 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
*Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	50	nAdc
*Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	50	nAdc
*Collector Cutoff Current (V_{CE} = 25 Vdc, V_{EB} = 1.5 Vdc, R_{BE} = 720 k Ohms)	I_{CEX}	–	–	5.0	μAdc
***ON CHARACTERISTICS**					
DC Current Gain (1)	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 300 mVdc)		15	25	–	
(I_C = 1.0 mAdc, V_{CE} = 300 mVdc)		20	30	–	
(I_C = 10 mAdc, V_{CE} = 400 mVdc)		30	45	–	
(I_C = 20 mAdc, V_{CE} = 400 mVdc)		40	50	–	
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	200	350	mVdc
Base-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	780	900	mVdc
***DYNAMIC CHARACTERISTICS**					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	3.0	5.0	pF
***SWITCHING CHARACTERISTICS**					
Turn-On Time (Figure 1) (V_{CC} = 15 Vdc, $V_{BE(off)}$ = 4.0 V, I_C = 20 mA, I_{B1} = 2.0 mA)	t_{on}	–	45	60	ns
Storage Time (Figure 2) (V_{CC} = 5.0 Vdc, I_C = 20 mAdc, I_{B1} = I_{B2} = 20 mAdc)	t_s	–	14	20	ns
Turn-Off Time (Figure 1) (V_{CC} = 15 Vdc, I_C = 20 mAdc, I_{B1} = I_{B2} = 2.0 mAdc)	t_{off}	–	40	50	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

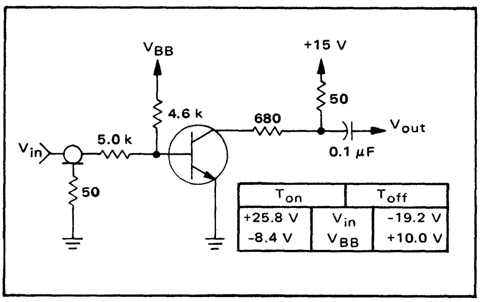
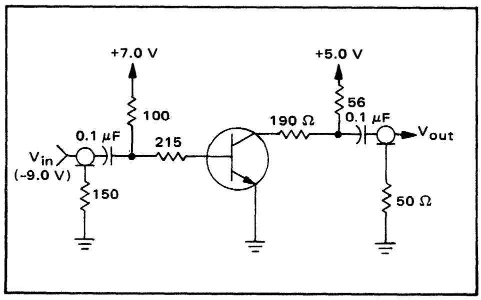


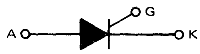
FIGURE 2 – STORAGE TIME TEST CIRCUIT



NOTES:

1. Bypass and decoupling capacitors omitted for clarity.
2. V_{in} (Z = 50 Ω) t_r ≤1 ns; t_p = 96 ns; Duty Cycle ≤2%.
3. V_{out} (Fig. 1) to 50 Ω probe; V_{out} (Fig. 2) to 100 k oscilloscope input.

2N2322 (SILICON) thru 2N2326



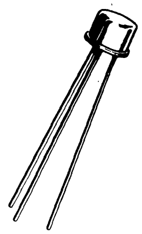
SILICON CONTROLLED RECTIFIERS

. . . all-diffused PNPN devices designed for gating operation in mA/μA signal or detection circuits.

- Low-Level Gate Characteristics — I_{GT} = 200 μA (Max) @ 25°C
- Low Holding Current — I_H = 2.0 mA (Max) @ 25°C
- Anode Common to Case
- Glass-to-Metal Bond for Maximum Hermetic Seal

THYRISTORS
PNPN

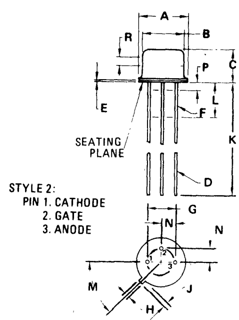
1.6 AMPERE RMS
25 thru 200 VOLTS



*MAXIMUM RATINGS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Rating	Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage (Notes 2 and 3) 2N2322	V_{RRM}	25	Volts
2N2323		50	
2N2324		100	
2N2325		150	
2N2326		200	
Non-Repetitive Peak Reverse Blocking Voltage ($t \leqslant 5.0$ ms, Notes 2 and 3) 2N2322	V_{RSM}	40	Volts
2N2323		75	
2N2324		150	
2N2325		225	
2N2326		300	
RMS On-State Current (All Conduction Angles)	$I_{T(RMS)}$	1.6	Amp
Average On-State Current T_C = 85°C	$I_{T(AV)}$	1.0	Amp
T_A = 30°C		0.45	
Peak Non-Repetitive Surge Current (One Cycle, 60 Hz, T_C = 80°C) Preceded and followed by rated current and voltage	I_{TSM}	15	Amp
Peak Gate Power	P_{GM}	0.1	Watt
Average Gate Power	$P_{G(AV)}$	0.01	Watt
Peak Gate Current	I_{GM}	0.1	Amp
Peak Gate Voltage	V_{GM}	6.0	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (> 1/16" from case, 10 s max)	–	+230	°C

*Indicates JEDEC Registered Data



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7 75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0 406	0.483	0.016	0 019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0 100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply

CASE 31-03
TO-5

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Max	Unit
*Peak Forward Blocking Voltage (Note 2)	V_{DRM}			Volts
2N2322		25	–	
2N2323		50	–	
2N2324		100	–	
2N2325		150	–	
2N2326		200	–	
*Peak Reverse Blocking Current (Rated V_{RRM}, T_J = 125°C)	I_{RRM}	–	100	μA
*Peak Forward Blocking Current (Rated V_{DRM}, T_J = 125°C)	I_{DRM}	–	100	μA
Peak On-State Voltage	V_{TM}			Volts
(I_{TM} = 1.0 A Peak)		–	1.5	
(I_{TM} = 3.14 A Peak, T_C = 85°C)*		–	2.0	
Gate Trigger Current (Note 1)	I_{GT}			μA
(V_{AK} = 6.0 Vdc, R_L = 100 ohms)		–	200	
(V_{AK} = 6.0 Vdc, R_L = 100 ohms, T_C = -65°C)		–	350*	
Gate Trigger Voltage	V_{GT}			Volts
(V_{AK} = 6.0 Vdc, R_L = 100 ohms)		–	0.8	
(V_{AK} = 6.0 Vdc, R_L = 100 ohms, T_C = -65°C)*		–	1.0	
(V_{AK} = Rated V_{DRM}, R_L = 100 ohms, T_J = 125°C)*		0.1	–	
Holding Current	I_H			mA
(V_{AK} = 6.0 Vdc)		–	2.0	
(V_{AK} = 6.0 Vdc, T_C = -65°C)*		–	3.0	
(V_{AK} = 6.0 Vdc, T_C = 125°C)*		0.15	–	

*Indicates JEDEC Registered Data.

Notes. 1. R_{GK} current is not included in measurement.

2. Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

3. Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

CURRENT DERATING

FIGURE 1 – CASE TEMPERATURE

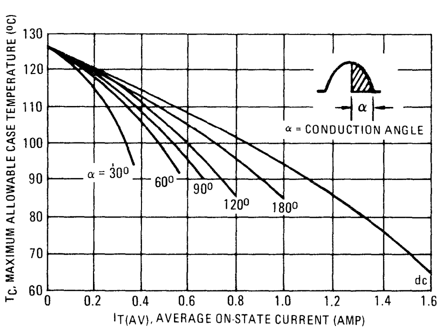
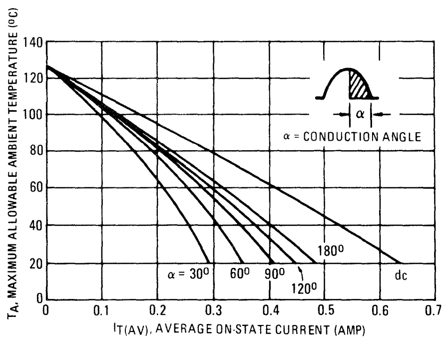
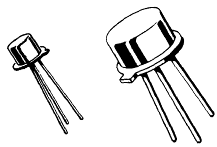


FIGURE 2 – AMBIENT TEMPERATURE



2N2330S (SILICON)
2N2331S

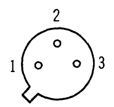


NPN silicon annular transistors for low-level DC/AC chopper applications.

CASE 22
(TO-18)
2N2331

CASE 79
(TO-39)
2N2330

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N2330 (TO-5)	2N2331 (TO-18)	Unit
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.8 5.33	0.5 3.33	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3.0 20	1.8 12	Watts $mW/^oC$
Operating Junction Temperature Range	T_J	-65 to +175		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

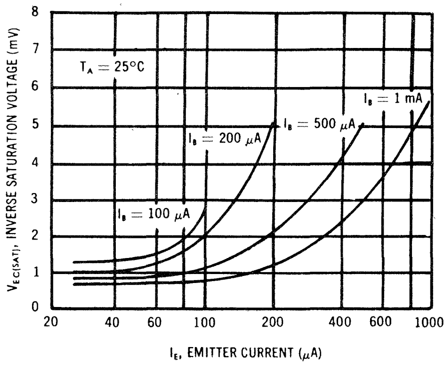
* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

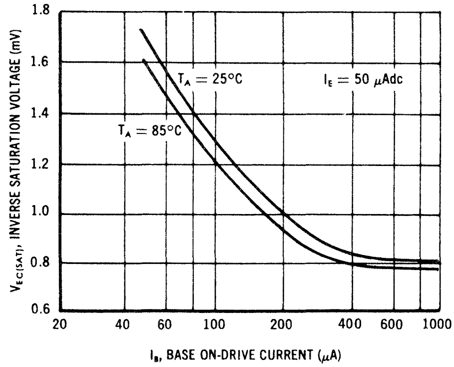
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 4.5 Vdc, I_E = 0)	I_{CBO}	-	1.0	nAdc
Emitter Cutoff Current (V_{BE} = 4.5 Vdc)	I_{EBO}	-	5.0	nAdc
Offset Current (V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 25°C)	$I_{(off)}$	-	1	nAdc
(V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 85°C)		-	10	
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	h_{FE}	50	-	-
Offset Voltage (I_B = 200 μAdc, I_E = 0)	$V_{(off)}$	-	0.75	mVdc
Inverse Saturation Voltage (I_B = 200 μAdc, I_E = 50 μAdc)	$V_{EC(sat)}$	-	3.0	mVdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 1 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 2 Vdc, I_E = 0)	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0)	C_{ib}	-	20	pF

* Indicates JEDEC Registered Data

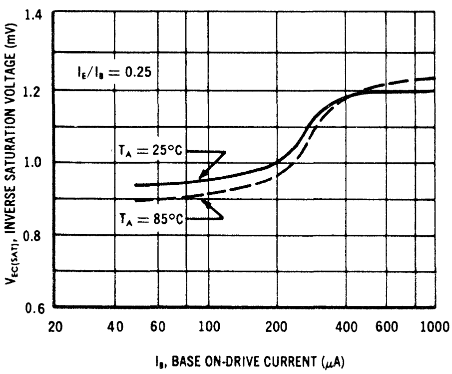
INVERSE SATURATION VOLTAGE
versus
EMITTER CURRENT



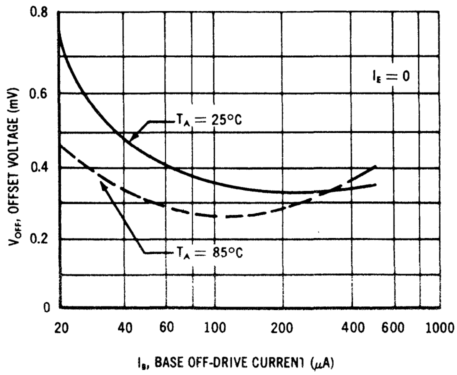
INVERSE SATURATION VOLTAGE
versus
BASE CURRENT



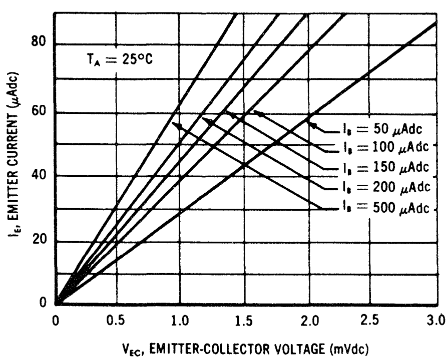
INVERSE SATURATION VOLTAGE
versus
BASE CURRENT



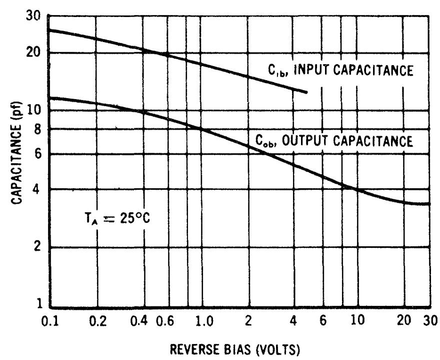
OFFSET VOLTAGE
versus
BASE CURRENT



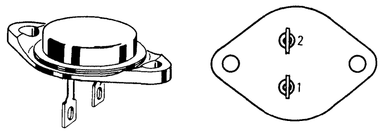
INVERSE
SATURATION
CHARACTERISTICS



OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE
and
INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE



2N2357 thru 2N2359 (Germanium)



CASE 161

Collector Connected to Case

STYLE 1
PIN 1 BASE
2 EMITTER
CASE-COLLECTOR

PNP Germanium power transistors designed for very high-current switching applications requiring low saturation voltages, fast switching times and good safe operating area.

MAXIMUM RATINGS

Rating	Symbol	2N2357	2N2358	2N2359	Unit
Collector-Emitter Voltage	V_{CEO}	30	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	100	120	Vdc
Emitter-Base Voltage	V_{EB}	←	2.5	→	Vdc
Collector Current - Continuous	I_C	←	50	→	Adc
Base Current - Continuous	I_B	←	10	→	Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	←	170 2.0	→	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←	-65 to +110	→	°C

THERMAL CHARACTERISTICS

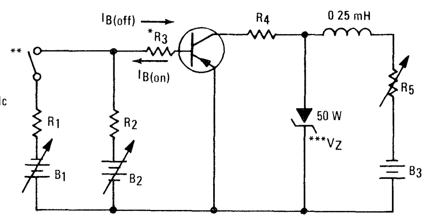
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 — SUSTAINING VOLTAGE TEST CIRCUIT

R_1 = 1.0 Ohm, 20 Watts
R_2 = 10 Ohms, 2.0 Watts
R_3 = 0.1 Ohm, 1.0%
$R_4 \leq$ 0.04 Ohm

R_5. I_C Adjust @ $V_{CE} = V_Z$
B_1 Adjust for $I_{B(on)} = \frac{I_C}{10}$
B_2 = 2.0 Vdc, Adjust for $I_{B(off)}$ = 0.2 Adc
B_3 = 12 Vdc

*Not required if current probe is used to read I_{B1}
**PRF ≈ 60 Hz
***Zener selected to establish Sustaining Voltage.
NOTE. Series impedance and inductance must be kept to a minimum.



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	2N2357 2N2358 2N2359	BV_{CEO}	30 60 80	- - -	- - -	Vdc
Collector-Emitter Sustaining Voltage (See Figure 1) (I_C = 50 Adc)	2N2357 2N2358 2N2359	$V_{CE(sus)}$	35 40 45	- - -	- - -	Vdc
Collector -Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0 (V_{CE} = 100 Vdc, V_{BE} = 0) (V_{CE} = 120 Vdc, V_{BE} = 0)	2N2357 2N2358 2N2359	I_{CES}	- - -	- - -	50 50 50	mAdc
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	-	200	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc) (V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc) (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc)	2N2357 2N2358 2N2359	I_{CEX}	- - -	- - -	5.0 5.0 5.0	mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C) (V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C) (V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C) (+0, -3.0°C)	2N2357 2N2358 2N2359		- - -	- - -	35 35 35	
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	-	-	50	mAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 20 Adc, V_{CE} = 1.5 Vdc) (I_C = 50 Adc, V_{CE} = 1.5 Vdc)		h_{FE}	30 15	- -	90 -	-
Collector-Emitter Saturation Voltage (I_C = 50 Adc, I_B = 5.0 Adc)		$V_{CE(sat)}$	-	-	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 50 Adc, I_B = 5.0 Adc)		$V_{BE(sat)}$	-	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 6.0 Vdc, f = 30 kHz)		h_{fe}	20	-	-	-
SWITCHING CHARACTERISTICS						
Rise Time	(V_{CC} = -28 Vdc, I_C = 50 Adc, I_{B1} = 5.0 Adc, I_{B2} = 3.0 Adc) (See Figure 3)	t_r	-	12	-	μs
Storage Time		t_s	-	5.0	-	μs
Fall Time		t_f	-	6.0	-	μs

FIGURE 2 – SWITCHING TIMES

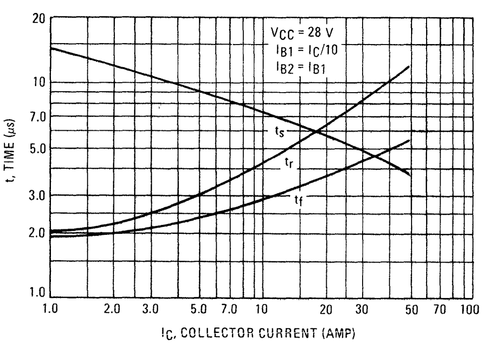
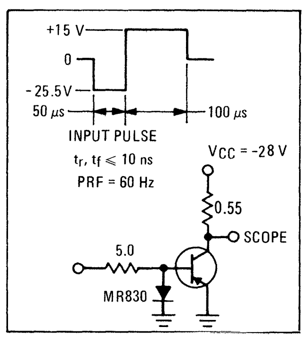
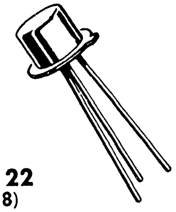


FIGURE 3 – SWITCHING TIME TEST CIRCUIT

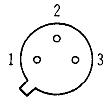


2N2368 (SILICON)



CASE 22
(TO-18)
Collector connected to case

NPN silicon annular transistor designed for high-speed, low-level, saturated-switching application.



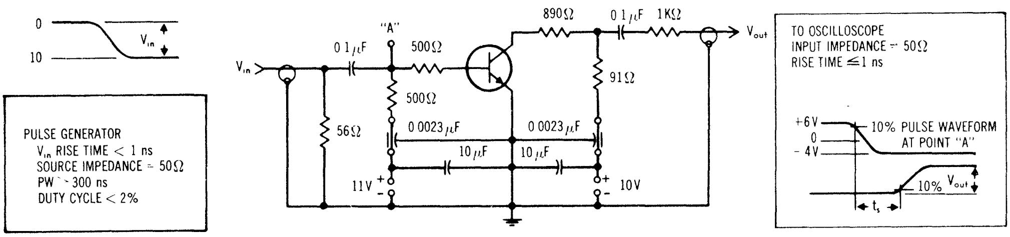
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ $T_A = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	0.36 2.06	Watt $mW/^{\circ}C$
Total Device Dissipation @ $T_C = 25^{\circ}C$ Derate above $25^{\circ}C$	P_D	1.2 6.85	Watt $mW/^{\circ}C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 200	$^{\circ}C$

* Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT

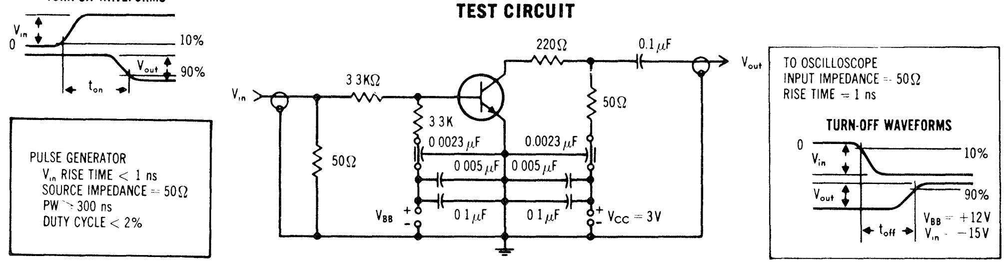


*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

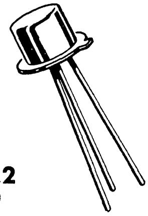
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μ Adc, I_C = 0)	BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.4 30	μAdc
ON CHARACTERISTICS				
DC Current Gain [1] (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	20 10 10	60 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	4.0	pF
Storage Time (Figure 1) (I_C = I_{B1} = 10 mAdc, I_{B2} = -10 mAdc)	t_s	—	10	ns
Turn-On Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{on}	—	12	ns
Turn-Off Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{off}	—	15	ns

[1] Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%
*Indicates JEDEC Registered Data

FIGURE 2 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

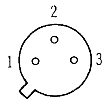


2N2369 (SILICON)
2N3227



NPN silicon annular transistors for low-current, high-speed switching applications.

CASE 22
(TO-18)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage 2N2369 2N3227	V_{CEO}	15 20	Vdc
Emitter-Base Voltage 2N2369 2N3227	V_{EB}	4.5 6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 0.36 2.06	 Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.85	 Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA

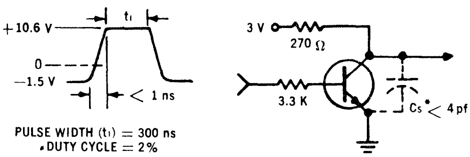


FIGURE 3 — t_{off} CIRCUIT — 10 mA

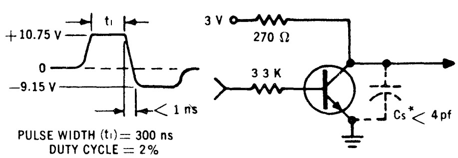


FIGURE 2 — t_{on} CIRCUIT — 100 mA

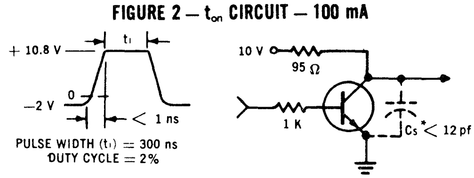
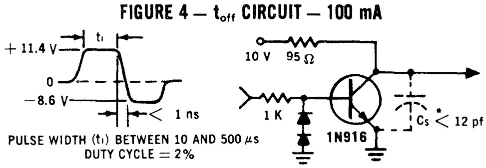


FIGURE 4 — t_{off} CIRCUIT — 100 mA



* Total shunt capacitance of test jig and connectors.

*ELECTRICAL CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current			I_{CBO}			μAdc
(V_{CB} = 20 Vdc)	2N2369			—	0.4	
	2N3227			—	0.2	
(V_{CB} = 20 Vdc, T_A = 150°C)	2N2369			—	30	
	2N3227			—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)	2N3227		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)	2N3227		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μ Adc, I_C = 0)	2N2369		BV_{EBO}	4.5	—	Vdc
	2N3227			6.0	—	
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)	2N2369		BV_{CEO}	15	—	Vdc
	2N3227			20	—	
Collector-Emitter Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage (1)			$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	11,13		—	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			—	0.45	
Base-Emitter Saturation Voltage (1)			$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	13		0.70	0.85	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			0.8	1.4	
DC Current Gain (1)			h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N2369			40	120	
	2N3227	12		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N2369			20	—	
	2N3227	12		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3227	12		30	—	
(I_C = 100 mAdc, V_{CE} = 2 Vdc)	2N2369			20	—	
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)			h_{fe}	5.0	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)		5	C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 kHz)	2N3227		C_{ib}		4.0	pF
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		10	t_s	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, $V_{EB(off)}$ = 1.5 Vdc)		1,6	t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		3,6	t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)	2N3227	7,8	Q_T	—	50	pC
Delay Time — V_{CC}=10 V, $V_{EB(off)}$ = 2 Vdc, I_C = 100 mA, I_{B1}=10 mA	2N3227	2,6	t_d	—	5.0	ns
Rise Time — V_{CC}=10 V, $V_{EB(off)}$ = 2 Vdc, I_C = 100 mA, I_{B1}=10 mA	2N3227		t_r	—	18	ns
Storage Time — V_{CC}= 10 V, I_C = 100 mA, I_{B1}=I_{B2} = 10 mA	2N3227	4,6	t_s	—	13	ns
Fall Time — V_{CC}= 10 V, I_C = 100 mA, I_{B1}=I_{B2} = 10 mA	2N3227		t_f	—	15	ns

(1) **Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%**
* Indicates JEDEC Registered Data

FIGURE 5 — JUNCTION CAPACITANCE VARIATIONS

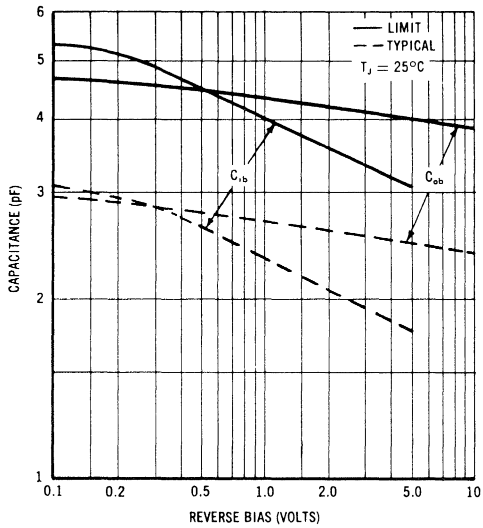


FIGURE 6 — TYPICAL SWITCHING TIMES

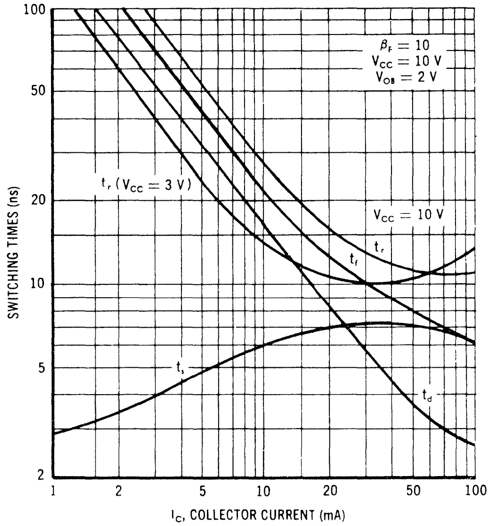


FIGURE 7 — MAXIMUM CHARGE DATA

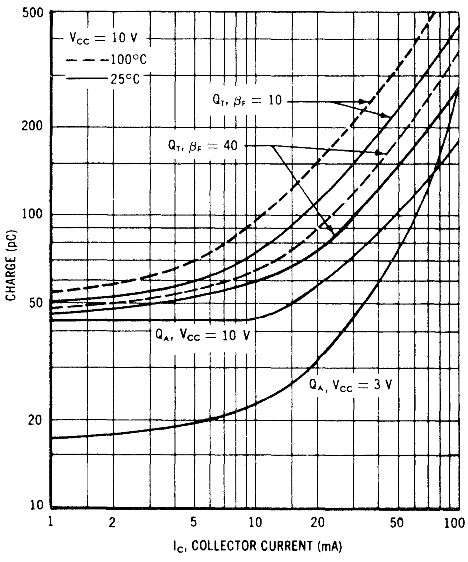


FIGURE 8 — Q_T TEST CIRCUIT

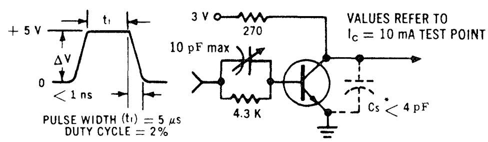


FIGURE 9 — TURN-OFF WAVE FORM

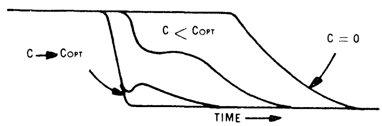
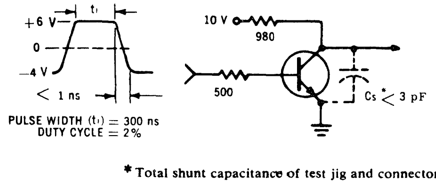


FIGURE 10 — STORAGE TIME EQUIVALENT TEST CIRCUIT



* Total shunt capacitance of test jig and connectors.

FIGURE 11 — MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

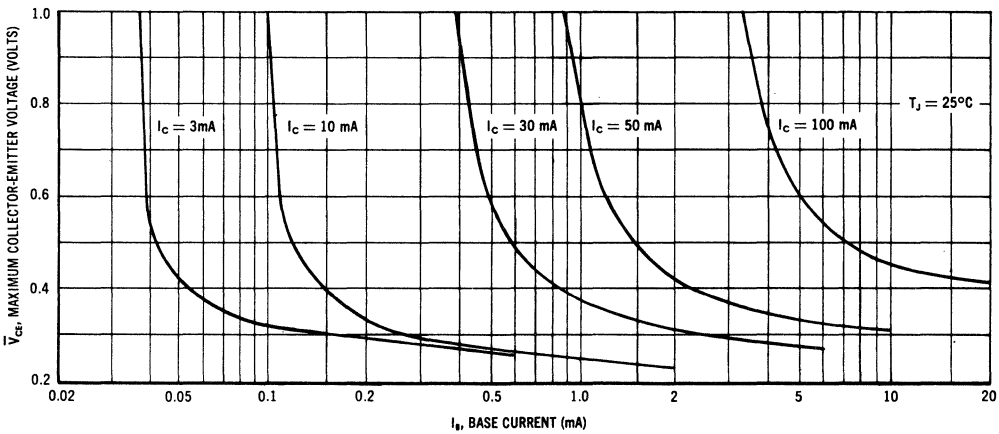


FIGURE 12 — MINIMUM CURRENT GAIN CHARACTERISTICS

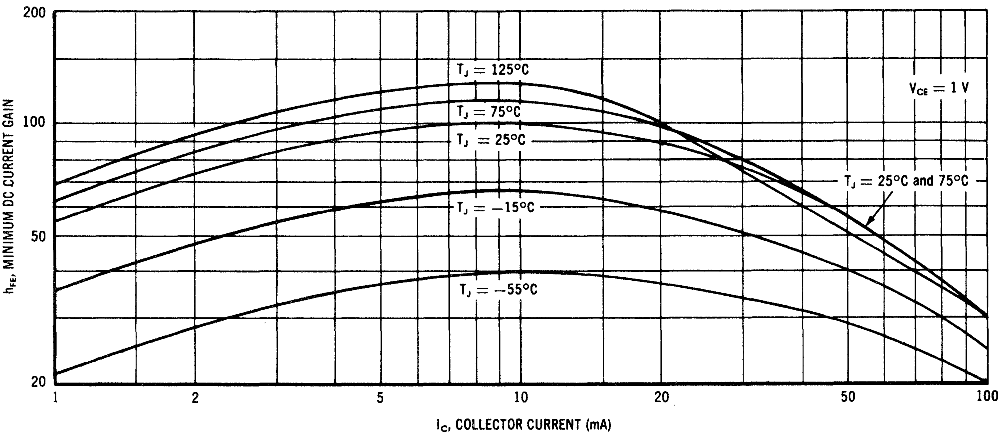


FIGURE 13 — SATURATION VOLTAGE LIMITS

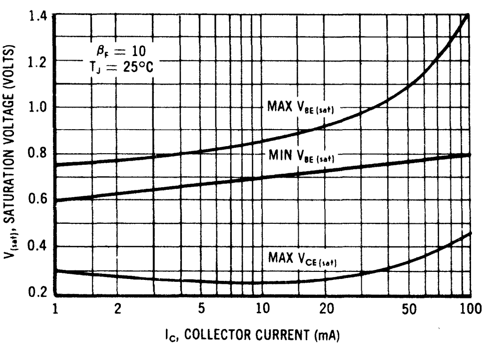
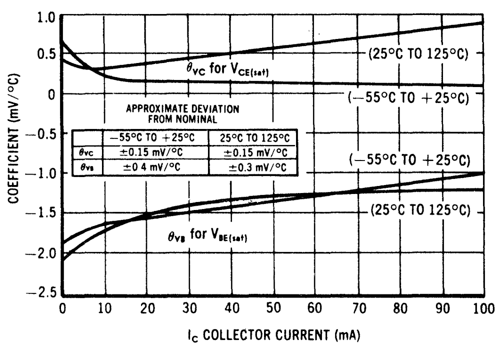
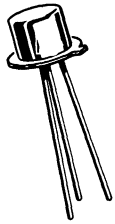


FIGURE 14 — TYPICAL TEMPERATURE COEFFICIENTS



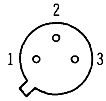
2N2369A (SILICON)
2N2369A JAN,JTX,JTXV AVAILABLE



NPN silicon epitaxial transistor for high-speed range of .10 – 100 mAdc switching applications. Specifications provided at -55°C to +125°C for critical dc characteristics.

CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

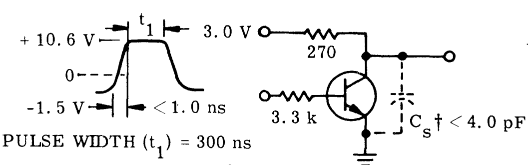
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current — Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

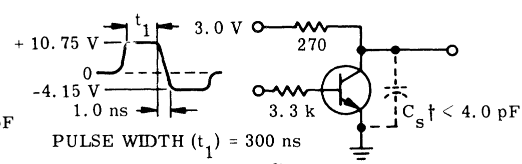
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — t_{on} CIRCUIT — 10 mA



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

FIGURE 2 — t_{off} CIRCUIT — 10 mA



PULSE WIDTH (t_1) = 300 ns
DUTY CYCLE = 2.0%

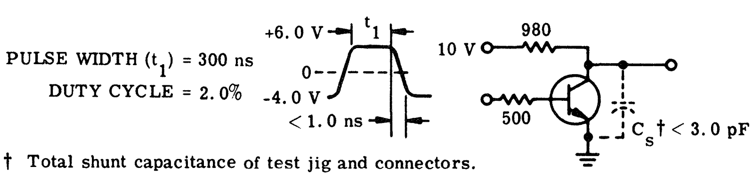
† Total shunt capacitance of test jig and connectors.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	-	BV_{CEO}	15	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, I_B = 0)	-	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	-	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	-	BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	-	I_{CES}	-	0.4	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	-	I_{CBO}	-	30	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0)	-	I_B	-	0.4	μAdc
ON CHARACTERISTICS					
DC Current Gain(1)	-	h_{FE}			-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			-	120	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc)			40	-	
(I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C)			20	-	
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)			30	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			20	-	
Collector-Emitter Saturation Voltage(1)	-	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			-	0.20	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)			-	0.30	
(I_C = 30 mAdc, I_B = 3.0 mAdc)			-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	0.50	
Base-Emitter Saturation Voltage(1)	-	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.70	0.85	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +125°C)			0.59	-	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = -55°C)			-	1.02	
(I_C = 30 mAdc, I_B = 3.0 mAdc)			-	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	1.60	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	-	f_T	500	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	-	C_{ob}	-	4.0	pF
Turn-On Time (V_{CC} = 3.0 V, $V_{BE(off)}$ = 1.5 V, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	1	t_{on}	-	12	ns
Turn-Off Time (V_{CC} = 3.0 V, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.5 mAdc)	2	t_{off}	-	18	ns
Storage Time (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	3	t_s	-	13	ns

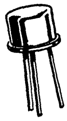
(1)Pulse Test: PW = 300 μs, Duty Cycle = 2.0%
* Indicates JEDEC Registered Data

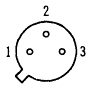
FIGURE 3 — STORAGE TIME EQUIVALENT TEST CIRCUIT



† Total shunt capacitance of test jig and connectors.

2N2381 (Ge Mesa)
2N2382





PNP germanium mesa transistors for high-speed, high-current switching applications.

CASE 79-02
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N2381	2N2382	Unit
Collector-Emitter Voltage	V_{CEO}	15	20	Vdc
Collector-Base Voltage	V_{CB}	30	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current-Continuous	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 4.0		mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 10		mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

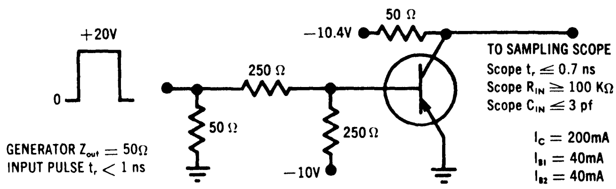
*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_E = 0) 2N2381 / 2N2382		BV_{CEO}	15 / 20	- / -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) 2N2381 / 2N2382		BV_{CBO}	30 / 45	- / -	Vdc
Latch-Up Voltage 2N2381 / 2N2382	2	LV_{CEX}	20 / 25	- / -	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0) 2N2381 / (V_{CE} = 45 Vdc, V_{BE} = 0) 2N2382		I_{CES}	- / -	100 / 100	μAdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0) / (V_{CB} = 5 Vdc, I_E = 0, T_A = 85°C) / (V_{CB} = 20 Vdc, I_E = 0) 2N2381 / 2N2382		I_{CBO}	- / - / - / -	7.0 / 100 / 25 / 15	μAdc
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0) / (V_{BE} = 4 Vdc, I_C = 0)		I_{EBO}	- / -	0.005 / 1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 200 mAdc, V_{CE} = 0.5 Vdc) / (I_C = 400 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	40 / 25	- / -	-
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc) / (I_C = 400 mAdc, I_B = 40 mAdc)		$V_{CE(sat)}$	- / -	0.4 / 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc) / (I_C = 400 mAdc, I_B = 40 mAdc)		$V_{BE(sat)}$	0.45 / -	0.7 / 0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4 MHz)		C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 4 MHz)		C_{ib}	-	15	pF
Delay Time	1	t_d	-	7.0	ns
Rise Time	1	t_r	-	15	ns
Storage Time	1	t_s	-	30	ns
Fall Time	1	t_f	-	15	ns
Active Region Time Constant	1	τ_A	-	3.0	ns

*Indicates JEDEC Registered Data

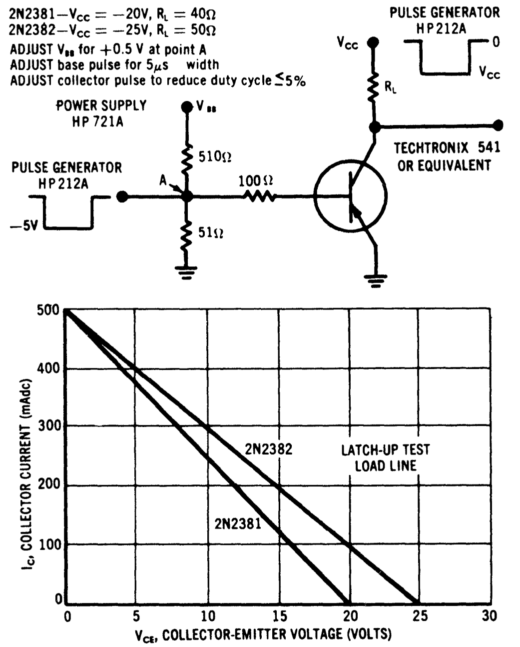
FIGURE 1 — SWITCHING TIME EQUATIONS & TEST CIRCUIT



Rise Time $= t_r = \tau_A \beta_F R$ = 10 to 90% Rise Time (fig. 5)
Fall Time $= t_f = \tau_A \beta_C F$ = 10 to 90% Fall Time (fig. 6)

$\beta_O = h_{FE}$ at Edge of Saturation
$\beta_C = I_C$ in Saturation / I_{B2} (Base "OFF" Current)
$\beta_F = I_C$ in Saturation / I_{B1} (Base "ON" Current)

FIGURE 2 — COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT



2N2405S

For Specifications, See 2N1893S Data

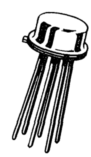
2N2453 (SILICON)
2N2453A

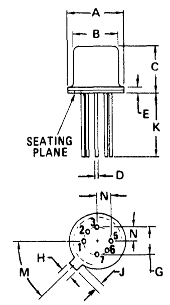
MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N2453A
  $\Delta|V_{BE1} - V_{BE2}| = 10\ \mu Vdc$ (Max) @ -55 to +25°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)} = 1.0$ Vdc (Typ) @ $I_C = 5.0$ mAdc
- DC Current Gain Specified — 10 µAdc to 1.0 mAdc
- High Current-Gain—Bandwidth Product —
  $f_T = 60$ MHz @ $I_C = 5.0$ mAdc

NPN SILICON MULTIPLE TRANSISTORS





STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

*MAXIMUM RATINGS

Rating	Symbol	2N2453	2N2453A	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	600 3.43	1200 6.86	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*ELECTRICAL CHARACTERISTICS (each side) ($T_A = 25°C$ unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) ($I_C = 10$ mAdc, $I_B = 0$)	 2N2453 2N2453A	$V_{CEO(sus)}$	 30 50	 – –	Vdc
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	 2N2453 2N2453A	BV_{CBO}	 60 80	 – –	Vdc
Emitter Base Breakdown Voltage ($I_E = 0.1\ \mu$Adc, $I_C = 0$)		BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current ($V_{CB} = 50$ Vdc, $I_E = 0$) ($V_{CB} = 50$ Vdc, $I_E = 0$, $T_A = 150°C$)		I_{CBO}	 – –	 0.005 10	µAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	–	0.002	µAdc

(1) Pulse Test Pulse Width ≤300 µs, Duty Cycle ≤2.0%
*Indicates JEDEC Registered Data

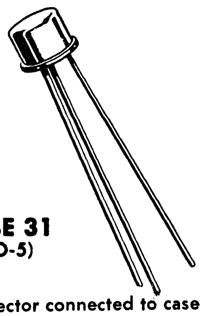
* ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		80	-	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		40	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		150	600	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		75	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	5.0	-	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	-	6.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	Ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	5.0	X 10^{-4}
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	NF	-	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (2)	h_{FE1}/h_{FE2}			-
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2453A		0.90	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		0.90	1.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C)		0.85	1.0	
Base-Emitter Voltage Differential	$\|V_{BE1}-V_{BE2}\|$			mVdc
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		-	3.0	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		-	5.0	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C)	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$			μV/°C
2N2453		-	10	
2N2453A		-	5.0	

*** Indicates JEDEC Registered Data**

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2476 (SILICON)
2N2477



CASE 31
(TO-5)

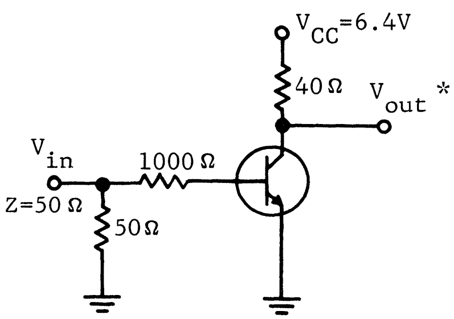
Collector connected to case

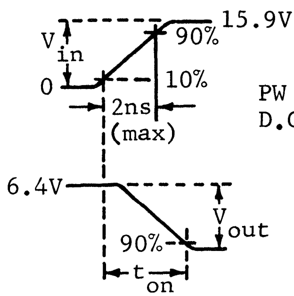
NPN silicon annular transistors designed for high-speed, low-power saturated switching applications.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.4	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.4	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — TURN-ON TIME TEST CIRCUIT





PW > 150 ns
D.C. < 2%

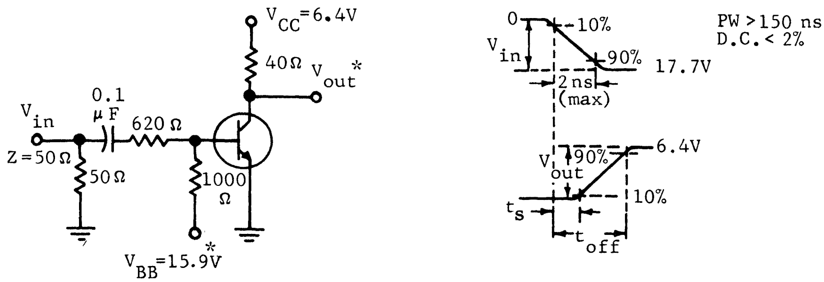
*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time < 0.5 ns; input capacitance of probe < 2.5 pF with shunt resistance ≥ 1 megohm.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 50 mAdc, I_B = 0)		BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 µAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	-	0.2	µAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)			-	200	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	100	µAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 150 mAdc, V_{CE} = 0.4 Vdc)	2N2476	h_{FE}	20	-	-
	2N2477		40	-	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 7.5 mAdc)	2N2476	$V_{CE(sat)}$	-	0.4	Vdc
(I_C = 150 mAdc, I_B = 3.75 mAdc)	2N2477		-	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N2476		-	0.75	
	2N2477		-	0.65	
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 7.5 mAdc)	2N2476	$V_{BE(sat)}$	-	1.0	Vdc
(I_C = 150 mAdc, I_B = 3.75 mAdc)	2N2477		-	0.95	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	10	pF
Turn-On Time (Figure 1) (V_{CC} = 6.4 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)		t_{on}	-	25	ns
Turn-Off Time (Figure 2) (V_{CC} = 6.4 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_{off}	-	45	ns
Storage Time (Figure 2) (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)		t_s	-	25	ns

(1) Pulse Test: pulse width ≦ 400 µs, duty cycle ≦ 3%.

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



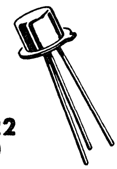
*Input and output waveforms monitored by means of an oscilloscope or other indicating device having a rise time<0.5 ns; input capacitance of probe < 2.5 pF with shunt resistance ≥ 1 megohm.

2N2480, A

For Specifications, See 2N2060 Data.

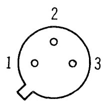
2N2481 (SILICON)

2N2481 JAN, JTX AVAILABLE



CASE 22
(TO-18)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular transistor for high-speed switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watt
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts
Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C

* Indicates JEDEC Registered Data

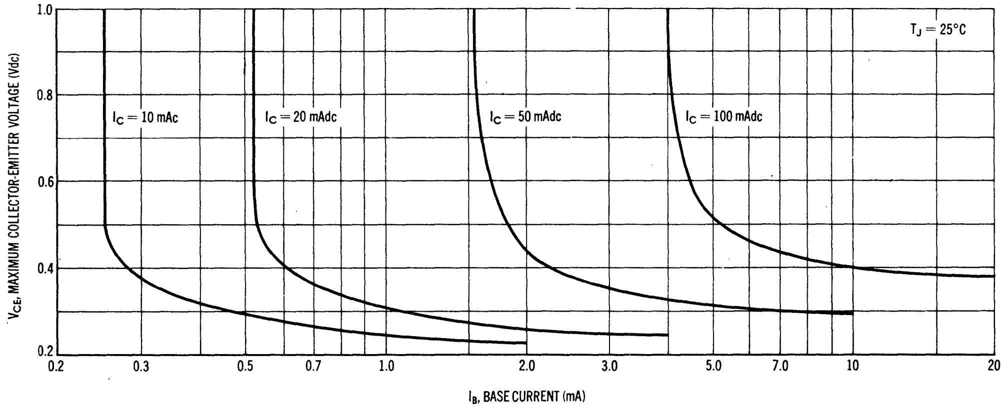
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 μAdc, V_{BE} = 0)	BV_{CES}	30	---	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc, T_A = 150°C)	I_{CEX}	--- ---	0.050 15	μAdc
Base Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)	I_{BL}	---	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	---	100	nAdc
DC Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (1)	h_{FE}	25 40 20 20	--- 120 --- ---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (1)	V_{CE} (sat)	--- ---	0.25 0.40	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) (1)	V_{BE} (sat)	0.7 ---	0.82 1.25	Vdc
Output Capacitance (V_{CB} = 5 V, I_C = 0, f = 1 MHz)	C_{ob}	---	5.0	pF
Input Capacitance (V_{EB} = 0.5 V, f = 1 MHz)	C_{ib}	---	7.0	pF
Small-Signal Forward Current Transfer Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 100 MHz)	h_{fe}	3.0	---	---
Small-Signal, Short-Circuit, Input Impedance (Real part) (I_C = 10 mA, V_{CE} = 10 V, f = 250 MHz)	$Re(h_{ie})$	---	60	ohms
Turn-On Time (I_C = 100 mA, I_{B1} = 10 mA, $V_{BE(off)}$ = 2 V) (I_C = 10 mA, I_{B1} = 1.0 mA, $V_{BE(off)}$ = 2 V)	t_{on}	--- ---	40 75	ns
Turn-Off Time (I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = 5 mA) (I_C = 10 mA, I_{B1} = 1.0 mA, I_{B2} = 0.5 mA)	t_{off}	--- ---	55 45	ns
Storage Time (I_C = 10 mA, I_{B1} = 10 mA, I_{B2} = 10 mA)	t_s	---	20	ns

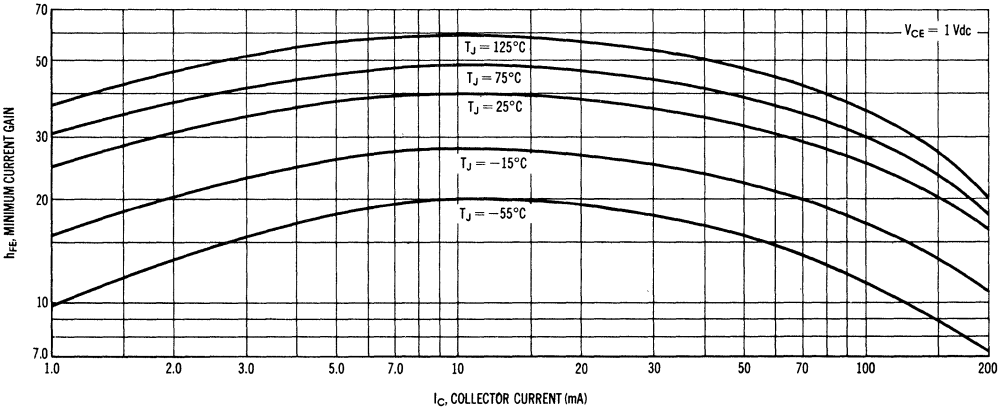
(1) Pulse width ≦ 300 μs, Duty Cycle ≦ 2%

* Indicates JEDEC Registered Data

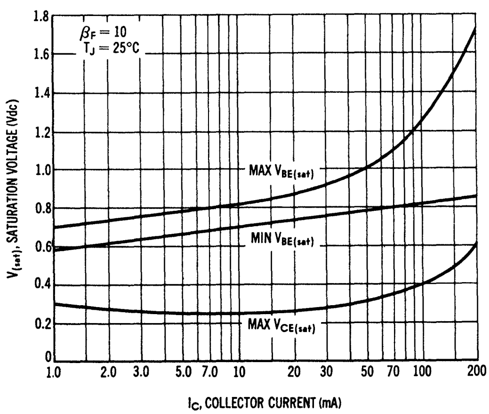
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



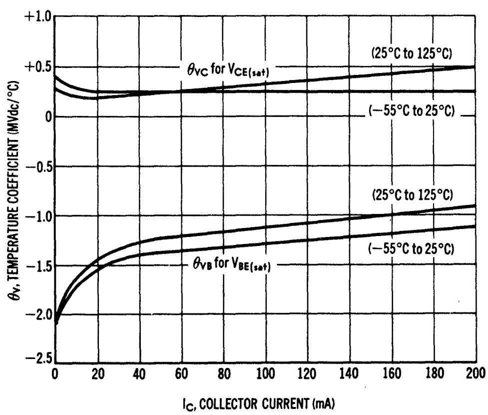
MINIMUM CURRENT GAIN CHARACTERISTICS



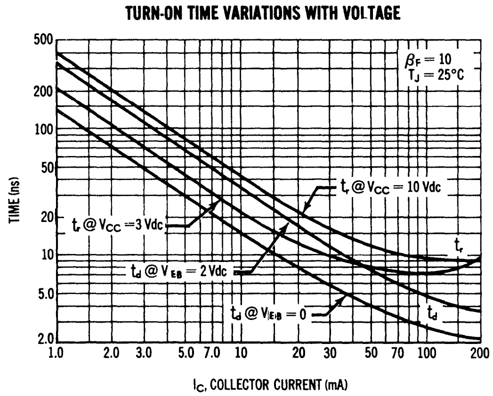
LIMITS OF SATURATION VOLTAGES

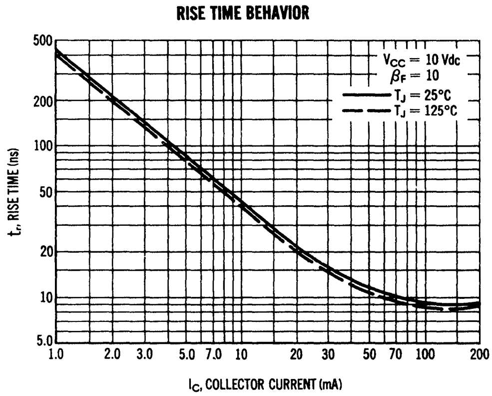


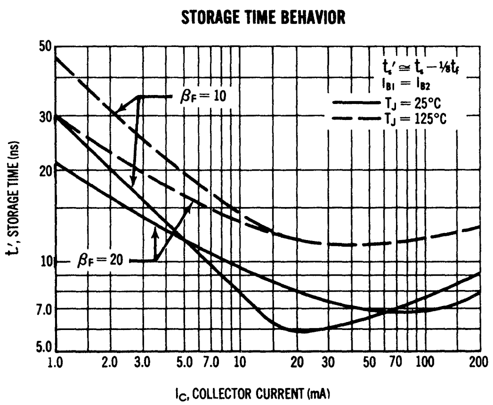
TYPICAL TEMPERATURE COEFFICIENTS

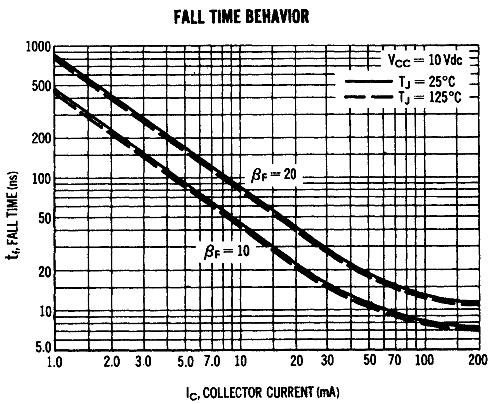


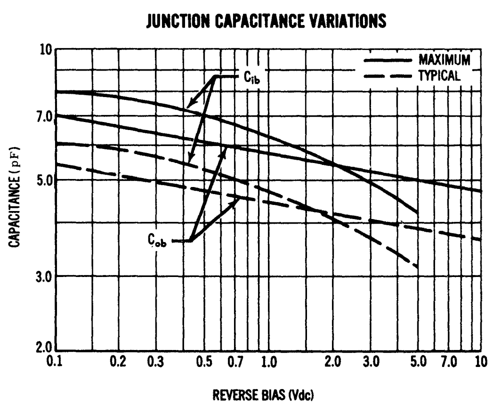
TYPICAL SWITCHING CHARACTERISTICS

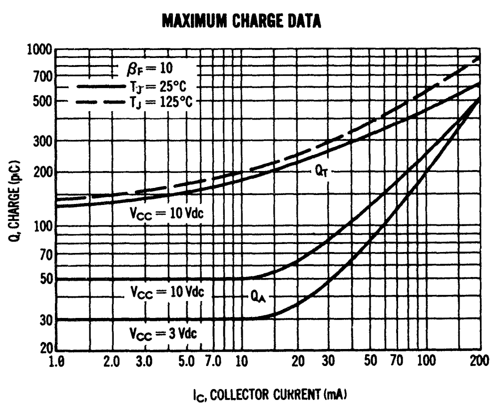












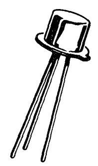
2N2483 (SILICON)
2N2484

NPN SILICON ANNULAR HIGH-GAIN TRANSISTORS

. . . designed for use in high-gain audio amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 60 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain — 1.0 μAdc to 10 mAdc — 2N2484
- Current-Gain — Bandwidth Product — f_T = 100 MHz (Typ) @ I_C = 500 μAdc
- Low Noise Figure — NF = 8.0 dB (Typ) @ I_C = 10 μAdc, f = 100 Hz

NPN SILICON HIGH GAIN AMPLIFIER TRANSISTORS



*MAXIMUM RATINGS

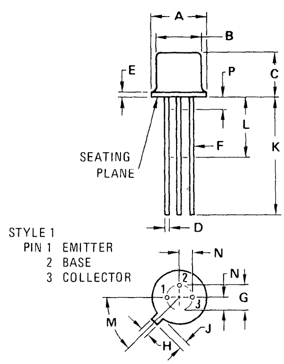
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	485	°C/W
Theraml Resistance, Junction to Case	$R_{\theta JC}$	146	°C/W
Lead Temperature 1/16" from Case for 10 Seconds	T_L	300	°C

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5 31	5.84	0 209	0 230
B	4.52	4 95	0 178	0 195
C	4.32	5.33	0.170	0 210
D	0.406	0 533	0.016	0.021
E	–	0.762	–	0 030
F	0.406	0 483	0 016	0.019
G	2 54 BSC		0.100 BSC	
H	0.914	1 17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12 70	–	0 500	–
L	6.35	–	0 250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1 27	–	0 050

All JEDEC notes and dimensions apply

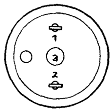
CASE 22-03
TO-18

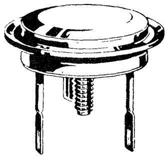
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 45 Vdc, I_E = 0)			–	–	10	nAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)			–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	10	nAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N2484		30	190	–	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2483		40	95	120	
	2N2484		100	250	500	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = 55°C	2N2483		10	20	–	
	2N2484		20	40	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2483		75	100	–	
	2N2484		175	275	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N2483		100	150	–	
	2N2484		200	300	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2483		175	200	–	
	2N2484		250	350	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) (1)	2N2483		–	300	500	
	2N2484		–	400	800	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.25	0.35	Vdc
Base-Emitter On Voltage (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	0.5	0.65	0.7	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain – Bandwidth Product		f_T				MHz
(I_C = 0.05 mAdc, V_{CE} = 5.0 Vdc, f = 5.0 MHz)	2N2483		12	50	–	
	2N2484		15	50	–	
(I_C = 0.5 mAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			60	100	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	3.0	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	4.0	6.0	pF
Input Impedance	2N2483	h_{ie}	1.5	–	13	kΩ
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2484		3.5	–	24	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{re}	–	–	800	x 10^{-6}
Small-Signal Current Gain	2N2483	h_{fe}	80	–	450	–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz	2N2484		150	–	900	
Output Admittance	2N2483	h_{oe}	–	–	30	μmhos
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2484		–	–	40	
Noise Figure		NF				dB
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ,	2N2483		–	8.0	15	
f = 100 Hz, BW = 20 Hz)	2N2484		–	8.0	10	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ,	2N2483		–	–	4.0	
f = 1.0 kHz, BW = 200 Hz)	2N2484		–	–	3.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ,	2N2483		–	–	3.0	
f = 10 kHz, BW = 2.0 kHz)	2N2484		–	–	2.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 kΩ,	2N2483		–	–	4.0	
f = 10 Hz to 15.7 kHz, BW = 15.7 kHz)	2N2484		–	–	3.0	

*Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

2N2490 thru 2N2493 (GERMANIUM)





STYLE 1·
PIN 1. BASE
2. EMITTER
3. COLLECTOR

CASE 5
(TO-36)

Collector connected to case

PNP germanium power transistors for general purpose power and switching applications.

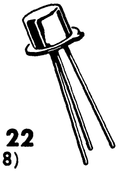
MAXIMUM RATINGS

Rating	Symbol	2N2490	2N2491	2N2492	2N2493	Unit
Collector-Base Voltage	V_{CB}	70	60	80	100	Volts
Collector-Emitter Voltage	V_{CES}	60	50	70	85	Volts
Emitter-Base Voltage	V_{EB}	40	30	60	80	Volts
Collector Current	I_C	15				Amp
Power Dissipation at $T_C = 25^oC$	P_D	170				Watts
Junction Temperature Range	T_J	-65 to +110				^oC

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -2 Vdc)		I_{CBO}	—	0.2	mAdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N2490		—	3.0	
(V_{EB} = -30 Vdc)	2N2491		—	3.0	
(V_{EB} = -60 Vdc)	2N2492		—	2.0	
(V_{EB} = -80 Vdc)	2N2493		—	3.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = -70 Vdc, V_{BE} = 1.5 Vdc)	2N2490		—	3.0	
(V_{CE} = -60 Vdc, V_{BE} = 1.5 Vdc)	2N2491		—	3.0	
(V_{CE} = -80 Vdc, V_{BE} = 1.5 Vdc)	2N2492		—	2.0	
(V_{CE} = -100 Vdc, V_{BE} = 1.5 Vdc)	2N2493		—	3.0	
(V_{CE} = -35 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2490,2N2491		—	35	
(V_{CE} = -40 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2492		—	35	
(V_{CE} = -50 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2493		—	35	
Collector-Emitter Breakdown Voltage (I_C = 1 A, I_B = 0)	2N2490	V_{CEO}	50	—	Volts
	2N2491		40	—	
	2N2492		65	—	
	2N2493		75	—	
Base-Emitter Voltage (I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490,2N2491	V_{BE}	—	0.9	Vdc
	2N2492,2N2493		—	0.8	
(I_C = 12 Adc, V_{CE} = -2 Vdc)			—	1.5	
Collector-Emitter Saturation Voltage (I_C = 12 Adc, I_B = 2 Adc)	2N2490, 2N2491	$V_{CE(sat)}$	—	0.7	Vdc
	2N2492, 2N2493		—	0.5	
DC Current Gain (I_C = 1 Adc, V_{CE} = -2 Vdc)	2N2490	h_{FE}	45	—	—
	2N2491		65	—	
	2N2492, 2N2493		50	—	
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490		20	40	
	2N2491		35	70	
	2N2492, 2N2493		25	50	
(I_C = 5 Adc, V_{CE} = -2 Vdc, T_A = -65°C)	2N2490		15	—	
	2N2491		25	—	
	2N2492, 2N2493		20	—	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N2490		8	—	
	2N2491		12	—	
	2N2492, 2N2493		10		
Common Emitter Cutoff Frequency (I_C = 5A, V_{CE} = -6 V)		$f_{\alpha e}$	5.0	—	kHz
Turn-On Time (I_C = 5 A, $I_{B1} = I_{B2}$ = 0.5 A)		t_{on}	—	25	μs
Turn-Off Time (I_C = 5 A, $I_{B1} = I_{B2}$ = 0.5 A)		t_{off}	—	15	μs

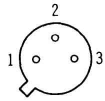
2N2501 (SILICON)



CASE 22
(TO-18)

Collector connected to case

NPN silicon annular transistor for high-speed switching applications.



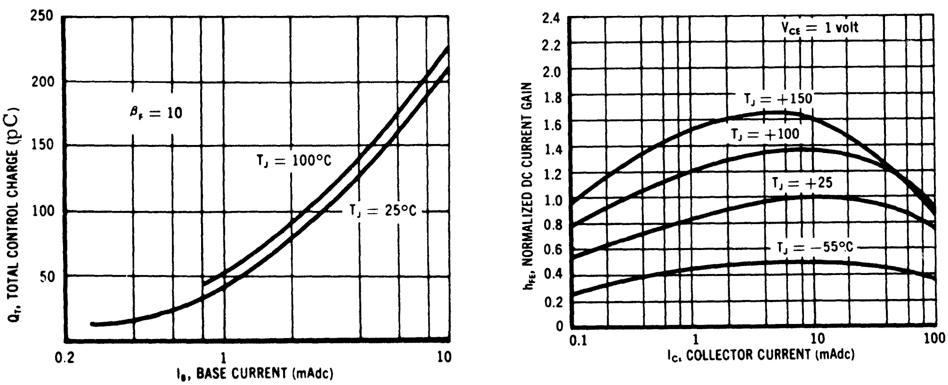
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watts
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts

* Indicates JEDEC Registered Data

TOTAL CONTROL CHARGE **NORMALIZED CURRENT GAIN CHARACTERISTICS**



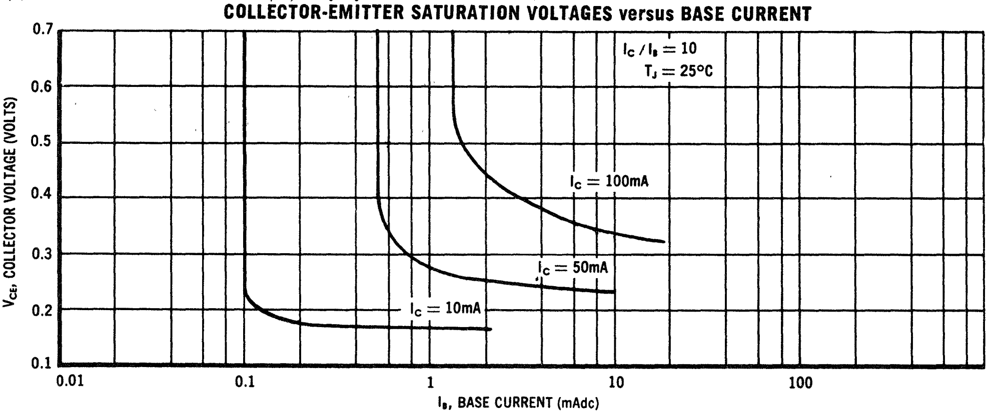
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0, Pulsed)	BV_{CEO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	–	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)	I_{CEX}	–	25	nAdc
Base Leakage Current	I_{BL}			
(V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)		–	0.025	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 3 Vdc, T_A = 150°C)		–	50	μAdc
DC Forward Current Transfer Ratio (1)	h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 1 Vdc)		20	–	
(I_C = 1 mAdc, V_{CE} = 1 Vdc)		30	–	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)		50	150	
(I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C)		20	–	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)		40	–	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)		30	–	
(I_C = 500 mAdc, V_{CE} = 5 Vdc)		10	–	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		–	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)		–	0.3	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.4	
Base-Emitter Saturation Voltage (1)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		–	0.85	
(I_C = 50 mAdc, I_B = 5 mAdc)		–	1.0	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	1.2	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	7.0	pF
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	h_{fe}	3.5	–	–
Current-Gain-Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 MHz)	f_T	350	–	MHz
Charge Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_S	–	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	Q_T	–	60	pC
Active Region Time Constant (I_C = 10 mAdc)	τ_A	–	2.5	ns

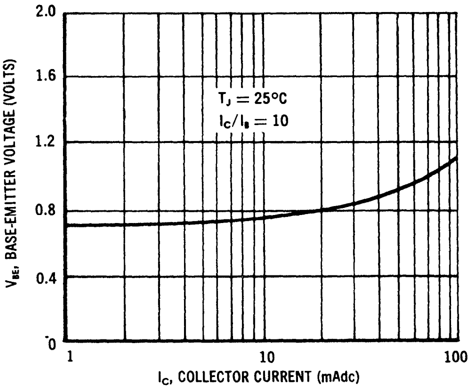
* Indicates JEDEC Registered

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

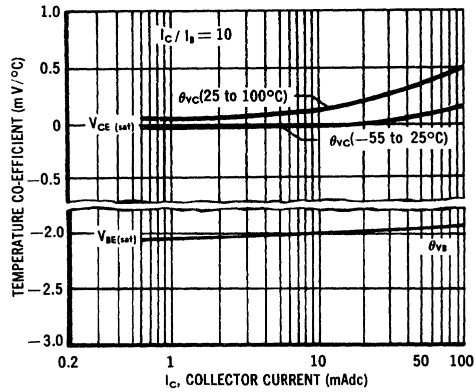
COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT



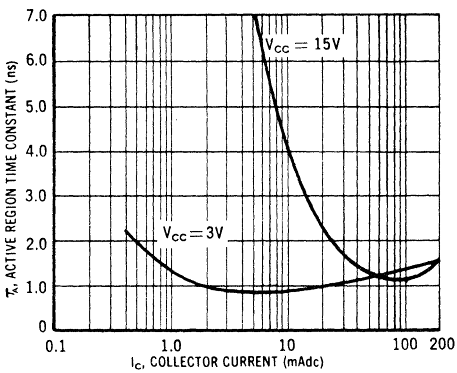
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



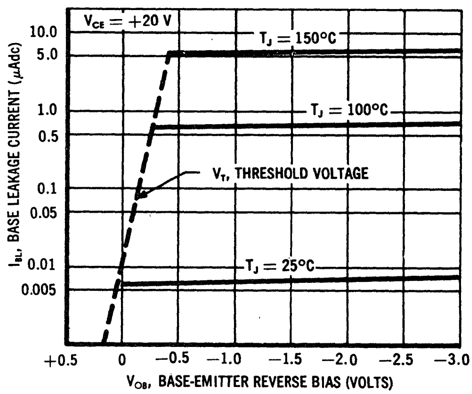
TEMPERATURE COEFFICIENTS



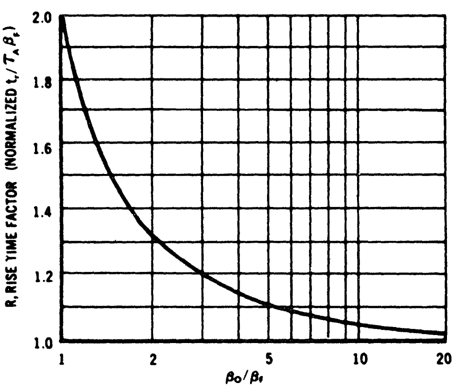
ACTIVE REGION TIME CONSTANT



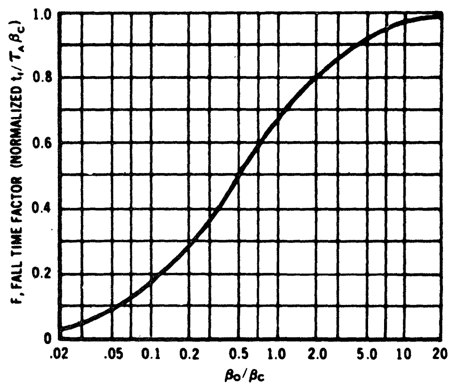
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR

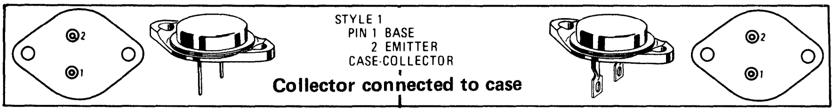


FALL TIME FACTOR



2N2526 (GERMANIUM) 2N2527 2N2528

PNIP germanium power transistors for high-voltage power switching applications.



CASE 11A — For units with solder lugs attached, specify devices MP2526 etc. (Case 4-04) — CASE 4-04

MAXIMUM RATINGS

Rating	Symbol	2N2526	2N2527	2N2528	Unit
Collector-Emitter Voltage	V_{CE}	80	120	160	Vdc
Collector-Base	V_{CB}	80	120	160	Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current - Continuous	I_C	10			Adc
Base Current	I_B	5.0			Adc
Emitter Reverse Current (Surge 60 Hz Recurrent)	I_E	1.5			Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

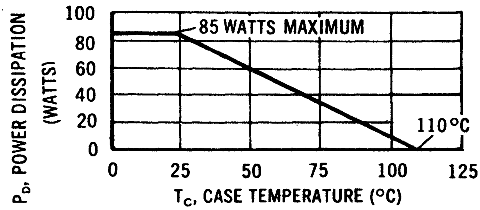
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

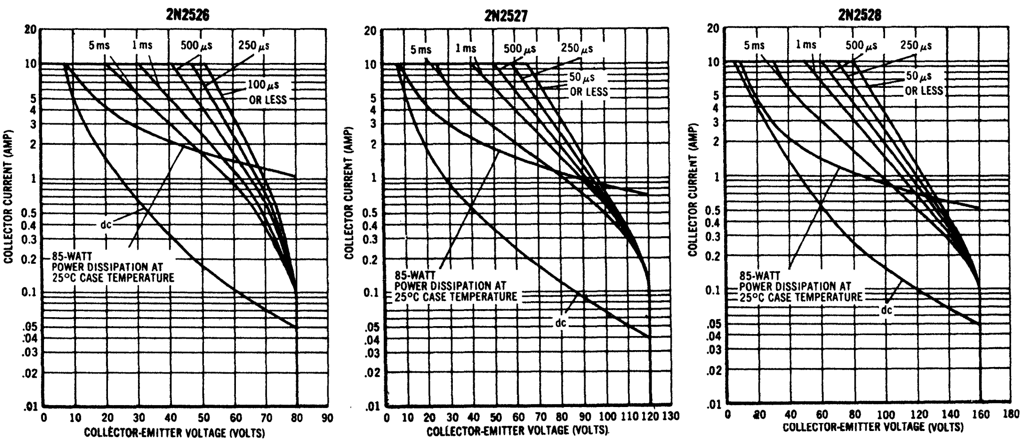
POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110° - T_C}{1.0} \text{ Watts}$$



SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

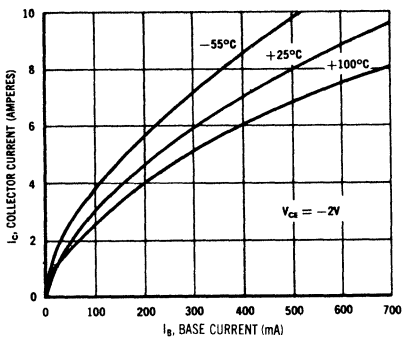
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N2526	$BV_{CEO(sus)}$*	80	-	-	Volts
	2N2527		120	-	-	
	2N2528		160	-	-	
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)		BV_{EBO}	5.0	-	-	Vdc
Collector Cutoff Current*		I_{CEX} *				mAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2526		-	-	35	
(V_{CE} = 120 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2527		-	-	35	
(V_{CE} = 160 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = 100°C)	2N2528		-	-	35	
Collector-Emitter Cutoff Current		I_{CER}				mAdc
(V_{CE} = 80 Vdc, R_{BE} = 100 ohms)	2N2526		-	-	25	
(V_{CE} = 120 Vdc, R_{BE} = 100 ohms)	2N2527		-	-	25	
(V_{CE} = 160 Vdc, R_{BE} = 100 ohms)	2N2528		-	-	25	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N2526		-	-	3.0	
(V_{CB} = 120 Vdc, I_E = 0)	2N2527		-	-	3.0	
(V_{CB} = 160 Vdc, I_E = 0)	2N2528		-	-	3.0	
(V_{CB} = 2.0 Vdc, I_E = 0)			-	-	150	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	20	-	50	-
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		g_{FE}	4.0	6.0	-	mhos
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$	-	0.5	0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$	-	0.8	1.2	Vdc
DYNAMIC CHARACTERISTICS						
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 30 kHz)		h_{fe}	10	15	-	-
Rise Time		t_r	-	5.5	-	μs
Storage Time		t_s	-	1.2	-	μs
Fall Time		t_f	-	2.0	-	μs

*To avoid excessive heating of collector junction, perform this test with a sweep method.

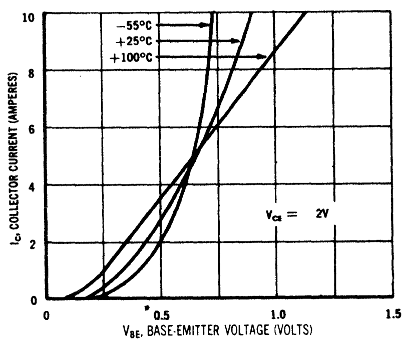
TYPICAL INPUT CHARACTERISTICS

ALL TYPES

COLLECTOR CURRENT versus BASE CURRENT

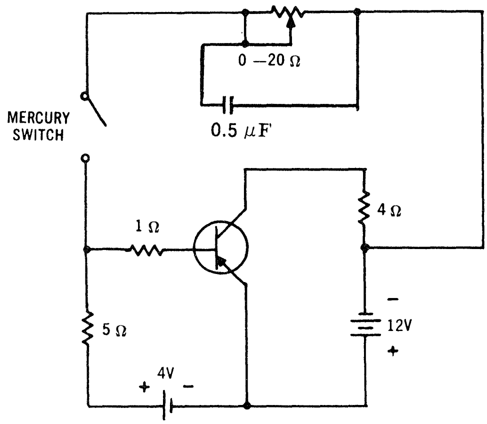


COLLECTOR CURRENT versus DRIVE VOLTAGE

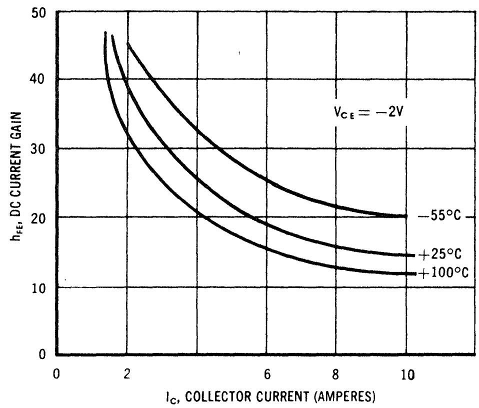


SWITCHING TEST CIRCUIT

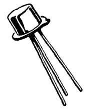
PULSE CONDITIONS ; $I_C = 3$ Adc, $I_B = 300$ mAdc



DC CURRENT GAIN versus COLLECTOR CURRENT



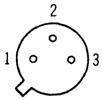
2N2539, 2N2540 (SILICON)



NPN silicon annular transistors for high-speed switching.

CASE 22
(TO-18)

2N2539
2N2540



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

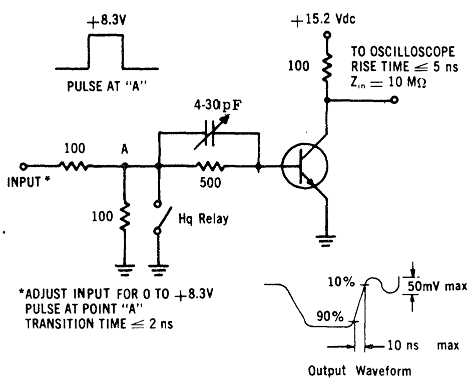
Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	1.8 10.3	Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	0.5 2.86	Watts mW/°C
Junction Temperature	T_J	-65 to +200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C

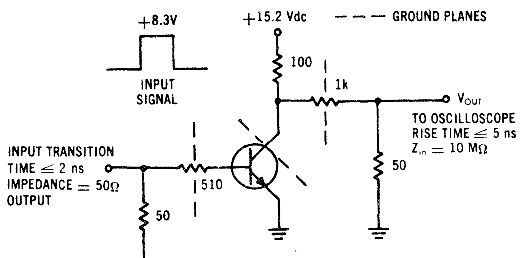
* Indicates JEDEC Registered Data

TOTAL CONTROL CHARGE TEST CIRCUIT



*ADJUST INPUT FOR 0 TO +8.3V
PULSE AT POINT "A"
TRANSITION TIME ≤ 2 ns

ACTIVE REGION TIME CONSTANT TEST CIRCUIT



$T_A = T_{RE} = T_{FE}$

$T_{RE} = \frac{I_{B1}}{I_{CS}} t_r$

$t_r = T_A \beta_F R$ = 10 to 90% Rise Time
$t_f = T_A \beta_C F$ = 10 to 90% Fall Time

$R = \frac{\beta_O}{\beta_F} \ln\left(\frac{\beta_O}{\beta_O - 0.9\beta_F}\right)$

$F = \frac{\beta_O}{\beta_C} \ln\left(1 + \frac{\beta_O}{\beta_C}\right)$

$\beta_O = h_{FE}$ at Edge of Saturation
$\beta_C = I_C$ in Saturation / I_{B2} (Base "OFF" Current)
$\beta_F = I_C$ in Saturation / I_{B1} (Base "ON" Current)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	— —	0.250 200	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)		I_{EBO}	—	0.05	μAdc
Collector Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc)		I_{CEX}	—	0.250	μAdc
Base Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc) (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc, T_A = 150°C)		I_{BL}	— —	0.250 200	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, I_B = 0)		BV_{CEO}	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, R_{BE} ≦ 10 Ω)		BV_{CER}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage * (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	— —	0.45 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc) (1) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	— —	1.3 2.6	Vdc
DC Forward Current Transfer Ratio		h_{FE}			—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	2N2539 2N2540		20 35	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2539 2N2540		30 50	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)	2N2539 2N2540		50 100	150 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (1)	2N2539 2N2540		20 30	— —	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	25	pF
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		h_{fe}	2.5	—	—

(1) Pulse Test: Pulse width ≦ 300 μs, duty cycle ≦ 2%
* Indicates JEDEC Registered Data

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Total Control Charge	Q_T	750	pC
Storage Time (I_C = I_{B1} = I_{B2} = 20 mAdc, V_{CC} = 5 V)	τ_S	20	ns
Active Region Time Constant	τ_A	2.0	ns
Turn-on Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{on}	40	ns
Turn-off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{off}	40	ns

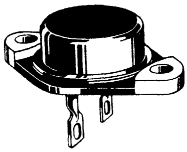
2N2552 thru 2N2559

For Specifications, See 2N1038 Data.

2N2560 thru 2N2567

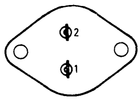
For Specifications, See 2N1042 Data.

2N2573 thru 2N2579 (SILICON)



Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance.

CASE 61 (TO-41) **CASE 54** (TO-3 Modified)



STYLE 1.
PIN 1. GATE
2. CATHODE
CASE: ANODE

For units with pins (TO-3 Modified) specify devices MCR649AP-1(2N2573) thru MCR649AP-7(2N2579).

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage*	$V_{RSM(rep)}$*		Volts
2N2573		25	
2N2574		50	
2N2575		100	
2N2576		200	
2N2577		300	
2N2578		400	
2N2579		500	
Forward Current RMS (all conduction angles)	$I_{T(RMS)}$	25	Amp
Circuit Fusing Considerations (T_J = -65° to +125°C, t ≦ 8.3 ms)	I^2t	275	A^2s
Peak Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	I_{TSM}	260	Amp
Peak Gate Power - Forward	P_{GM}	5.0	Watts
Average Gate Power - Forward	$P_{G(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GM}	2.0	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{RSM} for all types can be applied on a continuous dc basis without incurring damage.

V_{RSM} Ratings apply for zero or negative gate voltage.

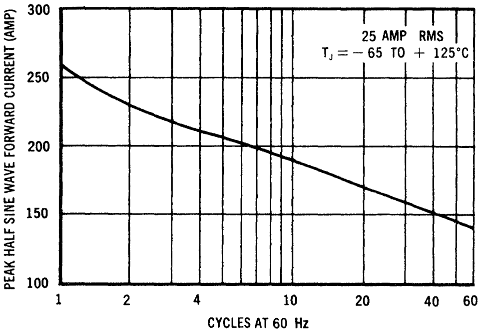
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C)	V_{DRM}*				Volts
2N2573		25	—	—	
2N2574		50	—	—	
2N2575		100	—	—	
2N2576		200	—	—	
2N2577		300	—	—	
2N2578		400	—	—	
2N2579		500	—	—	
Peak Forward Blocking Current (Rated V_{DRM} with gate open, T_J = 125°C)	I_{DRM}	—	0.6	5.0	mA
Peak Reverse Blocking Current (Rated V_{RSM}, T_J = 125°C)	I_{RRM}	—	0.6	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)	I_{GT}	—	20	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)	V_{GT}	—	1.0	3.5	Volts
(V_{DRM} = Rated R_L = 100Ω, T_J = 125°C)	V_{GNT}	0.3	—	3.5	
Forward On Voltage (I_T = 20 Adc)	V_T	—	1.1	1.4	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_H	—	20	—	mA
Turn-On Time (t_d + t_r) (I_{GT}= 50 mA, I_T = 10A)	t_{gt}	—	1.0	—	μs
Turn-Off Time (I_T = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 125°C) (V_{DRM} = rated voltage)	t_q	—	30	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)	dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	°C/W

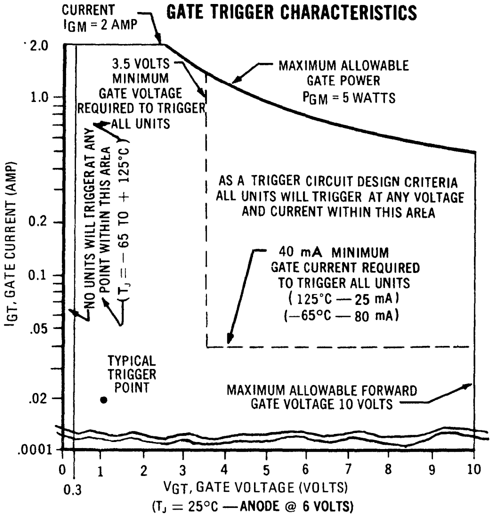
*V_{DRM} for all types can be applied on a continuous dc basis without incurring damage.

V_{DRM} ratings apply for zero or negative gate voltage.

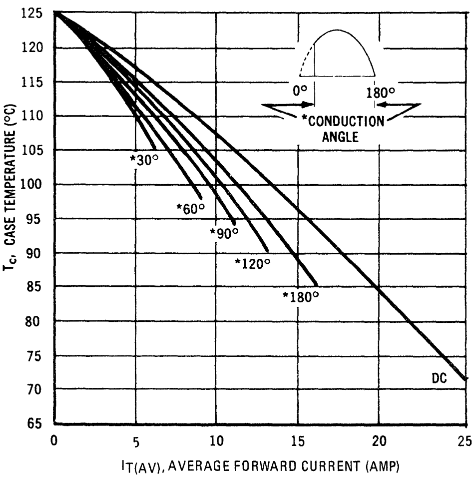
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



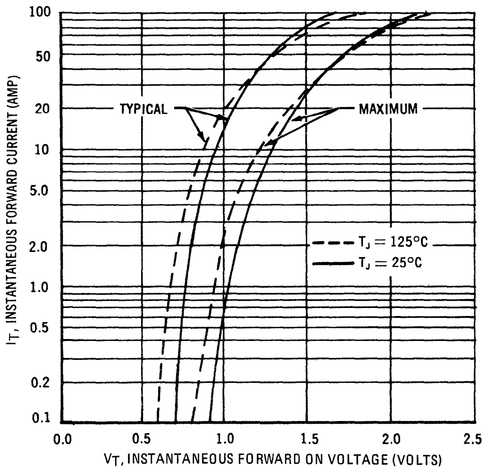
GATE TRIGGER CHARACTERISTICS



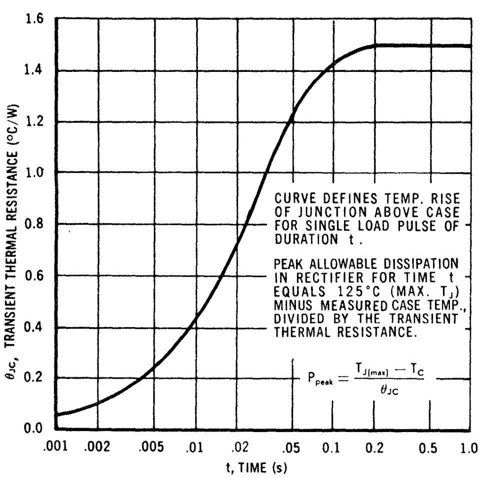
MAXIMUM ALLOWABLE CASE TEMPERATURE



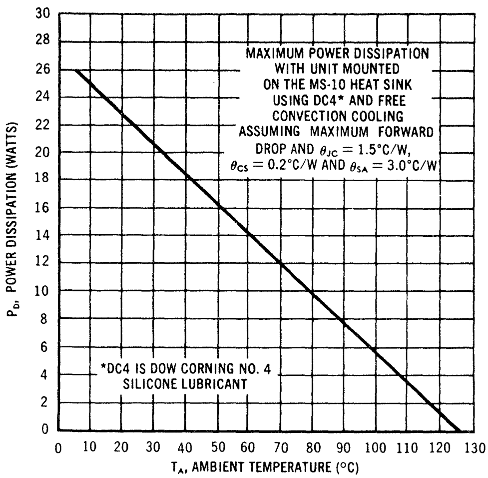
LOW CURRENT LEVEL



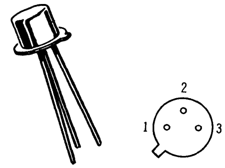
MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE



2N2635 (Ge Mesa)



CASE 22-03
(TO-18)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

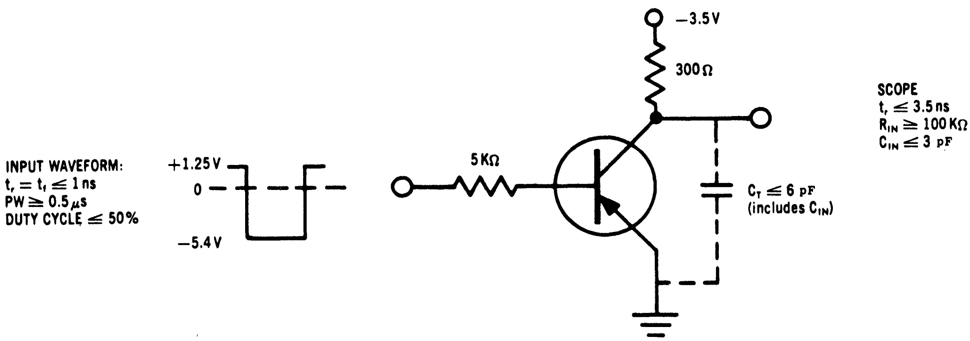
PNP germanium mesa transistor for high-speed switching applications.

* MAXIMUM RATINGS ($T_A = 25^oC$ unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	+100	^oC
Storage Temperature	T_{stg}	-65 to +100	^oC
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	150 2.0	mW mW/^oC

*Indicates JEDEC Registered Data

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	BV_{CEO}	15	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	---	Vdc
Collector-Base Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 25V, I_E = 0)		---	5.0	
(V_{CB} = 25V, I_E = 0, T_A = +55°C)		---	20	
Emitter-Base Cutoff Current (V_{EB} = 1V, I_C = 0)	I_{EBO}	---	20	μAdc
Static Forward Current Transfer Ratio	h_{FE}			---
(I_C = 10 mA, V_{CE} = 0.5V)		30	---	
(I_C = 50 mA, V_{CE} = 1V)		45	300	
(I_C = 50 mA, V_{CE} = 1V, T_A = -55°C)		25	---	
(I_C = 100 mA, V_{CE} = 1V)		30	---	
Base-Emitter Voltage	V_{BE}			Vdc
(I_C = 10 mA, I_B = 0.5 mA)		---	0.45	
(I_C = 50 mA, I_B = 2.5 mA)		---	0.70	
(I_C = 50 mA, I_B = 2.5 mA, T_A = -55°C)		---	0.85	
(I_C = 100 mA, I_B = 10 mA)		---	0.90	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mA, I_B = 0.5 mA)		---	0.20	
(I_C = 50 mA, I_B = 2.5 mA)		---	0.40	
(I_C = 50 mA, I_B = 2.5 mA, T_A = +55°C)		---	0.45	
(I_C = 100 mA, I_B = 10 mA)		---	0.75	
Small-Signal Forward Current Transfer Ratio (I_C = 30 mA, V_{CE} = 2V, f = 100 MHz)	$\|h_{fe}\|$	1.5	---	---
Collector Output Capacitance (V_{CB} = 5 V, I_E = 0, f = 1 MHz)	C_{ob}	---	5.0	pF
Input Capacitance (V_{BE} = 1V, I_C = 0, f = 1 MHz)	C_{ib}	---	4.0	pF
Delay Time (Figure 1)	t_d	---	20	ns
Rise Time (Figure 1)	t_r	---	30	ns
Storage Time (Figure 1)	t_s	---	185	ns
Fall Time (Figure 1)	t_f	---	65	ns

*Indicates JEDEC Registered Data

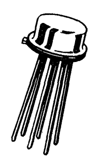
2N2639 thru 2N2644 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified — 10 μAdc to 1.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 40 MHz (Max) @ I_C = 1.0 mAdc
- 2N2639JAN,JTX,JTXV and 2N2642JAN,JTX,JTXV Available

NPN SILICON MULTIPLE TRANSISTORS

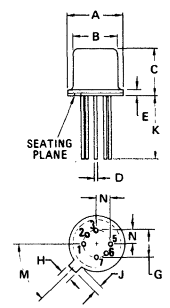


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.72	600 3.43	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	600 3.43	1200 6.87	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

*ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$	45	—	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 5 Vdc, I_B = 0)		I_{CEO}	—	0.010	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)			—	10	
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641	h_{FE}	50	300	—
	2N2642, 2N2643, 2N2644		100	300	
(I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N2639, 2N2640, 2N2641		10	—	
	2N2642, 2N2643, 2N2644		20	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641		55	—	
	2N2642, 2N2643, 2N2644		110	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2639, 2N2640, 2N2641		65	—	
	2N2642, 2N2643, 2N2644		130	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{BE(sat)}$	0.6	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	40	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	8.0	pF
Input Impedance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{ib}	25	32	k ohms
Reverse Voltage Transfer Ratio (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{rb}	—	600	$X 10^{-6}$
Small-Signal Current Gain (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)	2N2639, 2N2640, 2N2641	h_{fe}	65	600	—
	2N2642, 2N2643, 2N2644		130	600	
Output Admittance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kHz)		h_{ob}	—	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CB} = 5 Vdc, R_S = 10k ohms, Bandwidth = 10 Hz to 15 kHz)		NF	—	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2) (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2642	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N2640, 2N2643		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2639, 2N2642	$\|V_{BE1} - V_{BE2}\|$	—	5.0	mVdc
	2N2640, 2N2643		—	10	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C)	2N2639, 2N2642	$\frac{\Delta\|V_{BE1} - V_{BE2}\|}{\Delta T_A}$	—	10	μV/°C
	2N2640, 2N2643		—	20	

* Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%
(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

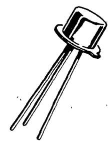
2N2646 (SILICON)
2N2647

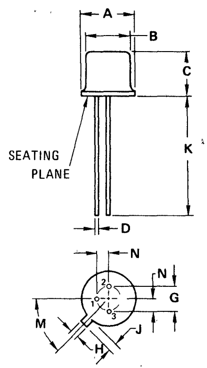
SILICON ANNULAR PN UNIJUNCTION TRANSISTORS

. . . designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits. These devices feature:

- Low Peak Point Current – 2.0 μA (Max)
- Low Emitter Reverse Current – 200 nA (Max)
- Passivated Surface for Reliability and Uniformity

PN UNIJUNCTION TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 TYP		0.100 TYP	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° TYP		45° TYP	
N	1.27 TYP		0.050 TYP	

CASE 22A

***MAXIMUM RATINGS** (T_A = 25°C unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Dissipation (1)	P_D	300	mW
RMS Emitter Current	$I_{E(RMS)}$	50	mA
Peak Pulse Emitter Current (2)	i_E	2.0	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Indicates JEDEC Registered Data.
(1) Derate 3.0 mW/°C increase in ambient temperature. The total power dissipation (available power to Emitter and Base-Two) must be limited by the external circuitry.
(2) Capacitor discharge – 10 μF or less, 30 volts or less.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) (Note 1)	2N2646 2N2647	η	0.56 0.68	– –	0.75 0.82	–
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		r_{BB}	4.7	7.0	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -55°C to +125°C)		$\alpha_{r_{BB}}$	0.1	–	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) (Note 2)		$V_{EB1(sat)}$	–	3.5	–	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	–	15	–	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	2N2646 2N2647	I_{EB2O}	– –	0.005 0.005	12 0.2	μA
Peak Point Emitter Current (V_{B2B1} = 25 V)	2N2646 2N2647	I_P	– –	1.0 1.0	5.0 2.0	μA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) (Note 2)	2N2646 2N2647	I_V	4.0 8.0	6.0 10	– 18	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	2N2646 2N2647	V_{OB1}	3.0 6.0	5.0 7.0	– –	Volts

*Indicates JEDEC Registered Data.

Notes:

(1) Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_F}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
V_F = Emitter to Base-One Junction Diode Drop ($\approx$0.5 V @ 10 μA)

(2) Use pulse techniques: PW $\approx$ 300 μs, duty cycle $\leqslant$ 2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

(3) Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1
UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

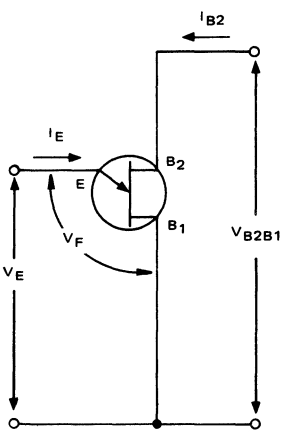


FIGURE 2
STATIC EMITTER CHARACTERISTIC CURVES
(Exaggerated to Show Details)

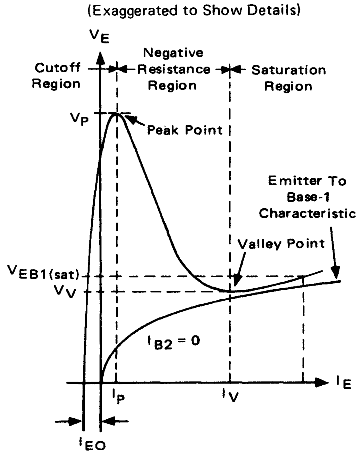
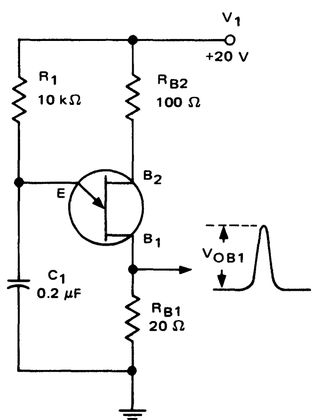


FIGURE 3 – V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)



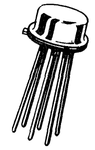
2N2652 (SILICON)
2N2652A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices
  $\Delta|V_{BE1} - V_{BE2}| = 10\ \mu$Vdc (Max) @ -55 to +25°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.2 Vdc (Max) @ I_C = 50 mAdc
- DC Current Gain Specified — 100 μAdc to 1.0 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 60 MHz @ I_C = 50 mAdc

NPN SILICON MULTIPLE TRANSISTORS

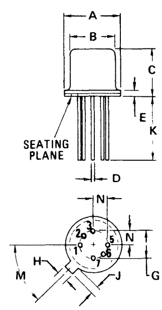


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	100		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	0.6 3.43	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 5.7	2.0 11.4	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0 335
C	3.81	4 70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0 71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

*ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 20 mAdc, I_B = 0)		BV_{CEO}	60	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	100	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N2652 2N2652A	I_{CBO}	- -	0.010 0.002	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N2652 2N2652A		- -	15 10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2652 2N2652A	I_{EBO}	- -	0.010 0.002	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		h_{FE}	35	-	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			50	200	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)			15	-	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	-	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0, 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	-	85	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{ie}	1.0	10.5	k ohms
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	20	35	ohms
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{fe}	50	300	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		h_{oe}	-	50	μmhos
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 510 ohms, B. W. = 1.0 Hz, f = 1.0 kHz)		NF		8.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2652 2N2652A	h_{FE1}/h_{FE2}	0.85 0.9	1.0 1.0	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2652 2N2652A		0.85 0.9	1.0 1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$\lvert V_{BE1}-V_{BE2}\rvert$	-	3.0	mVdc
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)			-	3.0	
Base -Emitter Voltage Differential Gradient (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +125°C)		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$	-	10	μV/°C

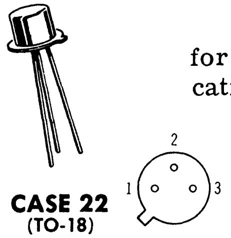
* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) The lowest of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

2N2710 (SILICON)

NPN silicon transistor primarily designed for high-speed, low-power saturated switching applications for industrial service.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

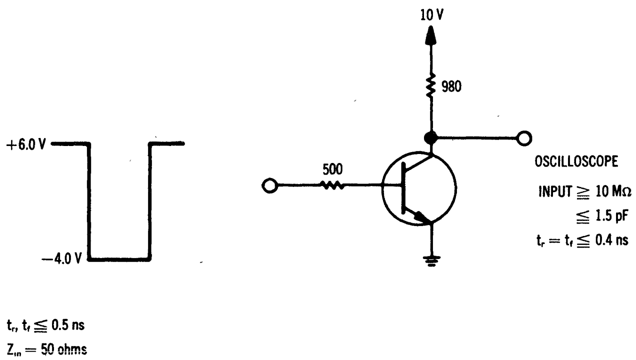
Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current-Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.1	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	W mW/°C
Operating Junction Temperature Range	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT

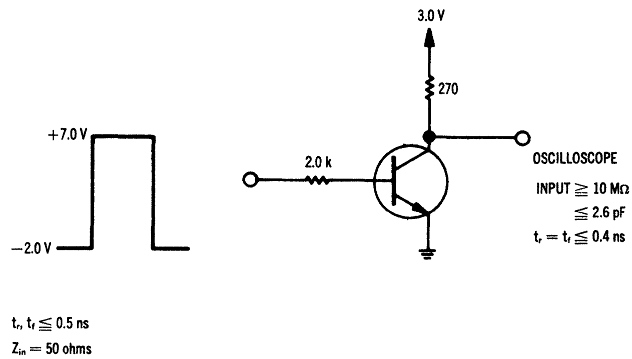


*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector-Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 VDC, I_E = 0, T_A = +150°C)	I_{CBO}	- -	0.03 30	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	40 40	- -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	- -	0.25 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	- -	0.9 1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	500	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4.0 MHz)	C_{ob}	-	4.0	pF
Turn-On Time (Figure 2) (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc)	t_{on}	-	20	ns
Turn-Off Time (Figure 2) (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = 1.0 mAdc)	t_{off}	-	35	ns
Charge-Storage Time (Figure 1) (V_{CC} = 10 Vdc, I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	-	15	ns

*Indicates JEDEC Registered Data

FIGURE 2 — TURN ON AND TURN OFF TIME TEST CIRCUIT



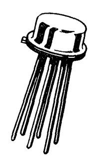
2N2720 (SILICON)
2N2721

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N2721
  $\Delta|V_{BE1} - V_{BE2}|$ = 1.6 mVdc (Max) @ -55 to +25°C
  = 2.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified — 100 μAdc to 10 mAdc
- High Current-Gain — Bandwidth Product —
  f_T = 80 MHz @ I_C = 10 mAdc

NPN SILICON
MULTIPLE TRANSISTORS

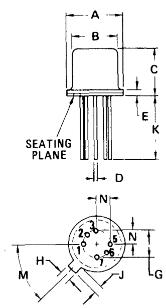


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	80		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.71	0.6 3.4	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

STYLE 1.
PIN 1. COLLECTOR
2 BASE
3 EMITTER
4 OMITTED
5. EMITTER
6 BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 51	9 40	0.335	0.370
B	7 75	8 51	0.305	0 335
C	3.81	4.70	0 150	0.185
D	0.41	0 53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0 71	0.86	0 028	0.034
J	0 74	1 14	0 029	0.045
K	12 70	—	0 500	—
M	45° BSC		45° BSC	
N	2 54 BSC		0 100 BSC	

CASE 654-07

*ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	-	10	nAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	I_{CBO}	-	0.01	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	h_{FE}	30	120	-
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		35	-	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)		42	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	80	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	500	$X\ 10^{-6}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	30	200	-
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	1.0	μmhos
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2720	h_{FE1}/h_{FE2}	0.9	1.0	-
2N2721		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N2720	$\|V_{BE1}-V_{BE2}\|$	-	5.0	mVdc
2N2721		-	10	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C) 2N2720	$\Delta(V_{BE1}-V_{BE2})$	-	0.8	mV
2N2721		-	1.6	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C) 2N2720		-	1.0	
2N2721		-	2.0	

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

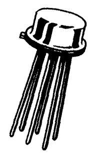
2N2722 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

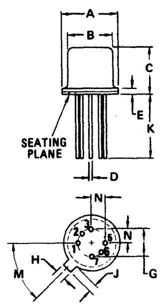
. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices –
  $\Delta|V_{BE1} - V_{BE2}|$ = 0.8 mVdc (Max) @ -55 to +25°C
  = 1.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified – 1.0 μAdc to 0.1 mAdc
- High Current-Gain – Bandwidth Product –
  f_T = 100 MHz @ I_C = 10 mAdc

NPN SILICON MULTIPLE TRANSISTORS



STYLE 1.
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0 370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	40		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.7	0.6 3.4	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.6 3.4	1.2 6.8	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

*** ELECTRICAL CHARACTERISTICS** (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	45	-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)	I_{CEO}	-	2.0	nAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.001 1.0	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	-	1.0	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) (I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	50 100 125	250 - -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.65	0.85	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	-	6.0	pF
Input Impedance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	32	ohms
Voltage Feedback Ratio (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	600	X 10^{-6}
Small-Signal Current Gain (I_E = 0.1 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	100	700	-
Output Admittance (I_E = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz)	NF	-	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (2) (I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.9	1.0	-
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	$\|V_{BE1} - V_{BE2}\|$	-	5.0	mVdc
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	$\Delta(V_{BE1} - V_{BE2})$	- -	0.8 1.0	mVdc

*** Indicates JEDEC Registered Data**

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

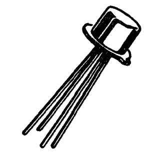
(2) The lower of the two h_{FE} readings is taken as h_{FE1} for the purpose of measurement.

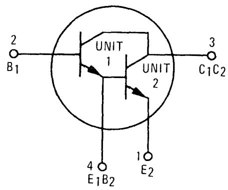
NPN SILICON ANNULAR DARLINGTON TRANSISTORS

. . . containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

- High DC Current Gain —
  h_{FE} = 2,000 (Min) @ I_C = 10 mAdc
- Low Noise —
  NF = 10 dB @ I_C = 50 μAdc
- Low Leakage —
  I_{CB10} = 0.01 μAdc(Max) @ V_{CB1} = 60 Vdc
  I_{E2B10} = 10 nAdc(Max) @ V_{B1E2} = 10 Vdc

NPN SILICON DARLINGTON TRANSISTORS



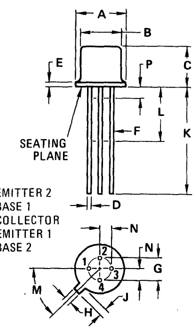


The input unit is identified as Unit 1 regardless of terminal numbering.

***MAXIMUM RATINGS** (Numerical subscripts refer to unit number.)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2O}	60	Vdc
Collector-Base Voltage	V_{CB1}	80	Vdc
Emitter-Base Voltage	V_{E2B1}	12	Vdc
Collector Current — Continuous	I_C	40	Adc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 2.9	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10.5	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



STYLE 8
PIN 1. EMITTER 2
2 BASE 1
3 COLLECTOR
4. EMITTER 1
BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

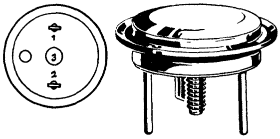
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_{B1} = 0)	BV_{CE2O}	60	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_{E2} = 0)	BV_{CB1O}	80	-	Vdc
Emitter-Base Breakdown Voltage (I_{E2} = 10 μAdc, I_C = 0)	BV_{E2B1O}	12	-	Vdc
Collector Cutoff Current (V_{CB1} = 60 Vdc, I_E = 0)	I_{CB1O}	-	0.01	μAdc
(V_{CB1} = 60 Vdc, I_E = 0, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{B1E2} = 10 Vdc, I_C = 0)	I_{E2B1O}	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, I_{B2} = 0)	h_{FE}	2000	10,000	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	$V_{CE2(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	$V_{BE2(sat)}$	-	1.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (Each Unit) (I_C = 10 mAdc, V_{CE1} or V_{CE2} = 10 Vdc, f = 20 MHz)	$\|h_{fe}\|$	5.0	-	-
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 140 kHz)	C_{ob1}	-	10	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz) 2N2723	h_{fe}	1500	15,000	-
Noise Figure (Input Stage Only) (I_C = 50 μAdc, V_{CE} = 5.0 Vdc, R_S = 3.0 k ohms, f = 1.0 kHz, BW = 100 kHz)	NF	-	10	dB

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤12 ms, Duty Cycle ≤2.0 %.

2N2728 (GERMANIUM)



CASE 7
(TO-68)

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

Collector connected to case

PNP germanium high-current power transistors especially designed for switching and power converter circuit operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells, and 1.5-volt batteries.

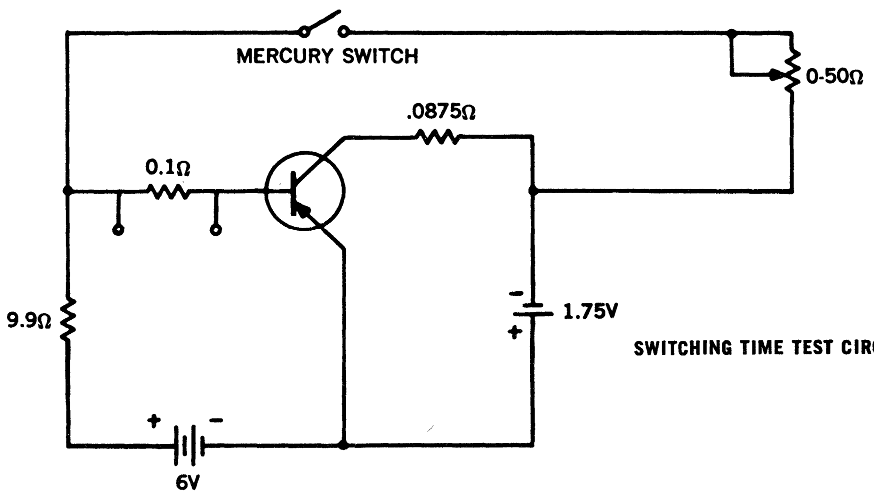
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (continuous)	I_C	50	Adc
Base Current (continuous)	I_B	10	Adc
Total Device Dissipation @ 25°C Case Temperature	P_D	170	Watts
Operating Temperature	T_J	+110	°C
Storage Temperature	T_{stg}	-65 to +110	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.5	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CE} = 15 V, V_{BE} = 1 V V_{CE} = 10 V, V_{BE} = 1 V, T_C = 100°C	I_{CEX}	- -	- -	10 35	mAdc
Emitter-Base Cutoff Current V_{EB} = 15 V	I_{EBO}	-	-	10	mAdc
Emitter Floating Potential V_{CB} = 15 V, I_E = 0	V_{EBF}	-	-	0.5	Vdc
Collector-Emitter Breakdown Voltage* I_C = 500 mA, I_B = 0	BV_{CEO}	5.0	10	-	V
DC Current Transfer Ratio I_C = 20 A, V_{CE} = 2 V	h_{FE}	40	-	130	-
Collector-Emitter Saturation Voltage I_C = 50 A, I_B = 5 A	$V_{CE(sat)}$	-	0.075	0.1	Vdc
Base-Emitter Voltage I_C = 50 A, I_B = 5 A	$V_{BE(sat)}$	-	0.85	1.0	Vdc
Common Emitter Cutoff Frequency I_C = 20 A, V_{CE} = 2 V	$f_{\alpha e}$	3.0	4.5	-	kHz
Rise Time I_C = 20 A, V_{CC} = 1.75 V, $I_{B(on)}$ = 2 A	t_r	-	18	25	µs
Storage Time V_{BE} = 6 V, R_{be} = 10 Ω	t_s	-	15	20	µs
Fall Time V_{BE} = 6 V, R_{be} = 10 Ω	t_f	-	10	15	µs

* To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.



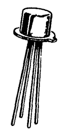
SWITCHING TIME TEST CIRCUIT

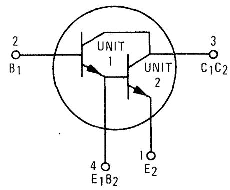
NPN SILICON ANNULAR DARLINGTON TRANSISTOR

. . . containing two NPN silicon annular transistors in a darlington connection, and designed for applications requiring:

- High DC Current Gain —
  h_{FE} = 2,000 (Min) @ I_C = 100 mAdc
- Guaranteed DC Current Gain from 1.0 mA to 100 mAdc
- Low Leakage —
  I_{CB1O} = 0.05 μAdc (Max) @ V_{CB1} = 30 Vdc
  I_{E2B1O} = 20 nAdc (Max) @ V_{E2B1} = 5.0 Vdc

NPN SILICON DARLINGTON TRANSISTOR



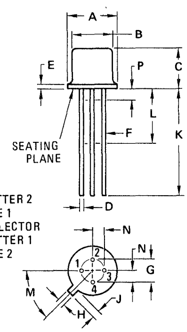


The input unit is identified as Unit 1 regardless of terminal numbering

***MAXIMUM RATINGS** (Numerical subscripts refer to unit number.)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (Base 1 and Base 2 open)	V_{CE2}	40	Vdc
Collector-Base Voltage	V_{CB1}	60	Vdc
Emitter-Base Voltage (Pin 4 to Pin 2)	V_{E2B1}	15 7.5	Vdc
**Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 3.33	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.



STYLE 8
PIN 1. EMITTER 2
2. BASE 1
3. COLLECTOR
4. EMITTER 1
BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 20 mAdc, I_{B1} = 0)	BV_{CE2O}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_{E2} = 0)	BV_{CB1O}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_{E2} = 100 μAdc, I_C = 0)	BV_{E2B1O}	15	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0)	I_{CEO}	-	500	nAdc
Collector Cutoff Current (V_{CB1} = 30 Vdc, I_E = 0)	I_{CB1O}	-	0.05	μAdc
(V_{CB1} = 30 Vdc, I_E = 0, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{E2B1} = 5.0 Vdc, I_C = 0)	I_{E2B1O}	-	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE2} = 4.0 Vdc)	h_{FE}	600	-	-
(I_C = 10 mAdc, V_{CE2} = 5.0 Vdc)		1200	-	
(I_C = 100 mAdc, V_{CE2} = 5.0 Vdc)		2000	20,000	
Collector-Emitter Saturation Voltage (I_C = 15 mAdc, I_{B1} = 3.0 mAdc)	$V_{CE2(sat)}$	-	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Current-Gain— High Frequency (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 10 MHz)	$\|h_{fe}\|$	1.0	-	-
Output Capacitance (V_{CB1} = 10 Vdc, I_{E2} = 0, f = 1.0 MHz)	C_{ob1}	-	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB1} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	30	80	Ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	10	x 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE2} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	600	-	-
Output Admittance (I_C = 1.0 mAdc, V_{CB1} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.5	μmhos

*** Indicates JEDEC Registered Data**

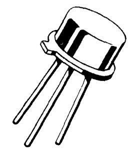
(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

NPN SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose amplifiers and switching applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 35 Vdc (Min) @ I_C = 10 mAdc
- Current-Gain — Bandwidth Product — f_T = 300 MHz (Typ) @ I_C = 20 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc
- Fast Switching Time (Figure 1 and 2) — @ $I_C \approx$ 16 mAdc
  t_{on} = 40 ns (Typ)
  t_{off} = 60 ns (Typ)

NPN SILICON AMPLIFIER TRANSISTOR



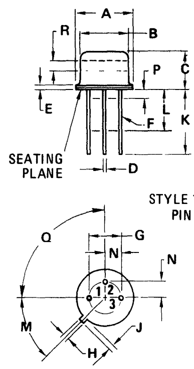
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Emitter Voltage	V_{CER}	50	Vdc
Collector-Base Voltage	V_{CB}	75	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	800	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 5.33	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 20	Watt mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	187	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

*Indicates JEDEC Registered Data.
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

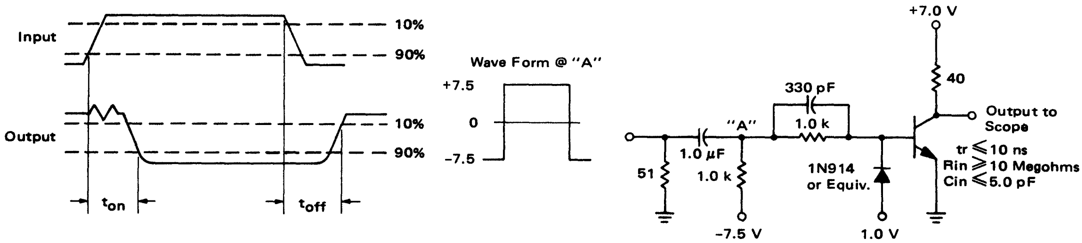
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

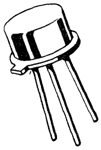
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, R_{BE} = 10 Ohms)	BV_{CER}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	75	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)		–	–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	
Collector Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.5 Vdc	I_{CEV}	–	–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.01	μAdc
Base Cutoff Current (V_{CE} = 35 Vdc, V_{EB} = 0.5 Vdc)	I_{BEV}	–	–	10	μAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		35	75	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	90	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	100	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		100	150	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		50	90	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		30	60	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.3	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	0.8	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.9	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	1.4	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	250	300	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	8.0	pF
Input Impedance					Ohms
(I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	25	–	35	
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 300 MHz)	$Re_{(hie)}$	20	–	60	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	0.9	–	2.5	$X10^{-4}$
Small-Signal Current Gain	h_{fe}				–
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		80	–	250	
(I_C = 20 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)		150	–	400	
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		2.5	–	7.0	
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	–	–	0.2	μmhos
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1)	t_{on}	–	40	50	ns
Turn-Off Time (Figure 1)	t_{off}	–	60	70	ns

*Indicates JEDEC Registered Data.
(1) Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT

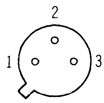


2N2800S (SILICON)
2N2801S



PNP silicon annular transistors for medium-speed switching applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

2N2800
2N2801

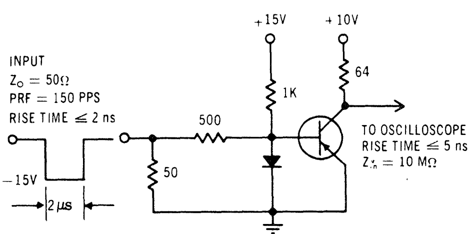
Collector connected to case

*MAXIMUM RATINGS

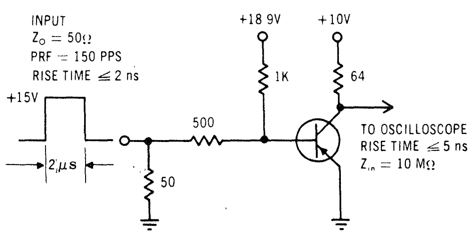
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	800	mA
Total Device Dissipation @ 25°C Ambient Temperature 2N2800, 2N2801 — TO-5 Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature 2N2800, 2N2801 — TO-5 Derating Factor Above 25°C	P_D	3.0 17.3	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	35	-	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	-	100	nAdc
Base Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	-	100	nAdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc) 2N2800		20	-	
2N2801		30	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1) 2N2800		30	90	
2N2801		75	225	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)(1) 2N2800		15	-	
2N2801		30	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1) 2N2800		25	-	
2N2801		40	-	
Collector Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.8	
Output Capacitance (V_{CB} = 10 Vdc, f = 100 kHz)	C_{ob}	-	25	pF
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	120	-	MHz

*SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise noted)

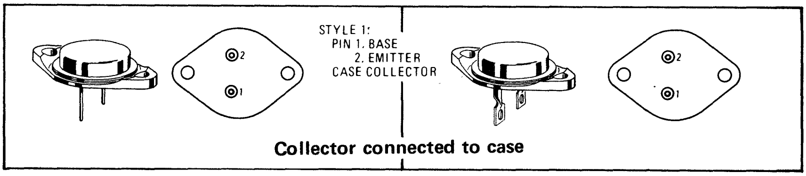
Characteristic	Symbol	Typical	Maximum	Unit
Delay Time	t_d	9	25	ns
Rise Time	t_r	25	45	ns
Storage Time	t_s	100	225	ns
Fall Time	t_f	30	45	ns

(1) Pulse Test: Pulse Width ≦ 300 μs, duty cycle ≦ 2%

*Indicates JEDEC Registered Data

2N2832 (GERMANIUM)
2N2833
2N2834

PNP germanium transistors for switching and amplifier applications.

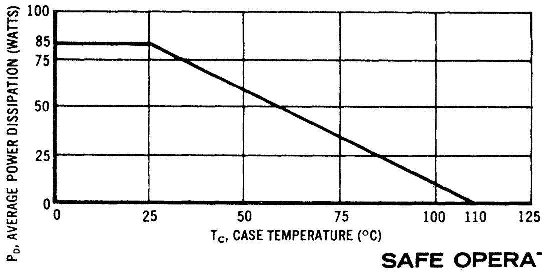


CASE 11A — For units with solder lugs attached, specify device MP2832 etc. (Case 4-04) — CASE 4-04

MAXIMUM RATINGS

Rating	Symbol	2N2832	2N2833	2N2834	Unit
Collector-Emitter Voltage	V_{CEO}	50	75	100	Vdc
Collector-Base Voltage	V_{CB}	80	120	140	Vdc
Emitter-Base Voltage	V_{EB}	2.0			Vdc
Collector Current - Continuous	I_C	20			Adc
Base Current	I_B	5.0			Adc
Total Device Dissipation @ T_C = 25°C	P_D	85			Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			

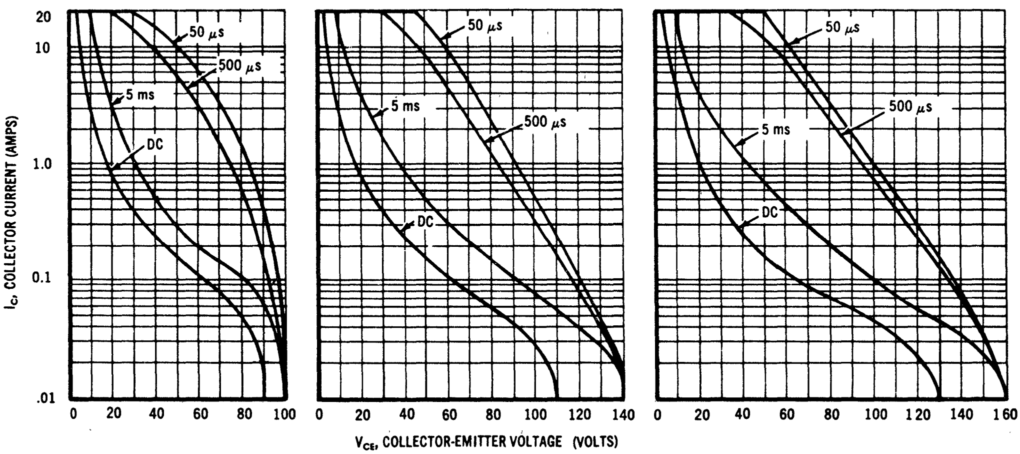
FIGURE 1 — POWER DERATING CURVE



THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 2, 3, 4. BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED

SAFE OPERATING AREAS

FIGURE 2 — 2N2832 FIGURE 3 — 2N2833 FIGURE 4 — 2N2834



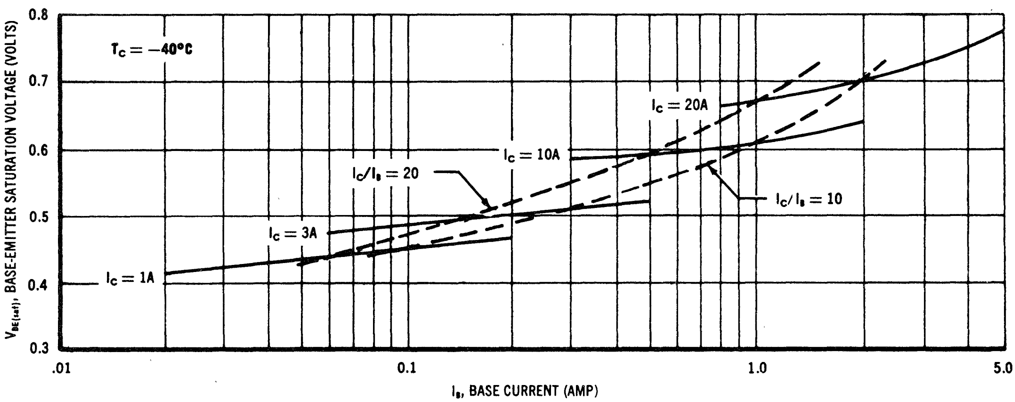
The Safe Operating Area Curves indicate the I_C - V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

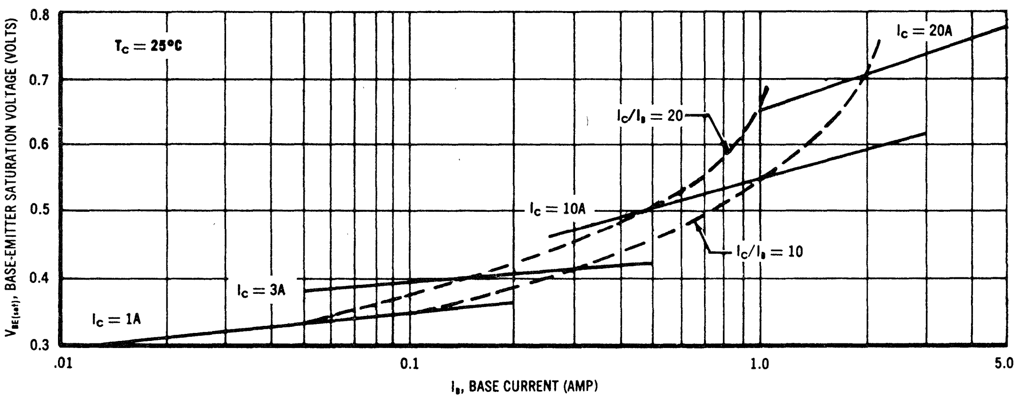
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage[1] (I_C = 100 mAdc, I_B = 0)	2N2832	$BV_{CEO(sus)}$	50	-	-	Volts
	2N2833		75	-	-	
	2N2834		100	-	-	
Emitter-Base Breakdown Voltage (I_E = 50 mAdc, I_C = 0)		BV_{EBO}	2.0	-	-	Vdc
Floating Potential* (V_{CB} = 80 Vdc, I_E = 0)	2N2832	V_{EBF}*	-	-	0.5	Volts
(V_{CB} = 120 Vdc, I_E = 0)	2N2833		-	-	0.5	
(V_{CB} = 140 Vdc, I_E = 0)	2N2834		-	-	0.5	
Collector Cutoff Current* (V_{CE} = 100 Vdc, V_{BE} = 0)	2N2832	I_{CES}*	-	-	20	mAdc
(V_{CE} = 140 Vdc, V_{BE} = 0)	2N2833		-	-	20	
(V_{CE} = 160 Vdc, V_{BE} = 0)	2N2834		-	-	20	
Collector Cutoff Current** (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2832	I_{CEX}**	-	-	40	mAdc
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2833		-	-	40	
(V_{CE} = 100 Vdc, $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C)	2N2834		-	-	40	
Collector Cutoff Current* (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}*	-	-	0.3	mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N2832		-	-	10	
(V_{CB} = 120 Vdc, I_E = 0)	2N2833		-	-	10	
(V_{CB} = 140 Vdc, I_E = 0)	2N2834		-	-	10	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	50	75	-	-
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)			25	-	100	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	-	-	0.15	Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			-	-	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			-	-	0.5	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	-	-	0.6	Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			-	-	0.75	
(I_C = 20 Adc, I_B = 2.0 Adc)			-	-	1.0	
DYNAMIC CHARACTERISTICS						
Small Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 5.0 MHz)		h_{fe}	2.0	3.5	-	-
Rise Time		t_r	-	2.0	4.0	μs
Storage Time		t_s	-	3.0	6.0	μs
Fall Time		t_f	-	1.0	2.5	μs

*SWEEP TEST: 1/2 Sine Wave, 60 Hz min.
(1)PULSE TEST: Pulse Width = 1.0 ms, 2.0% Duty Cycle.

FIG 5 — BASE-EMITTER SATURATION VOLTAGE VARIATIONS





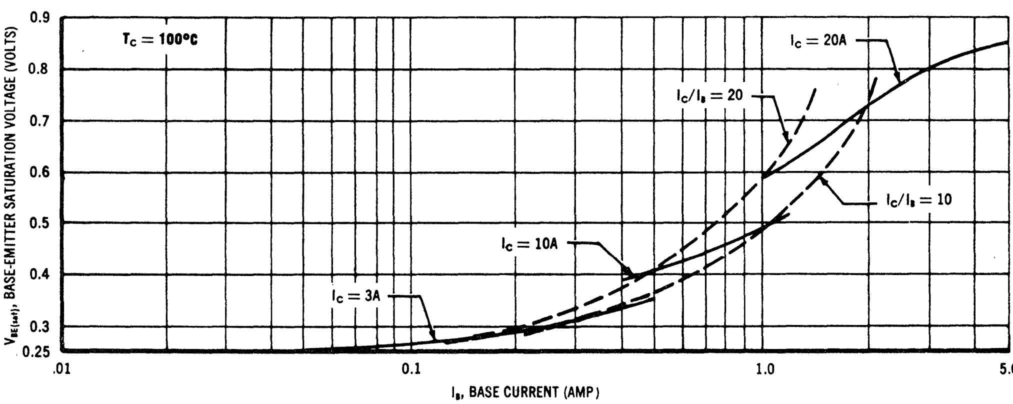


FIG 6 — COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

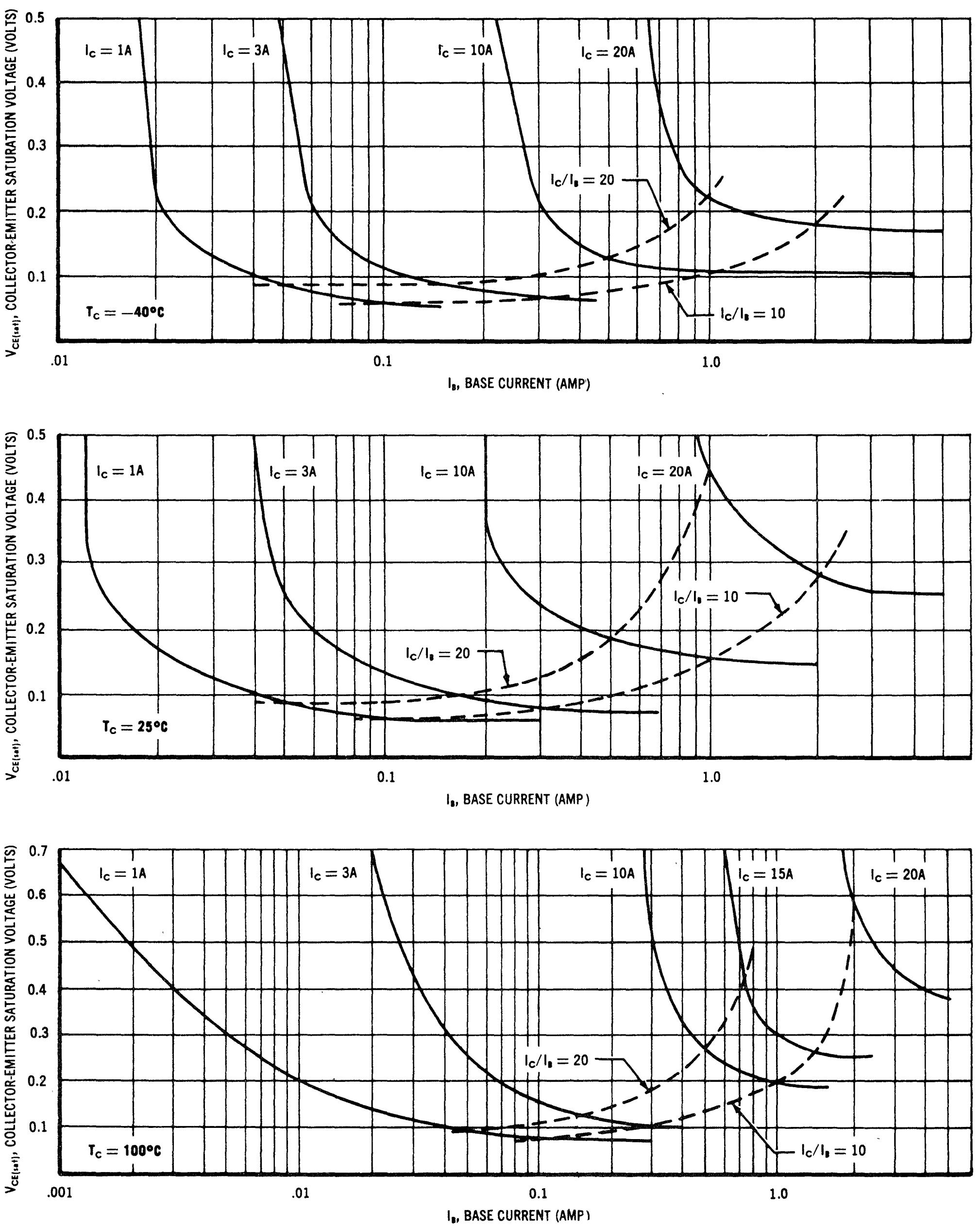


FIGURE 7 — CURRENT VARIATIONS

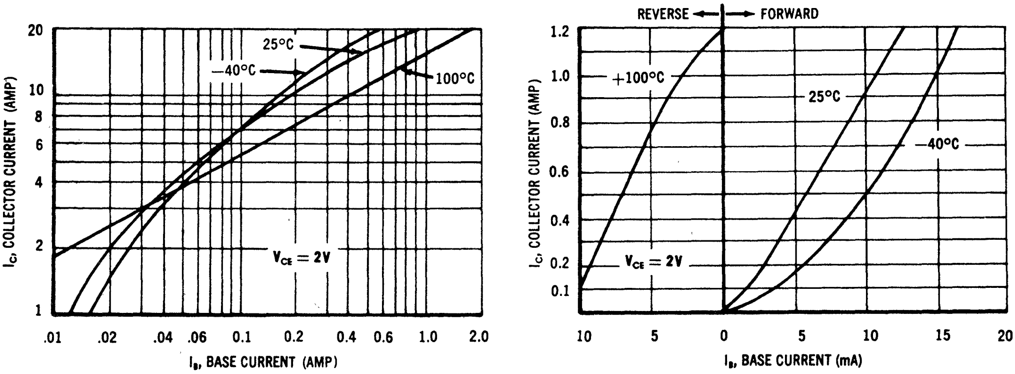


FIGURE 8 — COLLECTOR CURRENT-VOLTAGE VARIATION

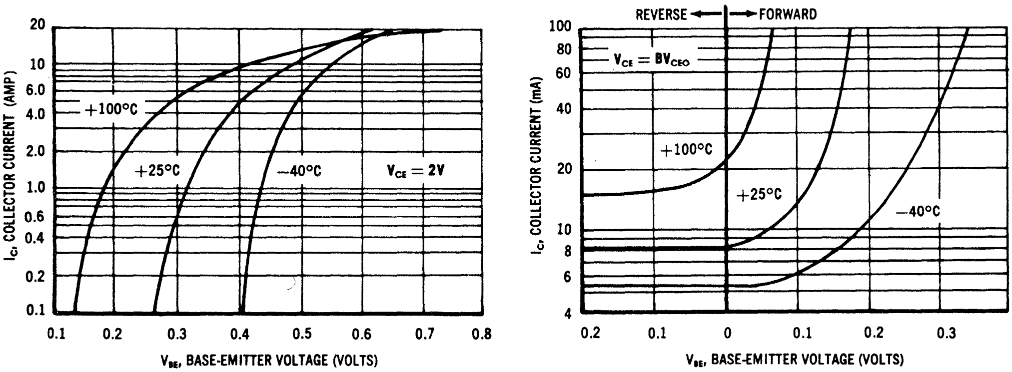


FIG 9 — BASE CURRENT-VOLTAGE VARIATIONS

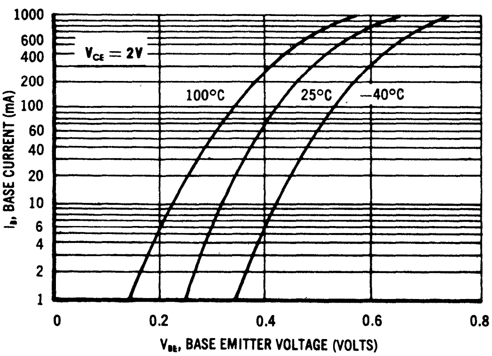


FIGURE 10 CURRENT-GAIN VARIATIONS

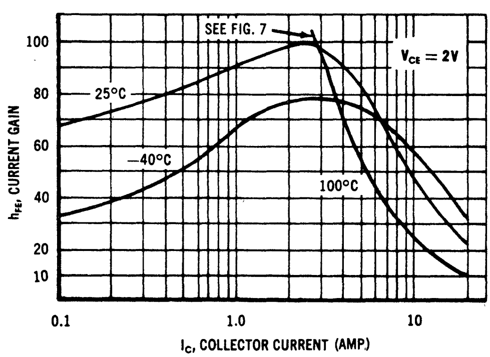


FIG 11 – RISE and FALL TIME vs COLLECTOR CURRENT

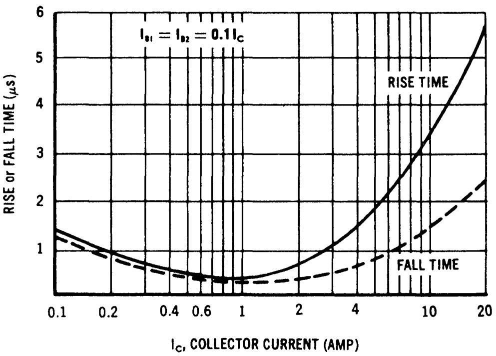


FIG 12 – STORAGE TIME vs COLLECTOR CURRENT

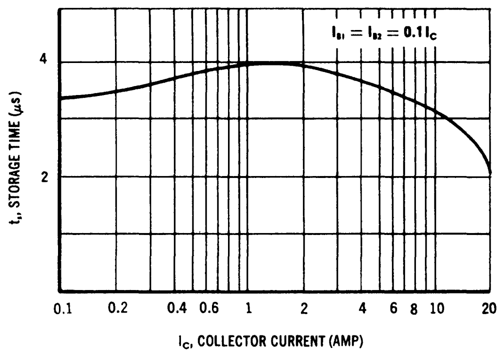
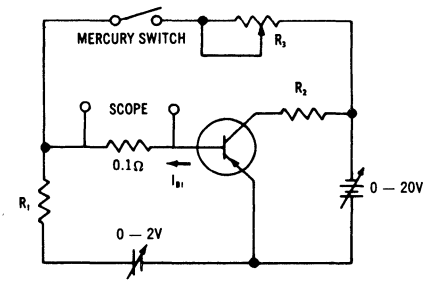


FIG 13 – SWITCHING TIME TEST CIRCUIT



Characteristic	Sym	Max	Unit
Rise Time	t_r	4	μs
Storage Time	t_s	6	μs
Fall Time	t_f	2.5	μs

ADJUST R_1, R_2, R_3, for $I_{B1} = I_{B2} = 0.1 I_C$

PULSE CONDITIONS; $I_C = 5$ AMP, $I_{B1} = 0.5$ AMP

Switching times shown are for constant current drive conditions. Faster times can be realized by the use of a lower source impedance or a speed-up capacitor. See Chapter 5 of the Motorola Switching Handbook for a more detailed explanation.

FIG 14 – CURRENT GAIN – BANDWIDTH PRODUCT vs COLLECTOR CURRENT

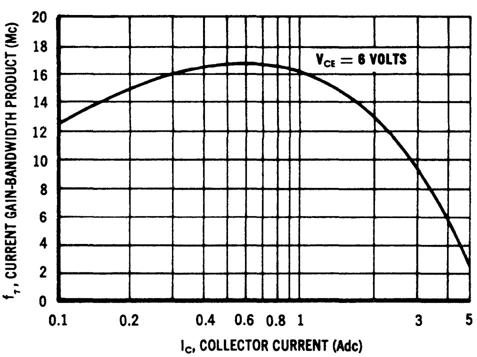
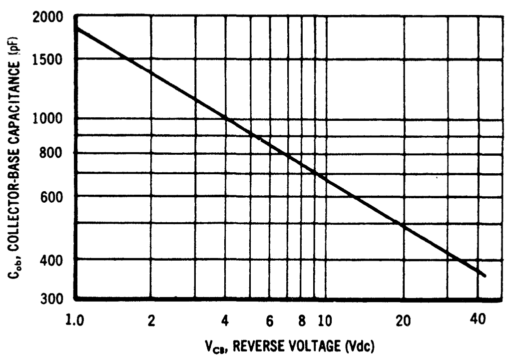
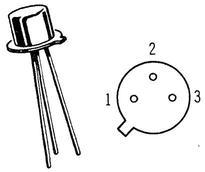


FIG 15 – OUTPUT CAPACITANCE vs REVERSE VOLTAGE



2N2845, 2N2847 (SILICON)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)
2N2845
2N2847

NPN silicon annular transistors designed for high-speed, medium-power saturated switching applications.

*MAXIMUM RATINGS

Rating	Symbol	2N2845	2N2847	Unit
Collector-Emitter Voltage(1)	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.1		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to 200		°C
Storage Temperature Range	T_{stg}	-65 to 200		°C

(1) Applicable from 1 mA to 30 mA (Pulsed)
*Indicates JEDEC Registered Data

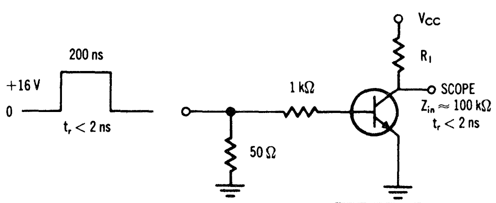
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$BV_{CEO(sus)}$			Vdc
(I_C = 30 mAdc, I_B = 0)	2N2845		30	—	
(I_C = 30 mAdc, I_B = 0)	2N2847		20	—	
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)		I_{CES}	—	0.2	μAdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	—	200	μAdc
Base Leakage Current (V_{CE} = 30 Vdc, V_{BE} = 0)		I_{BL}	—	0.2	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			—
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N2845		30	120	
	2N2847		40	140	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N2845		20	—	
	2N2847		30	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	All Types		10	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	All Types		—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N2845		—	1.0	
	2N2847		—	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	8.0	pF
Turn-On Time (Figure 1)		t_{on}			ns
(V_{CC} = 10 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ 15 mAdc)	2N2845		—	40	
(V_{CC} = 6 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ 15 mAdc)	2N2847		—	25	
Turn-Off Time (Figure 2)		t_{off}			ns
(V_{CC} = 10 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ I_{B2} ≈ 15 mAdc)	2N2845		—	40	
(V_{CC} = 6 Vdc, I_C ≈ 150 mAdc, I_{B1} ≈ I_{B2} ≈ 15 mAdc)	2N2847		—	40	

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = ≤ 2%

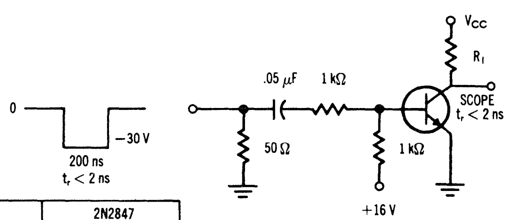
* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON TIME TEST CIRCUIT



	2N2845	2N2847
Vcc	10 V	6 V
R₁	62 Ω	39 Ω

FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



2N2857, 2N3839 (SILICON)

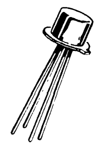
The RF Line

NPN SILICON RF SMALL-SIGNAL TRANSISTORS

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

- High Current-Gain—Bandwidth Product —
  f_T = 1.6 GHz (Typ) @ I_C = 8.0 mAdc
- Low Noise Figure —
  NF = 3.9 dB (Max) @ f = 450 MHz — 2N3839
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 15 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Ideal for Micro-Power Applications

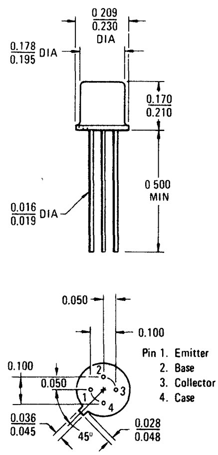
NPN SILICON RF SMALL-SIGNAL TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 20 (10)
TO-72 PACKAGE

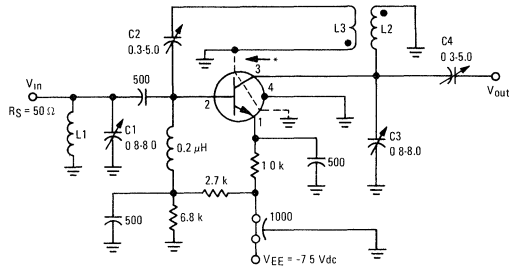
Active Elements Isolated from Case

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage** (I_C = 3.0 mAdc, I_B = 0)		BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)		BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	2.5	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)	Both Types		–	–	0.01	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N3839		–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	30	–	150	–
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	2N2857	f_T	1000	–	1900	MHz
	2N3839		1000	–	2000	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)		C_{cb}	–	0.7	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	50	–	220	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	2N2857	$r_b'C_c$	4.0	–	15	ps
	2N3839		1.0	–	15	
Noise Figure (Figure 1)		NF				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, R_S = 50 ohms, f = 450 MHz) ②	Both Types		–	5.8	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 450 MHz)	2N2857		–	4.1	4.5	
	2N3839		–	–	3.9	
FUNCTIONAL TEST						
Common-Emitter Amplifier Power Gain (Figure 1)		G_{pe}				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, f = 450 MHz) ②			–	11	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)			12.5	–	19	
Power Output (Figure 2) (I_E = 12 mAdc, V_{CB} = 10 Vdc, f = 500 MHz)		P_{out}	30	–	–	mW

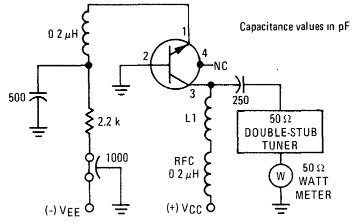
*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.
① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
② Micro-Power Specifications.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



Capacitance values in pF

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long

L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia Install at least 1/2" from nearest vertical chassis surface
L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2
* – External interlead shield to isolate collector lead from emitter and base leads

Neutralization Procedure

(A) Connect 450-MHz signal generator (with R_S = 50 ohms) to input terminals of amplifier

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier

(C) Apply V_{EE}, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary

FIGURE 3 – NOISE FIGURE versus FREQUENCY

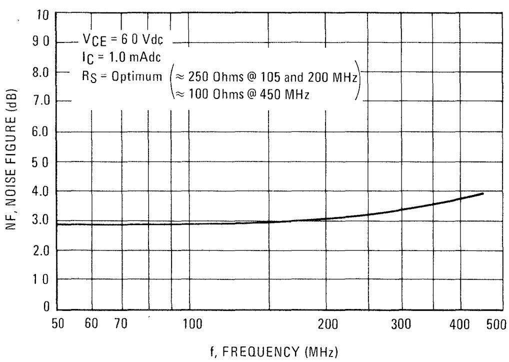


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

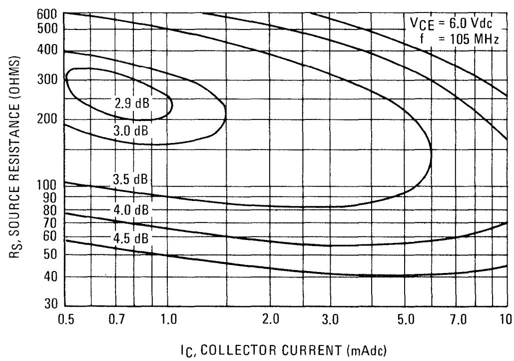


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

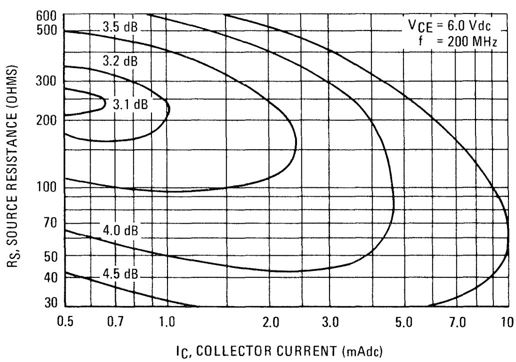


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

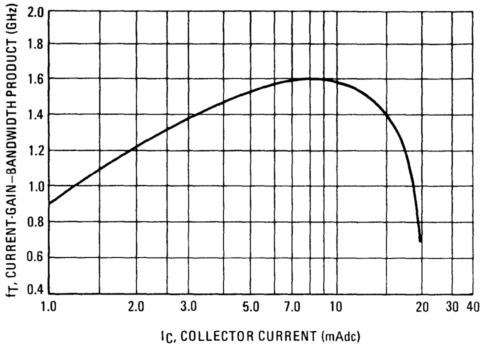


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

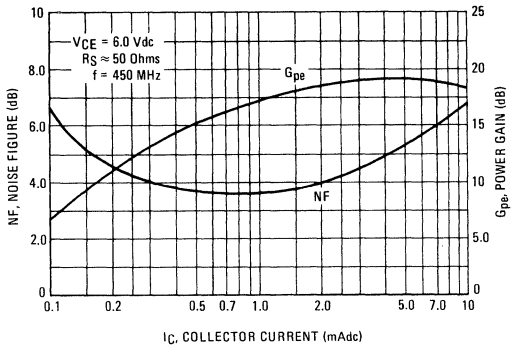


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

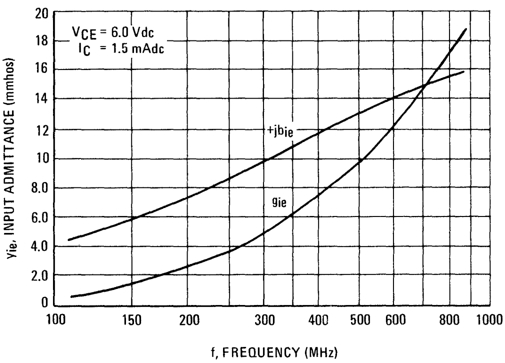


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

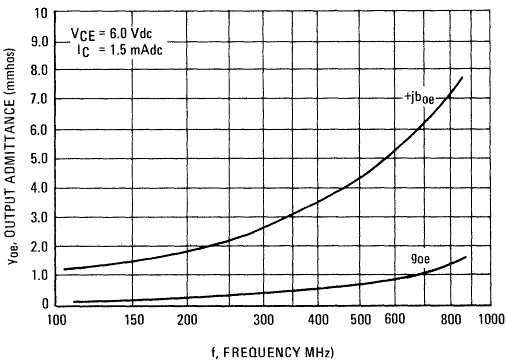


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

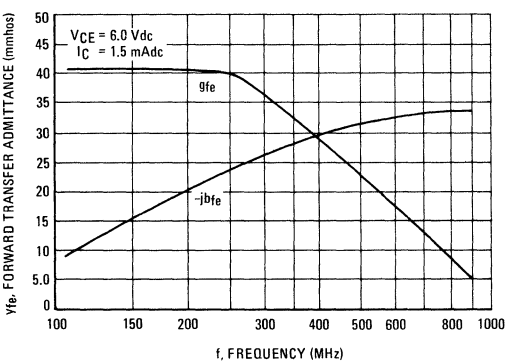


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

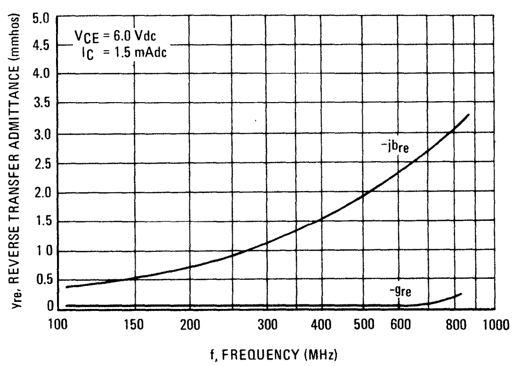


FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

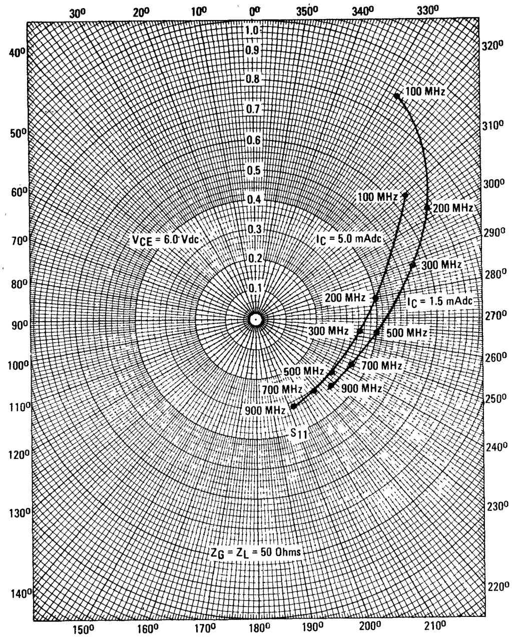


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

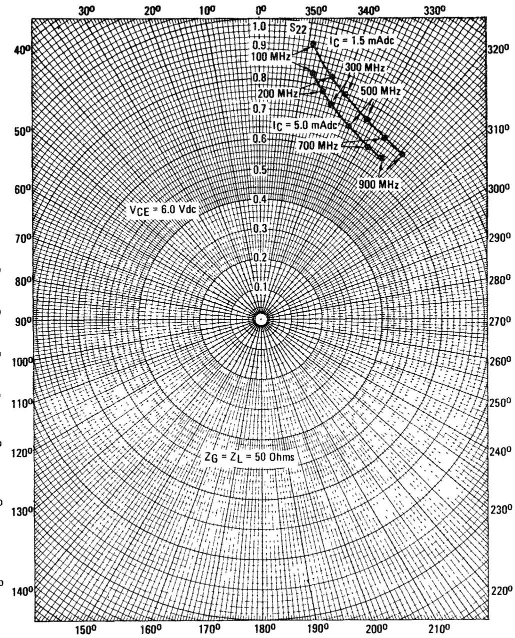


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

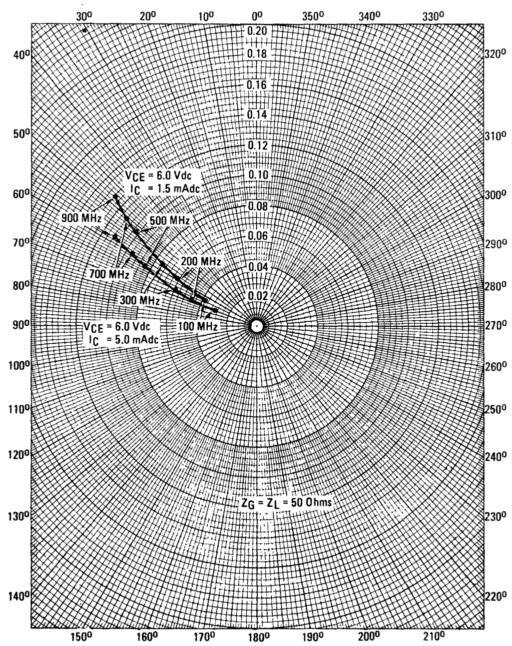


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

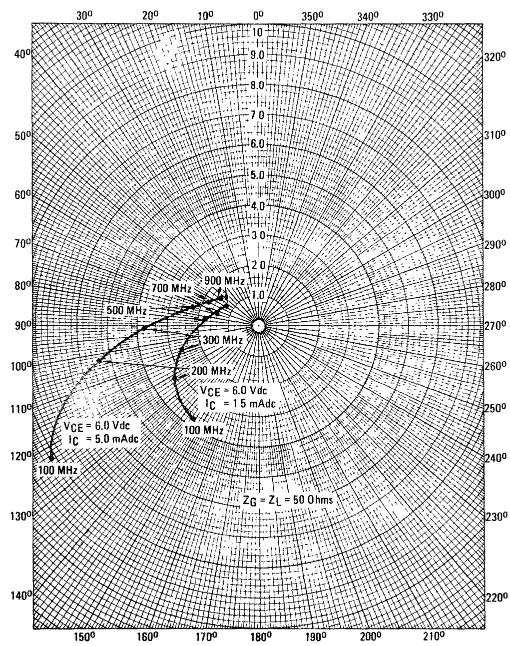
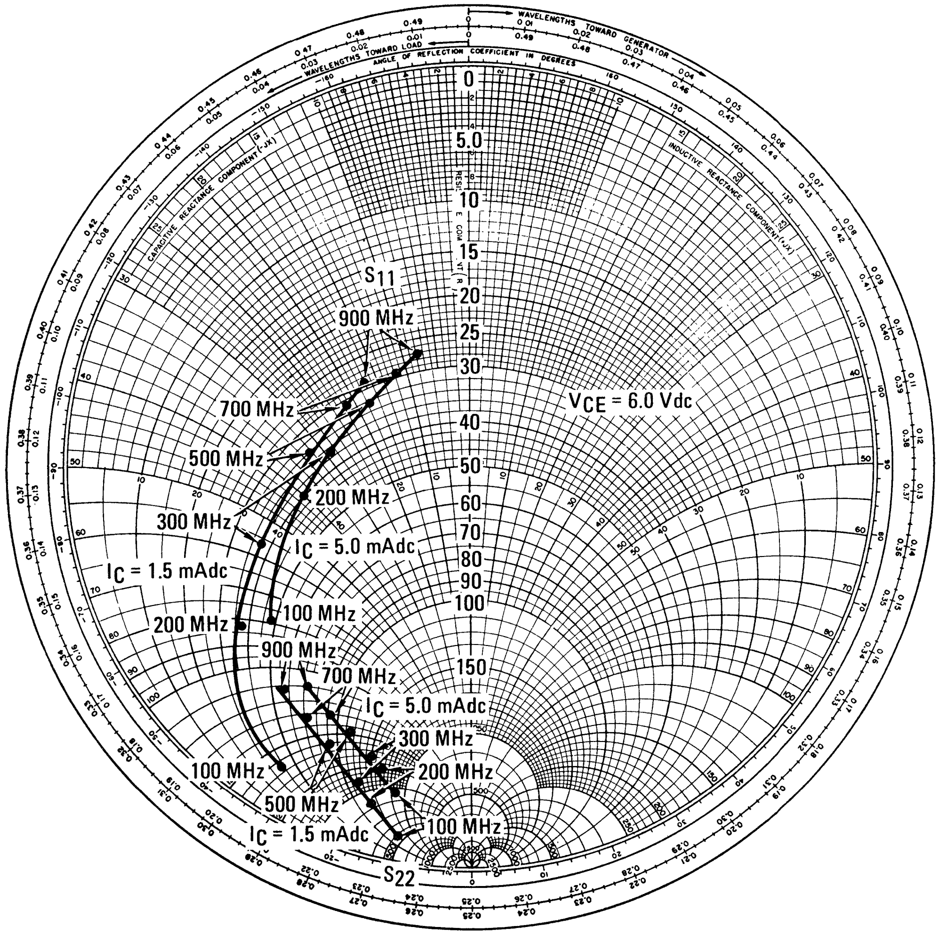
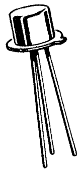


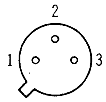
FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT





PNP silicon annular transistor designed for low-level, high-speed switching applications.

CASE 22
(TO-18)



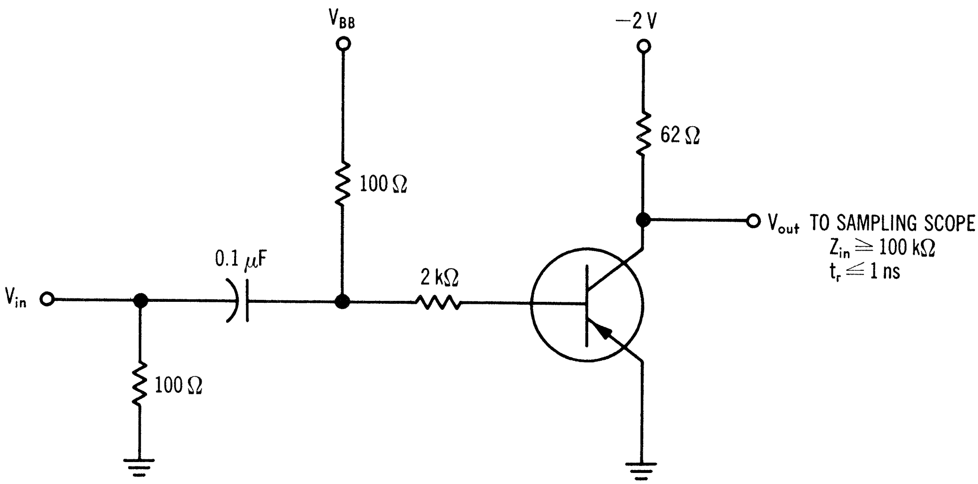
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1200 6.85	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

(1)Applicable from 0.01 to 10 mAdc.
* Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



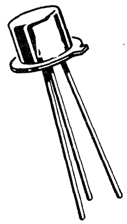
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	12	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 6 Vdc, V_{BE} = 0)	I_{CES}	—	80	nAdc
Collector-Cutoff Current (V_{CB} = 6 Vdc, I_E = 0, T_A = 125°C)	I_{CBO}	—	10	μAdc
Base Current (V_{CE} = 6 Vdc, V_{BE} = 0)	I_B	—	80	nAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			—
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	—	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		40	150	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)		17	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		25	—	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		—	0.15	
(I_C = 30 mAdc, I_B = 3 mAdc)		—	0.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	0.5	
Base-Emitter Saturation Voltag (1)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		0.78	0.98	
(I_C = 30 mAdc, I_B = 3 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		—	1.7	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	6.0	pF
Input Capacitance (V_{BE} = -0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	6.0	pF
Turn-On Time, Figure 1 (V_{CC} = 2 Vdc, $V_{BE(off)}$ = 3 Vdc, I_C = 30 mAdc, I_{B1} = 1.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time, Figure 1 (V_{CC} = 2 Vdc, I_C = 30 mAdc, I_{B1} = I_{B2} = 1.5 mAdc)	t_{off}	—	90	ns

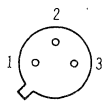
(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1%

*Indicates JEDEC Registered Data

2N2895 (SILICON)
2N2896
2N2897



NPN silicon annular transistors designed for small-signal amplifier and general purpose switching applications.



CASE 22
(TO-18)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N2895	2N2896	2N2897	Unit
Collector-Emitter Voltage	V_{CEO}	65	90	45	Vdc
Collector-Emitter Voltage	V_{CER}	80	140	60	Vdc
Collector-Base Voltage	V_{CB}	120	140	60	Vdc
Emitter-Base Voltage	V_{EB}		← 7.0 →		Vdc
Collector Current	I_C		← 1.0 →		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D		← 0.5 → ← 2.86 →		Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D		← 1.8 → ← 10.3 →		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}		← -65 to +200 →		°C

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	2N2895 2N2896 2N2897	$BV_{CEO(sus)}$	65 90 45	- - -	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 100 mAdc, R_{BE} = 10 ohms)	2N2895 2N2896 2N2897	BV_{CER}	80 140 60	- - -	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	2N2895 2N2896 2N2897	BV_{CBO}	120 140 60	- - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	7.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	2N2895 2N2896 2N2897	I_{CBO}	- - -	0.002 0.01 0.05	μAdc
(V_{CB} = 60 Vdc, I_E = 0, T_A = +150°C)	2N2895 2N2897		- -	2.0 50	
(V_{CB} = 90 Vdc, I_E = 0)	2N2896		-	0.01	
(V_{CB} = 90 Vdc, I_E = 0, T_A = +150°C)	2N2896		-	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	2N2895 2N2896 2N2897	I_{EBO}	- - -	0.002 0.01 0.05	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 μAdc, V_{CE} = 10 Vdc)	2N2895	h_{FE}	10	-	-
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	2N2895		20	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2896, 2N2897		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2895		35	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2895, 2N2896		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)	2N2895 2N2896 2N2897		40 60 50	120 200 200	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (1)	2N2895		25	-	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{CE(sat)}$	- -	0.6 1.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N2895, 2N2896 2N2897	$V_{BE(sat)}$	- -	1.2 1.3	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N2895, 2N2896 2N2897	f_T	120 100	- -	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	80	pF
Small-Signal Current Gain (I_C = 5.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	2N2895 2N2896, 2N2897	h_{fe}	50 50	200 275	-
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, R_S = 500 ohms, f = 1.0 kHz, BW = 15 kHz)	2N2895	NF	-	8.0	dB

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 1.8%.

*Indicates JEDEC Registered Data

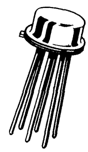
2N2903 (SILICON)
2N2903A

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N2903
  $\Delta|V_{BE1} - V_{BE2}|$ = 20 mVdc (Max) @ -55 to +25°C
  = 1.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 5.0 mAdc
- DC Current Gain Specified — 10 μAdc to 1.0 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 60 MHz @ I_C = 5.0 mAdc

NPN SILICON MULTIPLE TRANSISTORS



*MAXIMUM RATINGS

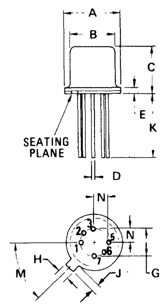
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	7.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	300 1.71	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.6 3.43	1.2 6.86	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 μAdc, I_C = 0)	BV_{EBO}	7 0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 – –	 0 01 15	μAdc
Emitter Cutoff Current (V_{BE} = 5 0 Vdc, I_C = 0)	I_{EBO}	–	0 01	μAdc

(1) Pulse Test   lse Width ≤300 μs, Duty Cycle ≤2 0%
*Indicates JEDEC Registered Data

STYLE 1·
PIN 1. COLLECTOR   5. EMITTER
2. BASE   6. BASE
3 EMITTER   7. COLLECTOR
4. OMITTED   8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9 40	0 335	0 370
B	7 75	8 51	0 305	0 335
C	3 81	4 70	0 150	0 185
D	0.41	0 53	0 016	0 021
G	5 08 BSC		0.200 BSC	
H	0 71	0 86	0.028	0 034
J	0 74	1 14	0 029	0 045
K	12.70	–	0 500	—
M	45° BSC		45° BSC	
N	2 54 BSC		0 100 BSC	

CASE 654-07

***ELECTRICAL CHARACTERISTICS** (each side) (T_A 25 C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)		60	-	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		25	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		125	625	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)		60	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)	f_T	60	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{ie}	1.0	-	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{re}	-	6.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{fe}	150	600	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1.0 kHz)	h_{oe}	5.0	30	μmhos
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ib}	20	30	ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{rb}	-	5.0	X 10^{-4}
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)	h_{ob}	-	0.2	μmho
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz)	NF	-	7.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (2) (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) 2N2903	h_{FE1}/h_{FE2}	0.8	1.0	-
2N2903A		0.9	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5.0 Vdc) 2N2903	$\lvert V_{BE1}-V_{BE2}\rvert$	-	10	mVdc
2N2903A		-	5.0	
Base-Emitter Voltage Differential Gradient (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +125°C) 2N2903	$\frac{\Delta\lvert V_{BE1}-V_{BE2}\rvert}{\Delta T_A}$	-	20	μV/°C
2N2903A		-	10	

* Indicates JEDEC Registered Data

(2) Lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N2904S, AS, 2N2905S, AS 2N2906, A 2N2907, A (SILICON)
2N3485, A, 2N3486, A

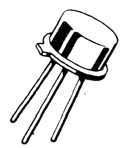
PNP SILICON ANNULAR HERMETIC TRANSISTORS

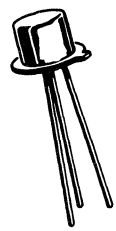
. . . designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

- High DC Current Gain Specified – 0.1 to 500 mAdc
- High Current-Gain–Bandwidth Product –
  f_T = 200 MHz (Min) @ I_C = 50 mAdc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- 2N2904,A thru 2N2907,A Complement to NPN 2N2218,A, 2N2219,A, 2N2221,A, 2N2222,A
- JAN, JTX, JTXV Available, Except 2N2904S, AS, 2N3485 and 2N3486

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS

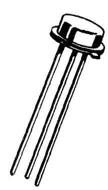
CASE 79-02
TO-39
2N2904S,AS
2N2905S,AS





CASE 22-03
(TO-18)
2N2906,A
2N2907,A

CASE 26-03
(TO-46)
2N3485,A
2N3486,A



SELECTOR GUIDE

Device Type	Characteristic BV_{CEO} I_C = 10 mAdc Volts	h_{FE} I_C = 1.0 mAdc Min	I_C = 150 mAdc Min	I_C = 500 mAdc Min	Package
2N2904	40	25	40	20	TO-39
2N2905	↓	50	100	30	
2N2906	↓	25	40	20	TO-18
2N2907	↓	50	100	30	
2N3485	↓	25	40	20	TO-46
2N3486	↓	50	100	30	
2N2904A	60	40	40	40	TO-39
2N2905A	↓	100	100	50	
2N2906A	↓	40	40	40	TO-18
2N2907A	↓	100	100	50	
2N3485A	↓	40	40	40	TO-46
2N3486A	↓	100	100	50	

*MAXIMUM RATINGS

Rating	Symbol	Non-A Suffix		A-Suffix	Unit
Collector-Emitter Voltage	V_{CEO}	40		60	Vdc
Collector-Base Voltage	V_{CB}	60			Vdc
Emitter-Base Voltage	V_{EB}	5.0			Vdc
Collector Current – Continuous	I_C	600			mAdc
		2N2904,A 2N2905,A	2N2906,A 2N2907,A	2N3485,A 2N3486,A	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	1.8 10.3	2.0 11.43	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25° unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	Non-A Suffix A-Suffix	BV_{CEO}	40 60	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_{CEX}	–	–	50	nAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	Non-A Suffix A-Suffix	I_{CBO}	– –	– –	0.020 0.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	Non-A Suffix A-Suffix		– –	– –	20 10	
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)		I_B	–	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485 2N2905,2N2907,2N3486 2N2904A,2N2906A,2N3485A 2N2905A,2N2907A,2N3486A	h_{FE}	20 35 40 75	– – – –	– – – –	–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485 2N2905,2N2907,2N3486 2N2904A,2N2906A,2N3485A 2N2905A,2N2907A,2N3486A		25 50 40 100	– – – –	– – – –	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2904,2N2906,2N3485 2N2905,2N2907,2N3486 2N2904A,2N2906A,2N3485A 2N2905A,2N2907A,2N3486A		35 75 40 100	– – – –	– – – –	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)(1)	2N2904,A,2N2906,A,2N3485,A 2N2905,A,2N2907,A,2N3486,A		40 100	– –	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)(1)	2N2904,2N2906,2N3485 2N2905,2N2907,2N3486 2N2904A,2N2906A,2N3485A 2N2905A,2N2907A,2N3486A		20 30 40 50	– – – –	– – – –	
Collector-Emitter Saturation Voltage(1) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	 – –	 – –	 0.4 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)(1) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	 – –	 – –	 1.3 2.6	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	30	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 15a)	t_{on}	–	26	45	ns
Delay Time		t_d	–	6.0	10	ns
Rise Time		t_r	–	20	40	ns
Turn-Off Time	(V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 15b)	t_{off}	–	70	180	ns
Storage Time		t_s	–	50	80	ns
Fall Time		t_f	–	20	150	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 15a – DELAY AND RISE TIME TEST CIRCUIT

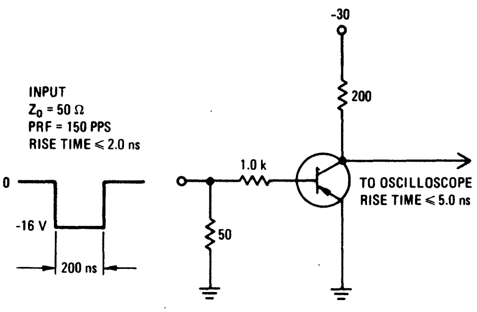
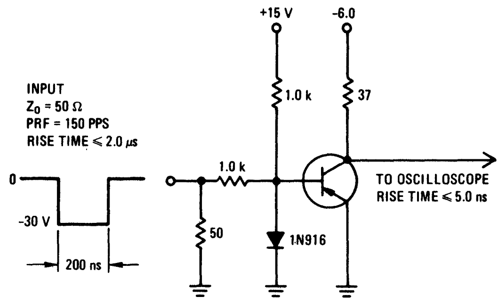
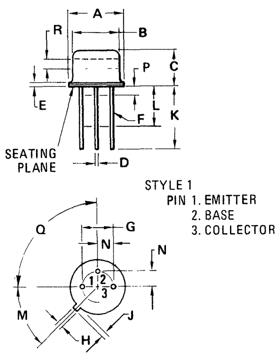


FIGURE 15b – STORAGE AND FALL TIME TEST CIRCUIT



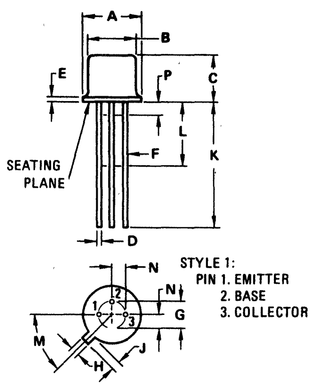
OUTLINE DIMENSIONS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

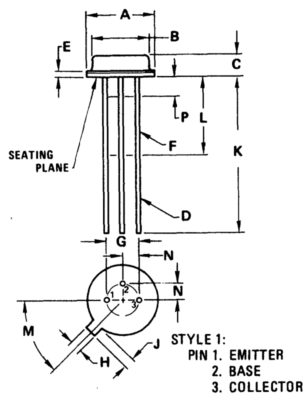
CASE 79-02
TO-39



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22
TO-18

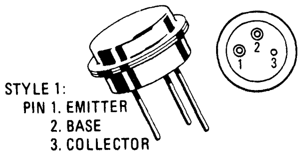


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26
TO-46

2N2912 (GERMANIUM)



CASE 8
Collector connected to case

PNP high-speed, high-frequency power transistor especially designed for switching and power converter circuits operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells and 1.5 volt batteries.

MAXIMUM RATINGS

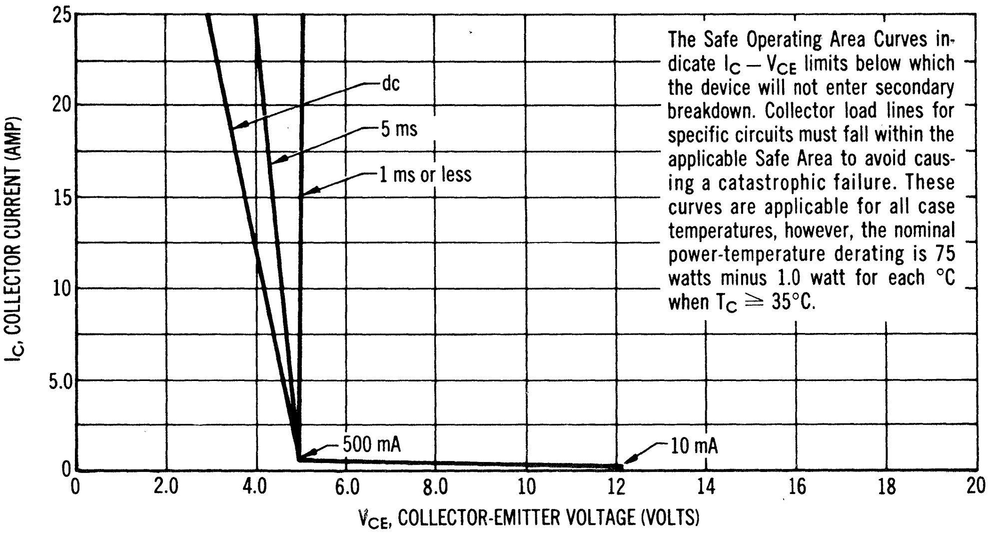
Rating	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	5.0	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	1.5	Vdc
Collector Current-Continuous	I_C	25	Adc
Base Current-Continuous	I_B	3.0	Adc
Total Device Dissipation @ T_C = 35°C Derate above 35°C	P_D	75 1.0	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110	°C

Lead temperature 1/16" from case for 10 seconds = 240°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	30	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc, I_B = 0)		BV_{CEO}*	5.0	—	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	—	10	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, R_{BE} = 5.0 ohms)		I_{CER}	—	10	mAdc
Collector Cutoff Current (V_{CE} = 15 Vdc, $V_{BE(off)}$ = 0.2 Vdc) (V_{CE} = 5.0 Vdc, $V_{EB(off)}$ = 0.2 Vdc, T_C = 85°C)		I_{CEX}	— —	10 15	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	—	10	mAdc
Emitter Cutoff Current (V_{BE} = 1.5 Vdc, I_C = 0)		I_{EBO}	—	50	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	2	h_{FE}	150 200	— 800	—
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc) (I_C = 25 Adc, I_B = 2.5 Adc)	2	$V_{CE(sat)}$	— —	0.12 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 0.5 Adc) (I_C = 25 Adc, I_B = 2.5 Adc)		$V_{BE(sat)}$	— —	0.5 1.2	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc, f = 1.0 MHz)		f_T	10	—	MHz
Rise Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_r	—	2.0	μs
Storage Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_s	—	10	μs
Fall Time (V_{CC} = 10 Vdc, I_C = 5.0 Adc)	3	t_f	—	2.0	μs

*Sweep Test: 1/2 Cycle sine wave, 60 Hz

FIGURE 2 — TYPICAL COLLECTOR CHARACTERISTICS

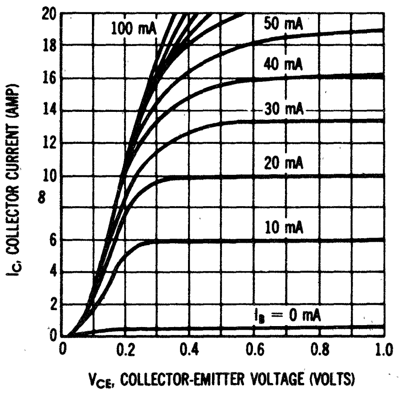
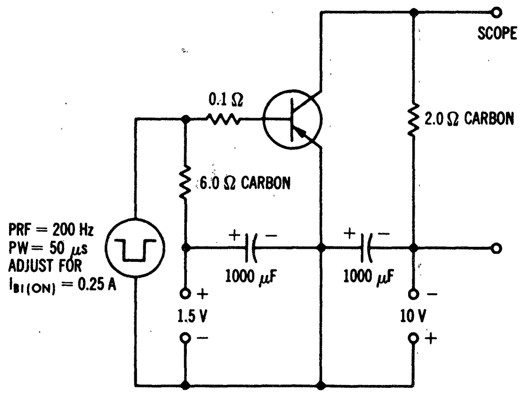


FIGURE 3 — SWITCHING-TIME TEST CIRCUIT



2N2913 thru 2N2920 (SILICON)

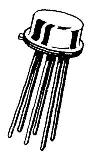
2N2919 JAN, JTX, JTXV Available
2N2920 JAN, JTX, JTXV Available

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N2917, 2N2918
  $\Delta|V_{BE1} - V_{BE2}| = 1.6$ mVdc (Max) @ –55 to +25°C
  $= 2.0$ mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 0.35$ Vdc (Max) @ $I_C = 1.0$ mAdc
- DC Current Gain Specified – 10 μAdc to 1.0 mAdc
- High Current-Gain – Bandwidth Product – $f_T = 60$ MHz @ $I_C = 500$ μAdc

NPN SILICON MULTIPLE TRANSISTORS

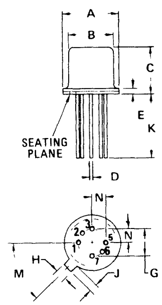


* MAXIMUM RATINGS

Rating	Symbol	2N2913 thru 2N2918	2N2919 2N2920	Unit
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Collector-Base Voltage	V_{CB}	45	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	600 3.4	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	750 4.3	1500 8.6	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

STYLE 1
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 51	9 40	0 335	0 370
B	7 75	8 51	0 305	0 335
C	3 81	4 70	0 150	0 185
D	0 41	0 53	0.016	0 021
G	5 08 BSC		0 200 BSC	
H	0 71	0 86	0 028	0.034
J	0 74	1 14	0 029	0.045
K	12 70	–	0.500	–
M	45° BSC		45° BSC	
N	2 54 BSC		0 100 BSC	

CASE 654-07

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

OFF CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N2913 thru 18,	$BV_{CEO(sus)}$	45		-	Vdc
	2N2919, 2N2920		60		-	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N2913 thru 18,	BV_{CBO}	45		-	Vdc
	2N2919, 2N2920		60		-	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0		-	Vdc
Collector Cutoff Current (V_{CE} = 5.0 Vdc, I_B = 0)		I_{CEO}	-	-	0.002	μAdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N2913 thru 18,	I_{CBO}	-	-	0.010	μAdc
	2N2919, 2N2920		-	-	0.002	
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	All Types		-	-	10	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	-	0.002	μAdc

ON CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
DC Current Gain (1) (I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19,	h_{FE}	60	-	240	-
	2N2914, 16, 18, 20		150	-	600	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N2913, 15, 17, 19,		15	-	-	
	2N2914, 16, 18, 20		30	-	-	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19,		100	-	-	
	2N2914, 16, 18, 20		225	-	-	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2913, 15, 17, 19,		150	-	-	
	2N2914, 16, 18, 20		300	-	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	-	-	0.35	Vdc
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	-	0.7	Vdc

SMALL-SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Current-Gain—Bandwidth Product (I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 20 MHz)		f_T	60	-	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	4.0	6.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ib}	25	28	32	ohms
Output Admittance (I_C = 1.0 mAdc, V_{CB} = 5.0 Vdc, f = 1.0 kHz)		h_{ob}	-	-	1.0	μmhos
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 200 Hz)	2N2914, 16, 18, 20,	NF	-	2.0	3.0	dB
	2N2913, 15, 17, 19		-	3.0	4.0	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 10 Hz to 15.7 kHz, BW = 10 kHz)	2N2914, 16, 18, 20,		-	2.0	3.0	
	2N2913, 15, 17, 19		-	3.0	4.0	
DC Current Gain Ratio (2) (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917, 18,	h_{FE1}/h_{FE2}	0.8	-	1.0	-
	2N2915, 16, 19, 20		0.9	-	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N2917, 18.	$\lvert V_{BE1}-V_{BE2}\rvert$	-	-	10	mVdc
	2N2915, 16, 19, 20		-	-	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N2917, 18,		-	-	5.0	
	2N2915, 16, 19, 20		-	-	3.0	
Base-Emitter Voltage Differential Change Due to Temperature (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +25°C)	2N2917, 18,	$\Delta(V_{BE1}-V_{BE2})$	-	-	1.6	mVdc
	2N2915, 16, 19, 20		-	-	0.8	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C)	2N2917, 18,		-	-	2.0	
	2N2915, 16, 19, 20		-	-	1.0	

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

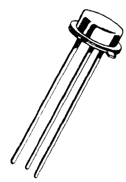
2N2944 (SILICON) thru 2N2946

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, high-speed chopper applications.

- Low Offset Voltage — $V_{EC(ofs)}$ = 0.18 mVdc (Typ) @ I_B = 200 μAdc
- High Emitter-Base Voltage — V_{EB} = 40 Vdc (2N2946)
- Low Dynamic "On" Series Resistance — $r_{ec(on)}$ = 4.0 Ohms (Typ) @ I_B = 1.0 mAdc (2N2944)

PNP SILICON CHOPPER TRANSISTORS



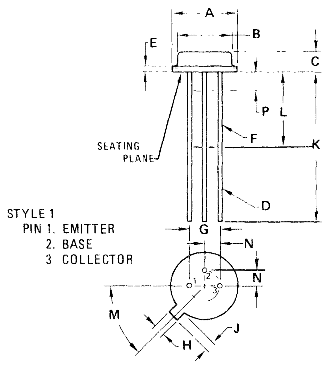
MAXIMUM RATINGS

Rating	Symbol	2N2944	2N2945	2N2946	Unit
*Emitter-Collector Voltage	V_{CEO}	10	20	35	Vdc
*Collector-Base Voltage	V_{CB}	15	25	40	Vdc
*Emitter-Base Voltage	V_{EB}	15	25	40	Vdc
*Collector Current	I_C	100			mAdc
*Total Power Dissipation @ T_A = 25°C	P_D	400			mW
Derate above 25°C		2.3			mW/°C
*Total Power Dissipation @ T_C = 25°C	P_D	2.0			Watts
Derate above 25°C		11.43			mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	°C/W

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N2944		–	–	0.1	
(V_{CB} = 25 Vdc, I_E = 0)	2N2945		–	–	0.2	
(V_{CB} = 40 Vdc, I_E = 0)	2N2946		–	–	0.5	
Emitter Cutoff Current		I_{EBO}				nAdc
(V_{EB} = 15 Vdc, I_C = 0)	2N2944		–	–	0.1	
(V_{EB} = 25 Vdc, I_C = 0)	2N2945		–	–	0.2	
(V_{EB} = 40 Vdc, I_C = 0)	2N2946		–	–	0.5	
ON CHARACTERISTICS						
*DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2944		80	180	–	
	2N2945		40	160	–	
	2N2946		30	130	–	
DC Current Gain (inverted connection)		$h_{FE(inv)}$				–
(I_E = 200 μAdc, V_{EC} = 0.5 Vdc)	2N2944		6.0	20	–	
	2N2945		4.0	17	–	
	2N2946		3.0	15	–	
Emitter-Collector Offset Voltage		$V_{EC(ofs)}$				mVdc
(I_B = 200 μAdc, I_E = 0)	2N2944		–	0.18	0.3	
	2N2945		–	0.23	0.5	
	2N2946		–	0.27	0.8	
(I_B = 1.0 mAdc, I_E = 0)*	2N2944		–	0.4	0.6	
	2N2945		–	0.5	1.0	
	2N2946		–	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2944		–	0.8	1.0	
	2N2945		–	0.9	1.6	
	2N2946		–	1.0	2.5	
***DYNAMIC CHARACTERISTICS**						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2944		10	15	–	
	2N2945		5.0	13	–	
	2N2946		3.0	12	–	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 500 kHz)		C_{ob}	–	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 500 kHz)		C_{ib}	–	1.9	6.0	pF
Dynamic "On" Series Resistance		$r_{ec(on)}$				Ohms
(I_B = 1.0 mAdc, I_E = 0, I_c = 100 μArms, f = 1.0 kHz)	2N2944		–	4.0	20	
	2N2945		–	4.5	35	
	2N2946		–	5.0	45	

*Indicates JEDEC Registered Data.

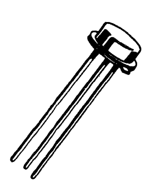
2N2945A (SILICON)
2N2946A

PNP SILICON ANNULAR TRANSISTORS

. . . designed for low level, high-speed chopper applications.

- Low Offset Voltage – $V_{EC(ofs)}$ = 0.23 mVdc (Typ) @ I_B = 200 μAdc (2N2945A)
- High Emitter-Base Voltage – V_{EB} = 40 Vdc (2N2946A)
- Low Dynamic "On" Series Resistance – $r_{ec(on)}$ = 5.0 Ohms (Typ) @ I_B = 1.0 mAdc (2N2945A)

PNP SILICON CHOPPER TRANSISTORS



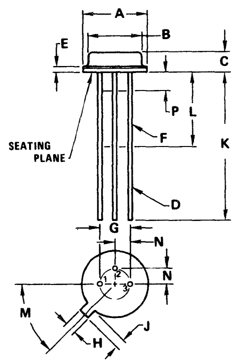
MAXIMUM RATINGS

Rating	Symbol	2N2945A	2N2946A	Unit
*Emitter-Collector Voltage	V_{ECO}	20	35	Vdc
*Collector-Base Voltage	V_{CB}	25	40	Vdc
*Emitter-Base Voltage	V_{EB}	25	40	Vdc
*Collector Current	I_C	100		mAdc
*Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.3		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.43		Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C
*Lead Temperature 1/16" from Case fo 10 seconds	T_L	240		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	435	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	°C/W

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

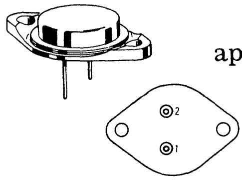
CASE 26-03
TO-46

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Emitter-Collector Breakdown Voltage		BV_{ECO}				Vdc
(I_E = 10 μAdc, I_B = 0)	2N2945A		20	–	–	
	2N2946A		35	–	–	
*Collector Cutoff Current		I_{CBO}				nAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N2945A		–	–	0.2	
(V_{CB} = 40 Vdc, I_E = 0)	2N2946A		–	–	0.5	
(V_{CB} = 25 Vdc, I_E = 0, T_A = 100°C)	2N2945A		–	–	20	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N2946A		–	–	25	
*Emitter Cutoff Current		I_{EBO}				nAdc
(V_{EB} = 25 Vdc, I_C = 0)	2N2945A		–	–	0.2	
(V_{EB} = 40 Vdc, I_C = 0)	2N2946A		–	–	0.5	
(V_{EB} = 25 Vdc, I_C = 0, T_A = 100°C)	2N2945A		–	–	15	
(V_{EB} = 40 Vdc, I_C = 0, T_A = 100°C)	2N2946A		–	–	20	
***ON CHARACTERISTICS**						
DC Current Gain		h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 0.5 Vdc)	2N2945A		70	200	–	
	2N2946A		50	200	–	
DC Current Gain (Inverted Connection)		$h_{FE(inv)}$				–
(I_B = 200 μAdc, V_{EC} = 0.5 Vdc)	2N2945A		30	32	–	
	2N2946A		20	25	–	
Emitter-Collector Offset Voltage		$V_{EC(ofs)}$				mVdc
(I_B = 200 μAdc, I_E = 0)	2N2945A		–	0.23	0.5	
	2N2946A		–	0.27	0.8	
(I_B = 1.0 mAdc, I_E = 0)	2N2945A		–	0.5	1.0	
	2N2946A		–	0.6	2.0	
(I_B = 2.0 mAdc, I_E = 0)	2N2945A		–	0.9	1.6	
	2N2946A		–	1.0	2.5	
***DYNAMIC CHARACTERISTICS**						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	2N2945A		10	15	–	
	2N2946A		5.0	8.0	–	
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 0.1 MHz to 1.0 MHz)		C_{ob}	–	3.2	10	pF
Input Capacitance (V_{EB} = 6.0 Vdc, I_C = 0, f = 0.1 MHz to 1.0 MHz)		C_{ib}	–	1.9	6.0	pF
Dynamic "On" Series Resistance		$r_{ec(on)}$				Ohms
(I_B = 1.0 mAdc, I_E = 0, I_e = 100 μArms, f = 1.0 kHz)	2N2945A		–	5.0	6.0	
	2N2946A		–	7.0	8.0	

*Indicates JEDEC Registered Data.

2N2947 (SILICON)
2N2948



NPN silicon annular transistors for power amplifier applications to 100 MHz.

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE - COLLECTOR

CASE 1
(TO-3)

Collector connected to case

MAXIMUM RATINGS*

Rating	Symbol	2N2947	2N2948	Unit
Collector-Base Voltage	V_{CB}	60	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	40	Vdc
Emitter - Base Voltage	V_{EB}	3.0	2.0	Vdc
Collector-Current (continuous)	I_C	1.5		Adc
Base-Current (continuous)	I_B	500		mAdc
Power Input (Nominal)	P_{in}	5.0		Watts
Power Output (Nominal)	P_{out}	20.0		Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0		Watts
Derating Factor above 25°C		167		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature Range	T_{stg}	-65 to + 175		°C

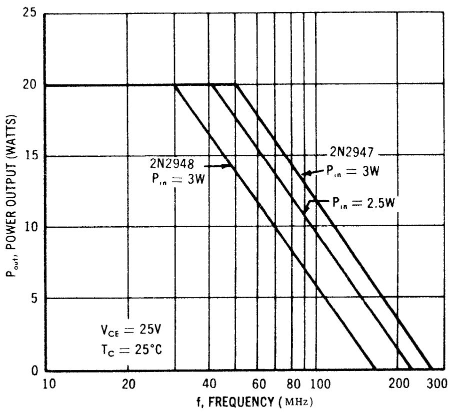
*The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

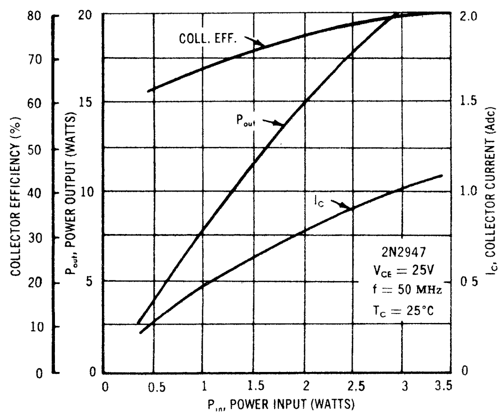
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$ (1)	2N2947: I_C = 0.250 A, R_{BE} = 0	90	120	--	Volts
		2N2948: I_C = 0.250A, R_{BE} = 0	80	100	--	
Collector-Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$ (1)	2N2947: I_C = 0.250A, I_B = 0	40	--	--	Volts
		2N2948: I_C = 0.250A, I_B = 0	20	--	--	
Collector-Emitter Current	I_{CES}	2N2947: V_{CE} = 60 Vdc, V_{BE} = 0	--	--	0.5	mAdc
		V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
		2N2948: V_{CE} = 40 Vdc, V_{BE} = 0	--	--	0.5	
		V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
Collector Cutoff Current	I_{CBO}	2N2947: V_{CB} = 50 Vdc, I_E = 0	--	--	1.0	μAdc
		2N2948: V_{CB} = 30 Vdc, I_E = 0	--	--	1.0	
Emitter Cutoff Current	I_{EBO}	2N2947: V_{EB} = 3 Vdc, I_C = 0	--	--	100	μAdc
		2N2948: V_{EB} = 2 Vdc, I_C = 0	--	--	100	
DC Current Gain	h_{FE}	2N2947: I_C = 400 mAdc, V_{CE} = 2Vdc	6.0	--	60	
		2N2948: I_C = 400 mAdc, V_{CE} = 2 Vdc	2.5	--	100	
		Both Types: I_C = 1 Adc, V_{CE} = 2 Vdc	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	2.0	Vdc
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 2.0 Vdc, I_C = 400 mAdc, f = 50 MHz	2.0	--	--	
Collector Output Capacitance	C_{ob}	V_{CB} = 25 Vdc, I_E=0, f = 100 kHz	--	--	60	pF
Power Input	P_{in}	P_{out} = 15 W, f = 50 MHz, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1A 2N2947	60	80	--	%
Power Input	P_{in}	P_{out} = 15 W, f = 30 MHz, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1.0 A 2N2948	60	70	--	%

(1) Pulse Measurement: Pulse Width ≦ 100 μs, Duty Cycle = 2.0%.

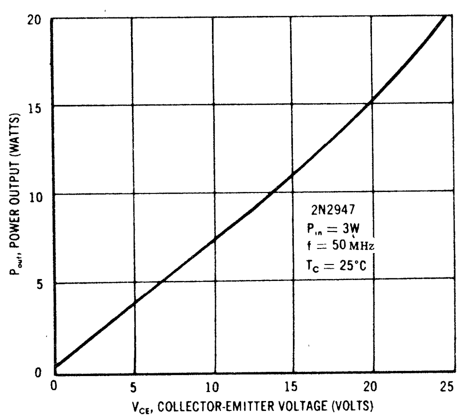
POWER OUTPUT versus FREQUENCY



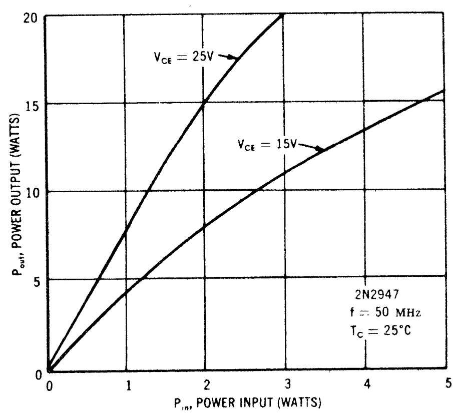
OUTPUT CHARACTERISTICS versus POWER INPUT



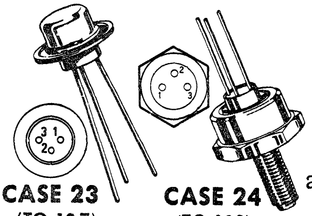
POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT



2N2949 (SILICON)
2N2950



CASE 23 (TO-107) 2N2949

CASE 24 (TO-102) 2N2950

NPN silicon annular transistors for power amplifier and driver applications to 100 MHz.

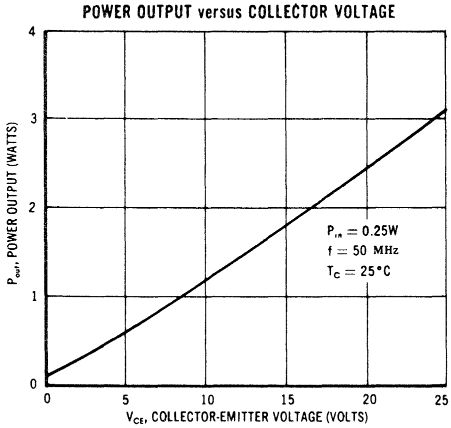
Collector connected to case;
stud isolated from case
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS*

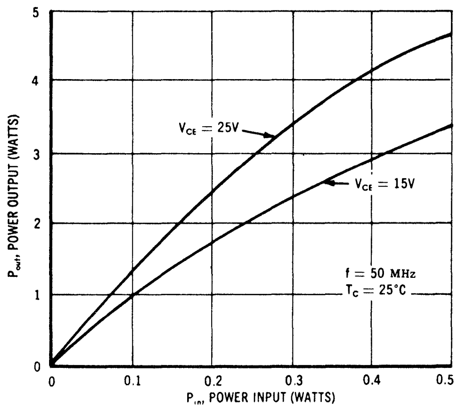
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter - Base Voltage	V_{EB}	3.0	Vdc
Collector Current (Continuous)	I_C	0.7	Adc
Base Current (Continuous)	I_B	100	mAdc
RF Input Power (Nom)	P_{in}	1.0	Watt
RF Output Power (Nom)	P_{out}	5.0	Watts
Total Device Dissipation (25°C Case temperature) (Derating Factor above 25°C)	P_D	6.0 40	Watts mW/°C
Total Device Dissipation at 25° Ambient (Derating Factor above 25°C)	P_D	2N2949: 0.5, 3.33 2N2950: 0.7, 4.67	Watt mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to + 175	°C

* The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.

POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT

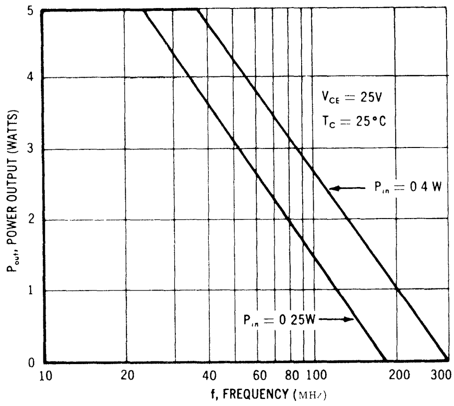


ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

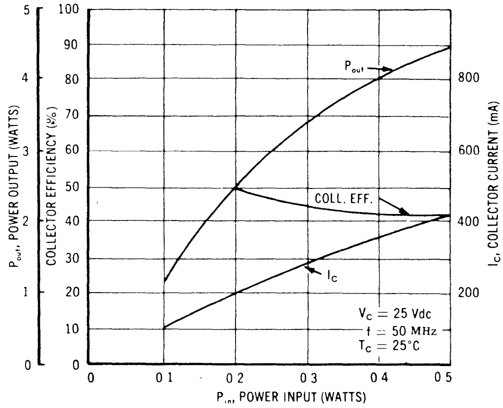
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$ (1)	I_C=0.250 A, R_{BE}= 0	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$ (1)	I_C=0.250A, I_B=0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE}= 60 Vdc, V_{BE}=0	--	--	100	μAdc
		V_{CE}=50 Vdc, V_{BE}= 0 T_C= + 175°C	--	--	500	
Collector - Cutoff Current	I_{CBO}	V_{CB}=50 Vdc, I_E=0	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB}= 3 Vdc, I_C=0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE}= 2.0 Vdc I_C= 40 mAdc	5.0	--	100	--
		V_{CE}=2.0 Vdc I_C= 400 mAdc	5.0	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C= 400 mAdc, I_B= 80 mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C=400 mAdc, I_B=80mAdc	--	--	2.0	Vdc
AC Current Gain	$\|h_{fe}\|$	V_{CE}=2.0 Vdc I_C=40 mAdc, f=50 MHz	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB}= 25 Vdc, I_E=0 f=100 kHz	--	--	20	pF
Power Input	P_{in}	P_{out}=3.5 watts, f=50 MHz V_{CE}=25 Vdc, $I_{C(max)}$=325 mA	--	--	0.35	Watt
Efficiency	η		43	--	--	%

(1) Pulse Width ≤ 100μs, Duty Cycle = 2%

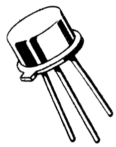
POWER OUTPUT versus FREQUENCY



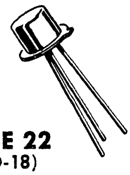
OUTPUT CHARACTERISTICS versus POWER INPUT



2N2951S (SILICON)
2N2952

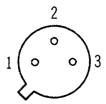


CASE 79
(TO-39)
2N2951



CASE 22
(TO-18)
2N2952

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon annular Star transistors for power amplifier applications to 100 MHz.

*MAXIMUM RATINGS(1)

Rating	Symbol	Value		Units
Collector-Base Voltage	V_{CB}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current (continuous)	I_C	250		mAdc
Base Current (continuous)	I_B	50		mAdc
		2N2951	2N2952	
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_D	3.0 20	1.8 12	Watts mW/°C
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	0.8 5.33	0.5 3.33	mW/°C
Junction Temperature	T_J	-65 to 175		°C
Storage Temperature Range	T_{stg}	-65 to 175		°C

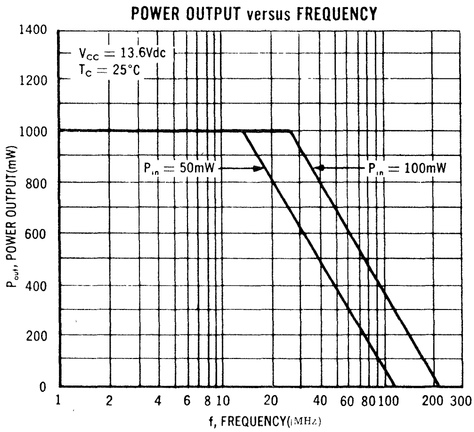
(1) The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See Electrical Characteristics.

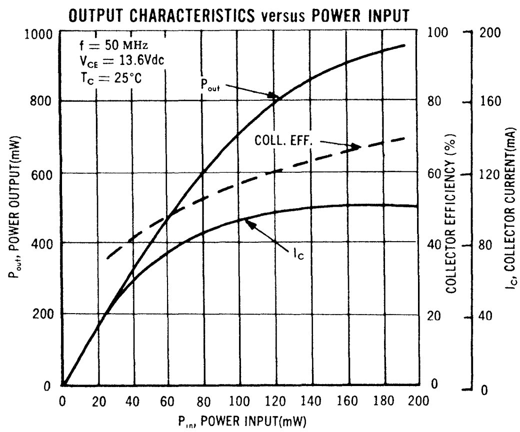
* Indicates JEDEC Registered Data

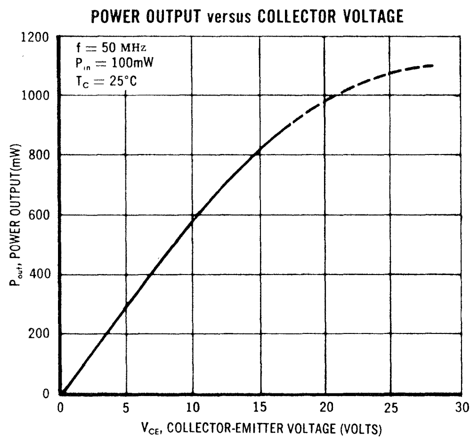
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	100	μAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = 175°C	--	500	μAdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 50 Vdc, I_E = 0	--	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5 Vdc, I_C = 0	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10Vdc	20	150	--
		I_C = 150mAdc, V_{CE} = 10 Vdc*	20	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 150 mAdc, I_B = 15 mAdc	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE}(sat)$	I_C = 150 mAdc, I_B = 15 mAdc	--	2.0	Vdc
Collector-Emitter Sustain Voltage (1)	$V_{CES(sus)}$	I_C = 100 mA, R_{BE} = 0	30	--	Volts
Collector-Emitter Open Base (1) Sustain Voltage	$V_{CEO(sus)}$	I_C = 100 mA, I_B = 0	20	--	Volts
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 50 MHz	4.0	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E=0 , f = 100kHz	--	8.0	pF
Power Input	P_{in}	Test Circuit Fig. 1 P_{out} = 600 mW f = 50 MHz V_{CE} = 13.6 Vdc $I_{C(max)}$ = 125 mA	--	100	mW
Efficiency	η		35	--	%

(1) Pulse Width = 100 μs, Duty Cycle = 2%
*Indicates JEDEC Registered Data







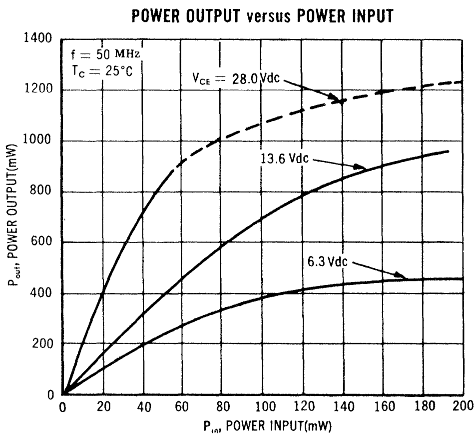
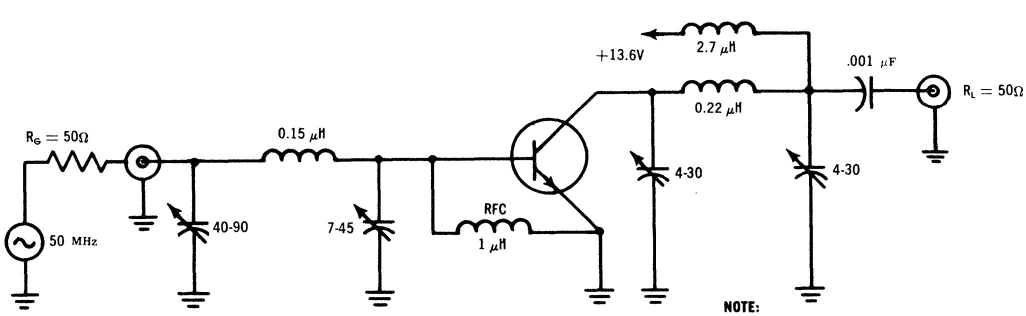


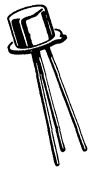
FIGURE 1 — POWER OUTPUT AND POWER GAIN CIRCUIT



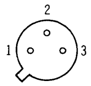
NOTE:
GROUND POINT must be kept as close as possible to the transistor emitter lead. Transistor must be mounted with heat sink.

2N2955 (Ge Mesa)
2N2956

PNP germanium mesa transistors for high-speed switching applications.



CASE 22-03
(TO-18)



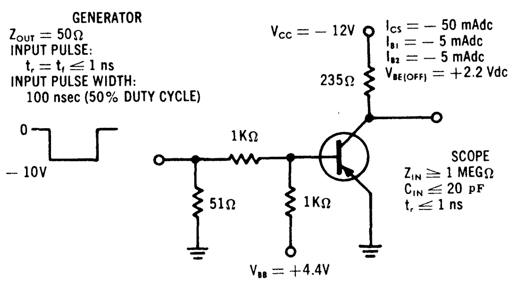
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

* MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector-Emitter Voltage 2N2955 2N2956 2N2957	V_{CEO}	25 20 18	Vdc
Collector Current - Continuous	I_C	100	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0	mW mW/°C

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



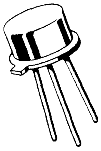
* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

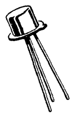
Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.5	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc)	2N2955	BV_{CEO}	25	---	Vdc
	2N2956		20	---	
Collector-Emitter Reverse Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)		I_{CEX}	---	10	μAdc
Base Leakage Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)		I_{BL}	---	10	μAdc
On Characteristics					
Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2955	h_{FE}	20	---	---
	2N2956		30	---	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N2955		20	60	
	2N2956		40	120	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N2956		30	---	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N2955	$V_{CE(sat)}$	---	0.20	Vdc
	2N2956		---	0.18	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955		---	0.30	
	2N2956		---	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956		---	0.34	
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N2955	V_{BE}	---	0.50	Vdc
	2N2956		---	0.47	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955		---	0.65	
	2N2956		---	0.60	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956		---	0.70	
Transient Characteristics					
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	---	4.0	pF
Small Signal Forward Current Transfer Ratio (V_{CE} = 5 Vdc, I_C = 10 mAdc, f = 100 MHz)	2N2955	h_{fe}	2.0	---	---
	2N2956		2.5	---	
Delay Time (V_{CC} = 12 Vdc, I_{CS} = 50 mAdc, I_{B1} = 5 mAdc, V_{BE} (Off) = 2.2 Vdc)		t_d	---	15	ns
Rise Time (same conditions as t_d)	2N2955	t_r	---	40	ns
	2N2956		---	30	
Storage Time (V_{CC} = 12 Vdc, I_{CS} = 50 mAdc, I_{B1} = 5 mAdc, I_{B2} = 5 mAdc)	2N2955	t_s	---	40	ns
	2N2956		---	55	
Fall Time (same conditions as t_s)	2N2955	t_f	---	40	ns
	2N2956		---	35	

*Indicates JEDEC Registered Data

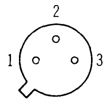
2N2959S (SILICON)

2N3116





NPN silicon annular transistors for high-speed switching and amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79 (TO-39)

CASE 22 (TO-18)

2N2959 2N3116

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N2959	2N3116	Unit
Collector-Base Voltage	V_{CB}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Emitter-Base Voltage	V_{EB}	5.0	5.0	Vdc
Collector-Current	I_C	600	600	mAdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	 3.0 20	 1.8 12	 Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	 0.6 4.00	 0.4 2.67	 Watts mW/°C
Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

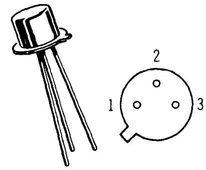
Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 --- ---	 0.025 15	μAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	---	.050	μAdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	---	.050	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, pulsed, I_B = 0)	BV_{CEO}	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	---	Vdc
Collector Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	V_{CE} (sat)	---	0.5	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	V_{BE} (sat)	---	1.3	Vdc
DC Forward Current Transfer Ratio (I_C = 150 mAdc, 2N2958, 2N3115 V_{CE} = 10 Vdc) 2N2959, 2N3116	h_{FE}	 40 100	 120 300	---
Common-Base Open Circuit Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 100 kHz)	C_{ob}	---	8.0	pF
Delay Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_d	---	20	ns
Rise Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_r	---	75	ns
Storage Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_s	---	300	ns
Fall Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = 15 mA, I_{B2} = 15 mA)	t_f	---	200	ns
Current Gain-Bandwidth Product (I_C = 20 mA, V_{CE} = 20 V, f = 100 MHz)	f_T	250	---	MHz

[1] **PULSE TEST: Pulse width ≤ 300 μs, duty cycle ≤ 2%**

*Indicates JEDEC Registered Data

2N3009 (SILICON)
2N3013
2N3013 JAN AVAILABLE
2N3014

NPN silicon epitaxial switching transistors designed for high-speed, medium-power saturated switching applications



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 27
(TO-52)

Collector Connected to Case

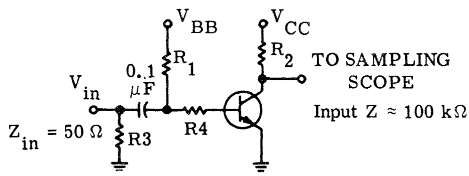
***MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}		Vdc
2N3009, 2N3013		15	
2N3014		20	
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}		Vdc
2N3009		4.0	
2N3013, 2N3014		5.0	
Collector Current — Continuous	I_C	200	mAdc
(10 μs pulse) Peak		500	
Total Device Dissipation @ T_A = 25°C	P_D	0.36	Watt
Derate above 25°C		2.06	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.20	Watts
@ T_C = 100°C		0.68	Watt
Derate above 25°C		6.85	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

(1) Applicable from 0.01 mA to 10 mA (Pulsed)

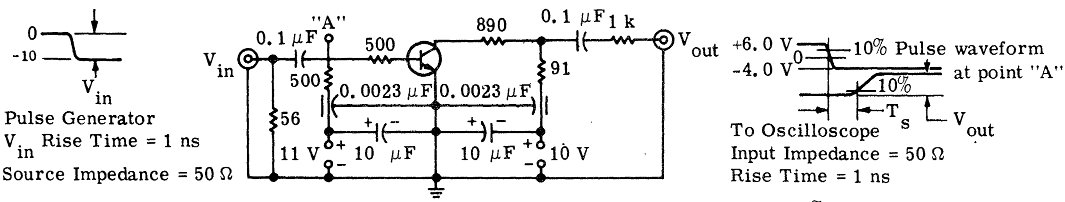
* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT



		SWITCHING TEST CIRCUIT VALUES							INPUT PULSE		
Type	Test	V_{in}	V_{BB}	V_{CC}	R_1	R_2	R_3	R_4	t_r	t_f	Pulse Width
		(volts)			(ohms)				(nanoseconds)		
2N3009 2N3013	t_{on} & t_{off}	11	-5.0	15	300	50	75	170	<1.0	<1.0	>100
2N3014	t_{on}	7.0	GND	2.0	100	62	100	2.0 k	<1.0	-	>200
	t_{off}	-13	7.0	2.0							

FIGURE 2 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



V_{in} Rise Time less than 1 ns PW = 300 ns Duty Cycle = 2%

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0) 2N3009, 2N3013 2N3014	$BV_{CEO(sus)}$	15 20	- -	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0) 2N3009 2N3013, 2N3014	BV_{EBO}	4.0 5.0	- -	Vdc
Collector-Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0) 2N3009 (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C) 2N3009 (V_{CE} = 20 Vdc, V_{BE} = 0) 2N3013, 2N3014 (V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +125°C) 2N3013, 2N3014	I_{CES}	- - - -	0.5 15 0.3 40	μAdc
Base Current (V_{CE} = 20 Vdc, V_{BE} = 0) 2N3009 2N3013, 2N3014	I_B	- -	0.5 0.3	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 30 mAdc, V_{CE} = 0.4 Vdc) All Types (I_C = 10 mAdc, V_{CE} = 0.4 Vdc) 2N3014 (I_C = 100 mAdc, V_{CE} = 0.5 Vdc) 2N3009, 2N3013 (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) 2N3014 (I_C = 300 mAdc, V_{CE} = 1.0 Vdc) 2N3009, 2N3013 (I_C = 30 mAdc, V_{CE} = 0.4 Vdc, T_A = -55°C) 2N3013, 2N3014	h_{FE}	30 25 25 25 15 12	120 - - - - -	
Collector-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) All Types (I_C = 100 mAdc, I_B = 10 mAdc) 2N3009, 2N3013 (I_C = 100 mAdc, I_B = 10 mAdc) 2N3014 (I_C = 300 mAdc, I_B = 30 mAdc) 2N3009, 2N3013 (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N3014 (I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +85°C) 2N3009 (I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +125°C) 2N3013, 2N3014	$V_{CE(sat)}$	- - - - - - -	0.18 0.28 0.35 0.50 0.18 0.30 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 30 mAdc, I_B = 3.0 mAdc) All Types (I_C = 100 mAdc, I_B = 10 mAdc) All Types (I_C = 300 mAdc, I_B = 30 mAdc) 2N3009, 2N3013 (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N3014	$V_{BE(sat)}$	0.75 - - 0.70	0.95 1.20 1.70 0.80	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	350	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	8.0	pF
Turn-On Time (Figure 1) ($V_{EB(off)}$ = 5.0 V, V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} ≈ 30 mAdc) 2N3009, 2N3013 ($V_{EB(off)}$ = 0, V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} ≈ 3.0 mAdc) 2N3014	t_{on}	- -	15 16	ns
Turn-Off Time (Figure 1) (V_{CC} = 15 V, I_C = 300 mAdc, I_{B1} ≈ I_{B2} ≈ 30 mAdc) 2N3009, 2N3013 (V_{CC} = 2.0 V, I_C = 30 mAdc, I_{B1} ≈ I_{B2} ≈ 3.0 mAdc) 2N3014	t_{off}	- -	25 25	ns
Charge-Storage Time (Figure 2) (I_C ≈ I_{B1} ≈ I_{B2} ≈ 10 mAdc)	t_s	-	18	ns

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle ≤ 2%.

*Indicates JEDEC Registered Data

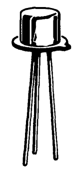
2N3010 (SILICON)

NPN SILICON SWITCHING TRANSISTOR

. . . designed primarily for high-speed, saturated switching applications.

- High Speed Switching Times @ I_C = 10 mAdc –
  $t_{on} \leq$ 12 ns (Max)
  $t_{off} \leq$ 12 ns (Max)

NPN SILICON SWITCHING TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	6.0	Vdc
Collector-Emitter Voltage	V_{CES}	11	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector-Current – Continuous	I_C	50	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.30 1.71	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C
Lead Temperature (Soldering, 60 second time limit)	T_L	300	°C

*Indicates JEDEC Registered Data.
(1) applicable from 0.01 mAdc to 10 mAdc (Pulsed).

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

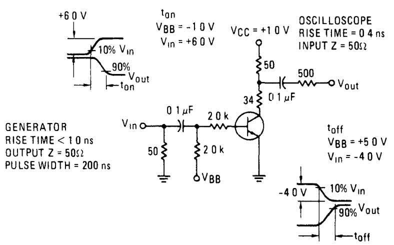
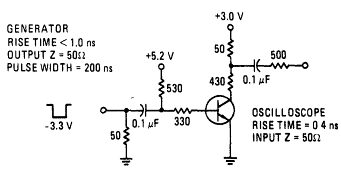
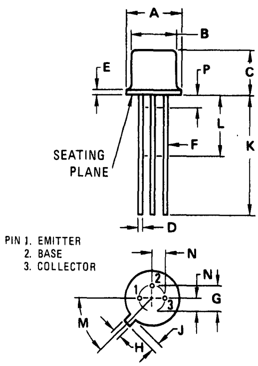


FIGURE 2 – CHARGE-STORAGE TIME TEST CIRCUIT





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

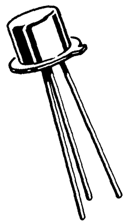
All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

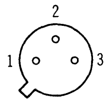
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	6.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	11	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0		Vdc
Collector Cutoff Current (V_{CE} = 11 Vdc, V_{BE} = 0) (V_{CE} = 5.0 Vdc, V_{BE} = 0) (V_{CE} = 5.0 Vdc, V_{BE} = 0, T_A = +85°C)	I_{CES}	 – – –	 10 0.1 5.0	μAdc
Base Cutoff Current (V_{CE} = 11 Vdc, $V_{EB(off)}$ = 0)	I_{BL}	–	10	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 0.4 Vdc) (I_C = 10 mAdc, V_{CE} = 0.4 Vdc) (I_C = 30 mAdc, V_{CE} = 0.4 Vdc)	h_{FE}	 15 25 15	 – 125 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = 85°C)	$V_{CE(sat)}$	 – – – –	 0.25 0.25 0.38 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	 0.68 0.75 –	 0.85 0.95 1.3	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 10 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	f_T	600	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	3.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f - 140 kHz)	C_{ib}	–	2.0	pF
SWITCHING TIMES				
Turn-On Time (Figure 1) (V_{CC} = 1.0 Vdc, $V_{BE(off)}$ = 1.0 Vdc, I_C = 10 mAdc, $I_{B1} \approx 2.0$ mAdc)	t_{on}	–	12	ns
Turn-Off Time (Figure 1) (V_{CC} = 1.0 Vdc, I_C = 10 mAdc, $I_{B1} \approx I_{B2} \approx 1.0$ mAdc)	t_{off}	–	12	ns
Charge Storage Time (Figure 2) ($I_C = I_{B1} \approx I_{B2}$ = 5.0 mAdc)	t_s	–	6.0	ns

*Indicates JEDEC Registered Data.
(1) pulse Test: Pulse Length = 300 μs; Duty Cycle ⩽ 2.0%)



NPN silicon low-power transistor primarily designed for high-speed, saturated switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

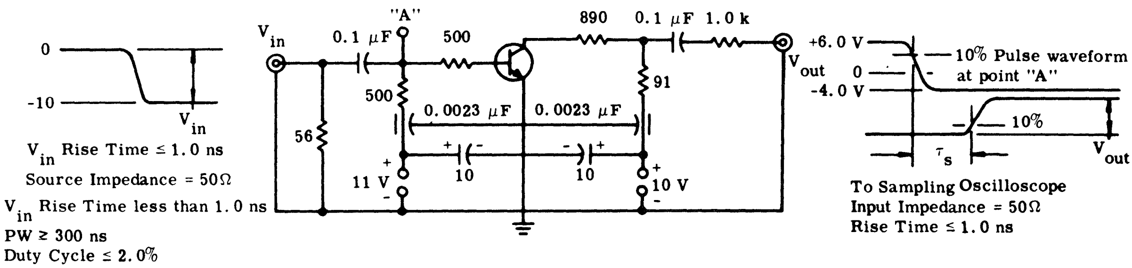
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage(1)	V_{CEO}	12	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector-Current-Continuous Peak (10 μs Pulse)	I_C	200 500	mAdc
Total Device Dissipation @ T_A=25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C=25°C T_C=100°C Derate above 25°C	P_D	1.20 0.68 6.85	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

(1)Applicable from 0.01 mA to 10 mA (Pulsed)

* Indicates JEDEC Registered Data

FIGURE 1 — CHARGE-STORAGE TIME TEST CIRCUIT

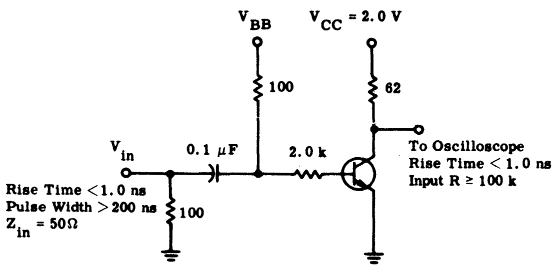


*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	12	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	-	0.4	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0, T_A = +85°C)		-	10	
Base Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{BL}	-	0.4	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.35 Vdc)	h_{FE}	30	120	-
(I_C = 30 mAdc, V_{CE} = 0.4 Vdc)		25	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		12	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.20	Vdc
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	0.50	
(I_C = 10 mAdc, I_B = 1.0 mAdc, T_A = +85°C)		-	0.30	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.72	0.87	Vdc
(I_C = 30 mAdc, I_B = 3.0 mAdc)		-	1.15	
(I_C = 100 mAdc, I_B = 10 mAdc)		-	1.60	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	400	-	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	4.0	pF
Turn-On Time (Figure 2) (V_{CC} = 2.0 Vdc, $V_{EB(off)}$ = 0, $I_C \approx$ 30 mAdc, $I_{B1} \approx$ 3.0 mAdc)	t_{on}	-	15	ns
Turn-Off Time (Figure 2) (V_{CC} = 2.0 Vdc, I_C = 30 mAdc, $I_{B1} \approx -I_{B2} \approx$ 3.0 mAdc)	t_{off}	-	20	ns
Charge Storage Time (Figure 1) ($I_C = I_{B1} \approx -I_{B2} \approx$ 10 mAdc)	t_s	-	13	ns

(1) Pulse Test: Pulse Length = 300 μs, Duty Cycle ≤ 2.0%.
* Indicates JEDEC Registered Data

FIGURE 2 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



T_{on}: V_{BB} Grounded
V_{in} = 7.0 V

T_{off}: V_{BB} = 7.0 V
V_{in} = -13 V

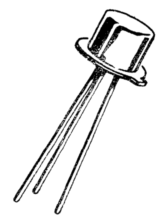
2N3012 (SILICON)

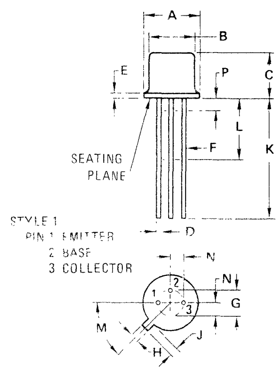
PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in medium-speed saturated switching applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 12 Vdc @ I_C = 10 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.15 Vdc @ I_C = 10 mAdc

PNP SILICON SWITCHING TRANSISTOR





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	[illegible]	[illegible]	0 209	0 230
B	[illegible]	4 95	0 178	0 195
C	4 32	5 33	0 170	0 210
D	0 406	0 533	0 016	0.021
E		0 762	–	0 030
F	0 406	0 483	0 016	0 019
G	2 54 BSC		0 100 BSC	
H	0 914	1 17	0.036	0 046
J	0 711	1.22	0 028	0 048
K	12 70		0 500	--
L	6 35	--	0 250	--
M	45° BSC		45° BSC	
N	1 27 BSC		0 050 BSC	
P	-	1 27	-	0.050

All JEDEC notes and dimensions apply

CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

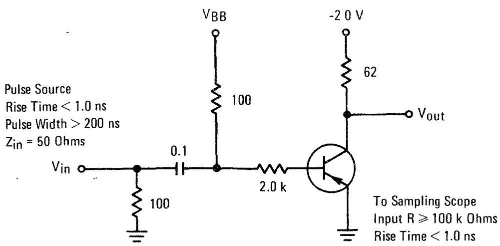
*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 10 mAdc, I_B = 0) (Emitter-Base Termination – Open Base)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	12	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CES}			
(V_{CE} = 6.0 Vdc, V_{BE} = 0)		–	80	nAdc
(V_{CE} = 6.0 Vdc, V_{BE} = 0, T_A = +85°C)		–	5.0	μAdc
Base Current (V_{CE} = 6.0 Vdc, V_{BE} = 0)	I_B	–	30	nAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		25	–	
(I_C = 30 mAdc, V_{CE} = 0.5 Vdc)		30	120	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		20	–	
Collector-Emitter Saturation Voltage(1)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		–	0.15	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		–	0.2	
(I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +85°C)		–	0.4	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	0.5	
Base-Emitter Saturation Voltage(1)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)		0.78	0.98	
(I_C = 30 mAdc, I_B = 3.0 mAdc)		0.85	1.2	
(I_C = 100 mAdc, I_B = 10 mAdc)		–	1.7	
SMALL-SIGNAL CHARACTERISTICS				
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	6.0	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}	4.0	–	–
SWITCHING CHARACTERISTICS (See Figure 1)				
Turn-On Time (V_{CC} = 2.0 Vdc, I_C≈30 mAdc, I_{B1}≈1.5 mAdc)	t_{on}	–	60	ns
Turn-Off Time (V_{CC} = 2.0 Vdc, I_C≈30 mAdc, I_{B1} = I_{B2}≈1.5 mAdc)	t_{off}	–	75	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

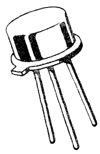


Notes:
(1) Collector Current≈30 mA
(2) Turn On and Turn Off Base Currents≈1.5 mA
(3) t_{on} V_{BB} = +3.0 V V_{in} = −7.0 V
t_{off} V_{BB} = −4.0 V V_{in} = +6.0 V

2N3013
2N3014

For Specifications, See 2N3009 Data.

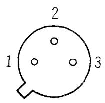
2N3019S (SILICON)
2N3020S



NPN silicon annular transistors designed for high-current, high-frequency amplifier applications.

CASE 79
(TO-39)

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 4.6	W mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	W mW/°C
Operating Junction Temperature Range	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 30 mAdc, I_B = 0)		BV_{CEO}	80	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)		I_{CBO}	–	0.010	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)			–	10	
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	–	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3019	h_{FE}	50	–	–
	2N3020		30	100	
(I_C = 10 mAc, V_{CE} = 10 Vdc)	2N3019		90	–	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3019		100	300	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = -55°C)	2N3019		40	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3019		50	–	
	2N3020		30	100	
(I_C = 1 Adc, V_{CE} = 10 Vdc)	Both Types		15	–	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			–	0.5	
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N3019	f_T	100	–	MHz
	2N3020		80		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	–	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ib}	–	60	pF
Small-Signal Current Gain (I_C = 1mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3019	h_{fe}	80	400	–
	2N3020		30	200	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 4 MHz)		$r_b'C_c$	–	400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, f = 1 kHz, R_S = 1 kohm)	2N3019	NF	–	4.0	dB

(1) Pulse Test: Pulse Width ≦ 300 μs, duty cycle ≦ 1%

*Indicates JEDEC Registered Data

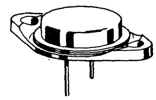
2N3021 (SILICON) thru 2N3026

HIGH-SPEED SILICON PNP POWER TRANSISTORS

. . . designed for high-speed switching and high-frequency amplifier applications.

- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 30 Vdc (Min) — 2N3021, 2N3024
  = 45 Vdc (Min) — 2N3022, 2N3025
  = 60 Vdc (Min) — 2N3023, 2N3026
- Low Collector-Emitter Saturation Voltage — @ I_C = 3.0 Adc
  $V_{CE(sat)}$ = 1.5 Vdc (Max) — 2N3021, 2N3022, 2N3023
  = 1.0 Vdc (Max) — 2N3024, 2N3025, 2N3026
- DC Current Gain — @ I_C = 1.0 Adc
  h_{FE} = 20-60 — 2N3021, 2N3022, 2N3023
  = 50-180 — 2N3024, 2N3025, 2N3026
- Current-Gain—Bandwidth Product —
  f_T = 100 MHz (Typ) @ I_C = 0.5 Adc
- Recommended for High-Current Core Switching and Class C Power Amplifier Applications

3 AMPERE
POWER TRANSISTORS
PNP SILICON
30, 45, 60 VOLTS
25 WATTS



*MAXIMUM RATINGS

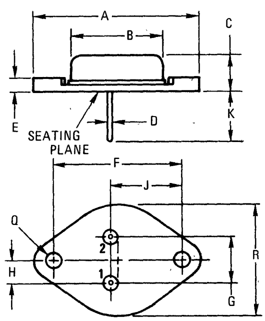
Rating	Symbol	2N3021 2N3024	2N3022 2N3025	2N3023 2N3026	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current — Continuous Peak	I_C	← 3.0 → ← 10 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 25 → ← 0.167 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +175 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	°C/W

*Indicates JEDEC Registered Data.

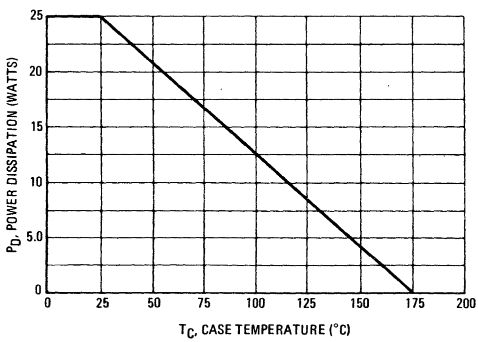
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

FIGURE 1 — POWER DERATING

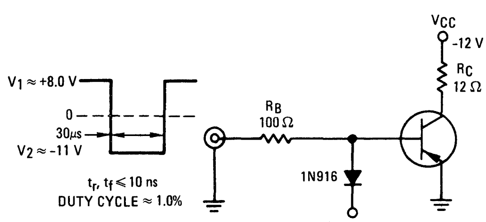


*** ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0	2N3021,2N3024		30	–	
(I_C = 50 mAdc, I_B = 0	2N3022,2N3025		45	–	
(I_C = 20 mAdc, I_B = 0	2N3023,2N3026		60	–	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 25 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	2N3021,2N3024		–	0.2	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	2N3022,2N3025		–	0.2	
(V_{CE} = 54 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	2N3023,2N3026		–	0.2	
(V_{CE} = 15 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = 150°C)	2N3021,2N3024		–	2.0	
(V_{CE} = 25 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = 150°C)	2N3022,2N3025		–	2.0	
(V_{CE} = 35 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = 150°C)	2N3023, 2N3026		–	2.0	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	2N3021,2N3022 2N3023		20	60	
	2N3024,2N3025, 2N3026		50	180	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.3 Adc)	2N3021,2N3022, 2N3023		–	1.5	
	2N3024,2N3025, 2N3026		–	1.0	
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (2) (I_C = 0.5 Adc, V_{CE} = 15 Vdc, f_{test} = 30 MHz)		f_T	60	–	MHz
SWITCHING CHARACTERISTICS					
Turn On Time (V_{CC} = 12 Vdc, $V_{BE(off)}$ = 0, I_C = 1.0 Adc, I_B = 100 mAdc)		t_{on}	–	100	ns
Storage Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)		t_s	–	325	ns
Fall Time (V_{CC} = 12 Vdc, I_C = 1.0 Adc I_{B1} = I_{B2} = 100 mAdc)		t_f	–	75	ns

*Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$.

FIGURE 2 – SWITCHING TIME TEST CIRCUIT



For information on Figures 3 and 6, R_B and R_C were varied to obtain desired test conditions. For t_d and t_r specifications, remove diode and set V_1 = 0.

FIGURE 3 – TURN-ON TIME

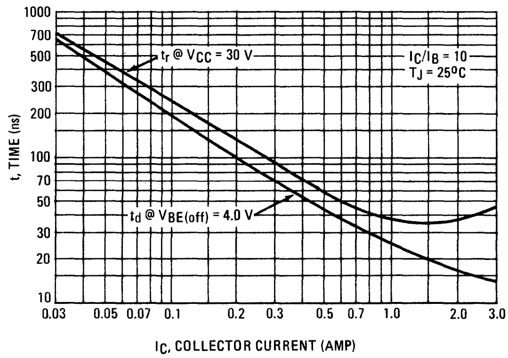


FIGURE 4 – THERMAL RESPONSE

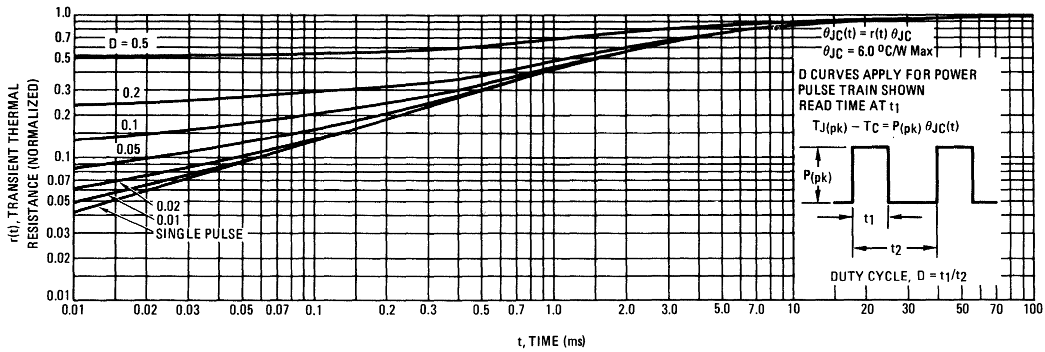
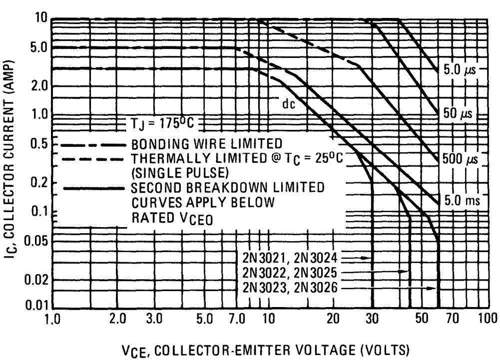


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C – V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 175^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 175^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

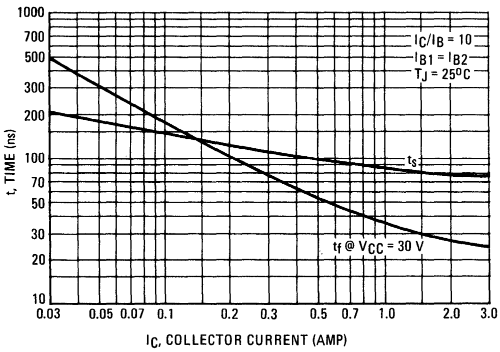


FIGURE 7 – CAPACITANCE

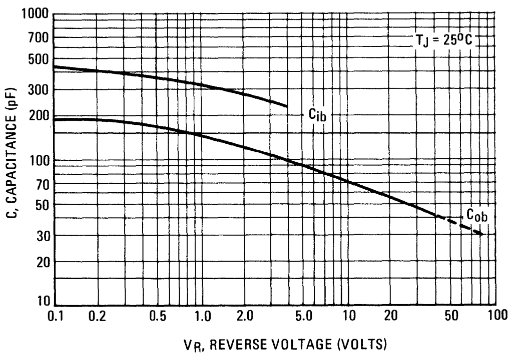


FIGURE 8 – DC CURRENT GAIN

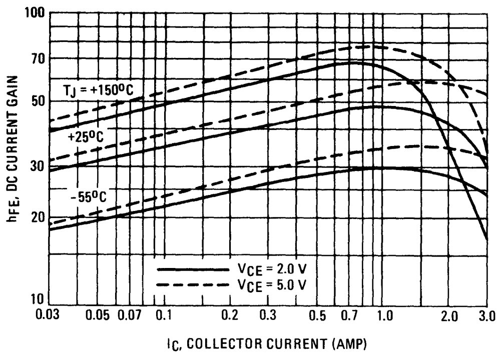


FIGURE 9 – COLLECTOR SATURATION REGION

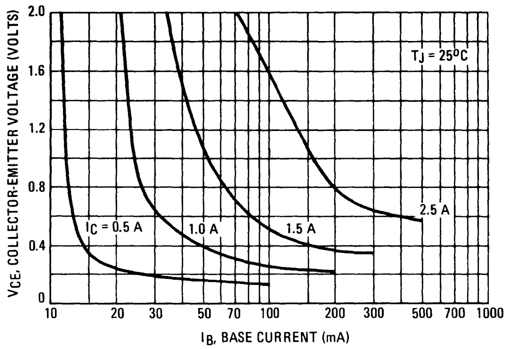


FIGURE 10 – "ON" VOLTAGES

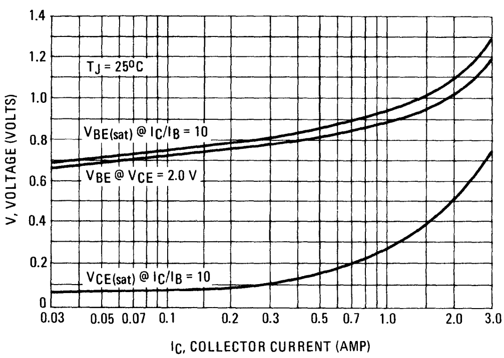


FIGURE 11 – TEMPERATURE COEFFICIENTS

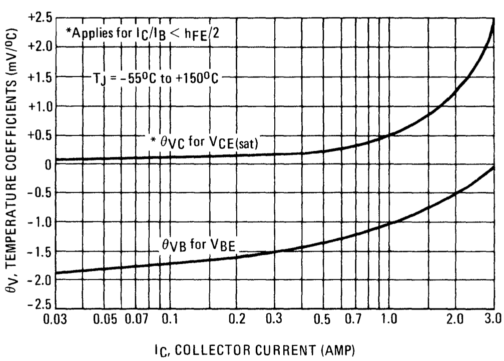


FIGURE 12 – COLLECTOR CUT-OFF REGION

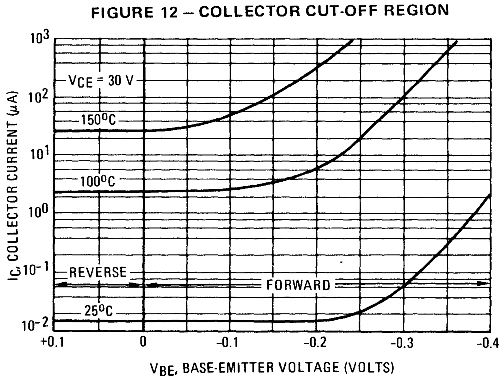
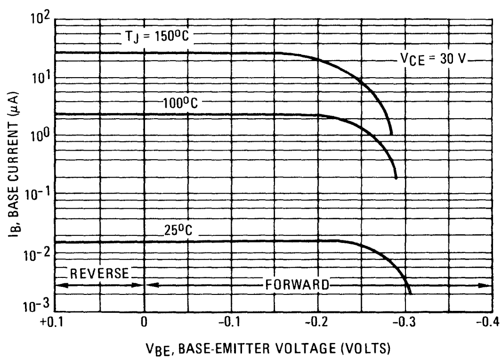


FIGURE 13 – BASE CUT-OFF REGION



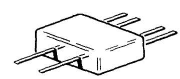
2N3043 thru 2N3048 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices – 2N3044, 2N3047 $\Delta|V_{BE1} - V_{BE2}| = 10\ \mu$Vdc (Max) @ -55 to +25°C
- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)} = 1.0$ Vdc (Max) @ $I_C = 10$ mAdc
- DC Current Gain Specified – 10 μAdc to 1.0 mAdc
- High Current-Gain–Bandwidth Product – $f_T = 30$ MHz @ $I_C = 1.0$ mAdc

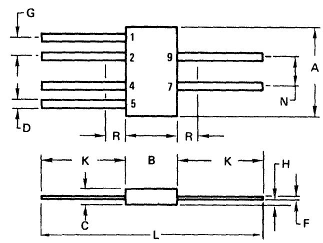
NPN SILICON MULTIPLE TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	30		mAdc
		One Die	Both Die	
Total Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	250 1.67	350 2.33	mW mW/°C
Total Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	0.7 4.67	1.4 9.33	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1. BASE
2. EMITTER
4. EMITTER
5. BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0 290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0 014	0.019
F	0.08	0.15	0 003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1 27	–	0.050

CASE 610A-03

* ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)		$BV_{CEO(sus)}$	45	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)		I_{CBO}	—	0.010	μAdc
(V_{CB} = 45 Vdc, I_E = 0, T_A = +150°C)			—	10	
Emitter-Base Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)		I_{EBO}	—	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3043, 2N3044, 2N3045	h_{FE}	100	300	—
	2N3046, 2N3047, 2N3048		50	200	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N3043, 2N3044, 2N3045		130	—	
	2N3046, 2N3047, 2N3048		65	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$	0.6	0.8	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	30	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	8.0	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3043, 2N3044, 2N3045	h_{ie}	3.2k	19k	Ohms
	2N3046, 2N3047, 2N3048		1.6k	13k	
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3043, 2N3044, 2N3045	h_{fe}	130	600	—
	2N3046, 2N3047, 2N3048		65	400	
Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3043, 2N3044, 2N3045	h_{oe}	—	100	μmhos
	2N3046, 2N3047, 2N3048		—	70	
Noise Figure (I_C = 10 μAdc, V_{CE} = 5 Vdc, R_S = 10k ohms, Bandwidth = 10 Hz to 15.7 kHz)		NF	—	5.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2) (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3043, 2N3046	h_{FE1}/h_{FE2}	0.9	1.0	—
	2N3044, 2N3047		0.8	1.0	
Base-Emitter Voltage Differential (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3043, 2N3046	$\lvert V_{BE1} - V_{BE2} \rvert$	—	5.0	mVdc
	2N3044, 2N3047		—	10	
Base-Emitter Voltage Differential Temperature Gradient (I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +125°C)	2N3043, 2N3046	$\frac{\Delta(V_{BE1} - V_{BE2})}{\Delta T_A}$	—	10	μV/°C
	2N3044, 2N3047		—	20	

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%

(2) The lowest h_{FE} reading is taken as h_{FE1} for this test.

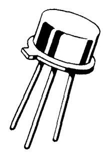
2N3053S (SILICON)
2N3053AS

NPN SILICON TRANSISTORS

. . . designed for general-purpose, medium-current amplifier applications.

- Collector-Emitter Breakdown Voltage – 2N3053A
  BV_{CEO} = 60 Vdc (Min) @ I_C = 100 μAdc
- Low Collector-Emitter Saturation Voltage – 2N3053A
  $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 150 mAdc

NPN SILICON TRANSISTORS



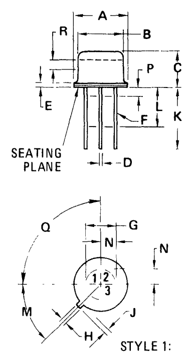
*MAXIMUM RATINGS

Rating	Symbol	2N3053	2N3053A	Unit
Collector-Emitter Voltage (1)	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	700		mAdc
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5.0 28.6		Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC
Lead Temperature 1/16″, ±1/32″ From Case for 10 s	T_L	+235		^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	$^oC/W$

*Indicates JEDEC Registered Data.
(1) Applicable 0 to 100 mA (Pulsed);
Pulse Width ⩽300 μsec., Duty Cycle ⩽2.0%
0 to 700 mA; Pulse Width ⩽10 μsec., Duty Cycle ⩽2.0%



STYLE 1:
PIN 1. EMITTER
2. BASE
CASE-COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8 00	8.51	0 315	0 335
C	6 10	6.60	0 240	0.260
D	0 406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0 406	0 483	0.016	0 019
G	4.83	5.33	0 190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0 029	0.040
K	12 70	–	0.500	–
L	6.35	–	0.250	–
M	45^0 NOM		45^0 NOM	
P	–	1.27	–	0.050
Q	90^0 NOM		90^0 NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Breakdown Voltage (2)		BV_{CEO}			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3053		40	–	
(I_C = 100 μAdc, I_B = 0)	2N3053A		60	–	
Collector-Emitter Breakdown Voltage (2)		BV_{CER}			Vdc
(I_C = 100 mAdc, R_{BE} = 10 Ohms)	2N3053		50	–	
	2N3053A		70	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N3053		60	–	
	2N3053A		80	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	2N3053	I_{EBO}	–	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3053A	I_{BEV}		0.25	μAdc
Collector Cutoff Current		I_{CEV}	–	0.25	μAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 5.0 Vdc)	2N3053				
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3057A				
***ON CHARACTERISTICS (1)**					
DC Current Gain		h_{FE}			–
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)			25	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			50	250	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3053		–	1.4	
	2N3053A		–	0.3	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3053		–	1.7	
	2N3053A		0.6	1.0	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	2N3053		–	1.7	
	2N3053A		–	1.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		f_T	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	–	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	–	80	pF

*Indicates JEDEC Registered Data.
(2) Pulse Test. Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

MEDIUM-POWER NPN SILICON TRANSISTOR

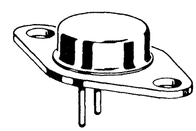
. . . designed for general purpose switching and amplifier applications.

- Aluminum TO-66 Package for Better Power Handling Capability — 75 Watts @ T_C = 25°C
- Excellent Safe Operating Area
- DC Current Gain Specified to 3.0 Amperes
- Complement to PNP Type 2N6049

4 AMPERE

POWER TRANSISTOR NPN SILICON

55 VOLTS
75 WATTS



*MAXIMUM RATINGS

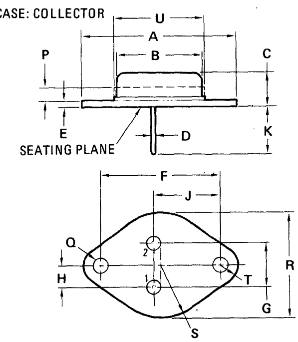
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	55	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	60	Vdc
Collector-Base Voltage	V_{CB}	90	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Peak		10	
Base Current	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D	75	Watts
Derate above 25°C		0.43	W/°C
Operating and Storage Junction, Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.33	°C/W

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

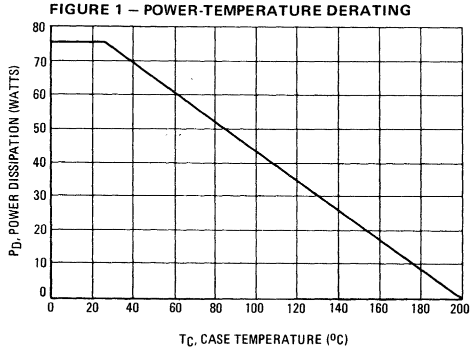


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

FIGURE 1 — POWER-TEMPERATURE DERATING



ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**				
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	$V_{CEO(sus)}$	55	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, R_{BE} = 100 Ω)	$V_{CER(sus)}$	60	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	500	μAdc
Collector Cutoff Current (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 90 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	1.0 6.0	mAdc
Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	1.0	mAdc
***ON CHARACTERISTICS** (1)				
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 4.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	25 5.0	100 –	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc) (I_C =3.0 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	– –	1.0 6.0	Vdc
Base-Emitter On Voltage (I_C = 500 mAdc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 200 mAdc, V_{CE} = 10 Vdc)	f_T	3.0	–	MHz
*Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	25	180	–
*Common-Emitter Cutoff Frequency (I_C = 100 mAdc, V_{CE} = 4.0 Vdc)	f_{hfe}	30	--	kHz

*Indicates JEDEC Registered Data
(1) Pulse test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%

FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUIT

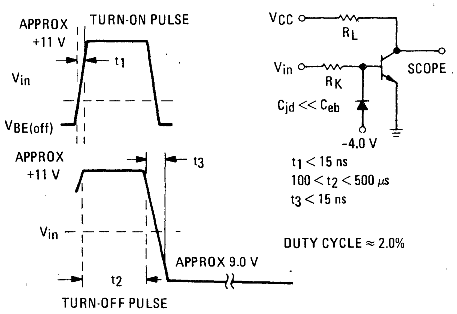


FIGURE 3 – TURN-ON TIME

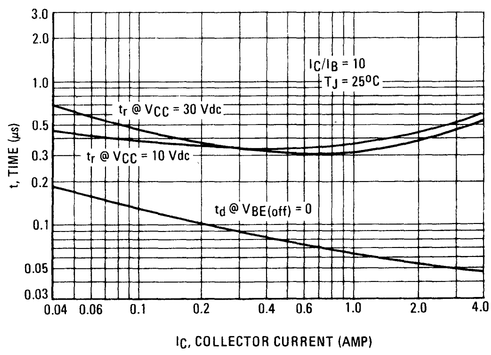


FIGURE 4 – THERMAL RESPONSE

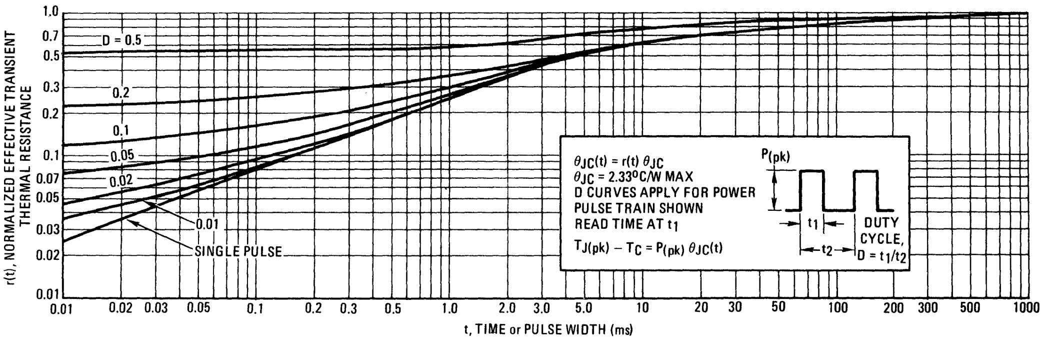
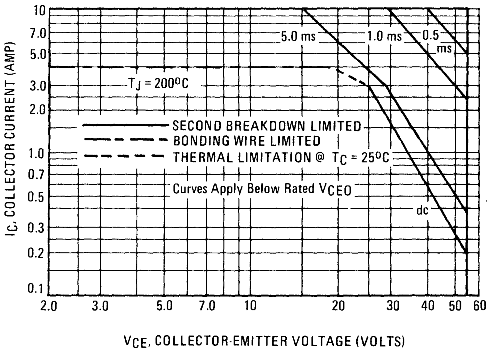


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

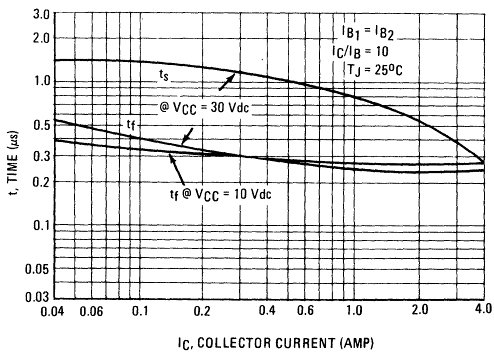


FIGURE 7 – CAPACITANCE

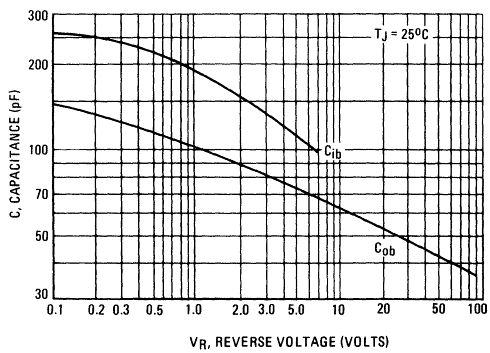


FIGURE 8 – DC CURRENT GAIN

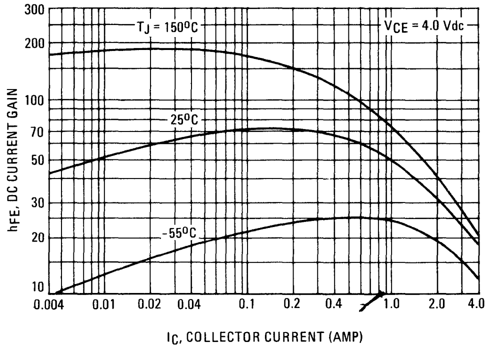


FIGURE 9 – COLLECTOR SATURATION REGION

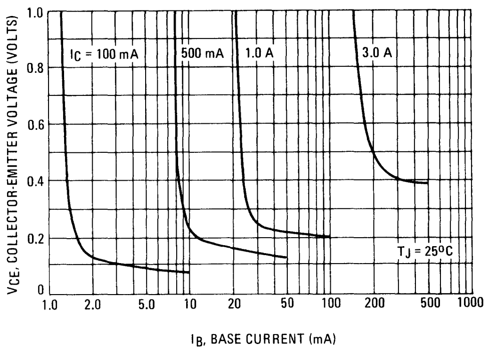


FIGURE 10 – TEMPERATURE COEFFICIENTS

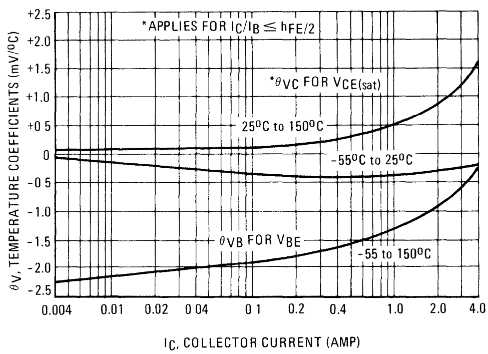


FIGURE 11 – "ON" VOLTAGES

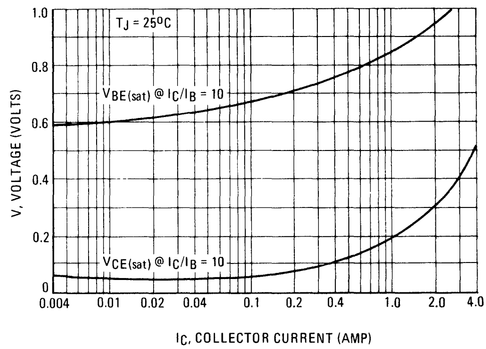


FIGURE 12 – COLLECTOR CUT-OFF REGION

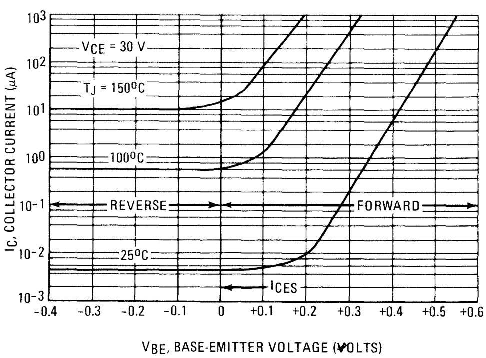
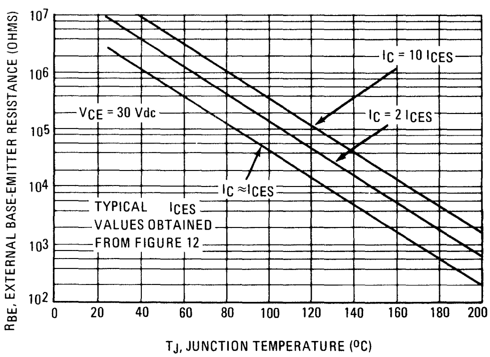


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N3055 (SILICON)

HIGH POWER NPN SILICON POWER TRANSISTOR

. . . EPIBASE transistors for ultimate circuit performance based on the designers requirements.

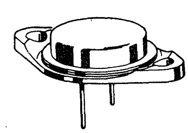
EPIBASE — designed for power amplifier and switching regulator applications. The best choice where high frequency response, low switching losses and good safe operating area are required.

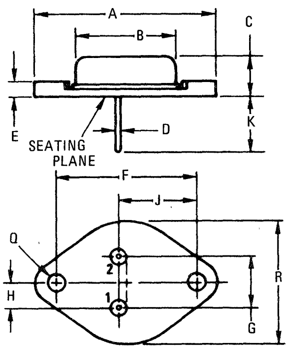
- Current-Gain — Bandwidth Product — f_T = 2.5 MHz (Min) @ I_C = 1.0 Adc
- Safe Operating Area — Full Power Rating to 40 V

15 AMPERE

POWER TRANSISTOR
NPN SILICON

60 VOLTS
115 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

NOTE:
1. DIM "Q" IS DIA.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 11

*MAXIMUM RATINGS

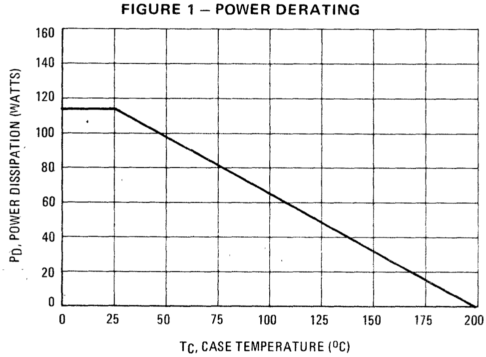
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage Uni-Base	V_{CEX}†	90	Vdc
Collector-Emitter Voltage (R_{BE} = 100 Ω)	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	15	Adc
Base Current	I_B	7.0	Adc
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D	115 0.657	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Devices selected from either process meet or exceed JEDEC Registration.
†Not a Registered Rating.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	°C/W

FIGURE 1 — POWER DERATING

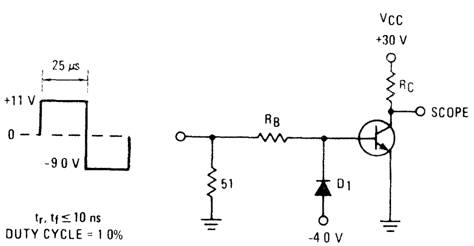


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
*Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, R_{BE} = 100 Ω)	$V_{CER(sus)}$	70	–	Vdc
*Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	I_{CEX}	–	1.0	mAdc
(V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)		–	5.0	
*Emitter Cutoff Current (V_{BE} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20	70	–
(I_C = 10 Adc, V_{CE} = 4.0 Vdc)		5.0	–	
Collector-Emitter Saturation Voltage *(I_C = 4.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$	–	1.1	Vdc
(I_C = 10 Adc, I_B = 3.3 Adc)		–	3.0	
Base-Emitter On Voltage (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	$V_{BE(on)}$	–	1.5	Vdc
Second Breakdown Collector Current With Base Forward-Biased (t = 1.0 s) (V_{CE} = 40 Vdc)	$I_{S/b}$	2.87	–	Adc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f_{test} = 1.0 MHz)	f_T	2.5	–	MHz
*Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 4.0 Vdc, f = 1.0 kHz)	h_{fe}	15	120	–

*Indicates JEDEC Registered Data.

FIGURE 2 — SWITCHING TIMES TEST CIRCUIT



RB and RC VARIED TO OBTAIN DESIRED CURRENT LEVELS

D1 MUST BE FAST RECOVERY TYPE, eg
MBD5300 USED ABOVE IB ≈ 100 mA
MSD6100 USED BELOW IB ≈ 100 mA

FIGURE 3 — TURN-ON TIME

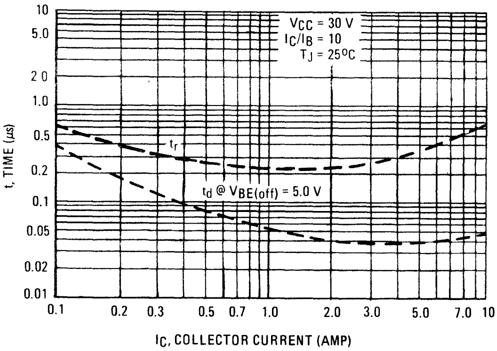
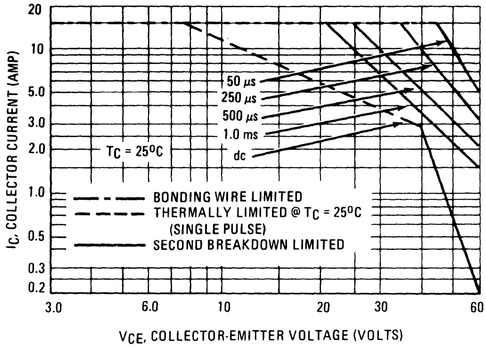


FIGURE 4 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

Second breakdown pulse limits are valid for duty cycles to 10%. At high case temperatures, thermal limitations may reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 5 — COLLECTOR CUT-OFF REGION

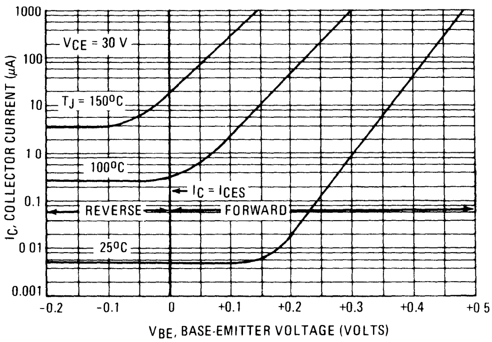


FIGURE 6 — TURN-OFF TIME

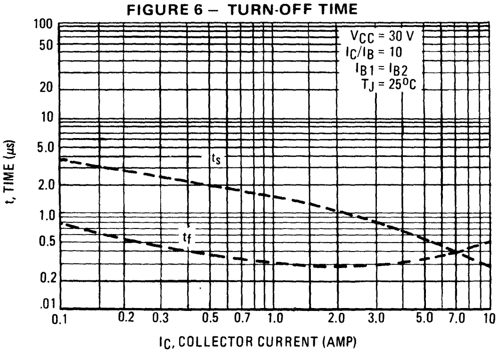


FIGURE 7 — CAPACITANCE

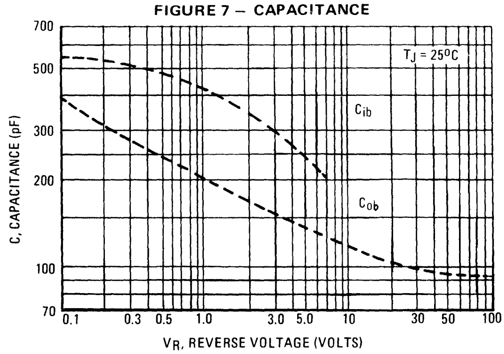


FIGURE 8 — DC CURRENT GAIN

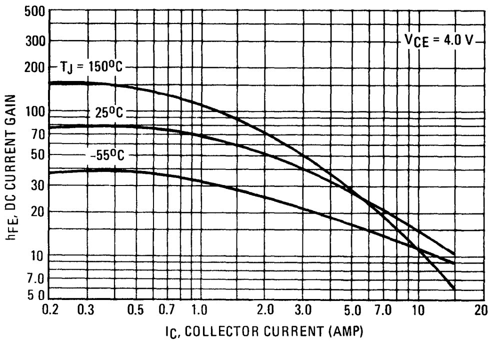


FIGURE 9 — COLLECTOR SATURATION REGION

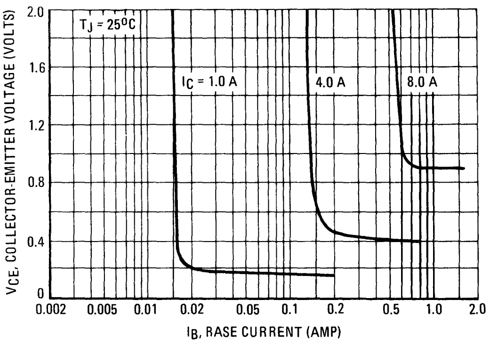
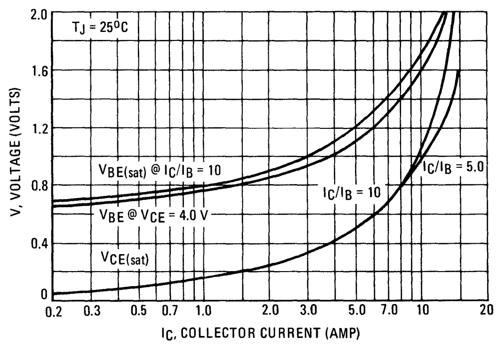


FIGURE 10 — "ON" VOLTAGES



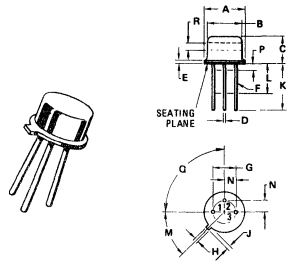
2N3072 (SILICON)
2N3073

PNP SILICON ANNULAR TRANSISTORS

. . . designed for medium-speed, industrial switching applications.

- Choice of Package and Power Ratings
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 50 mAdc
- High Small-Signal Current Gain — h_{fe} = 180 (Max) @ I_C = 10 mAdc

PNP SILICON TRANSISTORS



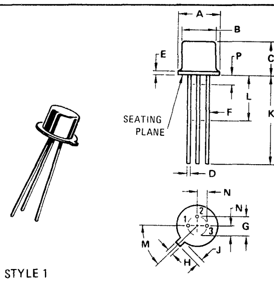
STYLE 1
Pin 1. Emitter
2. Base
3. Collector

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9 40	0.350	0.370
B	8.00	8.51	0 315	0 335
C	6 10	6 60	0.240	0.260
D	0 406	0 533	0 016	0.021
E	0.229	3.18	0 009	0.125
F	0.406	0 483	0 016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0 028	0.034
J	0 737	1.02	0.029	0 040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2 54	–	0 100	–

All JEDEC dimensions and notes apply

2N3072

CASE 79-02
TO-39



STYLE 1
Pin 1 Emitter
2 Base
3. Collector

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5 31	5 84	0 209	0 230
B	4 52	4 95	0 178	0 195
C	4 32	5 33	0 170	0 210
D	0 406	0 533	0 016	0 021
E	–	0 762	–	0 030
F	0 406	0 483	0 016	0 019
G	2 54 BSC		0 100 BSC	
H	0 914	1.17	0.036	0 046
J	0 711	1 22	0.028	0 048
K	12 70	–	0 500	–
L	6 35	–	0 250	–
M	45° BSC		45° BSC	
N	1 27 BSC		0.050 BSC	
P	–	1 27	–	0.050

All JEDEC notes and dimensions apply.

2N3073

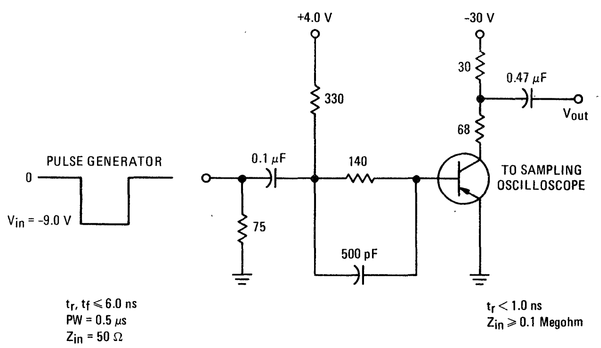
CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	2N3072	2N3073	Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

FIGURE 1 — TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_{CES}	–	10	nAdc
(V_{CE} = 30 Vdc, V_{BE} = 0, T_A = 125°C)		–	10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
Base Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_B	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		30	130	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	–	
(I_C = 300 mAdc, V_{CE} = 2.0 Vdc)		15	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	0.25	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	2.0	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	130	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	10	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	1.5	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	26	$X 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	180	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	1200	μmhos
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time ($I_C \approx$ 300 mAdc, $I_{B1} \approx$ 30 mAdc)	t_{on}	–	40	ns
Turn-Off Time ($I_C \approx$ 300 mAdc, $I_{B1} \approx I_{B2} \approx$ 30 mAdc)	t_{off}	–	100	ns

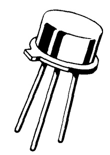
*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

NPN SILICON ANNULAR HIGH-CURRENT AMPLIFIER TRANSISTOR

. . . designed for use in medium-current amplifier applications.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 30 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc
- Low Noise Figure — NF = 5.0 dB (Typ) @ I_C = 30 μAdc

NPN SILICON AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current — Continuous	I_C	1000	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.57	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

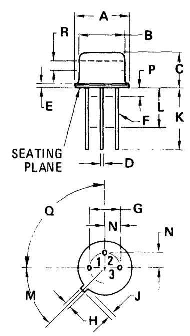
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(2)	220	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W
Lead Temperature, 1/16" ± 1/32" from Case for 60 Seconds	T_L	300	°C

*Indicates JEDEC Registered Data

(1) Applicable for I_C = 1.0 to 50 mA

(2) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.



STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

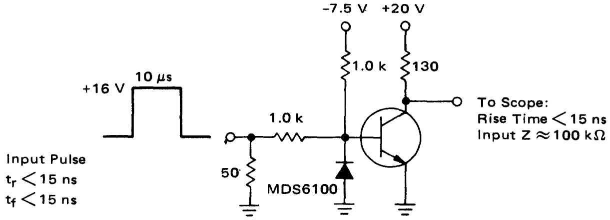
CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

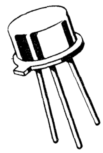
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	80	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	–	–	10	μAdc
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_{CES}	–	–	10	nAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
Base Current (V_{CE} = 60 Vdc, V_{BE} = 0)	I_B	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		20	60	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		40	80	120	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		25	70	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		15	30	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.25	
(I_C = 1.0 Adc, I_B = 100 mAdc)		–	0.8	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.8	1.1	
(I_C = 1.0 Adc, I_B = 100 mAdc)		–	1.2	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	60	100	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	15	25	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	60	80	pF
Noise Figure (I_C = 30 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 kΩ, f = 1.0 kHz, BW = 200 Hz)	NF	–	5.0	7.0	dB
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 20 Vdc, I_C = 150 mAdc, I_{B1} = 7.5 mAdc) (Figure 1)	t_{on}	–	150	200	ns
Turn-Off Time (V_{CC} = 20 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 7.5 mAdc) (Figure 1)	t_{off}	–	490	600	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

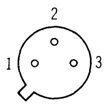


2N3114S (SILICON)



NPN silicon annular transistor designed for high-voltage, low-power video amplifier applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	150	Vdc
Collector-Emitter Voltage(1)	V_{CEO}	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

(1)Between 0 and 30 mA.
*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$	—	1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DC Current Gain(1)	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		15	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	120	
(I_C = 30 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		12	—	
Collector Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)		—	0.010	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)		—	10	
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.10	μAdc
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 20 MHz)	$\|h_{fe}\|$	2.0	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	9.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	80	pF
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5 V, f = 1 kHz)	h_{fe}	25	—	—
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 100 MHz)	$Re(h_{ie})$	—	30	ohms

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≦ 300 μs, duty cycle ≦ 1%

2N3116 (SILICON)

For Specifications, See 2N2959S Data

PNP SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose, medium-speed switching applications.

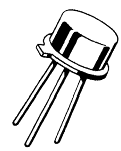
- Choice of Package and Power Ratings
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 50 mAdc
- DC Current Gain Specified From 50 mAdc to 300 mAdc

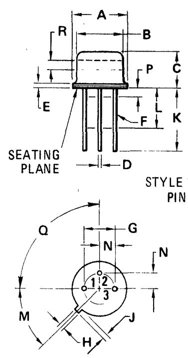
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	45	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.1	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

PNP SILICON TRANSISTOR





STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

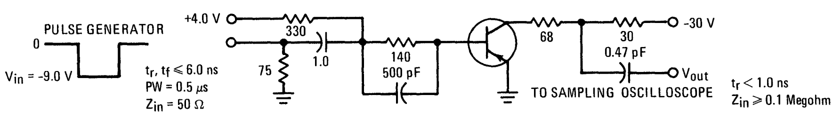
CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	45	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	45	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current	I_{CES}			
(V_{CE} = 30 Vdc, V_{BE} = 0)		–	10	nAdc
(V_{CE} = 30 Vdc, V_{BE} = 0, T_A = 125°C)		–	10	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
Base Current (V_{CE} = 30 Vdc, V_{BE} = 0)	I_B	–	10	nAdc
ON CHARACTERISTICS				
DC Current Gain(1)	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		30	130	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	–	
(I_C = 300 mAdc, V_{CE} = 2.0 Vdc)		15	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	0.25	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.5	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	1.0	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 2.5 mAdc)		–	1.2	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	2.0	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	$V_{BE(on)}$	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product(2) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	130	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	10	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	1.5	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	26	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	180	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	1200	μmhos
SWITCHING CHARACTERISTICS (Figure 1)				
Turn-On Time ($I_C \approx$ 300 mAdc, $I_{B1} \approx$ 30 mAdc)	t_{on}	–	40	ns
Turn-Off Time ($I_C \approx$ 300 mAdc, $I_{B1} = I_{B2} \approx$ 30 mAdc)	t_{off}	–	100	ns

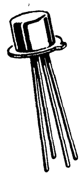
*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

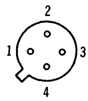
FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



2N3127 JAN (Ge Mesa)

PNP germanium mesa transistor designed for VHF/UHF amplifier applications.





CASE 20-03
(TO-72)

STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

Active Elements Isolated From Case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	0.75	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 1.33	mW mW/°C
Operating & Storage Junction Temperature	T_J, T_{stg}	-65 to +100	°C

*Indicates JEDEC Registered Data

*TABLE I - GROUP A INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	Symbol	Limits		Unit
		Min	Max	
SUBGROUP 1				
Visual and Mechanical Examination	—	—	—	—
SUBGROUP 2				
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	BV_{CEO}	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	25	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	—	3.0	μAdc
Emitter-Base Cutoff Current (V_{BE} = 0.75 Vdc, I_C = 0)	I_{EBO}	—	100	μAdc
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	100	—
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.6	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
SUBGROUP 3				
Small-Signal Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	20	125	—
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 100 MHz)	f_T	400	—	MHz
Collector - Base Capacitance (1) (V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 ≤ 1.0 MHz)	C_{cb} (1)	—	1.2	pF
SUBGROUP 4				
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 85°C)	I_{CBO}	—	50	μAdc
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc, T_A = -55^{+0}_{-3} °C)	h_{FE}	7.0	—	—
SUBGROUP 5				
Power Gain (Figure 1) (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	17	25	dB
Noise Figure (Figure 1) (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	—	5.0	dB

*Indicates JEDEC Registered Data

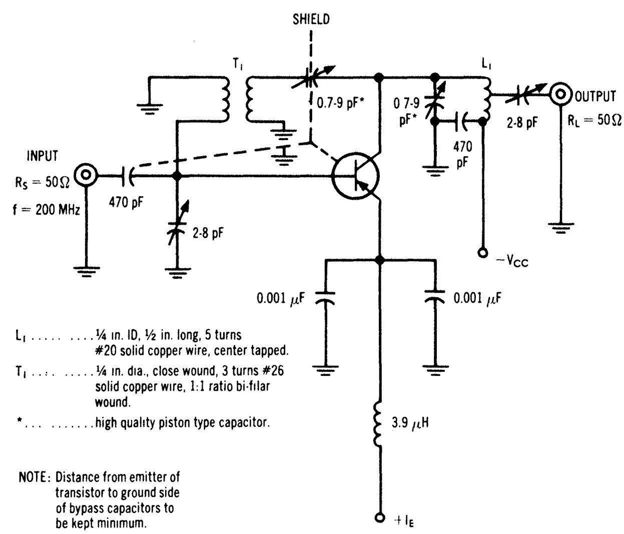
(1) **Measured in a guarded circuit, such that the can capacitance is not included.**

* TABLE II - GROUP C INSPECTION (T_A = 25°C unless otherwise noted)

Examination or Test	Symbol	Limits Min	Limits Max	Unit
SUBGROUP 1				
Collector-Base Time Constant (Figure 2) (I_C = 3 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	—	12	ps
Salt Atmosphere (Corrosion)	—	—	—	—
End-Point Tests:				
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	3.0	μAdc
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	100	—
SUBGROUP 2				
Output Conductance (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 30 MHz)	$Re(h_{oe})$	1.0	3.5	mmhos
Input Conductance (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 30 MHz)	$Re(y_{ie})$	1.25	5.0	mmhos

Group C tests shall be performed on the initial lot and every six months thereafter.

FIGURE 1 — TEST CIRCUIT FOR POWER GAIN AND NOISE FIGURE



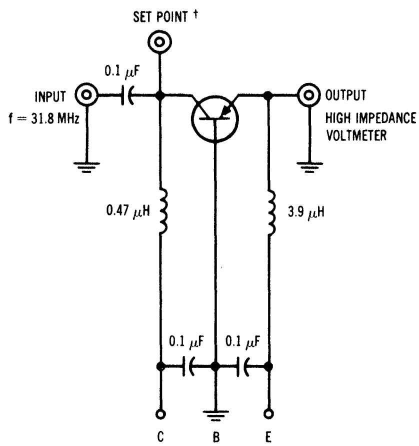
L1 . . . . ¼ in. ID, ½ in. long, 5 turns #20 solid copper wire, center tapped.

T1 . . . . ¼ in. dia., close wound, 3 turns #26 solid copper wire, 1:1 ratio bi-filar wound.

* . . . . high quality piston type capacitor.

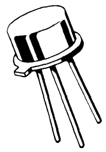
NOTE: Distance from emitter of transistor to ground side of bypass capacitors to be kept minimum.

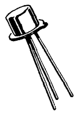
FIGURE 2 — TEST CIRCUIT FOR COLLECTOR-BASE TIME CONSTANT



† NOTE: E_{in} = 0.5 V measured at set point. $r_b'C_c$ = E_{out} (in mV) × 10

2N3133S, 2N3135 (SILICON)

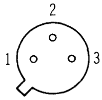




PNP silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

CASE 79
(TO-39)
2N3133

CASE 22
(TO-18)
2N3135



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N3133	2N3135	Unit
Collector-Base Voltage	V_{CB}	50	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	35	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current	I_C	600	600	mA
Total Device Dissipation @25°C Case Temperature Derate Above 25°C	P_D	3 17.3	1.8 10.3	Watts mW/°C
Total Device Dissipation @25°C Ambient Temperature Derate Above 25°C	P_D	0.6 3.43	0.4 2.28	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

*SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typ	Max	Unit
Turn-On Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_{on}	26	75	ns
Turn-Off Time (V_{CC} = 6V, I_{CS} = 150 mA, I_{B1} = I_{B2} = 15 mA)	t_{off}	70	150	ns

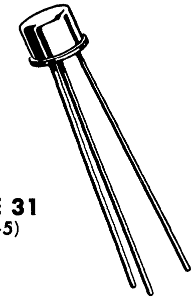
*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 --- ---	 0.05 30	μAdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)	I_{CEX}	---	0.1	μAdc
Base Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)	I_{BL}	---	0.1	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	---	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	35	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.0	---	Vdc
Collector Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	V_{CE} (sat)	---	0.6	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 150 mAdc, I_B = 15 mAdc)	V_{BE} (sat)	---	1.5	Vdc
DC Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) [1]	h_{FE}	 25 40	 --- 120	---
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	---	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	---	40	pF
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	---	MHz

[1] **Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 2%**
*Indicates JEDEC Registered Data

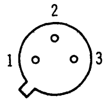
2N3137 (SILICON)
MM1803



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistors for large signal VHF and UHF applications.

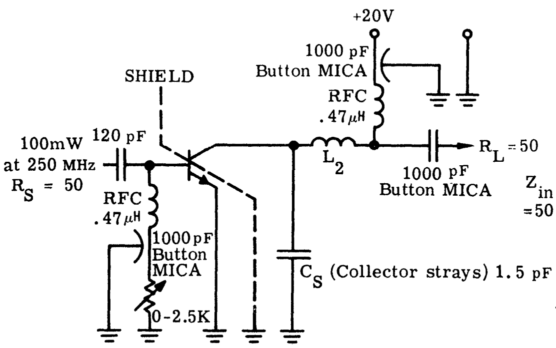


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

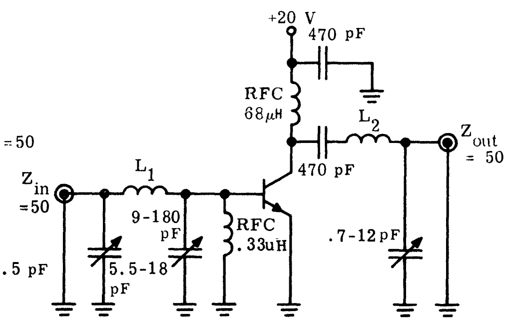
Rating	Symbol	2N3137	MM1803	Units
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	20	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	5.0	Vdc
Collector Current (Continuous)	I_C	150	150	mAdc
Power Dissipation @25°C Case Temperature @25°C Ambient Temperature	P_D	2.0 0.8		Watts
Operating Junction Temperature Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C
Thermal Resistance Junction to Case	θ_{JC}	87.5		°C/Watt
Thermal Resistance Junction to Ambient	θ_{JA}	153		°C/Watt

250 MHz POWER GAIN TEST CIRCUIT (2N3137)



L_2 = .075 µH (5.5 turns #16ga. ID = 3/16" length 1/2")

250 MHz POWER GAIN TEST CIRCUIT (MM1803)



L_1 = 3/4 turn No. 14 tinned wire 3/8" ID
L_2 = 4 turns No. 18 tinned wire 1/4" ID 7/16" long

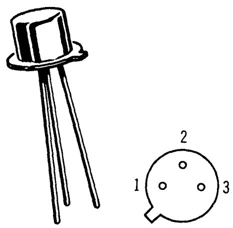
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Breakdown Voltage I_C = 0.1mAdc, I_E = 0	 2N3137 MM1803	V_{CBO}	 40 50			Vdc
Collector-Emitter Open Base Sus. Voltage I_C = 15mAdc, I_B = 0	 2N3137 MM1803	$V_{CEO(sus)}$	 20 25			Vdc
Collector Cutoff Current V_{CB}= 20Vdc, I_E = 0, T_C = +150°C		I_{CBO}			50	μAdc
Collector Cutoff Current V_{CB}= 20Vdc, I_E = 0		I_{CBO}			.05	μAdc
Emitter-Base Breakdown Voltage I_E = 100μA, I_C = 0	 2N3137 MM1803	V_{EBO}	 4.0 5.0			Vdc
DC Current Gain V_{CE} = 5Vdc, I_C = 50mAdc	 2N3137 MM1803	h_{FE}	 20 40		 120 160	
Collector-Emitter Saturation Voltage I_C = 50mAdc, I_E = 5mAdc		$V_{CE(sat)}$			0.3	Vdc
Small Signal Current Gain V_{CE} = 10Vdc, I_C = 50mAdc, f = 100 MHz		$\|h_{fe}\|$	5.0			
Common-base Output Capacitance V_{CB} = 10Vdc, I_C = 0, f = 100 kHz		C_{ob}			3.5	pF
Power Output Power Gain P_{in} = 100mw, f = 250 MHz Efficiency V_{CE} = 20Vdc	 2N3137 	P_{out} G_e η	400 6.0 40	600 7.7 65		mWatts dB %
Power Output Power Gain P_{in} = 100mw, f = 250 MHz Efficiency V_{CE} = 20V	 MM1803 	P_{out} G_e η	560 7.5 45	700 8.5 60		mWatts db %

*Pulse Width ≈ 300 μs, Duty cycle = 1%

2N3210 (SILICON)

NPN silicon high frequency switching transistor is designed for high speed, saturated switching applications for industrial service.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

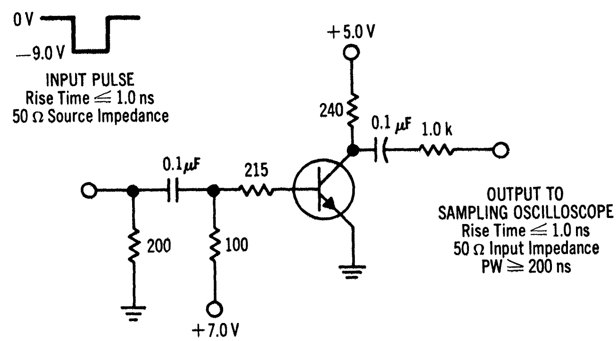
CASE 22
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable from 0 to 500 mAdc	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

*Indicates JEDEC Registered Data

FIGURE 1 — STORAGE TIME TEST CIRCUIT



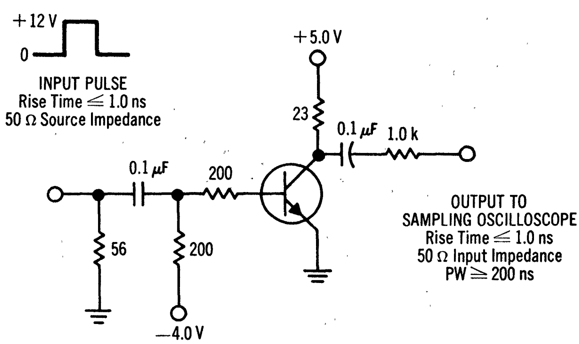
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 2.0 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	-	25	nAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 - -	 0.010 15	μAdc
Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	-	100	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{BL}	-	0.025	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	120	-
Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 2.0 mAdc, T_A = +125°C) (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	 - -	 0.25 0.75	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 200 mAdc, I_B = 20 mAdc)	$V_{BE(sat)}$	 0.7 -	 0.8 1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	6.0	pF
Turn-On Time ($V_{BE(off)}$ ≧ 0.2 Vdc, I_C = 200 mAdc, I_{B1} = 40 mAdc) (Figure 2)	t_{on}	-	40	ns
Turn-Off Time (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc) (Figure 2)	t_{off}	-	40	ns
Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx$ 20 mAdc) (Figure 1)	t_s	-	20	ns

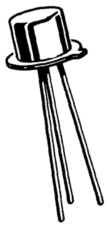
* **Indicates JEDEC Registered Data**

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

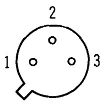
FIGURE 2 — TURN-ON AND TURN-OFF TEST CIRCUIT



2N3211 (SILICON)



CASE 22
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon high frequency switching transistor designed for high speed, saturated switching applications for industrial service.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc)	I_{CEX}	-	25	nAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc) (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3.0 Vdc, T_A = 85°C)	I_{BL}	 - -	 0.025 10	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 100 μAdc, V_{CE} = 1.0 Vdc) (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	 20 50 50 20 40 30 10	 - - 150 - - - -	-
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 - - -	 0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 - - -	 0.85 1.0 1.2	Vdc

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

* **Indicates JEDEC Registered Data**

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	350	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	-	7.0	pF
Charge-Storage Time Constant ($I_C \approx I_{B1} \approx I_{B2} \approx$ 10 mAdc) (Figure 1)	τ_s	-	15	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1.0 mAdc) (Figure 2)	Q_T	-	60	pC
Active Region Time Constant (I_C = 10 mAdc, I_B = 1.0 mAdc) (Figure 3)	τ_A	-	2.5	ns

* Indicates JEDEC Registered Data

FIGURE 1 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

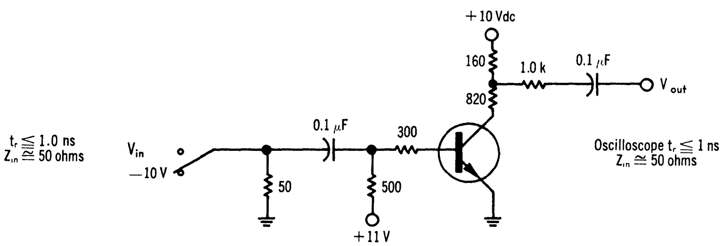


FIGURE 2 — TOTAL CONTROL CHARGE TEST CIRCUIT

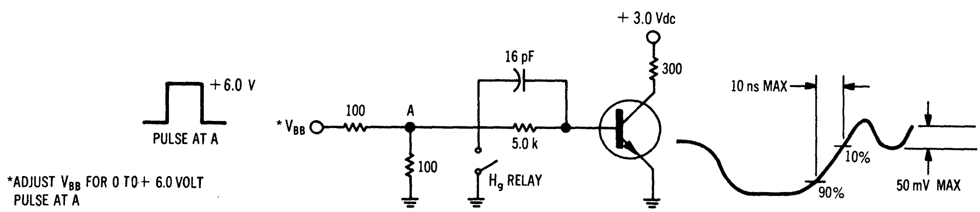
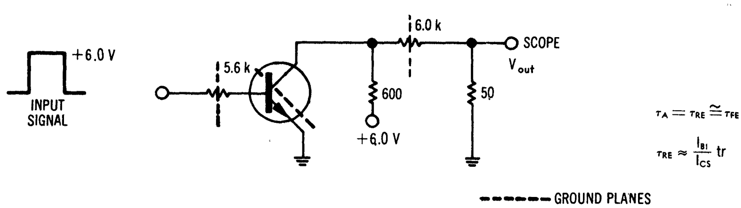


FIGURE 3 — ACTIVE REGION TIME CONSTANT TEST CIRCUIT

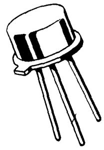


NOTES FOR FIGURES 2, 3

INPUT PULSE — TRANSITION TIME TO +6.0 Vdc ≤ 2.0 ns
INPUT PULSE — OPTIONAL GENERATOR OUTPUT IMPEDANCE: ADJUST FOR + 6.0 Vdc
SCOPE INPUT CAPACITANCE = 3.0 pF MAX
SCOPE INPUT IMPEDANCE = 10 MEGOHMS
SCOPE RISE TIME ≤ 0.7 ns

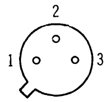
2N3227 (SILICON) For Specifications, See 2N2369 Data.

2N3244S (SILICON)
2N3245S



CASE 79
(TO-39)
Collector connected to case

PNP silicon annular transistors for medium-current, high-speed switching and driver applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N 3244	2N 3245	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	5.0 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.175 35		°C/mW °C/W

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)			I_{CBO}	—	.050	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)				—	10	
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)			I_{CEX}	—	50	nAdc
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)			I_{EBO}	—	30	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)			I_{BL}	—	80	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3244		BV_{CBO}	40	—	Vdc
	2N3245			50	—	
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3244		BV_{CEO}	40	—	Vdc
	2N3245			50	—	
Emitter-Base Breakdown Voltage (I_E = 10μ Adc, I_C = 0)			BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)	2N3244	2,3	$V_{CE(sat)}$	—	0.3	Vdc
	2N3245			—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3244			—	0.5	
	2N3245			—	0.6	
(I_C = 1 Adc, I_B = 100 mAdc)	2N3244			—	1.0	
	2N3245			—	1.2	
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		3	$V_{BE(sat)}$	—	1.1	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)				0.75	1.5	
(I_C = 1 Adc, I_B = 100 mAdc)				—	2.0	
DC Forward Current Transfer Ratio (1) (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N3244	1	h_{FE}	60	—	—
	2N3245			35	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3244			50	150	
	2N3245			30	90	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3244			25	—	
	2N3245			20	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		5	C_{ob}	—	25	pF
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		5	C_{ib}	—	100	pF
Current-Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3244		f_T	175	—	MHz
	2N3245			150	—	
Delay Time (I_C = 500 mA, I_{B1} = 50 mA, V_{OB} = 2 V, V_{CC} = 30 V)		6,8	t_d	—	15	ns
Rise Time	2N3244		t_r	—	35	ns
	2N3245			—	40	
Storage Time (I_C = 500 mA, V_{CC} = 30 V, I_{B1} = I_{B2} = 50 mA)	2N3244	6,9	t_s	—	140	ns
	2N3245				120	
Fall Time			t_f	—	45	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)	2N3244	7,10	Q_T	—	14	nC
	2N3245			—	12	

(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2%

*Indicates JEDEC Registered Data

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

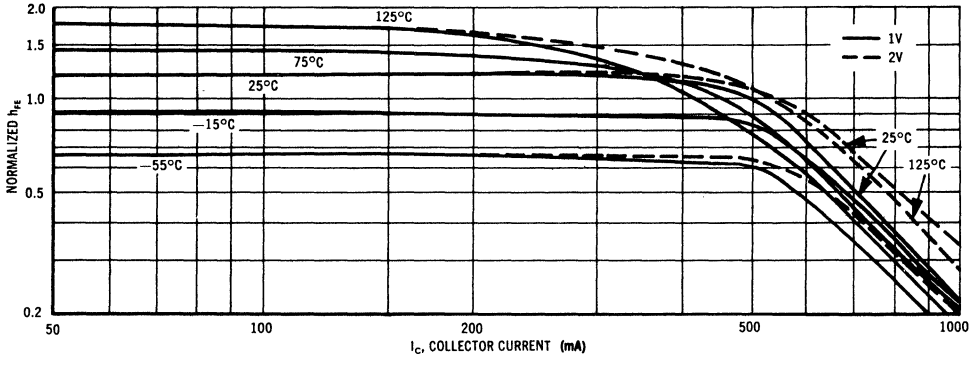
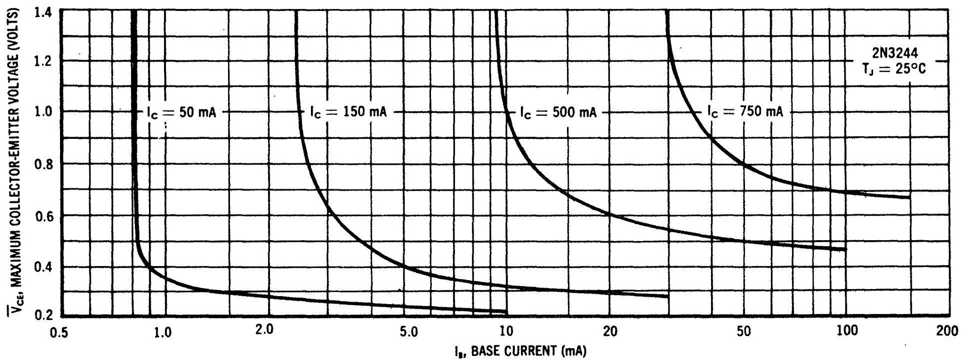


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS



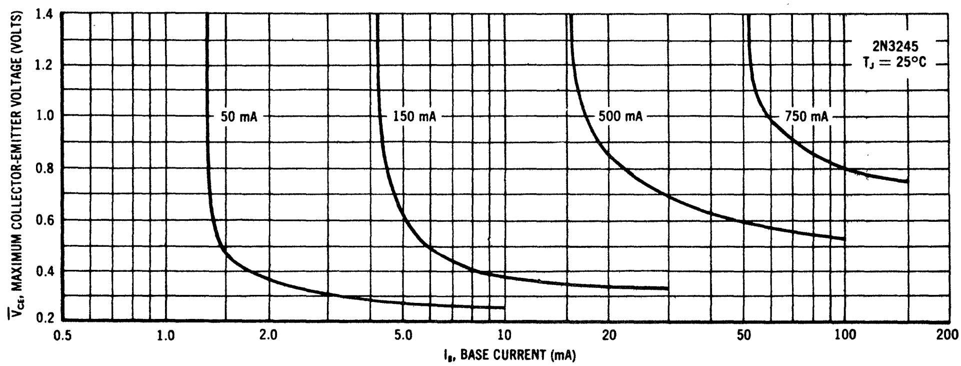


FIGURE 3 — MAXIMUM SATURATION VOLTAGES

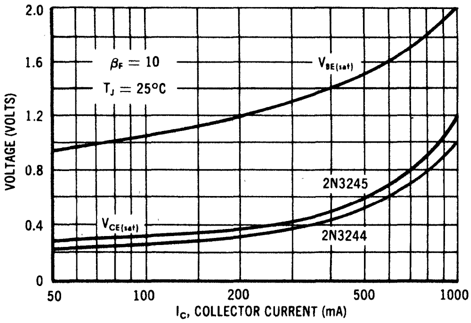


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

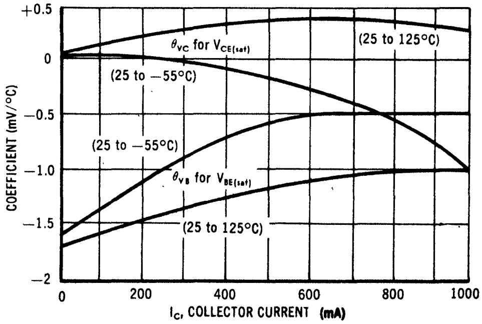


FIGURE 5 — JUNCTION CAPACITANCE

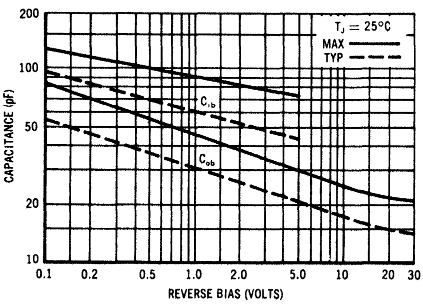


FIGURE 6 — TYPICAL SWITCHING TIMES

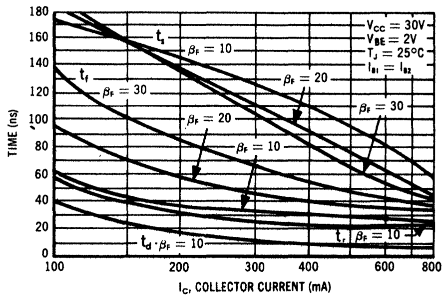


FIGURE 7 — CHARGE DATA

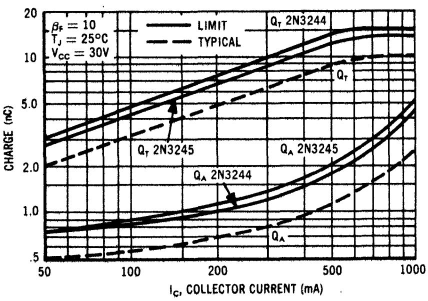


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

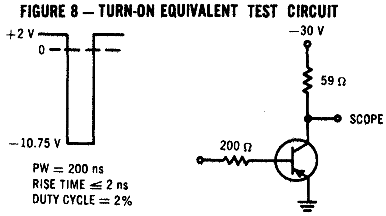


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

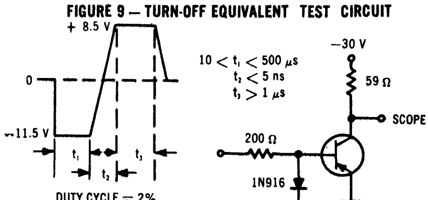


FIGURE 10 — Q_T TEST CIRCUIT

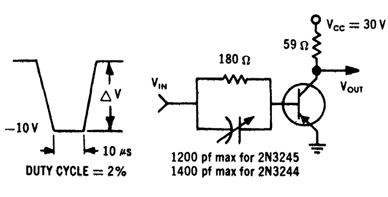
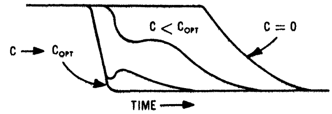
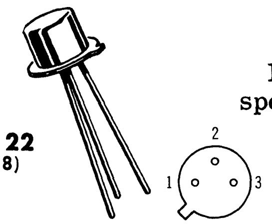


FIGURE 11 — TURN-OFF WAVEFORM



2N3248 (SILICON)
2N3249



CASE 22
(TO-18)

Collector connected to case

PNP silicon annular transistors for low-level, high-speed switching applications.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

FIGURE 1 — t_{on} CIRCUIT

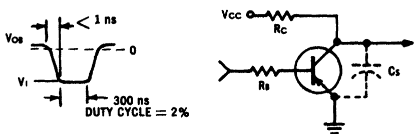
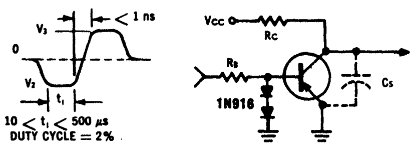


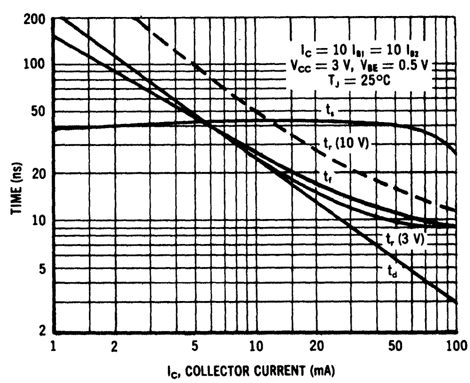
FIGURE 2 — t_{off} CIRCUIT



I_C mA	V_{CC} volts	R_B ohms	R_C ohms	$C_{S(max)}$* pF	V_{OB} volts	V_1 volts	V_2 volts	V_3 volts
10	3	10 K	285	4	+0.5	−10.6	−10.9	+9.1
100	10	1 K	95	12	+0.5	−10.7	−11.3	+8.7

*Total shunt capacitance of test jig and connectors.

FIGURE 3 — TYPICAL SWITCHING TIMES



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless othewise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Collector-Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc) (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc, T_A = 100°C)		I_{CEX}	— —	0.05 5.0	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 1 Vdc)		I_{BL}	—	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc) 2N3248 2N3249	7,8	$V_{CE(sat)}$	— — — —	0.125 0.25 0.4 0.45	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	8	$V_{BE(sat)}$	0.6 — 0.7	0.9 1.1 1.3	Vdc
DC Current Gain (1) (I_C = 0.1 mAdc, V_{CE} = 1 Vdc) 2N3248 2N3249 (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) 2N3248 2N3249 (I_C = 10 mAdc, V_{CE} = 1 Vdc) 2N3248 2N3249 (I_C = 50 mAdc, V_{CE} = 1 Vdc) 2N3248 2N3249 (I_C = 100 mAdc, V_{CE} = 1 Vdc) 2N3248 2N3249	4	h_{FE}	50 100 50 100 50 100 35 75 25 35	— — — — 150 300 — — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	6	C_{ob}	—	8.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	6	C_{ib}	—	8.0	pF
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N3248 2N3249		f_T	250 300	— —	MHz
Total Control Charge (I_C = 10 mA, I_B = 0.25 mA, V_{CC} = 3 V)	5,10	Q_T	—	150	pC
Delay Time — I_C = 100 mA, I_B = 10 mA, $V_{BE(off)}$ = 0.5 V, V_{CC} = 10 V	1,3	t_d	—	5.0	ns
Rise Time — I_C = 100 mA, I_B = 10 mA, $V_{BE(off)}$ = 0.5 V, V_{CC} = 10 V	1,3	t_r	—	15	ns
Storage Time — I_C = 100 mA, I_{B1} = I_{B2} = 10 mA, V_{CC} = 10 V	2,3	t_s	—	60	ns
Fall Time — I_C = 100 mA, I_{B1} = I_{B2} = 10 mA, V_{CC} = 10 V	2,3	t_f	—	20	ns
Turn-On Time — I_C = 10 mA, I_{B1} = 1 mA, $V_{BE(off)}$ = 0.5 V, V_{CC} = 3 V	1,3	t_{on}	—	90	ns
Turn-Off Time — I_C = 10 mA, I_{B1} = I_{B2} = 1 mA, V_{CC} = 3 V	2,3	t_{off}	—	100	ns

* Indicates JEDEC Registered Data

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%

FIGURE 4 — MINIMUM CURRENT GAIN CHARACTERISTICS

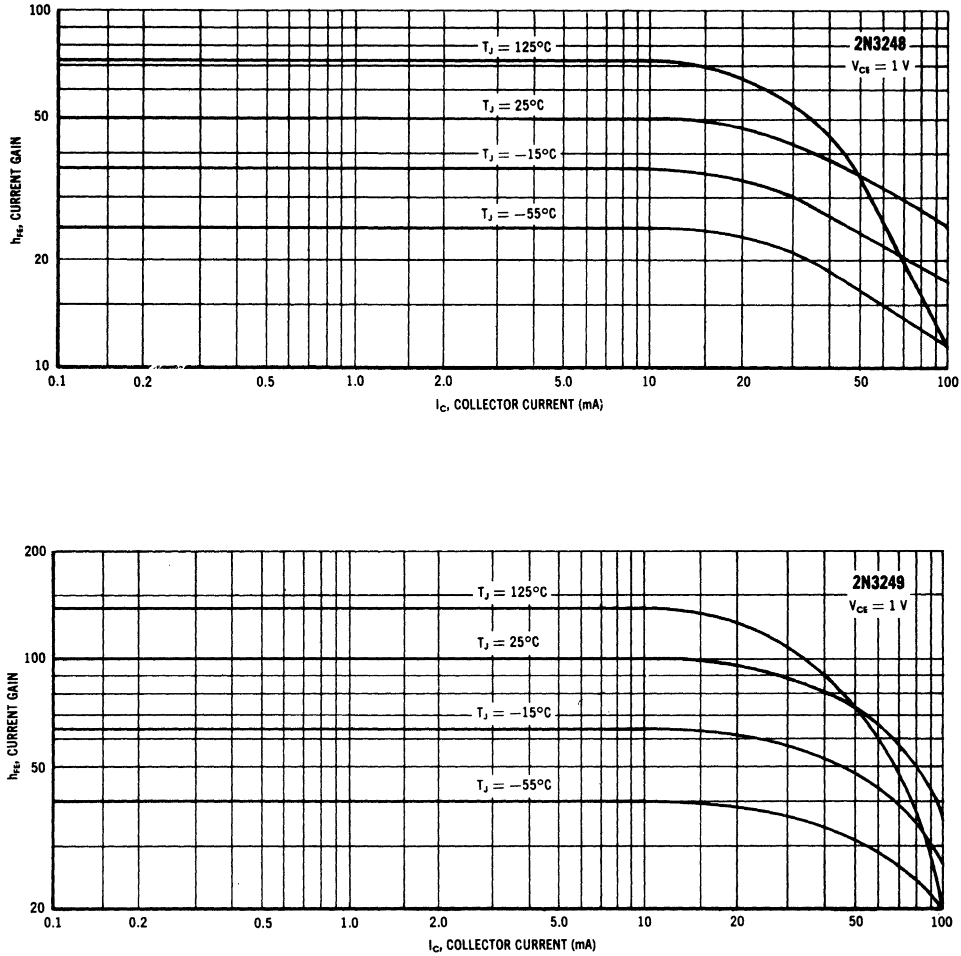


FIGURE 5 — MAXIMUM CHARGE DATA

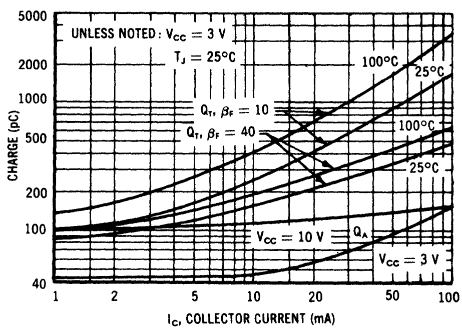


FIGURE 6 — JUNCTION CAPACITANCE

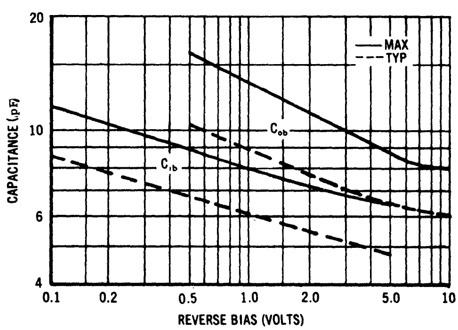
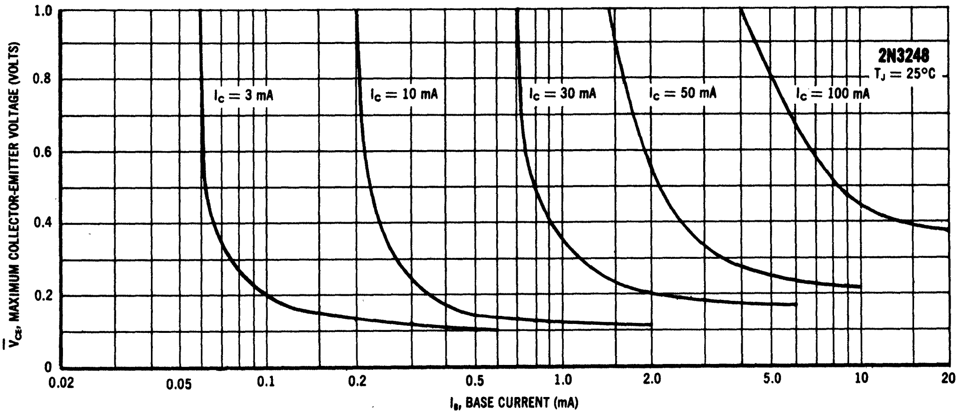


FIGURE 7 COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



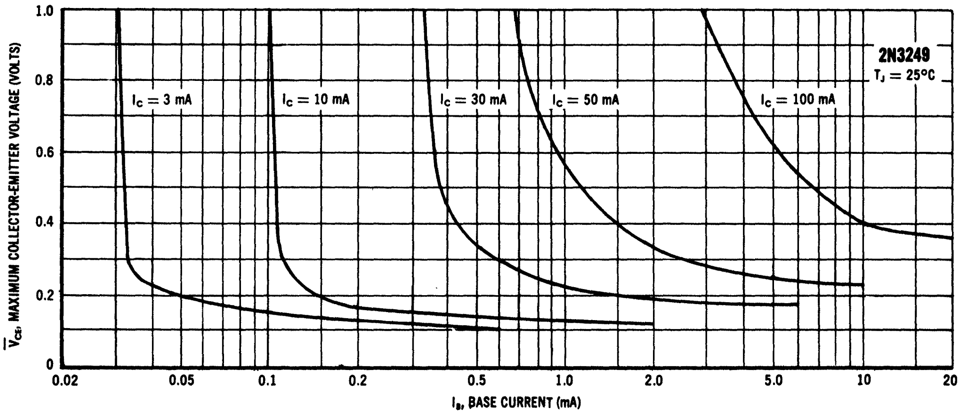


FIGURE 8 — SATURATION VOLTAGE LIMITS

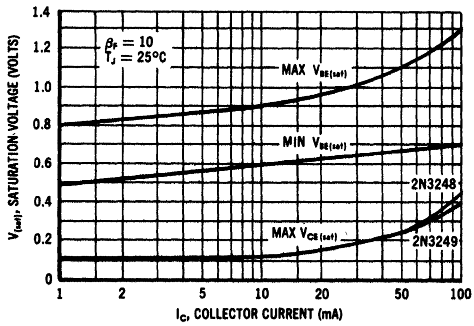


FIGURE 9 — TYPICAL TEMPERATURE COEFFICIENTS

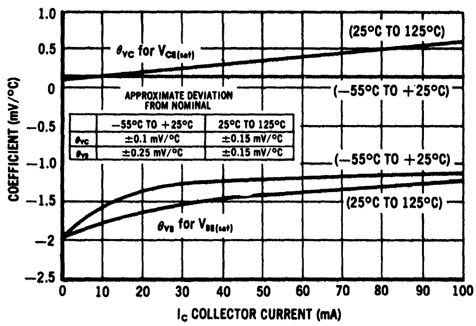


FIGURE 10 — Q_T TEST CIRCUIT

VALUES REFER TO $I_C = 10$ mA TEST POINT

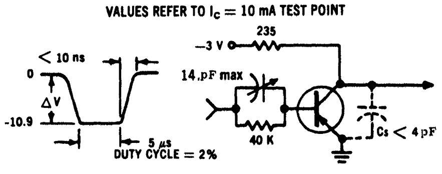
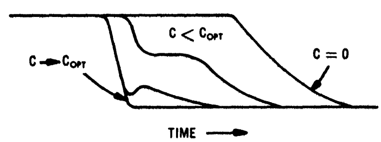
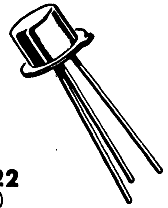


FIGURE 11 — TURN-OFF WAVE FORM

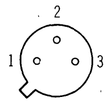


2N3250, A (SILICON)
2N3251, A

2N3250A JAN,JTX,JTXV AVAILABLE
2N3251A JAN,JTX AVAILABLE



PNP silicon annular transistors for high-speed switching and amplifier applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Base Voltage	V_{CB}	50	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	−65 to +200		°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.49 0.15		°C/mW °C/mW

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	--	20	nAdc
Base Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	--	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CBO}	50 60	--	Vdc
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CEO}	40 60	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		BV_{EBO}	5.0	--	Vdc
Collector Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	-- --	0.25 0.5	Vdc
Base-Emitter Saturation Voltage [1] (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	0.6 --	0.9 1.2	Vdc
DC Forward Current Transfer Ratio [1] (I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{FE}	40 80	-- --	--
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	-- --	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	-- --	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	--	6.0	pF
Input Capacitance (V_{CB} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	--	8.0	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	-- --	MHz

SMALL SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{fe}	50 100	200 400	--
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{re}	-- --	10 20	$X10^{-4}$
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{ie}	1.0 2.0	6.0 12	kohms
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3250, 2N3250A 2N3251, 2N3251A	h_{oe}	4.0 10	40 60	μ mhos
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V)		r'_bC_C	--	250	ps
Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_S = 1 kΩ, f = 100 Hz)		NF	--	6.0	dB

* Indicates JEDEC Registered Data

[1] Pulse Test: PW = 300 μs, Duty Cycle = 2%

SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = 3 Vdc, V_{BE} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1 mA)		t_d	35	ns
Rise Time			t_r	35	ns
Storage Time	(I_{B1} = I_{B2} = 1 mAdc V_{CC} = 3V)	2N3250, 2N3250A	t_s	175	ns
		2N3251, 2N3251A		200	
Fall Time			t_f	50	ns

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

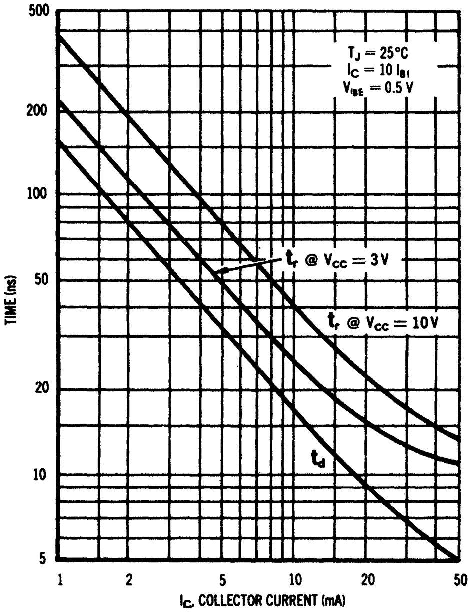
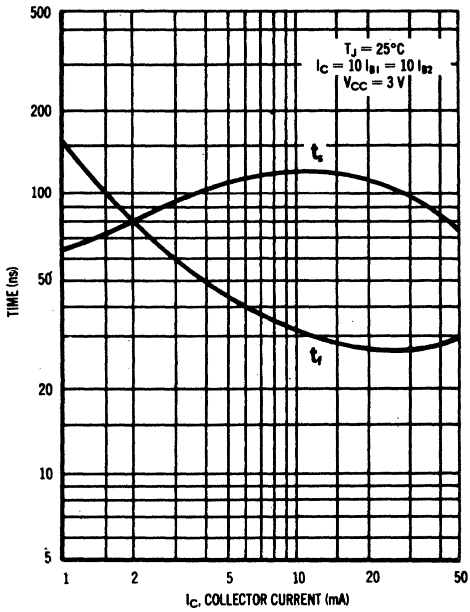


FIGURE 2 — STORAGE AND FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6 V, T_A = 25°C)

FIGURE 3 — FREQUENCY

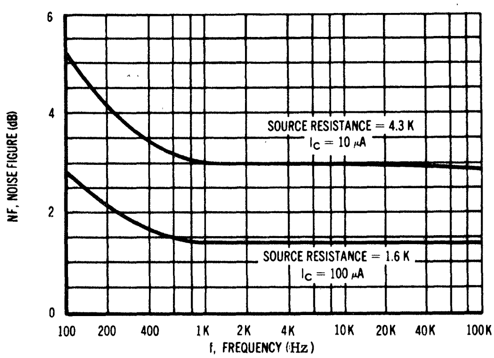
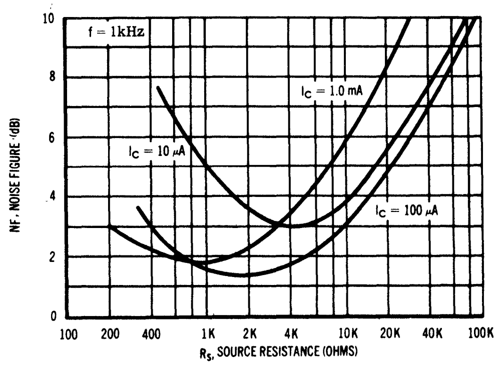


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

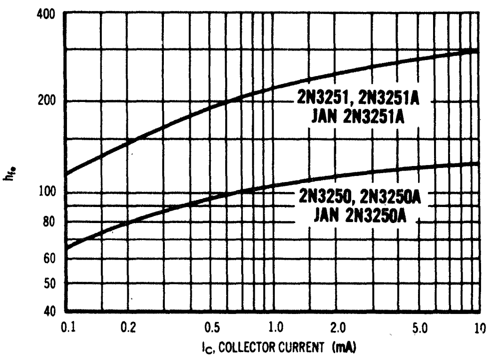


FIGURE 6 — OUTPUT ADMITTANCE

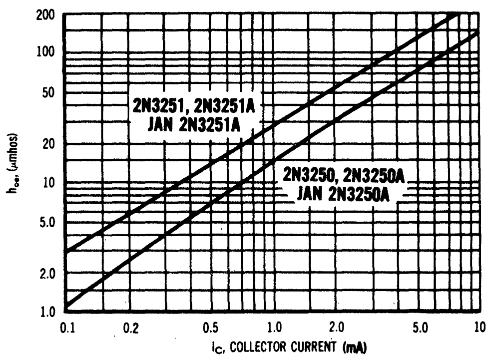


FIGURE 7 — VOLTAGE FEEDBACK RATIO

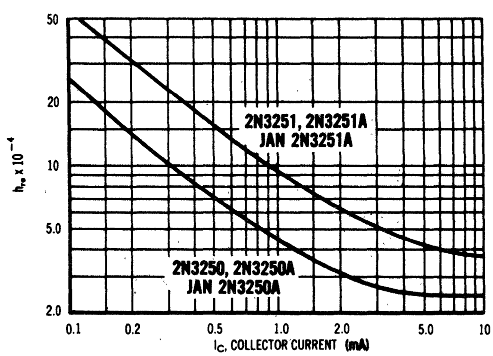


FIGURE 8 — INPUT IMPEDANCE

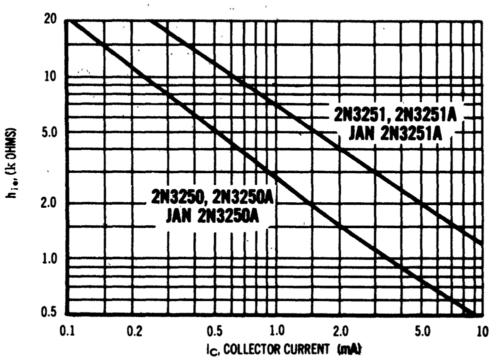


FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

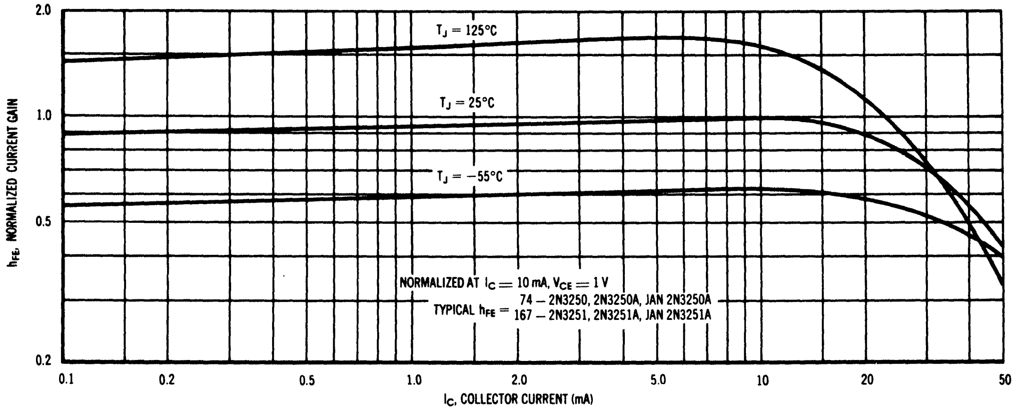
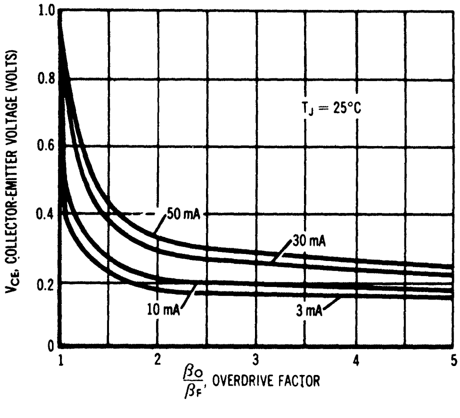


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at $I_C = 10$ mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 9, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design) . . .

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\text{ Volt}}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\text{ mA}/I_{BF}} \qquad I_{BF} \approx 6.68\text{ mA typ}$$

FIGURE 11 — SATURATION VOLTAGES

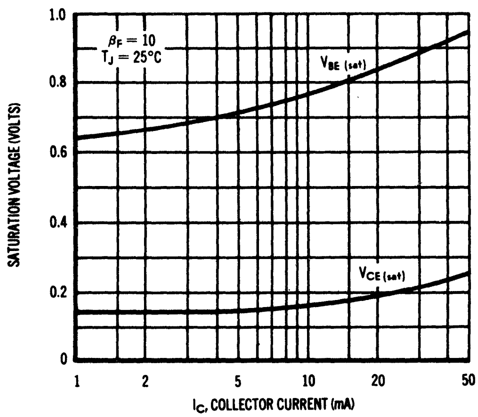


FIGURE 12 — TEMPERATURE COEFFICIENTS

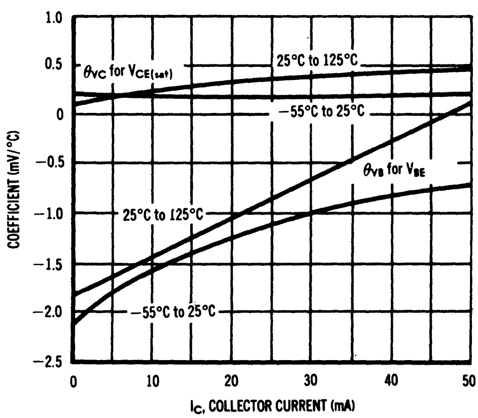


FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

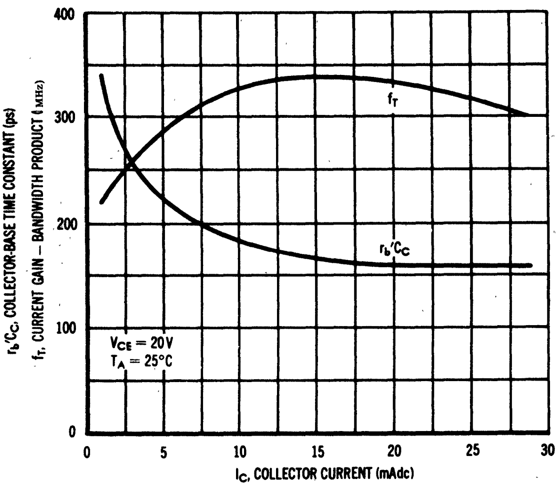


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

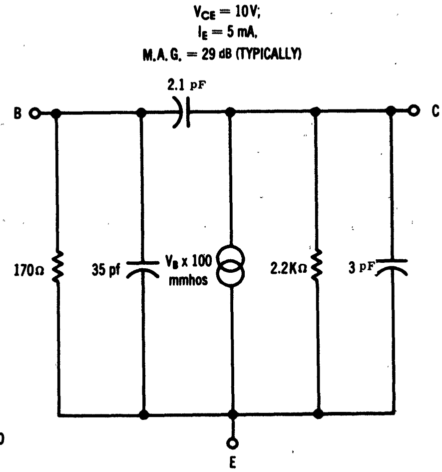


FIGURE 15 — JUNCTION CAPACITANCE

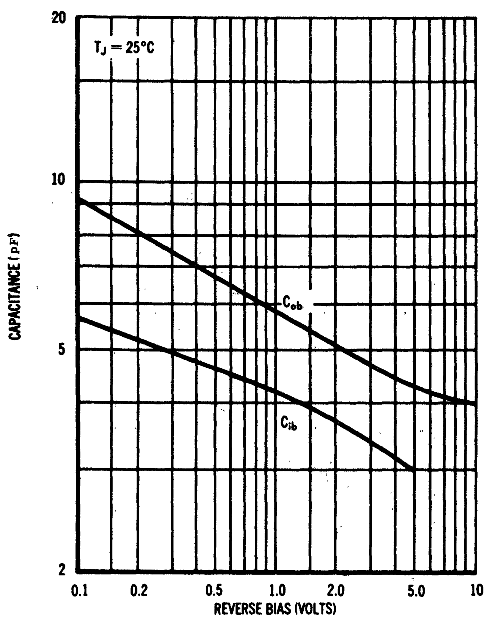
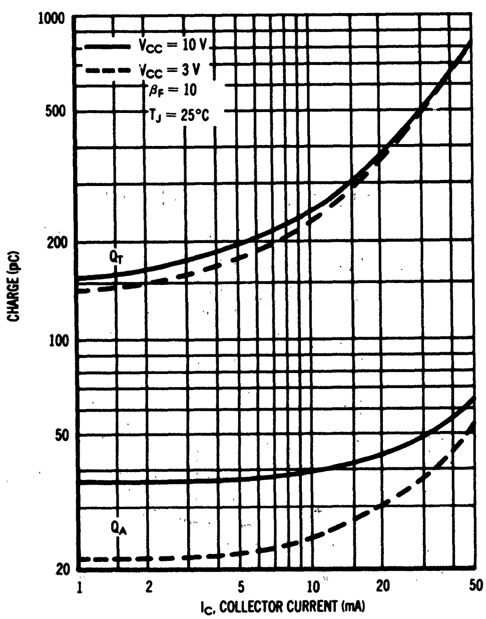


FIGURE 16 — CHARGE DATA

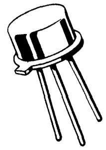


2N3252S, 2N3253S (SILICON)

2N3253 JAN AVAILABLE

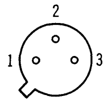
2N3444S

2N3444 JAN AVAILABLE



CASE 79
(TO-39)
Collector connected to case

NPN silicon annular transistors for high-current saturated switching and core driver applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Base Voltage	V_{CB}	60	75	80	Vdc
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	← 5.0 → ← 28.6 →			Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	← 1.0 → ← 5.71 →			Watt mW/°C
Junction Operating Temperature Range	T_J	← -65 to +200 →			°C
Storage Temperature Range	T_{stg}	← -65 to +200 →			°C
Thermal Resistance:	θ_{JC} θ_{JA}	35 0.175			°C/W °C/mW

SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	12	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N3252 2N3253, 2N3444		f_T	200 175	— —	MHz
Total Control Charge (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{CC} = 30 V)		Q_T	—	5.0	nC
Delay Time	I_C = 500 mAdc, I_{B1} = 50 mAdc	t_d	—	15	ns
Rise Time	V_{CC} = 30 V, V_{BE} = 2 V 2N3252 2N3253, 2N3444	t_r	— —	30 35	ns
Storage Time	I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc	t_s	—	40	ns
Fall Time	V_{CC} = 30 V	t_f	—	30	ns

* Indicates JEDEC Registered Data

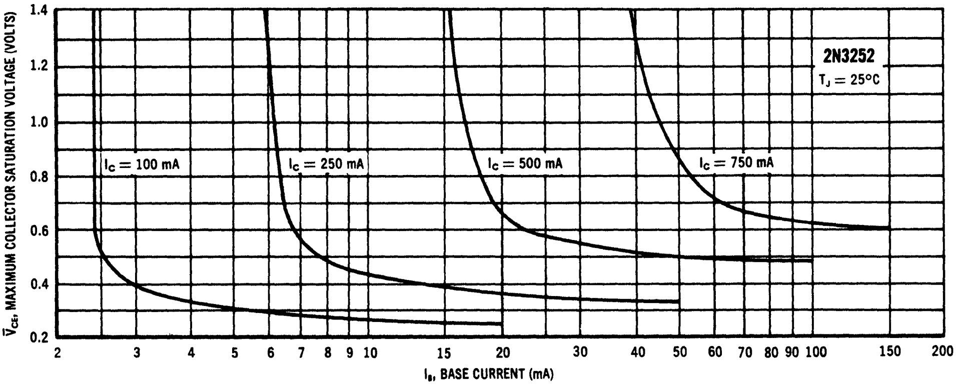
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

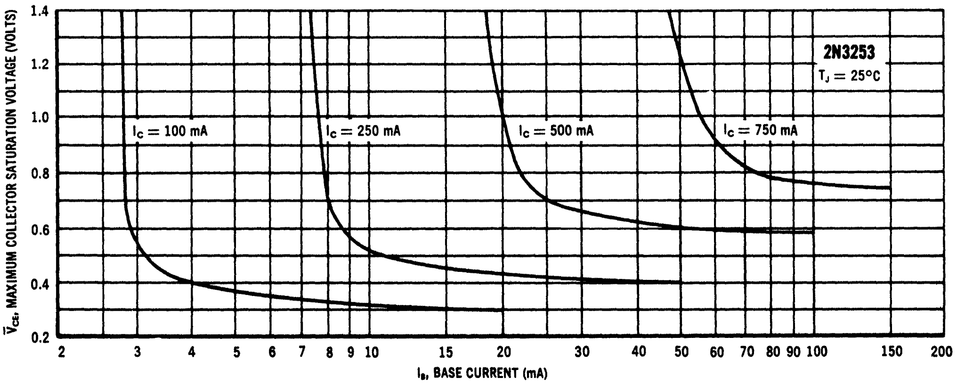
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N3252		—	0.50	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N3252			75.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N3253, 2N3444			0.50	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N3253, 2N3444			75.0	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{BF} = 4 Vdc, I_C = 0)			—	0.05	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3252		—	0.5	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3253, 2N3444,		—	0.5	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3252		—	0.50	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3253, 2N3444		—	0.50	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N3252		60	—	
	2N3253		75	—	
	2N3444		80	—	
Collector-Emitter Breakdown Voltage [1]		BV_{CEO}			Vdc
(I_C = 10 mAdc, pulsed, I_B = 0)	2N3252		30	—	
	2N3253		40	—	
	2N3444		50	—	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5.0	—	
Collector Saturation Voltage [1]		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3252		—	0.3	
	2N3253, 2N3444		—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3252		—	0.5	
	2N3253, 2N3444		—	0.60	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3252		—	1.0	
	2N3253, 2N3444		—	1.2	
Base-Emitter Saturation Voltage [1]		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.7	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.8	
DC Forward Current Transfer Ratio [1]		h_{FE}			—
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	2N3252		30	—	
	2N3253		25	—	
	2N3444		20	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3252		30	90	
	2N3253		25	75	
	2N3444		20	60	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3252		25	—	
	2N3253		20	—	
	2N3444		15	—	

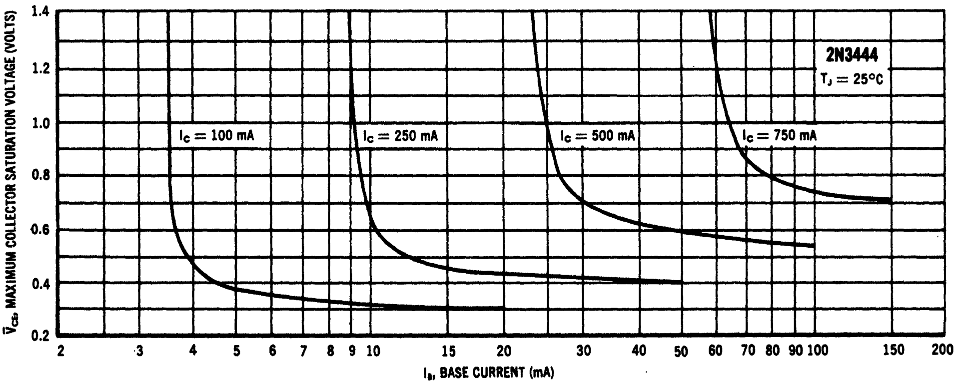
(1) Pulse Test: Pulse width = 300 μs, duty cycle = 2%

* Indicates JEDEC Registered Data

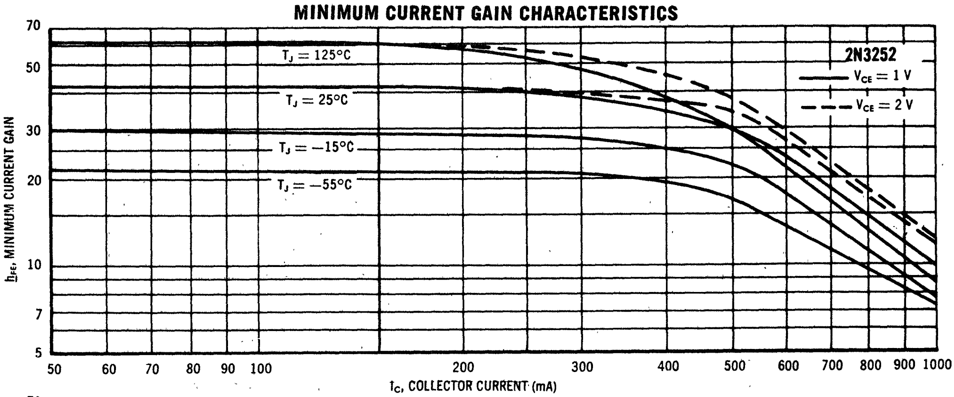
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

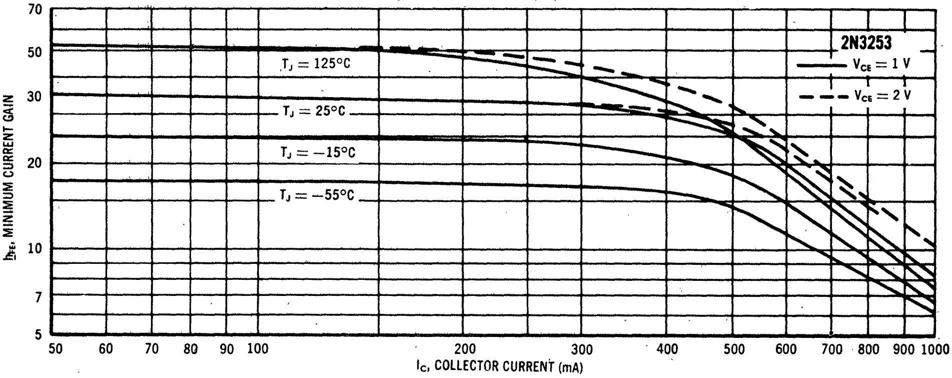


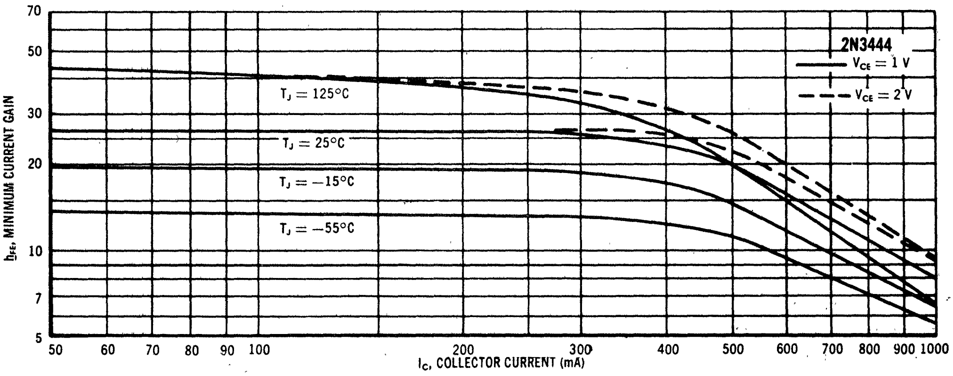




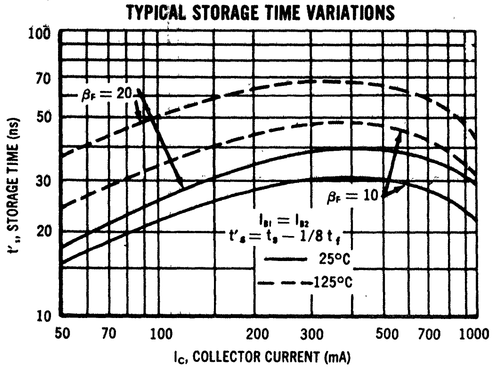
MINIMUM CURRENT GAIN CHARACTERISTICS



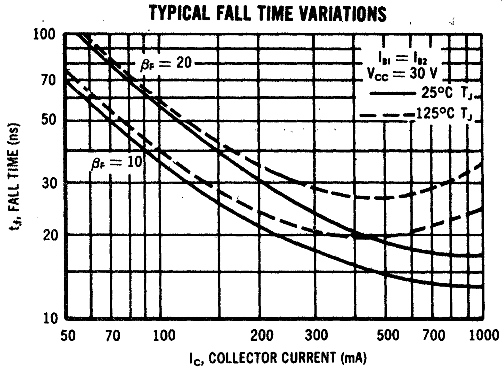




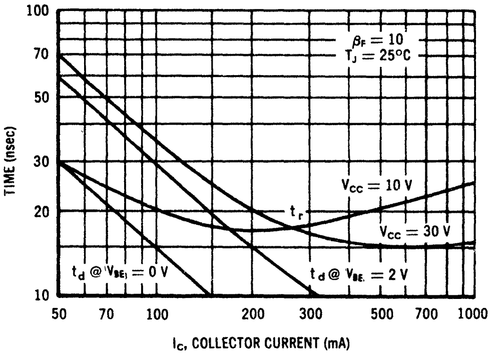
TYPICAL STORAGE TIME VARIATIONS



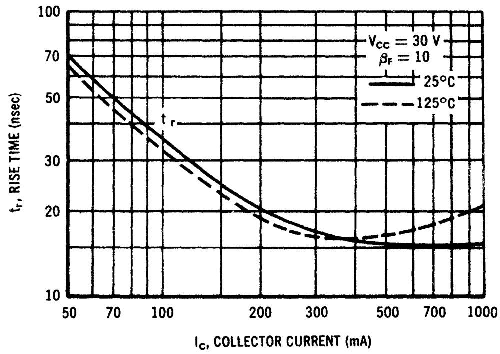
TYPICAL FALL TIME VARIATIONS



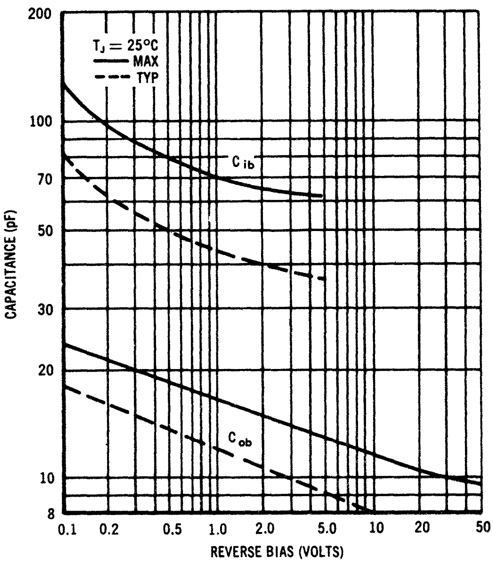
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



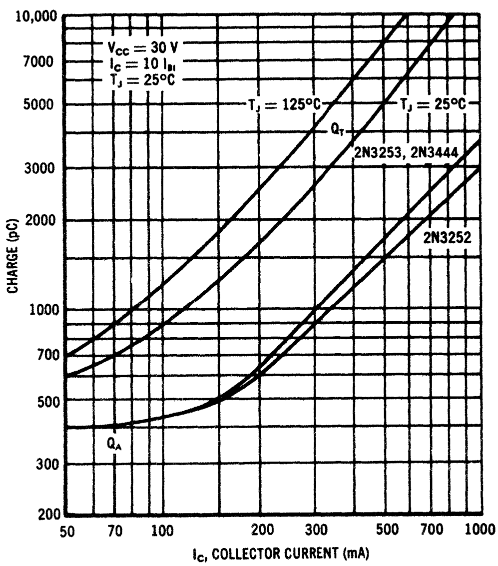
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



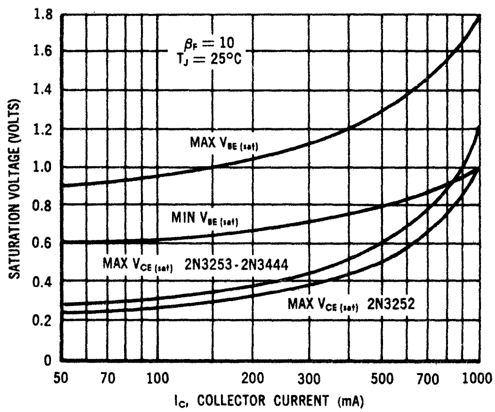
JUNCTION CAPACITANCE VARIATIONS



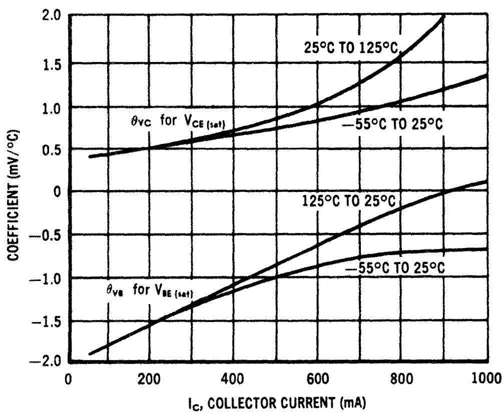
MAXIMUM CHARGE DATA



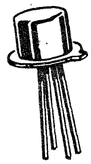
LIMITS OF SATURATION VOLTAGES



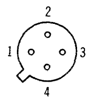
TYPICAL TEMPERATURE COEFFICIENTS



2N3283 thru 2N3285 (Ge Mesa)



CASE 20-03
(TO-72)



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

PNP germanium mesa transistors for IF and RF amplifier, oscillator and general purpose high-gain, low-noise amplifier applications.

* MAXIMUM RATINGS

Rating	Symbol	2N3283 2N3284	2N3285	Unit
Collector-Emitter Voltage	V_{CES}	25	20	Vdc
Collector-Base Voltage	V_{CB}	25	20	Vdc
Emitter-Base Voltage	V_{EB}	0.5		Vdc
Collector Current - Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 1.33		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		°C

*Indicates JEDEC Registered Data

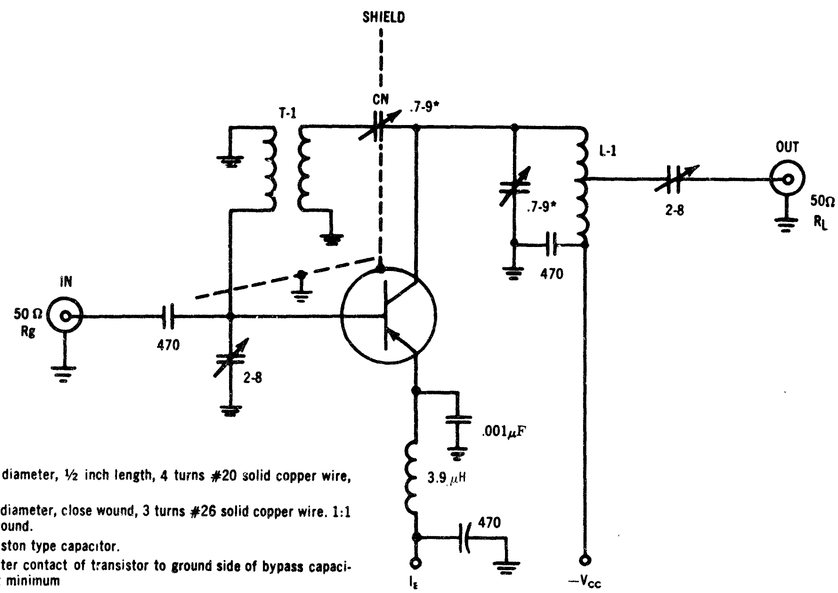
* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	2N3283, 2N3284	BV_{CES}	25	-	Vdc
	2N3285		20	-	
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)	2N3283, 2N3284	h_{FE}	10	-	-
	2N3285		5.0	-	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	250	800	MHz
Maximum Frequency of Oscillation (I_C = 3.0 mAdc, V_{CE} = 10 Vdc)		f_{max}	-	-	MHz
Output Capacitance (1) (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	1.5	pF
Small-Signal Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3283, 2N3284	h_{fe}	10	200	-
	2N3285		5.0	200	
Collector-Base Time Constant (I_E = 3.0 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)		$r_b'C_c$	-	25	ps
Noise Figure (I_C = 3.0 mAdc, V_{CE} = 10 Vdc, f = 200 MHz)	2N3283	NF	-	5.0	dB
	2N3284		-	6.0	
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 3.0 mAdc, f = 200 MHz)	2N3283, 2N3284	G_{pe}	16	23	dB
Power Output (V_{EE} = 12 Vdc, f = 247 MHz)	2N3285	P_{out}	2.0	-	mW

*Indicates JEDEC Registered Data

(1) C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

FIGURE 1 — 200 MHz POWER GAIN AND NOISE FIGURE TEST CIRCUIT



NOTES:

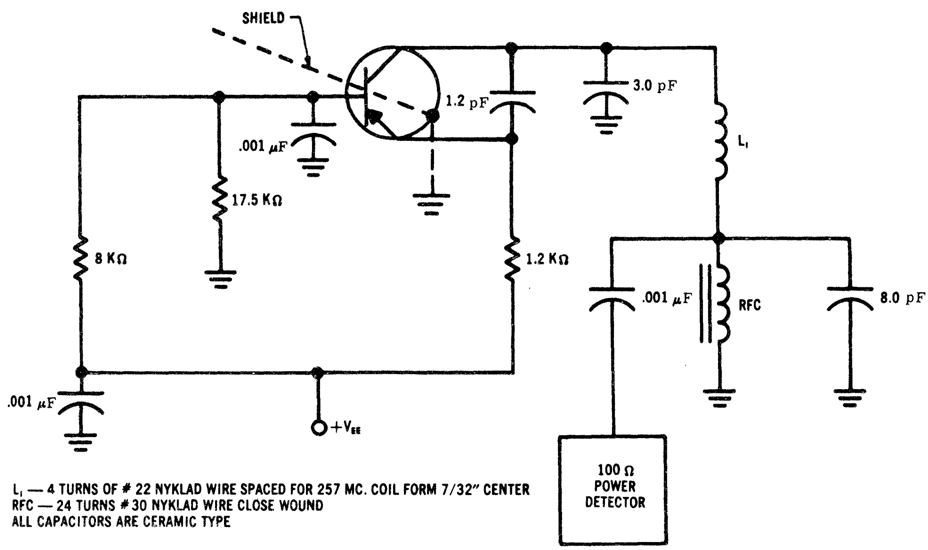
L-1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.

T-1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bi-filler wound.

* High Quality piston type capacitor.

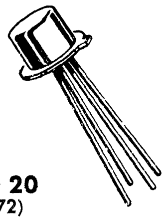
Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum

FIGURE 2 — 257 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT



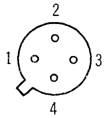
L_1 — 4 TURNS OF # 22 NYKLAD WIRE SPACED FOR 257 MC. COIL FORM 7/32" CENTER
RFC — 24 TURNS # 30 NYKLAD WIRE CLOSE WOUND
ALL CAPACITORS ARE CERAMIC TYPE

2N3287 (SILICON)



CASE 20
(TO-72)

NPN silicon annular transistor for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

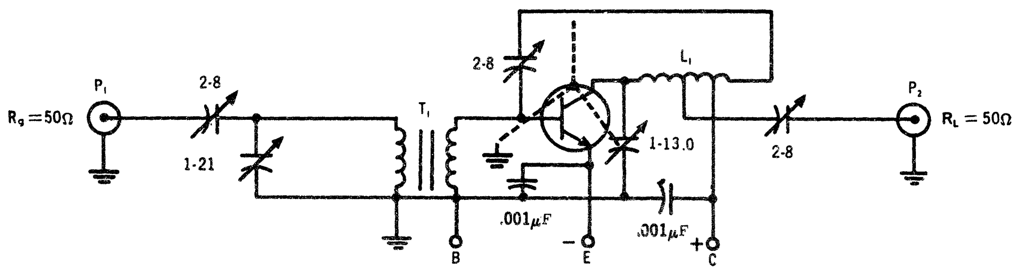


STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector - Base Voltage	V_{CB}	40	Volts
Collector - Emitter Voltage	V_{CES}	40	Volts
Collector - Emitter Voltage	V_{CEO}	20	Volts
Emitter - Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	mW
Power Dissipation at 25° C amb. Above 25°C derate 1.14 mW/°C	P_D	200	mW
Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

200 MHz TEST CIRCUIT: POWER GAIN, NOISE FIGURE, & AGC



L_1-6 turns of #16 tinned wire; ⅜″ ID; Air wound; winding length ¾″; V_{CC} feeds tap 4¾ turns from collector end; output tap 3½ turns from collector end.

T_1-3 turns primary and secondary Bifilar wound (close wound) on ¼″ ceramic form (cambion type) with brass slug. #22 enameled wire.

P_1-General Radio 874 G6 Pad (6 dB)
P_2-General Radio 874 G6 Pad (6 dB)

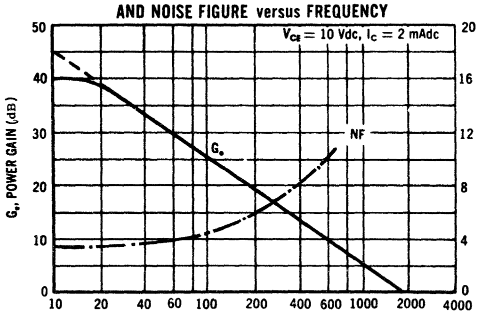
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	40	—	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μAdc, V_{BE} = 0	40	—	—	Vdc
Collector-Emitter Breakdown Voltage	BVCEO	I_C = 2.0 mAdc, I_B = 0	20	—	—	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 10 μAdc, I_C = 0	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc V_{CB} = 15 Vdc, T_A = 150°C	— —	— —	.010 3.0	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	15	—	100	—
Collector-Emitter Saturation Voltage	$V_{CE\,(sat)}$	I_C = 5 mAdc, I_B = 0.5 mAdc	—	—	0.3	Vdc
Base-Emitter Saturation Voltage	$V_{BE\,(sat)}$	I_C = 5 mAdc, I_B = 0.5 mAdc	—	—	0.9	Vdc
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz	15	—	150	—
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz (Note 1)	—	0.9	1.1	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc, f = 31.8 MHz	3.0	8.0	15	ps
Current Gain - Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 2 mAdc	350	600	1200	MHz
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mAdc	—	2000	—	MHz
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	17	—	24	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	—	4.9	6.0	dB
Power Gain (AGC)	G_e	V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz (Note 2)	—	—	0	dB

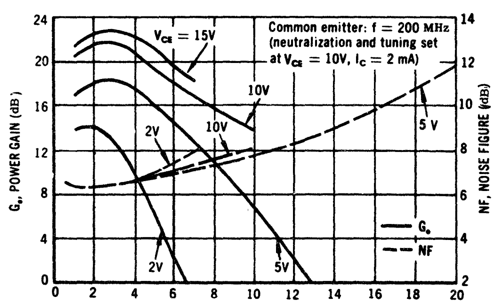
Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.

NEUTRALIZED POWER GAIN AND NOISE FIGURE versus FREQUENCY

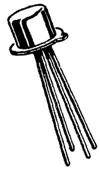


POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT

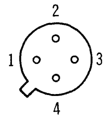


2N3291 (SILICON)
2N3292
2N3294

NPN silicon annular transistor for TV and FM mixer, RF and IF amplifier and general-purpose, low-noise, high-gain amplifier applications.



CASE 20
(TO-72)

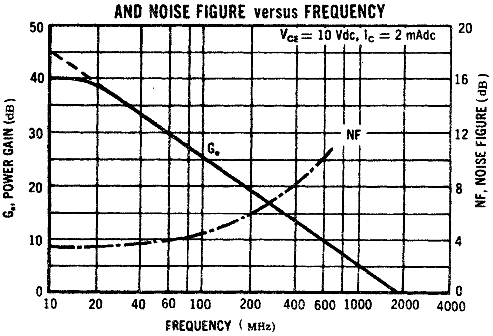


STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

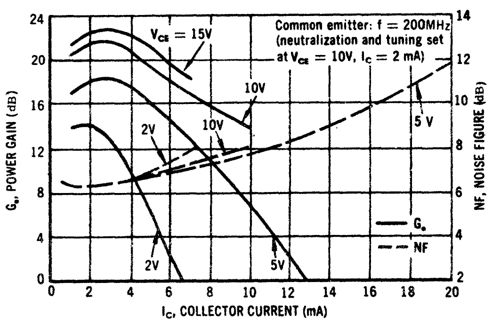
MAXIMUM RATINGS

Rating	Symbol	2N3291 2N3292	2N3294	Unit
Collector - Base Voltage	V_{CB}	25	20	Volts
Collector - Emitter Voltage	V_{CES}	25	20	Volts
Emitter - Base Voltage	V_{EB}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_D	300	300	mW
Power Dissipation at 25°C Amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_J	+200	+200	°C
Storage Temperature Range	T_{stg}	← -65 to +200 →		°C

NEUTRALIZED POWER GAIN AND NOISE FIGURE versus FREQUENCY



POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 25 μAdc, V_{BE} = 0 2N3291, 2N3292 2N3294	 25 20	 35 30	 — —	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	—	.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	10	—	—	—
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz	10	—	200	—
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz, Note 1	—	1.0	2.0	pF
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 100 MHz	2.5	6.0	12	—
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc f = 31.8 MHz	—	15	30	ps
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mA	—	2000	—	MHz
2N3291						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	16	20	24	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	—	6.0	8.0	dB
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 MHz	—	—	0	dB
2N3292						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	16	20	24	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	—	7.0	9.0	dB
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 MHz	—	0	—	dB
2N3294						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	14	—	—	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 MHz	—	7.0	—	dB

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.

2N3295 (SILICON)

The RF Line

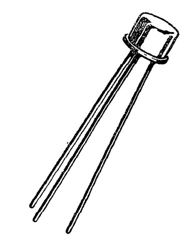
NPN SILICON RF HIGH FREQUENCY TRANSISTOR

. . . designed for amplifier applications from 2 MHz to 100 MHz.

- Amplifier Characteristics –
  30 MHz IMD: = 30 dB down @ P_{out} = 0.3 Watts PEP
- High Power Gain
  G_e = 14 dB Min @ 30 MHz with P_{out} = 0.3 Watts PEP

HIGH FREQUENCY TRANSISTOR

NPN SILICON

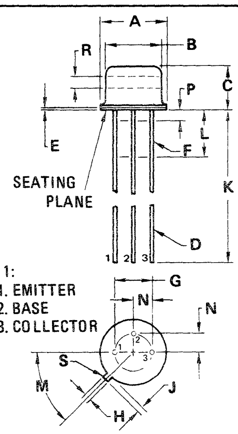


***MAXIMUM RATING** (Note 1)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	250	mAdc
Base Current – Continuous	I_B	50	mAdc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 13.3	Watts mW/°C
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.8 5.33	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 175	°C

*Indicates JEDEC Registered Data

Note 1: The maximum ratings as given for DC Conditions can be exceeded on a pulse basis. See Electrical Characteristics.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.41	0.48	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	38.10	–	1.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

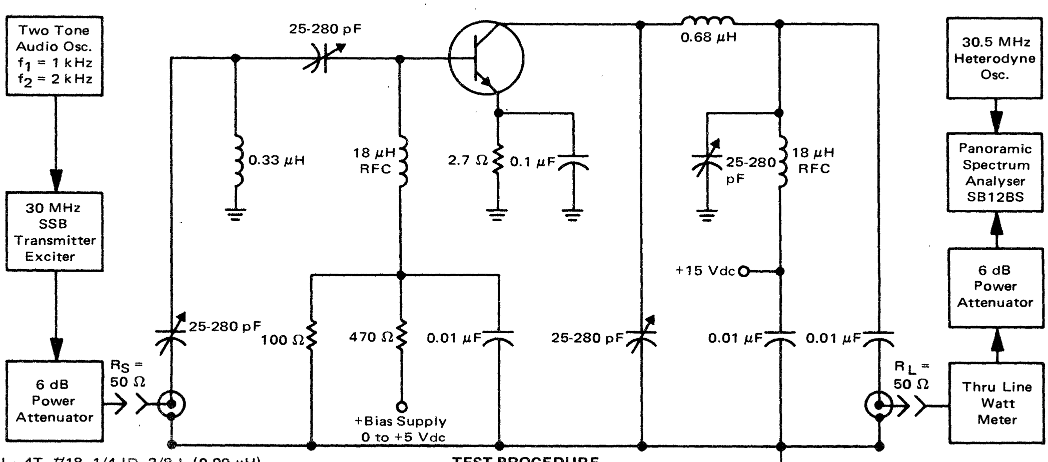
CASE 031-01

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mA, I_B = 0)		$V_{CEO(sus)}$	20	–	–	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mA, R_{BE} = 0)		$V_{CES(sus)}$	30	–	–	Vdc
Collector-Emitter Current (V_{CE} = 60 Vdc, V_{BE} = 0) (V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C)		I_{CES}	 – –	 – –	 100 500	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)		h_{FE}	 20 20	 – –	 60 –	–
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	–	–	2.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 50 MHz)		f_T	200	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	8.0	pF
FUNCTIONAL TEST (Figure 1)						
Power Input (PEP) (2)	(P_{out} = 0.3 Watts PEP (0.15 W rms), f = 30 MHz, V_{CE} = 15 Vdc, $I_{C(max)}$ = 40 mA)	P_{in}	–	–	12	mW
Power Gain		G_e	14	17	–	dB
Intermodulation Distortion		IMD	30	32	–	dB
Efficiency		η	25	30	–	%

*Indicates JEDEC Registered Data.
(1) Pulse Width = 100 μs, Duty Cycle = 2.0%.
(2) PEP — Peak Envelope Power

FIGURE 1 — 30 MHz TWO TONE LINEAR AMPLIFIER TEST CIRCUIT

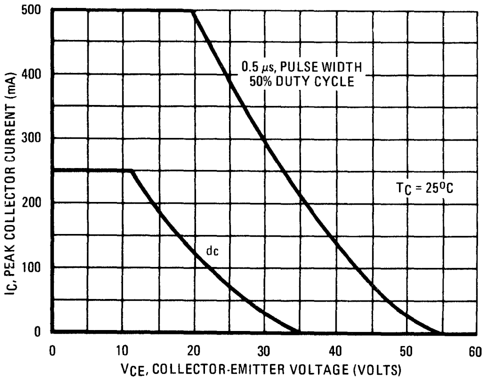


L_1 4T, #18, 1/4 ID, 3/8 L (0.09 μH)
L_2 6T, #18, 1/4 ID, 9/16 L (0.13 μH)

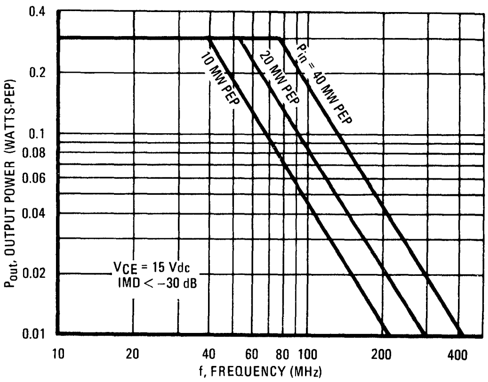
TEST PROCEDURE

1. Adjust bias supply for I_C = 3.4 mA, no RF signal applied.
2. Apply RF signal and tune until P_{out} = 0.3 watts PEP.
3. Read IMD, I_C, and P_{in}.

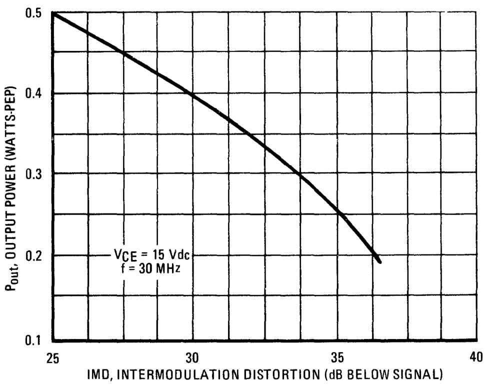
SAFE OPERATING AREA



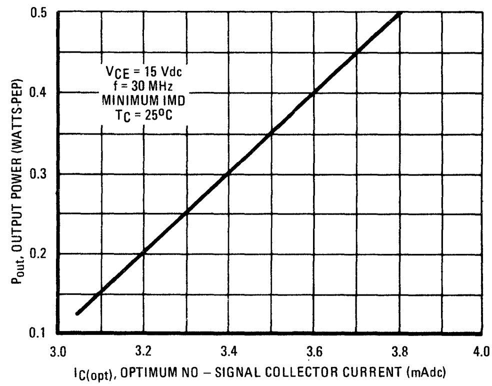
OUTPUT POWER versus FREQUENCY



MAXIMUM OUTPUT POWER FOR GIVEN INTERMODULATION DISTORTION LEVEL

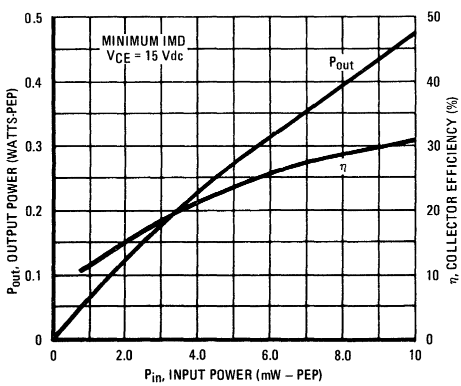


OUTPUT POWER versus OPTIMUM BIAS

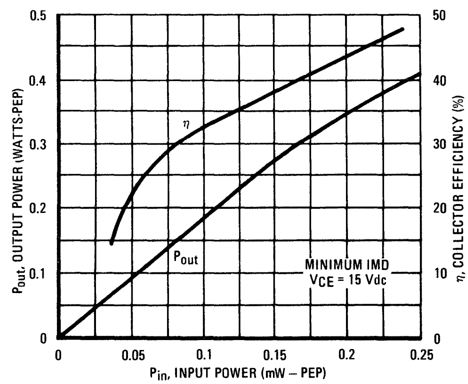


OUTPUT CHARACTERISTICS versus INPUT POWER

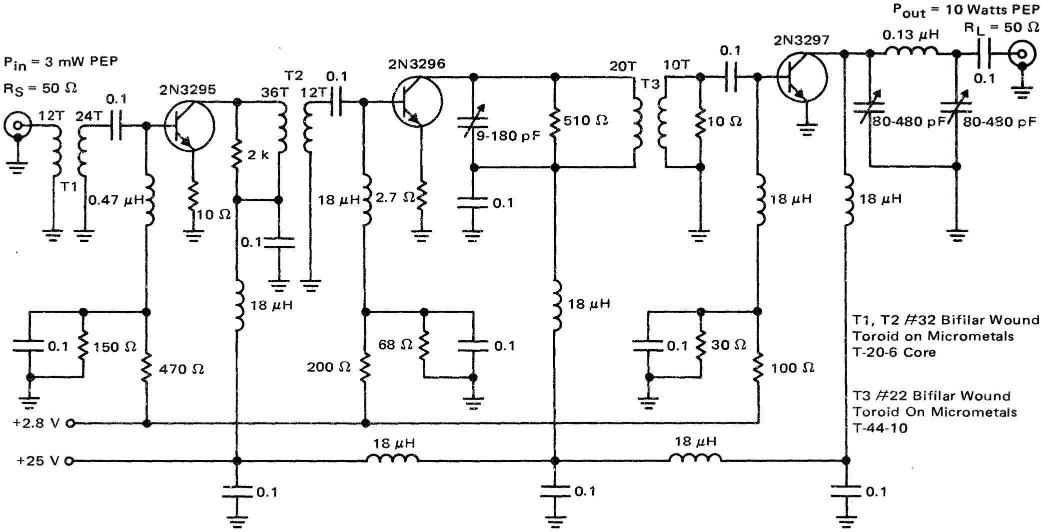
30 MHz



4 MHz



30 MHz SINGLE – SIDE BAND TRANSMITTER



APPLICATION NOTE

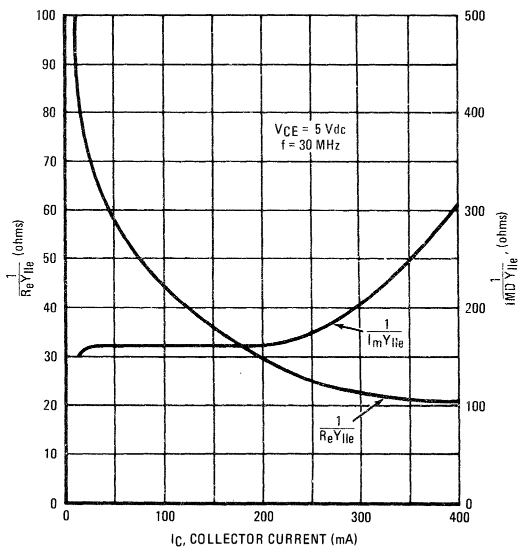
The schematic for a 30 MHz single sideband transmitter shown in Figure 1 illustrates circuitry which can be used to provide linear power amplification with Motorola RF Line transistors. This particular circuit provides peak envelope power output of 10 watts with an overall power gain of 35 dB. All odd order distortion products (Intermodulation Distortion – IMD) are more than 30 dB down from the reference level as measured in a two tone test with 1 kHz separation using a panoramic SB-12BS spectrum analyzer.

This performance is readily obtained without feedback loops. Current feedback for stability is obtained in stage one and stage two by the use of unbypassed emitter resistors.

Although the power output for this system is 10 watts of peak envelope power, you are not limited by the transistors. Four (2N3297) in parallel are capable of delivering in excess of 40 Watts PEP.

In the design of a linear amplifier stage there are two important factors which must be considered. These are optimum driving source impedance and slight forward bias. Optimum R_S is determined by observing the linearity of transistor collector characteristics when the device is driven from a variable generator source impedance. Forward bias is applied from a low-voltage bias supply and resistive divider. Values of resistance in the bias divider are critical. Resistive values too low decrease efficiency and present thermal runaway possibility; values too high degrade IMD performance. Optimum bias for the 2N3297 with no signal applied is approximately 5 mA to 10 mA. Note that improved IMD performance is possible as the device supply voltage is increased up to 30 volts.

R_eY_{11e} AND IMD Y_{Ile} versus COLLECTOR CURRENT



2N3296 (SILICON)

The RF Line

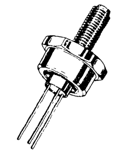
NPN SILICON RF HIGH FREQUENCY TRANSISTOR

. . . designed for amplifier applications from 2 MHz to 100 MHz.

- Amplifier Characteristics
  30 MHz IMD: 30 dB down @ P_{out} = 3.0 Watts PEP
- High Power Gain
  G_e = 16 dB (Min) @ 30 MHz with P_{out} = 3.0 Watts PEP
- High Pulse Breakdown Voltage
  BV_{CES} = 85 Volts (Min)
- Isolated Stud Package

HIGH FREQUENCY TRANSISTOR

NPN SILICON

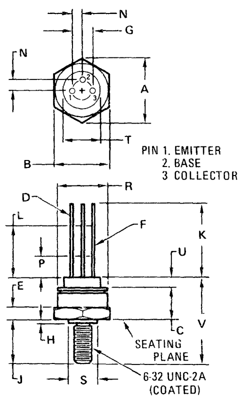


***MAXIMUM RATINGS** (Note 1.)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current — Continuous	I_C	700	mAdc
Base Current — Continuous	I_B	100	mAdc
RF Input Power	P_{in}	1.0	Watt (PEP)
RF Output Power	P_{out}	5.0	Watts (PEP)
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	6.0 40	Watts mW/°C
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.7 4.67	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	175	°C

***Indicates JEDEC Registered Data**

Note 1: The maximum ratings as given for DC Conditions can be exceeded on a pulse basis. See Electrical Characteristics.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.49	11.00	0.413	0.433
B	9.19	9.53	0.362	0.375
C	5.33	5.72	0.210	0.225
D	0.406	0.533	0.016	0.021
E	1.65	1.78	0.065	0.070
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.508	0.889	0.020	0.035
J	6.73	7.42	0.265	0.292
K	12.70	–	0.500	–
L	6.35	–	0.250	–
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050
R	8.89	9.14	0.350	0.360
S	4.45	4.83	0.175	0.190
T	4.11	4.29	0.162	0.169
U	1.14	1.52	0.045	0.060

All JEDEC dimensions and notes apply

CASE 24
TO-102

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

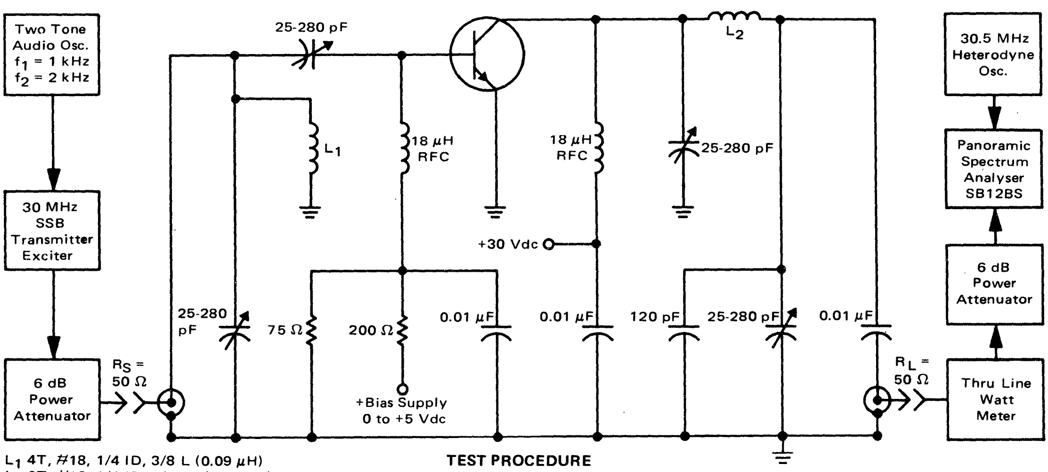
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, R_{BE} = 0)	$V_{CES(sus)}$	85	120	–	Vdc
Collector-Emitter Current (V_{CE} = 60 Vdc, V_{BE} = 0) (V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C)	I_{CES}	– –	– –	100 500	μAdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (V_{CE} = 2.0 Vdc, I_C = 40 mAdc) (V_{CE} = 2.0 Vdc, I_C = 400 mAdc)	h_{FE}	5.0 5.0	– –	50 –	–
Collector-Emitter Saturation Voltage (I_C = 400 mAdc, I_B = 80 mAdc)	$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 400 mAdc, I_B = 80 mAdc)	$V_{BE(sat)}$	–	–	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 2.0 Vdc, I_C = 40 mAdc, f = 50 MHz)	f_T	100	–	–	MHz
Output Capacitance (V_{CB} = 25 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	20	pF
FUNCTIONAL TEST (Figure 1) (P_{out} = 3.0 Watts (PEP) (1.5 W rms), V_{CE} = 30 Volts, f = 30 MHz, $I_{C(max)}$ = 125 mA)					
Power Input (PEP) (2)	P_{in}	–	–	75	mW
Power Gain	G_e	16	19	–	dB
Intermodulation Distortion	IMD	30	35	–	dB
Efficiency	η	40	48	–	%

*Indicates JEDEC Registered Data.

(1) Pulse Width = 100 μs, Duty Cycle = 2.0%.

(2) PEP – Peak Envelope Power

FIGURE 1 — 30 MHz TWO TONE LINEAR AMPLIFIER TEST CIRCUIT

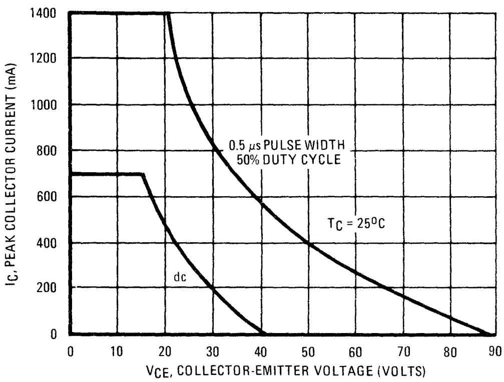


L_1 4T, #18, 1/4 ID, 3/8 L (0.09 μH)
L_2 6T, #18, 1/4 ID, 9/16 L (0.13 μH)

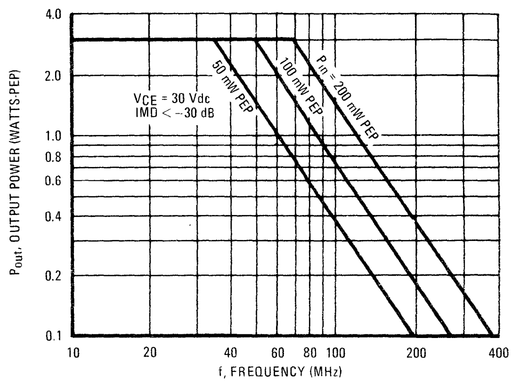
TEST PROCEDURE

1. Adjust bias supply for I_C = 3.4 mA, no RF signal applied.
2. Apply RF signal and tune until P_{out} = 0.3 watts PEP.
3. Read IMD, I_C, and P_{in}.

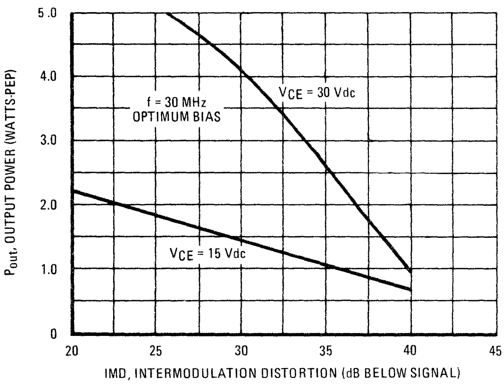
SAFE OPERATING AREA



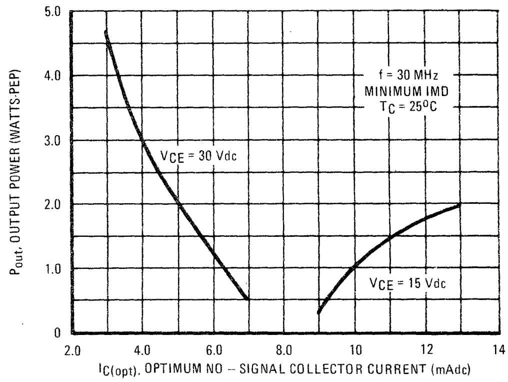
OUTPUT POWER versus FREQUENCY



MAXIMUM OUTPUT POWER FOR GIVEN INTERMODULATION DISTORTION LEVEL

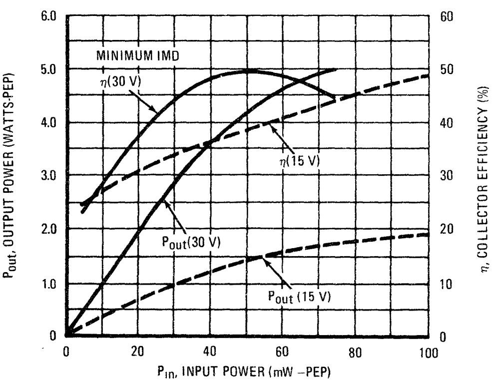


OUTPUT POWER versus OPTIMUM BIAS

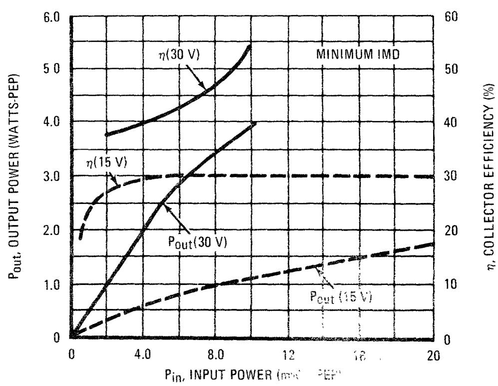


OUTPUT CHARACTERISTICS versus INPUT POWER

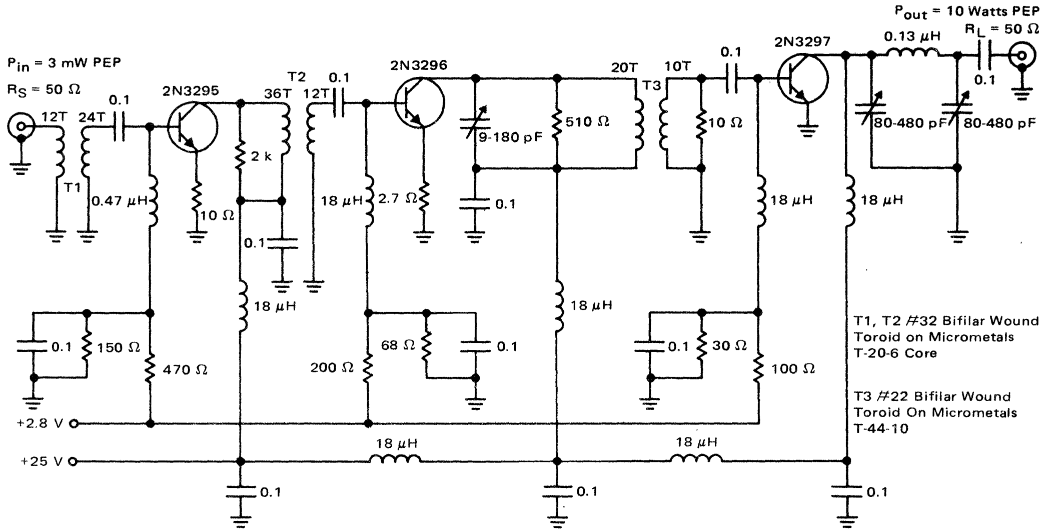
30 MHz



4 MHz



30 MHz SINGLE – SIDE BAND TRANSMITTER



APPLICATION NOTE

The schematic for a 30 MHz single sideband transmitter shown in Figure 1 illustrates circuitry which can be used to provide linear power amplification with Motorola RF Line transistors. This particular circuit provides peak envelope power output of 10 watts with an overall power gain of 35 dB. All odd order distortion products (Intermodulation Distortion – IMD) are more than 30 dB down from the reference level as measured in a two tone test with 1 kHz separation using a panoramic SB-12BS spectrum analyzer.

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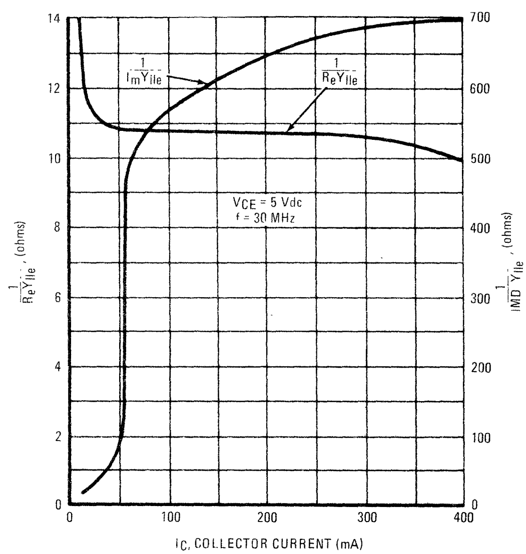
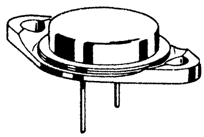
R_eY_{11e} AND IMD Y_{IIe} versus COLLECTOR CURRENT



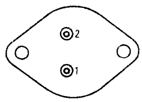
2N3297 (SILICON)

NPN silicon annular transistor for linear amplifier applications for 2 to 100 MHz.



CASE 1
(TO-3)

Collector connected to case



STYLE 1
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

MAXIMUM RATINGS *

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current (Continuous)	I_C	1.5	Adc
Base-Current (Continuous)	I_B	500	mAdc
Power Input (PEP)	P_{in}	5.0	Watts (PEP)
Power Output (PEP)	P_{out}	20.0	Watts (PEP)
Total Device Dissipation @ 25°C Case Temperature Derating Factor above 25°C	P_D	25.0 167	Watts mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

* **The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics**

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$ [1]	I_C = 0.250A, R_{BE} = 0	80	100	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$ [1]	I_C = 0.250A, I_B = 0	40	--	--	Volts

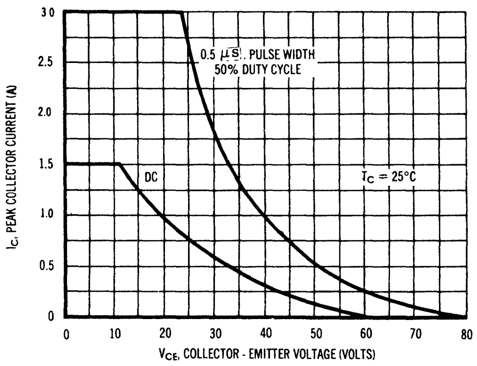
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	0.5	mAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = +175°C	--	--	1.0	
Collector-Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	1.0	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 3Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 400mAdc, V_{CE} = 2Vdc	6.0	--	60	--
		I_C = 1Adc, V_{CE} = 2Vdc	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	2.0	Vdc

AC Current Gain	$\|h_{fe}\|$	V_{CE} = 2Vdc, I_C = 400mAdc, f = 50MHz	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 25Vdc, I_E = 0, f = 100 kHz	--	--	60	pF

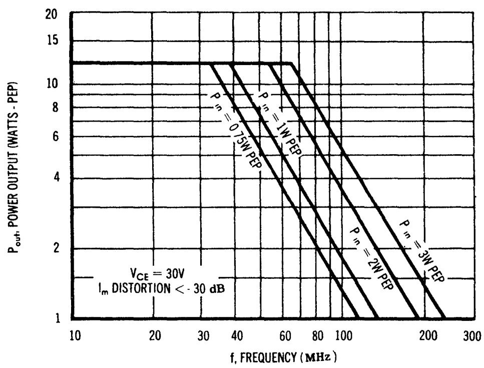
Power Input (PEP) Note 2	P_{in}	P_{out} = 12 Watts PEP (6.0W rms) V_{CE} = 30 Volts, f = 30MHz $I_{C(max)}$ = 0.50 Amp	--	--	1.2	Watts PEP
Power Gain	G_e		10	13	--	dB
Intermodulation Distortion Ratio	I_m		30	33	--	dB
Efficiency	η		40	45	--	%

[1] Pulse Test: Pulse Width = 100μs, Duty Cycle = 2 %
Note 2. PEP. Peak Envelope Power

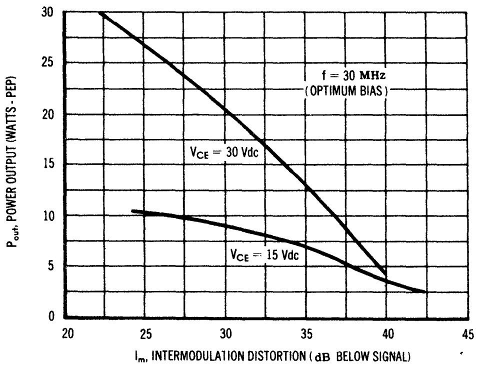
SAFE OPERATING AREA



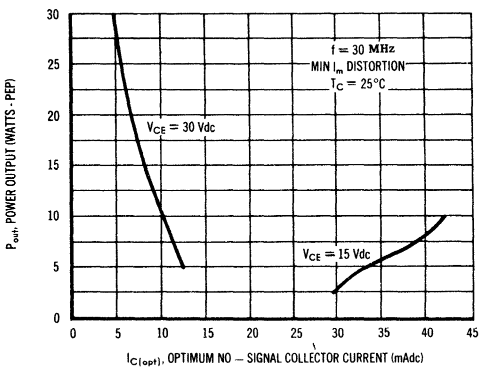
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

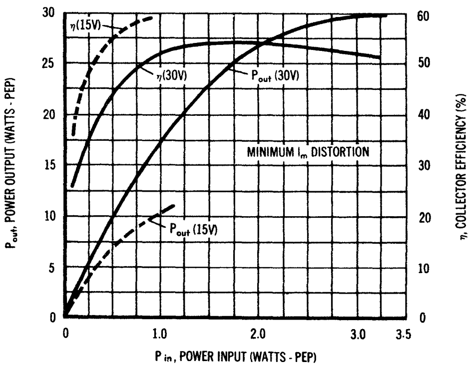


POWER OUTPUT versus OPTIMUM BIAS

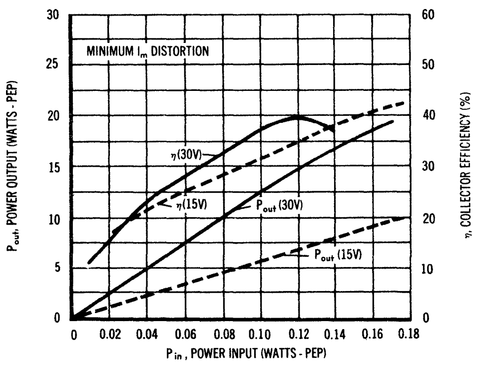


OUTPUT CHARACTERISTICS versus POWER INPUT

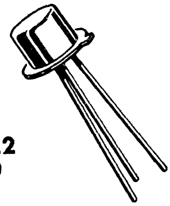
30 MHz



4 MHz



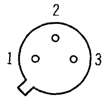
2N3298 (SILICON)



CASE 22
(TO-18)

Collector connected to case

NPN silicon annular transistor for power oscillator applications to 150 MHz.

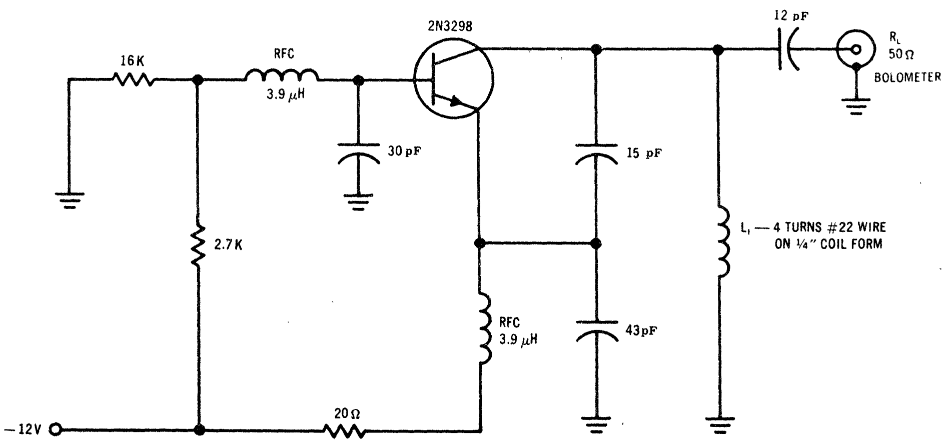


STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mA
Total Device Dissipation (25°C Case Temperature) Derate Above 25°C	P_D	1.0 6.67	Watt mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate Above 25°C 2mW/°C	P_D	0.3 2.0	Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

80 MHz OSCILLATOR POWER OUTPUT TEST CIRCUIT

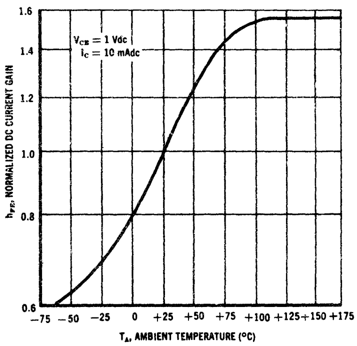


ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

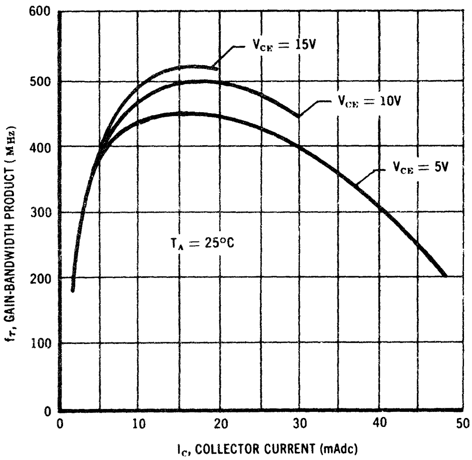
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C=25 μAdc, V_{BE}=0	25	35	-	Vdc
Collector-Emitter Open Base Sustaining Voltage	$BV_{CEO(sus)}$ (1)	I_C=10mA, I_B=0	15	24	-	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB}=10 Vdc, I_E=0 V_{CB}=10 Vdc, I_E=0, T_A=150°C	- -	0.01 10	0.5 50	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB}=3 Vdc, I_C = 0	-	-	10	μAdc
DC Current Gain	h_{FE}	V_{CE}= 1 Vdc, I_C= 10 mAdc	60	90	120	-
AC Current Gain	$\|h_{fe}\|$	V_{CE}= 10 Vdc, I_C= 10mAdc, f= 100 MHz	2.0	-	-	-
Collector Output Capacitance	C_{ob}	V_{CB}= 10 Vdc, I_E=0, f=100 kHz	-	5.0	6.0	pF
Power Output	P_{out}	f= 80 MHz V_{CC} = 12 Vdc $I_{C(max)}$ = 20 mA	60	-	100	mW
Efficiency	η		25	40	-	%

(1) Pulse Width = 300 μs, Duty Cycle = 2%

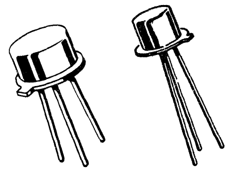
NORMALIZED DC CURRENT GAIN versus AMBIENT TEMPERATURE



f_T versus COLLECTOR CURRENT



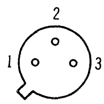
2N3299S, 2N3300S, 2N3301, 2N3302 (SILICON)



NPN silicon annular transistors for high-speed switching circuits and DC to UHF amplifier applications.

CASE 79
(TO-39)
2N3299
2N3300

CASE 22
(TO-18)
2N3301
2N3302



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage (Applicable 0 to 10 mAdc)	V_{CEO}	30		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	500		mAdc
Operating Junction Temperature Range	T_J	-65 to +200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		2N3299 2N3300	2N3301 2N3302	
Total Device Dissipation @ T_A = 25°C	P_D	0.8	0.36	Watt
Derate above 25°C		4.56	2.06	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	3.0	1.8	Watts
Derate above 25°C		17.2	10.3	mW/°C

*Indicates JEDEC Registered Data

FIGURE 1 — SATURATED TURN-ON SWITCHING TIME TEST CIRCUIT

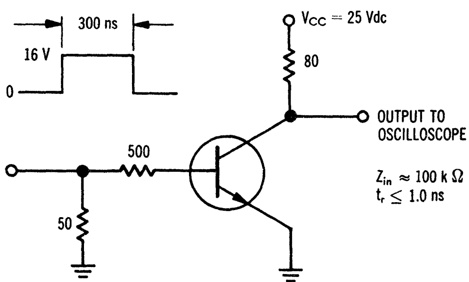
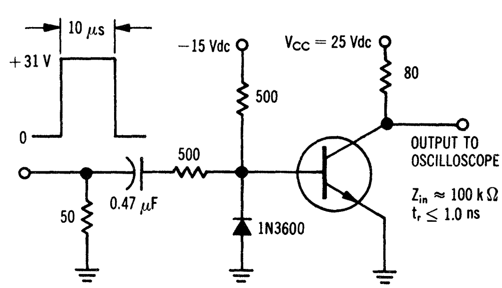


FIGURE 2 — SATURATED TURN-OFF SWITCHING TIME TEST CIRCUIT



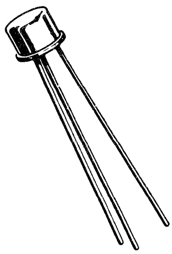
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current	I_{CES}			μAdc
(V_{CE} = 50 Vdc, V_{BE} = 0)		-	0.01	
(V_{CE} = 50 Vdc, V_{BE} = 0, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	-	10	nAdc
Base Current (V_{CE} = 50 Vdc, V_{BE} = 0)	I_B	-	10	nAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc) 2N3299, 2N3301		20	-	
2N3300, 2N3302		35	-	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc) 2N3299, 2N3301		25	-	
2N3300, 2N3302		50	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) (1) 2N3299, 2N3301		35	-	
2N3300, 2N3302		75	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (1) 2N3299, 2N3301		20	-	
2N3300, 2N3302		50	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (1) 2N3299, 2N3301		40	120	
2N3300, 2N3302		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc) (1) 2N3299, 2N3301		20	-	
2N3300, 2N3302		50	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	0.22	
(I_C = 300 mAdc, I_B = 30 mAdc)		-	0.45	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	0.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.1	
(I_C = 300 mAdc, I_B = 30 mAdc)		-	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.5	
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	1.1	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	8.0	pF
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	20	pF
Turn-On Time (Figure 1) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} ≈ 30 mAdc)	t_{on}	-	60	ns
Turn-Off Time (Figure 2) (V_{CC} = 25 Vdc, I_C ≈ 300 mAdc, I_{B1} = I_{B2} ≈ 30 mAdc)	t_{off}	-	150	ns

(1) Pulse Test: Pulse Width ≤ 300 μs; Duty Cycle ≤ 2%.

* Indicates JEDEC Registered Data

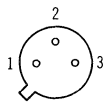
2N3303 (SILICON)



NPN silicon annular transistor designed for high-speed, high-current switching and driving applications.

CASE 31A

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.43	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage(1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.5 mAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	100	µAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_B	-	100	µAdc

(1) Pulse Test: Pulse Width = 300 µs, Duty Cycle ≤ 2%

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)		20	-	
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc) (1)		30	-	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc) (1)		30	120	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C) (1)		10	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc) (1)		-	0.23	
(I_C = 300 mAdc, I_B = 30 mAdc) (1)		-	0.33	
(I_C = 300 mAdc, I_B = 30 mAdc, T_A = 125°C) (1)		-	0.50	
(I_C = 1 Adc, I_B = 100 mAdc) (1)		-	0.70	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.78	
(I_C = 100 mAdc, I_B = 10 mAdc) (1)		-	1.10	
(I_C = 300 mAdc, I_B = 30 mAdc) (1)		-	1.30	
(I_C = 1 Adc, I_B = 100 mAdc) (1)		-	2.1	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T	450	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	25	pF
Turn-On Time (Figure 1) ($V_{EB(off)}$ ≈ 4 Vdc, I_C ≈ 1 Adc, I_{B1} ≈ 100 mAdc)	t_{on}	-	15	ns
Turn-Off Time (Figure 1) (I_C ≈ 1 Adc, I_{B1} ≈ I_{B2} ≈ 100 mAdc)	t_{off}	-	25	ns
Storage Time (Figure 2) (I_C ≈ 100 mAdc, I_{B1} ≈ I_{B2} ≈ 100 mAdc)	t_s	-	15	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT

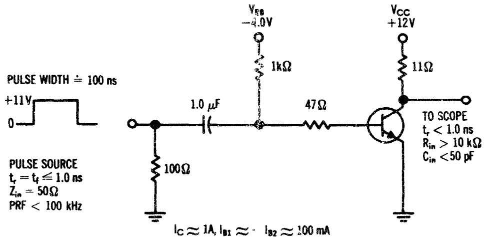
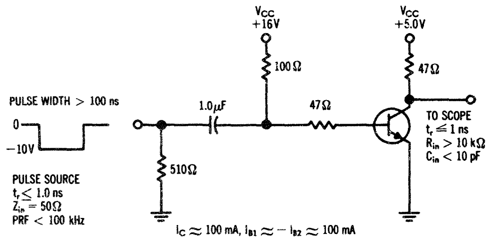
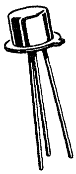


FIGURE 2 — STORAGE TIME TEST CIRCUIT



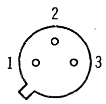
2N3304 (SILICON)



CASE 22
(TO-18)

Collector connected to case

PNP silicon annular transistor designed for low-level, high-speed switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	6.0	Vdc
Collector-Base Voltage	V_{CB}	6.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.72	mW mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	500 5.0	mW mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to+200	°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$BV_{CEO(sus)}$	6.0		Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	6.0	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	6.0	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 3 Vdc, V_{BE} = 0)	I_{CES}	—	0.01	μAdc
(V_{CE} = 3 Vdc, V_{BE} = 0, T_A = +125°C)		—	10	
Base Current (V_{CE} = 3 Vdc, V_{BE} = 0)	I_B	—	10	nAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 1 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	15	—	—
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_A = -55°C)		12	—	
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)		30	120	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)		20	—	
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{CE(sat)}$	—	0.15	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc, T_A = +125°C)		—	0.23	
(I_C = 10 mAdc, I_B = 1 mAdc)		—	0.16	
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)	$V_{BE(sat)}$	0.7	0.8	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		0.8	1.0	
(I_C = 50 mAdc, I_B = 5 mAdc)		—	1.5	
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T	500	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	—	3.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	—	3.5	pF
Turn-On Time (Figure 1) (V_{CC} = 1.5 Vdc, V_{BB} = 6 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{on}	—	60	ns
Turn-Off Time (Figure 1) (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 0.5 mAdc)	t_{off}	—	60	ns
Charge-Storage Time (Figure 2) (I_C = 10 mAdc, V_{CC} = 3 Vdc, I_{B1} = I_{B2} = 10 mAdc)	t_s	—	30	ns

(1) Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

* Indicates JEDEC Registered Data

FIGURE 1 — TURN-ON & TURN-OFF TIME TEST CIRCUIT

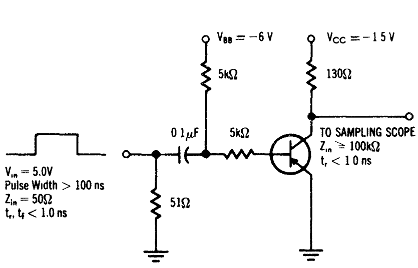
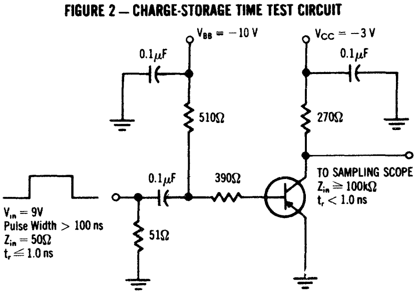
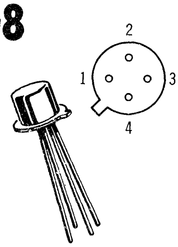


FIGURE 2 — CHARGE-STORAGE TIME TEST CIRCUIT



2N3307 (SILICON)
2N3308



CASE 20
(TO-72)

STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

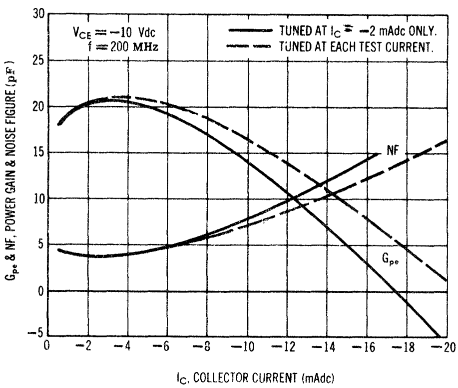
PNP silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

*MAXIMUM RATINGS

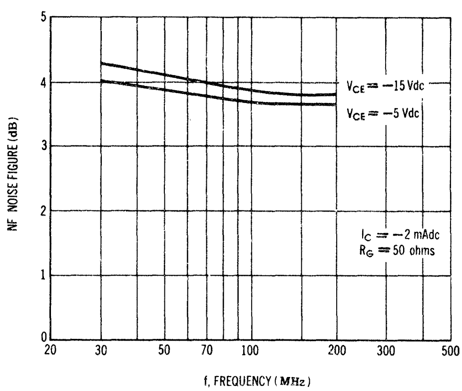
Rating	Symbol	Value		Unit
		2N3307	2N3308	
Collector-Base Voltage	V_{CB}	40	30	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0		Vdc
Collector Current	I_C	50		mAdc
Power Dissipation at T_C = 25°C Derate above 25°C	P_D	300 1.71		mW mW/°C
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	200 1.14		mW mW/°C
Junction Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

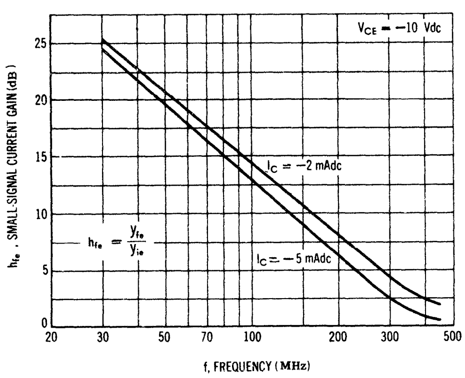
Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	2N3307 2N3308	40 30	– –	– –	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μAdc, V_{BE} = 0	2N3307 2N3308	40 30	– –	– –	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 2.0 mAdc, I_B = 0	2N3307 2N3308	35 25	– –	– –	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 10 μAdc, I_C = 0	Both Types	3.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc V_{CB} = 15 Vdc, T = 150 °C	Both Types 2N3307	– –	0.001 0.5	0.010 3.0	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	2N3307 2N3308	40 25	– –	250 250	–
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 3 mAdc, I_B = 0.6 mAdc	Both Types	–	–	0.4	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 3 mAdc, I_B = 0.6 mAdc	Both Types	–	–	1.0	Vdc
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz	2N3307 2N3308	40 25	– –	250 250	–
Output Capacitance (1)	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz	2N3307 2N3308	– –	1.0 1.2	1.3 1.6	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc, f = 31.8 MHz	2N3307 2N3308	2.0 2.0	– –	15 20	ps
Current Gain-Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 100 MHz	Both Types	300	–	1200	MHz
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mAdc	Both Types	–	2000	–	MHz
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	Both Types	17	–	24	dB
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 MHz	2N3307 2N3308	– –	4.0 5.0	4.5 6.0	dB
Power Gain (AGC) (2)	G_e	V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 MHz	2N3307 2N3308	– –	– 0	0 –	dB

(1) C_{ob} is measured in guarded circuit such that the can capacitance is not included.

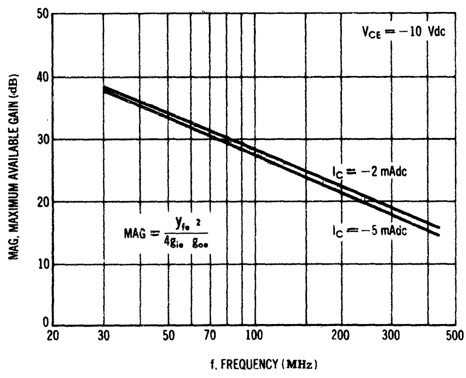
(2) AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = -10 Vdc, I_C = -2 mAdc operation.

* Indicates JEDEC Registered Data

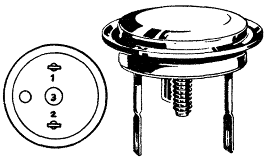
SMALL SIGNAL CURRENT GAIN versus FREQUENCY



MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N3311 thru 2N3316 (GERMANIUM)



CASE 5
(TO-36)

STYLE 1:
PIN 1. BASE
2. EMITTER
3. COLLECTOR

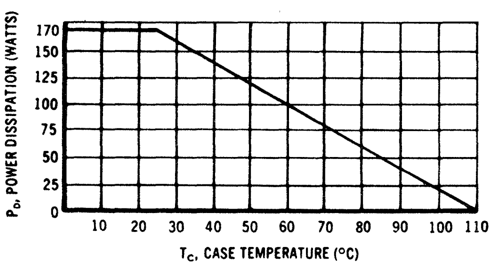
Collector connected to case

PNP germanium power transistors for high-power applications.

MAXIMUM RATINGS

Rating	Symbol	2N3311 2N3314	2N3312 2N3315	2N3313 2N3316	Unit
Collector-Base Voltage	V_{CB}	30	45	60	Volts
Collector-Emitter Voltage	V_{CES}	30	45	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EB}	20	25	30	Volts
Collector Current (Continuous)	I_C	5.0			Amp
Power Dissipation at $T_C = 25^oC$	P_D	170			Watts
Junction Temperature Range	T_J	-65 to +110			^oC
Thermal Resistance	θ_{JC}	0.5			°C/W

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25^oC and is 0 Watts at 110^oC with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^o - T_c}{0.5}$$

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

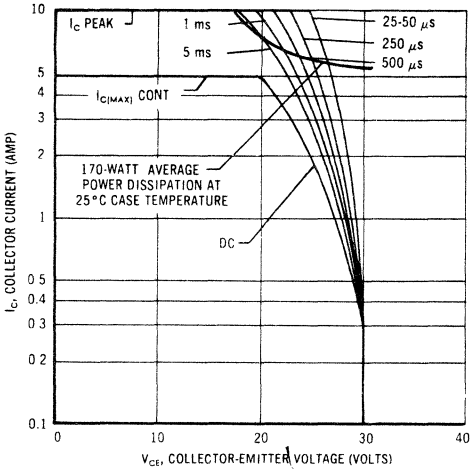
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc, I_B = 0)	2N3311, 2N3314	BV_{CEO}*	20	-	Vdc
	2N3312, 2N3315		30	-	
	2N3313, 2N3316		40	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N3311, 2N3314	BV_{CES}*	30	-	Vdc
	2N3312, 2N3315		45	-	
	2N3313, 2N3316		60	-	
Collector Cutoff Current (V_{CE} = 10 Vdc, I_B = 0)	2N3311, 2N3314	I_{CEO}	-	200	mAdc
(V_{CE} = 15 Vdc, I_B = 0)	2N3312, 2N3315		-	200	
(V_{CE} = 20 Vdc, I_B = 0)	2N3313, 2N3316		-	200	
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3311, 2N3314	I_{CEX}	-	35	mAdc
(V_{CE} = 40 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3312, 2N3315		-	35	
(V_{CE} = 55 Vdc, V_{BE} = 1.0 Vdc, T_C = 100°C)	2N3313, 2N3316		-	35	
Collector-Base Cutoff Current (V_{CB} = $V_{CB\ max}$)		I_{CBO}	-	5.0	mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	0.3	
Emitter-Base Cutoff Current (V_{BE} = $V_{BE\ max}$, I_C = 0)		I_{EBO}	-	4.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 500 mAdc, V_{CB} = 2.0 Vdc)	2N3311 thru 2N3313	h_{FE}	-	150	-
	2N3314 thru 2N3316		-	250	
(I_C = 3.0 Adc, V_{CB} = 2.0 Vdc)	2N3311 thru 2N3313		60	120	
	2N3314 thru 2N3316		100	200	
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc)		$V_{CE(sat)}$	-	0.1	Vdc
Base-Emitter Voltage (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	2N3311 thru 2N3313	$V_{BE(on)}$	-	0.6	Vdc
	2N3314 thru 2N3316		-	0.5	
DYNAMIC CHARACTERISTICS					
Common Emitter Cutoff Frequency (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	1.0	-	kHz
Small Signal Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc, f = 0.5 kHz)	2N3311 thru 2N3313	h_{fe}	30	90	-
	2N3314 thru 2N3316		40	120	

*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

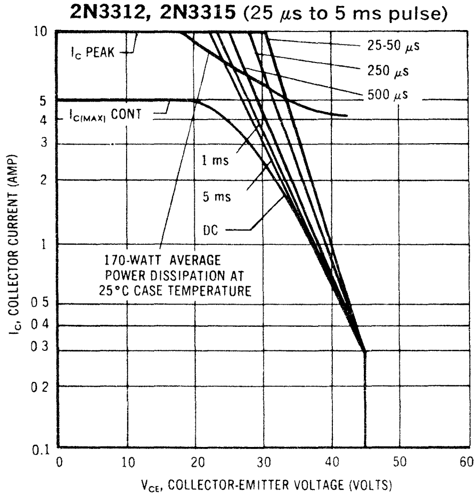
SAFE OPERATING AREA

The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

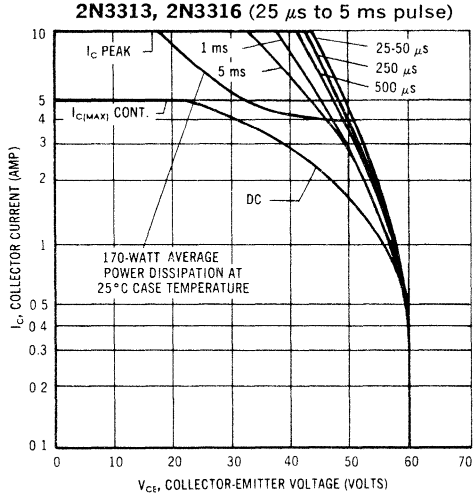
2N3311, 2N3314 (25 µsec to 5 msec pulse)



2N3312, 2N3315 (25 µs to 5 ms pulse)

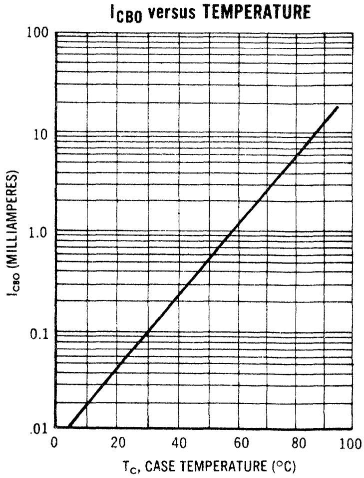


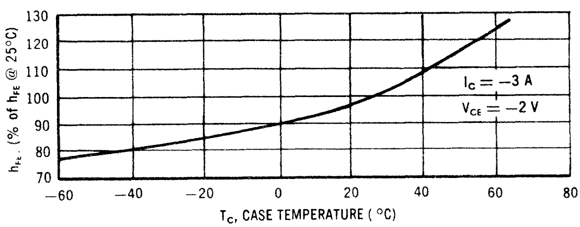
2N3313, 2N3316 (25 µs to 5 ms pulse)



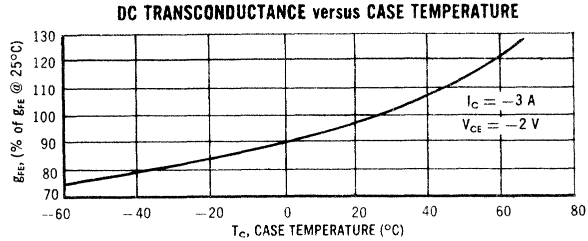
TEMPERATURE CHARACTERISTICS

I_{CBO} versus TEMPERATURE



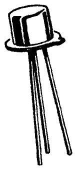


DC TRANSCONDUCTANCE versus CASE TEMPERATURE

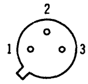


2N3323 (Ge Mesa)
2N3324
2N3325

PNP germanium transistors for RF, IF, mixer and oscillator and RF, IF and converter applications.



CASE 22-03
(TO-18)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	35	Vdc
Collector-Emitter Voltage	V_{CES}	35	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	100	mA
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25°C	P_D	300 4.0	mW mW/°C
Total Device Dissipation@ $T_A = 25^oC$ Derate above 25°C	P_D	150 2.0	mW mW/°C
Junction Temperature	T_J	+100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C

*Indicates JEDEC Registered Data

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CER}	I_C = 100 μAdc, R_{BE} = 10K	35	--	Vdc
Collector-Emitter Current	I_{CES}	V_{CE} = 35 Vdc, V_{BE} = 0	--	100	μAdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	--	10	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 2 Vdc, I_C = 0	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc	30	200	--
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 1 kHz	30	225	--
Current-Gain — Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 100 MHz	200	600	MHz
Collector-Base Time Constant	$r_b'C_C$	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 31.8 MHz	--	100	ps
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0 f = 100 kHz	--	3.0	pF

2N3323

Power Gain	G_e	Test Circuit Figure 1 V_{CE} = 10 Vdc, I_C = 3 mAdc f = 100 MHz	11	15	dB

2N3324

Power Gain	G_e	Test Circuit Figure 2 V_{CE} = 10 Vdc, I_C = 3 mAdc f = 10 MHz	24	31	dB

*Indicates JEDEC Registered Data

FIGURE 1: 100 MHz POWER GAIN TEST CIRCUIT — 2N3323

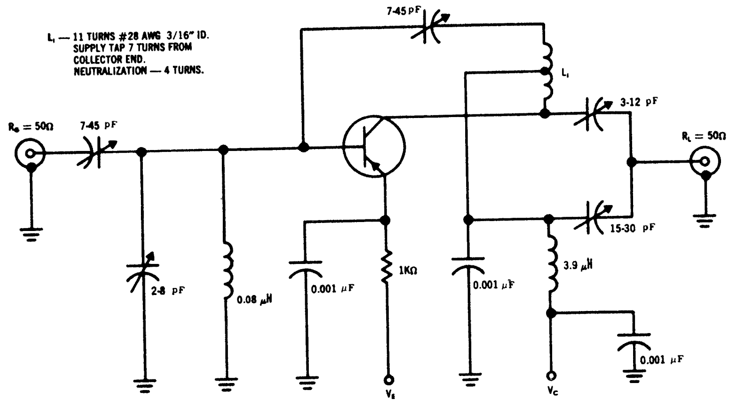
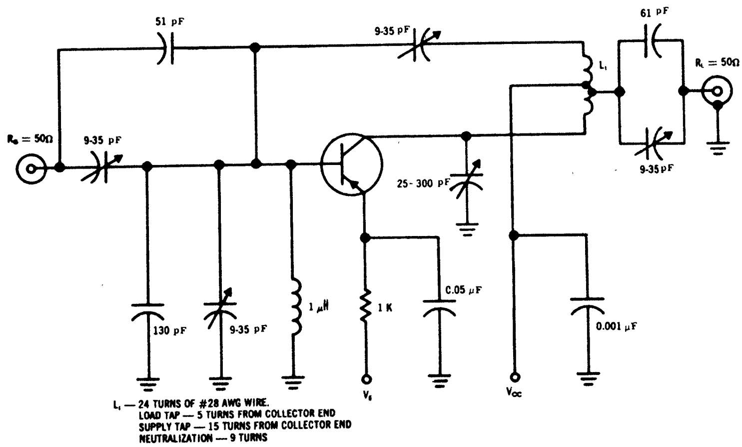


FIGURE 2: 10 MHz POWER GAIN TEST CIRCUIT — 2N3324



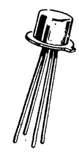
SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

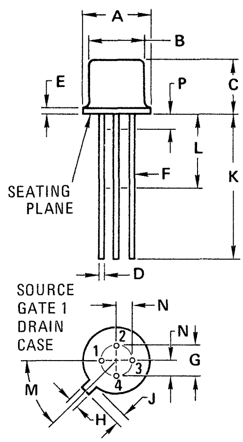
Depletion Mode (Type A) Junction Field-Effect Transistor designed primarily for low-power audio-amplifier applications.

- High AC Input Resistance — Typically > 30 Megohms @ f = 1.0 kHz
- Drain and Source Interchangeable
- Active Elements Isolated from Case

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

(Type A)





STYLE 5
PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
*Gate Current	I_G	10	mAdc
*Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 2.0	mW mW/^oC
*Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_C = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	20	–	Vdc
Gate Reverse Current	I_{GSS}			
(V_{GS} = 10 Vdc, V_{DS} = 0)		–	10	nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 150°C)		–	10	μAdc
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0)	I_{DSS}	2.0	6.0	mAdc
ON CHARACTERISTICS				
Gate-Source Voltage (V_{DG} = -15 Vdc, I_D = 10 μAdc)	V_{GS}	–	6.0	Vdc
Drain-Source Resistance (I_D = 100 μAdc, V_{GS} = 0)	r_{DS}	–	800	Ohms
SMALL-SIGNAL CHARACTERISTICS				
Forward Transadmittance (Note 1)	$\|y_{fs}\|$			μmhos
(V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)		1500	3000	
(V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 10 MHz)		1350	–	
Output Admittance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{os}\|$	–	40	μmhos
Reverse Transfer Conductance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{rs}\|$	–	0.1	μmhos
Input Conductance (V_{DS} = -10 Vdc, I_D = 2.0 mAdc, f = 1.0 kHz)	$\|y_{is}\|$	–	0.2	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 1.0 Vdc, f = 1.0 MHz)	C_{iss}	–	20	pF
Common-Source Noise Figure (V_{DS} = -5.0 Vdc, I_D = 1.0 mAdc, R_G = 1.0 Megohm, f = 1.0 kHz)	NF	–	3.0	dB

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤10%.

2N3365 (SILICON)
2N3366
2N3367

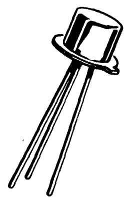
SILICON LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode Junction Field-Effect Transistors designed for audio amplifiers in low-power or battery operated applications.

- Low Zero-Gate Voltage Drain Current @ V_{DS} = 30 Vdc –
  I_{DSS} = 800 μAdc to 4.0 mAdc – 2N3365
  200 μAdc to 1.0 mAdc – 2N3366
  50 μAdc to 250 μAdc – 2N3367
- Low Gate Source Voltage @ V_{DS} = 20 Vdc and I_D = 1.0 μAdc –
  V_{GS} = 4.0 Vdc (Typ) and 11.5 Vdc (Max) – 2N3365
  3.0 Vdc (Typ) and 6.5 Vdc (Max) – 2N3366
  1.0 Vdc (Typ) and 2.2 Vdc (Max) – 2N3367
- Low Noise Voltage –
  $e_n = 75\ nV/\sqrt{Hz}$ (Max) @ f = 1.0 kHz
- Drain and Source Interchangeable

LOW NOISE N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

$e_n = 75\ nV/\sqrt{Hz}$



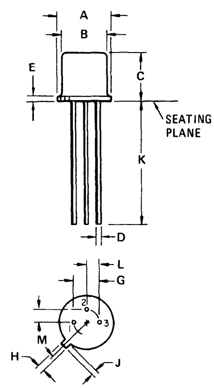
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(R)}$	40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.4	mW mW/°C
Operating Case Temperature	T_C	150	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS:

Maximum Lead Temperature for Soldering:
300°C, not less than 1/16" from case for 10 s.



PIN 1. DRAIN
2. SOURCE
3. GATE

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.209	0.230	5.310	5.840
B	0.178	0.195	4.520	4.950
C	0.170	0.210	4.320	5.330
D	0.016	0.019	0.406	0.483
E	–	0.030	–	0.762
G	0.100 NOM		2.540 NOM	
H	0.036	0.046	0.914	1.170
J	0.028	0.048	0.711	1.220
K	0.500	–	12.700	–
L	0.050 NOM		1.270 NOM	
M	45° NOM		45° NOM	

All JEDEC dimensions and notes apply

CASE 22
TO-18

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Gate-Drain Breakdown Voltage (I_D = 1.0 μAdc, I_S = 0)		$V_{(BR)GDO}$	40	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 20 Vdc, I_D = 5.0 nAdc)	2N3365	$V_{GS(off)}$	–	12	Vdc
	2N3366		–	7.0	
	2N3367		–	2.5	
Gate-Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 μAdc)	2N3365	V_{GS}	–	11.5	Vdc
	2N3366		–	6.5	
	2N3367		–	2.2	
Gate Reverse Current (V_{GS} = 30 Vdc, V_{DS} = 0)		I_{GSS}	–	5.0	nAdc
(V_{GS} = 30 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
***ON CHARACTERISTICS**					
Zero-Gate Voltage Drain Current (1) (V_{DS} = 30 Vdc, V_{GS} = 0)	2N3365	I_{DSS}	0.8	4.0	mAdc
	2N3366		0.2	1.0	
	2N3367		0.05	0.25	
SMALL-SIGNAL CHARACTERISTICS					
*Forward Transadmittance (1) (V_{DS} = 30 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3365	$\|y_{fs}\|$	400	2000	μmhos
	2N3366		250	1000	
	2N3367		100	1000	
*Output Admittance (V_{DS} = 30 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3365	$\|y_{os}\|$	–	50	μmhos
	2N3366		–	20	
	2N3367		–	10	
*Input Capacitance (V_{DS} = 8.0 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	15	pF
*Output Capacitance (V_{DS} = 30 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{oss}	–	2.5	pF
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz, BW = 1.0 Hz)		e_n	–	75	nV/$\sqrt{Hz}$

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width = 360 ms, Duty Cycle = 2.0%.

TYPICAL SMALL-SIGNAL CHARACTERISTICS

FIGURE 1 – FORWARD TRANSFER ADMITTANCE

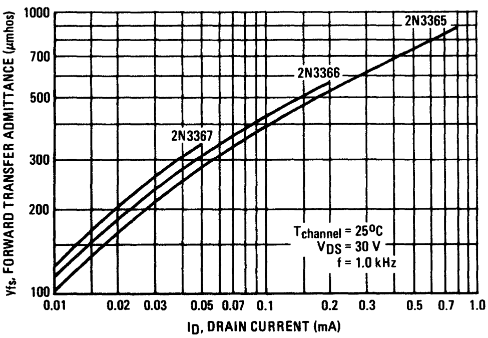
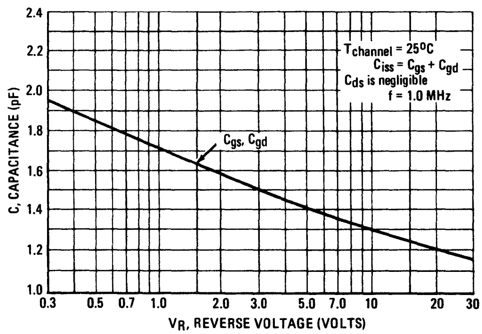
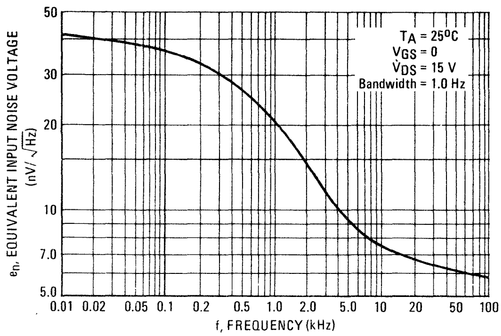


FIGURE 2 – CAPACITANCE



NOISE DATA

FIGURE 3 — TYPICAL NOISE VOLTAGE



In a junction field-effect transistor, the current flow is due to carrier drift, therefore total noise at the input may be expressed as:

$$V_T = [e^2_n + 4 KT R_S]^{1/2}$$

where V_T = total noise voltage at the FET input (volts/$\sqrt{Hz}$)
e_n = noise voltage of the FET referred to the input (Figure 3).
K = Boltzman's constant (1.38×10^{-23} j/^oK)
T = temperature of the source resistance (^oK)
R_S = source resistance (ohms)

Example:

Find the total noise at the input of a 2N3365 FET with a source impedance of 10 kilohms at a frequency of 1.0 kHz and at a temperature of 25°C.

Read e_n = 20.5 nV/$\sqrt{Hz}$ from Figure 3. (Note that this is for a one cycle bandwidth).

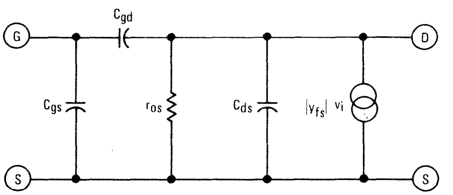
$$V_T = [(20.5 \times 10^{-9})^2 + (4)(1.38 \times 10^{-23})(300)(1 \times 10^4)]^{1/2}$$
$$= 24.2 \text{ nV}/\sqrt{Hz}$$

Noise over a frequency band can be handled in one of two ways depending upon whether FET noise is constant or variable over the bandwidth of interest:

1. For constant FET noise, multiply V_T by the square root of bandwidth, i.e., $V'_T = V_T \bullet \Delta f^{1/2}$
2. For variable FET noise, plot V'_T (where Δf = 1.0 Hz) versus frequency over the bandwidth and integrate the result.

Total noise voltage at the output of the FET stage can be found by multiplying V_T by the voltage gain of the stage.

FIGURE 4 — LOW FREQUENCY CIRCUIT MODEL



$y_{is} = j\omega C_{iss}$
$y_{os} = 1/r_{oss} + j\omega C_{oss}$
$y_{fs} = |y_{fs}|$
$y_{rs} = -j\omega C_{rss}$

$C_{iss} = C_{gd} + C_{gs}$
$C_{rss} = C_{gd}$
$C_{oss} = C_{gd} + C_{ds}$, $C_{ds} \approx 0$

TYPICAL LIMIT TRANSFER CHARACTERISTICS

(Temperatures Noted are $T_{channel}$)

FIGURE 5 – 2N3365

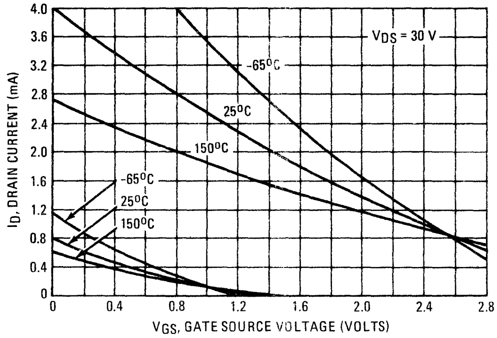


FIGURE 6 – 2N3366

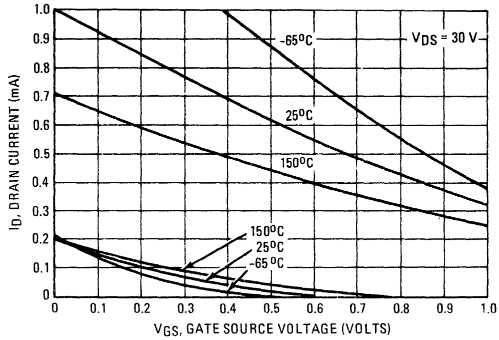


FIGURE 7 – 2N3367

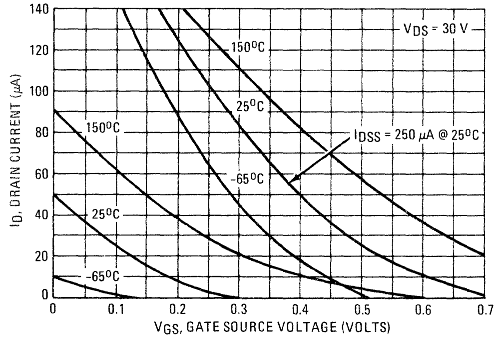
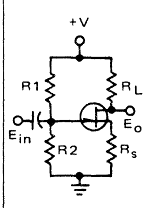
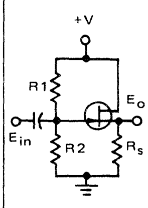
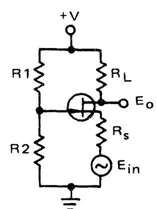
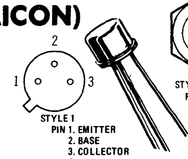


FIGURE 8 – AMPLIFIER EQUATIONS

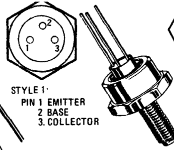
Circuit Characteristic	Common Source	Source Follower	Common Gate
			
Voltage Gain	$A_V \approx \frac{-R_L}{\frac{1}{gm} + R_s}$	$A_V \approx \frac{R_s}{\frac{1}{gm} + R_s}$	$A_V \approx \frac{R_L}{\frac{1}{gm} + R_s}$
Input Impedance	$Z_{in} \approx R1 \| R2$	$Z_{in} \approx R1 \| R2$	$Z_{in} \approx R_s + \frac{1}{gm}$
Output Impedance	$Z_o \approx R_L$	$Z_o \approx R_s \| \frac{1}{gm}$	$Z_o \approx R_L$

2N3375 (SILICON)
2N3553
2N3632
2N3961



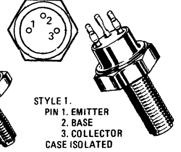
***CASE 79** (TO-39)

2N3553



****CASE 24** (TO-102)

2N3961



*****CASE 36** (TO-60)

2N3375
2N3632

* Collector Connected to Case

** Collector electrically connected to case; stud electrically isolated from case

*** Stud electrically isolated from case

NPN silicon RF Power transistors, optimized for large-signal power amplifier and driver applications to 400MHz, provide wide choice of power levels and guaranteed safe operating areas.

MAXIMUM RATINGS

Rating	Symbol	2N3375	2N3553	2N3632	2N3961	Unit
Collector-Emitter Voltage	V_{CEO}	←	40		→	Vdc
Collector-Base Voltage	V_{CB}	←	65		→	Vdc
Emitter-Base Voltage	V_{EB}	←	4.0		→	Vdc
Collector Current	I_C	1.5	1.0	3.0	1.0	Adc
Total Device Dissipation @ T_C = 25°C	P_D	11.6	7.0	23	10	Watts
Derate above 25°C		66.4	40	131	57.2	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	←	-65 to +200		→	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	40	-	Vdc
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 0.25 mAdc, I_C = 0)	2N3632		4.0	-	
(I_E = 0.1 mAdc, I_C = 0)	2N3375, 2N3553		4.0	-	
(I_E = 1.0 mAdc, I_C = 0)	2N3961		4.0	-	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N3375, 2N3553		-	0.1	
	2N3632		-	0.25	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 200°C)	2N3375, 2N3553		-	5.0	
	2N3632		-	10	
(V_{CE} = 65 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3375, 2N3553		-	1.0	
	2N3632		-	5.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 28 Vdc, I_E = 0, T_A = 150°C)	2N3961		-	5.0	
(V_{CB} = 65 Vdc, I_E = 0)	2N3632		-	0.5	
	2N3961		-	1.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 4.0 Vdc, I_C = 0)	2N3375, 2N3553		-	0.1	
	2N3632		-	0.25	

* Pulsed thru 25 mH inductor (See Figures 5 and 6).

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	2N3375, 2N3553, 2N3632		10	-	-	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N3632		5.0	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 250 mAdc, I_B = 50 mAdc)	2N3553		-	-	1.0	
(I_C = 500 mAdc, I_B = 100 mAdc)	2N3375, 2N3632		-	-	1.0	
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 5.0 Adc)	2N3632	$V_{BE(sat)}$	-	-	1.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product		f_T				MHz
(I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3553		-	500	-	
(I_C = 125 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3961		350		-	
(I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	2N3375		-	500	-	
	2N3632		-	400	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 28 Vdc, I_E = 0, f = 100 kHz)	2N3961		-	8.0	10	
(V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	2N3375, 2N3553		-	8.0	10	
	2N3632		-	16	20	

FUNCTIONAL TESTS

2N3375

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
Power Input	Test Circuit Figure 7 (V_{CE} = 28 Vdc, P_{out} = 7.5 Watts, f = 100 MHz)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	8.75	-	-	dB
Collector Efficiency		η	65	-	-	%
Power Input	Test Circuit Figure 8 (V_{CE} = 28 Vdc, P_{out} = 3.0 Watts, f = 400 MHz)	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	4.77	-	-	dB
Collector Efficiency		η	40	-	-	%

2N3553

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
Power Input	Test Circuit Figure 9 (V_{CE} = 28 Vdc, P_{out} = 2.5 Watts, f = 175 MHz)	P_{in}	-	-	0.25	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	10	-	-	dB
Collector Efficiency		η	50	-	-	%

2N3632

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
Power Input	Test Circuit Figure 10 (V_{CE} = 28 Vdc, P_{out} = 13.5 Watts, f = 175 MHz)	P_{in}	-	-	3.5	Watts
Common-Emitter Amplifier Power Gain		G_{pe}	5.86	-	-	dB
Collector Efficiency		η	70	-	-	%

2N3961

Characteristic	Test Conditions	Symbol	Min	Typ	Max	Unit
Power Input	Test Circuit Figure 11 (V_{CE} = 12.5 Vdc, P_{out} = 2.0 Watts, R_S = 50 ohms, R_L = 50 ohms, f = 135 MHz)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	6.0	-	-	dB
Collector Efficiency		η	60	-	-	%
Power Input	Test Circuit Figure 12 (V_{CE} = 28 Vdc, P_{out} = 4.0 Watts, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz)	P_{in}	-	-	0.5	Watt
Common-Emitter Amplifier Power Gain		G_{pe}	9.0	-	-	dB
Collector Efficiency		η	60	-	-	%

POWER OUTPUT versus FREQUENCY

COMMON EMITTER — V_{CE} = 28 Vdc, T_C = 25°C

FIGURE 1 – 2N3375

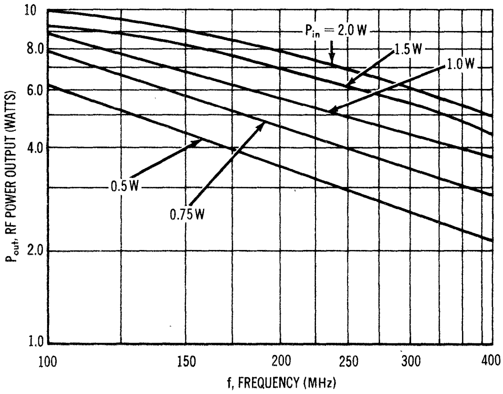


FIGURE 2 – 2N3553

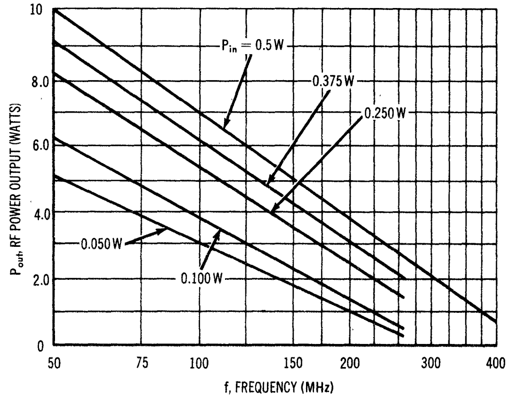


FIGURE 3 – 2N3632

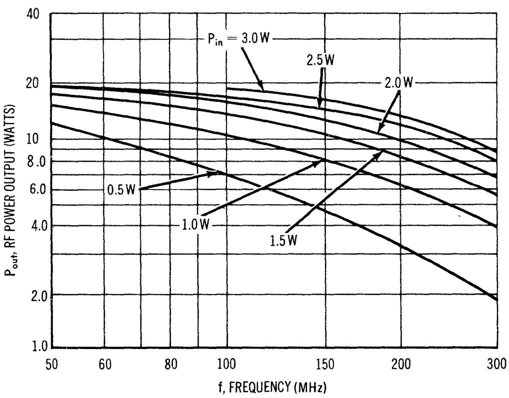
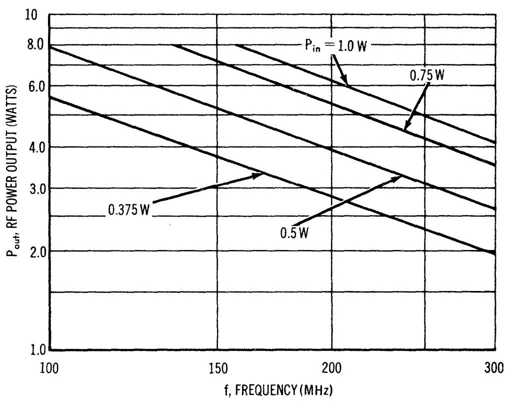


FIGURE 4 – 2N3961



$BV_{CEO(sus)}$ PULSE TEST CIRCUITS

FIGURE 5 – 2N3375, 2N3553, 2N3632

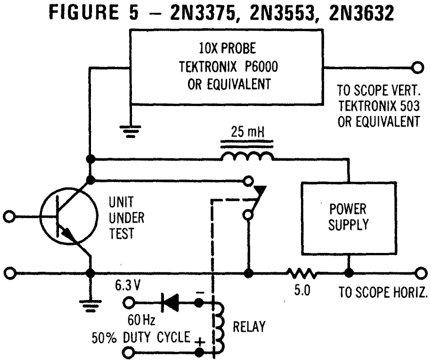
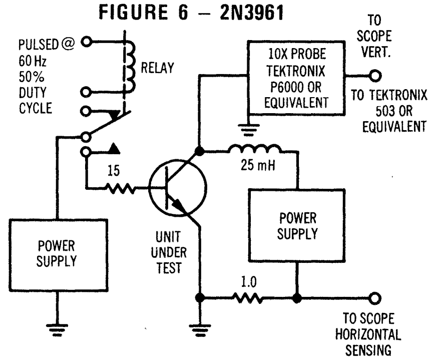
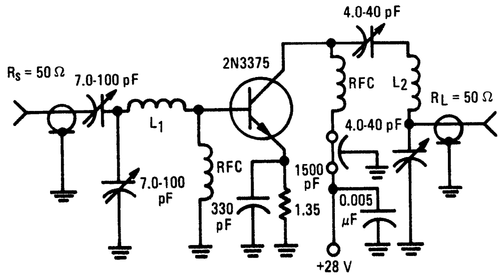


FIGURE 6 – 2N3961



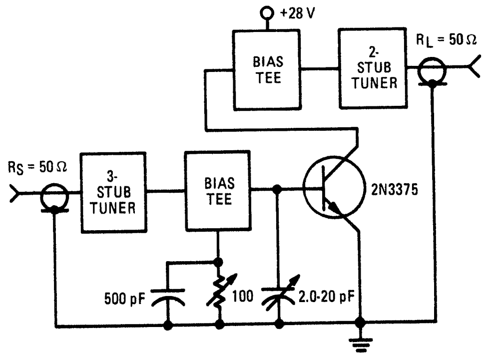
TEST CIRCUITS
2N3375

FIGURE 7 – 100 MHz



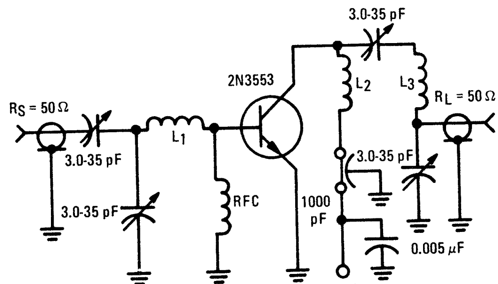
L1: 3 turns No. 16 AWG wire ¼" I.D., 5/16" long
L2: 5 turns No. 16 AWG wire 5/16" I.D., 7/16" long

FIGURE 8 – 400 MHz



2N3553

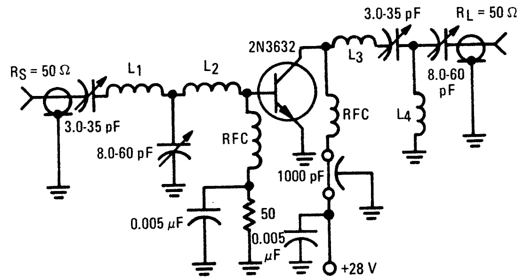
FIGURE 9 – 175 MHz



L1: 2 turns No. 16 AWG wire 3/16" I.D., ¼" long
L2: 2 turns No. 16 AWG wire 3/16" I.D., ¼" long
L3: 3 turns No. 16 AWG wire 3/8" I.D., 3/8" long

2N3632

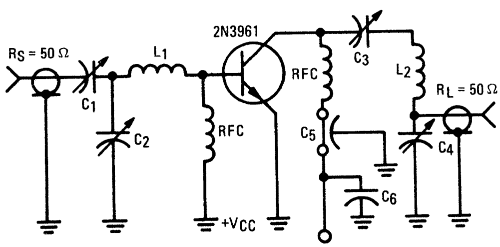
FIGURE 10 – 175 MHz



L1, L3: 4 turns No. 18 AWG wire ¼" I.D. 3/16" long
L2: 1 turn No. 16 AWG wire ¼" I.D., 3/16" long
L4: 2½ turns No. 16 AWG wire ¼" I.D., ¼" long

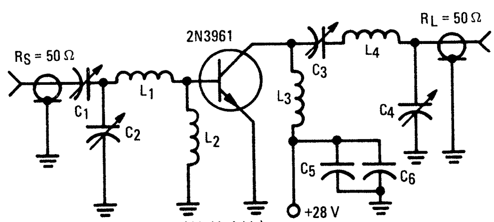
2N3961

FIGURE 11 – 135 MHz



C_1, C_3 = 5.0-50 pF (Air Variable)
C_2 = 7.0-100 pF (Air Variable)
C_4 = 1.0-30 pF (Air Variable)
C_5 = 1000 pF (Disc Ceramic)
C_6 = 0.02 μF (Disc Ceramic)
L_1 = 3 turns No. 16 AWG wire, 5/16" I.D., 5/16" long
L_2 = 5 turns No. 16 AWG wire, 7/16" I.D., 5/8" long

FIGURE 12 – 175 MHz



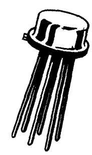
C_1	1.0-12 pF	(Air Variable)
C_2	1.0-30 pF	(Air Variable)
C_3	5.0-50 pF	(Air Variable)
C_4	7.0-75 pF	(Air Variable)
C_5	470 pF	(Disc Ceramic)
C_6	0.001 μF	(Disc Ceramic)
L_1, L_3, L_4	2 turns No. 18 AWG enameled wire ¼" I.D., air wound 3/16" long	
L_2	RFC, $Q_U < 1$	

MULTIPLE SILICON ANNULAR TRANSISTORS

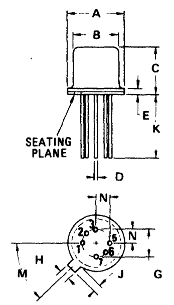
... designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 10 mAdc
- DC Current Gain Specified — 0.5 mAdc to 10 mAdc
- High Current-Gain—Bandwidth Product — f_T = 300 MHz @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

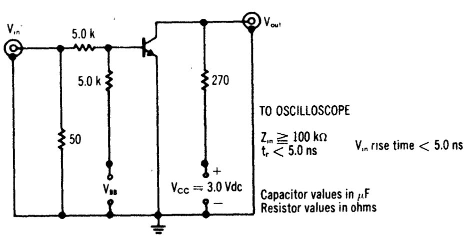
CASE 654-07

*MAXIMUM RATINGS

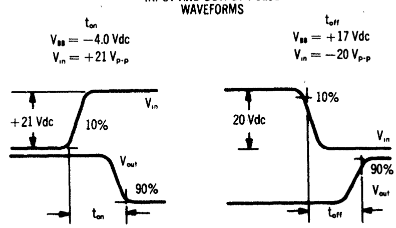
Rating	Symbol	Value One Die	Value Both Die	Unit
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Collector-Emitter Voltage ($R_{BE} \leqslant 10$ Ohms)	V_{CER}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 1.72	0.4 2.28	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.75 4.3	1.5 8.55	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME TEST CIRCUIT



INPUT AND OUTPUT PULSE WAVEFORMS



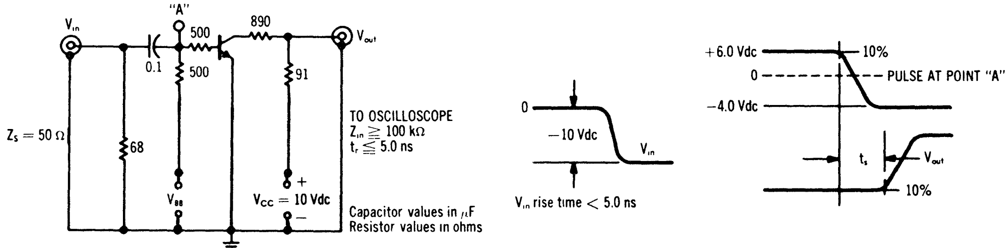
*ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 10 mAdc, I_B = 0)	$V_{CEO(sus)}$	15	-	Vdc
Collector-Emitter Sustaining Voltage (1) (I_C = 30 mAdc, R_{BE} ≦ 10 ohms)	$V_{CER(sus)}$	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	15	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	-	0.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		-	15	
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.2	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	12	-	-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		30	120	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)		12	-	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
(I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C to +125°C)		-	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
(I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C)		-	0.9	
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	9.0	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, f = 1.0 kHz)	h_{fe}	20	-	-
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)	$Re(h_{ie})$	-	50	Ohms
Turn-On Time (Figure 1) (V_{CC} = 3.0 Vdc, $V_{EB(off)}$ = 2.0 Vdc, I_C ≈ 10 mAdc, I_{B1} ≈ 3.0 mAdc)	t_{on}	-	50	ns
Turn-Off Time (Figure 1) (V_{CC} = 3.0 Vdc, I_C ≈ 10 mAdc, I_{B1} ≈ 3.0 mAdc, I_{B2} ≈ 1.0 mAdc)	t_{off}	-	90	ns
Storage Time (Figure 2) (I_C ≈ 10 mAdc, I_{B1} ≈ 10 mAdc, I_{B2} ≈ 10 mAdc)	t_s	-	40	ns

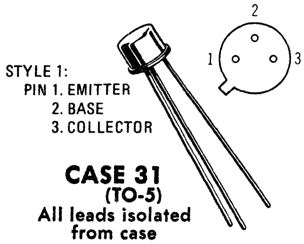
* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse width ≦ 300 μs, duty cycle ≦ 1%

FIGURE 2 — STORAGE TIME TEST CIRCUIT



2N3427, 2N3428 (GERMANIUM)



PNP germanium transistors for audio amplifier and medium-speed switching applications.

MAXIMUM RATINGS

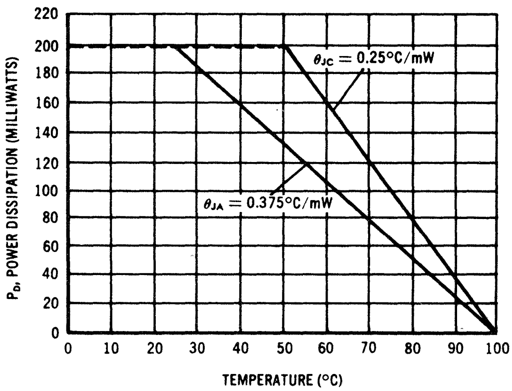
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EB}	30	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Base Current (Continuous)	I_B	50*	mAdc
Storage and Operating Temperature Range	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation, Ambient Derate Above 25°C	P_D	200 2.67	mW mW/°C

*Limited by power dissipation

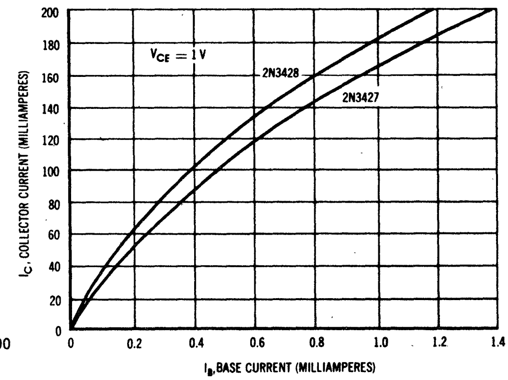
ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 1.5 Vdc, I_E = 0)			–	3.0	5.0	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C)			–	–	100	
(V_{CB} = 30 Vdc, I_E = 0)			–	–	10	
(V_{CB} = 45 Vdc, I_E = 0)			–	–	50	
Emitter-Base Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 10K ohms)		I_{CER}	–	–	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_{fl} = 1.0 Vdc, VTVM impedance ≥ 1 megohm)		V_{pt}	30	–	–	Vdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	–	10	20	pF
Noise Figure (V_{CE} = 4.5 Vdc, I_E = 0.5 mAdc, R_s = 1 K ohms, f = 1 kHz, Δf = 1 Hz)		NF	–	5.0	10	dB
Small-Signal Current-Gain Cutoff Frequency		$f_{\alpha b}$				MHz
(V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N3427		4.0	6.0	–	
	2N3428		5.0	8.0	–	
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ib}	25	–	35	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)		h_{ob}	0.05	–	0.50	μmho
Small-Signal Current Gain		h_{fe}				–
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kHz)	2N3427		200	325	500	
	2N3428		350	475	800	
Small-Signal Current Gain		$\|h_{fe}\|$				–
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 2 MHz)	2N3427		2.0	–	7.0	
	2N3428		2.5	–	8.0	
DC Current Gain		h_{FE}				–
(I_C = 20 mAdc, V_{CE} = 1 Vdc)	2N3427		150	275	–	
	2N3428		250	375	–	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3427		100	210	350	
	2N3428		150	260	400	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N3427		75	–	–	
	2N3428		125	–	–	
Base-Emitter Input Voltage (V_{CE} = 1 Vdc, I_C = 100 mAdc)		V_{BE}	–	–	0.5	Vdc
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 100 mAdc, I_B = 2 mAdc)	2N3427		–	0.155	0.200	
	2N3428		–	0.150	0.190	
(I_C = 200 mAdc, I_B = 4 mAdc)	2N3427		–	0.220	0.300	
	2N3428		–	0.200	0.280	

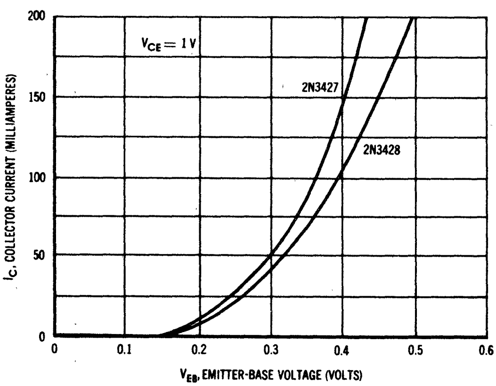
POWER-TEMPERATURE DERATING CURVE



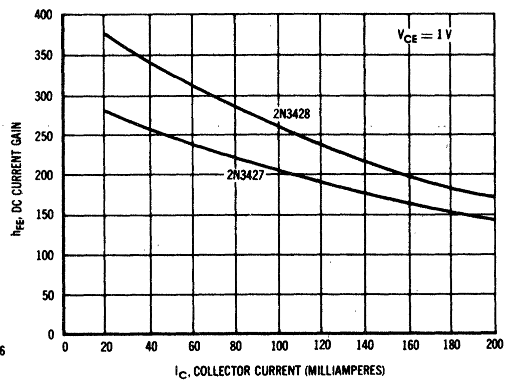
COLLECTOR CURRENT versus BASE CURRENT



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



2N3439, 2N3440 NPN (SILICON)
MJ5415, MJ5416 PNP

1 AMPERE
POWER TRANSISTORS
COMPLEMENTARY SILICON
200-350 VOLTS
5 and 10 WATTS

COMPLEMENTARY SILICON HIGH VOLTAGE POWER TRANSISTORS

. . . designed for use in consumer and industrial line-operated applications. These devices are particularly suited for audio, video and differential amplifiers as well as high-voltage, low-current inverters, switching and series pass regulators.

- High DC Current Gain –
  h_{FE} = 40-160 @ I_C = 20 mAdc – 2N3439, 2N3440
  = 30-150 @ I_C = 50 mAdc – MJ5415
  = 30-120 @ I_C = 50 mAdc – MJ5416
- Current-Gain – Bandwidth Product –
  f_T = 15 MHz (Min) @ I_C = 10 mAdc
- Low Output Capacitance @ f = 1.0 MHz –
  C_{ob} = 10 pF (Max) – 2N3439, 2N3440
  = 25 pF (Max) – MJ5415, MJ5416

*MAXIMUM RATINGS

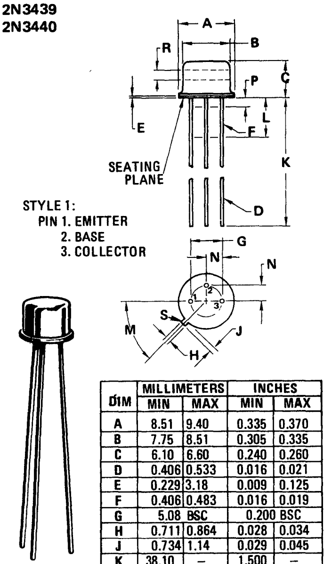
Rating	Symbol	PNP MJ5415	PNP MJ5416	NPN 2N3439	NPN 2N3440	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	350	250	Vdc
Collector-Base Voltage	V_{CB}	200	350	450	300	Vdc
Emitter-Base Voltage	V_{EB}	4.0	7.0	7.0	7.0	Vdc
Collector Current – Continuous	I_C	← 1.0 →				Adc
Base Current	I_B	← 0.5 →				Adc
Total Device Dissipation @ T_A = 50°C Derate above 50°C	P_D	1.0 6.7		– –		Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	– –		1.0 5.7		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57		5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MJ5415,MJ5416	2N3439,2N3440	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	150	175	°C/W

*Indicates JEDEC Registered Data.

2N3439
2N3440

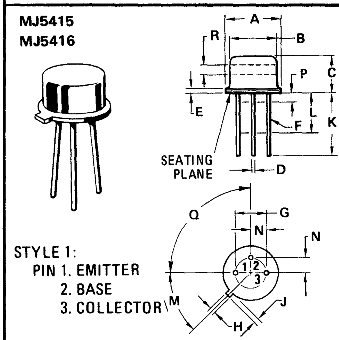


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

MJ5415
MJ5416



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

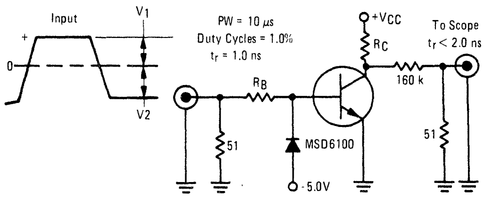
CASE 79-02
TO-39

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Sustaining Voltage (1)	MJ5415	$V_{CEO(sus)}$	200	–	Vdc
(I_C = 10 mAdc, I_B = 0)	MJ5416		300	–	
(I_C = 50 mAdc, I_B = 0)	2N3439		350	–	
	2N3440		250	–	
Collector Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 300 Vdc, I_B = 0)	2N3439		–	20	
(V_{CE} = 200 Vdc, I_B = 0)	2N3440		–	50	
(V_{CE} = 150 Vdc, I_B = 0)	MJ5415,MJ5416		–	50	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 450 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3439		–	500	
(V_{CE} = 300 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3440		–	500	
*Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 175 Vdc, I_E = 0)	MJ5415		–	50	
(V_{CB} = 280 Vdc, I_E = 0)	MJ5416		–	50	
(V_{CB} = 360 Vdc, I_E = 0)	2N3439		–	20	
(V_{CB} = 250 Vdc, I_E = 0)	2N3440		–	20	
*Emitter Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 4.0 Vdc, I_C = 0)	MJ5415		–	20	
(V_{EB} = 6.0 Vdc, I_C = 0)	MJ5416,2N3439,2N3440		–	20	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	2N3439		30	–	
*(I_C = 20 mAdc, V_{CE} = 10 Vdc)	2N3439,2N3440		40	160	
*(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJ5415		30	150	
	MJ5416		30	120	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
*(I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439,2N3440		–	0.5	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	MJ5415,MJ5416		–	2.5	
*Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 50 mAdc, I_B = 4.0 mAdc)	2N3439,2N3440		–	1.3	
Base-Emitter On Voltage		$V_{BE(on)}$			Vdc
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MJ5415,MJ5416		–	1.5	
DYNAMIC CHARACTERISTICS					
*Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)			15	–	
*Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	MJ5415,MJ5416		–	25	
	2N3439,2N3440		–	10	
*Input Capacitance		C_{ib}			pF
(V_{EB} = 5.0 Vdc, I_C = 0, f = 1.0 MHz)			–	75	
*Small-Signal Current Gain		h_{fe}			–
(I_C = 5.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	–	
*Real Part of Common Emitter Small-Signal Short-Circuit Input Impedance		$Re(h_{ie})$			Ohms
(V_{CE} = 10 Vdc, I_C = 5.0 mAdc, f = 1.0 MHz)			–	300	

*Indicates JECEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTE: V_{CC} and R_C adjusted for $V_{CE(off)}$ = 150 V and I_C as desired, R_B chosen for desired I_{B1}, $V_1 \approx 10$ V, $V_2 \approx 8.0$ V

For t_d and t_r, D1 is disconnected and V_2 = 2.0 V

For PNP test circuit, reverse all polarities.

PNP
MJ5415, MJ5416

NPN
2N3449, 2N3440

FIGURE 2 — TURN-ON TIME

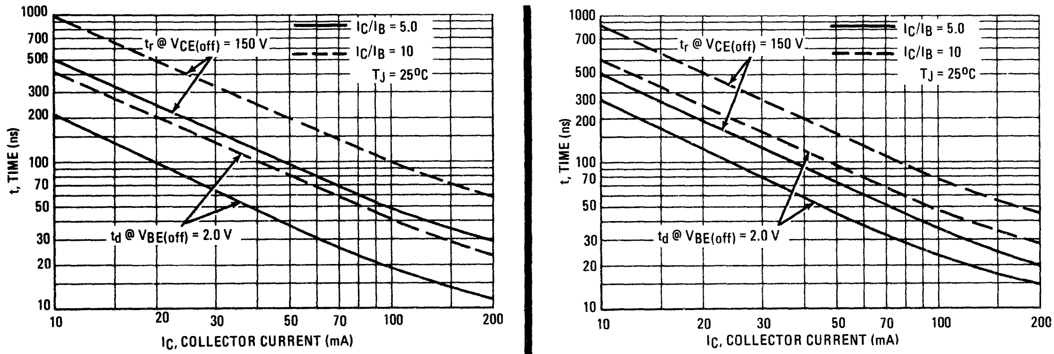


FIGURE 3 — TURN-OFF TIME

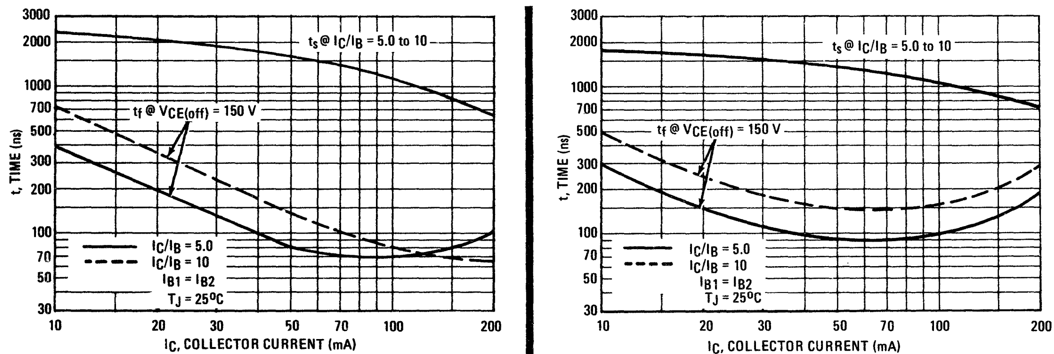


FIGURE 4 — CURRENT-GAIN — BANDWIDTH PRODUCT

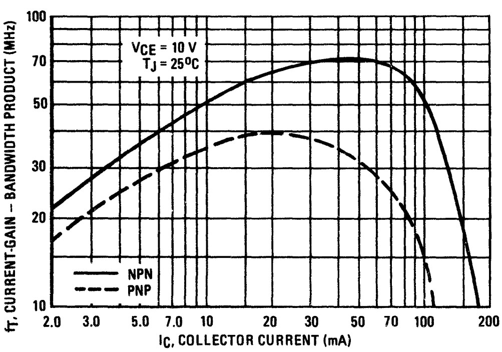


FIGURE 5 — CAPACITANCE

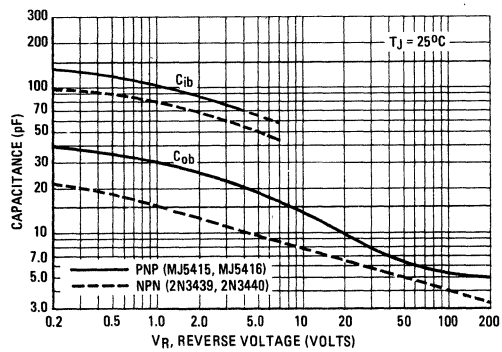


FIGURE 6 – THERMAL RESPONSE

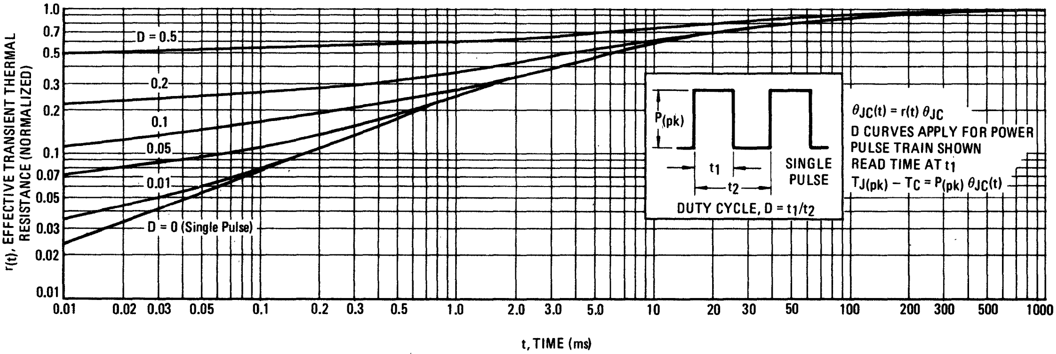
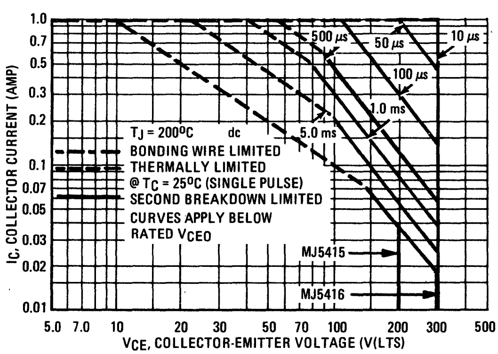


FIGURE 7 – ACTIVE-REGION SAFE OPERATING AREA

PNP – MJ5415, MJ5416



NPN – 2N3439, 2N3440

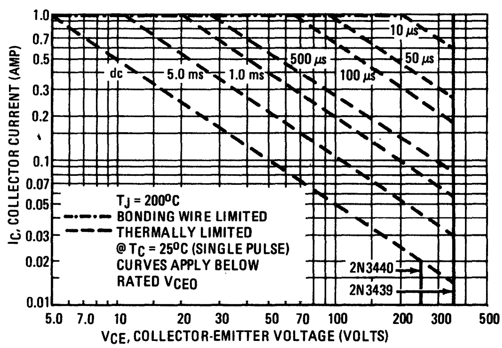
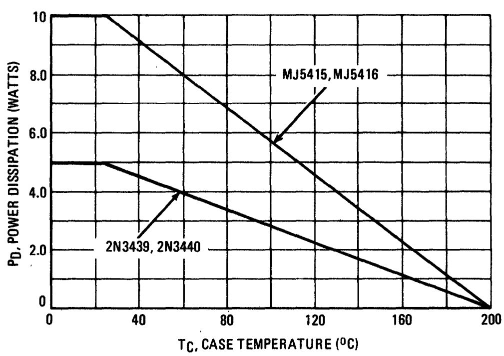


FIGURE 8 – POWER DERATING



There are two limitations on the power handling ability of a transistor, average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 7 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

PNP
MJ5415, MJ5416

NPN
2N3439 2N3440

FIGURE 9 – DC CURRENT GAIN

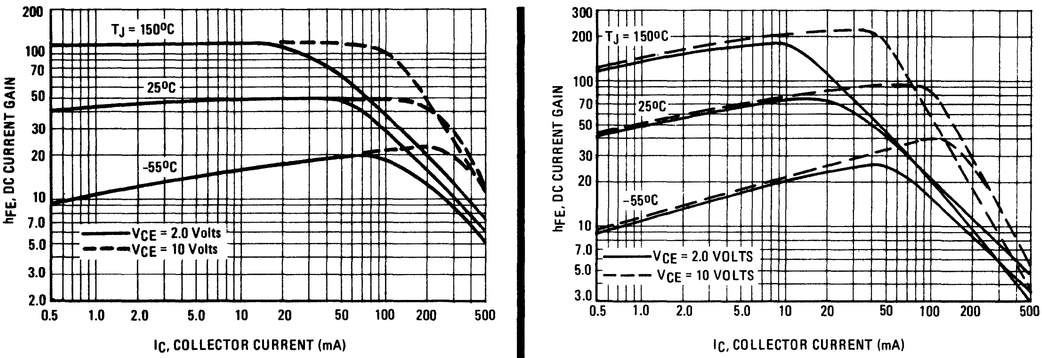


FIGURE 10 – COLLECTOR SATURATION REGION

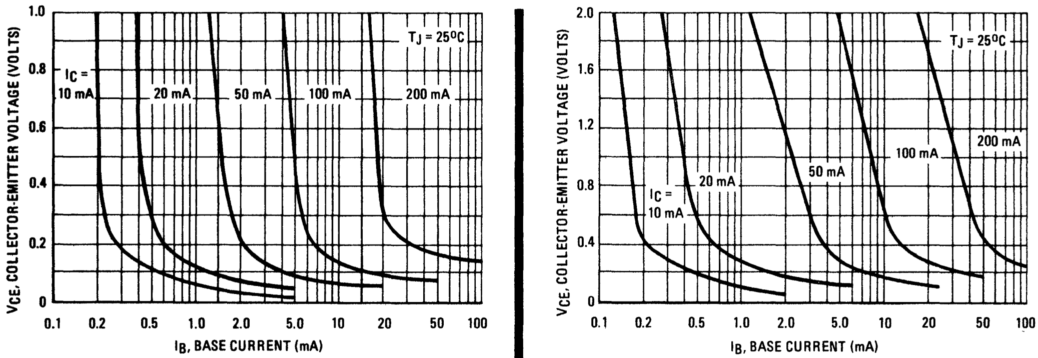


FIGURE 11 – "ON" VOLTAGES

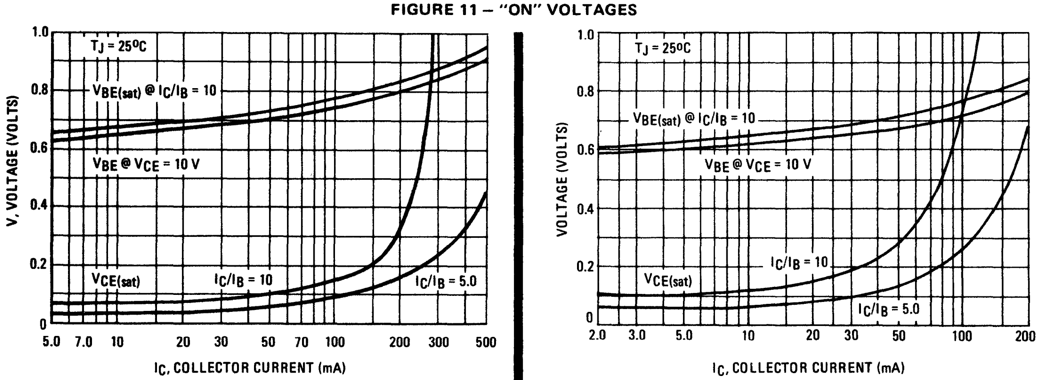


FIGURE 12 – TEMPERATURE COEFFICIENTS

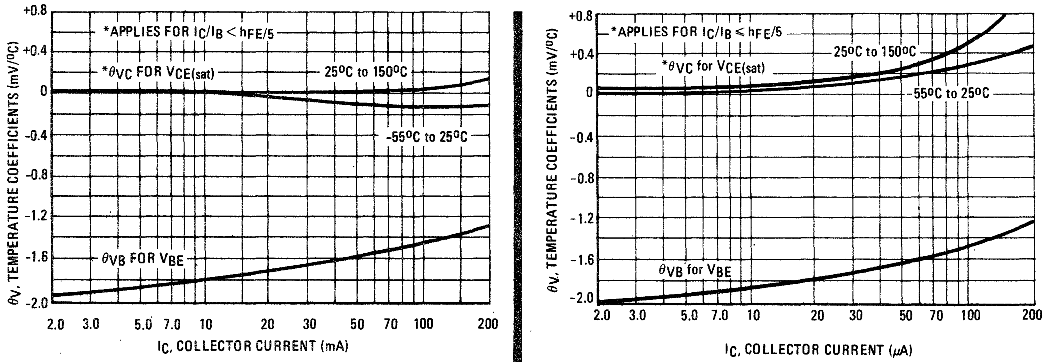


FIGURE 13 – COLLECTOR CUTOFF REGION

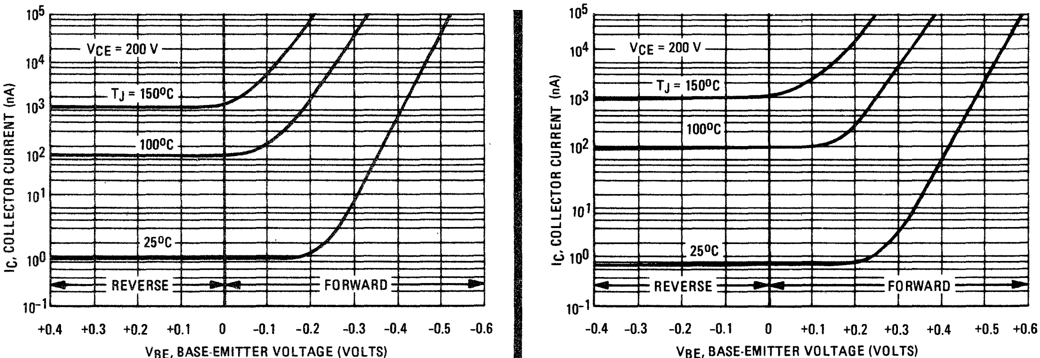
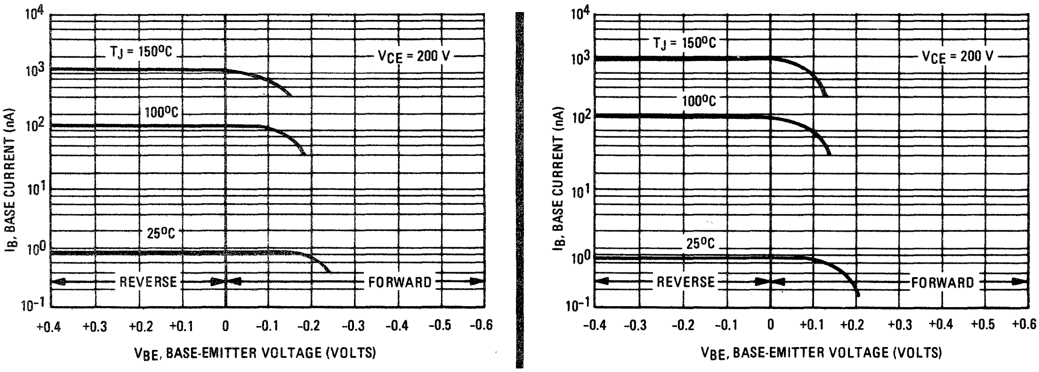


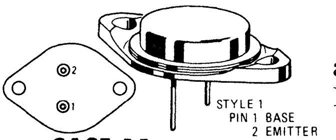
FIGURE 14 – BASE CUTOFF REGION



2N3444S

For Specifications, See 2N3252S Data.

2N3445 thru 2N3448 (SILICON)



CASE 11
Collector connected to case

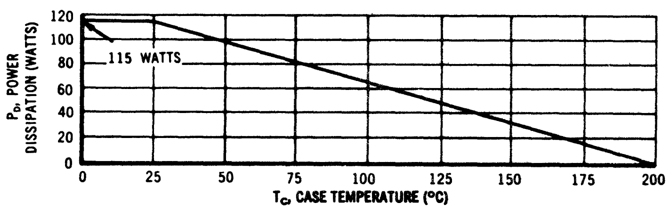
NPN silicon power transistors for switching and amplifier applications requiring fast response, wide band and good Beta linearity.

MAXIMUM RATINGS

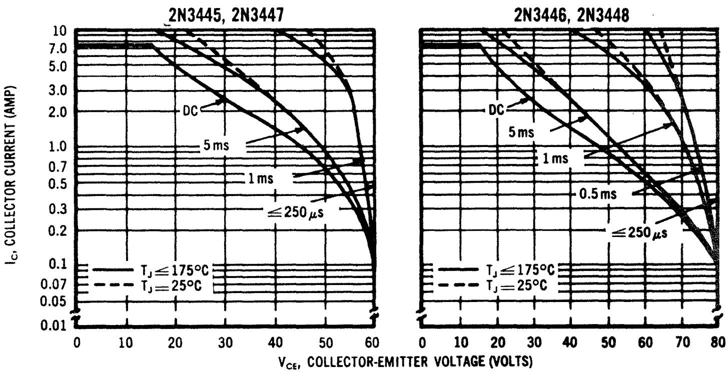
Rating	Symbol	2N3445 2N3447	2N3446 2N3448	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	6.0	10	Volts
Collector Current	I_C	7.5		Amp
Base Current	I_B	4.0		Amp
Power Dissipation	P_D	115		Watts
Junction Operating Temperature Range	T_J	-65 to +200		°C

POWER-TEMPERATURE DERATING CURVE

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



SAFE OPERATING AREAS

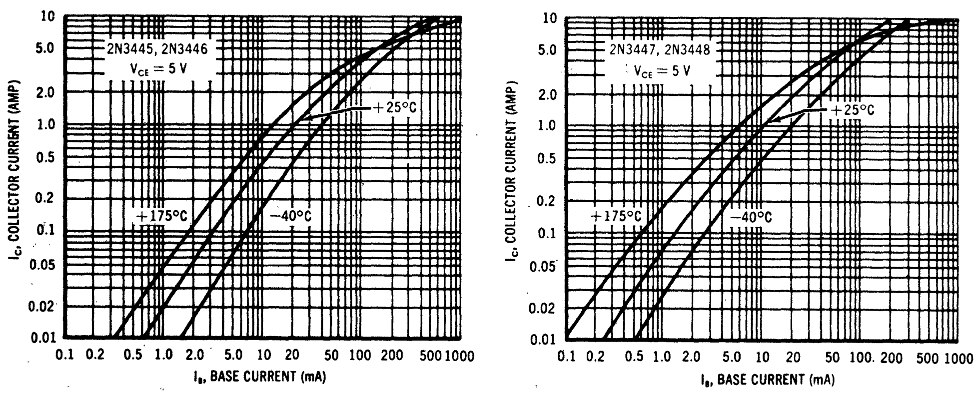


The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

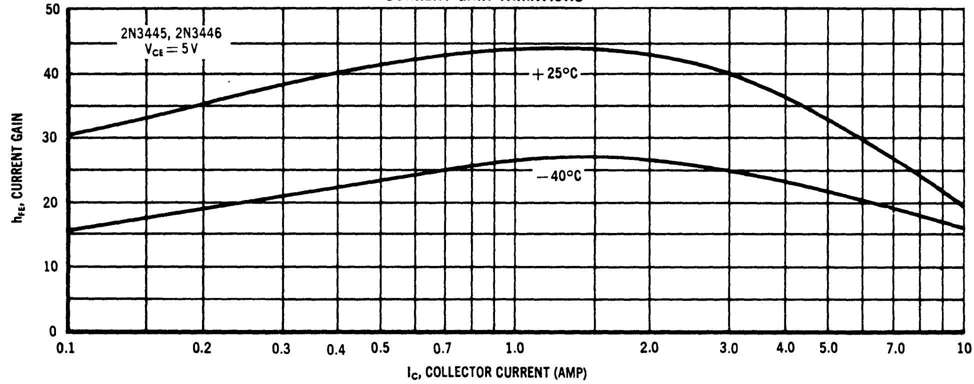
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

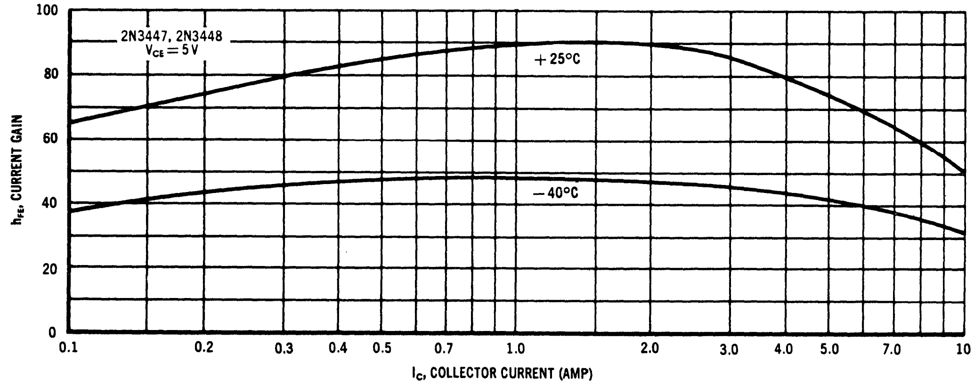
Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = 6 Vdc)	2N3445, 2N3447		—	—	0.25	
(V_{EB} = 10 Vdc)	2N3446, 2N3448		—	—	0.25	
Collector-Emitter Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3445, 2N3447		—	—	0.1	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3445, 2N3447		—	—	1.0	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3446, 2N3448		—	—	0.1	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3446, 2N3448		—	—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}				mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3445, 2N3447		—	—	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N3446, 2N3448		—	—	1.0	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 1 mAdc, I_E = 0)	2N3445, 2N3447		80	—	—	
	2N3446, 2N3448		100	—	—	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$				Vdc
(I_C = 100 mAdc, I_B = 0)	2N3445, 2N3447		60	—	—	
	2N3446, 2N3448		80	—	—	
DC Current Gain		h_{FE}				—
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		20	45	—	
	2N3447, 2N3448		40	85	—	
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		20	40	60	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		40	75	120	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446		—	0.6	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	0.8	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446		—	1.0	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	1.0	1.5	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		—	1.0	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		—	1.0	1.4	
Small Signal Current Gain		h_{fe}				—
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kHz)	2N3445, 2N3446		20	—	100	
	2N3447, 2N3448		40	—	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 MHz)			1.0	1.6	—	
Common Base Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, f = 0.1 MHz)			—	260	400	
Switching Times						μs
(V_{CC} ≈ 25 Vdc, R_L = 5 ohms, I_C = 5 A, I_{B1} = I_{B2} = 0.5 A)						
Delay Time plus Rise Time		$t_d + t_r$	—	0.15	0.35	
Storage Time		t_s	—	0.9	2.0	
Fall Time		t_f	—	0.15	0.35	

COLLECTOR CURRENT versus BASE CURRENT

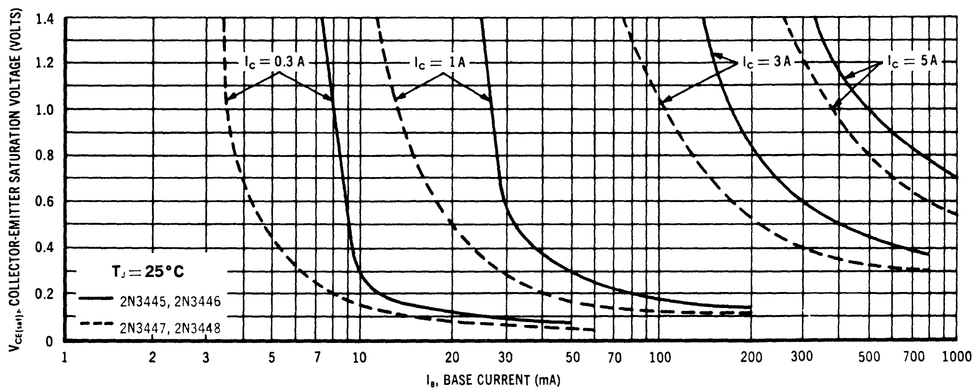


CURRENT GAIN VARIATIONS

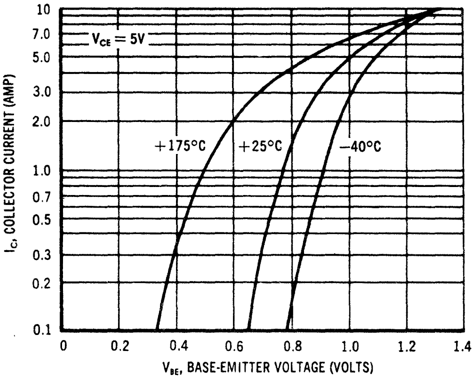




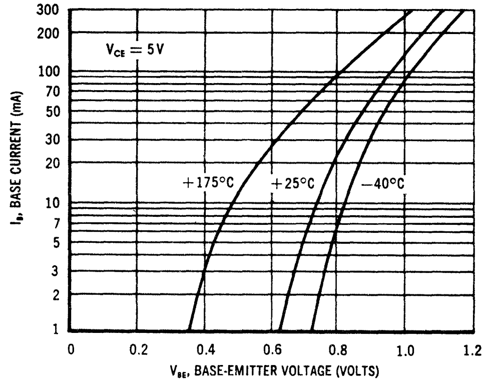
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



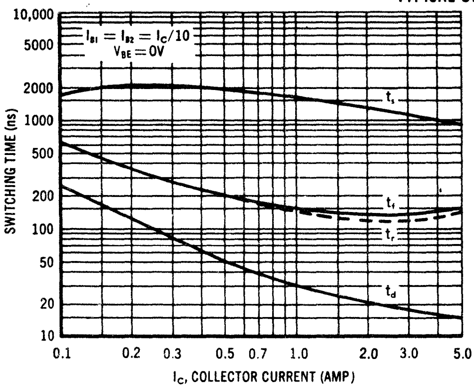
COLLECTOR CURRENT-VOLTAGE VARIATIONS

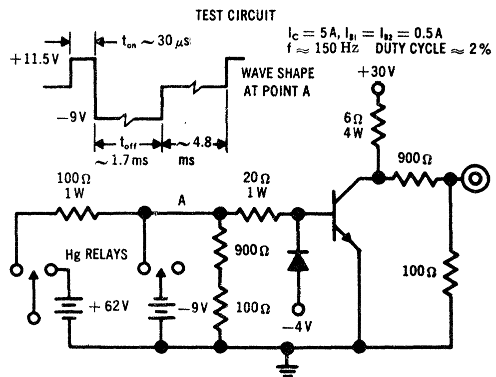


BASE CURRENT-VOLTAGE VARIATIONS

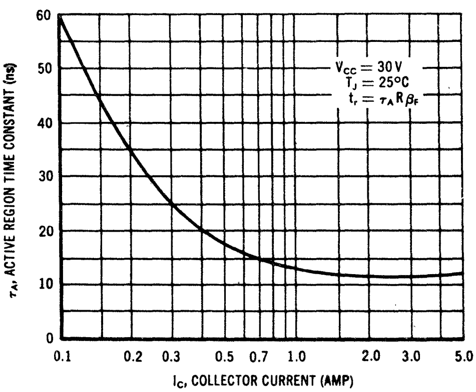


TYPICAL SWITCHING TIMES

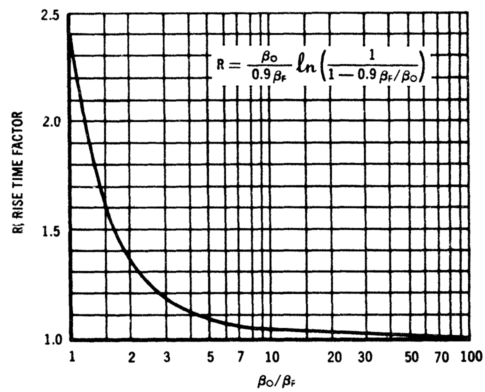




ACTIVE REGION TIME CONSTANT



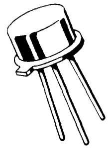
RISE TIME FACTOR



2N3467S, 2N3468S (SILICON)

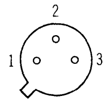
2N3467S JAN,JTX AVAILABLE
2N3468S JAN,JTX AVAILABLE

CASE 79
(TO-39)



Collector
connected to case

PNP silicon annular transistors for high-speed switching and driver applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

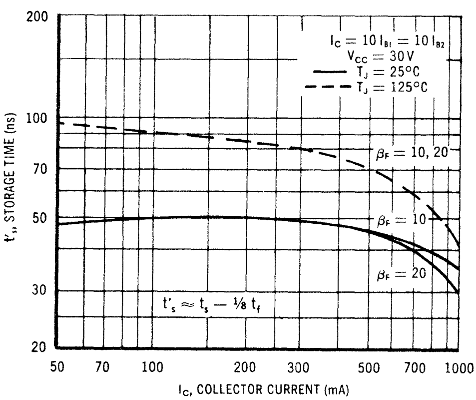
Rating	Symbol	2N3467	2N3468	Unit
Collector-Base Voltage	V_{CB}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ $T_A = 25^oC$ Derating Factor Above 25^oC	P_D	1.0 5.71		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derating Factor Above 25^oC	P_D	5.0 28.6		Watts $mW/^oC$
Junction Temperature, Operating	T_J	+200		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

*Indicates JEDEC Registered Data

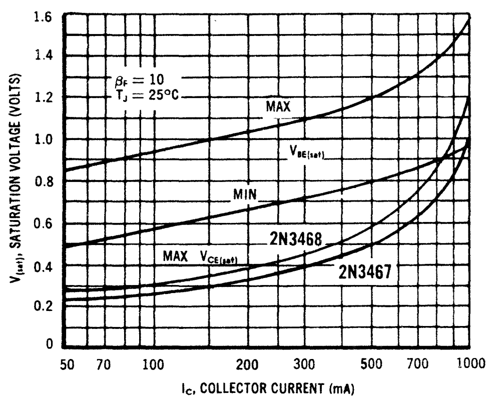
THERMAL RESISTANCE θ_{JA} (air) $= 0.175°C/mW$

θ_{JC} (case) $= 35°C/W$

STORAGE TIME VARIATION WITH TEMPERATURE



LIMITS OF SATURATION VOLTAGE



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	0.10	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)			—	15	
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	—	100	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	—	120	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3467	BV_{CBO}	40	—	Vdc
	2N3468		50	—	
Collector-Emitter Breakdown Voltage [1] (I_C = 10 mAdc, I_B = 0)	2N3467	BV_{CEO}	40	—	Vdc
	2N3468		50	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage [1]		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3467		—	0.3	
	2N3468		—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3467		—	0.5	
	2N3468		—	0.6	
(I_C = 1 Adc, I_B = 100 mAdc)	2N3467		—	1.0	
	2N3468		—	1.2	
Base-Emitter Saturation Voltage [1]		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.6	
DC Forward Current Transfer Ratio [1]		h_{FE}			—
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N3467		40	—	
	2N3468		25	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3467		40	120	
	2N3468		25	75	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3467		40	—	
	2N3468		25	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	25	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	100	pF
Current-Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3467	f_T	175	—	MHz
	2N3468		150	—	

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

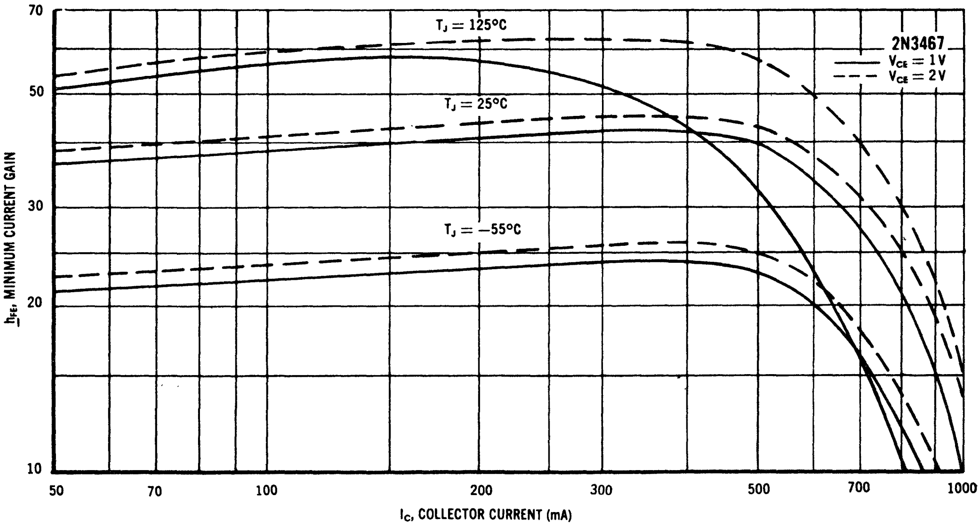
* Indicates JEDEC Registered Data

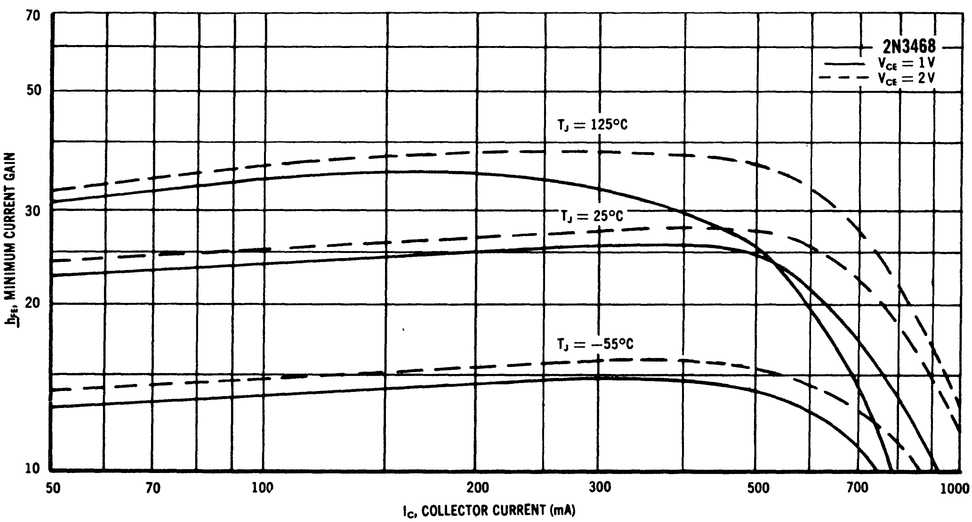
*ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{BE} = 2 V, V_{CC} = 30 V)	t_d	—	10	ns
Rise Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{BE} = 2 V, V_{CC} = 30 V)	t_r	—	30	ns
Storage Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_s	—	60	ns
Fall Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_f	—	30	ns
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6.0	nC

* Indicates JEDEC Registered Data

MINIMUM CURRENT GAIN CHARACTERISTICS

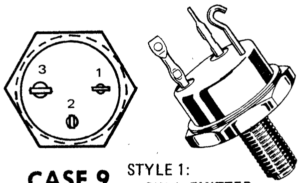




2N3485, A (SILICON)
2N3486, A

For Specifications, See 2N2904S Data

2N3487 thru 2N3492 (SILICON)



CASE 9
(TO-61)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

Rating	Symbol	2N3487 2N3490	2N3488 2N3491	2N3489 2N3492	Unit
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	10	10	10	Vdc
Collector Current (Continuous)	I_C	7.5	7.5	7.5	Adc
Base Current (Continuous)	I_B	4.0	4.0	4.0	Adc
Power Dissipation	P_D	117	117	117	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	1.5	1.5	$^{o}C/W$
Junction Operating Temperature Range	T_J	-65°C to +200°C			°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 10 Vdc)		I_{EBO}	-	0.10	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3487, 2N3490		-	25	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3488, 2N3491		-	25	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc)	2N3489, 2N3492		-	25	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3487, 2N3490		-	250	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3488, 2N3491		-	250	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3489, 2N3492		-	250	
Collector-Emitter Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3487, 2N3490		-	250	
(V_{CE} = 60 Vdc, I_B = 0)	2N3488, 2N3491		-	250	
(V_{CE} = 80 Vdc, I_B = 0)	2N3489, 2N3492		-	250	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N3487, 2N3490		80	-	
	2N3488, 2N3491		100	-	
	2N3489, 2N3492		120	-	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3487, 2N3490		60	-	
	2N3488, 2N3491		80	-	
	2N3489, 2N3490		100	-	
DC Current Gain		h_{FE}			-
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		20	-	
	2N3490, 2N3491, 2N3492		40	-	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488		20	60	
	2N3489		15	45	
(I_C = 5.0 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491		40	120	
	2N3492		30	90	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1 Adc, I_B = 0.1 Adc)			-	0.3	
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.2	
	2N3490, 2N3491, 2N3492		-	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491, 2N3492		-	1.4	
Small Signal Current Gain		h_{fe}			-
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kHz)	2N3487, 2N3488, 2N3489		20	100	
	2N3490, 2N3491, 2N3492		40	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 MHz)	All Types		1.0	-	
Common Base Output Capacitance (V_{CB} = 10 Vdc, f = 0.1 MHz)		C_{ob}	-	550	pF
Switching Times (V_{CC} ≈ 25 Vdc, R_L = 5Ω, I_C = 5 Adc, I_{B_1} = $-I_{B_2}$ = 0.5 Adc)			-	-	μs
Delay Time plus Rise Time		t_d+t_r	-	0.35	μs
Storage Time		t_s	-	2.0	
Fall Time		t_f	-	0.35	

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

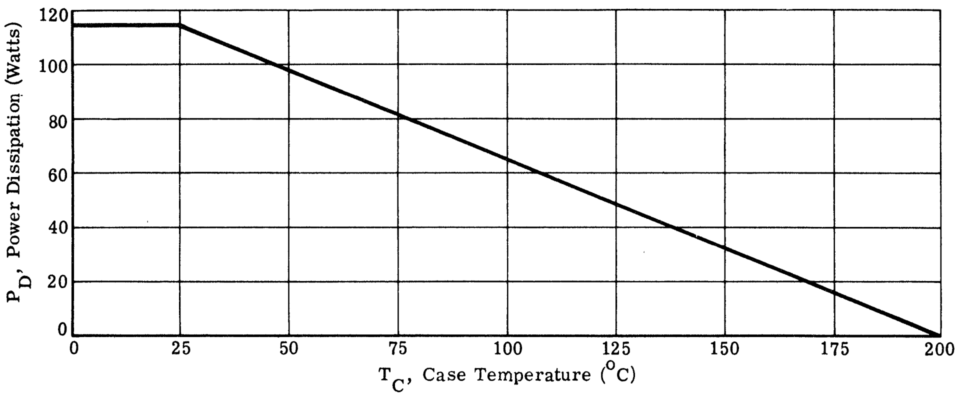
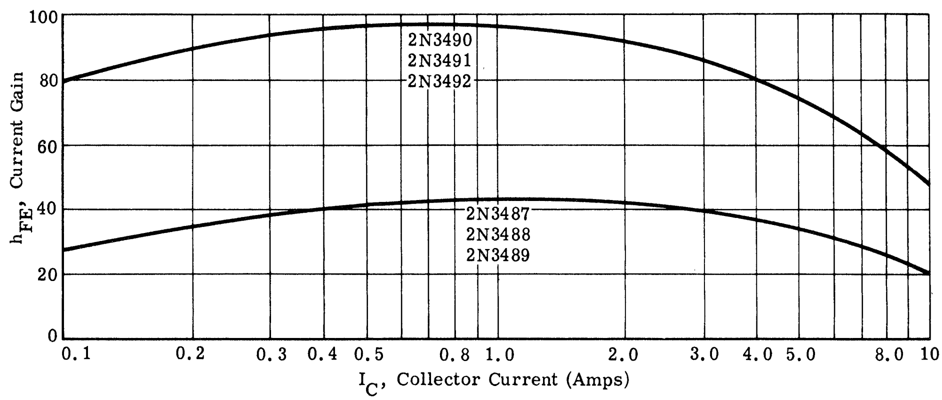


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT



ACTIVE - REGION SAFE OPERATING AREAS

FIGURE 3 — 2N3487, 2N3490

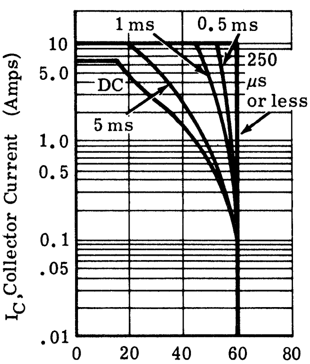


FIGURE 4 — 2N3489, 2N3492

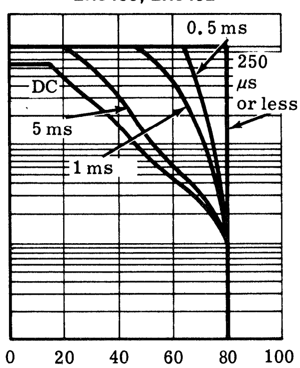
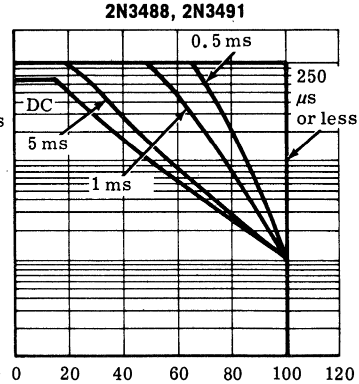


FIGURE 5 — 2N3488, 2N3491



V_{CE} Collector-Emitter Voltage (Volts)

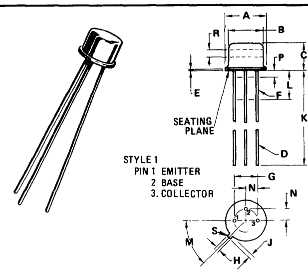
2N3494S, 2N3495S, 2N3496, 2N3497 (SILICON)

PNP SILICON ANNULAR STAR TRANSISTORS

. . . designed for high-voltage switching circuits and DC to VHF amplifier applications.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 120 Vdc (Min) @ I_C = 10 mAdc (2N3495,97)
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.3 Vdc (Max) @ I_C = 10 mAdc (2N3494,96)
- High Current-Gain—Bandwidth Product — f_T = 200 MHz (Min) @ I_C = 20 mAdc (2N3494,96)

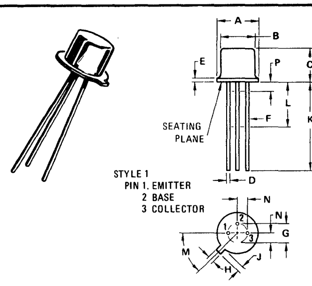
PNP SILICON HIGH-VOLTAGE TRANSISTORS



2N3494
2N3495

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 51	9 40	0 335	0.370
B	7.75	8.51	0.305	0 335
C	6.10	6.60	0.240	0.260
D	0.406	0 533	0 016	0.021
E	0.229	3.18	0 009	0 125
F	0.406	0 483	0.016	0.019
G	5 08 BSC		0.200 BSC	
H	0.711	0 864	0.028	0.034
J	0 734	1.14	0.029	0 045
K	38 10	–	1 500	–
L	6 35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0 100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0 007

All JEDEC dimensions and notes apply
CASE 31-03
TO-39



2N3496
2N3497

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5 31	5 84	0 209	0.230
B	4 52	4 95	0 178	0 195
C	4 32	5 33	0 170	0 210
D	0 406	0 533	0 016	0.021
E	–	0 762	–	0 030
F	0 406	0 483	0 016	0.019
G	2 54 BSC		0 100 BSC	
H	0 914	1 17	0.036	0.046
J	0 711	1.22	0 028	0 048
K	12 70	–	0 500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1 27 BSC		0 050 BSC	
P	–	1 27	–	0.050

All JEDEC notes and dimensions apply.
CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	2N3494 2N3496	2N3495 2N3497	Unit
Collector-Emitter Voltage	V_{CEO}	80	120	Vdc
Collector-Base Voltage	V_{CB}	80	120	Vdc
Emitter-Base Voltage	V_{EB}	4.5		Vdc
Collector Current — Continuous	I_C	100		mAdc
		2N3494 2N3495	**2N3496 2N3497**	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 3.43	400 2.28	mW mW/°C
Total Device Dissipation @ T_C = 25°C** Derate above 25°C	P_D	2.0 11.4	1.2 6.85	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N3494, 2N3496	BV_{CEO}	80	–	Vdc
	2N3495, 2N3497		120	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3494, 2N3496	BV_{CBO}	80	–	Vdc
	2N3495, 2N3497		120	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N3494, 2N3496	I_{CBO}	–	100	nAdc
(V_{CB} = 90 Vdc, I_E = 0)	2N3495, 2N3497		–	100	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	25	nAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 100 μAdc, V_{CE} = 10 Vdc)	All Types	h_{FE}	35	–	–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	All Types		40	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		40	–	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	All Types		40	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N3494, 2N3496		35	–	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	2N3494, 2N3496	$V_{CE(sat)}$	–	0.3	Vdc
	2N3495, 2N3497		–	0.35	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$	0.6	0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3494, 2N3496	f_T	200	–	MHz
	2N3495, 2N3497		150	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3494, 2N3496	C_{ob}	–	7.0	pF
	2N3495, 2N3497		–	6.0	
Input Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	30	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	0.1	1.2	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	2.0	$X\ 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	300	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	300	μmhos
Real Part of Input Impedance (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 300 MHz)		$Re(h_{ie})$	–	30	Ohms
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = 10 mAdc) (See Figure 1)		t_{on}	–	300	ns
Turn-Off Time (V_{CC} = 30 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) (See Figure 2)		t_{off}	–	1000	ns

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

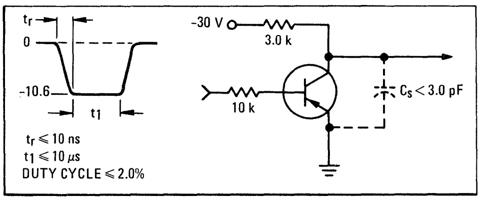
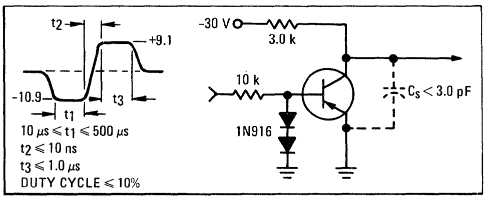


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT



2N3498S thru 2N3501S (SILICON)

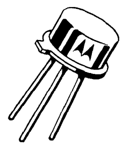
JAN,JTX,JTXV AVAILABLE

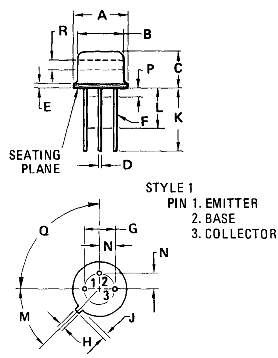
NPN SILICON ANNULAR TRANSISTORS

. . . designed for low-power amplifier and switching applications.

- High Voltage Ratings
  BV_{CEO} = 150 Vdc (Min) @ I_C = 10 mAdc –
  2N3500 and 2N3501
- Low Saturation Voltage –
  $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 300 mAdc –
  2N3498 and 2N3499
- Low Capacitance
  C_{ob} = 8.0 pF (Max) @ V_{CB} = 10 Vdc – 2N3500 and 2N3501
- Medium Current Capability with DC Current Gain Specified –
  0.1 to 500 mAdc – 2N3498 and 2N3499

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

*MAXIMUM RATINGS

Rating	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6.0		Vdc
Collector Current	I_C	500	300	mAdc
Total Power Dissipation @ T_A = 25°C Derate Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3498, 2N3499 2N3500, 2N3501	BV_{CEO}	100 150	– –	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3498, 2N3499 2N3500, 2N3501	BV_{CBO}	100 150	– –	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	–	–	Vdc
Emitter Cutoff Current ($V_{BE(off)}$ = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	25	nAdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)	2N3498, 2N3499		–	–	0.050	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	50	
(V_{CB} = 75 Vdc, I_E = 0)	2N3500, 2N3501		–	–	0.050	
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)			–	–	50	
***ON CHARACTERISTICS (1)**						
DC Current Gain		h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		20	–	–	
	2N3499, 2N3501		35	–	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		25	–	–	
	2N3499, 2N3501		50	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		35	–	–	
	2N3499, 2N3501		75	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		40	–	120	
	2N3499, 2N3501		100	–	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	2N3500		15	–	–	
	2N3501		20	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3498		15	–	–	
	2N3499		20	–	–	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		–	–	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		–	–	0.25	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		–	–	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		–	–	0.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)	All Types		–	–	0.8	
(I_C = 50 mAdc, I_B = 5.0 mAdc)	All Types		–	–	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501		–	–	1.2	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		–	–	1.4	
***SMALL-SIGNAL CHARACTERISTICS**						
Current-Gain–Bandwidth Product (2) (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 MHz)		f_T	150	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	2N3498, 2N3499 2N3500, 2N3501	C_{ob}	– –	– –	10 8.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	80	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{fe}	50 75	– –	300 375	–
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{re}	– –	– –	2.5 4.0	$X10^{-4}$
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{ie}	0.2 0.25	– –	1.0 1.25	k ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3498, 2N3500 2N3499, 2N3501	h_{oe}	– –	– –	100 200	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_d	–	20	–	ns
Rise Time (I_C = 150 mAdc, I_{B1} = 15 mAdc, V_{CC} = 100 Vdc, $V_{BE(off)}$ = 2.0 Vdc)		t_r	–	35	–	ns
Storage Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_s	–	800	–	ns
Fall Time (I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, V_{CC} = 100 Vdc)		t_f	–	80	–	ns

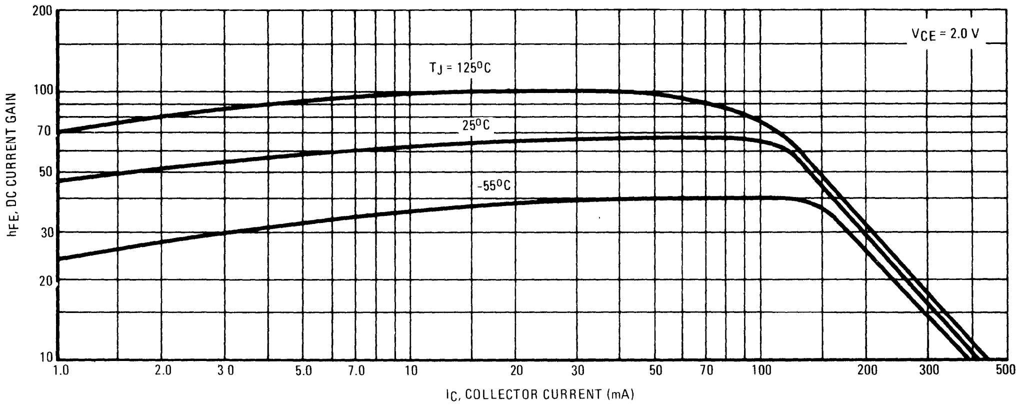
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width ⩽ 300 μs, Duty Cycle ⩽ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$.

FIGURE 1 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3498



2N3499

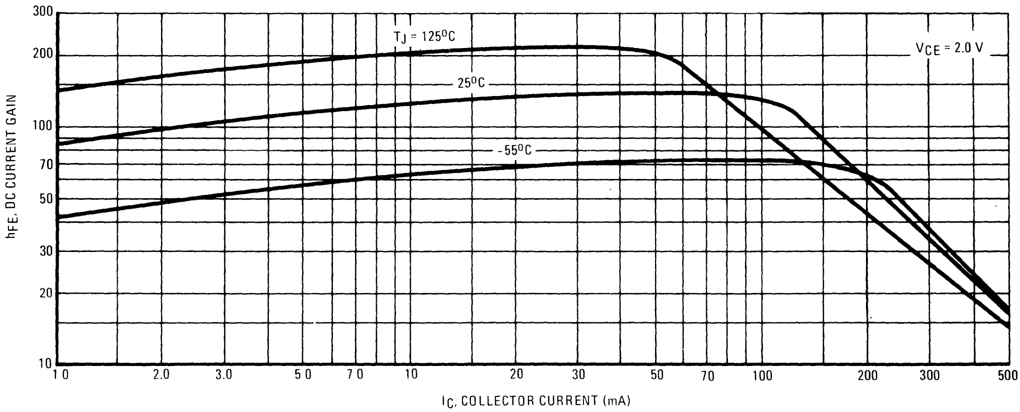


FIGURE 2 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

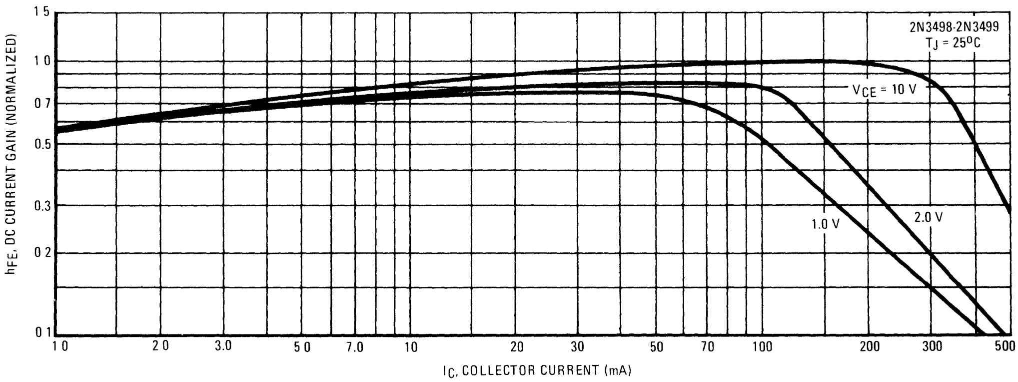
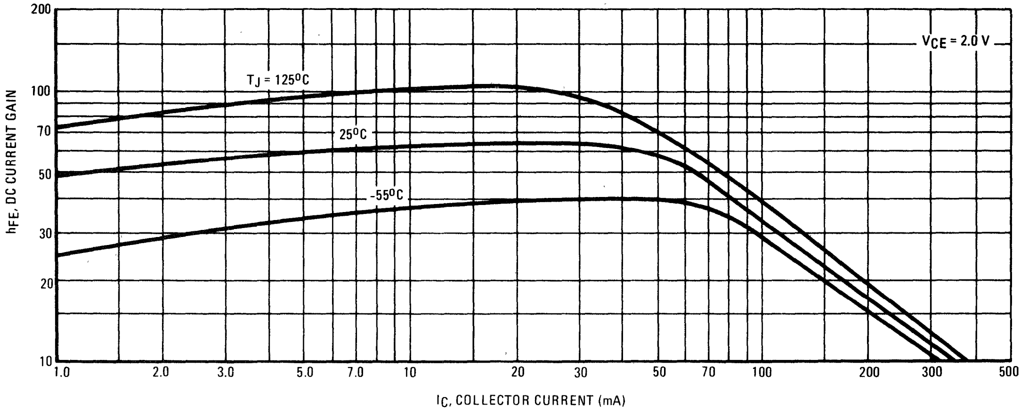


FIGURE 3 – CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

2N3500



2N3501

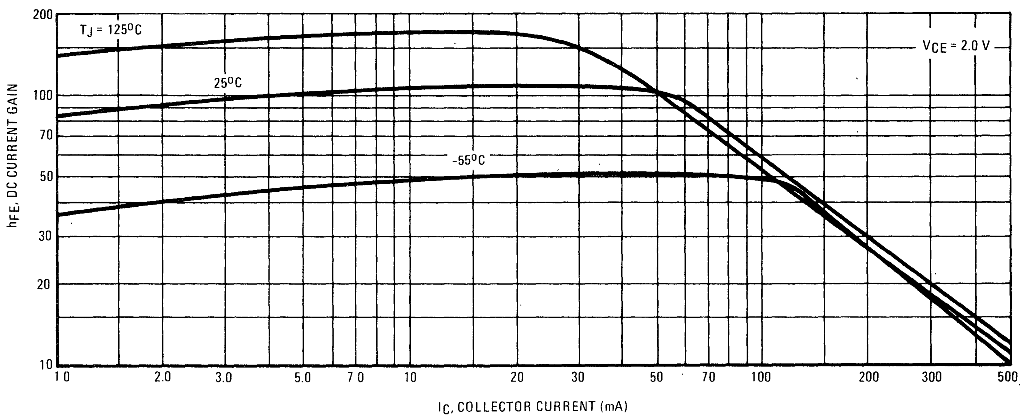


FIGURE 4 – CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE

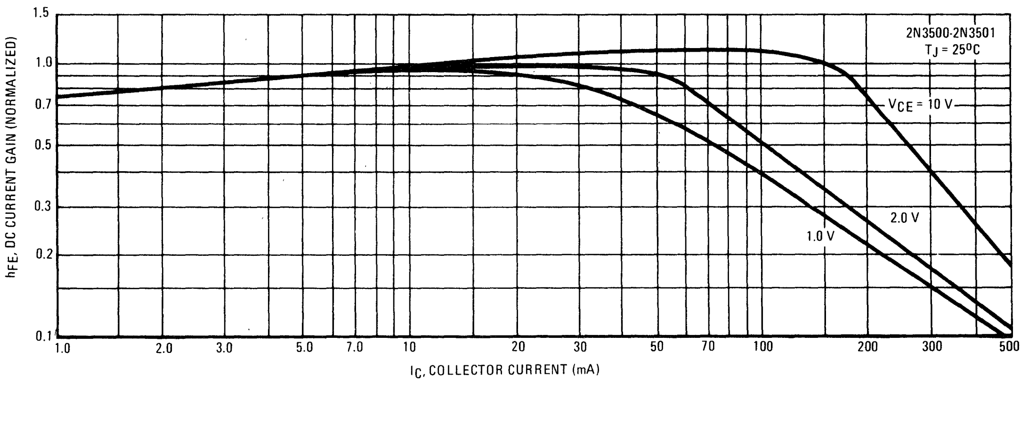


FIGURE 5 – "ON" VOLTAGES

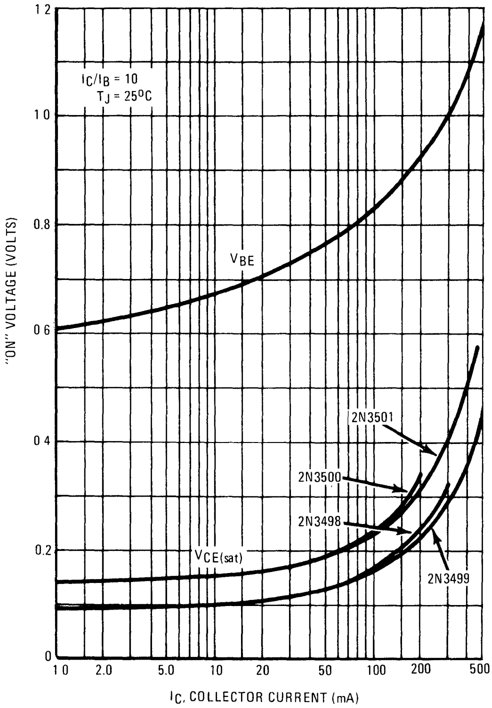


FIGURE 6 – TEMPERATURE COEFFICIENTS

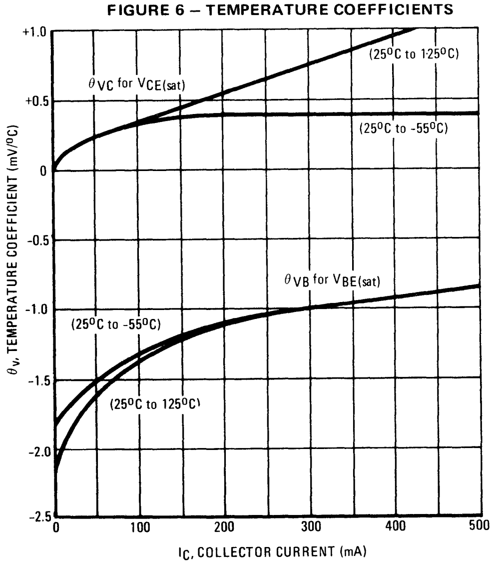
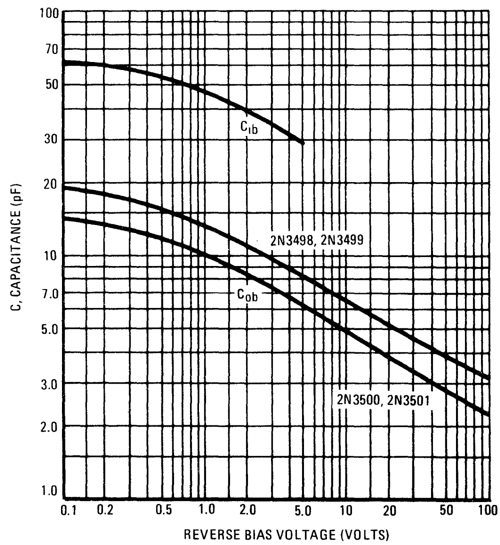


FIGURE 7 – CAPACITANCE



AUDIO SMALL-SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 Vdc, T_A = 25°C, f = 1.0 kHz)

FIGURE 8 – CURRENT GAIN

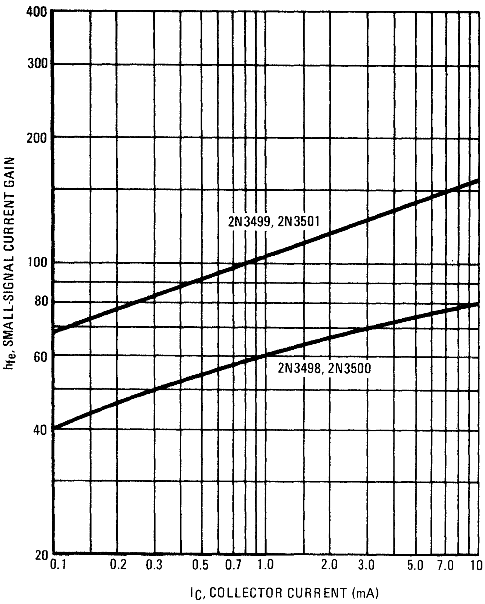


FIGURE 9 – OUTPUT IMPEDANCE

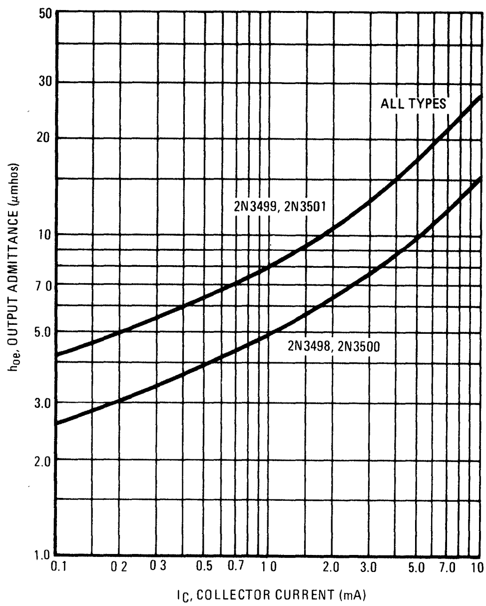


FIGURE 10 – INPUT IMPEDANCE

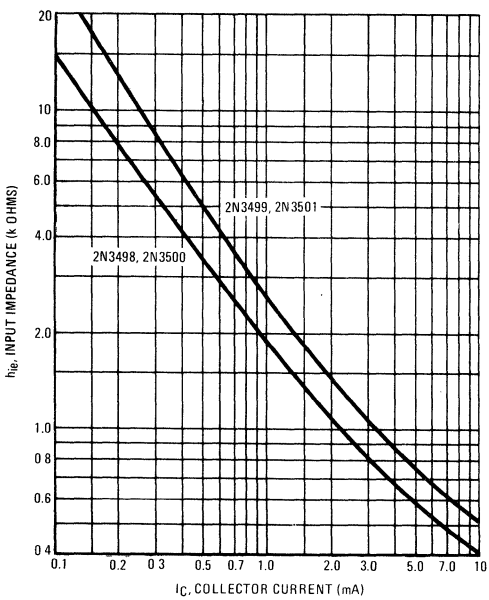
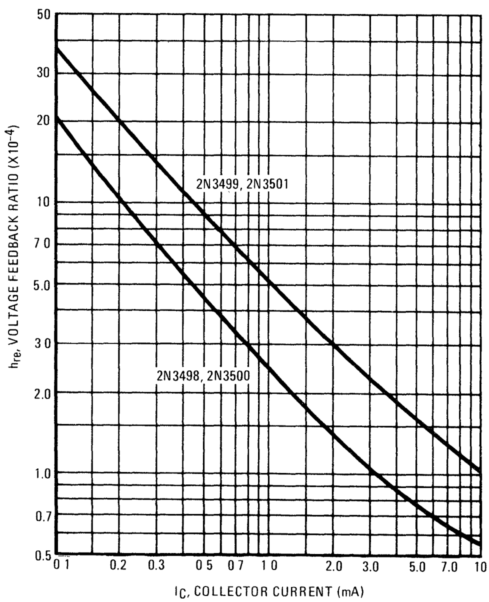
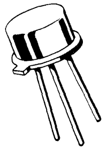


FIGURE 11 – VOLTAGE FEEDBACK RATIO



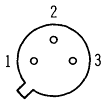
2N3506S, 2N3507S (SILICON)

JAN,JTX,JTXV AVAILABLE



NPN silicon annular transistors for high-current, high-speed, saturated switching and core driver applications.

CASE 79
(TO-39)
Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

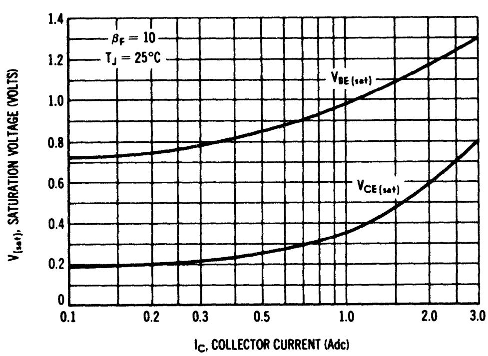
*MAXIMUM RATINGS

Rating	Symbol	2N3506	2N3507	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	3.0		Adc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

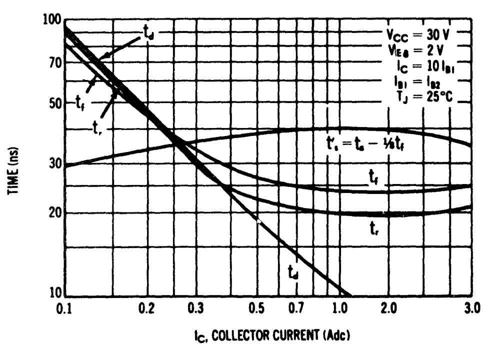
* Indicates JEDEC Registered Data

THERMAL RESISTANCE $\theta_{JA} = 0.175°C/mW$
$\theta_{JC} = 35°C/W$

SATURATION VOLTAGES



SWITCHING TIMES



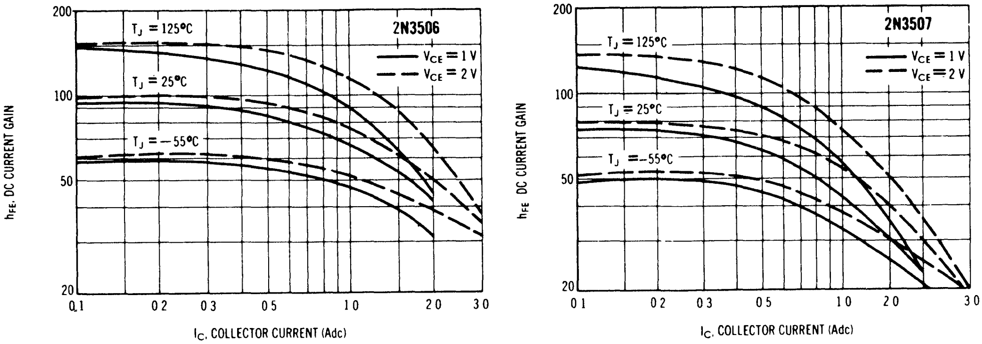
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc, T_A = 100°C)			--	150	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3507		--	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc, T_A = 100°C)			--	150	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 4 Vdc)	2N3507		--	1.0	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3506 2N3507	BV_{CBO}	60 80	-- --	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, pulsed, I_B = 0)	2N3506 2N3507	BV_{CEO}	40 50	-- --	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	--	Vdc
Collector Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	0.5	
(I_C = 1.5 Adc, I_B = 150 mAdc)			--	1.0	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	1.5	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	1.0	
(I_C = 1.5 Adc, I_B = 150 mAdc)			0.9	1.4	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	2.0	
DC Current Gain (1)		h_{FE}			--
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3506 2N3507		50 35	-- --	
(I_C = 1.5 Adc, V_{CE} = 2 Vdc)	2N3506 2N3507		40 30	200 150	
(I_C = 2.5 Adc, V_{CE} = 3 Vdc)	2N3506 2N3507		30 25	-- --	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3506 2N3507		25 20	-- --	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	--	40	pF
Input Capacitance (V_{BE} = 3 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	--	300	pF
Current Gain-Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	60	--	MHz
Delay Time	I_C = 1.5 Adc, I_{B1} = 150 mAdc	t_d	--	15	ns
Rise Time	V_{CC} = 30 V, V_{EB} = 0 V	t_r	--	30	ns
Storage Time	I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc	t_s	--	55	ns
Fall Time	V_{CC} = 30 V	t_f	--	35	ns

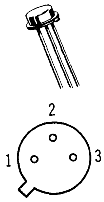
* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse width = 300 μs, duty cycle = 2%

CURRENT GAIN CHARACTERISTICS



2N3508 (SILICON)
2N3509



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 26
(TO-46)
Collector connected to case

NPN silicon annular transistor for high-speed, low-current switching applications.

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current (10 μs pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.0 11.43	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Case Thermal Resistance, Junction to Ambient	θ_{JC} θ_{JA}	0.0875 0.438	°C/mW °C/mW

*Indicates JEDEC Registered Data

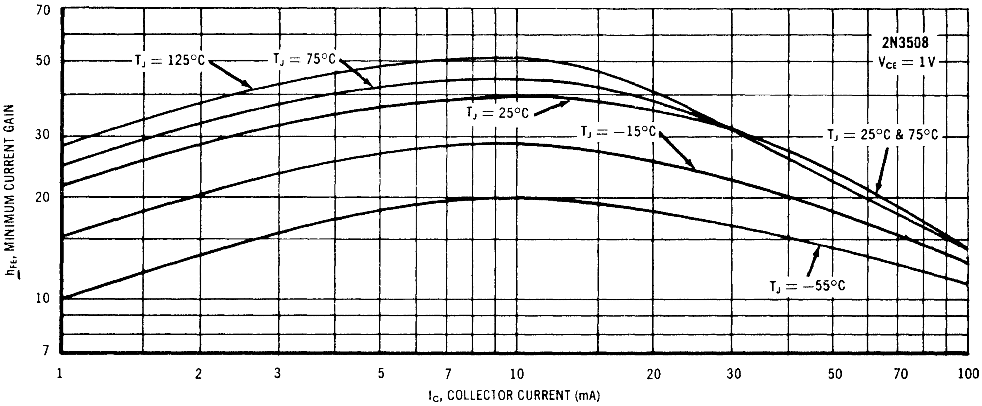
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

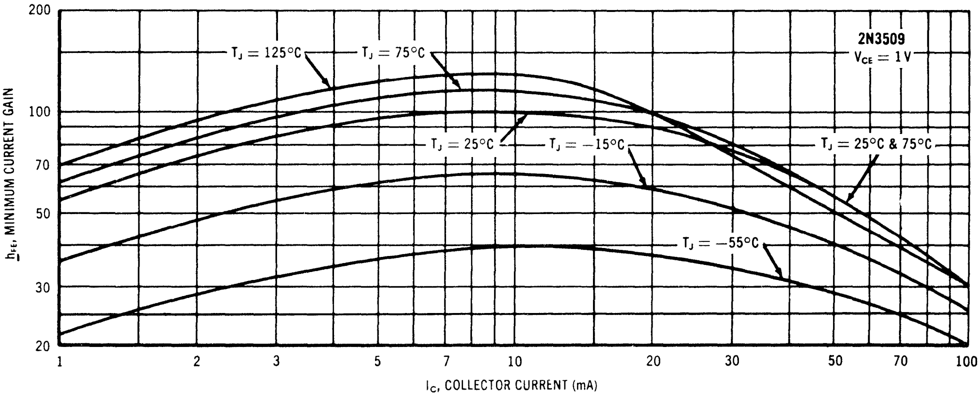
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 20 Vdc) (V_{CB} = 20 Vdc, T_A = 150°C)	 Both Types 2N3508 2N3509	I_{CBO}	 — — —	 0.2 30 50	μAdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 3 Vdc)		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc)		BV_{CEO}	20	—	Vdc
Collector-Emitter Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	 — —	 0.25 0.45	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	 0.70 0.8	 0.85 1.4	Vdc
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	 2N3508 2N3509 2N3508 2N3509 2N3508 2N3509	h_{FE}	 40 100 20 40 20 30	 120 300 — — — —	—
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f =100 MHz)		h_{fe}	5.0	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 140 kHz)		C_{ib}	—	4.0	pF
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		$t_s(\tau_s)$	—	13	ns
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, V_{OB} = 1.5 V)		t_{on}	—	12	ns
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		t_{off}	—	18	ns
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)		Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{EB} = 2 V, I_C = 100 mA, I_{B1} = 10 mA	t_d	—	5.0	ns
Rise Time		t_r	—	18	ns
Storage Time	V_{CC} = 10 V I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	t_s	—	13	ns
Fall Time		t_f	—	15	ns

* Indicates JEDEC Registered Data

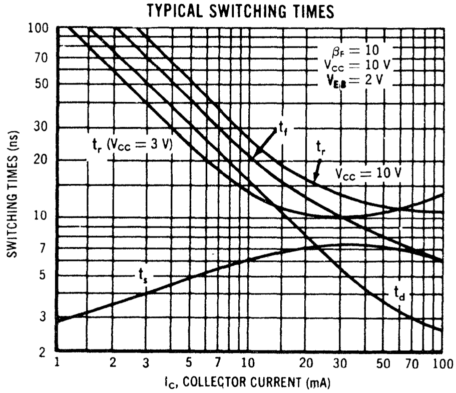
(1) Pulse Test: PW = 300μs, Duty Cycle ≤ 2%

MINIMUM CURRENT GAIN CHARACTERISTICS

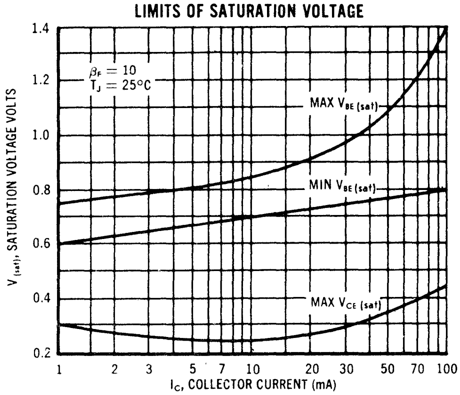




TYPICAL SWITCHING TIMES

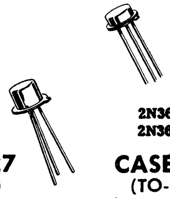


LIMITS OF SATURATION VOLTAGE



2N3510 (SILICON)
2N3511
2N3647
2N3648

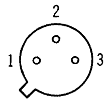
NPN silicon annular transistors for high-speed saturated switching applications to 500 mA.



2N3510
2N3511
CASE 27
(TO-52)

2N3647
2N3648
CASE 26
(TO-46)

Collector connected to case



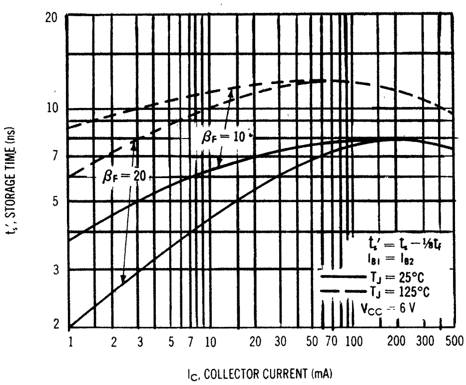
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

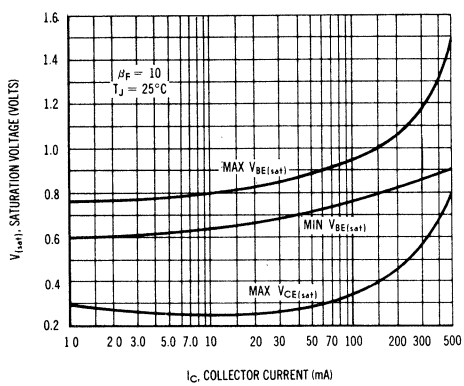
Rating	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Base Voltage	V_{CB}	40	40	Vdc
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	500		mAdc
		TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	400 2.28	360 2.06	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	2.0 11.43	1.2 6.9	Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

STORAGE TIME VARIATION



LIMITS OF SATURATION VOLTAGE



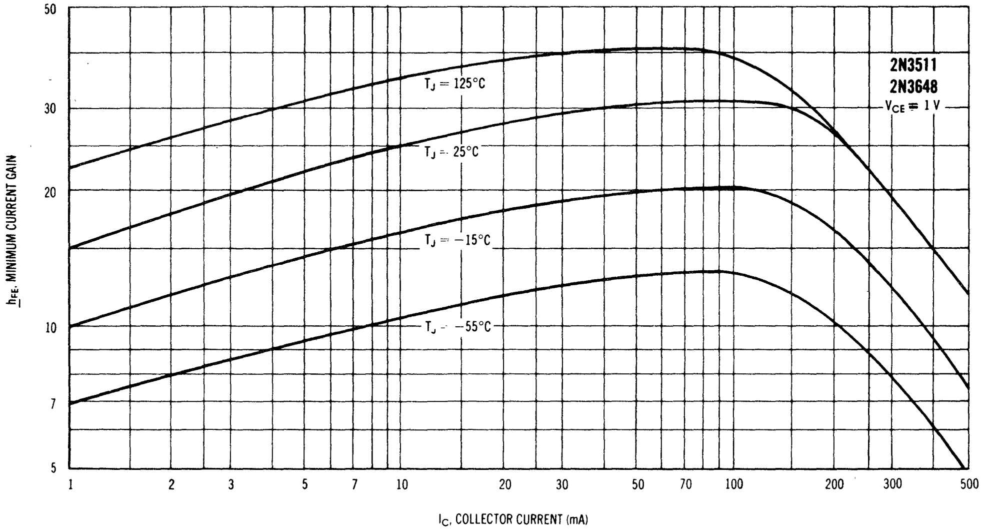
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

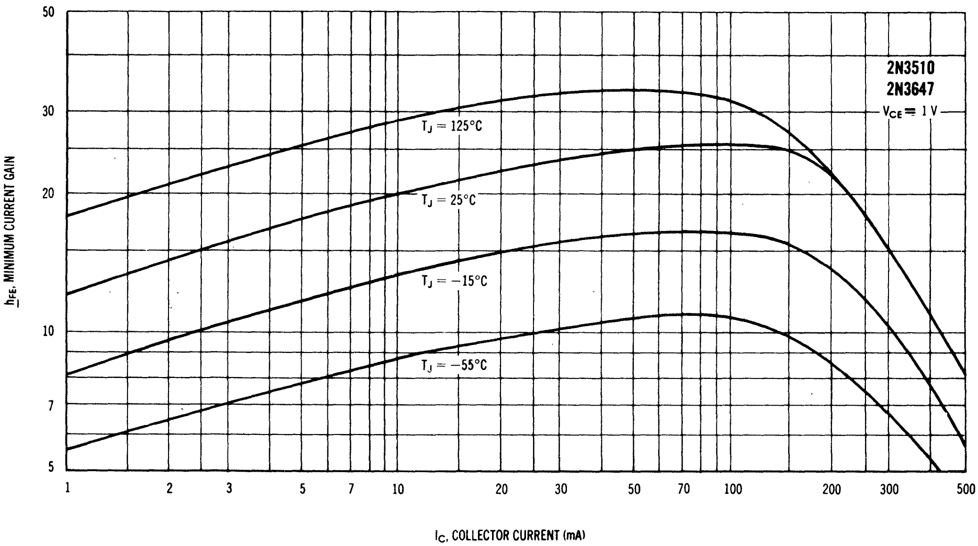
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1 Vdc)			—	.025	
(V_{CE} = 10 Vdc, $V_{EB(off)}$ = 1 Vdc, T_A = 150°C)			—	50	
Base Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc)		I_{BL}	—	.025	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	2N3510, 2N3647	BV_{CEO}	10	—	Vdc
	2N3511, 2N3648		15	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		—	0.25	
(I_C = 150 mAdc, I_B = 15 mAdc)	All Types		—	0.4	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3510, 2N3647		—	0.6	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3511, 2N3648		—	0.8	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		—	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)	All Types		0.8	1.0	
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3510, 2N3647		—	1.15	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3511, 2N3648		—	1.5	
DC Current Gain*		h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3510, 2N3647		12	—	
	2N3511, 2N3648		15	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3510, 2N3647		20	—	
	2N3511, 2N3648		25	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	2N3510, 2N3647		25	150	
	2N3511, 2N3648		30	120	
(I_C = 150 mAdc, V_{CE} = 1 Vdc, TA = -55°C)	2N3511, 2N3648		12	—	
(I_C = 300 mAdc, V_{CE} = 1 Vdc)	2N3510, 2N3647		15	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3511, 2N3648		12	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	8.0	pF
Small Signal Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3510, 2N3647	h_{fe}	3.5	—	—
	2N3511, 2N3648		4.5	—	
Delay Time (I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6 V)	2N3510, 2N3647	t_d	—	10	ns
	2N3511, 2N3648		—	8.0	
Rise Time (I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6 V)	2N3510, 2N3647	t_r	—	12	ns
	2N3511, 2N3648		—	10	
Turn-On Time (I_C = 150 mA, I_{B1} = 15 mA, V_{EB} = 0.5 V, V_{CC} = 6 V)	2N3510, 2N3647	t_{on}	—	20	ns
	2N3511, 2N3648		—	16	
Storage Time (I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6 V)	2N3510, 2N3647	t_s	—	16	ns
	2N3511, 2N3648		—	12	
Fall Time (I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6 V)	2N3510, 2N3647	t_f	—	12	ns
	2N3511, 2N3648		—	8.0	
Turn-Off Time (I_C = 150 mA, I_{B1} = $-I_{B2}$ = 15 mA, V_{CC} = 6 V)	2N3510, 2N3647	t_{off}	—	25	ns
	2N3511, 2N3648		—	18	
Total Control Charge (I_C = 150 mA, I_B = 15 mA, V_{CC} = 6 V)		Q_T	—	300	pC
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)		h_{fe}	20	150	—
Voltage Feedback Ratio (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)		h_{re}	—	25	$X10^{-4}$
Input Impedance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)		h_{ie}	0.6	4.5	kohms
Output Admittance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kHz)		h_{oe}	10	100	μmhos

* Indicates JEDEC Registered Data

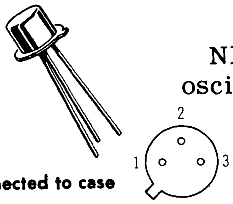
(1)**Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%**

MINIMUM CURRENT GAIN CHARACTERISTICS





2N3544 (SILICON)



NPN silicon annular transistor for VHF and UHF oscillator applications.

CASE 22
(TO-18)

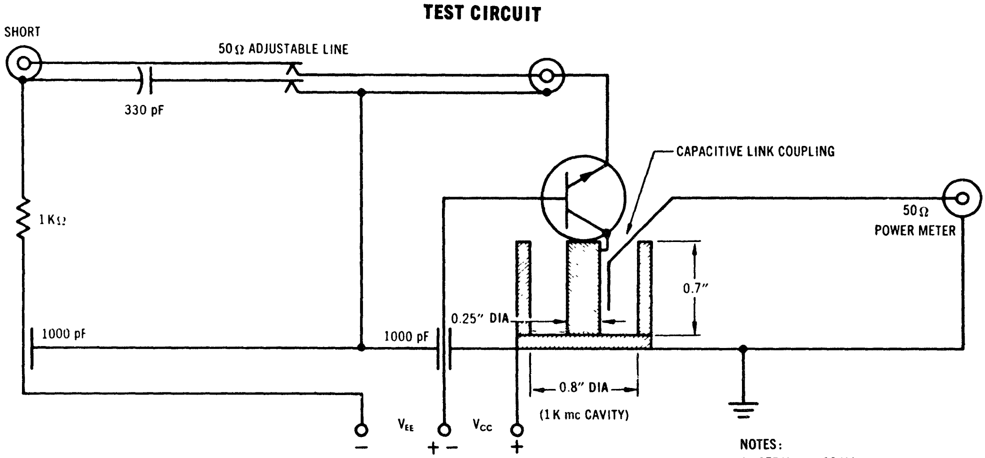
Collector connected to case

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current	I_C	100	mA
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

TEST CIRCUIT



NOTES:
1. SET V_{CC} = 12 Vdc.
2. ADJUST V_{EE} FOR I_C = 12 mAdc.
3. SET ADJUSTABLE LINE FOR MAXIMUM POWER OUTPUT.

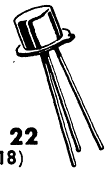
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	25	30	--	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μA, V_{BE} = 0	25	30	--	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0	--	0.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	--	0.1	10	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C=10 mAdc	25	50	--	--

AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C =10 mAdc, f = 100 MHz	6.0	9.0	15	--
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz	--	--	2.5	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 10 mAdc, f =31.8 MHz	--	--	10	ps

Oscillator Power Output	P_{out}	f =1.0 GHz, V_C = 12 Vdc, I_C=12 mAdc	10	16	--	mW

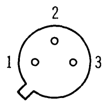
2N3546 (SILICON)



CASE 22
(TO-18)

PNP silicon annular transistor for low-level, high-speed switching applications.

Collector connected to case



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance, Junction to Ambient Thermal Resistance, Junction to Case	θ_{JA} θ_{JC}	0.49 0.15	°C/mW °C/mW

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 10 Vdc) (V_{CB} = 10 Vdc, T_A = 150°C)		I_{CBO}	-- --	0.010 10	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	--	0.010	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{BL}	--	0.10	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	--	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	12	--	Vdc
Collector Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	-- -- --	0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	0.7 0.8 --	0.9 1.3 1.6	Vdc
DC Current Gain (1) (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1Vdc)		h_{FE}	20 30 15 25 15	-- 120 -- -- --	--
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	--	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ib}	--	5.0	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	700	--	MHz
Total Control Charge (I_C = 50 mA, I_B = 5 mA, V_{CC} = 3 V)		Q_T	--	400	pC
Delay Time	I_C = 50 mA, I_{B1} = 5mA,	t_d	--	10	ns
Rise Time	V_{BE} = 2 V, V_{CC} = 3 V	t_r	--	15	ns
Storage Time	I_C = 50 mA, I_{B1} = I_{B2} = 5 mA,	t_s	--	20	ns
Fall Time	V_{CC} = 3 V	t_f	--	15	ns
Turn-On Time	(See Figure 3,4,5)	t_{on}	--	40	ns
Turn-Off Time		t_{off}	--	30	ns

* Indicates JEDEC Registered Data

(1) Pulse Test: PW = 300 μs, Duty Cycle ≤ 2%

FIGURE 1

LIMITS OF SATURATION VOLTAGES

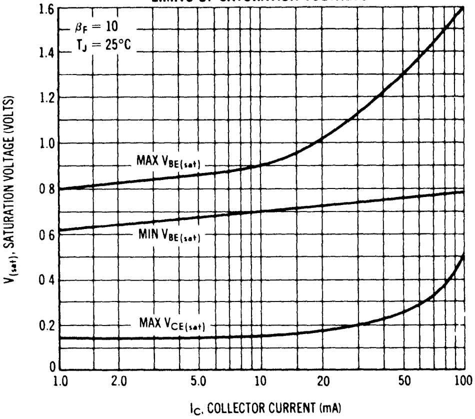


FIGURE 2

STORAGE TIME BEHAVIOR

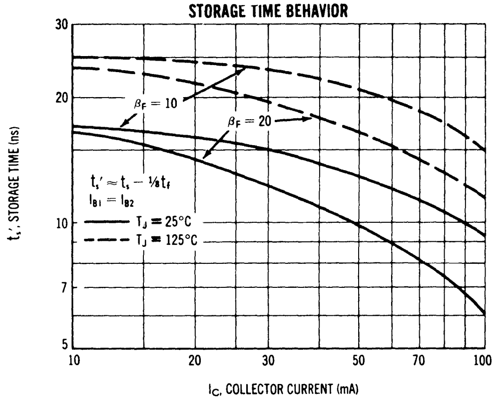
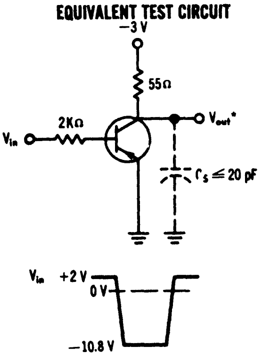


FIGURE 3

DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

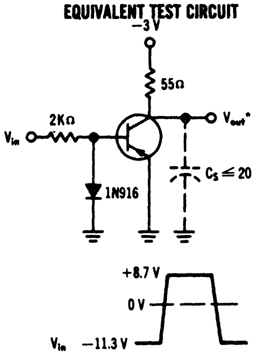


PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

*OSCILLOSCOPE RISE TIME ≤ 1 ns

FIGURE 4

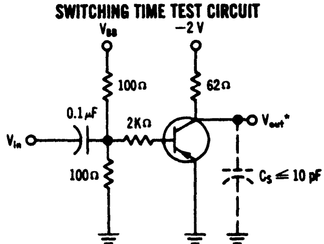
STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



PULSE WIDTH = 200 ns
RISE TIME ≤ 2 ns
DUTY CYCLE ≤ 10%

FIGURE 5

SWITCHING TIME TEST CIRCUIT

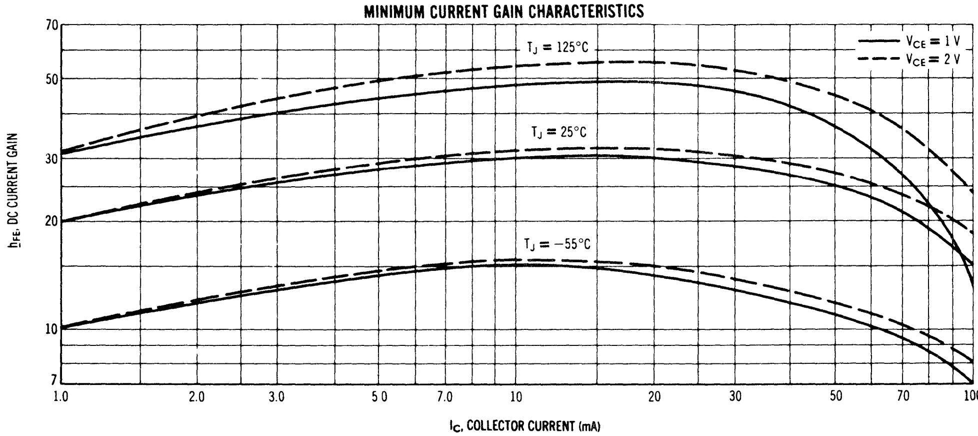


PULSE WIDTH > 200 ns
RISE TIME < 1 ns
$Z_{in} = 50Ω$

t_{on} : V_{BB} = +3 V, V_{in} = −7 V
t_{off} : V_{BB} = −4 V, V_{in} = +6 V

FIGURE 6

MINIMUM CURRENT GAIN CHARACTERISTICS



2N3553 (SILICON)

For Specifications, See 2N3375 Data.

2N3583 thru 2N3585, 2N4240 NPN (SILICON)
MJ3583 thru MJ3585, MJ4240 PNP

COMPLEMENTARY MEDIUM-POWER HIGH VOLTAGE POWER TRANSISTORS

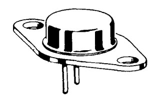
. . . designed for high-speed switching and linear amplifier applications for high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

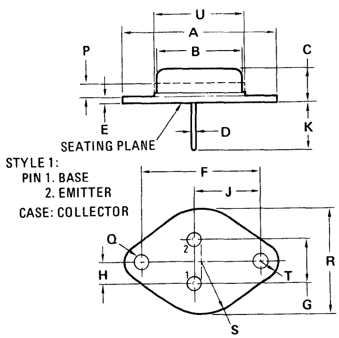
- Collector-Emitter Sustaining Voltage —
  $V_{CEO(sus)}$ = 175 to 300 Vdc @ I_C = 200 mAdc
- Second Breakdown Collector Current —
  $I_{s/b}$ = 350 mAdc @ V_{CE} = 100 Vdc – NPN
  = 150 mAdc @ V_{CE} = 100 Vdc – PNP
- Usable DC Current Gain to 2.0 Adc

1.0 AND 2.0 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

250-500 VOLTS
35 WATTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

*MAXIMUM RATINGS

Rating	Symbol	2N3583 MJ3583	2N3584 MJ3584	2N3585 MJ3585	2N4240 MJ4240	Unit
Collector-Emitter Voltage	V_{CEO}	175	250	300	300	Vdc
Collector-Base Voltage	V_{CB}	250	375	500	500	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →				Vdc
Collector Current – Continuous – Peak	I_C	1.0 5.0	← 2.0 → ← 5.0 →			Adc
Base Current	I_B	← 1.0 →				Adc
Total Device Dissipation @ T_C = 25°C, Derate above 25°C	P_D	← 35 → ← 0.2 →				Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← -65 to +200 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0	°C/W

*Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN Min	NPN Max	PNP Min	PNP Max	Unit
***OFF CHARACTERISTICS**								
Collector-Emitter Sustaining Voltage (I_C = 200 mAdc, I_B = 0) NPN	2N3583	MJ3583	$V_{CEO(sus)}$	175	–	175	–	Vdc
	2N3584	MJ3584		250	–	250	–	
	2N3585	MJ3585		300	–	300	–	
(I_C = 50 mAdc, I_B = 0) PNP	2N4240	MJ4240		300	–	300	–	
Collector Cutoff Current			I_{CEO}					mAdc
(V_{CE} = 150 Vdc, I_B = 0)	2N3583	MJ3583		–	10	–	10	
	2N3584	MJ3584		–	5.0	–	5.0	
	2N3585	MJ3585		–	5.0	–	5.0	
	2N4240	MJ4240		–	5.0	–	5.0	
Collector Cutoff Current			I_{CEX}					mAdc
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3583	MJ3583		–	1.0	–	1.0	
(V_{CE} = 340 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3584	MJ3584		–	1.0	–	1.0	
(V_{CE} = 450 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3585	MJ3585		–	1.0	–	1.0	
	2N4240	MJ4240		–	2.0	–	2.0	
(V_{CE} = 225 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3583	MJ3583		–	3.0	–	3.0	
(V_{CE} = 300 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3584	MJ3584		–	3.0	–	3.0	
	2N3585	MJ3585		–	3.0	–	3.0	
	2N4240	MJ4240		–	5.0	–	5.0	
Emitter Cutoff Current			I_{EBO}					mAdc
(V_{BE} = 6.0 Vdc, I_C = 0)	2N3583	MJ3583		–	5.0	–	5.0	
	2N3584	MJ3584		–	0.5	–	0.5	
	2N3585	MJ3585		–	0.5	–	0.5	
	2N4240	MJ4240		–	0.5	–	0.5	
ON CHARACTERISTICS								
DC Current Gain			h_{FE}					–
(I_C = 0.1 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		40	–	40	–	
	2N3584	MJ3584		40	–	40	–	
	2N3585	MJ3585		40	–	40	–	
	2N4240	MJ4240		40	–	40	–	
*(I_C = 0.5 Adc, V_{CE} = 10 Vdc)	2N3583	MJ3583		40	200	40	200	
*(I_C = 0.75 Adc, V_{CE} = 2.0 Vdc)	2N4240	MJ4240		10	100	10	100	
(I_C = 0.75 Adc, V_{CE} = 10 Vdc)	2N4240	MJ4240		30	150	30	150	
*(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	2N3584	MJ3584		8.0	80	8.0	80	
	2N3585	MJ3585		8.0	80	8.0	80	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		10	–	10	–	
	2N3584	MJ3584		25	100	25	100	
	2N3585	MJ3585		25	100	25	100	
*Collector-Emitter Saturation Voltage			$V_{CE(sat)}$					Vdc
(I_C = 0.75 Adc, I_B = 75 mAdc)	2N4240	MJ4240		–	1.0	–	1.0	
(I_C = 1.0 Adc, I_B = 125 mAdc)	2N3583	MJ3583		–	5.0	–	5.0	
	2N3584	MJ3584		–	0.75	–	0.75	
	2N3585	MJ3585		–	0.75	–	0.75	
*Base-Emitter Saturation Voltage			$V_{BE(sat)}$					Vdc
(I_C = 0.75 Adc, I_B = 75 mAdc)	2N4240	MJ4240		–	1.8	–	1.8	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3584	MJ3584		–	1.4	–	1.4	
	2N3585	MJ3585		–	1.4	–	1.4	
Base-Emitter On Voltage			$V_{BE(on)}$					Vdc
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N3583*	MJ3583		–	1.4	–	1.4	
	2N3584	MJ3584		–	1.4	–	1.4	
	2N3585	MJ3585		–	1.4	–	1.4	
	2N4240	MJ4240		–	1.4	–	1.4	

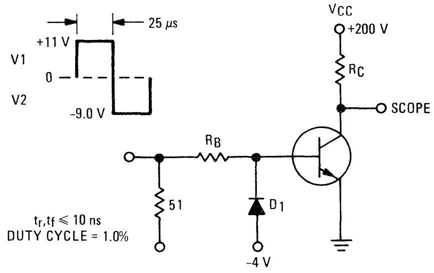
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic	NPN	PNP	Symbol	NPN Min	NPN Max	PNP Min	PNP Max	Unit
DYNAMIC CHARACTERISTICS								
*Current Gain — Bandwidth Product[(1)] (I_C = 200 mAdc, V_{CE} = 10 Vdc, f_{test} = 5.0 MHz)	2N3583 2N3584 2N3585 2N4240	MJ3583 MJ3584 MJ3585 MJ4240	f_T	10 15	— —	10 15	— —	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	All	All	C_{ob}	—	120	—	120	pF
*Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 30 Vdc, f = 1.0 kHz)	2N3583	MJ3583	h_{fe}	25	350	25	350	—
***SWITCHING CHARACTERISTICS**								
Rise Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, R_L = 200 Ohms, I_{B1} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, R_L = 267 Ohms, I_{B1} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_r	— —	3.0 0.5	— —	3.0 0.5	μs
Storage Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, I_{B1} = I_{B2} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_s	— —	4.0 6.0	— —	4.0 6.0	μs
Fall Time (V_{CC} = 200 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (V_{CC} = 200 Vdc, I_C = 0.75 Adc, I_{B1} = I_{B2} = 75 mAdc)	2N3584 2N3585 2N4240	MJ3584 MJ3585 MJ4240	t_f	— —	3.0 3.0	— —	3.0 3.0	μs
Second Breakdown Collector Current (V_{CE} = 100 Vdc)	All	All	$I_{s/b}$	350	—	150	—	mAdc

*Indicates JEDEC Registered Data for 2N3583 thru 2N3585 and 2N4240.

(1) $f_T = |h_{fe}| \bullet f_{test}$.

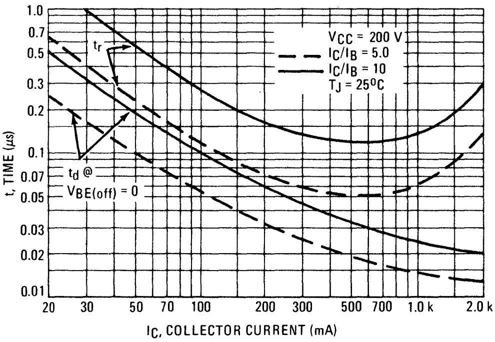
FIGURE 1 — SWITCHING TIME TEST CIRCUIT



R_B and R_C VARIED TO OBTAIN DESIRED CURRENT LEVELS
D_1 MUST BE FAST RECOVERY TYPE, eg.
MBD5300 USED ABOVE $I_B \approx$ 100 mA
MSD6100 USED BELOW $I_B \approx$ 100 mA
FOR t_d and t_r, D1 IS DISCONNECTED AND V_2 = 0.
FOR PNP TEST CIRCUIT, REVERSE DIODE AND VOLTAGE POLARITIES.

NPN 2N3583 thru 2N3585,2N4240	PNP MJ3583 thru MJ3585,MJ4240

FIGURE 2 – TURN-ON TIME



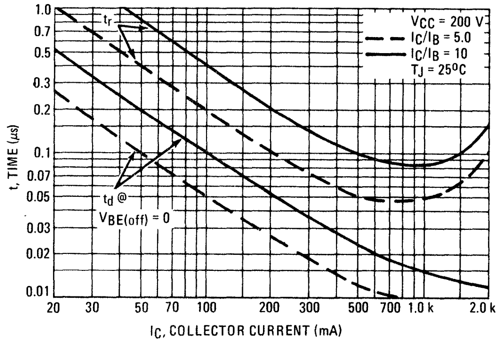
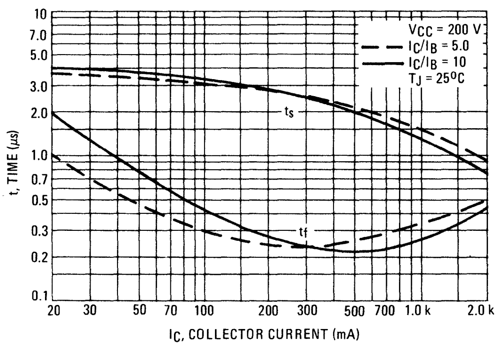


FIGURE 3 – TURN-OFF TIME



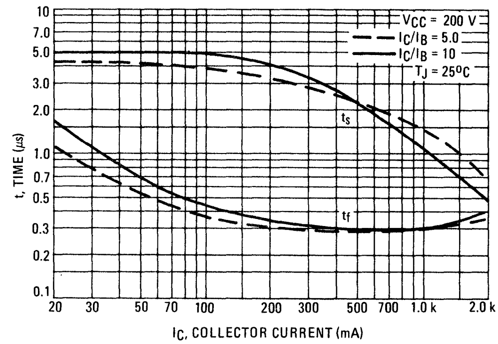


FIGURE 4 – CURRENT-GAIN – BANDWIDTH PRODUCT

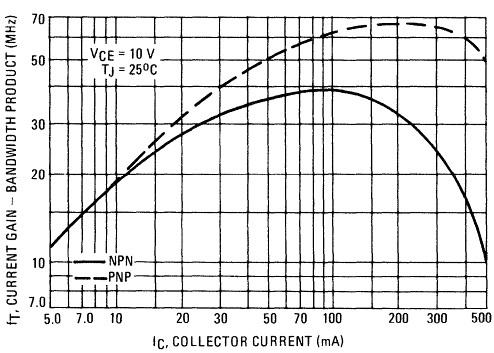


FIGURE 5 – CAPACITANCE

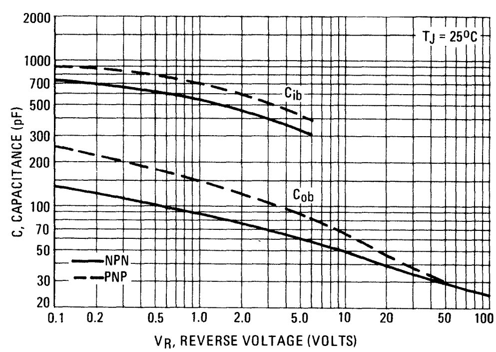
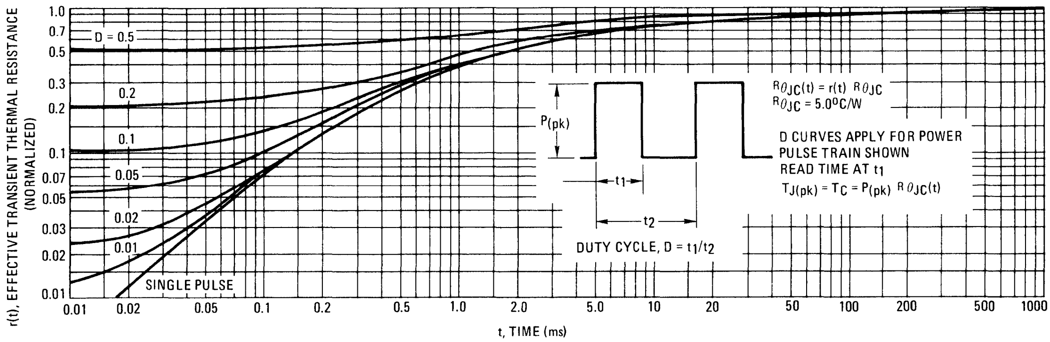


FIGURE 6 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 7 – 2N3583 thru 2N3585, 2N4240

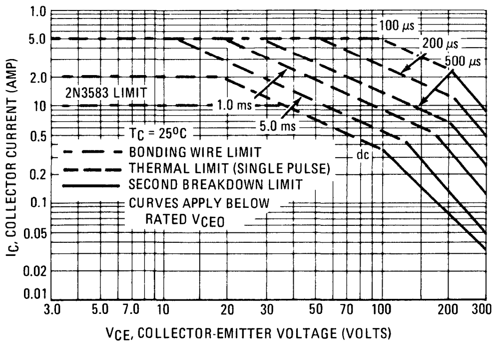


FIGURE 8 – MJ3583 thru MJ3585, MJ4240

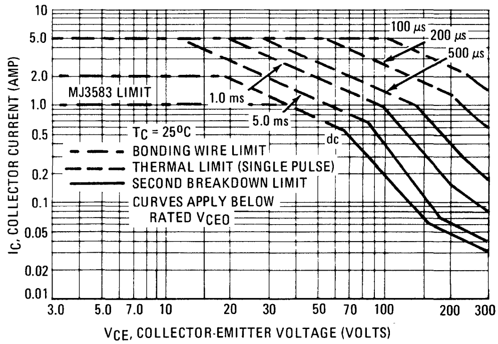
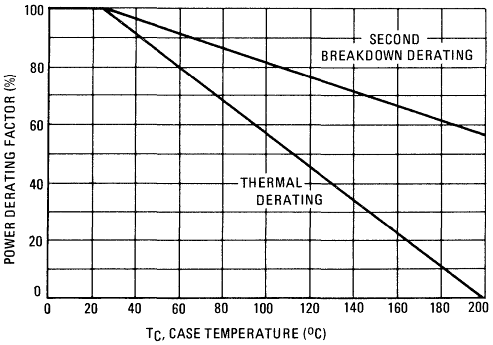


FIGURE 9 – POWER DERATING



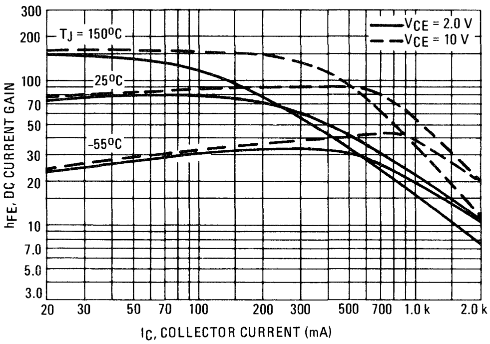
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 7 and 8 is based on $T_C = 25^{\circ}C$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated for temperature according to Figure 9.

$T_{J(pk)}$ may be calculated from the data in Figure 6. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 7 and 8 may be found at any case temperature by using the appropriate curve on Figure 9.

NPN 2N3583 thru 2N3585,2N4240	PNP MJ3583 thru MJ3585,MJ4240

FIGURE 10 – DC CURRENT GAIN



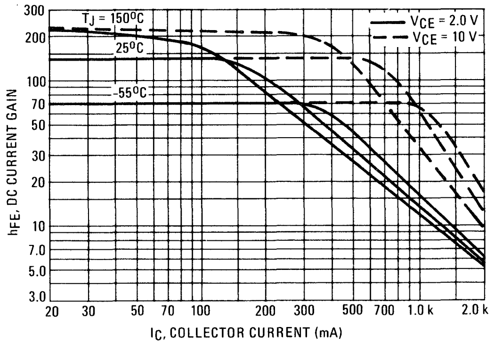
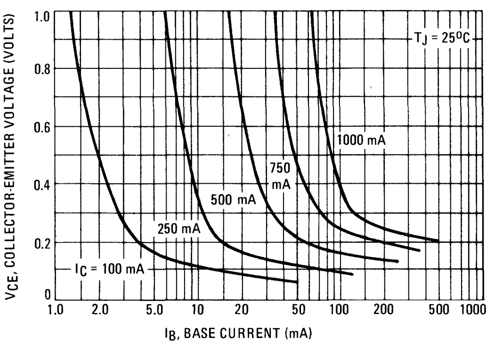


FIGURE 11 – COLLECTOR SATURATION REGION



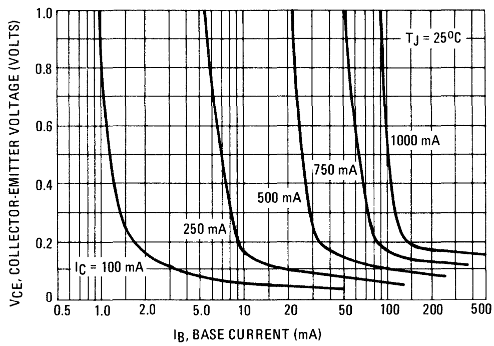
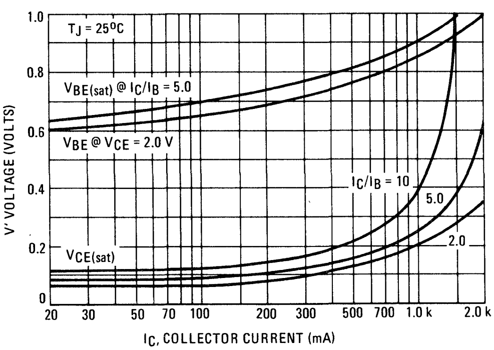
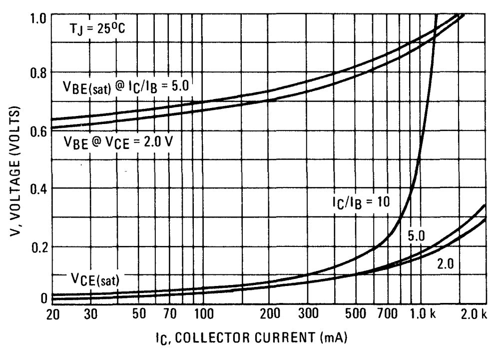


FIGURE 12 – "ON" VOLTAGES





NOTE: DC CURRENT LIMIT FOR 2N3583, MJ3583 is 1.0 Amp.

NPN 2N3583 thru 2N3585,2N4240	PNP MJ3583 thru MJ3585,MJ4240

FIGURE 13 – TEMPERATURE COEFFICIENTS

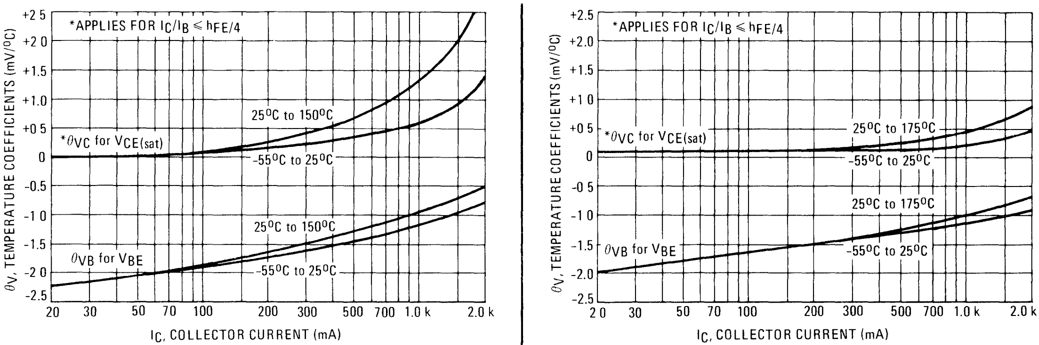


FIGURE 14 – COLLECTOR CUTOFF REGION

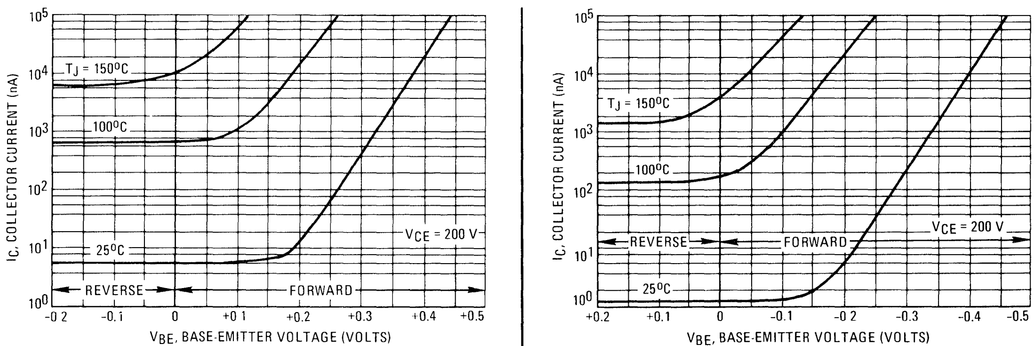
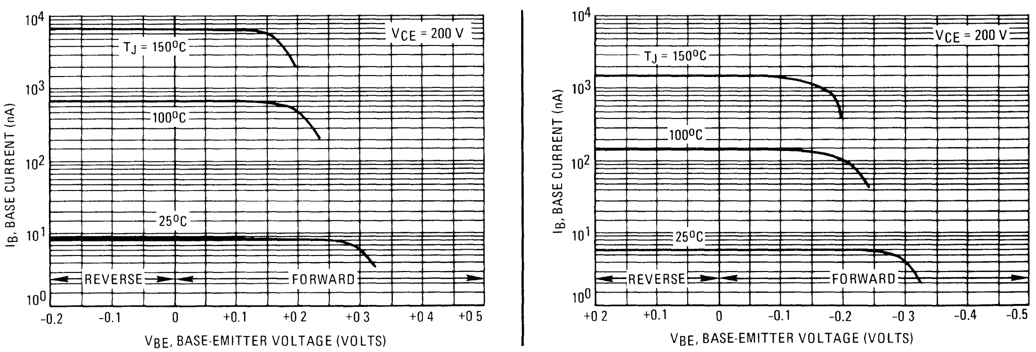
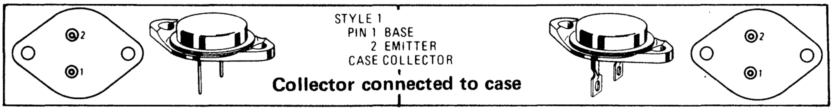


FIGURE 15 – BASE CUTOFF REGION



2N3611 thru 2N3614 (GERMANIUM)

PNP germanium power transistors for switching and amplifier applications.

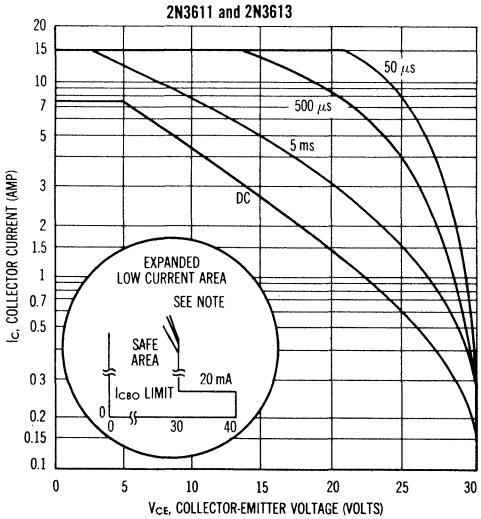


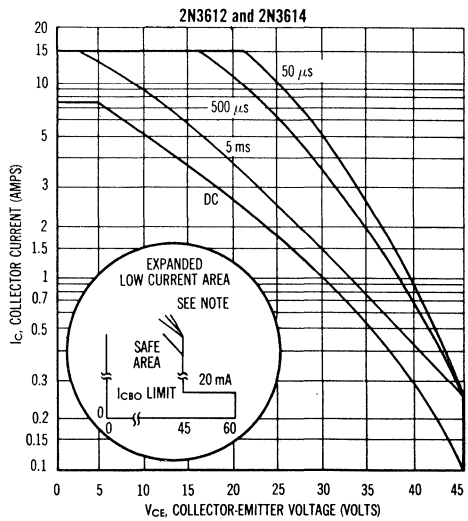
CASE 11 | For units with solder lugs attached, specify devices MP3611 etc. (Case 4-04) | CASE 4-04

MAXIMUM RATINGS

Rating	Symbol	2N3611 2N3613	2N3612 2N3614	Unit
Collector-Emitter Voltage	V_{CES}	30	45	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	20	30	Vdc
Collector Current (Continuous)	I_C	7.0		Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2.0		Adc
Storage Temperature Range	T_{stg}	-65 to +110		°C
Operating Case Temperature Range	T_C	-65 to +110		°C
Total Device Dissipation @ $T_C = 25°C$ Derate above $T_C = 25°C$	P_D	77 1.0		Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	1.1		°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		°C/W

SAFE OPERATING AREAS





The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

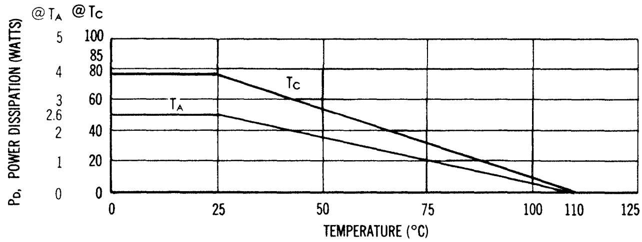
ELECTRICAL CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3611, 2N3613 2N3612, 2N3614	BV_{CES}*	30 45	– –	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc)	2N3611, 2N3613 2N3612, 2N3614	BV_{CEO}*	25 35	– –	Vdc
Floating Potential ($V_{CB} = V_{CB}$ max)		V_{EBF}	–	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)		I_{CEO}	–	30	mAdc
Collector-Emitter Leakage Current ($V_{CE} = V_{CE}$ max, V_{BE} = 1.0 Vdc, T_C = +100°C)		I_{CEX}	–	10	mAdc
Collector-Base Cutoff Current (V_{CB} = 2 Vdc) (V_{CB} = 25 Vdc) (V_{CB} = 40 Vdc) ($V_{CB} = V_{CB}$ max)	 2N3611, 2N3613 2N3612, 2N3614	I_{CBO}	-- – – –	.040 0.5 0.5 5.0	mAdc
Emitter-Base Cutoff Current ($V_{EB} = V_{EB}$ max)		I_{EBO}	–	500	μAdc
Collector-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 300 mAdc) (I_C = 7 Adc, I_B = 700 mAdc)		$V_{CE(sat)}$	– –	0.25 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 300 mAdc) (I_C = 7 Adc, I_B = 700 mAdc)	2N3611, 2N3612 2N3613, 2N3614 2N3611, 2N3612 2N3613, 2N3614	$V_{BE(sat)}$	– – – –	0.7 0.6 1.1 0.9	Vdc
Transconductance (I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612 2N3613, 2N3614	g_{FE}	3.0 3.5	– –	mhos
Small Signal Current Gain (I_C = 0.5 A, V_{CE} = 12 V, f = 20 kHz) (I_C = 0.5 A, V_{CE} = 2 V, f = 1 kHz)	 2N3611, 2N3612 2N3613, 2N3614	h_{fe}	15 40 60	– 100 150	–
DC Current Gain (I_C = 3 Adc, V_{CE} = 2 Vdc) (I_C = 7 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612 2N3613, 2N3614 2N3611, 2N3612 2N3613, 2N3614	h_{FE}	35 60 20 30	70 120 – –	–

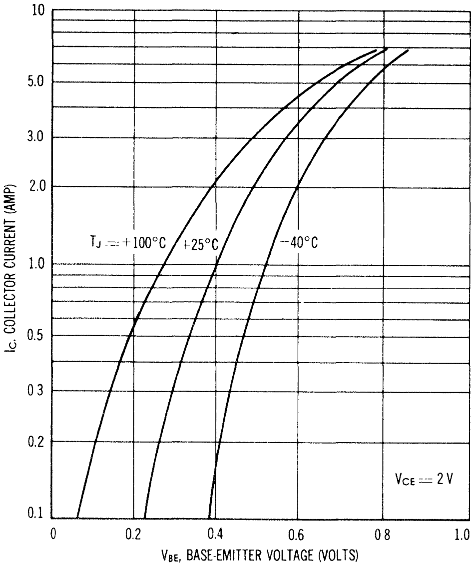
*Sweep Test: 1/2 sine wave, 60 Hz

POWER-TEMPERATURE DERATING CURVE

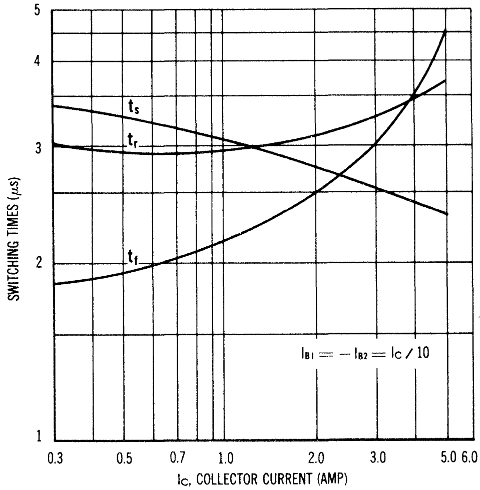
These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



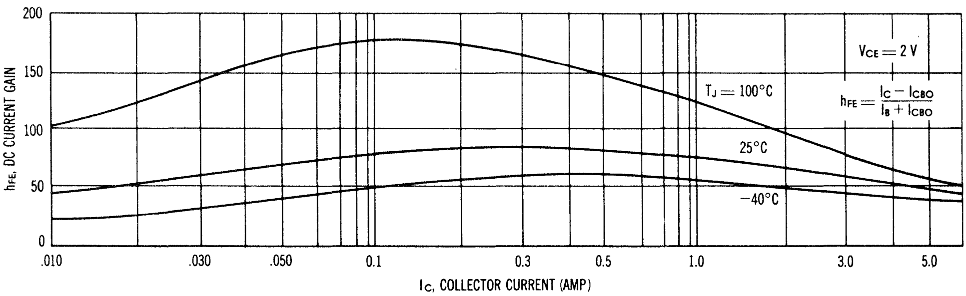
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



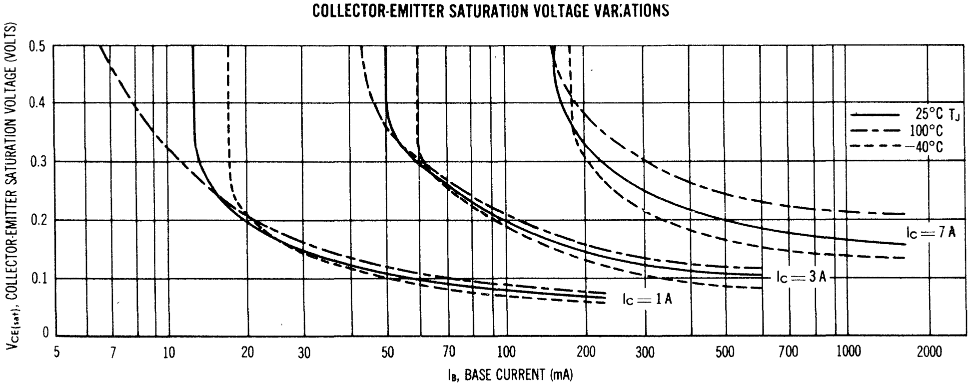
TYPICAL SWITCHING TIMES



DC CURRENT GAIN versus COLLECTOR CURRENT

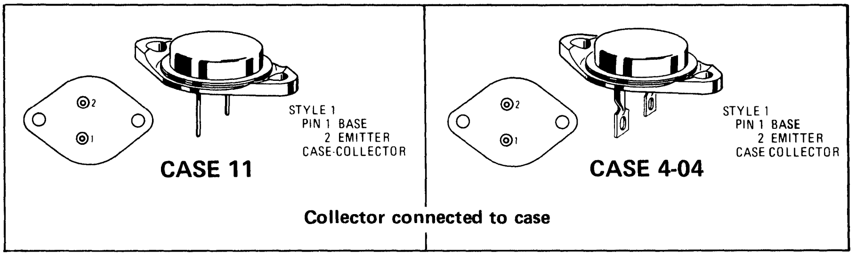


COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



2N3615 thru 2N3618 (GERMANIUM)

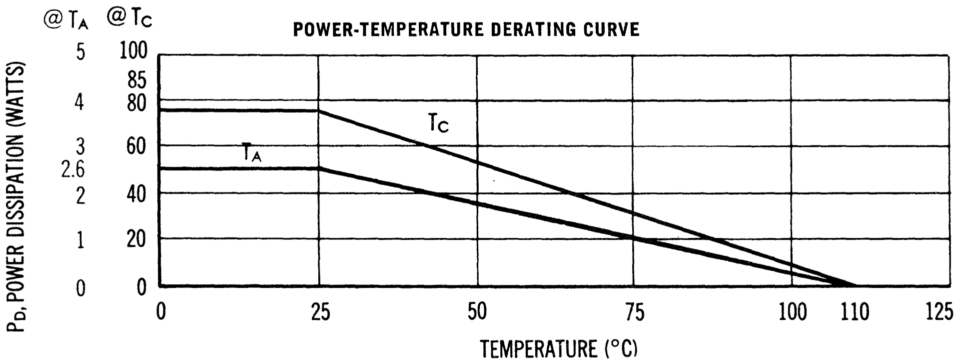
PNP germanium power transistors for switching and amplifier applications.



For units with solder lugs attached, specify devices MP3615 etc (Case 4-04)

MAXIMUM RATINGS

Rating	Symbol	2N3615 2N3617	2N3616 2N3618	Unit
Collector-Emitter Voltage	V_{CES}	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	50	60	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	40	50	Vdc
Collector Current (Continuous)	I_C	7.0		Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2.0		Adc
Storage Temperature	T_{stg}	-65 to +110		°C
Operating Case Temperature	T_C	-65 to +110		°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	77 1.0		Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	1.0		°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		°C/W



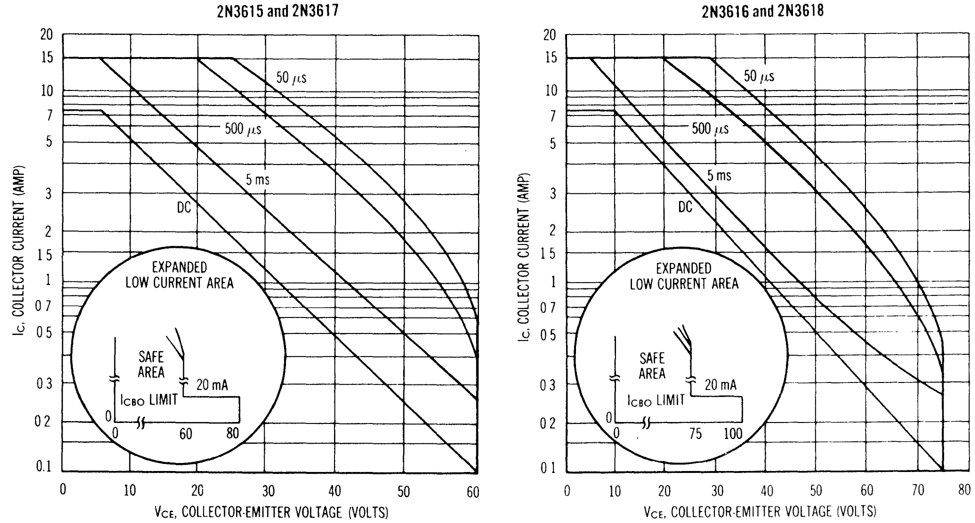
These transistors are also subject to safe area curves. Both limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3615, 2N3617 2N3616, 2N3618	BV_{CES}*	60 75	- -	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc)	2N3615, 2N3617 2N3616, 2N3618	BV_{CEO}*	50 60	-	Vdc
Floating Potential ($V_{CB} = V_{CB}$ max)		V_{EBF}	-	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)		I_{CEO}	-	30	mAdc
Collector-Emitter Leakage Current ($V_{CE} = V_{CE}$ max, V_{BE} = 1.0 Vdc, T_C = +100°C)		I_{CEX}	-	10	mAdc
Collector-Base Cutoff Current (V_{CB} = 2.0 Vdc) (V_{CB} = 55 Vdc) (V_{CB} = 65 Vdc) ($V_{CB} = V_{CB}$ max)	 2N3615, 2N3617 2N3616, 2N3618	I_{CBO}	- - - -	0.060 1.0 1.0 5.0	mAdc
Emitter-Base Cutoff Current ($V_{EB} = V_{EB}$ max) (V_{EB} = 12 Vdc)		I_{EBO}	 -	500	μAdc
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc) (I_C = 7.0 Adc, I_B = 700 mAdc)		$V_{CE(sat)}$	- -	0.25 0.35	Vdc
Base Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 300 mAdc) (I_C = 7.0 Adc, I_B = 700 mAdc)	2N3615, 2N3616 2N3617, 2N3618 2N3615, 2N3616 2N3617, 2N3618	$V_{BE(sat)}$	- - - -	0.7 0.6 1.1 0.9	Vdc
Transconductance (I_C = 3.0 A, V_{CE} = 2.0 V)	2N3615, 2N3616 2N3617, 2N3618	g_{FE}	3.0 3.5	- -	mhos
Small Signal Current Gain (I_C = 0.5 A, V_{CE} = 12 V, f = 20 kHz) (I_C = 0.5 A, V_{CE} = 2.0 V, f = 1.0 kHz)	 2N3615, 2N3616 2N3617, 2N3618	h_{fe}	15 40 60	- 100 150	-
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 7.0 Adc, V_{CE} = 2.0 Vdc)	2N3615, 2N3616 2N3617, 2N3618 2N3615, 2N3616 2N3617, 2N3618	h_{FE}	30 45 20 30	60 90 - -	-
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)		f_T	Typ 600		kHz

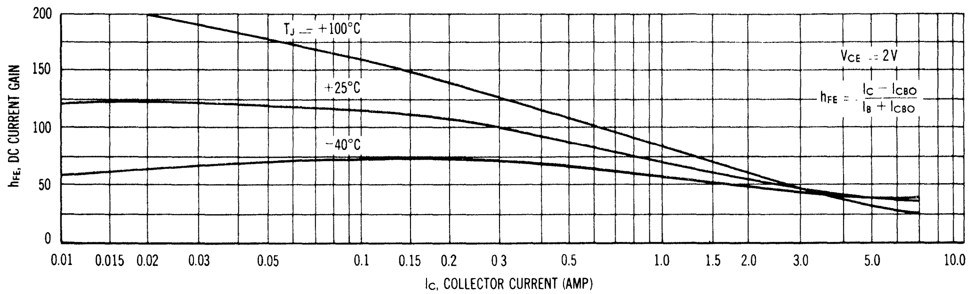
*Sweep Test: 1/2 sine wave, 60 Hz

SAFE OPERATING AREAS

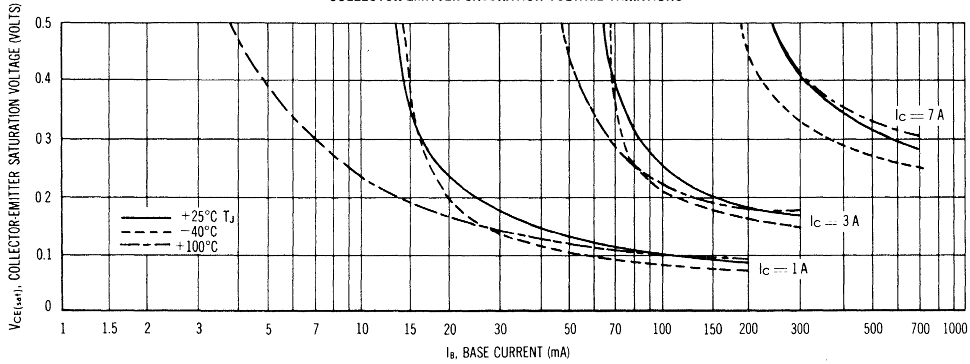


NOTE The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

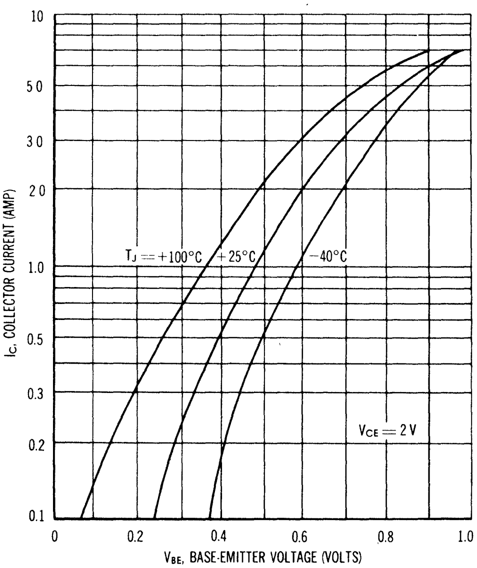
DC CURRENT GAIN versus COLLECTOR CURRENT



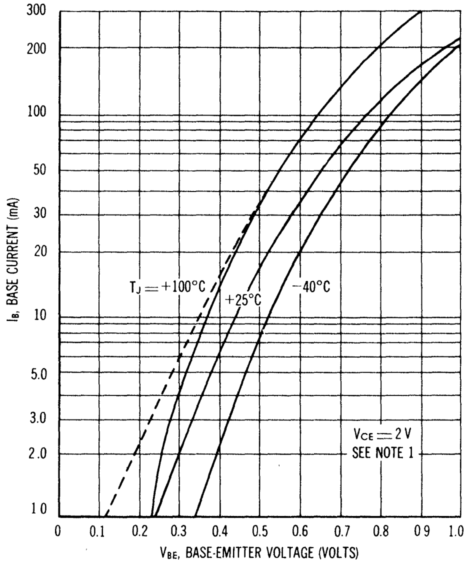
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

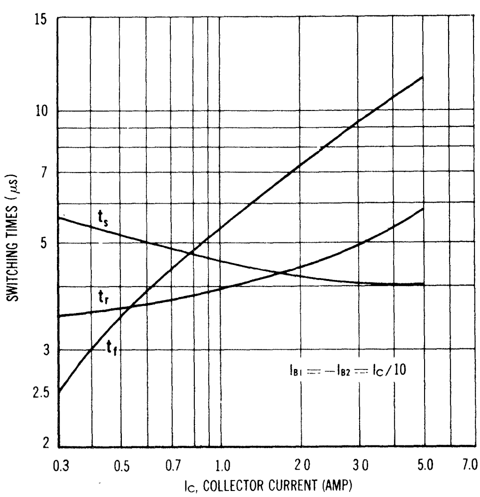


BASE CURRENT versus BASE-EMITTER VOLTAGE

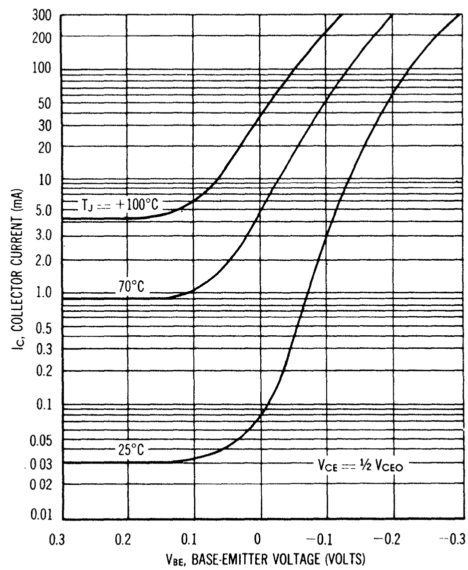


NOTE 1 — Dotted line indicates Metered Base Current plus the I_{CBO} of the transistor at 100°C.

TYPICAL SWITCHING TIMES



COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



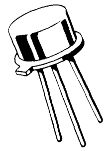
2N3632

For Specifications, See 2N3375 Data.

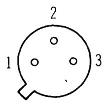
2N3634S thru 2N3637S (SILICON)

JAN,JTX AVAILABLE
JTXV AVAILABLE IN 2N3635S

PNP silicon annular transistors for high-voltage switching and low-power amplifier applications.



CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N3634 2N3635	2N3636 2N3637	Unit
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Collector-Base Voltage	V_{CB}	140	175	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

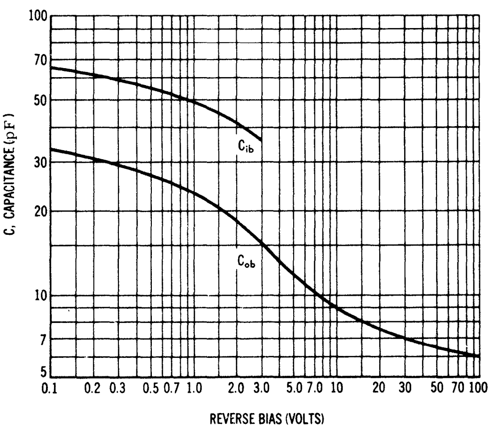
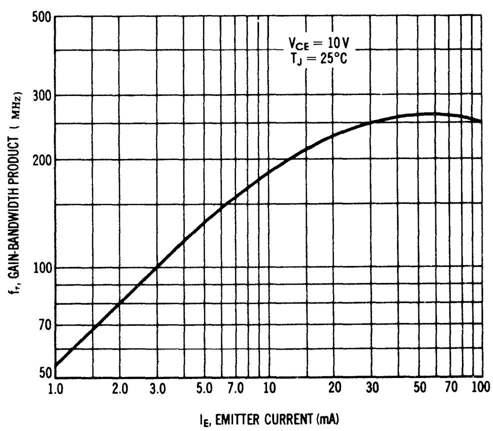


FIGURE 2 — GAIN-BANDWIDTH PRODUCT



*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3634, 2N3635 2N3636, 2N3637	-	BV_{CEO}	140 175	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3634, 2N3635 2N3636, 2N3637	-	BV_{CBO}	140 175	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		-	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)		-	I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		-	I_{EBO}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (1) (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637	3, 4, 5, 6	h_{FE}	40 80	- -	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			45 90	- -	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			50 100	- -	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			50 100	150 300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			25 50	- -	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		11, 12	$V_{CE(sat)}$	- -	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 50 mAdc, I_B = 5.0 mAdc)		11, 12	$V_{BE(sat)}$	- 0.65	0.8 0.9	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (V_{CE} = 30 Vdc, I_C = 30 mAdc, f = 100 MHz)	2N3634, 2N3636 2N3635, 2N3637	2	f_T	150 200	- -	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)		1	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 1.0 Vdc, I_C = 0, f = 100 kHz)		1	C_{ib}	-	75	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	7	h_{ie}	100 200	600 1200	ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		10	h_{re}	-	3.0	X 10^{-4}
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3634, 2N3636 2N3635, 2N3637	9	h_{fe}	40 80	160 320	-
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		8	h_{oe}	-	200	μmhos
Noise Figure (I_C = 0.5 mAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohms, f = 1.0 kHz)		-	NF	-	3.0	dB

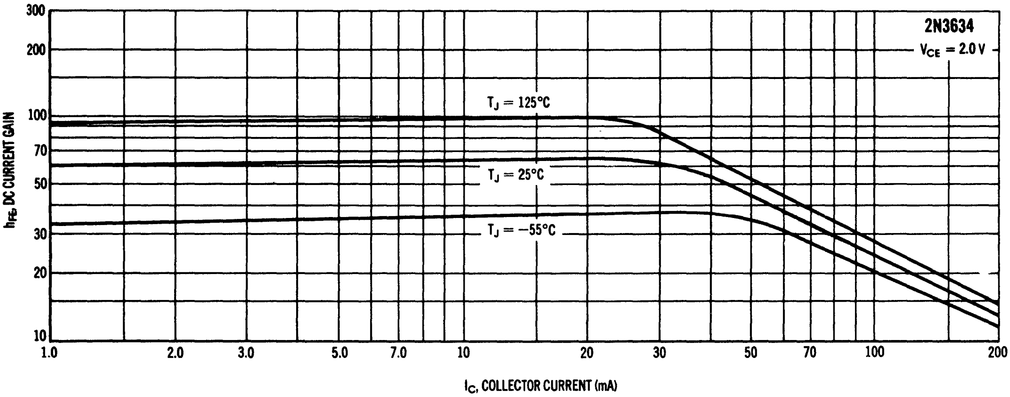
SWITCHING CHARACTERISTICS

	Conditions	Fig. No.	Symbol	Min	Max	Unit
Turn-On Time	(V_{CC} = 100 Vdc, V_{BE} = 4.0 Vdc, I_C = 50 mAdc, I_{B1} = I_{B2} = 5.0 mAdc)	13, 14	t_{on}	-	400	ns
Turn-Off Time		13, 15	t_{off}	-	600	ns

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

*Indicates JEDEC Registered Data

FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



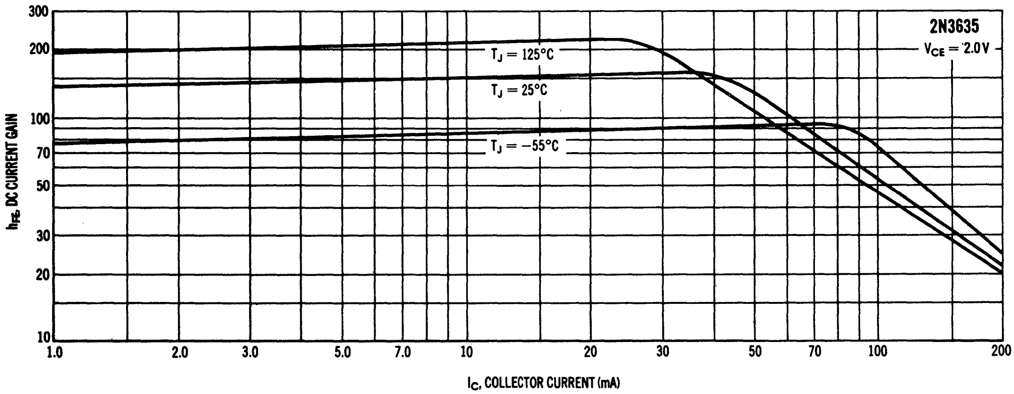


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

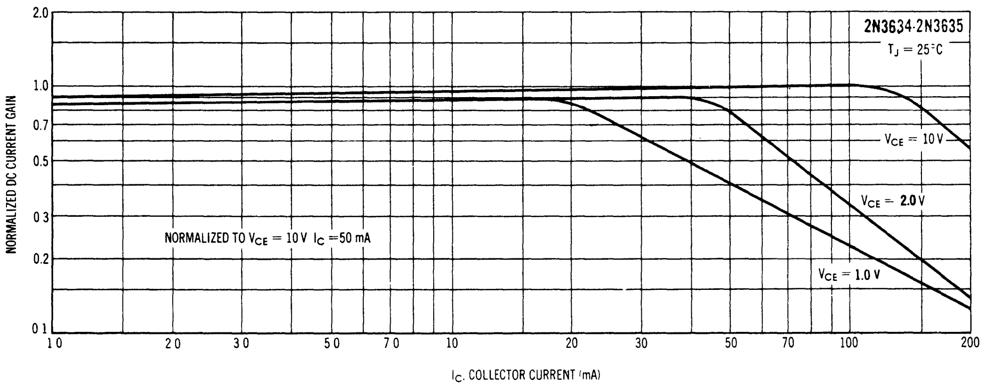


FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

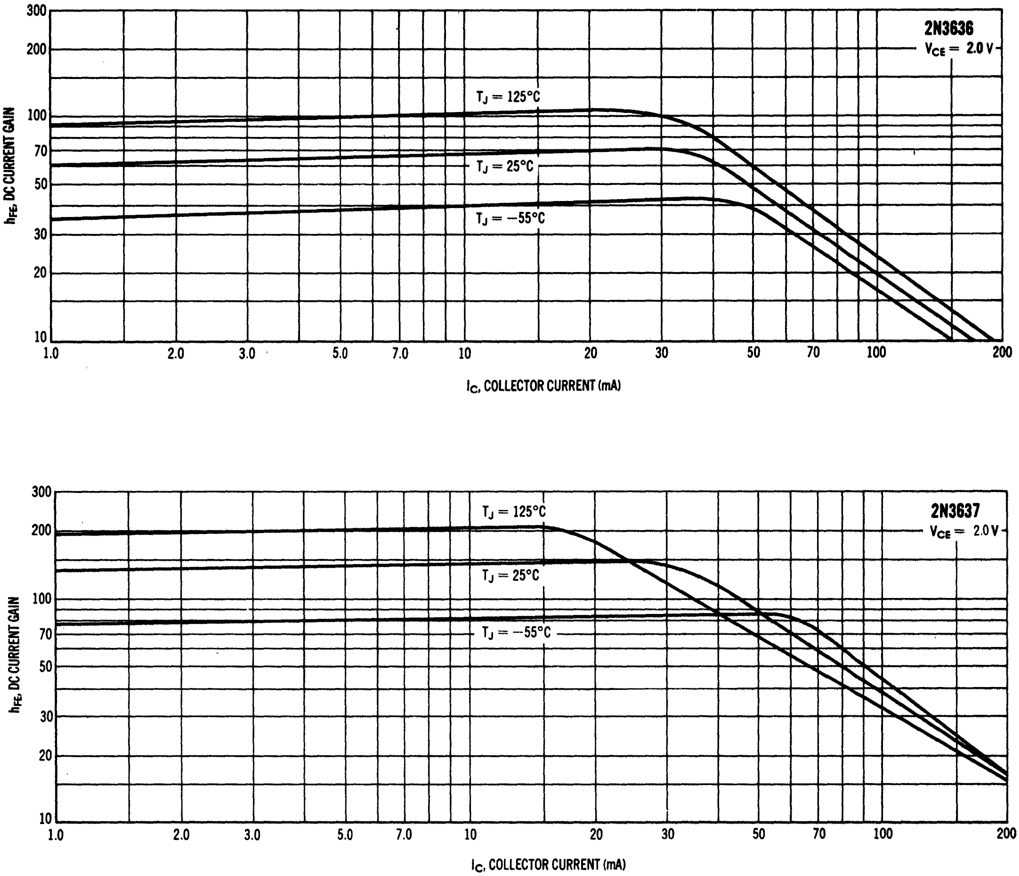


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

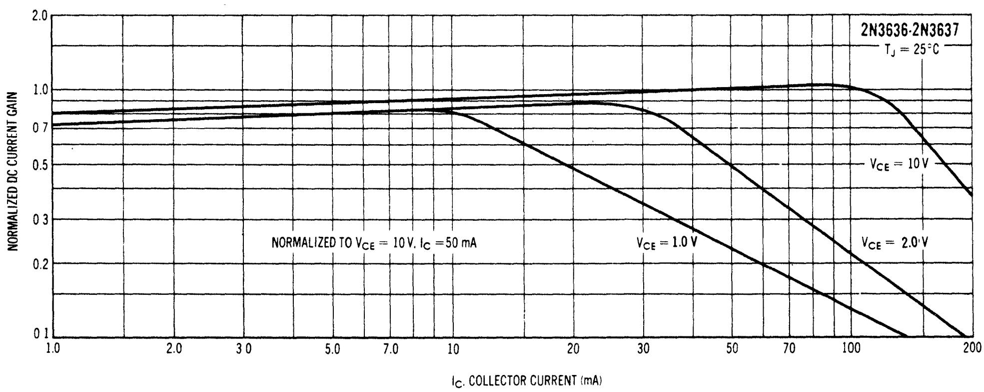


FIGURE 7 — INPUT IMPEDANCE

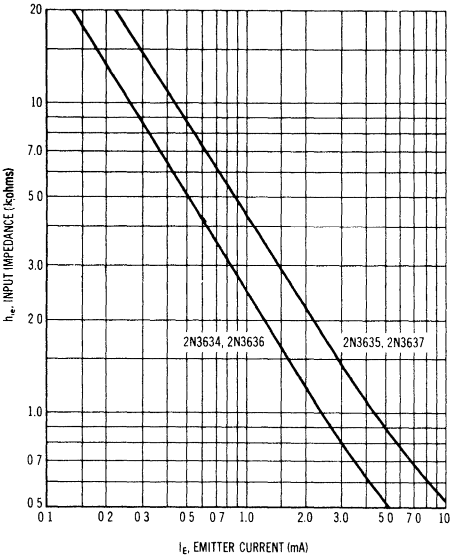


FIGURE 8 — OUTPUT IMPEDANCE

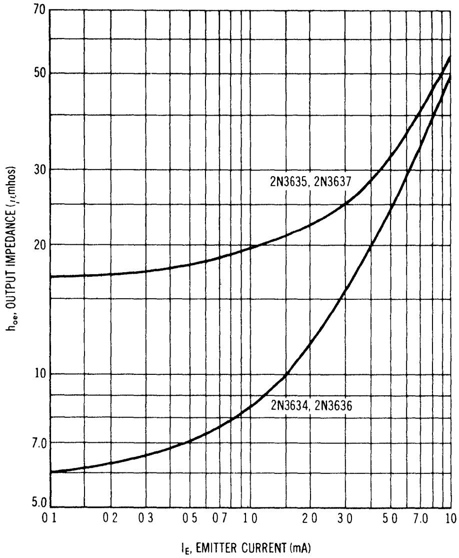


FIGURE 9 — CURRENT GAIN

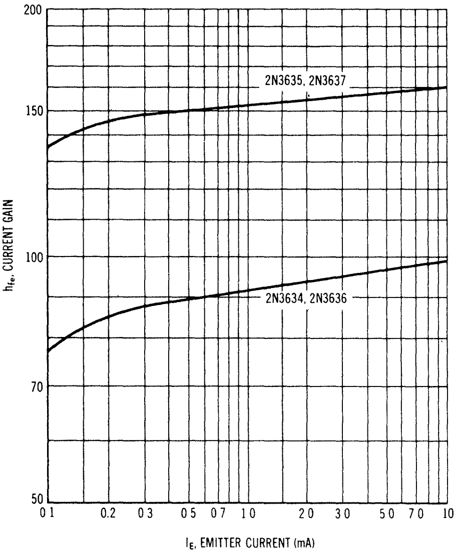


FIGURE 10 — VOLTAGE FEEDBACK RATIO

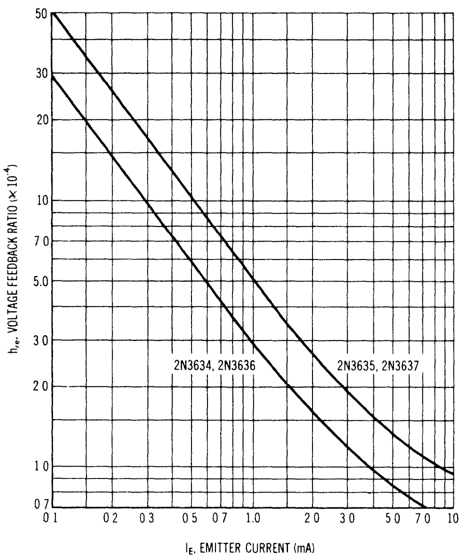


FIGURE 11 — SATURATION VOLTAGES

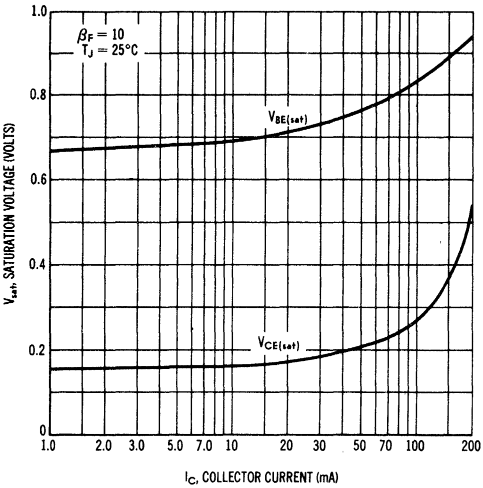


FIGURE 12 — TEMPERATURE COEFFICIENTS

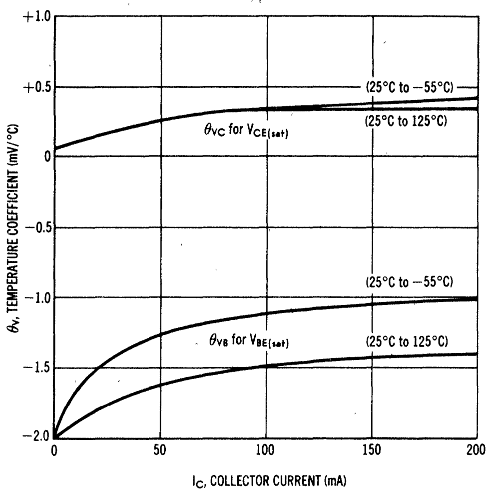
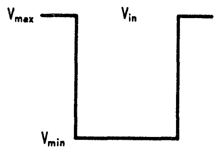


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μs
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 ns

	V_{max}	V_{min}
TURN-ON	+4.0 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

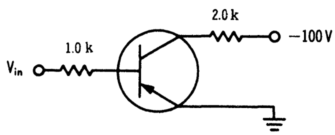


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

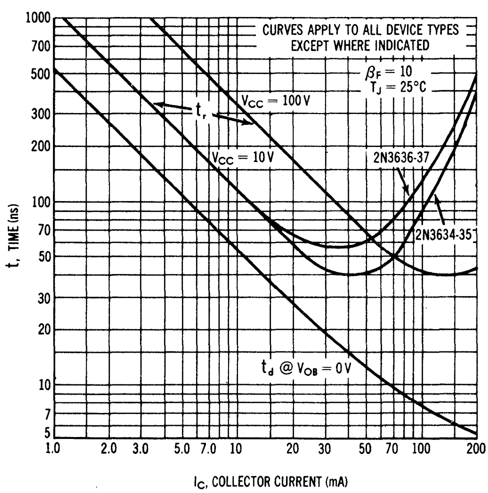
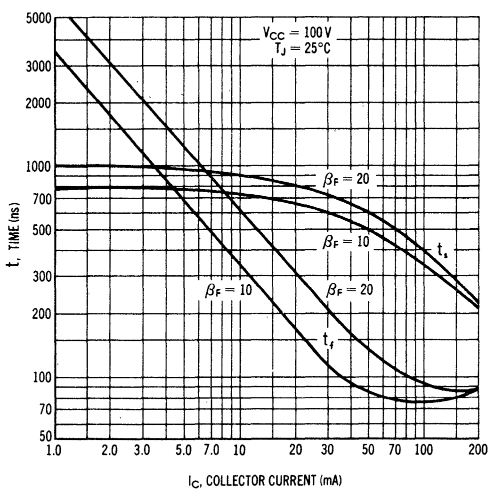


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN



2N3647 (SILICON)
2N3648

For Specifications, See 2N3510 Data.

2N 3673 (SILICON)

NPN SILICON ANNULAR SWITCHING TRANSISTOR

. . . designed for use in high-speed low-current switching applications.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.3 Vdc (Typ) @ I_C = 150 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 350 MHz (Typ) @ I_C = 50 mAdc

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.15	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

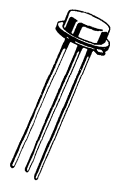
*THERMAL CHARACTERISTICS

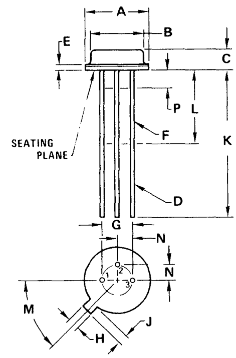
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	500	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58.3	°C/W

*Indicates JEDEC Registered Data

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

NPN SILICON
SWITCHING TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)		–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 0.5 Vdc)	I_{BEV}	–	–	50	nAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 0.5 Vdc)	I_{CEV}	–	–	50	nAdc
ON CHARACTERISTICS(1)					
DC Current Gain	h_{FE}				–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		55	75	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		75	90	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	90	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		75	150	225	
(I_C = 150 mAdc, V_{CE} = 0.6 Vdc)		20	50	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		40	50	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.3	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	0.8	1.6	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.78	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	1.3	2.6	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	f_T	200	350	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	9.0	pF
Input Capacitance (V_{EB} = 2.0 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	20	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_{on}	–	35	45	ns
Delay Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	–	5.0	10	ns
Rise Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_r	–	30	40	ns
Turn-Off Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_{off}	–	80	100	ns
Storage Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_s	–	60	80	ns
Fall Time (V_{CC} = 6.0 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 2)	t_f	–	20	30	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

FIGURE 1 – TURN-ON TIME

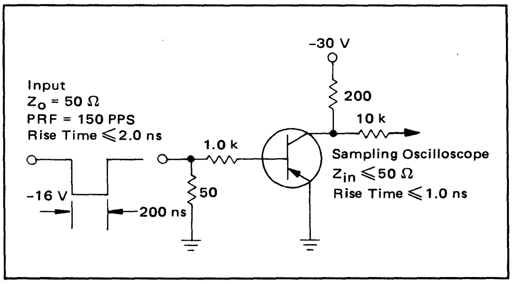
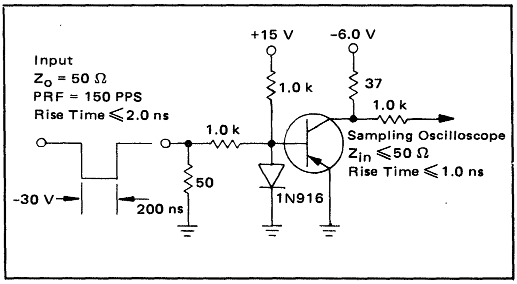
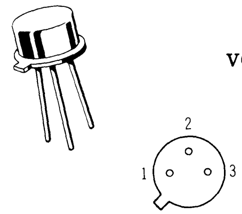


FIGURE 2 – TURN-OFF TIME



2N3712S (SILICON)



NPN silicon annular transistor designed for high-voltage DC to VHF amplifier applications.

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)
Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Collector-Base Voltage	V_{CB}	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

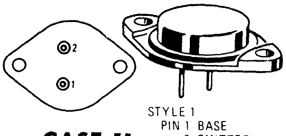
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	150	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)	I_{CBO}	-	0.1	μAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)		-	50	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	-	-
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	150	
Collector-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{CE(sat)}$	-	2.0	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	40	240	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	1.0	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	-	80	pF
Small-Signal Current Gain (I_C = 30 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	25	-	-
Collector-Base Time Constant (I_E = 30 mAdc, V_{CB} = 10 Vdc, f = 31.9 MHz)	$r_b'C_c$	-	100	ps

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.

* Indicates JEDEC Registered Data

2N3713 thru 2N3716 (SILICON)



CASE 11

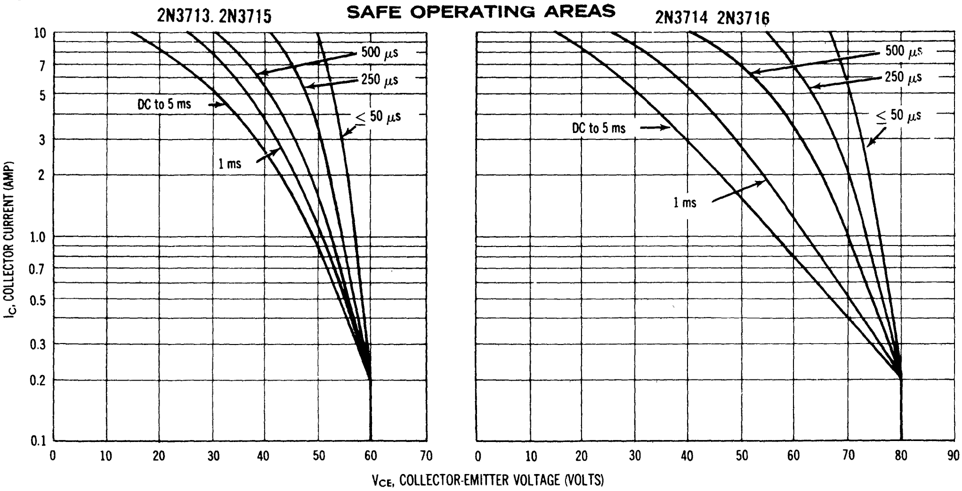
Collector connected to case

NPN silicon power transistors for medium-speed switching and amplifier applications. Complement to PNP types 2N3789 thru 2N3792.

MAXIMUM RATINGS

Rating	Symbol	2N3713 2N3715	2N3714 2N3716	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7.0	7.0	Volts
Collector Current	I_C	10	10	Amp
Base Current	I_B	4.0	4.0	Amp
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	θ_{JC}	1.17	1.17	°C/W
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		°C

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

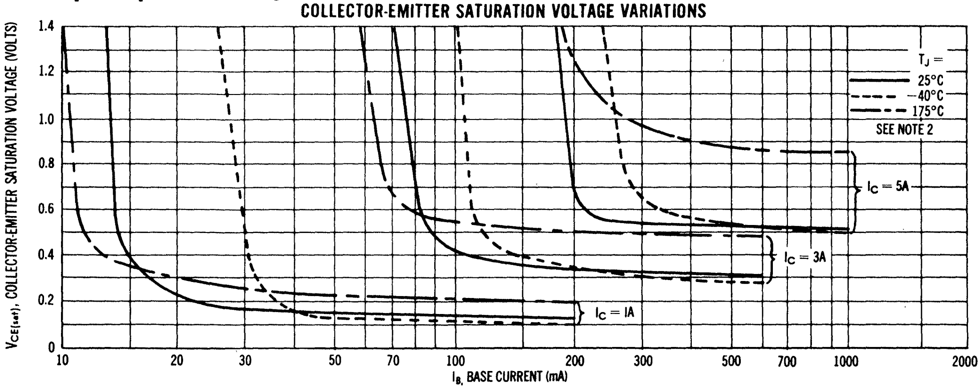
2N3713 thru 2N3716 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

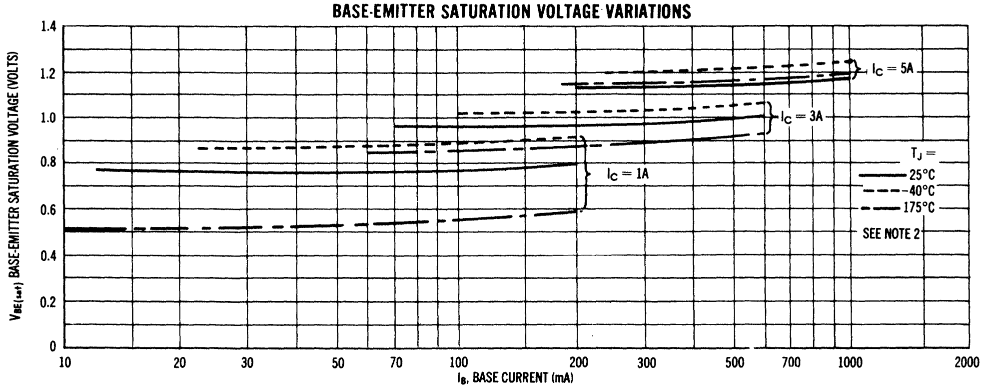
Characteristic	Types	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)		I_{EBO}	—	5.0	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3713, 2N3715		—	1.0	
(V_{CE} = 100 Vdc, V_{BE} = -1.5 Vdc)	2N3714, 2N3716		—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3713, 2N3715		—	10	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3714, 2N3716		—	10	
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	2N3713, 2N3715	$V_{CEO(sus)}$*	60	—	Vdc
	2N3714, 2N3716		80	—	
DC Current Gain*		h_{FE}*			—
(I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		25	90	
	2N3715, 2N3716		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		15	—	
	2N3715, 2N3716		30	—	
Collector-Emitter Saturation Voltage* (I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714	$V_{CE(sat)}$*	—	1.0	Vdc
	2N3715, 2N3716		—	0.8	
Base-Emitter Saturation Voltage* (I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714	$V_{BE(sat)}$*	—	2.0	Vdc
	2N3715, 2N3716		—	1.5	
Base-Emitter Voltage* (I_C = 3 Adc, V_{CE} = 2 Vdc)		V_{BE}*	—	1.5	Vdc
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 MHz)		h_{fe}	4.0	—	—
Switching Times (I_C = 5A, I_{B1} = I_{B2} = 0.5 A)			Typ		μs
Rise Time		t_r	0.45		
Storage Time		t_s	0.3		
Fall Time		t_f	0.4		

*Use sweep test to prevent overheating

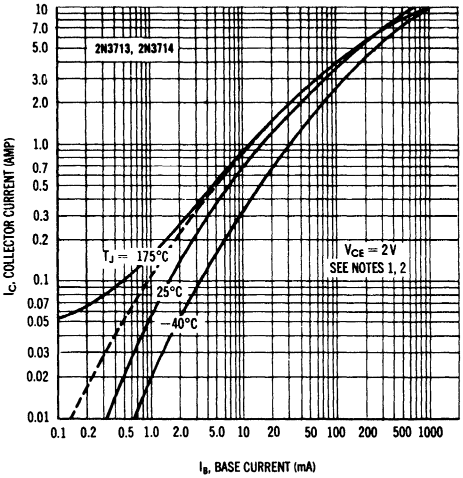
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

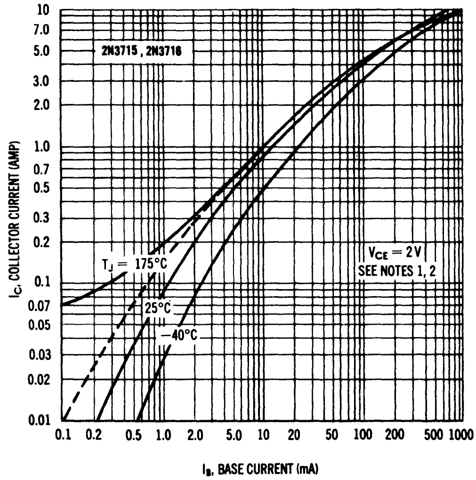


BASE-EMITTER SATURATION VOLTAGE VARIATIONS

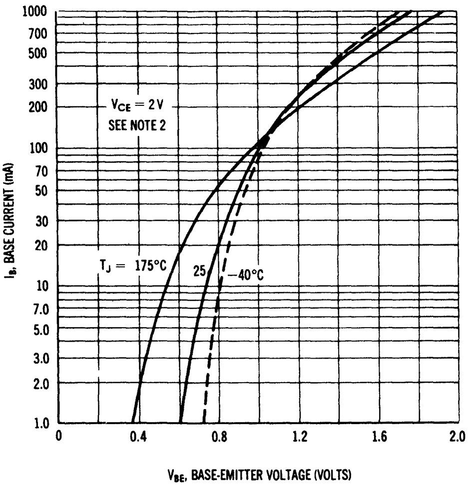


COLLECTOR CURRENT versus BASE CURRENT

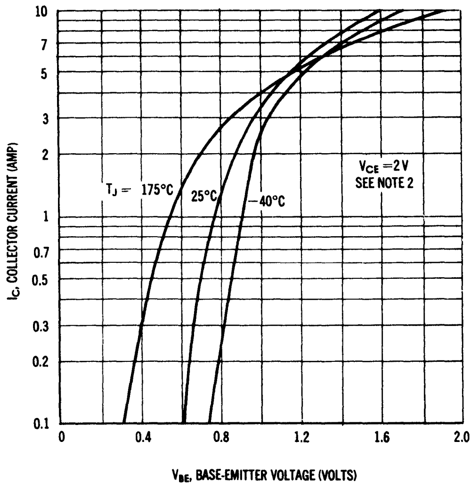




BASE CURRENT-VOLTAGE VARIATIONS

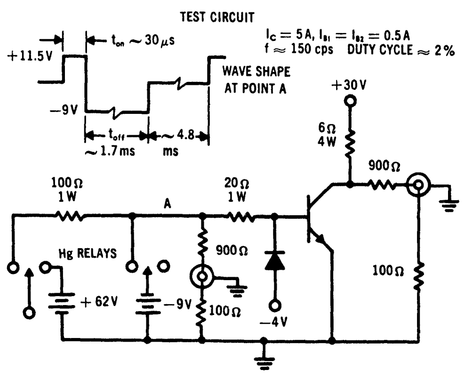


COLLECTOR CURRENT-VOLTAGE VARIATIONS

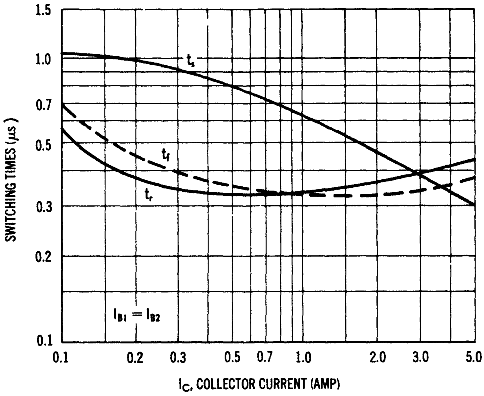


NOTE 1. Dotted line indicates metered base current plus the I_{CBO} of the transistor at 175°C.

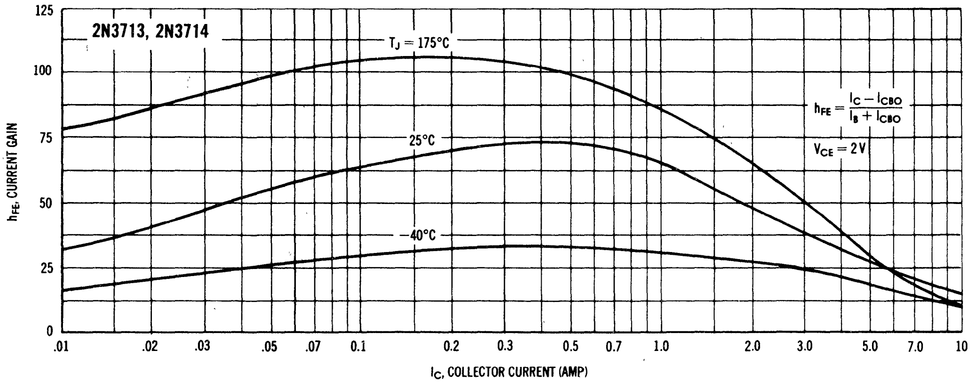
NOTE 2. Pulse test: pulse width ≈ 200 μs, duty cycle ≈ 1.5%

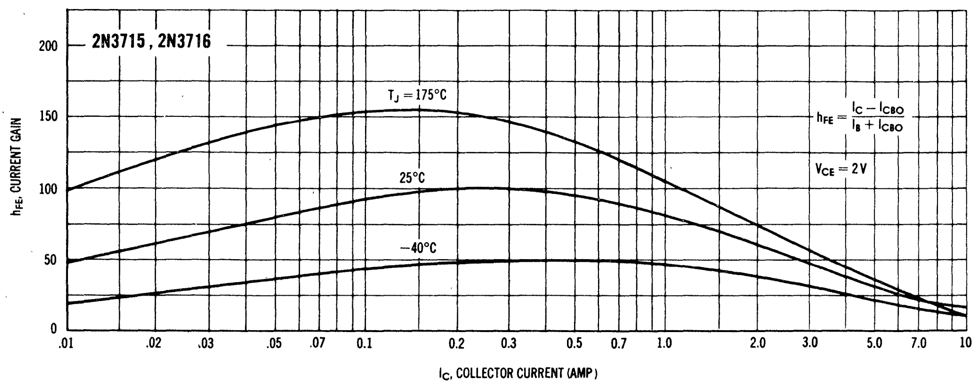


TYPICAL SWITCHING TIMES

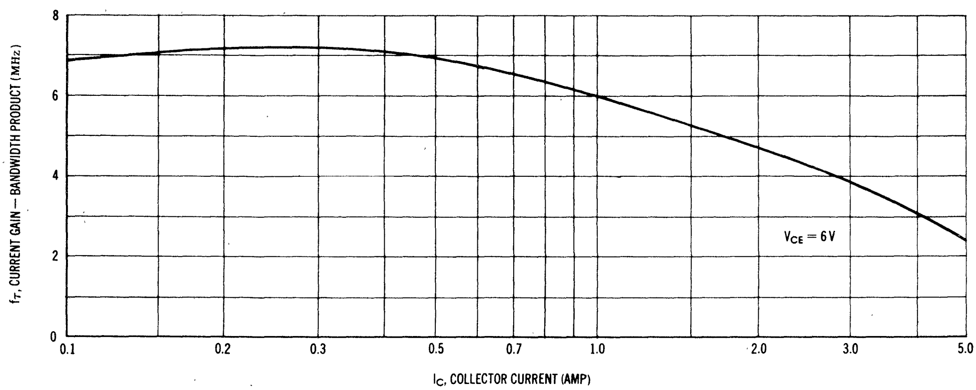


CURRENT GAIN VARIATIONS





CURRENT-GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N3719, 2N3720 (SILICON)
2N3867, 2N3868
2N6303

SILICON PNP POWER TRANSISTORS

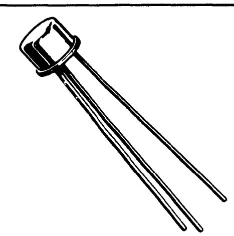
. . . designed for high-speed, medium-current switching and high-frequency amplifier applications.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 40 Vdc (Min) – 2N3719,2N3867
  = 60 Vdc (Min) – 2N3720,2N3868
  = 80 Vdc (Min) – 2N6303
- DC Current Gain –
  h_{FE} = 25-180 @ I_C = 1.0 Adc – 2N3719,2N3720
  = 40-200 @ I_C = 1.5 Adc – 2N3867
  = 30-150 @ I_C = 1.5 Adc – 2N3868,2N6303
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.75 Vdc @ I_C = 1.0 Adc – 2N3719,2N3720
  = 0.75 Vdc @ I_C = 1.5 Adc – 2N3867,2N3868, 2N6303
- High Current-Gain – Bandwidth Product –
  f_T = 90 MHz (Typ)
- 2N3867 JAN and 2N3868 JAN also Available

3 AMPERE

POWER TRANSISTORS
PNP SILICON

40,60,80 VOLTS
6 WATTS



*MAXIMUM RATINGS

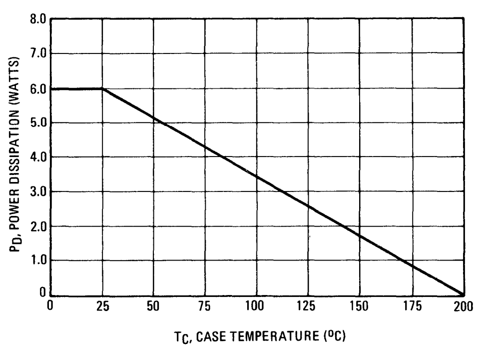
Rating	Symbol	2N3719 2N3867	2N3720 2N3868	2N6303	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →			Vdc
Collector Current – Continuous Peak	I_C	← 3.0 → ← 10 →			Adc
Base Current	I_B	← 0.5 →			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 6.0 → ← 34.3 →			Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	← 1.0 → ← 5.71 →			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

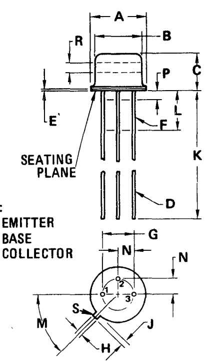
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.734	1.14	0.029	0.045
K	38.10	–	1.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
R	2.54	–	0.100	–
S	–	0.179	–	0.007

All JEDEC dimensions and notes apply.

CASE 31-03
TO-5

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1)	$V_{CEO(sus)}$			Vdc
(I_C = 20 mAdc, I_B = 0) 2N3867		40	–	
2N3868		60	–	
2N6303		80	–	
Collector-Base Breakdown Voltage	BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0) 2N3867		40	–	
2N3868		60	–	
2N6303		80	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CB}, $V_{BE(off)}$ = 2.0 Vdc)	I_{CEX}	–	1.0	μAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)	I_{CBO}	–	150	μAdc
ON CHARACTERISTICS (1)				
DC Current Gain	h_{FE}			–
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc) 2N3867		50	–	
2N3868, 2N6303		35	–	
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc) 2N3867		40	200	
2N3868, 2N6303		30	150	
(I_C = 2.5 Adc, V_{CE} = 3.0 Vdc) 2N3867		25	–	
2N3868, 2N6303		20	–	
(I_C = 3.0 Adc, V_{CE} = 5.0 Vdc) 2N3867		20	–	
2N3868, 2N6303				
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		–	0.5	
(I_C = 1.5 Adc, I_B = 150 mAdc)		–	0.75	
(I_C = 2.5 Adc, I_B = 250 mAdc)		–	1.3	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)		–	1.0	
(I_C = 1.5 Adc, I_B = 150 mAdc)		0.9	1.4	
(I_C = 2.5 Adc, I_B = 250 mAdc)		–	2.0	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (2) (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f_{test} = 20 MHz)	f_T	60	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	C_{ob}	–	120	pF
Input Capacitance (V_{EB} = 3.0 Vdc, I_C = 0, f = 0.1 MHz)	C_{ib}	–	1000	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0, I_C = 1.5 Adc, I_{B1} = 150 mAdc)	t_d	–	35	ns
Rise Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0, I_C = 1.5 Adc, I_{B1} = 150 mAdc)	t_r	–	65	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc)	t_s	–	325	ns
Fall Time (V_{CC} = 30 Vdc, I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc)	t_f	–	75	ns

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$.

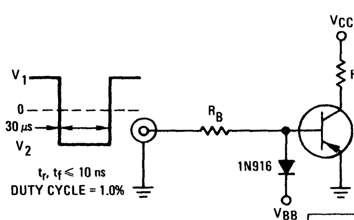
***ELECTRICAL CHARACTERISTICS** ($T_C = 25^oC$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 20 mAdc, I_B = 0)	2N3719		40	–	
	2N3720		60	–	
Collector Cutoff Current		I_{CEX}			
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	2N3719		–	10	μAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc)	2N3720		–	10	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = 150°C)	2N3719		–	1.0	mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = 150°C)	2N3720		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N3719		–	10	
(V_{CB} = 60 Vdc, I_E = 0)	2N3720		–	10	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 4.0 Vdc, I_C = 0)			–	1.0	
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			–
(I_C = 500 mAdc, V_{CE} = 1.5 Vdc)			20	–	
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)			25	180	
(I_C = 1.0 Adc, V_{CE} = 1.5 Vdc, T_C = −40°C)			15	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc, T_C = −40°C to +100°C)			–	0.75	
(I_C = 3.0 Adc, I_B = 300 mAdc, T_C = −40°C to +100°C)			–	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc, T_C = −40°C to +100°C)			–	1.5	
(I_C = 3.0 Adc, I_B = 300 mAdc, T_C = −40°C to +100°C)			–	2.3	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (2)		f_T			MHz
(I_C = 500 mAdc, V_{CE} = 10 Vdc, f_{test} = 30 MHz)			60	–	
Output Capacitance		C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)			–	120	
Input Capacitance		C_{ib}			pF
(V_{EB} = 0.5 Vdc, I_C = 0, f = 0.1 MHz)			–	1000	
SWITCHING CHARACTERISTICS					
Turn-On Time		t_{on}			ns
(V_{CC} = 12 Vdc, $V_{BE(off)}$ = 0, I_C = 1.0 Adc, I_{B1} = 0.1 Adc)			–	100	
Turn-Off Time		t_{off}			ns
(V_{CC} = 12 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)			–	400	

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle = 2.0%. (2) $f_T = |h_{fe}| \bullet f_{test}$.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



	2N3719 2N3720	2N3867 2N3868 2N6303
V_{CC}	-12 V	-30 V
R_C	12 Ω	19 Ω
R_B	100 Ω	100 Ω
V_1	+8.0 V	13.6 V
V_2	-11 V	-16.4 V
V_{BB}	≈ 3.0 V	≈ 3.0 V

NOTE:
For information on Figures 3 and 6, R_B and R_C were varied to obtain desired test conditions.
For t_d and t_r specifications, remove diode and set V_I = 0.

FIGURE 3 – TURN-ON TIME

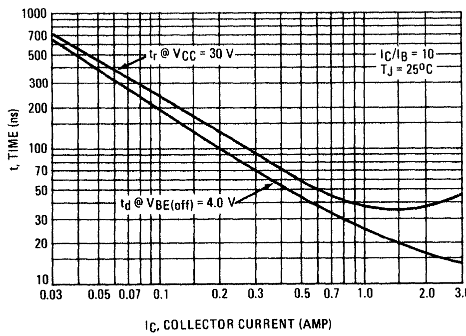


FIGURE 4 – THERMAL RESISTANCE

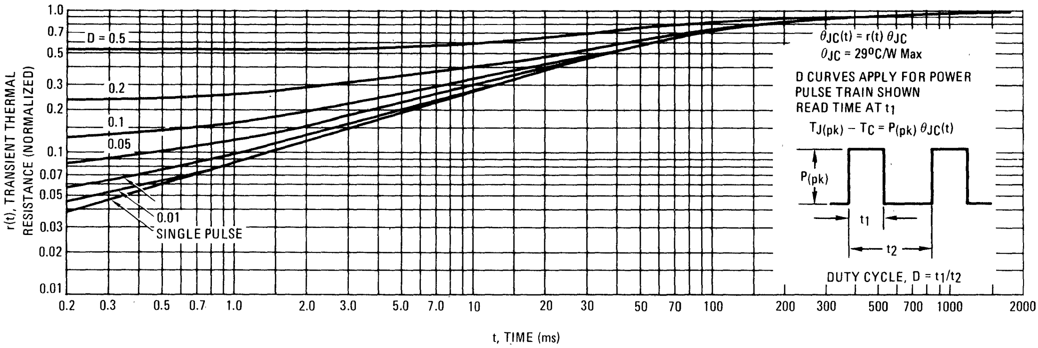
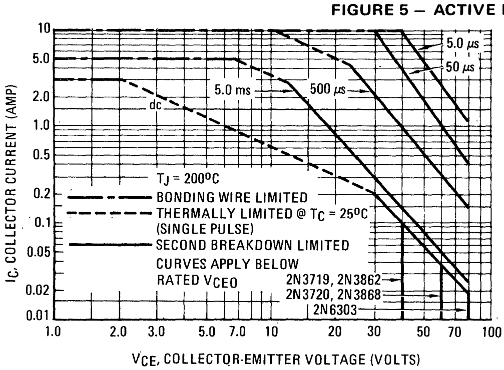


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415).

FIGURE 6 – TURN-OFF TIME

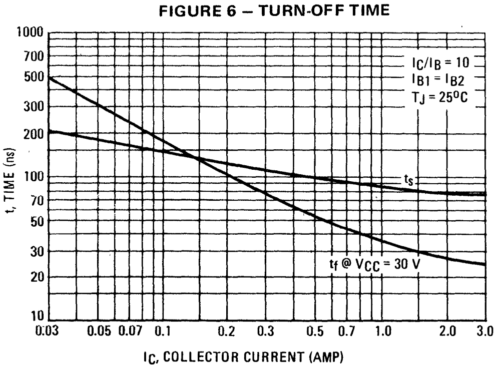


FIGURE 7 – CAPACITANCE

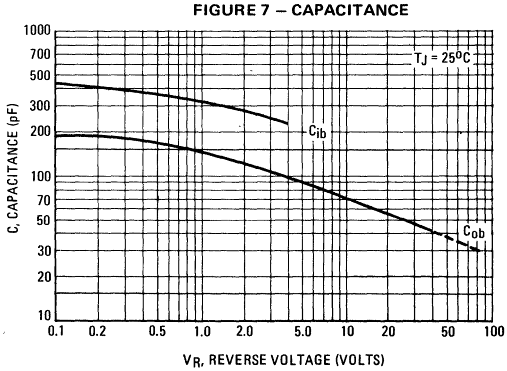


FIGURE 8 – DC CURRENT GAIN

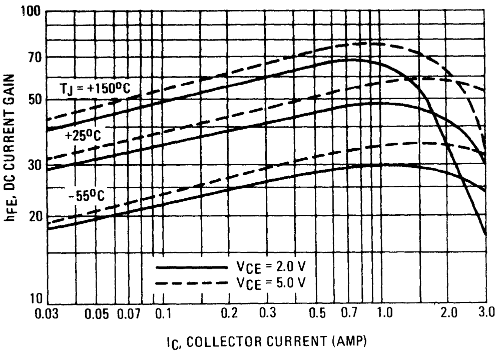


FIGURE 9 – COLLECTOR SATURATION REGION

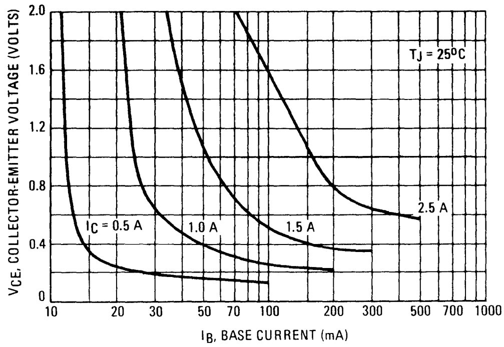


FIGURE 10 – "ON" VOLTAGES

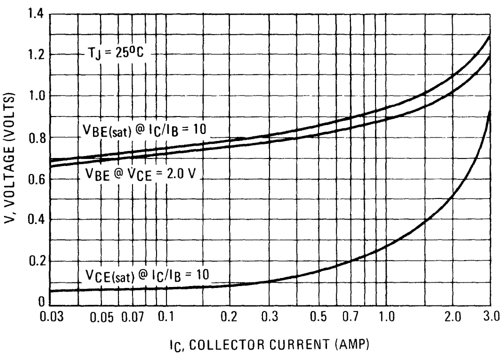


FIGURE 11 – TEMPERATURE COEFFICIENTS

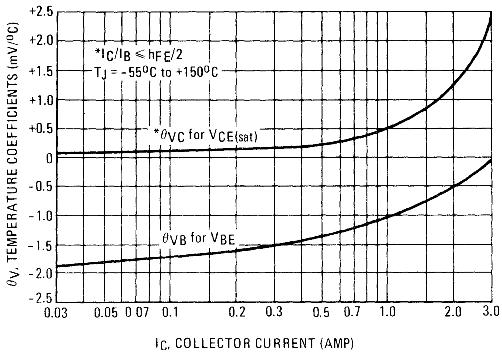


FIGURE 12 – COLLECTOR CUT-OFF REGION

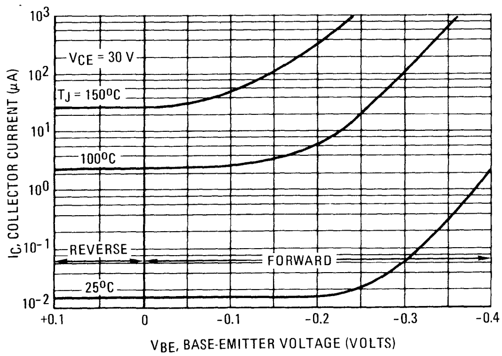
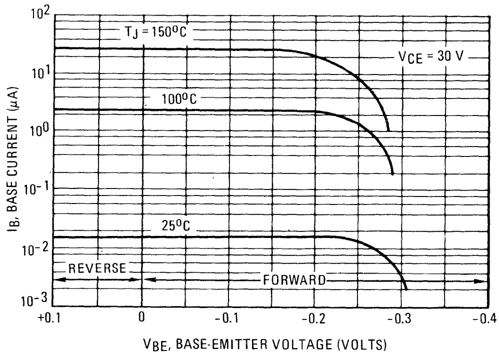


FIGURE 13 – BASE CUT-OFF REGION



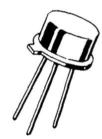
2N3724 (SILICON)
2N3725

NPN SILICON ANNULAR MEMORY DRIVER

. . . designed for medium-current, high-speed switching applications. Ideally suited for ferrite core memory driver circuits.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc – 2N3725
  = 30 Vdc (Min) @ I_C = 10 mAdc – 2N3724
- Guaranteed Fast Switching Times @ I_C = 500 mAdc
  t_{on} = 20 ns (Typ) t_{off} = 50 ns (Typ)
  = 35 ns (Max) = 60 ns (Max)
- Guaranteed High DC Current Gain —
  h_{FE} = 35 (Min) @ I_C = 500 mAdc
- Design Curves and Applications Information Provided

NPN SILICON MEMORY DRIVER TRANSISTOR

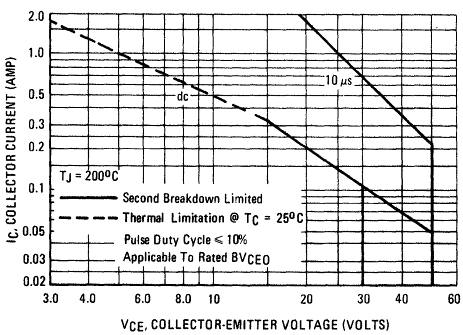


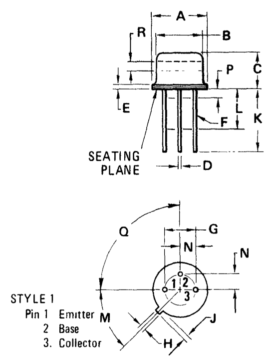
*MAXIMUM RATINGS

Rating	Symbol	2N3724	2N3725	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	50	80	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current — Continuous	I_C	2.0		Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71		Watts mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	2N3725		50	–	–	
	2N3724		30	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 10 μAdc, V_{BE} = 0)	2N3725		80	–	–	
	2N3724		50	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	2N3725		80	–	–	
	2N3724		50	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current		I_{CES}				μAdc
(V_{CE} = 80 Vdc, V_{EB} = 0)	2N3725		–	0.15	10	
(V_{CE} = 50 Vdc, V_{EB} = 0)	2N3724		–	0.15	10	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N3725		–	0.12	1.7	
(V_{CB} = 40 Vdc, I_E = 0)	2N3724		–	0.12	1.7	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N3725		–	–	120	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N3724		–	–	120	
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			30	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	–	150	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			30	–	–	
(I_C = 300 mAdc, V_{CE} = 1.0 Vdc)			40	–	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	–	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			20	–	–	
(I_C = 800 mAdc, V_{CE} = 2.0 Vdc)			25	–	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)			30	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc	2N3725		–	0.17	0.25	
	2N3724		–	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3725		–	0.19	0.26	
	2N3724		–	0.19	0.20	
(I_C = 300 mAdc, I_B = 30 mAdc	2N3725		–	0.25	0.40	
	2N3724		–	0.25	0.32	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3725		–	0.30	0.52	
	2N3724		–	0.30	0.42	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N3725		–	0.43	0.80	
	2N3724		–	0.43	0.65	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3725		–	0.55	0.95	
	2N3724		–	0.55	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	–	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)			–	–	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	–	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)			–	–	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	–	1.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain – Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	–	–	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N3725		–	–	10	
	2N3724		–	–	12	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	–	55	pF

*Indicates JEDEC Registered Data
(1) Pulse test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$

Characteristic		Symbol	Min	Typ	Max	Unit
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	–	5.0	10	ns
Rise Time		t_r	–	15	30	ns
Turn-On Time		t_{on}	–	20	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_s	–	35	50	ns
Fall Time		t_f	–	20	25	ns
Turn-Off Time		t_{off}	–	50	60	ns

*Indicates JEDEC Registered Data.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

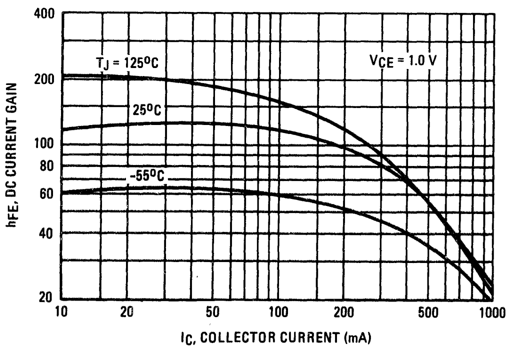


FIGURE 3 – "ON" VOLTAGES

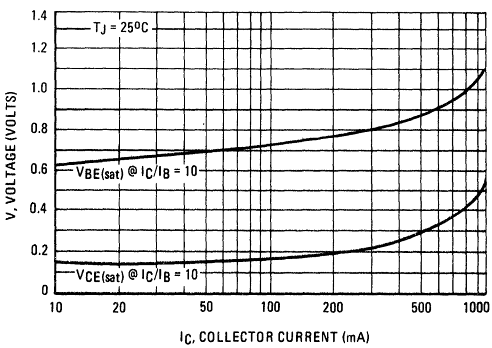


FIGURE 4 – COLLECTOR SATURATION REGION

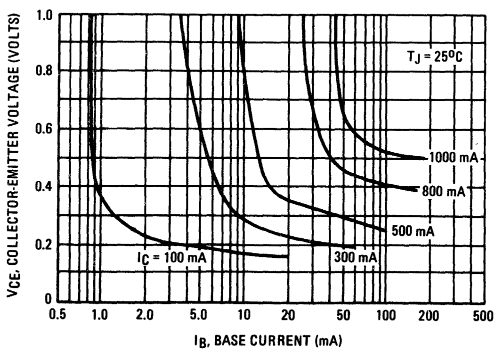
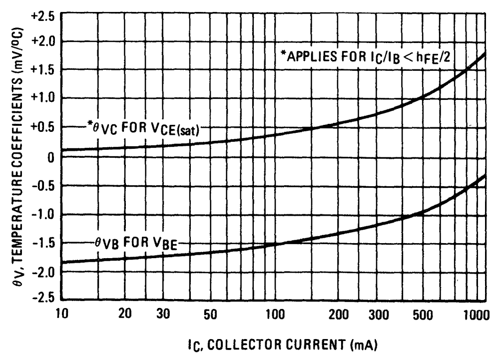


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

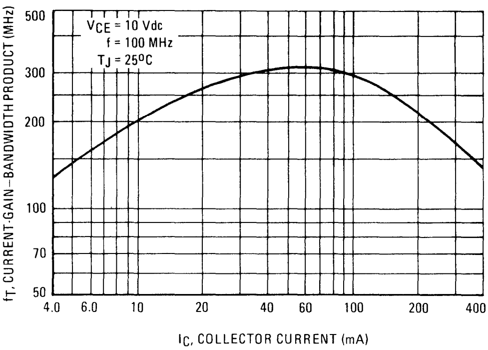


FIGURE 7 – CAPACITANCE

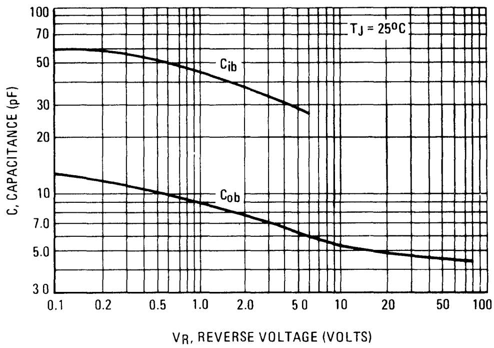


FIGURE 8 – TURN-ON TIME

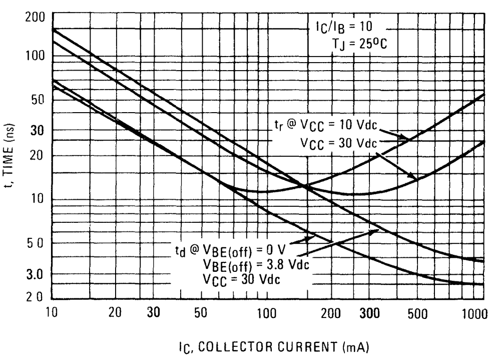


FIGURE 9 – TURN-OFF TIME

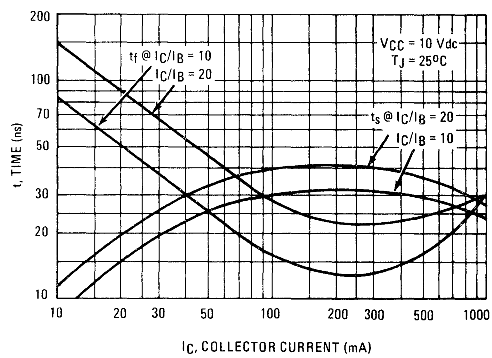
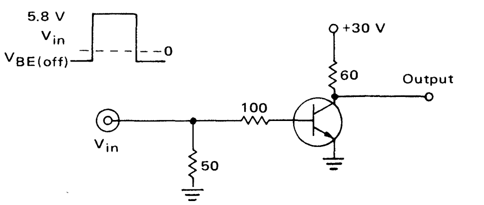


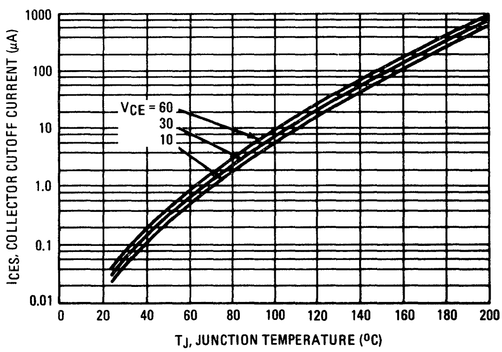
FIGURE 10 – SWITCHING TIME TEST CIRCUIT



Turn-On $V_{BE(off)}$ = 3.8 V
Turn-Off $V_{BE(off)}$ = −4.0 V

$t_r \leq$ 1.0 ns
PW $\geq$ 200 ns
Duty Cycle $\leq$ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope Tektronix 661 Sampling Scope

FIGURE 11 – COLLECTOR CUTOFF CURRENT



APPLICATIONS INFORMATION

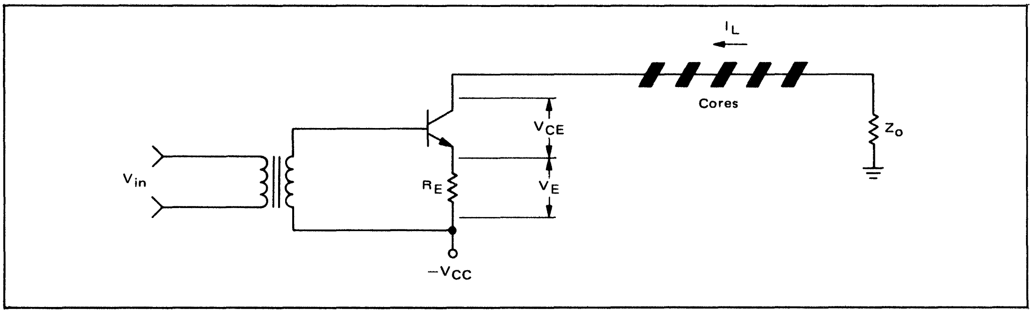
Core Memory Systems are getting larger, and their cycle times are continually being reduced. These trends place an ever increasing burden on core drivers due to the increased current, additional line inductance, and faster switching requirements. Switching highly inductive lines can cause voltage breakdown problems due to the inductive "kickback" voltages. Unfortunately, both high voltage and fast switching transistors cannot be achieved simultaneously, however, the 2N3725 offers the optimum tradeoff between high voltage breakdown and fast switching.

Both voltage and current type drivers are used in core memory systems. The type of driver to be used is dependent on many factors, some of which are:

(1) The characteristic impedance of the line and its variations
(2) Maximum allowable driver power dissipation
(3) Driver current tolerances

For example, a current driver would most likely be chosen if the drive current had tight tolerances and the line impedance varied greatly. With a voltage driver, the load impedance and the inductance of the line determine the amplitude and waveshape of the current pulse.

FIGURE 12 – Typical Core Driver Circuit

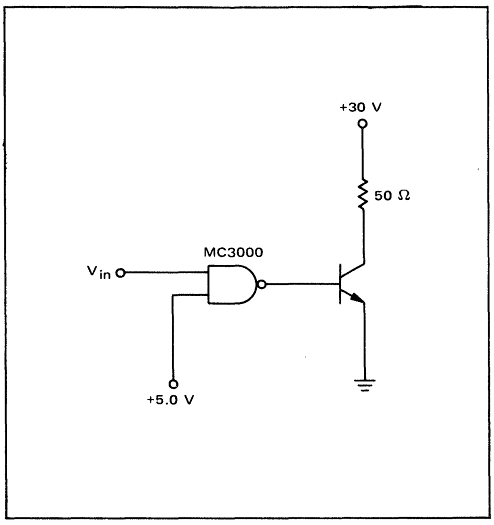


Considering the typical core driver circuit of Figure 12, note that the choice of input signal level determines whether the transistor will saturate or not. If the transistor in Figure 12 does not saturate, the circuit is a current switch and the load current (I_L) is given by: $I_L \approx \alpha \frac{V_E}{R_E}$, where α is the common base current gain. To insure that the transistor does not saturate during turn-on, the voltage generated in the line inductance due to the change in current (V = L di/dt) must be considered. The supply voltage required in this case becomes $V_{CC} > L\ di/dt + V_{CE(min)} + I_L(R_E + Z_o)$.

When used as a voltage switch, the transistor saturates and the load current becomes: $I_L \approx \frac{V_{CC} - V_{CE(sat)}}{R_E + Z_o}$.

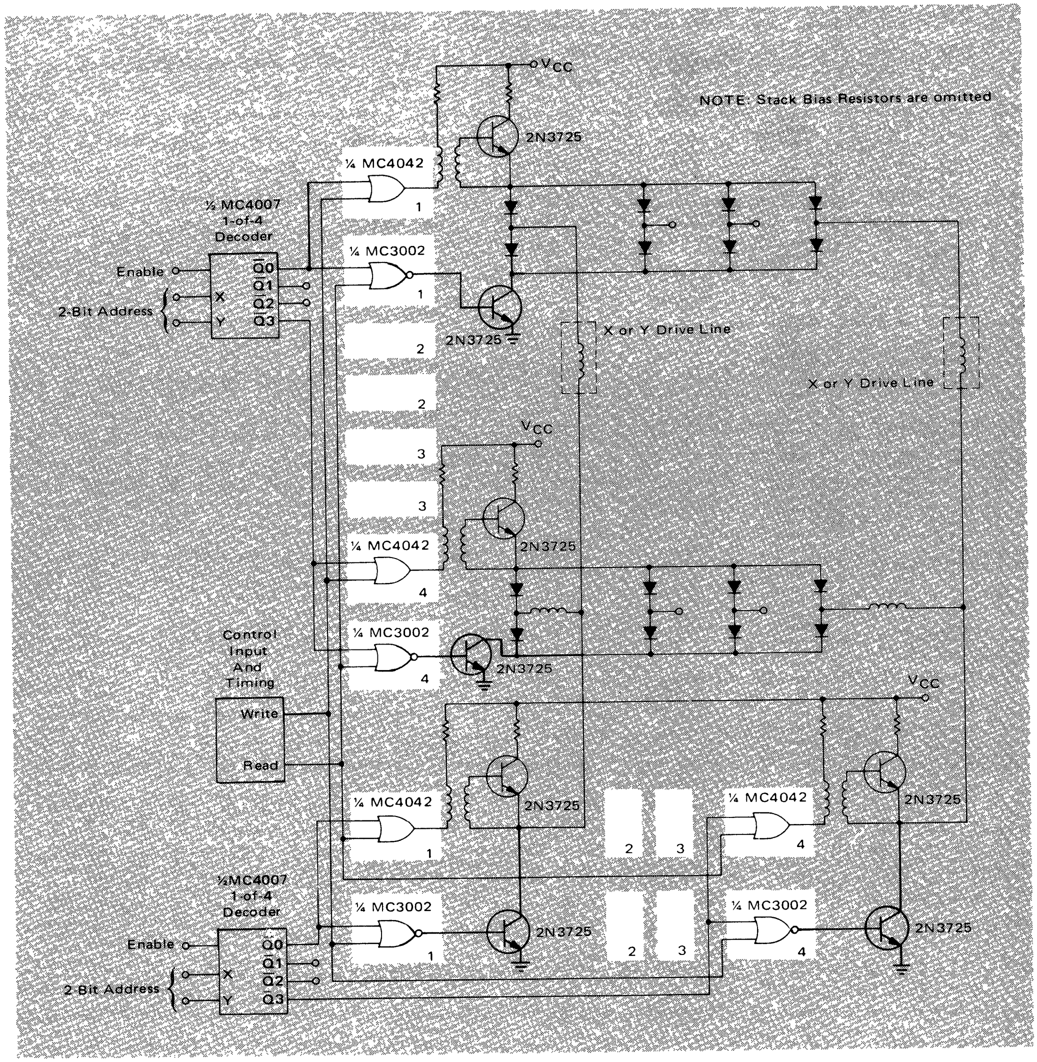
Most core memory driver current requirements are under 500 mA. The 2N3725 has a minimum h_{FE} of 35 at this current level which is sufficient to permit direct coupling to a standard TTL logic in some switching arrangements, thereby eliminating the need for a predriver stage. For example, the output voltage and current levels of an MC3000 are sufficient to cause the 2N3725 to easily switch 600 mA load current (see Figure 13).

FIGURE 13 – 500 mA TTL Compatible Switch



To indicate how both voltage and current switches can be used in a circuit to reduce the electronics needed to drive core memories, a diode-matrix system such as illustrated in Figure 14 can be employed. Note that current is sent through a given line by selecting one floating current switch and the appropriate voltage switch. The diodes steer the current through the proper line. There is one voltage and current switch pair at each end of the line causing current to be passed in either direction. In this system, the predriver transformer is required in some circuits in order to provide proper dc levels.

FIGURE 14 – X or Y Drive Selection Matrix



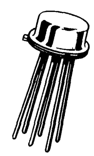
2N3726 (SILICON)
2N3727

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N3726
  $\Delta|V_{BE1} - V_{BE2}|$ = 1.6 mVdc (Max) @ -55 to +25°C
  = 2.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 50 mAdc
- DC Current Gain Specified — 0.01 mAdc to 50 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 200 MHz @ I_C = 50 mAdc

PNP SILICON MULTIPLE TRANSISTORS

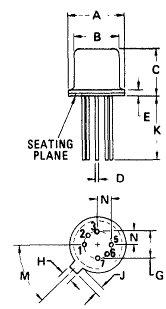


*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	45		Vdc
Collector-Base Voltage	V_{CB}	45		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	300		mAdc
Base Current	I_B	100		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.29	500 2.86	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4 70	0.150	0.185
D	0.41	0.53	0 016	0.021
G	5.08 BSC		0 200 BSC	
H	0.71	0 86	0.028	0 034
J	0 74	1.14	0.029	0.045
K	12.70	--	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07

***ELECTRICAL CHARACTERISTICS (each side)** (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	45	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	45	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 30 Vdc, I_E = 0)		–	10	nAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)		–	10	μAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc)		80	–	
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)		120	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		135	350	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (1)		115	–	
Collector-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	–	0.25	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product (2)	f_T			MHz
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		60	–	
(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		200	600	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	30	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	11.5	k ohm
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	1500	X 10^{-6}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	135	420	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	80	μmhos
Noise Figure (I_C = 30 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, B.W. = 200 Hz)	NF	–	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (3) (I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.9	1.0	–
Base-Emitter Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc) 2N3726		–	5.0	
2N3727		–	2.5	
Base-Emitter Differential Change Due to Temperature	$\Delta(V_{BE1}-V_{BE2})$			mVdc
(I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, 2N3726		–	1.6	
T_A = −55°C to +25°C) 2N3727		–	0.8	
(I_C = 0.1 mAdc to 1.0 mAdc, V_{CE} = 5.0 Vdc, 2N3726		–	2.0	
T_A = +25°C to +125°C) 2N3727		–	1.0	

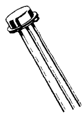
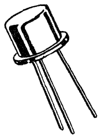
*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Length = 300 μs, Duty Cycle = 1.0%.

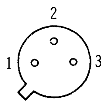
(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

(3) For purposes of this ratio, the lowest h_{FE} reading is taken as h_{FE1}.

2N3734S (SILICON)
2N3735S
2N3736
2N3737

Medium current NPN silicon annular transistors designed for high-speed switching and driver applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 26 (TO-46)
2N3736
2N3737

CASE 79 (TO-39)
2N3734
2N3735

Collector connected to case

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Base Voltage	V_{CB}	50	75	Vdc
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.5		Adc
		TO-39 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Thermal Resistance Junction to Ambient Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	°C/mW
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

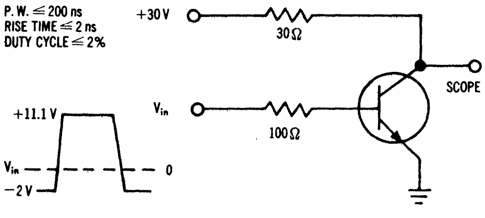
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3734, 2N3736	BV_{CBO}	50	—	Vdc
	2N3735, 2N3737		75	—	
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3734, 2N3736	BV_{CEO}	30	—	Vdc
	2N3735, 2N3737		50	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736	I_{CEX}	—	0.20	μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
Base Cutoff Current (V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736	I_{BL}	—	0.3	μAdc
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.3	
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1 Vdc)		h_{FE}	35	—	—
(I_C = 150 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	2N3734, 2N3736		30	120	
	2N3735, 2N3737		20	80	
(I_C = 1.5 Adc, V_{CE} = 5 Vdc)	2N3734, 2N3736		30	—	
	2N3735, 2N3737		20	—	
Collector Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.2	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	0.8	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			0.9	1.4	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	9.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
High-Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		h_{fe}	2.5	—	—
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8.0	ns
Rise Time		t_r	—	40	ns
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	30	ns
Fall Time		t_f	—	30	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	10	nC

(1)Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2%

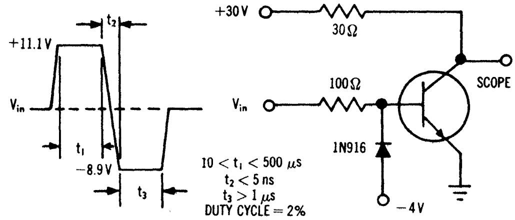
* Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-ON TIME



TURN-OFF TIME



2N3738, 2N3739 NPN (SILICON)
2N6424, 2N6425 PNP

HIGH VOLTAGE COMPLEMENTARY SILICON POWER TRANSISTORS

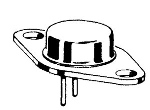
. . . designed for high-speed switching, linear amplifier applications, high-voltage operational amplifiers, switching regulators, converters, inverters, deflection stages and high fidelity amplifiers.

- Collector-Emitter Sustaining Voltage –
  $V_{CEO(sus)}$ = 225 Vdc @ I_C = 5.0 mAdc (2N3738, 2N6424)
  = 300 Vdc @ I_C = 5.0 mAdc (2N3739, 2N6425)
- DC Current Gain –
  h_{FE} = 40-200 @ I_C = 100 mAdc
- Current-Gain – Bandwidth Product –
  f_T = 10 MHz (Min) @ I_C = 100 mAdc
- $I_{S/b}$ Rated to 2.0 Amperes

2.0 AMPERE

POWER TRANSISTORS COMPLEMENTARY SILICON

225, 300 VOLTS
20 WATTS



*MAXIMUM RATINGS

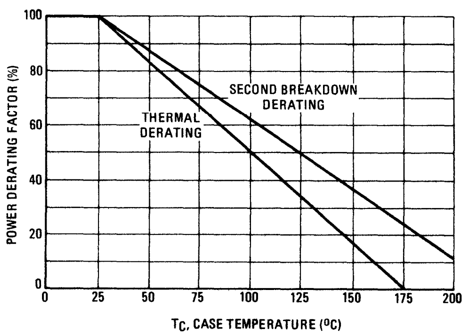
Rating	Symbol	2N3738 2N6424	2N3739 2N6425	Unit
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous – Peak	I_C	1.0 2.0		Adc
Base Current – Continuous – Peak	I_B	0.50 1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.133		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

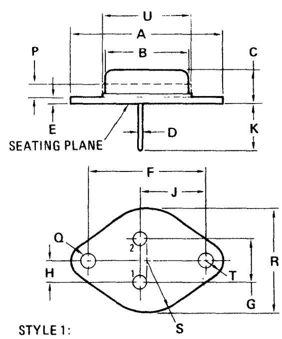
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	7.5	°C/W

*Indicates JEDEC Registered Data

FIGURE 1 – POWER DERATING





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

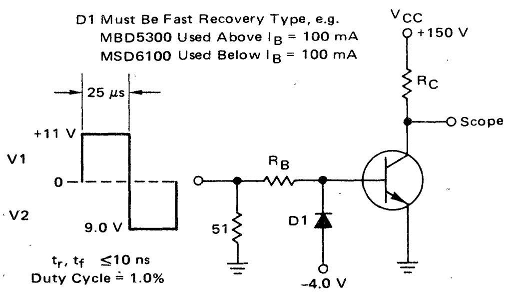
CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 5.0 mAdc, I_B = 0)	2N3738, 2N6424		225	–	
	2N3739, 2N6425		300	–	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 125 Vdc, I_B = 0)	2N3738, 2N6424		–	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	2N3739, 2N6425		–	0.25	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 250 Vdc, I_E = 0)	2N3738, 2N6424		–	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	2N3739, 2N6425		–	0.1	
Collector Cutoff Current		I_{CEV}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3738, 2N6424		–	0.5	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N3739, 2N6425		–	0.5	
(V_{CE} = 125 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N3738, 2N6424		–	1.0	
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N3739, 2N6425		–	1.0	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 6.0 Vdc)			–	0.1	
***ON CHARACTERISTICS**					
DC Current Gain (1)		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			40	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			25	–	
Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 250 mAdc, I_B = 25 mAdc)			–	2.5	
Base-Emitter "ON" Voltage (1)		$V_{BE(on)}$			Vdc
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			–	1.0	
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (2)		f_T			MHz
(I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)			10	–	
*Output Capacitance		C_{ob}			pF
(V_{CB} = 100 Vdc, I_E = 0, f = 100 kHz)			–	20	
*Small-Signal Current Gain		h_{fe}			–
(I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 1.0 kHz)			35	–	

*Indicates JEDEC Registered Data
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2%.
(2) $f_T = |h_{fe}| \bullet$ frequency

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



R_B and R_C Varied to Obtain Desired Current Levels

For t_d and t_r, D1 is disconnected and V2 = 0
For PNP test circuit, reverse diode and voltage polarities.

NPN 2N3738, 2N3739	PNP 2N6424, 2N6425

FIGURE 3 — TURN-ON TIME

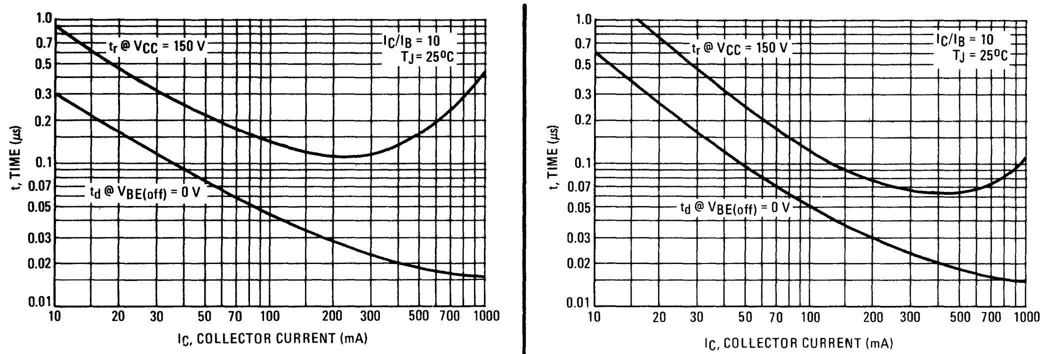


FIGURE 4 — TURN-OFF TIME

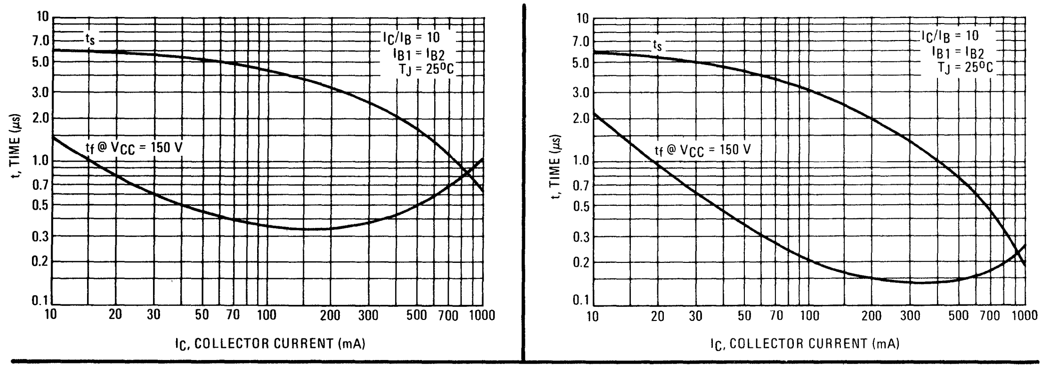


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

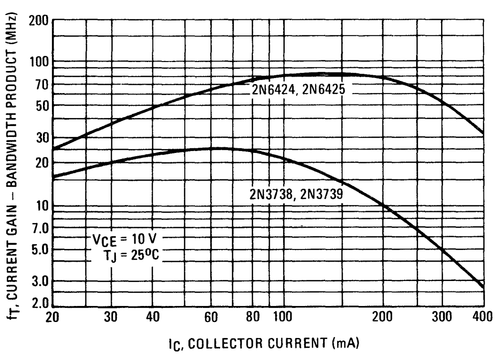


FIGURE 6 — CAPACITANCE

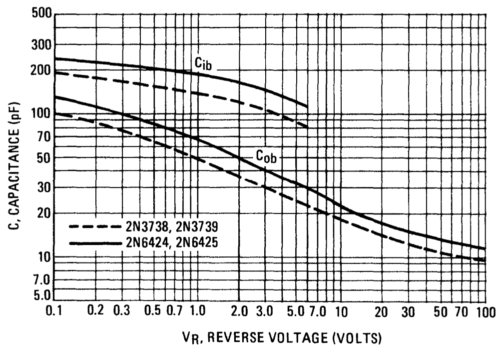
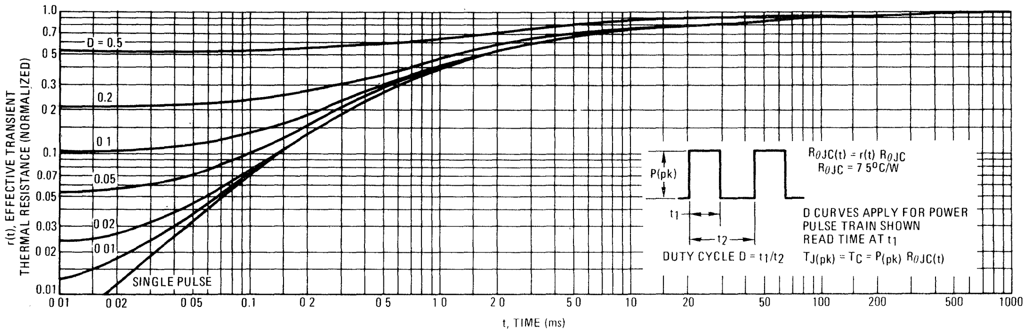


FIGURE 7 — THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 8 — 2N3738, 2N3739

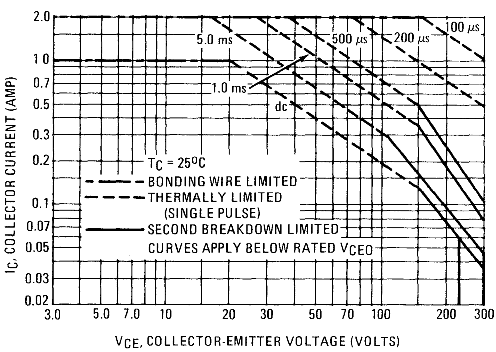
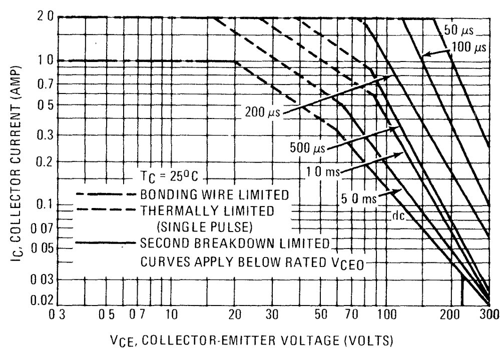


FIGURE 9 — 2N6424, 2N6425



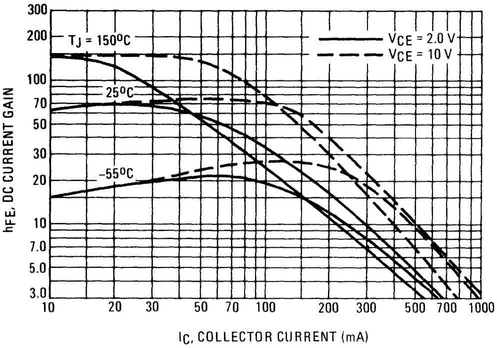
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 8 and 9 is based on $T_C = 25^oC$; $T_{J(pk)}$ is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 175^oC$. $T_{J(pk)}$ may be calculated from the data in Figure 7. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figures 8 and 9 may be found at any case temperature by using the appropriate curve on Figure 1.

NPN
2N3738, 2N3739

PNP
2N6424, 2N6425

FIGURE 10 — DC CURRENT GAIN



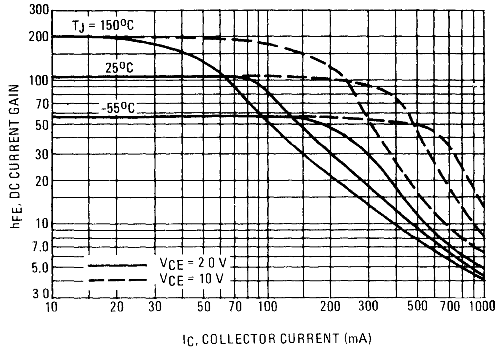
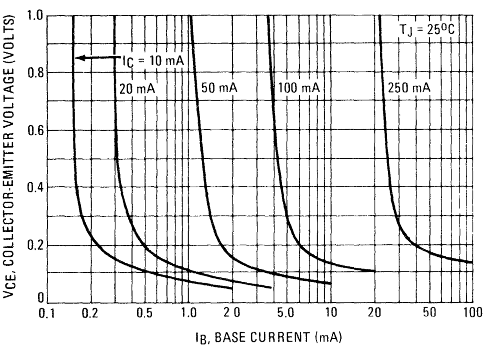


FIGURE 11 — COLLECTOR SATURATION REGION



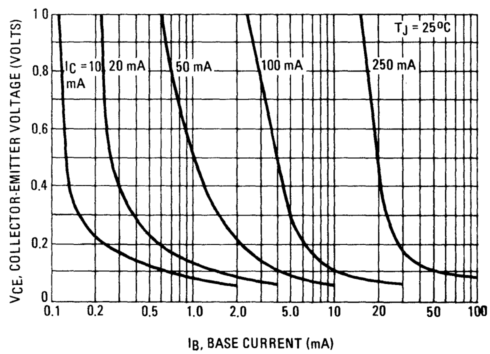
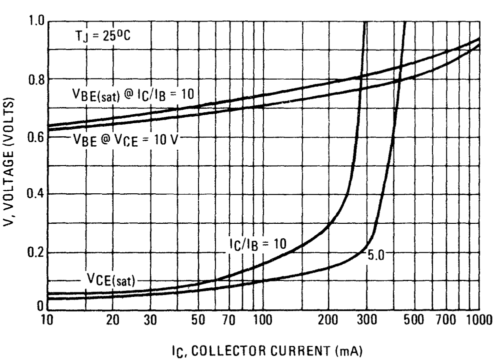
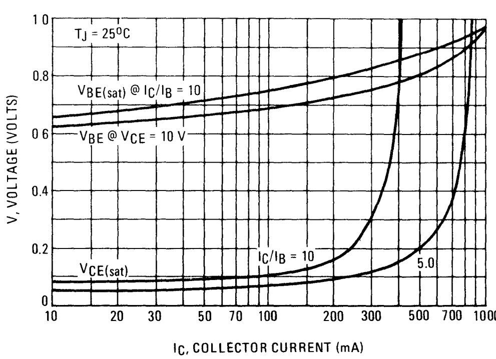


FIGURE 12 — "ON" VOLTAGE





NPN
2N3738, 2N3739

PNP
2N6424, 2N6425

FIGURE 13 – TEMPERATURE COEFFICIENTS

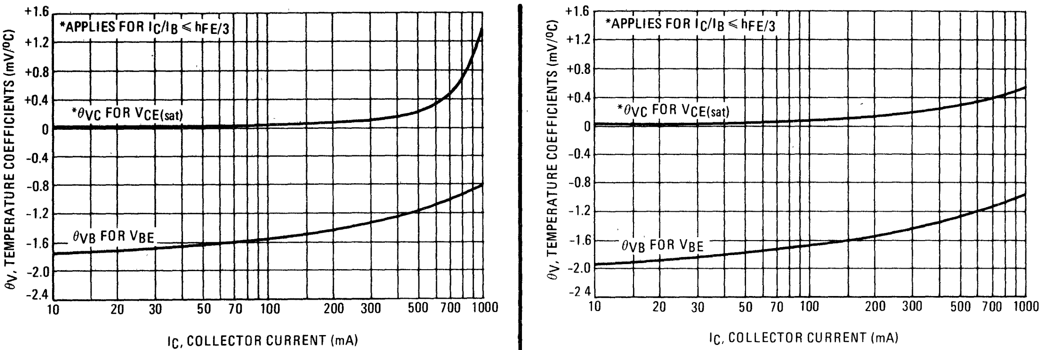


FIGURE 14 – COLLECTOR CUTOFF REGION

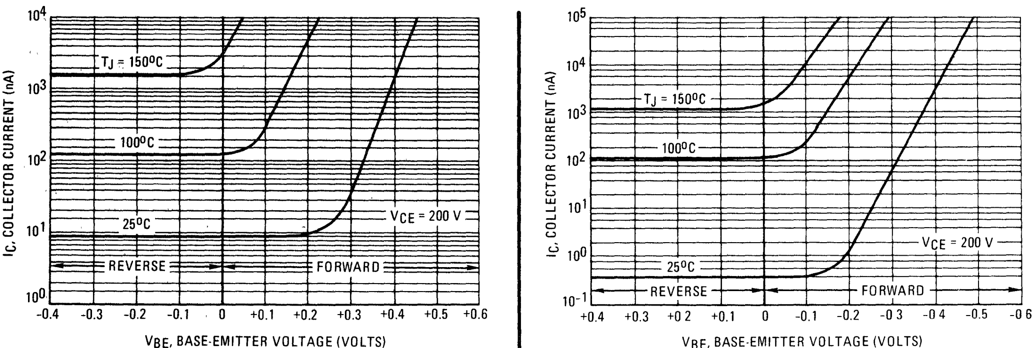
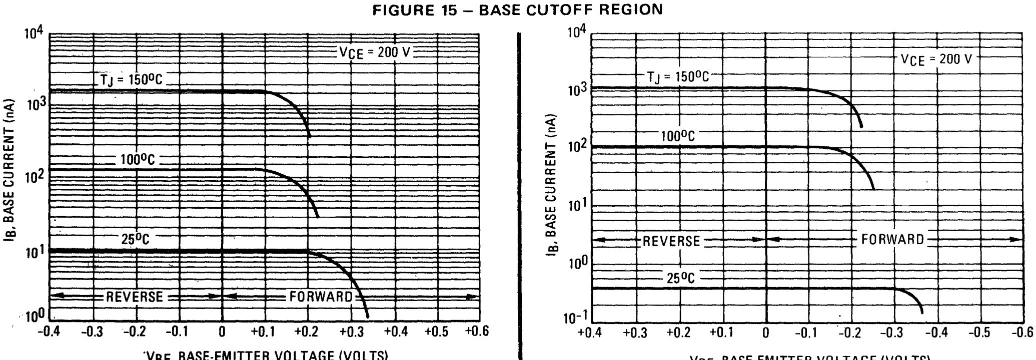


FIGURE 15 – BASE CUTOFF REGION



2N3740, A (SILICON)
2N3741, A

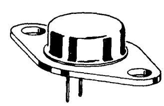
MEDIUM-POWER PNP TRANSISTORS

. . . ideal for use as drivers, switches and direct replacement of germanium medium-power devices. These devices feature:

- Low Saturation Voltage —
  $V_{CE(sat)}$ = 0.6 Vdc @ I_C = 1.0 Amp
- High Gain Characteristics —
  h_{FE} = 30—100 @ I_C = 250 mAdc
- Direct Substitution for Germanium Equivalents
- Excellent Safe Area Limits (See Figure 2)
- Low Collector Cutoff Current —
  100 nA (Max) 2N3740A, 2N3741A
- Complementary to NPN 2N3766 (2N3740) and 2N3767 (2N3741)

POWER TRANSISTORS

PNP SILICON
60–80 VOLTS
25 WATTS

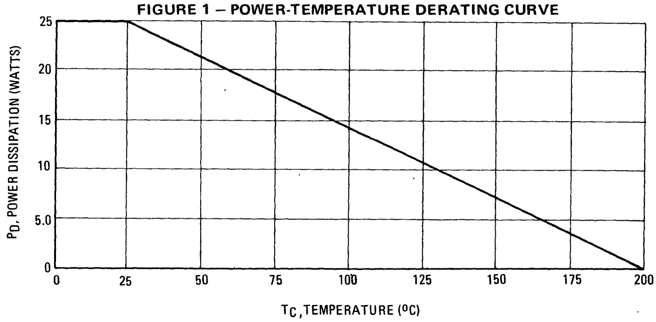


*MAXIMUM RATINGS

Rating	Symbol	2N3740 2N3740A	2N3741 2N3741A	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7.0	7.0	Vdc
Collector-Base Voltage	V_{CB}	60	80	vdc
Collector Current — Continuous — Peak (Note 1)	I_C	4.0 10		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 0.143		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

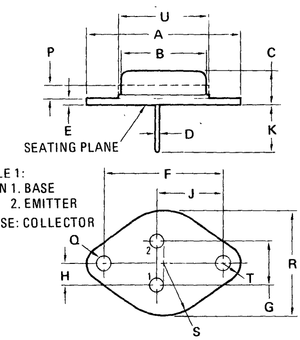
Note 1: See Figure 2

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
Both limits are applicable and must be observed.

*Indicates JEDEC Registered Data.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

CASE 80-02
TO-66

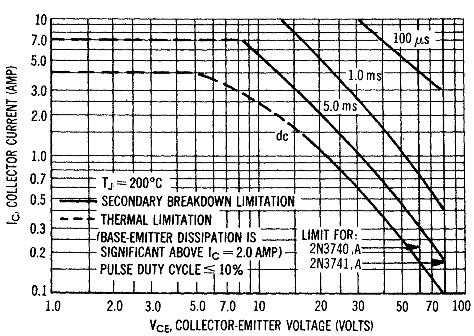
*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage ①		2	$V_{CEO(sus)}$ ①			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3740, 2N3740A			60	–	
	2N3741, 2N3741A			80	–	
Emitter Base Cutoff Current		–	I_{EBO}			
(V_{EB} = 7.0 Vdc)	2N3740, 2N3741			–	0.5	mAdc
	2N3740A, 2N3741A				100	nAdc
Collector Cutoff Current		5, 6②	I_{CEX}			
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3740			–	100	μAdc
	2N3740A			–	100	nAdc
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N3741			–	100	μAdc
	2N3741A			–	100	nAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3740			–	1.0	mAdc
	2N3740A			–	0.5	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N3741			–	1.0	mAdc
	2N3741A			–	0.5	
Collector-Emitter Cutoff Current		5, 6②	I_{CEO}			
(V_{CE} = 40 Vdc, I_B = 0)	2N3740			–	1.0	mAdc
	2N3740A			–	1.0	μAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3741			–	1.0	mAdc
	2N3741A			–	1.0	μAdc
Collector Base Cutoff Current		–	I_{CBO}			
(V_{CB} = 60 Vdc, I_E = 0)	2N3740			–	100	μAdc
	2N3740A			–	100	nAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N3741			–	100	μAdc
	2N3741A			–	100	nAdc
ON CHARACTERISTICS						
DC Current Gain		7	h_{FE}①			–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)				40	–	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)				30	100	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)				20	–	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)				10	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 125 mAdc)		8, 9, 10	$V_{CE(sat)}$①	–	0.6	Vdc
Base-Emitter Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		3, 4, 9, 10	V_{BE}①	–	1.0	Vdc
TRANSIENT CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		–	f_T	4.0	–	MHz
Common Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kHz)		14	C_{ob}	–	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		–	h_{fe}	25	–	–

*Indicates JEDEC Registered Data.

① Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
② Figures 5 and 6 apply to 2N3740 and 2N3741 only.

FIGURE 2 – ACTIVE REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

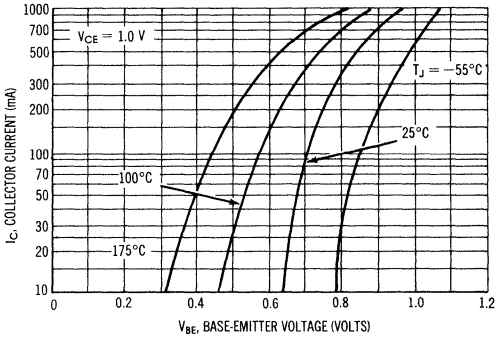
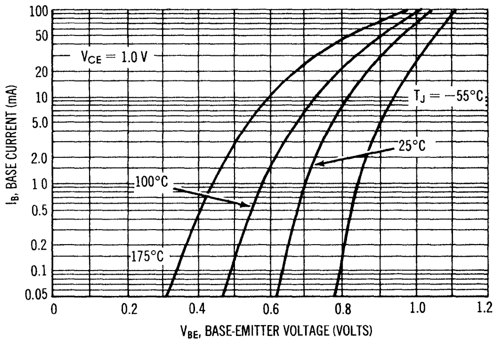


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

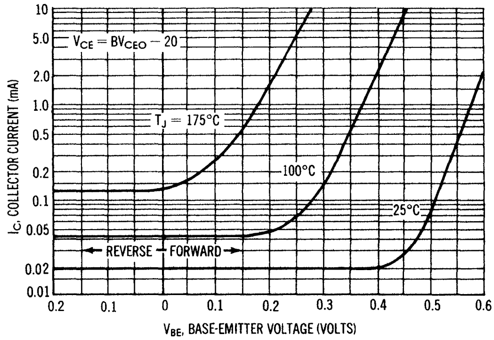
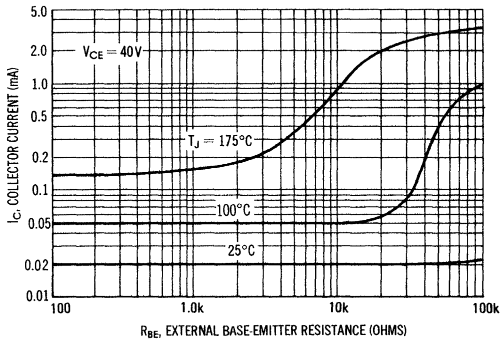


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE



② Figures 5 and 6 apply to 2N3740 and 2N3741.

FIGURE 7 — THERMAL RESPONSE

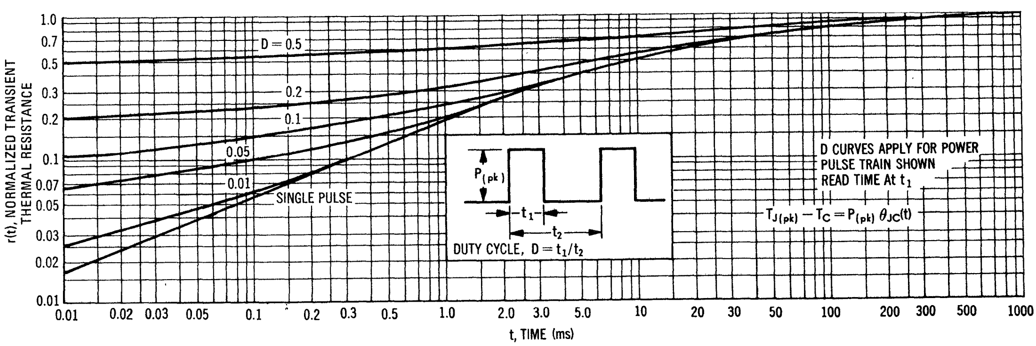
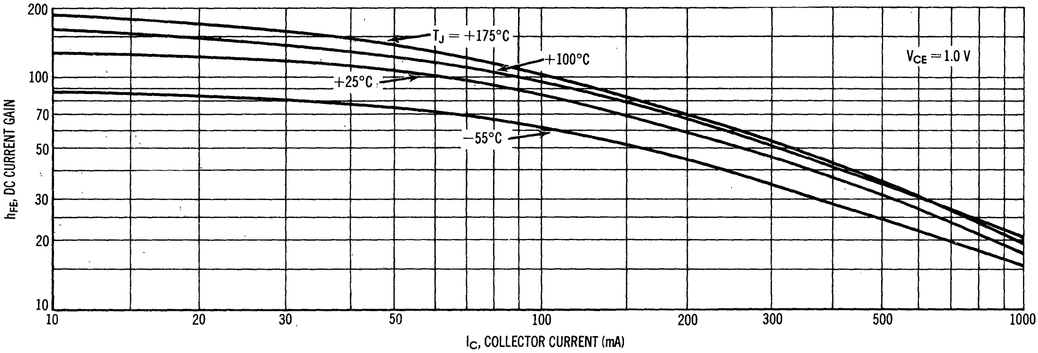


FIGURE 8 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 9 — COLLECTOR SATURATION REGION

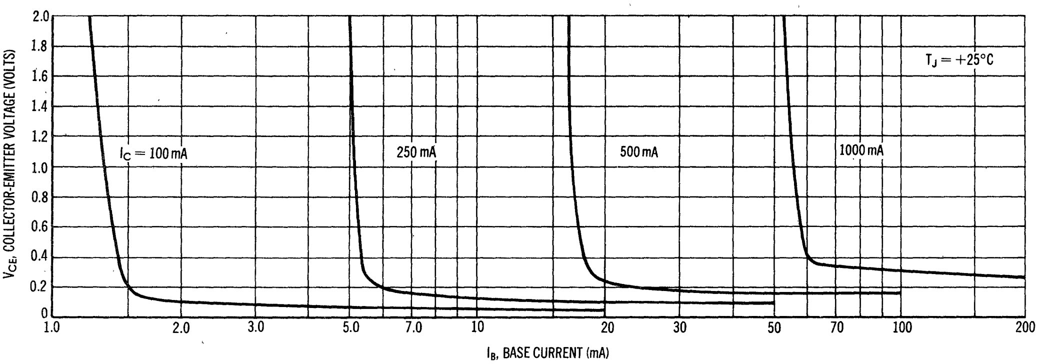


FIGURE 10 — "ON" VOLTAGES

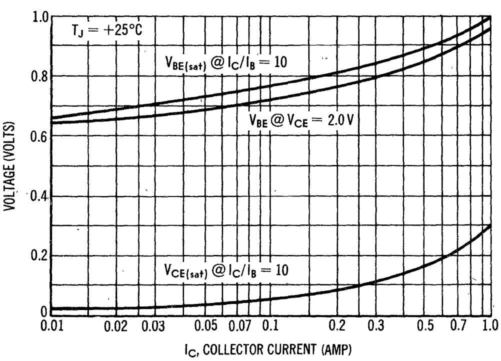


FIGURE 11 — TEMPERATURE COEFFICIENTS

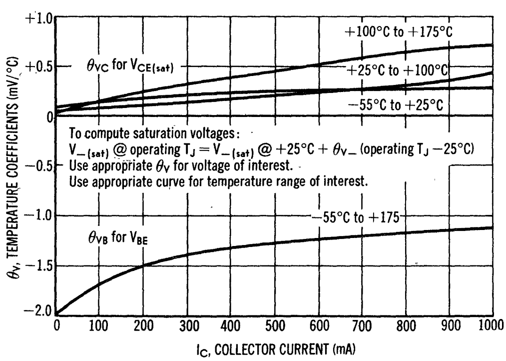


FIGURE 12 – TURN-ON TIME

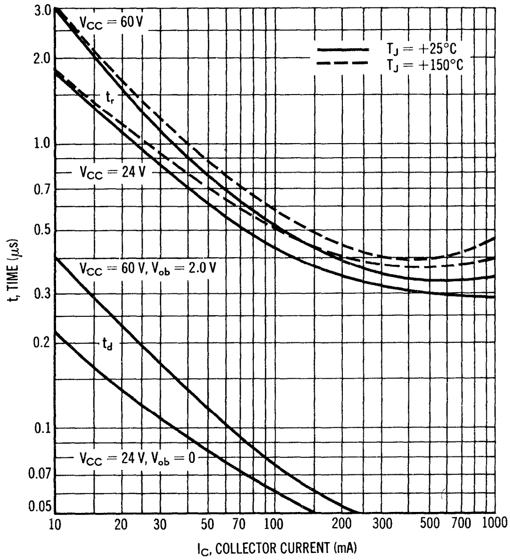


FIGURE 13 – CAPACITANCE

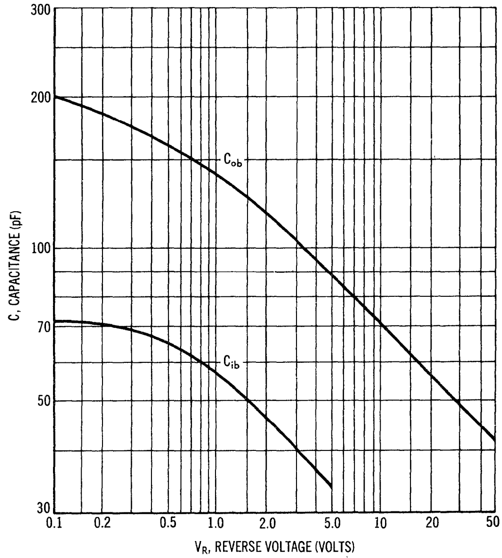


FIGURE 14 – STORAGE TIME

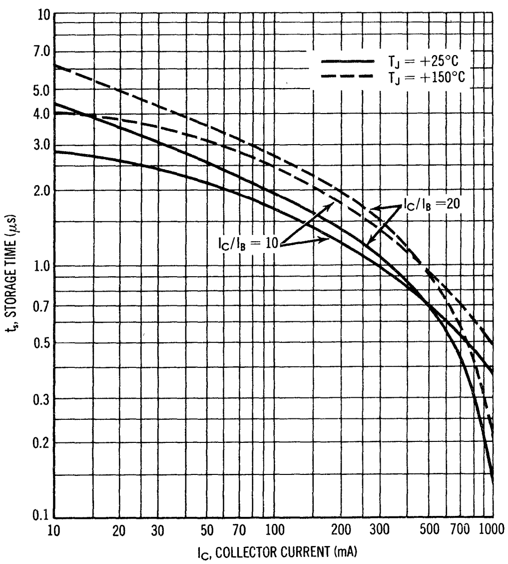
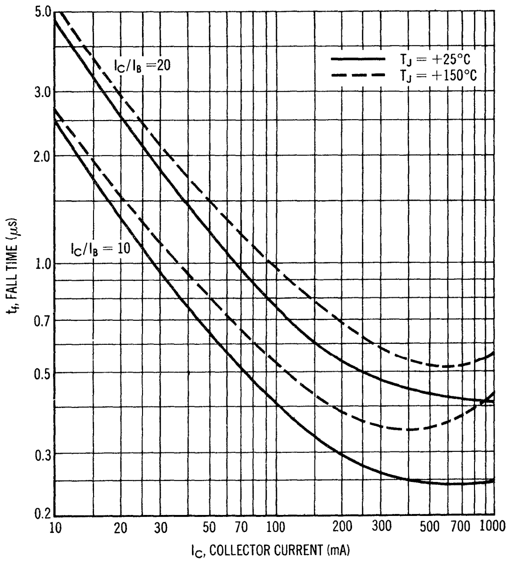


FIGURE 15 – FALL TIME

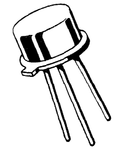


NPN SILICON ANNULAR♦ TRANSISTOR

. . designed for high-voltage amplifier driver applications

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 300 Vdc (Min) @ I_C = 10 mAdc
- Low Output Capacitance — C_{ob} = 6.0 pF (Max) @ V_{CB} = 10 Vdc
- DC Current Gain Specified — 3.0 mAdc to 50 mAdc

NPN SILICON
HIGH - VOLTAGE
AMPLIFIER
TRANSISTOR



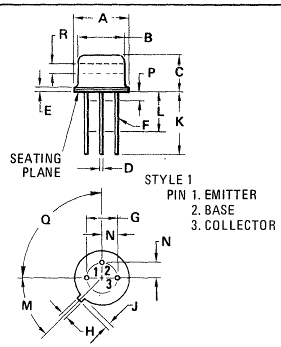
*MAXIMUM RATING

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Collector-Base Voltage	V_{CB}	300	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current - Continuous	I_C	50	mAdc
Total Power Dissipation @T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Power Dissipation @T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W

*Indicates JEDEC Registered Data



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	300	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C	I_{CBO}	–	0.2 20	μAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	I_{EBO}	–	0.2	μAdc
ON CHARACTERISTICS (2)				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 20 Vdc)	h_{FE}	 10 15 20 20	 – – 200 –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{CE(sat)}$	 – –	 0.75 1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 30 mAdc, I_B = 3.0 mAdc)	$V_{BE(sat)}$	 – –	 1.0 1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product (3) (I_C = 10 mAdc, V_{CE} = 20 Vdc , f = 20 MHz)	f_T	30	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	6.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	80	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	2.0	k ohms
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	2.0	$X10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 10 kHz)	h_{fe}	20	200	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	50	mhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5.0 MHz)	$Re(h_{ie})$	–	200	Ohms

*Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ⩽ 30 μs, Duty Cycle ⩽ 1.0%

(2) Pulse Test: Pulse width ⩽ 300 μs, Duty Cycle ⩽ 2.0%

(3) f_T is defined as the frequency at which $|h_{fe}|$ extropolates to unity.

FIGURE 1 – DC CURRENT GAIN

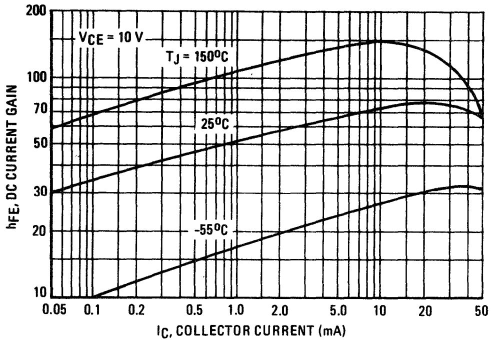


FIGURE 2 – DC SAFE OPERATING AREA

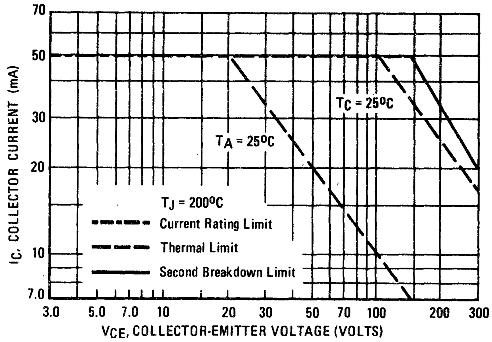


FIGURE 3 – "ON" VOLTAGES

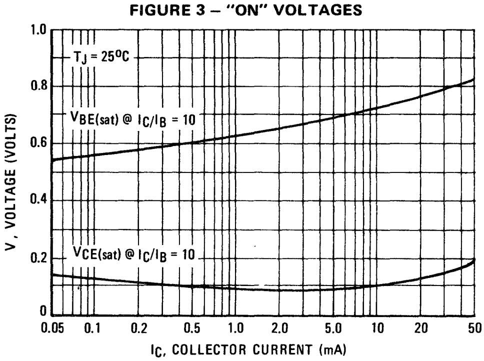


FIGURE 4 – TEMPERATURE COEFFICIENTS

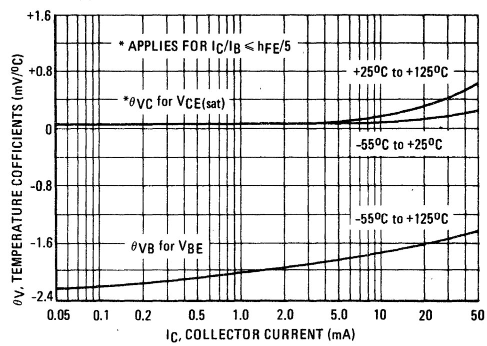


FIGURE 5 – CURRENT-GAIN-BANDWIDTH PRODUCT

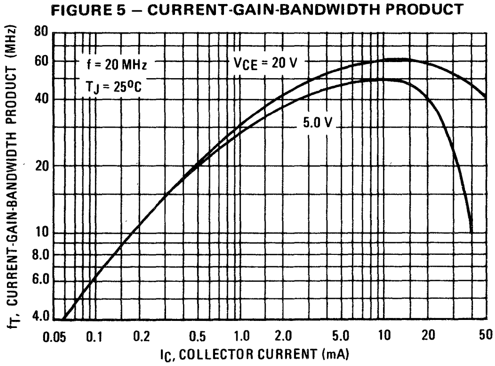
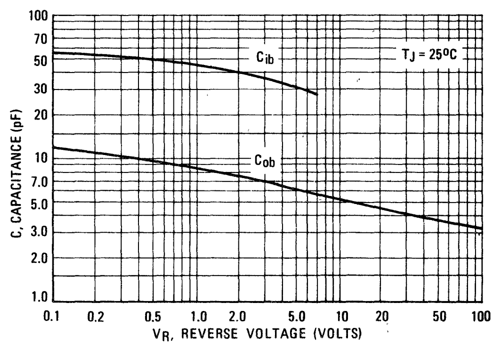
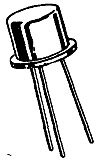


FIGURE 6 – CAPACITANCE

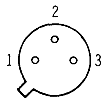


2N3743S (SILICON)
JAN,JTX AVAILABLE



PNP silicon annular transistor for high-voltage amplifier applications from dc to VHF.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

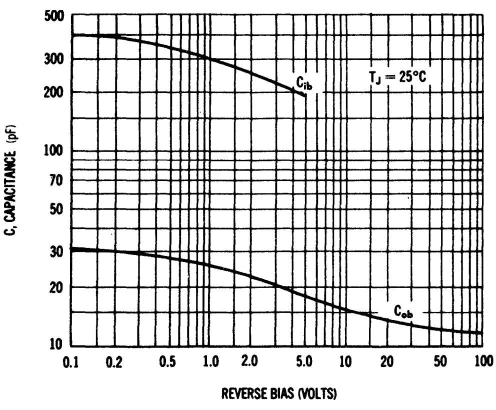
Collector connected to case

*MAXIMUM RATINGS

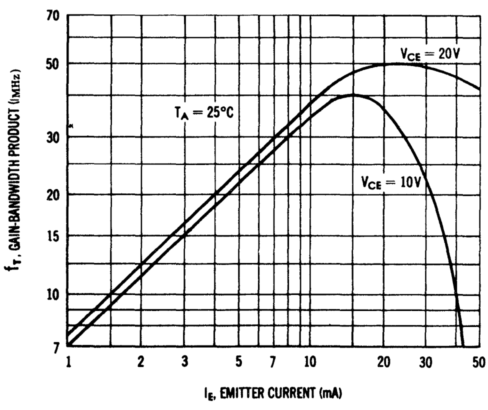
Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation@ T_C = 25°C Derate Above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



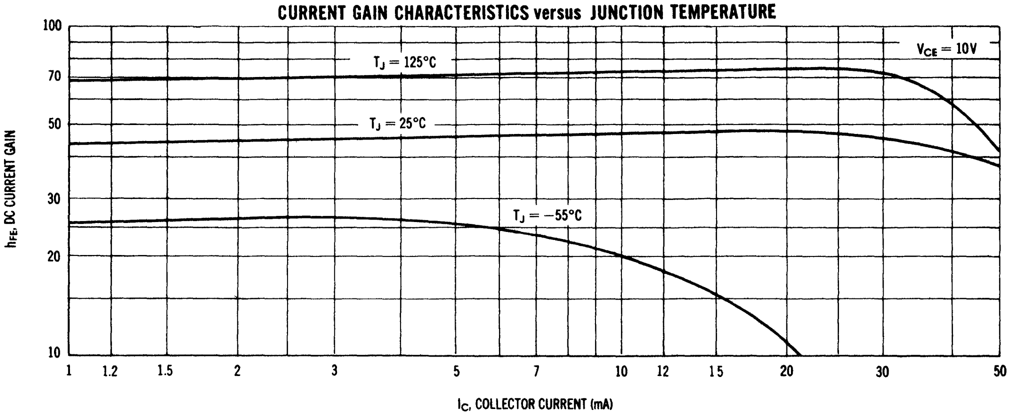
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

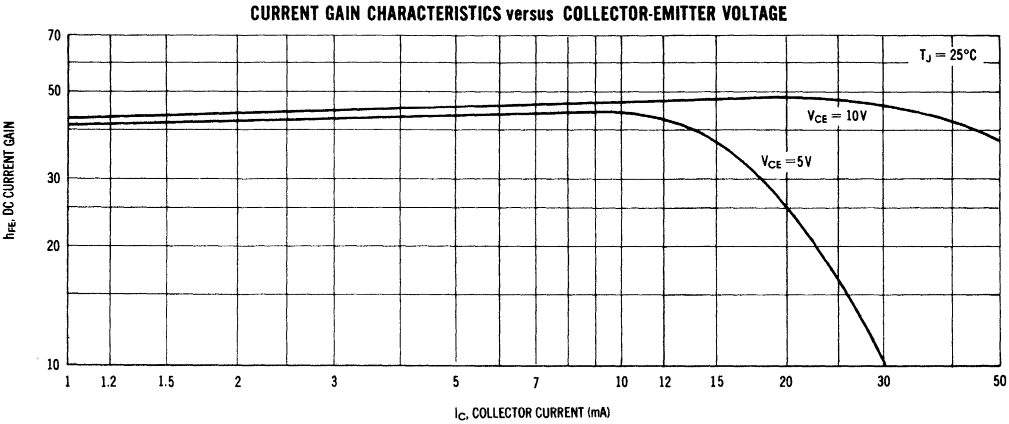
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Saturation Voltage (2)	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		—	5.0	
(I_C = 30 mAdc, I_B = 3 mAdc)		—	8.0	
Base-Emitter Saturation Voltage (2)	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		—	1.0	
(I_C = 30 mAdc, I_B = 3 mAdc)		—	1.2	
DC Forward Current Gain (2)	h_{FE}			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		20	—	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		25	250	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		25	—	
Collector Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 200 Vdc, I_E = 0)		—	0.3	
(V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)		—	30	
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20MHz)	$\|h_{fe}\|$	1.5	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	15	pF
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	400	pF
Small Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{fe}	30	300	—
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{re}	—	4.0	$X10^{-4}$
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{ie}	—	1.0	kohms
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kHz)	h_{oe}	—	200	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5 MHz)	$Re(h_{ie})$	—	40	ohms

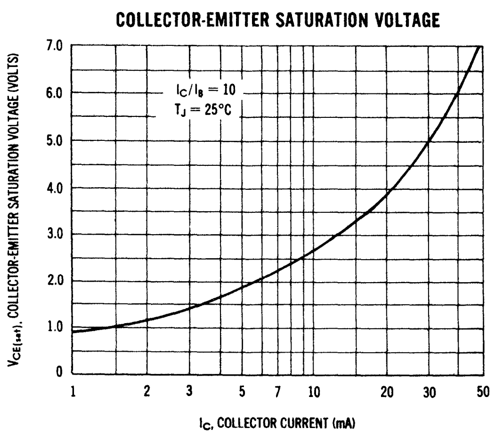
(1) PW ≤ 30 μs, Duty Cycle ≤ 1%

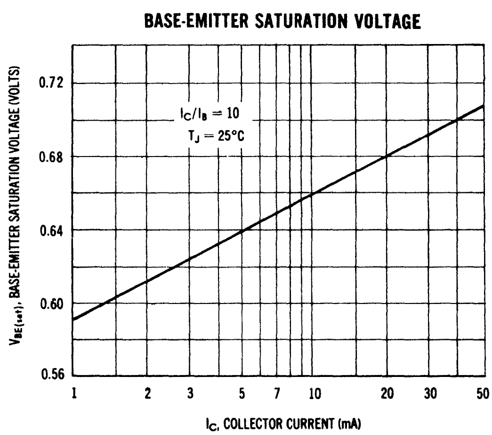
(2) PW ≤ 300 μs, Duty Cycle ≤ 2%

* Indicates JEDEC Registered Data


CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE
V_{CE} = 10V
T_J = 125°C
T_J = 25°C
T_J = −55°C
h_{FE}, DC CURRENT GAIN
100
70
50
30
20
10
1
1.2
1.5
2
3
5
7
10
12
15
20
30
50
I_C, COLLECTOR CURRENT (mA)

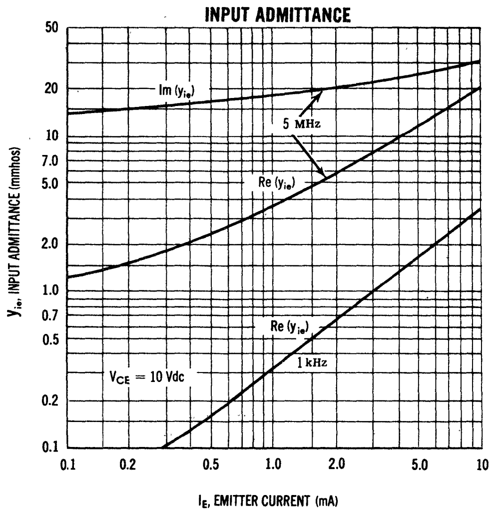

CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE
T_J = 25°C
V_{CE} = 10V
V_{CE} = 5V
h_{FE}, DC CURRENT GAIN
70
50
30
20
10
1
1.2
1.5
2
3
5
7
10
12
15
20
30
50
I_C, COLLECTOR CURRENT (mA)

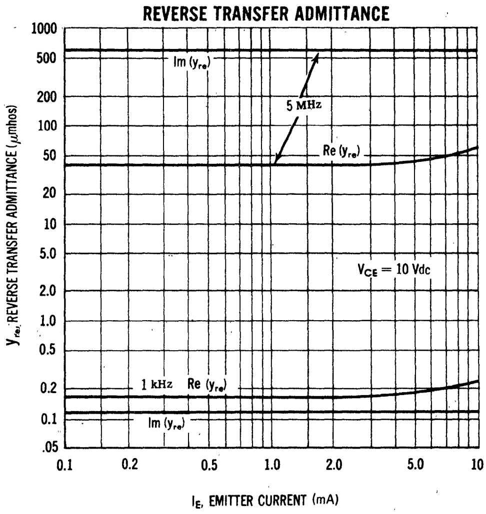

COLLECTOR-EMITTER SATURATION VOLTAGE
I_C/I_B = 10
T_J = 25°C
$V_{CE(sat)}$, COLLECTOR-EMITTER SATURATION VOLTAGE (VOLTS)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1
2
3
5
7
10
20
30
50
I_C, COLLECTOR CURRENT (mA)

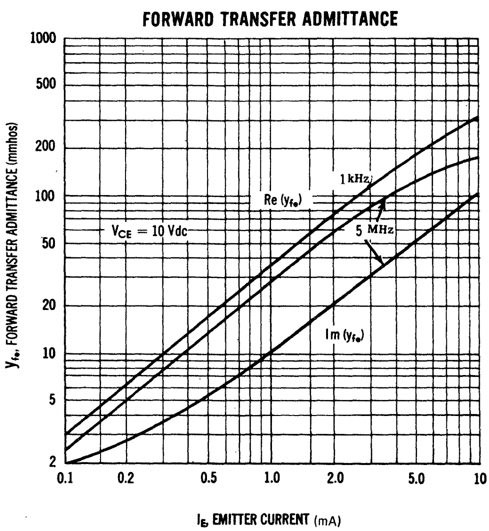

BASE-EMITTER SATURATION VOLTAGE
I_C/I_B = 10
T_J = 25°C
$V_{BE(sat)}$, BASE-EMITTER SATURATION VOLTAGE (VOLTS)
0.72
0.68
0.64
0.60
0.56
1
2
3
5
7
10
20
30
50
I_C, COLLECTOR CURRENT (mA)

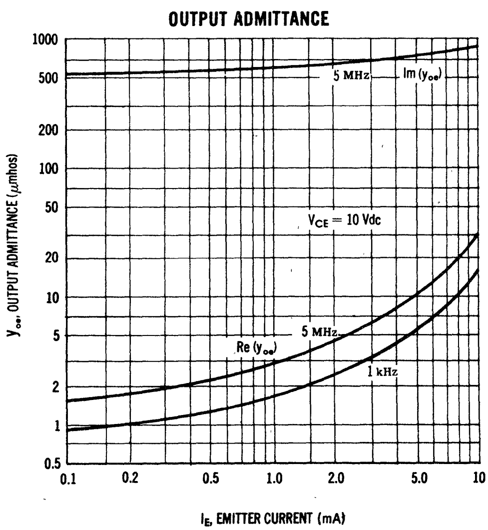
SMALL SIGNAL *y* PARAMETERS

$T_A = 25°C$



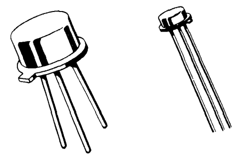


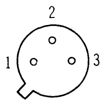




2N3762S (SILICON)
2N3763S
2N3763S JAN,JTX AVAILABLE
2N3764
2N3765
2N3765 JAN,JTX AVAILABLE

Medium-current PNP silicon annular transistor, designed for high-speed switching and driver applications.





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)
2N3762
2N3763

CASE 26
(TO-46)
2N3764
2N3765

Collector connected to case

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Base Voltage	V_{CB}	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Thermal Resistance Junction to Ambient Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	°C/mW
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3762, 2N3764 2N3763, 2N3765	BV_{CBO}	40 60	— —	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N3762, 2N3764 2N3763, 2N3765	BV_{CEO}	40 60	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 20 Vdc, V_{EB} = 2 Vdc, T_A = 100°C) (V_{CE} = 30 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)	2N3762, 2N3764 2N3763, 2N3765	I_{CEX}	— — — —	0.10 10 0.10 10	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 30 Vdc, V_{EB} = 2 Vdc)	2N3762, 2N3764 2N3763, 2N3765	I_{BL}	— —	0.2 0.2	μAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 1 Vdc) (I_C = 1 Adc, V_{CE} = 1.5 Vdc) (I_C = 1.5 Adc, V_{CE} = 5 Vdc)	 2N3762, 2N3764 2N3763, 2N3765 2N3762, 2N3764 2N3763, 2N3765	h_{FE}	35 40 35 30 20 30 20	— — — 120 80 — —	—
Collector Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		$V_{CE(sat)}$	— — — —	0.1 0.22 0.5 0.9	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	— — — 0.9	0.8 1.0 1.2 1.4	Vdc
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	80	pF
High Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3762, 2N3764 2N3763, 2N3765	$\|h_{fe}\|$	1.8 1.5	— —	—
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8.0	ns
Rise Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_r	—	35	ns
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	80	ns
Fall Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_f	—	35	ns
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	30	nC

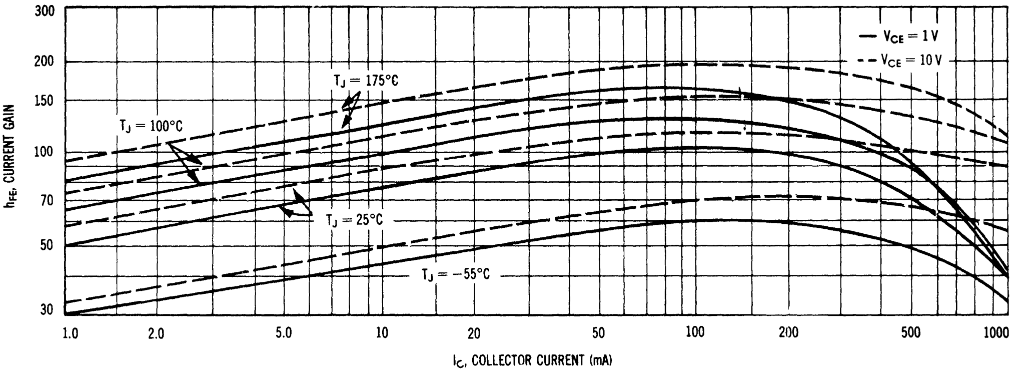
(1) Pulse Test: PW ≦ 300 μs, Duty Cycle ≦ 2%

* Indicates JEDEC Registered Data

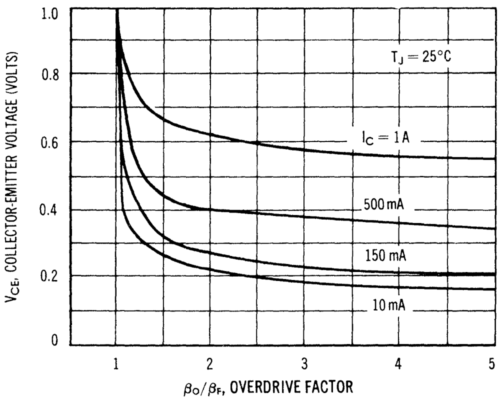
FIGURE 1

"ON" CONDITION CHARACTERISTICS

DC CURRENT GAIN



COLLECTOR SATURATION REGION

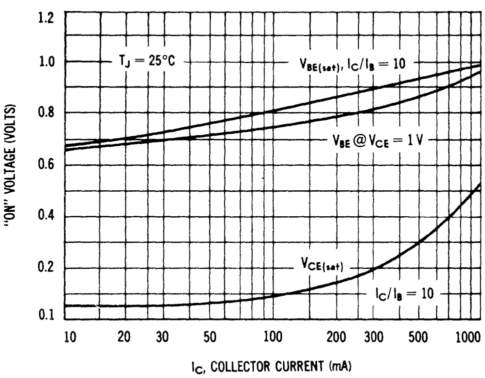


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to ensure saturation at a temperature of 25°C and a collector of 500 mA.

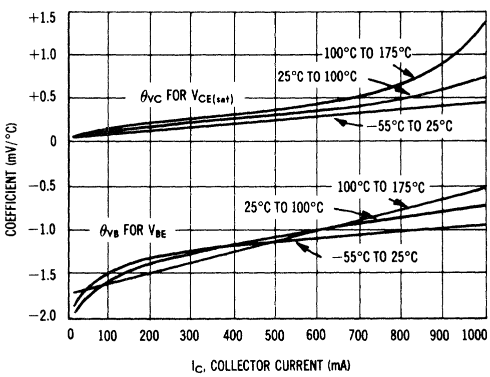
Observe that at $I_C = 500$ mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ \text{Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\ \text{mA}/I_{BF}} \qquad I_{BF} \approx 18.5\ \text{mA typ}$$

"ON" VOLTAGES

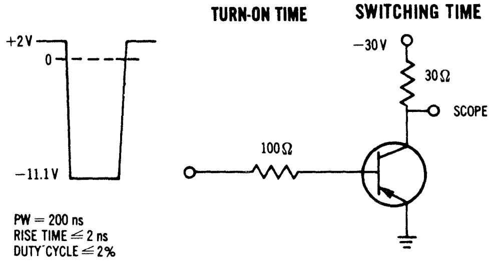


TEMPERATURE COEFFICIENTS

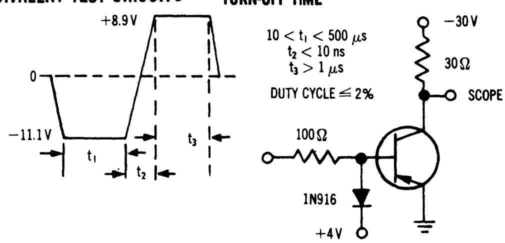


SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-ON TIME

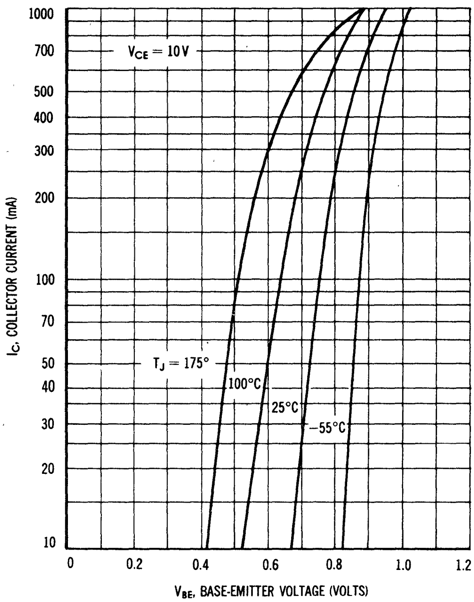


TURN-OFF TIME

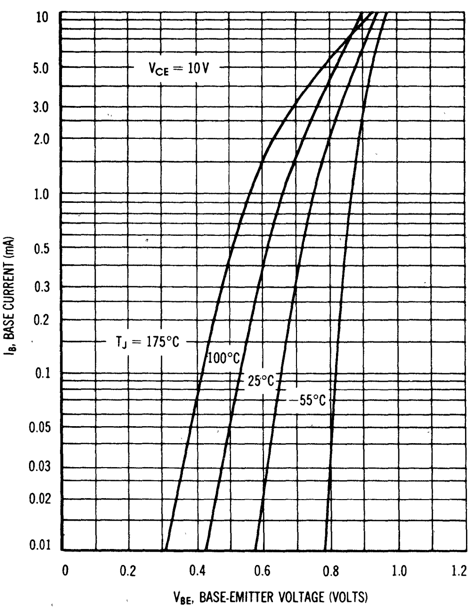


LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

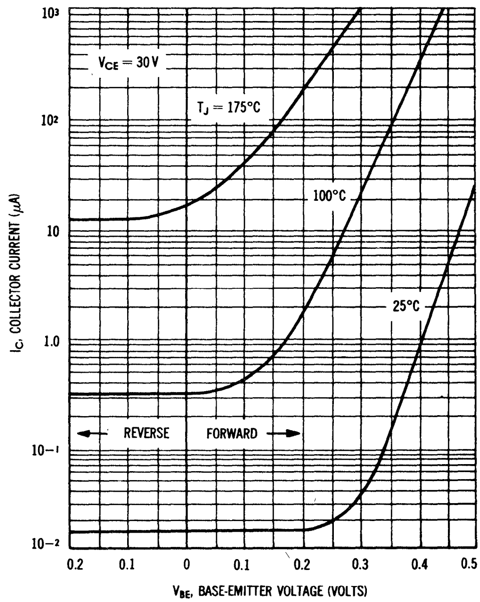


INPUT ADMITTANCE

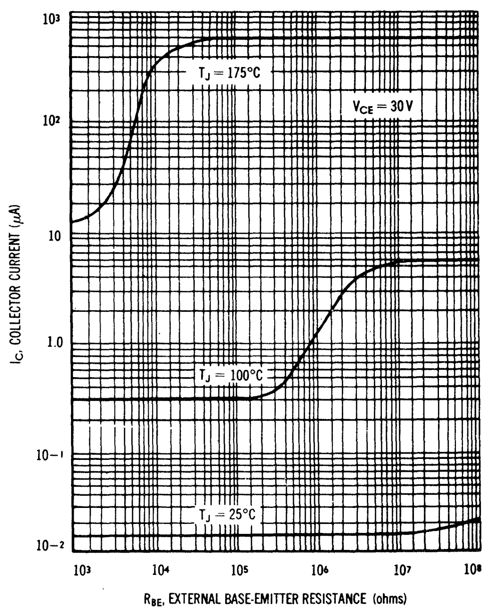


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE

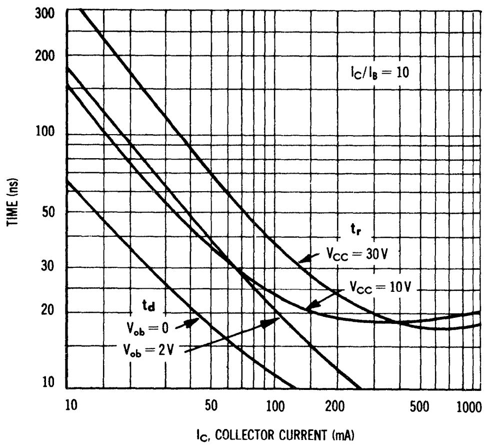


EFFECT OF BASE-EMITTER RESISTANCE

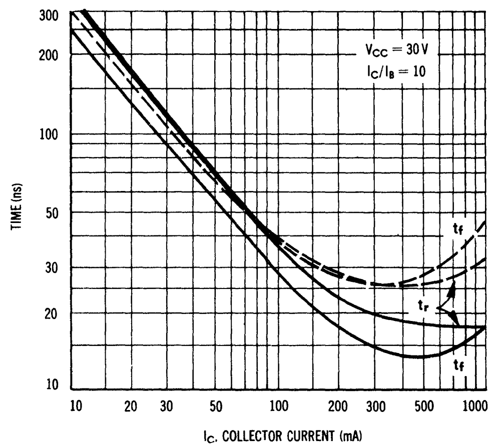


— $T_J = 25°C$ SWITCHING CHARACTERISTICS - - $T_J = 150°C$

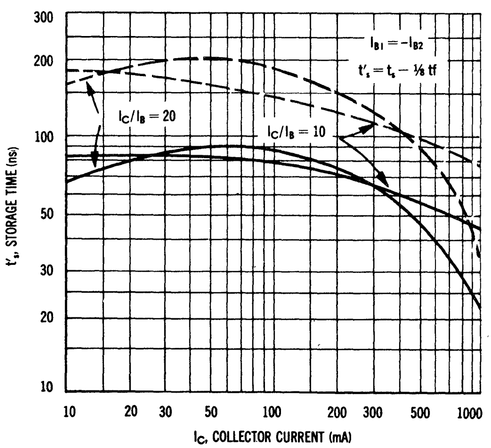
TURN-ON TIME



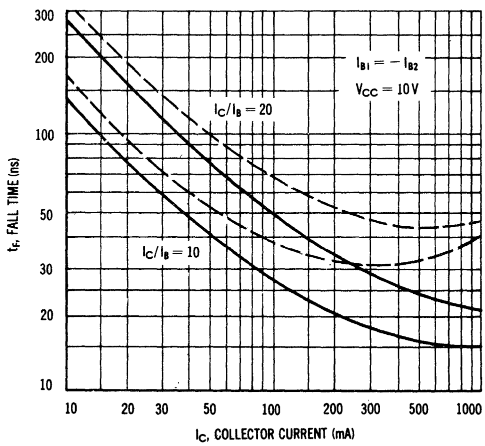
RISE AND FALL TIME



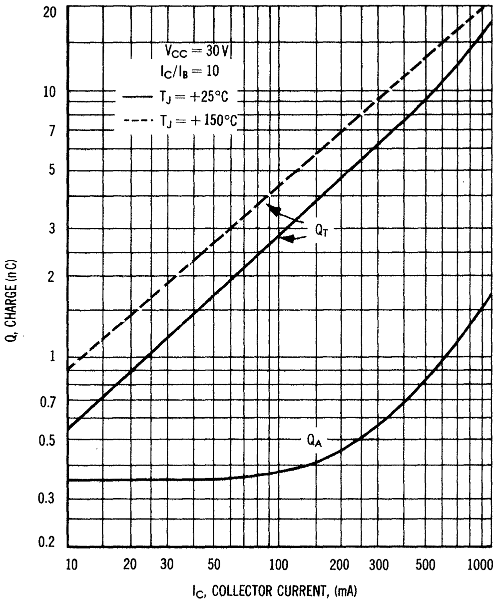
STORAGE TIME



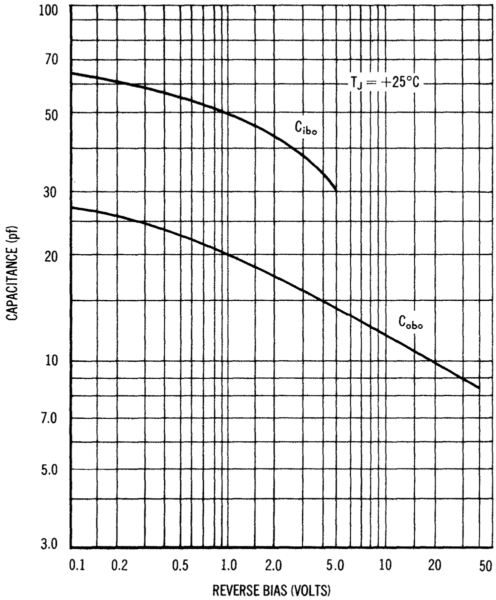
FALL TIME



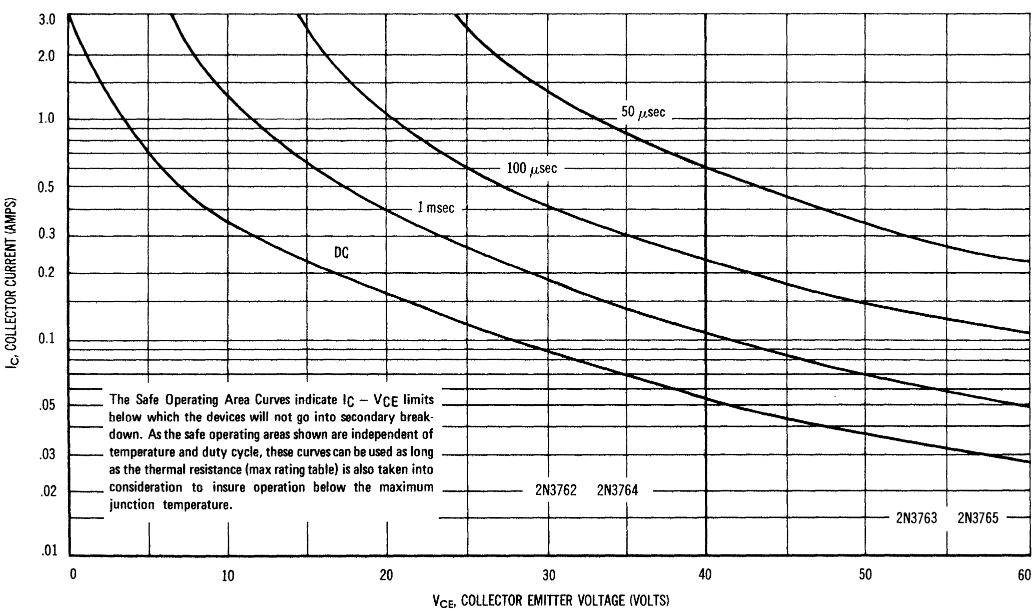
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3766 (SILICON)
2N3767

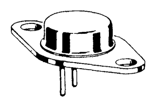
MEDIUM-POWER NPN SILICON TRANSISTORS

. . . for use in driver circuits, switching, and medium-power-amplifiers applications. These high performance devices feature:

- Low Saturation Voltage — 1.0 $V_{CE(sat)}$ @ I_C = 500 mA
- High Gain Characteristics — h_{FE} = 40-160 @ I_C = 500 mA
- Packaged in the Compact, High-Efficiency TO-66 Case
- Recommended for use @ I_C = 0 to 500 mAdc
- Complementary to PNP 2N3740 (2N3766) and 2N3741 (2N3767)

4 AMPERE POWER TRANSISTORS

NPN SILICON 60-80 VOLTS 20 WATTS



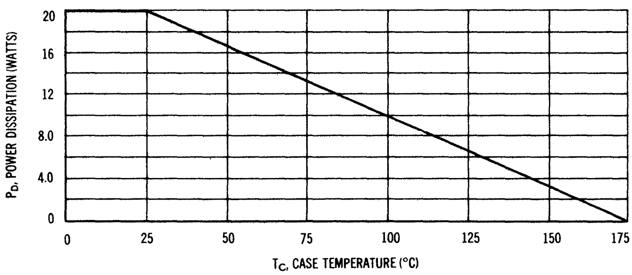
MAXIMUM RATINGS

Rating	Symbol	2N3766	2N3767	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current	I_C	4.0		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.133		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

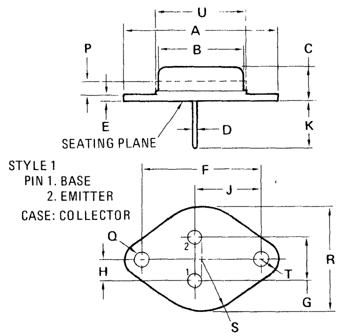
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.5	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
B	11.94	12.70	0.470	0.500
C	6.35	8.64	0.250	0.340
D	0.71	0.86	0.028	0.034
E	1.27	1.91	0.050	0.075
F	24.33	24.43	0.958	0.962
G	4.83	5.33	0.190	0.210
H	2.41	2.67	0.095	0.105
J	14.48	14.99	0.570	0.590
K	9.14	–	0.360	–
P	–	1.27	–	0.050
Q	3.61	3.86	0.142	0.152
S	–	8.89	–	0.350
T	–	3.68	–	0.145
U	–	15.75	–	0.620

All JEDEC Dimensions and and Notes Apply.

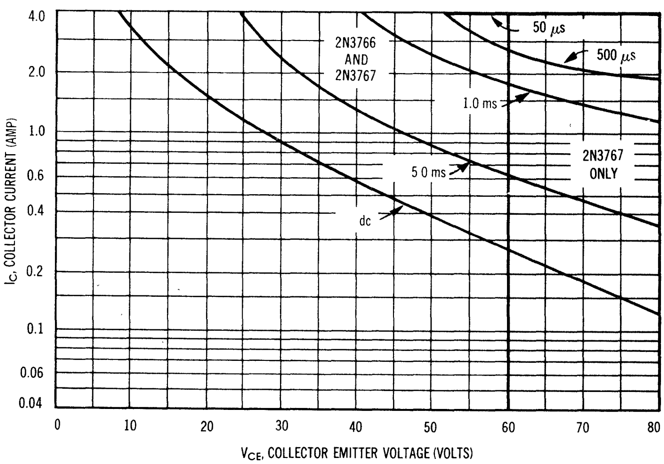
CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Voltage [1] (I_C = 100 mAdc, I_B = 0)	2N3766	2	BV_{CEO}	60	—	Vdc
	2N3767			80	—	
Emitter-Base Cutoff Current (V_{EB} = 6.0 Vdc)		—	I_{EBO}	—	0.75	mAdc
Collector Cutoff Current (V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc)	2N3766	4, 6	I_{CEX}	—	0.1	mAdc
(V_{CE} = 100 Vdc, V_{BE} = 1.5 Vdc)	2N3767			—	0.1	
(V_{CE} = 50 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3766			—	1.0	
(V_{CE} = 70 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3767			—	1.0	
Collector-Emitter Cutoff Current (V_{CE} = 60 Vdc, I_B = 0)	2N3766	6	I_{CEO}	—	0.7	mAdc
(V_{CE} = 80 Vdc, I_B = 0)	2N3767			—	0.7	
Collector-Base Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	2N3766	4	I_{CBO}	—	0.1	mAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N3767			—	0.1	
ON CHARACTERISTICS						
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		7	h_{FE}	30	—	—
(I_C = 500 mAdc, V_{CE} = 5.0 Vdc)				40	160	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)				20	—	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)		8,9	$V_{CE(sat)}$	—	2.5	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)				—	1.0	
Base-Emitter Voltage (I_C = 1.0 Adc, V_{CE} = 10 Vdc)		3, 5, 9	V_{BE}	—	1.5	Vdc
TRANSIENT CHARACTERISTICS						
Current-Gain - Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		—	f_T	10	—	MHz
Common-Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0 Adc, f = 100 kHz)		13	C_{ob}	—	50	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		—	h_{fe}	40	—	—

(1) Pulse Test: Pulse Width ≤300μs, Duty Cycle ≤2.0%.

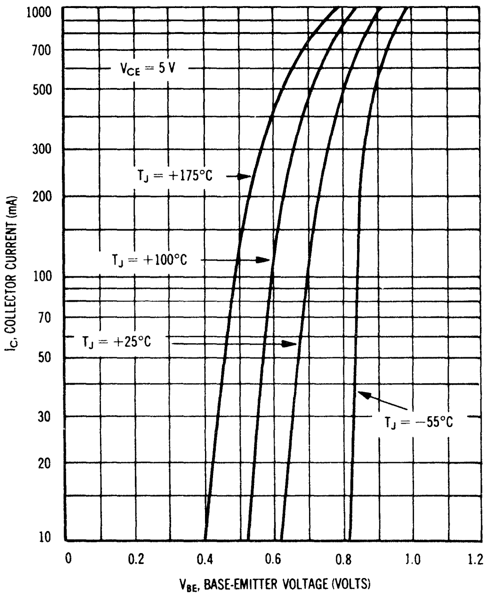
FIGURE 2 — ACTIVE REGION SAFE AREAS



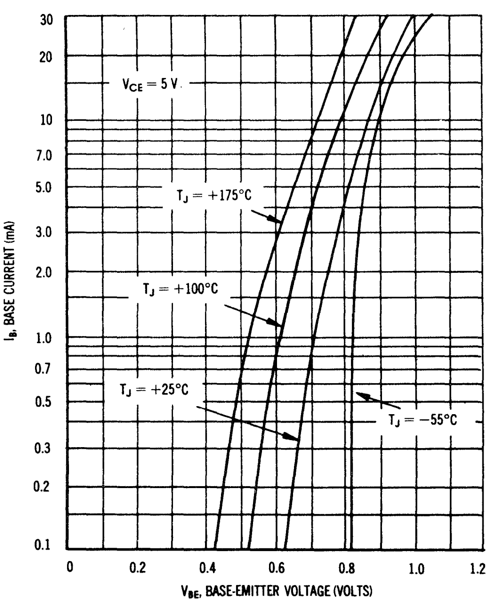
The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

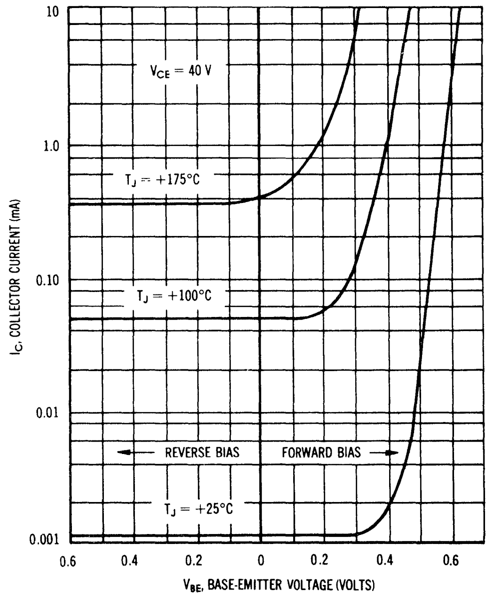


INPUT ADMITTANCE

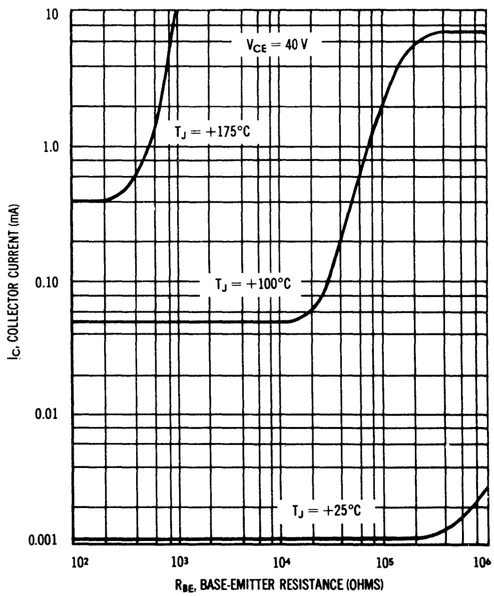


CUT-OFF CHARACTERISTICS

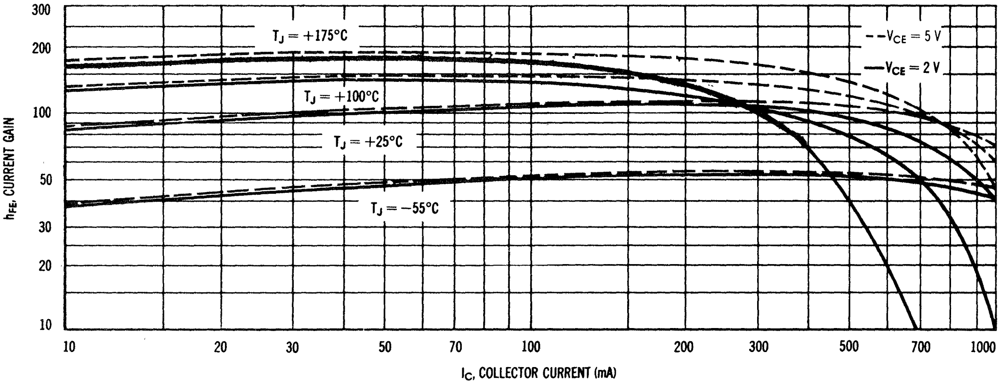
TRANSCONDUCTANCE



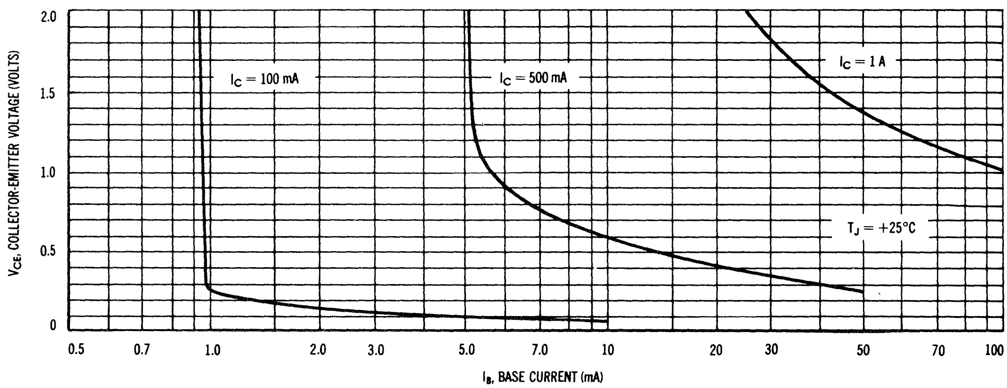
EFFECT OF BASE-EMITTER RESISTANCE



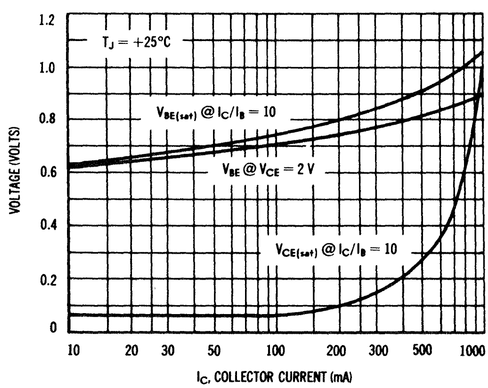
CURRENT GAIN



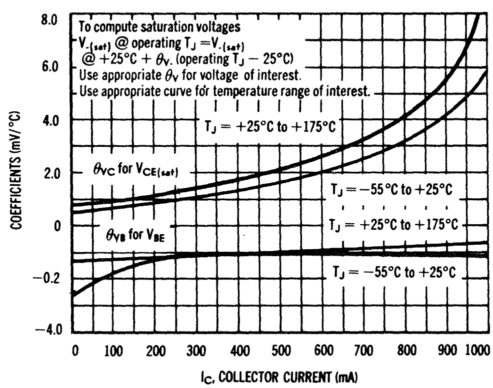
COLLECTOR SATURATION REGION



"ON" VOLTAGES



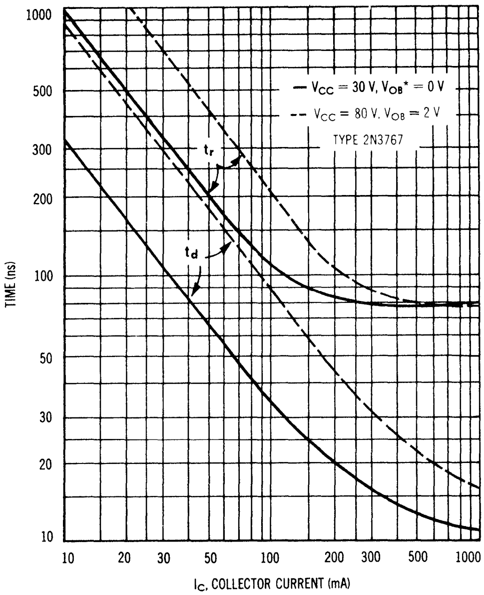
TEMPERATURE CO-EFFICIENTS



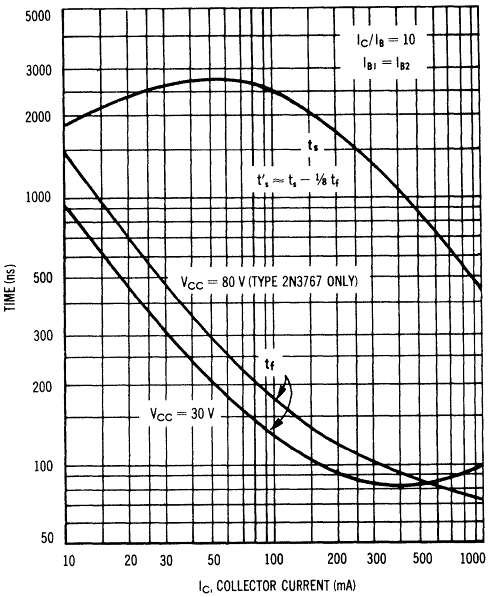
TRANSIENT CHARACTERISTICS

($T_J = 25°C$)

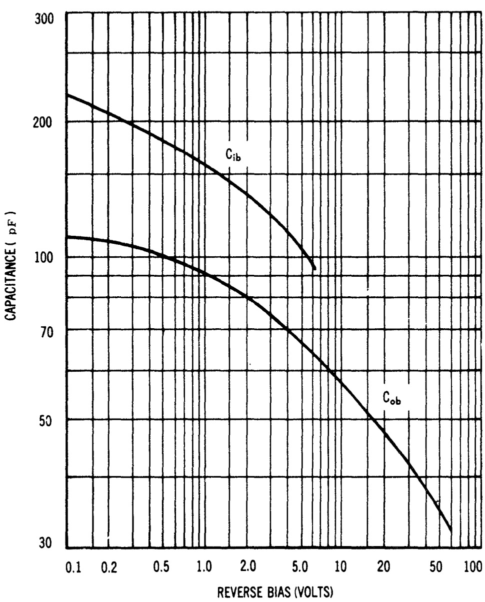
TURN-ON TIME



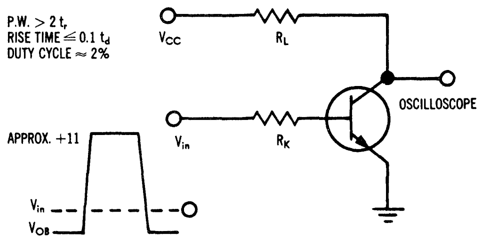
TURN-OFF TIME



CAPACITANCE

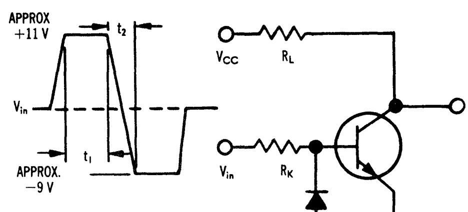


EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIME



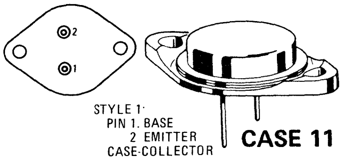
*V_{OB} = BASE-EMITTER "OFF" BIAS VOLTAGE

EQUIVALENT CIRCUIT FOR MEASURING STORAGE AND FALL TIMES



$100 < t_1 < 500\ \mu s$
$t_2 < 15$ ns
DUTY CYCLE ≈ 2%

2N3789 thru 2N3792 (SILICON)



Collector connected to case

PNP silicon power transistors for medium-speed switching and amplifier applications. Complement to NPN type 2N3713 thru 2N3716.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

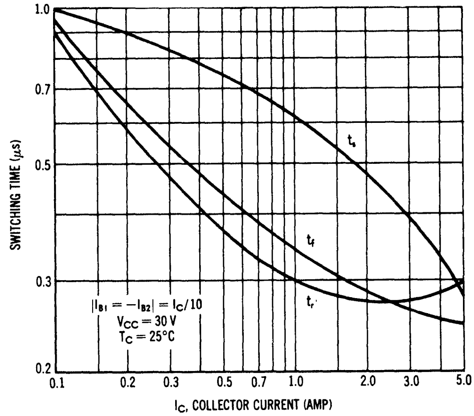
Rating	Symbol	2N3789 2N3791	2N3790 2N3792	Unit
Collector-Base Voltage	V_{CB}	60	80	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7.0	7.0	Volts
Collector Current	I_C	10	10	Amp
Collector Current (Peak)	I_C	10	10	Amp
Base Current (Continuous)	I_B	4.0	4.0	Amp
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	θ_{JC}	1.17	1.17	°C/W
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

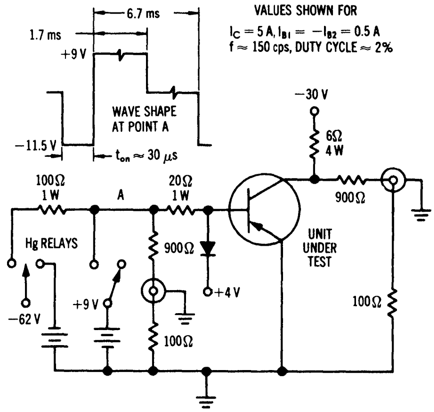
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	2N3789, 2N3791	$V_{CEO(sus)}$*	60	—	Vdc
	2N3790, 2N3792		80	—	
Collector-Emitter Cutoff Current (V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc)	2N3789, 2N3791	I_{CEX}	—	1.0	mAdc
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3790, 2N3792		—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3789, 2N3791		—	5.0	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3790, 2N3792		—	5.0	
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)		I_{EBO}	—	5.0	mAdc
DC Current Gain* (I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790	h_{FE}*	25	90	—
	2N3791, 2N3792		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790		15	—	
	2N3791, 2N3792		30	—	
Collector-Emitter Saturation Voltage* (I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790	$V_{CE(sat)}$*	—	1.0	Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.0	
Base-Emitter Saturation Voltage* (I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790	$V_{BE(sat)}$*	—	2.0	Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.5	
Current Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 0.5 Adc f = 1.0 MHz)		f_T	4.0	—	MHz

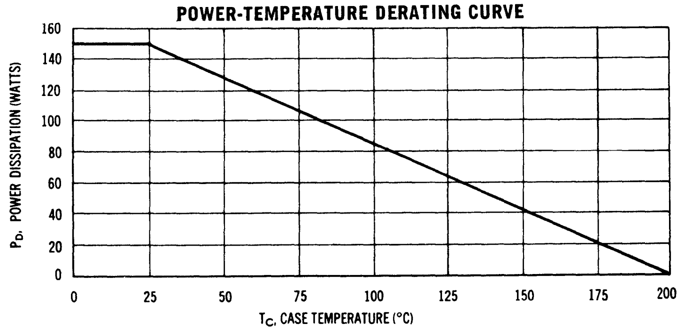
*Sweep Test: 1/2 sine wave cycle @ 60 Hz .

TYPICAL SWITCHING TIMES AND TEST CIRCUIT





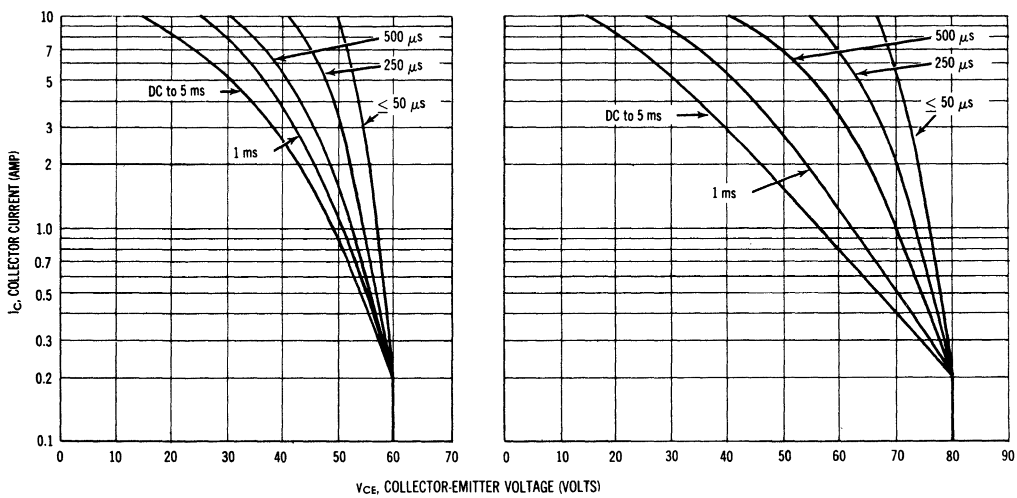
POWER-TEMPERATURE DERATING CURVE



Safe area curves are indicated. Both limits are applicable and must be observed.

ACTIVE-REGION SAFE OPERATING AREAS

2N3789, 2N3791 **2N3790, 2N3792**

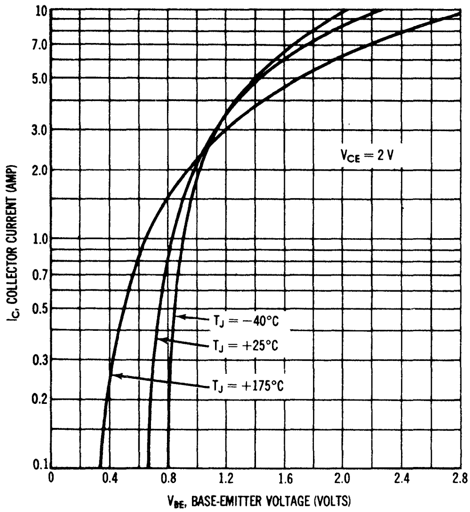


The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursion make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

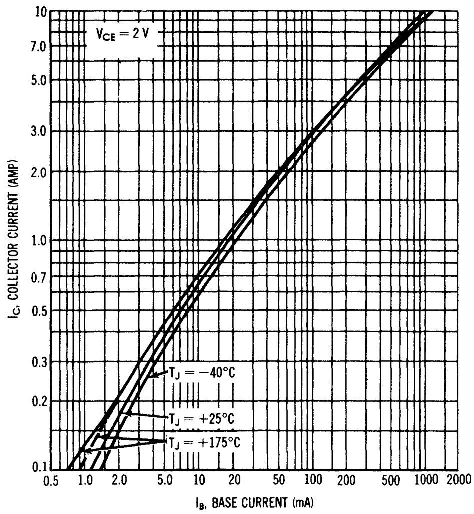
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3789, 2N3790

(PULSE TEST: pulse width ≈ 200 μs, duty cycle ≈ 1%)

TRANSCONDUCTANCE

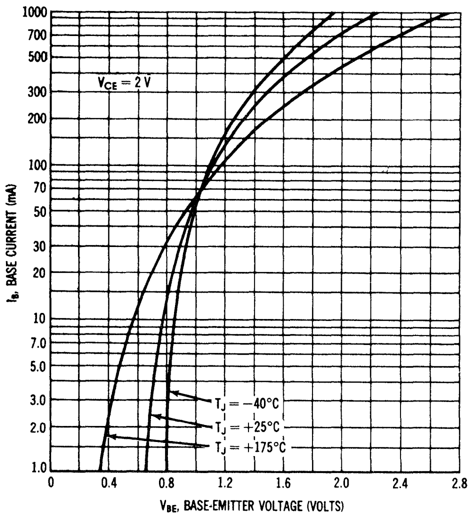


CURRENT GAIN *

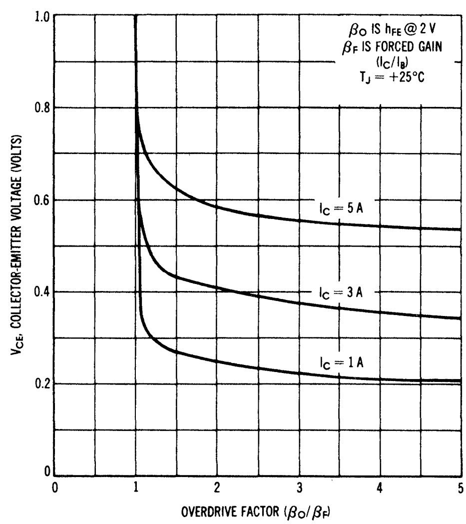


*Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

INPUT ADMITTANCE



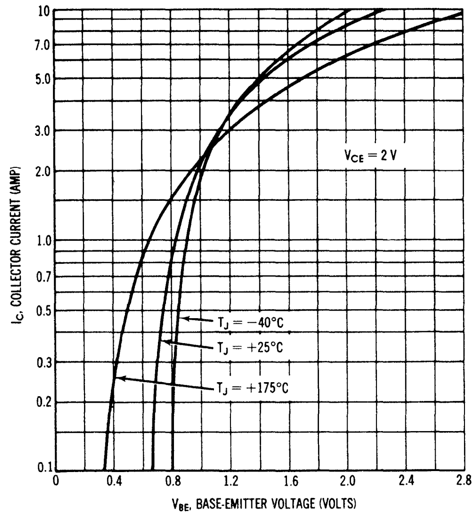
SATURATION REGION



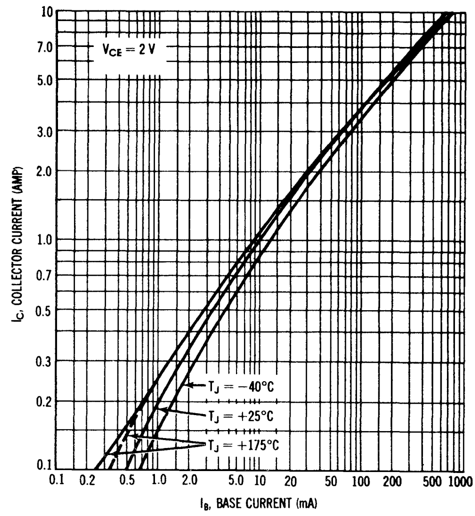
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3791, 2N3792

(PULSE TEST: pulse width ≈ 200 μsec, duty cycle ≈ 1%)

TRANSCONDUCTANCE

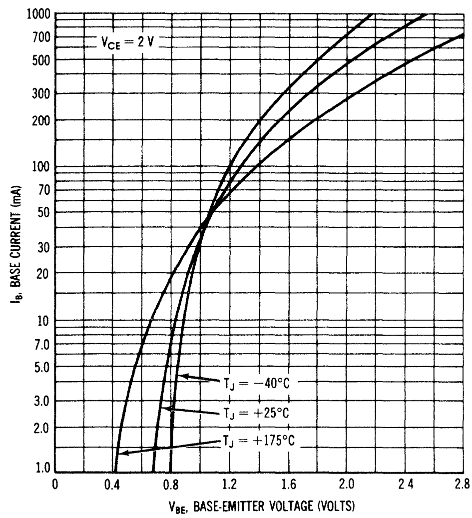


CURRENT GAIN

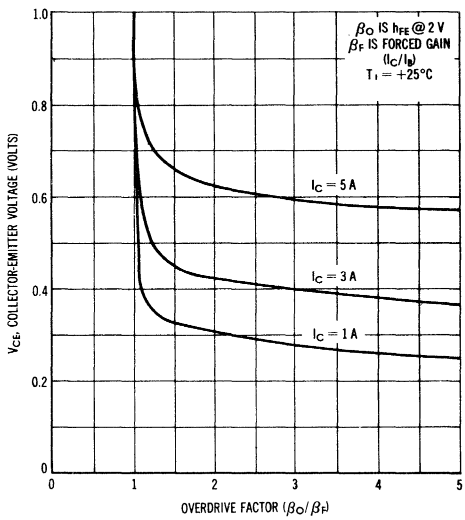


Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

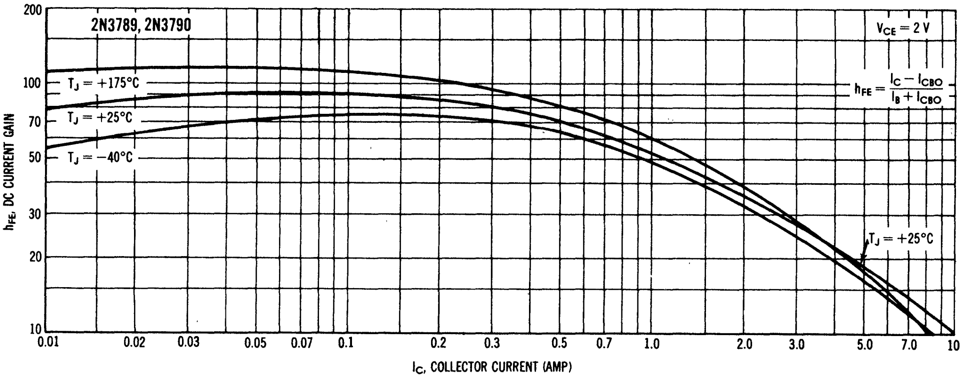
INPUT ADMITTANCE



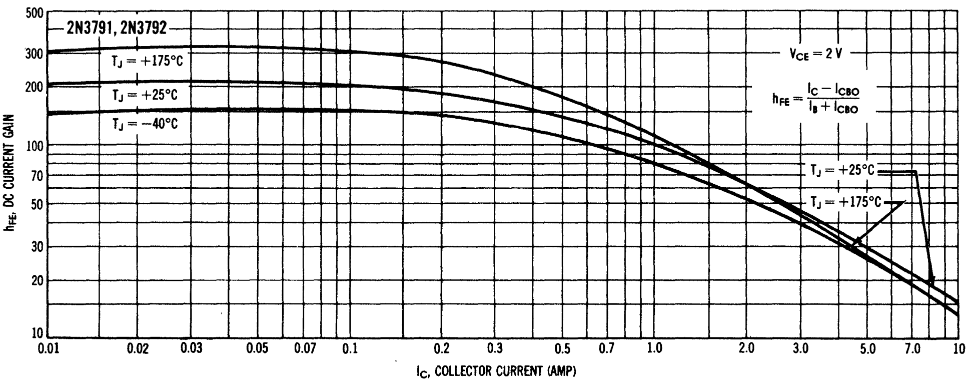
SATURATION REGION



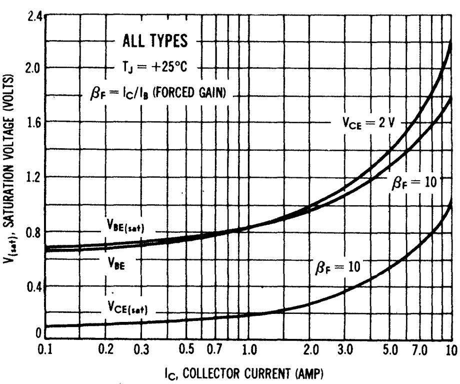
CURRENT GAIN VARIATIONS



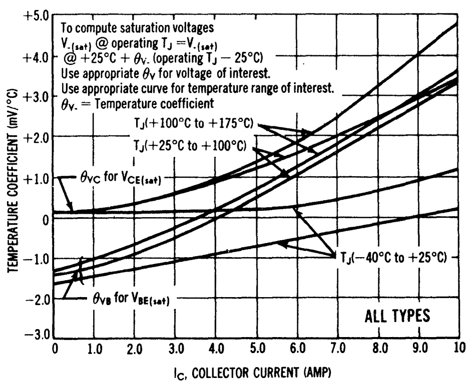
CURRENT GAIN VARIATIONS



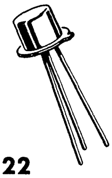
SATURATION VOLTAGES



TEMPERATURE COEFFICIENTS

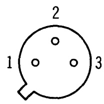


2N3796 (SILICON)
2N3797



Silicon N-channel MOS field-effect transistor designed for low-power applications in the audio frequency range.

CASE 22
(TO-18)



STYLE 2:
PIN 1. SOURCE,SUBSTRATE
AND CASE
2. GATE
3. DRAIN

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}		Vdc
2N3796		25	
2N3797		20	
Gate-Source Voltage	V_{GS}	**±30**	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Drain-Source Breakdown Voltage		BV_{DSX}				Vdc
(V_{GS} = -4.0 V, I_D = 5.0 μA)	2N3796		25	30	—	
(V_{GS} = -7.0 V, I_D = 5.0 μA)	2N3797		20	25	—	
Zero-Gate-Voltage Drain Current		I_{DSS}				mAdc
(V_{DS} = 10 V, V_{GS} = 0)	2N3796		0.5	1.5	3.0	
	2N3797		2.0	2.9	6.0	
Gate-Source Voltage Cutoff		$V_{GS(off)}$				Vdc
(I_D = 0.5 μA, V_{DS} = 10 V)	2N3796		—	3.0	4.0	
(I_D = 2.0 μA, V_{DS} = 10 V)	2N3797		—	5.0	7.0	
"On" Drain Current		$I_{D(on)}$				mAdc
(V_{DS} = 10 V, V_{GS} = +3.5 V)	2N3796		7.0	8.3	14	
	2N3797		9.0	14	18	
Drain-Gate Reverse Current * (V_{DG} = 10 V, I_S = 0)		I_{DGO} *	—	—	1.0	pAdc
Gate-Reverse Current *		I_{GSS} *				pAdc
(V_{GS} = -10 V, V_{DS} = 0)			—	—	1.0	
(V_{GS} = -10 V, V_{DS} = 0, T_A = 150°C)			—	—	200	
Small-Signal, Common-Source Forward Transfer Admittance		$\|y_{fs}\|$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	2N3796		900	1200	1800	
	2N3797		1500	2300	3000	
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	2N3796		900	—	—	
	2N3797		1500	—	—	
Small-Signal, Common-Source, Output Admittance		$\|y_{os}\|$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz)	2N3796		—	12	25	
	2N3797		—	27	60	
Small-Signal, Common-Source, Input Capacitance		C_{iss}				pF
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)	2N3796		—	5.0	7.0	
	2N3797		—	6.0	8.0	
Small-Signal, Common-Source, Reverse Transfer Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	—	0.5	0.8	pF
Noise Figure (V_{DS} = 10 V, V_{GS} = 0, f = 1.0 kHz, R_S = 3 megohms)		NF	—	3.8	—	dB

* This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under best attainable conditions.

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

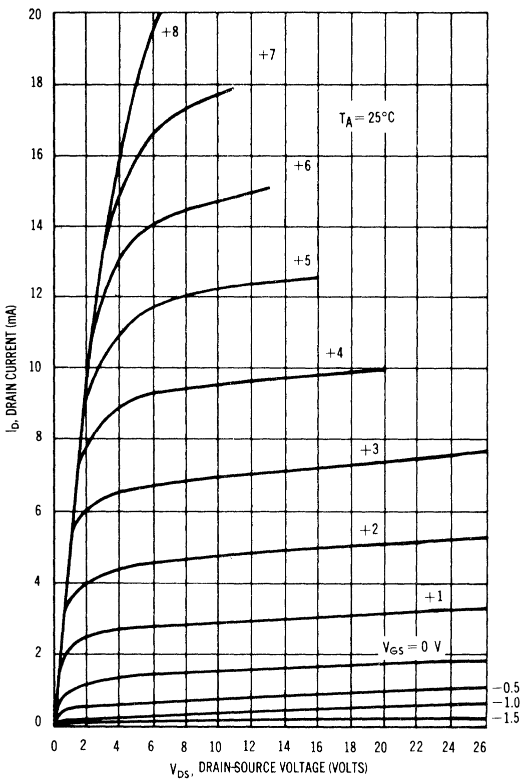
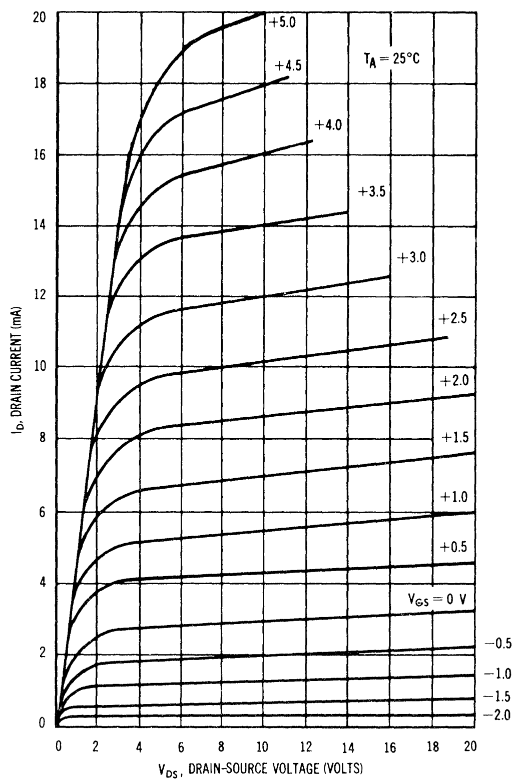


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

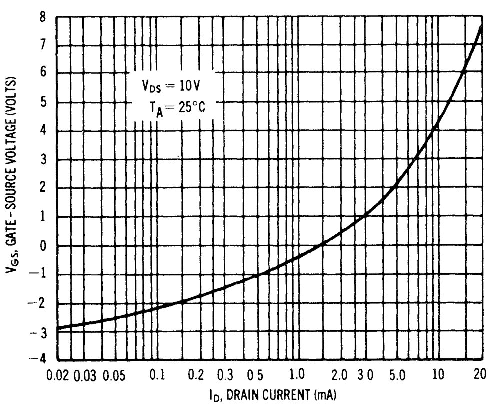


FIGURE 4 — 2N3797

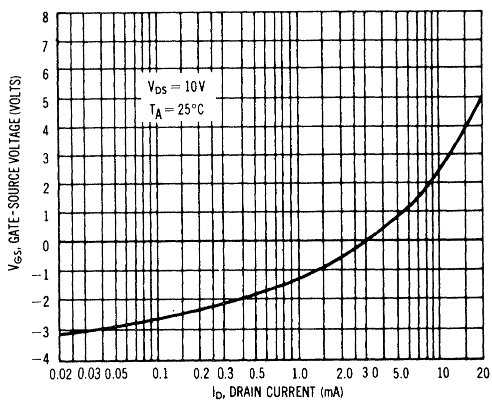


FIGURE 5 — FORWARD TRANSFER ADMITTANCE

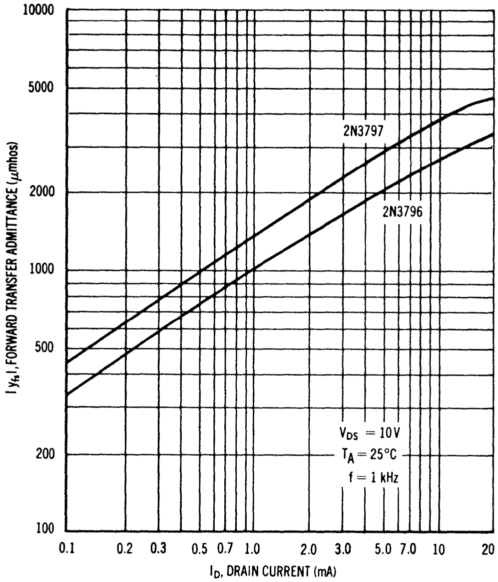


FIGURE 6 — AMPLIFICATION FACTOR

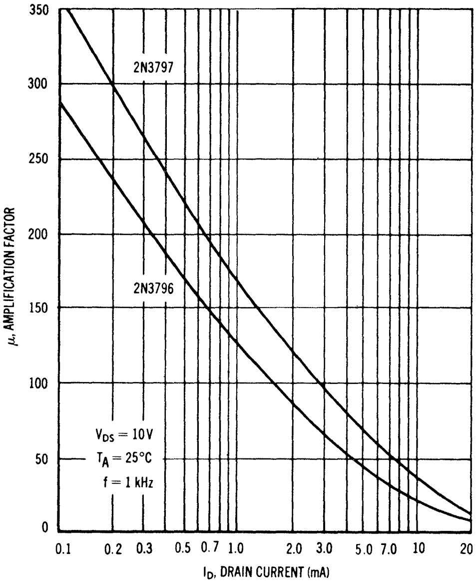


FIGURE 7 — OUTPUT ADMITTANCE

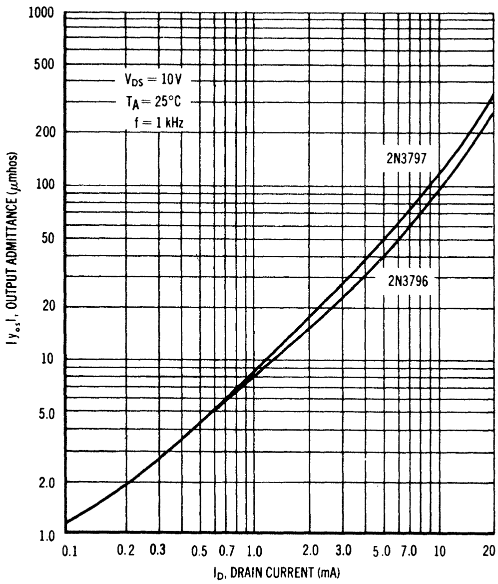
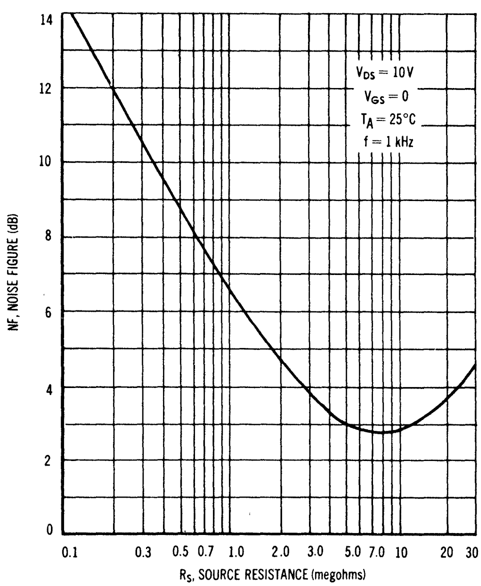


FIGURE 8 — NOISE FIGURE



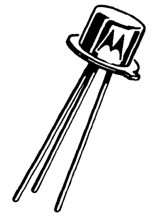
2N3798, 2N3798A (SILICON)
2N3799, 2N3799A

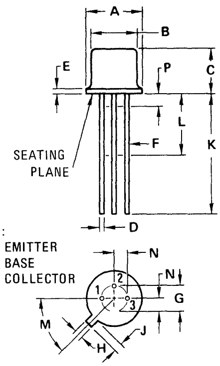
PNP SILICON ANNULAR TRANSISTORS

. . . designed for low-level, low-noise amplifier applications.

- High Collector-Emitter Breakdown Voltages –
  BV_{CEO} = 60 Vdc (Min) – 2N3798, 2N3799
  90 Vdc (Min) – 2N3798A, 2N3799A
- DC Current Gain – @ I_C = 500 μAdc
  h_{FE} = 150-450 – 2N3798, 2N3798A
  300-900 – 2N3799, 2N3799A
- Low Noise Figure –
  NF = 1.5 dB (Max) @ 1.0 kHz and 10 kHz

PNP SILICON AMPLIFIER TRANSISTORS





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	2N3798 2N3799	2N3798A 2N3799A	Unit
Collector-Emitter Voltage	V_{CEO}	60	90	Vdc
Collector-Base Voltage	V_{CB}	60	90	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06		Watt W/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.15	°C/mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.49	°C/mW

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	2N3798,2N3799	BV_{CEO}	60	–	–	Vdc
	2N3798A,2N3799A		90	–	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3798,2N3799	BV_{CBO}	60	–	–	Vdc
	2N3798A,2N3799A		90	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 50 Vdc, I_E = 0)			–	–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			–	–	10	
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	20	nAdc
ON CHARACTERISTICS						
DC Current Gain(1)		h_{FE}				–
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc)	2N3799,2N3799A		75	–	–	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc)	2N3798,2N3798A		100	–	–	
	2N3799,2N3799A		225	–	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3798,2N3798A		150	–	–	
	2N3799,2N3799A		300	–	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55°C)	2N3798,2N3798A		75	–	–	
	2N3799,2N3799A		150	–	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc)	2N3798,2N3798A		150	–	450	
	2N3799,2N3799A		300	–	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)	2N3798,2N3798A		150	–	–	
	2N3799,2N3799A		300	–	–	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc)	2N3798,2N3798A		125	–	–	
	2N3799,2N3799A		250	–	–	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			–	–	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	–	0.25	
Base-Emitter Saturation Voltage(1)		$V_{BE(sat)}$				Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)			–	–	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)			–	–	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	–	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product(2)		f_T				MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)			30	–	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)			100	–	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	–	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798,2N3798A	h_{ie}	3.0	–	15	k ohms
	2N3799,2N3799A		10	–	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	–	25	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3798,2N3798A	h_{fe}	150	–	600	–
	2N3799,2N3799A		300	–	900	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	–	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 k ohms),		NF				dB
Spot Noise: f = 100 Hz, B.W. = 20 Hz	2N3798,2N3798A		–	4.0	7.0	
	2N3799,2N3799A		–	2.5	4.0	
Spot Noise: f = 1.0 kHz, B.W. = 200 Hz	2N3798,2N3798A		–	1.5	3.0	
	2N3799,2N3799A		–	0.8	1.5	
Spot Noise: f = 10 kHz, B.W. = 2.0 kHz	2N3798,2N3798A		–	1.0	2.5	
	2N3799,2N3799A		–	0.8	1.5	
Broadband Noise-Bandwidth 10 Hz to 15.7 kHz	2N3798,2N3798A		–	2.5	3.5	
	2N3799,2N3799A		–	1.5	2.5	

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SPOT NOISE FIGURE

(V_{CE} = 10 Vdc, T_A = 25°C)

FIGURE 1 – SOURCE RESISTANCE EFFECTS, f = 1.0 kHz

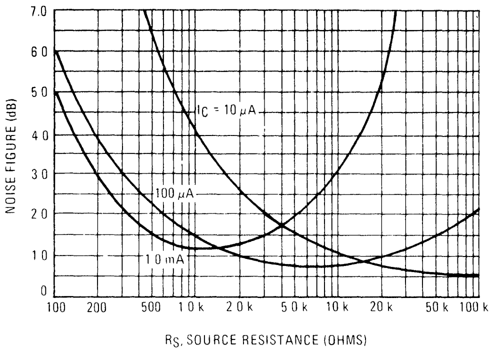


FIGURE 2 – SOURCE RESISTANCE EFFECTS, f = 10 Hz

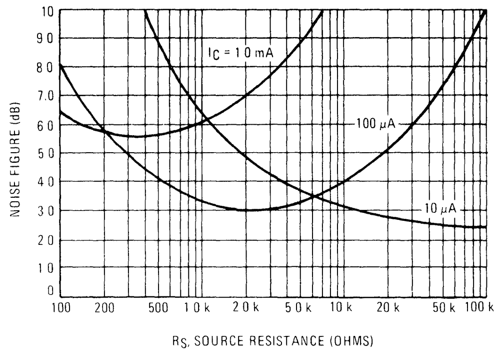


FIGURE 3 – FREQUENCY EFFECTS

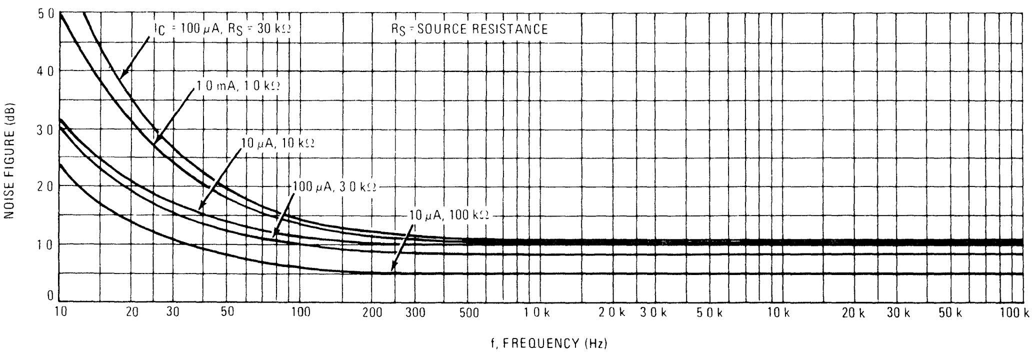
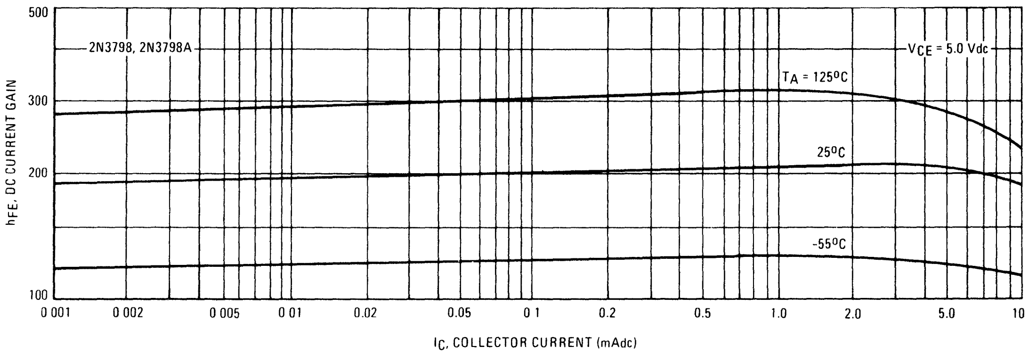
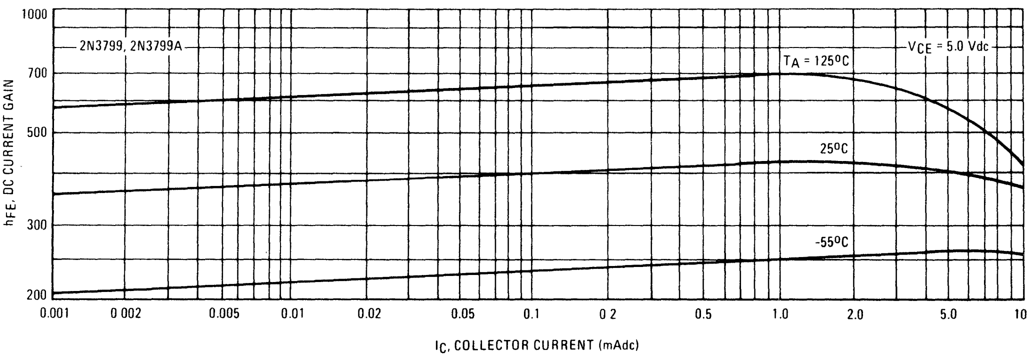


FIGURE 4 — TYPICAL CURRENT GAIN CHARACTERISTICS





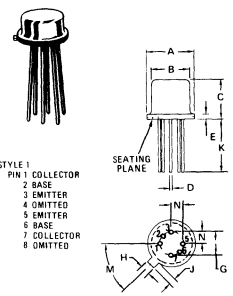
2N3806 thru 2N3810,A (SILICON)
2N3811,A
2N3812 thru 2N3816,A, 2N3817,A
2N3810, 2N3811, JAN,JTX,JTXV AVAILABLE

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking – Dual Devices
  2N3808, 9, 14, 15
  $\Delta|V_{BE1} - V_{BE2}|$ = 1.6 mVdc (Max) @ -55 to +25°C
  = 2.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 1.0 mAdc
- DC Current Gain Specified – 1.0 μAdc to 10 mAdc
- DC Current-Gain – Bandwidth Product –
  f_T = 100 MHz @ I_C = 1.0 mAdc

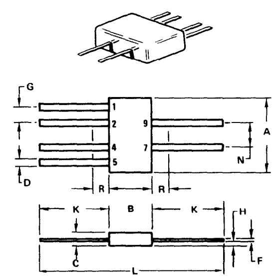
PNP SILICON MULTIPLE TRANSISTORS



STYLE 1
PIN 1 COLLECTOR
2 BASE
3 EMITTER
4 OMITTED
5 EMITTER
6 BASE
7 COLLECTOR
8 OMITTED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	–	0.500	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

CASE 654-07



STYLE 1
PIN 1 BASE
2 EMITTER
4 EMITTER
5 BASE
7. COLLECTOR
9. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

***MAXIMUM RATINGS**

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Metal Can (2N3806 thru 2N3810,A, 2N3811,A)	P_D	500	600	mW
Derate above 25°C		2.86	3.43	mW/°C
Total Power Dissipation @ T_C = 25°C Flat Package (2N3812 thru 2N3816,A, 2N3817,A)	P_D	250	350	mW
Derate above 25°C		1.43	2.06	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (each side) ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current	I_{CBO}			μAdc
(V_{CB} = 50 Vdc, I_E = 0)		–	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	10	
Emitter Cutoff Current ($V_{BE(off)}$= 4.0 Vdc, I_C = 0)	I_{EBO}	–	20	nAdc
ON CHARACTERISTICS				
DC Current Gain (1)	h_{FE}			–
(I_C = 1.0 μAdc, V_{CE} = 5.0 Vdc) 2N3807,9,11,A,13,15,17,A		75	–	
(I_C = 10 μAdc, V_{CE} = 5.0 Vdc) 2N3806,8,10,A,12,14,16,A		100	–	
2N3807,9,11,A,13,15,17,A		225	–	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc) 2N3806,8,10,A,12,14,16,A		150	450	
2N3807,9,11,A,13,15,17,A		300	900	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = −55°C) 2N3806,8,10,A,12,14,16,A		75	–	
2N3807,9,11,A,13,15,17,A		150	–	
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc) 2N3806,8,10,A,12,14,16,A		150	450	
2N3807,9,11,A,13,15,17,A		300	900	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc) 2N3806,8,10,A,12,14,16,A		150	450	
2N3807,9,11,A,13,15,17,A		300	900	
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc) 2N3806,8,10,A,12,14,16,A		125	–	
2N3807,9,11,A,13,15,17,A		250	–	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$			Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		–	0.2	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	0.25	
Base-Emitter Saturation Voltage (1)	$V_{BE(sat)}$			Vdc
(I_C = 100 μAdc, I_B = 10 μAdc)		–	0.7	
(I_C = 1.0 mAdc, I_B = 100 μAdc)		–	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	$V_{BE(on)}$	–	0.7	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current Gain – Bandwidth Product	f_T			MHz
(I_C = 500 μAdc, V_{CE} = 5.0 Vdc, f = 30 MHz)		30	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		100	500	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	4.0	pF
Input Capacitance ($V_{BE(off)}$ = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}			kΩ
2N3806,8,10,A,12,14,16,A		3.0	30	
2N3807,9,11,A,13,15,17,A		10	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	25	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}			–
2N3806,8,10,A,12,14,16,A		150	600	
2N3807,9,11,A,13,15,17,A		300	900	

*Indicates JEDEC Registered Data.

Characteristic		Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS (continued)					
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	60	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_G = 3.0 k ohms)		NF			dB
Spot Noise: f = 100 Hz, BW = 20 Hz	2N3806,8,10,A,12,14,16,A		–	7.0	
	2N3807,9,11,A,13,15,17,A		–	4.0	
Spot Noise: f = 1.0 kHz, BW = 2.0 kHz	2N3806,8,10,A,12,14,16,A		–	3.0	
	2N3807,9,11,A,13,15,17,A		–	1.5	
Spot Noise: f = 10 kHz, BW = 200 Hz	2N3806,8,10,A,12,14,16,A		–	2.5	
	2N3807,9,11,A,13,15,17,A		–	1.5	
Broadband Noise Bandwidth 10 Hz to 15.7 kHz	2N3806,8,10,A,12,14,16,A		–	3.5	
	2N3807,9,11,A,13,15,17,A		–	2.5	
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (2)		h_{FE1}/h_{FE2}			–
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		0.8	1.0	
	2N3810,11,16,17		0.9	1.0	
	2N3810A,11A,16A,17A		0.95	1.0	
(I_C = 100 μAdc, V_{CE} = 50 Vdc, T_A = -55 to +125°C)	2N3810A,11A,16A,17A		0.85	1.0	
Base-Emitter Voltage Differential		$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 10 μAdc to 10 mAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		–	8.0	
	2N3810,A,11,A,16,A,17,A		–	5.0	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc)	2N3808,9,14,15		–	5.0	
	2N3810,11,16,17		–	3.0	
	2N3810A,11A,16A,17A		–	1.5	
Base-Emitter Differential Change Due to Temperature		$\Delta\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = -55 to +25°C)	2N3808,9,14,15		–	1.6	
	2N3810,11,16,17		–	0.8	
	2N3810A,11A,16A,17A		–	0.4	
(I_C = 100 μAdc, V_{CE} = 5.0 Vdc, T_A = +25 to +125°C)	2N3808,9,14,15		–	2.0	
	2N3810,11,16,17		–	1.0	
	2N3810A,11A,16A,17A		–	0.5	

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.
(2) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N3818 (SILICON)

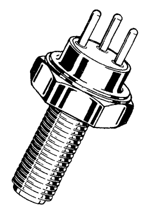
The RF Line

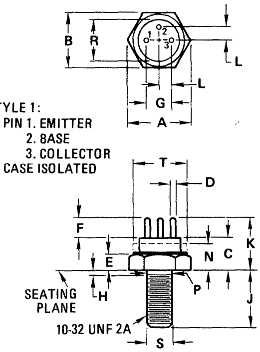
NPN SILICON RF POWER TRANSISTOR

. . . designed for applications to 150 MHz.

- High Collector-Emitter Sustaining Voltage –
  $V_{CE(sus)}$ = 80 Vdc (Min)
- Power Output –
  P_{out} = 15 Watts at 100 MHz
- Power Gain –
  G_{PE} = 7.0 dB (Typ) at 100 MHz with 15 Watts RF Power Output

15 W - 100 MHz
RF POWER
TRANSISTOR
NPN SILICON





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.57	13.08	0.495	0.515
B	10.77	11.10	0.424	0.437
C	5.46	8.13	0.215	0.320
D	0.762	1.17	0.030	0.046
E	2.29	3.43	0.090	0.135
G	4.70	5.46	0.185	0.215
H	–	1.98	–	0.078
J	9.53	11.56	0.375	0.455
K	9.02	12.19	0.355	0.480
L	2.29	2.79	0.090	0.110
N	–	4.19	–	0.165
P	4.14	4.80	0.163	0.189
R	8.13	9.14	0.320	0.360
T	9.14	11.10	0.360	0.437

All JEDEC dimensions and notes apply

CASE 36
TO-60

MAXIMUM RATINGS (Note 1)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CES}	60	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Base Current – Continuous	I_B	1.0	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	25 167	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C
Power Input (Nominal)	P_{in}	5.0	Watts
Power Output (Nominal)	P_{out}	20	Watts

Note 1. The maximum ratings as given for dc conditions can be exceeded on a pulse basis. See electrical characteristics.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (I_C = 0.25 Adc, I_B = 0)		$V_{CEO(sus)}$	40	–	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 0.25 Adc, R_{BE} = 0)		$V_{CES(sus)}$	80	100	–	Vdc
Collector-Emitter Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)			–	–	0.5	
(V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C)			–	–	1.0	
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	–	1.0	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	–	100	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 400 mAdc, V_{CE} = 2.0 Vdc)			5.0	–	50	
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)			5.0	–	–	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 250 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 250 mAdc)		$V_{BE(sat)}$	–	–	2.0	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product (V_{CE} = 2.0 Vdc, I_C = 400 mAdc, f = 50 MHz)		f_T	150	–	–	MHz
Output Capacitance (V_{CB} = 25 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	40	pF
FUNCTIONAL TEST						
Power Input	Test Circuit Figure 5 (P_{out} = 15 W, f = 100 MHz, V_{CE} = 25 Vdc, I_C(max) = 1.0 Adc)	P_{in}	–	3.0	3.75	Watts
Efficiency		η	60	70	–	%

(1)Pulse Test: Pulse Width ≤100 μs, Duty Cycle = 2.0%.

FIGURE 1 — OUTPUT POWER versus FREQUENCY

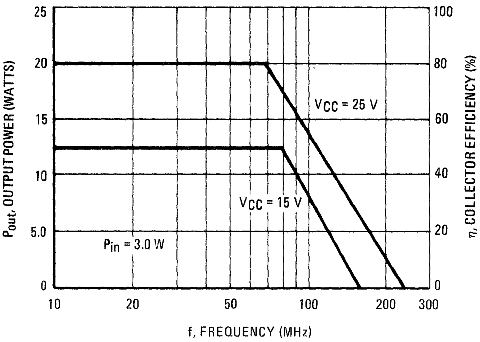


FIGURE 2 — OUTPUT CHARACTERISTICS versus INPUT POWER

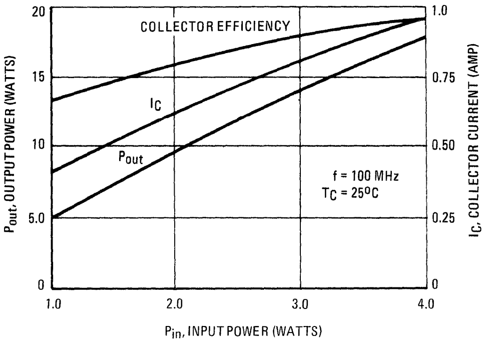


FIGURE 3 — OUTPUT POWER versus COLLECTOR VOLTAGE

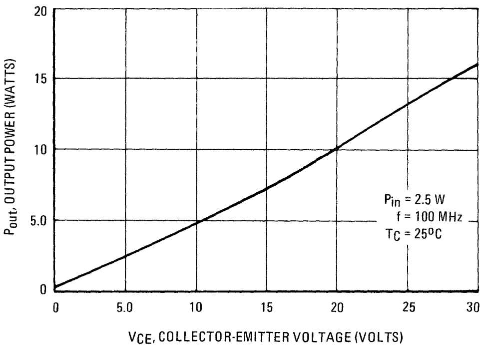


FIGURE 4 — OUTPUT POWER versus INPUT POWER

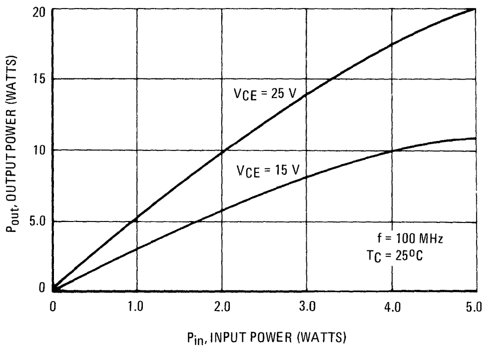
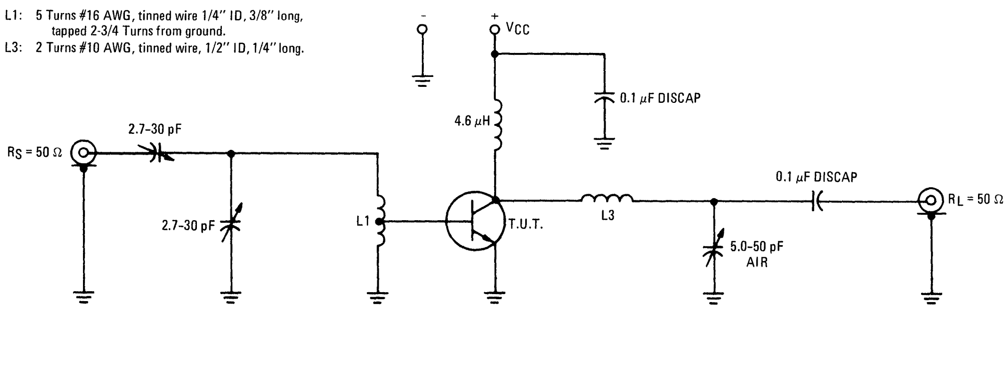


FIGURE 5 — TEST CIRCUIT

L1: 5 Turns #16 AWG, tinned wire 1/4" ID, 3/8" long, tapped 2-3/4 Turns from ground.
L3: 2 Turns #10 AWG, tinned wire, 1/2" ID, 1/4" long.



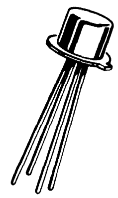
2N3821 (SILICON)
2N3822
2N3824

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

. . . designed for audio amplifier, chopper and switching applications.

- Drain and Source Interchangeable
- Low Drain-Source Resistance – $r_{ds(on)} \leq 250$ Ohms (Max) – 2N3824
- Low Noise Figure – NF = 5.0 dB (Max) – 2N3821, 2N3822
- High AC Input Impedance – C_{iss} = 6.0 pF (Max)
- High DC Input Resistance – I_{GSS} = 0.1 nA (Max)
- Low Transfer Capacitance – C_{rss} = 3.0 pF (Max)
- 2N3821 JAN and 2N3822 JAN also Available

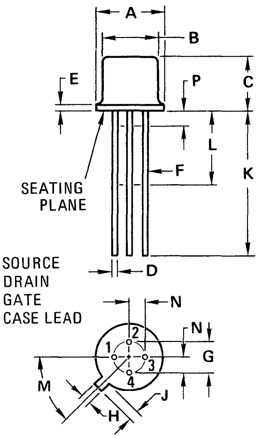
N-CHANNEL
JUNCTION
FIELD-EFFECT
TRANSISTORS
SYMMETRICAL
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	-50	Vdc
Drain Current	I_D	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



STYLE 1
PIN 1. SOURCE
2. DRAIN
3. GATE
4. CASE LEAD

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

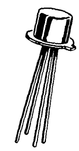
CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-50	–	Vdc
Gate Reverse Current		I_{GSS}			nAdc
(V_{GS} = -30 Vdc, V_{DS} = 0)			–	-0.1	
(V_{GS} = -30 Vdc, V_{DS} = 0, T_A = 150°C)			–	-100	
Gate-Source Cutoff Voltage		$V_{GS(off)}$			Vdc
(I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	2N3821		–	-4.0	
	2N3822		–	-6.0	
Gate-Source Voltage		V_{GS}			Vdc
(I_D = 50 μAdc, V_{DS} = 15 Vdc)	2N3821		-0.5	-2.0	
(I_D = 200 μAdc, V_{DS} = 15 Vdc)	2N3822		-1.0	-4.0	
Drain Cutoff Current		$I_{D(off)}$			nAdc
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc)	2N3824		–	0.1	
(V_{DS} = 15 Vdc, V_{GS} = -8.0 Vdc, T_A = 150°C)	2N3824		–	100	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current(1)		I_{DSS}			mAdc
(V_{DS} = 15 Vdc, V_{GS} = 0)	2N3821		0.5	2.5	
	2N3822		2.0	10	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance		$\|y_{fs}\|$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1)	2N3821		1500	4500	
	2N3822		3000	6500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)	2N3821		1500	–	
	2N3822		3000	–	
Output Admittance(1)		$\|y_{os}\|$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3821		–	10	
	2N3822		–	20	
Drain-Source Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3824		–	250	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	6.0	pF
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3821		–	3.0	
	2N3822		–	3.0	
(V_{GS} = -8.0 Vdc, V_{DS} = 0, f = 1.0 MHz)	2N3824		–	3.0	
Average Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 megohm, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	NF	–	5.0	dB
Equivalent Input Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 10 Hz, Noise Bandwidth = 5.0 Hz)	2N3821, 2N3822	e_n	–	200	nv/Hz½

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤100 ms, Duty Cycle ≤10%.

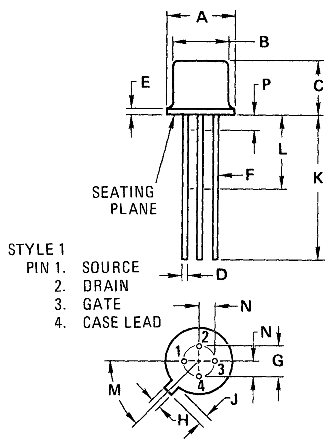
N-CHANNEL
JUNCTION
FIELD-EFFECT
TRANSISTOR
SYMMETRICAL
(Type A)



SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

. . . designed for VHF amplifier and mixer applications.

- Low Cross-Modulation and Intermodulation Distortion
- Drain and Source Interchangeable
- Low 100-MHz Noise Figure – 2.5 dB (Max)
- Low Transfer and Input Capacitances –
  C_{rss} = 2.0 pF (Max)
  C_{iss} = 6.0 pF (Max)
- 2N3823 JAN also Available



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ $T_A = 25^{\circ}C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = -1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-30	–	Vdc
Gate Reverse Current	I_{GSS}			nAdc
(V_{GS} = -20 Vdc, V_{DS} = 0)		–	-0.5	
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)		–	-500	
Gate-Source Cutoff Voltage (I_D = 0.5 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	–	-8.0	Vdc
Gate-Source Voltage (I_D = 0.4 mAdc, V_{DS} = 15 Vdc)	V_{GS}	-1.0	-7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	4.0	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance	$\lvert y_{fs} \rvert$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1)		3500	6500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		3200	–	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	–	800	μmhos
Output Conductance				μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)(1)	$\lvert y_{os} \rvert$	–	35	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{os})$	–	200	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	2.0	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	–	2.5	dB

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤10%.

2N3838 (SILICON)

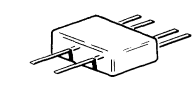
JAN,JTX,JTXV Available

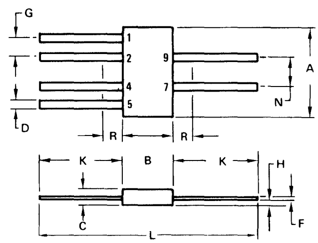
MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers and switches, front end detectors and temperature compensation applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- Fast Switching Times — t_{on} = 50 ns (Max) and t_{off} = 340 ns (Max)
- DC Current Gain Specified — 0.1 mAdc to 150 mAdc
- High Current-Gain—Bandwidth Product — f_T = 200 MHz @ I_C = 20 mAdc

NPN SILICON MULTIPLE TRANSISTORS





STYLE 1
PIN 1 BASE
2 EMITTER
4 EMITTER
5 BASE
7 COLLECTOR
9 COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0.080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±120 ±120		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.25 1.67	0.35 2.34	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.7 4.67	1.4 9.34	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

FIGURE 1 — TURN-ON TIME TEST CIRCUIT

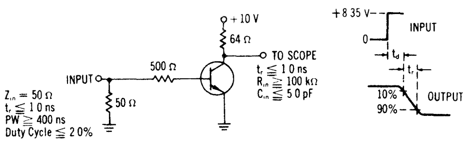


FIGURE 2 — TURN-OFF TIME TEST CIRCUIT

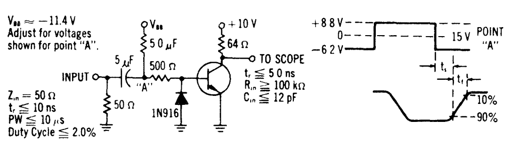
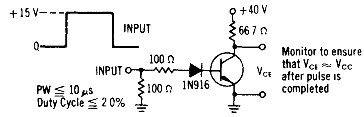


FIGURE 3 — COLLECTOR-EMITTER NONLATCHING VOLTAGE TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	-	Vdc
Collector-Emitter Nonlatching Voltage (Figure 3)† ($I_{C(on)}$ = 600 mAdc, $I_{B(on)}$ = 120 mAdc, $I_{B(off)}$ = 0)		$V_{CEO(NL)}$†	40	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{CEV}	-	0.01	μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_A = 150°C)			-	10	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	10	nAdc
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{BEV}	-	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)		h_{FE}	35	-	-
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) (1)			75	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)			100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (1)			50	-	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	0.85	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{ob}	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	1.5	9.0	k ohm
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	60	300	-
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	50	μmho
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)		NF	-	8.0	dB
Delay Time	(V_{CC} = 10 Vdc, $V_{BE(off)}$ = 0 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc, Figure 1)	t_d	-	10	ns
Rise Time		t_r	-	40	ns
Storage Time	(V_{CC} = 10 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc, Figure 2)	t_s	-	250	ns
Fall Time		t_f	-	90	ns

* Indicates JEDEC Registered Data

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

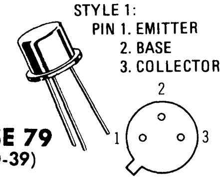
† The highest value of collector supply voltage that may be safely used with a resistive load switching circuit in which the collector current is 600 mAdc.

2N3839

For Specifications, See 2N2857 Data

2N3866 (SILICON)
2N3866A

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR



CASE 79
(TO-39)
Collector connected to case

NPN silicon transistor, designed for amplifier, frequency-multiplier, or oscillator applications in military and industrial equipment. Suitable for uses as output, driver, or pre-driver stages in VHF and UHF equipment.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Amp
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	BV_{CER}	55	–	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$BV_{CEO(sus)}$	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 0.1 mAdc)	BV_{CBO}	55	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	20	μA
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = 1.5 Vdc)	I_{CEX}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 0.36 Adc, V_{CE} = 5.0 Vdc)		5.0	–	–	
(I_C = 0.05 Adc, V_{CE} = 5.0 Vdc) 2N3866		10	–	200	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc) 2N3866A		25	–	200	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product	f_T				MHz
(I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz) 2N3866		500	800	–	
2N3866A		800	–	–	
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.0	3.0	pF

FUNCTIONAL TEST

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Power Gain	Test Circuit-Figure 1 P_{in} = 0.1 W, V_{CE} = 28 Vdc f = 400 MHz, T_C = 25°C	G_{pe}	10	–	–	dB
Power Output		P_{out}	1.0	–	–	Watts
Collector Efficiency		η	45	–	–	%

FIGURE 1 — 400 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST

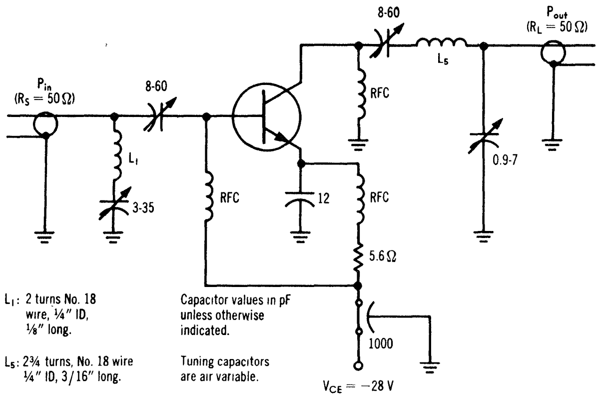


FIGURE 2 — POWER OUTPUT versus FREQUENCY (Class C)

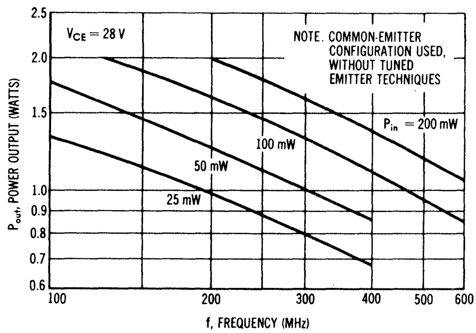


FIGURE 4 — PARALLEL INPUT RESISTANCE AND CAPACITANCE versus FREQUENCY (Class C)

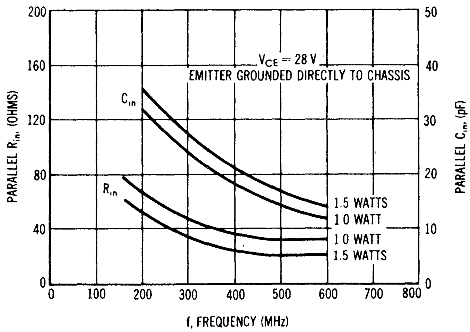


FIGURE 3 — POWER OUTPUT versus POWER INPUT (Class C)

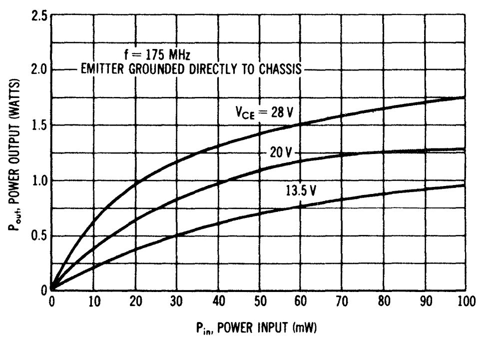


FIGURE 5 — PARALLEL OUTPUT CAPACITANCE versus FREQUENCY (Class C)

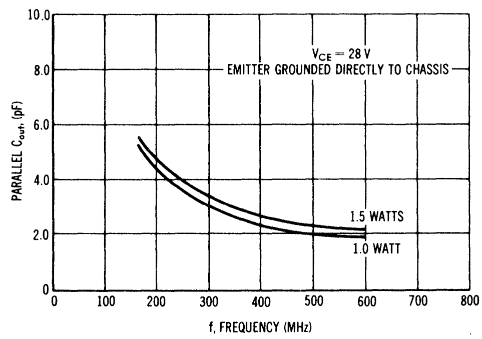


FIGURE 6 — SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

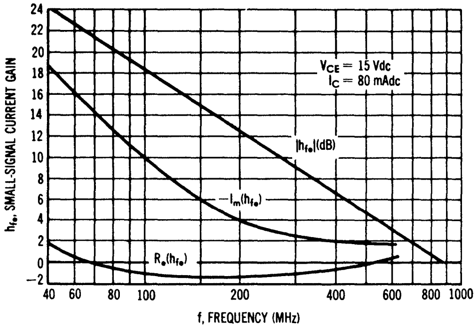


FIGURE 7 — OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

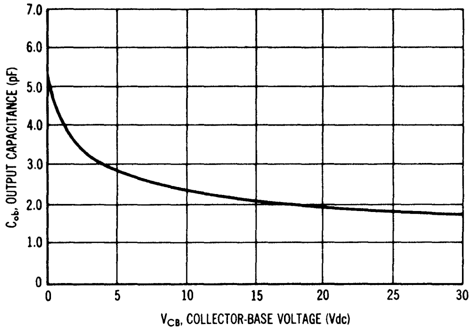


FIGURE 8 — f_T versus COLLECTOR CURRENT

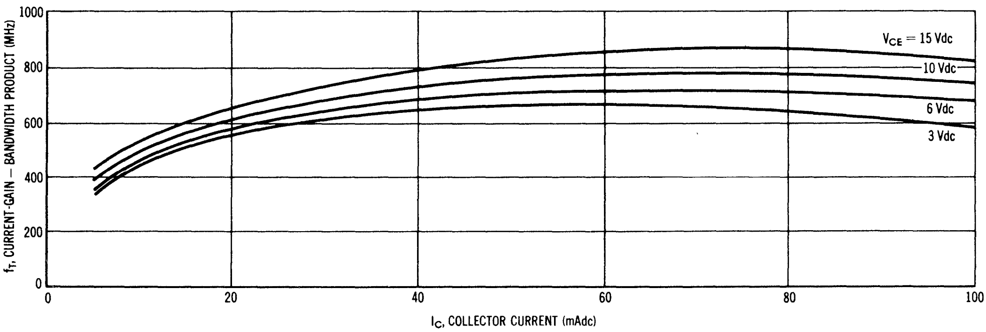


FIGURE 9 — $r_b'C_c$ versus COLLECTOR CURRENT

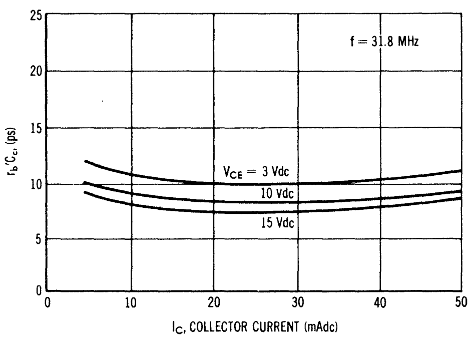
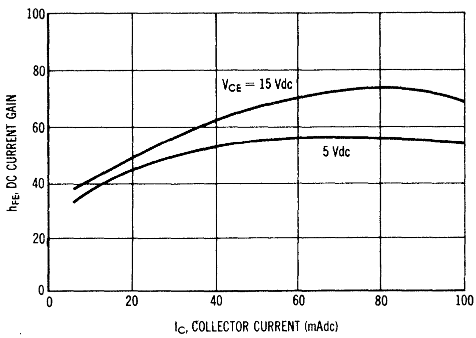


FIGURE 10 — DC CURRENT GAIN versus COLLECTOR CURRENT



y PARAMETER VARIATIONS

FIGURE 11 — SMALL-SIGNAL INPUT ADMITTANCE versus COLLECTOR CURRENT

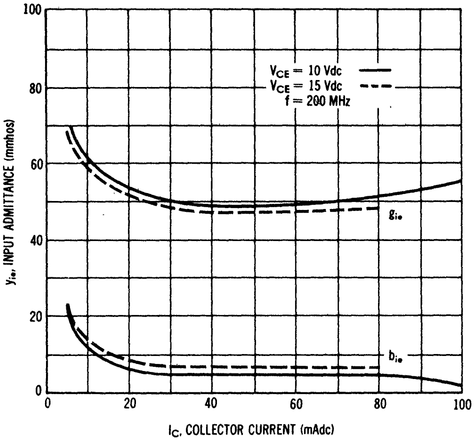


FIGURE 13 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

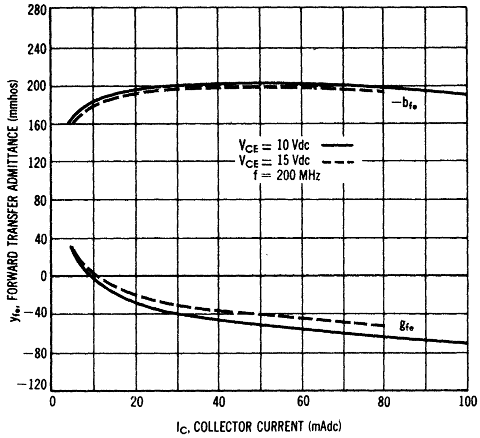


FIGURE 12 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

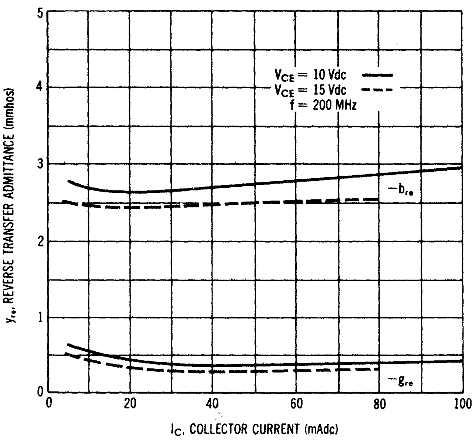
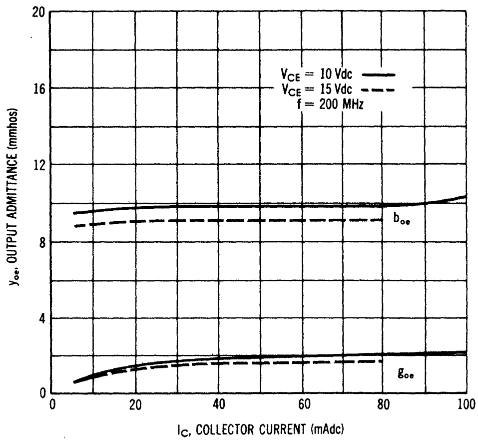


FIGURE 14 — SMALL-SIGNAL OUTPUT ADMITTANCE versus COLLECTOR CURRENT



DESIGN NOTE

Figures 11 through 18 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 and 5 give parallel output capacitance and the parallel input resistance and capacitance for Class C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression

$$R_L' = \frac{V_{CC}^2}{2P}$$

where P = RF power output. The computed R_L' may then be combined with the data in Figures 2 and 3 to comprise complete device impedance data for Class C power amplifier design.

y PARAMETER VARIATIONS

(V_{CE} = 15 Vdc, I_C = 80 mAdc, T_A = 25°C)

FIGURE 15 — SMALL-SIGNAL INPUT ADMITTANCE versus FREQUENCY

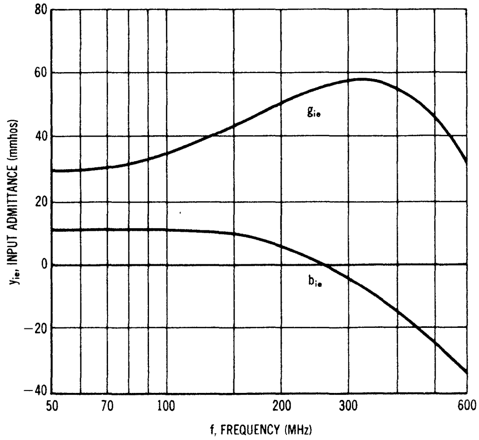


FIGURE 17 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

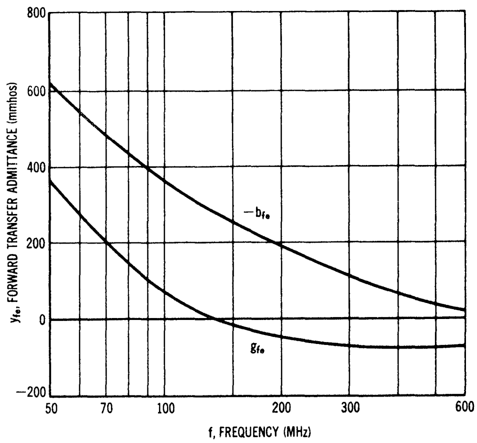


FIGURE 16 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus FREQUENCY

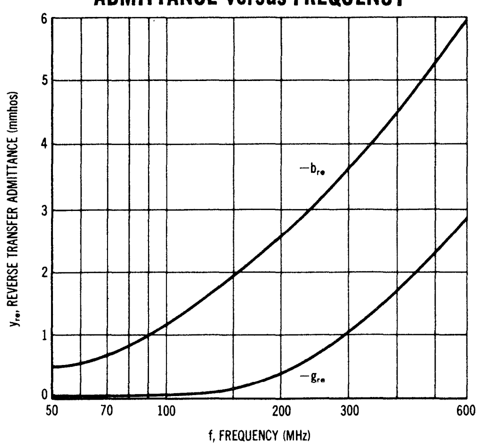
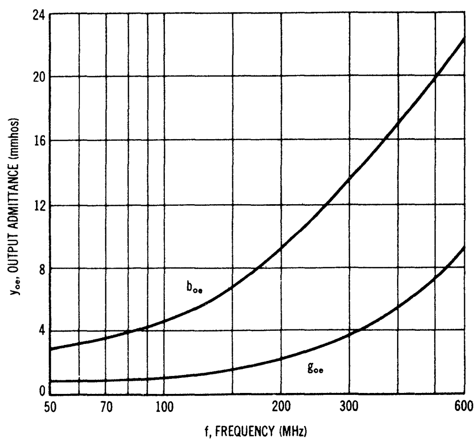


FIGURE 18 — SMALL-SIGNAL OUTPUT ADMITTANCE versus FREQUENCY



2N3867

2N3868

For Specifications, See 2N3719 Data

2N3870 thru 2N3873 (SILICON)
2N3896 thru 2N3899
2N6171 thru 2N6174

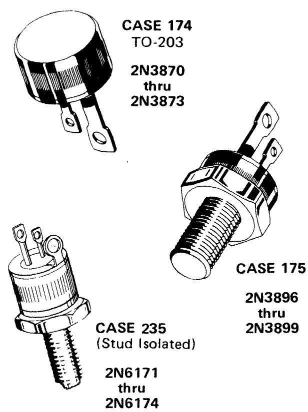
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies; battery chargers; temperature, motor, light and welder controls.

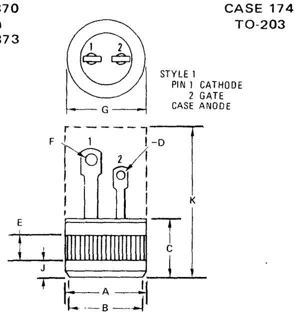
- Economical for a Wide Range of Uses
- High Surge Current – I_{TSM} = 350 Amp
- Practical Level Triggering and Holding Characteristics – 4.0 and 5.2 mA (Typ) @ T_C = 25°C
- Rugged Construction in Either Pressfit, Stud or Isolated Stud Package

THYRISTORS
PNPN

35 AMPERES RMS
100-600 VOLTS



2N3870 thru 2N3873 — CASE 174 TO-203



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	12 726	12 827	0 501	0 505
B	11 811	12 065	0 465	0 475
C	8 390	9 650	0 330	0 380
D	0 890	1 720	0 035	0 068
E	2 540	–	0 100	–
F	1 660	2 280	0 065	0 090
G	–	12 950	–	0 510
J	2 040	2 460	0 080	0 097
K	–	20 320	–	0 800

All JEDEC dimensions and notes apply

(continued on page 4)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage (1) (T_J = -40 to +100°C, 1/2 Sine Wave, 50 to 400 Hz, Gate Open)	V_{RRM}		Volts
2N3870, 2N3896, 2N6171		100	
2N3871, 2N3897, 2N6172		200	
2N3872, 2N3898, 2N6173		400	
2N3873, 2N3899, 2N6174		600	
*Non-Repetitive Peak Reverse Blocking Voltage ($t \leq$ 5 0 ms)	V_{RSM}		Volts
2N3870, 2N3896, 2N6171		150	
2N3871, 2N3897, 2N6172		330	
2N3872, 2N3898, 2N6173		660	
2N3873, 2N3899, 2N6174		700	
*Average On-State Current	$I_{T(AV)}$		Amp
(T_C = -40 to +65°C)		22	
(T_C = +85°C)		11	
Peak Non-Repetitive Surge Current (One cycle, 60 Hz) (T_C = +65°C)	I_{TSM}	350	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1 0 to 8 3 ms)	I^2t	510	A^2s
*Peak Gate Power	P_{GM}	20	Watts
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GM}	2 0	Amp
Peak Gate Voltage	V_{GM}	10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque 2N3896 thru 2N3899 * 2N6171 thru 2N6174	–	30	in lb.

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$		°C/W
2N3870 thru 2N3873, 2N3896 thru 2N3899		0 9	
2N6171 thru 2N6174		1 0	

*Indicates JEDEC Registered Data

(1) Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
* Peak Forward Blocking Voltage (T_J = 100°C)	V_{DRM}				Volts
2N3870, 2N3896, 2N6171		100	–	–	
2N3871, 2N3897, 2N6172		200	–	–	
2N3872, 2N3898, 2N6173		400	–	–	
2N3873, 2N3899, 2N6174		600	–	–	
* Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)	I_{DRM}				mA
2N3870, 2N3896, 2N6171		–	1.0	2.0	
2N3871, 2N3897, 2N6172		–	1.0	2.5	
2N3872, 2N3898, 2N6173		–	1.0	3.0	
2N3873, 2N3899, 2N6174		–	1.0	4.0	
* Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)	I_{RRM}				mA
2N3870, 2N3896, 2N6171		–	1.0	2.0	
2N3871, 2N3897, 2N6172		–	1.0	2.5	
2N3872, 2N3898, 2N6173		–	1.0	3.0	
2N3873, 2N3899, 2N6174		–	1.0	4.0	
*Peak On-State Voltage (I_{TM} = 69 A Peak)	V_{TM}	–	1.5	1.85	Volts
Gate Trigger Current, Continuous dc (V_{AK} = 12 V, R_L = 24 ohms) *T_C = −40°C	I_{GT}	–	9.0	80	mA
T_C = 25°C		–	4.0	40	
Gate Trigger Voltage, Continuous dc (V_{AK} = 12 V, R_L = 24 ohms) *T_C = −40°C	V_{GT}	–	0.9	3.0	Volts
T_C = 25°C		–	0.69	1.6	
Holding Current (Gate Open) (V_{AK} = 12 V, I_{TM} = 200 mA) *T_C = −40°C	I_H	–	14	90	mA
T_C = 25°C		–	5.2	50	
*Gate Controlled Turn-On Time (t_d + t_r) (I_{TM} = 41 Adc, V_{AK} = rated V_{DRM}, I_{GT} = 40 mAdc, Rise Time = 0.05 μs, Pulse Width = 10 μs)	t_{gt}	–	–	1.5	μs
Circuit Commutated Turn-Off Time	t_q				μs
(I_{TM} = 10 A, I_R = 10 A)		–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)		–	25	–	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs

*Indicates JEDEC Registered Data.

FIGURE 1 — AVERAGE CURRENT DERATING •

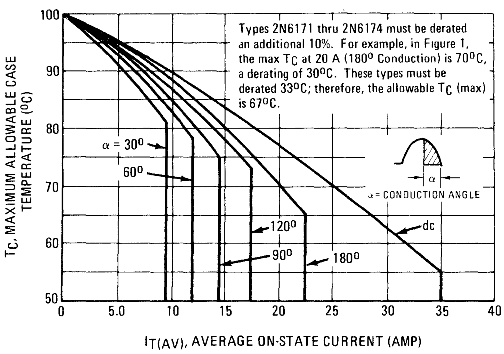


FIGURE 2 — ON-STATE POWER DISSIPATION

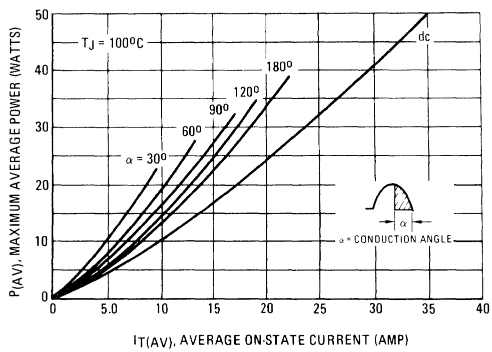


FIGURE 3 – MAXIMUM ON-STATE CHARACTERISTICS

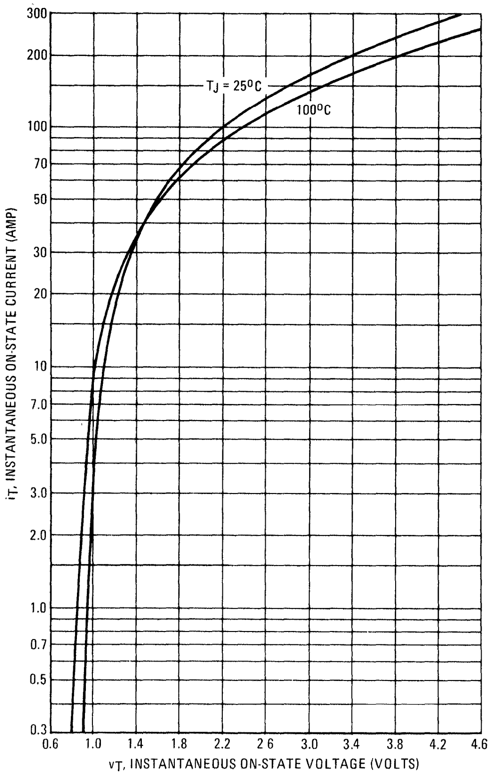


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CURRENT

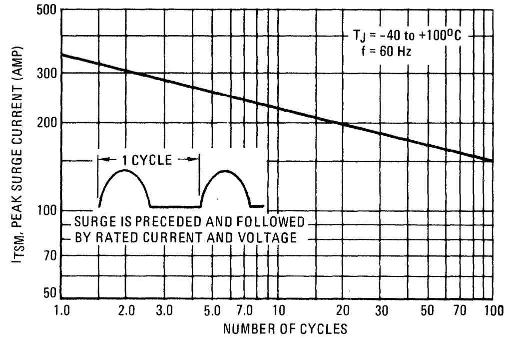


FIGURE 5 – CHARACTERISTICS AND SYMBOLS

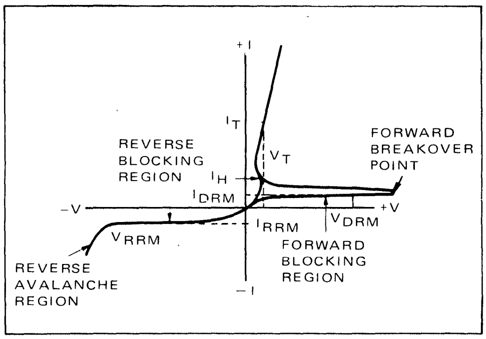


FIGURE 6 – TYPICAL THERMAL RESPONSE

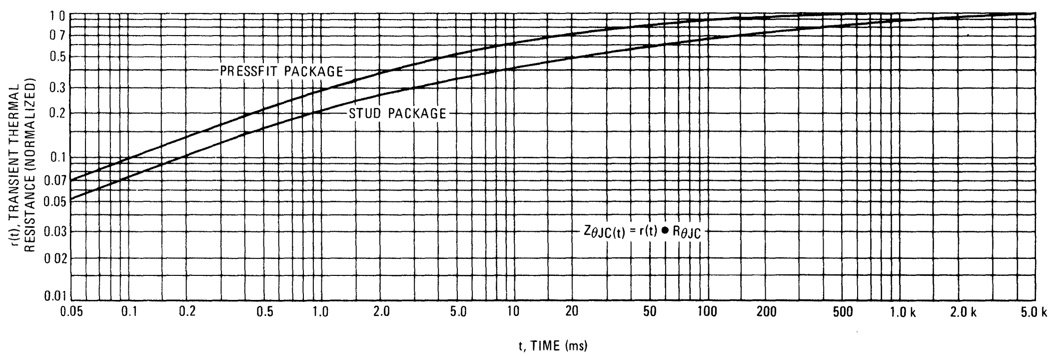


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

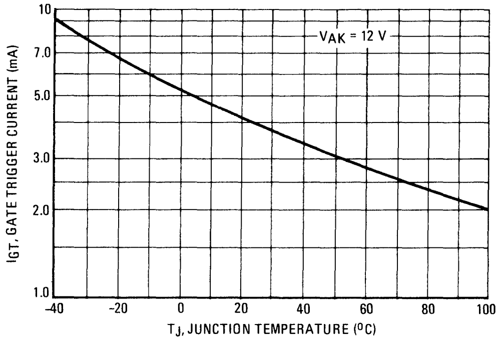


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE

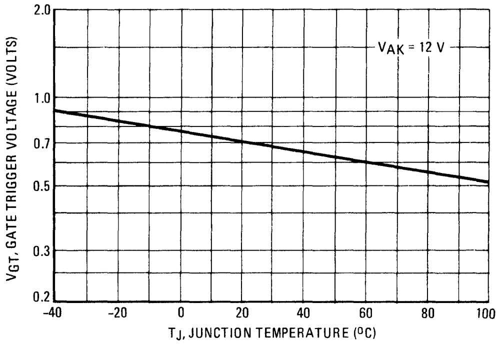
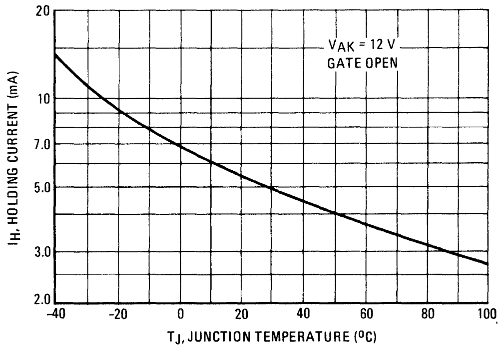


FIGURE 9 – TYPICAL HOLDING CURRENT



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240 – SCR Power Control Fundamentals
AN-295 – Suppressing RFI in Thyristor Circuits
AN-422 – Testers for Thyristors and Trigger Diodes
AN-453 – Zero Point Switching Techniques

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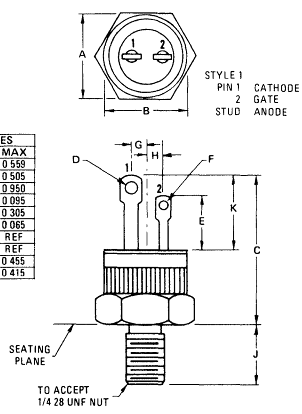
Motorola Semiconductor Products, Inc.
P.O Box 20924
Phoenix, Arizona 85036

PACKAGE DIMENSIONS

CASE 175

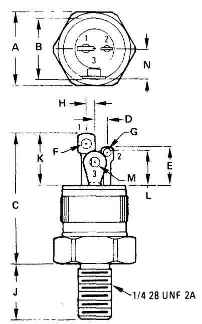
2N3896
thru
2N3899



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14 000	14 200	0 551	0 559
B	12 730	12 830	0 501	0 505
C	–	74.130	–	0 950
D	2 030	2 410	0 080	0 095
E	–	7.750	–	0 305
F	1 400	1 650	0 055	0 065
G	1 650	REF	0 065	REF
H	2 290	REF	0 090	REF
J	10.670	11 560	0 420	0 455
K	–	10 540	–	0 415

CASE 235

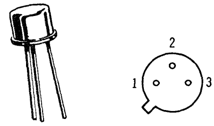
2N6171
thru
2N6174



STYLE 1
PIN 1 CATHODE
2 GATE
3 ANODE
STUD ISOLATED

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14 000	14 200	0 551	0 559
B	12 730	12 830	0 501	0 505
C	–	26 160	–	1 030
D	2 290 REF		0.090 REF	
E	–	7 750	–	0 305
F	2 030	2 410	0 080	0 095
G	1 400	1 650	0 055	0 065
H	1 650 REF		0 065 REF	
J	10 670	11 560	0 420	0 455
K	–	10 540	–	0 415
L	6 480	7 000	0 255	0 275
M	3 430	3 810	0 135	0 150
N	–	6 480	–	0 255

2N3883 (Ge Mesa)



CASE 79-02
(TO-39)

STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

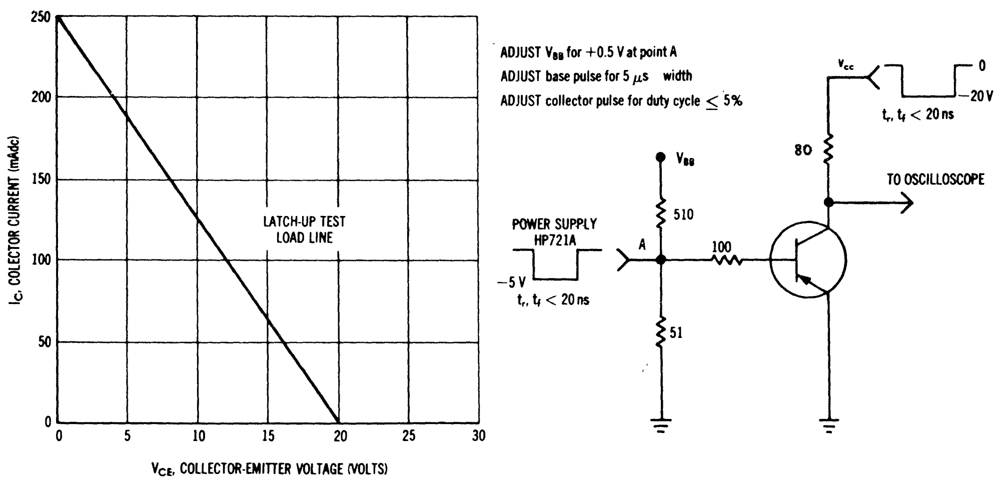
Medium-current, germanium PNP high-speed switching transistor.

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Units
Collector-Base Voltage	V_{CB}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current - Continuous	I_C	300	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 10	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 4.0	mW mW/°C

*Indicates JEDEC Registered Data

FIGURE 1—COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT

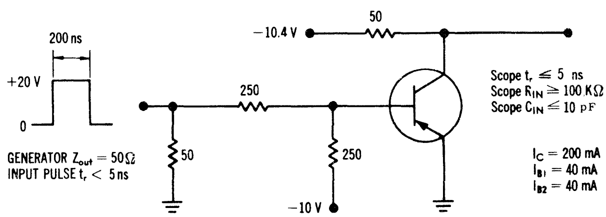


*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100μAdc, I_E = 0)	BV_{CBO}	25	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10mAdc, I_B = 0)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	—	Vdc
Latch-Up Voltage	LV_{CEX}	20	—	Vdc
Collector-Emitter Leakage Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	—	100	μAdc
Base Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_B	—	100	μAdc
DC Current Gain (I_C = 20C mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	—	—
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 40 mAdc	$V_{CE(sat)}$	—	0.5	Vdc
Base-Emitter Voltage (I_C = 200 mAdc, I_B = 40 mAdc)	V_{BE}	0.4	0.9	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	—	8.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	25	pF
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 40 mAdc, f = 100 MHz)	f_T	100	—	MHz
Delay Time (Figure 2)	t_d	—	15	ns
Rise Time (Figure 2)	t_r	—	40	ns
Storage Time (Figure 2)	t_s	—	70	ns
Fall Time (Figure 2)	t_f	—	40	ns

*Indicates JEDEC Registered Data

FIGURE 2—SWITCHING TIME TEST CIRCUIT



2N3896 thru 2N3899 (SILICON)

For Specifications, See 2N3870 Data

2N3902 NPN (SILICON)
2N5157

HIGH VOLTAGE NPN SILICON TRANSISTORS

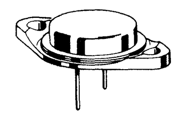
. . . designed for use in high-voltage inverters, converters, switching regulators and line operated amplifiers.

- High Collector-Emitter Voltage – V_{CEX} = 700 Vdc
- Excellent DC Current Gain –
  h_{FE} = 10 (Min) @ I_C = 2.5 Adc
- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.8 Vdc (Max) @ I_C = 1.0 Adc

3.5 AMPERE

POWER TRANSISTORS
NPN SILICON

400 and 500 VOLTS
100 WATTS



*MAXIMUM RATINGS

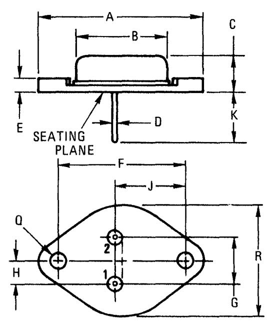
Rating	Symbol	2N3902	2N5157	Unit
Collector-Emitter Voltage	V_{CEO}	400	500	Vdc
Collector-Emitter Voltage	V_{CEX}	700		Vdc
Emitter-Base Voltage	V_{EB}	5.0	6.0	Vdc
Collector Current – Continuous	I_C	3.5		Adc
Base Current	I_B	2.0		Adc
Total Device Dissipation @ T_C = 75°C Derate above 75°C	P_D	100 1.33		Watts W/°C
Operating Junction Temperature Range	T_J	-65 to +150		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.75	°C/W

*Indicates JEDEC Registered Data

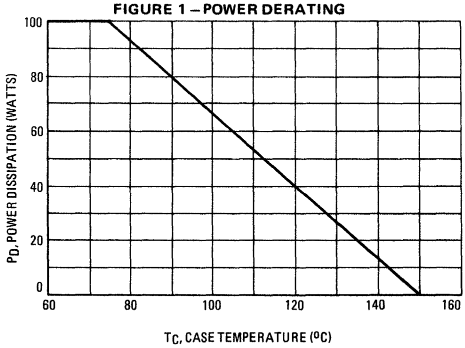
STYLE 1:
PIN 1. BASE
2. EMITTER
CASE: COLLECTOR



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	6.35	7.62	0.250	0.300
D	0.99	1.09	0.039	0.043
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

Collector connected to case.
CASE 11

FIGURE 1 – POWER DERATING

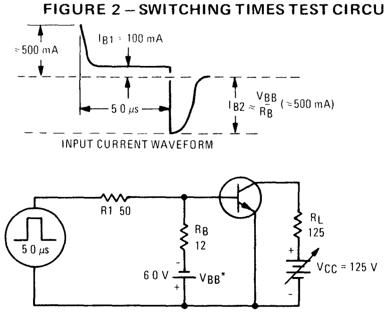


***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc, I_B = 0) (See Figure 12)	2N3902 2N5157	$V_{CEO(sus)}$	325 400	--	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3.5 Adc, R_{BE} = 10 Ohms) (See Figure 12)	2N5157	BV_{CER}	500	-	Vdc
Collector Cutoff Current (V_{CE} = 400 Vdc, I_B = 0) (V_{CE} = 500 Vdc, I_B = 0)	 2N3902 2N5157	I_{CEO}	 0.25 0.25		mAdc
Collector Cutoff Current (V_{CE} = 700 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 400 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)	 2N3902 2N5157 Both Types	I_{CEX}	 -- --	 2.5 0.5 0.5	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0) (V_{BE} = 6.0 Vdc, I_C = 0)	 2N3902 2N5157	I_{EBO}	 - -	 5.0 5.0	mAdc
ON CHARACTERISTICS(1)					
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc) (I_C = 2.5 Adc, V_{CE} = 5.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc, T_C = -55°C)	 2N3902,2N5157 2N3902,2N5157 2N5157	h_{FE}	 30 10 10	 90	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 2.5 Adc, I_B = 0.5 Adc) (I_C = 3.5 Adc, I_B = 0.7 Adc)	 2N3902,2N5157 2N3902 2N5157	$V_{CE(sat)}$	 -- -	 0.8 2.5 2.5	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 2.5 Adc, I_B = 0.5 Adc) (I_C = 3.5 Adc, I_B = 0.7 Adc)	 2N3902,2N5157 2N3902 2N5157	$V_{BE(sat)}$		 1.5 2.0 2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain Bandwidth Product (I_C = 0.2 Adc, V_{CE} = 10 Vdc) (I_C = 0.2 Adc, V_{CE} = 12 Vdc)	 2N3902 2N5157	f_T	 2.8 2.8	 --	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1.0 MHz)	2N5157	C_{ob}	-	150	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 125 Vdc, I_C = 1.0 Adc, I_{B1} = 0.1 Adc)	2N5157	t_{on}		0.8	μs
Turn-Off Time (V_{CC} = 125 Vdc, I_C = 1.0 Adc, I_{B1} = 0.1 Adc, I_{B2} = 0.5 Adc)	2N5157	t_{off}	-	1.7	μs

*Indicates JEDEC Registered Data
(1)Pulse Test Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – SWITCHING TIMES TEST CIRCUIT



5.0% Duty Cycle
t_r = 100 ns
*For 2N3902 – change V_{BB} to 5.0 V

FIGURE 3 – TURN-ON TIME

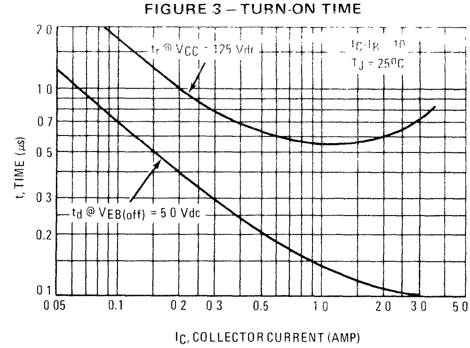


FIGURE 4 – THERMAL RESPONSE

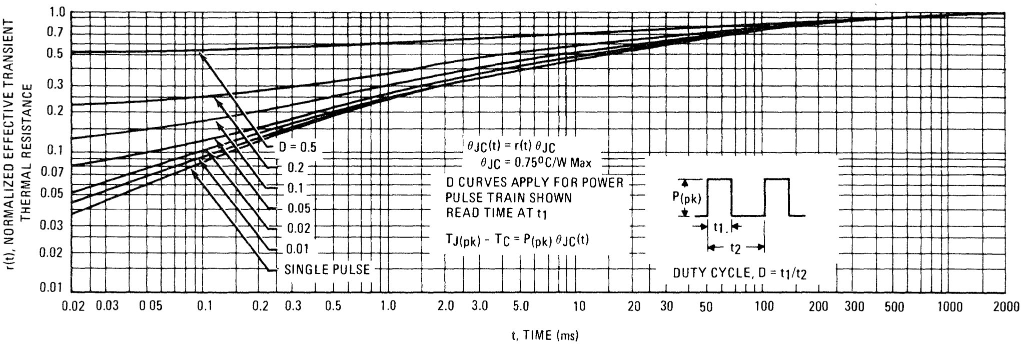
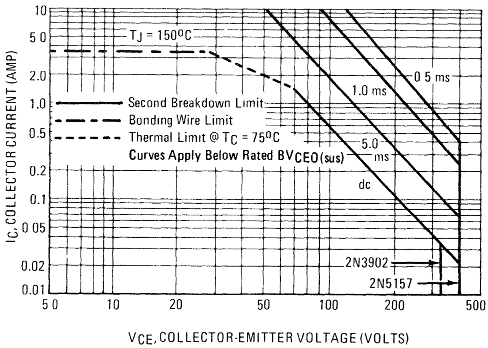


FIGURE 5 – ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 150^oC$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 150^oC$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown. (See AN-415)

FIGURE 6 – TURN-OFF TIME

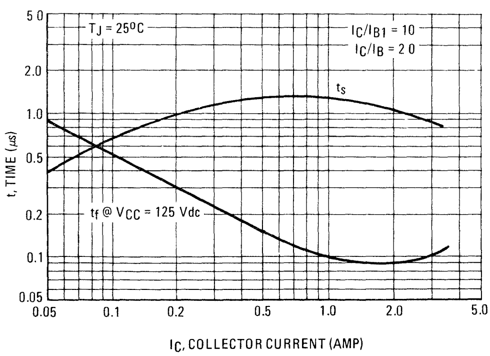


FIGURE 7 – CAPACITANCE

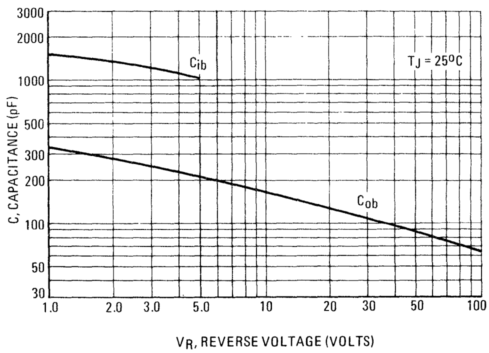


FIGURE 8 – DC CURRENT GAIN

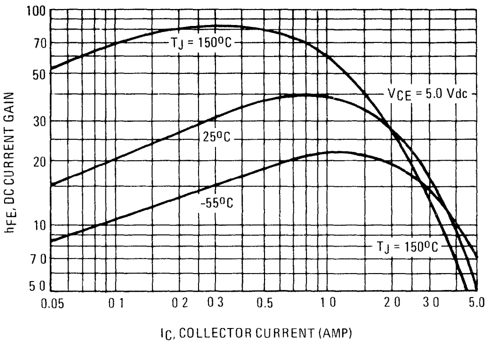


FIGURE 9 – "ON" VOLTAGES

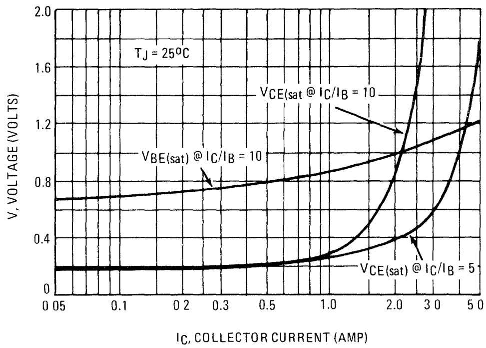


FIGURE 10 – COLLECTOR CUT-OFF REGION

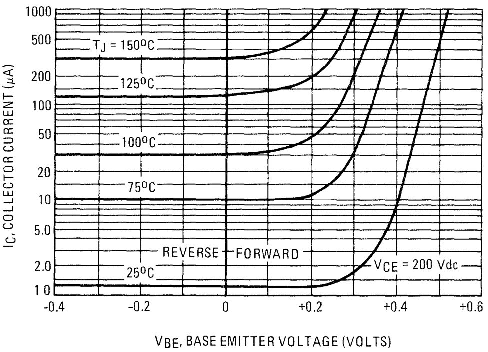


FIGURE 11 – TEMPERATURE COEFFICIENTS

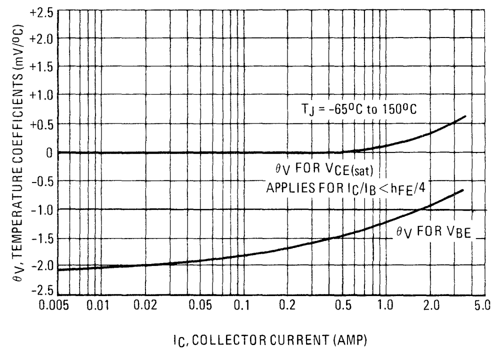
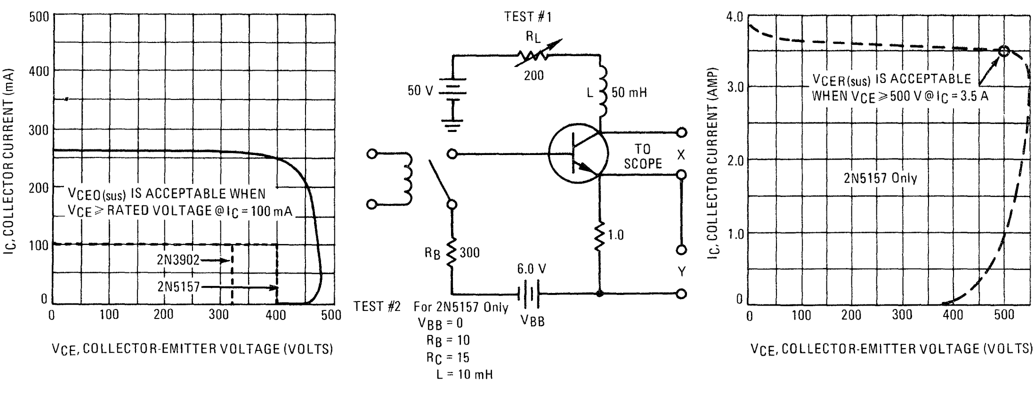


FIGURE 12 – COLLECTOR-EMITTER SUSTAINING VOLTAGE TEST CIRCUITS AND LOAD LINES



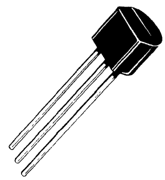
2N3903 (SILICON)
2N3904

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general purpose switching and amplifier applications and for complementary circuitry with types 2N3905 and 2N3906.

- Collector-Emitter Breakdown Voltage – BV_{CEO} = 40 Vdc (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications
- Low Capacitance – C_{ob} = 4.0 pF (Max)

NPN SILICON SWITCHING & AMPLIFIER TRANSISTORS



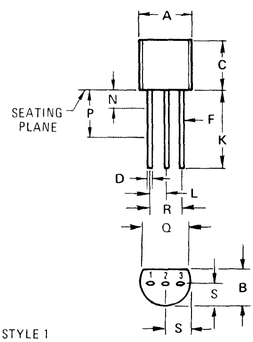
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current – Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watts mW/°C
Junction Operating Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data



STYLE 1
PIN 1 EMITTER
2 BASE
3 COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4 450	5 200	0 175	0 205
B	3 180	4 190	0 125	0 165
C	4 320	5 330	0 170	0 210
D	0 407	0 533	0 016	0 021
F	0 407	0 482	0 016	0 019
K	12 700	–	0 500	--
L	1 150	1.390	0 045	0.055
N	–	1 270	–	0.050
P	6 350	–	0 250	–
Q	3 430	·	0 135	–
R	2 410	2 670	0 095	0.105
S	2 030	2 670	0 080	0 105

CASE 29-02
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)			BV_{CEO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6.0	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)			I_{CEV}	-	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{EB(off)}$ = 3.0 Vdc)			I_{BEV}	-	50	nAdc
ON CHARACTERISTICS						
DC Current Gain (1)		15	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N3903			20	-	
	2N3904			40	-	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)	2N3903			35	-	
	2N3904			70	-	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3903			50	150	
	2N3904			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	2N3903			30	-	
	2N3904			60	-	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3903			15	-	
	2N3904			30	-	
Collector-Emitter Saturation Voltage (1)		16, 17	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				-	0.2	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.3	
Base-Emitter Saturation Voltage (1)		17	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)				0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)				-	0.95	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3903		f_T	250	-	MHz
	2N3904			300	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		3	C_{ob}	-	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		3	C_{ib}	-	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	13	h_{ie}	0.5	8.0	k ohms
	2N3904			1.0	10	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	14	h_{re}	0.1	5.0	X 10^{-4}
	2N3904			0.5	8.0	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N3903	11	h_{fe}	50	200	-
	2N3904			100	400	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		12	h_{oe}	1.0	40	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohms, f = 10 Hz to 15.7 kHz)	2N3903	9, 10	NF	-	6.0	dB
	2N3904			-	5.0	
SWITCHING CHARACTERISTICS						
Delay Time — (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		1, 5	t_d	-	35	ns
Rise Time — (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)		1, 5, 6	t_r	-	35	ns
Storage Time — (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	2N3903	2, 7	t_s	-	175	ns
	2N3904			-	200	
Fall Time — (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)		2, 8	t_f	-	50	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
*Indicates JEDEC Registered Data

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

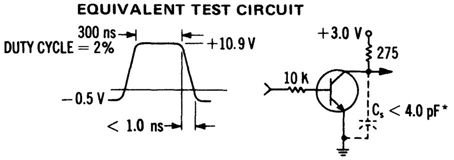
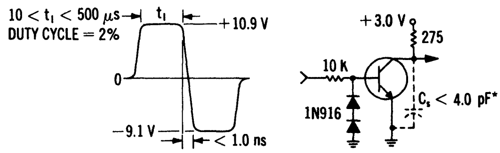


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TYPICAL TRANSIENT CHARACTERISTICS

—— $T_J = 25°C$ - - - $T_J = 125°C$

FIGURE 3 – CAPACITANCE

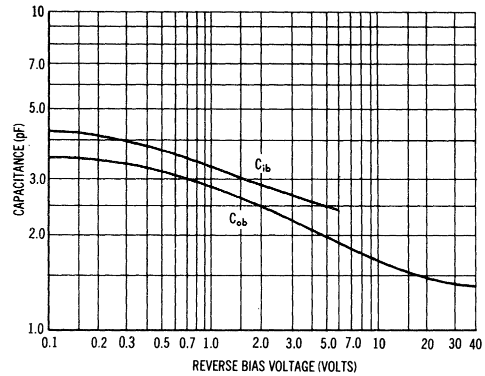


FIGURE 4 – CHARGE DATA

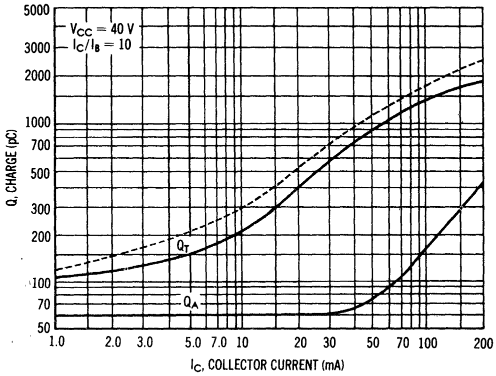


FIGURE 5 – TURN-ON TIME

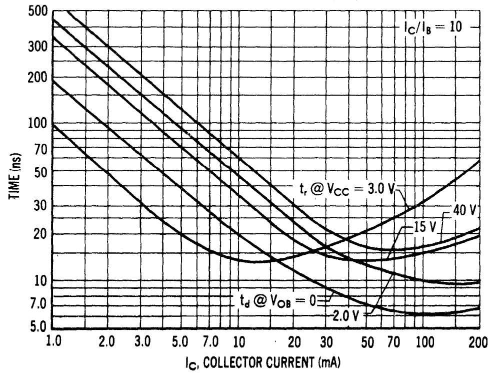


FIGURE 6 – RISE TIME

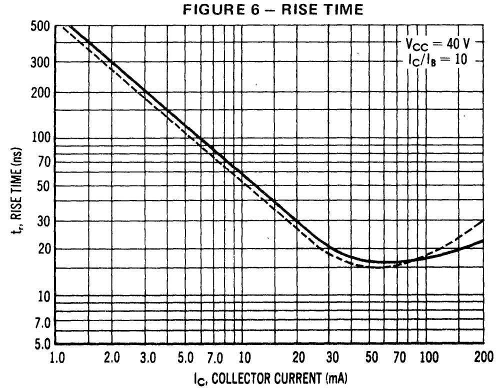


FIGURE 7 – STORAGE TIME

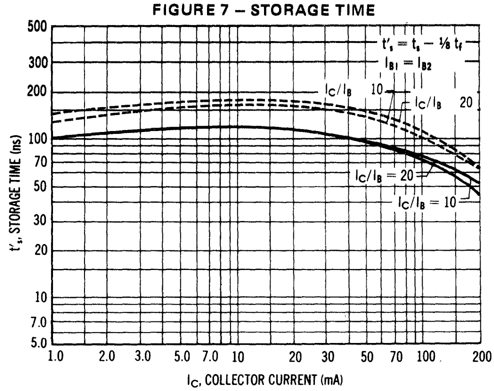
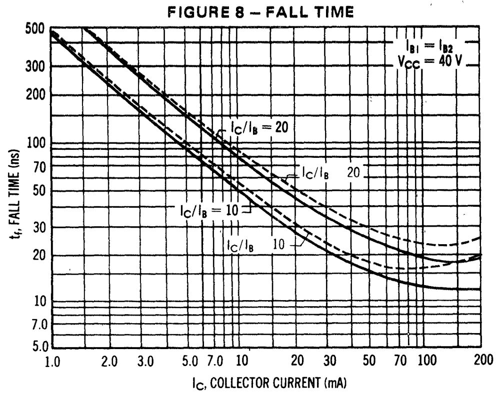


FIGURE 8 – FALL TIME



TYPICAL AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 9

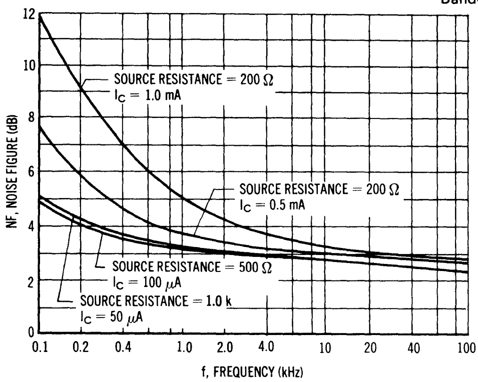
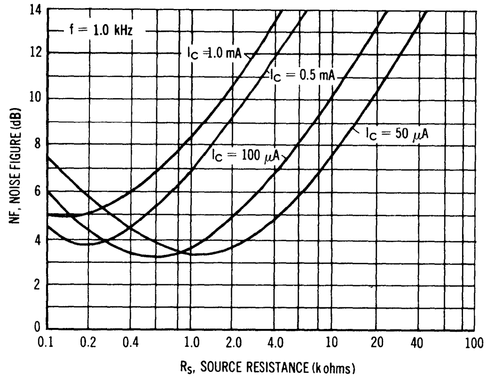


FIGURE 10



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – CURRENT GAIN

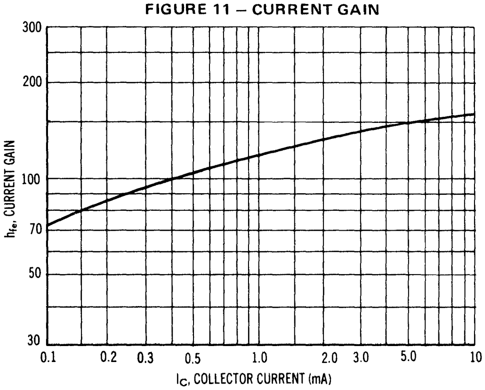


FIGURE 12 – OUTPUT ADMITTANCE

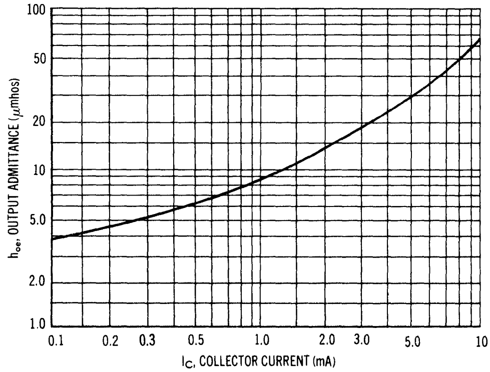


FIGURE 13 – INPUT IMPEDANCE

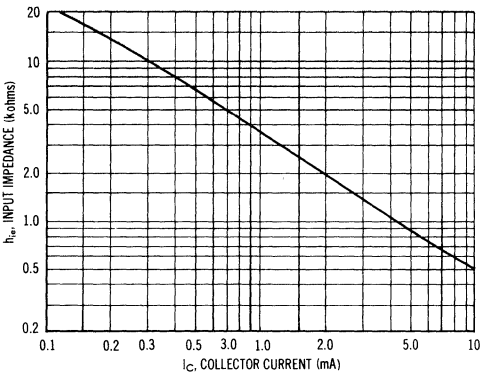
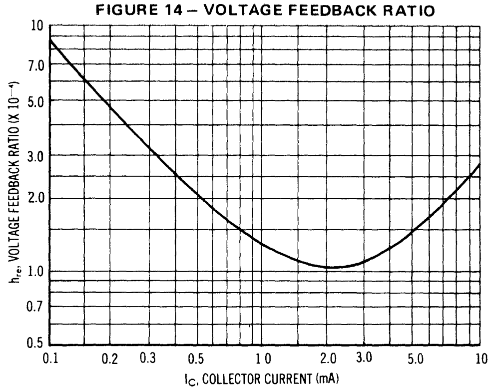


FIGURE 14 – VOLTAGE FEEDBACK RATIO



TYPICAL STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

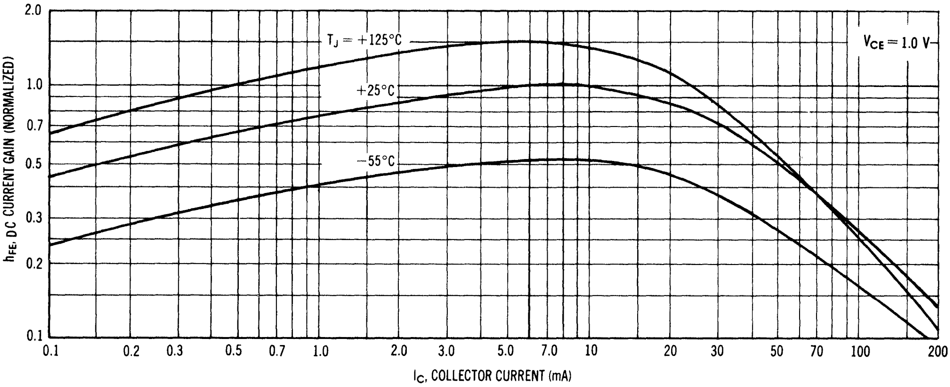


FIGURE 16 – COLLECTOR SATURATION REGION

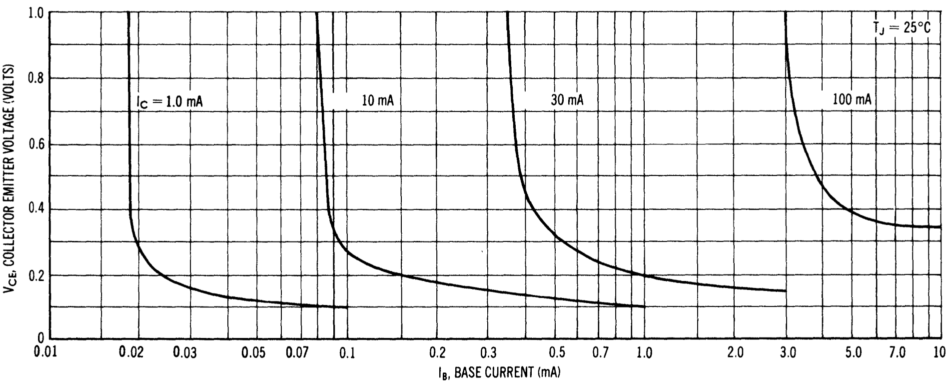


FIGURE 17 – "ON" VOLTAGES

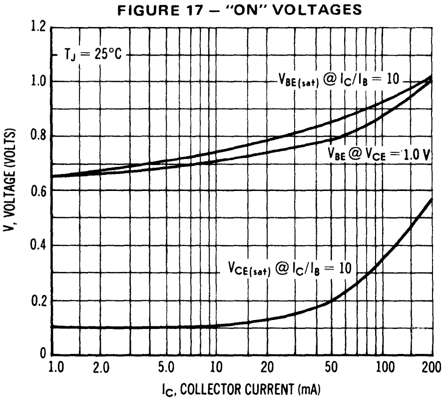
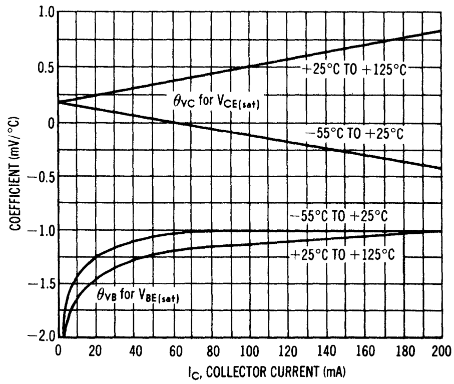


FIGURE 18 – TEMPERATURE COEFFICIENTS



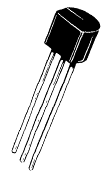
2N3905 (SILICON)
2N3906

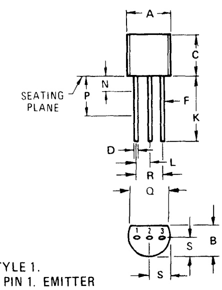
PNP SILICON ANNULAR TRANSISTORS

.... designed for general purpose switching and amplifier applications and for complementary circuitry with types 2N3903 and 2N3904.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min)
- Current Gain Specified from 100 μA to 100 mA
- Complete Switching and Amplifier Specifications
- Low Capacitance — C_{ob} = 4.5 pF (Max)

PNP SILICON SWITCHING & AMPLIFIER TRANSISTORS





STYLE 1.
PIN 1. EMITTER
2 BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4 450	5 200	0 175	0 205
B	3 180	4 190	0 125	0 165
C	4 320	5 330	0 170	0 210
D	0 407	0 533	0 016	0 021
F	0 407	0 482	0 016	0 019
K	12 700	–	0 500	–
L	1 150	1 390	0 045	0 055
N	–	1 270	–	0 050
P	6 350	–	0 250	–
Q	3 430	–	0 135	–
R	2 410	2 670	0 095	0 105
S	2 030	2 670	0.080	0 105

CASE 29-02
TO-92

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Junction Operating Temperature	T_J	+150	°C
Storage Temperature Range	T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 µAdc, I_E = 0)		BV_{CBO}	40	–	Vdc
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 µAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		I_{CEV}	–	50	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 3.0 Vdc)		I_{BEV}	–	50	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	15	h_{FE}			
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc) 2N3905			30	–	
2N3906			60	–	
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) 2N3905			40	–	
2N3906			80	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc) 2N3905			50	150	
2N3906			100	300	
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc) 2N3905			30	–	
2N3906			60	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc) 2N3905			15	–	
2N3906			30	–	
Collector-Emitter Saturation Voltage	16, 17	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	0.25	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.4	
Base-Emitter Saturation Voltage	17	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			0.65	0.85	
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.95	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) 2N3905			200	–	
2N3906			250	–	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)	3	C_{ob}	–	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	3	C_{ib}	–	10	pF
Input Impedance	13	h_{ie}			k ohms
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3905			0.5	8.0	
2N3906			2.0	12	
Voltage Feedback Ratio	14	h_{re}			X 10^{-4}
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3905			0.1	5.0	
2N3906			1.0	10	
Small-Signal Current Gain	11	h_{fe}			–
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3905			50	200	
2N3906			100	400	
Output Admittance	12	h_{oe}			µmhos
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz) 2N3905			1.0	40	
2N3906			3.0	60	
Noise Figure	9, 10	NF			dB
(I_C = 100 µAdc, V_{CE} = 5.0 Vdc, R_S = 1.0 k ohm, 2N3905			–	5.0	
f = 10 Hz to 15.7 kHz) 2N3906			–	4.0	
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.5 Vdc	1, 5	t_d	–	35	ns
Rise Time I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	1, 5, 6	t_r	–	35	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc) 2N3905	2, 7	t_s	–	200	ns
2N3906			–	225	
Fall Time 2N3905	2, 8	t_f	–	60	ns
2N3906			–	75	

*Indicates JEDEC Registered Data. (1) Pulse Width = 300 µs, Duty Cycle = 2.0 %.

FIGURE 1 — DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT

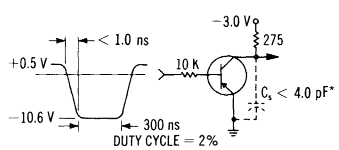
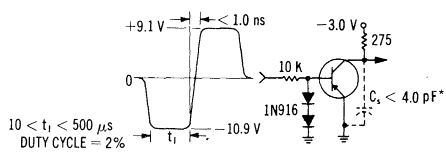


FIGURE 2 — STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors

TRANSIENT CHARACTERISTICS

—— $T_J = 25°C$ - - - $T_J = 125°C$

FIGURE 3 — CAPACITANCE

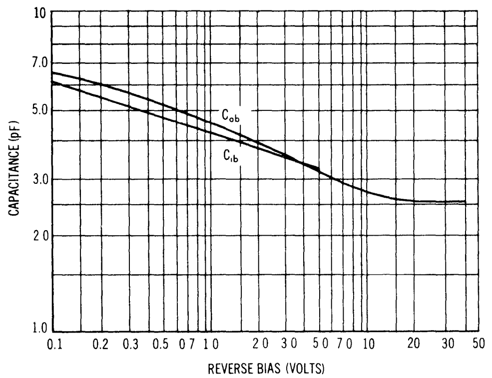


FIGURE 4 — CHARGE DATA

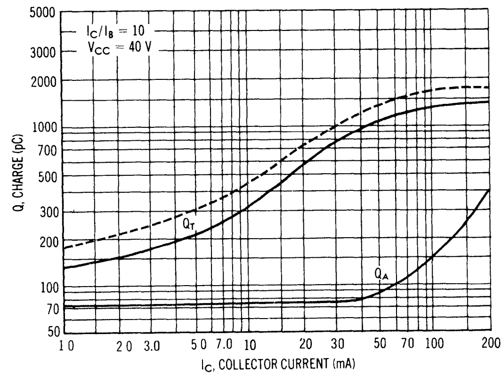


FIGURE 5 — TURN-ON TIME

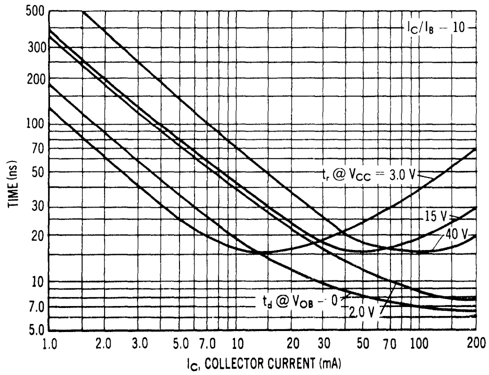


FIGURE 6 — RISE TIME

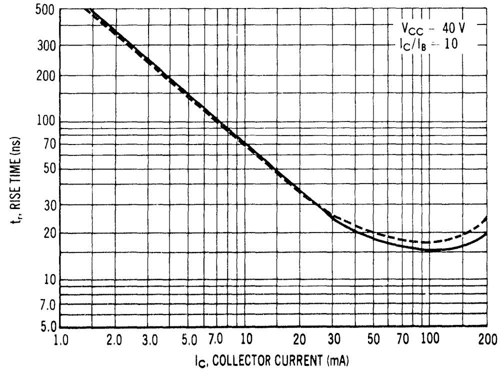


FIGURE 7 — STORAGE TIME

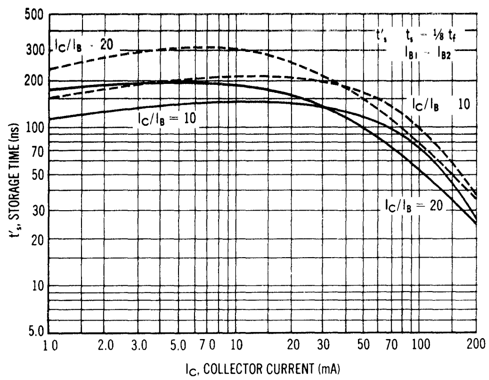
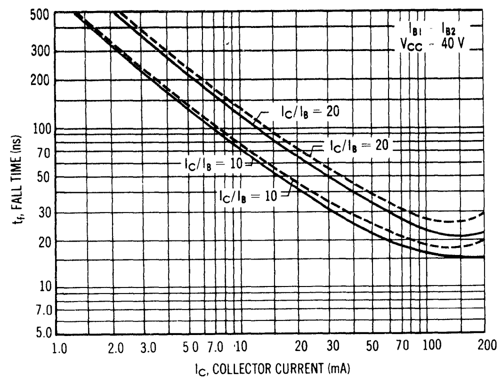


FIGURE 8 — FALL TIME



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 9 –

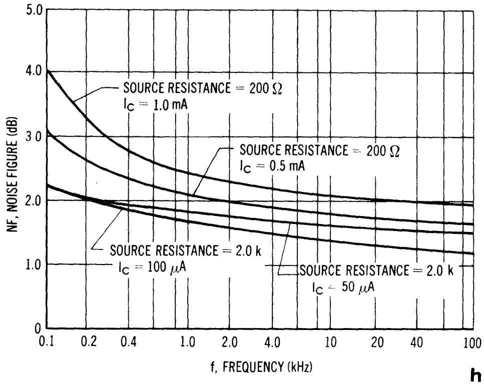
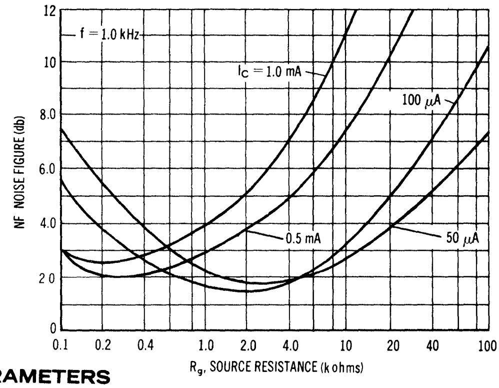


FIGURE 10 –



h PARAMETERS

(V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C)

FIGURE 11 – CURRENT GAIN

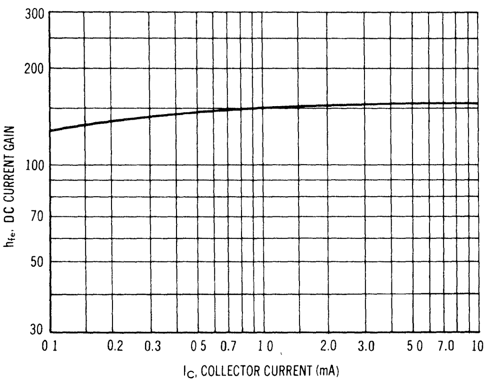


FIGURE 12 – OUTPUT ADMITTANCE

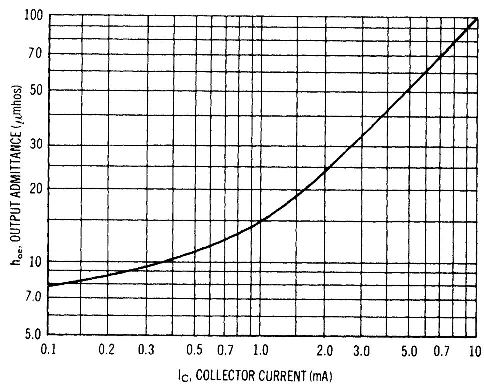


FIGURE 13 – INPUT IMPEDANCE

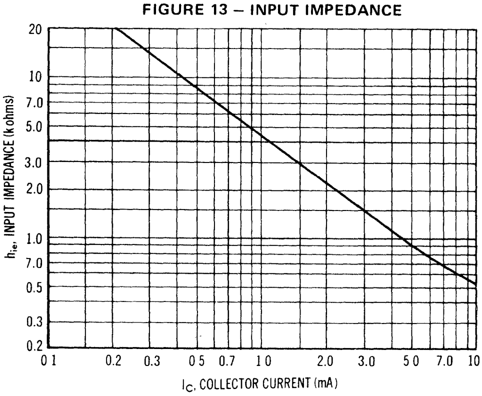
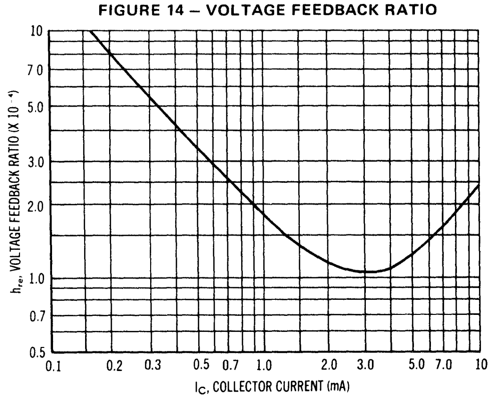


FIGURE 14 – VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

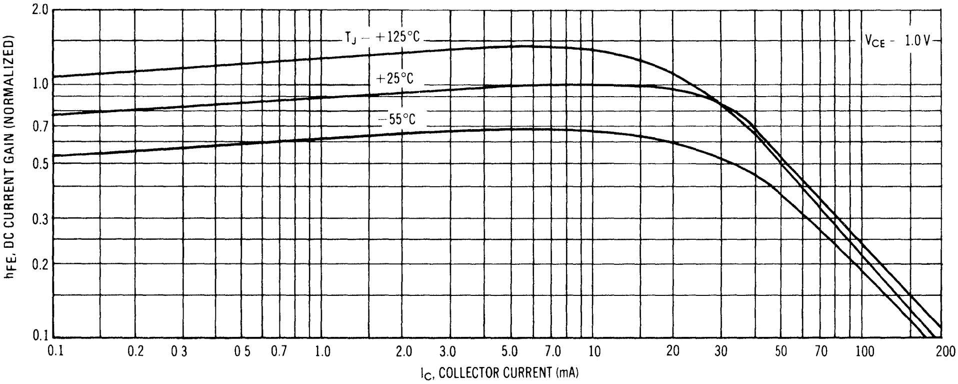


FIGURE 16 – COLLECTOR SATURATION REGION

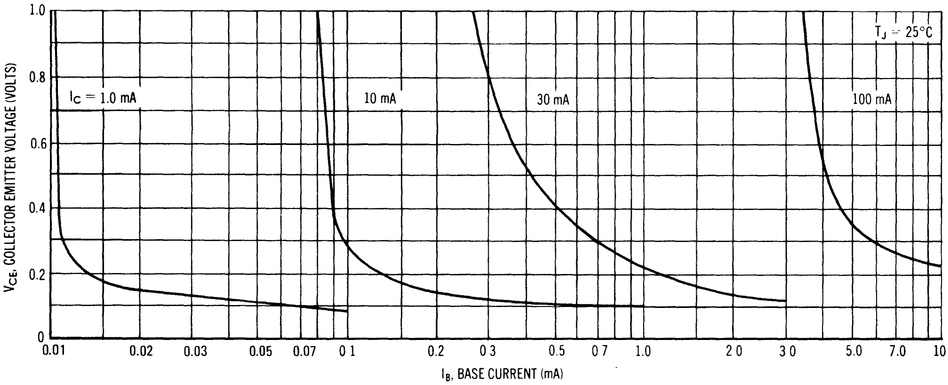


FIGURE 17 – "ON" VOLTAGES

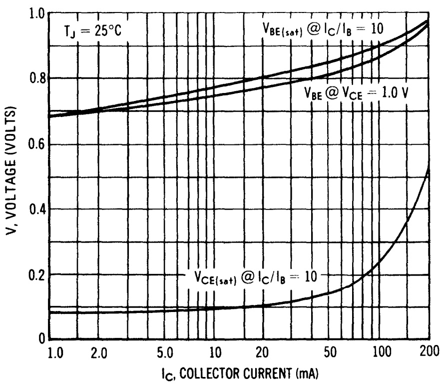
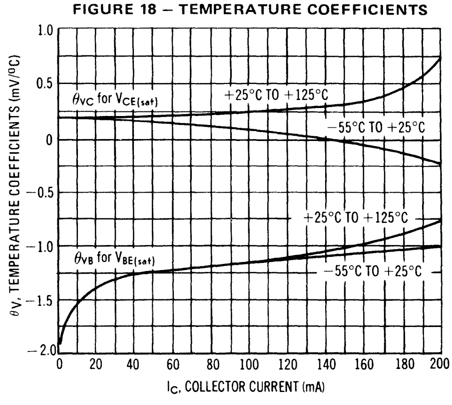


FIGURE 18 – TEMPERATURE COEFFICIENTS



2N3909 (SILICON)
2N3909A

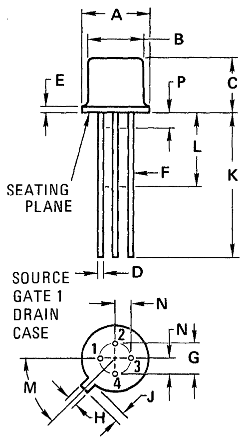
SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio amplifier applications.

- High AC Input Resistance – Typically > 30 Megohms @ f = 1.0 kHz
- Drain and Source Interchangeable
- Active Elements Isolated from Case

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



STYLE 5
PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Forward Gate-Source Voltage	V_{GSF}	20	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

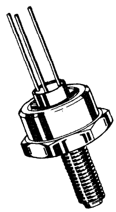
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted) (Note 1)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	20	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 10 Vdc, I_D = 10 μAdc)	2N3909 2N3909A	$V_{GS(off)}$	– –	8.0 8.0	Vdc
Gate Reverse Current (V_{GS} = 10 Vdc, V_{DS} = 0)		I_{GSS}	–	10	nAdc
(V_{GS} = 10 Vdc, V_{DS} = 0, T_A = 100°C)			–	1.0	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 2) (V_{DS} = –10 Vdc, V_{GS} = 0)	2N3909 2N3909A	I_{DSS}	0.3 1.0	15 15	mAdc
Gate-Source Voltage (V_{DS} = –10 Vdc, I_D = 30 μAdc)		V_{GS}	0.3	7.9	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (Note 2) (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3909 2N3909A	$\|y_{fs}\|$	1000 2200	5000 5000	μmhos
(V_{DS} = –10 Vdc, V_{GS} = 0, f = 10 MHz)	2N3909 2N3909A		900 2000	– –	
Output Admittance (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	–	100	μmhos
Input Capacitance (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3909 2N3909A	C_{iss}	– –	32 9.0	pF
Reverse Transfer Capacitance (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3909 2N3909A	C_{rss}	– –	16 3.0	pF

*Indicates JEDEC Registered Data.

Note 1: The fourth lead (case) is connected to the source for all measurements.
Note 2: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

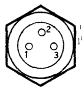
2N3924 (SILICON) thru 2N3927



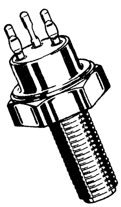
NPN silicon annular RF power transistors, optimized for large-signal power-amplifier and driver applications to 300 MHz.

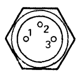
Collector electrically connected to case; stud electrically isolated from case

CASE 24
2N3925
(TO-102)



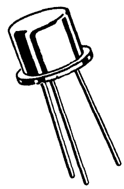
PIN 1. EMITTER
2. BASE
3. COLLECTOR

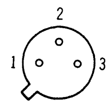




CASE 36
2N3926
2N3927
(TO-60)
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

Stud and case electrically connected to emitter





CASE 79
2N3924
(TO-39)
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

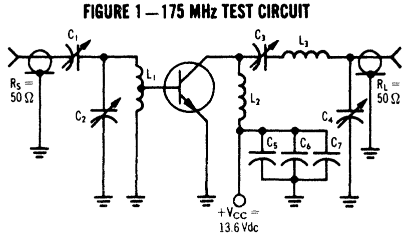
Rating	Symbol	2N3924	2N3925	2N3926	2N3927	Unit
Collector-Emitter Voltage	V_{CEO}	18	18	18	18	Vdc
Collector-Base Voltage	V_{CB}	36	36	36	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current	I_C	0.5	1.0	1.5	3.0	Adc
Power Dissipation @ T_C = 25°C	P_D	7.0	10	11.6	23.2	Watts
Derate above 25°C		40	57.1	66.3	132.5	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1)	I_C = 200 mAdc	$BV_{CEO(sus)}$	18	-	-	Vdc
Collector-Base Breakdown Voltage	I_C = 0.25 mAdc, I_E = 0 2N3924 thru 2N3926 I_C = 0.50 mAdc, I_E = 0 2N3927	BV_{CBO}	36 36	- -	- -	Vdc
Emitter-Base Breakdown Voltage	I_E = 1.0 mAdc, I_C = 0 2N3924 thru 2N3926 I_E = 2.0 mAdc, I_C = 0 2N3927	BV_{EBO}	4.0 4.0	- -	- -	Vdc
Collector Cutoff Current	V_{CB} = 15 Vdc, I_E = 0 2N3924 thru 2N3926 2N3927 V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C 2N3924 thru 2N3926 2N3927	I_{CBO}	- - -	- - -	0.1 0.25 5.0 10	mAdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product	I_C = 100 mAdc, V_{CE} = 13.6 Vdc, f = 100 MHz 2N3924 thru 2N3926 I_C = 200 mAdc, V_{CE} = 13.6 Vdc, f = 100 MHz 2N3927	f_T	- -	350 350	- -	MHz
Output Capacitance	V_{CB} = 13.6 Vdc, I_E = 0, f = 100 kHz 2N3924 thru 2N3926 2N3927	C_{ob}	- -	12.5 25	20 45	pF
FUNCTIONAL TESTS 2N3924						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1.0	Watt
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	6.0	7.3	-	dB
Collector Efficiency	P_{out} = 4.0 Watts	η	70	-	-	%
2N3925						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1.3	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	5.84	6.5	-	dB
Collector Efficiency	P_{out} = 5.0 Watts	η	70	-	-	%
2N3926						
Power Input	Test Circuit Figure 1	P_{in}	-	-	2.0	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	5.44	6.0	-	dB
Collector Efficiency	P_{out} = 7.0 Watts	η	70	-	-	%
2N3927						
Power Input	Test Circuit Figure 1	P_{in}	-	-	4.0	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 MHz	G_{pe}	4.77	5.0	-	dB
Collector Efficiency	P_{out} = 12 Watts	η	80	-	-	%

(1) Pulsed thru a 25-mH inductor (See Figure 2)

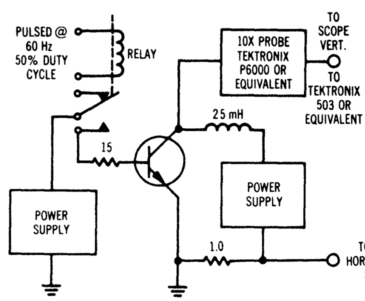
FIGURE 1 — 175 MHz TEST CIRCUIT



C_1, C_2, C_4 . . . . 5-50 pF (Air variable)
C_3 . . . . 7-100 pF (Air variable)
C_5 . . . . . 470 pF (Disc ceramic)
C_6 . . . 0.01 µF (Disc ceramic)
C_7 . . . . 0.001 µF (Disc ceramic)

L_1 — 1 1/2 turns #14 AWG tinned wire; 3/8" ID Air wound; winding length 3/16"; base tapped 1 turn from ground
L_2 — RFC
L_3 — 2 turns #14 AWG tinned wire; 1/4" ID Air wound; winding length 3/16"

FIGURE 2 — PULSE TEST CIRCUIT



CLASS C DESIGN DATA FOR V_{CE} = 13.6 Vdc, T_C = 25°C

(Emitter Grounded Directly to the Chassis — No Tuned-Emitter Techniques Used)

2N3924

FIGURE 3 — POWER OUTPUT vs FREQUENCY

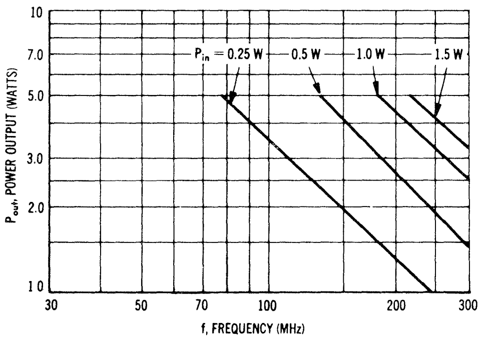


FIGURE 4 — POWER OUTPUT vs POWER INPUT

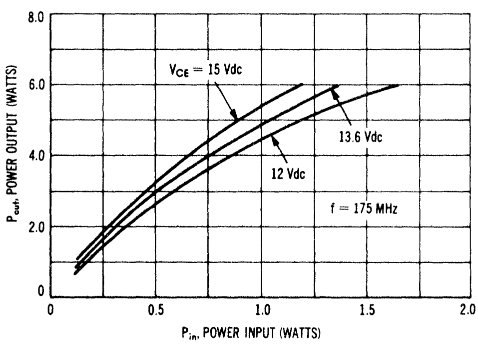


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

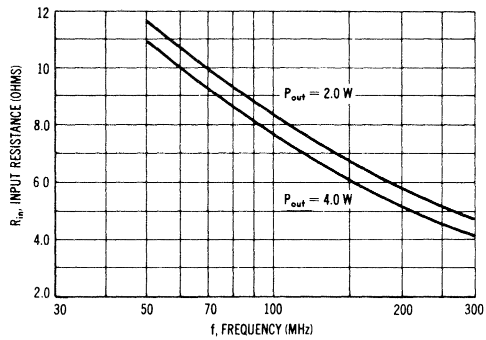


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE

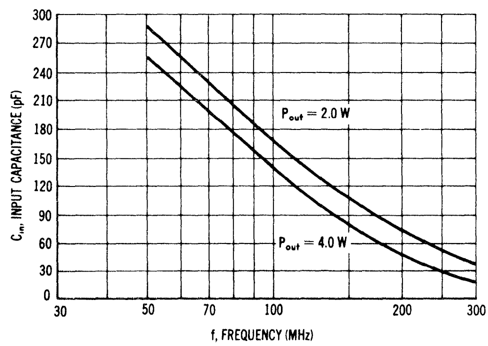
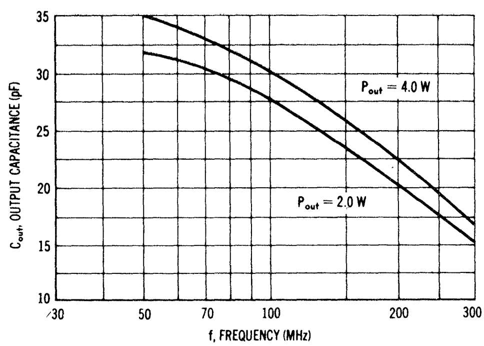


FIGURE 7 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3925

FIGURE 10 — PARALLEL EQUIVALENT INPUT RESISTANCE

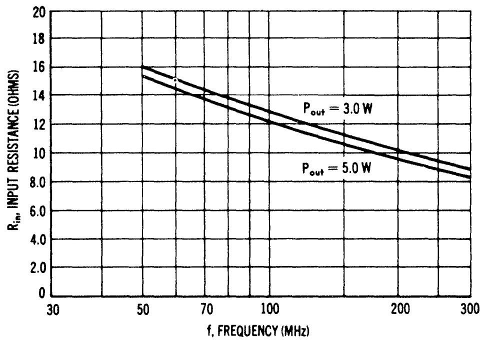


FIGURE 8 — POWER OUTPUT vs FREQUENCY

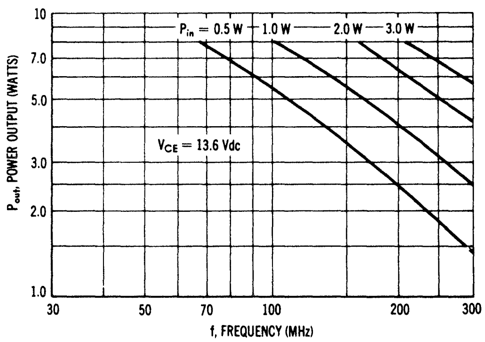


FIGURE 11 — PARALLEL EQUIVALENT INPUT CAPACITANCE

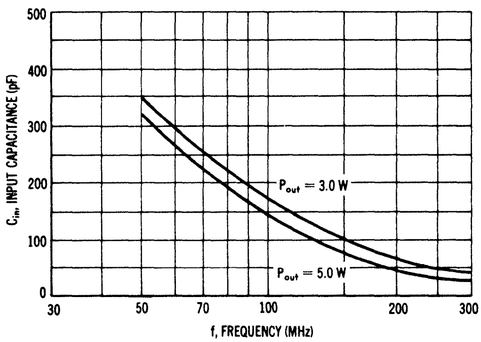


FIGURE 9 — POWER OUTPUT vs POWER INPUT

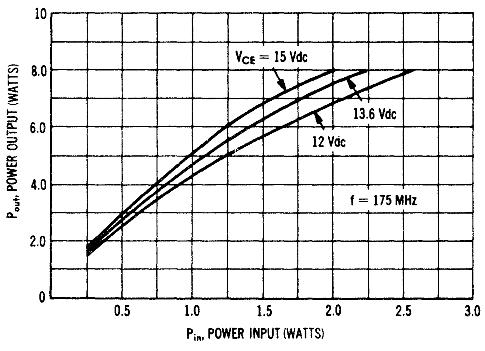


FIGURE 12 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

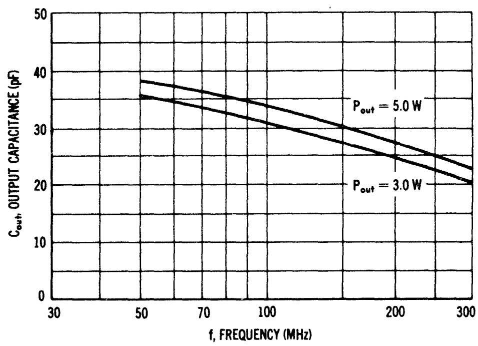


FIGURE 13 — POWER OUTPUT vs FREQUENCY

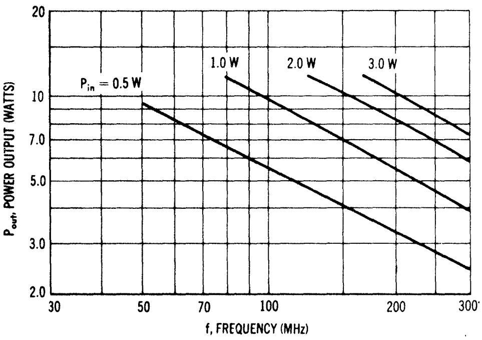
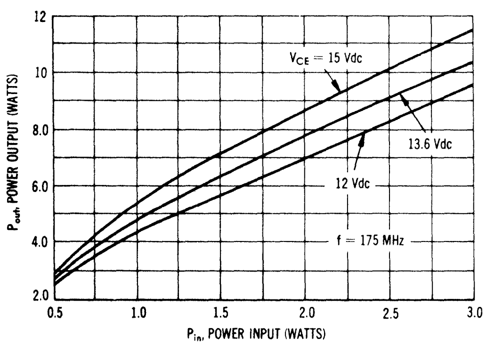


FIGURE 14 — POWER OUTPUT vs POWER INPUT



2N3926

FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

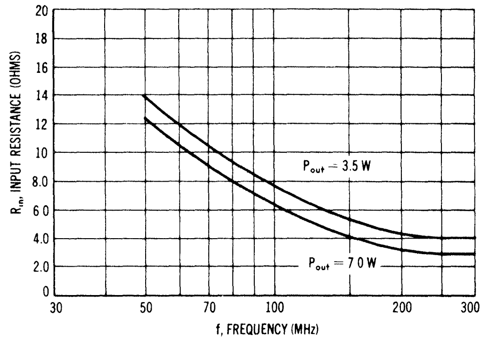


FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE

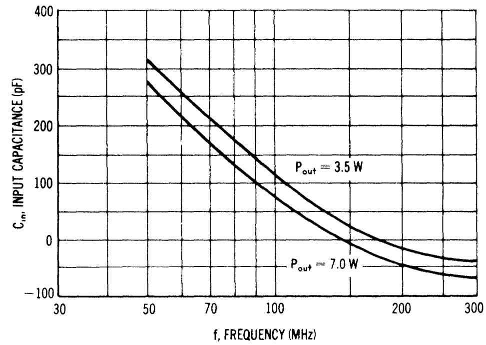
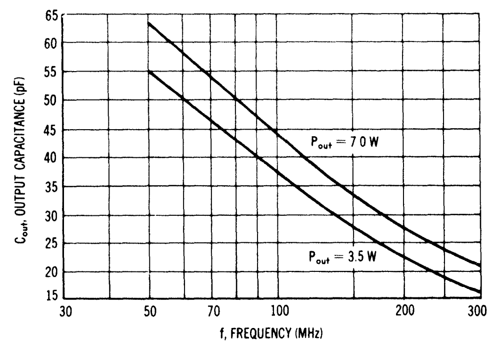


FIGURE 17 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE



2N3927

FIGURE 18 — POWER INPUT vs FREQUENCY

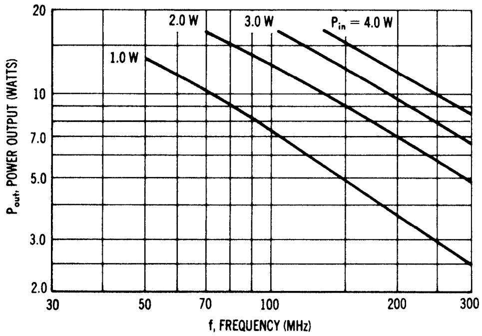


FIGURE 19 — POWER OUTPUT vs POWER INPUT

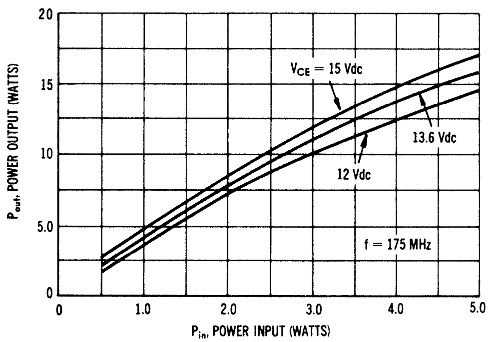


FIGURE 20 — PARALLEL EQUIVALENT INPUT RESISTANCE

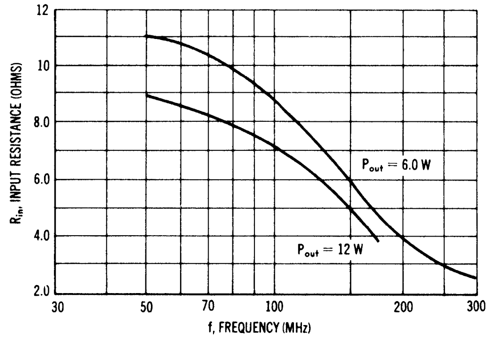


FIGURE 21 — PARALLEL EQUIVALENT INPUT CAPACITANCE

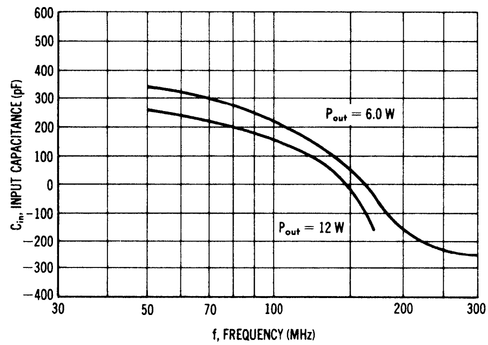
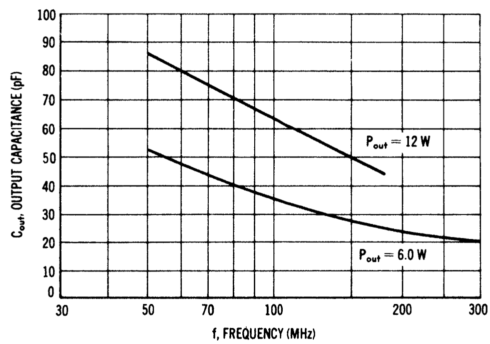


FIGURE 22 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

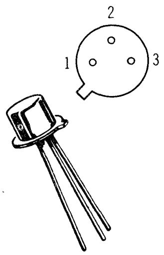


DESIGN NOTE

For Class C power-amplifier designs, small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier design are used.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data for Class C design to complete device impedance data.

2N3946 (SILICON)
2N3947



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 22
(TO-18)

Collector connected to case

NPN silicon annular transistors, designed for general purpose switching and amplifier applications. The 2N3946 and 2N3947 are complementary with PNP types 2N3250 and 2N3251, respectively.

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	1.2 6.9	Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.36 2.06	Watt mW/°C
Thermal Resistance Junction to Ambient Junction to Case	 θ_{JA} θ_{JC}	 0.49 0.15	 °C/mW °C/mW
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc)	BV_{CEO}*	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6.0	—	Vdc
Collector-Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc) (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc, T_A = 150°C)	I_{CEX}	 — —	 .010 15	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)	I_{BL}	—	.025	μAdc

(1)Pulse Test: PW ≤ 300 μs , Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (continued)

(T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3946		30	—	
	2N3947		60	—	
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3946		45	—	
	2N3947		90	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3946		50	150	
	2N3947		100	300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3946		20	—	
	2N3947		40	—	
Collector Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.3	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.6	0.9	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	1.0	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	4.0	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	—	8.0	pF
Current-Gain - Bandwidth Product		f_T			MHz
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N3946		250	—	
	2N3947		300	—	
Delay Time	V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc	t_d	—	35	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mA	t_r	—	35	ns
Storage Time	V_{CC} = 3 V, I_C = 10 mA, 2N3946	t_s	—	300	ns
	2N3947		—	375	
Fall Time	I_{B1} = $-I_{B2}$ = 1 mAdc	t_f	—	75	ns
SMALL SIGNAL CHARACTERISTICS					
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946		50	250	
	2N3947		100	700	
Voltage Feedback Ratio		h_{re}			$X10^{-4}$
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946		—	10	
	2N3947		—	20	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946		0.5	6.0	
	2N3947		2.0	12	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kHz)	2N3946		1.0	30	
	2N3947		5.0	50	
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 MHz)		r'_bC_C	—	200	ps
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_g = 1 kΩ, f = 10 Hz to 15.7 kHz)		NF	—	5.0	dB

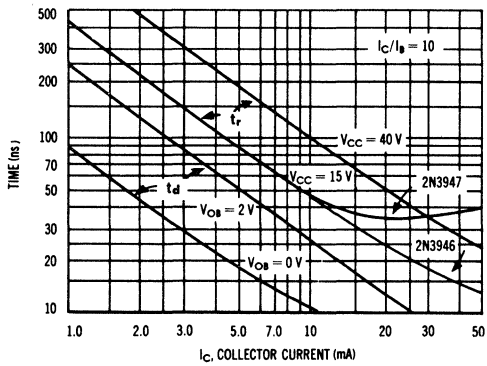
(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

* Indicates JEDEC Registered Data

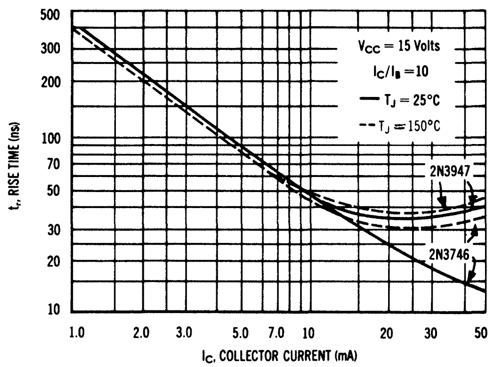
TYPICAL SWITCHING CHARACTERISTICS

(T_A = 25°C unless otherwise noted)

DELAY AND RISE TIME

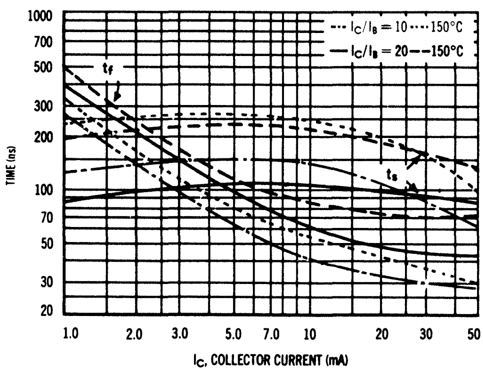


RISE TIME

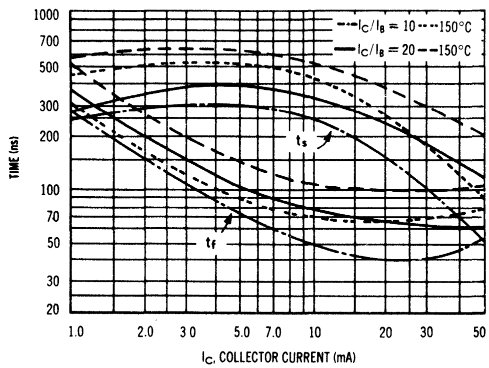


STORAGE AND FALL TIMES

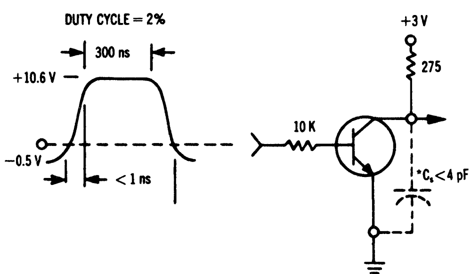
2N3946



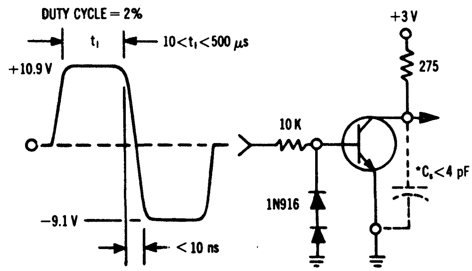
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT

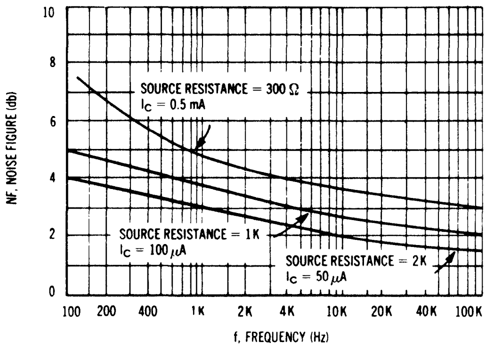


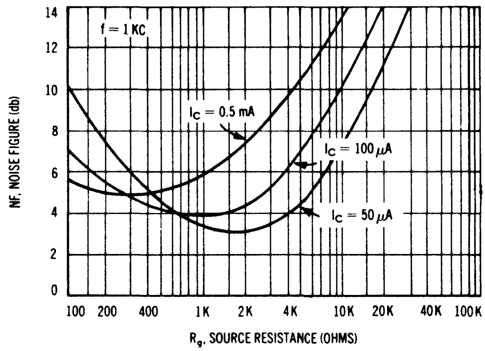
*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5 V, T_A = 25°C

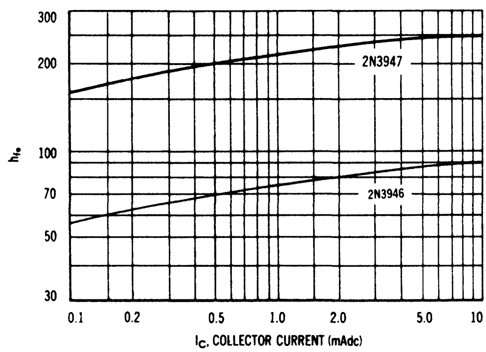




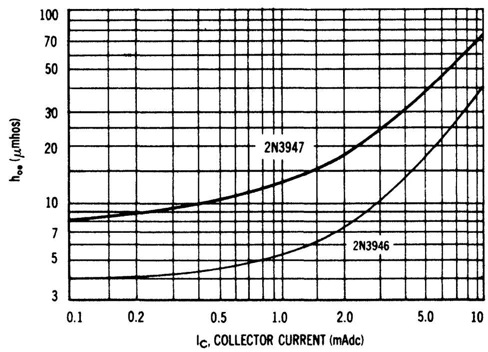
h PARAMETERS

V_{CE} = 10 V, T_A = 25°C, f = 1 Kc

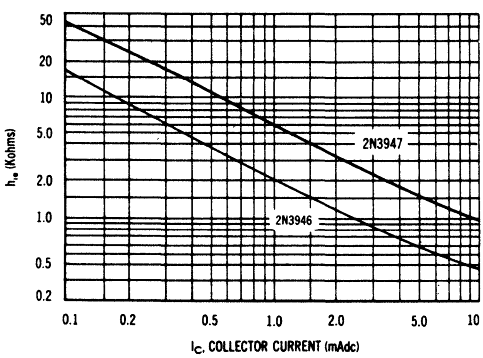
CURRENT GAIN



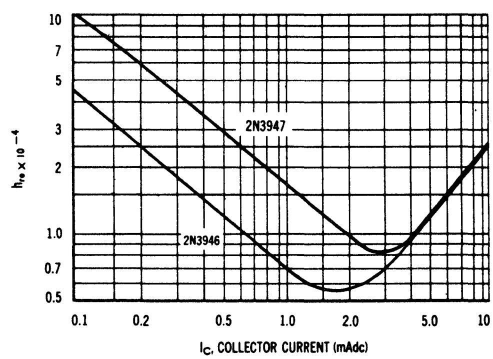
OUTPUT ADMITTANCE



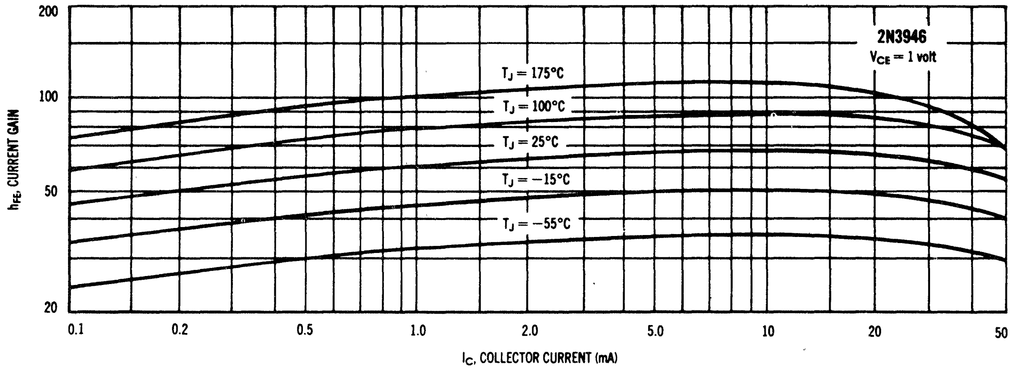
INPUT IMPEDANCE

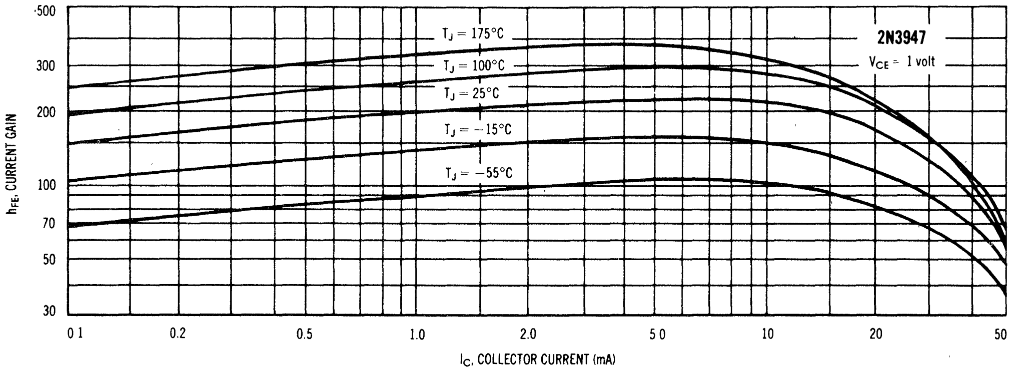


VOLTAGE FEEDBACK RATIO

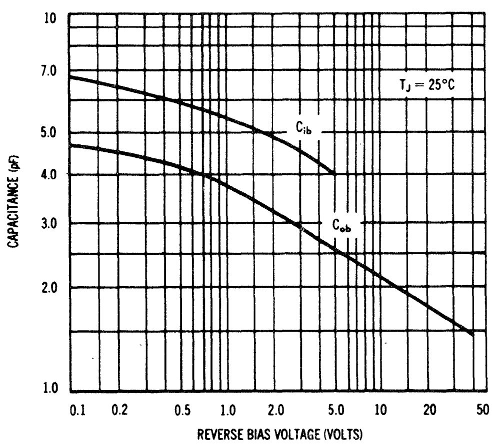


CURRENT GAIN CHARACTERISTICS

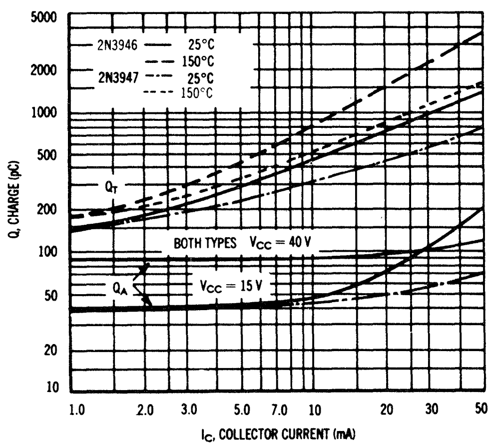




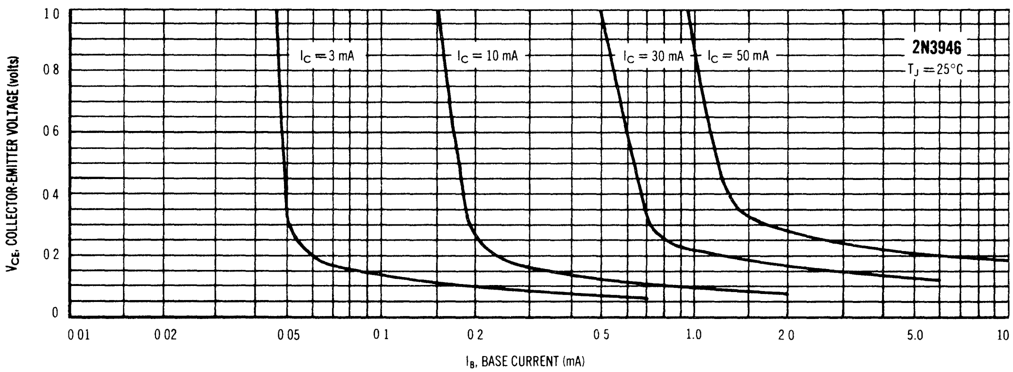
CAPACITANCE

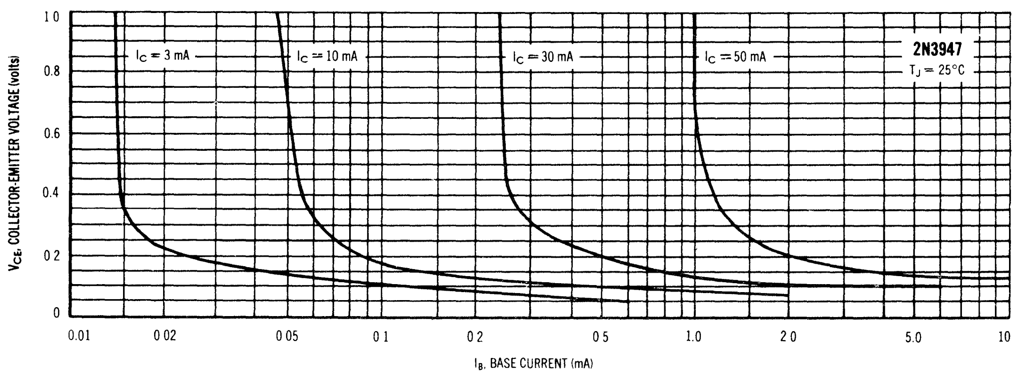


CHARGE DATA

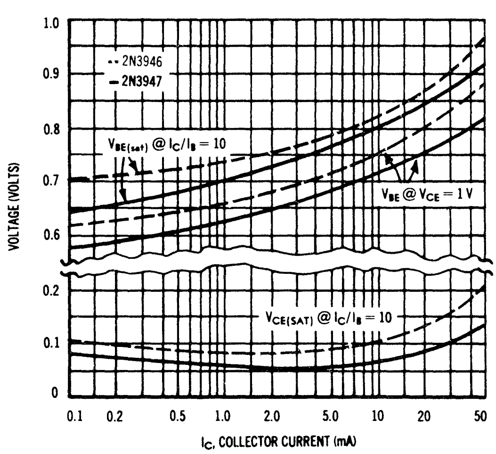


COLLECTOR SATURATION REGION

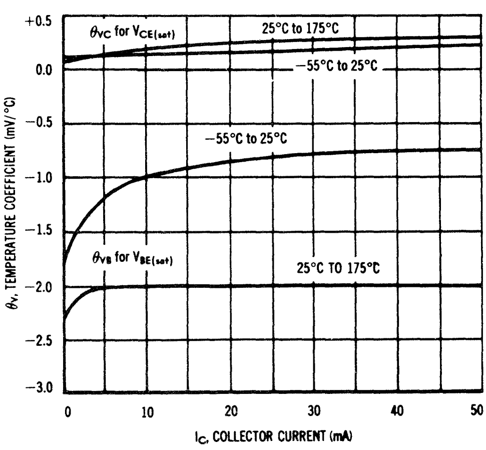




"ON" VOLTAGES

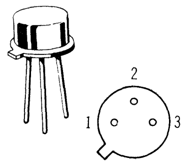


TEMPERATURE COEFFICIENTS



2N3948 (SILICON)

NPN silicon RF power transistor designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output, driver, or pre-driver stages in VHF and UHF equipment. Ideal for CATV applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	175	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5 mAdc, I_B = 0)	$BV_{CEO(sus)}$	20	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	36	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	—	0.1	μAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)		—	100	
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5 Vdc)	h_{FE}	15	—	—
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_E = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	700	—	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	4.5	pF

FUNCTIONAL TEST

Characteristic	Conditions	Symbol	Min	Max	Unit
Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 400 MHz, P_{in} = 0.25 W	G_{PE}	6.0	—	dB
Power Output		P_{out}	1.0	—	Watt
Collector Efficiency		η	45	—	%

SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS FREQUENCY

(I_C = 80 mAdc, V_{CE} = 15 Vdc, T_A = 25°C)

FIGURE 1 — y_{ie}

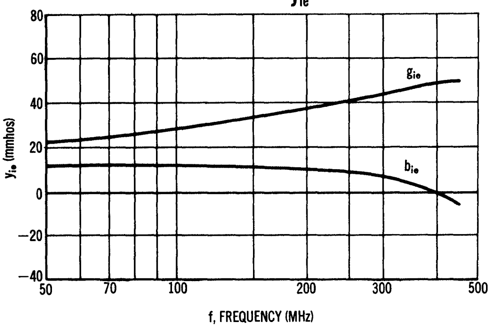


FIGURE 2 — y_{re}

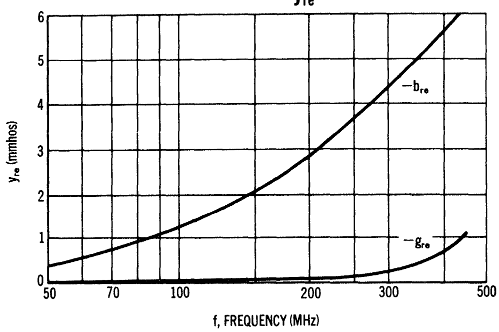


FIGURE 3 — y_{fe}

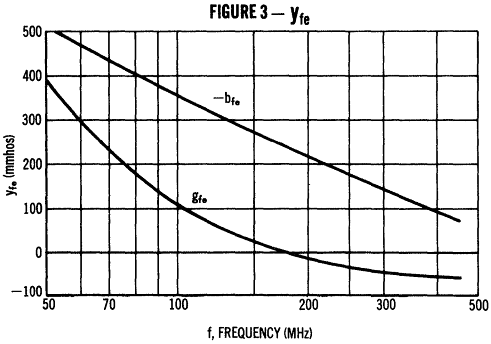


FIGURE 4 — y_{oe}

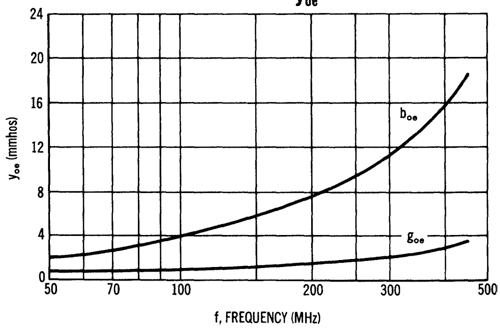


FIGURE 5 — SMALL-SIGNAL CURRENT GAIN

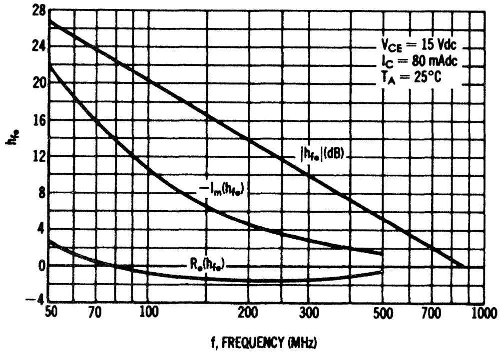
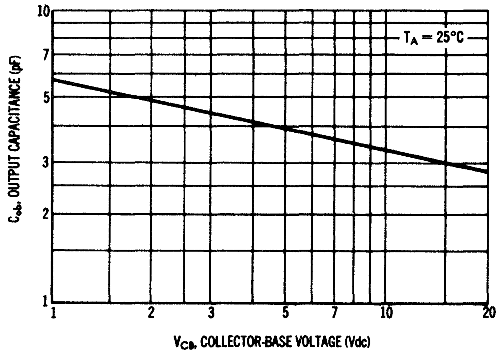


FIGURE 6 — OUTPUT CAPACITANCE



SMALL-SIGNAL ADMITTANCE PARAMETERS VERSUS COLLECTOR CURRENT

(f = 200 MHz, T_A = 25°C)

—— V_{CE} = 10 V —— V_{CE} = 15 V

FIGURE 7 — y_{ie}

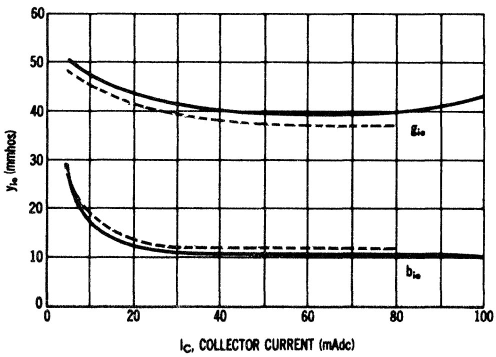


FIGURE 8 — y_{re}

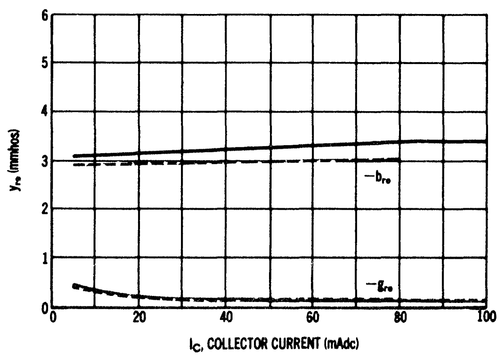


FIGURE 9 — y_{fe}

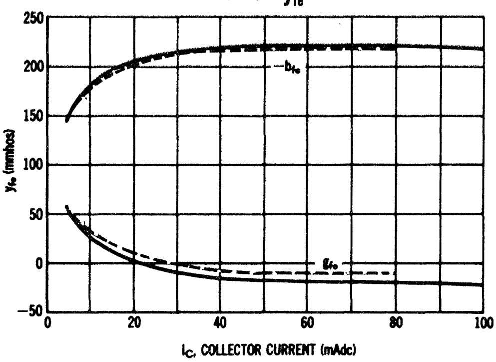


FIGURE 10 — y_{oe}

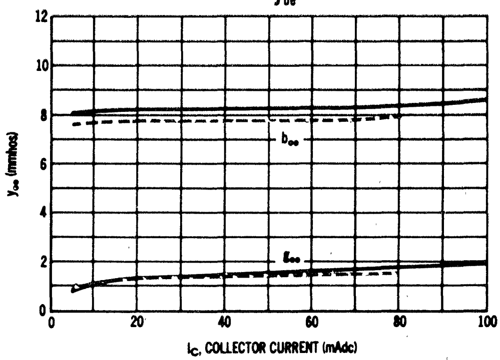
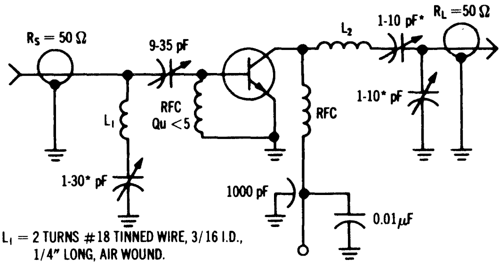
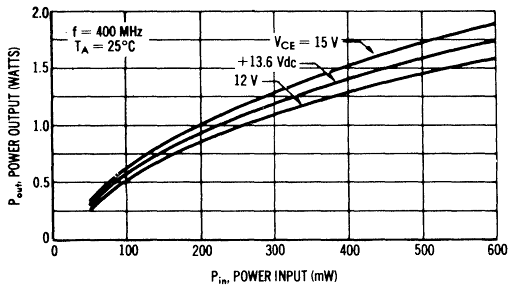


FIGURE 11 — 400 MHz RF AMPLIFIER TEST CIRCUIT



L_1 = 2 TURNS #18 TINNED WIRE, 3/16 I.D., 1/4" LONG, AIR WOUND.
L_2 = 2 TURNS, #18 TINNED WIRE, 1/2 I.D., 3/16" LONG, AIR WOUND.
*AIR VARIABLE CAPACITORS

FIGURE 12 — POWER GAIN



DESIGN NOTE

Figures 1 through 4 and 7 through 10 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. The parallel equivalent output capacitance and input resistance and capacitance for Class C power-amplifier operation are used

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data in Figures 14, 15 and 16 to comprise complete device impedance data for Class C power amplifier design.

CLASS C DESIGN DATA (EMITTER GROUNDED DIRECTLY TO CHASSIS)

(V_{CE} = 13.6 V, T_A = 25°C)

FIGURE 13 — POWER OUTPUT

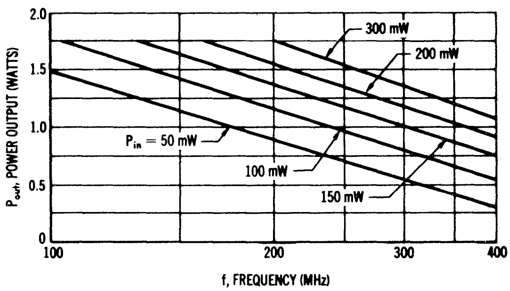


FIGURE 14 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

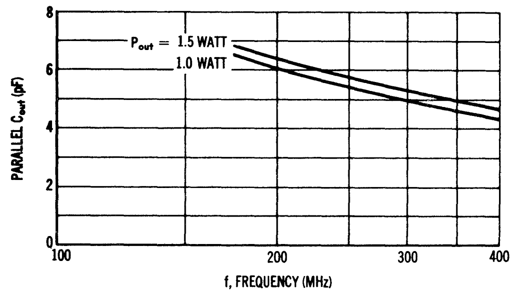


FIGURE 15 — PARALLEL EQUIVALENT INPUT RESISTANCE

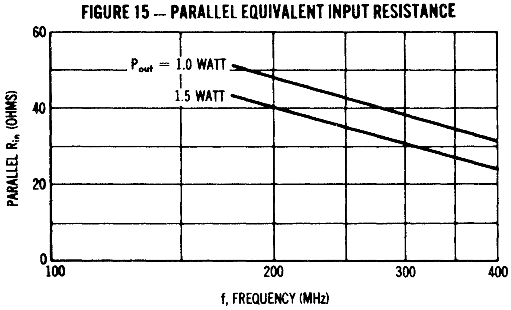
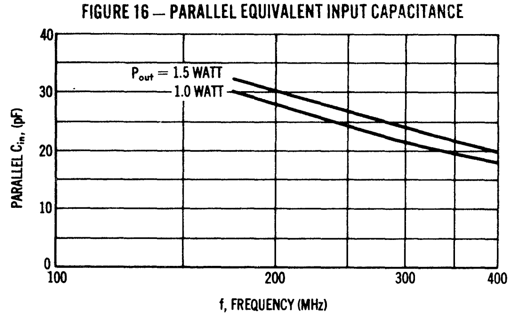
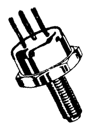


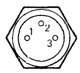
FIGURE 16 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3950 (SILICON)

NPN silicon RF power transistor designed for high-power RF amplifier applications in military and industrial equipment.





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

CASE 36
(TO-60)

Emitter common to stud and case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector-Current — Continuous	I_C	3.3	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	2.8 16	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	70 0.4	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

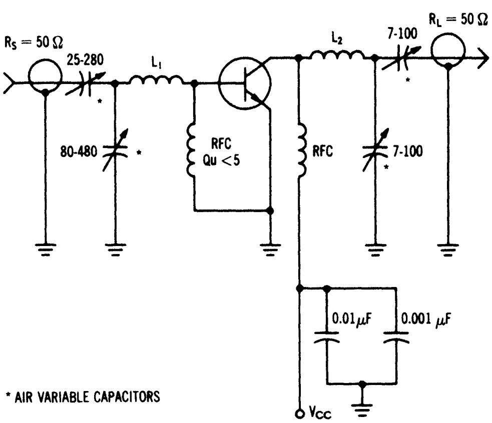
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	62.5	°C/W
Thermal Resistance, Junction to Case	θ_{JC}	2.5	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)		$BV_{CEO(sus)}$	35	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, V_{BE} = 0)		BV_{CES}	65	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)		BV_{EBO}	4.0	—	—	Vdc
Collector Cutoff Current (V_{CB} = 65 Vdc, I_E = 0)		I_{CBO}	—	—	10	mAdc
(V_{CB} = 28 Vdc, I_E = 0, T_A = 150°C)			—	—	10	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 500 mAdc, V_{CE} = 28 Vdc, f = 50 MHz)		f_T	—	150	—	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	—	80	120	pF
FUNCTIONAL TEST						
Power Gain	Test Circuit — Figure 1, P_{out} = 50 W, V_{CC} = 28 Vdc, R_S = 50 ohms, f = 50 MHz	G_{PE}	8.0	—	—	dB
Collector-Efficiency		η	60	—	—	%

(1) Pulsed through a 25 mH inductor; Duty factor = 50%, Rep. Rate ≤ 60 Hz.

FIGURE 1 — 50 MHz TEST CIRCUIT

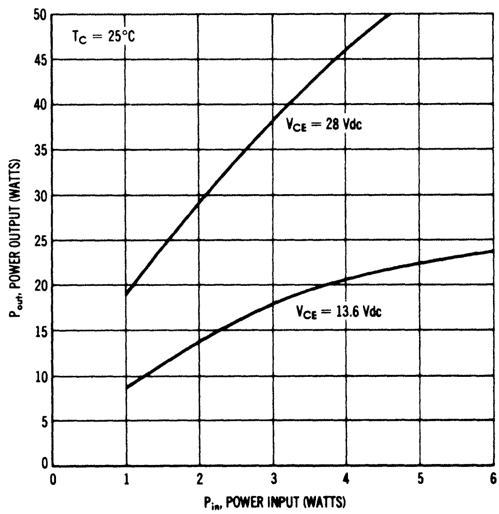


* AIR VARIABLE CAPACITORS

L_1 = 2 TURNS #18 TINNED WIRE, ¼" I.D., AIR WOUND, WINDING LENGTH ⅛".

L_2 = 5 TURNS #16 TINNED WIRE, ⅜" I.D., AIR WOUND, WINDING LENGTH ¾".

FIGURE 2 — 50 MHz POWER GAIN



CLASS C DESIGN DATA FOR V_{CE} = 28 Vdc, T_C = 25°C

(EMITTER GROUNDED DIRECTLY TO THE CHASSIS — NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 3 — POWER OUTPUT

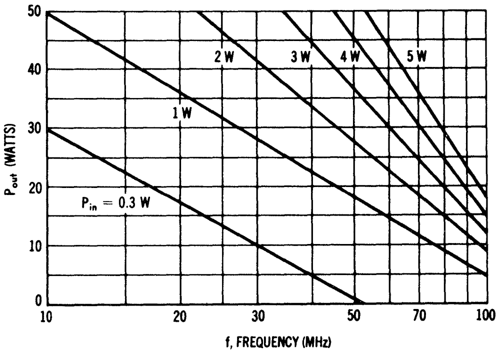


FIGURE 4 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

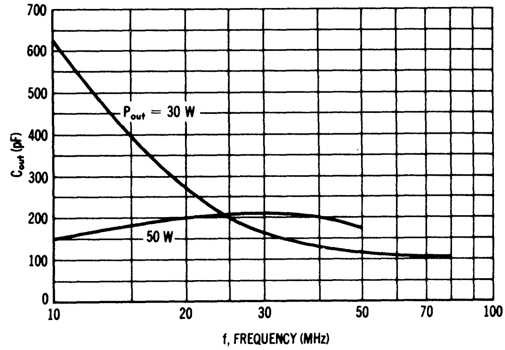


FIGURE 5 — PARALLEL EQUIVALENT INPUT RESISTANCE

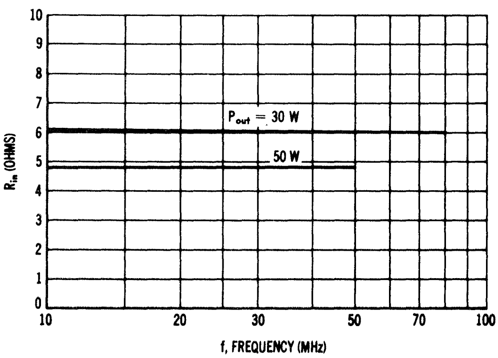
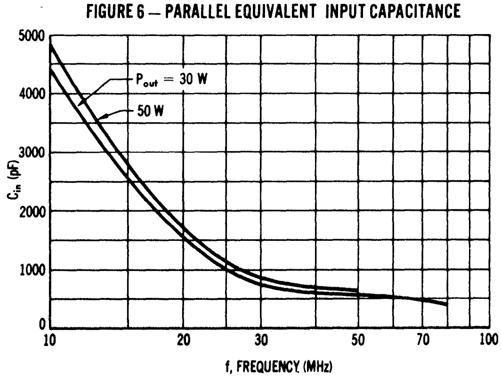


FIGURE 6 — PARALLEL EQUIVALENT INPUT CAPACITANCE



DESIGN NOTES

For Class-C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 thru 6 and 8 thru 10 give the parallel equivalent output capacitance and input capacitance and resistance for Class-C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L' may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression $R_L' = V_{CC}^2/2P$ where P = RF power output. The computed R_L' may then be combined with the data in Figures 4 through 10 to comprise complete device impedance data for Class-C power-amplifier design.

Due to the high performance capabilities of the 2N3950, care should be exercised during initial tuning of prototype circuits.

Input power should be increased gradually, while stopping at intermediate levels to tune. If tuning difficulties are experienced, or if the power or collector current are abnormal at any intermediate power input level, the difficulties should be resolved before increasing power levels further.

The 2N3950 is designed to provide maximum ruggedness commensurate with its high performance. Operation at loads with high SWR may produce dangerous voltage and current excursions, a condition which should be avoided. In addition, disconnecting the load at full power output could increase device dissipation to over 70 watts which could result in device failure due to dissipation beyond safe limits set by the junction to ambient thermal resistance, regardless of the internal construction and safe area of the device.

CLASS C DESIGN DATA FOR V_{CE} = 13.6 Vdc, T_C = 25°C

(EMITTER GROUNDED DIRECTLY TO THE CHASSIS — NO TUNED-EMITTER TECHNIQUES USED)

FIGURE 7 — POWER OUTPUT

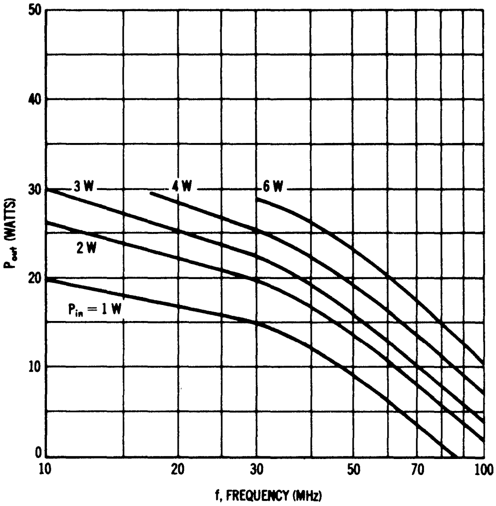


FIGURE 8 — PARALLEL EQUIVALENT OUTPUT CAPACITANCE

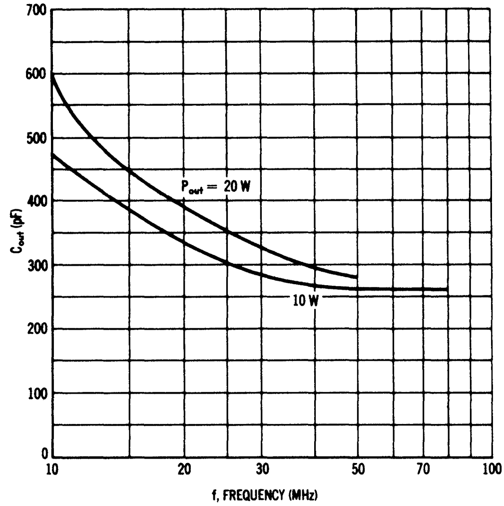


FIGURE 9 — PARALLEL EQUIVALENT INPUT RESISTANCE

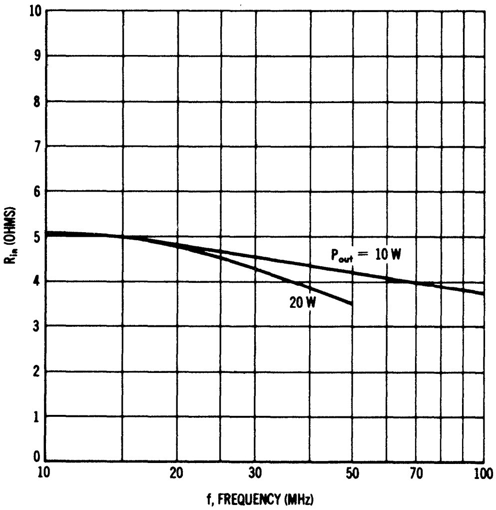
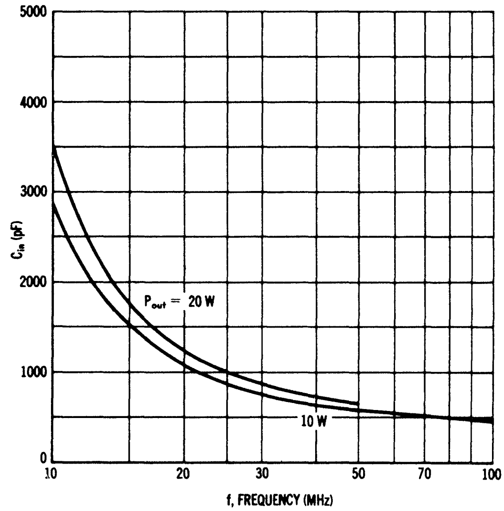


FIGURE 10 — PARALLEL EQUIVALENT INPUT CAPACITANCE



2N3959 (SILICON)
2N3960

The RF Line

1.8 GHz – 10 mAdc

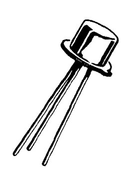
HIGH FREQUENCY TRANSISTORS

NPN SILICON

NPN SILICON HIGH-FREQUENCY TRANSISTORS

. . . designed for high-speed current-mode logic switching applications.

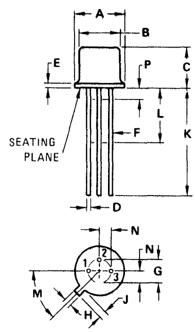
- High Current-Gain–Bandwidth Product – f_T = 1800 MHz (Typ) @ I_C = 10 mAdc
- Low Input and Output Capacitance – C_{ib} and C_{ob} = 2.5 pF (Max)
- Excellent Current-Mode Performance – t_r = 1.7 ns (Typ) @ I_C = 30 mAdc
- Low Collector-Base Time Constant – $r_b'C_c$ = 25 ps (Max) @ I_C = 10 mAdc – 2N3959



Current-Mode logic operation, because of the absence of storage time, offers improved high-speed performance for digital applications. In addition, the low impedance drive circuit offers improved delay, rise, and fall times.

The basic characteristics of importance in current-mode logic applications are Current-Gain–Bandwidth Product (f_T), Input and Output Capacitance (C_{ib} and C_{ob}), and Base Spreading Resistance (r'_b).

The 2N3959 and 2N3960 offer a combination of extremely high f_T values, low capacitances, and low base spreading resistance which results in exceptionally high speed in current-mode logic circuits.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03 (TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.3	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 4.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	0.436	°C/mW
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.233	°C/mW

*Indicates JEDEC Registered Data.

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted.)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
***OFF CHARACTERISTICS**							
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		–	BV_{CEO}	12	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		–	BV_{CBO}	20	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		–	BV_{EBO}	4.5	–	–	Vdc
Collector Reverse Current		–	I_{CEX}				μAdc
(V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc)				–	–	0.005	
(V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc, $T_A = 150^oC$)				–	–	5.0	
Base Cutoff Current (V_{CE} = 10 Vdc, V_{EB} = 2.0 Vdc)		–	I_{BL}	–	–	0.005	μAdc
Collector Forward Current (V_{CE} = 5.0 Vdc, V_{BE} = 0.4 Vdc)		–	I_{CEX}	–	–	1.0	μAdc
***ON CHARACTERISTICS**							
DC Current Gain		1	h_{FE}				–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)				25	–	–	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)				40	–	400	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)				25	–	–	
Collector-Emitter Saturation Voltage		–	$V_{CE(sat)}$				Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)				–	–	0.2	
(I_C = 30 mAdc, I_B = 3.0 mAdc)				–	–	0.3	
Base-Emitter "on" Voltage		–	$V_{BE(on)}$				Vdc
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)				–	–	0.8	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)				–	–	1.0	
***DYNAMIC CHARACTERISTICS**							
Current-Gain—Bandwidth Product		2	f_T				MHz
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	2N3959			1000	–	–	
	2N3960			1300	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N3959			1300	–	–	
	2N3960			1600	–	–	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc, f = 100 MHz)	2N3959			1000	–	–	
	2N3960			1200	–	–	
Output Capacitance (V_{CB} = 4.0 Vdc, I_E = 0, f = 1.0 MHz)		4	C_{ob}	–	2.0	2.5	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 MHz)		4	C_{ib}	–	1.5	2.5	pF
Collector-Base Time Constant		3	$r_b'C_c$				ps
(I_C = 5.0 mAdc, V_{CE} = 4.0 Vdc)	2N3959			–	–	30	
	2N3960			–	–	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3959			–	–	25	
	2N3960			–	–	40	
(I_C = 30 mAdc, V_{CE} = 4.0 Vdc)	2N3959			–	–	30	
	2N3960			–	–	50	
SWITCHING CHARACTERISTICS (Figure 7)							
Turn-On Delay Time		–	$t_{d(on)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)				–	2.4	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)				–	2.0	–	
Rise Time		–	t_r				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices			–	3.0	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959			–	2.2	–	
	2N3960			–	1.7	–	
Turn-Off Delay Time		–	$t_{d(off)}$				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)				–	1.6	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)				–	1.6	–	
Fall Time		–	t_f				ns
(I_C = 10 mAdc, V_{out} = 1.0 Vdc)	Both Devices			–	3.3	–	
(I_C = 30 mAdc, V_{out} = 1.0 Vdc)	2N3959			–	2.3	–	
	2N3960			–	1.9	–	

*Indicates JEDEC Registered Data.

FIGURE 1 – TYPICAL DC CURRENT GAIN

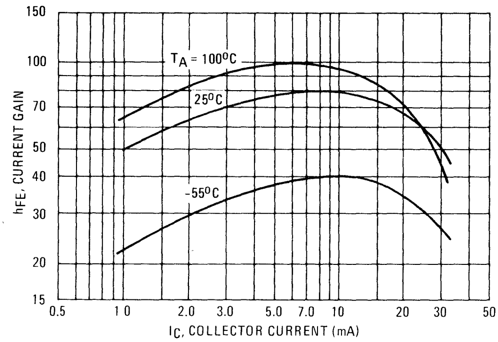


FIGURE 2 – TYPICAL CURRENT-GAIN – BANDWIDTH PRODUCT

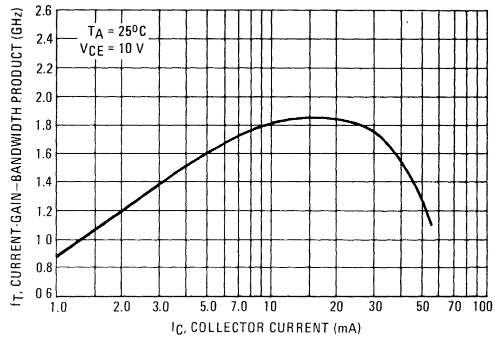


FIGURE 3 – TYPICAL COLLECTOR-BASE TIME CONSTANT

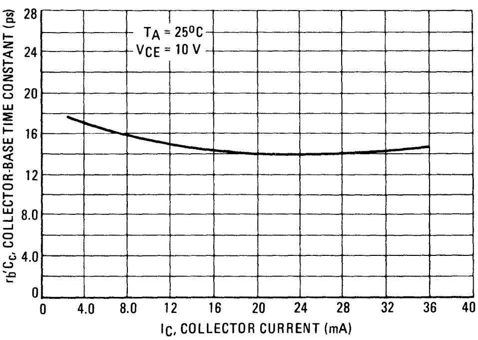
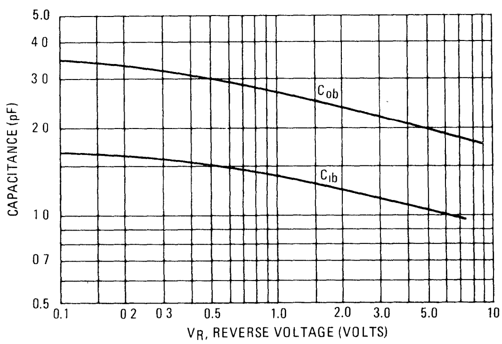


FIGURE 4 – TYPICAL JUNCTION CAPACITANCE



TURN-ON AND TURN-OFF TIMES

FIGURE 5 – V_{out} = 1.0 Vdc

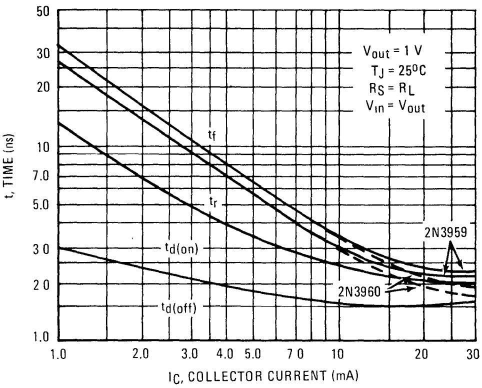


FIGURE 6 – V_{out} = 2.0 Vdc

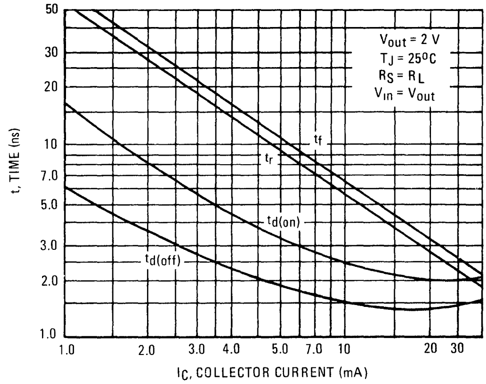
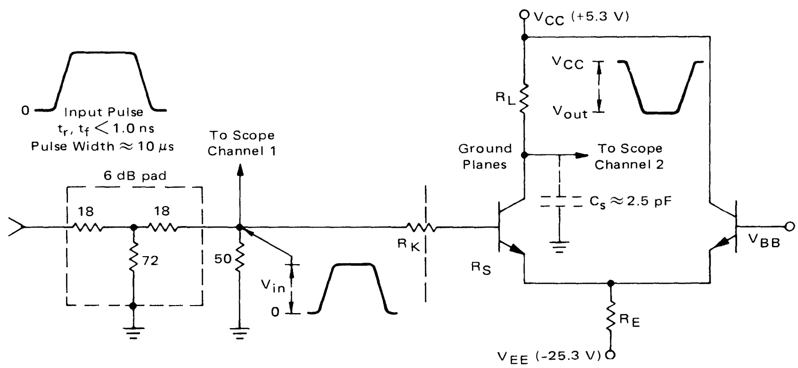


FIGURE 7 – SWITCHING TIMES TEST CIRCUIT



This test set up is designed to simulate a cascade of identical stages. ∴The source resistance (R_S) equals the load resistance (R_L). Values used in the test are shown in the table.

For V_{in} = V_{out} = 1 V, V_{BB} = +0.5 V, R_L & R_K values appropriately reduced.

V_{in} = V_{out} = 2 volts, V_{BB} = +1 0V			
I_C (mA)	R_E (kΩ)	R_L (Ω)	R_K (Ω)
1 0	24.0	2.0 k	2.0 k
3 0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

2N3961

For Specifications, See 2N3375 Data

2N3970 (SILICON)
2N3971
2N3972

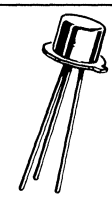
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

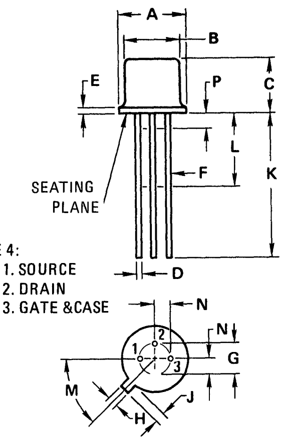
Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- High Input Impedance – I_{GSS} = 250 pAdc (Max) @ V_{GS} = 20 Vdc
- Low Drain-Source "ON" Resistance – $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N3970)
- Guaranteed Switching Characteristics

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)





STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{GS} = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	–	250	pAdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = 20 Vdc, I_S = 0)			–	250	pAdc
(V_{DG} = 20 Vdc, I_S = 0, T_A = 150°C)			–	500	nAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc)			–	250	pAdc
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc, T_A = 150°C)			–	500	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = 20 Vdc, V_{GS} = 0)	2N3970		50	150	
	2N3971		25	75	
	2N3972		5.0	30	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N3970		4.0	10	
	2N3971		2.0	5.0	
	2N3972		0.5	3.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	2N3970		–	1.0	
(I_D = 10 mAdc, V_{GS} = 0)	2N3971		–	1.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N3972		–	2.0	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$			Ohms
(I_D = 1.0 mAdc, V_{GS} = 0)	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	25	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = – 12 Vdc, f = 1.0 MHz)		C_{rss}	–	6.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Test Condition		Symbol	Min	Max	Unit
Turn-On Delay Time	Test Condition for 2N3970: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 20 mAdc, $V_{GS(off)}$ = 10 Vdc)	2N3970	$t_{d(on)}$	–	10	ns
		2N3971		–	15	
		2N3972		–	40	
Rise Time	Test Condition for 2N3971: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 5.0 Vdc)	2N3970	t_r	–	10	ns
		2N3971		–	15	
		2N3972		–	40	
Turn-Off Time	Test Condition for 2N3972: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(off)}$ = 3.0 Vdc)	2N3970	t_{off}	–	30	ns
		2N3971		–	60	
		2N3972		–	100	

*Indicates JEDEC Registered Data.

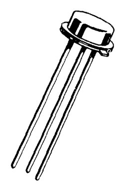
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 3.0%.

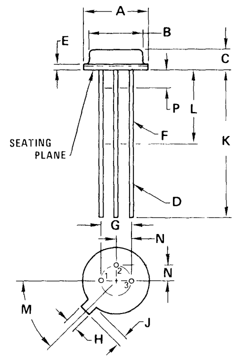
PNP SILICON ANNULAR CHOPPER TRANSISTOR

. . . designed for use in high emitter-base breakdown voltage and chopper applications.

- High Emitter-Base Breakdown Voltage — BV_{EBO} = 25 Vdc (Min) @ I_C = 10 μAdc
- Low Offset Voltage — $V_{EC(ofs)}$ = 1.0 mVdc @ I_B = 1.0 mAdc

PNP SILICON CHOPPER TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	20	Vdc
*Collector-Base Voltage	V_{CB}	25	Vdc
*Emitter-Base Voltage	V_{EB}	25	Vdc
*Collector Current — Continuous	I_C	100	mAdc
*Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.28	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	2.0 11.4	Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(1)	438	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	87.5	°C/W

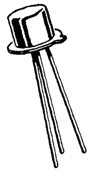
*Indicates JEDEC Registered Data
(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
*Collector-Emitter Breakdown Voltage (I_C = 1.0 μAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
*Emitter-Collector Breakdown Voltage (I_E = 1.0 μAdc, I_B = 0)	BV_{ECO}	20	–	–	Vdc
*Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	25	–	–	Vdc
*Collector Cutoff Current (V_{CB} = 25 Vdc, I_E = 0)	I_{CBO}	–	–	1.0	nAdc
*Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 5.0 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	30	50	–	–
Collector-Emitter Saturation Voltage (I_C = 5.0 mA, I_B = 0.5 mA)	$V_{CE(sat)}$	–	–	0.15	Vdc
Emitter-Collector Saturation Voltage (I_E = 10 μA, I_B = 200 μA)	$V_{EC(sat)}$	–	–	5.0	mVdc
Base-Emitter Saturation Voltage (I_C = 5.0 mAdc, I_B = 0.5 mAdc)	$V_{BE(sat)}$	0.65	0.8	1.0	Vdc
Offset Voltage	$V_{EC(ofs)}$				mVdc
(I_B = 200 μAdc, I_E = 0)		–	1.2	2.0	
(I_B = 1.0 mAdc, I_E = 0)		–	1.0	1.5	
***DYNAMIC CHARACTERISTICS**					
Current-Gain—Bandwidth Product (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 MHz)	f_T	1.0	–	–	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 4.0 MHz)	C_{ob}	–	10	14	pF
Input Capacitance (V_{BE} = 6.0 Vdc, I_C = 0, f = 4.0 MHz)	C_{ib}	–	6.0	8.0	pF
"On" Series Resistance (I_B = 1.0 mAdc, I_E = 0, I_C = 100 μA RMS, f = 1.0 kHz)	$r_{ec(on)}$	–	–	35	Ohms

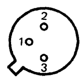
*Indicates JEDEC Registered Data.

2N3980 (SILICON)



Silicon annular PN unijunction transistor designed for military and industrial use in pulse, timing, sensing, and oscillator circuits.

CASE 22 A
(TO-18 Modified)
(Lead 3 connected to case)



STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	360*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage	V_{B2B1}	35	Volts
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Derate 2.4 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry.

**Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR ≤ 10 PPS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	η	0.68	—	0.82	—
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	R_{BB}	4.0	6.0	8.0	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to +100°C)	αR_{BB}	0.4	—	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2	$V_{EB1(sat)}$	—	2.5	3.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)	$I_{B2(mod)}$	12	15	—	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	I_{EO}	—	5.0	10	nA
(V_{B2E} = 30 V, I_{B1} = 0, T_A = 125°C)		—	—	1.0	μA
Peak Point Emitter Current (V_{B2B1} = 25 V)	I_P	—	0.6	2.0	μA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	I_V	1.0	4.0	10	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	V_{OB1}	6.0	8.0	—	Volts
Maximum Oscillation Frequency (Figure 4)	f(max)	1.0	1.25	—	MHz

NOTES

1. Intrinsic standoff ratio, η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop (≈0.5 V @ 10 μA)

2. Use pulse techniques: PW ≈ 300 μs duty cycle ≦2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

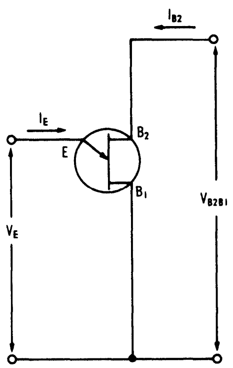


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES

(Exaggerated to Show Details)

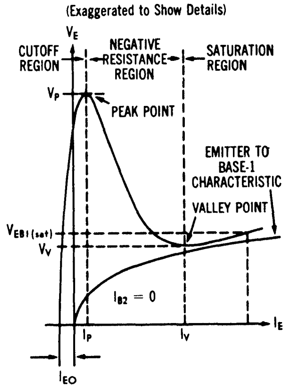


FIGURE 3 — V_{OB1} TEST CIRCUIT

(Typical Relaxation Oscillator)

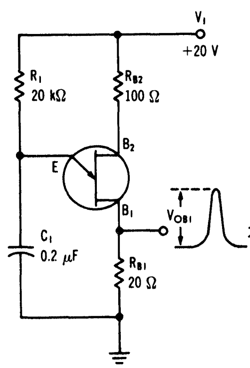
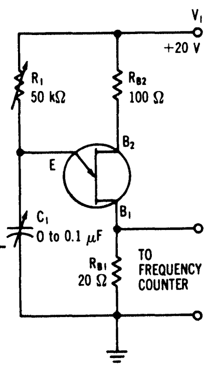


FIGURE 4 — F(max) MAXIMUM FREQUENCY TEST CIRCUIT



2N3993, 2N3994 (SILICON)
2N3994A

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

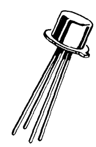
- Low Leakage Current – I_{DGO} = 1.2 nAdc (Max) @ V_{DG} = 15 Vdc
- Low Reverse Transfer Capacitance – C_{rss} = 4.5 pF (Max) @ V_{GS} = 10 Vdc (2N3993)
- Low Drain-Source "ON" Resistance – $r_{ds(on)}$ = 150 Ohms (Max) @ f = 1.0 kHz (2N3993)

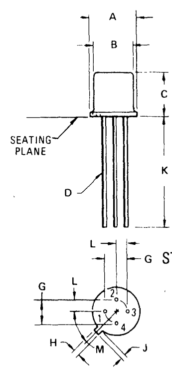
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS





STYLE 5
PIN 1. SOURCE
2. GATE 1
3. DRAIN
4. CASE

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0 209	0 230	5 310	5 840
B	0 178	0 195	4 520	4 950
C	0 170	0 210	4 320	5 330
D	0 016	0 019	0 406	0 483
G	0 100 TYP		0 254 TYP	
H	0 036	0 045	0 914	1 140
J	0 028	0 048	0 711	1 220
K	0 500	–	12 700	–
L	0 050 TYP		1 270 TYP	
M	45° TYP		45° TYP	

All JEDEC dimensions and notes apply

CASE 20-01
TO-72

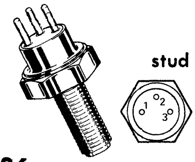
***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	Vdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = –15 Vdc, I_S = 0)			–	1.2	nAdc
(V_{DG} = –15 Vdc, I_S = 0, T_A = 150°C)			–	1.2	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = –10 Vdc, V_{GS} = 10 Vdc)	2N3993		–	1.2	nAdc
(V_{DS} = –10 Vdc, V_{GS} = 6.0 Vdc)	2N3994, 2N3994A		–	1.2	
(V_{DS} = –10 Vdc, V_{GS} = 10 Vdc, T_A = 150°C)	2N3993		–	1.0	μAdc
(V_{DS} = –10 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°C)	2N3994, 2N3994A		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1) (V_{DS} = –10 Vdc, V_{GS} = 0)	2N3993	I_{DSS}	10		mAdc
	2N3994, 2N3994A		2.0	–	
Gate-Source Voltage (V_{DS} = –10 Vdc, I_D = –1.0 μAdc)	2N3993	V_{GS}	4.0	9.5	Vdc
	2N3994, 2N3994A		1.0	5.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3993	$r_{ds(on)}$	–	150	Ohms
	2N3994, 2N3994A		–	300	
Forward Transadmittance (1) (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3993	$\|y_{fs}\|$	6.0	12	mmhos
	2N3994		4.0	10	
	2N3994A		5.0	10	
Input Capacitance (V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3993, 2N3994	C_{iss}	–	16	pF
	2N3994A		–	12	
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	2N3993	C_{rss}	–	4.5	pF
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	2N3994		–	5.0	
	2N3994A		–	3.5	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%

2N4012 (SILICON)



CASE 36
(TO-60)

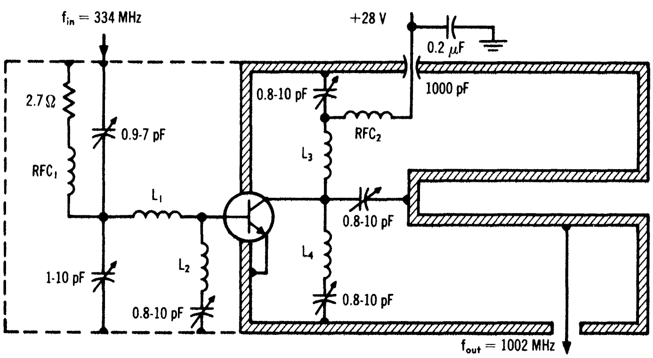
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR
CASE ISOLATED

NPN silicon annular transistor, designed for frequency-multiplication applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)}$ = 1.5 Vdc)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current	I_C	1.5	Amps
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	11.6 66.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — TRIPLER TEST CIRCUIT



RFC_1 = 0.22 μH
RFC_2 = 0.33 OHMS, W.W. RESISTOR
L_1 = 2 TURNS, 3/8" DIAMETER, NO. 16 WIRE
L_2 = 1/16" WIDTH COPPER STRIP, 3/8" LONG
L_3 = 2 TURNS, 3/8" DIAMETER, NO. 18 WIRE
L_4 = 1½ TURNS, 3/8" DIAMETER, 1/16" COPPER STRIP
OUTPUT CAVITY = 1¼" X 1¼" X 2¼"
CENTER CONDUCTOR = ¼" OD TUBE
OUTPUT DIRECT COUPLE = 1" FROM SHORTED END

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 0 to 200 mAdc, I_B = 0)	BV_{CEO}	40	-	-	Vdc
Collector-Emitter Breakdown Voltage(1) (I_C = 0 to 200 mAdc, $V_{EB(off)}$ = 1.5 Vdc)	BV_{CEV}	65	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	-	0.1	mAdc
ON CHARACTERISTICS					
DC Current-Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE1}	4.0	–	40	–
(I_C = 125 mAdc, V_{CE} = 5.0 Vdc)	h_{FE2}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 125 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	-	350	-	MHz
Collector-Base Cutoff Frequency † (V_{CE} = 28 Vdc, I_C = 0)	f_c	-	25	-	GHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0)	C_{ob}	-	-	10	pF
Base-Spreading Resistance (I_C = 250 mAdc, V_{CE} = 28 Vdc, f = 400 MHz)	r_{bb}	-	10	-	Ohms

FUNCTIONAL TEST

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Power Output	Tripler (Test Circuit Figure 1) V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 334 MHz, f_{out} = 1002 MHz	P_{out}	2.5	-	-	Watts
Efficiency		η	25	-	-	%
Power Output	Doubler V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 400 MHz, f_{out} = 800 MHz	P_{out}	-	3.0	-	Watts
Efficiency		η	-	35	-	%

(1) Pulsed through a 25 mH inductor; duty cycle = 50%

† f_c is determined from Q measured at 210 MHz. f_c = Q x 210 MHz.

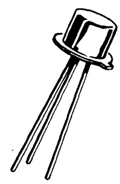
2N4013 (SILICON)
2N4014

NPN SILICON ANNULAR MEMORY DRIVER

. . . designed for medium-current, high-speed switching applications. Ideally suited for ferrite core memory driver circuits.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 50 Vdc (Min) @ I_C = 10 mAdc – 2N4013
  = 30 Vdc (Min) @ I_C = 10 mAdc – 2N4014
- Guaranteed Fast Switching Times @ I_C = 500 mAdc
  t_{on} = 20 ns (Typ) t_{off} = 50 ns (Typ)
  = 35 ns (Max) = 60 ns (Max)
- Guaranteed High DC Current Gain –
  h_{FE} = 35 (Min) @ I_C = 500 mAdc

NPN SILICON MEMORY DRIVER TRANSISTOR

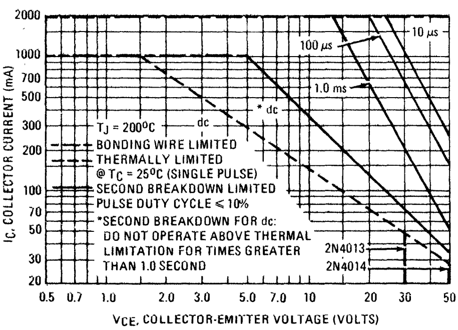


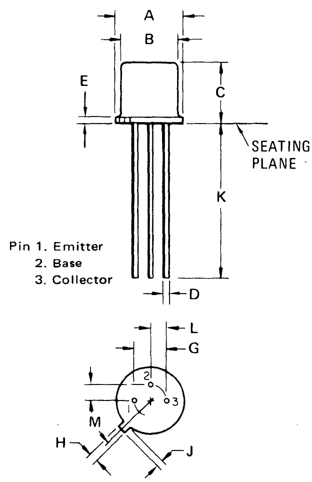
*MAXIMUM RATINGS

Rating	Symbol	2N4013	2N4014	Unit
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Collector-Base Voltage	V_{CB}	50	80	Vdc
Emitter-Base Voltage	V_{EB}	6 0		Vdc
Collector Current – Continuous – Peak	I_C	1.0 2.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.5 28.6		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.4 8.0		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA





All JEDEC dimensions and notes apply

CASE 22
TO-18

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	0 209	0 230	5 310	5 840
B	0 178	0 195	4 520	4 950
C	0 170	0 210	4 320	5 330
D	0.016	0 019	0 406	0 483
E	–	0 030	–	0 762
G	0 100 NOM		2 540 NOM	
H	0 036	0 046	0 914	1 170
J	0 028	0 048	0 711	1 220
K	0 500	–	12 700	–
L	0 050 NOM		1 270 NOM	
M	45° NOM		45° NOM	

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	2N4014		50	–	–	
	2N4013		30	–	–	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 10 μAdc, V_{BE} = 0)	2N4014		80	–	–	
	2N4013		50	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 10 μAdc, I_E = 0)	2N4014		80	–	–	
	2N4013		50	–	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0		BV_{EBO}	6.0	–	–	Vdc
Collector Cutoff Current		I_{CES}				μAdc
(V_{CE} = 80 Vdc, V_{EB} = 0)	2N4014		–	0.15	10	
(V_{CE} = 50 Vdc, V_{EB} = 0)	2N4013		–	0.15	10	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4014		–	0.12	1.7	
(V_{CB} = 40 Vdc, I_E = 0)	2N4013		–	0.12	1.7	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N4014		–	–	120	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N4013		–	–	120	
ON CHARACTERISTICS (1)						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)			30	–	–	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)			60	–	150	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			30	–	–	
(I_C = 300 mAdc, V_{CE} = 1.0 Vdc)			40	–	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			35	–	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)			20	–	–	
(I_C = 800 mAdc, V_{CE} = 2.0 Vdc)	2N4014		20			
	2N4013		25	–	–	
(I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	2N4014		25			
	2N4013		30	–	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc	2N4014		–	0.17	0.25	
	2N4013		–	0.17	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N4014		–	0.19	0.26	
	2N4013		–	0.19	0.20	
(I_C = 300 mAdc, I_B = 30 mAdc	2N4014		–	0.25	0.40	
	2N4013		–	0.25	0.32	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N4014		–	0.30	0.52	
	2N4013		–	0.30	0.42	
(I_C = 800 mAdc, I_B = 80 mAdc)	2N4014		–	0.43	0.80	
	2N4013		–	0.43	0.65	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N4014		–	0.55	0.95	
	2N4013		–	0.55	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	–	0.76	
(I_C = 100 mAdc, I_B = 10 mAdc)			–	–	0.86	
(I_C = 300 mAdc, I_B = 30 mAdc)			–	–	1.1	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	–	1.1	
(I_C = 800 mAdc, I_B = 80 mAdc)			–	–	1.5	
(I_C = 1.0 Adc, I_B = 100 mAdc)			–	–	1.7	
SMALL-SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (2) (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	–	–	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	2N4014		–	–	10	
	2N4013		–	–	12	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{ib}	–	–	55	pF

*Indicates JEDEC Registered Data. (1) Pulse test: Pulse Width = 300 μs, Duty Cycle = 1.0%. (2) $f_T = |h_{fe}| \bullet f_{test}$

Characteristic		Symbol	Min	Typ	Max	Unit
***SWITCHING CHARACTERISTICS**						
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 3.8 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figures 8, 10)	t_d	–	5.0	10	ns
Rise Time		t_r	–	15	30	ns
Turn-On Time		t_{on}	–	20	35	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figures 9, 10)	t_s	–	30	50	ns
Fall Time	2N4014	t_f	–	20	25	ns
	2N4013			25	30	
Turn-Off Time		t_{off}	–	50	60	ns

*Indicates JEDEC Registered Data.

TYPICAL DC CHARACTERISTICS

FIGURE 2 – DC CURRENT GAIN

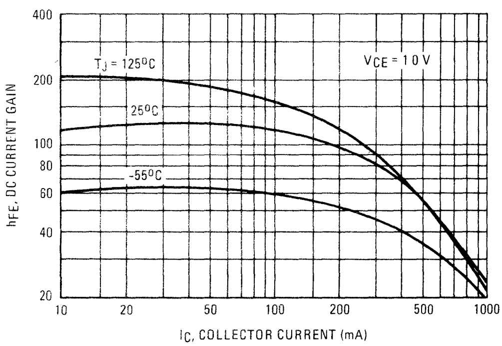


FIGURE 3 – "ON" VOLTAGES

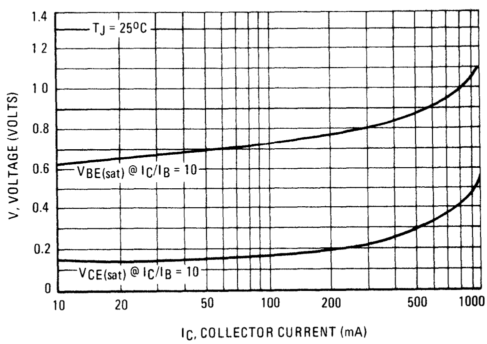


FIGURE 4 – COLLECTOR SATURATION REGION

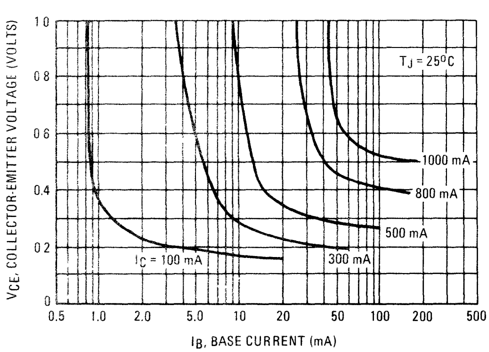
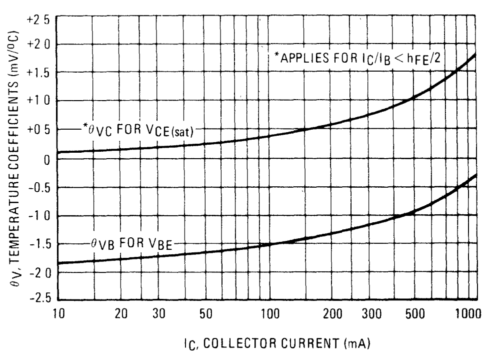


FIGURE 5 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 – CURRENT-GAIN – BANDWIDTH PRODUCT

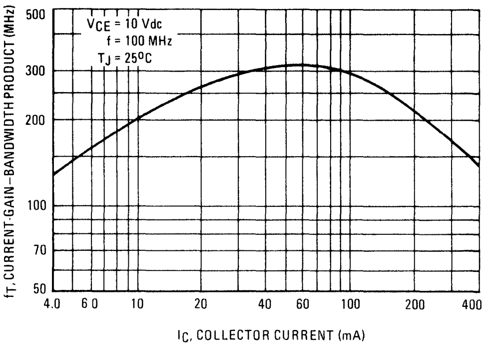


FIGURE 7 – CAPACITANCE

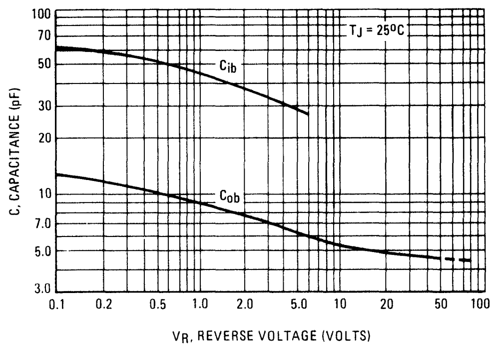


FIGURE 8 – TURN-ON TIME

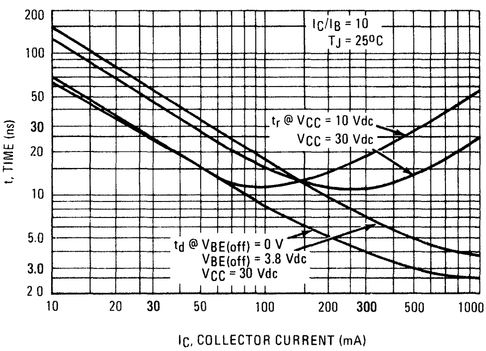


FIGURE 9 – TURN-OFF TIME

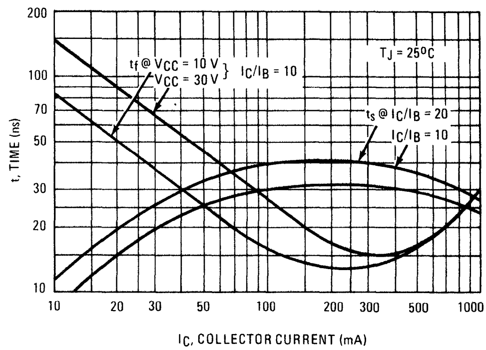
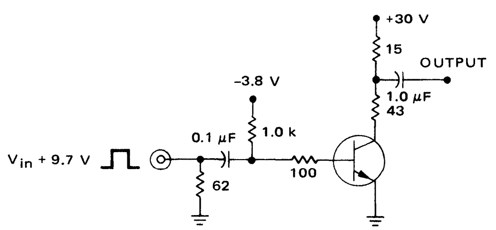
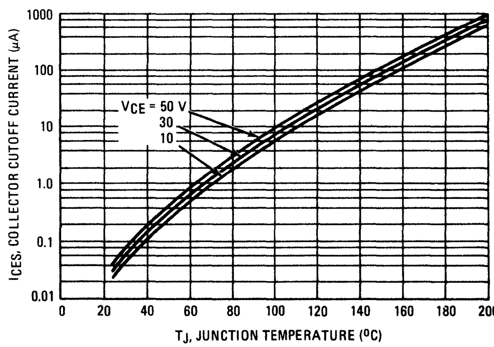


FIGURE 10 – SWITCHING TIME TEST CIRCUIT



$t_r \leq 1.0$ ns
P.W. ≥ 200 ns
Duty Cycle ≤ 2.0%
Generator Source Impedance = 50 Ω
Pulse Generator EH1421 Timing Unit and 1121 Pulse Driver
Oscilloscope Tektronix 661 Sampling Scope

FIGURE 11 – COLLECTOR CUTOFF CURRENT



2N4015 (SILICON)
2N4016

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

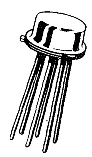
- Excellent Temperature Tracking — Dual Devices — 2N4015
  $\Delta|V_{BE1} - V_{BE2}|$ = 1.6 mVdc (Max) @ -55 to +25°C
  = 2.0 mVdc (Max) @ +25 to +125°C
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.25 Vdc (Max) @ I_C = 50 mAdc
- DC Current Gain Specified — 0.01 mAdc to 50 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 200 MHz @ I_C = 50 mAdc

*MAXIMUM RATINGS

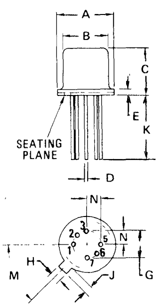
Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5 0		Vdc
Collector Current — Continuous	I_C	300		mAdc
Base Current	I_B	100		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2 29	500 2 86	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	0.85 4.85	1.4 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data

PNP SILICON
MULTIPLE TRANSISTORS



STYLE 1
PIN 1. COLLECTOR
2 BASE
3 EMITTER
4 OMITTED
5 EMITTER
6 BASE
7. COLLECTOR
8 OMITTED



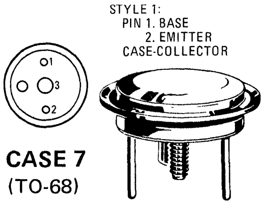
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8 51	9 40	0 335	0 370
B	7 75	8 51	0 305	0 335
C	3 81	4 70	0 150	0 185
D	0 41	0 53	0 016	0 021
G	5.08 BSC		0 200 BSC	
H	0 71	0 86	0 028	0 034
J	0 74	1 14	0 029	0 045
K	12 70	—	0 500	—
M	45° BSC		45° BSC	
N	2 54 BSC		0 100 BSC	

CASE 654-07

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	60	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 50 Vdc, I_E = 0)		–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = +150°C)		–	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 0.01 mAdc, V_{CE} = 5.0 Vdc)		80	–	
(I_C = 0.1 mAdc, V_{CE} = 5.0 Vdc)		120	–	
(I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		135	350	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)(1)		115	–	
Collector-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{CE(sat)}$	–	0.25	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 50 mAdc, I_B = 2.5 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain—Bandwidth Product(2)	f_T			MHz
(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		200	600	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)		60	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	25	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{ie}	–	11.5	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{re}	–	15	$\times 10^{-4}$
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	135	420	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{oe}	–	80	μmhos
Noise Figure (I_C = 0.03 mAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, f = 1.0 kHz, BW = 200 Hz)	NF	–	4.0	dB
MATCHING CHARACTERISTICS				
DC Current Gain Ratio (I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc)	h_{FE1}/h_{FE2}	0.9	1.0	–
Base-Emitter Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc 2N4015		–	5.0	
2N4016		–	2.5	
Base-Emitter Voltage Differential Gradient	$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$			mVdc
(I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = -55°C to +25°C) 2N4015		–	1.6	
2N4016		–	0.8	
(I_C = 0.1 to 1.0 mAdc, V_{CE} = 5.0 Vdc, T_A = +25°C to +125°C) 2N4015		–	2.0	
2N4016		–	1.0	

*Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 7
(TO-68)

Collector connected to case

PNP germanium power transistors designed for high-current applications requiring high gain and extremely low saturation voltage.

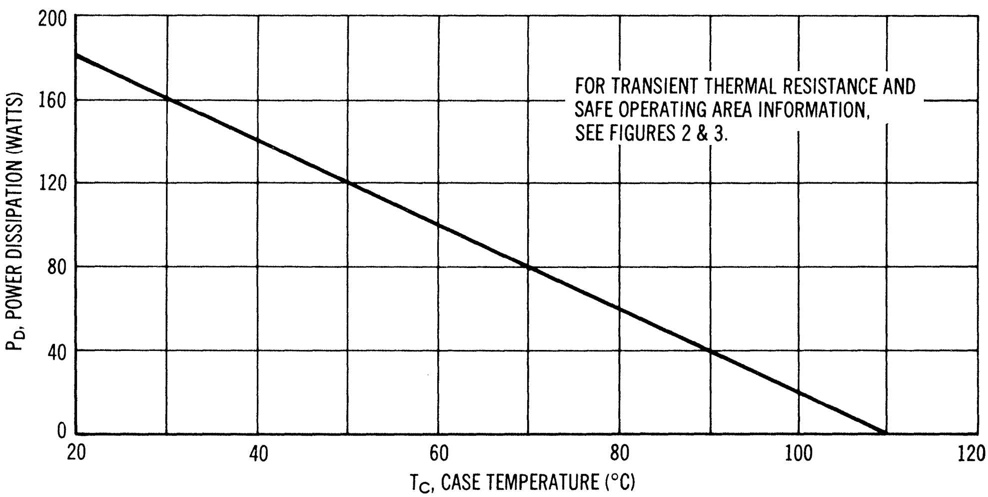
MAXIMUM RATINGS

Rating	Symbol	2N4048 2N4051	2N4049 2N4052	2N4050 2N4053	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current — Continuous	I_C*	← 60 →			Adc
Total Device Dissipation @ $T_C = 25°C$	P_D	← 170 →			Watts
Derate above 25°C		← 2.0 →			W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	← 0.5 →	°C/W

FIGURE 1 — AVERAGE POWER-TEMPERATURE DERATING CURVE



* JEDEC Registered Values, For True Capability See Figure 3

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage†		BV_{CEO}†			Vdc
(I_C = 1.0 Adc, I_B = 0)	2N4048, 2N4051		30	-	
	2N4049, 2N4052		45	-	
	2N4050, 2N4053		60	-	
Collector-Emitter Breakdown Voltage		BV_{CES}			Vdc
(I_C = 300 mAdc, V_{BE} = 0)	2N4048, 2N4051		45	-	
	2N4049, 2N4052		60	-	
	2N4050, 2N4053		75	-	
Floating Potential		V_{EBF}			Vdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	0.5	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4048, 2N4051		-	15	
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4049, 2N4052		-	15	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4050, 2N4053		-	15	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2.0 Vdc, I_E = 0)			-	0.2	
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	4.0	
Emitter Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 25 Vdc, I_C = 0)	2N4048, 2N4051		-	4.0	
(V_{BE} = 25 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 30 Vdc, I_C = 0)	2N4049, 2N4052		-	4.0	
(V_{BE} = 30 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 40 Vdc, I_C = 0)	2N4050, 2N4053		-	4.0	
(V_{BE} = 40 Vdc, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain†		h_{FE}†			-
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4048, 2N4049, 2N4050		60	180	
	2N4051, 2N4052, 2N4053		120	240	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage†		$V_{CE(sat)}$†			Vdc
(I_C = 15 Adc, I_B = 1.0 Adc)			-	0.15	
(I_C = 60 Adc, I_B = 6.0 Adc)			-	0.3	
Base-Emitter Saturation Voltage†		$V_{BE(sat)}$†			Vdc
(I_C = 15 Adc, I_B = 1.0 Adc)			-	0.6	
(I_C = 60 Adc, I_B = 6.0 Adc)			-	1.0	
SMALL SIGNAL CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	2.0	-	kHz

† To avoid excessive heating of the collector junction, perform test with pulse method.

The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T*, and the behavior of the base-spreading resistance, r_B'

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t_r on Figure 6 follows theory closely, i.e.:

$$t_r = 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level A lower supply voltage will increase rise time slightly.

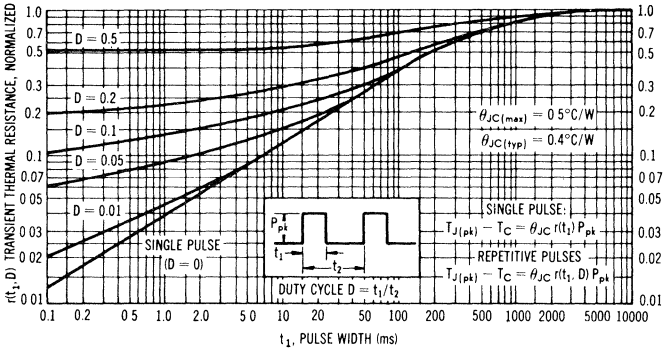
Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge, i.e., charge in excess of that necessary to sustain the circuit limited value of I_C. As a result, the base resistivity and consequently r_B' become very low During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, i_{B2}, as can be seen from the waveforms of Figure 5 During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B. This unusual behavior occurs because r_B' limits the amount of reverse current which can be achieved. Also, it seems evident that r_B' increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 6 Delay time is not shown as it is negligible in comparison to the other times.

* $f_T \approx f_{\alpha e} \times h_{fe}$

FIGURE 2 — TRANSIENT THERMAL RESISTANCE



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 110°C$, T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 3 — ACTIVE REGION SAFE-OPERATING AREA

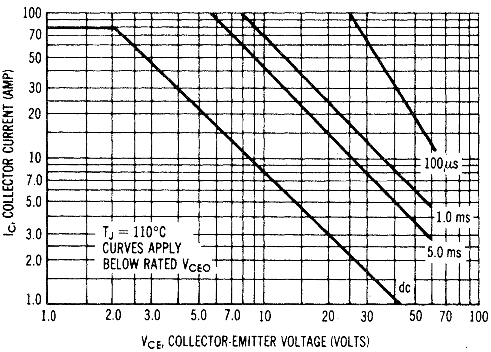
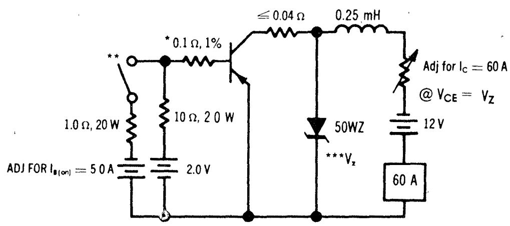


FIGURE 4 — SAFE OPERATING AREA TEST CIRCUIT



*NOT REQUIRED IF CURRENT PROBE USED TO READ $I_{B(on)}$

**PRF ≈ 60 Hz

SERIES IMPEDANCE & INDUCTANCE MUST BE KEPT TO A MINIMUM.

***ZENER SELECTED TO ESTABLISH SAFE OPERATING AREA VOLTAGE.

@ I_C = 60 Adc:
2N4048, 2N4051 = 35 Vdc
2N4049, 2N4052 = 40 Vdc
2N4050, 2N4053 = 45 Vdc

FIGURE 5 — SWITCHING TEST CIRCUIT

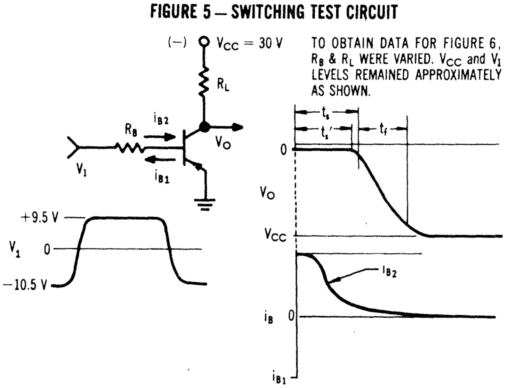
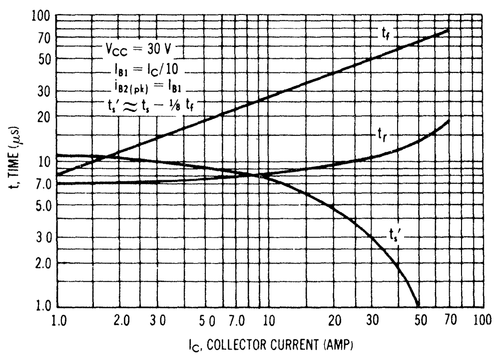


FIGURE 6 — SWITCHING TIMES



TYPICAL DC CHARACTERISTICS

FIGURE 7 — DC CURRENT GAIN

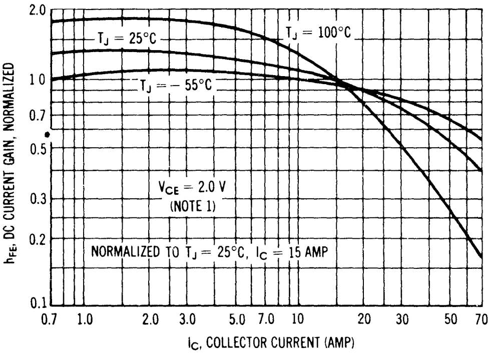


FIGURE 8 — COLLECTOR SATURATION REGION

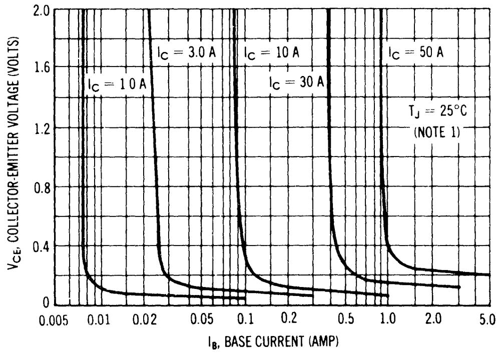


FIGURE 9 — EFFECTS OF BASE-EMITTER RESISTANCE

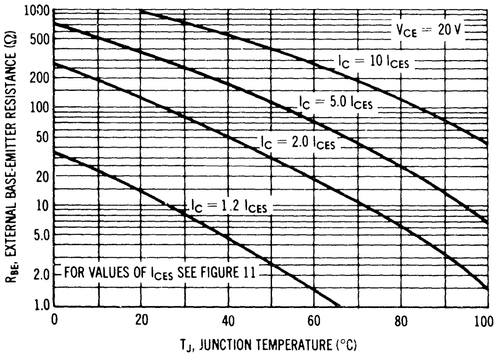


FIGURE 10 — "ON" VOLTAGES

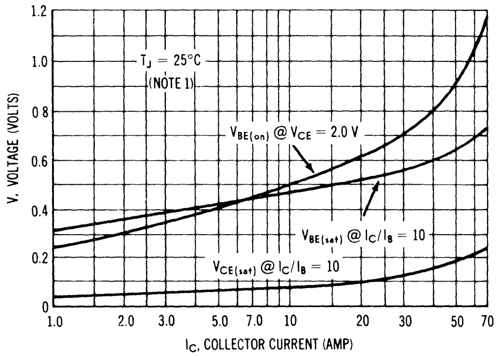


FIGURE 11 — COLLECTOR CUTOFF REGION

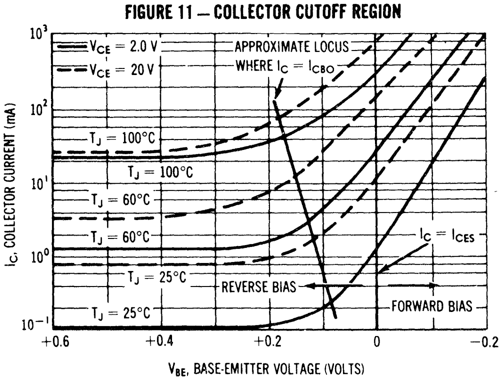
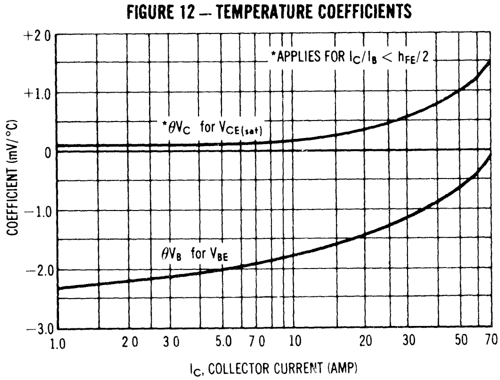


FIGURE 12 — TEMPERATURE COEFFICIENTS



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

2N4066 (SILICON)
2N4067

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS

Enhancement Mode MOS Field-Effect Transistors designed primarily for low-power, chopper or switching applications.

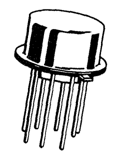
- High Forward Transadmittance —
  $|y_{fs}|$ = 2.5 mmhos (Min) @ V_{DS} = -15 Vdc (2N4067)
- Low Forward Gate Current —
  I_{GF} = 2.5 pAdc (Max) @ V_{GS} = -25 Vdc
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 250 Ohms (Max) @ V_{GS} = -15 Vdc (2N4067)

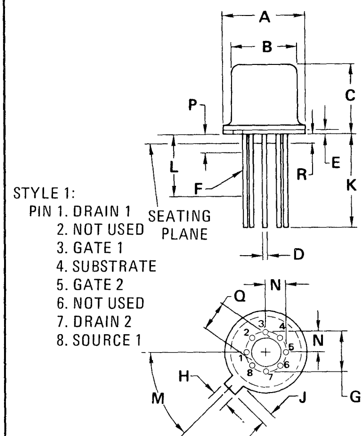
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-30	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	+25	Vdc
Forward Gate-Source Voltage	V_{GSF}	-25	Vdc
Drain Current	I_D	200	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 4.0	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.7 11.3	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Operating Junction Temperature Range	T_J	-65 to +175	°C

*Indicates JEDEC Registered Data.

DUAL P-CHANNEL MOS FIELD-EFFECT TRANSISTORS





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.406	0.483	0.016	0.019
G	5.08 BSC		0.200 BSC	
H	0.711	0.864	0.028	0.034
J	0.737	1.14	0.029	0.045
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	
P	–	1.27	–	0.050
Q	3.05	4.06	0.120	0.160
R	0.254	1.02	0.010	0.040

All JECEC dimensions and notes apply

CASE 642-02
(TO-76)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μAdc, V_{GS} = 0)		$V_{(BR)DSS}$	-30	–	Vdc
Source-Drain Breakdown Voltage (I_S = 10 μAdc, V_{GD} = 0)		$V_{(BR)SDS}$	-30	–	Vdc
Zero-Gate Voltage Source Current		I_{SDS}			
(V_{SD} = –15 Vdc, V_{GD} = 0)			–	1.0	nAdc
(V_{SD} = –15 Vdc, V_{GD} = 0, T_A = 150°C)			–	2.0	μAdc
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			
(V_{DS} = –15 Vdc, V_{GS} = 0)			–	1.0	nAdc
(V_{DS} = –15 Vdc, V_{GS} = 0, T_A = 150°C)			–	2.0	μAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = –15 Vdc, I_D = 10 μAdc)		$V_{GS(TH)}$	-3.0	-6.0	Vdc
Forward Gate Current (V_{GS} = –25 Vdc, V_{DS} = 0)		I_{GF}	–	2.5	pAdc
"ON" Drain Current (V_{DS} = –15 Vdc, V_{GS} = –15 Vdc)		$I_{D(on)}$	10	50	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Static Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = –15 Vdc, I_D = 0, f = 1.0 kHz)	2N4066		–	500	
	2N4067		–	250	
Forward Transadmittance (Note 1)		$\|y_{fs}\|$			mmhos
(V_{DS} = –15 Vdc, V_{GS} = –15 Vdc, f = 1.0 kHz)	2N4066		1.5	–	
	2N4067		2.5	–	
(V_{DS} = –15 Vdc, V_{GS} = –15 Vdc, f = 1.0 kHz,	2N4066		1.0	–	
T_A = 100°C)	2N4067		1.75	–	
Output Admittance (V_{DS} = –15 Vdc, V_{GS} = –15 Vdc, f = 1.0 kHz)		$\|y_{os}\|$	–	300	μmhos
Input Capacitance (V_{DS} = –15 Vdc, V_{GS} = –15 Vdc, f = 1.0 MHz)		C_{iss}	–	7.0	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF
Source-Substrate Capacitance (V_{DU} = –15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{SU}	–	5.0	pF
Drain-Substrate Capacitance (V_{SU} = –15 Vdc, V_{GS} = 0, I_S = 0, f = 1.0 MHz)		C_{DU}	–	5.0	pF

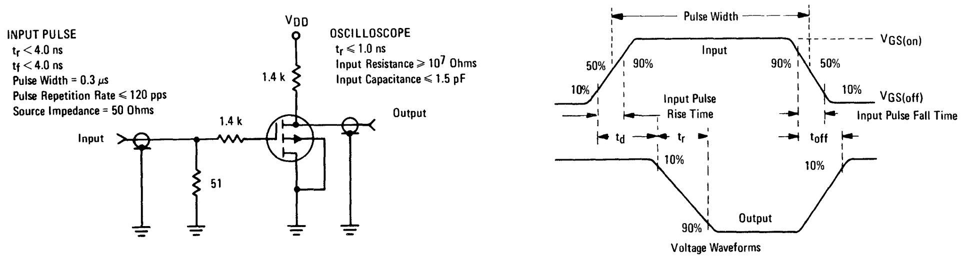
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	(V_{DD} = –15 Vdc, $I_{D(on)}$ = 10 mAdc,	t_d	–	20	ns
Rise Time	$V_{GS(on)}$ = –15 Vdc, $V_{GS(off)}$ = 0)	t_r	–	30	ns
Turn-Off Time		t_{off}	–	50	ns

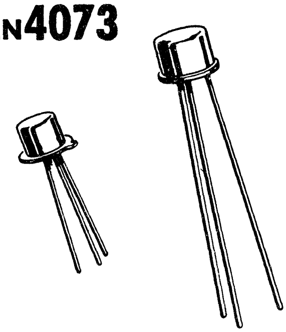
*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



2N4072 (SILICON)
2N4073

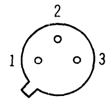


CASE 22
(TO-18)
2N4072

CASE 31
(TO-5)
2N4073

Collector connected to case

NPN silicon annular transistors designed as amplifiers and drivers for large-signal VHF and UHF applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	2N4072	2N4073	Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	100	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	0.35 2.0	- -	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	- -	1.5 8.57	Watts mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
STATIC CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 15 mAdc, I_B = 0)	$BV_{CEO(sus)}$	20	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	- -	0.1 100	μAdc
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2 Vdc)	h_{FE}	10	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 25 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	-	550	-	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	3.0	4.0	pF

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL TEST						
Power Gain	2N4072 Test Circuit - Figure 5 P_{in} = 25 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	250	-	-	mW
Collector Effecincy		η	50	60	-	%
Power Gain	2N4073 Test Circuit - Figure 5 P_{in} = 50 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	500	650	-	mW
Collector Efficiency		η	50	65	-	%

2N4072

FIGURE 1 — POWER OUTPUT versus FREQUENCY

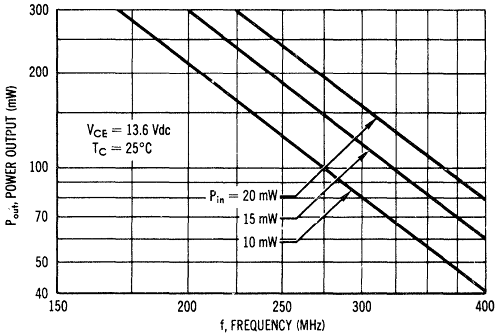
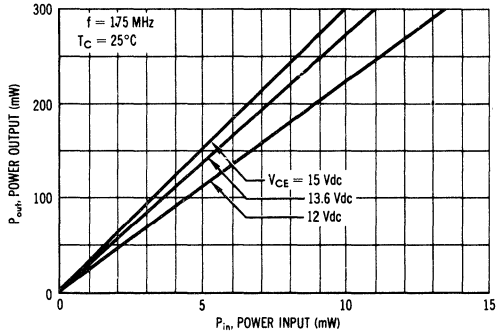


FIGURE 2 — POWER OUTPUT versus POWER INPUT



2N4073

FIGURE 3 — POWER OUTPUT versus FREQUENCY

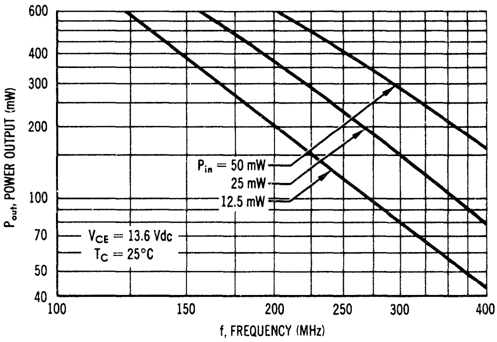


FIGURE 4 — POWER OUTPUT versus POWER INPUT

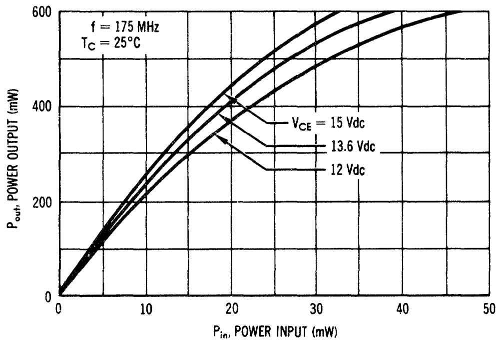
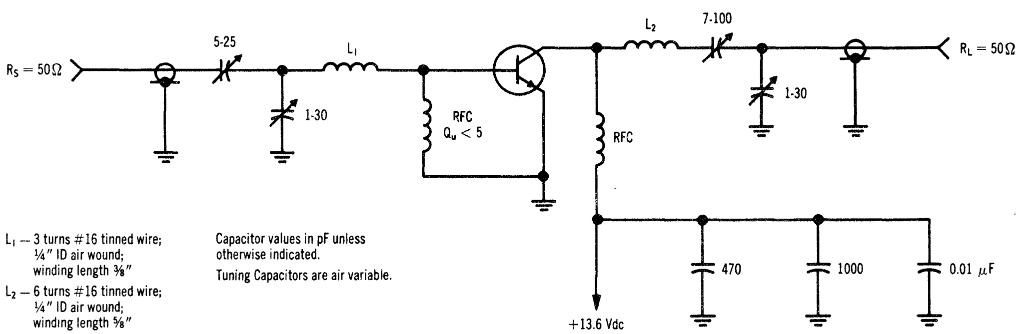


FIGURE 5 — 175 MHz TEST CIRCUIT



L_1 — 3 turns #16 tinned wire; ¼" ID air wound; winding length ⅜"

L_2 — 6 turns #16 tinned wire; ¼" ID air wound; winding length ⅝"

Capacitor values in pF unless otherwise indicated.

Tuning Capacitors are air variable.

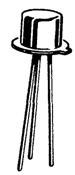
2N4091 (SILICON)
2N4092
2N4093

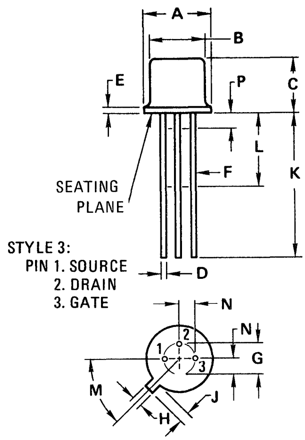
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

- Low Drain-Source "On" Resistance —
  $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N4091)
- Low Source Reverse Current —
  I_{SGO} = 0.2 nAdc (Max) @ V_{SG} = 20 Vdc
- Guaranteed Switching Characteristics

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS (Type A)





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

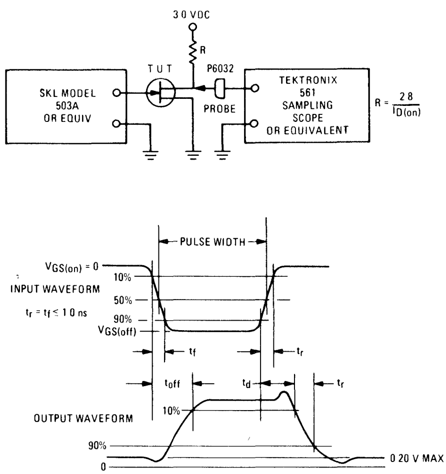
All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Gate Current	I_G	10	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating Junction Temperature Range	T_J	-65 to +175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Drain-Gate Breakdown Voltage (I_D = 1.0 μAdc, I_S = 0)		$V_{(BR)DGO}$	40	-	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N4091	$V_{GS(off)}$	5.0	10	Vdc
	2N4092		2.0	7.0	
	2N4093		1.0	5.0	
Source Reverse Current (V_{SG} = 20 Vdc, I_D = 0)		I_{SGO}	-	0.2	nAdc
Drain Reverse Current (V_{DG} = 20 Vdc, I_S = 0)		I_{DGO}	-	0.2	nAdc
(V_{DG} = 20 Vdc, I_D = 0, T_A = 150°C)			-	0.4	μAdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc)	2N4091	$I_{D(off)}$	-	0.2	nAdc
(V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc)	2N4092		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc)	2N4093		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)	2N4091		-	0.4	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 8.0 Vdc, T_A = 150°C)	2N4092		-	0.4	
(V_{DS} = 20 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°C)	2N4093		-	0.4	
ON CHARACTERISTICS					
Zero-Gate Voltate Drain Current (1) (V_{DS} = 20 Vdc, V_{GS} = 0)	2N4091	I_{DSS}	30	-	mAdc
	2N4092		15	-	
	2N4093		8.0	-	
Drain-Source "ON" Voltage (I_D = 6.6 mAdc, V_{GS} = 0)	2N4091	$V_{DS(on)}$	-	0.2	Vdc
(I_D = 4.0 mAdc, V_{GS} = 0)	2N4092		-	0.2	
(I_D = 2.5 mAdc, V_{GS} = 0)	2N4093		-	0.2	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	2N4091	$r_{DS(on)}$	-	30	Ohms
	2N4092		-	50	
	2N4093		-	80	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4091	$r_{ds(on)}$	-	30	Ohms
	2N4092		-	50	
	2N4093		-	80	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	16	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 20 Vdc, f = 1.0 MHz)		C_{rss}	-	5.0	pF
SWITCHING CHARACTERISTICS					
Delay Time (See Figure 1) ($I_{D(on)}$ = 6.6 mAdc)	2N4091	t_d	-	15	ns
($I_{D(on)}$ = 4.0 mAdc)	2N4092		-	15	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		-	20	
Rise Time (See Figure 1) ($I_{D(on)}$ = 6.6 mAdc)	2N4091	t_r	-	10	ns
($I_{D(on)}$ = 4.0 mAdc)	2N4092		-	20	
($I_{D(on)}$ = 2.5 mAdc)	2N4093		-	40	
Turn-Off Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc)	2N4091	t_{off}	-	40	ns
($V_{GS(off)}$ = 8.0 Vdc)	2N4092		-	60	
($V_{GS(off)}$ = 6.0 Vdc)	2N4093		-	80	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 3.0%.

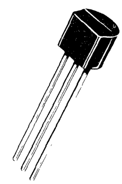
2N4123 (SILICON)
2N4124

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry with types 2N4125 and 2N4126.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 30 Vdc (Min) @ I_C = 1.0 mAdc — 2N4123
- Current Gain Specified at 2.0 mAdc and 50 mAdc
- Low Output Capacitance — C_{ob} = 40 pF (Max) @ V_{CB} = 5.0 Vdc

NPN SILICON AMPLIFIER TRANSISTORS



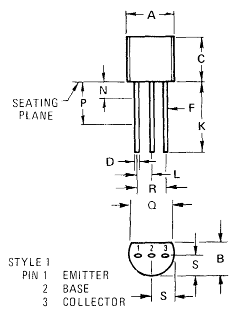
*MAXIMUM RATINGS

Rating	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8		mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

*Indicates JEDEC Registered Data.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_E = 0)	2N4123	BV_{CEO}	30	–	Vdc
	2N4124		25	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4123	BV_{CBO}	40	–	Vdc
	2N4124		30	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4123	h_{FE}	50	150	–
	2N4124		120	360	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4123		25	–	
	2N4124		60	–	
Collector-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	–	0.3	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS					
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123	$\lvert h_{fe} \rvert$	2.5	–	–
	2N4124		3.0	–	
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123	f_T	250	–	MHz
	2N4124		300	–	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	8.0	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4123	h_{fe}	50	200	–
	2N4124		120	480	
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4123	NF	–	6.0	dB
	2N4124		–	5.0	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

*Indicates JEDEC Registered Data

FIGURE 1 — CAPACITANCE

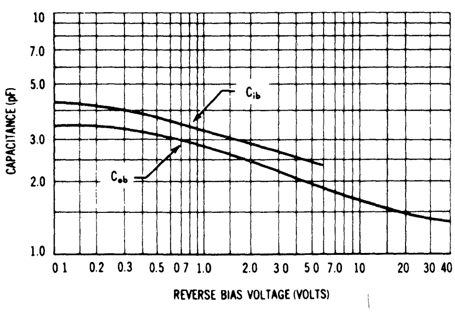
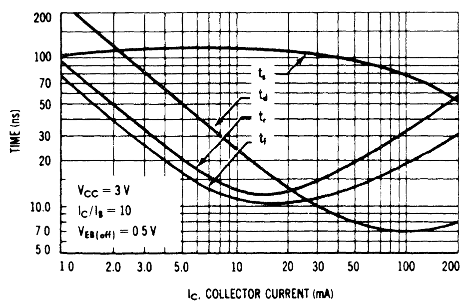


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

(V_{CE} = 5 Vdc, T_A = 25°C)
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

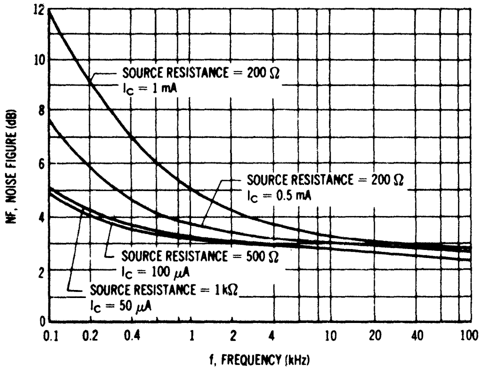
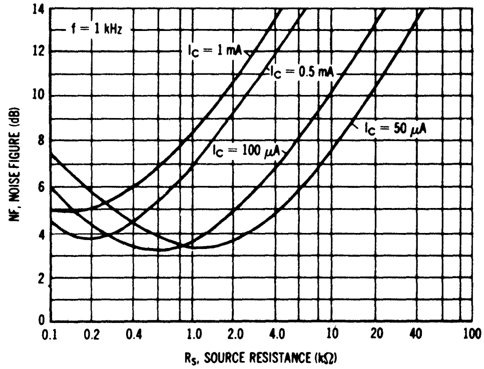


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

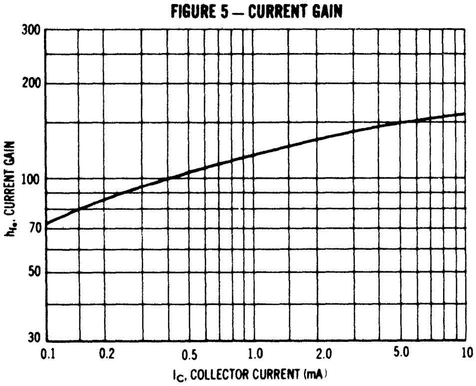


FIGURE 6 — OUTPUT ADMITTANCE

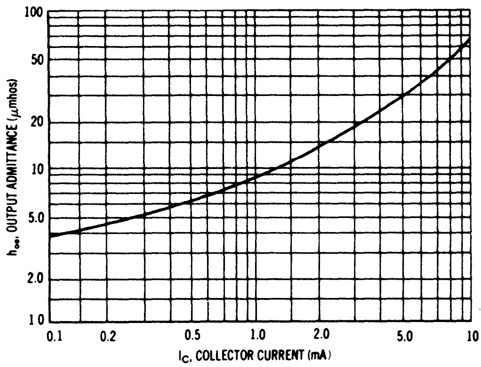


FIGURE 7 — INPUT IMPEDANCE

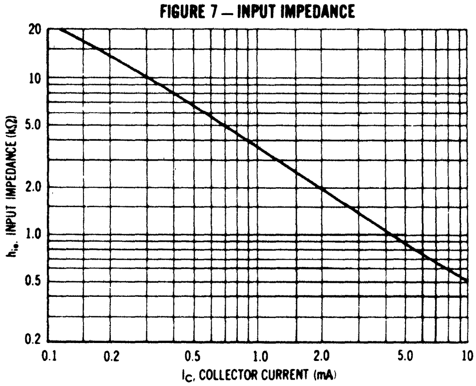
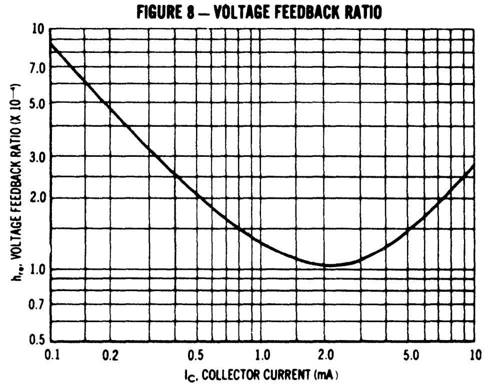


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

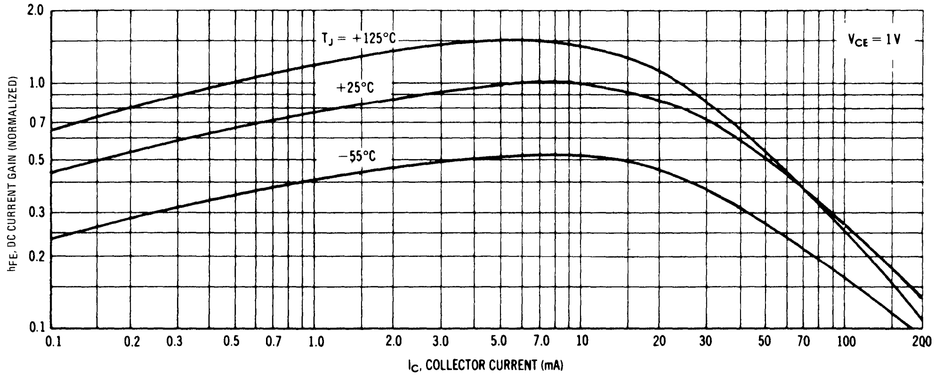


FIGURE 10 – COLLECTOR SATURATION REGION

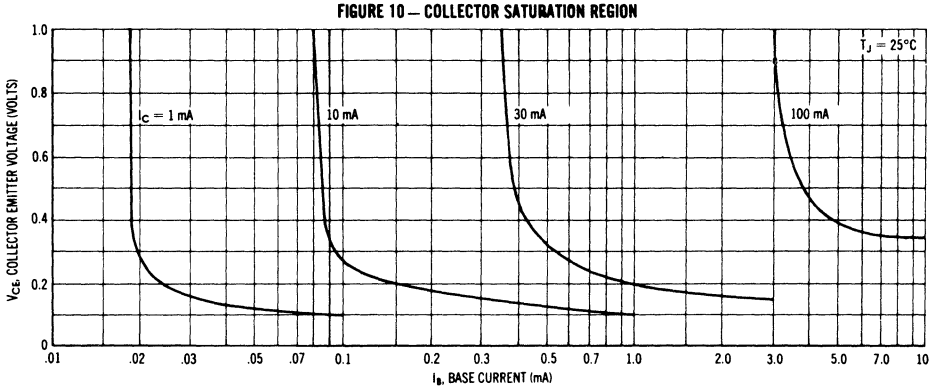


FIGURE 11 – "ON" VOLTAGES

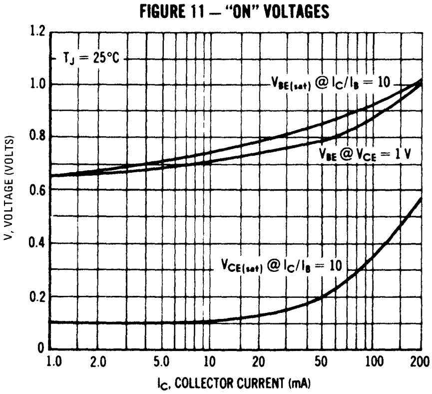
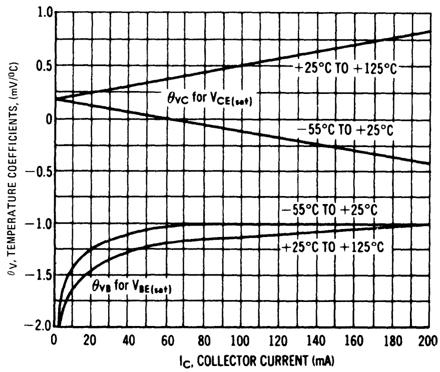


FIGURE 12 – TEMPERATURE COEFFICIENTS



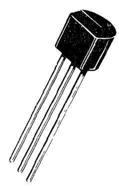
2N4125 (SILICON)
2N4126

PNP SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry with types 2N4123 and 2N4124.

- Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 30 Vdc (Min) @ I_C = 1.0 mAdc — 2N4125
- Current Gain Specified at 2.0 mAdc and 50 mAdc
- Collector-Base Capacitance —
  C_{cb} = 4.5 pF (Max) @ V_{CB} = 5.0 Vdc

PNP SILICON AMPLIFIER TRANSISTORS



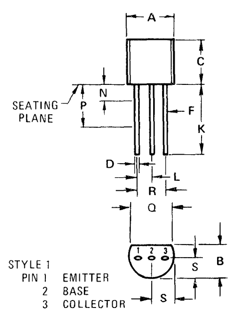
*MAXIMUM RATINGS

Rating	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	30	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	200		mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	350 2.8		mW $mW/^oC$
Total Power Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.0 8.0		Watt $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	$^oC/W$
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	$^oC/W$

*Indicates JEDEC Registered Data.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4 450	5 200	0 175	0 205
B	3 180	4.190	0 125	0 165
C	4.320	5 330	0.170	0 210
D	0.407	0.533	0 016	0 021
F	0.407	0.482	0.016	0.019
K	12.700	–	0 500	–
L	1 150	1.390	0.045	0.055
N	–	1 270	–	0 050
P	6 350	–	0.250	–
Q	3.430	–	0 135	–
R	2.410	2 670	0.095	0 105
S	2.030	2.670	0.080	0 105

CASE 29
TO-92

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_E = 0)	2N4125 2N4126	BV_{CEO}	30 25	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4125 2N4126	BV_{CBO}	30 25	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	–	50	nAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126	h_{FE}	50 120	150 360	–
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126		25 60	– –	
Collector-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS					
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126	$\|h_{fe}\|$	2.0 2.5	– –	–
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126	f_T	200 250	– –	MHz
Collector-Base Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	–	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	–	10	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4125 2N4126	h_{fe}	50 120	200 480	–
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 k ohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4125 2N4126	NF	– –	5.0 4.0	dB

(1) Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2%
*Indicates JEDEC Registered Data

FIGURE 1 — CAPACITANCE

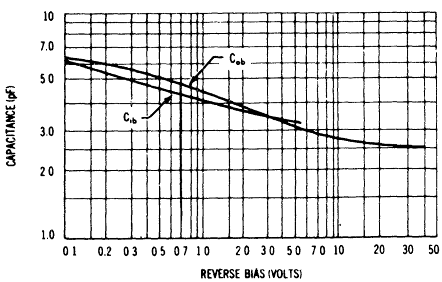
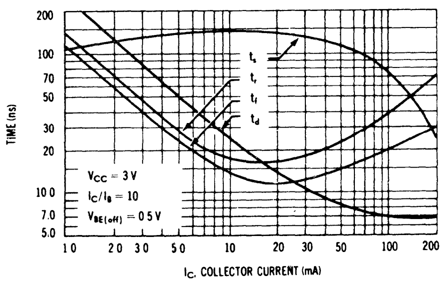


FIGURE 2 — SWITCHING TIMES



AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5.0 Vdc, T_A = 25°C,
Bandwidth = 1.0 Hz

FIGURE 3 — FREQUENCY VARIATIONS

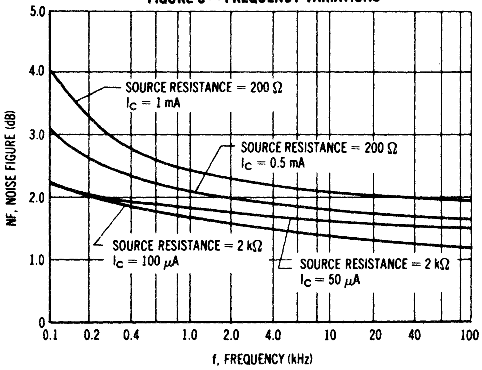
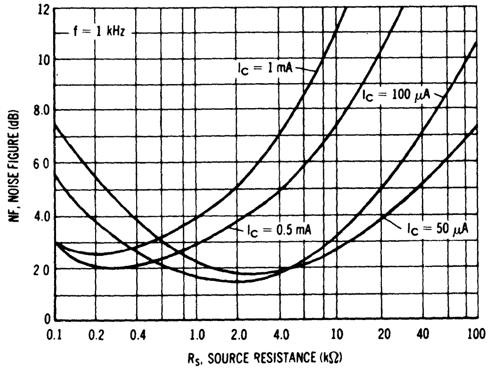


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

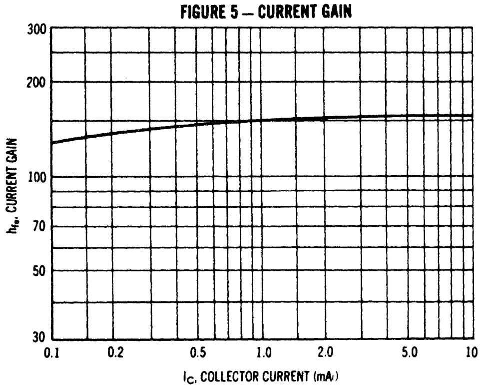


FIGURE 6 — OUTPUT ADMITTANCE

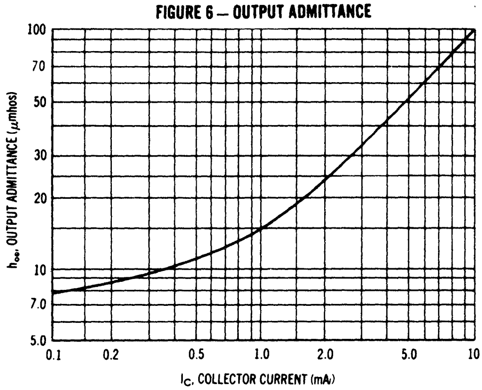


FIGURE 7 — INPUT IMPEDANCE

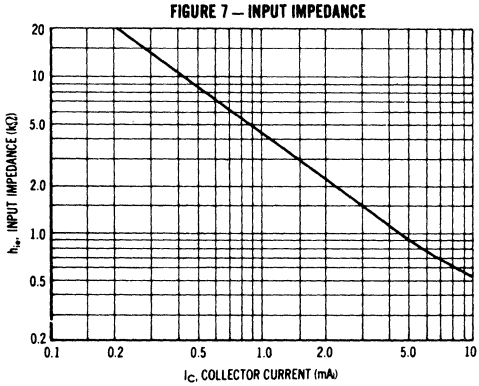
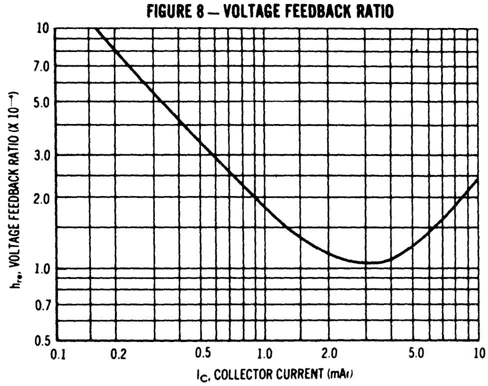


FIGURE 8 — VOLTAGE FEEDBACK RATIO



STATIC CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

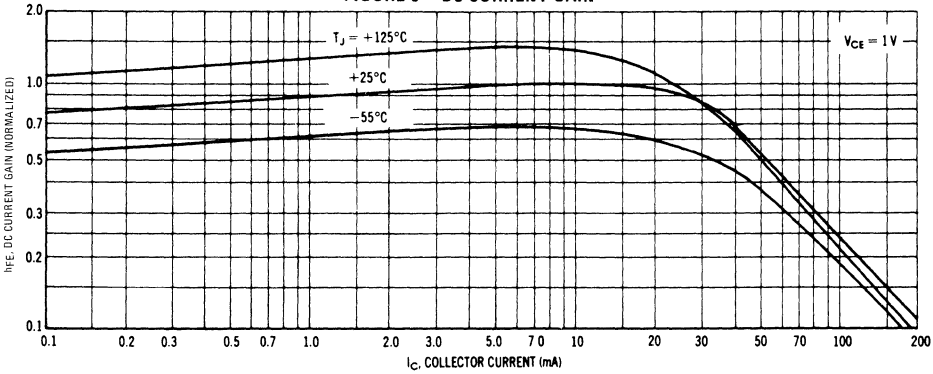


FIGURE 10 — COLLECTOR SATURATION REGION

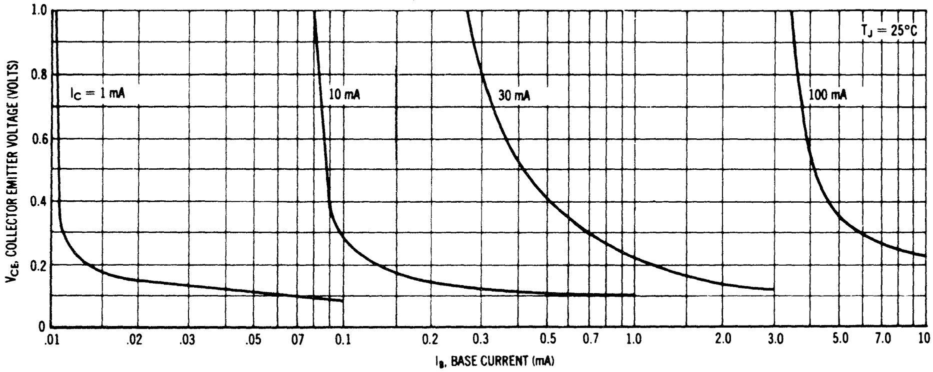


FIGURE 11 — "ON" VOLTAGES

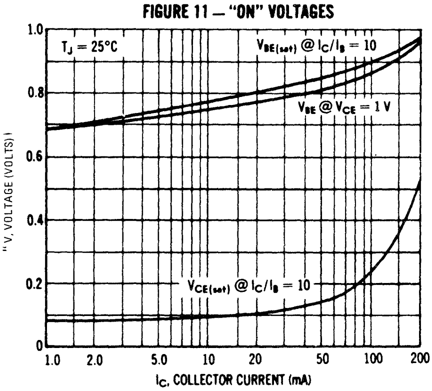
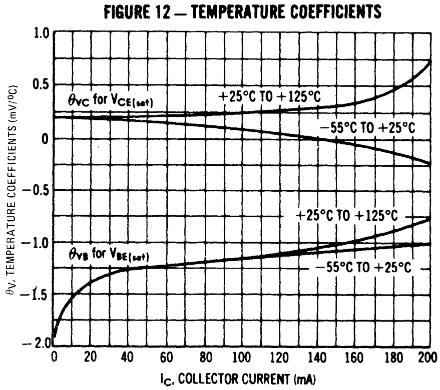


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4130 NPN (SILICON)

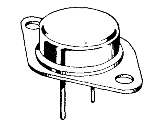
The RF Line

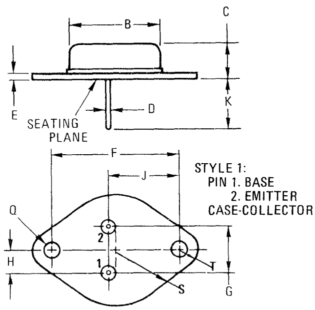
NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large-signal output amplifier stages. Intended for use in industrial communications equipment operating to 100 MHz. High breakdown voltages allow a high percentage of up-modulation in AM circuits operated at 28 volts.

- Balanced Emitter Construction
- Power Output – P_{out} = 50 W @ 70 MHz
- Collector-Base Voltage – 80 Vdc
- Case Common to Emitter

50 W - 70 MHz
RF POWER TRANSISTOR
NPN SILICON





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
B	–	22 23	–	0 875
C	6 35	11 43	0 250	0 450
D	0 97	1 09	0 038	0 043
E	–	3 43	–	0 135
F	29.90	30.40	1 177	1 197
G	10 67	11 18	0.420	0 440
H	5 21	5 72	0.205	0 225
J	16 64	17 15	0 655	0 675
K	7.92	–	0 312	–
Q	3 84	4.09	0 151	0 161
S	–	13 34	-	0 525
T	–	4 78	–	0 188

All JEDEC dimensions and notes apply

CASE 1-03
(TO-3)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	65	Vdc
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current – Continuous	I_C	10	Adc
Base Current – Continuous	I_B	2.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	120 0.8	Watts W/°C
Operating Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, I_B = 0)	$V_{CEO(sus)}$	65	–	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 50 mAdc, R_{BE} = 0)	$V_{CES(sus)}$	80	–	–	Vdc
Collector Cutoff Current	I_{CEV}				mAdc
(V_{CE} = 75 Vdc, V_{BE} = −1.5 Vdc)		–	–	0.2	
(V_{CE} = 50 Vdc, V_{BE} = −1.5 Vdc, T_C = 150°C)		–	–	1.0	
Collector Cutoff Current (V_{CB} = 80 Vdc, I_E = 0)	I_{CBO}	–	–	0.02	mAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1)	h_{FE}				–
(I_C = 2.0 Adc, V_{CE} = 5.0 Vdc)		10	–	60	
(I_C = 10 Adc, V_{CE} = 5.0 Vdc)		10	–	–	
Collector-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 2.0 Adc)	$V_{CE(sat)}$	–	–	2.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 2.0 Adc, V_{CE} = 10 Vdc, f = 50 MHz)	f_T	125	–	–	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 0.13 MHz)	C_{ob}	–	125	200	pF
FUNCTIONAL TEST (Figure 1)					
Power Input (Figure 1) (P_{out} = 50 W, R_S = 50 Ohms, V_{CE} = 28 Vdc, f = 70 MHz)	P_{in}	–	–	8.0	Watts
Collector Efficiency (P_{out} = 50 W, R_S = 50 Ohms, V_{CE} = 28 Vdc, f = 70 MHz)	η	50	–	–	%

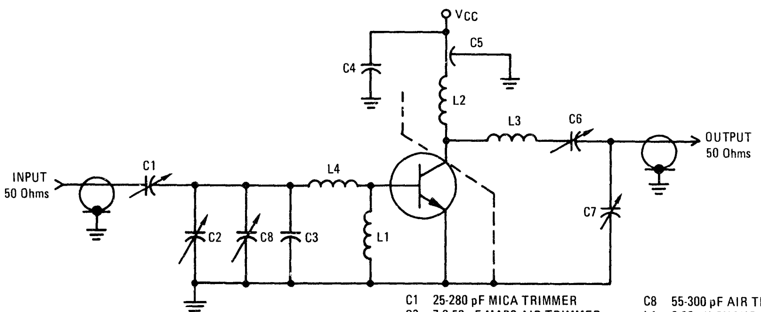
*Indicates JEDEC Registered Data

Notes:

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle = 1.0%.

(2) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 — 70 MHz POWER GAIN TEST CIRCUIT



C1 25-280 pF MICA TRIMMER
C2 7.0-50 pF MAPC AIR TRIMMER
C3 200 pF MICA CAPACITOR
C4 0.005 μF CERAMIC CAPACITOR
C5 1500 pF FEEDTHRU CAPACITOR
C6,C7 24-200 pF MICA TRIMMER
C8 55-300 pF AIR TRIMMER
L1 0.22 μH CHOKE
L2 0.1 μH CHOKE
L3 2 TURNS, #14 AWG, 1" DIA., 1/4" LONG
L4 3/4" LONG, 1/4" WIDE, 0.3" THICK COPPER STRAP

2N4167 (SILICON) thru 2N4198

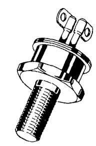
THYRISTORS

. . . multi-purpose PNPN silicon controlled rectifiers suited for industrial, consumer, and mulitary applications. Offered in a choice of space-saving, economical packages for mounting versatility.

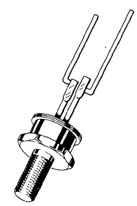
- Uniform Low-Level Noise-Immune Gate Triggering — I_{GT} = 10 mA (Typ) @ T_C = 25°C
- Low Forward "On" Voltage — v_T = 1.0 V (Typ) @ 5.0 Amp @ 25°C
- High Surge-Current Capability — I_{TSM} = 100 Amp Peak
- Fatigue-Free Solder Construction
- Shorted Emitter Construction

SILICON CONTROLLED RECTIFIERS

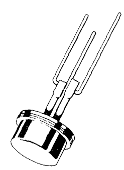
8-AMPERE RMS
25 thru 600 VOLTS



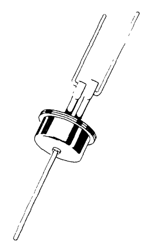
2N4167–74
CASE 86



2N4175-82
CASE 86L



2N4183-90
CASE 87L



2N4191-98
CASE 88L

MAXIMUM RATINGS

(Apply over operating temperature range and for all case types unless otherwise noted)

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1)	V_{RRM}		Volts
2N4167, 75, 83, 91		25	
2N4168, 76, 84, 92		50	
2N4169, 77, 85, 93		100	
2N4170, 78, 86, 94		200	
2N4171, 79, 87, 95		300	
2N4172, 80, 88, 96		400	
2N4173, 81, 89, 97		500	
2N4174, 82, 90, 98		600	
Forward Current RMS	$I_{T(RMS)}$	8.0	Amp
*Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	100	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≦ 8.3 ms)	I^2t	40	A^2s
*Peak Gate Power	P_{GM}	5.0	Watt
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Gate Current	I_{GM}	2.0	Amp
Peak Gate Voltage (2)	V_{GM}	10	Volts
*Operating Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque 2N4167-2N4182		15	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	1.5	2.5*	°C/W
Thermal Resistance, Case to Ambient (See Fig. 11) 2N4151-66, 2N4183-98	$R\theta_{CA}$	50	—	°C/W

(1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.
(2) Devices should not be operated with a positive bias applied to the gate concurrently with a negative potential applied to the anode.
*Indicates JEDEC Registered Data

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (1)		V_{DRM}				Volts
(T_J = 100°C)	2N4167, 75, 83, 91		25	–	–	
	2N4168, 76, 84, 92		50	–	–	
	2N4169, 77, 85, 93		100	–	–	
	2N4170, 78, 86, 94		200	–	–	
	2N4171, 79, 87, 95		300	–	–	
	2N4172, 80, 88, 96		400	–	–	
	2N4173, 81, 89, 97		500	–	–	
	2N4174, 82, 90, 98		600	–	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)		I_{DRM}	–	–	2.0	mA
*Peak Reverse Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)		I_{RRM}	–	–	2.0	mA
Gate Trigger Current (Continuous dc) (2)		I_{GT}				mA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)			–	–	30	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω T_C = -40°C)			–	–	60	
Gate Trigger Voltage (Continuous dc)		V_{GT}				Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)			–	–	1.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)			–	–	2.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_J = 100°C)			0.2	–	–	
*Forward "On" Voltage (pulsed, 1.0 ms max, duty cycle ≤ 1%) (I_F = 15.7 A)		V_T	–	–	2.0	Volts
Holding Current		I_H				mA
(Anode Voltage = 7.0 Vdc, gate open)			–	–	30	
*(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)			–	–	60	
Turn-On Time (t_d + t_r) (I_G = 20 mAdc, I_F = 5.0 Adc)		t_{on}	–	1.0	–	µs
Turn-Off Time		t_{off}				µs
(I_F = 5.0 Adc, I_R = 5.0 Adc)			–	15	–	
(I_F = 5.0 Adc, I_R = 5.0 Adc, T_J = 100°C)			–	25	–	
(V_{FXM} = rated voltage)						
(dv/dt = 30 V/µs)						
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	–	50	–	V/µs

(1) Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.
(2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA minimum.
*Indicates JEDEC Registered Data

TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – CONSTANT CURRENT TRIGGERING

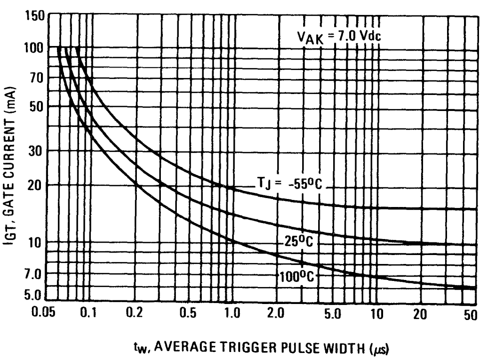
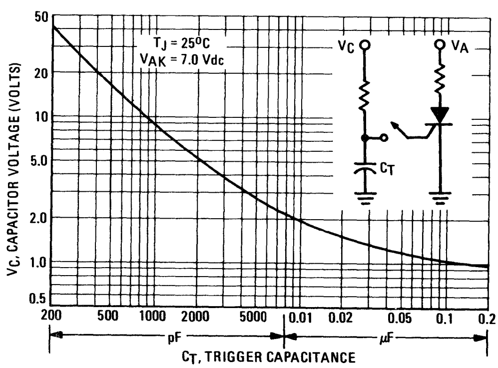


FIGURE 2 – CAPACITIVE DISCHARGE TRIGGERING



CURRENT DERATING

FIGURE 3 – MAXIMUM CASE TEMPERATURE

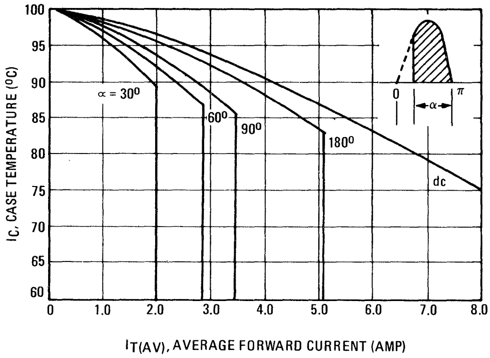


FIGURE 4 – MAXIMUM AMBIENT TEMPERATURE

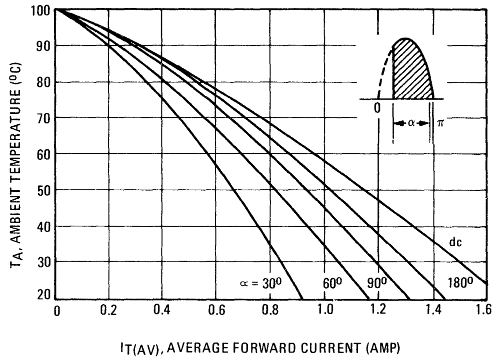


FIGURE 5 – FORWARD POWER DISSIPATION

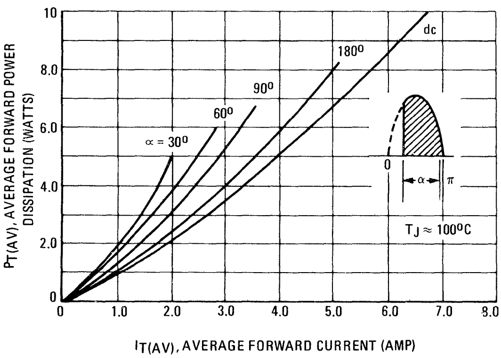


FIGURE 6 – MAXIMUM SURGE CAPABILITY

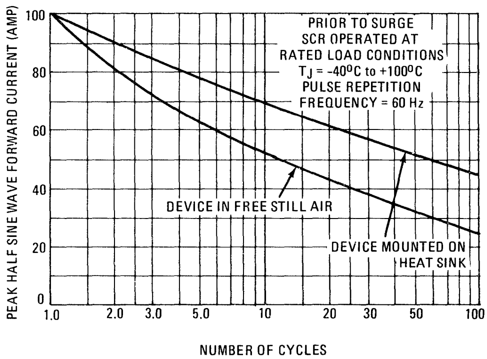


FIGURE 7 – THERMAL RESPONSE

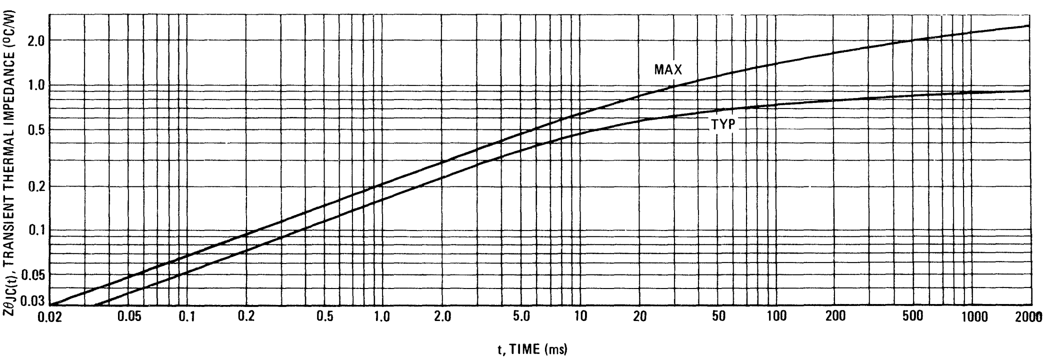


FIGURE 8 – FORWARD VOLTAGE

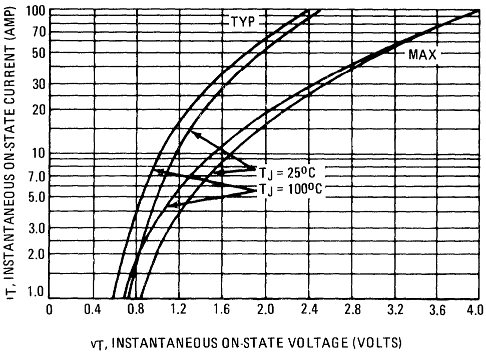


FIGURE 9 – HOLDING CURRENT

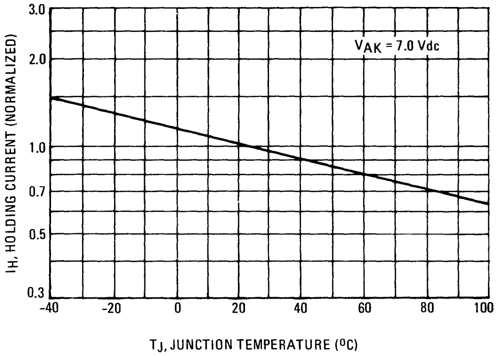


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES

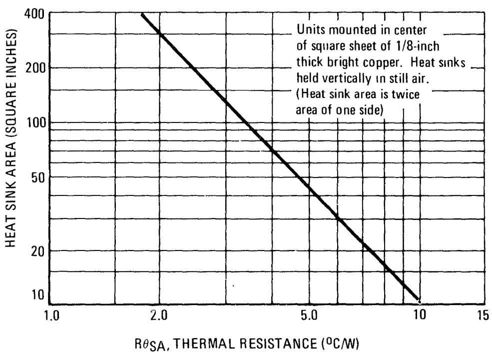
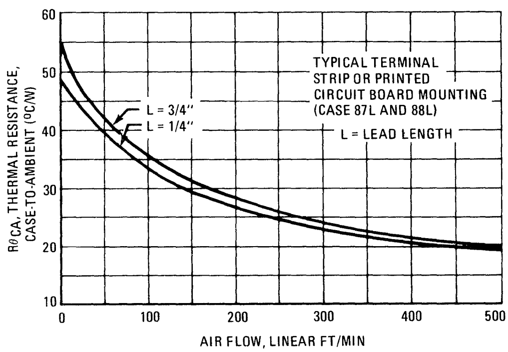


FIGURE 11 – CASE-TO-AMBIENT THERMAL RESISTANCE



MOUNTING and THERMAL INFORMATION

The versatility of the Motorola SCR can-type package affords a variety of mounting methods to meet individual requirements. Depending upon the thermal resistance value between the SCR case and a heat sink, any mounting method which satisfies the current derating curves may be used. Possible mounting media include: solder, epoxy cements; clips (fuse, resistor, transistor, special); clamps; commercial or special dissipators, retainers, coolers, and radiators.

When mounting the SCR's to a heat sink, the following recommendations apply:

A. Heat Sink Contact

1. Since the silicon die is located in the case bottom, (opposite end from tubed header point A as shown on the mechanical outline drawing, Figure 12.) the heat sink contact should be made with case bottom for proper heat transfer.

B. General Soldering Precautions

1. Solder — Use solder with melting points between +175°C and +225°C. The commonly-used tin-lead alloy solders have melting points of +188°C (60/40 alloy) and +214°C (50/50 alloy).
2. Flux (when used) — Non-corrosive resin preferred.
3. When soldering to the device terminals or leads, use of a heat dissipator between soldering point and SCR case is recommended.

C. Case Soldering Methods

1. Heat Sink Materials:
   a. Copper and most of its alloys present no problem in soldering and would probably be the most favorable heat sink material.
   b. Stainless steel is difficult to solder. However, using a strong acid-filled solder, satisfactory soldering can be achieved.
   c. In most cases where soldering is difficult, such as with aluminum, proper preparation with a tin coating on the material can bring about good results.

Depending on specific needs, soldering can be effected by using either hot plate, oven, or belt feed furnace. In all cases, temperature must be controlled.

2. Hot Plate — The hot plate is probably the most effective and flexible method of soldering. The following method is recommended:
   a. Set surface temperature of hot plate to a maximum of 225°C.
   b. Place heat sinks on hot plate for approximately 5 minutes.
   c. Place ⅛"-¼" diameter solder preform on area of heat sink to be soldered.
   d. After solder becomes liquid, place device on this area applying slight pressure and rotating the device slightly to assure good contact. Flux may be used here if required. Frequently, suitable wetting can be achieved mechanically when the device is rotated in the liquid solder, depending upon the device surface conditions.
   e. Remove heat sinks from heat source and free air cool.
3. Oven — When soldering is performed in an oven, use a solder preform (disc, 0.300" x 0.010") or flatten solder wire (⅛"-¼") before placing it on the heat sink. For an inert atmosphere such as N_2, dry air, etc., a flux is recommended. If H_2N_2 is available and used, flux should not be required. Again, temperature must be controlled.
4. Belt Feed Furnace — The procedures are much the same as with the oven method, with the exception that possibly a jig would be required to hold the device and the heat sink in the proper position.

D. Epoxy Mounting Suggestions

1. There are many good commercial epoxies available today, such as Hysol's "HY-TAC" kit or 3M's "Scotch Cast #9". Suitable mounting may be obtained by following the epoxy manufacturer's recommendations for mixing and then cementing the thyristor to the mounting surface with a slight pressure and rotary movement. If improved thermal conductivity is desired, powdered alumina (325 mesh) may be mixed into the epoxy in a proportion of 70% (epoxy) to 30% (alumina). If electrical insulation is desired between the thyristor and a heat-sink, thin fiberglass tape (course surface) or mica discs may be used.

The primary reason for specifying mounting details is to help maintain the junction temperature of the SCR at a safe level and hence provide satisfactory operation. The fundamental relationship between junction temperature and heat sinks can be expressed as follows:

$$T_J = T_A + R\theta_{JA} P_D$$

where:

T_J = junction temperature (100°C max operating for these devices)

T_A = ambient temperature

$R\theta_{JA}$ = junction-to-ambient thermal resistance
= $R\theta_{JC} + R\theta_{CA}$ (with $R\theta_{CA} = R\theta_{CS} + R\theta_{SA}$ when heat sink used)

$R\theta_{JC}$ = junction-to-case thermal resistance

$R\theta_{CA}$ = case-to-ambient thermal resistance

$R\theta_{CS}$ = case-to-heat sink thermal resistance

$R\theta_{SA}$ = heat sink-to-ambient thermal resistance

P_D = average power dissipated in the SCR

It is more accurate to base circuit designs upon the case temperature. The preferred method to determine case temperature is to place a thermocouple on the package at point A as shown on the mechanical outline drawing, Figure 12. Even when used in free air, the mass of the package is large enough so that it will not respond to heat surges generated at a 60 Hz rate or higher once steady-state conditions are achieved.

For operation with a heat sink, normally, the $R\theta_{CS}$ portion of $R\theta_{CA}$ will range between 0.2 and 1°C/W for the can type SCR's, depending upon the particular mounting. $R\theta_{CA}$ is approximately 0.2°C/W for the stud packages when used with a thermal grease. Likewise, the $R\theta_{SA}$ portion of $R\theta_{CA}$ will vary with the shape, material, and configuration of the heat sink as well as with the surrounding conditions. Figure 10 is a very basic guide to $R\theta_{SA}$.

For free air operation, in instances where the case temperature cannot be measured or for preliminary engineering work, the case temperature can be estimated by using values of case-to-ambient thermal resistance, obtained from Figure 11 and the relation:

$$T_C = R\theta_{CA} P_D + T_A$$

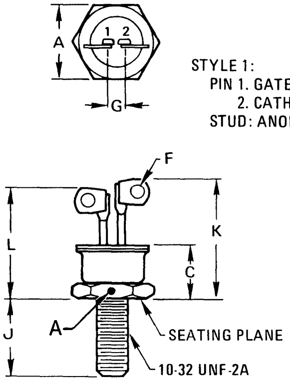
The graph of Figure 11 indicates that the lead length of the SCR and the thermal mass of the connection to the lead will influence the value of $R\theta_{CA}$.

For convenience, Figure 4 shows derating information when the parts are in a still air ambient mounted on a typical P.C. board.

FIGURE 12 – OUTLINE DIMENSIONS

2N4167-74
CASE 86

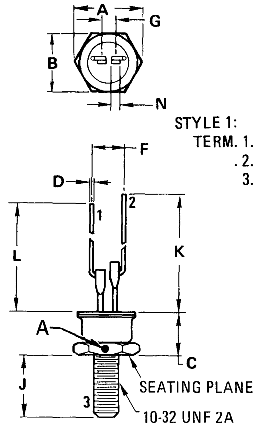
NOTE:
1. DIM "G" MEASURED AT CAN.



STYLE 1:
PIN 1. GATE
2. CATHODE
STUD: ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.10	–	0.437
C	–	7.87	–	0.310
F	1.78 TYP		0.070 TYP	
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	–	16.76	–	0.660
L	–	15.49	–	0.610

2N4175-82
CASE 86L

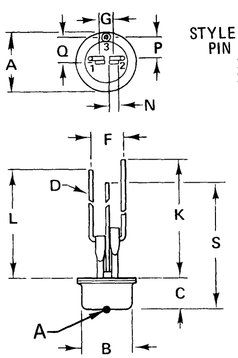


STYLE 1:
TERM. 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	12.82	–	0.505
B	–	11.10	–	0.437
C	–	7.87	–	0.310
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
J	10.72	11.48	0.422	0.452
K	33.53	–	1.320	–
L	31.50 TYP		1.240 TYP	
N	1.65	1.91	0.065	0.075

2N4183-90
CASE 87L

NOTES:
1. DIM. "G" MEASURED AT CAN.
2. LEAD NO. 3 ±7.5° DISPLACEMENT.

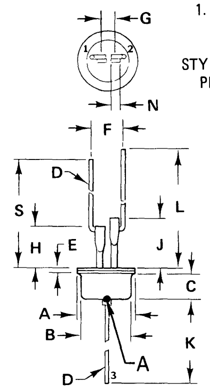


STYLE 1:
PIN 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	10.92	–	0.430
B	–	8.89	–	0.350
C	–	5.97	–	0.235
D	0.76	0.86	0.030	0.034
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
K	33.53	–	1.320	–
L	31.50 TYP		1.240 TYP	
N	1.65	1.91	0.065	0.075
P	3.43	3.68	0.135	0.145
Q	4.57	5.08	0.180	0.200
S	30.48	–	1.20	–

2N4191-98
CASE 88L

NOTE:
1. DIM "G" MEASURED AT CAN.



STYLE 1:
PIN 1. GATE
2. CATHODE
3. ANODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	10.92	–	0.430
B	–	8.89	–	0.350
C	–	4.70	–	0.185
D	0.76	0.86	0.030	0.034
E	0.76	1.27	0.030	0.050
F	4.83	5.33	0.190	0.210
G	2.29	2.79	0.090	0.110
H	–	6.86	–	0.270
J	–	8.13	–	0.320
K	22.86	–	0.900	–
L	33.53	–	1.320	–
N	1.65	1.91	0.065	0.075
S	31.50		1.240	

NOTES:

1. The case (anode) leads for the 2N4183-90 and 2N4191-98 series may be attached by either soldering or welding techniques.
2. On all package types: Manufacturer may optionally use a small metal tab on the case perimeter opposite the gate terminal for terminal identification purposes.
3. Point A indicates temperature reference point

2N4199 thru 2N4204 (SILICON)

THYRISTORS
SILICON CONTROLLED RECTIFIERS

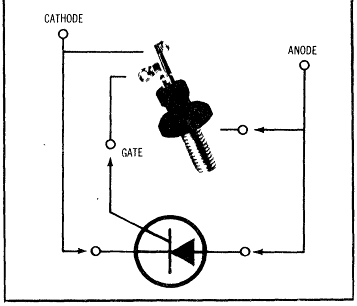
. . . fast switching, high-voltage Thyristors especially designed for pulse modulator applications in radar and other similar equipment.

- Guaranteed Limits on All Critical Parameters
- High-Voltage: V_{FOM} = 300 to 800 Volts
- Turn-On Times: in Nanosecond Range
- Repetitive Pulse Current to 100 Amperes
- Stable Switching Characteristics Over an Operating Temperature Range From −65 to +105°C
- Pulse Repetition Rates as High as 20,000 pps
- 2N4199 JAN thru 2N4204 JAN Available

THYRISTORS

PNPN

100 AMPERE PULSE
300 thru 800 VOLTS



DESIGNERS DATA FOR "WORST CASE" CONDITIONS

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage* (T_J=105°C)	$V_{ROM(rep)}$*	50	Volts
Repetitive Peak Forward Current (PW = 3.0 μs, Duty Cycle = 0.6%, T_C = 85°C max)	$I_{FM(rep)}$	100	Amp
Current Application Rate**	di/dt**	5000	A/μs
Peak Gate Power-Forward	P_{GFM}	20	Watts
Average Gate Power-Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current-Forward	I_{GFM}	5.0	Amp
Peak Gate Voltage-Forward Reverse ***	V_{GFM} V_{GRM} ***	10 10	Volts
Operating Junction Temperature Range Blocking State Conducting State	T_J	 -65 to +105 -65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Stud Torque	—	15	in. lb.

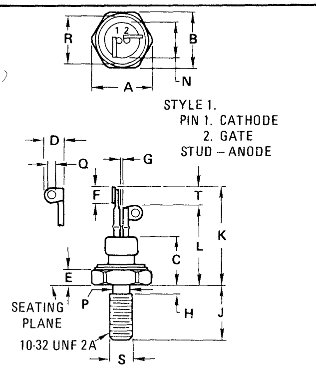
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R\theta_{JC}$	3.0	°C/W

*Characterized for unilateral applications where reverse blocking capability is not important. Higher voltage units available upon request. $V_{ROM(rep)}$ may be applied as a continuous d c voltage for zero or negative gate voltage but positive gate voltage must not be applied concurrently with a negative potential on the anode. When checking blocking capability, do not permit the applied voltage to exceed the rated voltage.

**Minimum Gate Trigger Pulse: i_G = 200 mA, PW = 1 μs, t_r = 20 ns.

***Do not reverse bias gate during forward conduction if anode current exceeds 10 amperes.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	12.57	12.83	0.495	0.505
B	10.77	11.10	0.424	0.437
C	–	10.80	–	0.425
D	3.94	4.70	0.155	0.185
E	–	3.56	–	0.140
J	10.16	11.51	0.400	0.453
K	–	21.72	–	0.855
L	–	17.78	–	0.700
N	–	7.11	–	0.280
Q	1.02	1.91	0.040	0.075

CASE 63-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage* (T_C = 105°C)	2N4199	15	V_{FOM}*	300	—	Volts
	2N4200			400	—	
	2N4201			500	—	
	2N4202			600	—	
	2N4203			700	—	
	2N4204			800	—	
Peak Forward and Reverse Blocking Current (Rated V_{FOM} and V_{ROM}, T_C = 105°C, gate open)		17	I_{FOM}	—	2.0	mA
			I_{ROM}	—	2.0	
Gate Trigger Current (Continuous dc)		14	I_{GT}			mA
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)				—	50	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)				—	100	
Gate Trigger Voltage (Continuous dc)		12	V_{GT}			Volts
(Anode Voltage = rated V_{FOM}, R_L = 100 ohms, T_C = 105°C)				0.2	—	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = 25°C)				—	1.5	
(Anode Voltage = 7.0 Vdc, R_L = 100 ohms, T_C = -65°C)				—	2.0	
Holding Current (Anode Voltage = 7.0 Vdc, gate open, T_C = 105°C)		18	I_{HO}	3.0	—	mA
Forward "On" Voltage (I_f = 2 Adc, PW = 1.0 ms max, Duty cycle ≤ 1%)		8	V_F	—	1.5	Volts
Dynamic Forward "On" Voltage (0.5 μs after 50% decay point on dynamic forward voltage waveform.) Forward Current: 30 A pulse (PFN discharge circuit.) Gate Pulse: at 200 mA, PW = 1.0 μs, t_r = 20 ns		7	$V_{F(on)}$	—	25	Volts
Turn-On Time						ns
Delay Time	All types	1, 9	t_d	—	200	
Rise Time	2N4199 and 2N4200	1, 11	t_r	—	200	
	2N4201			—	150	
	2N4202			—	130	
	2N4203 and 2N4204			—	100	
Pulse Turn-Off Time Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5.0 A, T_C = 85°C, dv/dt = 250 V/μs to Rated V_{FOM}; Reverse anode voltage during turn-off interval = 0 V; Reverse gate bias during turn-off interval = 6.0 V.		2, 13	$t_{off(pulse)}$	—	20	μs
Forward Voltage Application Rate (Linear Rise of Voltage) (T_C = 105°C, gate open)		16	dv/dt	250	—	V/μs

*V_{FOM} for all types can be applied on a continous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. When checking forward or reverse blocking capability, these devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage. Other voltage units available upon request.

TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

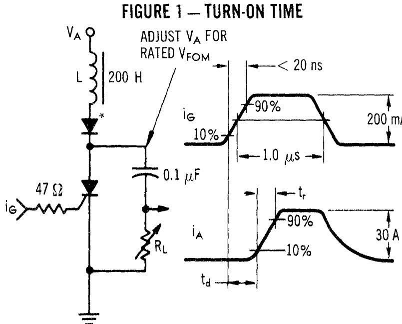
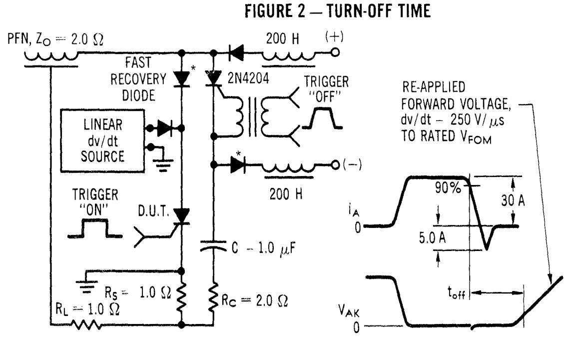
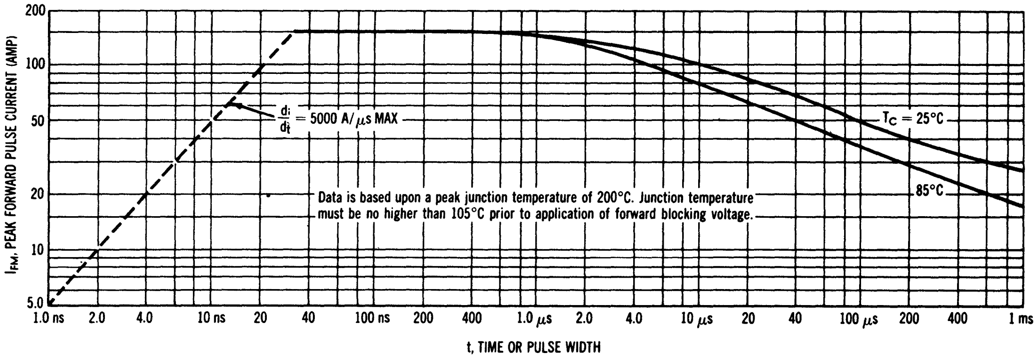


FIGURE 2 — TURN-OFF TIME



*Two MR1337 5 fast recovery diodes in series (use voltage sharing net work as described in Chapter 8 of Motorola Silicon Rectifier Handbook)

FIGURE 3 — MAXIMUM ALLOWABLE FORWARD PULSE CURRENT



CURRENT DERATING DATA

FIGURE 4 — DERATING USING NO SWITCHING LOSSES

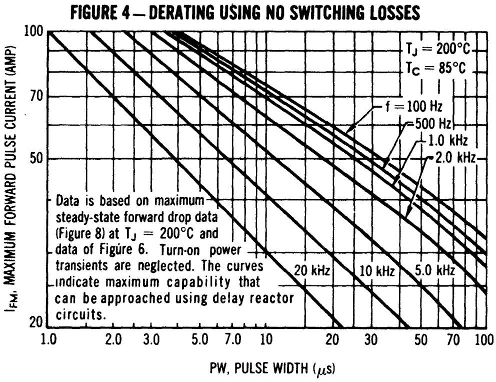
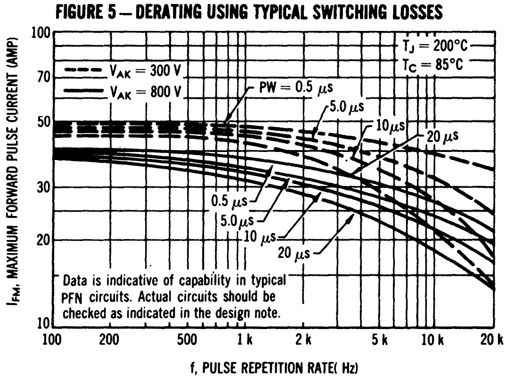


FIGURE 5 — DERATING USING TYPICAL SWITCHING LOSSES



DESIGN NOTE

Use of Transient Thermal Resistance Data

A train of periodical power pulses can be represented by the model shown in Fig. A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Fig. 6 was calculated for various duty cycles from:

$$r(t) = D + (1 - D) \cdot r(t_A + t_P) + r(t_A) - r(t_P)$$

To find $\theta_{JC}(t)$ multiply the value obtained from Fig. 6 by the steady-state value $\theta_{JC}(\infty)$. Use 3°C/W for worst-case results; use 2°C/W for typical information.

DESIGN EXAMPLE

A 2N4199 discharging a PFN, transient power pulse shown in Fig. C.

Conditions: V_{AK} = 150 V., I_{PK} = 44 A., f = 5000 Hz.

Determine: ΔT

Method 1: (See Fig. A) $P_A t_A$ is chosen to have the same energy as the actual power pulse, i.e.: the area under the curves are equal. P_A equals the peak of the actual power pulse. At a pulse repetition frequency of 5000 Hz and $T_A = 2.14$ μs (D = 0.0107); the reading on Fig. 6 is 0.039.

$$\therefore \Delta T = r(t)\theta_{JC}(\infty) P_A = (0.039)(3)(1000) = 120°C.$$

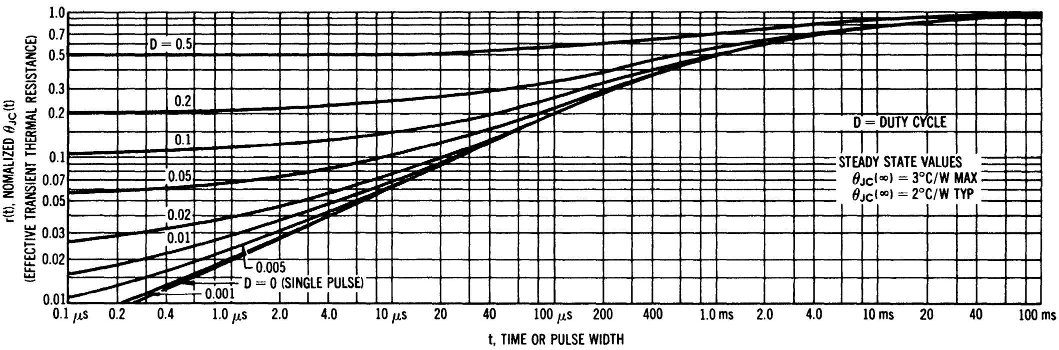
Method 2: For a power waveform where the time of the peak power is short compared to the total transient, the foregoing method results in an overly large safety factor. A pulse model closer to the real case is shown in Fig. B. Using the transient thermal resistance information for D = 0 in Fig. 6, $\Delta T(t_4)$ and $\Delta T(t_5)$ can be evaluated from

$$\Delta T(t_4) = \Big[P_1\,[r(T_1) + (1 - D_1) \cdot r(T + T_1) + D - r(T)] + P_2[(1 - D_2) \cdot r(T) + D_2 - r(T - T_2)]\Big]\theta_{JC}(\infty)$$

$$\Delta T(t_5) = \Big[P_1[r(T_1 + T_2) + (1 - D_1) \cdot r(T + T_1 + T_2) - r(T + T_2) - r(T_2)] + P_2\,[r(T_2) + (1 - D_2 \cdot r(T + T_2) + D_2 - r(T)]\Big]\theta_{JC}(\infty)$$

The two results are compared; the one with higher value is taken for worst-case design. For the problem, values for the equivalent pulses of Fig. B are P_1 = 1000 W, P_2 = 700 W, T_1 = 1.05 μs, T_2 = 1.55 μs, $D_1 = 5.25(10^{-3})$, $D_2 = 7.75(10^{-3})$.

FIGURE 6 — NORMALIZED EFFECTIVE TRANSIENT THERMAL RESISTANCE



FORWARD "ON" VOLTAGE DATA

FIGURE 7 — TYPICAL DYNAMIC FORWARD "ON" VOLTAGE

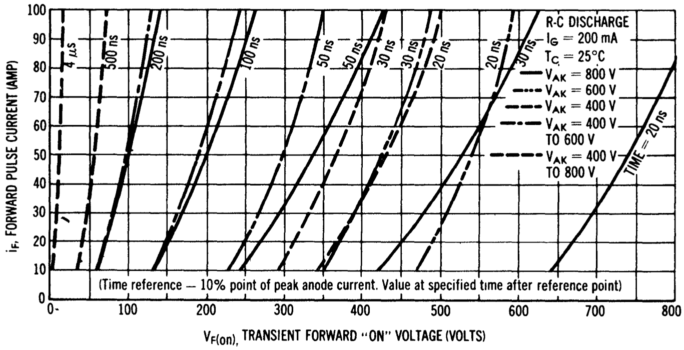
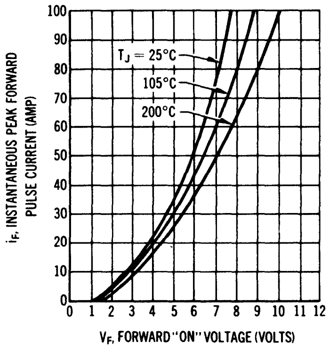


FIGURE 8 — MAXIMUM STEADY-STATE



$$\Delta T(t_4) = \Big[1000\,[0.0205 + (1 - 5.25 \cdot 10^{-3})\,0.27 + 5.25 \cdot 10^{-3} - 0.27]$$

$$+ 700\,[(1 - 7.75 \cdot 10^{-3})\,0.27 + 7.75 \cdot 10^{-3} - 0.27] \Big]\, 3 = 93.51°C$$

$$\Delta T(t_5) = \Big[1000\,[0.032 + (1 - 5.25 \cdot 10^{-3})\,0.27 + 5.25 \cdot 10^{-3} - 0.27 - 0.0205]$$

$$+ 700\,[0.025 + (1 - 7.75 \cdot 10^{-3})\,0.27 + 7.75 \cdot 10^{-3} - 0.27] \Big]\, 3 = 105.6°C$$

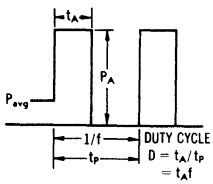


FIGURE A — SIMPLE MODEL

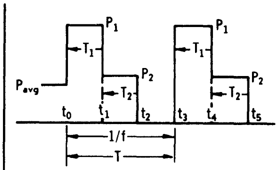


FIGURE B — MORE ACCURATE MODEL

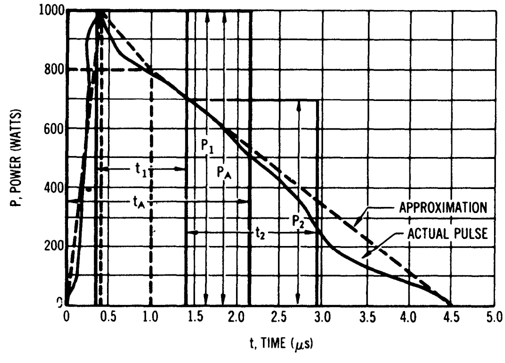


FIGURE C — AN ACTUAL TRANSIENT POWER PULSE

SWITCHING CHARACTERISTICS

FIGURE 9 — DELAY TIME

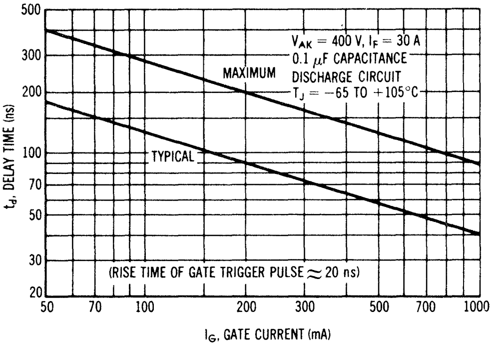


FIGURE 11 — CURRENT RISE TIME

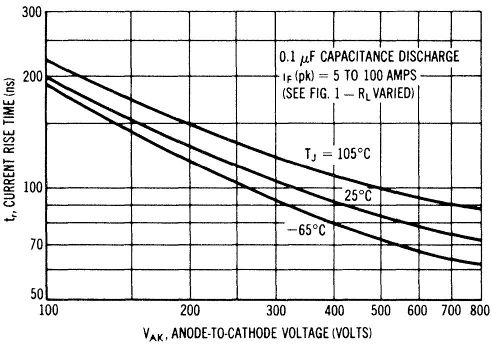
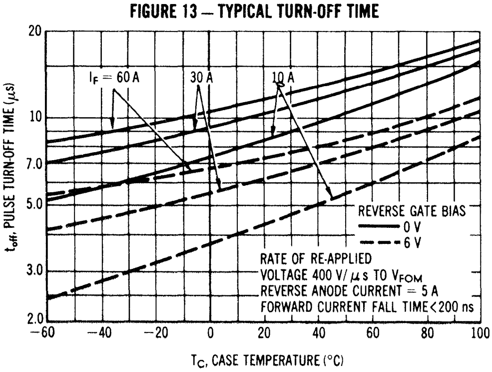


FIGURE 13 — TYPICAL TURN-OFF TIME



TRIGGERING CHARACTERISTICS

FIGURE 10 — TYPICAL PULSE TRIGGER CHARGE/CURRENT

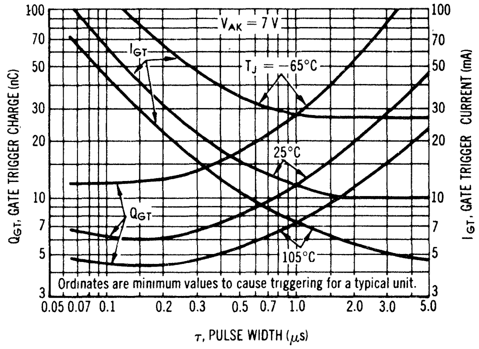


FIGURE 12 — DC GATE TRIGGER VOLTAGE

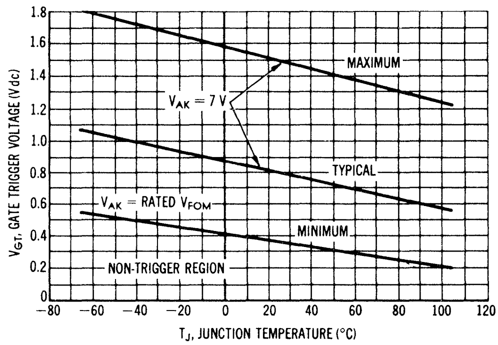


FIGURE 14 — DC GATE TRIGGER CURRENT

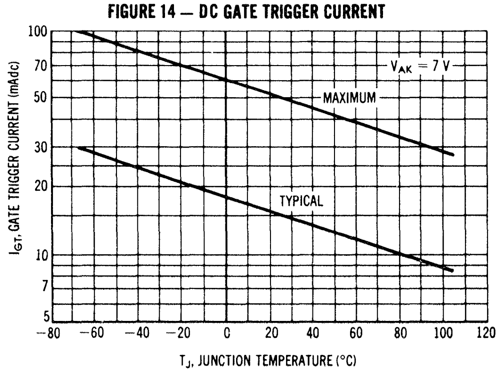


FIGURE 15 — TYPICAL BLOCKING VOLTAGE DERATING

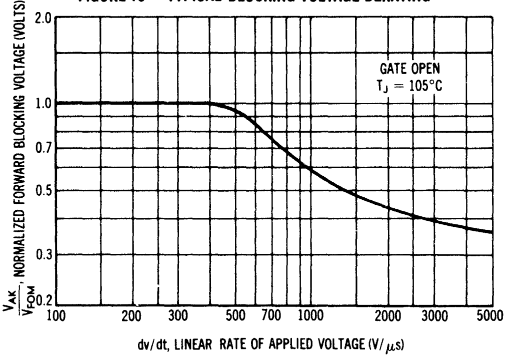


FIGURE 16 — TYPICAL dv/dt CAPABILITY

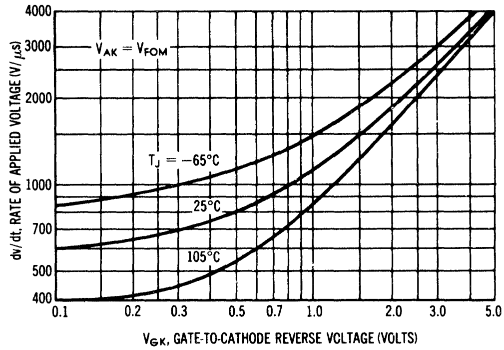


FIGURE 17 — FORWARD BLOCKING CURRENT

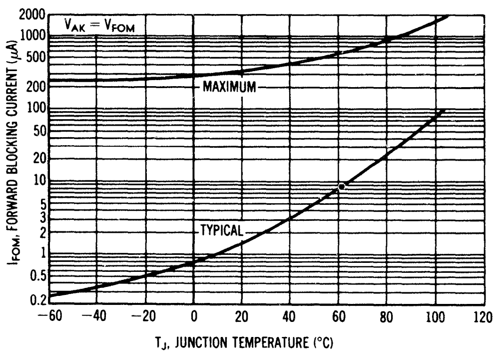


FIGURE 18 — HOLDING CURRENT

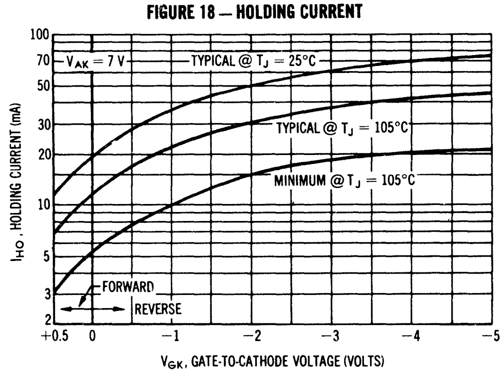


FIGURE 19 — TYPICAL ANODE-TO-CATHODE CAPACITANCE

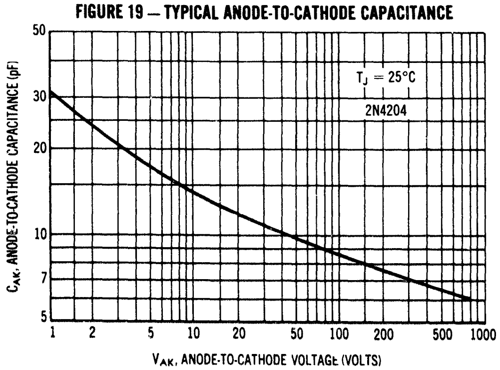
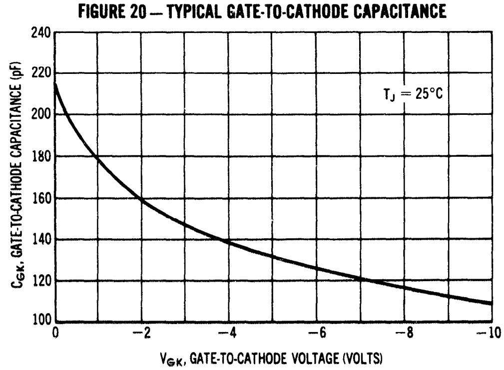
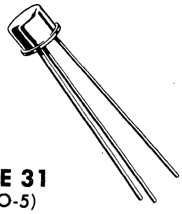


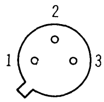
FIGURE 20 — TYPICAL GATE-TO-CATHODE CAPACITANCE





CASE 31
(TO-5)

PNPN thyristors (silicon controlled rectifiers) designed for operation in mA/μA signal or detection circuits.



STYLE 2
PIN 1. CATHODE
2. GATE
3 ANODE

MAXIMUM RATINGS * (T_J = 125°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Reverse Blocking Voltage (Note 1) 2N4212 2N4213 2N4214 2N4215 2N4216	$V_{RSM(rep)}$	25 50 100 150 200	Volt
Forward Current RMS (All Conduction Angles)	I_T	1.6	Amp
Peak Surge Current (One Cycle, 60 Hz) No Repetition until Thermal Equilibrium is Restored	$I_{FM(surge)}$	15	Amp
Peak Gate Power - Forward	P_{GM}	0.1	Watt
Average Gate Power - Forward	$P_{G(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GM}	0.1	Amp
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	6.0 6.0	Volt
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Lead Solder Temperature (> 1/16" from case, 10 sec. max)	-	+230	°C

* JEDEC Registered Values.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted, R_{GK} = 1000 ohms)

Characteristic	Symbol	Min	Max	Unit
Peak Forward Blocking Voltage (Note 1)	V_{DRM}			Volt
2N4212		25*	-	
2N4213		50*	-	
2N4214		100*	-	
2N4215		150*	-	
2N4216		200*		
Peak Reverse Blocking Current (Rated V_{RSM}, T_J = 125°C)	I_{RRM}	-	200*	μA
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 125°C)	I_{DRM}	-	200*	μA
Forward "On" Voltage	V_F			Volt
(I_F = 1.0 A Peak)		-	1.5	
(I_F = 3.14 A Peak)		-	2.0*	
Gate Trigger Current (Note 2) (Anode Voltage = 7.0 V, R_L = 100 ohms)	I_{GT}			μAdc
(T_C = 25°C)		-	100	
(T_C = -65°C)		-	300*	
Gate Trigger Voltage (Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = 25°C)	V_{GT}	-	0.8	Volt
(Anode Voltage = 7.0 V, R_L = 100 ohms, T_C = -65°C)	V_{GT}	-	1.0*	
(Anode Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 125°C)	V_{GNT}	0.1*	-	
Holding Current (Anode Voltage = 7.0 V) T_C = 25°C	I_{HX}		3.0	mA
T_C = -65°C			7.0*	
Turn-On Time	t_{gt}	Circuit dependent, consult manufacturer		
Turn-Off Time	t_q			

* JEDEC Registered Values

Notes: 1. V_{RRM} and V_{DRM} can be applied for all types on a continuous dc basis without incurring damage.

2. R_{GK} current is not included in measurement.

Thyristor devices shall not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

Thyristor devices shall not have a positive bias applied to the gate concurrently with a negative potential applied to the anode.

FIGURE 1 — CASE TEMPERATURE vs CURRENT

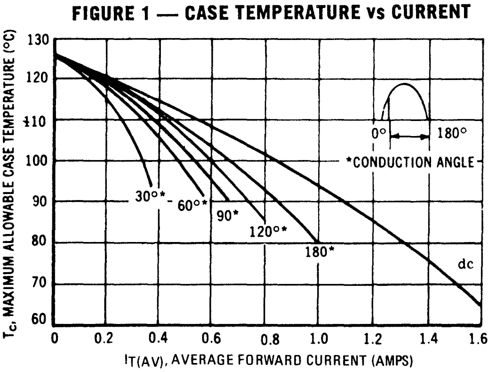
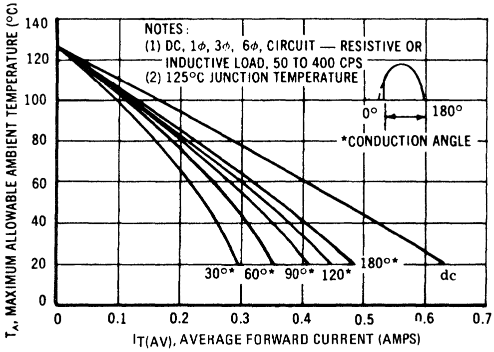
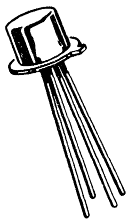


FIGURE 2 — AMBIENT TEMPERATURE vs CURRENT

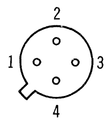


2N4220 thru 2N4222 (SILICON)
2N4220A thru 2N4222A

N-channel junction silicon field-effect transistors designed for general purpose amplifier and switching applications. "A" types guarantee low noise figure (2.5 dB maximum @ 100 kHz).



CASE 20-03
(TO-72)



STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD

MAXIMUM RATINGS

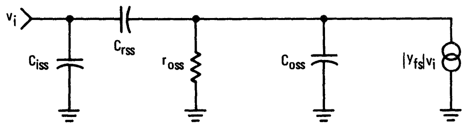
Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-30	-	-	Vdc
Gate Reverse Current (V_{GS} = -15 Vdc, V_{DS} = 0)		I_{GSS}	-	-	-0.1	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)			-	-	-100	
Gate-Source Voltage (I_D = 50 μAdc, V_{DS} = 15 Vdc)	2N4220, 2N4220A	V_{GS}	-0.5	-	-2.5	Vdc
(I_D = 200 μAdc, V_{DS} = 15 Vdc)	2N4221, 2N4221A		-1.0	-	-5.0	
(I_D = 500 μAdc, V_{DS} = 15 Vdc)	2N4222, 2N4222A		-2.0	-	-6.0	
Gate-Source Cutoff Voltage (I_D = 0.1 nAdc, V_{DS} = 15 Vdc)	2N4220, 2N4220A	$V_{GS(off)}$	-	-	-4.0	Vdc
	2N4221, 2N4221A		-	-	-6.0	
	2N4222, 2N4222A		-	-	-8.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4220, 2N4220A	I_{DSS}	0.5	-	3.0	mAdc
	2N4221, 2N4221A		2.0	-	6.0	
	2N4222, 2N4222A		5.0	-	15	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220, 2N4220A	$\|y_{fs}\|$	1000	2500	4000	μmhos
	2N4221, 2N4221A		2000	3500	5000	
	2N4222, 2N4222A		2500	4500	6000	
Output Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4220, 2N4220A	$\|y_{os}\|$	-	-	10	μmhos
	2N4221, 2N4221A		-	-	20	
	2N4222, 2N4222A		-	-	40	
Drain-Source Resistance (V_{DS} = 0, V_{GS} = 0)	2N4220, 2N4220A	$r_{ds(on)}$	-	500	-	Ohms
	2N4221, 2N4221A		-	400	-	
	2N4222, 2N4222A		-	300	-	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	-	1.2	2.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 30 MHz)		C_{osp}	-	1.5	-	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1.0 Megohm, f = 100 Hz)	2N4220A	NF	-	-	2.5	dB
	2N4221A		-	-	2.5	
	2N4222A		-	-	2.5	

(1) Pulse Test: Pulse Width = 630 ms, Duty Cycle = 10%

FIGURE 1 — EQUIVALENT LOW FREQUENCY CIRCUIT



Common Source
Y Parameters for Frequencies
Below 30 MHz

$y_{is} = j\omega C_{iss}$

$y_{os} = j\omega C_{osp}^* + 1/r_{oss}$

$y_{fs} = |y_{fs}|$

$y_{rs} = -j\omega C_{rss}$

*C_{osp} is C_{oss} in parallel with Series Combination of C_{iss} and C_{rss}.

FIGURE 2 – FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

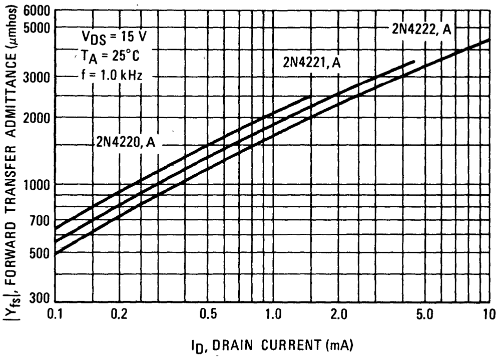


FIGURE 3 – TEMPERATURE COEFFICIENT OF Y_{fs} versus DRAIN CURRENT

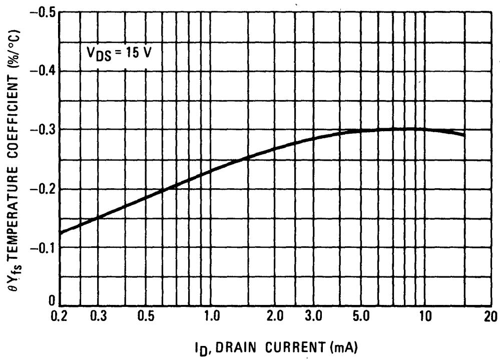


FIGURE 4 – OUTPUT RESISTANCE versus DRAIN CURRENT

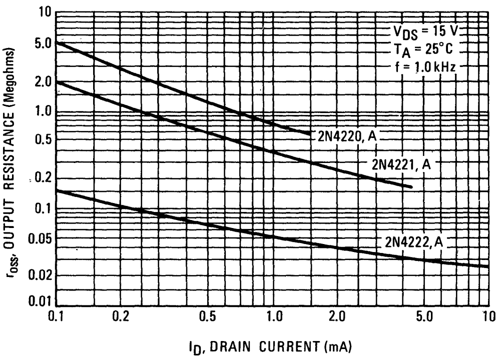


FIGURE 5 – CAPACITANCE versus DRAIN-SOURCE VOLTAGE

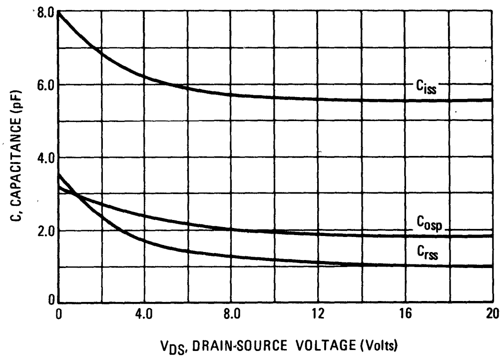


FIGURE 6 – NOISE FIGURE versus FREQUENCY

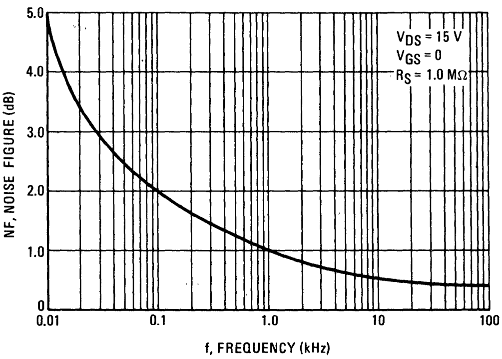


FIGURE 7 – NOISE FIGURE versus SOURCE RESISTANCE

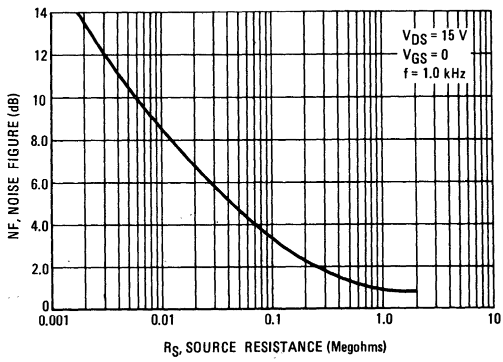


FIGURE 8 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

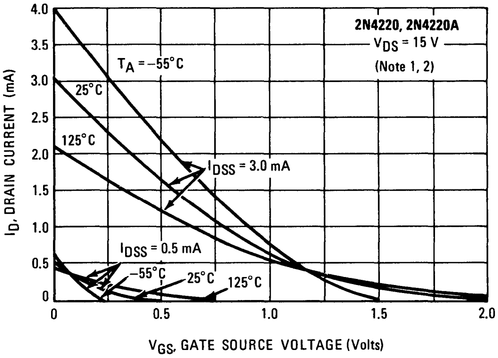


FIGURE 9 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

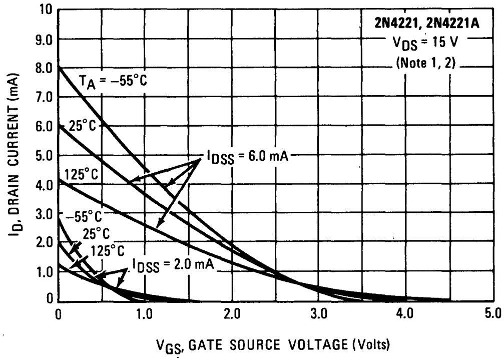


FIGURE 10 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

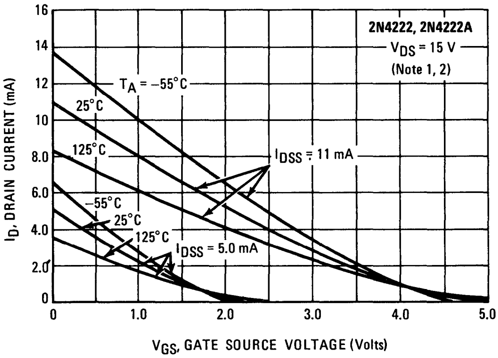
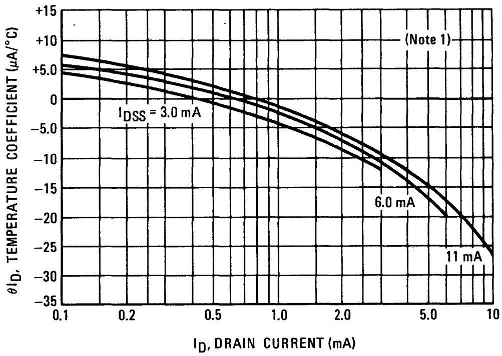


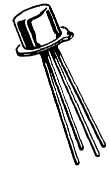
FIGURE 11 – TEMPERATURE COEFFICIENT OF DRAIN CURRENT versus DRAIN CURRENT



NOTES:

1. Graphical data is presented for dc conditions. Tabular data is given for pulsed conditions (Pulse Width = 630 ms, Duty Cycle = 10%). Under dc conditions, self heating in higher I_{DSS} units reduces I_{DSS} (See Figure 10).
2. Figures 8, 9, 10: Data taken in a standard printed circuit with a TO-18 type socket mounting and 1/4" lead length.

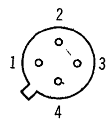
2N4223 (SILICON)
2N4224



Silicon N-channel junction field-effect transistors, designed for VHF amplifier and mixer applications. Drain and Source interchangeable.

CASE 20-03
(TO-72)

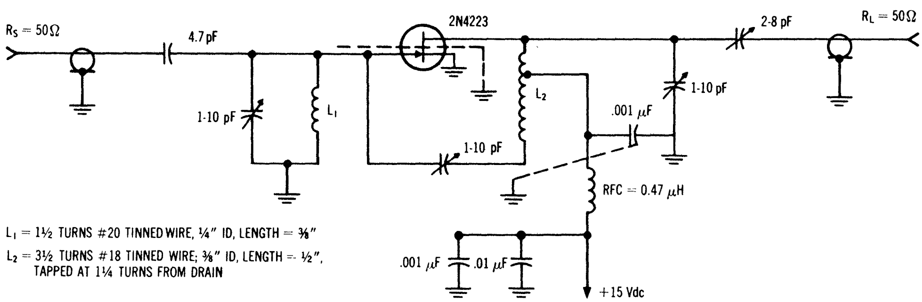
STYLE 3
PIN 1. DRAIN
2. SOURCE
3. GATE
4. CASE LEAD



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Junction Temperature	T_J	+ 175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



L1 = 1½ TURNS #20 TINNED WIRE, ¼" ID, LENGTH = ⅜"
L2 = 3½ TURNS #18 TINNED WIRE; ⅜" ID, LENGTH = ½",
TAPPED AT 1¼ TURNS FROM DRAIN

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	-	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)	2N4223	I_{GSS}	-	0.25	nAdc
	2N4224		-	0.50	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 100°C)	2N4223		-	250	
	2N4224		-	500	
Gate-Source Cutoff Voltage (I_D = 0.25 nAdc, V_{DS} = 15 Vdc)	2N4223	$V_{GS(off)}$	-	8.0	Vdc
(I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	2N4224		-	8.0	
Gate-Source Voltage (I_D = 0.3 mAdc, V_{DS} = 15 Vdc)	2N4223	V_{GS}	1.0	7.0	Vdc
(I_D = 0.2 mAdc, V_{DS} = 15 Vdc)	2N4224		1.0	7.5	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current [1] (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4223	I_{DSS}	3.0	18	mAdc
	2N4224		2.0	20	
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz) [1]	2N4223	$\|y_{fs}\|$	3000	7000	μmhos
	2N4224		2000	7500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223		2700	-	
	2N4224		1700	-	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	-	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	-	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	-	6.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	-	2.0	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1 k ohm, f = 200 MHz)	2N4223	NF	-	5.0	dB
Small-Signal Power Gain (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223	G_{ps}	10	-	dB

[1] Pulse Test: Pulse Width ≦ 630 ms, Duty Cycle ≦ 10%

FIGURE 2 – DRAIN CURRENT versus GATE-SOURCE VOLTAGE

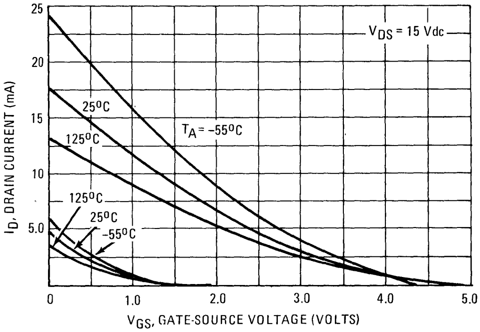


FIGURE 3 – TEMPERATURE COEFFICIENT FOR DRAIN CURRENT

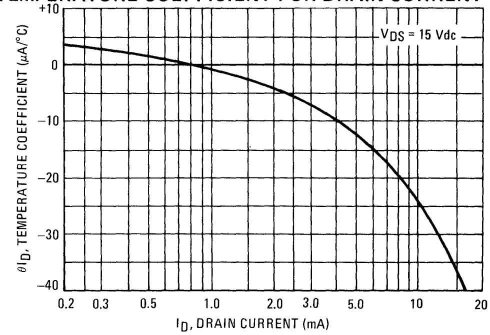


FIGURE 4 – FORWARD TRANSFER ADMITTANCE versus GATE-SOURCE VOLTAGE

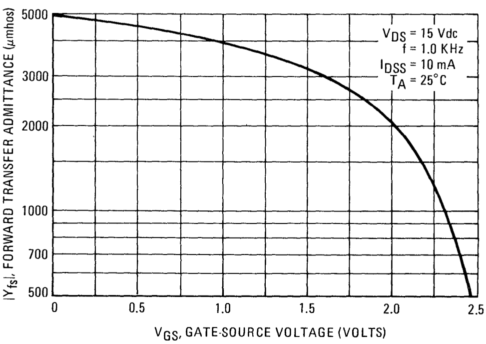


FIGURE 5 – TEMPERATURE COEFFICIENT FOR Y_{fs} versus DRAIN CURRENT

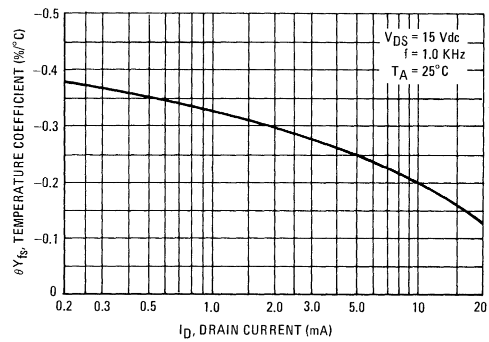


FIGURE 6 – CAPACITANCES

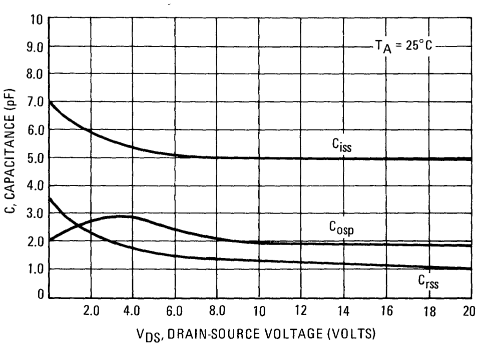


FIGURE 7 – COMMON SOURCE NOISE FIGURE versus SOURCE RESISTANCE

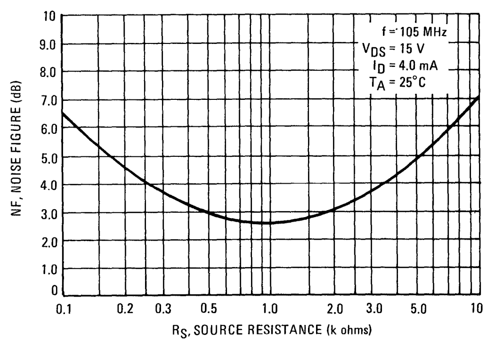


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

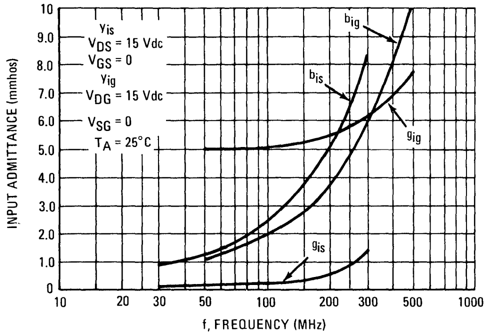


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

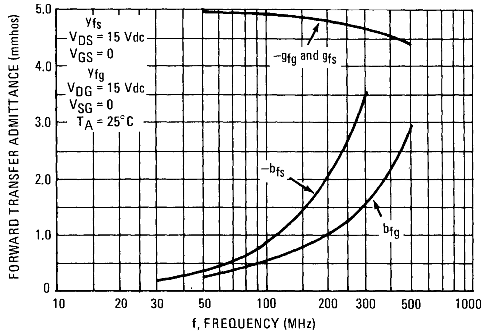


FIGURE 10 – OUTPUT ADMITTANCE versus FREQUENCY

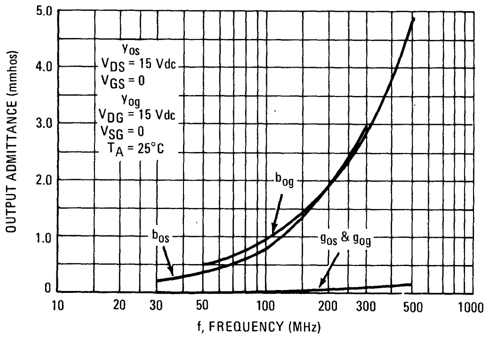


FIGURE 11 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

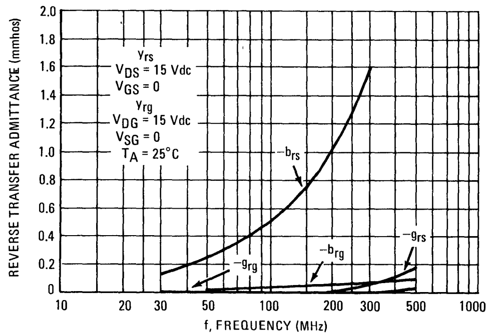


FIGURE 12 – POWER GAIN versus FREQUENCY

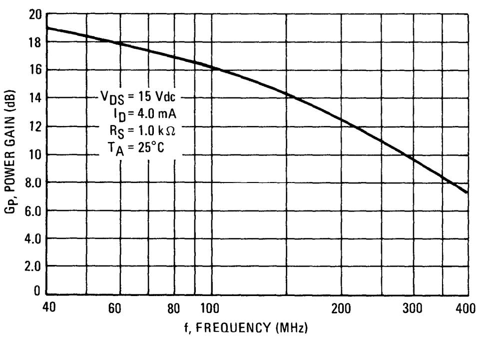
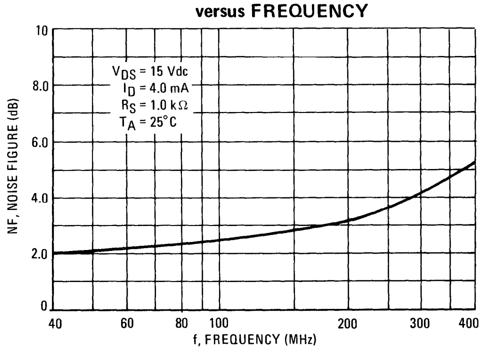
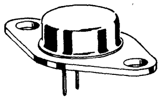


FIGURE 13 – COMMON SOURCE NOISE FIGURE versus FREQUENCY



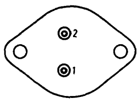
2N4231 thru 2N4233 (SILICON)

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.



CASE 80
(TO-66)

Collector
connected to case



STYLE 1.
PIN 1 BASE
2 EMITTER
CASE-COLLECTOR

MAXIMUM RATINGS

Rating	Symbol	2N4231	2N4232	2N4233	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current - Continuous*	I_C*		3.0 5.0		Adc
Base Current	I_B		1.0		Adc
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D		35 0.2		Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}		-55 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	5.0	°C/W

* The 3.0 Amp maximum I_C value is based upon JEDEC current gain requirements.
The 5.0 Amp maximum value is based upon actual current-handling capability of the device.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1]		$BV_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N4231		40	-	
	2N4232		60	-	
	2N4233		80	-	
Collector Cutoff Current		I_{CEO}			mA
(V_{CE} = 30 Vdc, I_B = 0)	2N4231		-	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N4232		-	1.0	
(V_{CE} = 70 Vdc, I_B = 0)	2N4233		-	1.0	
Collector Cutoff Current		I_{CEX}			mA
(V_{CE} @ rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} @ rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} @ rated V_{CB}, I_E = 0)		I_{CBO}	-	0.05	mA
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	500	uA
ON CHARACTERISTICS					
DC Current Gain[1]		h_{FE}			-
(I_C = 0.5 Adc, V_{CE} = 2.0 Vdc)			40	-	
(I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)			25	100	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage[1]		$V_{CE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			-	0.7	
(I_C = 3.0 Adc, I_B = 0.3 Adc)			-	2.0	
Base-Emitter Voltage[1] (I_C = 1.5 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	-	1.4	Vdc

(1) Pulse Test, PW ≈ 300 μs, Duty Cycle ≈ 2.0%

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	4.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 kHz)	C_{ob}	-	200	pF
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	-	-

FIGURE 1 — NORMALIZED DC CURRENT GAIN

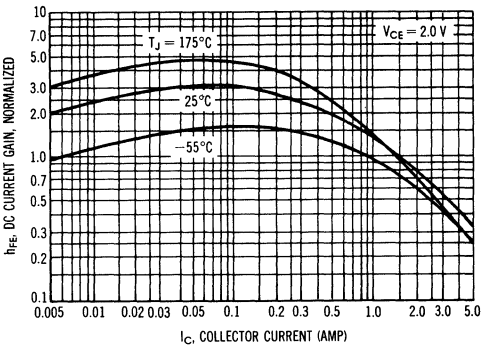


FIGURE 2 — COLLECTOR SATURATION REGION

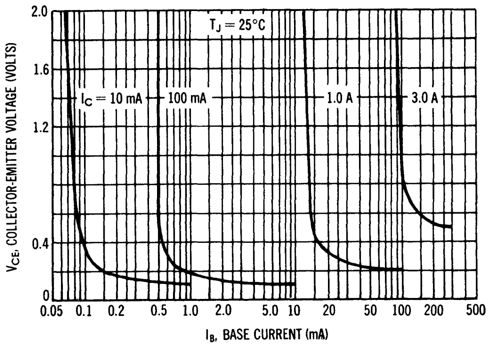


FIGURE 3 — "ON" VOLTAGES

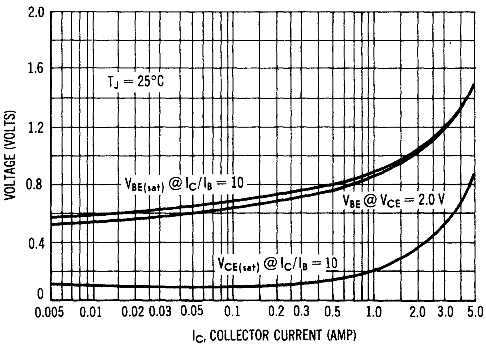


FIGURE 4 — TEMPERATURE COEFFICIENTS

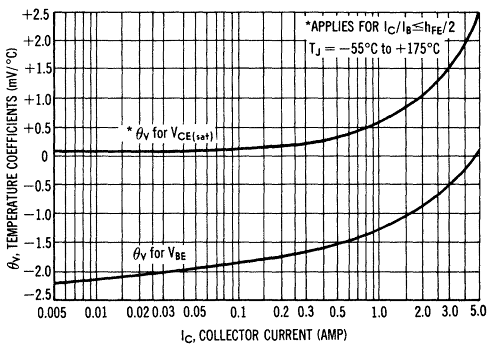


FIGURE 5 — SWITCHING TIME EQUIVALENT CIRCUIT

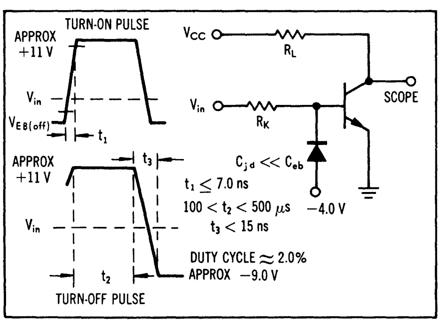


FIGURE 6 — CAPACITANCE

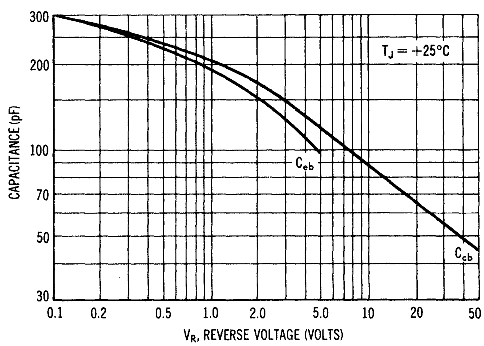


FIGURE 7 —TURN-ON TIME

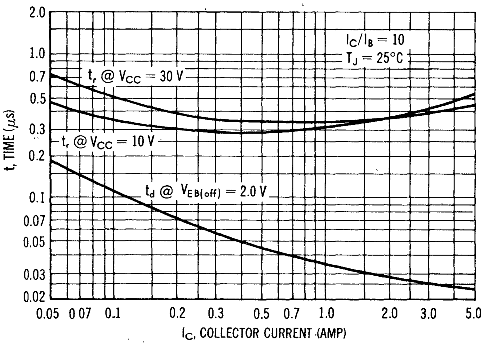
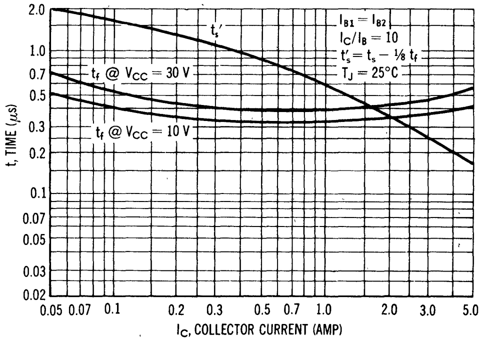


FIGURE 8 — TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 9 — CUT-OFF REGION

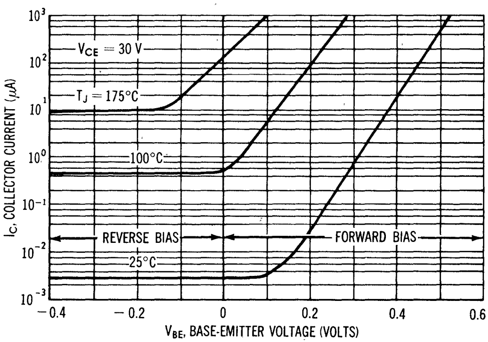


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

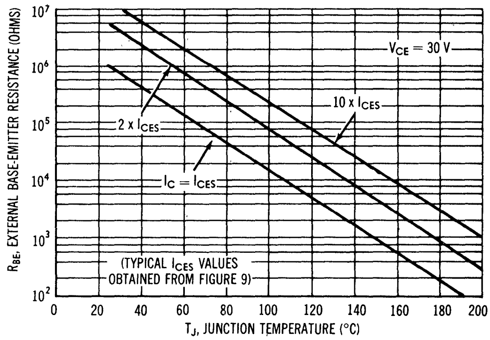
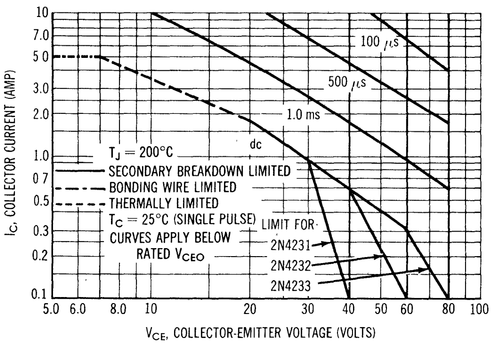


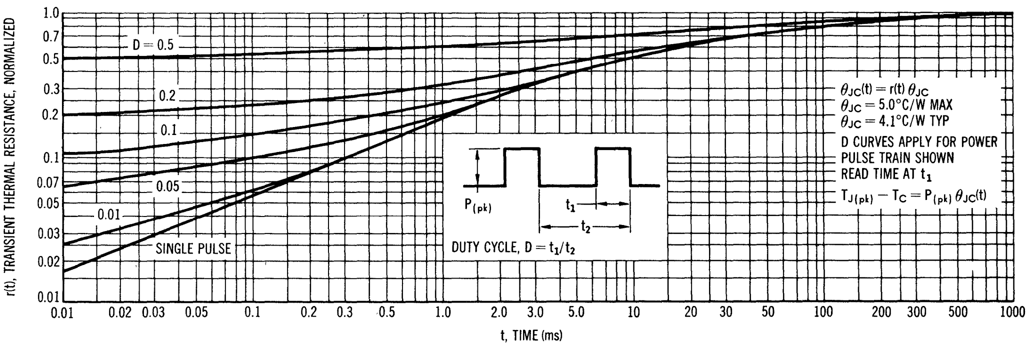
FIGURE 11 — ACTIVE-REGION SAFE-OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — THERMAL RESPONSE



2N4231A thru 2N4233A NPN (SILICON)
2N6312 thru 2N6314 PNP

COMPLEMENTARY SILICON MEDIUM-POWER TRANSISTORS

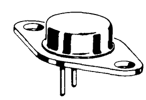
. . . designed for general-purpose power amplifier and switching applications.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.5 Adc
- Low Leakage Current – I_{CEX} = 0.1 mAdc (Max)
- Excellent DC Current Gain – h_{FE} = 25-100 @ I_C = 1.5 Adc
- High Current Gain – Bandwidth Product – f_T = 4.0 MHz @ I_C = 0.25 Adc
- Aluminum TO-66 Package for Better Power Handling Capability

5.0 AMPERE

COMPLEMENTARY SILICON POWER TRANSISTORS

40-60-80 VOLTS
75 WATTS



*MAXIMUM RATINGS

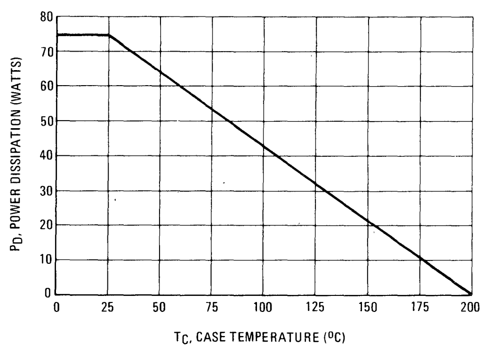
Rating	Symbol	2N4231A 2N6312	2N4232A 2N6313	2N4233A 2N6314	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current – Continuous / Peak	I_C	← 5.0 → / ← 10 →			Adc
Base Current	I_B	← 2.0 →			Adc
Total Device Dissipation @ T_C = 25°C / Derate above 25°C	P_D	← 75 → / ← 0.43 →			Watts / W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

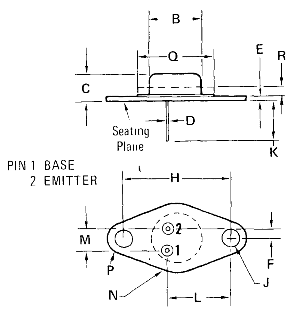
* THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.32	°C/W

*Indicates JEDEC registered data (All values meet or exceed JEDEC registered data)

FIGURE 1 – POWER DERATING





DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
B	470	500	11 94	12.70
C	250	.340	6 35	8.64
D	028	034	.711	864
E	.050	075	1 27	1 91
F	.093	107	2.36	2 72
H	958	962	24 33	24.43
J	.142	152	3 61	3 86
K	.360	–	9 14	–
L	.570	590	14 48	14 99
M	190	210	4 83	5 33
N	–	350	–	8.89
P	–	145	–	3.68
Q	–	620	–	15 75
R	–	050	–	1.27

All JEDEC dimensions and notes apply

CASE 80-02
TO-66

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (1)		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N4231A, 2N6312		40	–	
	2N4232A, 2N6313		60	–	
	2N4233A, 2N6314		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N4231A, 2N6312		–	1.0	
(V_{CE} = 50 Vdc, I_B = 0)	2N4232A, 2N6313		–	1 0	
(V_{CE} = 70 Vdc, I_B = 0)	2N4233A, 2N6314		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1 5 Vdc)	2N4231A, 2N6312		–	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4232A, 2N6313		–	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4233A, 2N6314		–	0.1	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4231A, 2N6312		–	1.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4232A, 2N6313		–	1.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4233A, 2N6314		–	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N4231A, 2N6312		–	0.05	
(V_{CB} = 60 Vdc, I_E = 0)	2N4232A, 2N6313		–	0.05	
(V_{CB} = 80 Vdc, I_E = 0)	2N4233A, 2N6314		–	0.05	
Emitter Cutoff Current (V_{BE} = 5 0 Vdc, I_C = 0)		I_{EBO}	–	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)		h_{FE}			–
*(I_C = 0.5 Adc, V_{CE} = 2 0 Vdc)			40	–	
*(I_C = 1 5 Adc, V_{CE} = 2 0 Vdc)			25	100	
*(I_C = 3 0 Adc, V_{CE} = 2.0 Vdc)			10	–	
(I_C = 5.0 Adc, V_{CE} = 4 0 Vdc)			4.0	–	
*Collector-Emitter Saturation Voltage (1)		$V_{CE(sat)}$			Vdc
(I_C = 1.5 Adc, I_B = 0.15 Adc)			–	0.7	
(I_C = 3 0 Adc, I_B = 0.3 Adc)			–	2 0	
(I_C = 5.0 Adc, I_B = 1 25 Adc)			–	4.0	
*Base-Emitter On Voltage (1) (I_C = 1 5 Adc, V_{CE} = 2 0 Vdc)		$V_{BE(on)}$	–	1 4	Vdc
***DYNAMIC CHARACTERISTICS**					
Current-Gain – Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f_{test} = 1.0 MHz)		f_T	4 0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	300	pF
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

*Indicates JEDEC registered data.
(1) Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2 0%

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

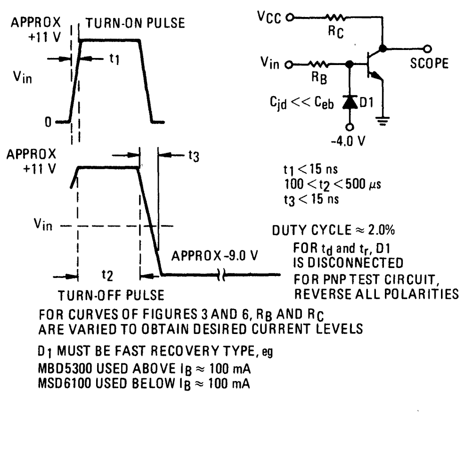


FIGURE 3 – TURN "ON" TIME

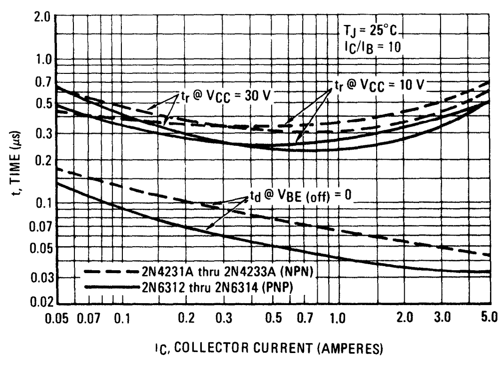


FIGURE 4 – THERMAL RESPONSE

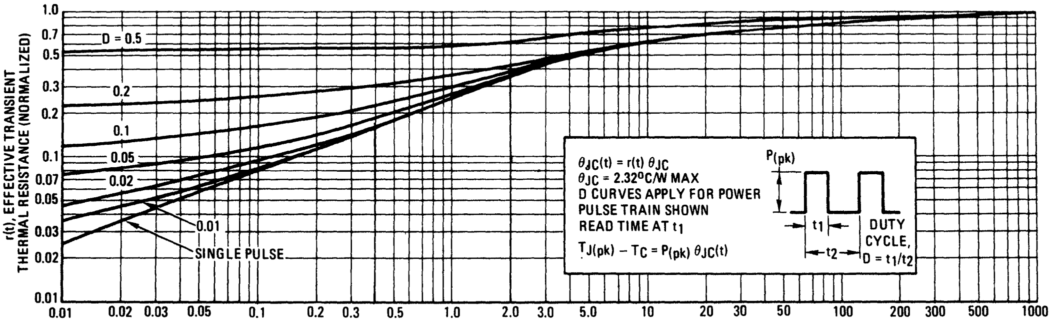
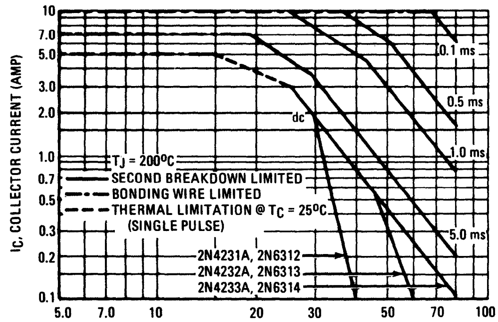


FIGURE 5 – ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor; average junction temperature and second breakdown. Safe operating area curves indicate I_C – V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power than can be handled to values less than the limitations imposed by second breakdown. (See Motorola Application Note AN-415).

FIGURE 6 – TURN "OFF" TIME

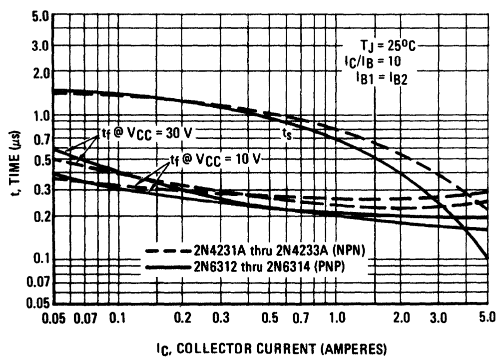
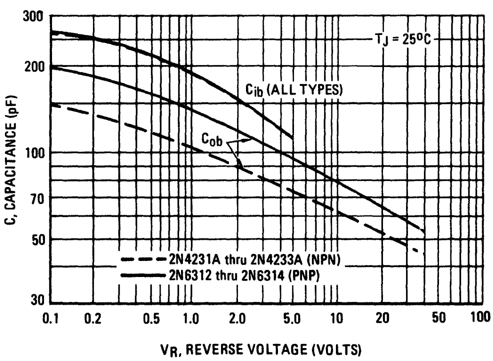


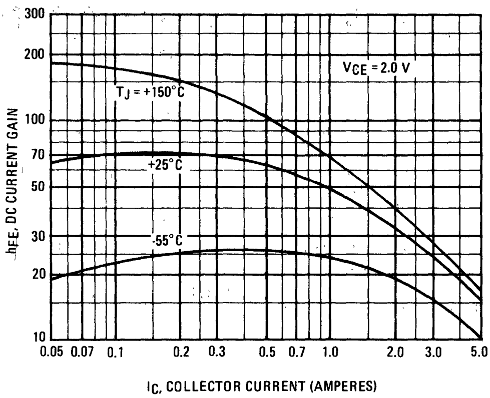
FIGURE 7 – CAPACITANCE



NPN
2N4231A thru 2N4233A

PNP
2N6312 thru 2N6314

FIGURE 8 – DC CURRENT GAIN



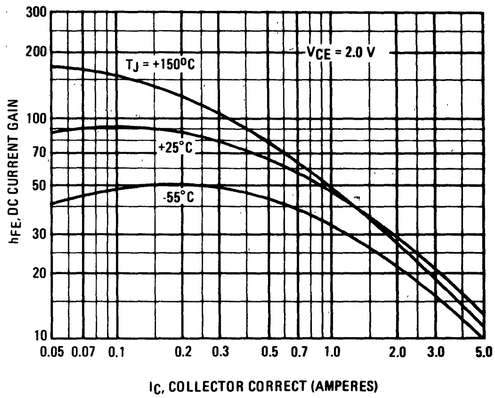
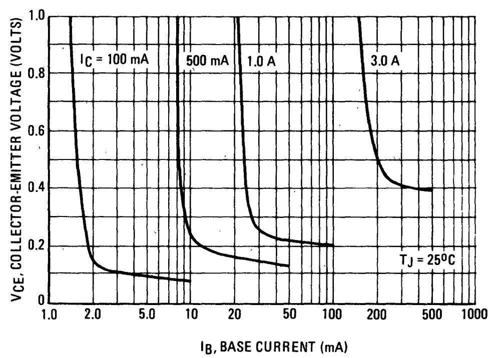


FIGURE 9 – COLLECTOR SATURATION REGION



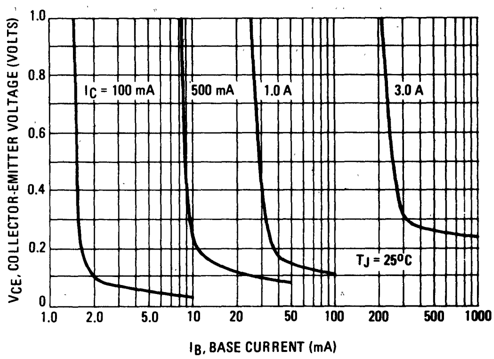
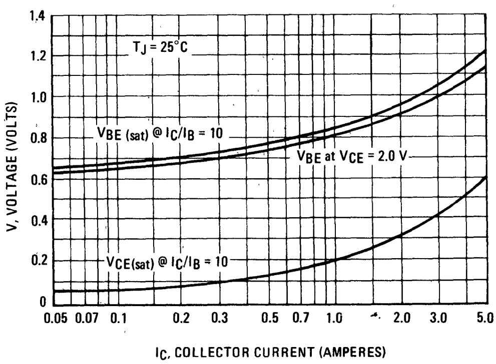
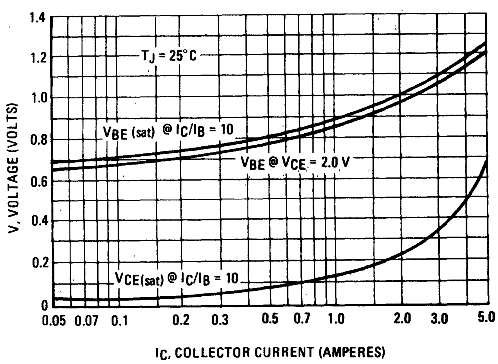


FIGURE 10 – "ON" VOLTAGES NPN PNP





NPN — **2N4231A thru 2N4233A** | **PNP** — **2N6312 thru 2N6314**

FIGURE 11 – TEMPERATURE COEFFICIENTS

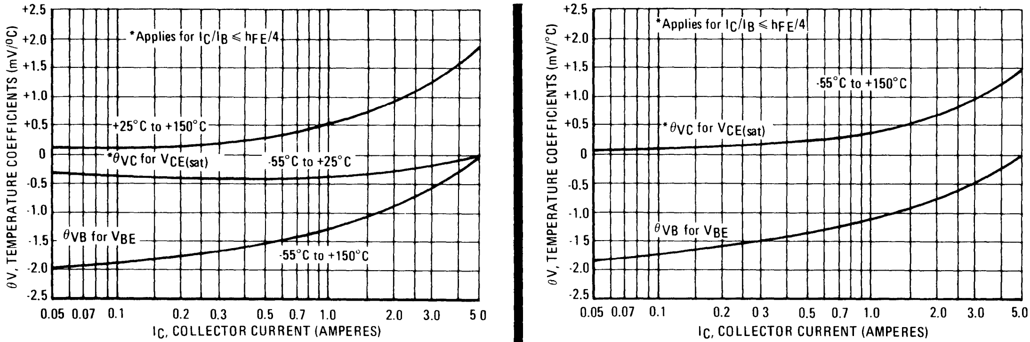


FIGURE 12 – COLLECTOR CUT-OFF REGION

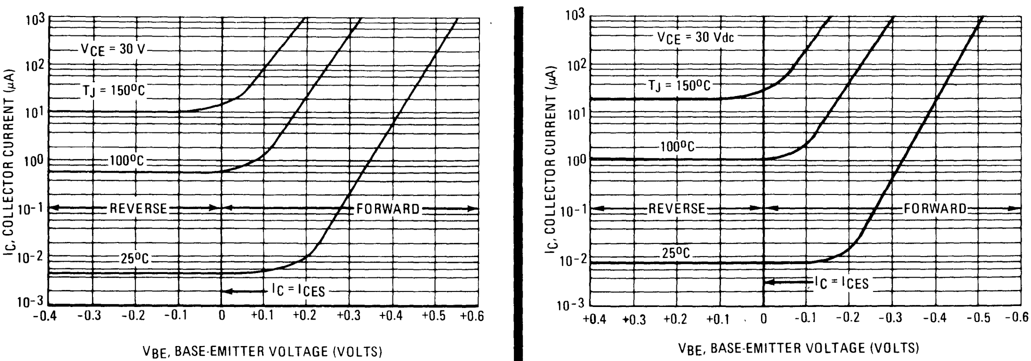
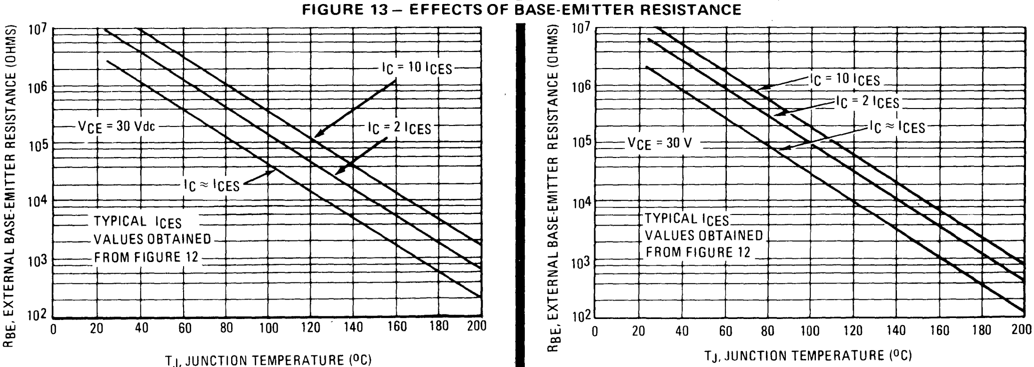
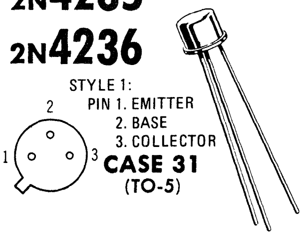


FIGURE 13 – EFFECTS OF BASE-EMITTER RESISTANCE



2N4234 (SILICON)
2N4235
2N4236



PNP silicon power transistors ideal for use as drivers, switches, and direct replacement of germanium medium-power devices. Complement to NPN 2N4237 thru 2N4239.

Collector connected to case

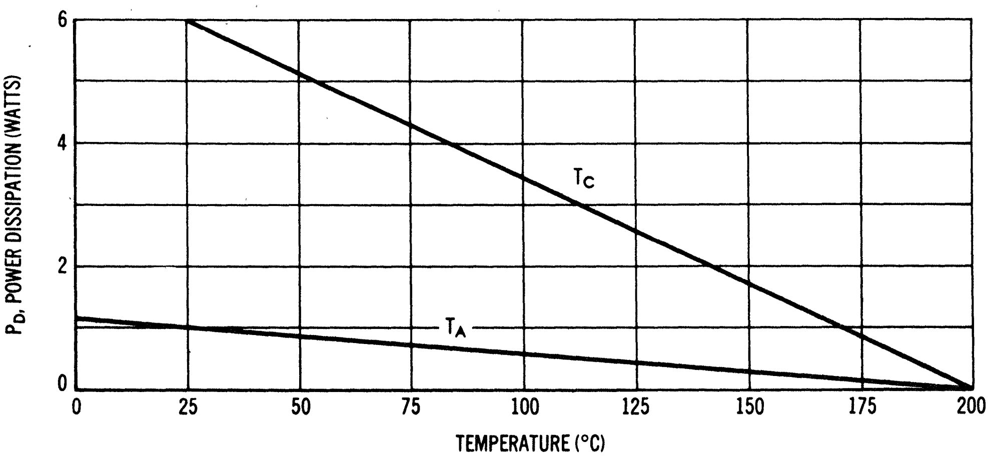
MAXIMUM RATINGS

Rating	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 7.0 →			Vdc
Collector Current — Continuous	I_C	← 3.0 →			Adc
Base Current	I_B	← 0.2 →			Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	← 1.0 → ← 5.7 →			Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 6.0 → ← 34 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θJC	29	°C/W

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.

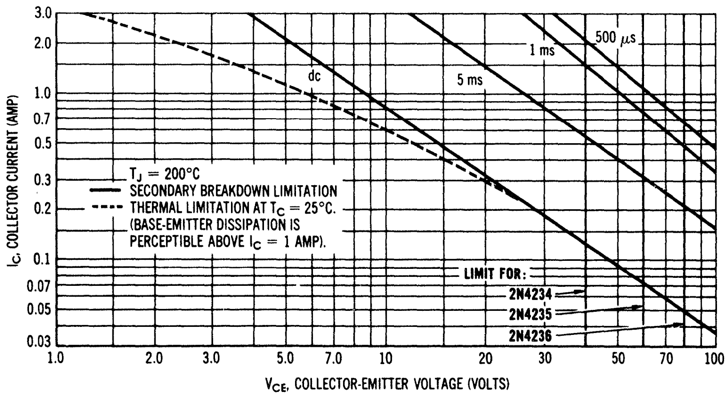
All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0)	2N4234 2N4235 2N4236	$BV_{CEO(sus)}$	40 60 80	— — —	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0) (V_{CE} = 40 Vdc, I_B = 0) (V_{CE} = 60 Vdc, I_B = 0)	2N4234 2N4235 2N4236	I_{CEO}	— — —	1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C) (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4234 2N4235 2N4236 2N4234 2N4235 2N4236	I_{CEX}	— — — — — —	0.1 0.1 0.1 1.0 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0)	2N4234 2N4235 2N4236	I_{CBO}	— — —	0.1 0.1 0.1	mAdc
Emitter Cutoff Current (V_{BE} = 7 Vdc, I_C = 0)		I_{EBO}	—	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (1) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 250 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 1 Vdc) (I_C = 1.0 Adc, V_{CE} = 1 Vdc)		h_{FE}	40 30 20 10	— 150 — —	—
Collector-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 125 mAdc)		$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 100 mAdc)		$V_{BE(sat)}$	—	1.5	Vdc
Base-Emitter On Voltage (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	—	1.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	3.0	—	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	—	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	—	—

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2%

FIGURE 2 — ACTIVE-REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C—V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

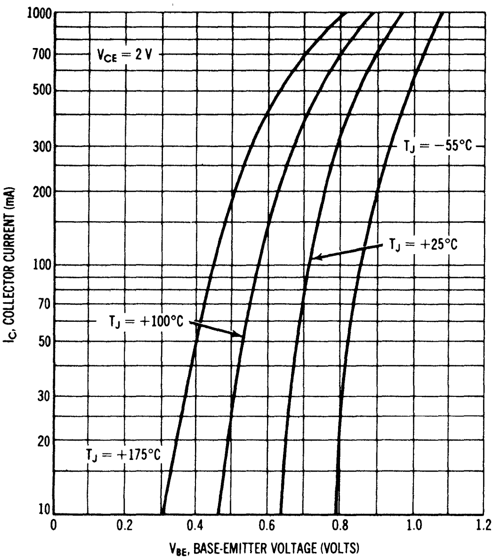
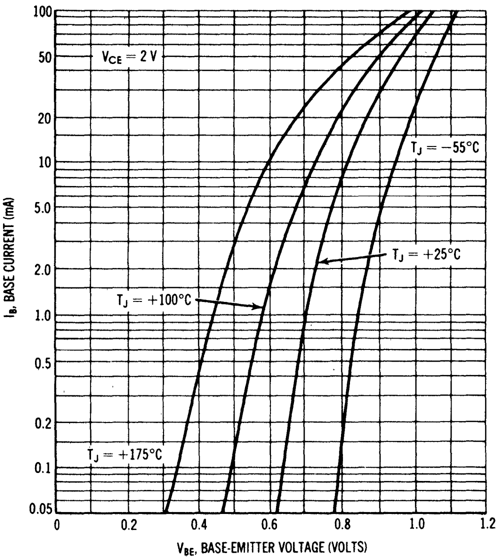


FIGURE 4 — INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 — TRANSCONDUCTANCE

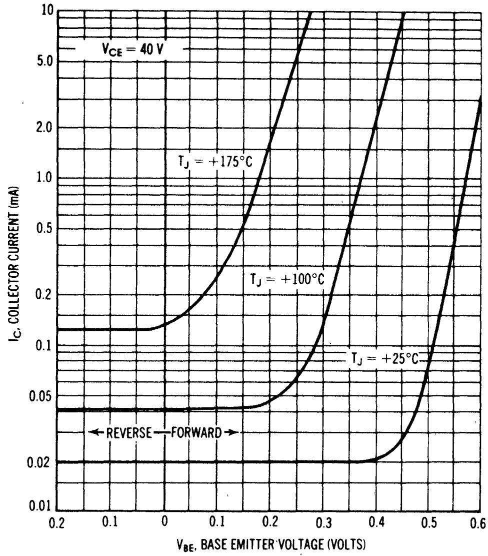


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

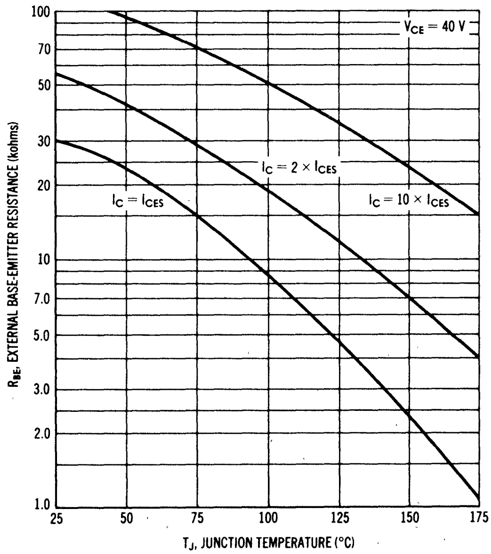
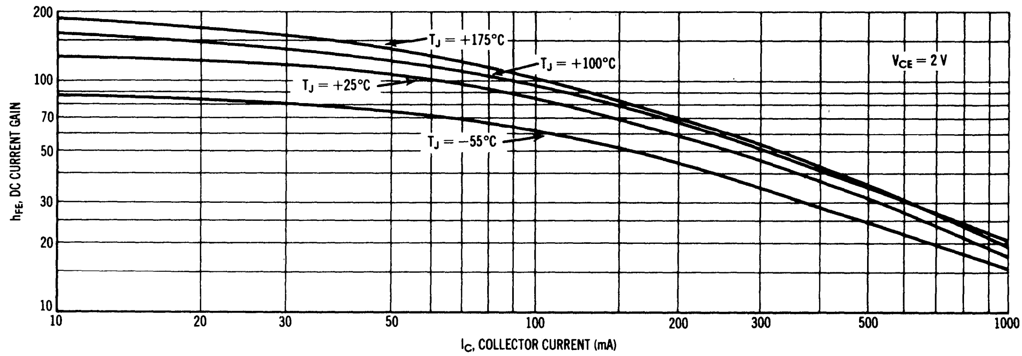


FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

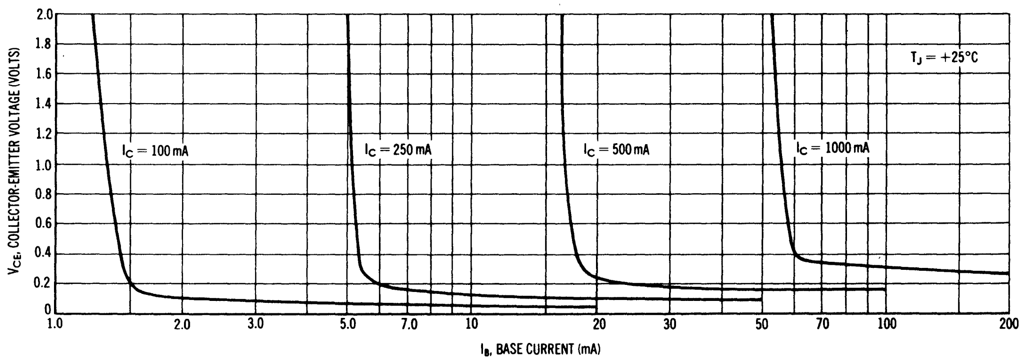


FIGURE 9 — "ON" VOLTAGES

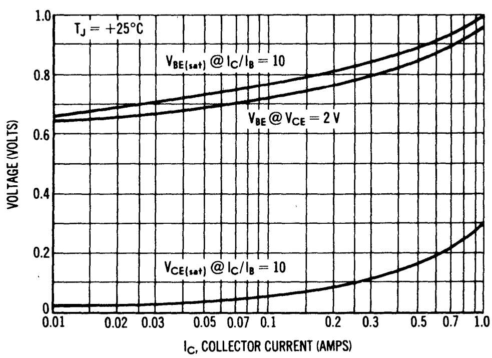
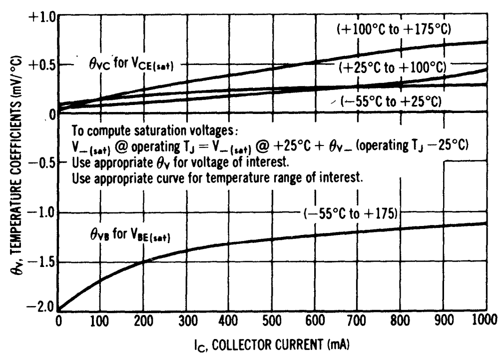


FIGURE 10 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

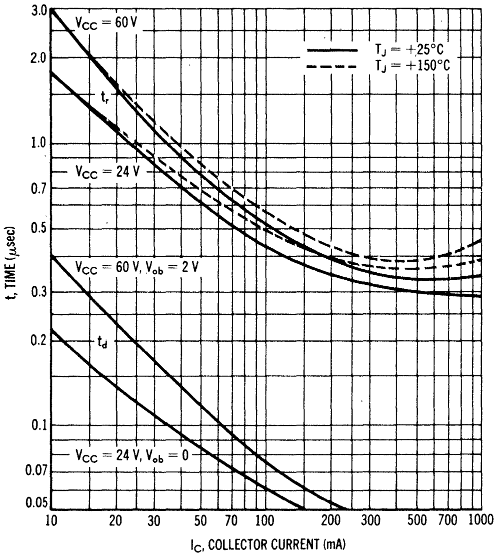


FIGURE 13 — CAPACITANCE

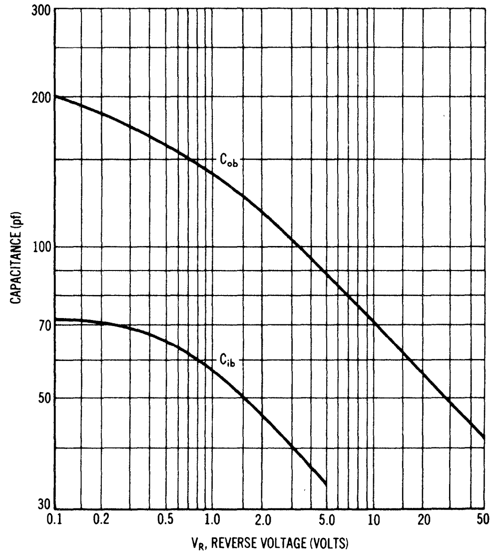


FIGURE 12 — STORAGE TIME

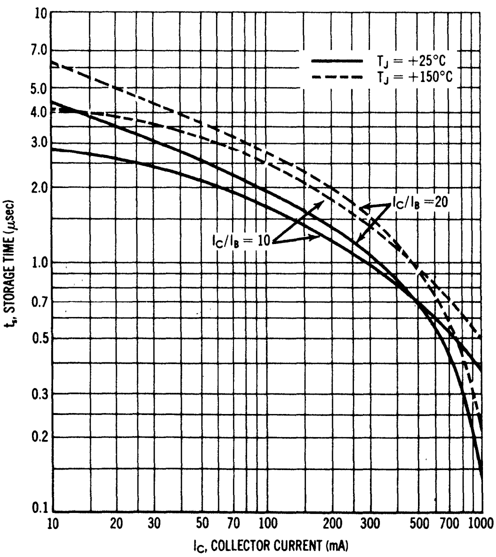
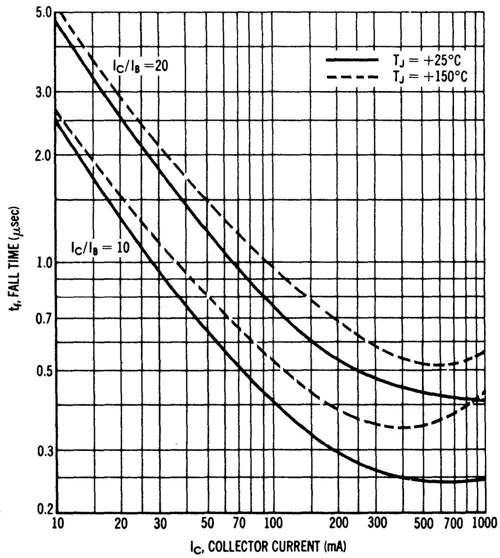
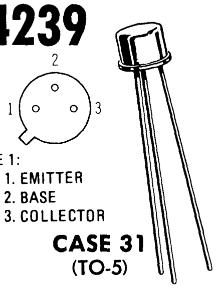


FIGURE 14 — FALL TIME



2N4237 (SILICON) thru 2N4239



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 31
(TO-5)

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications.

Collector connected to case

MAXIMUM RATINGS

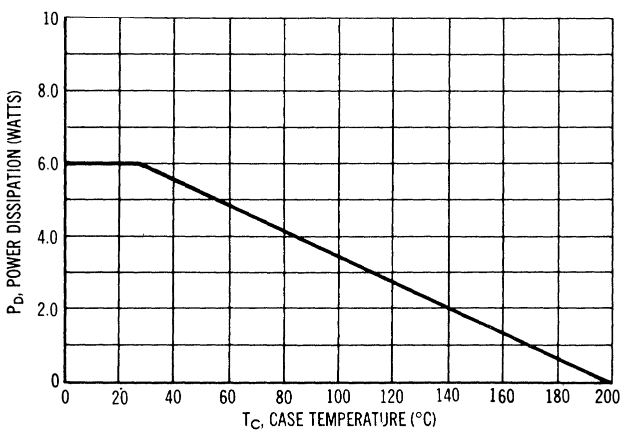
Rating	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Emitter-Base Voltage	V_{EB}	← 6.0 →			Vdc
Collector Current — Continuous*	I_C	← 1.0 → ← 3.0 →			Adc
Base Current — Continuous	I_B	← 500 →			mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 6.0 → ← 34 →			Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	29	°C/W

*The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 100 mAdc, I_B = 0) 2N4237 / 2N4238 / 2N4239	-	$BV_{CEO(sus)}$	40 / 60 / 80	- / - / -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)	-	I_{CEO}	-	0.7	mAdc
Collector Cutoff Current	12	I_{CEX}			mAdc
(V_{CE} = 45 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 75 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 90 Vdc, $V_{EB(off)}$ = 1.5 Vdc)			-	0.1	
(V_{CE} = 30 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
(V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CBO}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)	-	I_{EBO}	-	0.5	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)	8	h_{FE}			-
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			30	-	
(I_C = 250 mAdc, V_{CE} = 1.0 Vdc)			30	150	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			30	-	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage (1)	9, 11, 13	$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			-	0.3	
(I_C = 1.0 Adc, I_B = 0.1 Adc)			-	0.6	
Base-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 0.1 Adc)		$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage (1) (I_C = 250 mAdc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	2.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	30	-	-

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING CHARACTERISTICS

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

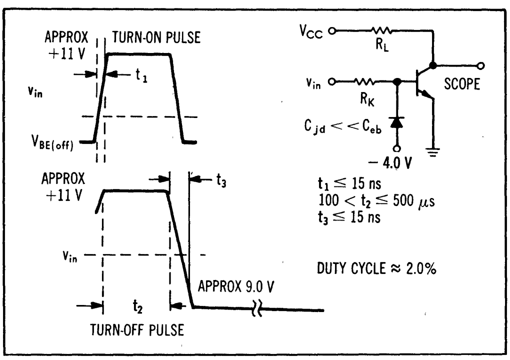


FIGURE 3 — TURN-ON TIME

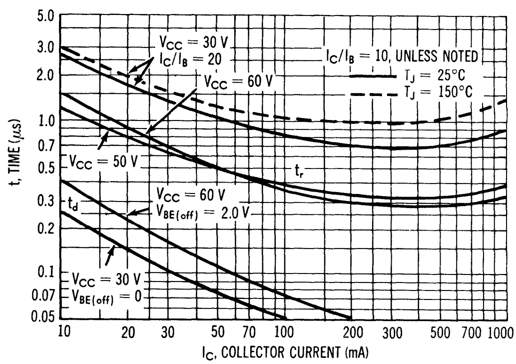


FIGURE 4 — THERMAL RESPONSE

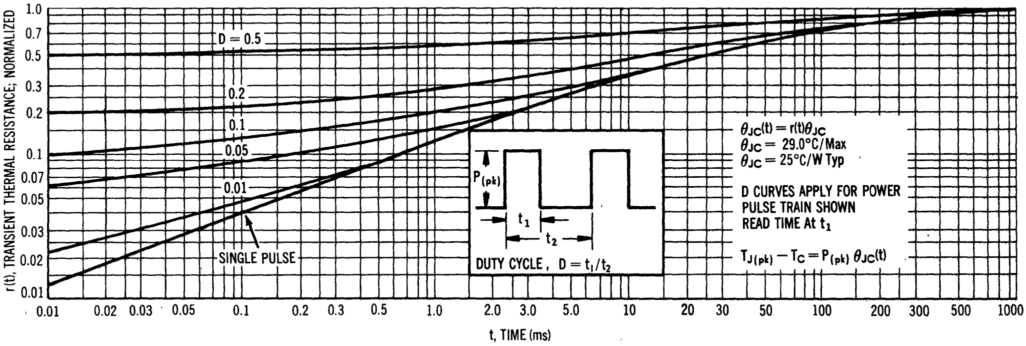
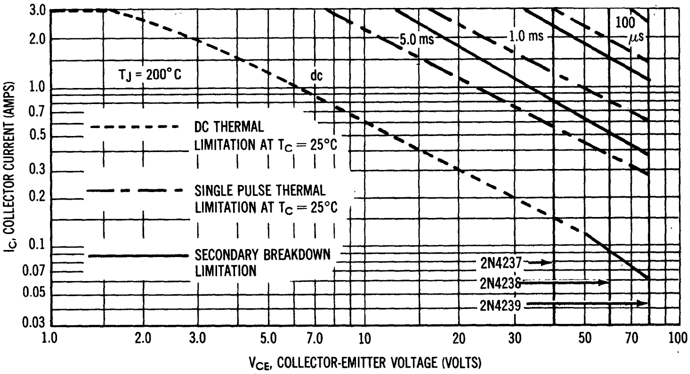


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

For this particular transistor family, the thermal curves are the limiting design values, except for a small portion of the dc curve. The pulse secondary breakdown curves are shown for information only.

FIGURE 6 — STORAGE TIME

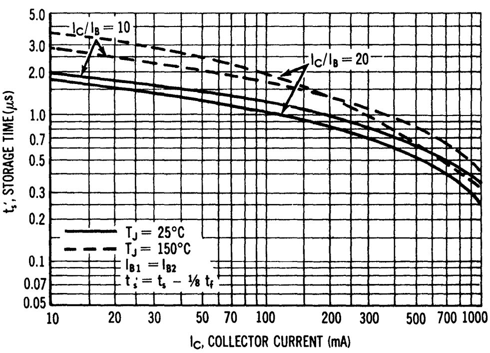
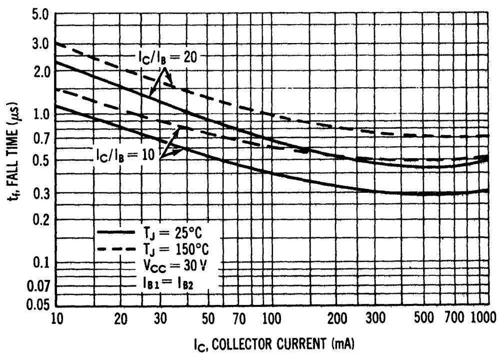


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

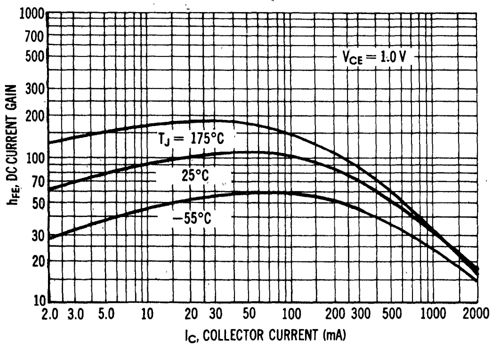


FIGURE 9 — COLLECTOR SATURATION REGION

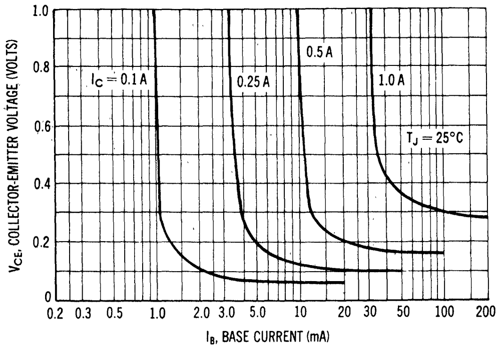


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

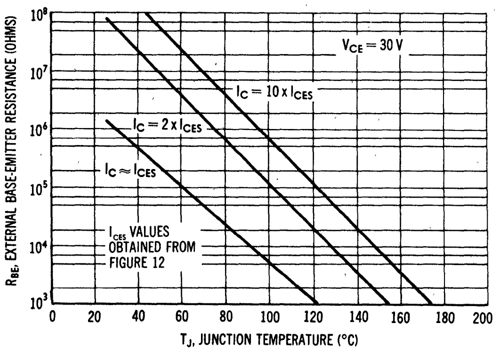


FIGURE 11 — "ON" VOLTAGE

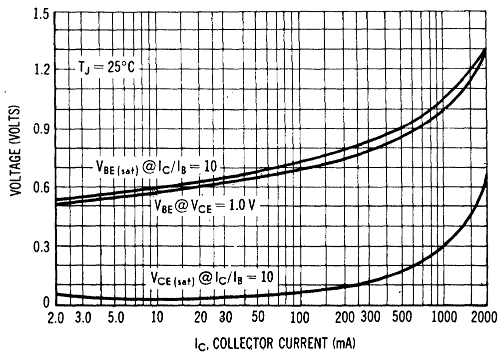


FIGURE 12 — COLLECTOR CUTOFF REGION

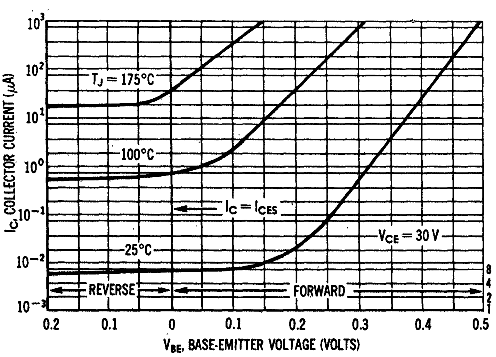
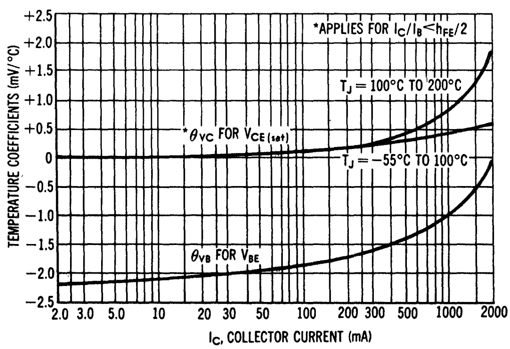
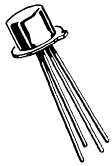


FIGURE 13 — TEMPERATURE COEFFICIENTS

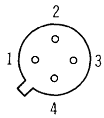


2N4260 (SILICON)
2N4261



PNP silicon annular transistors, designed for high-speed current-mode logic switching applications and for complementary circuitry with NPN types 2N3959 and 2N3960.

CASE 20
(TO-72)



STYLE 10
PIN 1. EMITTER
2. BASE
3. COLLECTOR
4. CASE

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage ($I_C = 10$ mAdc, $I_E = 0$)			BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)			BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)			BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2$ Vdc)			I_{CEX}	-	0.005	μAdc
($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2$ Vdc, $T_A = 150°C$)				-	5.0	
($V_{CE} = 10$ Vdc, $V_{EB(on)} = 0.4$ Vdc)				-	0.05	
Base Cutoff Current ($V_{CE} = 10$ Vdc, $V_{BE(off)} = 2$ Vdc)			I_{BL}	-	0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 1$ mAdc, $V_{CE} = 1$ Vdc)		1	h_{FE}	25	-	-
($I_C = 10$ mAdc, $V_{CE} = 1$ Vdc)				30	150	
($I_C = 30$ mAdc, $V_{CE} = 2$ Vdc)				20	-	
Collector-Emitter Saturation Voltage ($I_C = 1$ mAdc, $I_B = 0.1$ Adc)		2, 3, 4	$V_{CE(sat)}$	-	0.15	Vdc
($I_C = 10$ mAdc, $I_B = 1$ mAdc)				-	0.35	
Base-Emitter On Voltage ($I_C = 1$ mAdc, $V_{CE} = 1$ Vdc)		3, 4	$V_{BE(on)}$	-	0.8	Vdc
($I_C = 10$ mAdc, $V_{CE} = 1$ Vdc)				-	1.0	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product ($I_C = 5$ mAdc, $V_{CE} = 4$ Vdc, f = 100 MHz)	2N4260	5	f_T	1200	-	MHz
	2N4261			1500	-	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	2N4260			1600	-	
	2N4261			2000	-	
High-Frequency Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 100 MHz)	2N4260		$\|h_{fe}\|$	16	-	-
	2N4261			20	-	
Output Capacitance ($V_{CB} = 4$ Vdc, $I_E = 0$, f = 100 kHz)		8	C_{ob}	-	2.5	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, f = 100 kHz)		8	C_{ib}	-	2.5	pF
Collector-Base Time Constant ($I_C = 5$ mAdc, $V_{CE} = 4$ Vdc, f = 31.8 MHz)	2N4260	6	$r'_b C_c$	-	35	ps
	2N4261			-	60	
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, f = 31.8 MHz)	2N4260			-	30	
	2N4261			-	50	

TYPICAL SWITCHING TIMES

	Fig. No.	Symbol	Typical Performance ($v_{out} = 1$ V) @ 10 mA	Typical Performance ($v_{out} = 1$ V) @ 30 mA	Unit
Turn-On Delay Time	Test Circuit Figure 7	$t_{on(delay)}$	1.0	1.2	ns
Rise Time		t_r	0.5	0.9	ns
Turn-Off Delay Time	Test Circuit Figure 7	$t_{off(delay)}$	1.0	1.2	ns
Fall-Time		t_f	1.0	1.2	ns

* Indicates JEDEC Registered Data

FIGURE 1 — DC CURRENT GAIN

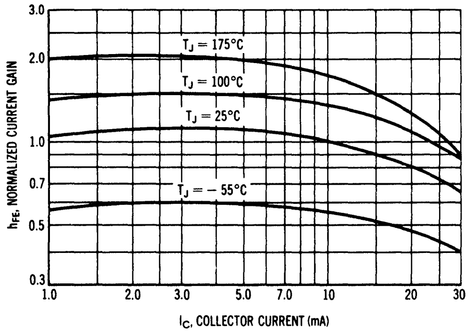


FIGURE 2 — COLLECTOR SATURATION REGION

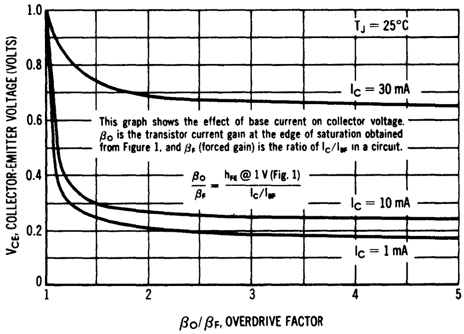


FIGURE 3 — "ON" VOLTAGES

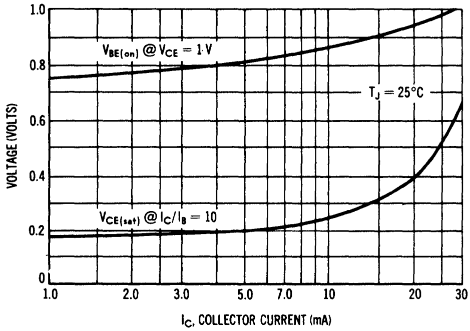


FIGURE 4 — TEMPERATURE COEFFICIENTS

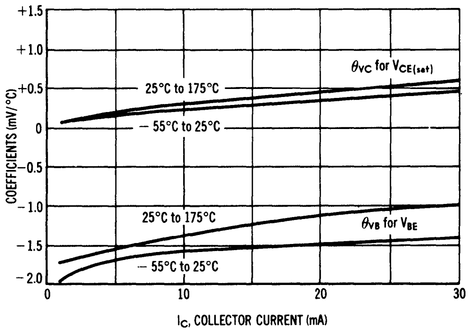


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

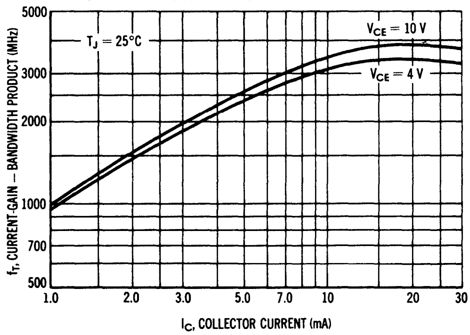


FIGURE 6 — COLLECTOR-BASE TIME CONSTANT

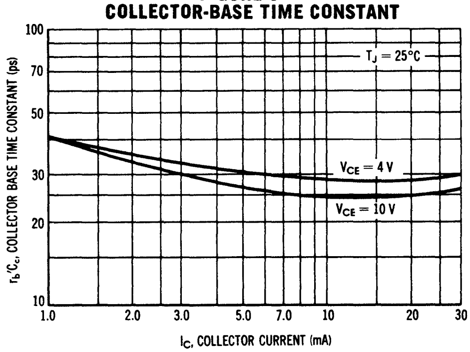
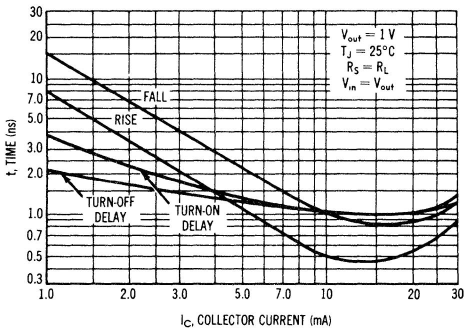
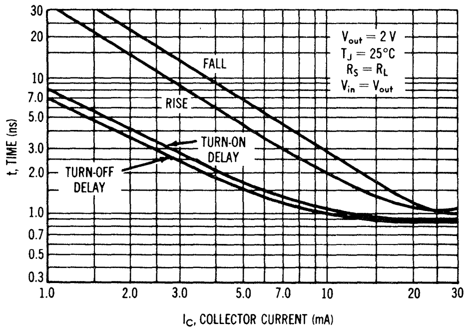
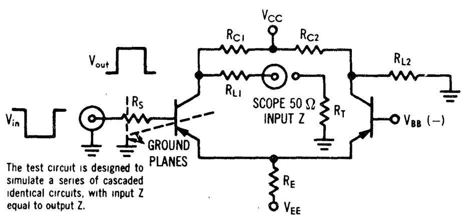


FIGURE 7 — SWITCHING TIMES







The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

	$V_{in} = V_{out} = 2$ V $V_{BB} = 1$ V $R_{C1} = R_{C2}$							$V_{in} = V_{out} = 1$ V $V_{BB} = 0.5$ V $R_{C1} = R_{C2}$						
I_C mA	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts
1	2 k	6 k	3 k	3 k	10 k	10	16	1 k	6 k	1.2 k	1 2 k	24 k	24	32
5	360	3.56 k	400	450	2 k	10	47	175	1 k	200	250	3 k	15	27
10	160	1 k	200	250	3 k	30	26 3	75	300	100	150	3 k	30	17
20	62	300	100	150	1 k	20	16	25	150	25	75	1 k	20	11
30	28	157	66	116	1 k	30	13	8	77	0	50	1 k	30	9

FIGURE 8 — CAPACITANCE

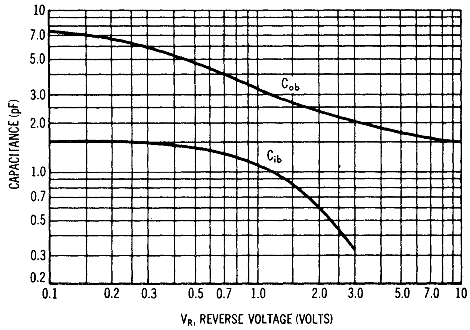
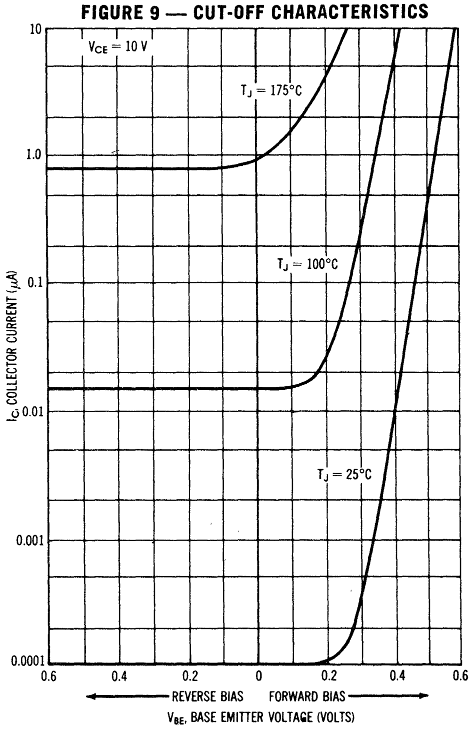


FIGURE 9 — CUT-OFF CHARACTERISTICS



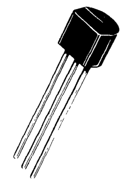
2N4264 (SILICON)
2N4265

NPN SILICON ANNUAL TRANSISTORS

. . . designed for general-purpose switching and amplifier applications.

- Collector-Emitter Breakdown Voltage –
  BV_{CEO} = 15 Vdc (Min) @ I_C = 1.0 mAdc – 2N4264
- Current Gain Specified from 0.1 mAdc to 200 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance –
  C_{cb} = 4.0 pF (Max) @ V_{CB} = 5.0 Vdc

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS



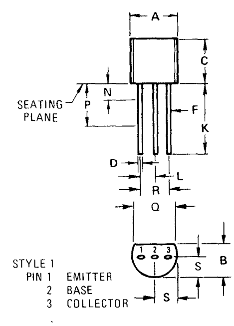
*MAXIMUM RATINGS

Rating	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	6.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

2N4264, 2N4265 (continued)

* ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

OFF CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	2N4264 2N4265	BV_{CEO}	15 12	— —	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)		I_{CEV}	—	100	nAdc
Base Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc) (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 100°C)		I_{BEV}	— —	0.1 10	μAdc

ON CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
DC Current Gain (I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4264 2N4265	h_{FE}	25 50	— —	—
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4264 2N4265		40 100	160 400	
(I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C)	2N4264 2N4265		20 45	— —	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)	2N4264 2N4265		40 90	— —	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N4264 2N4265		30 55	— —	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N4264 2N4265		20 35	— —	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$	— —	0.22 0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$	0.65 0.75	0.80 0.95	Vdc

SMALL SIGNAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	—	MHz
Collector-Base Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	4.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	—	8.0	pF

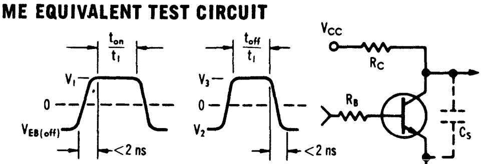
SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Turn-On Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc	t_{on}	—	25	ns
Turn-Off Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1.5 mAdc	t_{off}	—	35	ns
Storage Time	Figure 1, Test Condition B V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc	t_s	—	20	ns
Delay Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2 Vdc,	t_d	—	8.0	ns
Rise Time	I_C = 100 mAdc, I_{B1} = 10 mAdc	t_r	—	15	ns
Storage Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, I_C = 100 mAdc,	t_s	—	20	ns
Fall Time	I_{B1} = I_{B2} = 10 mAdc	t_f	—	15	ns
Total Control Charge	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_B = mAdc	Q_T	—	80	pC

*Indicates JEDEC Registered Data

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_B	R_C	$C_{S(max)}$	$V_{EB(off)}$	V_1	V_2	V_3
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	–	–	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



PULSE WIDTH (t_1) = 300 ns   DUTY CYCLE = 2%

CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

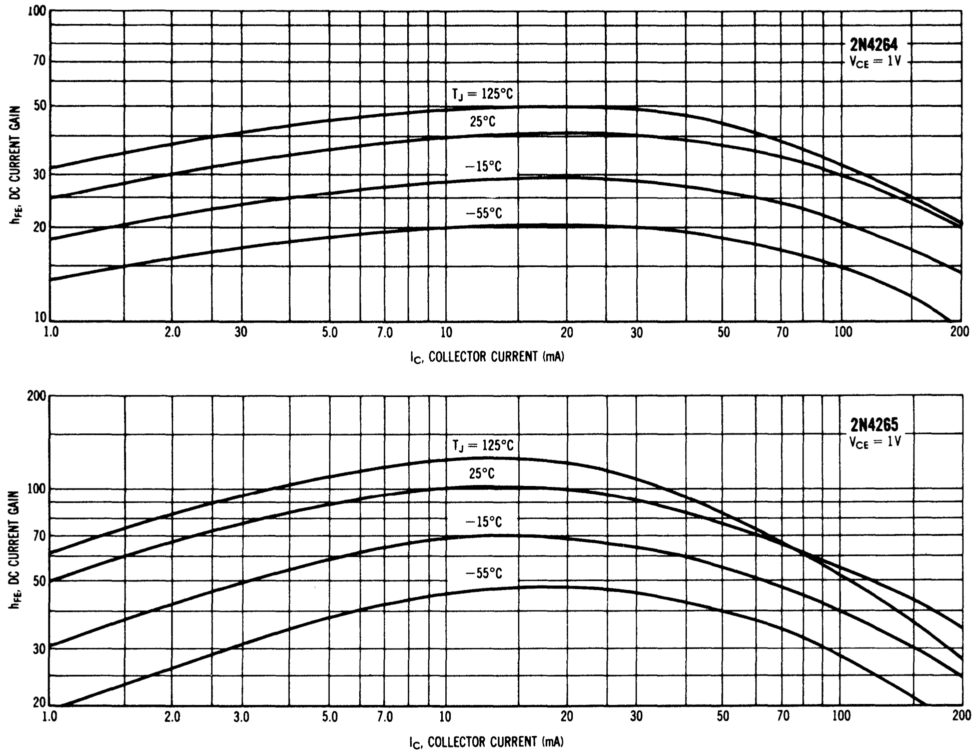


FIGURE 3 — Q_T TEST CIRCUIT

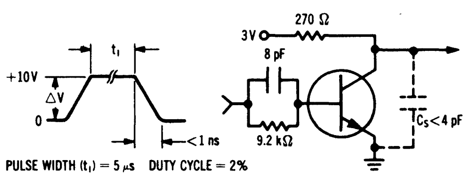
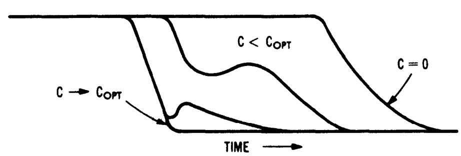


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_1 + Q_V + Q_X$.

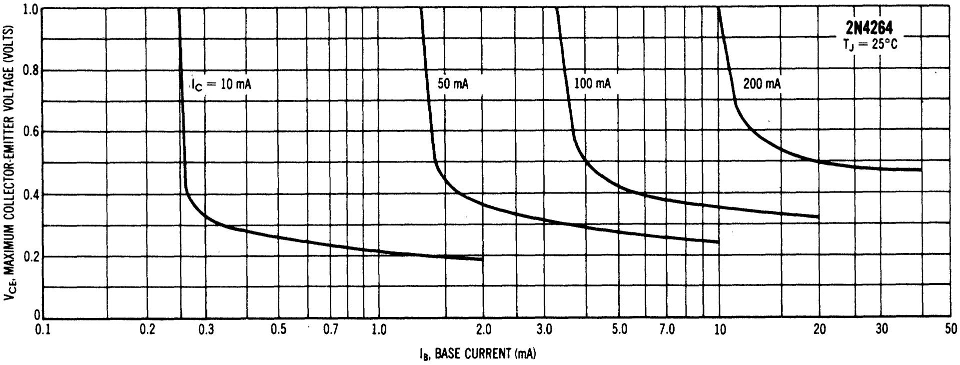
Q_1 is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i.e., operation in saturation.

The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_1 and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t_r$ when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\Delta V$, where ΔV is defined in Figure 3.

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



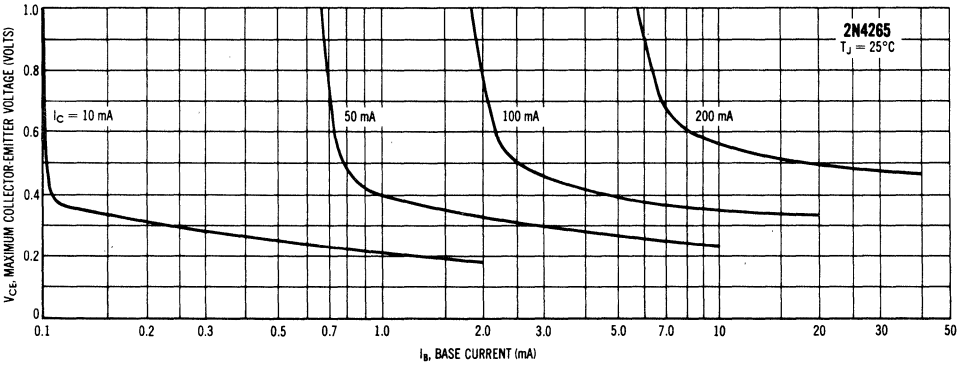


FIGURE 6 — SATURATION VOLTAGE LIMITS

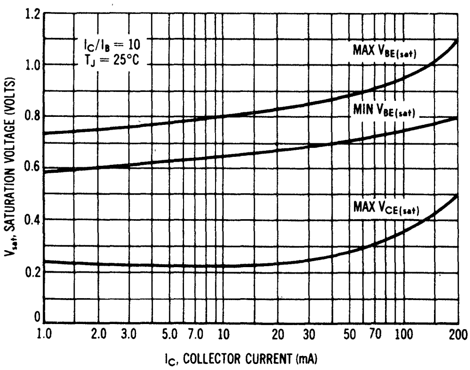
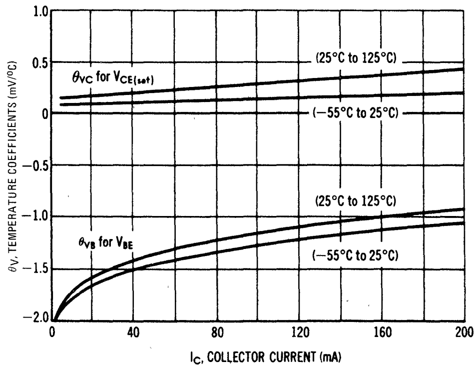


FIGURE 7 — TEMPERATURE COEFFICIENTS



DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

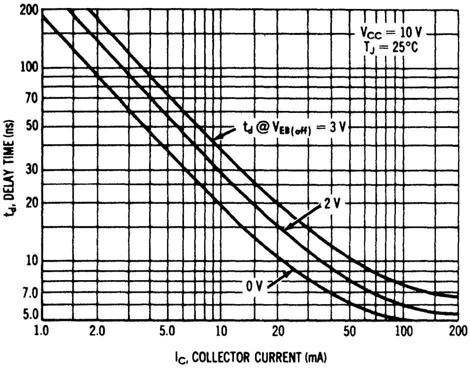


FIGURE 9 — RISE TIME

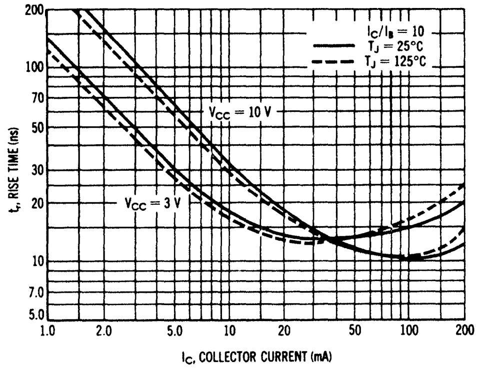


FIGURE 10 — STORAGE TIME

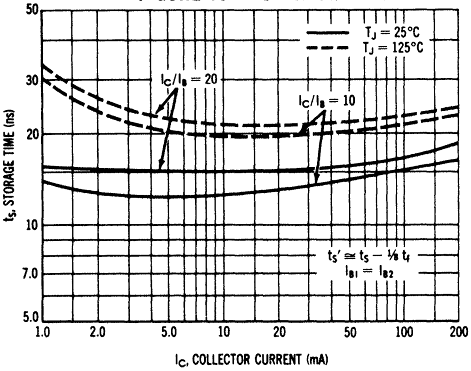


FIGURE 11 — FALL TIME

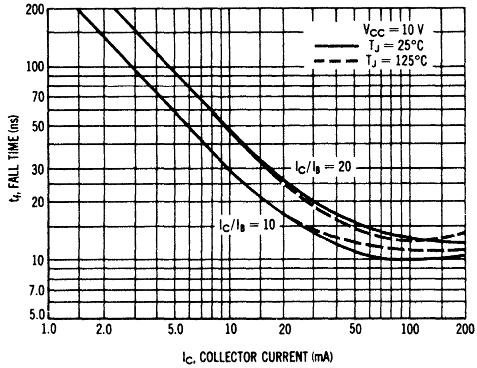


FIGURE 12 — JUNCTION CAPACITANCE

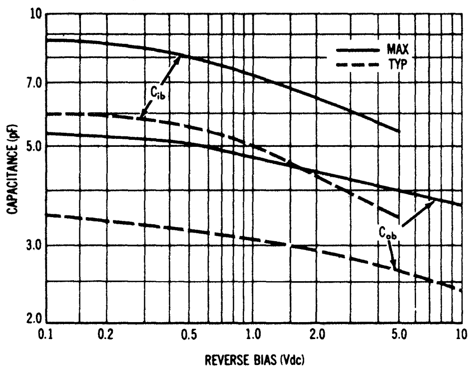
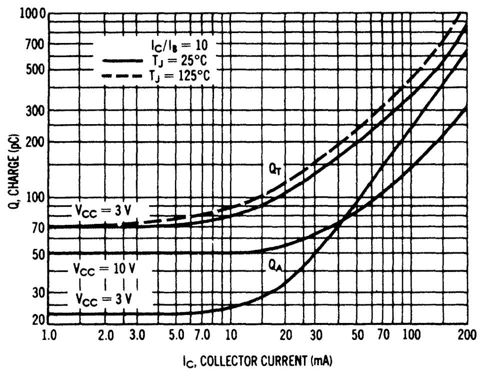
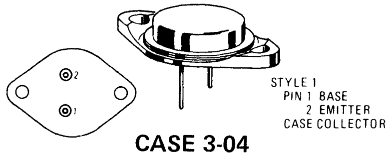


FIGURE 13 — MAXIMUM CHARGE DATA

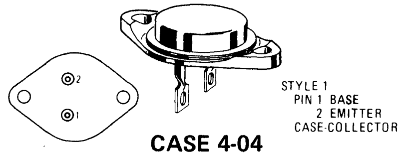


2N4276 (GERMANIUM) thru 2N4283

PNP germanium power transistors designed for high current applications requiring high-gain and low saturation voltages.



CASE 3-04
(TO-3 modified)



CASE 4-04

Collector connected to case

For units with solder lugs attached, specify devices MP4276 etc (Case 4-04)

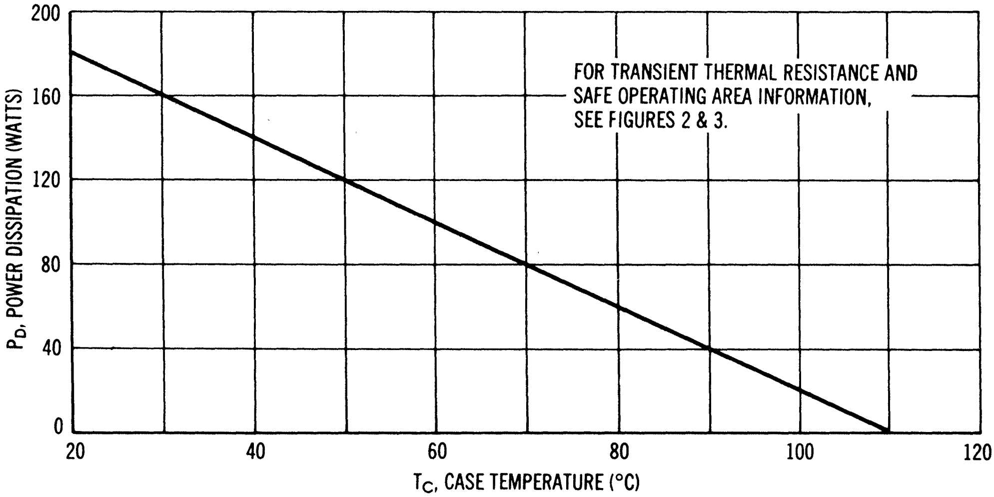
MAXIMUM RATINGS

Rating	Symbol	2N4276 2N4277	2N4278 2N4279	2N4280 2N4281	2N4282 2N4283	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	20	25	30	40	Vdc
Collector Current — Continuous *	I_C*	← 60 →				Adc
Total Device Dissipation @ T_C = 25°C	P_D	← 170 →				Watts
Derate above 25°C		← 2.0 →				W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	°C/W

FIGURE 1 — AVERAGE POWER-TEMPERATURE DERATING CURVE



*JEDEC Registered Values, For True Capability See Figure 3.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage† (I_C = 1.0 Adc, I_B = 0)	2N4276, 2N4277	BV_{CEO}†	20	-	Vdc
	2N4278, 2N4279		30	-	
	2N4280, 2N4281		45	-	
	2N4282, 2N4283		60	-	
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	2N4276, 2N4277	BV_{CES}	30	-	Vdc
	2N4278, 2N4279		45	-	
	2N4280, 2N4281		60	-	
	2N4282, 2N4283		75	-	
Floating Potential (V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277	V_{EBF}	-	0.5	Vdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	0.5	
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4276, 2N4277	I_{CEX}	-	15	mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4278, 2N4279		-	15	
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4280, 2N4281		-	15	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 2.0 Vdc, T_C = +71°C)	2N4282, 2N4283		-	15	
Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	-	0.2	mAdc
(V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277		-	4.0	
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	4.0	
Emitter Cutoff Current (V_{BE} = 20 Vdc, I_C = 0)	2N4276, 2N4277	I_{EBO}	-	4.0	mAdc
(V_{BE} = 20 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 25 Vdc, I_C = 0)	2N4278, 2N4279		-	4.0	
(V_{BE} = 25 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 30 Vdc, I_C = 0)	2N4280, 2N4281		-	4.0	
(V_{BE} = 30 Vdc, I_C = 0, T_C = +71°C)			-	15	
(V_{BE} = 40 Vdc, I_C = 0)	2N4282, 2N4283		-	4.0	
(V_{BE} = 40 Vdc, I_C = 0, T_C = +71°C)			-	15	
ON CHARACTERISTICS					
DC Current Gain† (I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4276, 2N4278, 2N4280, 2N4282	h_{FE}†	60	180	-
	2N4277, 2N4279, 2N4281, 2N4283		120	240	
(I_C = 60 Adc, V_{CE} = 2.0 Vdc)			15	-	
Collector-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{CE(sat)}$†	-	0.15	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	0.3	
Base-Emitter Saturation Voltage† (I_C = 15 Adc, I_B = 1.0 Adc)		$V_{BE(sat)}$†	-	0.6	Vdc
(I_C = 60 Adc, I_B = 6.0 Adc)			-	1.0	
SMALL SIGNAL CHARACTERISTICS					
Common-Emitter Cutoff Frequency (I_C = 15 Adc, V_{CE} = 2.0 Vdc)		$f_{\alpha e}$	2.0	-	kHz

† To avoid excessive heating of the collector junction, perform test with pulse method.

FIGURE 2 — TRANSIENT THERMAL RESISTANCE

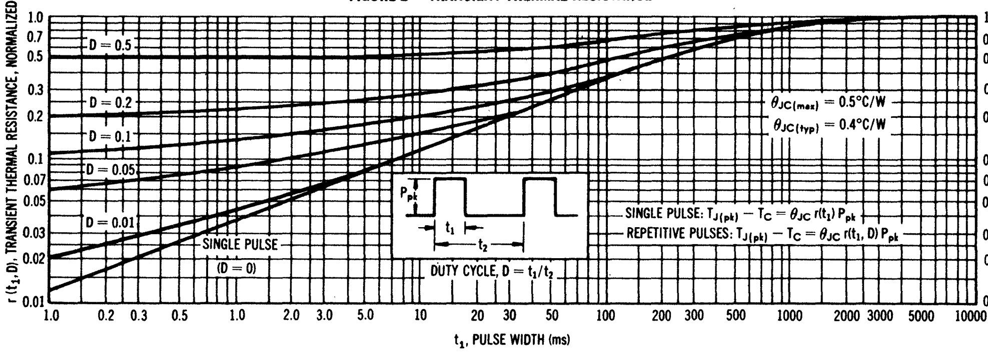
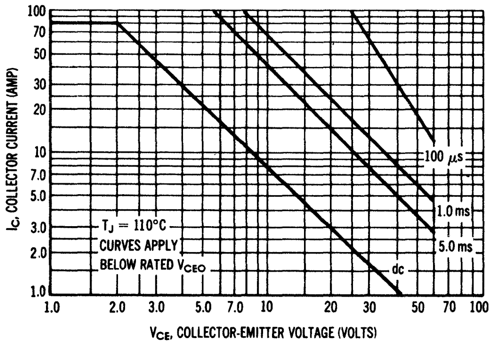


FIGURE 3 — ACTIVE REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e. the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 3 is based on $T_{J(pk)} = 110°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 110°C$. $T_{J(pk)}$ may be calculated from the data in Figure 2. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 4 — SWITCHING TEST CIRCUIT

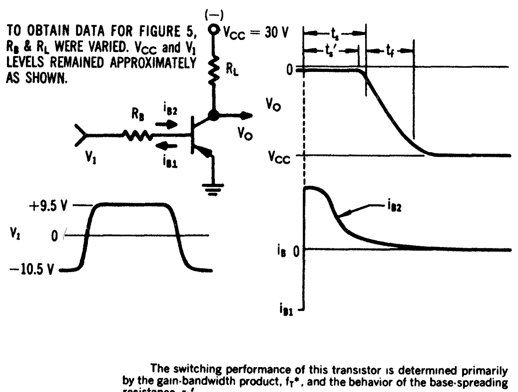
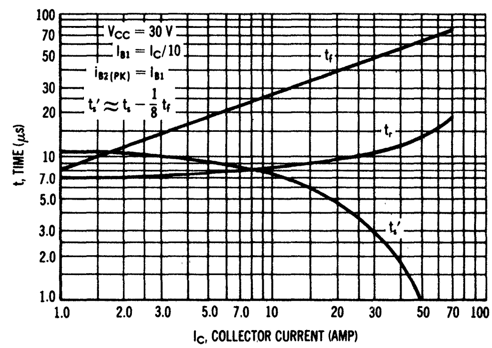


FIGURE 5 — SWITCHING TIMES



The switching performance of this transistor is determined primarily by the gain-bandwidth product, f_T*, and the behavior of the base-spreading resistance, r_B'.

In the case of rise time, the base-spreading resistance plays a small part, and the test circuit delivers a constant current step of turn-on current to the transistor (I_{B1}). Therefore, the curve of t_r on Figure 5 follows theory closely, i.e.:

$$t_r \approx 0.8 \frac{I_C}{I_{B1}} \cdot \frac{1}{2\pi f_T}$$

From the curve, it can be seen that f_T is roughly constant with current; using the equation, its large signal value can be calculated to be approximately 120 kHz at the 20-Amp level. A lower supply voltage will increase rise time slightly.

Turn-off time is slow because of conductivity modulation which occurs in the base region. When the transistor is held "on" in saturation, the base region becomes filled with excess charge; i.e., charge in excess of that necessary to sustain the circuit limited value of I_C. As a result, the base resistivity and consequently r_B' become very low. During turn off, as the excess charge is reduced, the accompanying increase in resistivity causes a marked reduction in the turn-off current, i_{B2}, as can be seen from the waveforms of Figure 4. During fall time, the i_{B2} current is very low causing an extended fall time.

Only a slight improvement in turn-off performance is achieved with a "speed-up" capacitor placed across R_B. This unusual behavior occurs because r_B' limits the amount of reverse current which can be achieved. Also, it seems evident that r_B' increases with applied reverse current, so that efforts to speed up the turn-off behavior are somewhat futile.

In most applications, switching time will be close to the values shown on Figure 5. Delay time is not shown as it is negligible in comparison to the other times.

* $f_T \sim f_{\alpha e} \times h_{fe}$

TYPICAL DC CHARACTERISTICS

FIGURE 6 — DC CURRENT GAIN

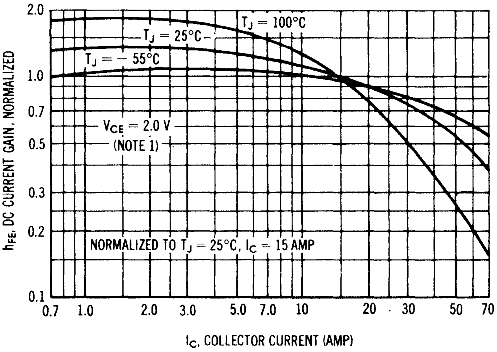


FIGURE 7 — COLLECTOR SATURATION REGION

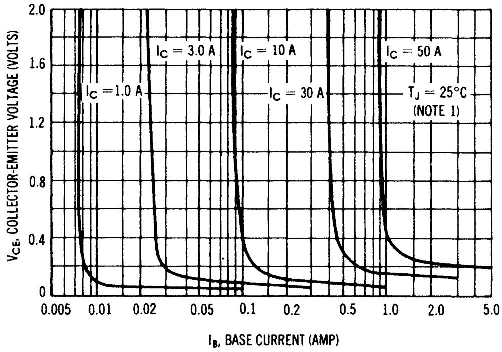


FIGURE 8 — EFFECTS OF BASE-EMITTER RESISTANCE

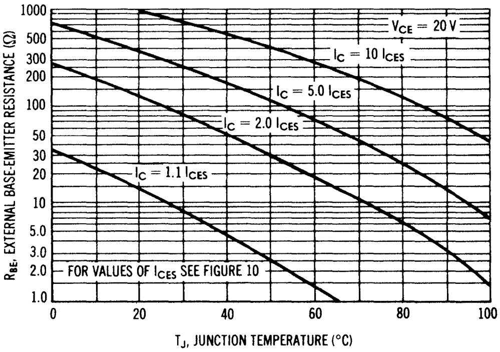


FIGURE 9 — "ON" VOLTAGES

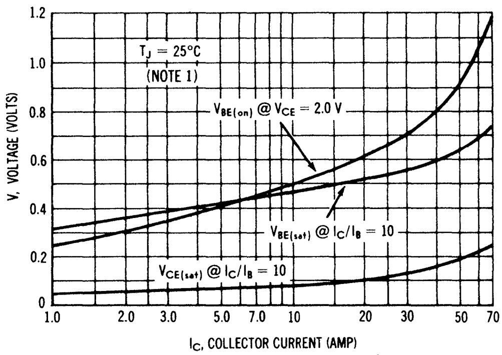


FIGURE 10 — COLLECTOR CUTOFF REGION

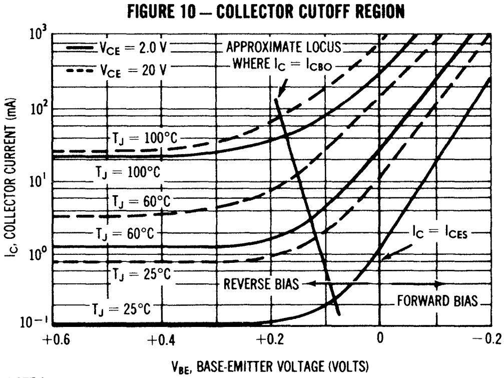
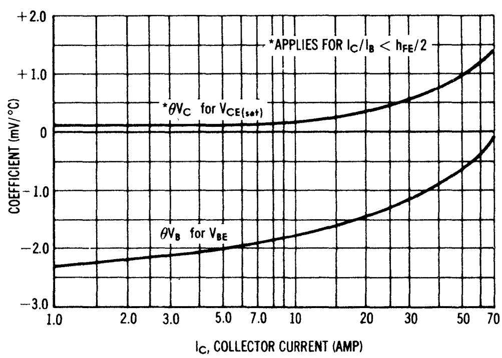


FIGURE 11 — TEMPERATURE COEFFICIENTS



NOTE 1: Data is obtained from pulse tests and adjusted to nullify the effect of I_{CBO}.

2N4342 (SILICON)

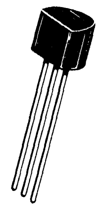
SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

Depletion Mode (Type A) Junction Field-Effect Transistor designed primarily for high-gain audio frequency applications.

- High Forward Transadmittance –
  $|y_{fs}|$ = 2.0 mmhos (Min) @ V_{DS} = -10 Vdc (2N4342)
- Low Noise Figure –
  NF = 1.5 dB (Max) @ f = 100 Hz
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 700 Ohms (Max) @ f = 1.0 kHz (2N4342)

P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

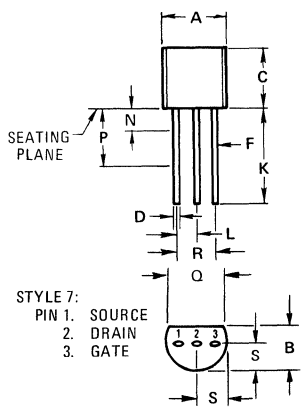
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

*Indicates JEDEC Registered Data.



STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

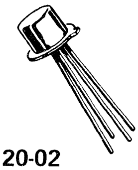
CASE 29-02
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

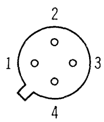
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	25	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	1.0	5.5	Vdc
Gate Reverse Current	I_{GSS}			
(V_{GS} = 15 Vdc, V_{DS} = 0)		–	10	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)		–	0.5	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0)	I_{DSS}	4.0	12	mAdc
Gate-Source Voltage	V_{GS}			Vdc
(V_{DS} = -10 Vdc, I_D = 0.4 mAdc)		0.7	5.0	
(V_{DS} = -10 Vdc, I_D = 1.0 mAdc)				
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	–	700	Ohms
Forward Transadmittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{fs}	2000	6000	μmhos
Forward Transconductance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	$Re(y_{fs})$	1500	–	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	y_{os}	–	75	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	20	pF
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	5.0	pF
Common-Source Noise Figure (V_{DS} = -10 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz)	NF	–	1.5	dB
		–		
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -10 Vdc, V_{GS} = 0, f = 100 Hz, BW = 15 Hz)	E_n	–	0.08	$\mu V/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

2N4351 (SILICON)



CASE 20-02
(TO-72)



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND
CASE LEAD

Silicon N-channel MOS field effect transistors, designed for enhancement-mode operation in low power switching applications. The 2N4351 is complementary with type 2N4352 .

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Power Dissipation at T_C = 25°C Derate about 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current (V_{GS} = ±30 Vdc, V_{DS} = 0)	—	I_{GSS}	—	10	pAdc
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	—	I_{DSS}	—	10	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = 10 V, I_D = 10 μA)	—	$V_{GS(TH)}$	1.0	5.0	Vdc
"ON" Drain Current (V_{GS} = 10 V, V_{DS} = 10 V)	3	$I_{D(on)}$	3.0	—	mAdc
Drain-Source "ON" Voltage (I_D = 2 mA, V_{GS} = 10 V)	—	$V_{DS(on)}$	—	1.0	Vdc
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = 10 V, I_D = 0, f = 1 kHz)	4	$r_{ds(on)}$	—	300	ohms
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 2 mA, f = 1 kHz)	1	$\|y_{fs}\|$	1000	—	μmho
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	2	C_{rss}	—	1.3	pF
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 140 kHz)	2	C_{iss}	—	5.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 V, f = 140 kHz)	—	$C_{d(sub)}$	—	5.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Figure No.	Symbol	Min	Max	Unit
Turn-On Delay	I_D = 2.0 mAdc, V_{DS} = 10 Vdc, V_{GS} = 10 Vdc (See Figure 10; Times Circuit Determined)	6, 10	t_{d1}	—	45	ns
Rise Time		7, 10	t_r	—	65	ns
Turn-Off Delay		8, 10	t_{d2}	—	60	ns
Fall Time		9, 10	t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

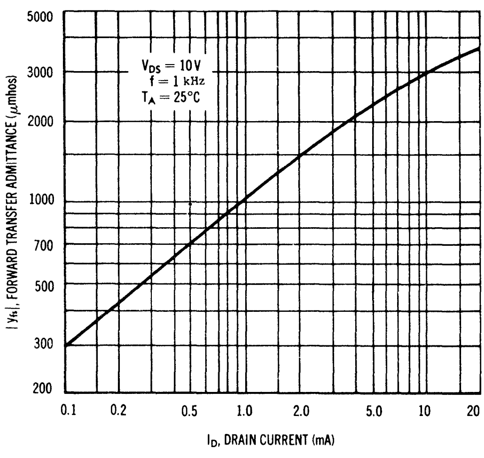


FIGURE 2 — CAPACITANCE

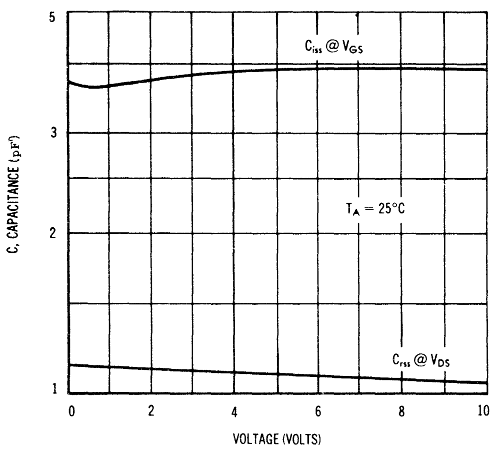


FIGURE 3 — TRANSFER CHARACTERISTICS

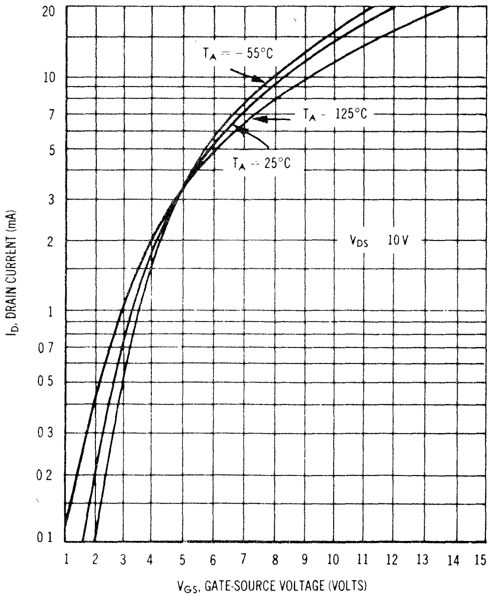


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

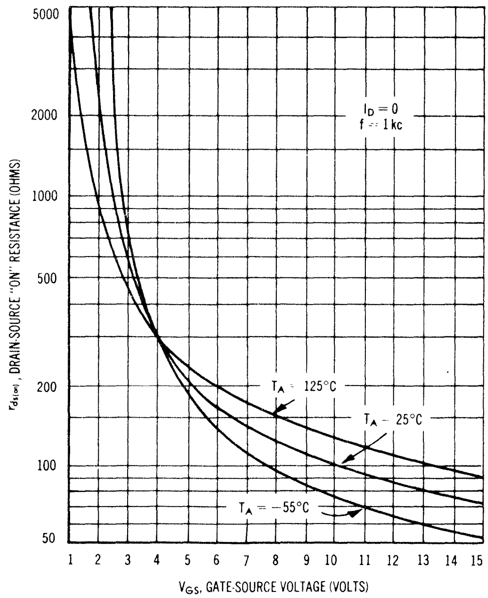
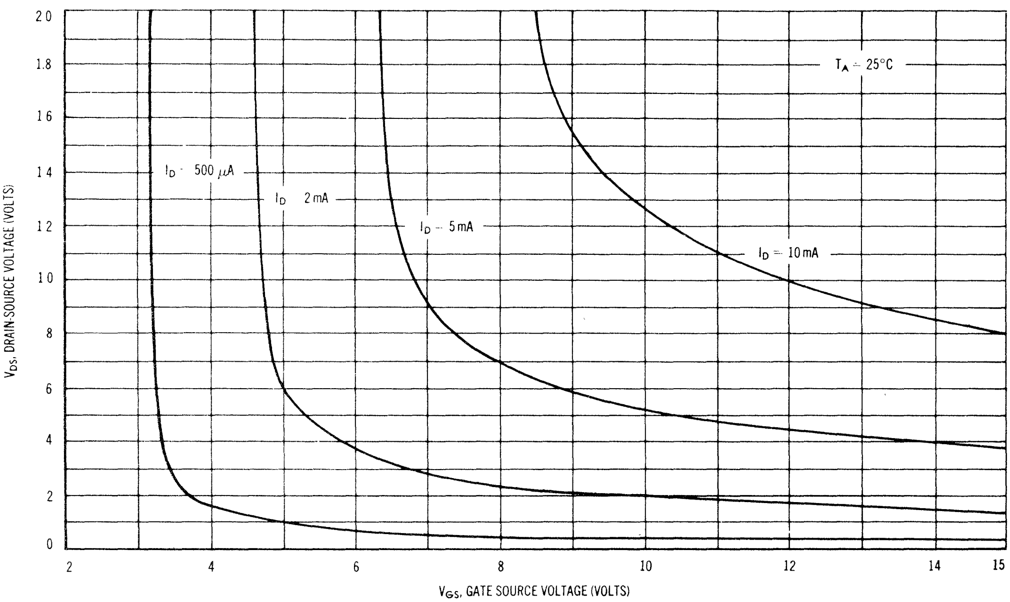


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS

($T_A = 25^oC$)

FIGURE 6 — TURN-ON DELAY TIME

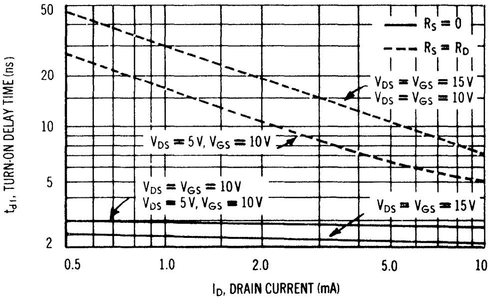


FIGURE 7 — RISE TIME

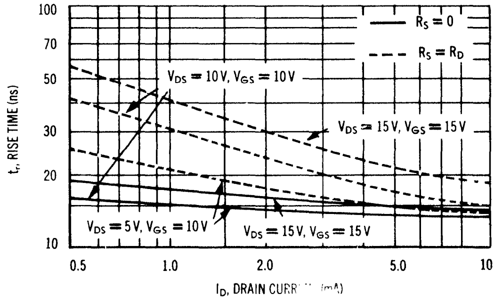


FIGURE 8 — TURN-OFF DELAY TIME

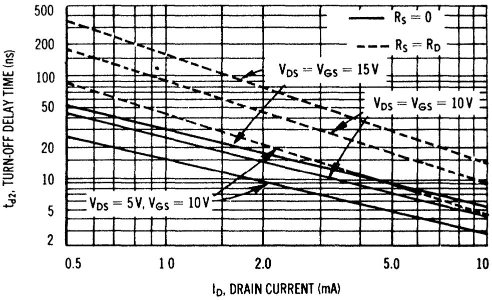


FIGURE 9 — FALL TIME

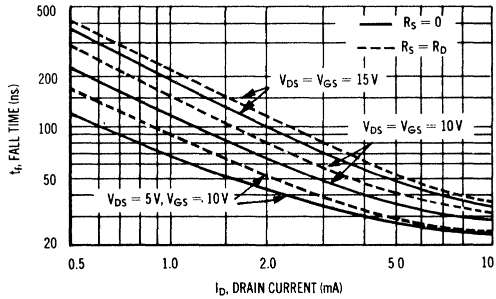
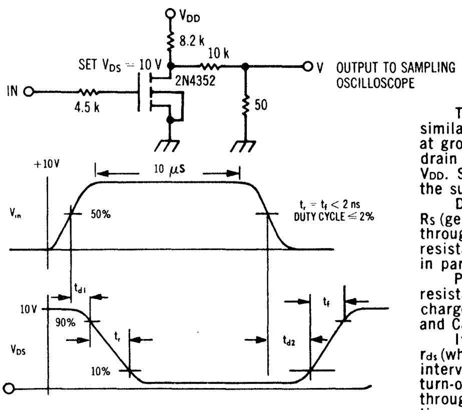


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

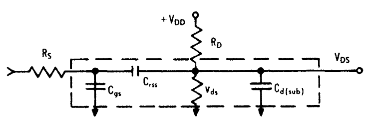
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

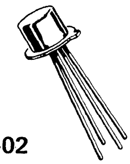
If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

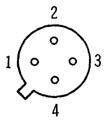
FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



2N4352 (SILICON)



CASE 20-02
(TO-72)



STYLE 2
PIN 1. SOURCE
2. GATE
3. DRAIN
4. SUBSTRATE AND CASE LEAD

Silicon P-channel MOS field-effect transistor designed for enhancement-mode operation in low-power switching applications. The 2N4352 is complementary with type 2N4351.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	± 30	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at T_A = 25°C Derate above 25°C	P_D	300 1.7	mW mW/°C
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to + 175	°C

HANDLING PRECAUTIONS:

MOS field-effect transistors have extremely high input resistance. They can be damaged by the accumulation of excess static charge. Avoid possible damage to the devices while handling, testing, or in actual operation, by following the procedures outlined below:

1. To avoid the build-up of static charge, the leads of the devices should remain shorted together with a metal ring except when being tested or used.
2. Avoid unnecessary handling. Pick up devices by the case instead of the leads.
3. Do not insert or remove devices from circuits with the power on because transient voltages may cause permanent damage to the devices.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Substrate connected to source.

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = -10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current (V_{GS} = ±30 V, V_{DS} = 0)	—	I_{GSS}	—	10	pAdc
Zero-Gate Voltage Drain Current (V_{DS} = -10 V, V_{GS} = 0)	—	I_{DSS}	—	10	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = -10 V, I_D = -10 μA)	—	$V_{GS(TH)}$	1.0	5.0	Vdc
"ON" Drain Current (V_{GS} = -10 V_{DS} = -10 V)	3	$I_{D(on)}$	3.0	—	mA
Drain-Source "ON" Voltage (I_D = -2.0 mA, V_{GS} = -10 V)	5	$V_{DS(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = -10 V, I_D = 0, f = 1 kHz)	4	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance (V_{DS} = -10 V, I_D = 2 mA, f = 1 kHz)	1	$\|y_{fs}\|$	1000	—	μmho
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kHz)	2	C_{rss}	—	1.3	pF
Input Capacitance (V_{DS} = -10 V, V_{GS} = 0, f=140 kHz)	2	C_{iss}	—	5.0	pF
Drain-Substrate Capacitance ($V_{D(SUB)}$= -10 V, f=140 kHz)	—	$C_{d(sub)}$	—	4.0	pF

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Figure No.	Symbol	Min	Max	Unit
Turn-On Delay	I_D = -2.0 mAdc, V_{DS} = -10 Vdc, V_{GS} = -10 V (See Figure 10, Times Circuit Determined)	6, 10	t_{d1}	—	45	ns
Rise Time		7, 10	t_r	—	65	ns
Turn-Off Delay		8, 10	t_{d2}	—	60	ns
Fall Time		9, 10	t_f	—	100	ns

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

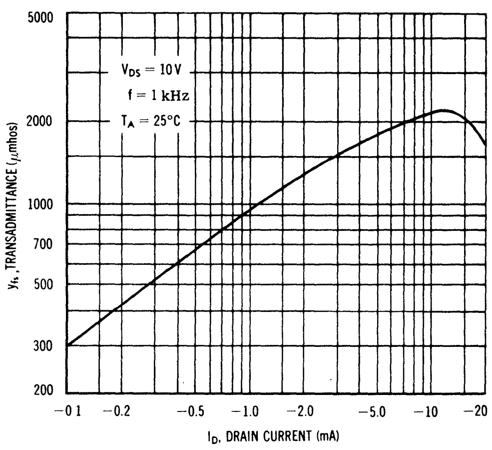


FIGURE 2 — CAPACITANCE

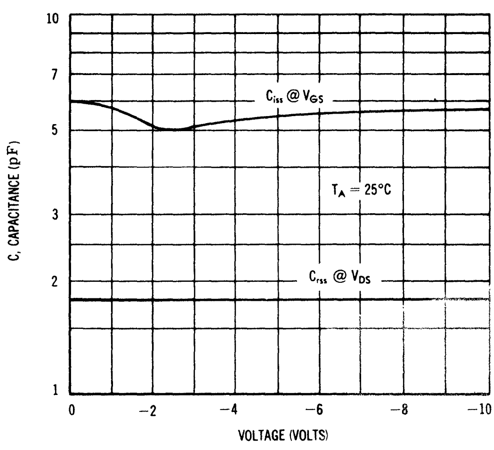


FIGURE 3 — TRANSFER CHARACTERISTICS

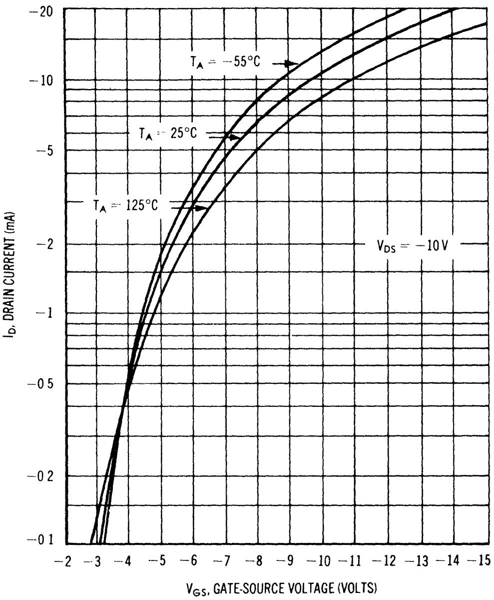


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

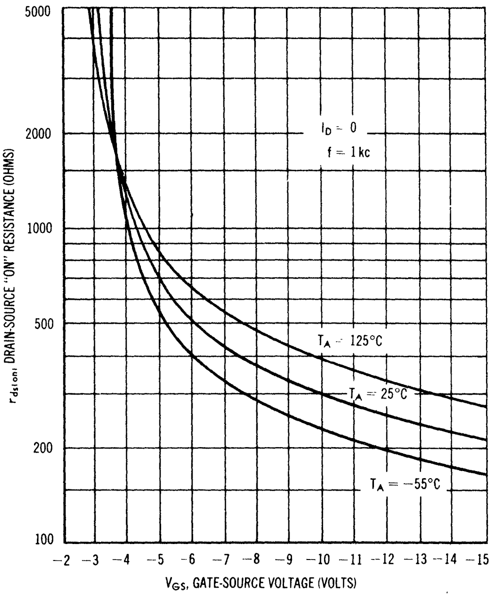
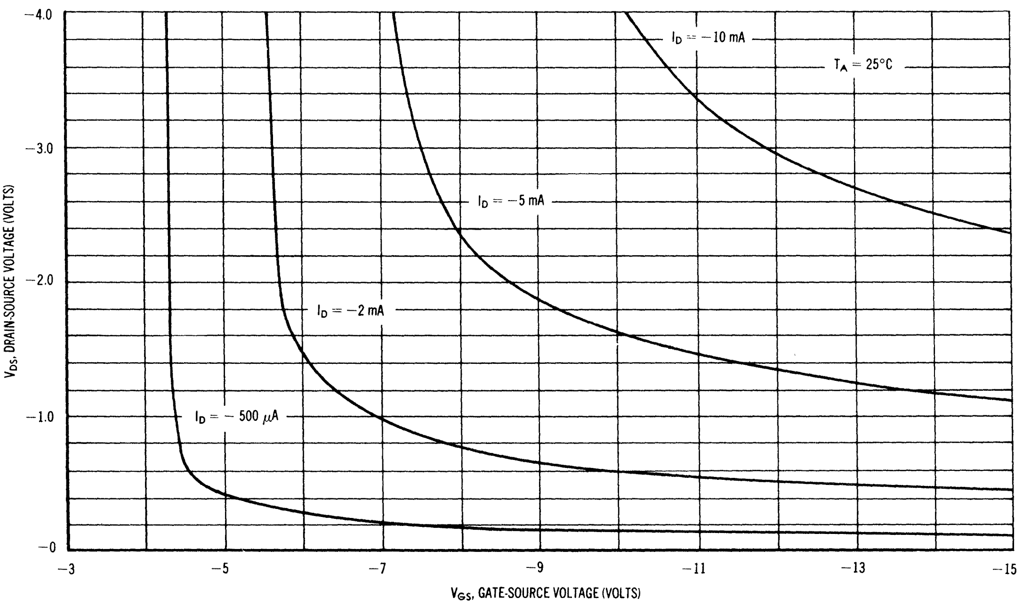


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



SWITCHING CHARACTERISTICS
($T_A = 25°C$)

FIGURE 6 — TURN-ON DELAY TIME

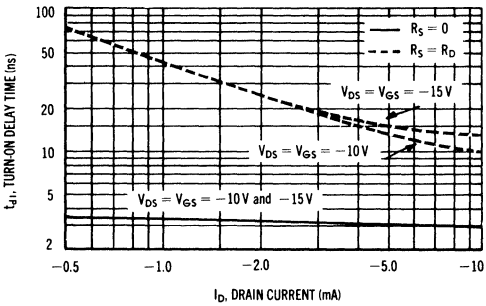


FIGURE 7 — RISE TIME

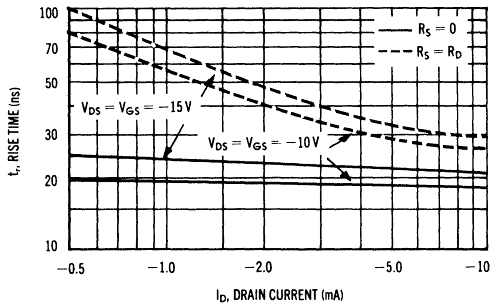


FIGURE 8 — TURN-OFF DELAY TIME

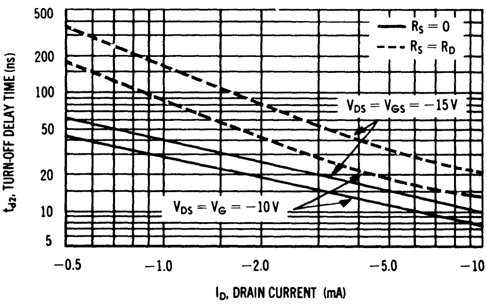


FIGURE 9 — FALL TIME

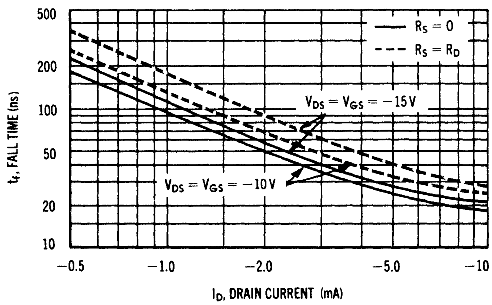
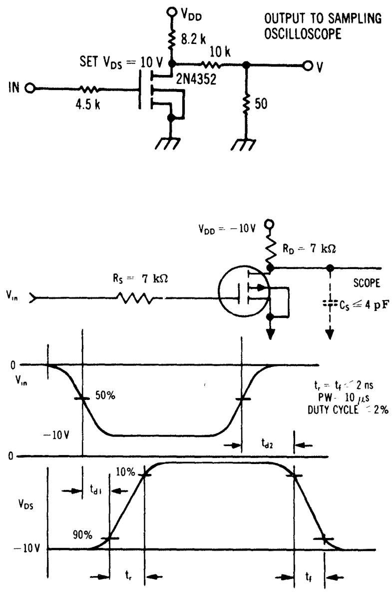


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

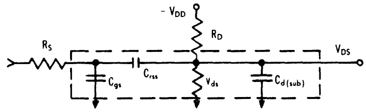
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

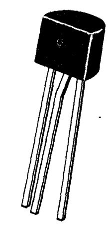
The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 11 — SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)



Case 29 with leads formed to a TO-18 configuration.

SILICON P-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

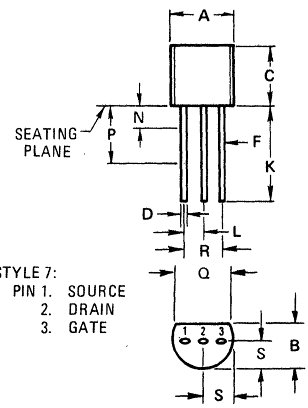
Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio frequency applications

- Forward Transadmittance – $|y_{fs}| = 2.0$ mmhos (Min) @ $V_{DS} = -10$ Vdc
- Low Reverse Transfer Capacitance – $C_{rss} = 5.0$ pF (Max) @ $V_{DS} = -10$ Vdc

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-20	Vdc
Drain-Gate Voltage	V_{DG}	-20	Vdc
Reverse Gate-Source Voltage	V_{GSR}	20	Vdc
Gate Current	I_G	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

*Indicates JEDEC Registered Data.



STYLE 7:
PIN 1. SOURCE
2. DRAIN
3. GATE

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	20	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -10 Vdc, I_D = 1.0 μAdc)	$V_{GS(off)}$	0.7	10	Vdc
Gate Reverse Current	I_{GSS}			
(V_{GS} = 15 Vdc, V_{DS} = 0)		–	10	nAdc
(V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)		–	0.5	μAdc
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0)	I_{DSS}	3.0	30	mAdc
Gate-Source Voltage (V_{DS} = -10 Vdc, I_D = 0.3 mAdc)	V_{GS}	0.4	9.0	Vdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	$r_{ds(on)}$	–	700	Ohms
Forward Transadmittance (Note 1) (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	2000	8000	μmhos
Forward Transconductance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	$Re(y_{fs})$	1500	–	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	–	100	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	20	pF
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	5.0	pF
Common-Source Noise Figure (V_{DS} = -10 Vdc, I_D = 1.0 mAdc, R_G = 1.0 Megohm, f = 100 Hz)	NF	–	5.0	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -10 Vdc, I_D = 1.0 mAdc, f = 100 Hz, BW = 15 Hz)	E_n	–	0.19	$\mu V/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%.

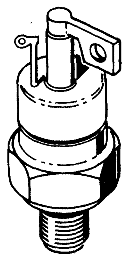
2N4361 thru 2N4368 PNPN (SILICON)
2N4371 thru 2N4378

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for high power industrial and consumer applications in power and speed controls such as welders, furnaces, motors, space heaters and other equipment where control of high current is needed.

THYRISTORS
PNPN

110 AMPERES RMS
100 thru 1400 VOLTS**



2N4371
SERIES
CASE 246
TO-83

2N4361
SERIES
CASE 219
TO-94

MAXIMUM RATINGS

Rating		Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
	2N4361, 2N4371		100	
	2N4362, 2N4372		200	
	2N4363, 2N4373		400	
	2N4364, 2N4374		600	
	2N4365, 2N4375		800	
	2N4366, 2N4376		1000	
	2N4367, 2N4377		1200	
	2N4368, 2N4378		1400	
Non-Repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)		V_{RSM}		Volts
	2N4361, 2N4371		200	
	2N4362, 2N4372		300	
	2N4363, 2N4373		500	
	2N4364, 2N4374		700	
	2N4365, 2N4375		900	
	2N4366, 2N4376		1100	
	2N4367, 2N4377		1300	
	2N4368, 2N4378		1500	
Forward Current RMS, $T_C = 75^oC$		$I_{T(RMS)}$	110	Amp
*Peak Surge Current (One cycle, 60 Hz) ($T_J = -40$ to $+125^oC$)		I_{TSM}	1600	Amp
Circuit Fusing Considerations		I^2t		A^2s
($T_J = -40$ to $+125^oC$)	(t = 1.5 ms)		8400	
	(t = 8.3 ms)		10,700	
*Peak Gate Power		P_{GFM}	15	Watts
*Average Gate Power		$P_{GF(AV)}$	3.0	Watt
*Peak Forward Gate Current		I_{GFM}	4.0	Amp
*Peak Reverse Gate Voltage		V_{GRM}	5.0	Volts
*Operating Junction Temperature Range		T_J	-40 to +125	^oC
*Storage Temperature Range		T_{stg}	-40 to +150	^oC
Stud Torque		—	130	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.28	$^oC/W$

*Indicates JEDEC Registered Data.
**Consult factory for higher and intermediate voltages.
(1) Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.
(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.
(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or seal broken.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (T_J = 125°C)	2N4361, 2N4371	V_{DRM}(1)	100	–	–	Volts
	2N4362, 2N4372		200	–	–	
	2N4363, 2N4373		400	–	–	
	2N4364, 2N4374		600	–	–	
	2N4365, 2N4375		800	–	–	
	2N4366, 2N4376		1000	–	–	
	2N4367, 2N4377		1200	–	–	
	2N4368, 2N4378		1400	–	–	
*Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 125°C)		I_{DRM}	–	–	10	mA
*Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 125°C)		I_{RRM}	–	–	10	mA
Forward "On" Voltage (I_T = 50 A Peak, T_J = 25°C)		V_T	–	–	1.6	Volts
Forward "On" Voltage (I_{TM} = 500 A Peak T_J = 25°C)		V_{TM}	–	–	2.5	Volts
Gate Trigger Current (Anode Voltage = 12 V, R_L = 3.0 ohms)		I_{GT}	–	–	200	mA
Gate Trigger Voltage (Anode Voltage = 12 V, R_L = 3.0 ohms)		V_{GT}	–	–	3.0	Volts
Holding Current (Anode Voltage = 12 V, gate open, T_J = 125°C)		I_H	–	30	–	mA
*Non-Triggering Gate Voltage (Anode Voltage = Rated V_{DM}, R_L = 100 ohms, T_J = 125°C)		V_{GD}	–	–	0.15	Volts
Turn-Off Time (I_{TM} = 50 A, I_R = 20 A, T_J = 125°C)		t_q	–	40	–	μs
*Forward Voltage Application Rate (Exponential to V_{DRM})		dv/dt	100	–	–	V/μs

*Indicates JEDEC Registered Data.
(1) Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 50 to 400 Hz, SQUARE WAVE)

FIGURE 1 – CURRENT DERATING

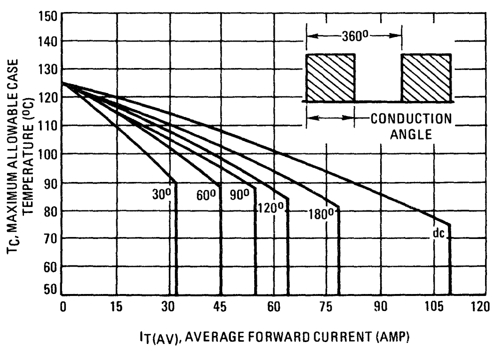
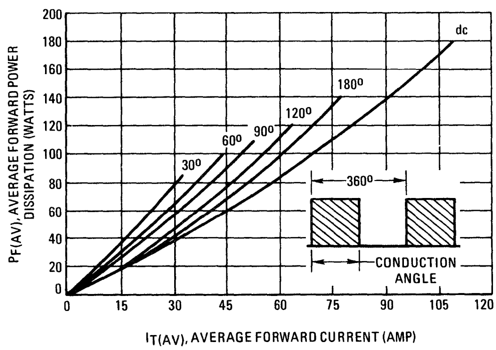


FIGURE 2 – FORWARD POWER DISSIPATION



DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 50 to 400 Hz, SINE WAVE)

FIGURE 3 — CURRENT DERATING

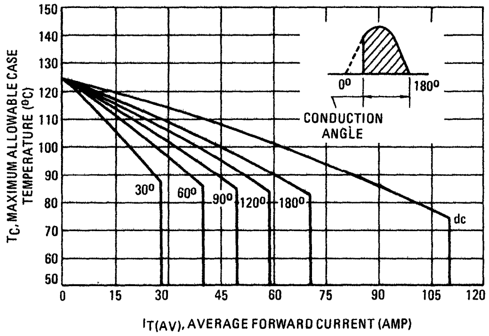


FIGURE 4 — FORWARD POWER DISSIPATION

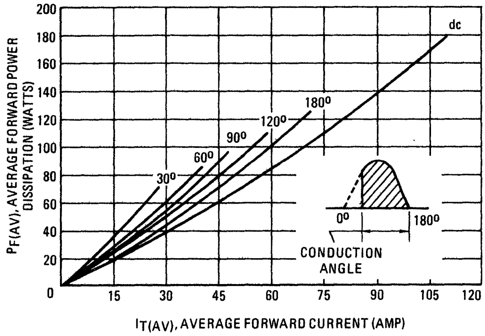
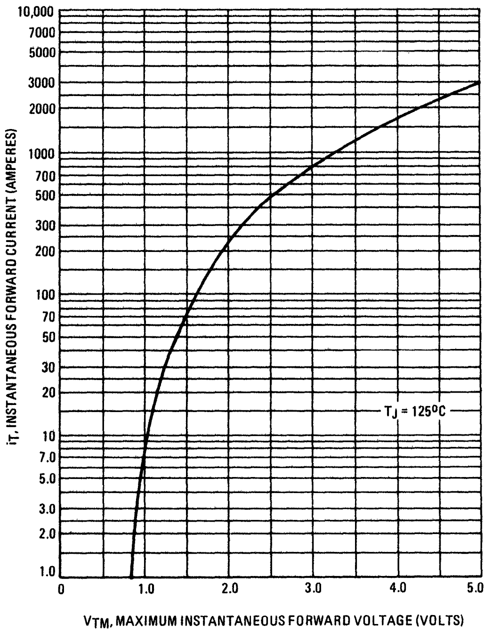
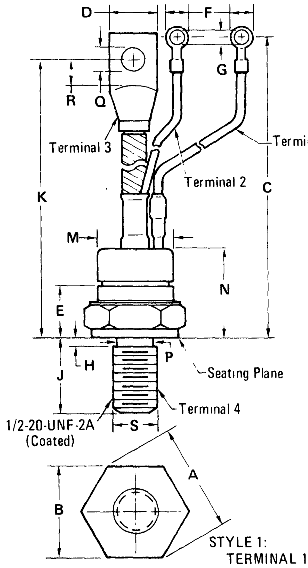


FIGURE 5 — FORWARD CONDUCTION CHARACTERISTIC



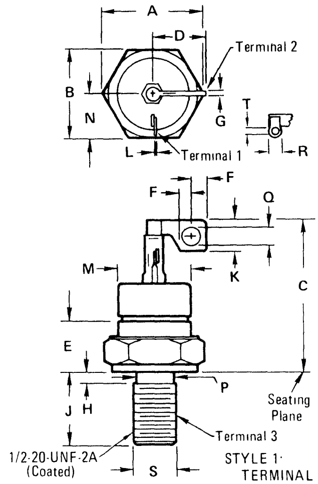


STYLE 1:
TERMINAL 1. GATE
2. CATHODE
3. CATHODE
4. ANODE

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	6.850	7.500	174.000	190.500
D	0.437	0.650	11.100	16.500
E	0.170	0.500	4.400	12.700
F	0.215	0.300	5.490	7.620
G	0.140	0.150	3.560	3.810
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	5.775	6.265	146.700	159.100
M	–	1.031	–	26.180
N	–	2.500	–	63.500
P	0.425	0.499	10.800	12.670
Q	0.260	0.310	6.610	7.870
R	0.250	–	6.350	–
S	0.4619	0.4675	11.733	11.874

All JEDEC dimensions and notes apply

CASE 219
TO-94



STYLE 1:
TERMINAL 1. GATE
2. CATHODE
3. ANODE

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	–	1.227	–	31.160
B	1.031	1.063	26.190	27.000
C	–	1.810	–	45.970
D	–	0.650	–	16.510
E	0.170	0.500	4.320	12.700
F	0.180	–	4.580	–
G	0.060	0.115	1.530	2.920
H	–	0.125	–	3.170
J	0.797	0.827	20.250	21.000
K	0.360	0.470	9.200	11.900
L	0.012	0.050	0.310	1.270
M	–	1.031	–	26.180
N	–	0.575	–	14.600
P	0.425	0.499	10.800	12.670
Q	0.180	0.260	4.580	6.600
R	0.115	0.160	2.930	4.060
S	0.4619	0.4675	11.733	11.874
T	0.060	0.080	1.530	2.030

All JEDEC dimensions and notes apply

CASE 246
TO-83

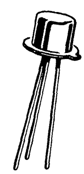
2N4391 (SILICON)
2N4392
2N4393

SILICON N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed for chopper and high-speed switching applications.

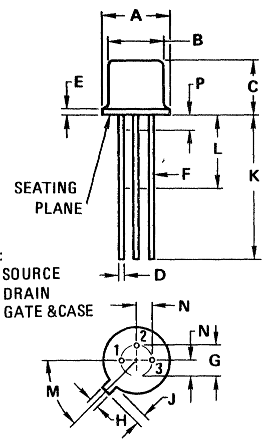
- Low Drain-Source "On" Resistance –
  $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N4391)
- Low Gate Reverse Current –
  I_{GSS} = 0.1 nAdc (Max) @ V_{GS} = 20 Vdc
- Guaranteed Switching Characteristics

N-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS
(Type A)



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Gate-Source Voltage	V_{GS}	40	Vdc
Forward Gate Current	$I_{G(f)}$	50	mAdc
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



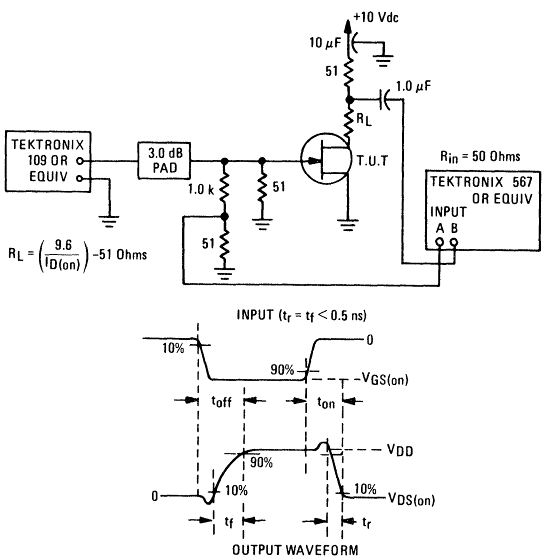
STYLE 4:
PIN 1. SOURCE
2. DRAIN
3. GATE & CASE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	40	-	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)		$V_{GS(f)}$	-	1.0	Vdc
Gate-Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)	2N4391	V_{GS}	4.0	10	Vdc
	2N4392		2.0	5.0	
	2N4393		0.5	3.0	
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	-	0.1	nAdc
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = 150°C)			-	0.2	μAdc
Drain-Cutoff Current (V_{DS} = 20 Vdc, V_{GS} = 12 Vdc)	2N4391	$I_{D(off)}$	-	0.1	nAdc
(V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc)	2N4392		-	0.1	
(V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc)	2N4393		-	0.1	
(V_{DS} = 20 Vdc, V_{GS} = 12 Vdc, T_A = 150°C)	2N4391		-	0.2	μAdc
(V_{DS} = 20 Vdc, V_{GS} = 7.0 Vdc, T_A = 150°C)	2N4392		-	0.2	
(V_{DS} = 20 Vdc, V_{GS} = 5.0 Vdc, T_A = 150°C)	2N4393		-	0.2	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current(1) (V_{DS} = 20 Vdc, V_{GS} = 0)	2N4391	I_{DSS}	50	150	mAdc
	2N4392		25	75	
	2N4393		5.0	30	
Drain-Source "ON" Voltage (I_D = 12 mAdc, V_{GS} = 0)	2N4391	$V_{DS(on)}$	-	0.4	Vdc
(I_D = 6.0 mAdc, V_{GS} = 0)	2N4392		-	0.4	
(I_D = 3.0 mAdc, V_{GS} = 0)	2N4393		-	0.4	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)	2N4391	$r_{DS(on)}$	-	30	Ohms
	2N4392		-	60	
	2N4393		-	100	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4391	$r_{ds(on)}$	-	30	Ohms
	2N4392		-	60	
	2N4393		-	100	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	-	14	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 12 Vdc, f = 1.0 MHz)	2N4391	C_{rss}	-	3.5	pF
(V_{DS} = 0, V_{GS} = 7.0 Vdc, f = 1.0 MHz)	2N4392		-	3.5	
(V_{DS} = 0, V_{GS} = 5.0 Vdc, f = 1.0 MHz)	2N4393		-	3.5	
SWITCHING CHARACTERISTICS					
Turn-On Time (See Figure 1) ($I_{D(on)}$ = 12 mAdc)	2N4391	t_{on}	-	15	ns
($I_{D(on)}$ = 6.0 mAdc)	2N4392		-	15	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		-	15	
Rise Time (See Figure 1) ($I_{D(on)}$ = 12 mAdc)	2N4391	t_r	-	5.0	ns
($I_{D(on)}$ = 6.0 mAdc)	2N4392		-	5.0	
($I_{D(on)}$ = 3.0 mAdc)	2N4393		-	5.0	
Turn-Off Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc)	2N4391	t_{off}	-	20	ns
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		-	35	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		-	50	
Fall Time (See Figure 1) ($V_{GS(off)}$ = 12 Vdc)	2N4391	t_f	-	15	ns
($V_{GS(off)}$ = 7.0 Vdc)	2N4392		-	20	
($V_{GS(off)}$ = 5.0 Vdc)	2N4393		-	30	

(1) Pulse Test: Pulse Width ≤ 100 μs, Duty Cycle ≤ 1.0%.

2N4398 PNP (SILICON)
2N4399
2N5745

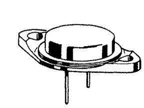
PNP SILICON HIGH-POWER TRANSISTORS

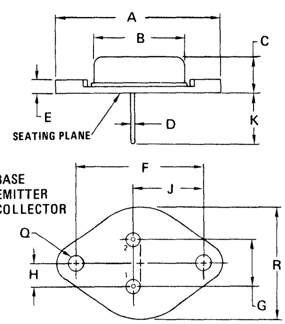
. . . designed for use in power amplifier and switching circuits; serves as direct replacements for Germanium high-power devices.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 15 Adc (2N4398, 2N4399)
- DC Current Gain Specified — 1.0 to 30 Adc
- Complements to NPN 2N5301, 2N5302, 2N5303

20, 30 AMPERE
POWER TRANSISTORS
PNP SILICON

40-60-80 VOLTS
200 WATTS





STYLE 1:
PIN 1. BASE
2. EMITTER
CASE – COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
B	–	21.08	–	0.830
C	–	7.62	–	0.300
D	1.22	1.32	0.048	0.052
E	–	3.43	–	0.135
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.21	5.72	0.205	0.225
J	16.64	17.15	0.655	0.675
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050

CASE 12-01

*MAXIMUM RATINGS

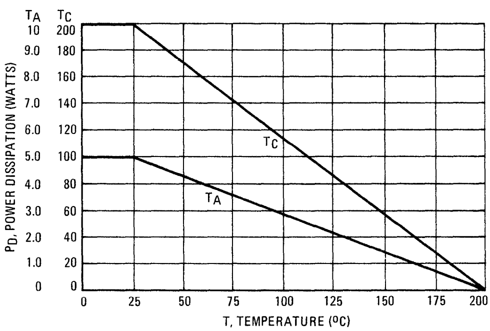
Rating	Symbol	2N4398	2N4399	2N5745	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous Peak	I_C	30 50	30 50	20 50	Adc
Base Current — Continuous Peak	I_B	← 7.5 → ← 15 →			Adc
Total Device Dissipation @ T_A = 25°C** Derate above 25°C	P_D	← 5.0 → ← 28.6 →			Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 200 → ← 1.15 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	35	°C/W

*Indicates JEDEC Registered Data
**Motorola guarantees this data in addition to JEDEC Registered Data.

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 13. All limits are applicable and must be observed.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	2N4398	$V_{CEO(sus)}$	40	–	Vdc
	2N4399		60	–	
	2N5745		80	–	
Collector Cutoff Current (V_{CE} = 40 Vdc, I_B = 0)	2N4398	I_{CEO}	–	5.0	mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N4399		–	5.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5745		–	5.0	
Collector Cutoff Current (V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4398	I_{CEX}	–	5.0	mAdc
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4399		–	5.0	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N5745		–	5.0	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4398, 2N4399		–	10	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5745		–	10	
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	2N4398	I_{CBO}	–	1.0	mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N4399		–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5745		–	1.0	
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain(1) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	All Types	h_{FE}	40	–	–
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5745		15	60	
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4398, 2N4399		15	60	
(I_C = 20 Adc, V_{CE} = 2.0 Vdc)	2N5745		5.0	–	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N4398, 2N4399		5.0	–	
Collector-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	2N4398, 2N4399	$V_{CE(sat)}$	–	0.75	Vdc
	2N5745		–	1.0	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N4398, 2N4399		–	1.0	
	2N5745		–	1.5	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N4398, 2N4399		–	2.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5745		–	2.0	
(I_C = 30 Adc, I_B = 6.0 Adc)	2N4398, 2N4399		–	4.0	
Base-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)**	2N4398, 2N4399	$V_{BE(sat)}$	–	1.6	Vdc
	2N5745		–	1.7	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N4398, 2N4399		–	1.85	
	2N5745		–	2.0	
(I_C = 20 Adc, I_B = 2.0 Adc)**	2N4398, 2N4399		–	2.5	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5745		–	2.5	
Base-Emitter On Voltage(1) (I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5745	$V_{BE(on)}$	–	1.5	Vdc
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N4398, 2N4399		–	1.7	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5745		–	2.5	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N4398, 2N4399		–	3.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product(2) (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	2N4398, 2N4399	f_T	4.0	–	MHz
	2N5745		2.0	–	
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–
SWITCHING CHARACTERISTICS (See Figures 2 and 3)					
Rise Time (V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	2N4398, 2N4399	t_r	–	0.4	µs
	2N5745		–	1.0	
Storage Time	2N4398, 2N4399	t_s	–	1.5	µs
	2N5745		–	2.0	
Fall Time	2N4398, 2N4399	t_f	–	0.6	µs
	2N5745		–	1.0	

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.

(1)Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2.0%.
(2)f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 — TURN-ON TIME

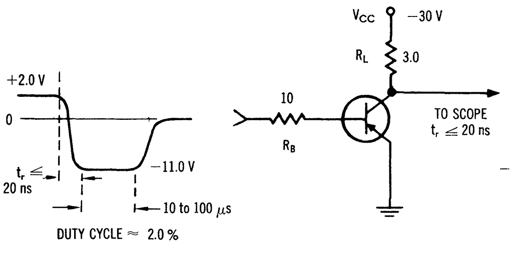
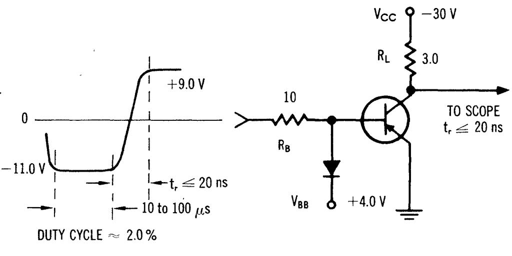


FIGURE 3 — TURN-OFF TIME



FOR CURVES OF FIGURES 5 & 6, R_B, R_L, & V_{CC} ARE VARIED.
INPUT LEVELS ARE APPROXIMATELY AS SHOWN.

TYPICAL TRANSIENT CHARACTERISTICS

FIGURE 4 – CAPACITANCES

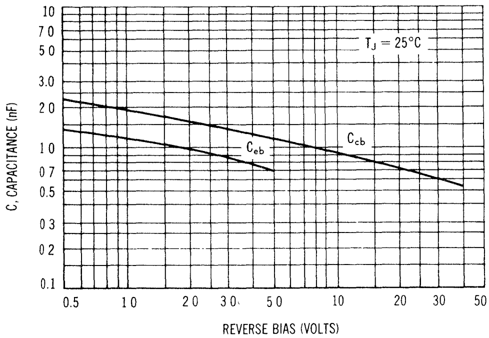


FIGURE 5 – TURN-ON TIME

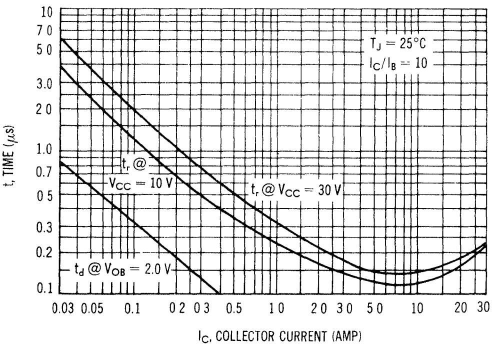
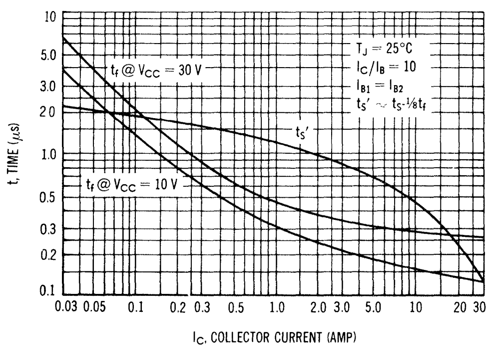


FIGURE 6 – TURN-OFF TIME



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 7 – TRANSCONDUCTANCE

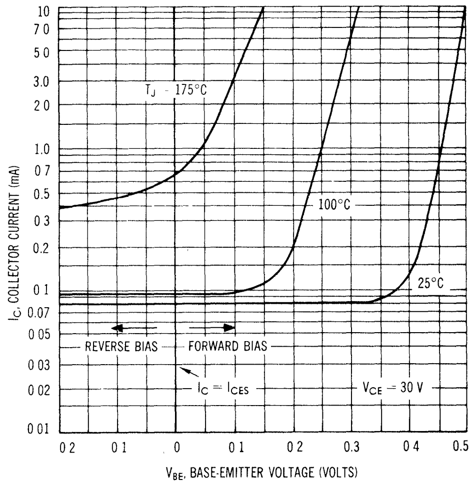
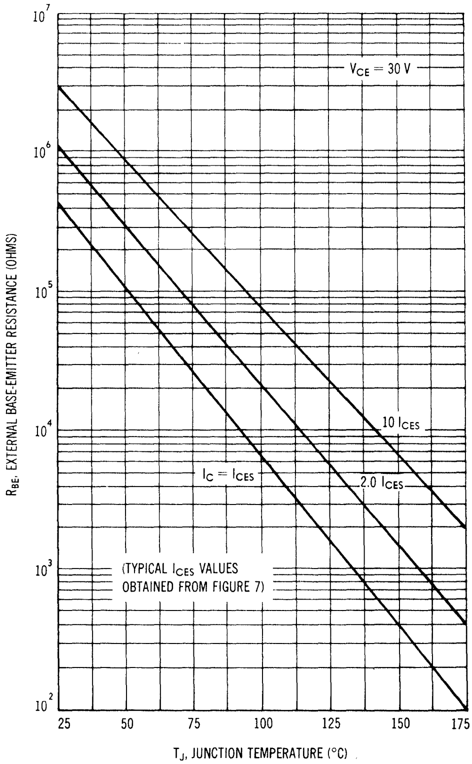


FIGURE 8 – EFFECT OF BASE-EMITTER RESISTANCE



TYPICAL "ON" REGION CHARACTERISTICS

FIGURE 9 – DC CURRENT GAIN

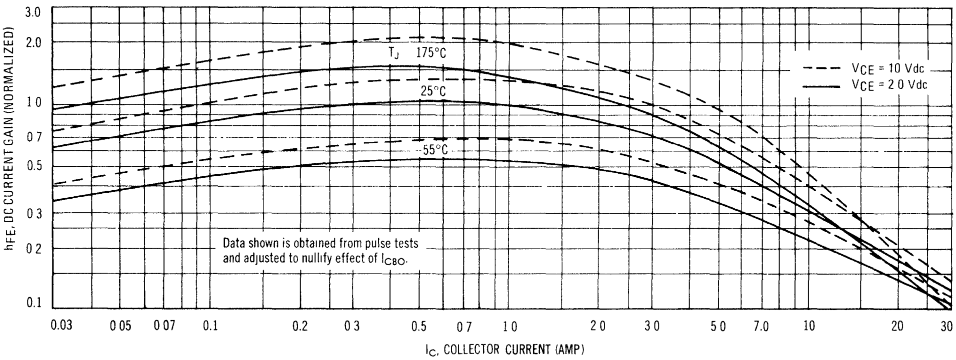


FIGURE 10 – COLLECTOR SATURATION REGION

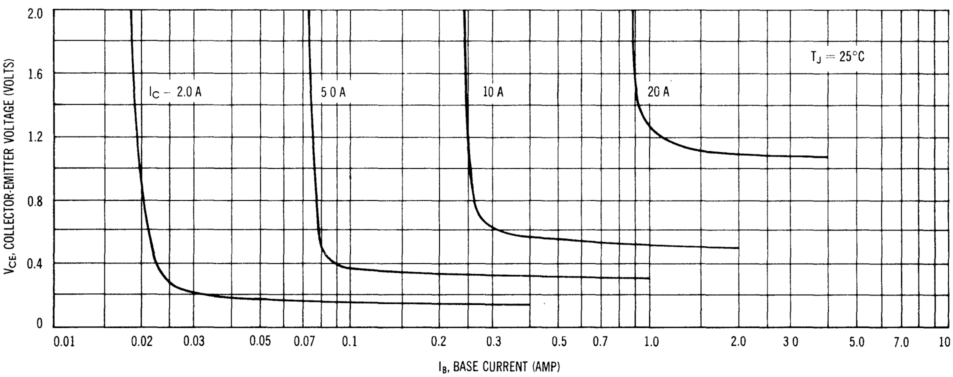


FIGURE 11 – "ON" VOLTAGES

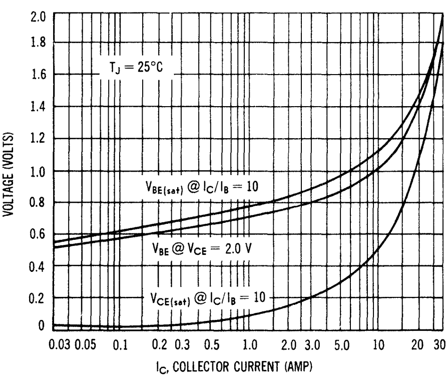
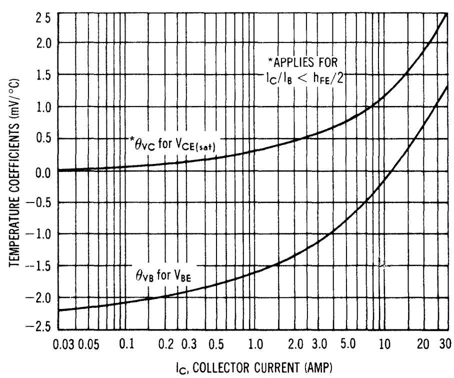
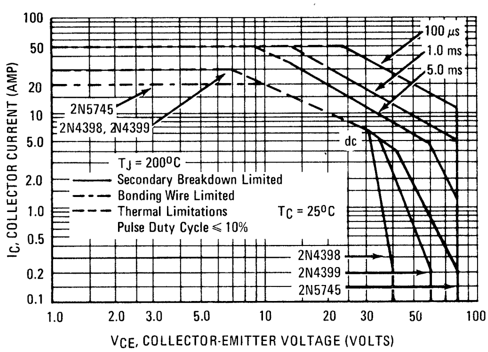


FIGURE 12 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

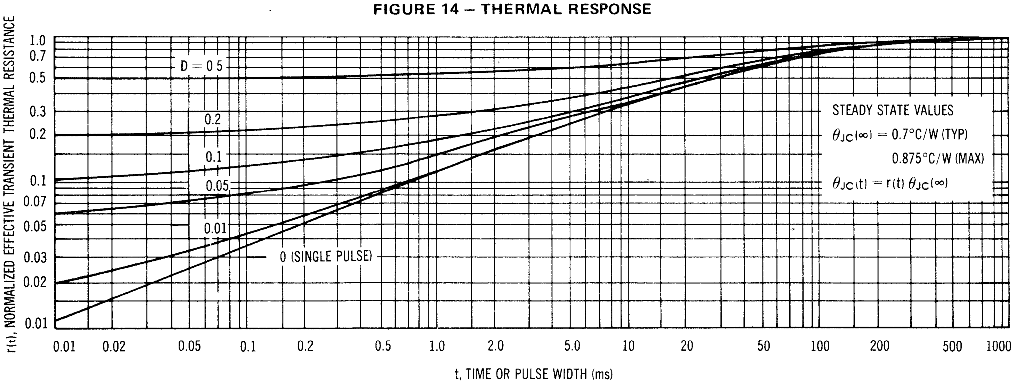
FIGURE 13 — ACTIVE-REGION SAFE OPERATING AREA



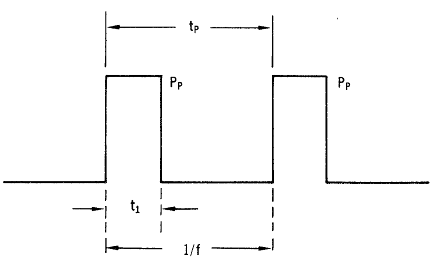
There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 13 is based on $T_{J(pk)} = 200^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200^{\circ}C$. $T_{J(pk)}$ may be calculated from the data in Figure 14. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 14 — THERMAL RESPONSE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA



DUTY CYCLE $D = t_1 f = \frac{t_1}{t_P}$

PEAK PULSE POWER = P_P

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal reponse, the normalized effective transient thermal resistance of Figure 14 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 14 by the steady state value $\theta_{JC}(\infty)$.

Example:

The 2N4398 is dissipating 100 watts under the following conditions: $t_1 = 1.0$ ms, $t_P = 5.0$ ms. $(D = 0.2)$

Using Figure 14, at a pulse width of 1.0 ms and D = 0.2, the reading of r (t) is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_P \times \theta_{JC}(\infty) = 0.28 \times 100 \times 0.875 = 24.5^{\circ}C$$

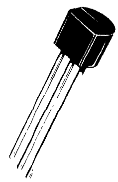
2N4400 (SILICON)
2N4401

NPN SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications and for complementary circuitry with types 2N4402 and 2N4403.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Current Gain Specified from 0.1 mAdc to 500 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance — C_{cb} = 6.5 pF (Max) @ V_{CB} = 5.0 Vdc

NPN SILICON SWITCHING AND AMPLIFIER TRANSISTORS



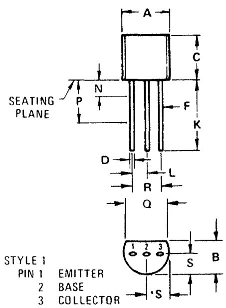
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	6.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0 205
B	3.180	4.190	0.125	0 165
C	4.320	5.330	0.170	0 210
D	0.407	0.533	0 016	0 021
F	0.407	0 482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0 055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0 105
S	2.030	2.670	0.080	0.105

CASE 29
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)		I_{CEV}	—	0.1	μAdc
Base Cutoff Current (V_{CE} = 35 Vdc, $V_{EB(off)}$ = 0.4 Vdc)		I_{BEV}	—	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain		h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N4401		20	—	
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4400		20	—	
	2N4401		40	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4400		40	—	
	2N4401		80	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	2N4400		50	150	
	2N4401		100	300	
(I_C = 500 mAdc, V_{CE} = 2 Vdc)	2N4400		20	—	
	2N4401		40	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.75	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4400	f_T	200	—	MHz
	2N4401		250	—	
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kHz)		C_{cb}	—	6.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		C_{eb}	—	30	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400	h_{ie}	0.5	7.5	k ohms
	2N4401		1.0	15	
Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{re}	0.1	8.0	$\times 10^{-4}$
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	2N4400	h_{fe}	20	250	—
	2N4401		40	500	
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)		h_{oe}	1.0	30	μmhos
SWITCHING CHARACTERISTICS					
Delay Time	V_{CC} = 30 Vdc, $V_{EB(off)}$ = 2 Vdc,	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc	t_r	—	20	ns
Storage Time	V_{CC} = 30 Vdc, I_C = 150 mAdc,	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc	t_f	—	30	ns

(1) Pulse Test: Pulse Width ≦ 300 μs, Duty Cycle ≦ 2.0%.
*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 — TURN-ON TIME

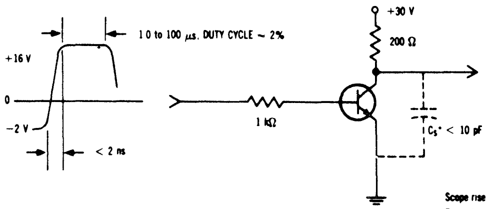
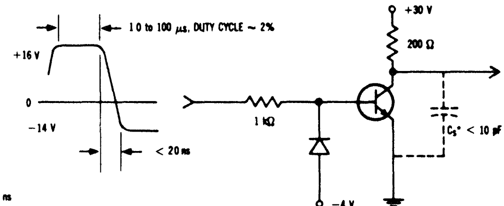


FIGURE 2 — TURN-OFF TIME



Scope rise time < 4 ns
*Total shunt capacitance of test jig, connectors, and oscilloscope

TRANSIENT CHARACTERISTICS

——— 25°C   – – – 100°C

FIGURE 3 — CAPACITANCES

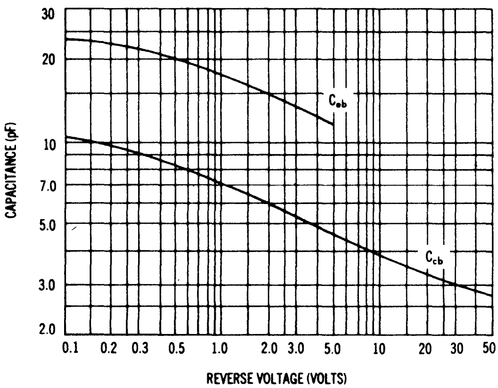


FIGURE 4 — CHARGE DATA

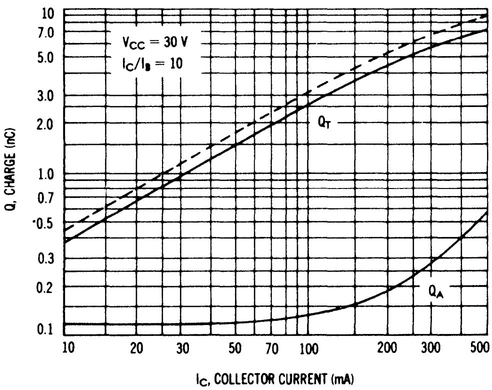


FIGURE 5 — TURN-ON TIME

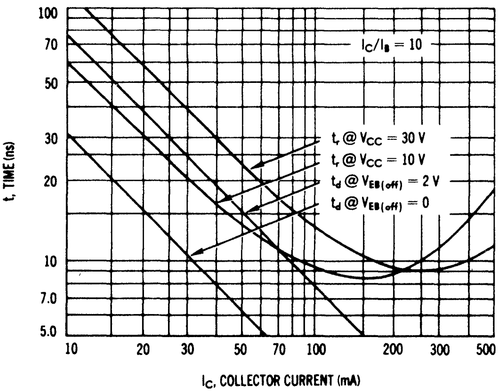


FIGURE 6 — RISE AND FALL TIMES

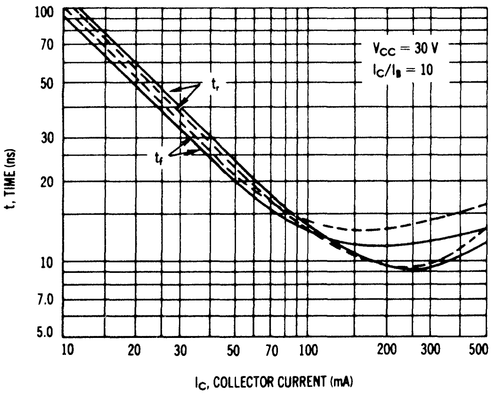


FIGURE 7 — STORAGE TIME

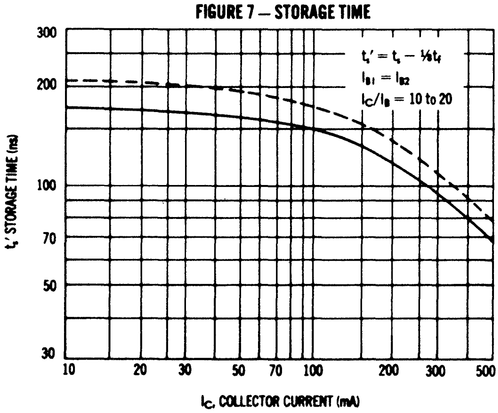
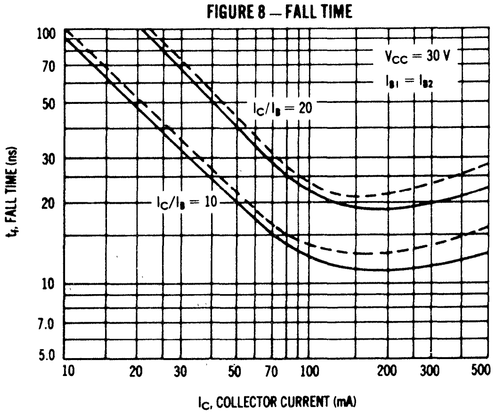


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C
Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

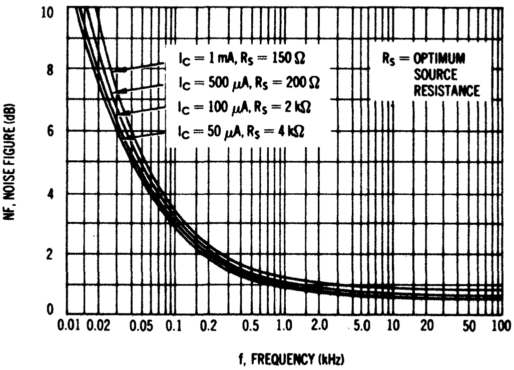
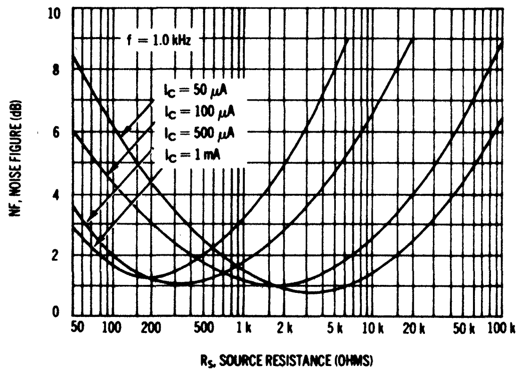


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4400 and 2N4401 lines, and the same units were used to develop the correspondingly numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

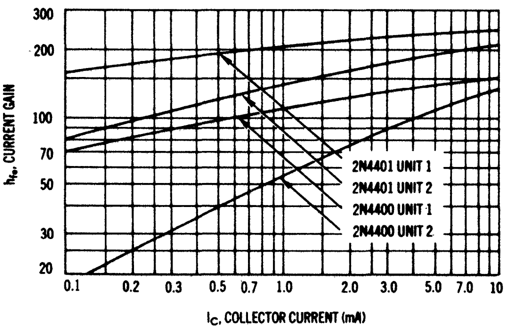


FIGURE 12 — INPUT IMPEDANCE

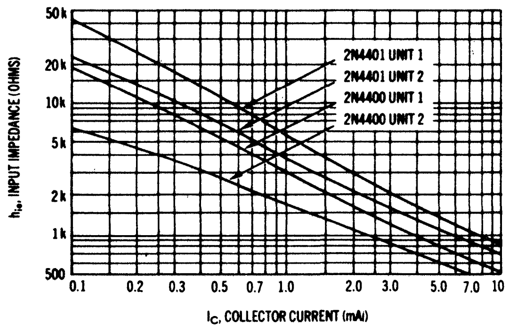


FIGURE 13 — VOLTAGE FEEDBACK RATIO

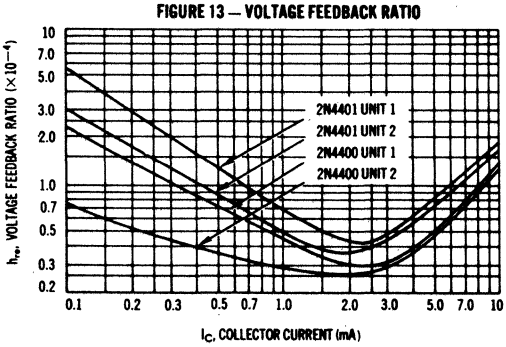
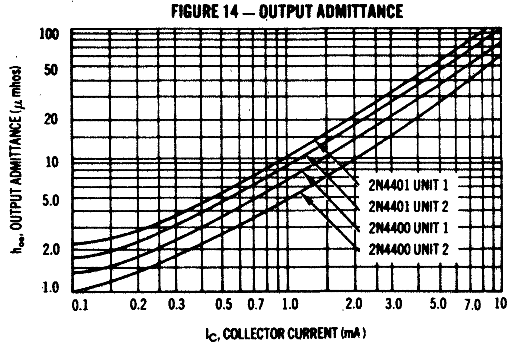


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

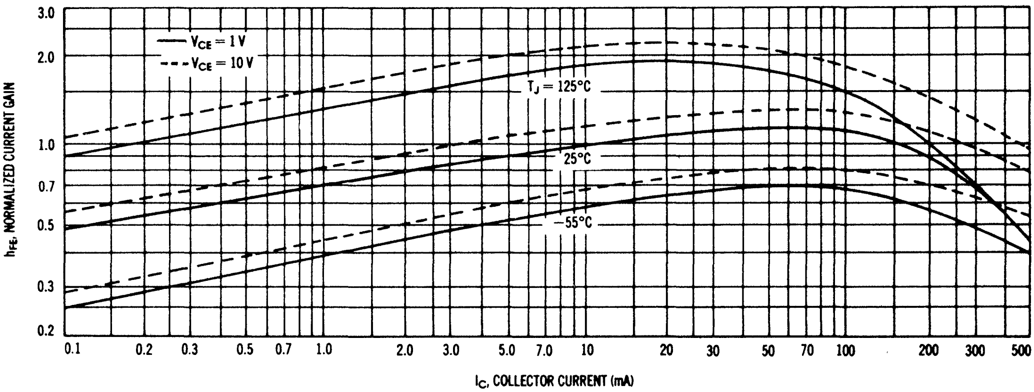


FIGURE 16 — COLLECTOR SATURATION REGION

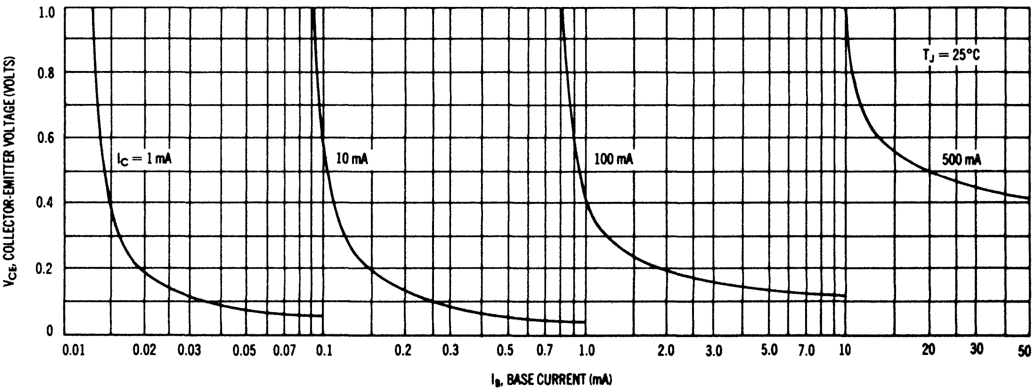


FIGURE 17 — "ON" VOLTAGES

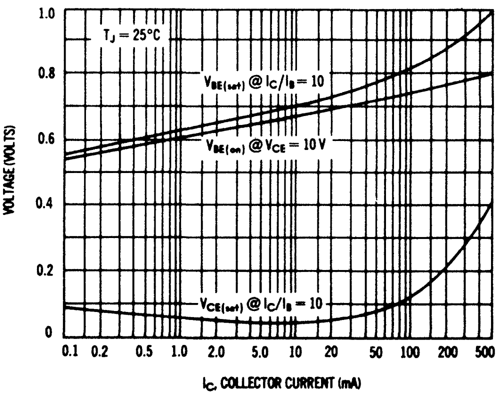
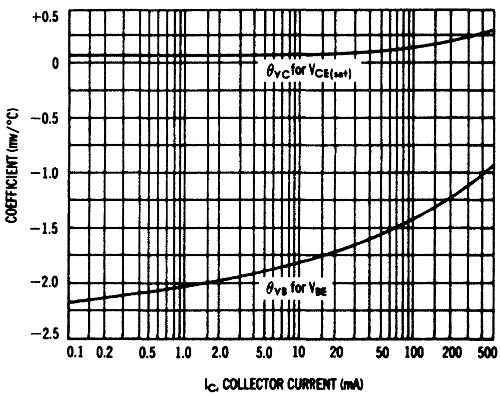


FIGURE 18 — TEMPERATURE COEFFICIENTS



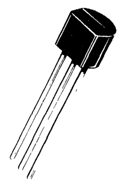
2N4402 (SILICON)
2N4403

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose switching and amplifier applications and for complementary circuitry with types 2N4400 and 2N4401.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 40 Vdc (Min) @ I_C = 1.0 mAdc
- Current Gain Specified from 0.1 mAdc to 500 mAdc
- Complete Switching and Amplifier Specifications
- Collector-Base Capacitance — C_{cb} = 8.5 pF (Max) @ V_{CB} = 5.0 Vdc

PNP SILICON SWITCHING AND AMPLIFIER TRANSISTORS



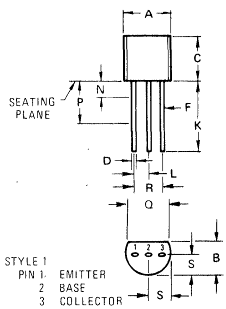
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	600	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	350 2.8	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 8.0	Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	357	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	125	°C/W

*Indicates JEDEC Registered Data.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4 450	5 200	0 175	0 205
B	3 180	4 190	0 125	0 165
C	4 320	5 330	0 170	0.210
D	0 407	0.533	0 016	0 021
F	0.407	0 482	0 016	0 019
K	12 700	–	0 500	–
L	1.150	1 390	0 045	0.055
N	–	1.270	–	0 050
P	6 350	–	0 250	–
Q	3 430	–	0 135	–
R	2 410	2.670	0 095	0 105
S	2 030	2.670	0 080	0 105

CASE 29
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	5.0	—	Vdc
Collector Cutoff Current (V_{CE} = 35 Vdc, $V_{BE(off)}$ = 0.4 Vdc)	I_{CEV}	—	0.1	µAdc
Base Cutoff Current (V_{CE} = 35 Vdc, $V_{BE(off)}$ = 0.4 Vdc)	I_{BEV}	—	0.1	µAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc) 2N4403		30	—	
(I_C = 1 mAdc, V_{CE} = 1 Vdc) 2N4402		30	—	
2N4403		60	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc) 2N4402		50	—	
2N4403		100	—	
(I_C = 150 mAdc, V_{CE} = 2 Vdc) (1) 2N4402		50	150	
2N4403		100	300	
(I_C = 500 mAdc, V_{CE} = 2 Vdc) (1)		20	—	
Collector-Emitter Saturation Voltage (1)	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		—	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	0.75	
Base-Emitter Saturation Voltage (1)	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		0.75	0.95	
(I_C = 500 mAdc, I_B = 50 mAdc)		—	1.3	
SMALL-SIGNAL CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz) 2N4402	f_T	150	—	MHz
2N4403		200	—	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	—	8.5	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{eb}	—	30	pF
Input Impedance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz) 2N4402	h_{ie}	750	7.5k	ohms
2N4403		1.5k	15k	
Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{re}	0.1	8.0	X 10^{-4}
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz) 2N4402	h_{fe}	30	250	—
2N4403		60	500	
Output Admittance (I_C = 1 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{oe}	1.0	100	µmhos

SWITCHING CHARACTERISTICS

Characteristic	Conditions	Symbol	Min	Max	Unit
Delay Time	V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2 Vdc,	t_d	—	15	ns
Rise Time	I_C = 150 mAdc, I_{B1} = 15 mAdc	t_r	—	20	ns
Storage Time	V_{CC} = 30 Vdc, I_C = 150 mAdc,	t_s	—	225	ns
Fall Time	I_{B1} = I_{B2} = 15 mAdc	t_f	—	30	ns

(1) **Pulse Test: Pulse Width ≤ 300 µs, Duty Cycle ≤ 2%**

*Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUIT

FIGURE 1 — TURN-ON TIME

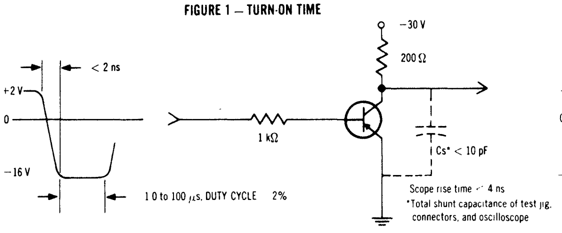
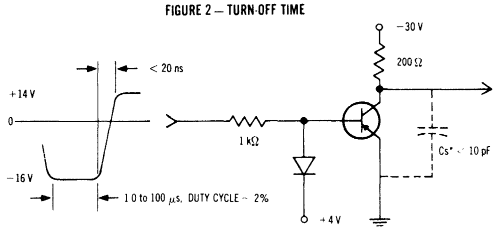


FIGURE 2 — TURN-OFF TIME



TRANSIENT CHARACTERISTICS

—— 25°C – – – 100°C

FIGURE 3 — CAPACITANCES

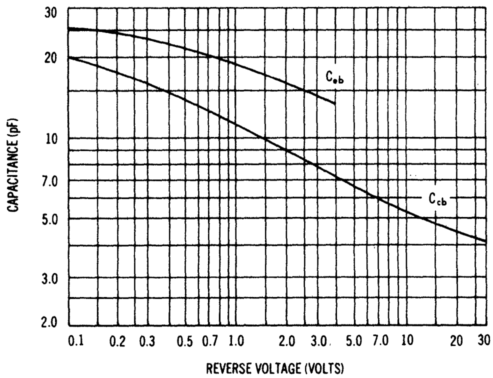


FIGURE 4 — CHARGE DATA

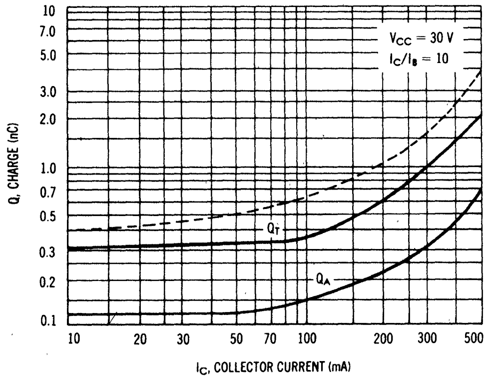


FIGURE 5 — TURN-ON TIME

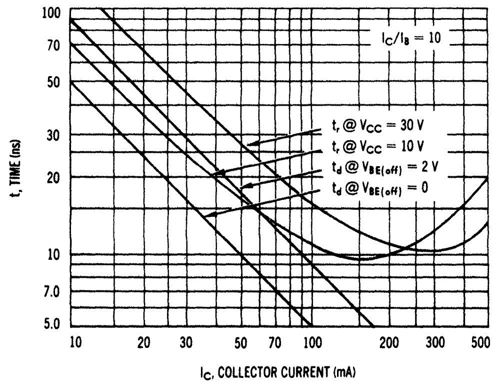


FIGURE 6 — RISE TIME

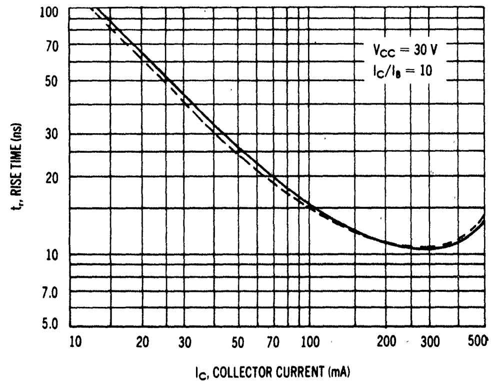


FIGURE 7 — STORAGE TIME

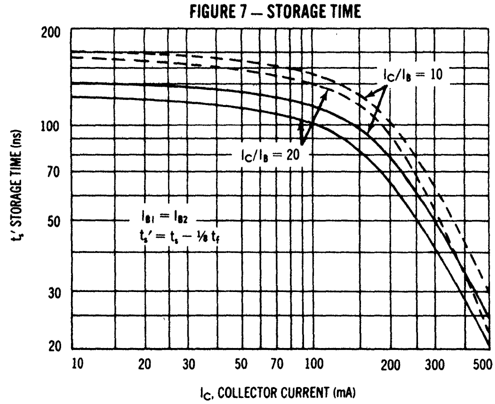
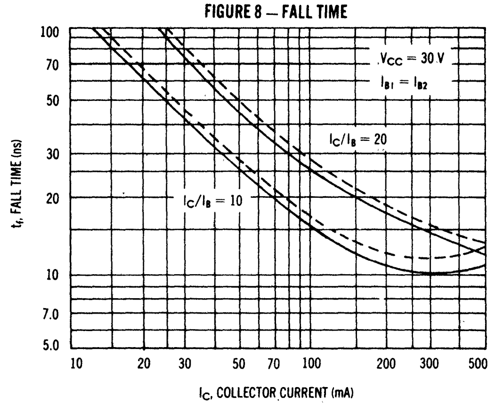


FIGURE 8 — FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

Bandwidth = 1.0 Hz

FIGURE 9 — FREQUENCY EFFECTS

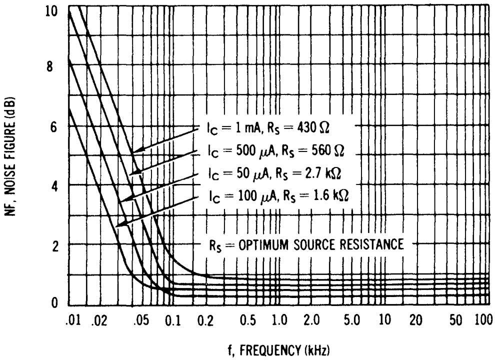
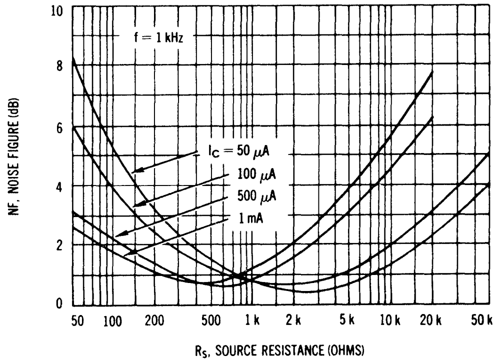


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1 kHz, T_A = 25°C

This group of graphs illustrates the relationship between h_{fe} and other "h" parameters for this series of transistors. To obtain these curves, a high-gain and a low-gain unit were selected from both the 2N4402 and 2N4403 lines, and the same units were used to develop the correspondingly-numbered curves on each graph.

FIGURE 11 — CURRENT GAIN

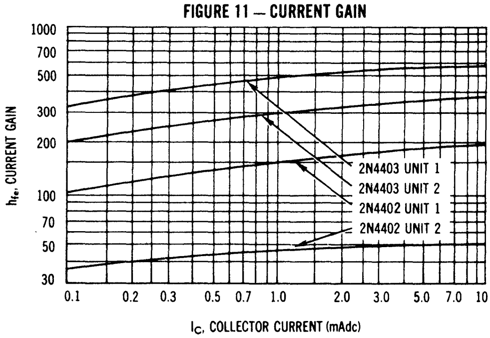


FIGURE 12 — INPUT IMPEDANCE

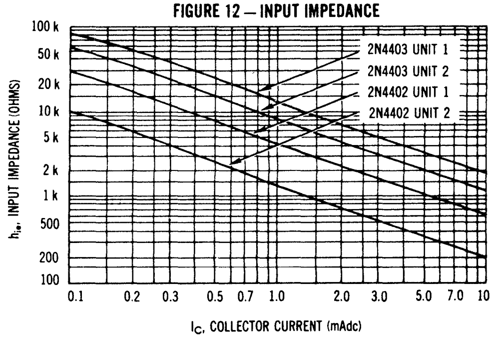


FIGURE 13 — VOLTAGE FEEDBACK RATIO

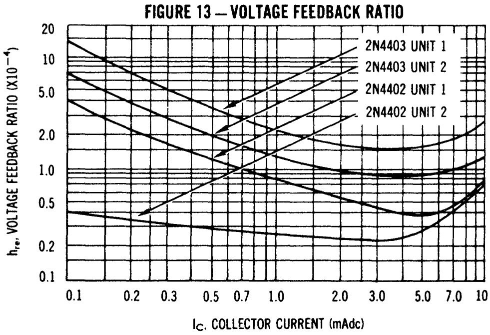
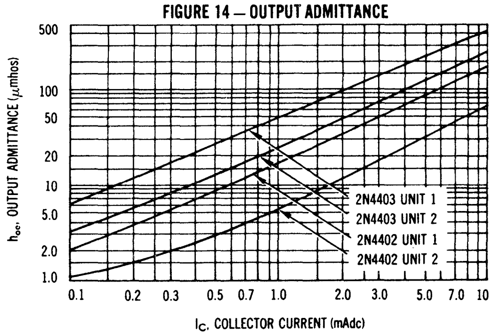


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 — DC CURRENT GAIN

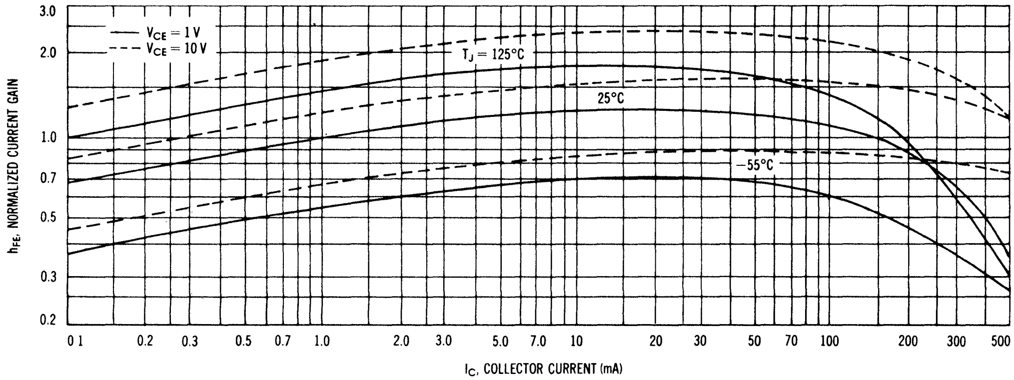


FIGURE 16 — COLLECTOR SATURATION REGION

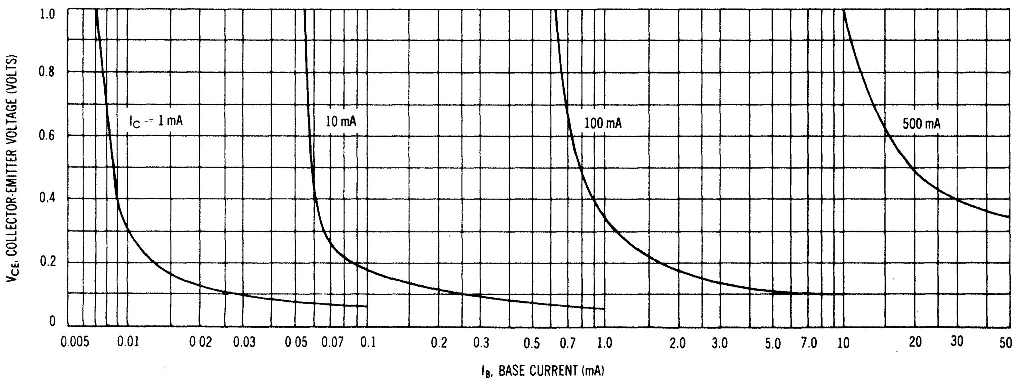


FIGURE 17 — "ON" VOLTAGE

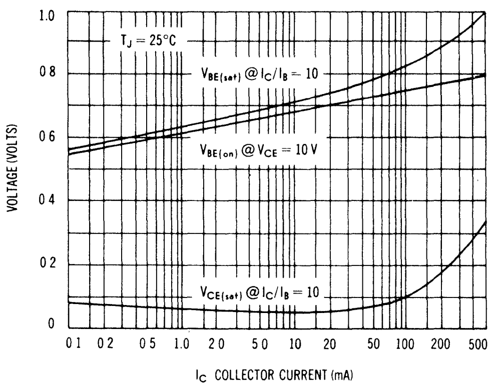
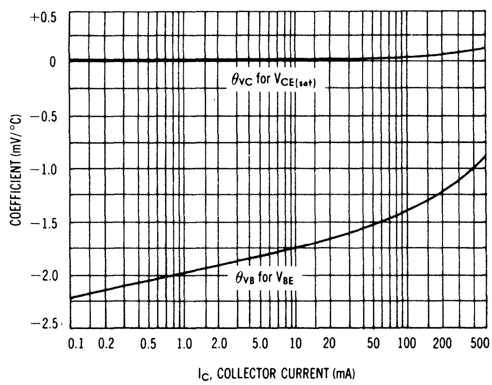
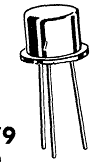


FIGURE 18 — TEMPERATURE COEFFICIENTS

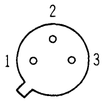


2N4404 (SILICON)
2N4405



CASE 79
(TO-39)

PNP silicon annular transistors designed for general-purpose amplifier and switching applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	1.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	25	°C/W
Thermal Resistance, Junction to Ambient (Lead Length 1/4")	θ_{JA}	140	°C/W

* Indicates JEDEC Registered Data

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – TURN-ON

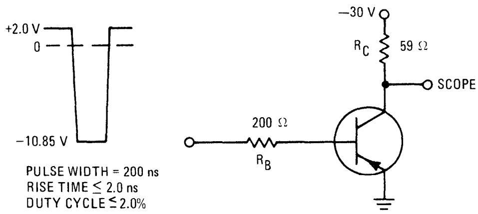
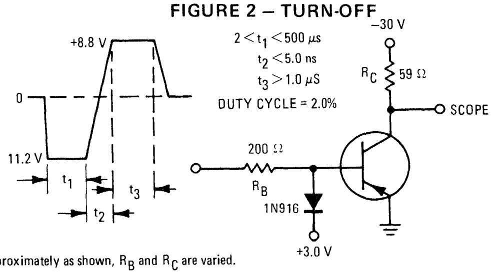


FIGURE 2 – TURN-OFF



To obtain data for curves, voltage levels are approximately as shown, R_B and R_C are varied.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage[1] (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	80	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	25	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 1.0 Vdc)	2N4404 2N4405		30 75	- -	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4404 2N4405		40 100	- -	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)[1]	2N4404 2N4405		40 100	120 300	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)[1]	2N4404 2N4405		15 25	- -	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)[1] (I_C = 500 mAdc, I_B = 50 mAdc)[1]		$V_{CE(sat)}$	 - - -	 0.15 0.2 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)[1]		$V_{BE(sat)}$	 - 0.85	 0.8 1.2	Vdc
Base-Emitter On Voltage* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	200	600	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	-	10	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	-	75	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 500 mAdc, I_{B1} = 50 mAdc) (Figure 1)	t_d	-	15	ns
Rise Time		t_r	-	25	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc) (Figure 2)	t_s	-	175	ns
Fall Time		t_f	-	35	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

*** Indicates JEDEC Registered Data**

TRANSIENT CHARACTERISTICS

——— 25°C   – – –100°C

FIGURE 3 – CAPACITANCES

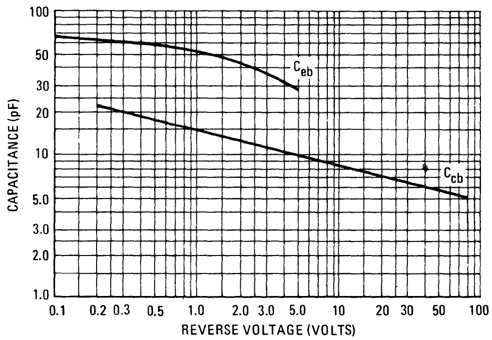


FIGURE 4 – CHARGE DATA

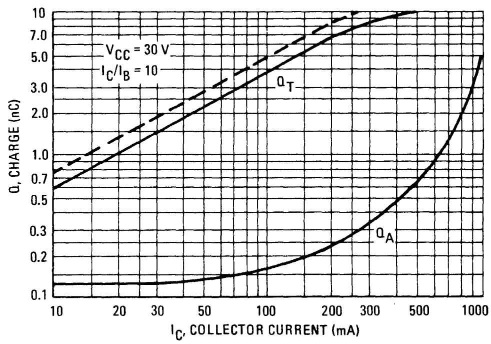


FIGURE 5 – DELAY TIME

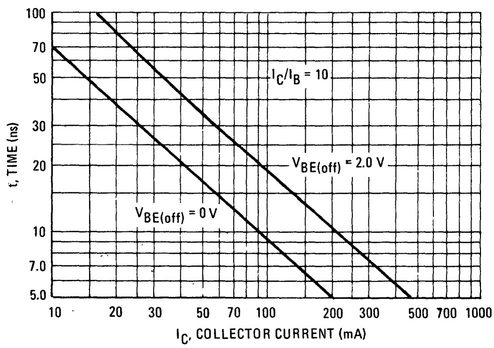


FIGURE 6 – RISE TIME

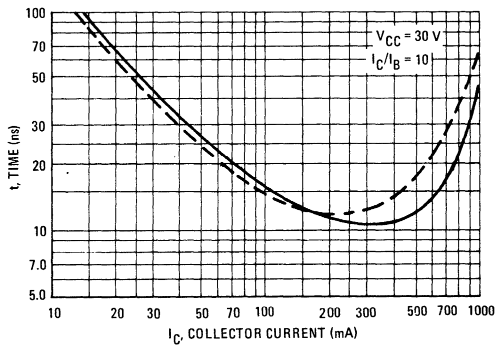


FIGURE 7 – STORAGE TIME

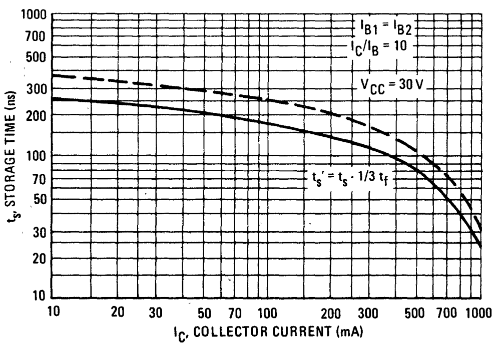
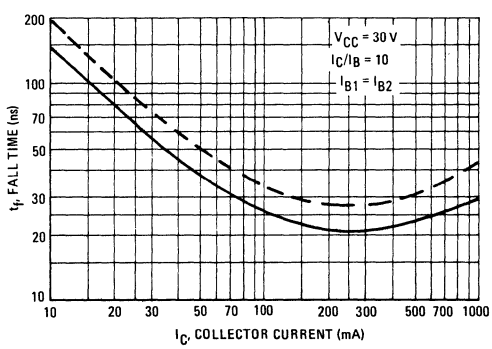


FIGURE 8 – FALL TIME



SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 10 Vdc, T_A = 25°C

FIGURE 9 — FREQUENCY EFFECTS

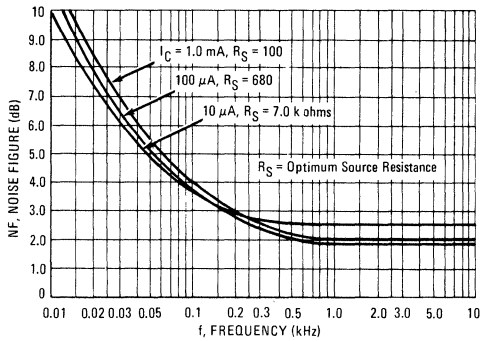
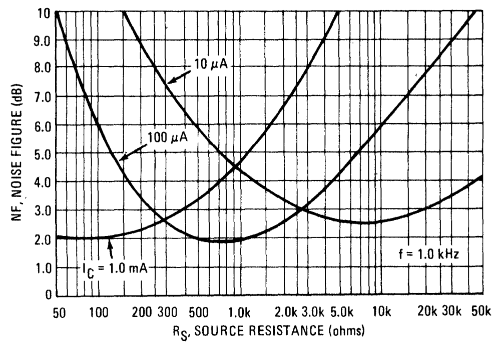


FIGURE 10 — SOURCE RESISTANCE EFFECTS



h PARAMETERS

V_{CE} = 10 Vdc, f = 1.0 kHz, T_A = 25°C

This group of graphs illustrates the relationship of the "h" parameters for this series of transistors. To obtain these curves, 4 units were selected and identified by number — the same units were used to develop curves on each graph.

FIGURE 11 — CURRENT GAIN

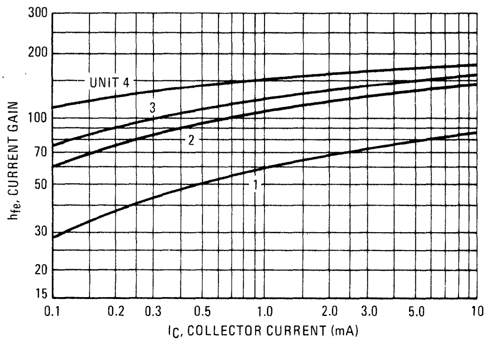


FIGURE 12 — INPUT IMPEDANCE

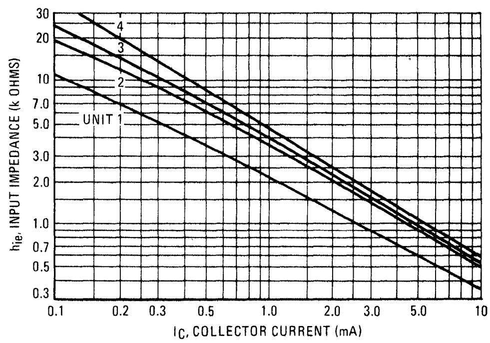


FIGURE 13 — VOLTAGE FEEDBACK RATIO

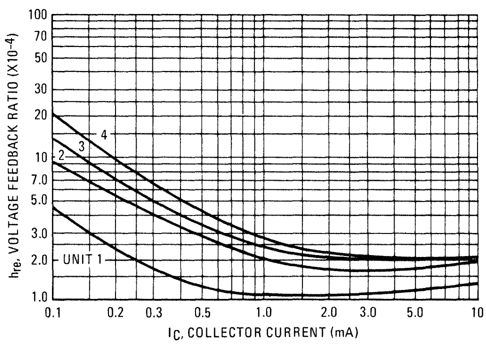
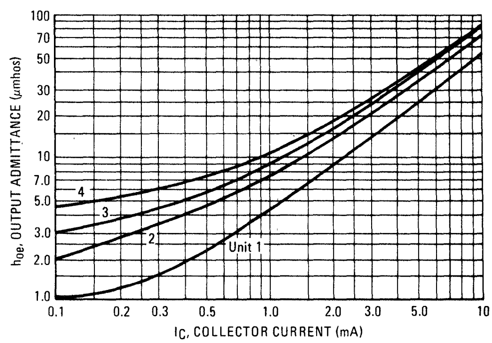


FIGURE 14 — OUTPUT ADMITTANCE



STATIC CHARACTERISTICS

FIGURE 15 – DC CURRENT GAIN

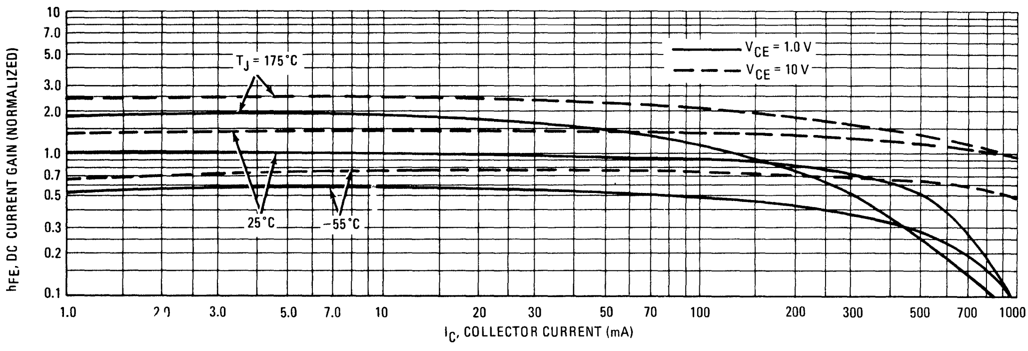


FIGURE 16 – COLLECTOR SATURATION REGION

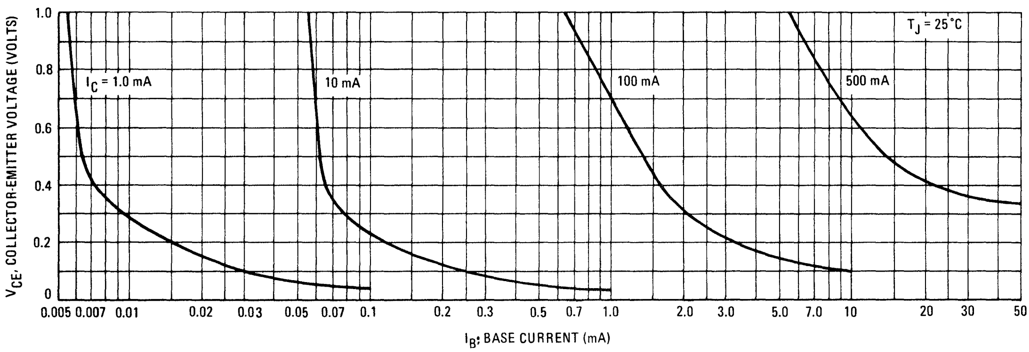


FIGURE 17 – "ON" VOLTAGES

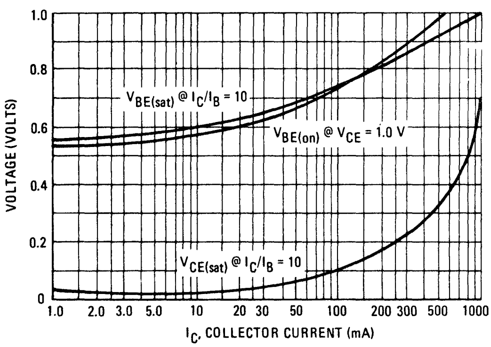
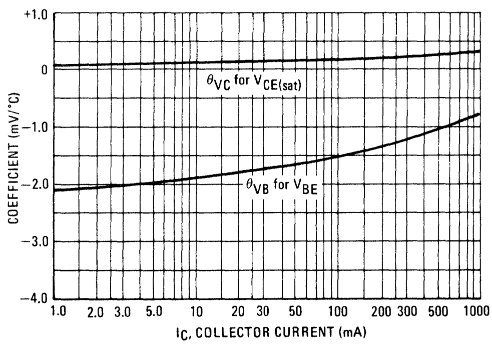
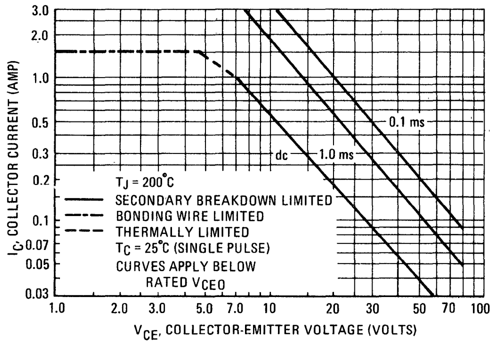


FIGURE 18 – TEMPERATURE COEFFICIENTS



RATINGS AND THERMAL DATA

FIGURE 19 — SAFE OPERATING AREA

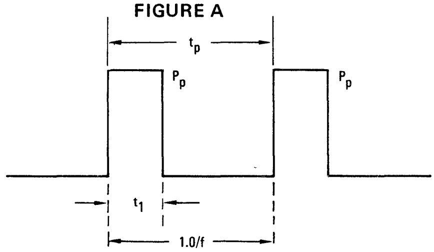


The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 19 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 20. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 f = \frac{t_1}{t_p}$

PEAK PULSE POWER = P_p

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 20 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 20 by the steady state value $\theta_{JC}(\infty)$.

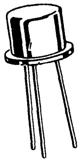
Example:

If the 2N4404 is dissipating 8.0 watts peak under the following conditions: t_1 = 1.0 ms, t_p = 5.0 ms, (D = 0.2), find ΔT.

Using Figure 20 at a pulse width of 1.0 ms and D = 0.2, the reading of $r(t_1 D)$ is 0.4.

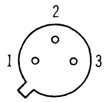
The peak rise in junction temperature above case temperature is, therefore, $\Delta T = r(t_1 D) \times P_p \times \theta_{JC}(\infty) = 0.4 \times 8.0 \times 25$ = 80°C.

2N4406 (SILICON)
2N4407



PNP silicon annular transistors designed for general-purpose amplifier and switching applications.

CASE 79
(TO-39)



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current	I_C	2.0	Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.25 7.15	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	8.75 50	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	20	°C/W
Thermal Resistance, Junction to Ambient	θ_{JA}	140	°C/W

*Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage(1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	80	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	80	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	-	25	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	-	25	nAdc
ON CHARACTERISTICS					
DC Current Gain(1)		h_{FE}			-
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N4406		30	-	
	2N4407		80	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N4406		25	100	
	2N4407		75	225	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N4406		20	-	
	2N4407		35	-	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	2N4406		10	-	
	2N4407		15	-	
(I_C = 1.5 Adc, V_{CE} = 5.0 Vdc)	2N4406, 2N4407		10	-	
Collector-Emitter Saturation Voltage(1)		$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			-	0.2	
(I_C = 500 mAdc, I_B = 50 mAdc)			-	0.4	
(I_C = 1.0 Adc, I_B = 100 mAdc)			-	0.7	
(I_C = 1.5 Adc, I_B = 150 mAdc)			-	1.5	
Base-Emitter Saturation Voltage (1)		$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			-	0.9	
(I_C = 1.0 Adc, I_B = 100 mAdc)			0.9	1.3	
(I_C = 1.5 Adc, I_B = 150 mAdc)			-	1.5	
Base-Emitter On Voltage (1) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc)		$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	150	750	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	-	15	pF
Collector-Emitter Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)		C_{eb}	-	160	pF
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 2.0 Vdc, I_C = 1.0 Adc, I_{B1} = 100 mAdc) (Figure 11)	t_d	-	15	ns
Rise Time		t_r	-	60	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc) (Figure 12)	t_s	-	175	ns
Fall Time		t_f	-	50	ns

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

* **Indicates JEDEC Registered Data**

STATIC CHARACTERISTICS

FIGURE 2 - DC CURRENT GAIN

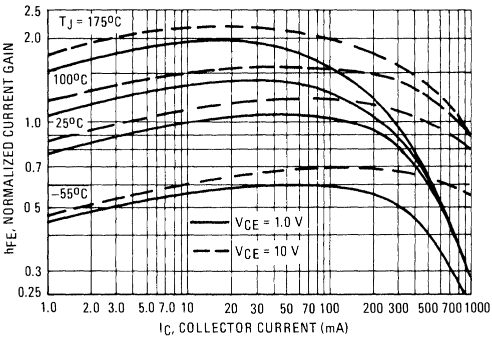


FIGURE 3 - COLLECTOR SATURATION REGION

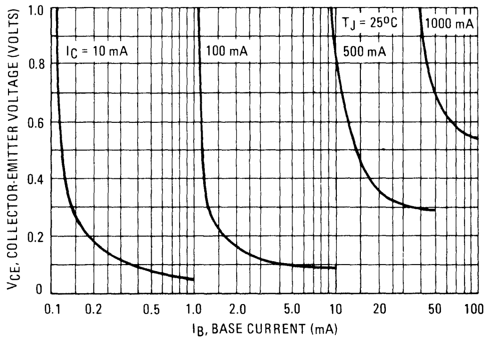


FIGURE 4 - "ON" VOLTAGES

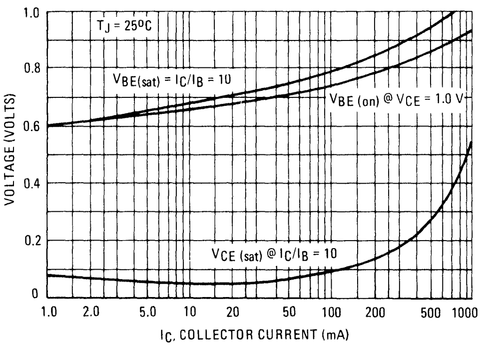


FIGURE 5 - TEMPERATURE COEFFICIENTS

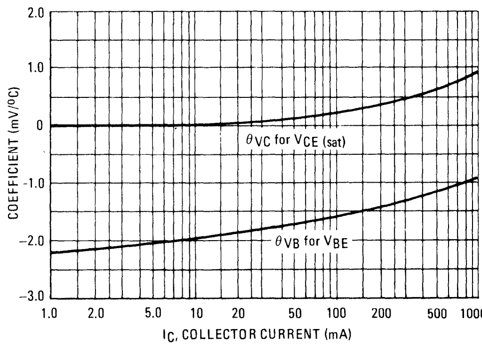
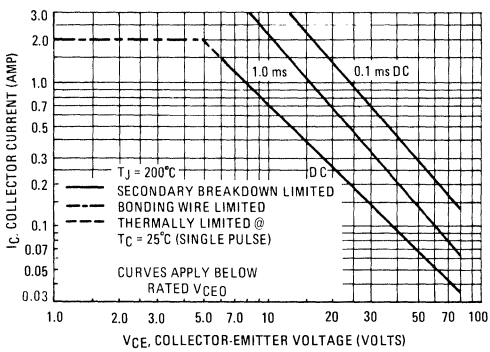


FIGURE 6 - SAFE OPERATING AREA



The safe operating area curves indicate I_C-V_{CE} limits of the transistor that must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 6 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leqq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 1. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

TRANSIENT CHARACTERISTICS

——— 25°C – – – – 100°C

FIGURE 7 - CAPACITANCES

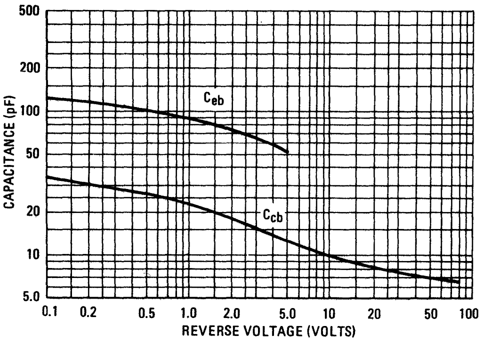


FIGURE 8 - CHARGE DATA

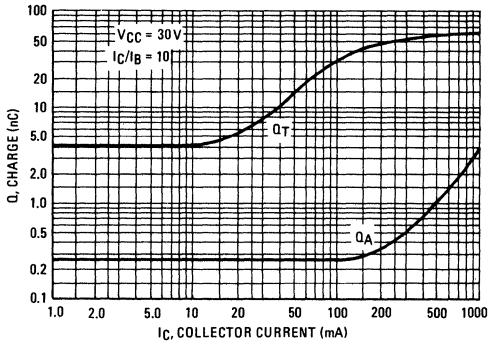


FIGURE 9 - TURN-ON TIME

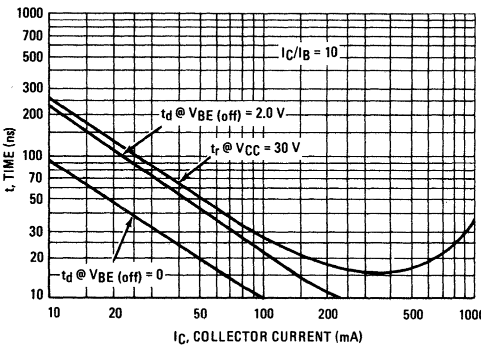
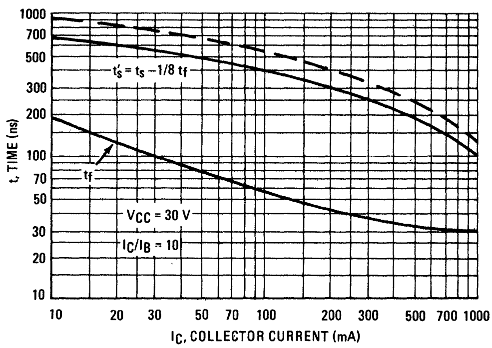


FIGURE 10 - TURN-OFF TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 11 - TURN-ON TIME

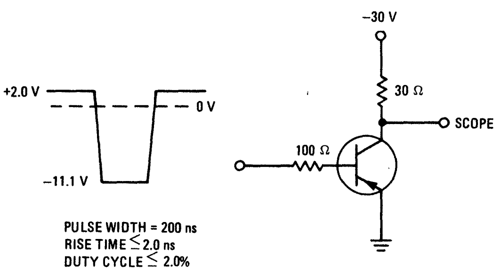
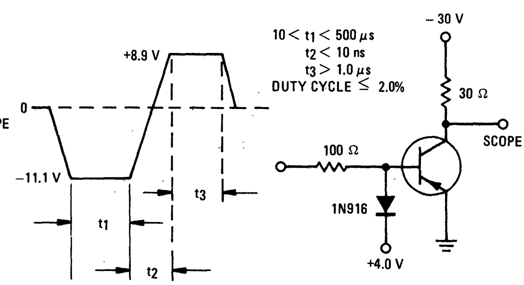


FIGURE 12 - TURN-OFF TIME



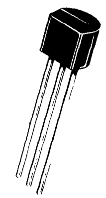
2N4409 (SILICON)
2N4410

NPN SILICON AMPLIFIER TRANSISTORS

. . . designed for high-voltage amplifier applications.

- High Collector-Emitter Breakdown Voltage –
  BV_{CEX} = 80 Vdc (Min) – 2N4409
  = 120 Vdc (Min) – 2N4410
- Low Collector Cutoff Current –
  I_{CBO} = 1.0 μAdc (Max) @ T_A = 100°C
- High DC Current Gain –
  h_{FE} = 150 (Typ) @ I_C = 1.0 mAdc

NPN SILICON AMPLIFIER TRANSISTORS



***MAXIMUM RATINGS**

Rating	Symbol	2N4409	2N4410	Unit
Collector-Emitter Voltage	V_{CEO}	50	80	Vdc
Collector-Base Voltage	V_{CB}	80	120	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	250		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0		mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150		°C

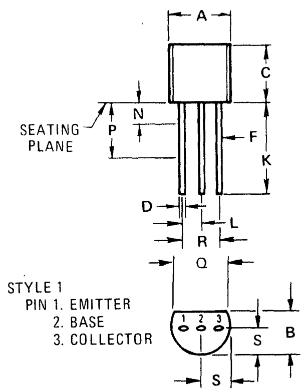
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTIC**					
Collector-Emitter Breakdown Voltage (1) (I_C = 1.0 mAdc, I_B = 0)	2N4409 2N4410	BV_{CEO}	50 80	– –	Vdc
Collector-Emitter Breakdown Voltage (I_C = 500 μAdc, $V_{BE(off)}$ = 5.0 Vdc, R_{BE} = 8.2 kohms)	2N4409 2N4410	BV_{CEX}	80 120	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4409 2N4410	BV_{CBO}	80 120	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C) (V_{CB} = 100 Vdc, I_E = 0) (V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)	 2N4409 2N4409 2N4410 2N4410	I_{CBO}	 – – – –	 0.01 1.0 0.01 1.0	μAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	0.1	μAdc
***ON CHARACTERISTICS**					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)		h_{FE}	 60 60	 – 400	–
Collector-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{CE(sat)}$	–	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 mAdc, I_B = 0.1 mAdc)		$V_{BE(sat)}$	–	0.8	Vdc
Base-Emitter On Voltage (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	–	0.8	Vdc
DYNAMIC CHARACTERISTICS					
*Current-Gain – Bandwidth Product (2) (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 30 MHz)		f_T	60	300	MHz
*Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	–	12	pF
Emitter-Base Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	–	50	pF

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.
(2) $f_T = |h_{fe}| \bullet f_{test}$



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.450	5.200	0.175	0.205
B	3.180	4.190	0.125	0.165
C	4.320	5.330	0.170	0.210
D	0.407	0.533	0.016	0.021
F	0.407	0.482	0.016	0.019
K	12.700	–	0.500	–
L	1.150	1.390	0.045	0.055
N	–	1.270	–	0.050
P	6.350	–	0.250	–
Q	3.430	–	0.135	–
R	2.410	2.670	0.095	0.105
S	2.030	2.670	0.080	0.105

CASE 29-02
TO-92

TYPICAL DC CHARACTERISTICS

FIGURE 1 – DC CURRENT GAIN

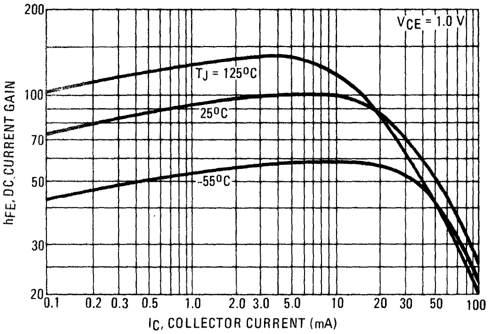


FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA

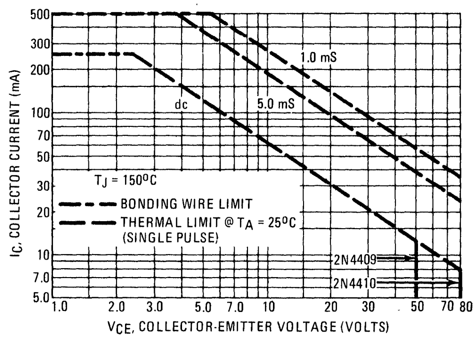


FIGURE 3 – "ON" VOLTAGE

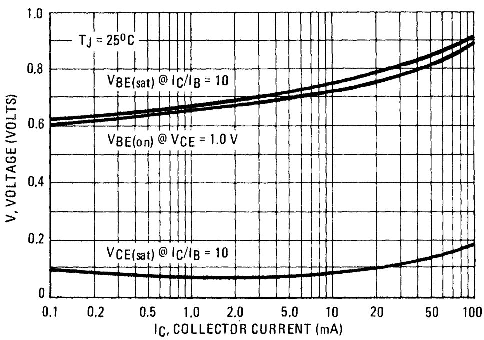
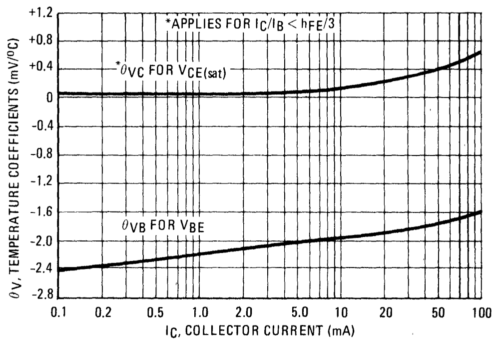


FIGURE 4 – TEMPERATURE COEFFICIENTS



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 5 – CURRENT-GAIN – BANDWIDTH PRODUCT

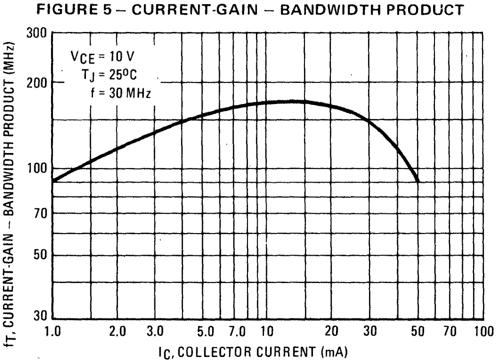
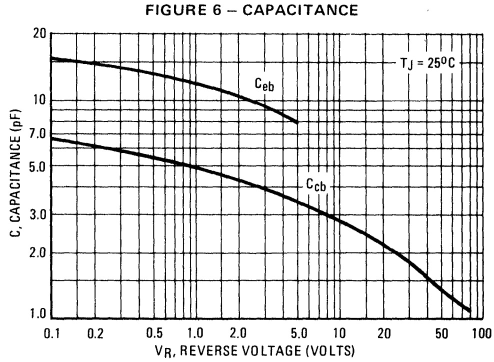


FIGURE 6 – CAPACITANCE

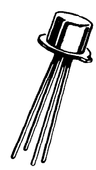


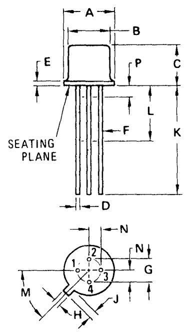
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR

. . . designed for VHF/UHF amplifier applications.

- Low Noise Figure –
  NF = 2.0 dB (Max) @ 100 MHz
  = 4.0 dB (Max) @ 400 MHz
- Low Feedback Capacitance –
  C_{rss} = 0.8 pF (Max)
- Low Output Capacitance –
  C_{oss} = 2.0 pF (Max)
- High Transfer Admittance –
  $y_{fs(real)}$ = 4000 μmho (Min)
- High Power Gain –
  G_{ps} = 18 dB (Min) @ 100 MHz
  = 10 dB (Min) @ 400 MHz
- S and Y Parameter Curves Provided

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTOR





STYLE 1
PIN 1 SOURCE
2 DRAIN
3 GATE
4 CASE LEAD

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0 209	0.230
B	4.52	4.95	0 178	0.195
C	4.32	5.33	0.170	0 210
D	0.41	0.53	0 016	0.021
E	–	0.76	–	0.030
F	0.41	0 48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0 91	1.17	0.036	0.046
J	0.71	1 22	0.028	0 048
K	12.70	–	0 500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1 27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	30	Vdc
Gate Current	I_G	10	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Channel Temperature Range	$T_{channel}$, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTIC				
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	30	–	Vdc
Gate-Source Cutoff Voltage (I_D = 1.0 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	–	6.0	Vdc
Gate-Source Voltage (I_D = 0.5 mAdc, V_{DS} = 15 Vdc)	V_{GS}	1.0	5.5	Vdc
Gate-Source Forward Voltage (I_G = 1.0 mAdc, V_{DS} = 0)	$V_{GS(F)}$	–	1.0	Vdc
Gate Reverse Current	I_{GSS}			pAdc
(V_{GS} = 20 Vdc, V_{DS} = 0)		–	100	
(V_{GS} = 20 Vdc, V_{DS} = 0, T_A = +150°C)		–	200	
ON CHARACTERISTICS				
Zero-Gate Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}	5.0	15	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Forward Transfer Admittance (1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{fs}\|$	4500	7500	μmhos
Real Part of Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)	$y_{fs(real)}$	4000	–	μmhos
Real Part of Input Admittance	$y_{is(real)}$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		–	100	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		–	1000	
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	$\|y_{os}\|$	–	50	μmhos
Real Part of Output Admittance	$y_{os(real)}$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		–	75	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		–	100	
Imaginary Part of Input Admittance	$y_{is(imag)}$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		–	2500	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		–	10,000	
Imaginary Part of Output Admittance	$y_{os(imag)}$			μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 100 MHz)		–	1000	
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 400 MHz)		–	4000	
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{iss}	–	4.0	pF
Common-Source Output Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{oss}	–	2.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)	C_{rss}	–	0.8	pF
Common-Source Spot Noise (Figures 3 and 4)	NF			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ohms, f = 100 MHz)		–	2.0	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, $R_g \approx$ 1000 Ohms, f = 400 MHz)		–	4.0	
Small-Signal Power Gain (Figure 1)	G_{ps}			dB
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 100 MHz)		18	–	
(V_{DS} = 15 Vdc, I_D = 5.0 mAdc, f = 400 MHz)		10	–	

(1) Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 1.0%.
*Indicates JEDEC Registered Data.

POWER GAIN

FIGURE 1 – EFFECTS OF DRAIN CURRENT

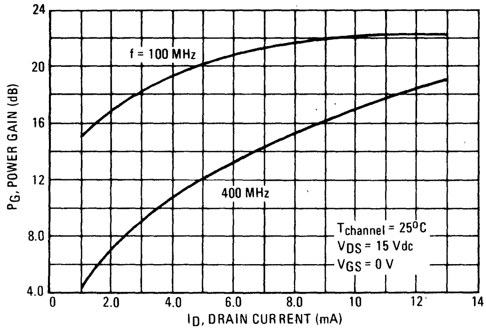
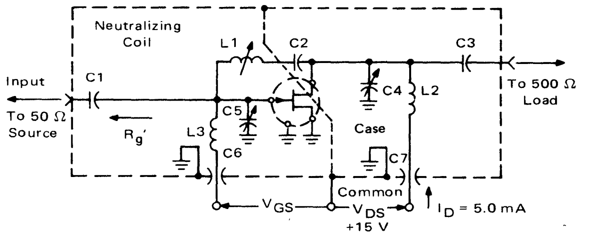


FIGURE 2 – 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for I_D = 50 mA $V_{GS} < 0$ Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. – depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. – depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

NOISE FIGURE

($T_{channel}$ = 25°C)

FIGURE 3 – EFFECTS OF DRAIN-SOURCE VOLTAGE

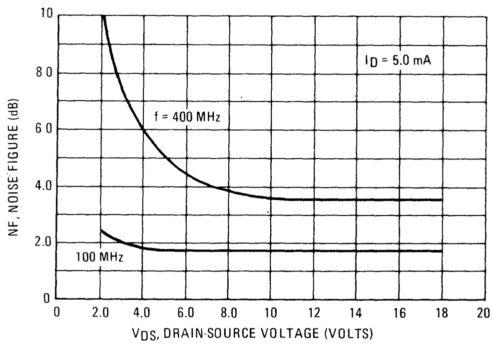
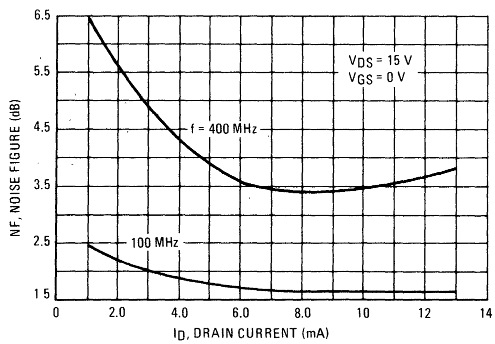
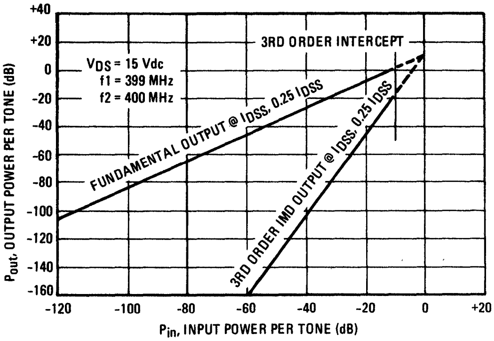


FIGURE 4 – EFFECTS OF DRAIN CURRENT



INTERMODULATION CHARACTERISTICS

FIGURE 5 – THIRD ORDER INTERMODULATION DISTORTION



COMMON SOURCE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 6 – INPUT ADMITTANCE (y_{is})

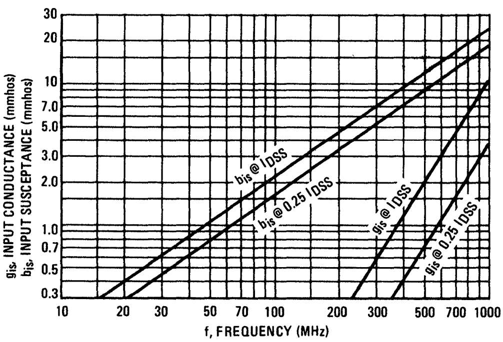


FIGURE 7 – REVERSE TRANSFER ADMITTANCE (y_{rs})

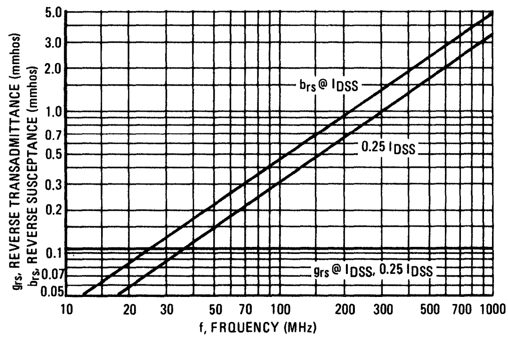


FIGURE 8 – FORWARD TRANSADMITTANCE (y_{fs})

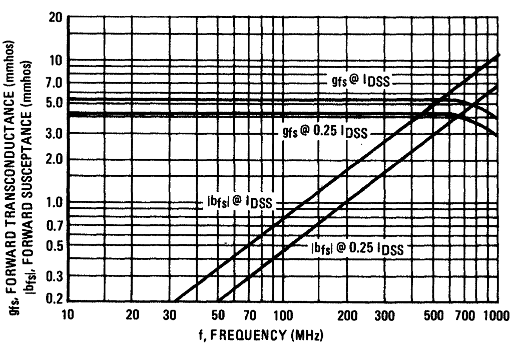
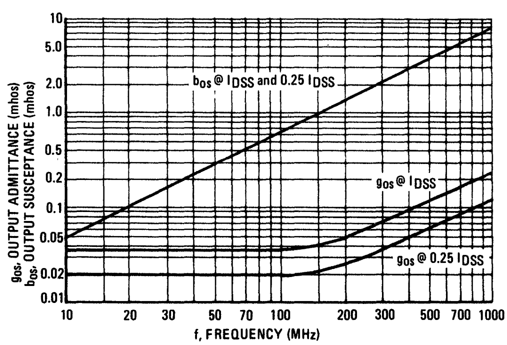


FIGURE 9 – OUTPUT ADMITTANCE (y_{os})



COMMON SOURCE CHARACTERISTICS
S-PARAMETERS
(V_{DS} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 10 – S_{11s}

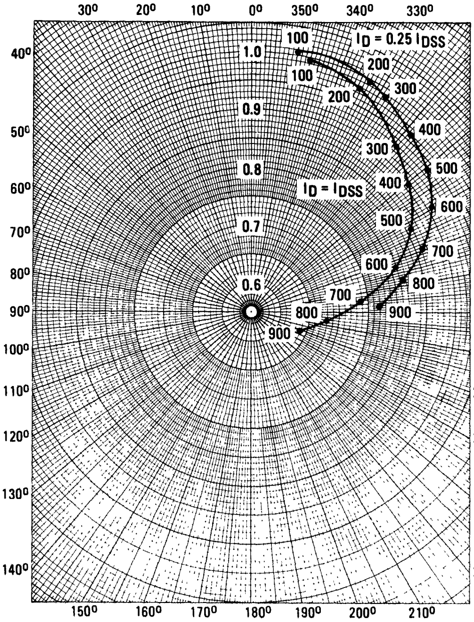


FIGURE 11 – S_{12s}

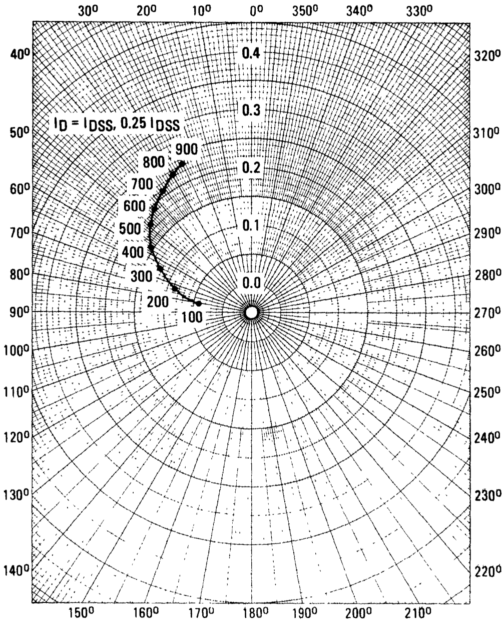


FIGURE 12 – S_{21s}

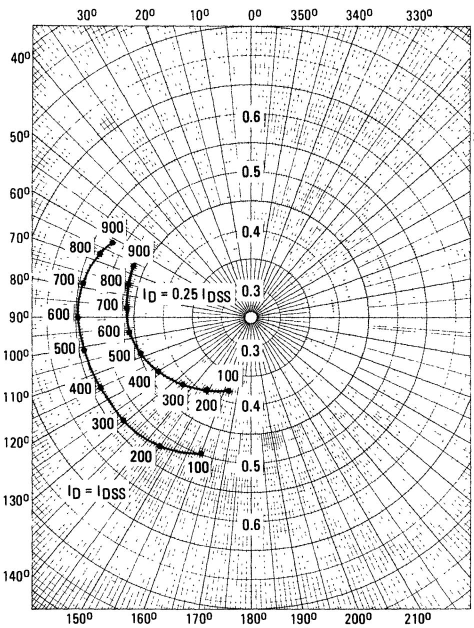
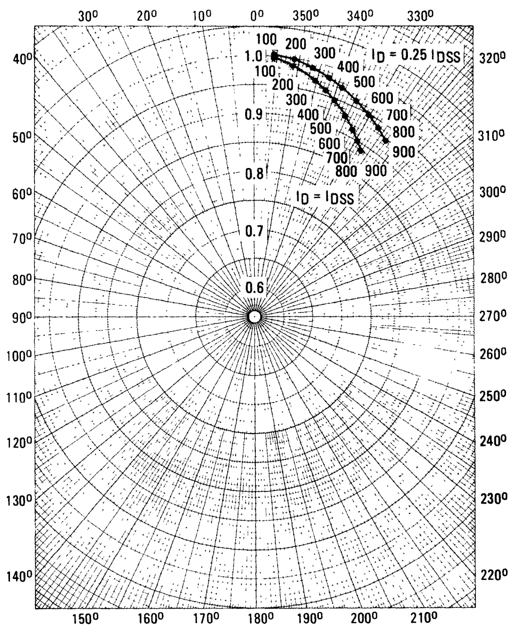


FIGURE 13 – S_{22s}



COMMON GATE CHARACTERISTICS

ADMITTANCE PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C)

FIGURE 14 – INPUT ADMITTANCE (y_{ig})

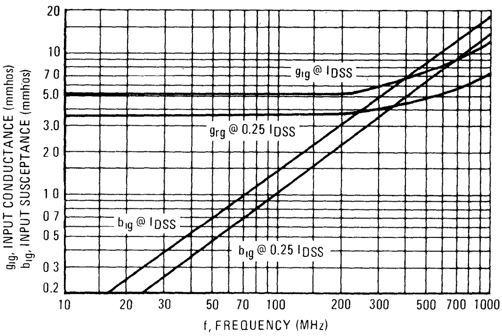


FIGURE 15 – REVERSE TRANSFER ADMITTANCE (y_{rg})

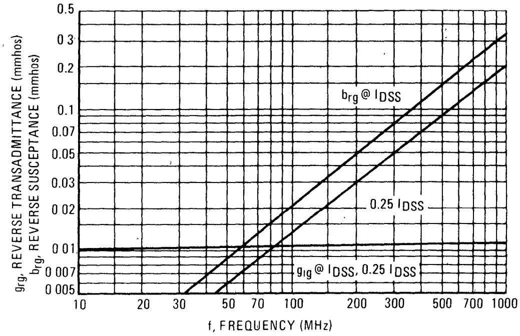


FIGURE 16 – FORWARD TRANSFER ADMITTANCE (y_{fg})

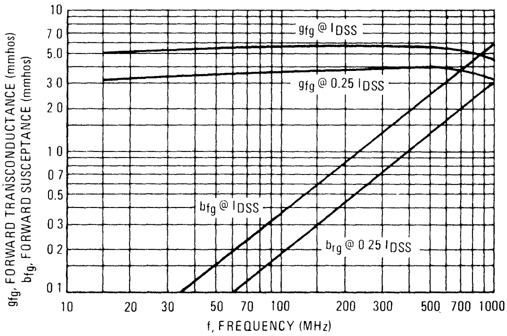
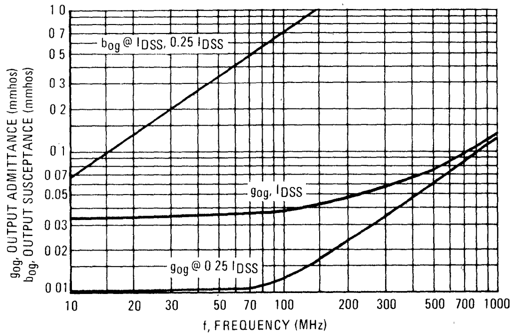


FIGURE 17 – OUTPUT ADMITTANCE (y_{og})



COMMON GATE CHARACTERISTICS

S-PARAMETERS

(V_{DG} = 15 Vdc, $T_{channel}$ = 25°C, Data Points in MHz)

FIGURE 18 — S_{11g}

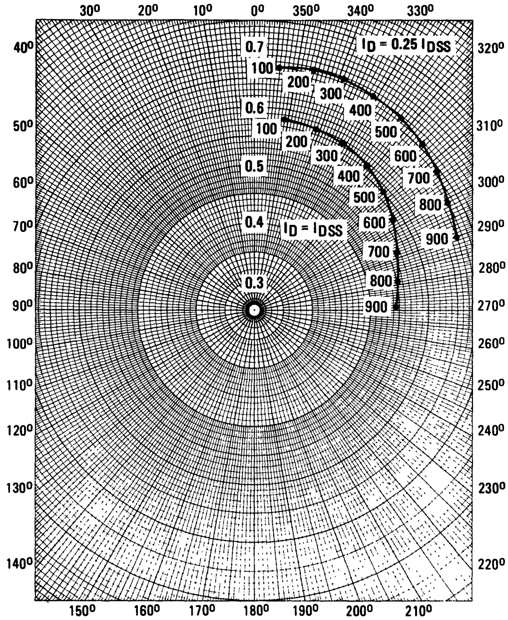


FIGURE 19 — S_{12g}

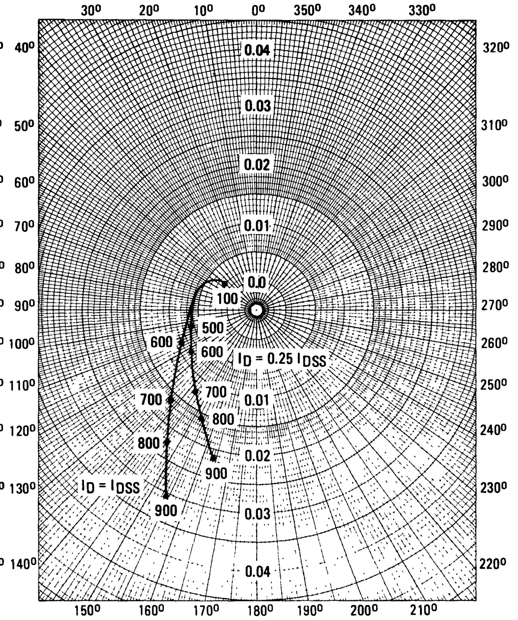


FIGURE 20 — S_{21g}

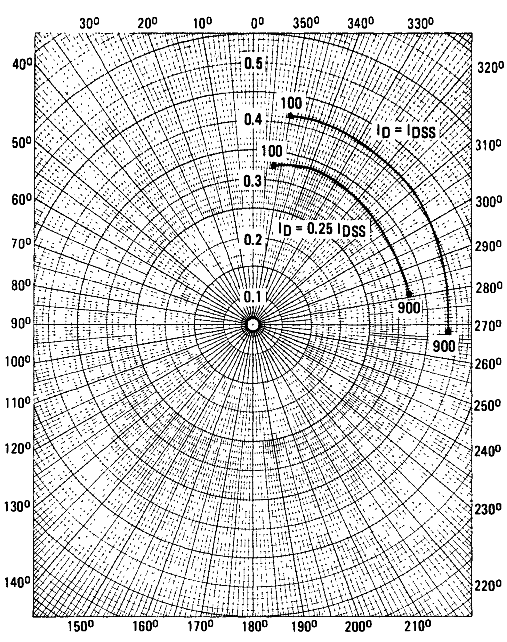
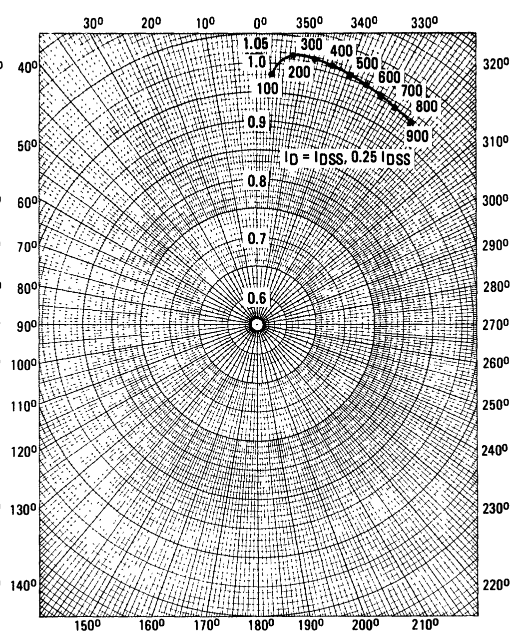


FIGURE 21 — S_{22g}



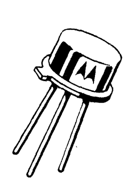
The RF Line

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier, or oscillator applications in military and industrial equipment. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- Current-Gain—Bandwidth Product — f_T = 500 MHz (Min) @ I_C = 50 mAdc
- Power Gain — G_{pe} = 10 dB (Min) @ V_{CE} = 12 Vdc
- 1 Watt Minimum Power Output @ f = 175 MHz
- Multiple-Emitter Construction for Excellent High-Frequency Performance

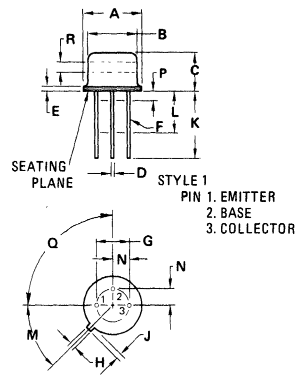
1 W — 175 MHz
RF POWER TRANSISTOR
NPN SILICON



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	20	Vdc
*Collector-Base Voltage	V_{CB}	40	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current — Continuous	I_C	400	mAdc
*Base Current — Continuous	I_B	400	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
*Storage Temperature Range	T_{stg}	-65 to + 200	°C

*Indicates JEDEC Registered Data



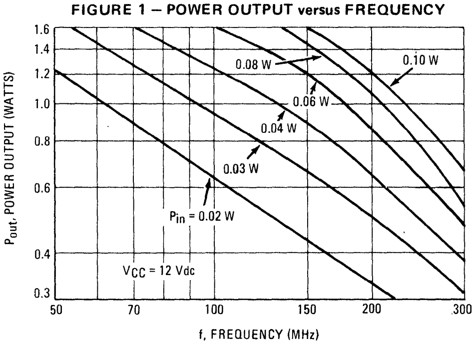
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

CASE 79-02
TO-39

All JEDEC notes and dimensions apply.

Available in TO-46 Package as MRF604

FIGURE 1 — POWER OUTPUT versus FREQUENCY

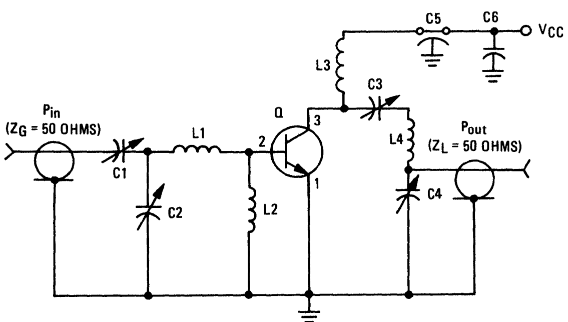


ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
*Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	20	–	Vdc
*Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	40	–	Vdc
*Collector Cutoff Current (V_{CE} = 12 Vdc, I_B = 0)	I_{CEO}	–	0.02	mAdc
*Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = -1.5 Vdc) (V_{CE} = 12 Vdc, V_{BE} = -1.5 Vdc, T_C = +150°C)	I_{CEV}	– –	0.1 5.0	mAdc
*Emitter Cutoff Current (V_{EB} = 2.0 Vdc, I_C = 0)	I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS				
*DC Current Gain (I_C = 100 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	200 –	–
*Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	0.5	Vdc
DYNAMIC CHARACTERISTICS				
*Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	–	MHz
*Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	4.0	pF
FUNCTIONAL TEST				
*Power Input (Figure 1) (P_{out} = 1.0 W, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	P_{in}	–	100	mW
Common-Emitter Amplifier Power Gain (P_{in} = 100 mW, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	G_{pe}	10	–	dB
*Collector Efficiency (Figure 1) (P_{out} = 1.0 W, Z_S = 50 Ohms, V_{CC} = 12 Vdc, f = 175 MHz)	η	50	–	%

*Indicates JEDEC Registered Data

FIGURE 1 — 175 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST



C1, C2, C3, and C4: 3-30 pF
C5: 1,000 pF
C6: 0.01 μF
L1: 2 turns No. 16 wire, 3/16″ ID, 1/4″ long
L2: Ferrite choke, Z = 450 ohms
L3: 2 turns No. 16 wire, 1/4″ ID, 1/4″ long
L4: 4 turns No. 16 wire, 3/8″ ID, 3/8″ long
Q: 2N4427

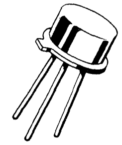
2N4428 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed primarily for use in large signal VHF and UHF amplifier output stages in military and industrial communications applications.

- High Power Output —
  P_{out} = 0.75 Watt with 10 dB Gain @ f = 500 MHz
- High Current-Gain—Bandwidth Product —
  f_T = 1000 MHz (Typ) @ I_C = 50 mAdc
- Multiple Emitter Construction for Excellent High Frequency Performance

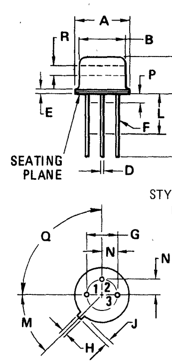
NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current — Continuous	I_C	425	mAdc
Base Current — Continuous	I_B	150	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.5 20	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



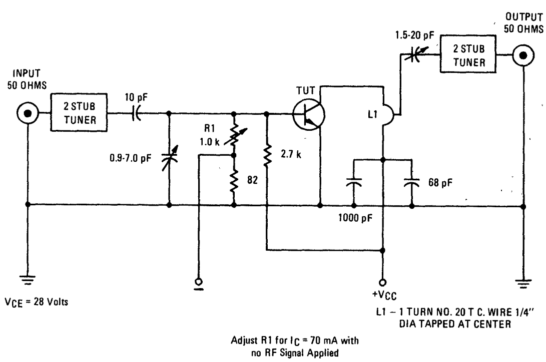
STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 — 500 MHz TEST CIRCUIT



***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 20 mAdc, I_B = 0)	$V_{CEO(sus)}$	35	–	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 20 mAdc, R_{BE} = 10 ohms)	$V_{CER(sus)}$	55	–	–	Vdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = -1.5 Vdc)	I_{CEX}	–	–	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc)		20	–	200	
(I_C = 400 mAdc, V_{CE} = 5.0 Vdc)		5.0	–	–	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	700	1000	–	MHz
Output Capacitance (V_{CB} = 28 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	1.2	3.5	pF
FUNCTIONAL TEST					
Power Input (Figure 1) (P_{out} = 750 mW, V_{CE} = 28 Vdc, R_S = 50 Ohms, f = 500 MHz)	P_{in}	–	–	75	mW
Collector Efficiency (Figure 1) (P_{out} = 750 mW, V_{CE} = 28 Vdc, R_S = 50 Ohms, f = 500 MHz)	η	35	–	–	%

*Indicates JEDEC Registered Data.

FIGURE 2 — CURRENT-GAIN—BANDWIDTH PRODUCT

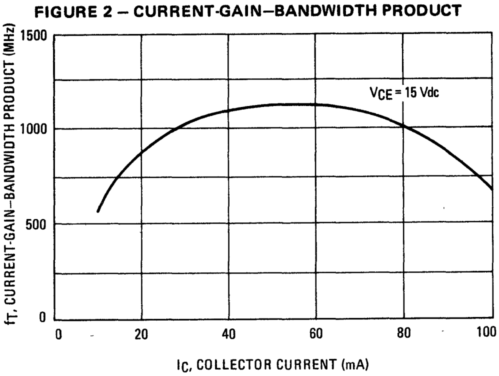
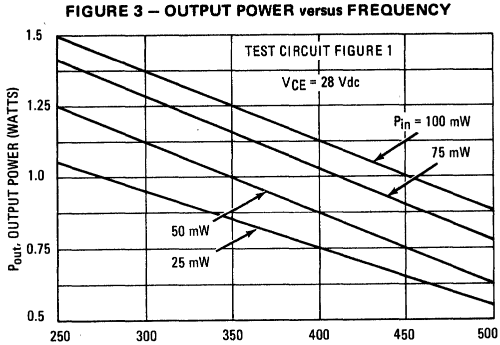
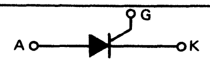


FIGURE 3 — OUTPUT POWER versus FREQUENCY



2N4441 (SILICON) thru 2N4444



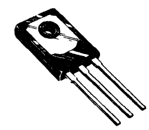
PLASTIC THYRISTORS

. . . designed for high-volume consumer phase-control applications such as motor speed, temperature, and light controls and for switching applications in ignition and starting systems, voltage regulators, vending machines, and lamp drivers requiring:

- Small, Rugged, Thermopad Construction – for Low Thermal Resistance, High Heat Dissipation, and Durability.
- Practical Level Triggering and Holding Characteristics @ 25°C
  I_{GT} = 7.0 mA (Typ)
  I_H = 6.0 mA (Typ)
- Low "On" Voltage – V_{TM} = 1.0 Volt (Typ) @ 5.0 Amp @ 25°C
- High Surge Current Rating – I_{TSM} = 80 Amp

PLASTIC SILICON CONTROLLED RECTIFIERS

8.0 AMPERES RMS
50 thru 600 VOLTS



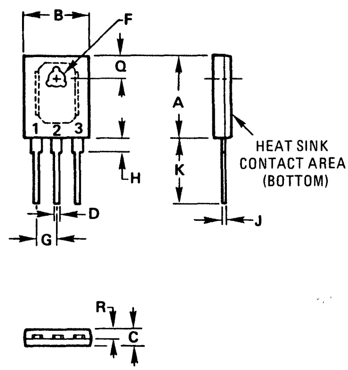
MAXIMUM RATING (T_J = 100°C unless otherwise noted.)

Rating	Symbol	Value	Unit
*Repetitive Peak Reverse Blocking Voltage (Note 1)	V_{RRM}		Volts
2N4441		50	
2N4442		200	
2N4443		400	
2N4444		600	
*Non-Repetitive Peak Reverse Blocking Voltage (t = 5.0 ms (max) duration)	V_{RSM}		Volts
2N4441		75	
2N4442		300	
2N4443		500	
2N4444		700	
*RMS On-State Current (All Conduction Angles)	$I_{T(RMS)}$	8.0	Amp
Average On-State Current, T_C = 73°C	$I_{T(AV)}$	5.1	Amp
*Peak Non-Repetitive Surge Current (1/2 cycle, 60 Hz preceded and followed by rated current and voltage)	I_{TSM}	80	Amp
Circuit Fusing Considerations (T_J = −40 to +100°C; t = 1.0 to 8.3 ms)	I^2t	25	A^2s
*Peak Gate Power	P_{GM}	5.0	Watts
*Average Gate Power	$P_{G(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GM}	2.0	Amp
*Peak Reverse Gate Voltage	V_{RGM}	10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Mounting Torque (6-32 screw) (Note 2)	–	8.0	in. lb.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
*Thermal Resistance, Junction to Case	$R_{\theta JC}$	–	2.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	40	–	°C/W

*Indicates JEDEC Registered Data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.95	16.71	0.628	0.658
B	12.45	13.21	0.490	0.520
C	3.05	3.81	0.120	0.150
D	1.09	1.25	0.043	0.049
F	3.51	3.76	0.138	0.148
G	4.22 BSC		0.166 BSC	
H	–	3.18	–	0.125
J	0.76	0.86	0.030	0.034
K	14.99	16.51	0.590	0.650
Q	4.50	5.00	0.177	0.197
R	1.91	2.16	0.075	0.085

CASE 90-04

STYLE 1:
PIN 1. CATHODE
2. ANODE
3. GATE

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Peak Forward Blocking Voltage (T_J = 100°C) Note 1	V_{DRM}				Volts
2N4441		50	–	–	
2N4442		200	–	–	
2N4443		400	–	–	
2N4444		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, T_J = 100°C, gate open)	I_{DRM}	–	–	2.0	mA
Peak Reverse Blocking Current (Rated V_{DRM}, T_J = 100°C, gate open)	I_{RRM}	–	–	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms)	I_{GT}				mA
T_C = 25°C		–	7.0	30	
* T_C = -40°C				60	
Gate Trigger Voltage (Continuous dc)	V_{GT}				Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ohms) T_C = 25°C		–	0.75	1.5	
* (Anode Voltage = 7.0 Vdc, R_L = 100 Ohms) T_C = –40°C		–	–	2.5	
* (Anode Voltage = Rated V_{DRM}, R_L = 100 Ohms) T_J = 100°C		0.2	–	–	
Peak On-State Voltage (Pulse Width = 1.0 to 2.0 ms, Duty Cycle ⩽ 2.0%)	V_{TM}				Volts
(I_{TM} = 5.0 A peak)		–	1.0	1.5	
* (I_{TM} = 15.7 A peak)		–	–	2.0	
Holding Current (Anode Voltage = 7.0 Vdc, gate open)	I_H				mA
T_C = 25°C		–	6.0	40	
* T_C = -40°C		–	–	70	
Gate Controlled Turn-On Time (I_{TM} = 5.0 A, I_{GT} = 20 mA)	t_{gt}	–	1.0	–	μs
Circuit Commutated Turn-Off Time	t_q				μs
(I_{TM} = 5.0 A, I_R = 5.0 A)		–	15	–	
(I_{TM} = 5.0 A, I_R = 5.0 A, T_J = 100°C)		–	20	–	
Critical Rate of Rise of Off-State Voltage (Rated V_{DRM}, Exponential Waveform, T_J = 100°C, Gate Open)	dv/dt	–	50	–	V/μs

*Indicates JEDEC Registered Data

Note 1. Ratings apply for zero or negative gate voltage but positive gate voltage shall not be applied concurrently with a negative potential on the anode. When checking forward or reverse blocking capability, thyristor devices should not be tested with a constant current source in a manner that the voltage applied exceeds the rated blocking voltage.

Note 2. Torque rating applies with use of torque washer (Shakeproof WD19522 #6 or equivalent). Mounting torque in excess of 8 in. lbs. does not appreciably lower case-to-sink thermal resistance. Anode lead and heatsink contact pad are common.

For soldering purposes (either terminal connection or device mounting), soldering temperatures shall not exceed +225°C.

FIGURE 1 – MAXIMUM FORWARD VOLTAGE

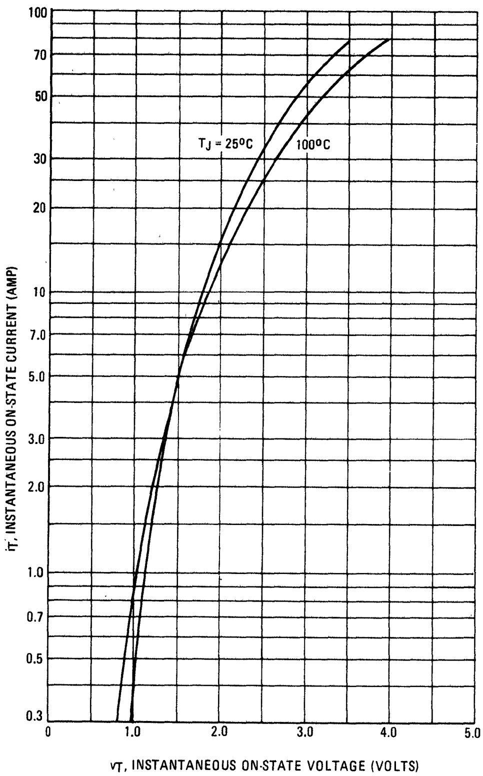


FIGURE 2 – MAXIMUM ON-STATE POWER DISSIPATION

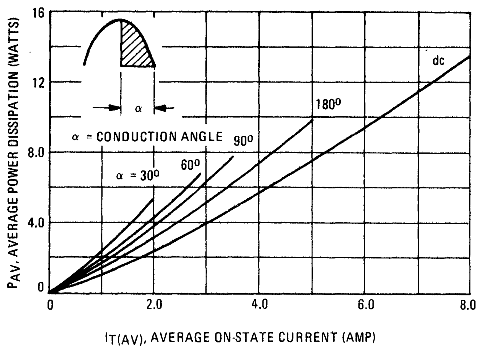


FIGURE 3 – AVERAGE CURRENT DERATING

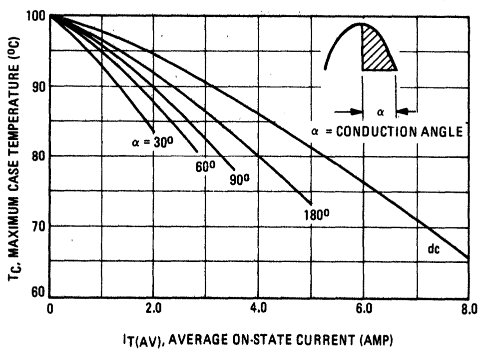


FIGURE 4 – THERMAL RESPONSE

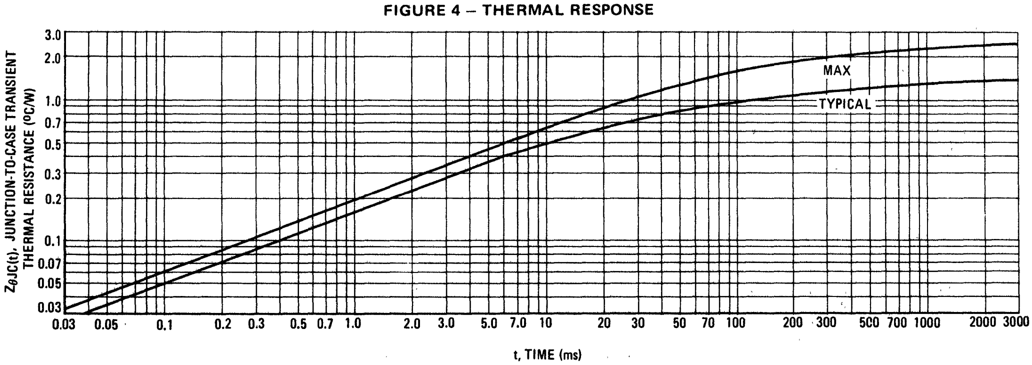


FIGURE 5 – MAXIMUM NON-REPETITIVE SURGE CURRENT

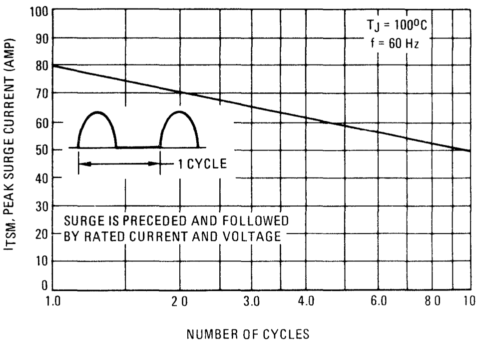


FIGURE 6 – TYPICAL HOLDING CURRENT

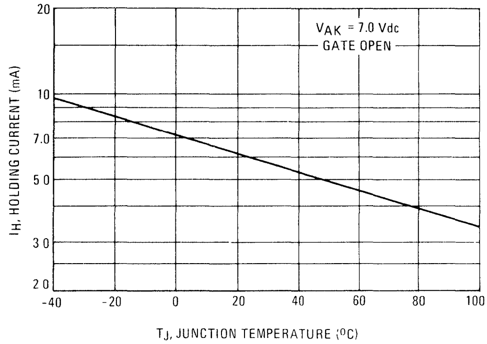


FIGURE 7 – TYPICAL GATE TRIGGER CURRENT

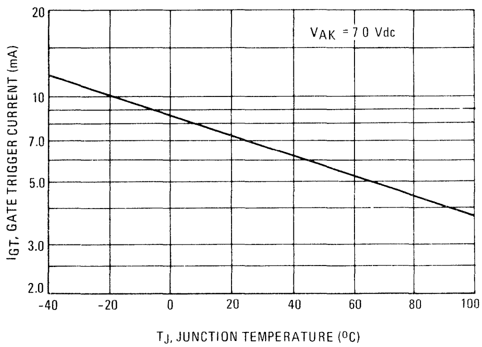
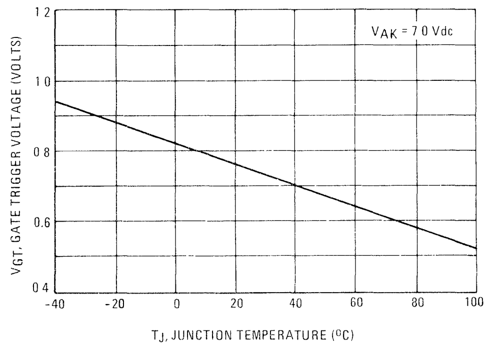


FIGURE 8 – TYPICAL GATE TRIGGER VOLTAGE



SELECTED THYRISTOR-TRIGGER APPLICATION NOTES

AN-240 —SCR Power Control Fundamentals
AN-290B —Mounting Procedure for, and Thermal Aspects of, Thermopad Plastic Power Devices
AN-295 —Suppressing RFI in Thyristor Circuits
AN-422 —Testers for Thyristors and Trigger Diodes
AN-453 —Zero Point Switching Techniques

To obtain copies of these notes list the AN number(s) on your company letterhead and send your request to

Technical Information Center
Motorola Semiconductor Products, Inc.
P.O. Box 20924
Phoenix, Arizona 85036

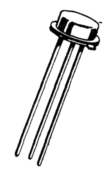
2N4450 (SILICON)

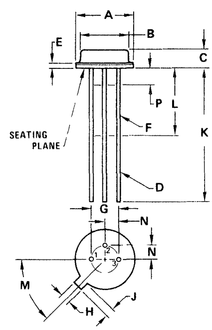
NPN SILICON ANNULAR TRANSISTOR

. . . designed for general-purpose amplifier and switching applications requiring TO-46 package configurations.

- Collector-Emitter Breakdown Voltage — BV_{CEO} = 30 Vdc (Min) @ I_C = 10 mAdc
- DC Current Gain — 100 μAdc to 500 mAdc
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.2 Vdc (Typ) @ I_C = 150 mAdc
- High Current-Gain—Bandwidth Product — f_T = 350 MHz (Typ) @ I_C = 50 mAdc
- Fast Switching Time — (Figures 1 and 2)
  t_{on} = 50 ns (Typ)
  t_{off} = 125 ns (Typ)

NPN SILICON GENERAL PURPOSE TRANSISTOR





STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	1.65	2.16	0.065	0.085
D	0.406	0.533	0.016	0.021
E	–	1.02	–	0.040
F	0.305	0.483	0.012	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC dimensions and notes apply

CASE 26-03
TO-46

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage (1)	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	500	mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$(2)	485	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	58	°C/W
Lead Temperature 1/16" From Case for 60 Seconds	T_L	300	°C

*Indicates JEDEC Registered Data.
(1) Applicable 0 to 100 mA, Pulse Width = 10 μs, Duty Cycle ≤ 2.0%.
(2) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (1)	I_{CBO}				
(V_{CB} = 50 Vdc, I_E = 0)		–	–	10	nAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		–	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)	I_{EBO}	–	–	10	nAdc
Base Current (V_{CE} = 50 Vdc, V_{BE} = 0)	I_B	–	–	10	nAdc
ON CHARACTERISTICS (1)					
DC Current Gain	h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		35	75	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		50	90	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		75	125	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		100	200	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)		50	–	–	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)		50	–	–	
(I_C = 300 mAdc, V_{CE} = 1.0 Vdc)		35	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_A = -55°C) (1)		30	–	–	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.2	0.22	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.3	0.45	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	0.5	0.60	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$				Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		–	0.7	1.1	
(I_C = 300 mAdc, I_B = 30 mAdc)		–	0.9	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		–	1.2	1.5	
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	–	0.8	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	350	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 150 kHz)	C_{cb}	–	40	8.0	pF
Collector-Emitter Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz)	C_{eb}	–	15	20	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (V_{CC} = 25 Vdc, $V_{BE(off)}$ = 0 V, I_C = 300 mAdc, I_{B1} = 30 mAdc) (Figure 1)	t_{on}	–	50	60	ns
Delay Time	t_d	–	10	30	ns
Rise Time	t_r	–	40	55	ns
Turn-Off Time (V_{CC} = 25 Vdc, I_C = 300 mAdc, I_{B1} = I_{B2} = 30 mAdc) (Figure 2)	t_{off}	–	125	150	ns
Storage Time	t_s	–	100	140	ns
Fall Time	t_f	–	25	100	ns

*Indicates JEDEC Registered Data.
(1) Pulse Test: Pulse Width ≤300 μs, Duty Cycle ≤2.0%.

FIGURE 1 – TURN-ON TIME

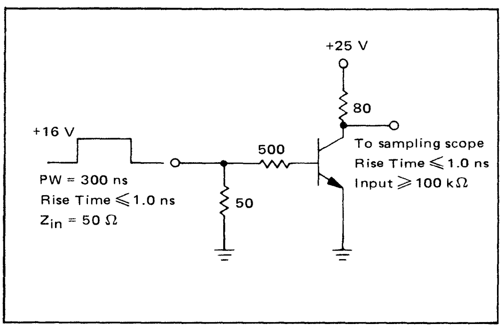
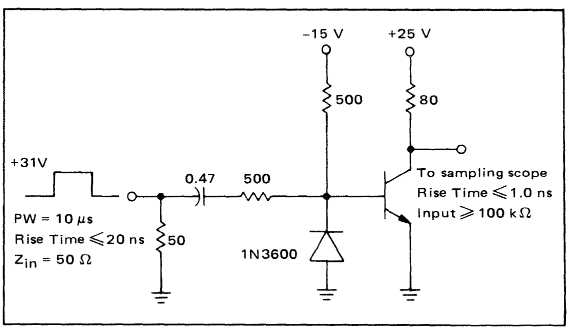


FIGURE 2 – TURN-OFF TIME



2N4453

For Specifications, See 2N869A Data

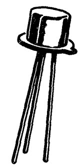
2N4851 thru 2N4853 (SILICON)

SILICON ANNULAR UNIJUNCTION TRANSISTORS

. . . designed for pulse and timing circuits, sensing circuits, and thyristor trigger circuits.

- Low Peak-Point Current — $I_P = 0.4\ \mu A$ Max
- Low Emitter Reverse Current — $I_{EO} = 50$ nA Max
- Fast Switching — 1.0 MHz Min

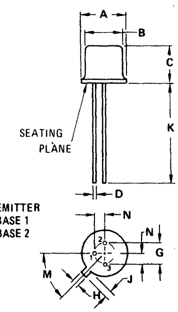
PN UNIJUNCTION TRANSISTORS



*MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation (1)	P_D	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current (2)	i_e	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage (3)	V_{B2B1}	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Indicates JEDEC Registered Data
(1) Derate 3.0 mW/°C increase in ambient temperature.
(2) Duty cycle ≤ 1%, PRR = (see figure 6)
(3) Based upon power dissipation at T_A = 25°C



STYLE 1
PIN 1. EMITTER
2. BASE 1
3. BASE 2

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.48	0.016	0.019
G	2.54 TYP		0.100 TYP	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
M	45° TYP		45° TYP	
N	1.27 TYP		0.050 TYP	

CASE 22A

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

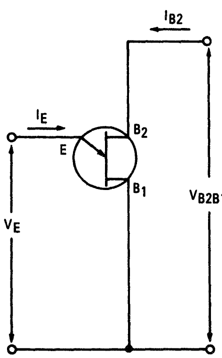
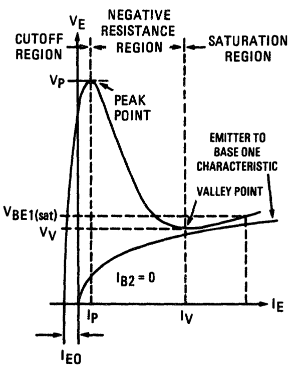


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Rating		Figure No.	Symbol	Min	Typ	Max	Unit
*Intrinsic Standoff Ratio (1) (V_{B2B1} = 10 V)	2N4851 2N4852, 2N4853	4, 8	η	0.56 0.70	— —	0.75 0.85	—
*Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		11, 12	r_{BB}	4.7	—	9.1	k ohms
*Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		12	αr_{BB}	0.2	—	0.8	%/°C
Emitter Saturation Voltage (2) (V_{B2B1} = 10 V, I_E = 50 mA)			$V_{EB1(sat)}$	—	2.5	—	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)			$I_{B2(mod)}$	—	15	—	mA
*Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)	2N4851, 2N4852 2N4853	7	I_{EB2O}	— —	— —	0.1 0.05	µA
*Peak-Point Emitter Current (V_{B2B1} = 25 V)	2N4851, 2N4852 2N4853	9, 10	I_P	— —	— —	2.0 0.4	µA
*Valley-Point Current (2) (V_{B2B1} = 20 V, R_{B2} = 100 ohms)	2N4851 2N4852 2N4853	13, 14	I_V	2.0 4.0 6.0	— — —	— — —	mA
*Base-One Peak Pulse Voltage	2N4851 2N4852 2N4853	3, 17	V_{OB1}	3.0 5.0 6.0	— — —	— — —	Volts
*Maximum Frequency of Oscillation		5	$f_{(max)}$	1.0	1.25	—	MHz

* Indicates JEDEC Registered Data.

(1) η, Intrinsic standoff ratio, is defined in terms of the peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is about 0.49 volt at 25°C @ I_F = 10 µA and decreases with temperature at about 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator; the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

(2) Use pulse techniques: PW ≈ 300 µs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

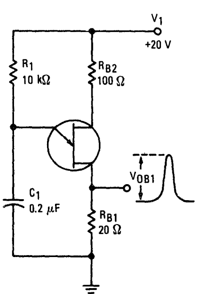
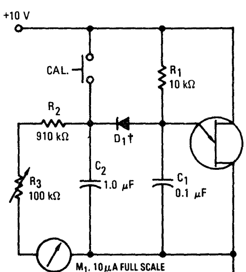


FIGURE 4 — η TEST CIRCUIT



†D1 diode with the following characteristics.
V_F = 0.49 V @ I_F = 10 µA
I_R ≦ 2.0 µA @ V_R = 20 V

FIGURE 5 — $f_{(max)}$ TEST CIRCUIT

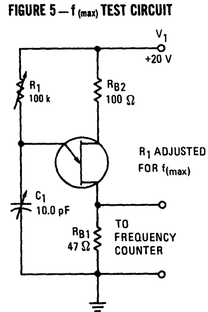
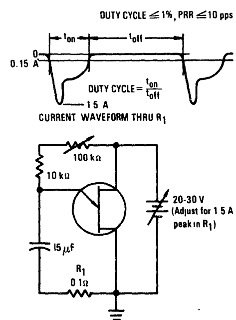


FIGURE 6 — PRR TEST CIRCUIT AND WAVEFORM



TYPICAL CHARACTERISTICS

FIGURE 7 — EMITTER REVERSE CURRENT

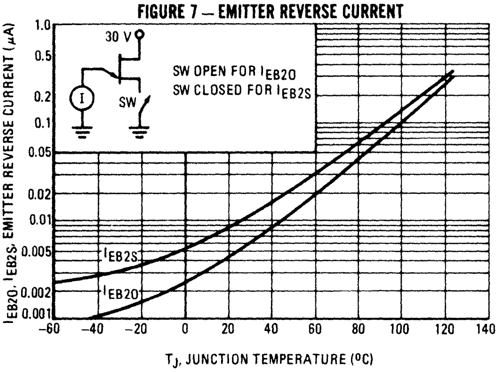
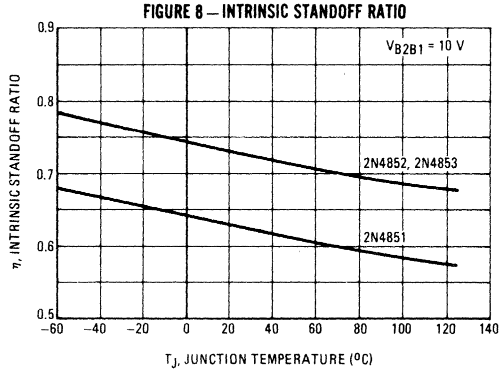


FIGURE 8 — INTRINSIC STANDOFF RATIO



PEAK POINT CURRENT

FIGURE 9 — EFFECT OF VOLTAGE

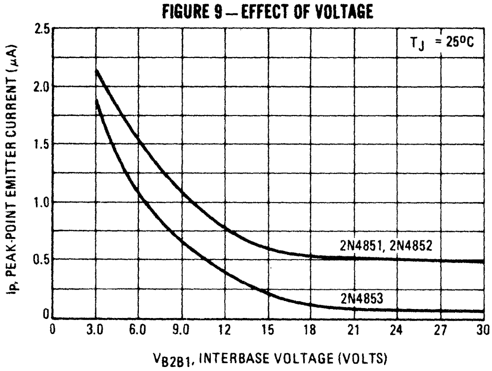
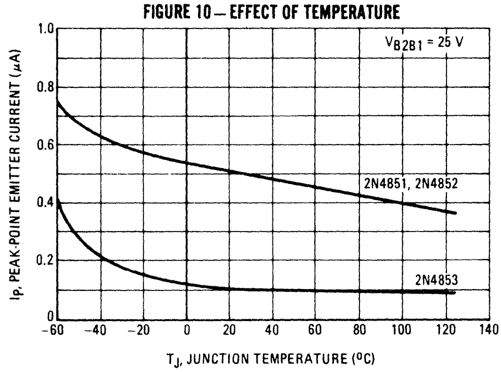


FIGURE 10 — EFFECT OF TEMPERATURE



INTERBASE RESISTANCE

FIGURE 11 — EFFECT OF VOLTAGE

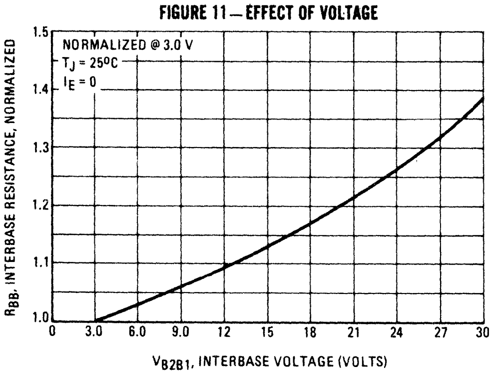
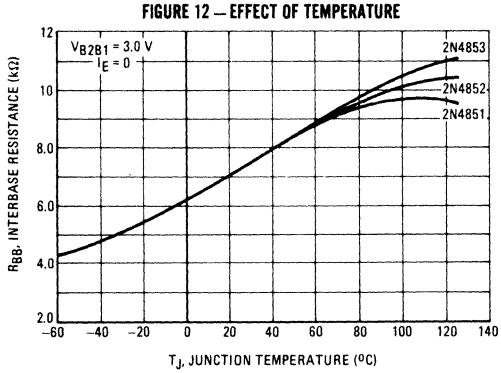


FIGURE 12 — EFFECT OF TEMPERATURE



TYPICAL CHARACTERISTICS

VALLEY CURRENT

FIGURE 13 — EFFECT OF VOLTAGE

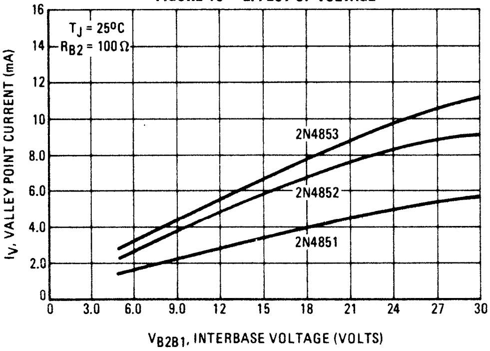
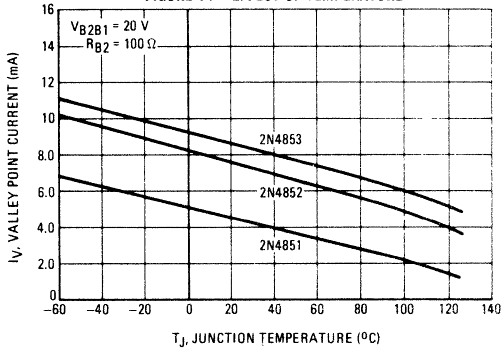


FIGURE 14 — EFFECT OF TEMPERATURE



VALLEY VOLTAGE

FIGURE 15 — EFFECT OF VOLTAGE

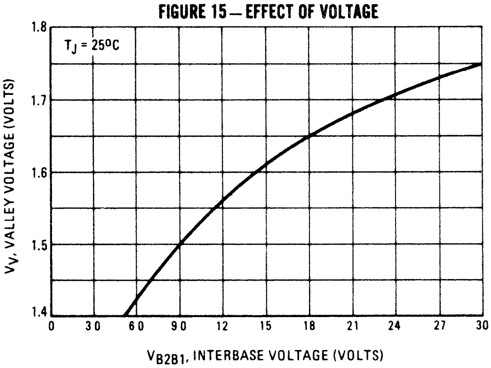


FIGURE 16 — EFFECT OF TEMPERATURE

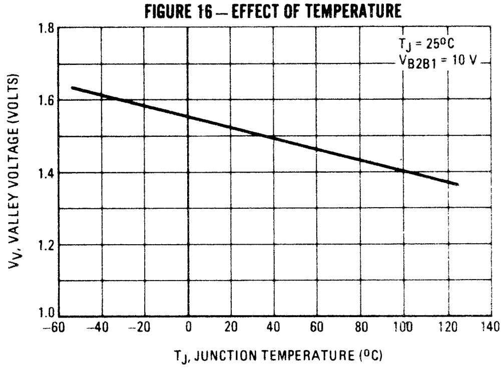
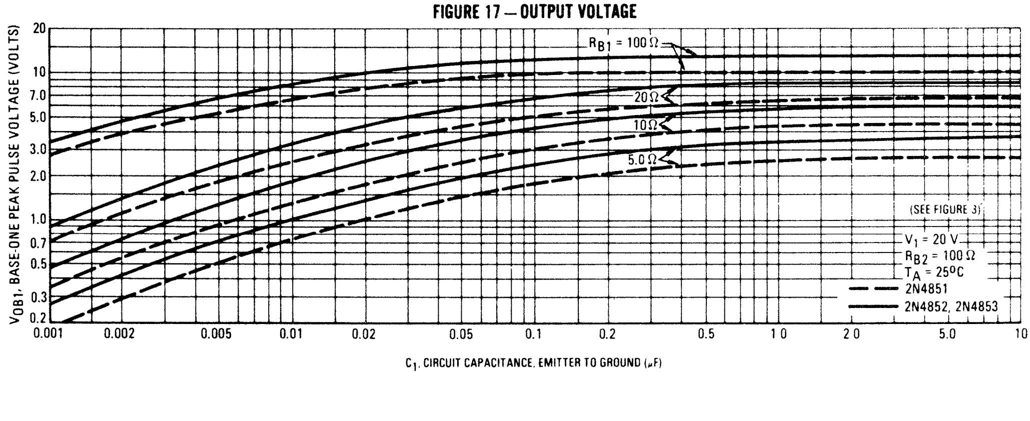


FIGURE 17 — OUTPUT VOLTAGE



2N4854 (SILICON)
2N4855

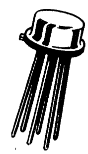
2N4854JAN,JTX,JTXV Available

MULTIPLE SILICON ANNULAR TRANSISTORS

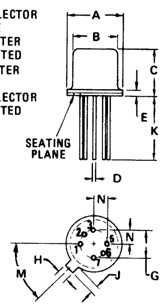
. . . designed for use as differential amplifiers, dual general-purpose switches and amplifiers, front end detectors, and temperature compensation amplifiers.

- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.4 Vdc (Max) @ I_C = 150 mAdc
- Fast Switching Times —
  t_{on} = 60 ns (Max) and t_{off} = 350 ns (Max)
- DC Current Gain Specified —
  0.1 mAdc to 300 mAdc
- High Current-Gain—Bandwidth Product —
  f_T = 200 MHz (Typ) @ I_C = 20 mAdc

NPN/PNP SILICON MULTIPLE TRANSISTORS



STYLE 1:
PIN 1. COLLECTOR
2. BASE
3. EMITTER
4. OMITTED
5. EMITTER
6. BASE
7. COLLECTOR
8. OMITTED



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.51	9.40	0.335	0.370
B	7.75	8.51	0.305	0.335
C	3.81	4.70	0.150	0.185
D	0.41	0.53	0.016	0.021
G	5.08 BSC		0.200 BSC	
H	0.71	0.86	0.028	0.034
J	0.74	1.14	0.029	0.045
K	12.70	—	0.500	—
M	45° BSC		45° BSC	
N	2.54 BSC		0.100 BSC	

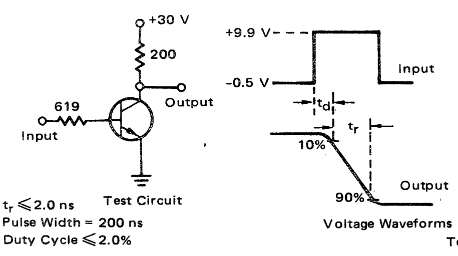
CASE 654-07

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating any Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CB}	60		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	600		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	600 4.0	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67	2.0 13.33	Watts
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

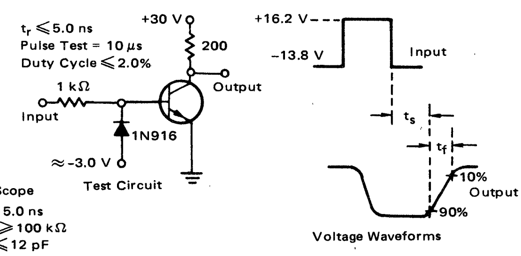
FIGURE 1 — DELAY AND RISE TIMES



$t_r \leq$ 2.0 ns
Pulse Width = 200 ns
Duty Cycle $\leq$ 2.0%

Test Circuit

FIGURE 2 — STORAGE AND FALL TIMES



$t_r \leq$ 5.0 ns
Pulse Test = 10 μs
Duty Cycle $\leq$ 2.0%

Test Circuit

To Scope
$t_r \leq$ 5.0 ns
$R_{in} \geq$ 100 kΩ
$C_{in} \leq$ 12 pF

Voltage Waveforms

For PNP Test Circuit, Reverse diode and voltage polarities.

*ELECTRICAL CHARACTERISTICS (Each Side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	10	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N4854		35	–	
	2N4855		20	–	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N4854		50	–	
	2N4855		25	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N4854		75	–	
	2N4855		35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc) (1)	2N4854		100	300	
	2N4855		40	120	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (1)	2N4854		50	–	
	2N4855		20	–	
(I_C = 300 mAdc, V_{CE} = 10 Vdc) (1)	2N4854		35	–	
	2N4855		20	-	
Collector-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$	0.75	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	200	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)		C_{cb}	–	8.0	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854	h_{ie}	1.5	9.0	k ohms
	2N4855		0.75	4.5	
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854	h_{fe}	60	300	–
	2N4855		30	150	
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	2N4854	h_{oe}	–	50	μmhos
	2N4855		–	25	
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 1.0 k ohm, f = 1.0 kHz)		NF	–	8.0	dB
SWITCHING CHARACTERISTICS					
Delay Time	(V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.5 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc)	t_d	–	20	ns
Rise Time		t_r	–	40	ns
Storage Time	(V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc)	t_s	–	280	ns
Fall Time		t_f	–	70	ns

* Indicates JEDEC Registered Data.
(1)Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle≤2 0%.

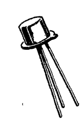
2N4856, A
thru
2N4861, A

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode symmetrical Field-Effect transistors designed for low-power switching and chopper applications.

- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 25 Ohms (Max) @ f = 1.0 kHz – 2N4856,A, 2N4859,A
- Low Drain Cutoff Current –
  $I_{D(off)}$ = 250 pAdc (Max) @ V_{DS} = 15 Vdc

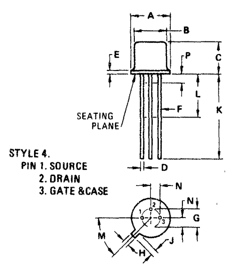
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS



*MAXIMUM RATINGS

Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	-30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

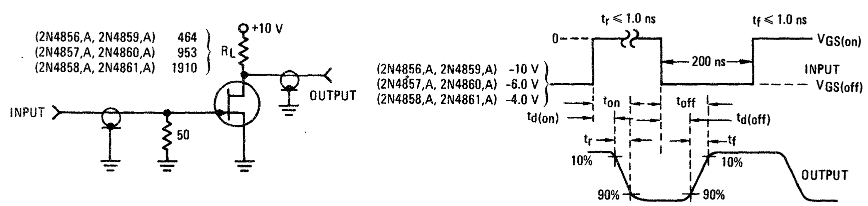


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



TEST CIRCUIT

VOLTAGE WAVEFORMS

NOTES: a. The input waveforms are supplied by a generator with the following characteristics:
Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%.
b. Waveforms are monitored on an oscilloscope with the following characteristics:
$t_r \leq$ 0.75 ns, $R_{in} \geq$ 1.0 megohm, $C_{in} \leq$ 2.5 pF.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A	$V_{(BR)GSS}$	-40	–	Vdc
	2N4859,A,2N4860,A,2N4861,A		-30	–	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	2N4856,A,2N4859,A	$V_{GS(off)}$	-4.0	-10	Vdc
	2N4857,A,2N4860,A		-2.0	-6.0	
	2N4858,A,2N4861,A		-0.8	-4.0	
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A	I_{GSS}	–	0.25	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0)	2N4859,A,2N4860,A,2N4861,A		–	0.25	
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)	2N4856,A,2N4857,A,2N4858,A		–	0.5	μAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)	2N4859,A,2N4860,A,2N4861,A		–	0.5	
Drain Cutoff Current (V_{DS} = 15 Vdc, V_{GS} = -10 Vdc)		$I_{D(off)}$	–	0.25	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -10 Vdc, T_A = 150°C)			–	0.5	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4856,A,2N4859,A	I_{DSS}	50	–	mAdc
	2N4857,A,2N4860,A		20	100	
	2N4858,A,2N4861,A		8.0	80	
Drain-Source "ON" Voltage (I_D = 20 mAdc, V_{GS} = 0)	2N4856,A,2N4859,A	$V_{DS(on)}$	–	0.75	Vdc
(I_D = 10 mAdc, V_{GS} = 0)	2N4857,A,2N4860,A		–	0.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N4858,A,2N4861,A		–	0.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4856,A,2N4859,A	$r_{ds(on)}$	–	25	Ohms
	2N4857,A,2N4860,A		–	40	
	2N4858,A,2N4861,A		–	60	
Input Capacitance (V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861	C_{iss}	–	18	pF
	2N4856 A thru 2N4861 A			10	
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861	C_{rss}	–	8.0	pF
	2N4856 A,2N4859 A		–	4.0	
	2N4857 A,2N4858 A,2N4860 A,2N4861 A		–	3.5	

SWITCHING CHARACTERISTICS (See Figure 1) (2)

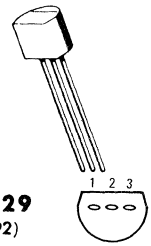
Characteristic	Conditions	Device	Symbol	Min	Max	Unit
Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc)	2N4856, 2N4859	$t_{d(on)}$	–	6.0	ns
		2N4856A, 2N4859A		–	5.0	
		2N4857, 2N4860		–	6.0	
		2N4857A, 2N4860A		–	6.0	
		2N4858, 2N4861		–	10	
		2N4858A, 2N4861A		–	8.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -6.0 Vdc)	2N4856,A, 2N4859,A	t_r	–	3.0	ns
		2N4857,A, 2N4860,A		–	4.0	
		2N4858, 2N4861		–	10	
		2N4858A, 2N4861A		–	8.0	
Turn-Off Time	Conditions for 2N4858,A, 2N4861,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -4.0 Vdc)	2N4856, 2N4859	t_{off}	–	25	ns
		2N4856A, 2N4859A		–	20	
		2N4857, 2N4860		–	50	
		2N4857A, 2N4860A		–	40	
		2N4858, 2N4861		–	100	
		2N4858A; 2N4861A		–	80	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

(2) The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

2N4870 (SILICON)
2N4871



STYLE 9
PIN 1. BASE 1
2. EMITTER
3 BASE 2

CASE 29
(TO-92)

PN unijunction transistors designed for use in pulse and timing circuits, sensing circuits and thyristor trigger circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D*	300	mW
RMS Emitter Current	I_e	50	mA
Peak-Pulse Emitter Current**	i_e**	1.5	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Interbase Voltage†	V_{B2B1}†	35	Volts
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Derate 3.0 mW/°C increase in ambient temperature.
**Duty cycle ≦ 1%, PRR = 10 PPS (see Figure 5).
†Based upon power dissipation at T_A = 25°C.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

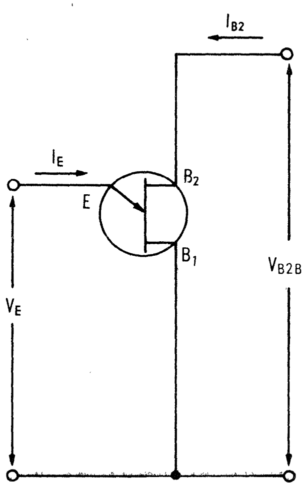
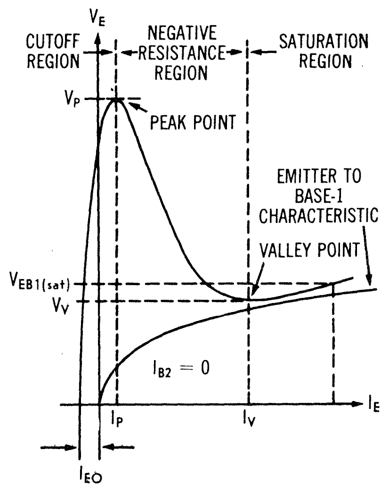


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio* (V_{B2B1} = 10 V)	2N4870 2N4871	4, 7	η*	0.56 0.70	- -	0.75 0.85	-
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)		10, 11	R_{BB}	4.0	6.0	9.1	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65 to +125°C)		11	αR_{BB}	0.10	-	0.90	%/°C
Emitter Saturation Voltage** (V_{B2B1} = 10 V, I_E = 50 mA)			$V_{EB1(sat)}$**	-	2.5	-	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)			$I_{B2(mod)}$	-	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0)		6	I_{EB2O}	-	0.005	1.0	µA
Peak-Point Emitter Current (V_{B2B1} = 25 V)		8, 9	I_P	-	1.0	5.0	µA
Valley-Point Current** (V_{B2B1} = 20 V, R_{B2} = 100 ohms)	2N4870 2N4871	12, 13	I_V**	2.0 4.0	5.0 7.0	- -	mA
Base-One Peak Pulse Voltage	2N4870 2N4871	3, 16	V_{OB1}	3.0 5.0	6.0 8.0	- -	Volts

* η Intrinsic standoff ratio, is defined in terms of peak-point voltage, V_P, by means of the equation: $V_P = \eta V_{B2B1} + V_F$, where V_F is approximately 0.49 volt at 25°C @ I_F = 10 µA and decreases with temperature at approximately 2.5 mV/°C. The test circuit is shown in Figure 4. Components R_1, C_1, and the UJT form a relaxation oscillator, the remaining circuitry serves as a peak-voltage detector. The forward drop of Diode D_1 compensates for V_F. To use, the "cal" button is pushed, and R_3 is adjusted to make the current meter, M_1, read full scale. When the "cal" button is released, the value of η is read directly from the meter, if full scale on the meter reads 1.0.

** Use pulse techniques: PW ≈ 300 µs, duty cycle ≦ 2.0% to avoid internal heating, which may result in erroneous readings.

FIGURE 3 — V_{OB1} TEST CIRCUIT

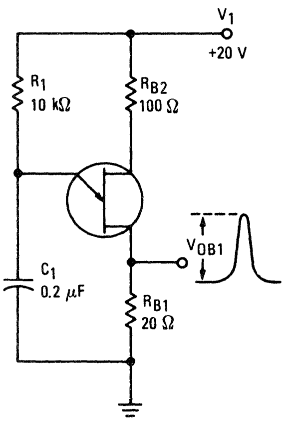
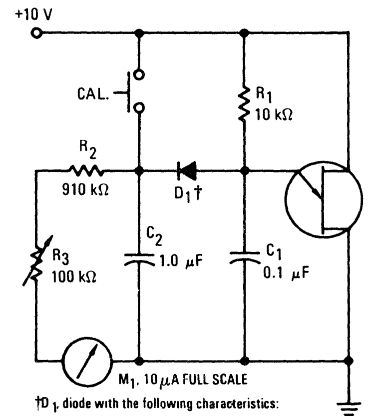
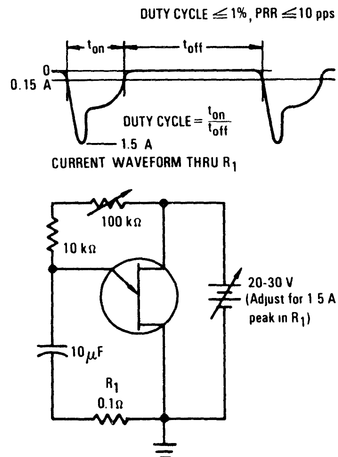


FIGURE 4 — η TEST CIRCUIT



†D1, diode with the following characteristics:
V_F = 0.49 V @ I_F = 10 µA
I_R ≦ 2.0 µA @ V_R = 20 V

FIGURE 5 — PRR TEST CIRCUIT AND WAVEFORM



TYPICAL CHARACTERISTICS

FIGURE 6 — EMITTER REVERSE CURRENT

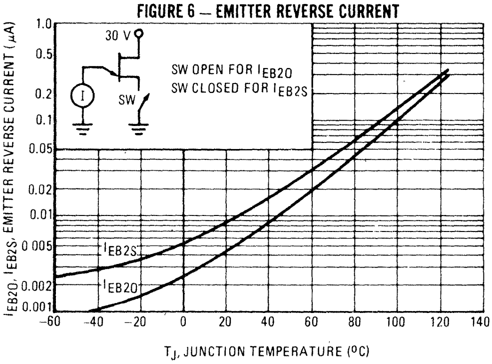
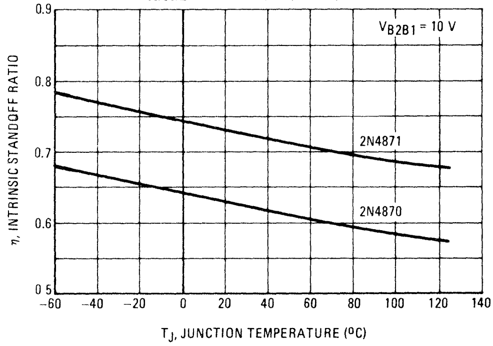


FIGURE 7 — INTRINSIC STANDOFF RATIO



PEAK POINT CURRENT

FIGURE 8 — EFFECT OF VOLTAGE

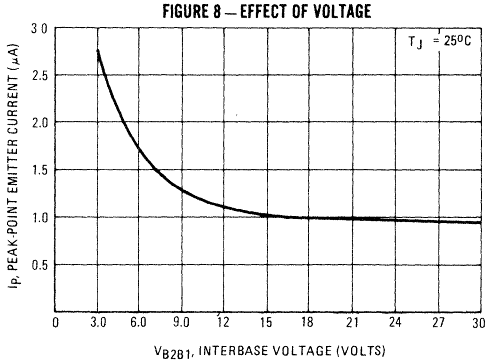
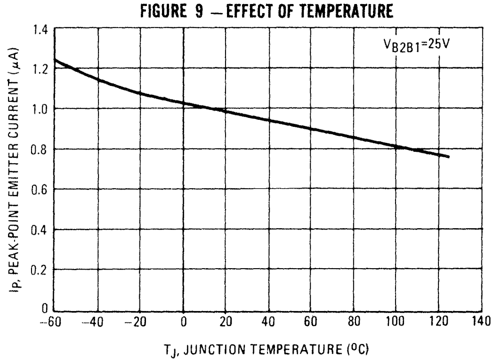


FIGURE 9 — EFFECT OF TEMPERATURE



INTERBASE RESISTANCE

FIGURE 10 — EFFECT OF VOLTAGE

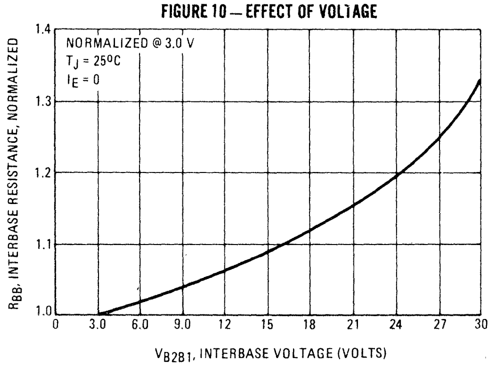
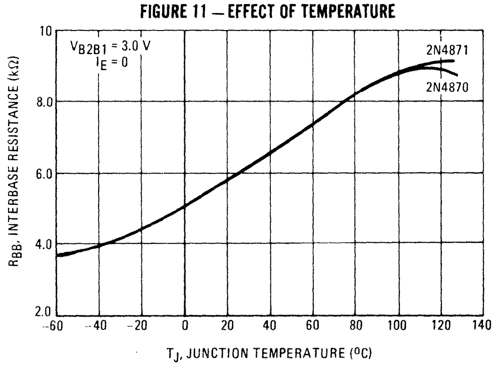


FIGURE 11 — EFFECT OF TEMPERATURE



TYPICAL CHARACTERISTICS

VALLEY CURRENT

FIGURE 12 — EFFECT OF VOLTAGE

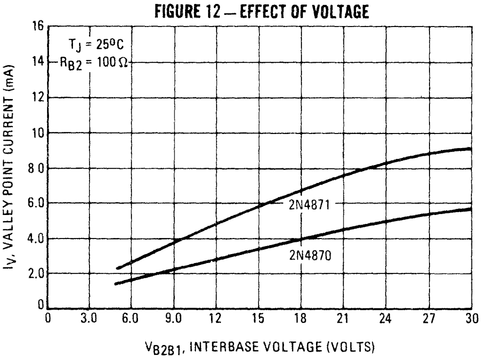
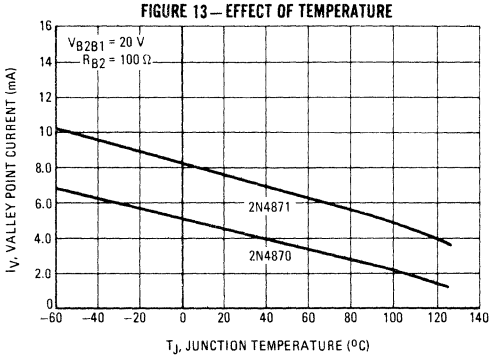


FIGURE 13 — EFFECT OF TEMPERATURE



VALLEY VOLTAGE

FIGURE 14 — EFFECT OF VOLTAGE

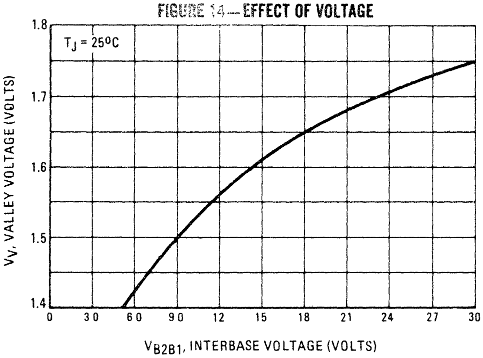


FIGURE 15 — EFFECT OF TEMPERATURE

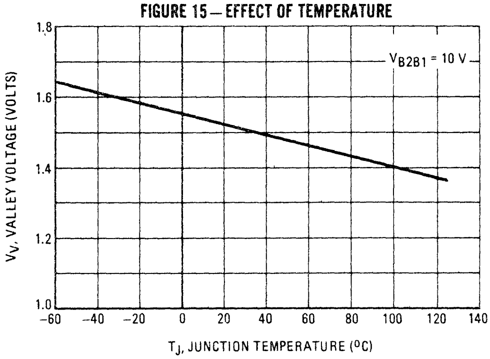
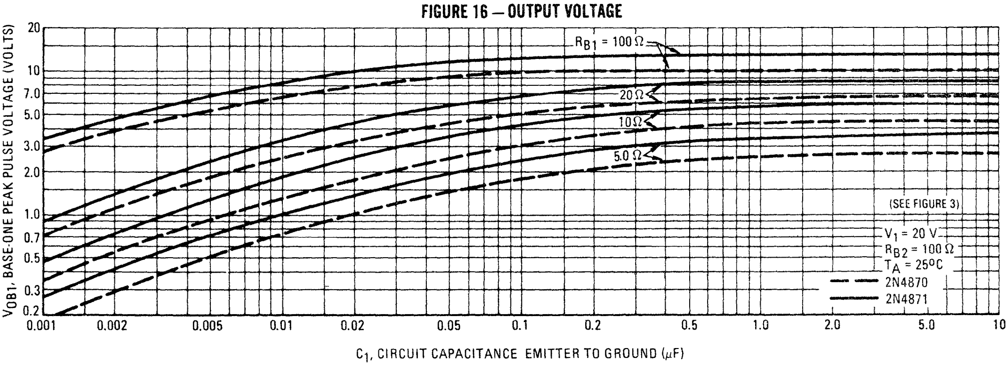


FIGURE 16 — OUTPUT VOLTAGE



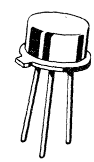
MEDIUM-POWER NPN SILICON TRANSISTOR

. . . designed for switching and wide band amplifier applications.

- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 4.0 Amp
- DC Current Gain Specified to 4 Amperes
- Excellent Safe Operating Area
- Packaged in the Compact TO-39 Case for Critical Space-Limited Applications.

4 AMPERE
POWER TRANSISTOR

NPN SILICON
60 VOLTS
10 WATTS



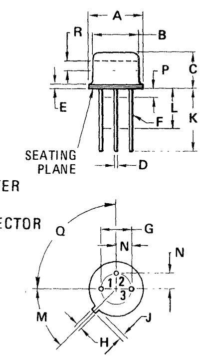
* MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Base Voltage	V_{CB}	70	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	4.0	Adc
Base Current	I_B	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	10 57.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	17.5	°C/W



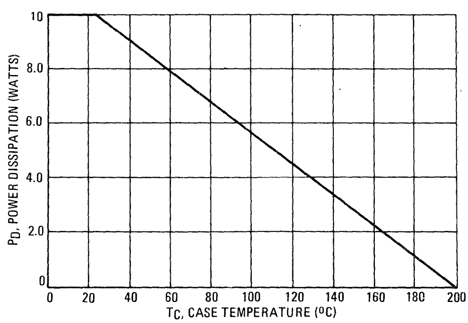
STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. All limits are applicable and must be observed.

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector Cutoff Current	I_{CEX}			
(V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc)		–	100	μAdc
(V_{CE} = 70 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)		–	1.0	mAdc
Collector Cutoff Current (V_{CB} = 70 Vdc, I_E = 0)	I_{CBO}	–	100	μAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	100	μAdc
ON CHARACTERISTICS(1)				
DC Current Gain	h_{FE}			–
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)		30	–	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)		20	100	
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 0.4 Adc)	$V_{BE(sat)}$	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product	f_T			MHz
(I_C = 0.25 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		4.0	–	
(I_C = 0.25 Adc, V_{CE} = 10 Vdc, f = 10 MHz)**		30	–	
SWITCHING CHARACTERISTICS				
Rise Time (V_{CC} = 25 Vdc, I_C = 4.0 Adc, I_{B1} = 0.4 Adc)	t_r	–	100	ns
Storage Time (V_{CC} = 25 Vdc, I_C = 4.0 Adc, I_{B1} = I_{B2} = 0.4 Adc)	t_s	–	1.5	μs
Fall Time (V_{CC} = 25 Vdc, I_C = 4.0 Adc, I_{B1} = I_{B2} = 0.4 Adc)	t_f	–	500	ns

*Indicates JEDEC Registered Data.
**Motorola guarantees this value in addition to JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA

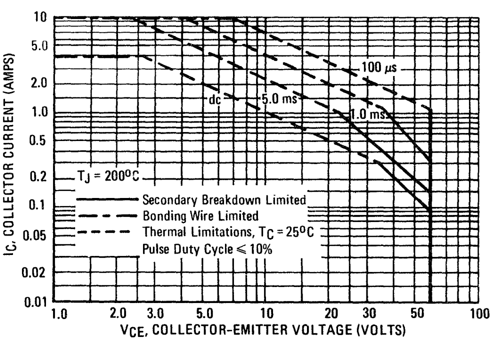
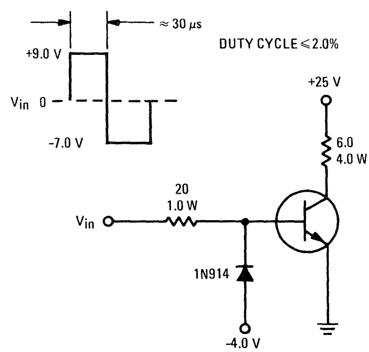


FIGURE 3 – SWITCHING TIME TEST CIRCUIT



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C–V_{CE} limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 2 is based on $T_{J(pk)}$ = 200°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

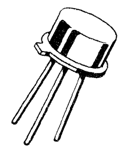
2N4890S (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for applications in audio-output feedback control, and general, medium-current switching and amplifier circuits.

- Direct Complement to NPN 2N3053
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = 0.12 Vdc (Typ) @ I_C = 150 mAdc
- High Current-Gain—Bandwidth Product — f_T = 280 (Typ) @ I_C = 50 mAdc

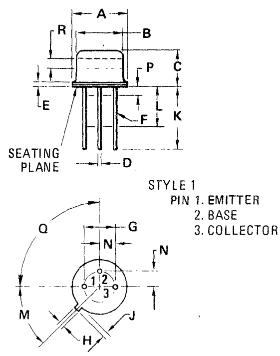
PNP SILICON SWITCHING AND AMPLIFIER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Collector Current — Continuous	I_C	500 700**	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.
**Motorola Guarantees this Data in Addition to JEDEC Registered Data.



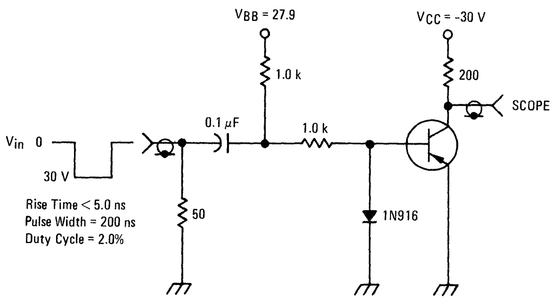
STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 89	9 40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0 406	0.533	0.016	0.021
E	0.229	3.18	0 009	0.125
F	0.406	0.483	0 016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0 864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12 70	–	0.500	–
L	6 35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2 54	–	0.100	–

All JEDEC dimensions and notes apply.

CASE 79-02
TO-39

FIGURE 1 — SWITCHING TIMES TEST CIRCUIT

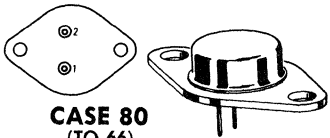


SCOPE CHARACTERISTICS
IMPEDANCE 10 MEG MIN
CAPACITANCE 7.0 pF MAX

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 μAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 ohms)	BV_{CER}	50	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{CEX}	–	–	0.25	μAdc
Base Cutoff Current (V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	I_{BL}	–	–	0.25	μAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)	h_{FE}				–
(I_C = 150 mAdc, V_{CE} = 2.5 Vdc)		25	130	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)		50	140	250	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	–	0.12	1.4	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	–	0.82	1.7	Vdc
Base-Emitter On Voltage (I_C = 150 mAdc, V_{CE} = 2.5 Vdc)	$V_{BE(on)}$	–	0.74	1.7	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	f_T	100	280	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	–	9.0	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	–	60	80	pF
SWITCHING CHARACTERISTICS					
Delay Time (V_{CC} = 30 Vdc, $V_{BE(off)}$ = 0.8 Vdc, I_C = 150 mAdc, I_{B1} = 15 mAdc) (Figure 1)	t_d	–	15	50	ns
Rise Time	t_r	–	20	50	ns
Storage Time (V_{CC} = 30 Vdc, I_C = 150 mAdc, I_{B1} = I_{B2} = 15 mAdc) (Figure 1)	t_s	–	110	200	ns
Fall Time	t_f	–	20	70	ns

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.



CASE 80
(TO-66)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

Collector connected to case

Medium-power PNP silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to NPN 2N4910 thru 2N4912.

MAXIMUM RATINGS

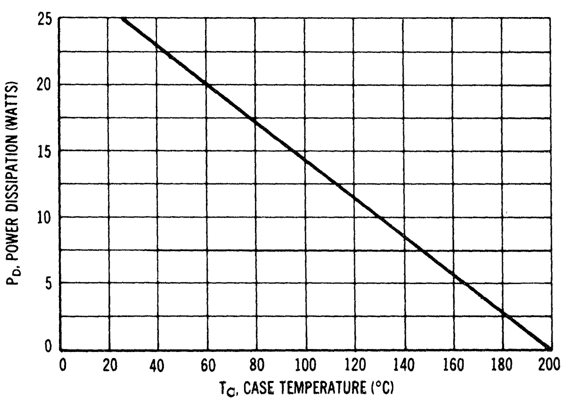
Rating	Symbol	2N4898	2N4899	2N4900	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous *	I_C*	← 1.0 → ← 4.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	← 25 → ← 0.143 →			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.
The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage [1] (I_C = 0.1 Adc, I_B = 0) 2N4898 / 2N4899 / 2N4900	-	$BV_{CEO(sus)}$	40 / 60 / 80	- / - / -	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) 2N4898 / (V_{CE} = 30 Vdc, I_B = 0) 2N4899 / (V_{CE} = 40 Vdc, I_B = 0) 2N4900		I_{CEO}	- / - / -	0.5 / 0.5 / 0.5	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc) / (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	12	I_{CEX}	- / -	0.1 / 1.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS [1]					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc) / (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) / (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	8	h_{FE}	40 / 20 / 10	- / 100 / -	-
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$	-	1.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C - 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	-

(1) Pulse Test: PW ≈300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

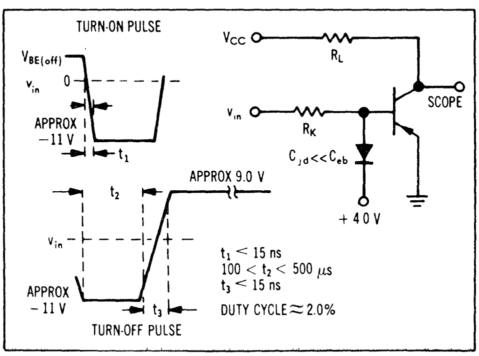


FIGURE 3 — TURN-ON TIME

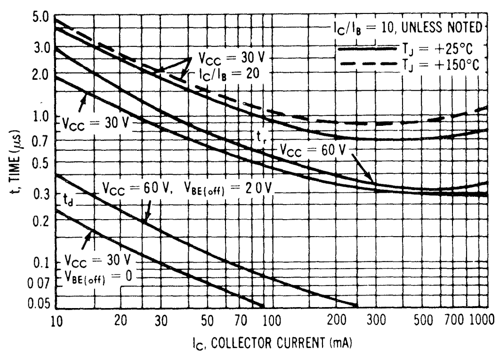


FIGURE 4 — THERMAL RESPONSE

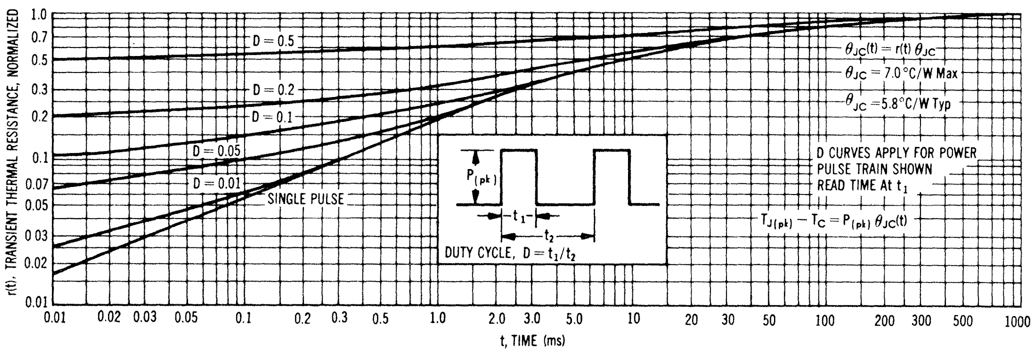
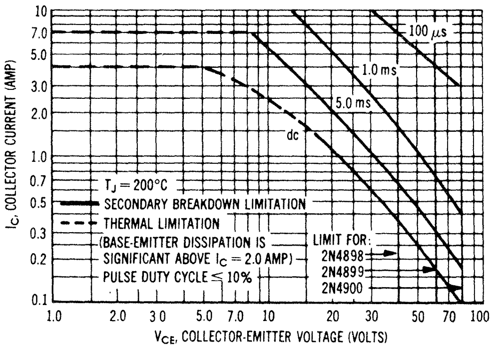


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



The safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor which must be observed for reliable operation. Collector load lines for specific circuits must fall below the limits indicated by the applicable curve.

The data of Figure 5 is based upon $T_{J(pk)}$ = 200°C; T_C is variable depending upon conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} \leq$ 200°C. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power which can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

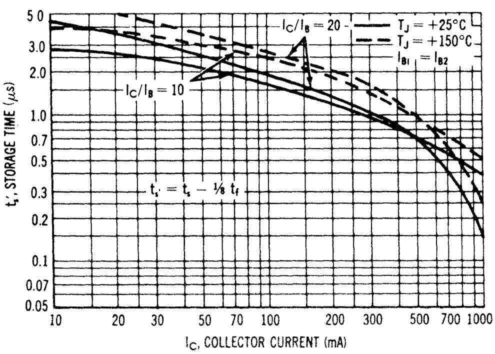


FIGURE 7 — FALL TIME

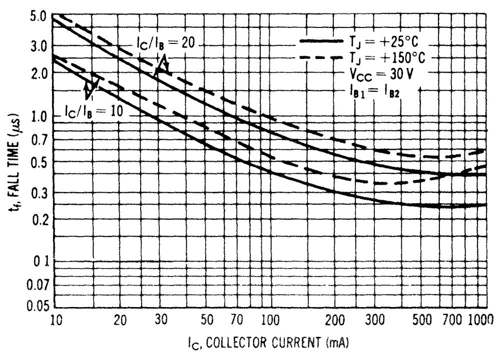


FIGURE 8 — CURRENT GAIN

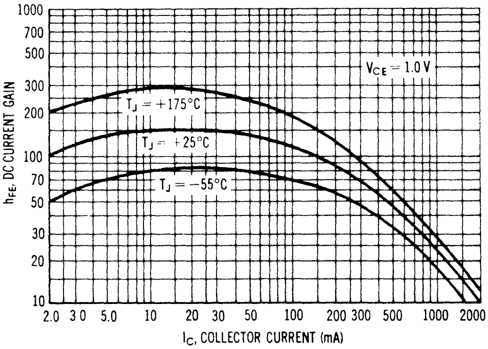


FIGURE 9 — COLLECTOR SATURATION REGION

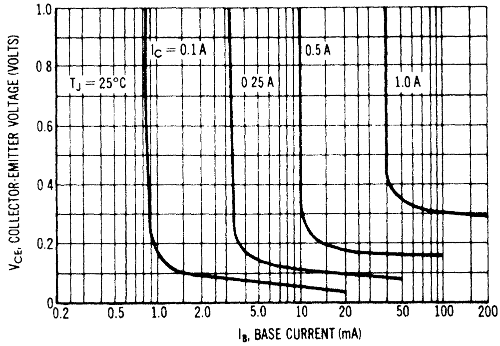


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

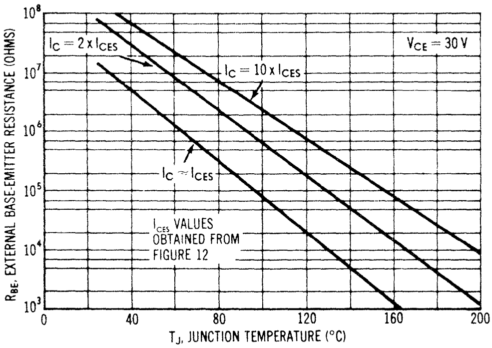


FIGURE 11 — "ON" VOLTAGE

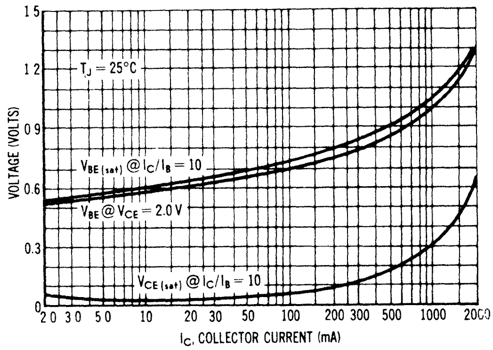


FIGURE 12 — COLLECTOR CUTOFF REGION

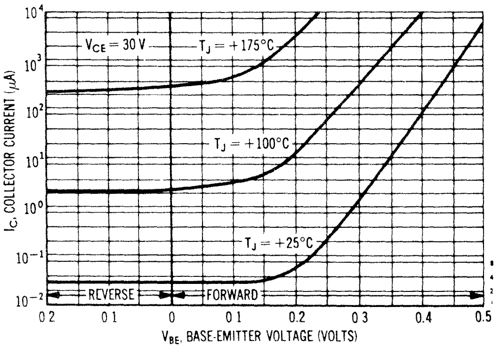
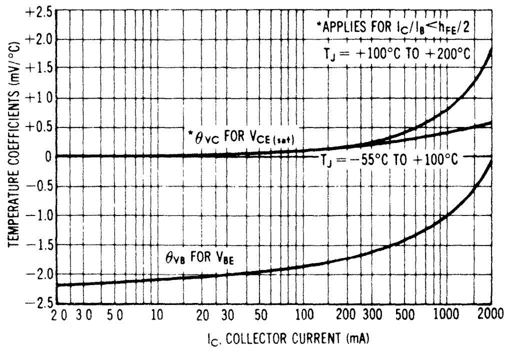
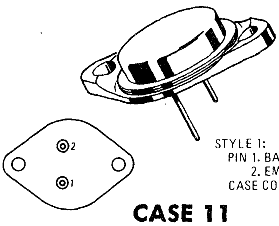


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4901 (SILICON)
2N4902
2N4903

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N5067, 2N5068, 2N5069.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

CASE 11

MAXIMUM RATINGS

Rating	Symbol	2N4901	2N4902	2N4903	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	←5.0→			Vdc
Collector Current — Continuous	I_C	←5.0→			Adc
Base Current	I_B	←1.0→			Adc
Total Device Dissipation $T_C = 25°C$ Derate above 25°C	P_D	←87.5→ ←0.5→			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* ($I_C = 0.2$ Adc, $I_B = 0$) 2N4901 / 2N4902 / 2N4903	11	$V_{CEO(sus)}$*	40 60 80	- - -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $I_B = 0$)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)} = 1.5$ Vdc) (V_{CE} = Rated V_{CEO}, $V_{BE(off)} = 1.5$ Vdc, $T_C = 150°C$)	5, 6	I_{CEX}	- -	0.1 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, $I_E = 0$)		I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current ($V_{BE} = 5.0$ Vdc, $I_C = 0$)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain* ($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc) ($I_C = 5.0$ Adc, $V_{CE} = 2.0$ Vdc)	1	h_{FE}*	20 7.0	80 -	-
Collector-Emitter Saturation Voltage* ($I_C = 1.0$ Adc, $I_B = 0.1$ Adc ($I_C = 5.0$ Adc, $I_B = 1.0$ Adc)	2, 3, 4	$V_{CE(sat)}$*	- -	0.4 1.5	Vdc
Base-Emitter On Voltage* ($I_C = 1.0$ Adc, $V_{CE} = 2.0$ Vdc)	3, 4	$V_{BE(on)}$*	-	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 1.0$ Adc, $V_{CE} = 10$ Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain ($I_C = 0.5$ Adc, $V_{CE} = 10$ Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

* Pulse Test: PW = 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

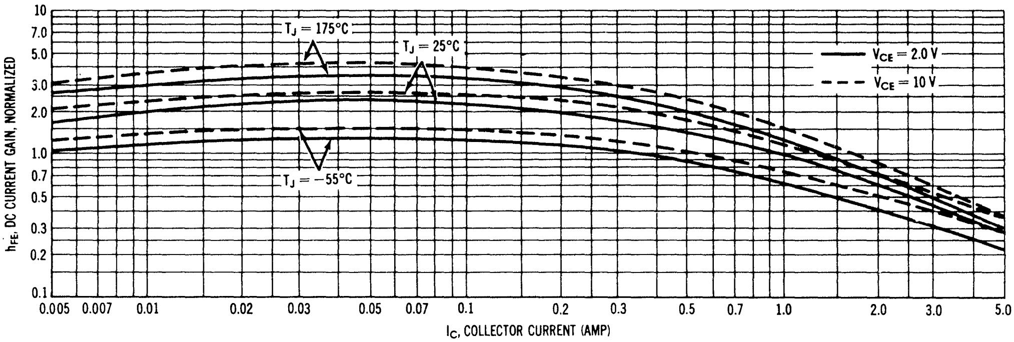


FIGURE 2 — COLLECTOR SATURATION REGION

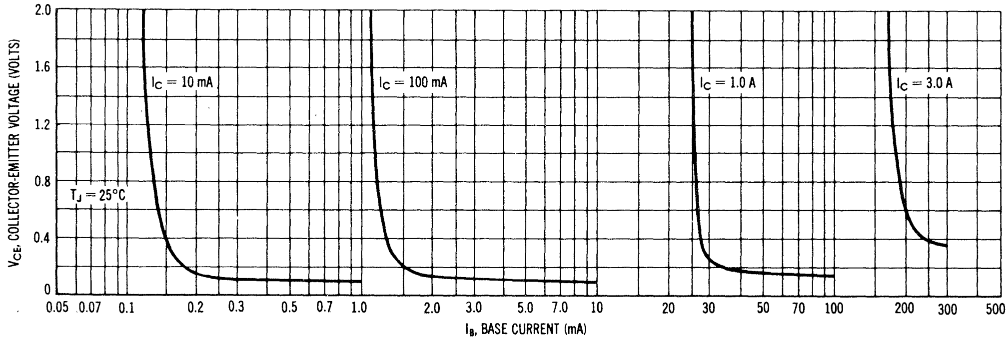


FIGURE 3 — "ON" VOLTAGE

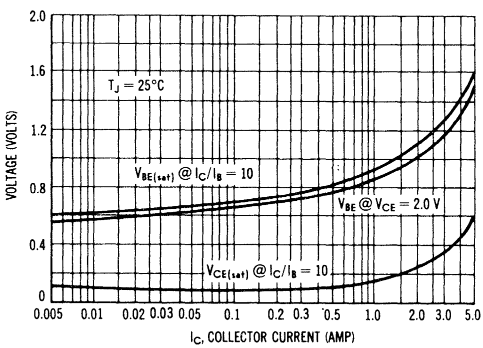
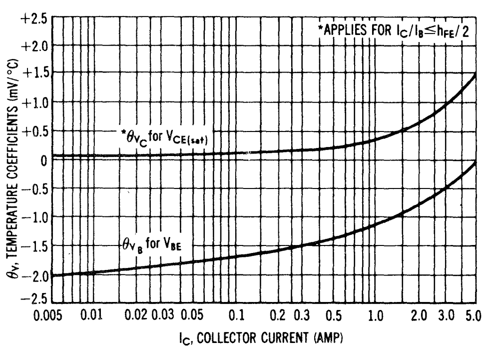


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

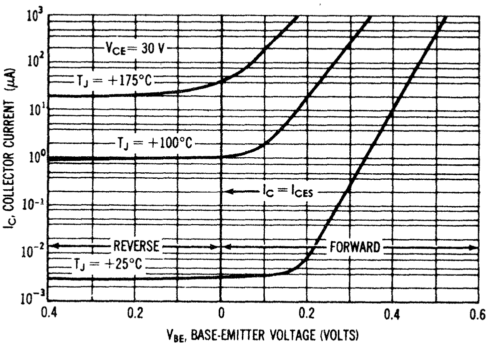


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

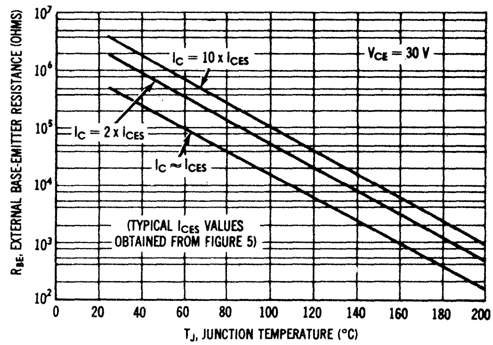


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

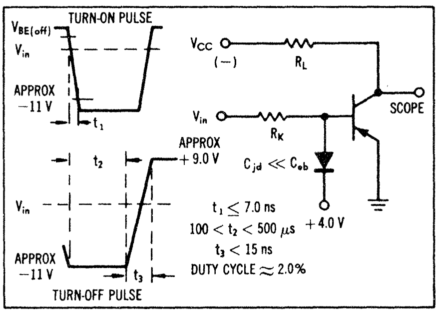


FIGURE 8 — CAPACITANCE

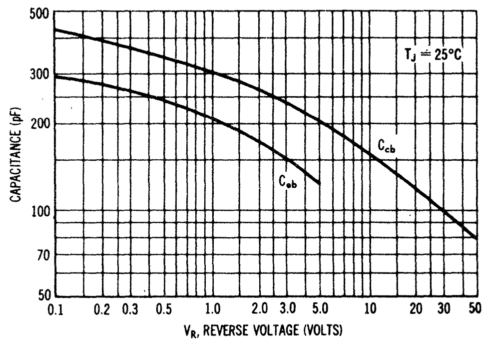


FIGURE 9 — TURN-ON TIME

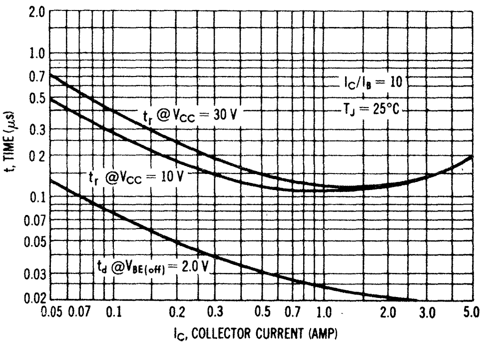
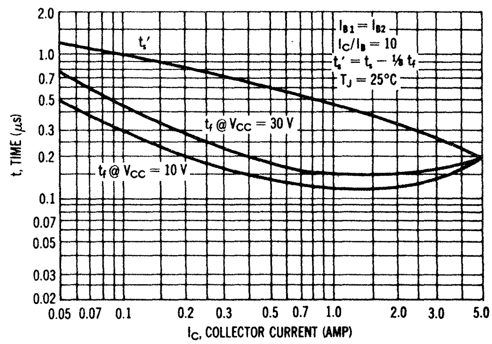
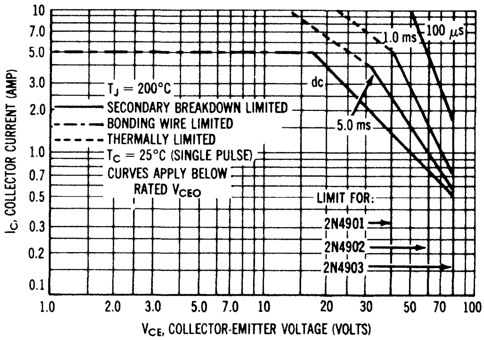


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

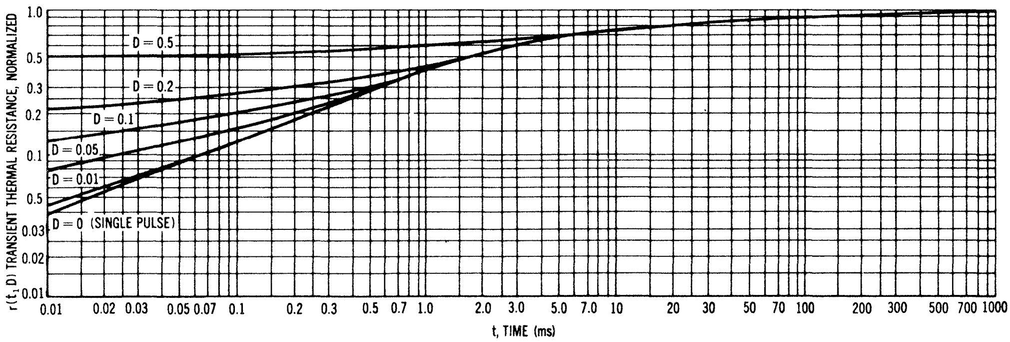
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

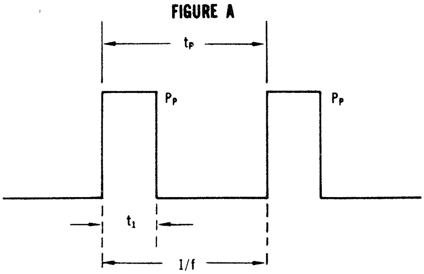
The data of Figure 11 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_P}$

PEAK PULSE POWER = P_P

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N4901 is dissipating 100 watts under the following conditions: $t_1 = 0.1$ ms, $t_P = 0.5$ ms. $(D = 0.2)$

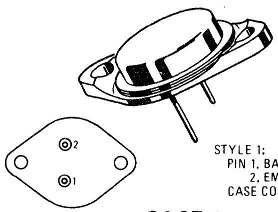
Using Figure 12, at a pulse width of 0.1 ms and $D = 0.2$, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54°C$$

2N4904 (SILICON)
2N4905
2N4906

PNP power transistors for use in power amplifier and switching circuits. Complement to NPN 2N4913 thru 2N4915.



STYLE 1:
PIN 1. BASE
2. EMITTER
CASE COLLECTOR

CASE 11

MAXIMUM RATINGS

Rating	Symbol	2N4904	2N4905	2N4906	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous	I_C	← 5.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
Total Device Dissipation T_C = 25°C Derate above 25°C	P_D	← 87.5 → ← 0.5 →			Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 0.2 Adc, I_B = 0) 2N4904 2N4905 2N4906	11	$V_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	5, 6	I_{CEX}	- -	0.1 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)		I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}	25 7.0	100 -	-
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 0.25 Adc) (I_C = 5.0 Adc, I_B = 1.0 Adc)	2, 3, 4	$V_{CE(sat)}$	- -	1.0 1.5	Vdc
Base-Emitter On Voltage (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$	-	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	-	

(1) Pulse Test: PW = 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

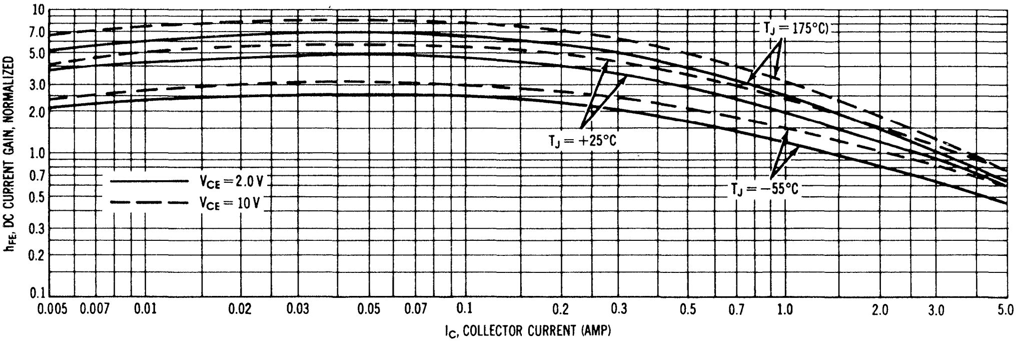


FIGURE 2 — COLLECTOR SATURATION REGION

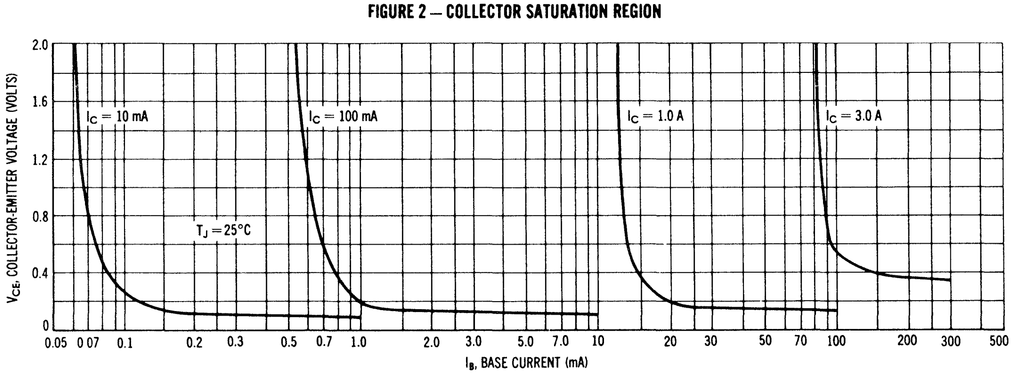


FIGURE 3 — "ON" VOLTAGE

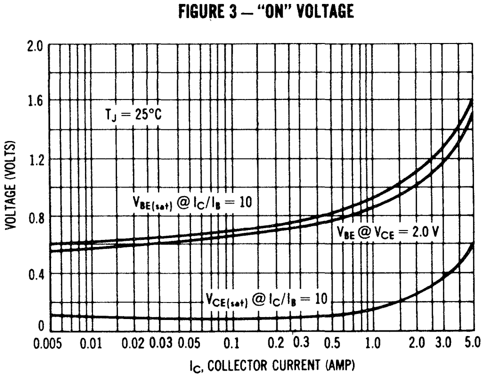
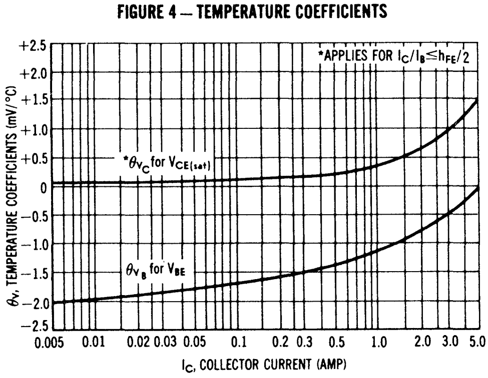


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

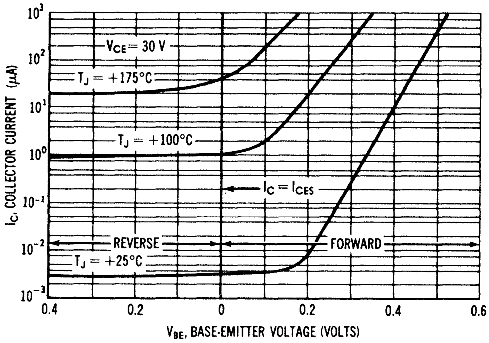


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

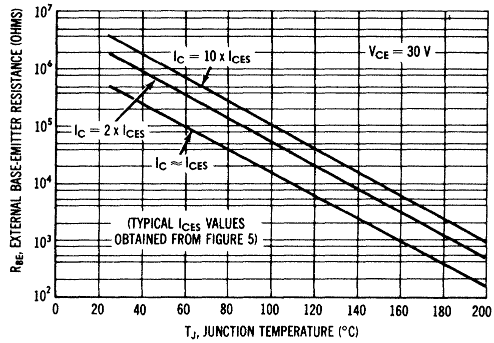


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

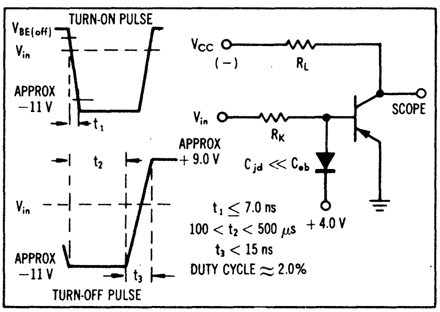


FIGURE 8 — CAPACITANCE

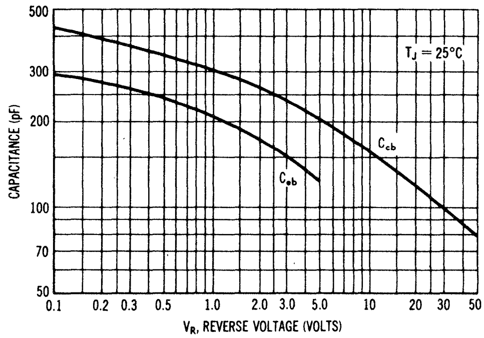


FIGURE 9 — TURN-ON TIME

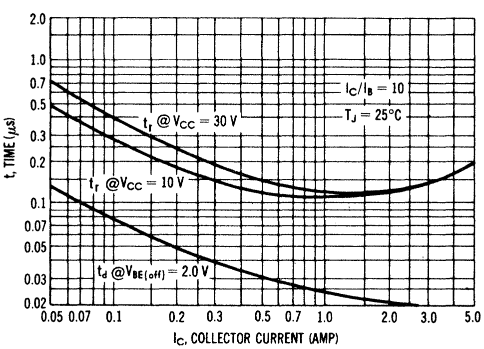
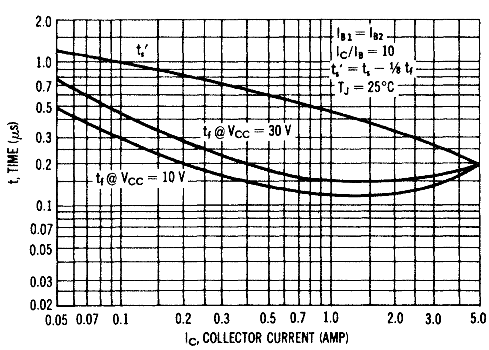
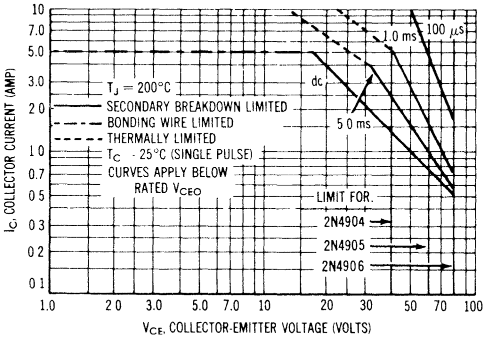


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

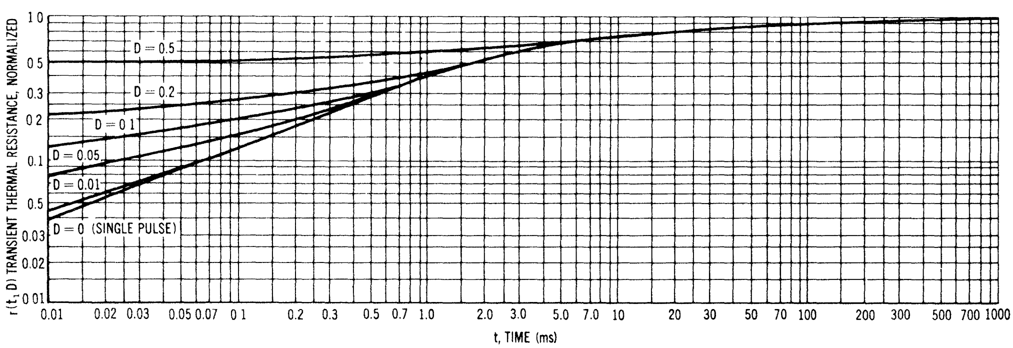
FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

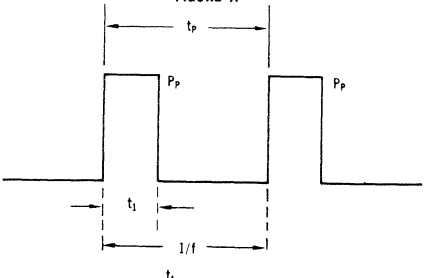
The data of Figure 11 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_P}$

PEAK PULSE POWER = P_P

A train of periodical power pulses can be represented by the model shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

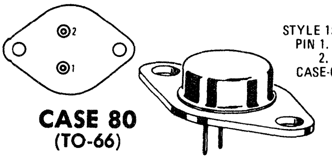
The 2N4904 is dissipating 100 watts under the following conditions: $t_1 = 0.1$ ms, $t_P = 0.5$ ms. (D = 0.2)

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of $r(t_1, D)$ is 0.27.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.27 \times 100 \times 2.0 = 54°C$$

2N4910 thru 2N4912 (SILICON)



CASE 80
(TO-66)

STYLE 1:
PIN 1. BASE
2. EMITTER
CASE-COLLECTOR

Medium-power NPN silicon transistors designed for driver circuits, switching, and amplifier applications. Complement to PNP 2N4898 thru 2N4900.

Collector connected to case

MAXIMUM RATINGS

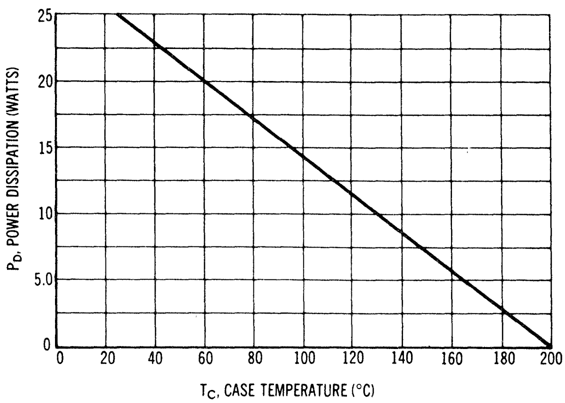
Rating	Symbol	2N4910	2N4911	2N4912	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous*	I_C*	← 1.0 → ← 4.0 →			Adc
Base Current — Continuous	I_B	← 1.0 →			Adc
Total Device Dissipation $T_C = 25°C$	P_D	← 25 →			Watts
Derate above 25°C		← 0.143 →			mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	°C/W

* The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements.
The 4.0 Amp maximum value is based upon actual current-handling capability of the device (see Figure 5).

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 5. All limits are applicable and must be observed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 0.1 Adc, I_B = 0) 2N4910	-	$BV_{CEO(sus)}$	40	-	Vdc
2N4911			60	-	
2N4912			80	-	
Collector Cutoff Current (V_{CE} = 20 Vdc, I_B = 0) 2N4910	-	I_{CEO}	-	0.5	mAdc
(V_{CE} = 30 Vdc, I_B = 0) 2N4911			-	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4912			-	0.5	
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)	12	I_{CEX}	-	0.1	mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)			-	1.0	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	-	I_{CBO}	-	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	-	I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	8	h_{FE}	40	-	-
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	-	
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	9, 11, 13	$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc)	11, 13	$V_{BE(sat)}$	-	1.3	Vdc
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	11, 13	$V_{BE(on)}$	-	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	-	f_T	3.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	-	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	-	h_{fe}	25	-	

(1) Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

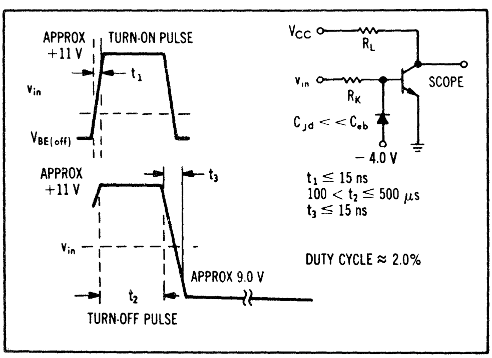


FIGURE 3 — TURN-ON TIME

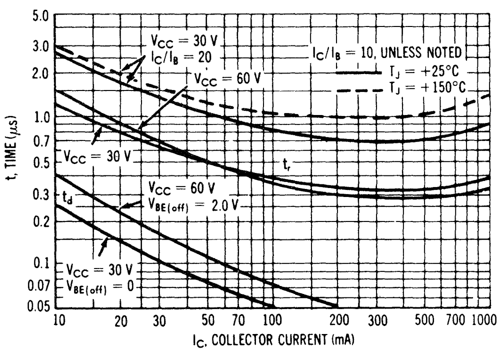


FIGURE 4 — THERMAL RESPONSE

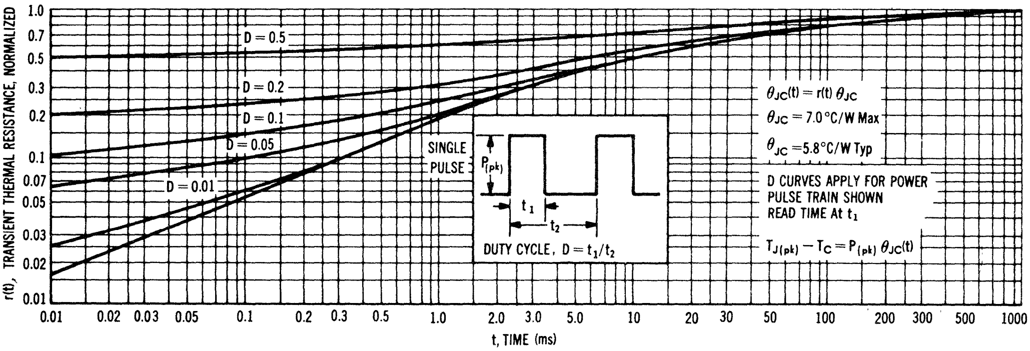
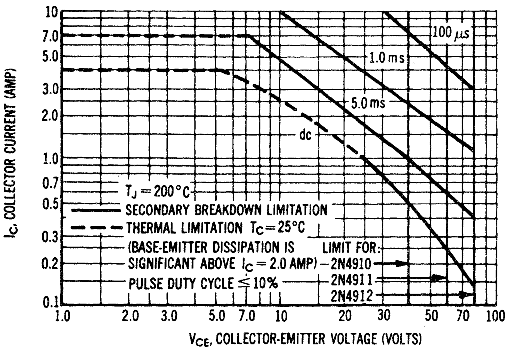


FIGURE 5 — ACTIVE-REGION SAFE OPERATING AREA



There are two limitations on the power handling ability of a transistor: junction temperature and secondary breakdown. Safe operating area curves indicate $I_C - V_{CE}$ limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 5 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles of 10% provided $T_{J(pk)} \leq 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 4. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 6 — STORAGE TIME

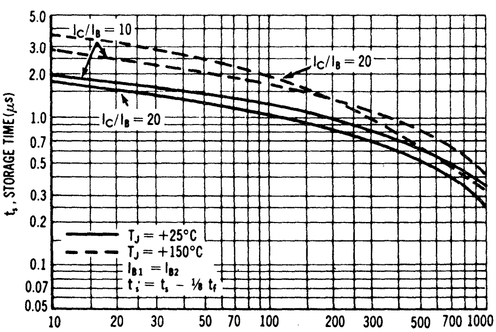
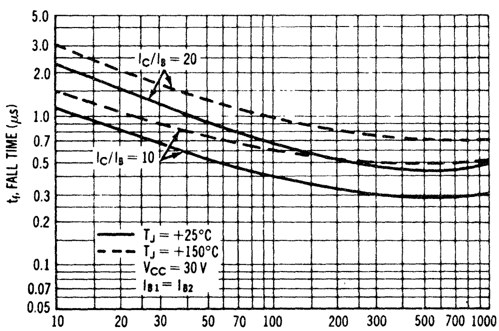


FIGURE 7 — FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 8 — CURRENT GAIN

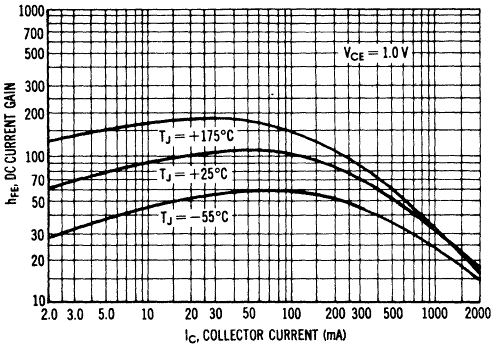


FIGURE 9 — COLLECTOR SATURATION REGION

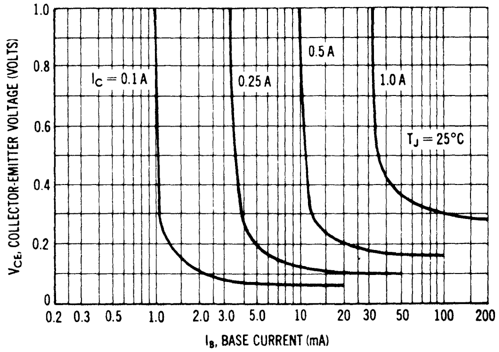


FIGURE 10 — EFFECTS OF BASE-EMITTER RESISTANCE

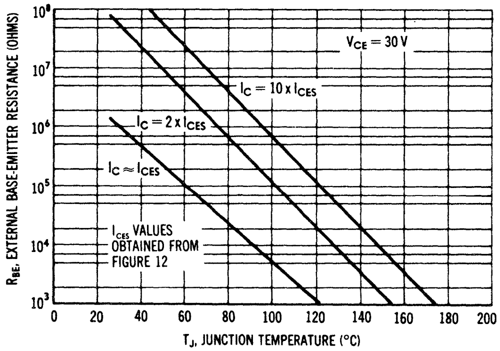


FIGURE 11 — "ON" VOLTAGE

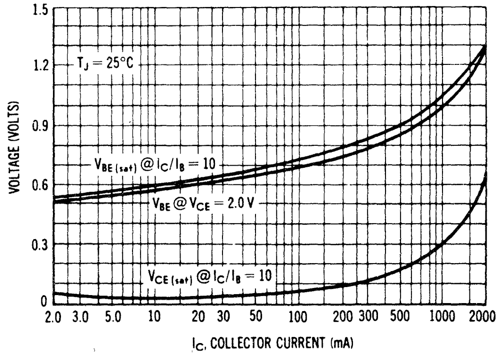


FIGURE 12 — COLLECTOR CUTOFF REGION

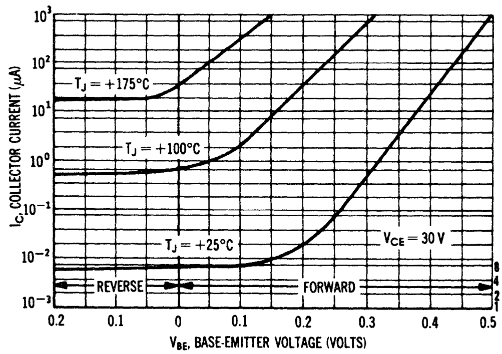
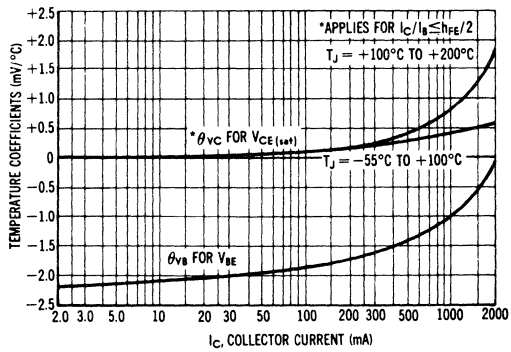
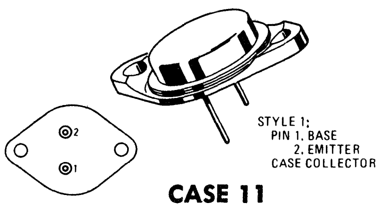


FIGURE 13 — TEMPERATURE COEFFICIENTS



2N4913 (SILICON)
2N4914
2N4915

NPN power transistors for use in power amplifier and switching circuits. Complement to PNP 2N4904 thru 2N4906.



CASE 11

Collector connected to case

MAXIMUM RATINGS

Rating	Symbol	2N4913	2N4914	2N4915	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}		5.0		Vdc
Collector Current — Continuous	I_C		5.0		Adc
Base Current - Continuous	I_B		1.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D		87.5 0.5		Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}		-65 to +200		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1) (I_C = 0.2 Adc, I_B = 0) 2N4913 2N2914 2N4915	11	$BV_{CEO(sus)}$	40 60 80	- - -	Vdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, I_B = 0)		I_{CEO}	-	1.0	mAdc
Collector Cutoff Current (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	5, 6	I_{CEX}	- -	1.0 2.0	mAdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	5, 6	I_{CBO}	-	1.0	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)		I_{EBO}	-	1.0	mAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc) (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	1	h_{FE}	25 7.0	100 -	-
Collector-Emitter Saturation Voltage (I_C = 2.5 Adc, I_B = 250 mAdc) (I_C = 5.0 Adc, I_B = 1.0 Adc)	2, 3, 4	$V_{CE(sat)}$	- -	1.0 1.5	Vdc
Base-Emitter On Voltage (I_C = 2.5 Adc, V_{CE} = 2.0 Vdc)	3, 4	$V_{BE(on)}$	-	1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	-	MHz
Small-Signal Current Gain (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	-	-

(1) Pulse Test, PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 1 — NORMALIZED DC CURRENT GAIN

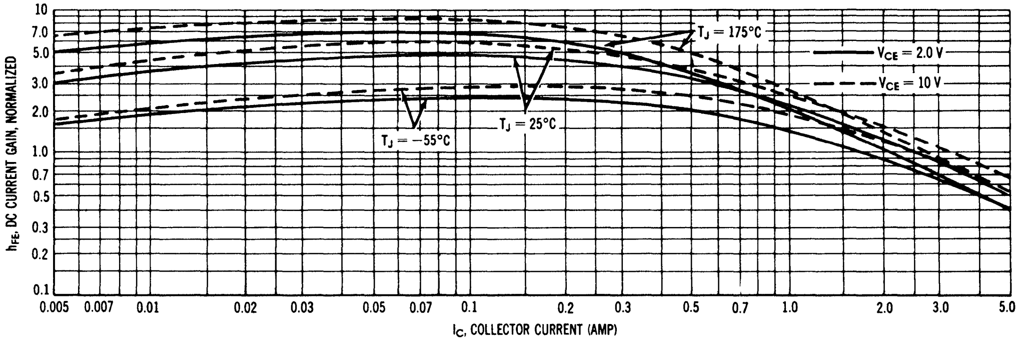


FIGURE 2 — COLLECTOR SATURATION REGION

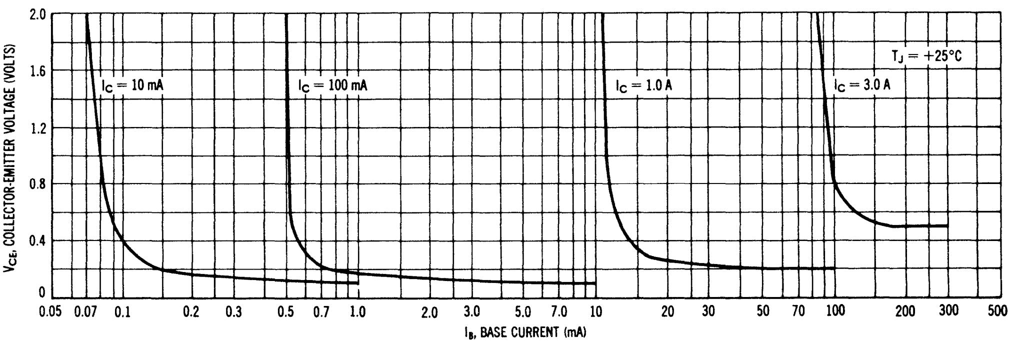


FIGURE 3 — "ON" VOLTAGES

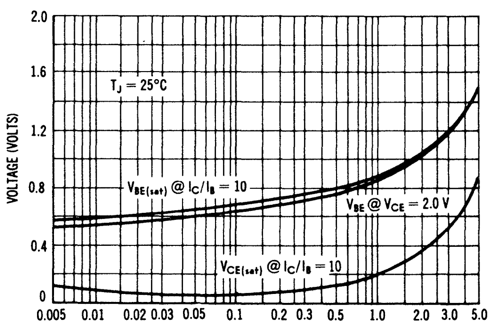
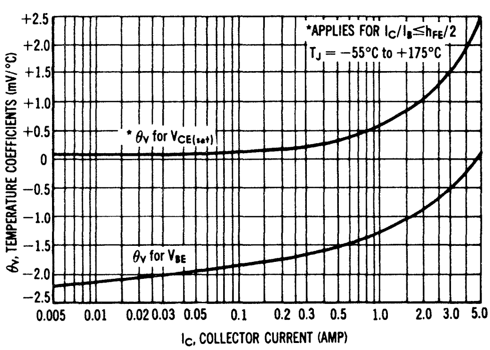


FIGURE 4 — TEMPERATURE COEFFICIENTS



TYPICAL "OFF" REGION CHARACTERISTICS

FIGURE 5 — CUT-OFF REGION

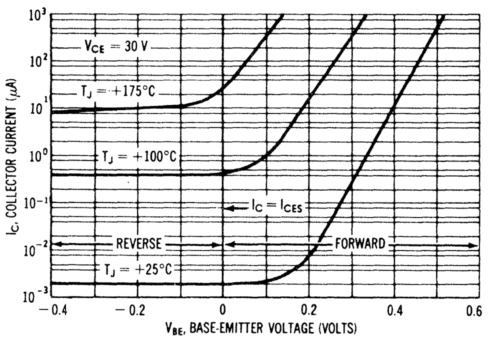


FIGURE 6 — EFFECTS OF BASE-EMITTER RESISTANCE

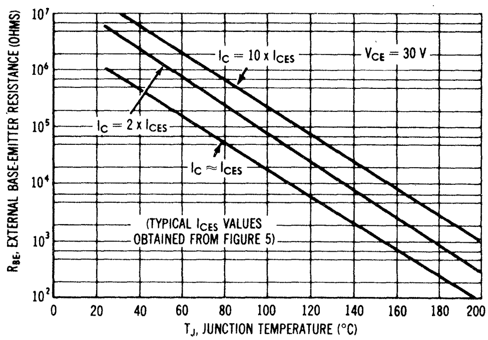


FIGURE 7 — SWITCHING TIME EQUIVALENT CIRCUIT

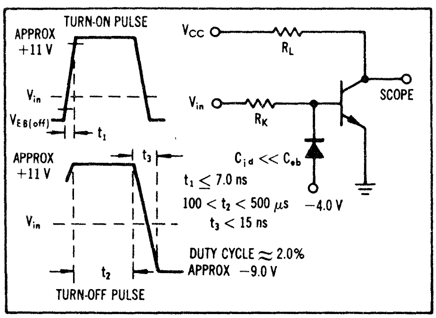


FIGURE 8 — CAPACITANCE

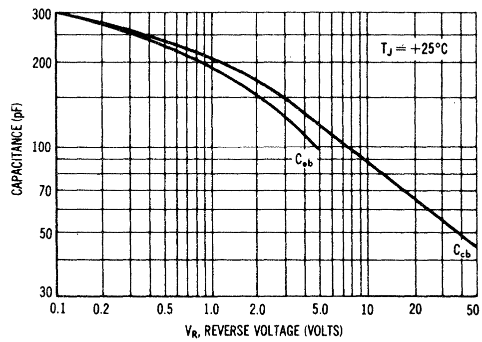


FIGURE 9 — TURN-ON TIME

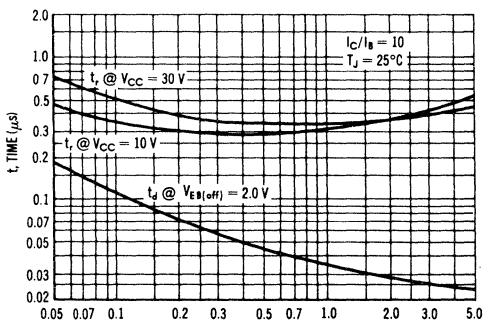
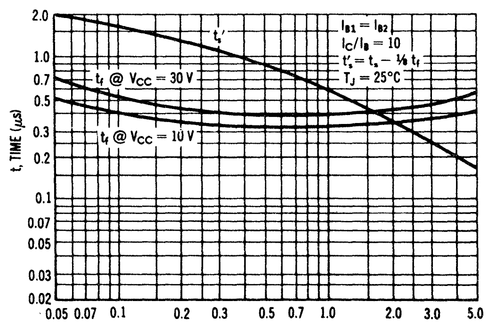
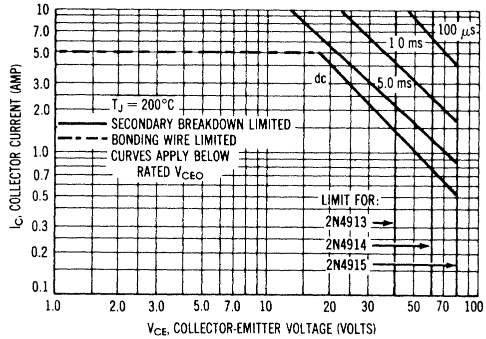


FIGURE 10 — TURN-OFF TIME



RATING AND THERMAL DATA

FIGURE 11 — ACTIVE-REGION SAFE OPERATING AREAS



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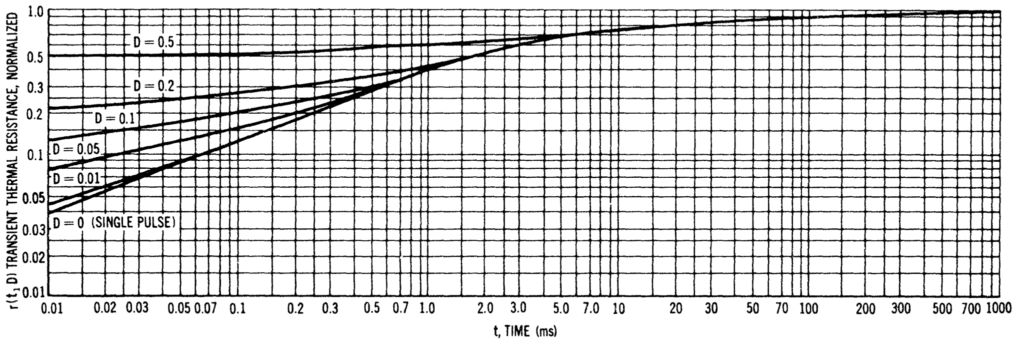
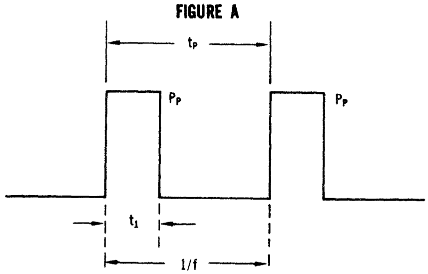
The data of Figure 11 is based on $T_{J(pk)} = 200°C$; T_C is variable depending on conditions. Pulse curves are valid for duty cycles to 10% provided $T_{J(pk)} < 200°C$. $T_{J(pk)}$ may be calculated from the data in Figure 12. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by secondary breakdown.

FIGURE 12 — TRANSIENT THERMAL RESISTANCE



DESIGN NOTE: USE OF TRANSIENT THERMAL RESISTANCE DATA

FIGURE A



DUTY CYCLE $D = t_1 \cdot f = \frac{t_1}{t_P}$

PEAK PULSE POWER $= P_P$

A train of periodical power pulses can be represented by the model as shown in Figure A. Using the model and the device thermal response, the normalized effective transient thermal resistance of Figure 12 was calculated for various duty cycles.

To find $\theta_{JC}(t)$, multiply the value obtained from Figure 12 by the steady state value θ_{JC}.

Example:

The 2N4913 is dissipating 100 watts under the following conditions: $t_1 = 0.1$ ms, $t_P = 0.5$ ms. $(D = 0.2)$

Using Figure 12, at a pulse width of 0.1 ms and D = 0.2, the reading of r (t_1, D) is 0.28.

The peak rise in junction temperature is therefore

$$\Delta T = r(t) \times P_P \times \theta_{JC} = 0.28 \times 100 \times 2.0 = 56°C$$

2N4918 thru 2N4920 (SILICON)
MJE4918 thru MJE4920

3 AMPERE GENERAL-PURPOSE POWER TRANSISTORS

40-80 VOLTS
30 and 40 WATTS

MEDIUM-POWER PLASTIC PNP SILICON TRANSISTORS

. . . designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage — $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 1.0 Amp
- Excellent Power Dissipation Due to Thermopad Construction — P_D = 30 and 40 W @ T_C = 25°C
- Excellent Safe Operating Area
- Gain Specified to I_C = 1.0 Amp
- Complement to NPN 2N4921, 2N4922, 2N4923 and MJE4921, MJE4922, MJE4923
- Choice of Packages — 2N4918 thru 2N4920, 30 Watts, Case 77
  MJE4918 thru MJE4920, 40 Watts, Case 199

*MAXIMUM RATINGS

Ratings	Symbol	2N4918 MJE4918	2N4919 MJE4919	2N4920 MJE4920	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous (1)	I_C*	← 1.0 → ← 3.0 →			Adc
Base Current	I_B	← 1.0 →			Adc
		2N4918 series		MJE4918 series	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	30 0.24		40 0.32	Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

THERMAL CHARACTERISTICS (2)

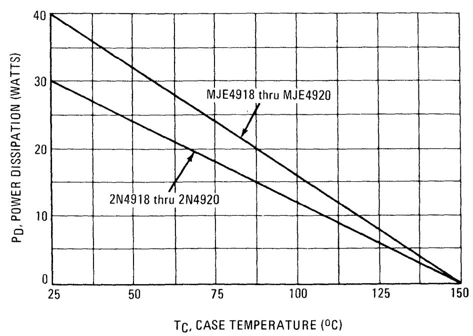
Characteristic	Symbol	2N4918/20	MJE4918/20	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	3.125	°C/W

*Indicates JEDEC Registered Data for 2N4918 Series

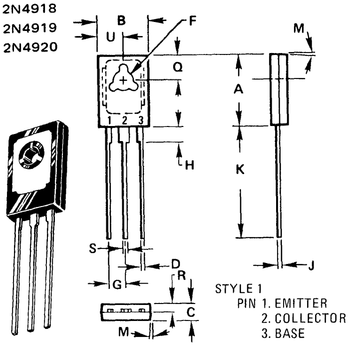
(1) The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements. The 3.0 Amp maximum value is based upon actual current-handling capability of the device (See Figure 5).

(2) Recommend use of thermal compound for lowest thermal resistance.

FIGURE 1 — POWER DERATING



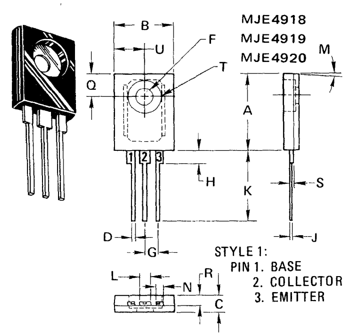
2N4918
2N4919
2N4920



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

MJE4918
MJE4919
MJE4920



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.

CASE 199-04

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)	–	$V_{CEO(sus)}$			Vdc
(I_C = 0.1 Adc, I_B = 0) 2N4918,MJE4918			40	–	
2N4919,MJE4919			60	–	
2N4920,MJE4920			80	–	
Collector Cutoff Current	–	I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0) 2N4918,MJE4918			–	0.5	
(V_{CE} = 30 Vdc, I_B = 0) 2N4919,MJE4919			–	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4920,MJE4920			–	0.5	
Collector Cutoff Current	13	I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc)			–	0.1	
(V_{CE} = Rated V_{CEO}, $V_{BE(off)}$ = 1.5 Vdc, T_C = 125°C)			–	0.5	
Collector Cutoff Current	–	I_{CBO}			mAdc
(V_{CB} = Rated V_{CB}, I_E = 0)			–	0.1	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	–	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)	9	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage (1)	10	$V_{CE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)	12		–	0.6	
	14				
Base-Emitter Saturation Voltage (1)	12	$V_{BE(sat)}$			Vdc
(I_C = 1.0 Adc, I_B = 0.1 Adc)	14		–	1.3	
Base-Emitter On Voltage (1)	12	$V_{BE(on)}$			Vdc
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	14		–	1.3	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product	–	f_T			MHz
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)			3.0	–	
Output Capacitance	–	C_{ob}			pF
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)			–	100	
Small-Signal Current Gain	–	h_{fe}			–
(I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)			25	–	

*Indicates JEDEC Registered Data for 2N4918 Series.
(1) Pulse Test: PW ≈ 300 μs, Duty Cycle ≈ 2.0%

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

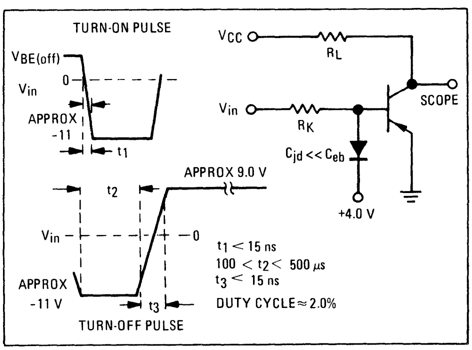


FIGURE 3 — TURN-ON TIME

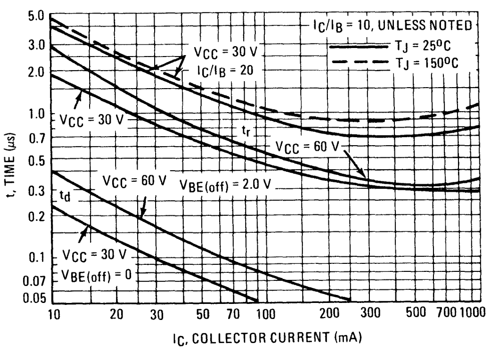
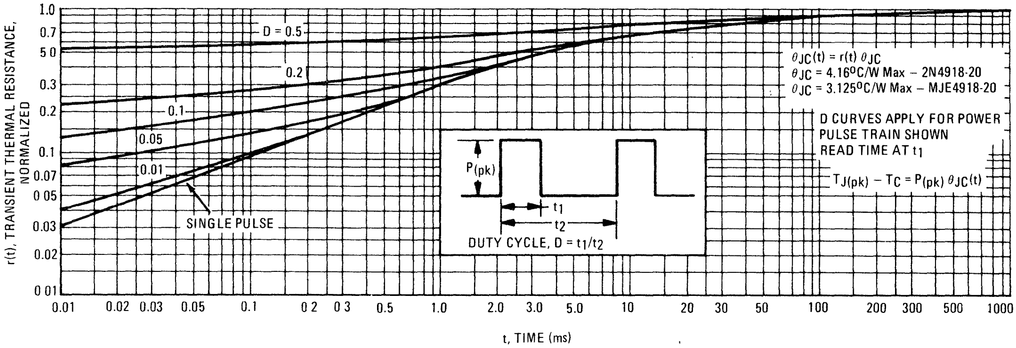


FIGURE 4 – THERMAL RESPONSE



ACTIVE-REGION SAFE OPERATING AREA

FIGURE 5 – 2N4918 thru 2N4920

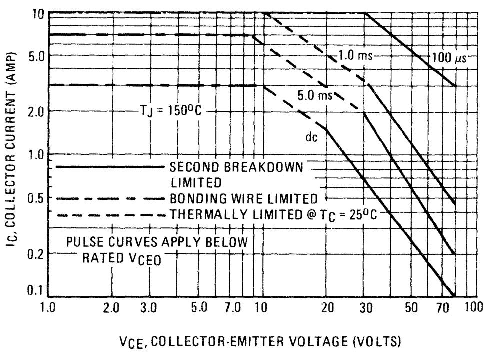
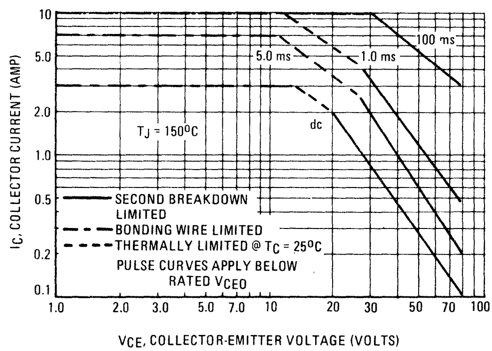


FIGURE 6 – MJE4918 thru MJE4920



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C - V_{CE} operation i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)} = 150^{\circ}C$; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leq 150^{\circ}C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – STORAGE TIME

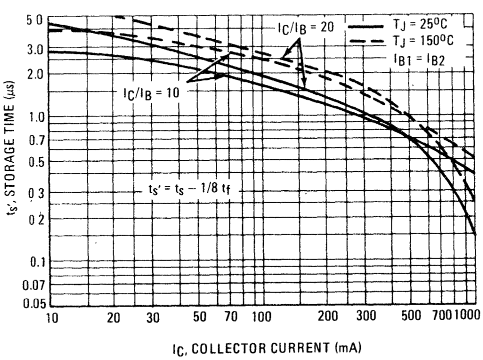
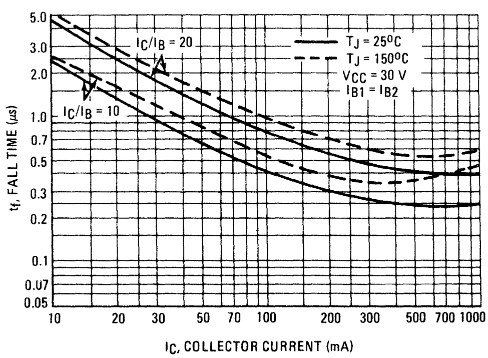


FIGURE 8 – FALL TIME



TYPICAL DC CHARACTERISTICS

FIGURE 9 – CURRENT GAIN

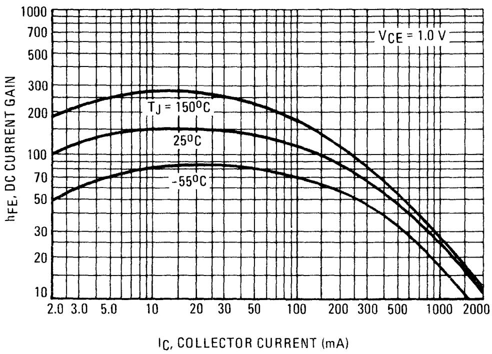


FIGURE 10 – COLLECTOR SATURATION REGION

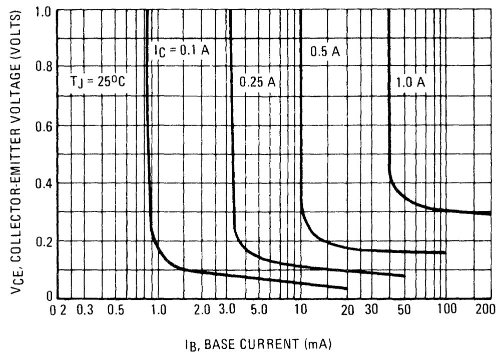


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

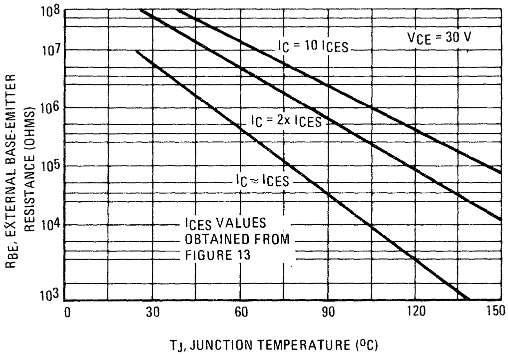


FIGURE 12 – "ON" VOLTAGE

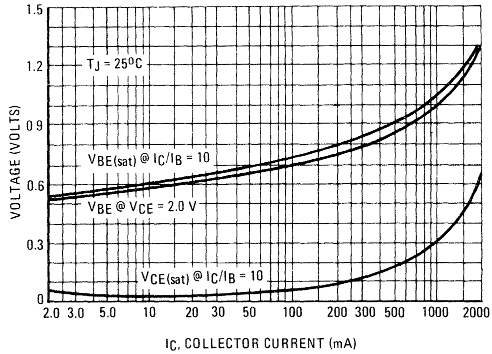


FIGURE 13 – COLLECTOR CUTOFF REGION

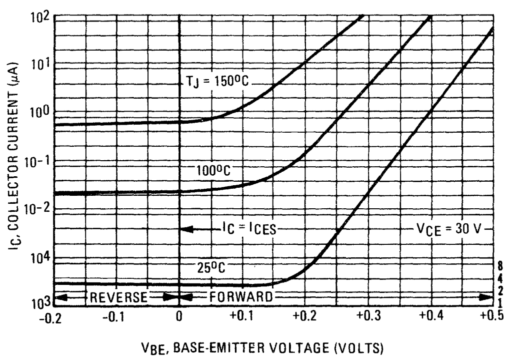
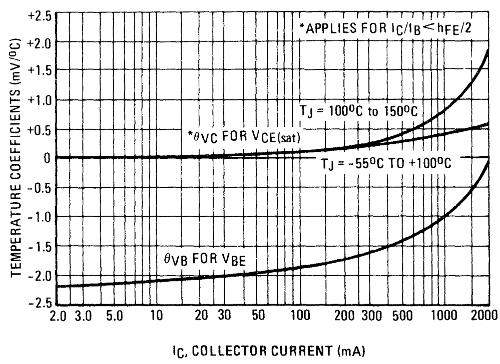


FIGURE 14 – TEMPERATURE COEFFICIENTS



2N4921 thru 2N4923 (SILICON)
MJE4921 thru MJE4923

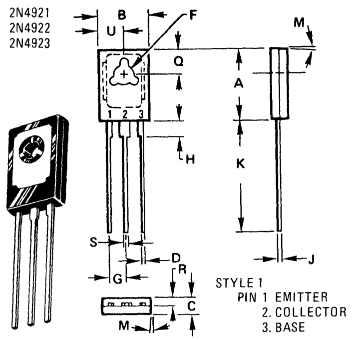
3 AMPERE
GENERAL-PURPOSE
POWER TRANSISTORS

40-80 VOLTS
30 and 40 WATTS

MEDIUM-POWER PLASTIC NPN SILICON TRANSISTORS

. . . designed for driver circuits, switching, and amplifier applications. These high-performance plastic devices feature:

- Low Saturation Voltage — $V_{CE(sat)}$ = 0.6 Vdc (Max) @ I_C = 1.0 Amp
- Excellent Power Dissipation Due to Thermopad Construction — P_D = 30 and 40 W @ T_C = 25°C
- Excellent Safe Operating Area
- Gain Specified to I_C = 1.0 Amp
- Complement to PNP 2N4918, 2N4919, 2N4920 and MJE4918, MJE4919, MJE4920
- Choice of Packages — 2N4921 thru 2N4923, 30 Watts — Case 77
  MJE4921 thru MJE4923, 40 Watts — Case 199



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.80	11.05	0.425	0.435
B	7.49	7.75	0.295	0.305
C	2.41	2.67	0.095	0.105
D	0.51	0.66	0.020	0.026
F	2.92	3.00	0.115	0.118
G	2.36 BSC		0.093 BSC	
H	2.16	2.41	0.085	0.095
J	0.38	0.64	0.015	0.025
K	15.38	16.64	0.605	0.655
M	3° TYP		3° TYP	
Q	3.76	4.01	0.148	0.158
R	1.14	1.40	0.045	0.055
S	0.64	0.89	0.025	0.035
U	3.68	3.94	0.145	0.155

CASE 77-03

*MAXIMUM RATINGS

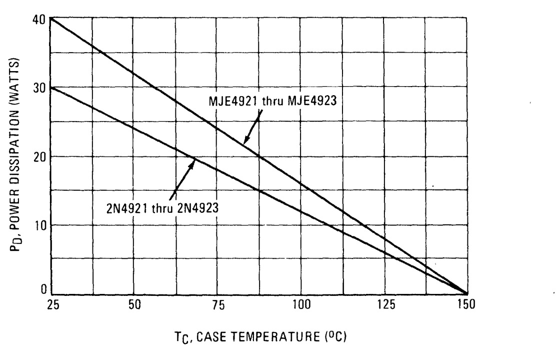
Rating	Symbol	2N4921 MJE4921	2N4922 MJE4922	2N4923 MJE4923	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current - Continuous (1)	I_C	← 1.0 → ← 3.0 →			Adc
Base Current — Continuous	I_B	← 1.0 →			Adc
		2N4921 Series		MJE4921 Series	
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	30 0.24		40 0.32	Watts W/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →			°C

THERMAL CHARACTERISTICS (2)

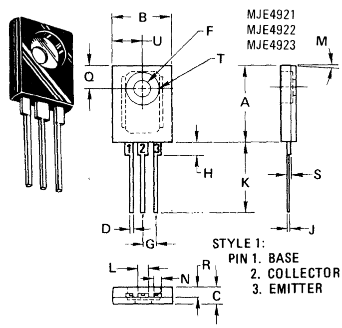
Characteristic	Symbol	2N4921/4923	MJE4921/4923	Unit
Thermal Resistance, Junction to Case	θ_{JC}	4.16	3.125	°C/W

(1) The 1.0 Amp maximum I_C value is based upon JEDEC current gain requirements
The 3.0 Amp maximum value is based upon actual current handling capability of the device (see Figures 5 and 6)
(2) Recommend use of thermal compound for lowest thermal resistance
*Indicates JEDEC Registered Data for 2N4921 Series

FIGURE 1 — POWER DERATING



Safe Area Curves are indicated by Figures 5 and 6. All limits are applicable and must be observed



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.08	16.33	0.633	0.643
B	12.57	12.83	0.495	0.505
C	3.18	3.43	0.125	0.135
D	0.51	0.76	0.020	0.030
F	3.61	3.86	0.142	0.152
G	2.54 BSC		0.100 BSC	
H	2.67	2.92	0.105	0.115
J	0.43	0.69	0.017	0.027
K	14.73	14.99	0.580	0.590
L	2.16	2.41	0.085	0.095
M	3° TYP		3° TYP	
N	1.47	1.73	0.058	0.068
Q	4.78	5.03	0.188	0.198
R	1.91	2.16	0.075	0.085
S	0.81	0.86	0.032	0.034
T	6.99	7.24	0.275	0.285
U	6.22	6.48	0.245	0.255

1. DIM "G" IS TO CENTER LINE OF LEADS.
CASE 199-04

*ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (1)	–	$V_{CEO(sus)}$			Vdc
(I_C = 0.1 Adc, I_B = 0) 2N4921, MJE4921			40	–	
2N4922, MJE4922			60	–	
2N4923, MJE4923			80	–	
Collector Cutoff Current	–	I_{CEO}			mAdc
(V_{CE} = 20 Vdc, I_B = 0) 2N4921, MJE4921			–	0.5	
(V_{CE} = 30 Vdc, I_B = 0) 2N4922, MJE4922			–	0.5	
(V_{CE} = 40 Vdc, I_B = 0) 2N4923, MJE4923			–	0.5	
Collector Cutoff Current	13	I_{CEX}			mAdc
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc)			–	0.1	
(V_{CE} = Rated V_{CEO}, $V_{EB(off)}$ = 1.5 Vdc, T_C = 125°C)			–	0.5	
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	–	I_{CBO}	–	0.1	mAdc
Emitter Cutoff Current (V_{EB} = 5.0 Vdc, I_C = 0)	–	I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (1)	9	h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 1.0 Vdc)			40	–	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)			20	100	
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)			10	–	
Collector-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 0.1 Adc)	10, 12, 14	$V_{CE(sat)}$	–	0.6	Vdc
Base-Emitter Saturation Voltage (1) (I_C = 1.0 Adc, I_B = 0.1 Adc)	12, 14	$V_{BE(sat)}$	–	1.3	Vdc
Base-Emitter On Voltage (1) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	12, 14	$V_{BE(on)}$	–	1.3	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 MHz)	–	f_T	3.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	–	C_{ob}	–	100	pF
Small-Signal Current Gain (I_C = 250 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	–	h_{fe}	25	–	–

(1) Pulse Test: PW≈300 μs, Duty Cycle≈2.0%.
*Indicates JEDEC Registered Data for 2N4921 Series.

FIGURE 2 — SWITCHING TIME EQUIVALENT CIRCUIT

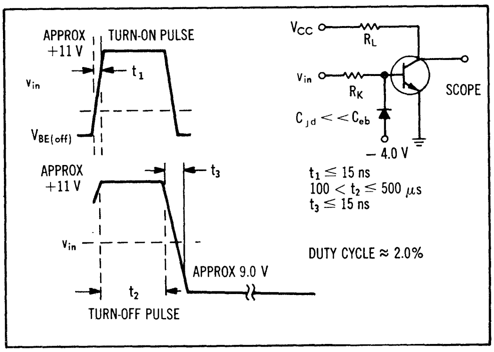


FIGURE 3 — TURN-ON TIME

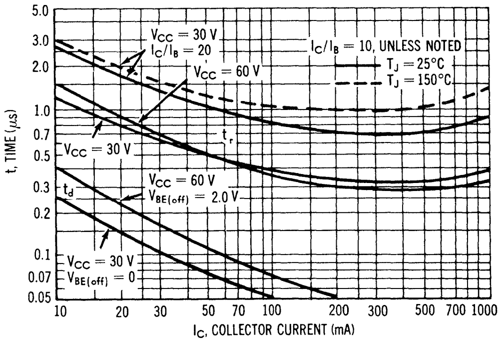
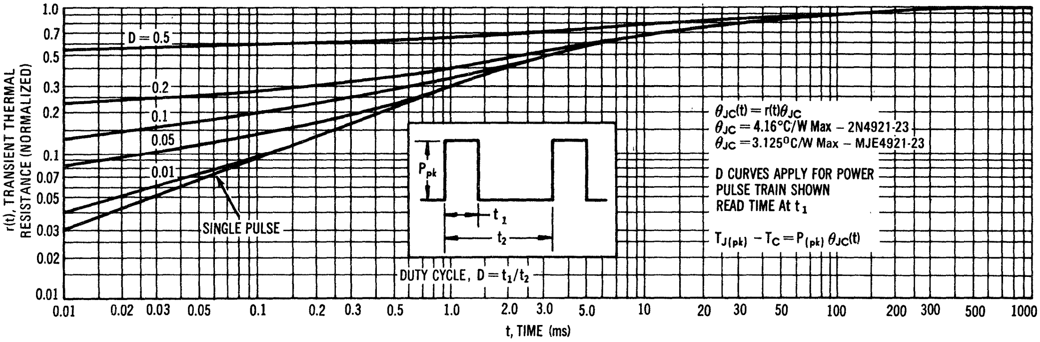


FIGURE 4 – THERMAL RESPONSE



ACTIVE – REGION SAFE OPERATING AREA

FIGURE 5 – 2N4921 thru 2N4923

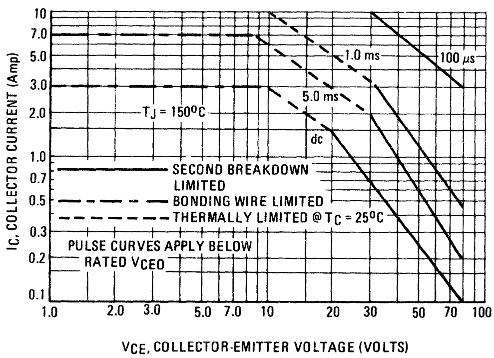
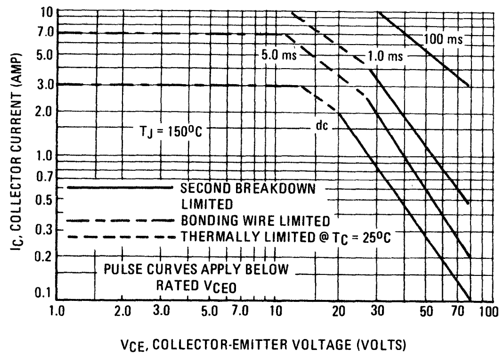


FIGURE 6 – MJE4921 thru MJE4923



There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I_C-V_{CE} operation, i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figures 5 and 6 is based on $T_{J(pk)}$ = 150°C; T_C is variable depending on conditions. Second breakdown pulse limits are valid for duty cycles to 10% provided $T_{J(pk)} \leqslant 150°C$. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown. (See AN-415)

FIGURE 7 – STORAGE TIME

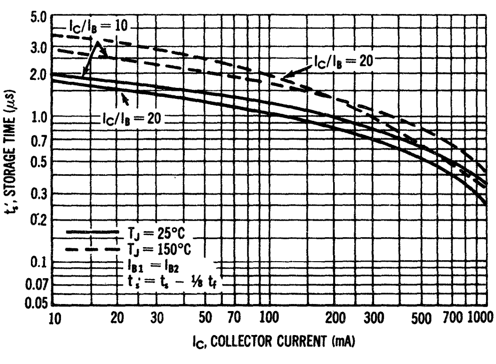


FIGURE 8 – FALL TIME

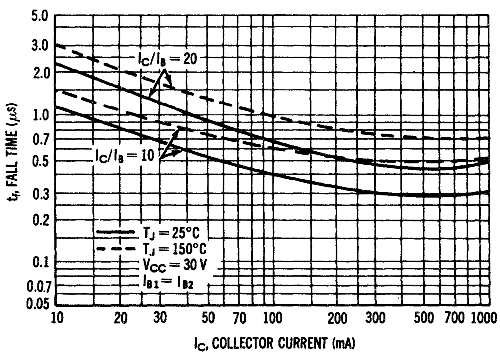


FIGURE 9 – CURRENT GAIN

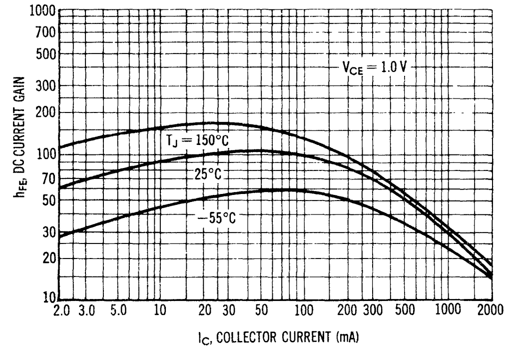


FIGURE 10 – COLLECTOR SATURATION REGION

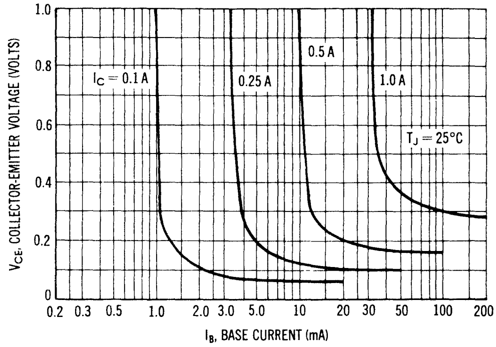


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

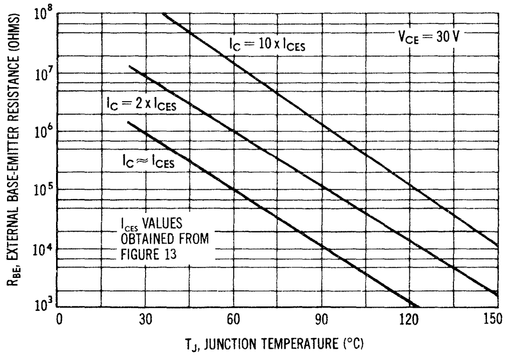


FIGURE 12 – "ON" VOLTAGE

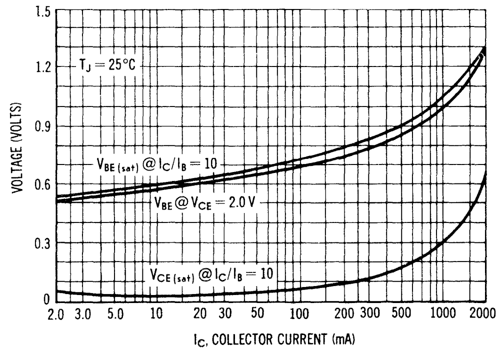


FIGURE 13 – COLLECTOR CUTOFF REGION

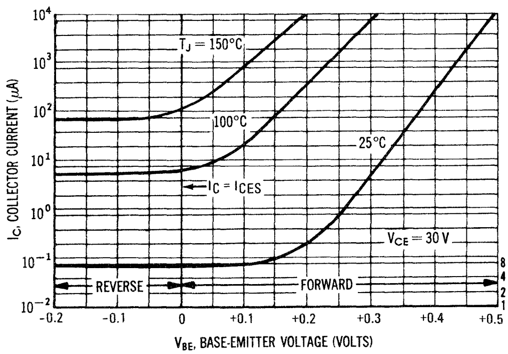
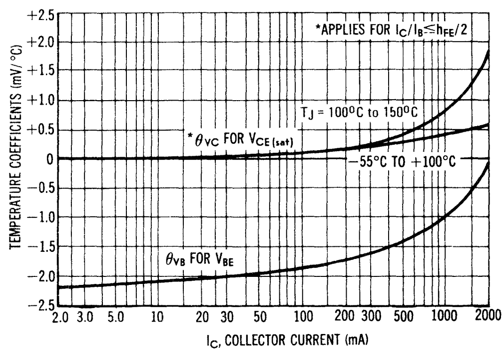


FIGURE 14 – TEMPERATURE COEFFICIENTS



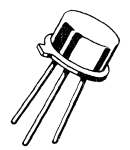
2N4924S (SILICON)
2N4925

NPN SILICON ANNULAR TRANSISTORS

. . .designed for high-voltage high-frequency amplifier applications

- High Collector-Emitter Breakdown Voltage
  BV_{CEO} = 100 Vdc (Min) @ I_C = 10 mAdc – 2N4924
  150 Vdc (Min) @ I_C = 10 mAdc – 2N4925

NPN SILICON AMPLIFIER TRANSISTORS



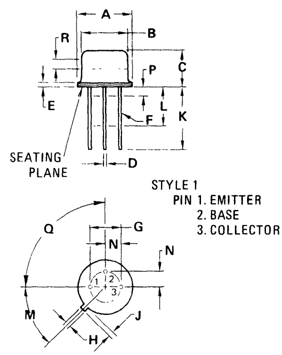
*MAXIMUM RATING

Rating	Symbol	2N4924	2N4925	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Collector-Base Voltage	V_{CB}	100	150	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current – Continuous	I_C	200		mAdc
Total Power Dissipation @ T_A = 25°C	P_D	1.0		Watt
Derate above 25°C		5.71		mW/°C
Total Power Dissipation @ T_C = 25°C	P_D	5.0		Watts
Derate above 25°C		28.6		mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6.10	6.60	0.240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0.019
G	4.83	5.33	0.190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0.100	–

All JEDEC notes and dimensions apply.

CASE 79-02
TO-39

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0)	2N4924	BV_{CEO}	100	–	Vdc
	2N4925		150	–	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4924	BV_{CBO}	100	–	Vdc
	2N4925		150	–	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	–	0.1	μAdc
(V_{CB} = 75 Vdc, I_E = 0)			–	0.1	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS (1)					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)		h_{FE}	25	–	–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)			40	200	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$	–	0.25	Vdc
(I_C = 50 mAdc, I_B = 5.0 mAdc)			–	0.4	
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	0.95	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (2) (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)		f_T	100	500	MHz
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	–	10	pF
Emitter-Base Capacitance (V_{EB} = 1.0 Vdc, I_C = 0, f = 140 kHz)		C_{eb}	–	80	pF

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width $\leqslant$ 300 μs, Duty Cycle $\leqslant$ 2.0%.

(2) $f_T = |h_{fe}| \bullet f_{test}$.

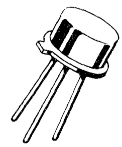
2N4926 (SILICON)
2N4927

NPN SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage amplifier applications.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 200 Vdc (Min) @ I_C = 10 mAdc – 2N4926
  250 Vdc (Min) @ I_C = 10 mAdc – 2N4927

NPN SILICON AMPLIFIER TRANSISTORS



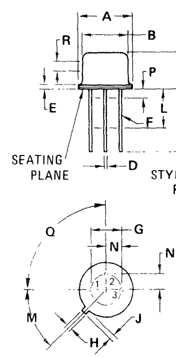
MAXIMUM RATINGS

Rating	Symbol	2N4926	2N4927	Unit
*Collector-Emitter Voltage	V_{CEO}	200	250	Vdc
*Collector-Base Voltage	V_{CB}	200	250	Vdc
*Emitter-Base Voltage	V_{EB}	7.0		Vdc
*Collector-Current – Continuous	I_C	50		mAdc
Total Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.71		Watt mW/°C
*Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	5 0 28.6		Watts mW/°C
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	175	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	35	°C/W



STYLE 1
PIN 1. EMITTER
2. BASE
3. COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 89	9.40	0.350	0.370
B	8.00	8.51	0.315	0.335
C	6 10	6.60	0 240	0.260
D	0.406	0.533	0.016	0.021
E	0.229	3.18	0.009	0.125
F	0.406	0.483	0.016	0 019
G	4.83	5.33	0 190	0.210
H	0.711	0.864	0.028	0.034
J	0.737	1.02	0.029	0.040
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45° NOM		45° NOM	
P	–	1.27	–	0.050
Q	90° NOM		90° NOM	
R	2.54	–	0100	–

All JEDEC notes and dimensions apply.

CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

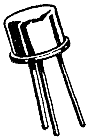
Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Breakdown Voltage (1)		BV_{CEO}			Vdc
(I_C = 10 mAdc, I_B = 0)	2N4926		200	–	
	2N4927		250	–	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 0.1 mAdc, I_C = 0)	2N4926		200	–	
	2N4927		250	–	
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)		BV_{EBO}	7.0	–	Vdc
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 100 Vdc, I_E = 0)	2N4926		–	0.1	
(V_{CB} = 100 Vdc, I_E = 0, T_A = 100°C)			–	10	
(V_{CB} = 150 Vdc, I_E = 0)	2N4927		–	0.1	
(V_{CB} = 150 Vdc, I_E = 0, T_A = 100°C)			–	10	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc)		I_{EBO}	–	0.1	μAdc
ON CHARACTERISTICS (1)					
*DC Current Gain		h_{FE}			–
(I_C = 3.0 mAdc, V_{CE} = 10 Vdc)			10	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			15	–	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)			20	200	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)			20	–	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	1.0	
(I_C = 30 mAdc, I_B = 3.0 mAdc)			–	2.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1.0 mAdc)			–	1.2	
(I_C = 50 mAdc, I_B = 3.0 mAdc)			–	1.5	
Base-Emitter On Voltage (I_C = 30 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.5	Vdc
***SMALL-SIGNAL CHARACTERISTICS**					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)		f_T	30	300	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz)		C_{cb}	–	6.0	pF
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	75	2000	ohm
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	0.1	2.0	$X 10^{-4}$
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	250	–
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	–	50	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 5.0 MHz)		$Re(h_{ie})$	4.0	200	ohms

*Indicates JEDEC Registered Data.

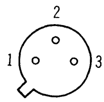
(1) Pulse Test: Pulse Width ⩽300 μs, Duty Cycle ⩽2.0%.

2N4928S thru 2N4931S (SILICON)

2N4930S JAN & JTX
2N4931S JAN & JTX AVAILABLE



High-voltage PNP silicon annular transistors for use in general-purpose high-voltage applications.



STYLE 1:
PIN 1. EMITTER
2. BASE
3. COLLECTOR

CASE 79
(TO-39)

Collector connected to case

*MAXIMUM RATINGS

Rating	Symbol	2N4928	2N4929	2N4930	2N4931	Unit
Collector-Emitter Voltage	V_{CEO}	100	150	200	250	Vdc
Collector-Base Voltage	V_{CB}	100	150	200	250	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	4.0	4.0	Vdc
Collector Current — Continuous	I_C	100	500	500	500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.6 3.4	1.0 5.71	1.0 5.71	1.0 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3.0 17.2	5.0 28.6	5.0 28.6	5.0 28.6	Watt mW/°C
Operating & Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200				°C

* Indicates JEDEC Registered Data

*ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (1) (I_C = 10 mAdc, I_B = 0) 2N4928	BV_{CEO}	100	-	Vdc
2N4929		150	-	
2N4930		200	-	
2N4931		250	-	
Collector-Base Breakdown Voltage (I_E = 0, I_C = 100 μAdc) 2N4928	BV_{CBO}	100	-	Vdc
2N4929		150	-	
2N4930		200	-	
2N4931		250	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) 2N4928	I_{CBO}	-	0.5	μAdc
(V_{CB} = 75 Vdc, I_E = 0) 2N4929		-	0.5	
(V_{CB} = 150 Vdc, I_E = 0) 2N4930, 2N4931		-	1.0	
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0) 2N4928, 2N4929	I_{EBO}	-	0.5	μAdc
(V_{BE} = 3.0 Vdc, I_C = 0) 2N4930, 2N4931		-	1.0	
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) All Types	h_{FE}	20	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc) (1) 2N4928, 2N4929		25	200	
(I_C = 10 mAdc, V_{CE} = 10 Vdc) (1) 2N4930, 2N4931		20	200	
(I_C = 50 mAdc, V_{CE} = 10 Vdc) (1) 2N4928, 2N4929		20	-	
(I_C = 30 mAdc, V_{CE} = 10 Vdc) (1) 2N4930, 2N4931		20	-	
Collector-Emitter Saturation Voltage (1) (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N4928, 2N4929	$V_{CE(sat)}$	-	0.5	Vdc
2N4930, 2N4931		-	5.0	
Base-Emitter On Voltage (I_C = 10 mAdc, V_{CE} = 10 Vdc)	$V_{BE(on)}$	-	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Gandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 MHz) 2N4928, 2N4929	f_T	100	1,000	MHz
(I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 20 MHz) 2N4930, 2N4931		20	200	
Collector-Base Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz) 2N4928	C_{cb}	-	6.0	pF
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz) 2N4929		-	10	
(V_{CB} = 20 Vdc, I_E = 0, f = 140 kHz) 2N4930, 2N4931		-	20	
Emitter-Base Capacitance (V_{BE} = 2.0 Vdc, I_C = 0, f = 140 kHz) 2N4928	C_{eb}	-	40	pF
(V_{BE} = 1.0 Vdc, I_C = 0, f = 140 kHz) 2N4929		-	80	
(V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) 2N4930, 2N4931		-	400	

* Indicates JEDEC Registered Data

(1) Pulse Width ≤ 300 μs: Duty Cycle ≤ 2.0%

2N4937 thru 2N4942 (SILICON)

MULTIPLE SILICON ANNULAR TRANSISTORS

. . . designed for use as differential amplifiers, dual general-purpose amplifiers, front end detectors and temperature compensation applications.

- Excellent Temperature Tracking — Dual Devices — 2N4938, 2N4930
  $\Delta|V_{BE1} - V_{BE2}|$ = 1.6 mVdc (Max) @ -55 to +25°C
  = 2.0 mVdc (Max) @ +25 to +125°C
- DC Current Gain Specified — 100 μAdc to 1.0 mAdc
- High Current-Gain—Bandwidth Product — f_T = 300 MHz @ I_C = 10 mAdc

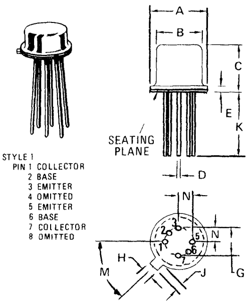
PNP SILICON MULTIPLE TRANSISTORS

*MAXIMUM RATINGS

Rating	Symbol	Value		Unit
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Collector 1 to Collector 2 Voltage Voltage Rating and Lead to Case	V_{C1C2}	±200 ±200		Vdc
Collector-Base Voltage	V_{CB}	50		Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous	I_C	50		mAdc
		One Die	Both Die	
Total Power Dissipation @ T_A = 25°C Metal Can Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.85	2.0 11.42	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.

2N4937
2N4938
2N4939

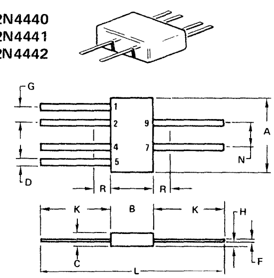


STYLE 1
PIN 1 COLLECTOR
2 BASE
3 EMITTER
4 OMITTED
5 EMITTER
6 BASE
7 COLLECTOR
8 OMITTED

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8 51	9 40	0 335	0.370
B	7 75	8 51	0 305	0 335
C	3 81	4 70	0 150	0 185
D	0 41	0 53	0.016	0.021
G	5 08 BSC		0.200 BSC	
H	0.71	0.86	0 028	0.034
J	0 74	1 14	0 029	0.045
K	12 70	—	0.500	—
M	45° BSC		45° BSC	
N	2 54 BSC		0.100 BSC	

CASE 654-07

2N4440
2N4441
2N4442



STYLE 1
PIN 1 BASE
2 EMITTER
4 EMITTER
5 BASE
7 COLLECTOR
9 COLLECTOR

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	7.36	0.240	0.290
B	2.92	4.06	0.115	0.160
C	0.76	2.03	0.030	0 080
D	0.36	0.48	0.014	0.019
F	0.08	0.15	0.003	0.006
G	1.27 BSC		0.050 BSC	
H	–	0.89	–	0.035
K	3.81	–	0.150	–
N	2.54 BSC		0.100 BSC	
R	–	1.27	–	0.050

CASE 610A-03

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

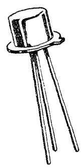
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5.0	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)		I_{CBO}	–	20	nAdc
Emitter Cutoff Current (V_{BE} = 3.0 Vdc, I_C = 0)		I_{EBO}	–	20	nAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)			40	200	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)			50	250	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			50	250	
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	900	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz) Emitter Guarded		C_{cb}	–	5.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz) Collector Guarded		C_{eb}	–	10	pF
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{ie}	1.0	10	kΩ
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{re}	–	10	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	50	–	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	5.0	50	μmhos
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, R_S = 3.0 kΩ, f = 10 Hz to 15.7 kHz)		NF	–	4.0	dB
MATCHING CHARACTERISTICS					
DC Current Gain Ratio (1)		h_{FE1}/h_{FE2}			–
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941		0.9	1.0	
	2N4938, 2N4940		0.8	1.0	
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = -55°C to 125°C)	2N4937, 2N4941		0.85	1.0	
	2N4938, 2N4940		0.7	1.0	
Base-Emitter Voltage Differential		$\|V_{BE1}-V_{BE2}\|$			mVdc
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc)	2N4937, 2N4941		–	3.0	
	2N4938, 2N4940		–	5.0	
Base-Emitter Voltage Differential Gradient		$\frac{\Delta(V_{BE1}-V_{BE2})}{\Delta T_A}$			mVdc
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = 25°C to +125°C)	2N4937, 2N4941		–	1.0	
	2N4938, 2N4940		–	2.0	
(I_C = 100 μAdc to 1.0 mAdc, V_{CE} = 10 Vdc, T_A = -55°C to 25°C)	2N4937, 2N4941		–	0.8	
	2N4938, 2N4940		–	1.6	

*Indicates JEDEC Registered Data.

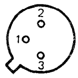
(1) The lowest h_{FE} reading is taken as h_{FE1} for this ratio.

2N4948 (SILICON)
2N4949

Silicon annular unijunction transistors designed for military and industrial use in pulse, timing, triggering, sensing, and oscillator circuits. The annular process provides low leakage current, fast switching and low peak-point currents as well as outstanding reliability and uniformity.



CASE 22A
(TO-18 Modified)
(Lead 3 connected to case)



STYLE 1:
PIN 1. EMITTER
2. BASE 1
3. BASE 2

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
RMS Power Dissipation*	P_D	360*	mW
RMS Emitter Current	I_e	50	mA
Peak Pulse Emitter Current**	i_e	1.0**	Amp
Emitter Reverse Voltage	V_{B2E}	30	Volts
Storage Temperature Range	T_{stg}	-65 to +200	°C

* Derate 2.4 mW/°C increase in ambient temperature. Total power dissipation (available power to Emitter and Base-Two) must be limited by external circuitry. Interbase voltage (V_{B2B1}) limited by power dissipation, $V_{B2B1} = \sqrt{R_{BB} \cdot P_D}$.

** Capacitance discharge current must fall to 0.37 Amp within 3.0 ms and PRR $\leq$ 10 PPS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Intrinsic Standoff Ratio (V_{B2B1} = 10 V) Note 1	2N4948 2N4949	η	0.55 0.74	- -	0.82 0.86	-
Interbase Resistance (V_{B2B1} = 3.0 V, I_E = 0)	2N4948, 2N4949	R_{BB}	4.0	7.0	12.0	k ohms
Interbase Resistance Temperature Coefficient (V_{B2B1} = 3.0 V, I_E = 0, T_A = -65°C to +100°C)		αR_{BB}	0.1	-	0.9	%/°C
Emitter Saturation Voltage (V_{B2B1} = 10 V, I_E = 50 mA) Note 2		$V_{EB1(sat)}$	-	2.5	3.0	Volts
Modulated Interbase Current (V_{B2B1} = 10 V, I_E = 50 mA)		$I_{B2(mod)}$	12	15	-	mA
Emitter Reverse Current (V_{B2E} = 30 V, I_{B1} = 0) (V_{B2E} = 30 V, I_{B1} = 0, T_A = 125°C)		I_{EB2O}	- -	5.0 -	10 1.0	nA μA
Peak Point Emitter Current (V_{B2B1} = 25 V)	2N4948 2N4949	I_P	- -	0.6 0.6	2.0 1.0	μA
Valley Point Current (V_{B2B1} = 20 V, R_{B2} = 100 ohms) Note 2	2N4948, 2N4949	I_V	2.0	4.0	- -	mA
Base-One Peak Pulse Voltage (Note 3, Figure 3)	2N4949 2N4948	V_{OB1}	3.0 6.0	5.0 8.0	- -	Volts
Maximum Oscillation Frequency (Figure 4)		$f_{(max)}$	-	1.25	-	MHz

NOTES

1. Intrinsic standoff ratio.
η, is defined by equation:

$$\eta = \frac{V_P - V_{(EB1)}}{V_{B2B1}}$$

Where V_P = Peak Point Emitter Voltage
V_{B2B1} = Interbase Voltage
$V_{(EB1)}$ = Emitter to Base-One Junction Diode Drop ($\approx$0.5 V @ 10 μA)

2. Use pulse techniques: PW $\approx$ 300 μs duty cycle $\leq$2% to avoid internal heating due to interbase modulation which may result in erroneous readings.

3. Base-One Peak Pulse Voltage is measured in circuit of Figure 3. This specification is used to ensure minimum pulse amplitude for applications in SCR firing circuits and other types of pulse circuits.

FIGURE 1 — UNIJUNCTION TRANSISTOR SYMBOL AND NOMENCLATURE

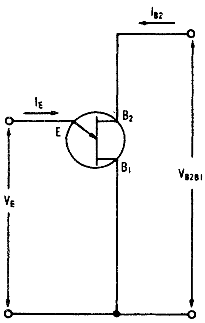


FIGURE 2 — STATIC EMITTER CHARACTERISTICS CURVES
(Exaggerated to Show Details)

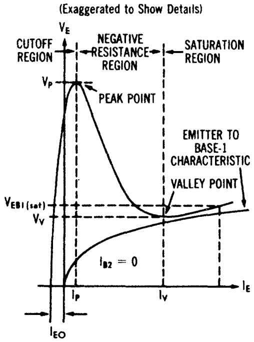


FIGURE 3 — V_{OB1} TEST CIRCUIT
(Typical Relaxation Oscillator)

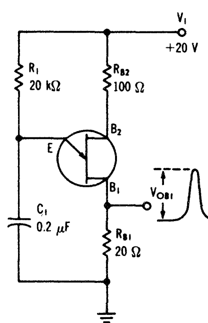
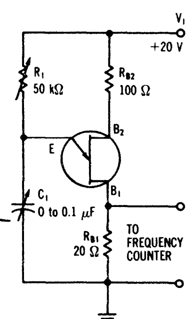


FIGURE 4 — F(max) MAXIMUM FREQUENCY TEST CIRCUIT



2N4957, 2N4958 (SILICON) 2N4959, 2N5829

The RF Line

PNP SILICON SMALL-SIGNAL TRANSISTORS

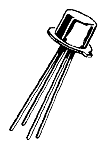
. . . designed for high-gain, low-noise amplifier, oscillator and mixer applications.

- Specified 2.0 mAdc, 10 Vdc Characteristics –
  Noise Figure = 2.5 dB – 2N5829
  (@ 450 MHz) = 3.0 dB – 2N4957
  = 3.3 dB – 2N4958
  = 3.8 dB – 2N4959
  Minimum Gain = 17 dB – 2N4957, 2N5829
  (@ 450 MHz) = 16 dB – 2N4958
  = 15 dB – 2N4959
  Current-Gain–Bandwidth Product –
  = 1.2 GHz – 2N4957, 2N5829
  = 1.0 GHz – 2N4958, 2N4959

1.2 GHz – 2.0 mAdc – 2N4957, 2N5829
1.0 GHz – 2.0 mAdc – 2N4958, 2N4959

HIGH FREQUENCY TRANSISTORS

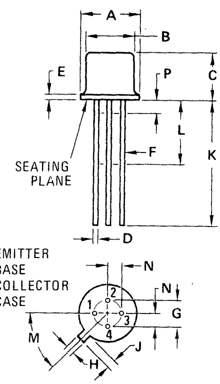
PNP SILICON



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Power Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	200 1.14	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



STYLE 10
PIN 1 EMITTER
2 BASE
3 COLLECTOR
4. CASE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.41	0.53	0.016	0.021
E	–	0.76	–	0.030
F	0.41	0.48	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.91	1.17	0.036	0.046
J	0.71	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45°BSC		45° BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

ALL JEDEC dimensions and notes apply

CASE 20-03
TO-72

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current	I_{CBO}				μAdc
(V_{CB} = 10 Vdc, I_E = 0) All Types		–	–	0.1	
(V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C) 2N4957,8,9		–	–	100	
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc) 2N4957,8,9		20	40	–	
2N5829		20	40	150	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T				MHz
2N4957		1200	1600	–	
2N5829		1200	–	2500	
2N4958, 2N4959		1000	1500	2500	
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}				–
2N5829		20	–	200	
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_c$				ps
2N4957,8,9		–	–	8.0	
2N5829		1.0	–	8.0	
Noise Figure (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	NF				dB
2N4957		–	2.6	3.0	
2N4958		–	2.9	3.3	
2N4959		–	3.2	3:8	
2N5829		–	2.3	2.5	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc, R_G = 50 ohms, f = 1.0 GHz) 2N4957		–	5.0	–	
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}				dB
2N5829		17	–	–	
2N4957		17	–	25	
2N4958		16	–	25	
2N4959		15	–	25	
(V_{CE} = 10 Vdc, I_C = 2.0 mAdc, R_G = 50 ohms, f = 1.0 GHz) 2N4957		–	13	–	

*Indicates JEDEC Registered Data.
(1) f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

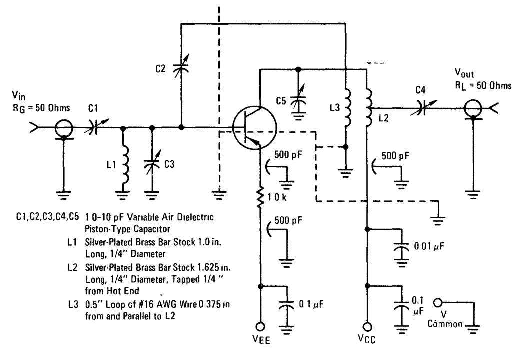


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

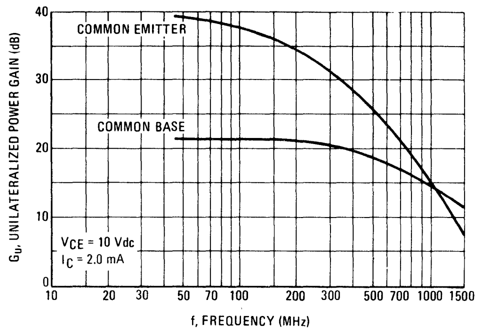


FIGURE 3 – NOISE FIGURE versus FREQUENCY

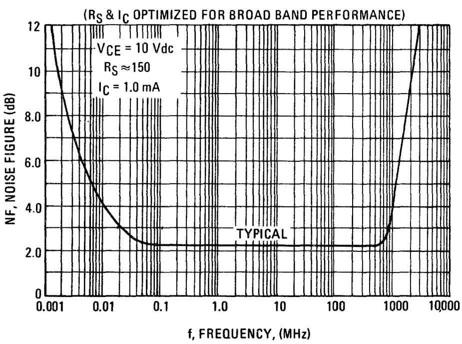


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

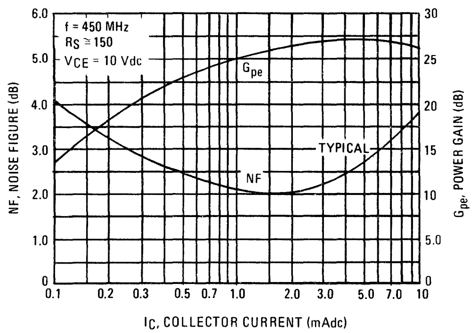


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

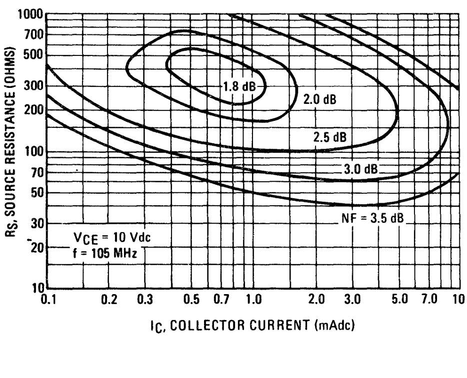
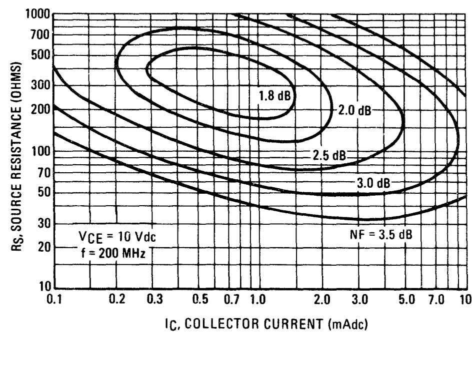


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

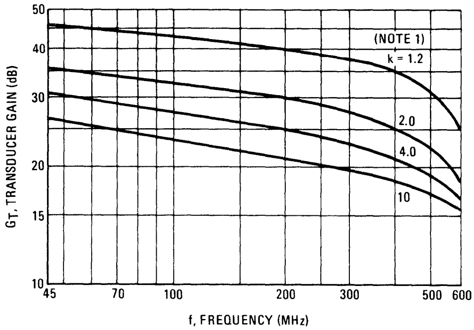


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

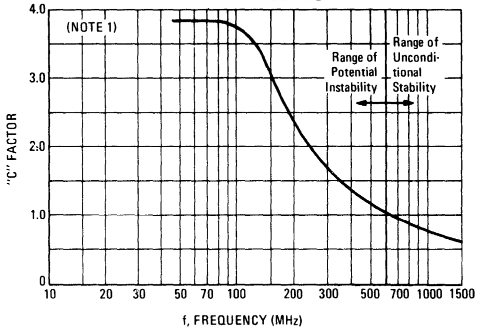


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

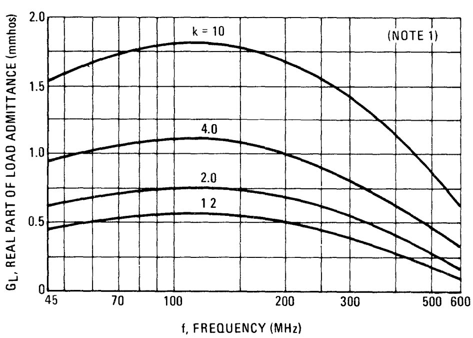


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

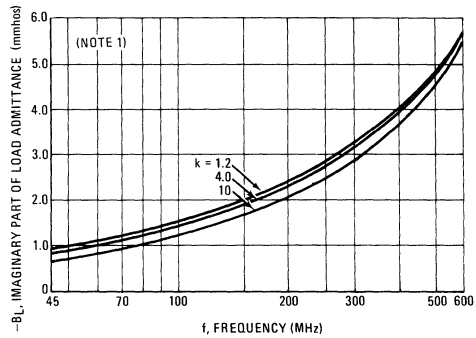


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

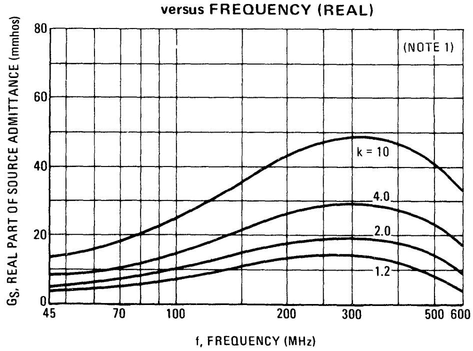
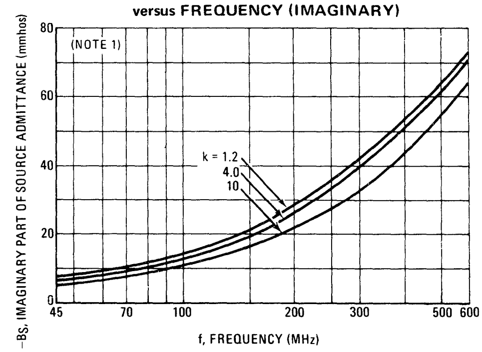


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

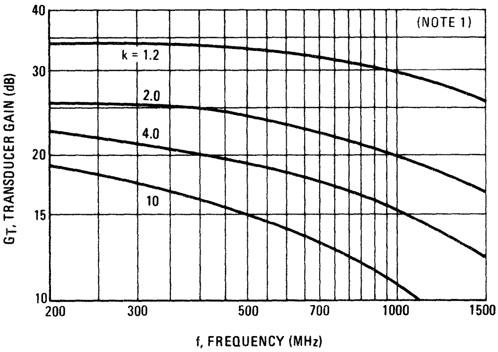


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

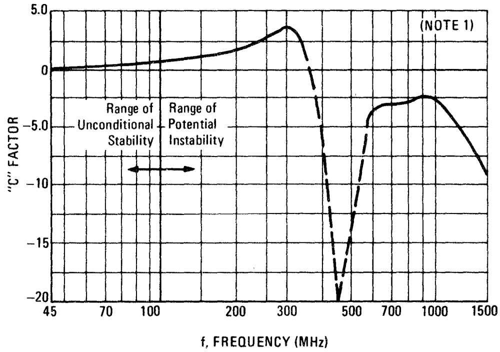


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

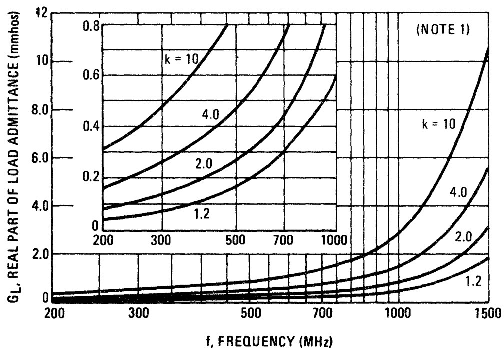


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

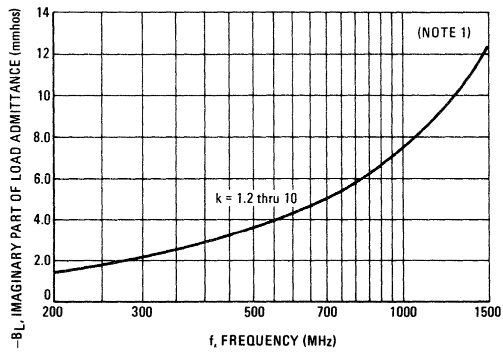


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

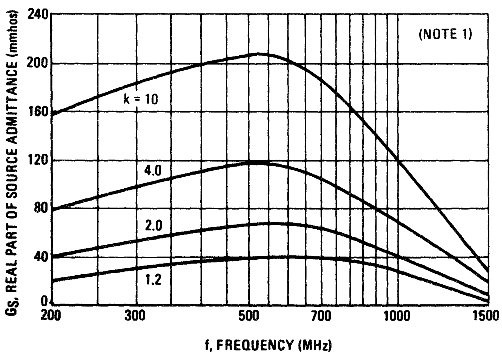


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

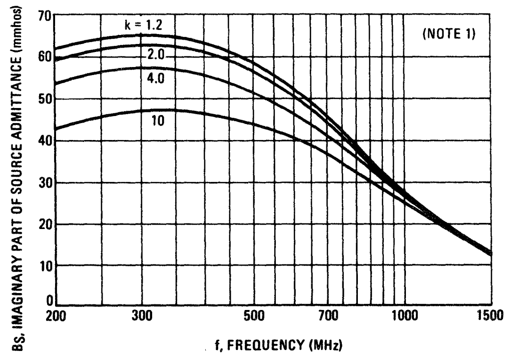


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

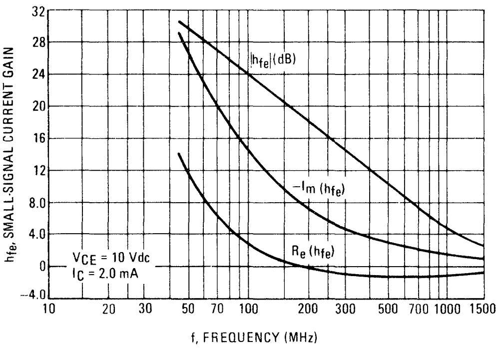


FIGURE 20 – POLAR h_{fe}

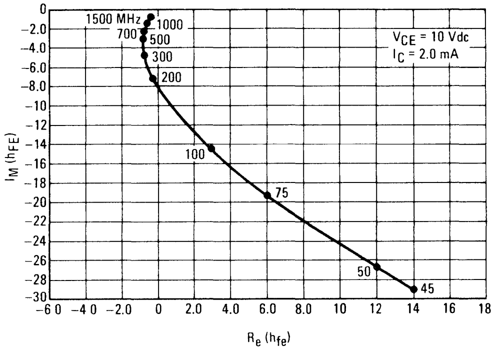


FIGURE 21 – f_T versus COLLECTOR CURRENT

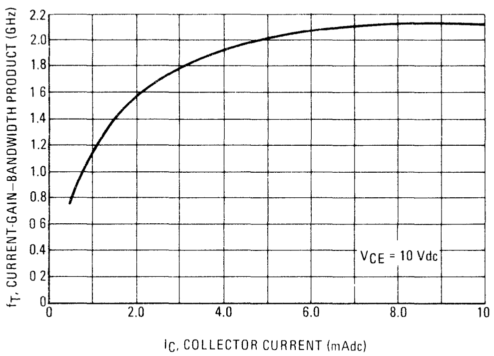


FIGURE 22 – DC CURRENT GAIN

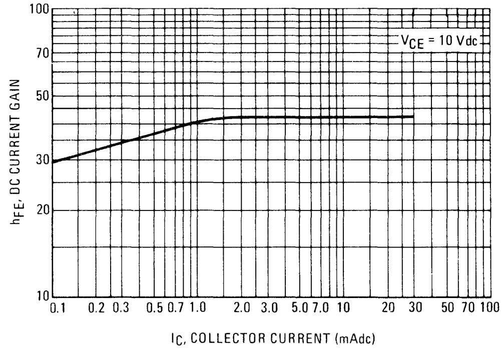


FIGURE 23 – CAPACITANCE

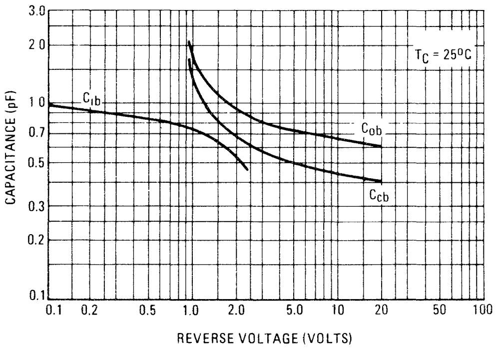
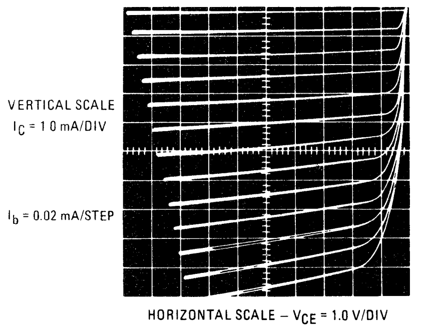
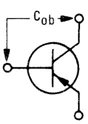
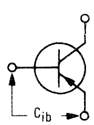


FIGURE 24 – COLLECTOR CHARACTERISTICS

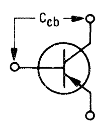




Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE — V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc – – –

COMMON EMITTER — V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc – – –

FIGURE 25 – INPUT ADMITTANCE

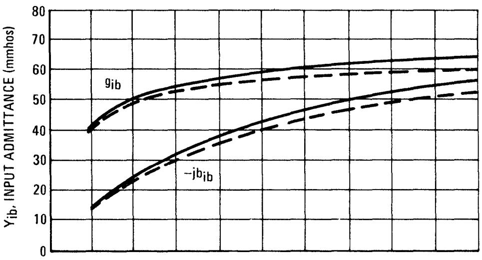


FIGURE 26 – INPUT ADMITTANCE

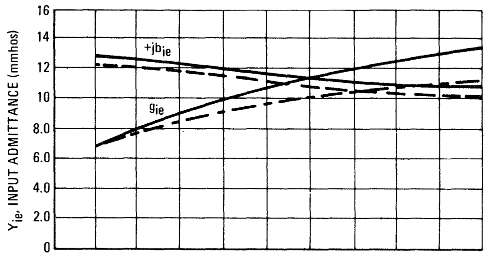


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

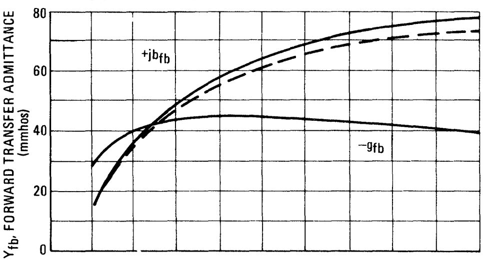


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

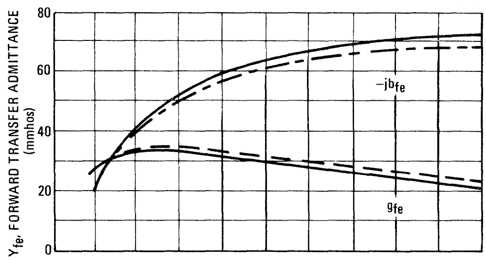


FIGURE 29 – OUTPUT ADMITTANCE

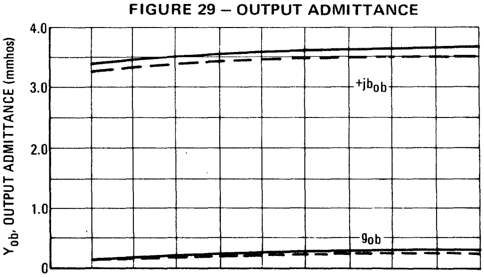


FIGURE 30 – OUTPUT ADMITTANCE

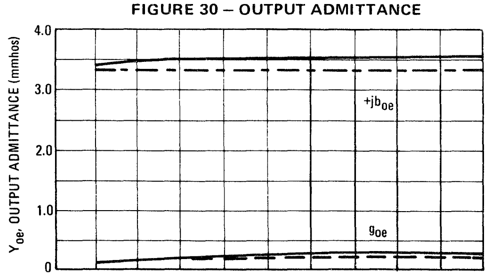


FIGURE 31 – REVERSE TRANSFER ADMITTANCE

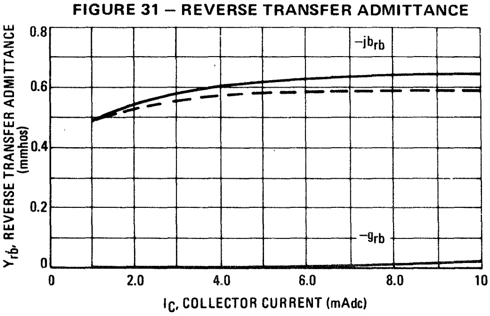
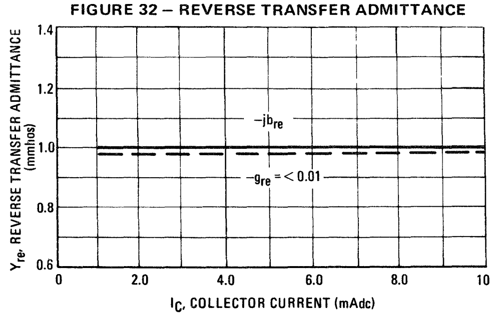


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

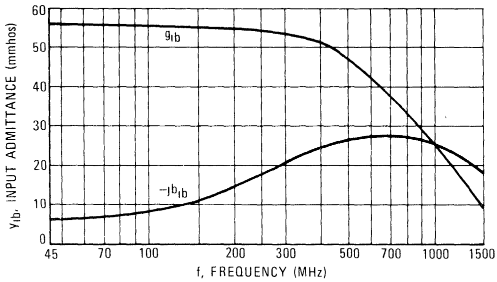


FIGURE 33 – y_{ib} INPUT ADMITTANCE

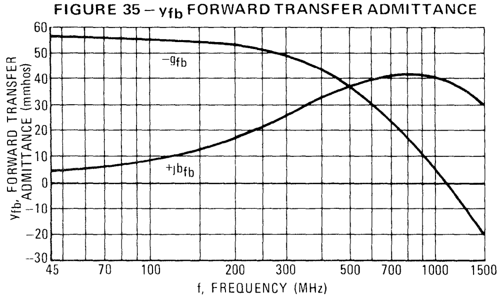


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

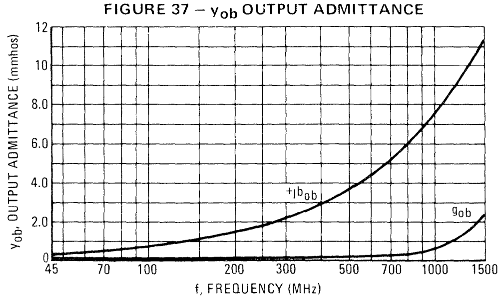


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

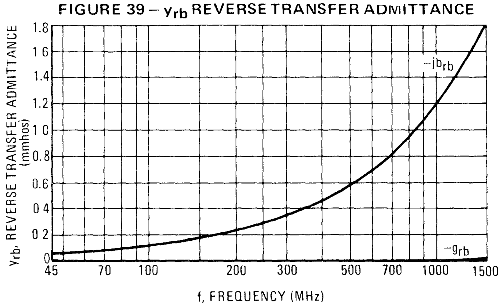


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE

POLAR Y PARAMETERS versus FREQUENCY

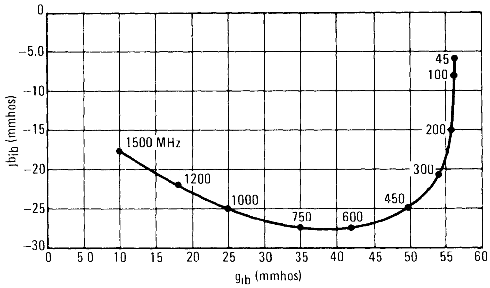


FIGURE 34 – y_{ib} INPUT ADMITTANCE

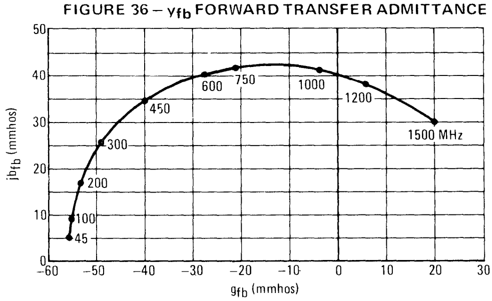


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

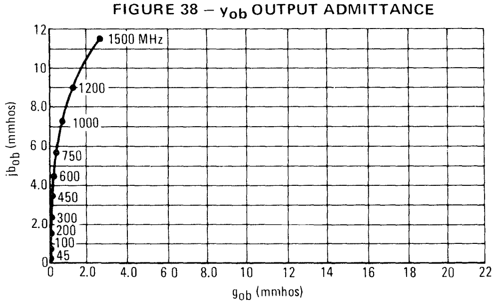


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

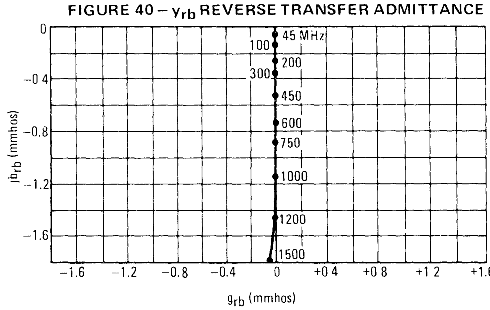


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE

COMMON EMITTER Y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

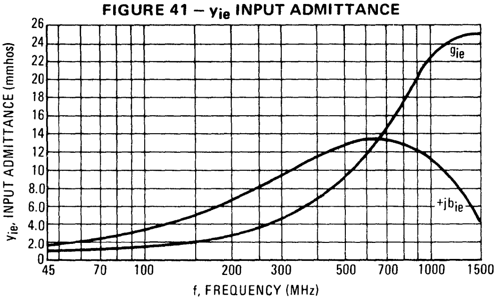


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

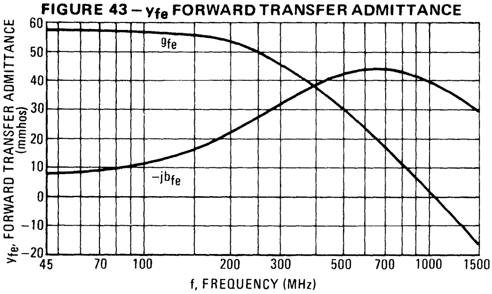


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

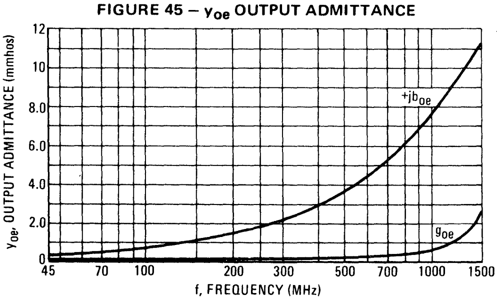
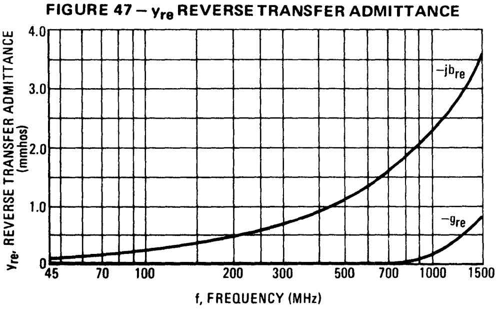


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

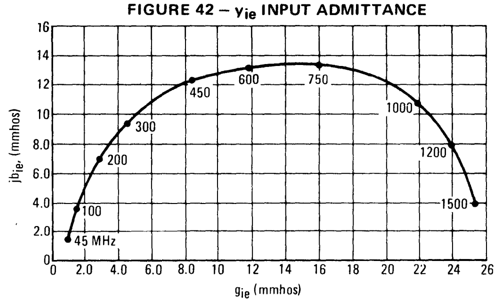


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

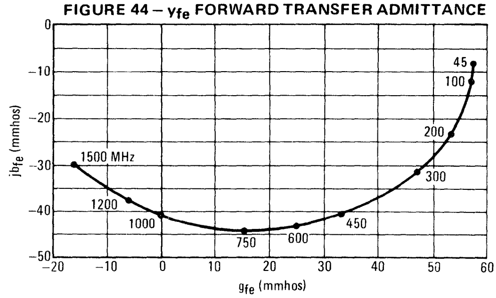


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

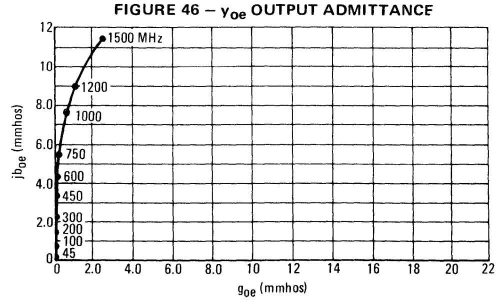
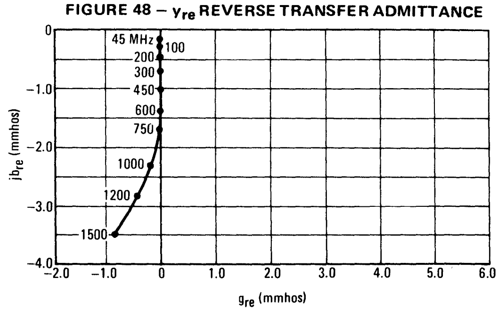
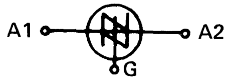


FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



2N4993 (SILICON)



SILICON BIDIRECTIONAL SWITCH

. . . designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering applications and as voltage level detectors.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.7 Volts Maximum
- Low Off-State Current – 1.0 μA Maximum
- Low Temperature Coefficient – 0.02 %/^{o}C Typical

*MAXIMUM RATINGS

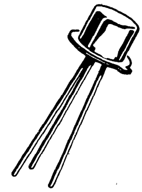
Rating	Symbol	Value	Unit
Power Dissipation	P_D	350	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	I_G(off)	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width)	I_{FM}(rep)	1.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width	I_{FM}(nonrep)	5.0	Amp
Operating Junction Temperature Range	T_J	-55 to +150	^{o}C
Storage Temperature Range	T_{stg}	-65 to +200	^{o}C

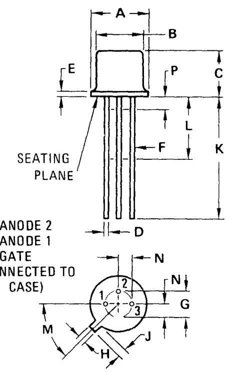
*Indicates JEDEC Registered Data

SILICON BIDIRECTIONAL SWITCH

6.0–10 VOLTS
350 mW

DS 2519





STYLE 9:
PIN 1. ANODE 2
2. ANODE 1
3. GATE (CONNECTED TO CASE)

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	5.31	5.84	0.209	0.230
B	4.52	4.95	0.178	0.195
C	4.32	5.33	0.170	0.210
D	0.406	0.533	0.016	0.021
E	–	0.762	–	0.030
F	0.406	0.483	0.016	0.019
G	2.54 BSC		0.100 BSC	
H	0.914	1.17	0.036	0.046
J	0.711	1.22	0.028	0.048
K	12.70	–	0.500	–
L	6.35	–	0.250	–
M	45^{o} BSC		45^{o} BSC	
N	1.27 BSC		0.050 BSC	
P	–	1.27	–	0.050

All JEDEC notes and dimensions apply.

CASE 22-03
(TO-18)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
*Switching Voltage	V_S	6.0	8.0	10	Vdc
*Switching Current	I_S	–	175	500	μAdc
*Switching Voltage Differential	$\|V_{S1}-V_{S2}\|$	–	0.3	0.5	Vdc
Holding Current	I_H	–	0.7	1.5	mAdc
*Off-State Blocking Current	I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)		–	0.08	1.0	
(V_F = 5.0 Vdc, T_A = 100°C)		–	6.0	10	
*Forward On-State Voltage (I_F = 200 mAdc)	V_F	–	1.4	1.7	Vdc
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, (Figure 7)	V_o	3.5	4.8	–	Vdc
Turn-On Time (Figure 8)	t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 9)	t_{off}	–	30	–	μs
Temperature Coefficient of Switching Voltage	T_C	–	+0.02	–	%/°C
*Switching Current Differential	$\|I_{S2}-I_{S1}\|$	–	–	100	μAdc

*Indicates JEDEC Registered Data

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE versus TEMPERATURE

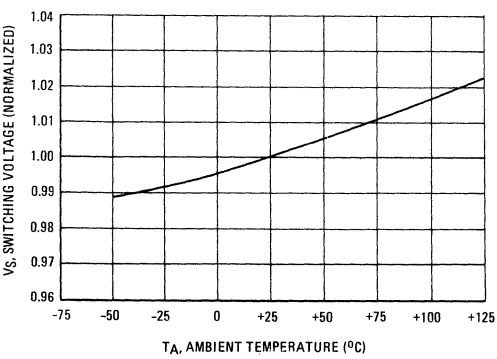


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

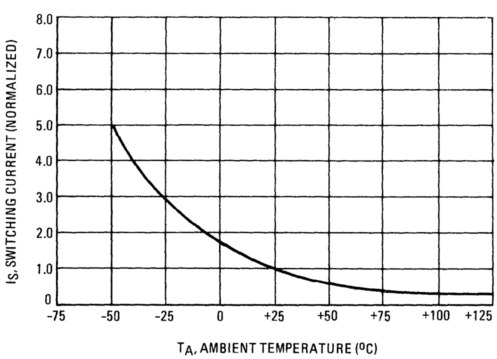


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

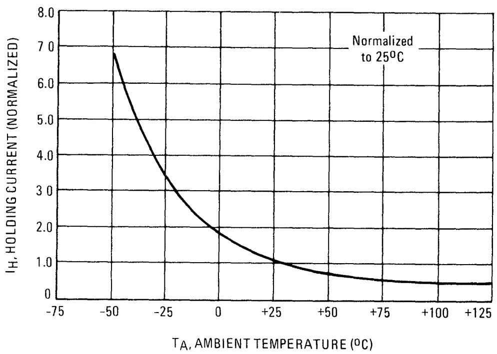


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

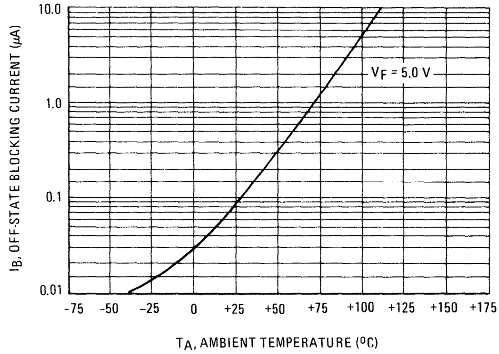


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

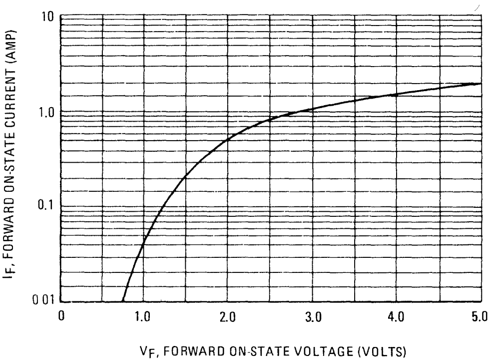


FIGURE 6 – PEAK OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

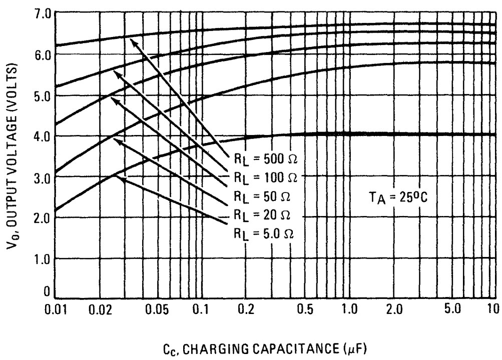


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

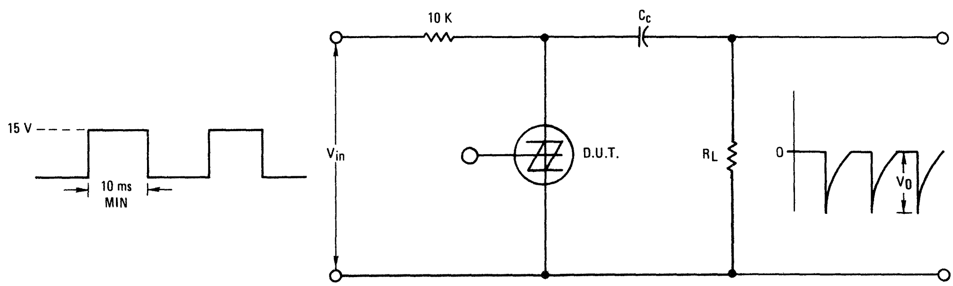
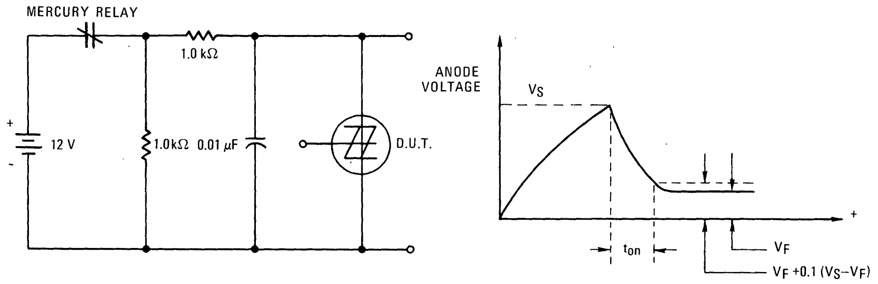
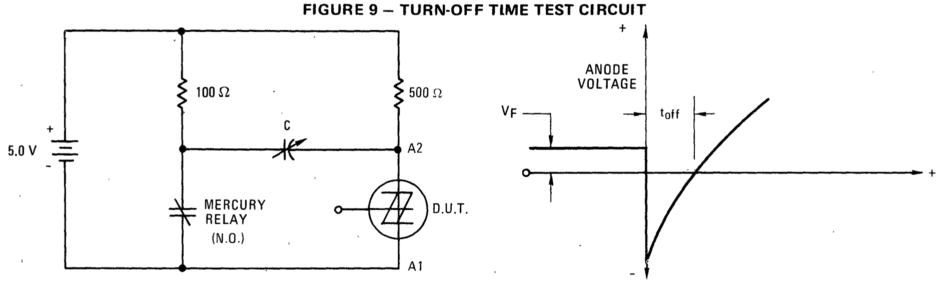


FIGURE 8 – TURN-ON TIME TEST CIRCUIT



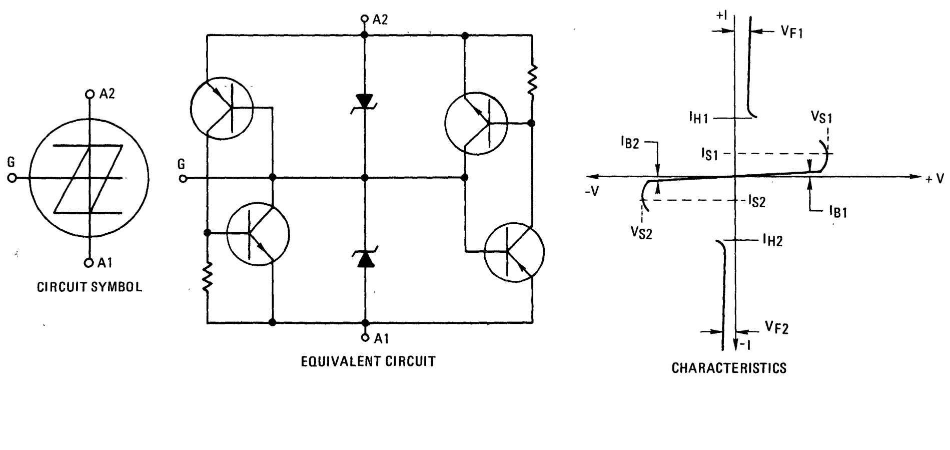
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT



With the SBS in conduction and the relay contacts open, close the contacts to cause anode A2 to be driven negative. Decrease C until the SBS just remains off when anode A2 becomes positive. The turn-off time, t_{off}, is the time from initial contact closure and until anode A2 voltage reaches zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS



NOTES

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