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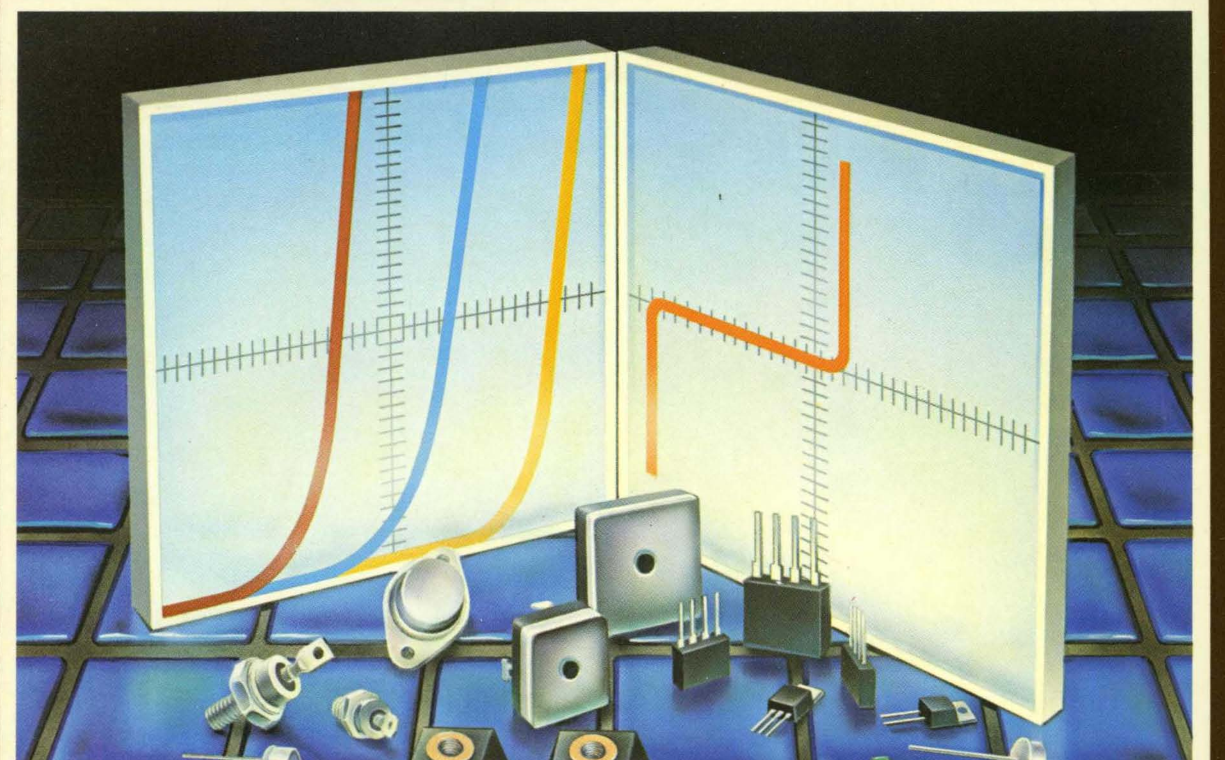

RECTIFIERS AND ZENER DIODES DATA

MOTOROLA

RECTIFIERS AND ZENER DIODES DATA BOOK

Prepared by
Technical Information Center

This book presents technical data for the broad line of Motorola Silicon Rectifiers and Zener Diodes. Complete specifications for the individual devices are provided in the form of data sheets. In addition, a comprehensive selector guide and industry cross-reference guide are included to simplify the task of choosing the best set of components required for a specific application.

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VHE2403	MUR1615CT		3-286
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.4T6.8,A,B	.5M6.8Z,10,5		—
THRU	THRU		
.4T110,A,B	.5M110Z,10,5		—
.4Z6.8D,10,5	.5M6.8Z,10,5		—
THRU	THRU		
.4Z110D,10,5	.5M110Z,10,5		—
.5M2.4ZS10,5	.5M2.4AZ,10,5		—
THRU	THRU		
.5M110ZS10,5	.5M110Z,10,5		—
.7JZ6.8,A,B,C,D	1M6.8ZS,10,5,1,2		—
THRU	THRU		
.7JZ200,A,B,C,D	1M200ZS,10,5,1,2		—
.7ZM6.8,A,B,C,D	1M6.8ZS,10,5,1,2		—
THRU	THRU		
.7ZM200,A,B,C,D	1M200ZS,10,5,1,2		—
.25T5.6,A		.5M5.6Z10,5	—
THRU		THRU	
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1.5JZ6.8,A,B,C,D		MZG41-6.8A,B	—
THRU		THRU	
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THRU		THRU	
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THRU		THRU	
1.5Z200,A,B,C,D		MZG41-200A,B	—
1.5Z6.8D,10,5	1.5M6.8Z,10,5		—
THRU	THRU		
1.5Z200D,10,5	1.5M200Z,10,5		—
1/2R6.8,A,B	.5M6.8Z,10,5		—
THRU	THRU		
1/2R110,A,B	.5M110Z,10,5		—
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*These devices are manufactured by Motorola but no data sheet available — Consult Factory.

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THRU		THRU	
1D6.2,A,B		1M6.2ZS,10,5	—
1D6.8,A,B		1M6.8ZS,10,5	—
THRU		THRU	
1D200,A,B		1M200ZS,10,5	—
1EZ110D5	1M110ZS5		—
1EZ120D5	1M120ZS5		—
1EZ130D5	1M130ZS5		—
1EZ140D5	1M140ZS5		—
1EZ150D5	1M150ZS5		—
1EZ160D5	1M160ZS5		—
1EZ170D5	1M170ZS5		—
1EZ180D5	1M180ZS5		—
1EZ190D5	1M190ZS5		—
1EZ200D5	1M200ZS5		—
1M110ZS10	1M110ZS10		—
1M120ZS10	1M120ZS10		—
1M130ZS10	1M130ZS10		—
1M150ZS10	1M150ZS10		—
1M160ZS10	1M160ZS10		—
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THRU	THRU		
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1N703A-0*	1N703A-0		—
THRU	THRU		
1N703A-6	1N703A-6		—
1N704A-0*	1N704A-0		—
THRU	THRU		
1N704A-5	1N704A-5		—
1N705A-0*	1N705A-0		—
THRU	THRU		
1N705A-8	1N705A-8		—
1N706A-0*	1N706A-0		—
THRU	THRU		
1N706A-9	1N706A-9		—
1N707A-0*	1N707A-0		—
THRU	THRU		
1N707A-7	1N707A-7		—
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1N761,-1,-2*	1N761,-1,-2		—
1N761-69*	1N761-69		—
1N762,-1,-2*	1N762,-1,-2		—
1N763,-1,-2,-3*	1N763,-1,-2,-3		—
1N764,-1*	1N764,-1		—
THRU	THRU		
1N764,-4	1N764,-4		—
1N765,-1,-2*	1N765,-1,-2		—
1N766,-1,-2,-3*	1N766,-1,-2,-3		—
1N767,-1,-2,-3*	1N767,-1,-2,-3		—

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1N829A	1N829A		4-10
1N935	1N935		4-13
1N935A	1N935A		4-13
1N935B	1N935B		4-13
1N936	1N936		4-13
1N936A	1N936A		4-13
1N936B	1N936B		4-13
1N937	1N937		4-13
1N937A	1N937A		4-13
1N937B	1N937B		4-13
1N938	1N938		4-13
1N938A	1N938A		4-13
1N938B	1N938B		4-13
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1N941A	1N941A		4-17
1N941B	1N941B		4-17
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1N943A	1N943A		4-17
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1N944A	1N944A		4-17
1N944B	1N944B		4-17
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1N945B	1N945B		4-17
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1N958A	1N958A		4-4
1N959A	1N959A		4-4
1N960A	1N960A		4-4
1N961A	1N961A		4-4
1N962A	1N962A		4-4
1N963A	1N963A		4-4
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1N4357		1M180ZS10	—
1N4357A		1M180ZS10	—
1N4357B		1M180ZS5	—
1N4358		1M200ZS10	—
1N4358A		1M200ZS10	—
1N4358B		1M200ZS5	—
1N4360		1N4370A	—
1N4370	1N4370		—
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1N4401		1N4737	4-50
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1N4403		1N4739	4-50
1N4404		1N4740	4-50
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1N4406		1N4742	4-50
1N4407		1N4743	4-50
1N4408		1N4744	4-50
1N4409		1N4745	4-50
1N4410		1N4746	4-50
1N4411		1N4747	4-50
1N4412		1N4748	4-50
1N4413		1N4749	4-50
1N4414		1N4750	4-50
1N4415		1N4751	4-50
1N4416		1N4752	4-50
1N4417		1N4753	4-50
1N4418		1N4754	4-50
1N4419		1N4755	4-50
1N4420		1N4756	4-50
1N4421		1N4757	4-50
1N4422		1N4758	4-50
1N4423		1N4759	4-50
1N4424		1N4760	4-50
1N4425		1N4761	4-50
1N4426		1N4762	4-50
1N4427		1N4763	4-50
1N4428		1N4764	4-50
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1N4430		1M120ZS10	—
1N4431		1M130ZS10	—
1N4432		1M150ZS10	—
1N4433		1M160ZS10	—
1N4434		1M180ZS10	—
1N4435		1M200ZS10	—
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1N4461		1N4736A	4-50
1N4462		1N4737A	4-50
1N4463		1N4738A	4-50
1N4464		1N4739A	4-50
1N4465		1N4740A	4-50
1N4466		1N4741A	4-50
1N4467		1N4742A	4-50
1N4468		1N4743A	4-50
1N4469		1N4744A	4-50
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1N4477		1N4752A	4-50
1N4478		1N4753A	4-50
1N4479		1N4754A	4-50
1N4480		1N4755A	4-50
1N4481		1N4756A	4-50
1N4482		1N4757A	4-50
1N4483		1N4758A	4-50
1N4484		1N4759A	4-50
1N4485		1N4760A	4-50
1N4486		1N4761A	4-50
1N4487		1N4762A	4-50
1N4488		1N4763A	4-50
1N4489		1N4764A	4-50
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1N4491		1M120ZS5	—
1N4492		1M130ZS5	—
1N4493		1M150ZS5	—
1N4494		1M160ZS5	—
1N4495		1M180ZS5	—
1N4496		1M200ZS5	—
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1N4549RA	1N4549RA		4-23
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1N4550RA	1N4550RA		4-23
1N4551A	1N4551A		4-23
1N4551RA	1N4551RA		4-23
1N4552A	1N4552A		4-23
1N4552RA	1N4552RA		4-23
1N4553A	1N4553A		4-23
1N4553RA	1N4553RA		4-23
1N4554A	1N4554A		4-23
1N4554RA	1N4554RA		4-23
1N4555A	1N4555A		4-23
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1N4556RA	1N4556RA		4-23
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1N4557RA	1N4557RA		4-23
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1N4558RA	1N4558RA		4-23
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1N4559RA	1N4559RA		4-23
1N4560A	1N4560A		4-23
1N4560RA	1N4560RA		4-23
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1N4699	1N4699		4-48
1N4700	1N4700		4-48
1N4701	1N4701		4-48
1N4702	1N4702		4-48
1N4703	1N4703		4-48
1N4704	1N4704		4-48
1N4705	1N4705		4-48
1N4706	1N4706		4-48
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1N4730,A	1N4730,A		4-50
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1N4732,A	1N4732,A		4-50
1N4733,A	1N4733,A		4-50
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1N4735,A	1N4735,A		4-50
1N4736,A	1N4736,A		4-50
1N4737,A	1N4737,A		4-50
1N4738,A	1N4738,A		4-50
1N4739,A	1N4739,A		4-50
1N4740,A	1N4740,A		4-50
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1N4745,A	1N4745,A		4-50
1N4746,A	1N4746,A		4-50
1N4747,A	1N4747,A		4-50
1N4748,A	1N4748,A		4-50
1N4749,A	1N4749,A		4-50
1N4750,A	1N4750,A		4-50
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1N4752,A	1N4752,A		4-50
1N4753,A	1N4753,A		4-50
1N4754,A	1N4754,A		4-50
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1N4756,A	1N4756,A		4-50
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1N4758,A	1N4758,A		4-50
1N4759,A	1N4759,A		4-50
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1N4766A	1N4766A		4-46
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1N4776A	1N4776A		4-46
1N4777	1N4777		4-46
1N4777A	1N4777A		4-46
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1N4782	1N4782		4-46
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1N4857A		1M110ZS10	—
1N4857B		1M110ZS5	—
1N4858		1M120ZS10	—
1N4858A		1M120ZS10	—
1N4858B		1M120ZS5	—
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THRU	THRU		
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THRU		THRU	
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THRU	THRU		
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LPZ7.5,A	1M7.5ZS10,5		—
THRU	THRU		
LPZ200,A	1M200ZS10,5		—
LPZT8.2	1M8.2ZZ10		—
THRU	THRU		
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THRU		THRU	
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THRU		THRU	
MC6030,A		1N957A-1N977A	—
MC6107,A		1M6.8ZS10,5	—
THRU		THRU	
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THRU	THRU		
MLL4135	MLL4135		4-92
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MLL4614	MLL4614		4-92
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MLL4627	MLL4627		4-92
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THRU		THRU	
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THRU	THRU		
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THRU	THRU		
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MZ92-3.0		1N4372	4-4
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MZ92-6.0		.5M6.0AZ10	—
MZ92-6.2		1N753	4-4
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MZ92-8.2		1N756	4-4
MZ92-8.7		.5M8.7AZ10	—
MZ92-9.1		1N757	4-4
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THRU		THRU	
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THRU		THRU	
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THRU		THRU	
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THRU		THRU	
MZ806		5M6.8ZS10	—
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MZ1000-19		1N4746	4-50
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THRU		THRU	
MZ5220		5M200ZS10	—
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THRU		THRU	
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THRU	THRU		
MZT3015	MZT3015		—
MZT3305	MZT3305		—
THRU	THRU		
MZT3350	MZT3350		—
MZT4549	MZT4549		—
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SVR4764,A		1M100ZS10,5	—
SX30		1M30ZS5	—
THRU		THRU	
SX120		1M120ZS5	—
SZ2.4,A	1M2.4ZS10,5		—
THRU	THRU		
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TZ3.9,A,B,C,D	1M3.9ZS,10,5,1,2		—
THRU	THRU		
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UZ120		5M200ZS5	—
THRU		THRU	
UZ220		5M200ZS10	—
UZ122		5M110ZSB5	—
THRU		THRU	
UZ222		5M100ZSB10	—
UZ140		5M200ZSB5	—
THRU		THRU	

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THRU		THRU	
UZ3281,A,B		1N5281,A,B	—
UZ3470,A,B		1N2970A,B	4-27
UZ3515,A,B		1N3015A,B	4-27
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UZ4706,A,B		1N5342A,B	—
UZ4736,A		1N4736,A	4-50
THRU		THRU	
UZ4764,A		1N4764,A	4-50
UZ5120		5M200ZS5	—
THRU		THRU	
UZ5220		5M200ZS10	—
UZ5122		5M110ZSB5	—
THRU		THRU	
UZ5222		5M110ZSB10	—
UZ5140		5M200ZSB5	—
THRU		THRU	
UZ5240		5M200ZSB10	—
UZ5706		5M6.8ZS5	—
THRU		THRU	
UZ5806		5M6.8ZS10	—
UZ7110		10M100Z5	—
THRU		THRU	
UZ7210		10M100Z10	—
UZ7706		10M6.8Z5	—
THRU		THRU	
UZ7806		10M6.8Z10	—
UZ8120		1M200ZS5	—
THRU		THRU	
UZ8220		1M200ZS10	—
UZ8706		1M6.8ZS5	—
THRU		THRU	
UZ8806		1M6.8ZS10	—
VR6.2	1M6.2ZS10		—
THRU	THRU		
VR200	1M200ZS10		—
Z4X5.1B,A	1M5.1AZ10,5		—
THRU	THRU		
Z4X14B,A	1M14Z10,5		—
ZA6.8,A,B		1M6.8ZS,10,5	—
THRU		THRU	
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ZAC6.8,A,B		5M6.8ZS,10,5	—
THRU		THRU	
ZAC200,A,B		5M200ZS,10,5	—
ZB6.8,A,B		1M6.8ZS,10,5	—
THRU		THRU	
ZB200,A,B		1M200ZS,10,5	—
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THRU		THRU	
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THRU		THRU	
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ZCC6.8,A,B,C,D,E		5M6.8ZS,10,5,1,2	—
THRU		THRU	
ZCC200,A,B,C,D,E		5M200ZS,10,5,1,2	—
ZD3.3,A,B		1M3.3ZS,10,5	—
THRU		THRU	
ZD6.2,A,B		1M6.2ZS,10,5	—
ZD3.9	1M3.9ZS,10,5		—
THRU	THRU		
ZD200	1M200ZS,10,5		—
ZD6.8,A,B		1M6.8ZS,10,5	—
THRU		THRU	
ZD200,A,B		1M200ZS,10,5	—
ZM3.9,A,B,C,D	1M3.9ZS,10,5,1,2		—
THRU	THRU		
ZM200,A,B,C,D	1M200ZS,10,5,1,2		—
ZS4.7,A,B		1M4.7ZS,10,5	—
THRU		THRU	
ZS36,A,B		1M36ZS,10,5	—

*These devices are manufactured by Motorola but no data sheet available — Consult Factory.

RECTIFIERS

Motorola is the world's leading supplier of rectifiers, including those for use in switching power supplies. Wafer fabrication technology has constantly improved, leading to the product offering outlined in this selector guide. Today's Motorola rectifiers embody the same precision technology as the most advanced ICs, and are capable of passing stringent environmental testing, including under the hood of an automobile.

In addition to improved quality, rectifier product trends are toward higher operating temperature, faster switching times, plastic packages (translate lower cost) and use of dual rectifier modules.

ZENER DIODES

Motorola's standard Zeners and Avalanche Regulator diodes comprise the largest inventoried line in the industry. Continuous development of improved manufacturing techniques have resulted in computerized diffusion and test, as well as critical process controls learned from surface-sensitive MOS fabrication. Resultant high yields lower factory costs. Check the following features for application to your specific requirements:

- Wide selection of package materials and styles:
  - Plastic (Surmetic) for low cost, mechanical ruggedness
  - Glass for highest reliability, lowest cost
  - Metal for highest power
- Power ratings from 0.25 to 50 Watts
- Breakdown voltages from 1.8 to 200 V in approximately 10% steps
- Available tolerances from 10% (low cost) to a tight as 1% (critical applications) with off-the-shelf delivery
- Special selection of electrical characteristics available at low cost due to high-volume lines (check your Motorola sales representative for special quotations)
- JAN/JANTX(V) availability
- Special glass now used in DO-35 type packages is compatible with low temperature alloy processes, yielding sharper breakdown and low leakage.

Contents

Selector Guides

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Rectifiers

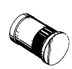
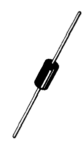
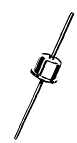
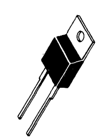
Schottky Rectifiers

SWITCHMODE Schottky Power Rectifiers with the high speed and low forward voltage drop characteristic of Schottky's metal/silicon junctions are produced with ruggedness and temperature performance comparable to silicon-junction rectifiers. Ideal for use in low voltage, high frequency power supplies and as very fast clamping diodes, these devices feature switching times less than 10 ns, and are offered in current ranges from 0.5 to 300 amperes, and reverse voltages to 60 volts.

In some current ranges, devices are available with junction temperature specifications of 125°C, 150°C, 175°C. Devices with higher T_J ratings can have significantly lower leakage currents, but higher forward-voltage specifications. These parameter tradeoffs should be considered when selecting devices for applications that can be satisfied by more than one device type number. Detailed specifications are available on the individual data sheets.

All devices are connected cathode to case or cathode to heatsink, where applicable. Reverse polarity may be available on some devices upon special request. Contact your Motorola representative for more information.

2

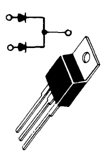
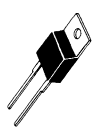
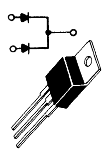
	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)							
	0.5		1.0	3.0		5.0	7.5	10
	362-01 Glass Leadless	299-02 (DO-204AH) Glass	59-04 Plastic	267 Plastic		60 Metal	221B-01 (TO-220AC) Plastic	
V_{RRM} (Volts)								
20			1N5817	1N5820	MBR320	1N5823		
30	MBRL030	MBR030	1N5818	1N5821	MBR330	1N5824		
35							MBR735	MBR1035
40	MBRL040	MBR040	1N5819	1N5822	MBR340	1N5825	MBR740	MBR1040
45							MBR745	MBR1045
50			MBR150††		MBR350			
60			MBR160††		MBR360			MBR1060
I_{FSM} (Amps)	5.0	5.0	25	80	80	500	150	150
†T_C @ Rated I_O (°C)							105	135
†T_L @ Rated I_O (°C)	75	75	90	95		80		
T_J (Max) (°C)	150	150	125	125	150	125	150	150
Max V_F @ $I_{FM} = I_O$	*0.65 $T_L = 25°C$	*0.65 $T_L = 25°C$	*0.60 $T_L = 25°C$	*0.525 $T_L = 25°C$	***0.740 $T_L = 25°C$	*0.38 $T_C = 25°C$	0.57 $T_C = 125°C$	0.57 $T_C = 125°C$

▨ TX versions available.
* Values are for the 40-Volt units. The lower voltage parts provide lower limits and higher voltage units provide slightly higher limits.
** I_O is total device output.
*** Values are for 60 volt units. The lower voltages parts ≤40 volts provide lower limits.
† Must be derated for reverse power dissipation. See Data Sheet.
†† T_J (Max) = 150°C

SCHOTTKY RECTIFIERS (continued)

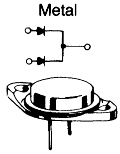
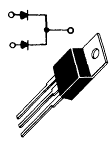
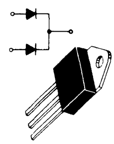
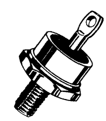
There are many other standard features in Motorola Schottky rectifiers that give added performance and reliability.

1. GUARDRINGS are included in all Schottky die for reverse voltage stress protection from high rates of dv/dt to virtually eliminate the need for snubber networks. The guardring also operates like a zener and avalanches when subjected to voltage transients.
2. MOLYBDENUM DISCS on both sides of the die minimize fatigue from power cycling in all metal product. The plastic TO-220 devices have a special solder formulation for the same purpose.
3. QUALITY CONTROL monitors all critical fabrication operations and performs selected stress tests to assure constant processes.

I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)					
15		16	20	25	
221A-02 (TO-220AB) Plastic  Dual Diode**	56-02 (DO-4) Metal 	221B-01 (TO-220AC) Plastic 	221A-02 (TO-220AB) Plastic  Dual Diode**	56-02 (DO-4) Metal 	
	1N5826			1N5829	
	1N5827			1N5830	1N6095
MBR1535CT		MBR1635	MBR2035CT		
MBR1540CT	1N5828	MBR1640	MBR2040CT	1N5831	1N6096
MBR1545CT		MBR1645	MBR2045CT		
150	500	300	150	800	400
105	85	125	135	85	70
150	125	150	150	125	125
0.72 @ 15 A T_C = 125°C	*0.50 T_C = 25°C	0.57 T_C = 125°C	0.72 @ 20 A T_C = 125°C	*0.48 T_C = 25°C	0.86 @ 78.5 A T_C = 70°C

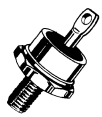
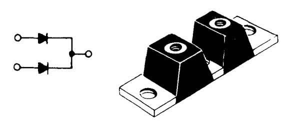
□ TX versions available.
* Values are for the 40-Volt units. The lower voltage parts provide lower limits.
** I_O is total device output.

SCHOTTKY RECTIFIERS (continued)

V_{RRM} (Volts)	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes) 30			35	40	50
	11-03 (TO-3) Metal  Dual Diode** (40 Mil Pins)	221A-02 (TO-220AB) Plastic  Dual Diode**	340-01 (TO-218AC) Plastic  Dual Diode**	56-02 (DO-4) Metal 	257 (DO-5) Metal 	
20					1N5832	
30					1N5833	1N6097
35	MBR3035CT	MBR2535CT	MBR3035PT	MBR3535		
40	MBR3040CT	MBR2540CT	MBR3040PT	MBR3540	1N5834	1N6098
45	SD241 MBR3045CT	MBR2545CT	MBR3045PT	SD41 MBR3545		
50						
60						
I_{FSM} (Amps)	400	300	400	600	800	800
†T_C @ Rated I_O (°C)	105	125	105	90	75	70
†T_L @ Rated I_O (°C)						
T_J (Max) (°C)	150	150	150	150	125	125
Max V_F @ I_{FM} = I_O	0.72 @ 30 A T_C = 125°C	0.73 @ 30 A T_C = 125°C	0.72 @ 30 A T_C = 125°C	0.55 T_C = 25°C	*0.59 T_C = 25°C	0.86 @ 157 A T_C = 70°C

▩ TX versions available.
* Values are for the 40-Volt units. The lower voltage parts provide lower limits.
** I_O is total device output.
† Must be derated for reverse power dissipation. See Data Sheet.

SCHOTTKY RECTIFIERS (continued)

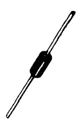
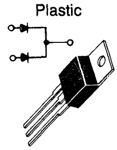
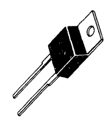
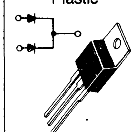
I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)						
60	**65**	**75**	**80**	**120**	**200**	**300**
257 (DO-5) Metal 				357B-01 Plastic POWER TAP  Dual Diode**		
MBR6035	MBR6535	MBR7535	MBR8035	MBR12035CT	MBR20035CT	MBR30035CT
MBR6040	MBR6540	MBR7540				MBR30040CT
SD51 MBR6045	MBR6545	MBR7545	MBR8045	MBR12045CT	MBR20045CT	MBR30045CT
				MBR12050CT	MBR20050CT	
				MBR12060CT	MBR20060CT	
800	800	1000	1000	1500	1500	2500
90	120	90	120	140	140	140
150	175	150	175	175	175	175
*0.6 T_C = 125°C	0.62 T_C = 150°C	0.60 T_C = 125°C	0.59 T_C = 150°C	0.68 T_C = 125°C	0.71 T_C = 125°C	0.64 T_C = 125°C

☐ TX versions available.
** I_O is total device output.

Ultrafast Recovery Rectifiers

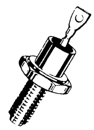
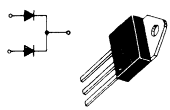
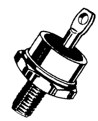
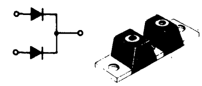
EXPANDING the SWITCHMODE Rectifier family are these ultrafast devices with reverse recovery times of 25 to 100 nanoseconds. They complement the broad Schottky offering for use in the higher voltage outputs and internal circuitry of switching power supplies as operating frequencies increase from 20 kHz to 250 kHz. Additional package styles and operating current levels are planned.

All devices are connected cathode to case or cathode to heatsink, where applicable. Reverse polarity may be available on some devices upon special request. Contact your Motorola representative for more information.

	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)					
	1.0	4.0	6.0	8.0	15	16
V_{RRM} (Volts)	59-04 (DO-41) Plastic 	267-01 Plastic 	221A-02 (TO-220AB) Plastic  Dual Diode**	221B-01 (TO-220AC) Plastic 		221A-02 (TO-220AB) Plastic  Dual Diode**
50	MUR105	MUR405	MUR605CT	MUR805	MUR1505	MUR1605CT
100	MUR110	MUR410	MUR610CT	MUR810	MUR1510	MUR1610CT
150	MUR115	MUR415	MUR615CT	MUR815	MUR1515	MUR1615CT
200	MUR120	MUR420	MUR620CT	MUR820	MUR1520	MUR1620CT
300	MUR130	MUR430		MUR830	MUR1530	MUR1630CT
400	MUR140	MUR440		MUR840	MUR1540	MUR1640CT
500	MUR150	MUR450		MUR850	MUR1550	MUR1650CT
600	MUR160	MUR460		MUR860	MUR1560	MUR1660CT
700	MUR170	MUR470		MUR870		
800	MUR180	MUR480		MUR880		
900	MUR190	MUR490		MUR890		
1000	MUR1100	MUR4100		MUR8100		
I_{FSM} (Amps)	35	125	75	100	200	100
T_A @ Rated I_O (°C)	50	80				
T_C @ Rated I_O (°C)			130	150	150	150
T_J (Max) (°C)	175	175	175	175	175	175
t_{rr} ns	25/50/75	25/50/75	35	35/60/100	35/60	35

** I_O is total device output.

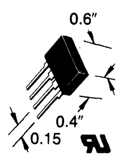
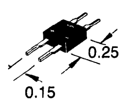
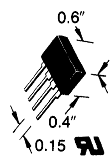
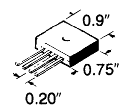
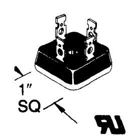
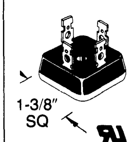
ULTRAFAST RECOVERY RECTIFIERS (continued)

I_I, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)					
25	30		50	100	200
56-02 (DO-4) Metal 	340-01 (TO-218AC) Plastic  Dual Diode**		257 (DO-5) Metal 	357B-01 Plastic POWER TAP  Dual Diode**	
MUR2505	R710XPT	MUR3005PT	MUR5005	MUR10005CT	MUR20005CT
MUR2510	R711XPT	MUR3010PT	MUR5010	MUR10010CT	MUR20010CT
MUR2515		MUR3015PT	MUR5015	MUR10015CT	MUR20015CT
MUR2520	R712XPT	MUR3020PT	MUR5020	MUR10020CT	MUR20020CT
		MUR3030PT			MUR20030CT
	R714XPT	MUR3040PT			MUR20040CT
500	150	400	600	400	800
145	100	150	125	140	95
175	150	175	175	175	175
50	100	35	50	50	50

** I_O is total device output.

Rectifier Bridges

Motorola SUPERBRIDGES offer cost effectiveness and reliability in single phase applications. Chip/leadframe techniques are used for lower-current types, while the higher current assemblies combine pretested "button" rectifier cells for low assembly cost and high yields. Performance of four individual diodes is achieved with reliability of the whole assembly comparable to that of a single unit. The higher current assemblies feature versatile slip-on/solder/wire wrap terminals.

V_{RRM} (Volts)	I_O, DC OUTPUT CURRENT (Amperes)					
	1.0	1.5	2.0	4.0/8.0	25	35
	312-02 	109-03 	312-02 	117A-02 Note 1 	309A-03 	309A-02 
50	3N246 MDA100A	MDA920A2	3N253 MDA200	MDA970A1	MDA2500	MDA3500
100	3N247 MDA101A	MDA920A3	3N254 MDA201	MDA970A2	MDA2501	MDA3501
200	3N248 MDA102A	MDA920A4	3N255 MDA202	MDA970A3	MDA2502	MDA3502
400	3N249 MDA104A	MDA920A6	3N256 MDA204	MDA970A5	MDA2504	MDA3504
600	3N250 MDA106A	MDA920A7	3N257 MDA206	MDA970A6	MDA2506	MDA3506
800	3N251 MDA108A	MDA920A8	3N258 MDA208	CF		MDA3508
1000	3N252 MDA110A	MDA920A9	3N259 MDA210	CF		MDA3510
I_{FSM} (Amps)	30	45	60	100	400	400
T_A @ Rated I_O (°C)	75	50	55	25 @ 4.0 A		
T_C @ Rated I_O (°C)				55 @ 8.0 A	55	55
T_J (Max) (°C)	150	175	175	150	175	175

CF: Consult Factory.

UL RECOGNIZED E61980

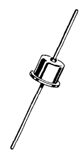
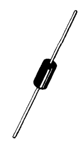
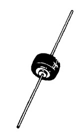
Dimensions given are nominal

Note 1. The MDA970A series replaces the MDA970 in the new Case 117A-02, which has minor changes over the old Case 117.

Fast Recovery Rectifiers

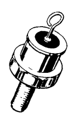
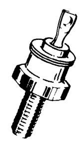
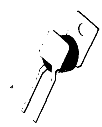
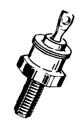
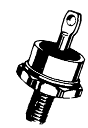
. . . available for designs requiring a power rectifier having maximum switching times ranging from 200 ns to 750 ns. These devices are offered in current ranges of 1.0 to 50 amperes and in voltages to 1000 volts.

All devices are connected cathode to case or cathode to heatsink, where applicable. Reverse polarity may be available on some devices upon special request. Contact your Motorola representative for more information.

	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)					
	1.0		3.0			5.0
V_{RRM} (Volts)	59-04 Plastic 		60 Metal 	267-01 Plastic 		194-04 Plastic 
50	†1N4933	MR810	MR830	MR850	MR910	MR820
100	†1N4934	MR811	MR831	MR851	MR911	MR821
200	†1N4935	MR812	MR832	MR852	MR912	MR822
400	†1N4936	MR814	MR834	MR854	MR914	MR824
600	†1N4937	MR816	MR836	MR856	MR916	MR826
800		MR817			MR917	
1000		MR818			MR918	
I_{FSM} (Amps)	30	30	100	100	100	300
T_A @ Rated I_O (°C)	75	75		*90	*90	*55
T_C @ Rated I_O (°C)		100	100			
T_J (Max) (°C)	150	150	150	175	175	175
t_{rr} (μs)	0.2	0.75	0.2	0.2	0.75	0.2

* Must be derated for reverse power dissipation. See Data Sheet.
† Package Size: 0.120″ Max Diameter by 0.260″ Max Length.

FAST RECOVERY RECTIFIERS (continued)

V_{RRM} (Volts)	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)						
	6.0	12	20	24	30	40	50
	245 (DO-4) Metal 		42A (DO-5) Metal 	339 Plastic Note 1 	42A (DO-5) Metal 	257 (DO-5) Metal 	
50	1N3879	1N3889	1N3899	MR2400F	1N3909	MR860	MR870
100	1N3880	1N3890	1N3900	MR2401F	1N3910	MR861	MR871
200	1N3881	1N3891	1N3901	MR2402F	1N3911	MR862	MR872
400	1N3883	1N3893	1N3903	MR2404F	1N3913	MR864	MR874
600	MR1366	MR1376	MR1386	MR2406F	MR1396	MR866	MR876
800							
1000							
I_{FSM} (Amps)	150	200	250	300	300	350	400
T_A @ Rated I_O (°C)							
T_C @ Rated I_O (°C)	100	100	100	125	100	100	100
T_J (max) (°C)	150	150	150	175	150	160	160
t_{rr} μs	0.2	0.2	0.2	0.2	0.2	0.2	0.2

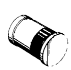
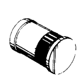
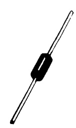
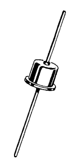
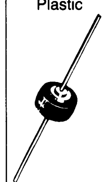
▩ TX versions available.

Note 1. Meets mounting configuration of TO-220 outline.

General-Purpose Rectifiers

Motorola offers a wide variety of low-cost devices, packaged to meet diverse mounting requirements. Avalanche capability is available in the axial lead 1.5,3 and 6 amp packages shown below to provide protection from transients.

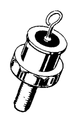
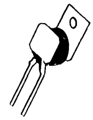
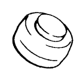
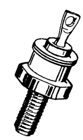
All devices are connected cathode to case or cathode to heatsink, where applicable. Reverse polarity may be available on some devices upon special request. Contact your Motorola representative for more information.

	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)							
	0.5	1.0		1.5	3.0			6.0
V_{RRM} (Volts)	362-01 Glass Leadless 	362B-01 Glass Leadless 	59-04 (DO-15) Plastic 		60 Metal 	267 Plastic 		194-04 Plastic 
50	MRL005	MLL4001	†1N4001	**1N5391	1N4719	**MR500	1N5400	**MR750
100	MRL010	MLL4002	†1N4002	**1N5392	1N4720	**MR501	1N5401	**MR751
200	MRL020	MLL4003	†1N4003	1N5393 *MR5059	1N4721	**MR502	1N5402	**MR752
400	MRL040	MLL4004	†1N4004	1N5395 *MR5060	1N4722	**MR504	1N5404	**MR754
600			†1N4005	1N5397 *MR5061	1N4723	**MR506	1N5406	**MR756
800			†1N4006	1N5398	1N4724	MR508		MR758
1000			†1N4007	1N5399	1N4725	MR510		MR760
I_{FSM} (Amps)	10	20	30	50	300	100	200	400
T_A @ Rated I_O (°C)	75	75	75	T_L = 70	75	95	T_L = 105	60
T_C @ Rated I_O (°C)								
T_J (Max) (°C)	175	175	175	175	175	175	175	175

† Package Size: 0.120″ Max Diameter by 0.260″ Max Length.

* 1N5059 series equivalent Avalanche Rectifiers.

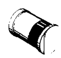
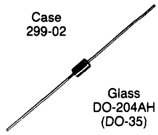
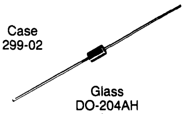
** Avalanche versions available, consult factory.

V_{RRM} (Volts)	I_O, AVERAGE RECTIFIED FORWARD CURRENT (Amperes)							
	12	20	24	25	30		40	50
	245 (DO-4) Metal		339 Plastic Note 1	193-03 Plastic Note 2	43-02 (DO-21) Metal		42A (DO-5) Metal	43-04 Metal
								
50	MR1120 1N1199,A,B	MR2000	MR2400	MR2500	1N3491	1N3659	1N1183A	MR5005
100	MR1121 1N1200,A,B	MR2001	MR2401	MR2501	1N3492	1N3660	1N1184A	MR5010
200	MR1122 1N1202,A,B	MR2002	MR2402	MR2502	1N3493	1N3661	1N1186A	MR5020
400	MR1124 1N1204,A,B	MR2004	MR2404	MR2504	1N3495	1N3663	1N1188A	MR5040
600	MR1126 1N1206,A,B	MR2006	MR2406	MR2506	MR328	Note 3	1N1190A	Note 3
800	MR1128 1N3988	MR2008		MR2508	MR330	Note 3	Note 3	Note 3
1000	MR1130 1N3990	MR2010		MR2510	MR331	Note 3	Note 3	Note 3
I_{FSM} (Amps)	300	400	400	400	300	400	800	600
T_A @ Rated I_O (°C)								
T_C @ Rated I_O (°C)	150	150	125	150	130	100	150	150
T_J (Max) (°C)	190	175	175	175	175	175	190	195

Note 1. Meets mounting configuration of TO-220 outline.
Note 2. Request Data Sheet for Mounting Information.
Note 3. Available on special order.

Zener and Avalanche Regulator Diodes

General-Purpose Regulator Diodes

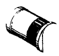
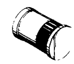
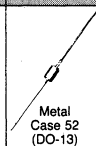
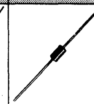
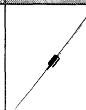
Nominal Zener Voltage	250 mW Low Level Cathode = Polarity Mark	250 mW Low Noise Cathode = Polarity Mark	250 mW Low Level Cathode = Polarity Mark	250 mW Low Noise Cathode = Polarity Mark	350 mW Cathode = Polarity Mark		400 mW Low Noise Low Leakage Cathode = Polarity Mark	500 mW Cathode = Polarity Mark		
(*Note 1)	(*Notes 2,3,14)		(*Notes 2,3)	(*Notes 2,3)	(*Notes 2,6,17)		(*Notes 2,4)	(*Notes 2,5)	(*Notes 2,6)	(*Notes 1,2,13)
	 Glass Case 362-01		Case 299-02  Glass DO-204AH (DO-35)		 Case 318-02,-03 Style 8 SOT-23 (TO-236AA/AB)		Case 299-02  Glass DO-204AH (DO-35)			
1.8	MLL4678	MLL4614	1N4678	1N4614						
2.0	MLL4679	MLL4615	1N4679	1N4615						
2.2	MLL4680	MLL4616	1N4680	1N4616						
2.4	MLL4681	MLL4617	1N4681	1N4617				1N4370	1N5221	1N5985A
2.5										
2.7	MLL4682	MLL4618	1N4682	1N4618				1N4371	1N5223	
2.8										1N5986A
3.0	MLL4683	MLL4619	1N4683	1N4619				1N4372	1N5225	1N5987A
3.3	MLL4684	MLL4620	1N4684	1N4620	MMBZ5226		1N5518A	1N746	1N5226	1N5988A
3.6	MLL4685	MLL4621	1N4685	1N4621	MMBZ5227		1N5519A	1N747	1N5227	1N5989A
3.9	MLL4686	MLL4622	1N4686	1N4622	MMBZ5228		1N5520A	1N748	1N5228	1N5990A
4.3	MLL4687	MLL4623	1N4687	1N4623	MMBZ5229		1N5221A	1N749	1N5229	1N5991A
4.7	MLL4688	MLL4624	1N4688	1N4624	MMBZ5230	BZX84C4V7	1N5522A	1N750	1N5230	1N5992A
5.1	MLL4689	MLL4625	1N4689	1N4625	MMBZ5231	BZX84C5V1	1N5523A	1N751	1N5231	1N5993A
5.6	MLL4690	MLL4626	1N4690	1N4626	MMBZ5232	BZX84C5V6	1N5524A	1N752	1N5232	1N5994A
6.0					MMBZ5233					
6.2	MLL4691	MLL4627	1N4691	1N4627	MMBZ5234	BZX84C6V2	1N5525A	1N753	1N5234	1N5995A
6.8	MLL4692	MLL4099	1N4692	1N4099	MMBZ5235	BZX84C6V8	1N5526A	1N754 1N957A	1N5235	1N5996A
7.5	MLL4693	MLL4100	1N4693	1N4100	MMBZ5236	BZX84C7V5	1N5527A	1N755 1N958A	1N5236	1N5997A
8.2	MLL4694	MLL4101	1N4694	1N4101	MMBZ5237	BZX84C8V2	1N5228A	1N756 1N959A	1N5237	1N5998A
8.7	MLL4695	MLL4102	1N4695	1N4102	MMBZ5238				1N5238	
9.1	MLL4696	MLL4103	1N4696	1N4103	MMBZ5239	BZX84C9V1	1N5529A	1N757 1N960A	1N5239	1N5999A
10	MLL4697	MLL4104	1N4697	1N4104	MMBZ5240	BZX84C10	1N5530A	1N758 1N961A	1N5240	1N6000A
11	MLL4698	MLL4105	1N4698	1N4105	MMBZ5241	BZX84C11	1N5531A	1N962A	1N5241	1N6001A
12	MLL4699	MLL4106	1N4699	1N4106	MMBZ5242	BZX84C12	1N5532A	1N759 1N963A	1N5242	1N6002A
13	MLL4700	MLL4107	1N4700	1N4107	MMBZ5243	BZX84C13	1N5533A	1N964A	1N5243	1N6003A
14	MLL4701	MLL4108	1N4701	1N4108	MMBZ5244		1N5334A		1N5244	
15	MLL4702	MLL4109	1N4702	1N4109	MMBZ5245	BZX84C15	1N5335A	1N965A	1N5245	1N6004A
16	MLL4703	MLL4110	1N4703	1N4110	MMBZ5246	BZX84C16	1N5336A	1N966A	1N5246	1N6005A
17	MLL4704	MLL4111	1N4704	1N4111	MMBZ5247		1N5337A		1N5247	
18	MLL4705	MLL4112	1N4705	1N4112	MMBZ5248	BZX84C18	1N5338A	1N967A	1N5248	1N6006A
19	MLL4706	MLL4113	1N4706	1N4113	MMBZ5249		1N5539A		1N5249	
20	MLL4707	MLL4114	1N4707	1N4114	MMBZ5250	BZX84C20	1N5540A	1N968A	1N5250	1N6007A
22	MLL4708	MLL4115	1N4708	1N4115	MMBZ5251	BZX84C22	1N5541A	1N969A	1N5251	1N6008A
24	MLL4709	MLL4116	1N4709	1N4116	MMBZ5252	BZX84C24	1N5542A	1N970A	1N5252	1N6009A
25	MLL4710	MLL4117	1N4710	1N4117	MMBZ5253		1N5543A		1N5253	
27	MLL4711	MLL4118	1N4711	1N4118	MMBZ5254	BZX84C27		1N971A	1N5254	1N6010A
28	MLL4712	MLL4119	1N4712	1N4119	MMBZ5255		1N5544A		1N5255	
30	MLL4713	MLL4120	1N4713	1N4120	MMBZ5256	BZX84C30	1N5545A	1N972A	1N5256	1N6011A
33	MLL4714	MLL4121	1N4714	1N4121	MMBZ5257	BZX84C33	1N5546A	1N973A	1N5257	1N6012A
36	MLL4715	MLL4122	1N4715	1N4122				1N974A	1N5258	1N6013A
39	MLL4716	MLL4123	1N4716	1N4123				1N975A	1N5259	1N6014A
43	MLL4717	MLL4124	1N4717	1N4124				1N976A	1N5260	1N6015A
47		MLL4125		1N4125				1N977A	1N5261	1N6016A
51		MLL4126		1N4126				1N978A	1N5262	1N6017A
56		MLL4127		1N4127				1N979A	1N5263	1N6018A
60		MLL4128		1N4128					1N5264	
62		MLL4129		1N4129				1N980A	1N5265	1N6019A
68		MLL4130		1N4130				1N981A	1N5266	1N6020A
75		MLL4131		1N4131				1N982A	1N5267	1N6021A
82		MLL4132		1N4132				1N983A	1N5268	1N6022A
87		MLL4133		1N4133					1N5269	
91		MLL4134		1N4134				1N984A	1N5270	1N6023A
100		MLL4135		1N4135				1N985A	1N5271	1N6024A
110								1N986A	1N5272	1N6025A
120								†1N987A	1N5273#	
130								†1N988A	1N5274#	
140									1N5275#	
150								†1N989A	1N5276#	
160								†1N990A	1N5277#	
170									1N5278#	
180								†1N991A	1N5279#	
200								†1N992A	1N5281#	

☐ JAN JANTX(V) available, ±5% only. # 1N5273–1N5281 supplied in Surmetic DO-7 plastic package.

† 1N987–1N992 supplied in DO-7 glass package. * See Notes on page 20.

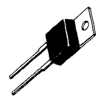
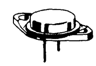
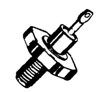
2

General-Purpose Regulator Diodes (continued)

Nominal Zener Voltage	500 mW Cathode = Polarity Mark		1 Watt Cathode = Polarity Mark		1 Watt Cathode to Case	1.5 Watt Cathode = Polarity Mark	1.5 Watt Cathode to Case	5 Watt Cathode = Polarity Mark
(*Note 1)	(*Notes 2,5,14)	(*Notes 2,6,14)	(*Notes 2,7)	(*Notes 2,7,15)	(*Notes 2,8)	(*Notes 2,9)	(*Notes 2,10)	(*Notes 2,11)
	 Glass Case 362-01		 Glass Case 59 (DO-41)	 Glass Case 362B-01	 Metal Case 52 (DO-13)	 Surmetic 30 Case 59 (DO-41)	 Metal Case 55	 Surmetic 40 Case 17
1.8								
2.0								
2.2								
2.4	MLL4370	MLL5221						
2.5		MLL5222						
2.7	MLL4371	MLL5223						
2.8		MLL5224						
3.0	MLL4372	MLL5225						
3.3	MLL746	MLL5226	1N4728	MLL4728	1N3821	1N5913A		1N5333A
3.6	MLL747	MLL5227	1N4729	MLL4729	1N3822	1N5914A		1N5334A
3.9	MLL748	MLL5228	1N4730	MLL4730	1N3823	1N5915A		1N5335A
4.3	MLL749	MLL5229	1N4731	MLL4731	1N3824	1N5916A		1N5336A
4.7	MLL750	MLL5230	1N4732	MLL4732	1N3825	1N5917A		1N5337A
5.1	MLL751	MLL5231	1N4733	MLL4733	1N3826	1N5918A		1N5338A
5.6	MLL752	MLL5232	1N4734	MLL4734	1N3827	1N5919A		1N5339A
6.0		MLL5233						
6.2	MLL753	MLL5234	1N4735	MLL4735	1N3828	1N5920A		1N5341A
6.8	MLL754 MLL957A	MLL5235	1N4736	MLL4736	1N3829 1N3016A	1N5921A	1N3785A	1N5342A
7.5	MLL755 MLL958A	MLL5236	1N4737	MLL4737	1N3830 1N3017A	1N5922A	1N3786A	1N5343A
8.2	MLL756 MLL959A	MLL5237	1N4738	MLL4738	1N3018A	1N5923A	1N3787A	1N5344A
8.7		MLL5238						1N5345A
9.1	MLL757 MLL960A	MLL5239	1N4739	MLL4739	1N3019A	1N5924A	1N3788A	1N5346A
10	MLL758 MLL961A	MLL5240	1N4740	MLL4740	1N3020A	1N5925A	1N3789A	1N5347A
11	MLL962A	MLL5241	1N4741	MLL4741	1N3021A	1N5926A	1N3790A	1N5348A
12	MLL759 MLL963A	MLL5242	1N4742	MLL4742	1N3022A	1N5927A	1N3791A	1N5349A
13	MLL964A	MLL5243	1N4743	MLL4743	1N3023A	1N5928A	1N3792A	1N5350A
14		MLL5244						1N5351A
15	MLL965A	MLL5245	1N4744	MLL4744	1N3024A	1N5929A	1N3793A	1N5352A
16	MLL966A	MLL5246	1N4745	MLL4745	1N3025A	1N5930A	1N3794A	1N5353A
17		MLL5247						1N5354A
18	MLL967A	MLL5248	1N4746	MLL4746	1N3026A	1N5931A	1N3795A	1N5355A
19		MLL5249						1N5356A
20	MLL968A	MLL5250	1N4747	MLL4747	1N3027A	1N5932A	1N3796A	1N5357A
22	MLL969A	MLL5251	1N4748	MLL4748	1N3028A	1N5933A	1N3797A	1N5358A
24	MLL970A	MLL5252	1N4749	MLL4749	1N3029A	1N5934A	1N3798A	1N5359A
25		MLL5253						1N5360A
27	MLL971A	MLL5254	1N4750	MLL4750	1N3030A	1N5935A	1N3799A	1N5361A
28		MLL5255						1N5362A
30	MLL972A	MLL5256	1N4751	MLL4751	1N3031A	1N5936A	1N3800A	1N5363A
33	MLL973A	MLL5257	1N4752	MLL4752	1N3032A	1N5937A	1N3801A	1N5364A
36	MLL974A	MLL5258	1N4753	MLL4753	1N3033A	1N5938A	1N3802A	1N5365A
39	MLL975A	MLL5259	1N4754	MLL4754	1N3034A	1N5939A	1N3803A	1N5366A
43	MLL976A	MLL5260	1N4755	MLL4755	1N3035A	1N5940A	1N3804A	1N5367A
47	MLL977A	MLL5261	1N4756	MLL4756	1N3036A	1N5941A	1N3805A	1N5368A
51	MLL978A	MLL5262	1N4757	MLL4751	1N3037A	1N5942A	1N3806A	1N5369A
56	MLL979A	MLL5263	1N4758	MLL4758	1N3038A	1N5943A	1N3807A	1N5370A
60		MLL5264						1N5371A
62	MLL980A	MLL5265	1N4759	MLL4759	1N3039A	1N5944A	1N3808A	1N5372A
68	MLL981A	MLL5266	1N4760	MLL4760	1N3040A	1N5945A	1N3809A	1N5373A
75	MLL982A	MLL5267	1N4761	MLL4761	1N3041A	1N5946A	1N3810A	1N5374A
82	MLL983A	MLL5268	1N4762	MLL4762	1N3042A	1N5947A	1N3811A	1N5375A
87		MLL5269						1N5376A
91	MLL984A	MLL5270	1N4763	MLL4763	1N3043A	1N5958A	1N3812A	1N5377A
100	MLL985A		1N4764	MLL4764	1N3044A	1N5949A	1N3813A	1N5378A
110	MLL986A		♦1M110ZS10		1N3045A	1N5950A	1N3814A	1N5379A
120			♦1M120ZS10		1N3046A	1N5951A	1N3815A	1N5380A
130			♦1M130ZS10		1N3047A	1N5952A	1N3816A	1N5831A
150			♦1M150ZS10		1N3048A	1N5953A	1N3817A	1N5383A
160			♦1M160ZS10		1N3049A	1N5954A	1N3818A	1N5384A
170			♦1M170ZS10					1N5385A
175								
180			♦1M180ZS10		1N3050A	1N5955A	1N3819A	1N5386A
200			♦1M200ZS10		1N3051A	1N5956A	1N3820A	1N5388A

♦ 1M110ZS10 Series supplied in Surmetic (Plastic) DO-41 package.

General-Purpose Regulator Diodes (continued)

Nominal Zener Voltage	10 Watt Cathode to Case = 1N3993 & MZT2970 Series Anode to Case = 1N2970 Series		50 Watt Cathode to Case = MZT4549 Series Anode to Case = 1N4557A Series		
(*Note 1)	(*Notes 2,10,12)	(*Notes 2,16)	(*Notes 2,16)	(*Notes 2,10,12)	(*Notes 2,10,12)
	 Metal Case 56 (DO-4)	 221B-01 (TO-220AC) Plastic		 Metal Case 54 (TO-3)	 Metal Case 58 (DO-5 Type)
1.8					
2.0					
2.2					
2.4					
2.5					
2.7					
2.8					
3.0					
3.3					
3.6					
3.9	1N3993&R		MZT4549	1N4557A&RA	1N4549A&RA
4.3	1N3994&R		MZT4550	1N4558A&RA	1N4550A&RA
4.7	1N3995&R		MZT4551	1N4559A&RA	1N4551A&RA
5.1	1N3996&R		MZT4552	1N4560A&RA	1N4552A&RA
5.6	1N3997&R		MZT4553	1N4561A&RA	1N4553A&RA
6.0					
6.2	1N3998&R		MZT4554	1N4562A&RA	1N4554A&RA
6.8	1N3999&R 1N2970A&RA	MZT2970	MZT3305	1N4563A&RA 1N2804A&RA	1N4555A&RA 1N3305A&RA
7.5	1N4000&R 1N2971A&RA	MZT2971	MZT3306	1N4564A&RA 1N2805A&RA	1N4556A&RA 1N3306A&RA
8.2	1N2972A&RA	MZT2972	MZT3307	1N2806A&RA	1N3307A&RA
8.7					
9.1	1N2973A&RA	MZT2973	MZT3308	1N2807A&RA	1N3308A&RA
10	1N2974A&RA	MZT2974	MZT3309	1N2808A&RA	1N3309A&RA
11	1N2975A&RA	MZT2975	MZT3310	1N2809A&RA	1N3310A&RA
12	1N2976A&RA	MZT2976	MZT3311	1N2810A&RA	1N3311A&RA
13	1N2977A&RA	MZT2977	MZT3312	1N2811A&RA	1N3312A&RA
14	1N2878A&RA	MZT2978	MZT3313	1N2812A&RA	1N3313A&RA
15	1N2979A&RA	MZT2979	MZT3314	1N2813A&RA	1N3314A&RA
16	1N2980A&RA	MZT2980	MZT3315	1N2814A&RA	1N3315A&RA
17			MZT3316	1N2815A&RA	1N3316A&RA
18	1N2982A&RA	MZT2981	MZT3317	1N2816A&RA	1N3317A&RA
19	1N2983A&RA	MZT2982	MZT3318	1N2817A&RA	1N3318A&RA
20	1N2984A&RA	MZT2983	MZT3319	1N2818A&RA	1N3319A&RA
22	1N2985A&RA	MZT2984	MZT3320	1N2819A&RA	1N3320A&RA
24	1N2986A&RA	MZT2986	MZT3321	1N2820A&RA	1N3321A&RA
25			MZT3322	1N2821A&RA	1N3322A&RA
27	1N2988A&RA	MZT2987	MZT3323	1N2822A&RA	1N3323A&RA
28					
30	1N2989A&RA	MZT2988	MZT3324	1N2823A&RA	1N3324A&RA
33	1N2990A&RA	MZT2989	MZT3325	1N2824A&RA	1N3325A&RA
36	1N2991A&RA	MZT2990	MZT3326	1N2825A&RA	1N3326A&RA
39	1N2992A&RA	MZT2992	MZT3327	1N2826A&RA	1N3327A&RA
43	1N2993A&RA	MZT2993	MZT3328	1N2827A&RA	1N3328A&RA
47	1N2996A&RA	MZT2995	MZT3330	1N2829A&RA	1N33330A&RA
50		MZT2996	MZT3331		
51	1N2997A&RA	MZT2997	MZT3332	1N2831A&RA	1N3332A&RA
52		MZT2998	MZT3333		1N3334A&RA
56	1N2999A&RA	MZT2999	MZT3334	1N2832A&RA	
60					1N3335A&RA
62	1N3000A&RA	MZT3000	MZT3335	1N2833A&RA	1N3336A&RA
68	1N3001A&RA	MZT3001	MZT3336	1N2834A&RA	
75	1N3002A&RA	MZT3002	MZT3337	1N2835A&RA	1N3337A&RA
82	1N3003A&RA	MZT3003	MZT3338	1N2836A&RA	1N3338A&RA
87					
91	1N3004A&RA	MZT3004	MZT3339	1N2837A&RA	1N3339A&RA
100	1N3005A&RA	MZT3005	MZT3340	1N2838A&RA	1N3340A&RA
105		MZT3006	MZT3341		
110	1N3007A&RA	MZT3007	MZT3342	1N2840A&RA	1N3342A&RA
120	1N3008A&RA	MZT3008	MZT3343	1N2841A&RA	1N3343A&RA
130	1N3009A&RA	MZT3009	MZT3344	1N2842A&RA	1N3344A&RA
140					1N3345A&RA
150	1N3011A&RA	MZT3010	MZT3345	1N2843A&RA	1N3346A&RA
160	1N3012A&RA	MZT3011	MZT3347	1N2844A&RA	1N3347A&RA
170					
175		MZT3012	MZT3348		
180	1N3014A&RA	MZT3014	MZT3349	1N2845A&RA	1N3349A&RA
200	1N3015A&RA	MZT3015	MZT3350	1N2846A&RA	1N3350A&RA

* See Notes

NOTES

1. The Zener Voltage is measured at approximately 1/4 the rated power, with the following exceptions: the 1N4678–4717 is measured with I_{ZT} = 50 μAdc; the 1N4614/1N4099 is measured with I_{ZT} = 250 μAdc; the 1N4370/1N746 and the 1N5221–5242 are measured with I_{ZT} = 20 mAdc; the 1N5985A–6012A is measured with I_{ZT} = 5.0 mA; 1N6013A–6023A is measured with I_{ZT} = 2.0 mA; 1N6024–6025 is measured with I_{ZT} = 1.0 mA.
2. Contact your Motorola representative for information on intermediate voltages and tighter tolerances.

Tolerances

3. No suffix = ±5%
4. A Suffix = ±10% — with guaranteed limits on V_Z, V_F, and I_R only
   B suffix = ±5%
   C suffix = ±2%
   D suffix = ±1%
5. MLL4370/1N4370/1N746 series:
   No suffix = ±10%
   A suffix = ±5%
   MLL957/1N957 series:
   A suffix = ±10%
   B suffix = ±5%

Military parts in 1N4370/746/962 series and standard 1N987–1N992 supplied in DO-7. Military parts in 1N4370/746/962 are also available in the cost effective DO-204AH (DO-35) package as the -1 version. This version can be ordered by inserting a 1 between the part number and the JAN, JTX or JTXV suffix, i.e. 1N746A1JAN. MIL-STD 19500/117 and 127 state the -1 version is a direct substitute for the non -1 version. The -1 versions appear on MIL-STD 701 as the preferred parts for new designs. Military parts in 1N4614, 1N4099 and 1N5518A series supplied in DO-7.

6. No suffix = ±10% with guaranteed limits on V_Z, V_F and I_R only.
   A suffix = ±10%
   B suffix = ±5%
7. No suffix = ±10%
   A suffix = ±5%
8. 1N3821 series: No suffix = ±10%, A suffix = ±5%
   1N3016 series: A suffix = ±10%, B suffix = ±5%
9. A suffix = ±10% C suffix = ±2%
   B suffix = ±5% D suffix = ±1%
10. A* suffix = ±10%
    B suffix = ±5%
    Exception:
    1N3993–1N4000: No suffix = ±10%, A suffix = ±5%
11. A suffix = ±10%
    B suffix = ±5%
12. RA and RB = Reverse Polarity Types Available
13. A suffix = ±10%
    B suffix = ±5%
14. Available in 8 mm Tape and Reel
    T1 Cathode Facing Sprocket Holes
    T2 Anode Facing Sprocket Holes
15. Available in 12 mm Tape and Reel
    T1 Cathode Facing Sprocket Holes
    T2 Anode Facing Sprocket Holes
16. The type numbers shown indicate a tolerance of ±20% with guaranteed limits on only V_Z and I_R as shown. ±10% tolerance is available by adding suffix "A," and ±5% is available by adding suffix "B."
17. Available in 8 mm tape and reel, both T1 and T2 options.

2

2

Selected Zener Diode Options

In cases where standard specifications do not meet application requirements, an appropriate device can be selected and ordered from the following options. This coding system is provided as a means of communicating a specific requirement to Motorola. Certain voltages, tolerances and packages may not be available. Contact your Motorola sales representative for availability, price, and minimum order quantities.

NON-STANDARD ZENER DIODES SPECIAL VOLTAGE AND TOLERANCE RATINGS

JEDEC "1N" type numbers denote a specific Zener voltage, power rating, and tolerance. For example, JEDEC type 1N4728 is a standard 1 watt diode, rated at 3.3 volts ± 10%. A suffix "A" on this type number indicates a ± 5% voltage tolerance.

Special Motorola devices, with a choice of voltages and tolerances, are also available. The following diagram explains the Motorola coding system:

(blank)	M	XXXX	Z or AZ	(blank)
Power Rating (Watts)	Motorola	Nominal Zener Voltage (Volts) ⟨4 Characters Max Excluding Decimal⟩	Zener Diode	Tolerance (±%) (omit for ±20% units)

For example, the code for a special 10 watt Zener diode with a voltage of 41 volts and a tolerance of ± 1% would be: 10M41Z1.

Following is a list of other standard Motorola symbols for special Zener device orders (X's indicate nominal Zener voltage):

Basic Motorola Type	**Electrically Similar Series	Device Description
1/4MXXAZXX	1/4M2.4AZ10 series	250 mW, Glass, DO-35
1/4MXXXZXX	1.4M6.8Z10 series	250 mW, Glass, DO-35
.4MXXAZXX	1N4370 & 1N746 series	400 mW/500 mW, Glass, DO-35
.4MXXXZXX	1N957 series	400 mW/500 mW, Glass, DO-35
.5MXXAZXX	1N4370 & 1N746 series	400 mW/500 mW, Glass, DO-35
.5MXXXZXX	1N957 series	400 mW/500 mW, Glass, DO-35
1MXXAZXX	1N3821 series	1 Watt, Metal DO-13
1MXXXZXX	1N3016 series	1 Watt, Metal, DO-13
1MXXXZGXX	1N4728 series	1 Watt, Glass, DO-41
1MXXXZSXX	1N4728 series	1 Watt, Surmetic-30, DO-41
1.5MXXXZXX	1N3785 series	1.5 Watt Metal Can
5MXXXZSXX	1N5333 series	5 Watt Surmetic-40
10MXXAZXX	1N3993 series	10 Watt, Stud, DO-4
10MXXXZXX	1N2970 series	10 Watt, Stud, DO-4
50MXXAZXX	1N4557 series	50 Watt, TO-3
50MXXXZXX	1N2804 series	50 Watt, TO-3
50MXXAZSXX	1N4549 series	50 Watt, Stud, DO-5
50MXXXZSXX	1N3305 series	50 Watt, Stud, DO-5
MZG35-YYZ	1N5985 series	500 mW, Glass, DO-35
MZG41-YYZ	1N5913 series	1.5 Watt, Surmetic-30

**Electrical parameters shall be tested per the similar series listed. Test currents for non-standard voltages will be linearly interpoled between the test currents for standard parts on either side. For reverse polarity devices (10 W and 50 W) insert an "R" before tolerance.

1N5518 thru 1N5546 — This series may be ordered in ±2% and ±1% tolerance by adding the following suffix:

C = ±2% D = ±1%

For example the 1N5518D would be the same as the 1N5518B except V_Z = 3.3 ±1%.

MATCHED SETS OF ZENER DIODES

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

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.

(blank)	M	(blank)	Z or AZ	(blank)	(blank)	(blank)
Power Rating (Watts)	Motorola	Nominal Voltage (each device) ⟨4 Characters Max Excluding Decimal⟩	Zener Diodes	Tolerance per device (±%) (omit for ±20% units)	Code* (A-Not used)	Overall Tolerance of set (±%)

*Code:

- B — Two devices in series
- C — Three devices in series
- D — Four devices in series
- E — Five devices in series
- F — Six devices in series
- G — Seven devices in series
- H — Eight devices in series
- X — Two devices; one standard polarity, the other reverse polarity. (10 and 50 watts only)

i.e., 10M51Z5B1 is for two 10 watt zeners, each of 51 volts, ± 5%, matched to a total voltage of 102 volts ± 1%.

ZENER CLIPPERS

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

(blank)	M	(blank)	Z or AZ	Z	(blank)
Power Rating (Watts)		Nominal Voltage	Zener Diode	Clipper	Tolerance for each of the two Zener Voltages (Is not a matching requirement. Omit for ±20% Units.)

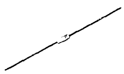
i.e., 10M20ZZ10

This nomenclature is applicable to all packages and power ratings as restricted in the above paragraphs.

Special Purpose Regulators

Field-Effect Current Regulator Diodes

High impedance diodes whose "constant current source" characteristic complements the "constant voltage" of the zener line. Currents are available from 0.22 to 4.7 mA, with usable voltage range from a minimum limit of 1.0 to 2.5 V, up to a voltage compliance of 100 V, for the 1N5283 series, or 70 V, for the MCL1300 series.



Glass
Case 51-02
DO-204AA
(DO-7)

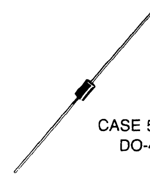
Reg. Current I_P @V_T = 25 V mA Nom	Device Type	Knee Imp Z_K @V_K = 6.0 V MΩ Min	Limiting Voltage @I_L = 0.8 I_P Volts Max
0.22	1N5283	2.75	1.00
0.24	1N5284	2.35	1.00
0.27	1N5285	1.95	1.00
0.30	1N5286	1.60	1.00
0.33	1N5287	1.35	1.00
0.39	1N5288	1.00	1.05
0.43	1N5289	0.870	1.05
0.47	1N5290	0.750	1.05
0.56	1N5291	0.560	1.10
0.62	1N5292	0.470	1.13
0.68	1N5293	0.400	1.15
0.75	1N5294	0.335	1.20
0.82	1N5295	0.290	1.25
0.91	1N5296	0.240	1.29
1.00	1N5297	0.205	1.35
1.10	1N5298	0.180	1.40
1.20	1N5299	0.155	1.45
1.30	1N5300	0.135	1.50
1.40	1N5301	0.115	1.55
1.50	1N5302	0.105	1.60
1.60	1N5303	0.092	1.65
1.80	1N5304	0.074	1.75
2.00	1N5305	0.061	1.85
2.20	1N5306	0.052	1.95
2.40	1N5307	0.044	2.00
2.70	1N5308	0.035	2.15
3.00	1N5309	0.029	2.25
3.30	1N5310	0.024	3.35
3.60	1N5311	0.020	2.50
3.90	1N5312	0.017	2.60
4.30	1N5313	0.014	2.75
4.70	1N5314	0.012	2.90
0.5±.03	MCL1300	0.500	1.00
1.0±0.6	MCL1301	0.200	1.50
2.0±0.6	MCL1302	0.100	2.00
3.0±0.6	MCL1303	0.050	2.00
4.0±0.6	MCL1304	0.025	2.50

☐ JAN/JANTX (V) availability

Low-Voltage Regulators

High-conductance silicon diodes designed as stable forward-reference sources for transistor amplifier biasing and similar applications. Available in high reliability glass construction or economic plastic packaging.

CASE 51-02
DO-204AA
(DO-7)
Surmetic 20



CASE 59-03
DO-41

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted).

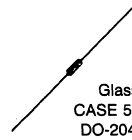
Forward Reference Voltage Min	Forward Reference Voltage Max	I_F Test Current mA	Leakage Current I_R @ V_R µA	Leakage Current I_R @ V_R Volts	Device Type	Case
0.63	0.71	10	10	5.0	MZ2360	59 Surmetic
1.24	1.38	10	10	5.0	MZ2361	51 Surmetic

2

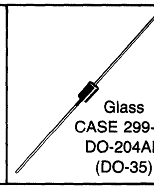
Temperature Compensated Reference Devices

For applications where output voltage must remain within narrow limits during changes in input voltage, load resistance and temperature. Motorola guarantees all References Devices to fall within the specified maximum voltage variations, ΔV_Z, at the specifically indicated test temperatures and test current (JEDEC Standard #5). Temperature Coefficient is also specified but should be considered as a reference only — not a maximum rating.

Devices in this table are hermetically sealed structures. Includes JAN, JANTX and JTXV Devices.



Glass
CASE 51-02
DO-204AA
(DO-7)



Glass
CASE 299-02
DO-204AH
(DO-35)

2

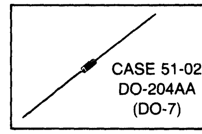
V_Z Volts	Test Current mAdc	Test Temp Points	AVERAGE TEMPERATURE COEFFICIENT OVER THE OPERATING RANGE — 0.01 %/°C Device Type	0.01 %/°C ΔV_Z Max Volts	0.005 %/°C Device Type	0.005 %/°C ΔV_Z Max Volts	0.002 %/°C Device Type	0.002 %/°C ΔV_Z Max Volts	0.001 %/°C Device Type	0.001 %/°C ΔV_Z Max Volts	0.0005 %/°C Device Type	0.0005 %/°C ΔV_Z Max Volts	Case
6.2 △1	7.5	A	1N821	0.096	1N823	0.048	1N825	0.019	1N827	0.009	1N829	0.005	299-02
6.2 △1	7.5	A	1N821A	0.096	1N823A	0.048	1N825A	0.019	1N827A	0.009	1N829A	0.005	
6.4	0.5	B	1N4565	0.018	1N4566	0.024	1N4567	0.010	1N4568	0.005	1N4569	0.002	DO-204AH (DO-35)
	0.5	A	1N4565A	0.099	1N4566A	0.050	1N4567A	0.020	1N4568A	0.010	1N4569A	0.005	
	1.0	B	1N4570	0.048	1N4571	0.024	1N4572	0.010	1N4573	0.005	1N4574	0.002	
	1.0	A	1N4570A	0.099	1N4571A	0.050	1N4572A	0.020	1N4573A	0.010	1N4574A	0.005	
	2.0	B	1N4575	0.048	1N4576	0.024	1N4577	0.010	1N4578	0.005	1N4579	0.002	
	2.0	A	1N4575A	0.099	1N4576A	0.025	1N4577A	0.020	1N4578A	0.010	1N4579A	0.005	
	4.0	B	1N4580	0.048	1N4581	0.024	1N4582	0.010	1N4583	0.005	1N4584	0.002	
	4.0	A	1N4580A	0.099	1N4581A	0.050	1N4582A	0.020	1N4583A	0.010	1N4584A	0.005	
8.4	10	A	1N3154	0.130	1N3155	0.065	1N3156	0.026	1N3157	0.013			51-02
	10	C	1N3154A	0.072	1N3155A	0.085	1N3156A	0.034	1N3157A	0.017			
8.5	0.5	B	1N4775	0.064	1N4776	0.032	1N4777	0.013	1N4778	0.006	1N4779	0.003	DO-204AA (DO-7)
	0.5	A	1N4775A	0.132	1N4776A	0.066	1N4777A	0.026	1N4778A	0.013	1N4779A	0.007	
	1.0	B	1N4780	0.064	1N4781	0.032	1N4782	0.013	1N4783	0.006	1N4784	0.003	
	1.0	A	1N4780A	0.132	1N4781A	0.066	1N4782A	0.026	1N4783A	0.013	1N4784A	0.007	
9.0	7.5	B	1N935	0.067	1N936	0.033	1N937	0.013	1N938	0.006	1N939	0.003	
	7.5	A	1N935A	0.139	1N936A	0.069	1N937A	0.027	1N938A	0.013	1N939A	0.007	
	7.5	C	1N935B	0.184	1N936B	0.092	1N937B	0.037	1N938B	0.018	1N939B	0.009	
9.1	0.5	B	1N4765	0.068	1N4766	0.034	1N4767	0.014	1N4768	0.007	1N4769	0.003	
	0.5	A	1N4765A	0.141	1N4766A	0.070	1N4767A	0.028	1N4768A	0.014	1N4769A	0.007	
	1.0	B	1N4770	0.068	1N4771	0.034	1N4772	0.014	1N4773	0.007	1N4774	0.003	
	1.0	A	1N4770A	0.141	1N4771A	0.070	1N4772A	0.028	1N4773A	0.014	1N4774A	0.007	
11.7	7.5	B	1N941	0.088	1N942	0.044	1N943	0.018	1N944	0.009	1N945	0.004	51-02 DO-204AA (DO-7)
	7.5	A	1N941A	0.081	1N942A	0.090	1N943A	0.036	1N944A	0.018	1N945A	0.009	
	7.5	C	1N941B	0.239	1N942B	0.120	1N943B	0.047	1N944B	0.024	1N945B	0.012	

△1 Non-suffix — Z_{ZT} = 15, "A" Suffix — Z_{ZT} = 10

▨ JAN/JANTX(V) available, ±5% only, Military part in the 1N821 and 1N4565 series and supplied in the DO-7 package.

Test Temperature Points	
A	−55, 0, +25, +75, +100
B	0, +25, +75
C	−55, 0, +25, +75, +100, +150
D	0, +25, +70
E	−55, 0, +25, +75, +125
F	−55, 0, +75, +125, +185
G	+25, +75, +100

Temperature Compensated Reference Devices (continued)



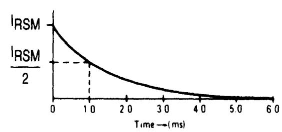
Precision Reference Diodes

Designed, manufactured and tested for ultra-high stability of voltage with time and temperature change. Use of special measurement equipment and voltage standards provide calibration directly traceable to the National Bureau of Standards.

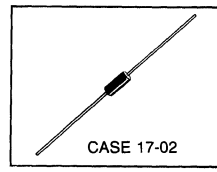
Reference Voltage Volts	Test Current mA	Temperature Stability		CERTIFIED VOLTAGE TIME STABILITY OVER 1000 HOURS OF OPERATION (Parts/Million Change)							
				<5 PPM/1000 HR		<10 PPM/1000 HR		<20 PPM/1000 HR		<40 PPM/1000 HR	
		Δ V_Z (mV)	OP Temp Range °C	Device Type	Change µV Max	Device Type	Change µV Max	Device Type	Change µV Max	Device Type	Change µV Max
6.2±5%	7.5	2.5	25,75,100	MZ605	30	MZ610	60	MZ620	120	MZ640	240

Transient Suppressors

Transient suppressors are designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Select from standard factory available types or design the suppressor to meet specific needs by paralleling cells. For specific options, i.e., non-standard voltage, higher power capacity, and package configurations, consult factory.



Surge Current Characteristics



PEAK POWER DISSIPATION @ 1.0 ms = 600 WATTS

Breakdown Voltage $V_{(BR)}$ Volts Nom	Breakdown Voltage @I_T mA	Device Type	I_{RSM} Maximum Reverse Surge Current Amp	V_{RSM} Maximum Reverse Voltage @ I_{RSM} Volts	Case
6.8	10	P6KE6.8	56	10.8	17-02
7.5	10	P6KE7.5	51	11.7	↓
8.2	10	P6KE8.2	48	12.5	
9.1	1.0	P6KE9.1	44	13.8	
10	1.0	P6KE10	40	15	
11	1.0	P6KE11	37	16.2	
12	1.0	P6KE12	35	17.3	
13	1.0	P6KE13	32	19	
15	1.0	P6KE15	27	22	
16	1.0	P6KE16	26	23.5	
18	1.0	P6KE18	23	26.5	
20	1.0	P6KE20	21	29.1	
22	1.0	P6KE22	19	31.9	
24	1.0	P6KE24	17	34.7	
27	1.0	P6KE27	15	39.1	
30	1.0	P6KE30	14	43.5	
33	1.0	P6KE33	12.6	47.7	
36	1.0	P6KE36	11.6	52	
39	1.0	P6KE39	10.6	56.4	
43	1.0	P6KE43	9.6	61.9	
47	1.0	P6KE47	8.9	67.8	
51	1.0	P6KE51	8.2	73.5	
56	1.0	P6KE56	7.4	80.5	
62	1.0	P6KE62	6.8	89	
68	1.0	P6KE68	6.1	98	
75	1.0	P6KE75	5.5	108	
82	1.0	P6KE82	5.1	118	
91	1.0	P6KE91	4.8	131	
100	1.0	P6KE100	4.2	144	
110	1.0	P6KE110	3.8	158	

Breakdown Voltage for Standard is ±10% Tolerance; ±5% version is available by adding "A", i.e., P6KE6.8A. Clipper (back to back) versions are available by ordering with a "C" or "CA" suffix, i.e., P6KE6.8C or P6KE6.8CA.

PEAK POWER DISSIPATION @ 1.0 ms = 600 WATTS (continued)

Breakdown Voltage $V_{(BR)}$ Volts Nom	@I_T mA	Device Type	I_{RSM} Maximum Reverse Surge Current Amp	V_{RSM} Maximum Reverse Voltage @ I_{RSM} Volts	Case
120	1.0	P6KE120	3.5	173	17-02
130	1.0	P6KE130	3.2	187	↓
150	1.0	P6KE150	2.8	215	↓
160	1.0	P6KE160	2.6	230	↓
170	1.0	P6KE170	2.5	244	↓
180	1.0	P6KE180	2.3	258	↓
200	1.0	P6KE200	2.1	287	↓

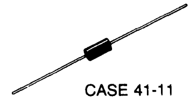
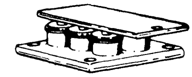
2

PEAK POWER DISSIPATION @ 1.0 ms = 1500 WATTS

Breakdown Voltage $V_{(BR)}$ Volts Nom	@I_T mA	Device Type		I_{RSM} Maximum Reverse Surge Current Amp	V_{RSM} Maximum Reverse Voltage @ I_{RSM} Volts	Case
6.0	1.0	1N5908		120	8.5	41-11
6.8	10	1N6267	1.5KE6.8	139	10.8	↓
7.5	10	1N6268	1.5KE7.5	128	11.7	↓
8.2	10	1N6269	1.5KE8.2	120	12.5	↓
9.1	1.0	1N6270	1.5KE9.1	109	13.8	↓
10	1.0	1N6271	1.5KE10	100	15.0	↓
11	1.0	1N6272	1.5KE11	93	16.2	↓
12	1.0	1N6273	1.5KE12	87	17.3	↓
13	1.0	1N6274	1.5KE13	79	19.0	↓
15	1.0	1N6275	1.5KE15	68	22.0	↓
16	1.0	1N6276	1.5KE16	64	23.5	↓
18	1.0	1N6277	1.5KE18	56.5	26.5	↓
20	1.0	1N6278	1.5KE20	51.5	29.1	↓
22	1.0	1N6279	1.5KE22	47.0	31.9	↓
24	1.0	1N6280	1.5KE24	43.0	34.7	↓
27	1.0	1N6281	1.5KE27	38.5	39.1	↓
30	1.0	1N6282	1.5KE30	34.5	43.5	↓
33	1.0	1N6283	1.5KE33	31.5	47.7	↓
36	1.0	1N6284	1.5KE36	29.0	52	↓
39	1.0	1N6285	1.5KE39	26.5	56.4	↓
43	1.0	1N6286	1.5KE43	24	61.9	↓
47	1.0	1N6287	1.5KE47	22.2	67.8	↓
51	1.0	1N6288	1.5KE51	20.4	73.5	↓
56	1.0	1N6289	1.5KE56	18.6	80.5	↓
62	1.0	1N6290	1.5KE62	16.9	89	↓
68	1.0	1N6291	1.5KE68	15.3	98	↓
75	1.0	1N6292	1.5KE75	13.9	108	↓
82	1.0	1N6293	1.5KE82	12.7	118	↓
91	1.0	1N6294	1.5KE91	11.4	131	↓
100	1.0	1N6295	1.5KE100	10.4	144	↓
110	1.0	1N6296	1.5KE110	9.5	158	↓
120	1.0	1N6297	1.5KE120	8.7	173	↓
130	1.0	1N6298	1.5KE130	8.0	187	↓
150	1.0	1N6299	1.5KE150	7.0	215	↓
160	1.0	1N6300	1.5KE160	6.5	230	↓
170	1.0	1N6301	1.5KE170	6.2	244	↓
180	1.0	1N6302	1.5KE180	5.8	258	↓
200	1.0	1N6303	1.5KE200	5.2	287	↓
220	1.0		1.5KE220	4.3	344	↓
250	1.0		1.5KE250	5.0	360	↓

Breakdown Voltage for Standard is ±10% Tolerance; ±5% version is available by adding "A", i.e., 1N6267A, 1.5KE6.8A. Clipper (back to back) versions are available by ordering the 1.5KE series with a "C" or "CA" suffix, i.e., 1.5KE6.8C or 1.5KE6.8CA.

TRANSIENT SUPPRESSORS (continued)

	
CASE 41-11	CASE 119-01

PEAK POWER DISSIPATION @ 1.0 ms = 1500 WATTS

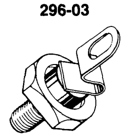
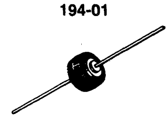
V_{RWM} Working Peak Reverse Voltage (Blocking or Stand-Off Voltage)	Device Type	Clipper (Back To Back) Version	I_{RSM} Maximum Reverse Surge Current Amp	V_{RSM} Maximum Reverse Voltage @ I_{RSM} Volts	Case
5.0	1N6373 / ICTE-5 / MPTE-5	ICTE-5C	160	9.4	41-11
8.0	1N6374 / ICTE-8 / MPTE-8	1N6382	100	15	
10	1N6375 / ICTE-10 / MPTE-10	1N6383	90	16.7	
12	1N6376 / ICTE-12 / MPTE-12	1N6384	70	21.2	
15	1N6377 / ICTE-15 / MPTE-15	1N6385	60	25	
18	1N6378 / ICTE-18 / MPTE-18	1N6386	50	30	
22	1N6379 / ICTE-22 / MPTE-22	1N6387	40	37.5	
36	1N6380 / ICTE-36 / MPTE-36	1N6388	23	65.2	
45	1N6381 / ICTE-45 / MPTE-45	1N6389	19	78.9	↓

PEAK POWER DISSIPATION @ 1.0 ms = 8000 WATTS

V_R Operating Voltage			I_R Reverse Current	Δ V_Z Breakdown Voltage		V_C Clamping Voltage		V_F Forward Voltage		
Nom Vdc	$V_{(RMS)}$	Device Type	μA	Min Volts @	I_{ZT} mA	Max Volts @	I_{PP} Amp	Volts @	I_F Amp	Case
14	10	MPZ5-16A	50	16	0.4	24	200	1.5	10	119-01
14	10	MPZ5-16B		16	0.4	20	200			
28	20	MPZ5-32A		32	0.2	50	100			
28	20	MPZ5-32B		32	0.2	45	100			
28	20	MPZ5-32C		32	0.2	40	100			
165	117	MPZ5-180A		180	0.03	250	20			
165	117	MPZ5-180B		180	0.03	225	20			
165	117	MPZ5-180C	↓	180	0.03	205	20	↓	↓	↓

Automotive Transient Suppressors

Automotive Transient Suppressors are designed for protection against over-voltage conditions in the auto electrical system including the "LOAD DUMP" phenomenon that occurs when the battery open circuits while the car is running.

AUTOMOTIVE TRANSIENT SUPPRESSOR				
V_{RRM} (Volts)	296-03 	194-01 		
23	MR2525 MR2525R	MR2525L	MR2520L	MR2530L
I_O (Amp)	25	6	6	6
$V_{(BR)}$ (Volts)	24–32	24–32	24–32	24–32
I_{RSM}* (Amp)	110	110	68	125
T_C @ Rated I_O (°C)	150	150	150	150
T (°C)	175	175	175	175

* Time Constant = 10 ms, Duty Cycle ≤ 1.0%, T_C = 25°C.

Lead Tape Packaging Standards for Axial-Lead Components

1.0 SCOPE — This document covers packaging requirements for the following axial-lead components' use in automatic testing and assembly equipment: Motorola Case 51 (DO-7), Case 52 (DO-13), Case 59 (DO-41), Case 267, Case 299 (DO-35), Case 59-04 and Case 17. Packaging, as covered in this document, shall consist of axial-lead components mounted by their leads on pressure-sensitive tape, wound onto a reel.

2.0 PURPOSE — This document establishes Motorola standard practices for lead-tape packaging of axial-lead components and meets the requirements of EIA Standard RS-296-D "Lead-taping of components on axial lead configuration for automatic insertion," level 1.

3.0 REQUIREMENTS

2

3.1 Component Leads

3.1.1 — Component leads shall not be bent beyond dimension E from their nominal position. See Figure 2.

3.1.2 — The "C" dimension shall be governed by the overall length of the reel packaged component. The distance between flanges shall be 0.059 inch to 0.315 inch greater than the overall component length. See Figures 2 and 3.

3.1.3 — Cumulative dimension "A" tolerance shall not exceed 0.059 over 5 in consecutive components.

ORIENTATION — All polarized components must be oriented in one direction. The cathode lead tape shall be blue, and the anode tape shall be white. See Figure 1.

3.3 Reeling

3.3.1 — Components on any reel shall not represent more than two date codes when date code identification is required.

3.3.2 — Components leads shall be positioned perpendicularly between pairs of 0.250 inch tape. See Figure 2.

3.3.3 — A minimum 1 inch leader of tape shall be provided before the first and last component on the reel.

3.3.4 — 50 lb. Kraft paper is wound between layers of components as far as necessary for component protection. Width of paper is 0.062 inch to 0.750 inch less than "C" dimension of reel. See Figure 3.

3.3.5 — Components shall be centered between tapes such that the difference between D1 and D2 does not exceed 0.055.

3.3.6 — Staple shall not be used for splicing. No more than 4 layers of tape shall be used in any splice area and no tape shall be offset from another by more than 0.031 inch noncumulative. Tape splices shall overlap at least 6 inches for butt joints and at least 3 inches for lap joints, and shall not be weaker than unspliced tape.

3.3.7 — Quantity per reel shall be as indicated in Table 1. Orders for tape and reeled product will only be processed and shipped in full reel increments. Scheduled orders must be in releases of full reel increments or multiples thereof. High volume orders and releases (item numbers 6 through 10 excepted) may be reeled on 14.00 inch reels at Motorola's option, therefore making the quantity per reel twice that shown for the 10.50 inch reels.

3.3.8 — A maximum of 0.25% of the components per reel quantity may be missing without consecutive missing per level 1 of RS-296-D.

3.3.9 — The single face roll pad shall be placed around the finished reel and taped securely. Each reel shall then be placed in an appropriate container.

3.4 MARKING — Minimum reel and carton marking shall consist of the following: See Figure 3.

Part number
Purchase order number
Quantity
Date of reeling (when applicable)
Manufacturer's name
Electrical value (when applicable)
Date codes (when applicable; see note 3.3.1)
Tape (when applicable)

4.0 — Requirements differing from this Motorola standard shall be negotiated with the factory.

The packages indicated in the following table are suitable for lead tape packaging. The table indicates the specific devices (rectifiers and/or zeners) that can be obtained from Motorola in reel packaging, and provides the appropriate packaging specification.

TABLE 1 — PACKAGING DETAILS (ALL DIMENSIONS IN INCHES)

Case Type	Product Category	Quantity Per Reel (Item 3.3.7)	Component Spacing A	Tape Spacing B	Reel Dimensions C	Reel Dimensions D (max)	Max Off Alignment E	Item Number
Case 51 (DO-7)	All	3000	0.200 ± 0.020	2.062 ± .059	3.00	10.50	0.047	1
Case 299 (DO-35)	Zeners	3000	0.200 ± 0.020	2.062 ± .059	3.00	10.50		2
Case 17	Zeners	2000	0.200 ± 0.015	2.062 ± .059	3.00	10.50		3
Case 59-03 (DO-41)	Zeners	3000	0.200 ± 0.015	2.062 ± .059	3.00	10.50		4
Case 59-01 (DO-41)	Zeners	3000	0.200 ± 0.015	2.062 ± .059	3.00	10.50		5
Case 59-01 (DO-41)	Rectifiers	6000	0.200 ± 0.020	2.062 ± .059	3.00	14.00		6
Case 59-04	Rectifiers	5000	0.200 ± 0.020	2.062 ± .059	3.00	14.00		7
Case 52 (DO-13)	Zeners	1500	0.400 ± 0.020	2.500 ± .059	3.81	14.00		8
Case 267	Rectifiers	1500	0.400 ± 0.020	2.062 ± .059	3.00	14.00		9
Case 41-11	Zeners	1500	0.400 ± 0.020	2.500 ± .059	3.81	14.00		10
Case 194-01	Rectifiers	900	0.500 ± 0.020	1.875 ± .059	3.00	14.00		11
Case 194-05	Rectifiers	900	0.400 ± 0.020	1.875 ± .059	3.00	14.00		12

FIGURE 1 — REEL PACKING

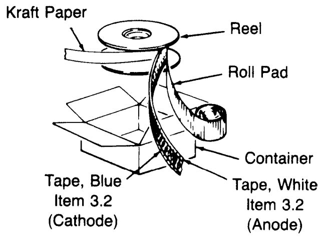


FIGURE 2 — COMPONENT SPACING

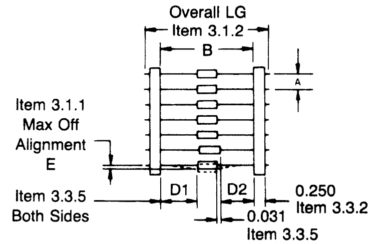
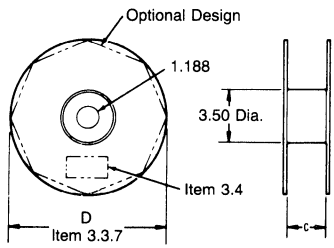


FIGURE 3 — REEL DIMENSIONS



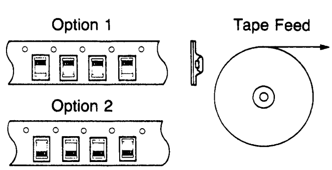
SURFACE MOUNT TAPE AND REEL

In conjunction with the industry trend to use automatic placement equipment for microminiature components, Motorola offers MLL34 and SOT-23 devices in the industry accepted 8 mm tape and reel format. MLL41 devices are offered in 12 mm tape. The current packaging method is plastic tape with embossed cavities, which serve as a pocket for the individual device. A sealing tape is then applied to retain the device.

- Device Orientation: Either in T1 (Option 1) or T2 (Option 2) configuration.
- Quantity Per Reel: 3,000 devices for MLL34.
  6,000 devices for MLL41.
  3,000 devices for SOT-23.
- Minimum Order Quantity: 1 reel.

For ordering information, please contact your local Motorola representative. (See listing on back cover.)

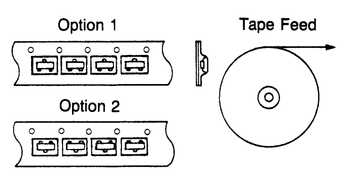
Tape & Reel Options
MLL34, MLL41



Polarity band indicates cathode.

Option 1 = T1 Designator, Cathode Facing Sprocket Holes
Option 2 = T2 Designator, Anode Facing Sprocket Holes

Tape & Reel Options
SOT-23



EIA Std RS481

Option 1 = T1 Designator
Option 2 = T2 Designator

Rectifier Data Sheets

3

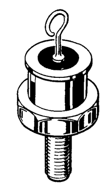
1N1199
thru
1N1206

MOTOROLA

MEDIUM-CURRENT SILICON RECTIFIERS

50-600 VOLTS
12 AMPERES

DIFFUSED JUNCTION



MEDIUM-CURRENT SILICON RECTIFIERS

Silicon rectifiers for medium-current applications requiring:

- High Current Surge — 240 Amperes @ T_J = 190°C
- Peak Performance at Elevated Temperature — 12 Amperes @ T_C = 150°C

3

*MAXIMUM RATINGS

Characteristic	Symbol	1N 1199	1N 1200	1N 1202	1N 1204	1N 1206	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	12					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	240 (for 1 cycle)					Amp
Operating Junction Temperature Range	T_J	-65 to +190					°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage (i_F = 40 A, T_C = 25°C)	v_F	1.8	Volts
Maximum Instantaneous Reverse Current (Rated voltage, T_C = 150°C)	i_R	10	mA

*Indicates JEDEC registered data.

MECHANICAL CHARACTERISTICS

Case: Welded, hermetically sealed

Finish: All external surfaces are corrosion-resistant and the terminal lead is readily solderable

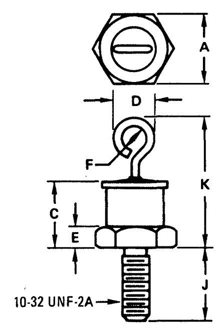
Polarity: Cathode to case (reverse polarity units are available and designed by an "R" suffix, i.e., 1N1202R)

Mounting Positions: Any

Stud Torque: 15 in/lbs max

Maximum Terminal Temperature for Soldering Purposes: 275°C for 10 seconds at 3 kg tension.

Weight: 6 grams (approx)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245
DO-203AA
(DO-4)

MOTOROLA

1N1199A thru 1N1206A

3

MEDIUM-CURRENT SILICON RECTIFIERS

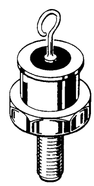
Silicon rectifiers for medium-current applications requiring:

- High Current Surge — 240 Amperes @ $T_J = 200°C$
- Peak Performance at Elevated Temperature — 12 Amperes @ $T_C = 150°C$

MEDIUM-CURRENT SILICON RECTIFIERS

50-600 VOLTS
12 AMPERES

DIFFUSED JUNCTION



*MAXIMUM RATINGS

Characteristic	Symbol	1N 1199A	1N 1200A	1N 1202A	1N 1204A	1N 1206A	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage (Halfwave, single phase, 60 Hz peak)	V_{RSM}	100	200	350	600	800	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, $T_C = 150°C$)	I_O	← 12 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	← 240 (for 1 cycle) →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →					°C

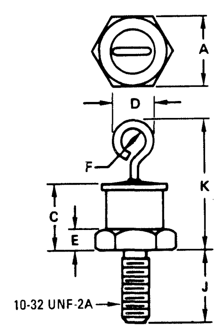
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage ($i_F = 40$ A, $T_C = 25°C$)	v_F	1.35	Volts
Maximum Average Reverse Current at Rated Conditions	I_{RO}		mA
1N1199A		3.0	
1N1200A		2.5	
1N1202A		2.0	
1N1204A		1.5	
1N1206A		1.0	

*Indicates JEDEC registered data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245
DO-203AA
(DO-4)

MECHANICAL CHARACTERISTICS

Case: Welded, hermetically sealed

Finish: All external surfaces are corrosion-resistant and the terminal lead is readily solderable

Polarity: Cathode to case (reverse polarity units are available and designed by an "R" suffix, i.e., 1N1202RA)

Mounting Positions: Any

Stud Torque: 15 in/lbs max

Maximum Terminal Temperature for Soldering Purposes: 275°C for 10 seconds at 3 kg tension.

Weight: 6 grams (approx)

1N1199B thru 1N1206B

MOTOROLA

MEDIUM-CURRENT SILICON RECTIFIERS

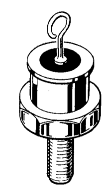
Compact, highly efficient silicon rectifiers for medium-current applications requiring:

- High Current Surge — 250 Amperes @ $T_J = 200°C$
- Peak Performance at Elevated Temperature — 12 Amperes @ $T_C = 150°C$

MEDIUM-CURRENT SILICON RECTIFIERS

50-600 VOLTS
12 AMPERES

DIFFUSED JUNCTION



*MAXIMUM RATINGS

Characteristic	Symbol	1N 1199B	1N 1200B	1N 1202B	1N 1204B	1N 1206B	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage (Halfwave, single phase, 60 Hz peak)	V_{RSM}	100	200	350	600	800	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, $T_C = 150°C$)	I_O	← 12 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	← 250 (for 1 cycle) →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +200 →					°C

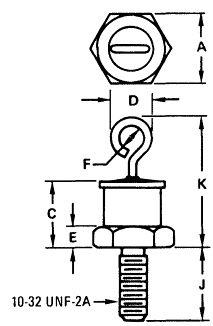
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage ($i_F = 40$ A, $T_C = 25°C$)	v_F	1.2	Volts
Maximum Reverse Current (Rated dc voltage, $T_C = 150°C$)	I_R	1.0	mA
Maximum Average Reverse Current at Rated Conditions	I_{RO}	0.9	mA
DC Forward Voltage ($I_F = 12$ A, $T_C = 25°C$)	V_F	1.1	Volts
Reverse Recovery Time ($I_{FM} = 40$ A, di/dt = 25 A/μs to $I_{FM} = 0$, $t_p \geq 4.0$ μs, 60 pulses/second, 25°C)	t_{rr}	5.0	μs

*Indicates JEDEC registered data.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245
DO-203AA
(DO-4)

MECHANICAL CHARACTERISTICS

Case: Metal hermetically sealed

Finish: All external surfaces are corrosion-resistant and the terminal lead is readily solderable

Polarity: Cathode to case (reverse polarity units are available and designed by an "R" suffix, i.e., 1N1202RB)

Mounting Positions: Any

Stud Torque: 15 in/lbs max

Maximum Terminal Temperature for Soldering Purposes: 275°C for 10 seconds at 3 kg tension.

Weight: 6 grams (approx)

MOTOROLA

1N3208 thru 1N3212

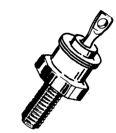
MEDIUM-CURRENT RECTIFIERS

. . . for applications requiring low forward voltage drop and rugged construction.

- High Surge Handling Ability
- Rugged Construction
- Reverse Polarity Available; Eliminates Need for Insulating Hardware in Many Cases
- Hermetically Sealed

15-AMP RECTIFIERS

SILICON DIFFUSED-JUNCTION



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***MAXIMUM RATINGS**

Rating	Symbol	1N3208 1N3208R	1N3209 1N3209R	1N3210 1N3210R	1N3211 1N3211R	1N3212 1N3212R	Unit
DC 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 Hz and 25°C Case Temperature)	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

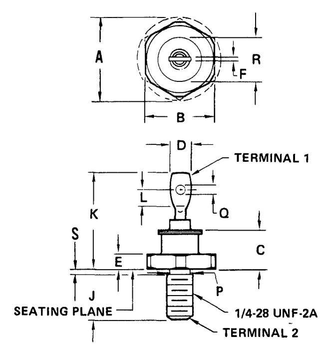
***ELECTRICAL CHARACTERISTICS** (All Types) at 25°C Case Temperature

Characteristic	Symbol	Value	Unit
Maximum Forward Voltage at 40 Amp DC Forward Current	V_F	1.5	Volts
Maximum Reverse Current at Rated DC Reverse Voltage	I_R	1.0	mAdc

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typical	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.7	°C/W

*Indicates JEDEC registered data.
**T_C = 150°C



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	20.07	–	0.790
B	16.94	17.45	0.669	0.687
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	19.05	25.40	0.750	1.000
L	3.96	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	16.94	–	0.667
S	–	2.26	–	0.089

CASE 42A-01

MECHANICAL CHARACTERISTICS

CASE: Welded hermetically sealed construction
FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable
WEIGHT: 25 grams (approx.)
POLARITY: Cathode connected to case (reverse polarity available denoted by Suffix R, ie: 1N3212R)
MOUNTING POSITION: Any

1N3491 thru 1N3495
MR327 MR330
MR328 MR331

MOTOROLA

Designers Data Sheet

MEDIUM-CURRENT SILICON RECTIFIERS

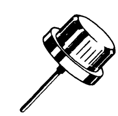
. . .compact, highly efficient silicon rectifiers for medium-current applications.

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.

SILICON RECTIFIERS
25 AMPERE

50-1000 VOLTS
DIFFUSED JUNCTION



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*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
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 = 100°C	I_O	← 25 →									Amp
Nonrepetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	I_{FSM}	← 300 (for 1/2 cycle) →									Amp
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

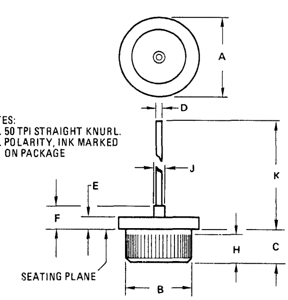
CASE: Welded, hermetically sealed construction.

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.

NOTES:
1. 50 TPI STRAIGHT KNURL.
2. POLARITY, INK MARKED ON PACKAGE



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.494	16.256	0.610	0.640
B	12.725	12.827	0.501	0.505
C	5.08	6.35	0.200	0.250
D	1.193	1.346	0.047	0.053
E	2.032	4.826	0.080	0.190
F	–	10.77	–	0.424
H	4.572	6.350	0.180	0.250
J	–	3.556	–	0.140
K	12.70	–	0.500	–

CASE 43-02
DO-21

*Indicates JEDEC registered data for 1N3491-1N3495

***ELECTRICAL CHARACTERISTICS**

Characteristic and Conditions	Symbol	Max	Unit
Instantaneous Forward Voltage Drop (i_F = 57 Amps, T_J = 25°C)	v_F	1.7	Volts
Full Cycle Average Reverse Current (18 Amp AV 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

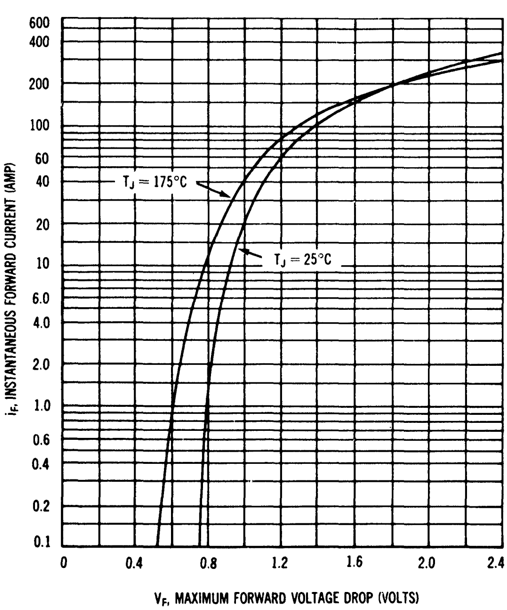


FIGURE 2 — MAXIMUM FORWARD POWER DISSIPATION

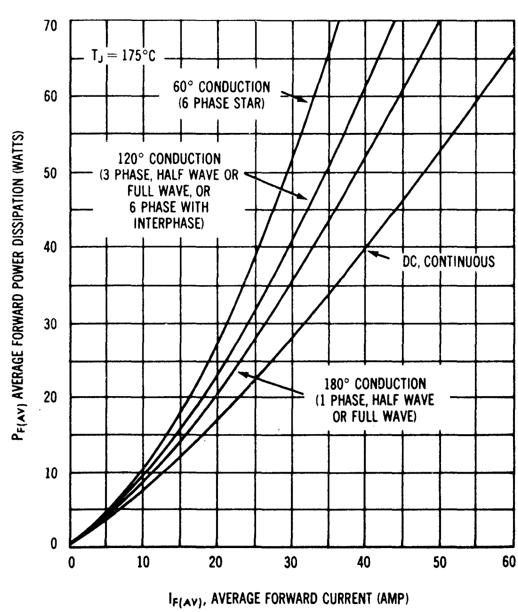


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FIGURE 3 — MAXIMUM CURRENT RATINGS

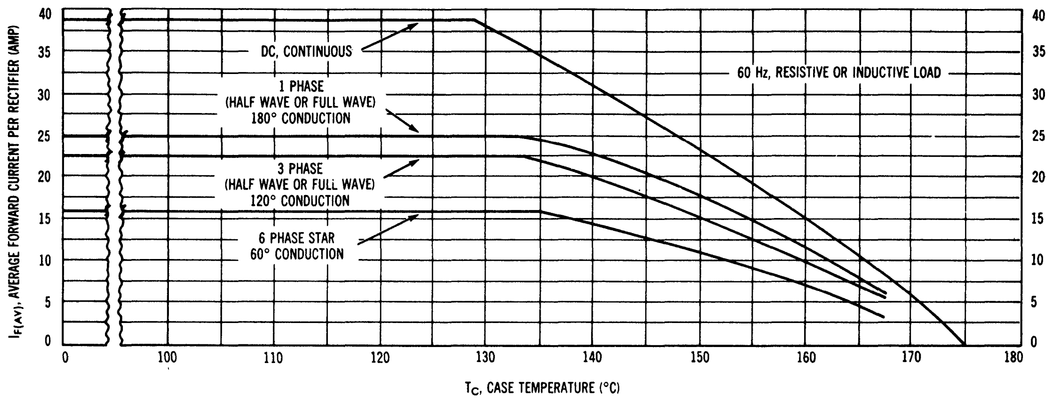

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FIGURE 4 — MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE

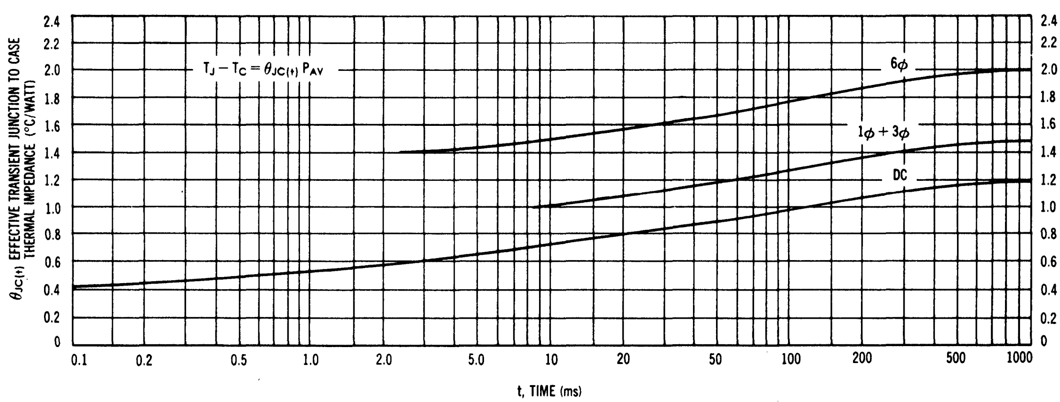
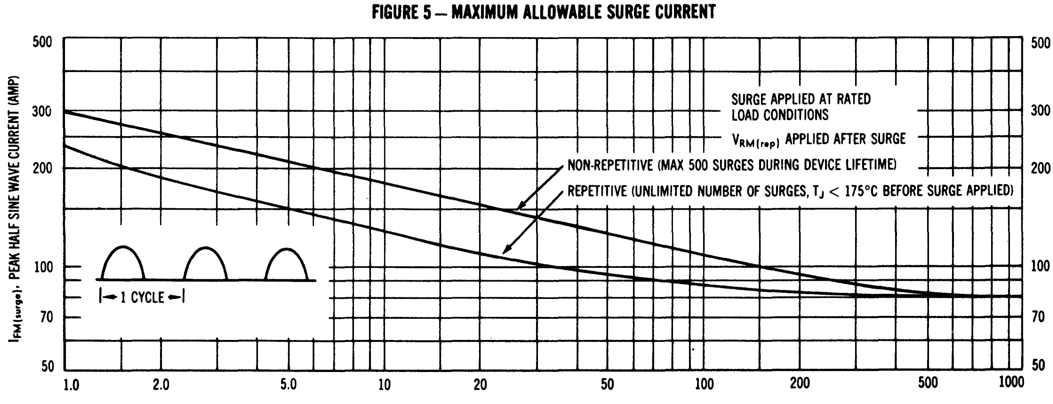


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 6 — RECTIFICATION EFFICIENCY

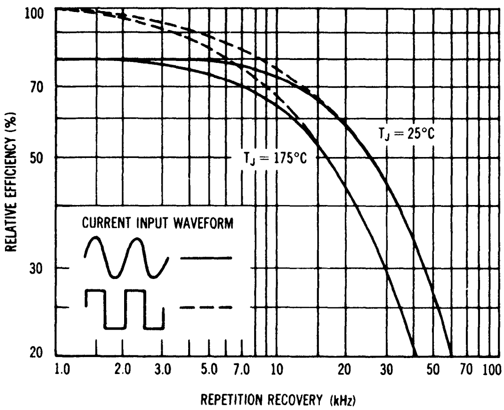


FIGURE 7 — REVERSE RECOVERY TIME

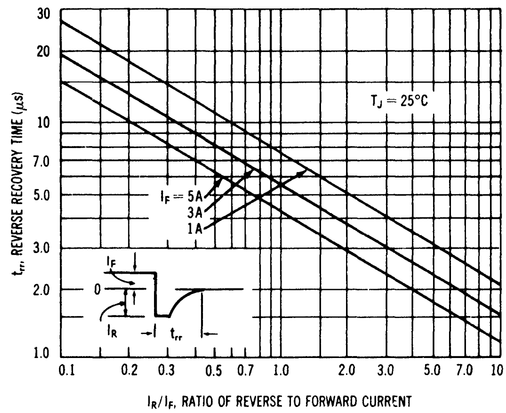


FIGURE 8 — JUNCTION CAPACITANCE

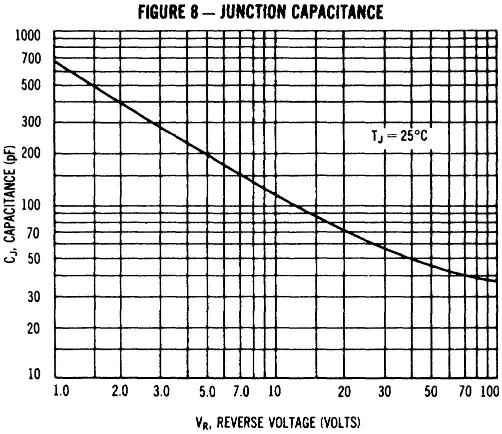
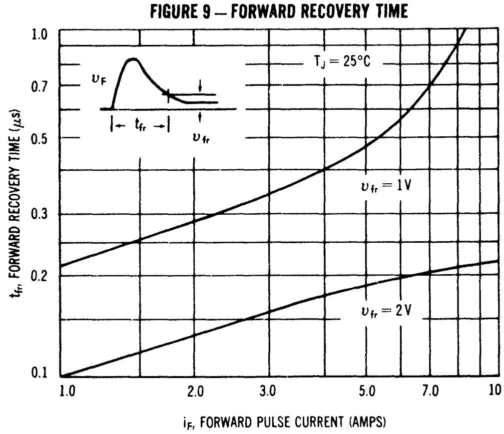
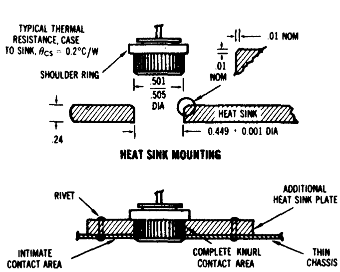


FIGURE 9 — FORWARD RECOVERY TIME





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.

1N3659
thru
1N3663

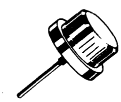
MOTOROLA

LOW COST RECTIFIERS FOR MEDIUM CURRENT INDUSTRIAL AND COMMERCIAL APPLICATIONS

- High Surge Handling Ability
- Rugged Construction for Operation Under Severe Conditions
- Reverse Polarity Available; Eliminates Need for Insulation Hardware in Many Cases
- Hermetically Sealed

30-AMP RECTIFIERS

SILICON DIFFUSED-JUNCTION



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

Rating	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Unit
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
Instantaneous Forward Voltage Drop (i_F = 78.5 Amps, T_J = 25°C)	v_F	1.4					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

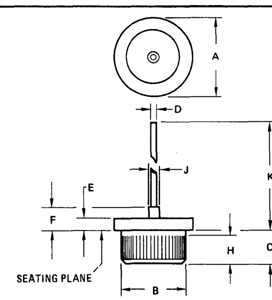
***THERMAL CHARACTERISTICS**

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

*Indicates JEDEC registered data.

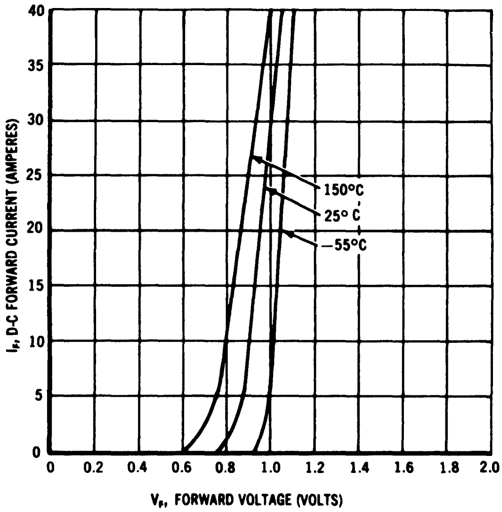
MECHANICAL CHARACTERISTICS

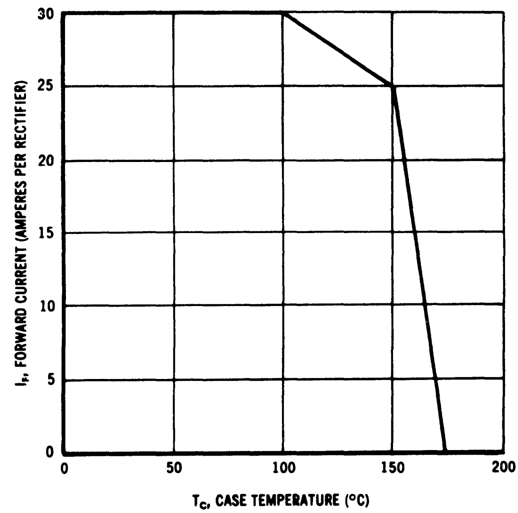
CASE: Welded hermetically sealed construction
FINISH: All external surfaces corrosion resistant, terminals readily solderable
WEIGHT: 9 grams (approx.)
POLARITY: Cathode connected to case (reverse polarity available denoted by Suffix R, i.e.: 1N3660R)
MOUNTING POSITION: Any



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.494	16.256	0.610	0.640
B	12.725	12.827	0.501	0.505
C	5.08	6.35	0.200	0.250
D	1.193	1.346	0.047	0.053
E	2.032	4.826	0.080	0.190
F	–	10.77	–	0.424
H	4.572	6.350	0.180	0.250
J	–	3.556	–	0.140
K	12.70	–	0.500	–

CASE 43-02



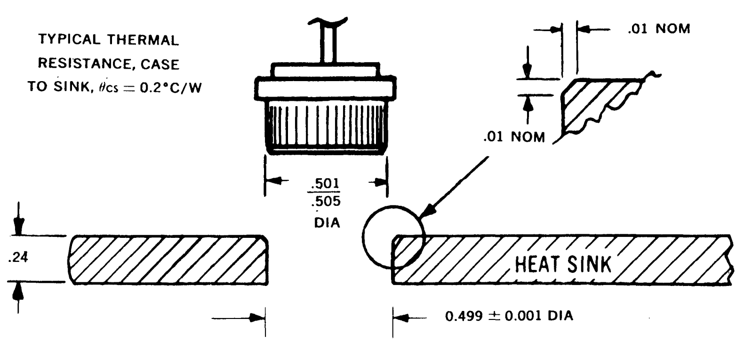


1N3659-1N3663 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

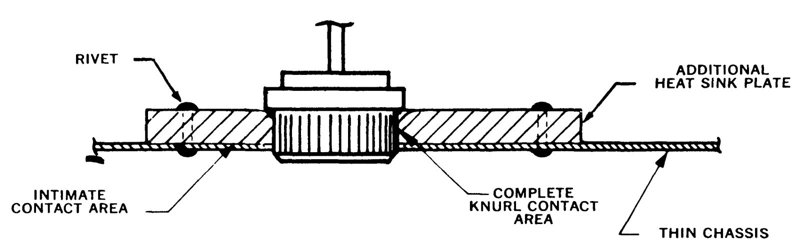
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat sink surface contact with the knurled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

1N3879 thru 1N3883
MR1366

MOTOROLA

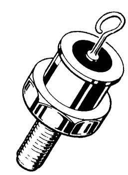
Designers Data Sheet

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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

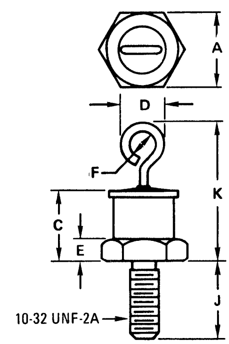
FAST RECOVERY
POWER RECTIFIERS
50-600 VOLTS
6 AMPERES

3



Designei 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.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01
DO-4

*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}	 – –	 150 200	 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 1N3879 Series.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case

WEIGHT: 5.6 Grams (approximately)

MOUNTING TORQUE: 15 in-lbs max.

FIGURE 1 — FORWARD VOLTAGE

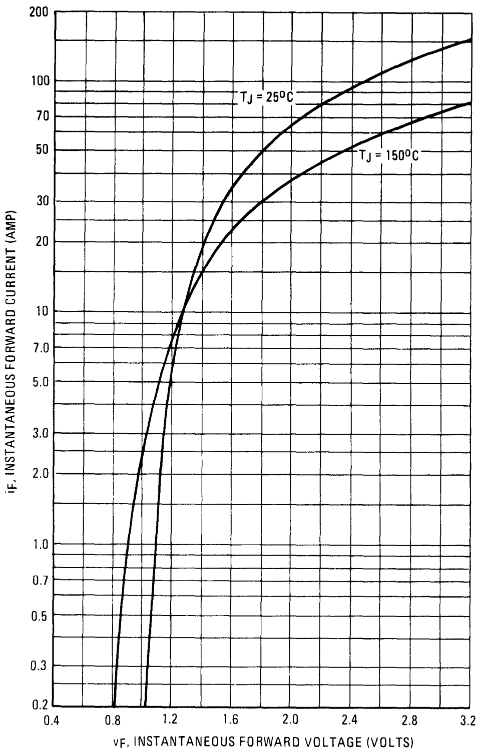
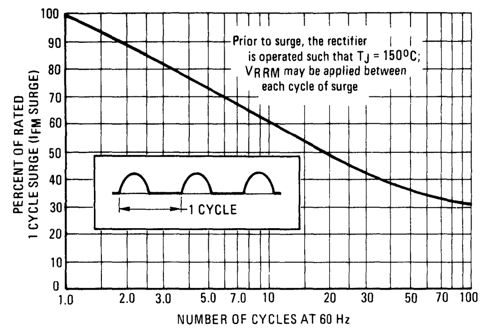
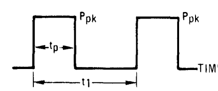


FIGURE 2 — MAXIMUM SURGE CAPABILITY



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:

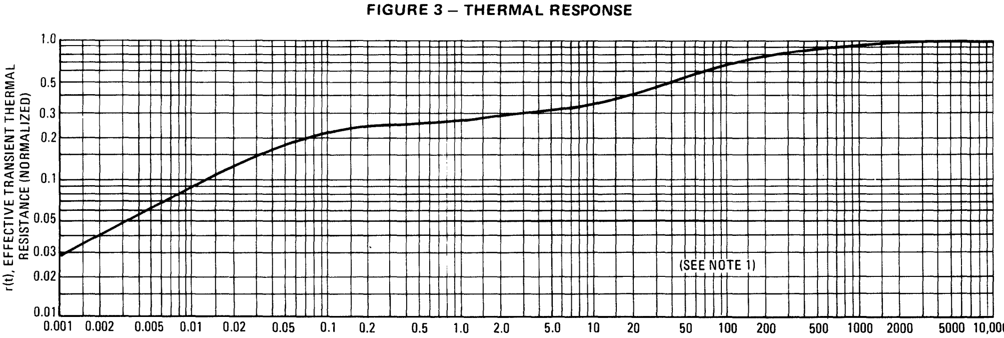
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

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 $t_1 + t_p$.

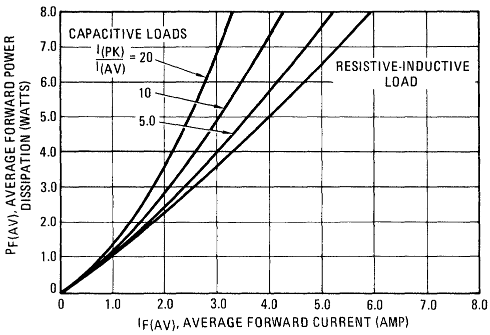
FIGURE 3 — THERMAL RESPONSE



3

SINE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 — FORWARD POWER DISSIPATION

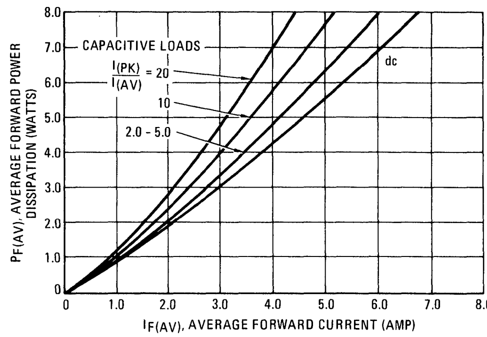


FIGURE 6 — CURRENT DERATING

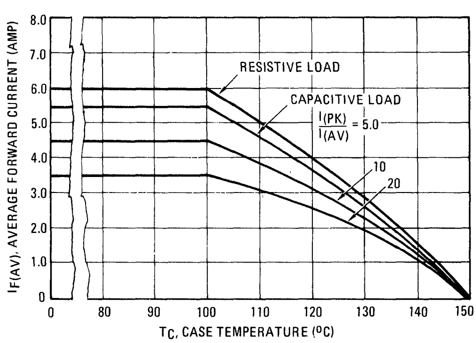


FIGURE 7 — CURRENT DERATING

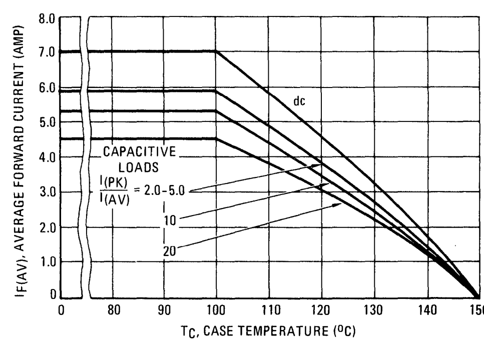


FIGURE 8 — TYPICAL REVERSE CURRENT

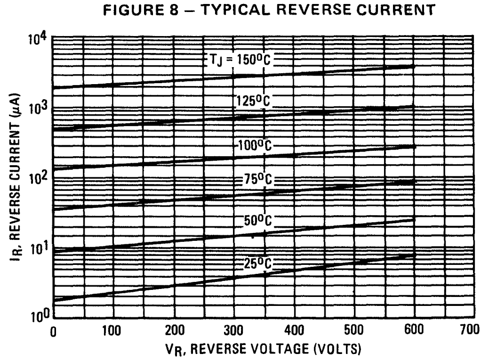
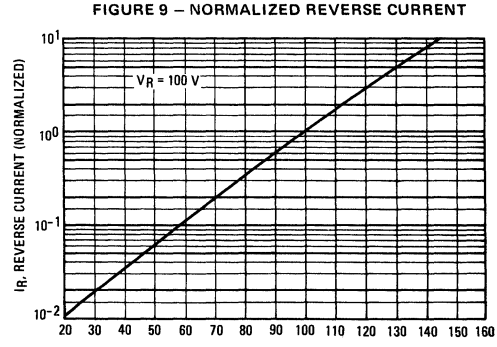


FIGURE 9 — NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

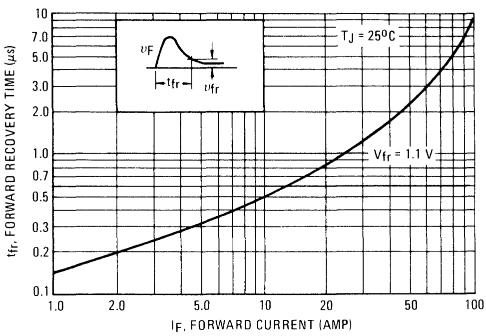
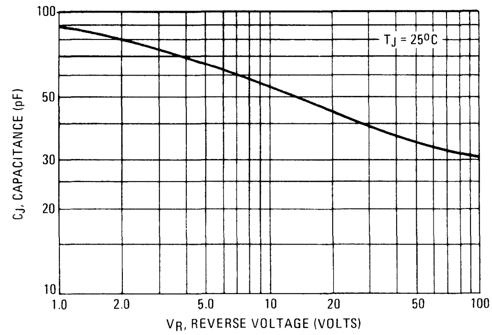


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA (SEE NOTE 2)

FIGURE 12 – $T_J = 25^oC$

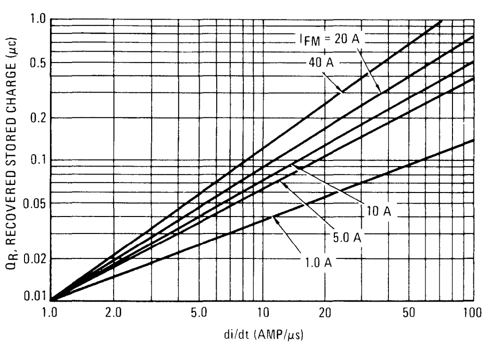


FIGURE 13 – $T_J = 75^oC$

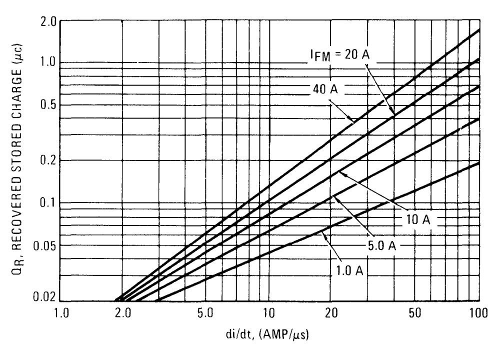


FIGURE 14 – $T_J = 100^oC$

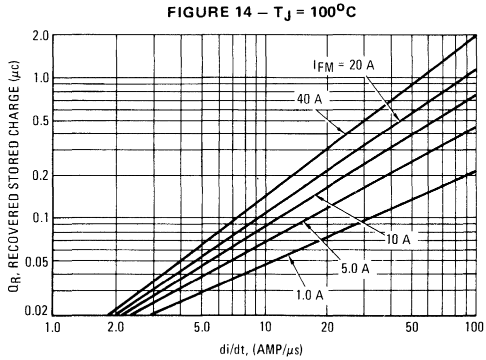


FIGURE 15 – $T_J = 150^oC$

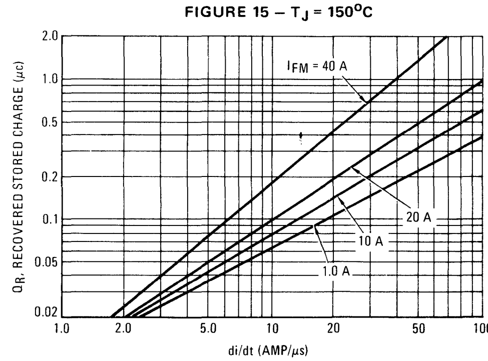


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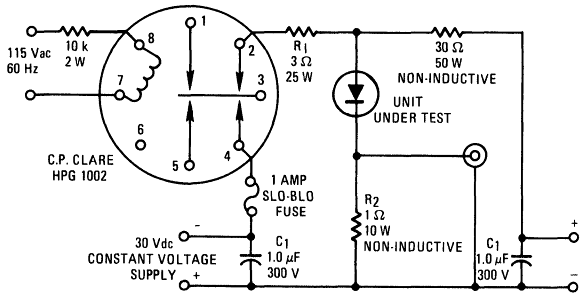
FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

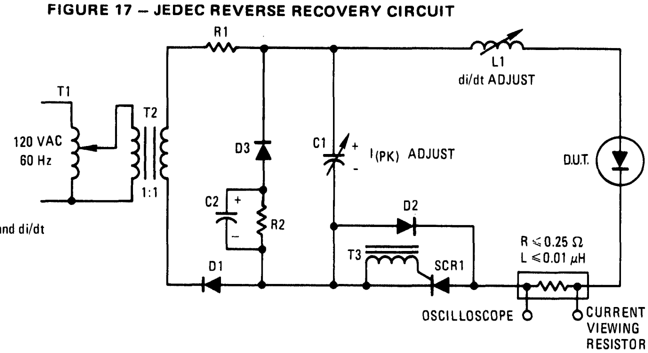
$T_A = 25\,^{+10}_{-0}$ °C FOR RECTIFIER

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)



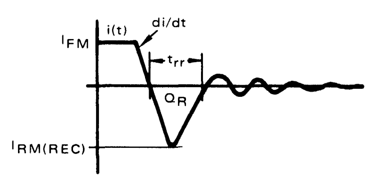
NOTE 2

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:

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

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

MOTOROLA

1N3889 thru 1N3893
MR1376

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

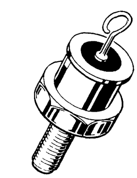
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 150 nanoseconds providing high efficiency 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



3

*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, $T_C = 100°C$)	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 →						°C
Storage Temperature Range	T_{stg}	← −65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°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.

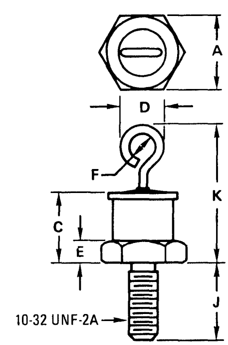
*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($i_F = 38$ Amp, $T_J = 150°C$)	v_F	—	1.2	1.5	Volts
Forward Voltage ($I_F = 12$ 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	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}	— —	150 200	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.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01
DO-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case

WEIGHT: 5.6 grams (approximately)

MOUNTING TORQUE: 15 in-lbs max.

3

FIGURE 1 – FORWARD VOLTAGE

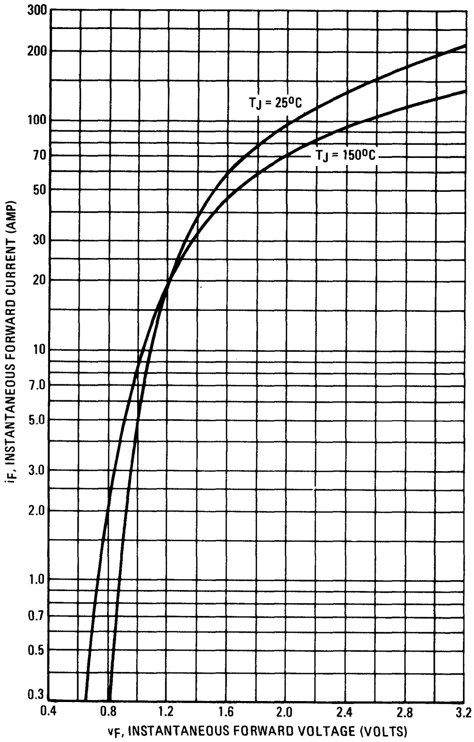
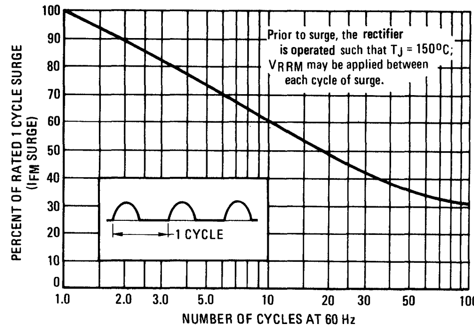
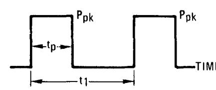


FIGURE 2 – MAXIMUM SURGE CAPABILITY



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:

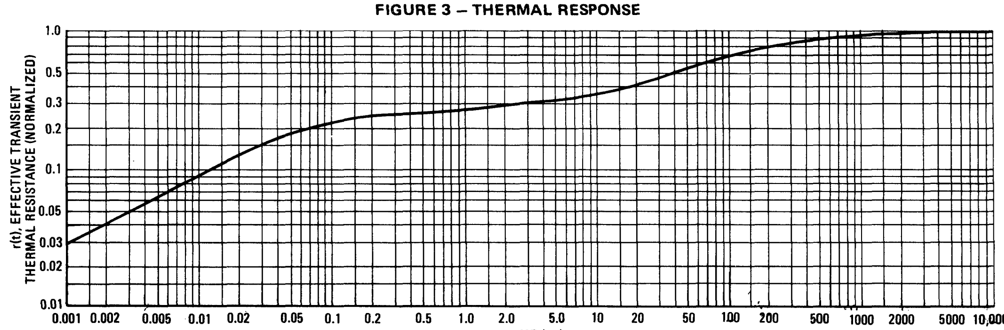
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

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



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SINE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION

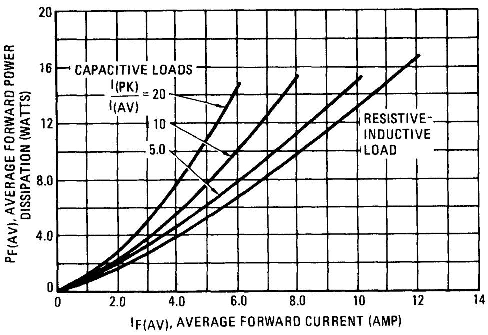


FIGURE 6 — CURRENT DERATING

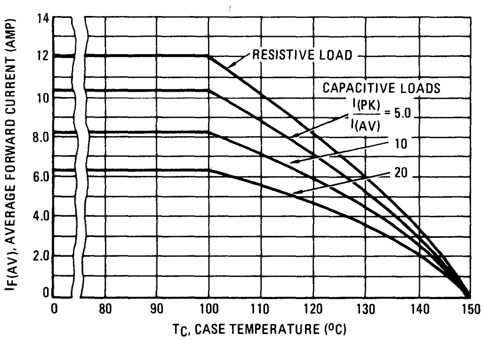
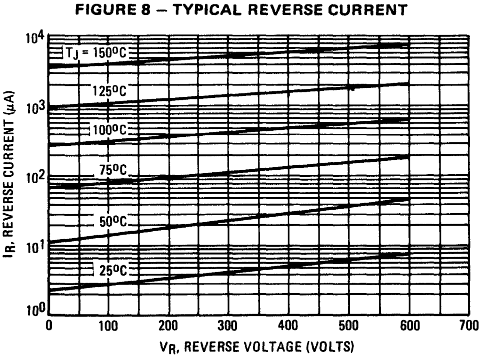


FIGURE 8 — TYPICAL REVERSE CURRENT



SQUARE WAVE INPUT

FIGURE 5 — FORWARD POWER DISSIPATION

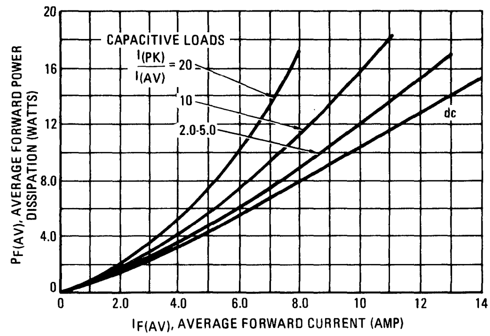


FIGURE 7 — CURRENT DERATING

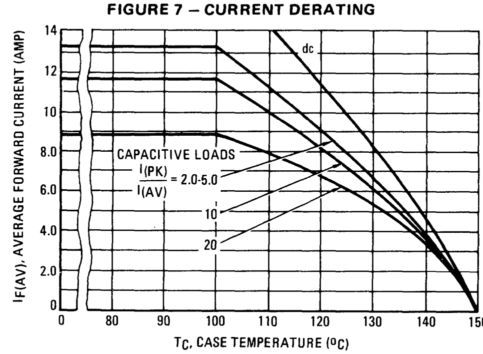
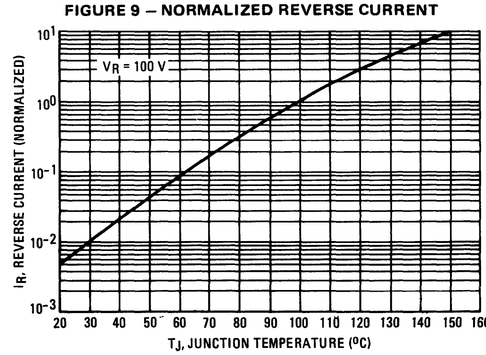


FIGURE 9 — NORMALIZED REVERSE CURRENT



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TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

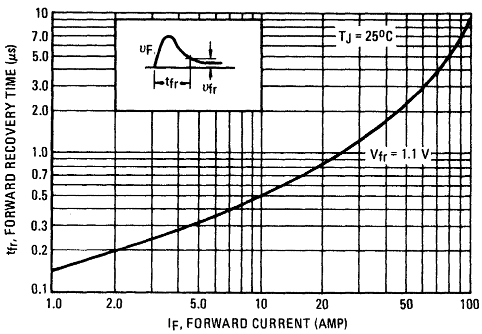
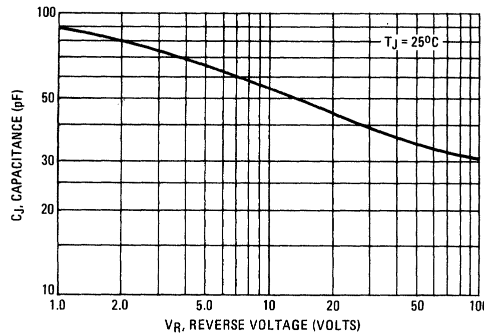


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25°C$

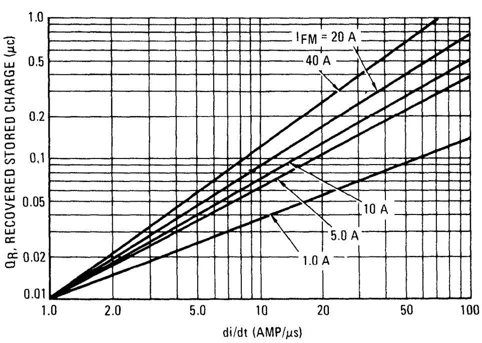


FIGURE 13 – $T_J = 75°C$

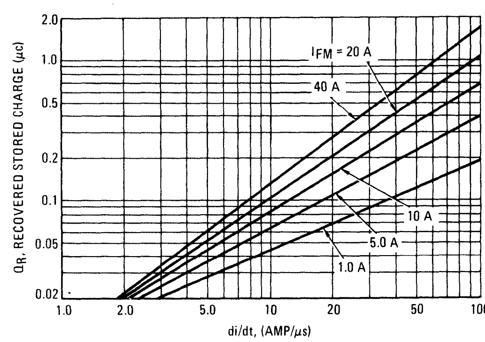


FIGURE 14 – $T_J = 100°C$

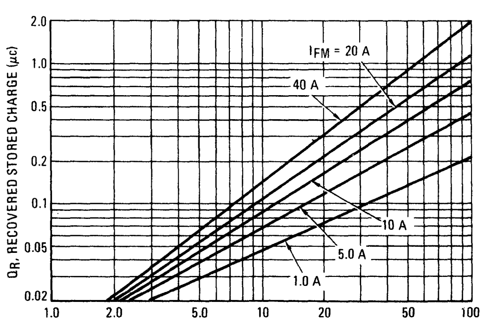


FIGURE 15 – $T_J = 150°C$

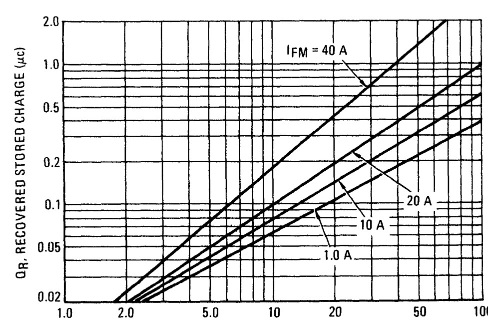
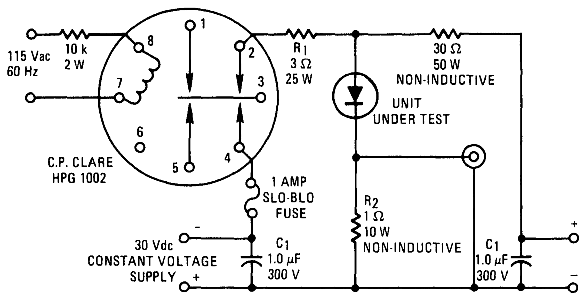


FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

R_I – 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

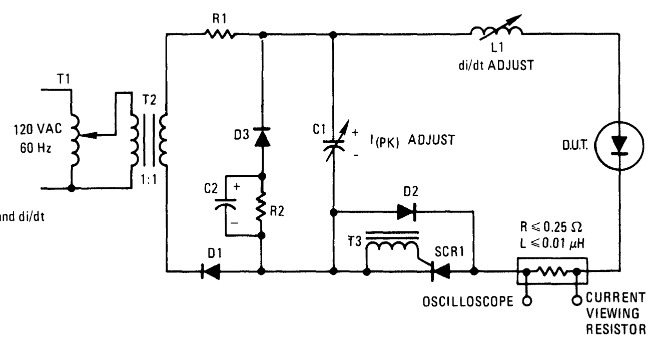
$T_A = 25^{+10}_{-0}$ °C FOR RECTIFIER

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)



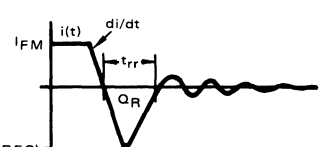
NOTE 2

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:

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

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

1N3899 thru 1N3903
MR1386

MOTOROLA

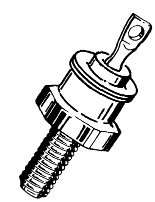
Designers Data Sheet

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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

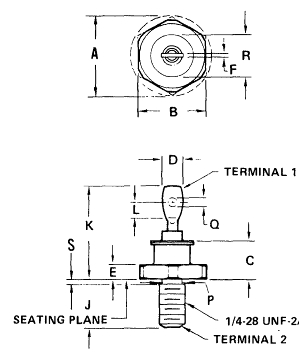
50-600 VOLTS
20 AMPERES



3

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.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	–	20.07	–	0.790
B	16.94	17.45	0.669	0.687
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	19.05	25.40	0.750	1.000
L	3.96	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	16.94	–	0.667
S	–	2.26	–	0.089

CASE 42A-01
DO-5

*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, $T_C = 100^oC$)	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, $T_J = 150^oC$)	v_F	–	1.2	1.5	Volts
Forward Voltage ($I_F = 20$ 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	50 6.0	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}	 – –	 150 200	 200 400	ns
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.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case

WEIGHT: 17 Grams (Approximately)

MOUNTING TORQUE: 25 in-lbs max.

FIGURE 1 – FORWARD VOLTAGE

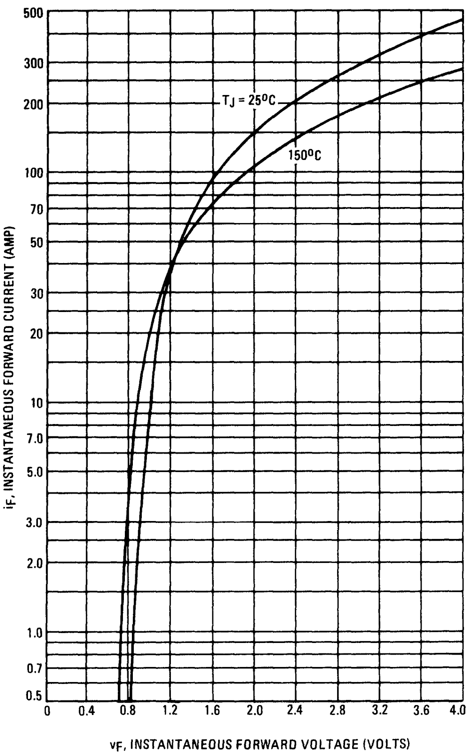
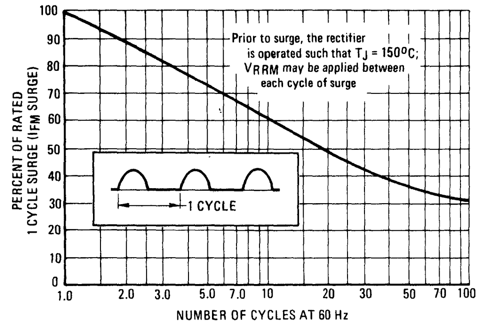
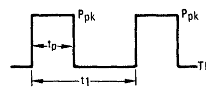


FIGURE 2 – MAXIMUM SURGE CAPABILITY



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:

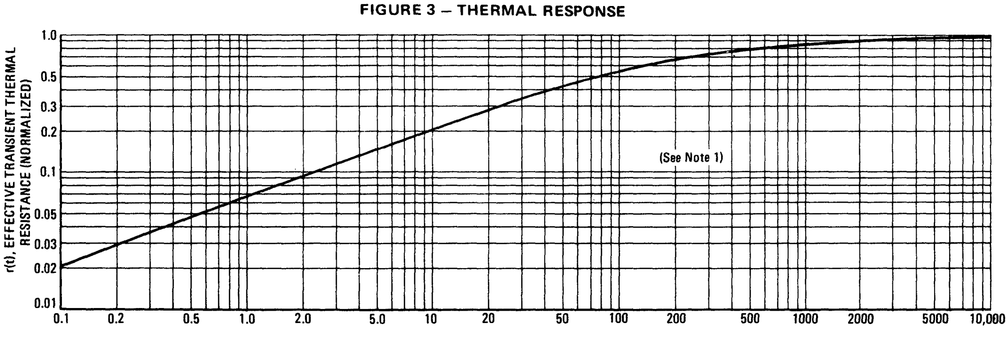
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} \, [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

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 $t_1 + t_p$.

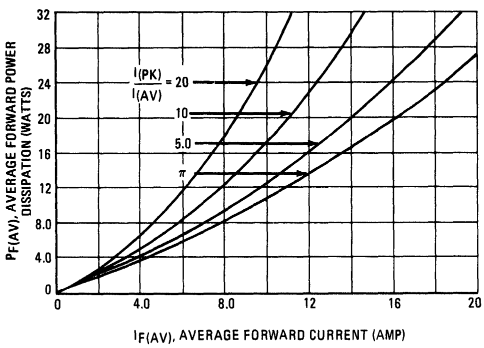
FIGURE 3 – THERMAL RESPONSE



3

SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

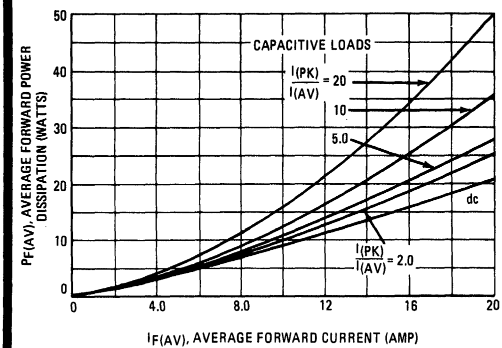


FIGURE 6 – CURRENT DERATING

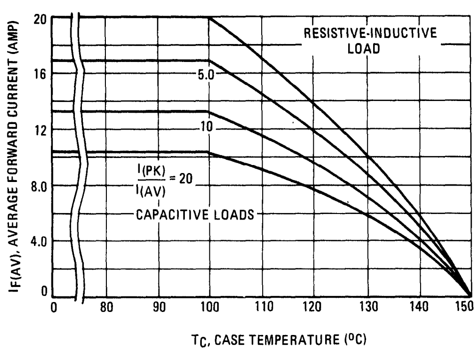


FIGURE 7 – CURRENT DERATING

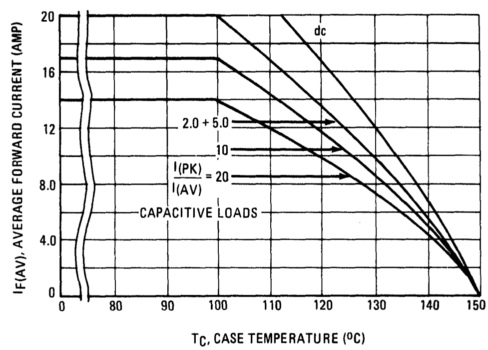


FIGURE 8 – TYPICAL REVERSE CURRENT

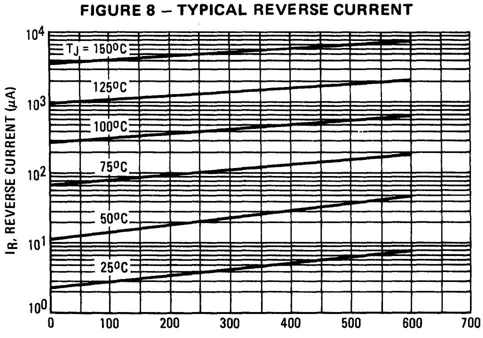
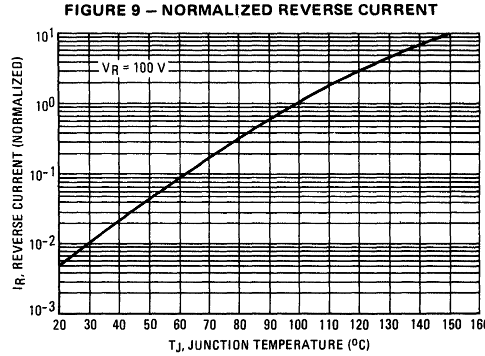


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

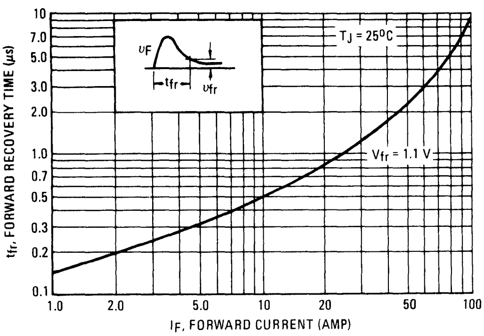
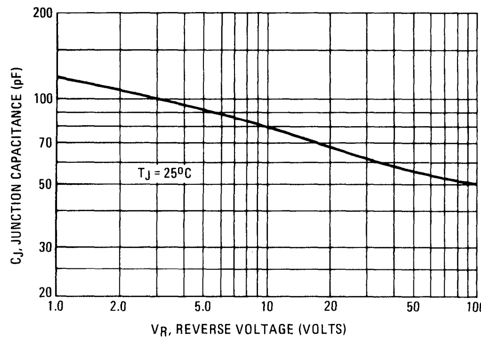


FIGURE 11 – JUNCTION CAPACITANCE



3

TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25°C$

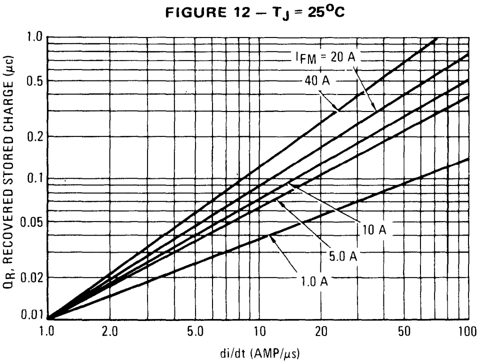
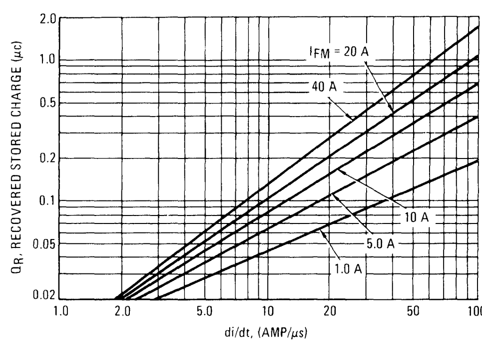


FIGURE 13 – $T_J = 75°C$



STORED CHARGE DATA

FIGURE 14 – $T_J = 100°C$

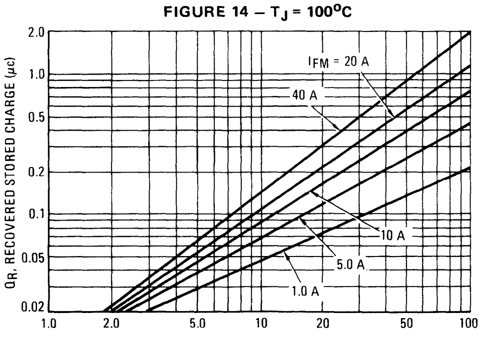


FIGURE 15 – $T_J = 150°C$

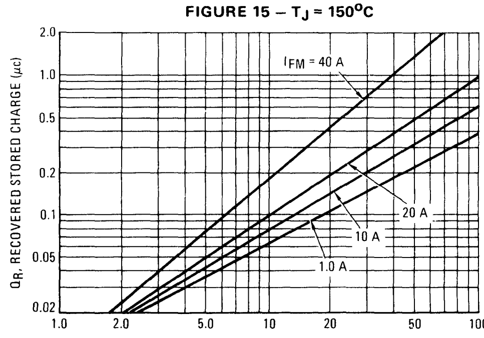


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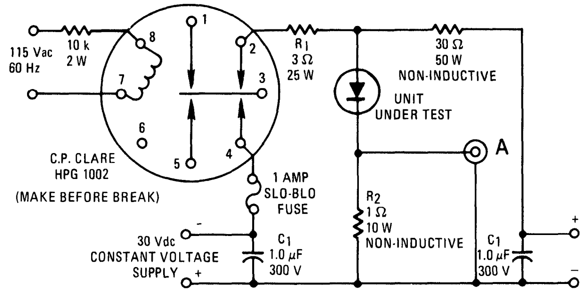
FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

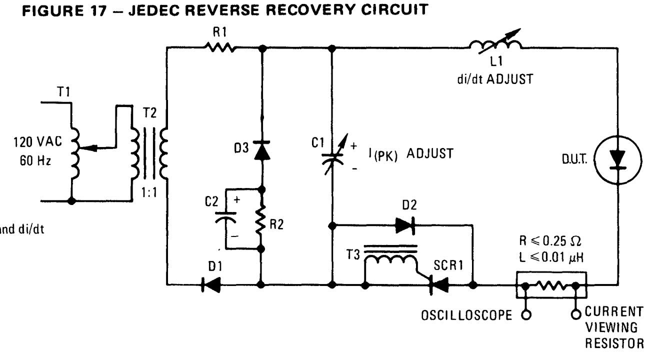
$T_A = 25\ ^{+10}_{-0}\ ^{\circ}C$ FOR RECTIFIER

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)



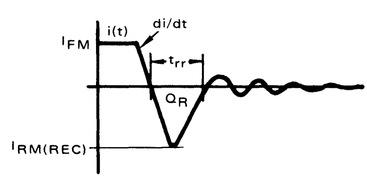
NOTE 2

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:

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

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

MOTOROLA

1N3909 thru 1N3913
MR1396

Designers Data Sheet

STUD MOUNTED
FAST RECOVERY POWER RECTIFIERS

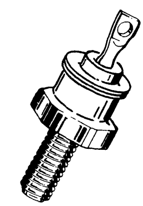
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

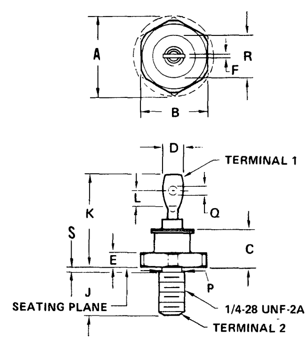
Designer's Data for "Worst Case" Conditions

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





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	–	20.07	–	0.790
B	16.94	17.45	0.669	0.687
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	19.05	25.40	0.750	1.000
L	3.96	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	16.94	–	0.667
S	–	2.26	–	0.089

CASE 42A-01
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, $T_C = 100°C$)	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 →						°C
Storage Temperature Range	T_{stg}	← -65 to +175 →						°C

THERMAL CHARACTERISTICS

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

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($i_F = 93$ Amp, $T_J = 150°C$)	v_F	–	1.2	1.5	Volts
Forward Voltage ($I_F = 30$ Amp, $T_C = 25°C$)	V_F	–	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25°C$ $T_C = 100°C$	I_R	– –	10 0.5	25 1.0	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}	 – –	 150 200	 200 400	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM(REC)}$	–	1.5	2.0	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

WEIGHT: 17 Grams (Approximately)

MOUNTING TORQUE: 25 in-lbs max.

FIGURE 1 — FORWARD VOLTAGE

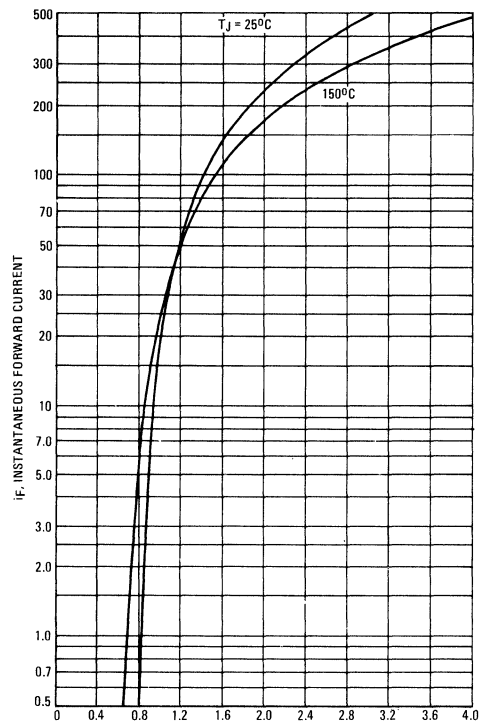
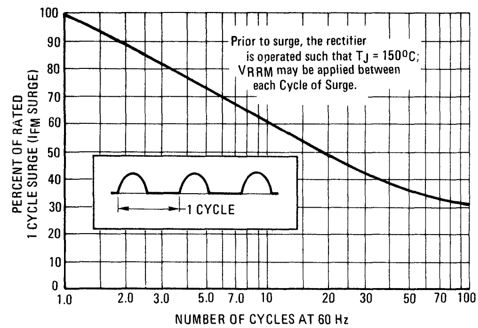
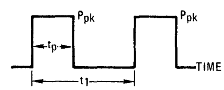


FIGURE 2 — MAXIMUM SURGE CAPABILITY



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:

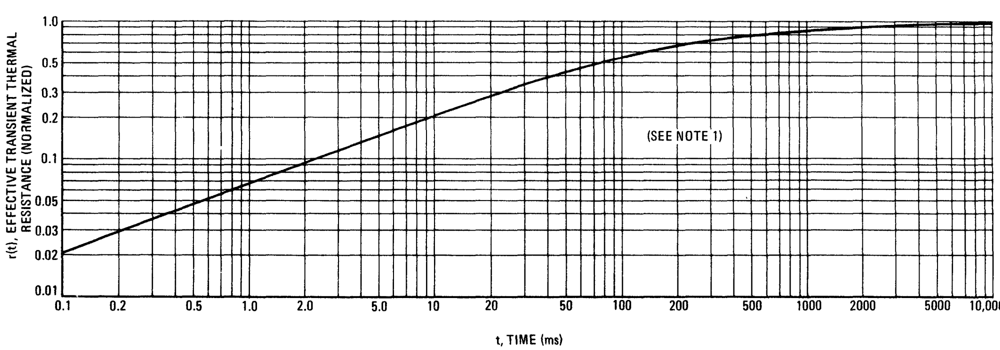
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

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 $t_1 + t_p$.

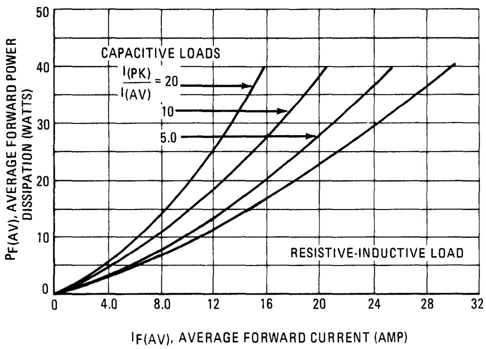
FIGURE 3 — THERMAL RESPONSE



3

SINE WAVE INPUT

FIGURE 4 — FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 — FORWARD POWER DISSIPATION

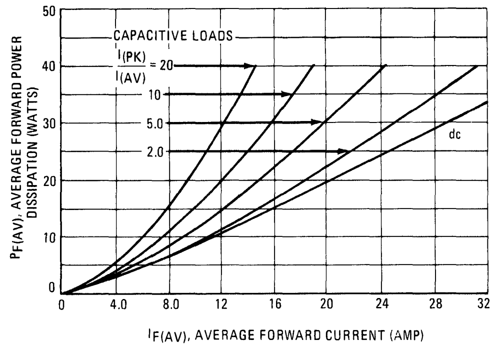


FIGURE 6 — CURRENT DERATING

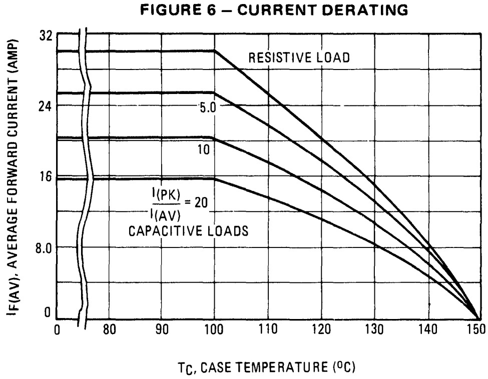


FIGURE 7 — CURRENT DERATING

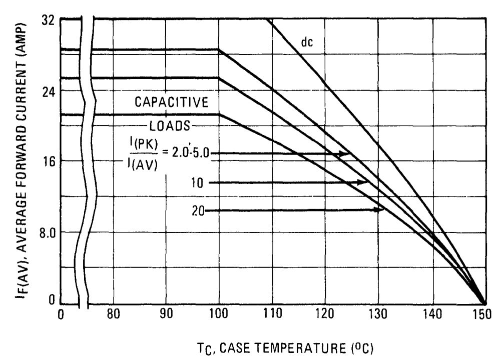


FIGURE 8 — TYPICAL REVERSE CURRENT

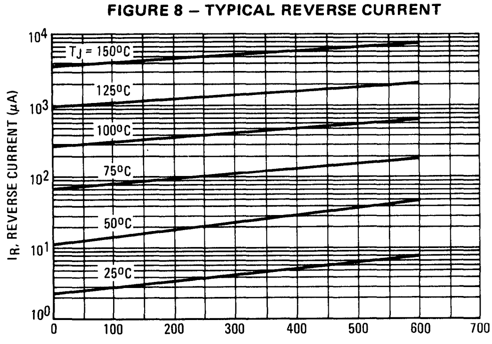
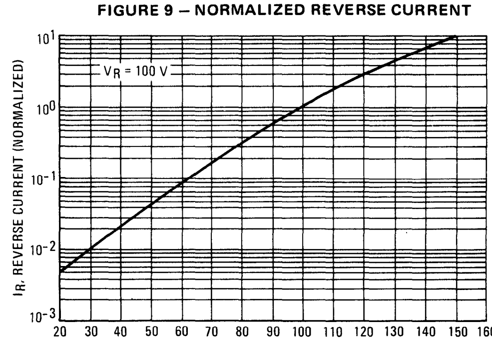


FIGURE 9 — NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

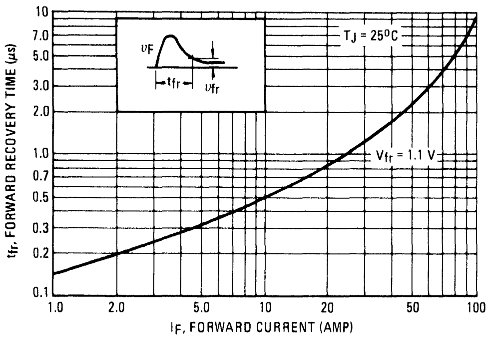
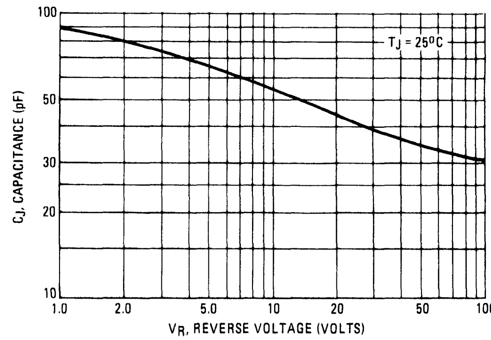


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – T_J = 25°C

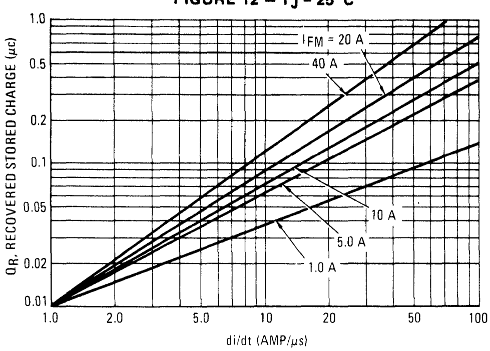


FIGURE 13 – T_J = 75°C

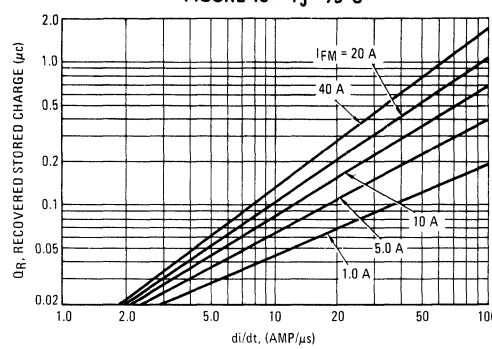


FIGURE 14 – T_J = 100°C

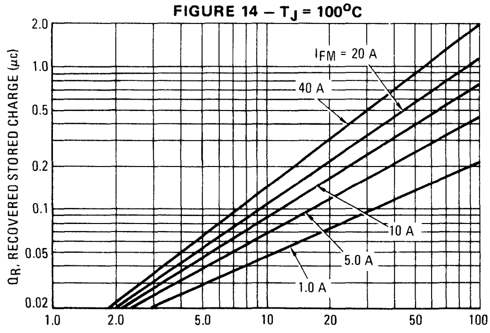


FIGURE 15 – T_J = 150°C

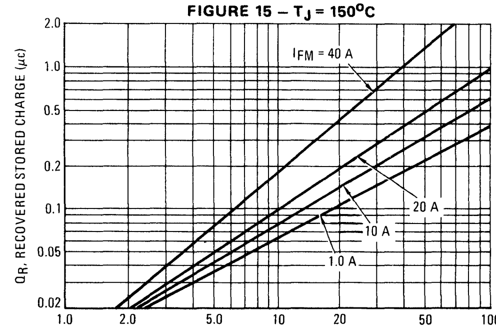
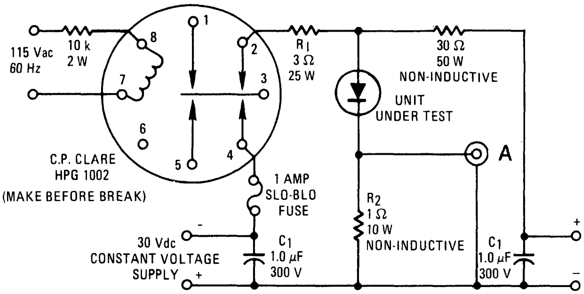


FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

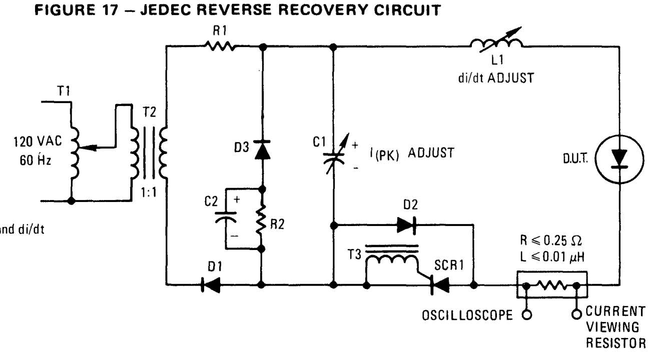
$T_A = 25^{+10}_{-0}$ °C FOR RECTIFIER

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)



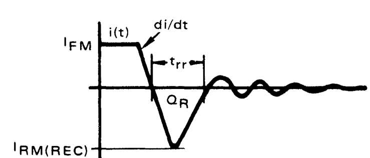
NOTE 2

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:

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

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

3

1N4001
thru
1N4007

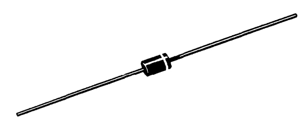
MOTOROLA

GENERAL-PURPOSE RECTIFIERS

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

LEAD MOUNTED SILICON RECTIFIERS

50-1000 VOLTS
DIFFUSED JUNCTION



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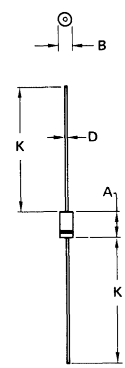
***MAXIMUM RATINGS**

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, $T_A = 75^oC$)	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 →							^oC

***ELECTRICAL CHARACTERISTICS**

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

*Indicates JEDEC Registered Data.



NOTES:
1. POLARITY DENOTED BY CATHODE BAND.
2. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04
(Does not meet DO-41 outline)

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
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)

MOTOROLA

1N4719 thru 1N4725

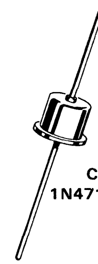
LEAD MOUNTED POWER RECTIFIERS

. . . having low forward voltage drop and hermetic metal packages. High surge current capability and good thermal characteristics provide reliable operation.

- $R\Theta_{JA}$ = 30°C/W

SILICON RECTIFIERS

3.0 AMPERES
50-1000 VOLTS
DIFFUSED JUNCTION



CASE 60-01
1N4719 thru 1N4725

3

***MAXIMUM RATINGS** (Both Package Types) T_A = 25°C unless otherwise noted.

Rating	Symbol	1N4719	1N4720	1N4721	1N4722	1N4723	1N4724	1N4725	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
Nonrepetitive 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°C)	I_O	← 3.0 →							Amp
Nonrepetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	I_{FSM}	← 300 (for 1/2 cycle) →							Amp
Operating and Case Temperature	T_J, T_{stg}	← -65 to +175 →							°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
*Instantaneous Forward Voltage (i_F = 3.0 A, T_J = 75°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

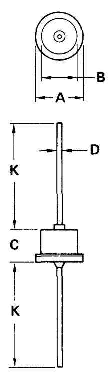
*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction
FINISH: All external surfaces corrosion-resistant and leads readily solderable.
POLARITY: CATHODE TO CASE
MOUNTING POSITIONS: Any.

3

OUTLINE DIMENSIONS



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60-1

MOTOROLA

1N4933 thru 1N4937

Designers Data Sheet

AXIAL-LEAD, 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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

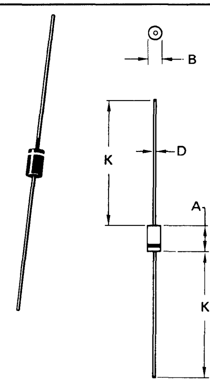
Designer's Data for "Worst Case" Conditions

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.

FAST RECOVERY RECTIFIERS

50–600 VOLTS
1 AMPERE

3



NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04
(Does not meet DO-41 outline)

***MAXIMUM RATINGS**

Rating	Symbol	1N4933	1N4934	1N4935	1N4936	1N4937	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Nonrepetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_A = 75°C$)	I_O	← 1.0 →					Amp
Nonrepetitive 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)	$R_{\theta JC}$	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}	–	150	200	ns
($I_{FM} = 15$ Amp, di/dt = 10A/μs (Figure 22)		–	175	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

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
FINISH: External leads are readily solderable
POLARITY: Cathode indicated by polarity band
WEIGHT: 0.4 Gram (approximately)

3

FIGURE 1 – FORWARD VOLTAGE

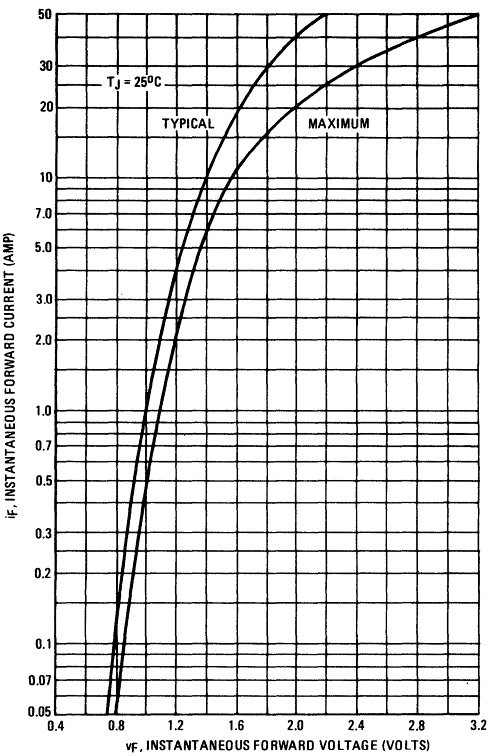


FIGURE 2 – MAXIMUM SURGE CAPABILITY

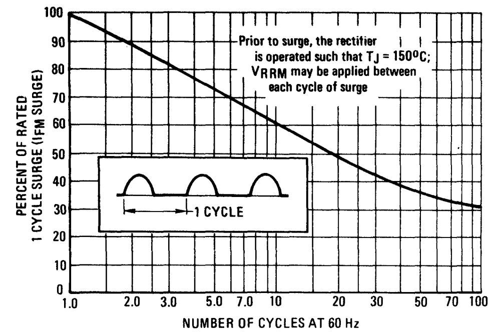
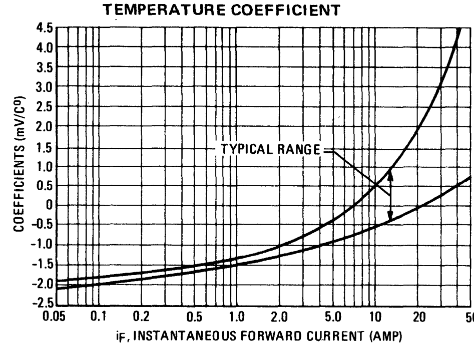
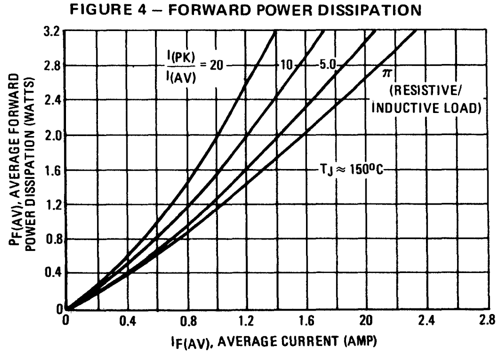


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



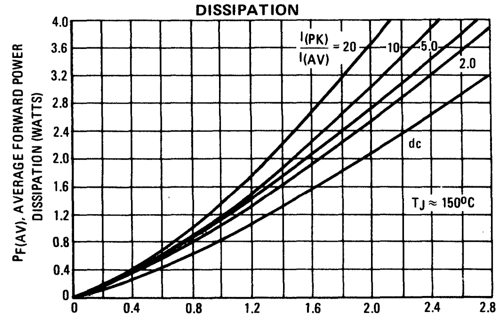
SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION



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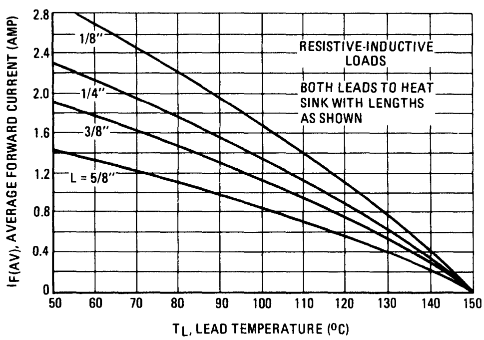
MAXIMUM CURRENT RATINGS

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

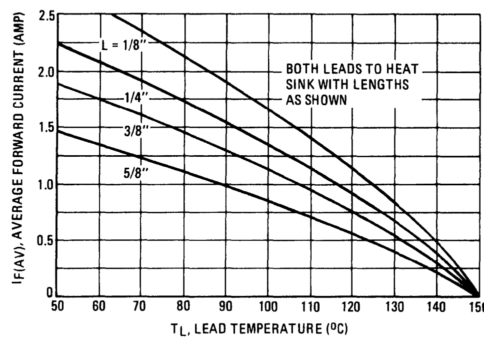


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

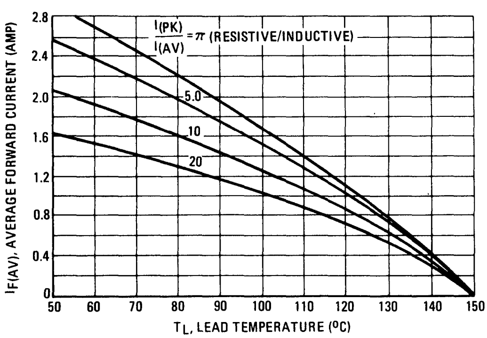


FIGURE 9 – 1/8" LEAD LENGTHS, VARIOUS LOADS

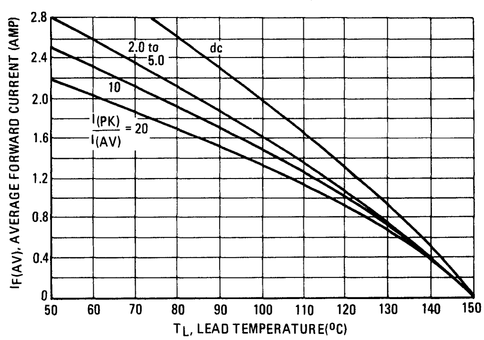


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

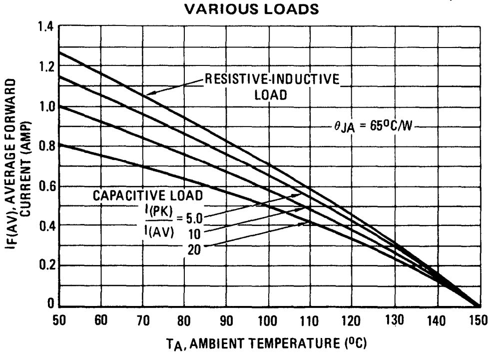


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

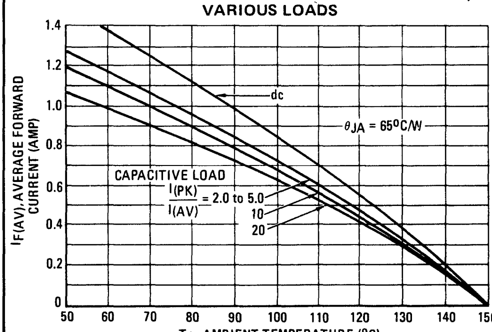


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FIGURE 12 – THERMAL RESPONSE

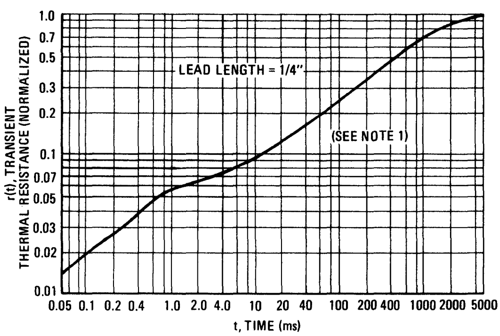
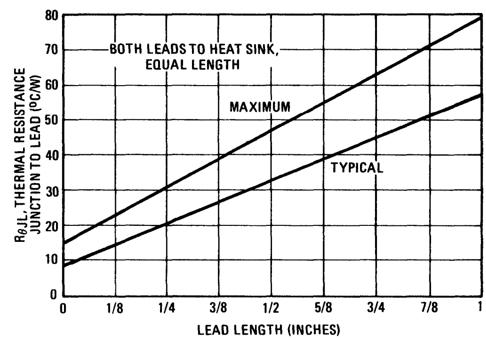
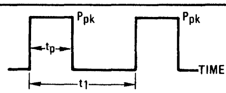


FIGURE 13 – THERMAL RESISTANCE



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

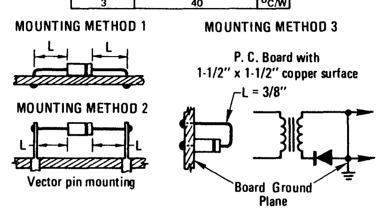
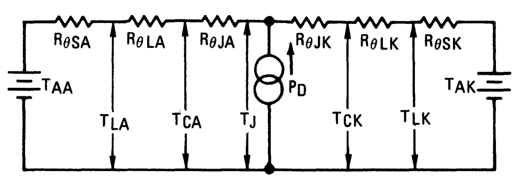


FIGURE 14 – THERMAL CIRCUIT MODEL
(For Heat Conduction Through The Leads)



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
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
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:

$$T_L = 150° - \Delta T_{JL}$$

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.

3

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 — FORWARD RECOVERY TIME

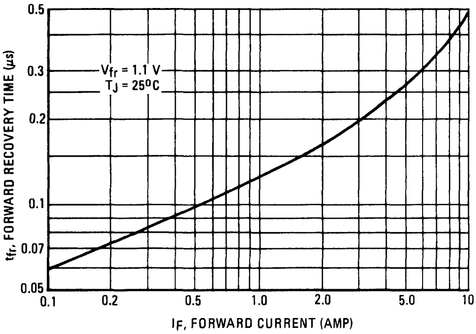
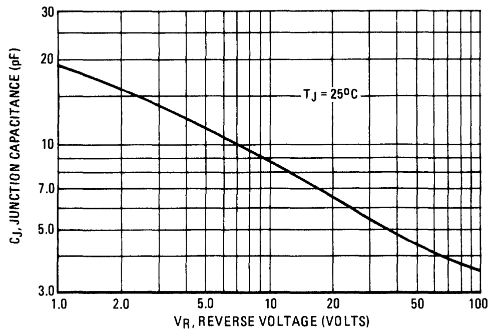


FIGURE 16 — JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGED DATA

FIGURE 17 — T_J = 25°C

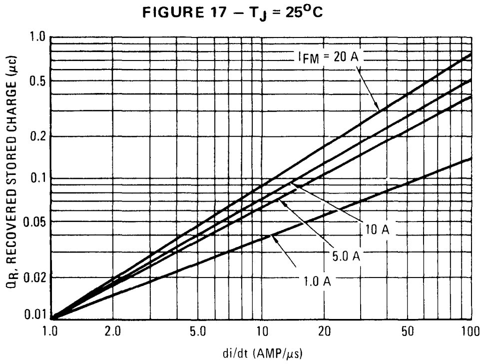


FIGURE 18 — T_J = 75°C

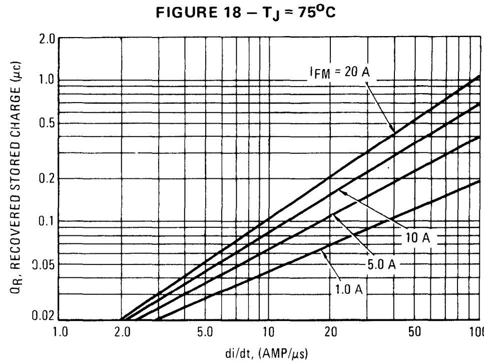


FIGURE 19 — T_J = 100°C

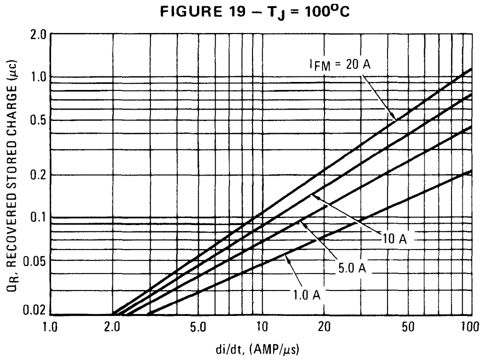
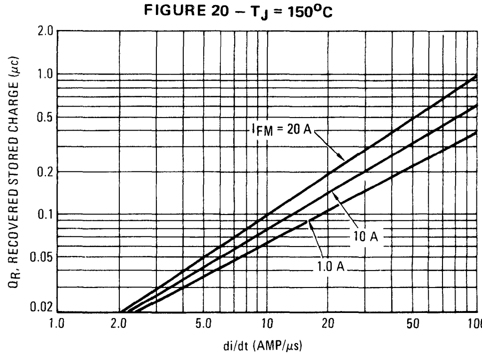


FIGURE 20 — T_J = 150°C



RECOVERY TIME

FIGURE 21 – REVERSE RECOVERY CIRCUIT

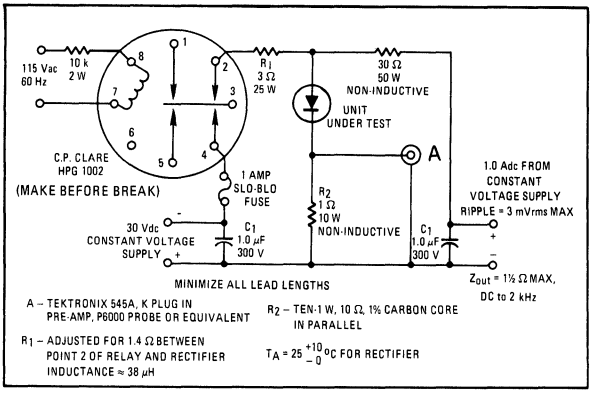
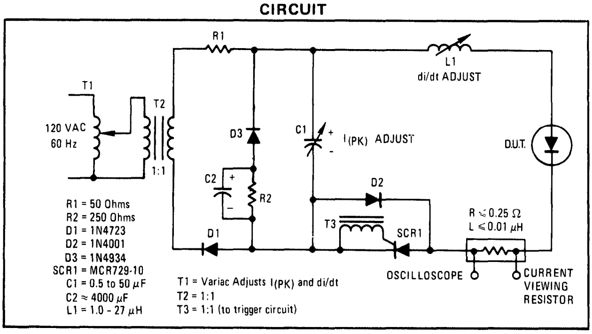


FIGURE 22 – JEDEC REVERSE RECOVERY CIRCUIT



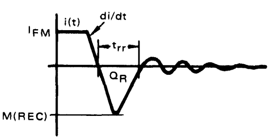
NOTE 3

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

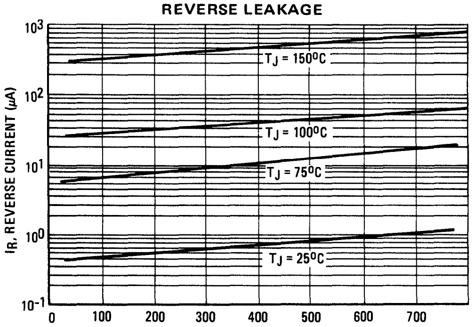
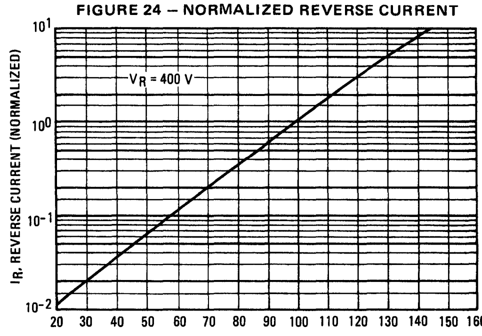


FIGURE 24 – NORMALIZED REVERSE CURRENT



MOTOROLA

1N5391 thru 1N5399

Designers Data Sheet

"SURMETIC" RECTIFIERS

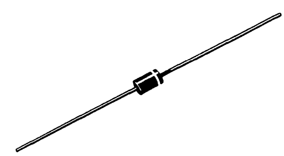
. . . subminiature size, axial lead-mounted rectifiers for general-purpose, low-power applications.

Designers Data for "Worst Case" Conditions

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limits 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	1N5391	1N5392	1N5393	1N5395	1N5397	1N5398	1N5399	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
Nonrepetitive Peak Reverse Voltage (Halfwave, Single Phase, 60 Hz)	V_{RSM}	100	200	300	525	800	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_L = 70°C, 1/2" From Body)	I_O	← 1.5 →							Amp
Nonrepetitive Peak Surge Current (Surge Applied at Rated Load Conditions, See Figure 2)	I_{FSM}	← 50 (for 1 cycle) →							Amp
Storage Temperature Range	T_{stg}	← -65 to +175 →							°C
Operating Temperature Range	T_L	← -65 to +170 →							°C
DC Blocking Voltage Temperature	T_L	← 150 →							°C

*ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Typ	Max	Unit
Maximum Instantaneous Forward Voltage Drop (i_F = 4.7 Amp Peak, T_L = 170°C, 1/2 Inch Leads)	v_F	–	1.4	Volts
Maximum Reverse Current (Rated dc Voltage) (T_L = 150°C)	I_R	250	300	μA
Maximum Full-Cycle Average Reverse Current (1) (I_O = 1.5 Amp, T_L = 70°C, 1/2 Inch Leads)	$I_{R(AV)}$	–	300	μA

*Indicates JEDEC Registered Data.

NOTE 1: Measured in a single-phase, halfwave circuit such as shown in Figure 6.25 of EIA RS-282, November 1963. Operated at rated load conditions I_O = 1.5 A, V_r = V_{RWM}, T_L = 70°C.

MECHANICAL CHARACTERISTICS

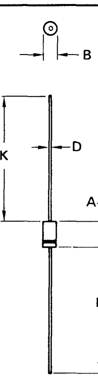
CASE: Transfer molded plastic

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 240°C, 1/8" 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)



NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04

Dimensions Within JEDEC DO-15 Outline.

3

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FIGURE 1 — FORWARD VOLTAGE

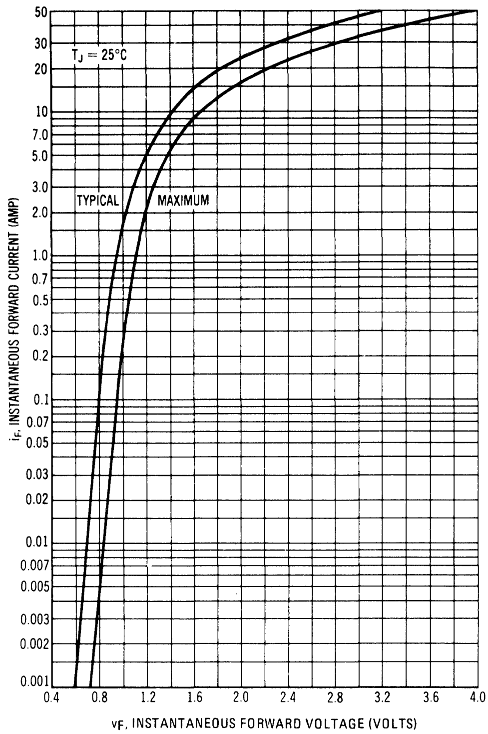


FIGURE 2 — MAXIMUM NONREPETITIVE SURGE CURRENT

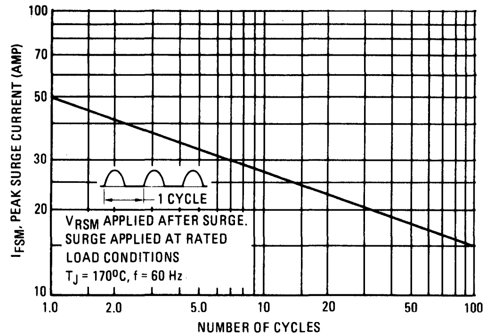


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

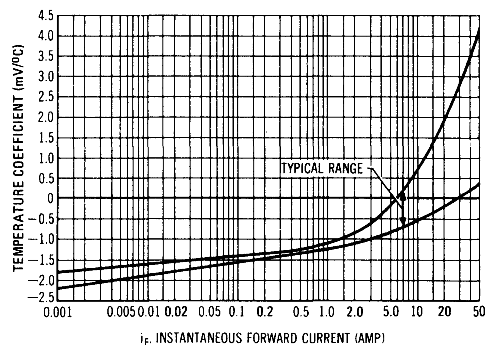
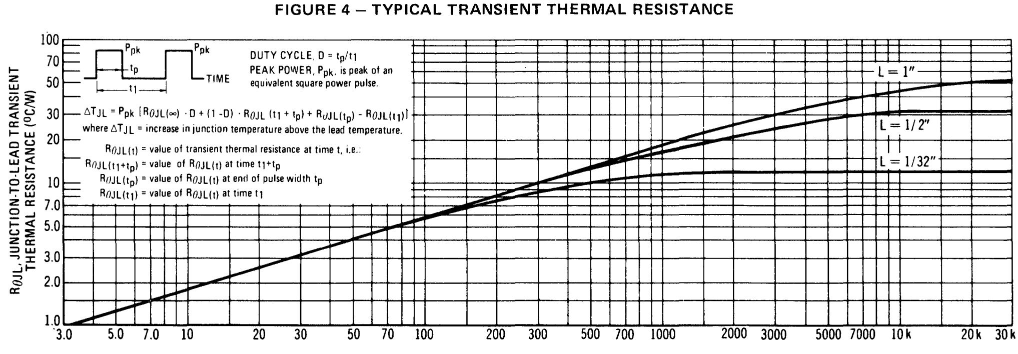


FIGURE 4 — TYPICAL TRANSIENT THERMAL RESISTANCE



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:

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

FIGURE 5 — FORWARD POWER DISSIPATION

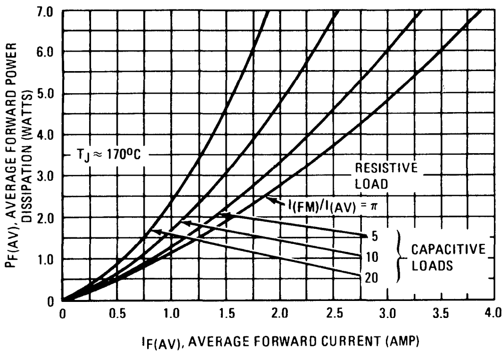


FIGURE 6 — EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

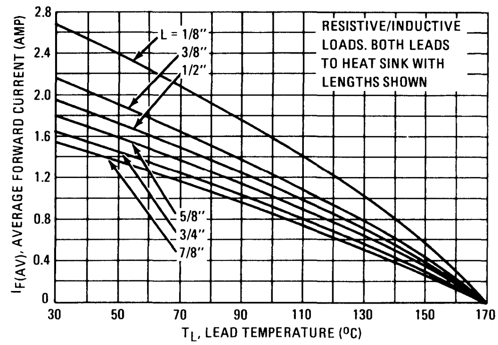


FIGURE 7 — 1/2" LEAD LENGTH, VARIOUS LOADS

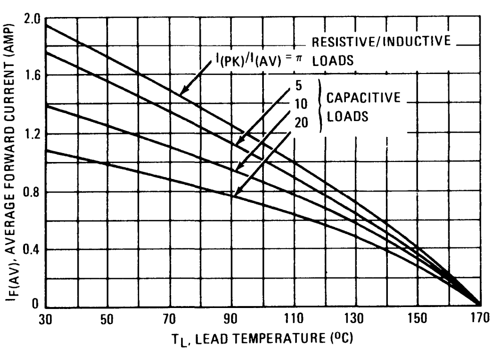


FIGURE 8 — PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

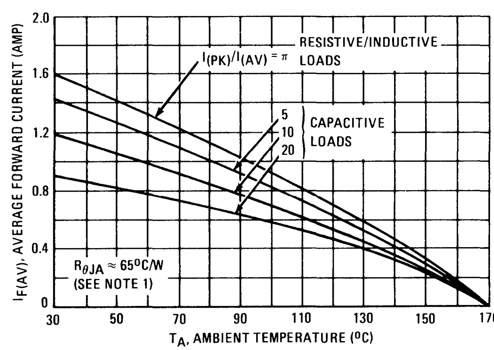


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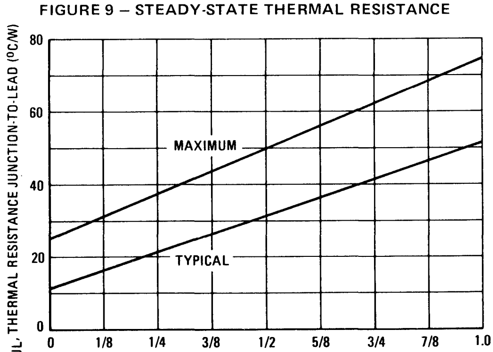
FIGURE 9 — STEADY-STATE THERMAL RESISTANCE



NOTE 1

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)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	65	72	82	92	°C/W
2	74	81	91	101	°C/W
3	40				°C/W

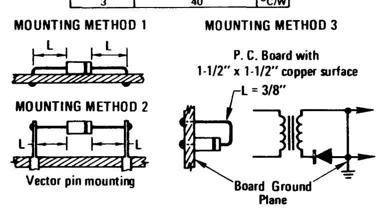


FIGURE 10 – FORWARD RECOVERY TIME

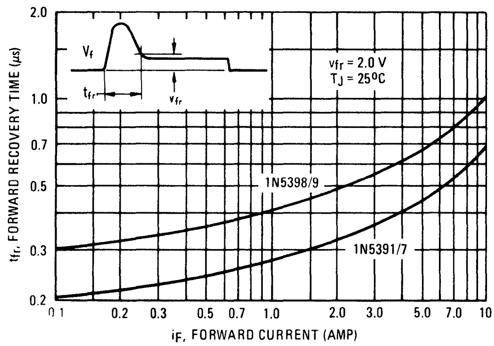


FIGURE 11 – REVERSE RECOVERY TIME

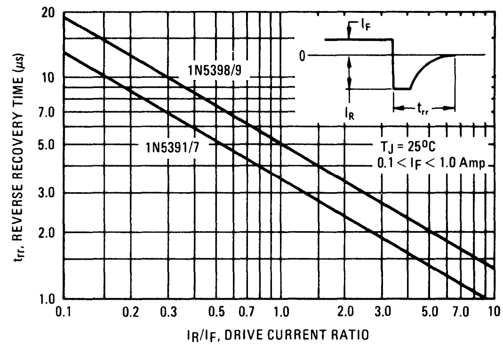


FIGURE 12 – JUNCTION CAPACITANCE

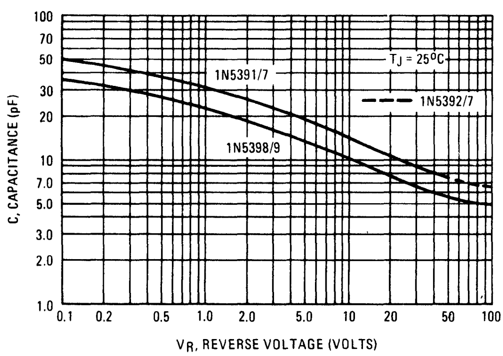


FIGURE 13 – RECTIFICATION WAVEFORM EFFICIENCY FOR SINE WAVE

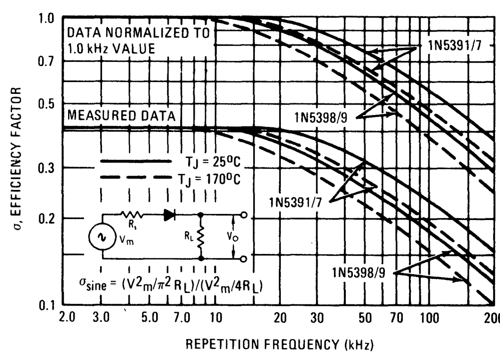
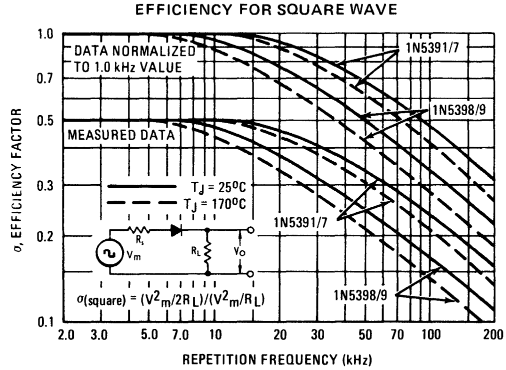


FIGURE 14 – RECTIFICATION WAVEFORM EFFICIENCY FOR SQUARE WAVE



RECTIFIER EFFICIENCY NOTE

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

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

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.

MOTOROLA

1N5400 thru 1N5406

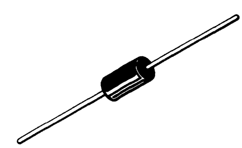
LEAD MOUNTED STANDARD RECOVERY RECTIFIERS

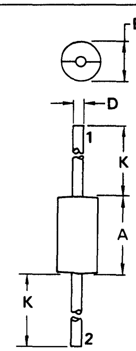
. . . designed for use in power supplies and other applications having need of a device with the following features:

- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Economical Plastic Package
- Available in Volume Quantities

STANDARD RECOVERY RECTIFIERS

50-1000 VOLTS
3 AMPERE





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

MAXIMUM RATINGS

Rating	Symbol	1N5400	1N5401	1N5402	1N5404	1N5406	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Nonrepetitive Peak Reverse Voltage	V_{RSM}	100	200	300	525	800	Volts
Average Rectified Forward Current (Single Phase Resistive Load, (1/2" Leads, T_L = 105°C)	I_O	← 3.0 →					Amp
Nonrepetitive Peak Surge Current (Surge Applied at Rated Load Conditions)	I_{FSM}	← 200 (one cycle) →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Unit
Thermal Resistance, Junction to Ambient (PC Board Mount, 1/2" Leads)	$R_{\theta JA}$	53	°C/W

*ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 9.4 Amp)	v_F	–	–	1.2	Volts
Average Reverse Current (1) DC Reverse Current (Rated dc Voltage, T_L = 150°C)	$I_{R(AV)}$ I_R	– –	– –	500 500	μA

*JEDEC Registered Data.

(1) Measured in a single-phase half-wave circuit such as shown in Figure 6.25 of EIA RS-282, November 1963. Operated at rated load conditions T_L=105°C, I_O=3.0 A, V_r=V_{RWM}.

MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for
Soldering Purposes:
240°C, 1/8" from case for 10 s at 5.0 lb. tension

3

FIGURE 1 – FORWARD VOLTAGE

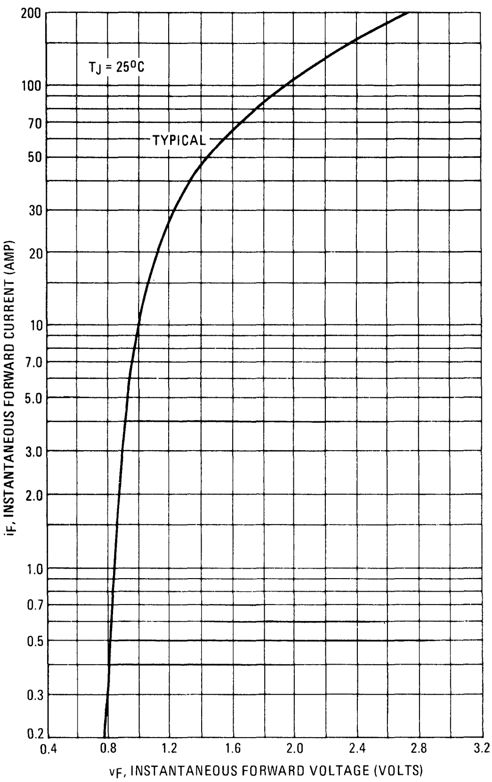


FIGURE 2 – MAXIMUM NONREPETITIVE SURGE CURRENT

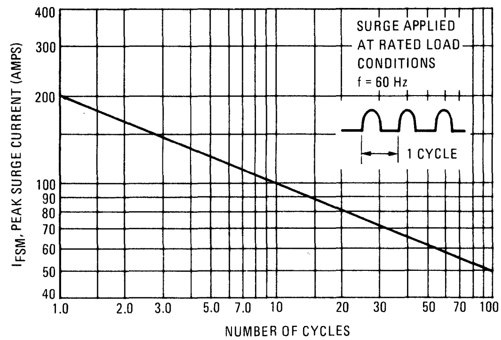
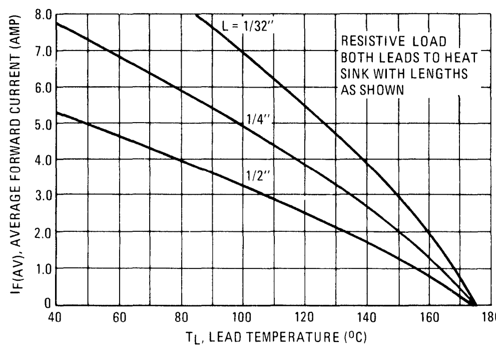


FIGURE 3 – CURRENT DERATING VARIOUS LEAD LENGTHS



NOTE 1 – AMBIENT MOUNTING DATA

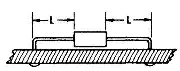
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

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

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

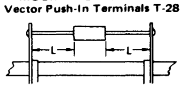
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



MOUNTING METHOD 2

Vector Push-In Terminals T-28



MOUNTING METHOD 3

P.C. Board with 1-1/2" x 1-1/2" Copper Surface

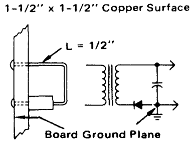
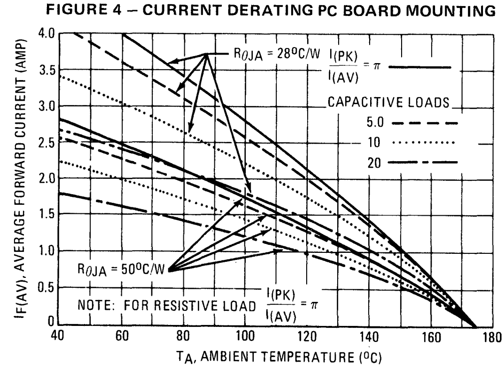


FIGURE 4 – CURRENT DERATING PC BOARD MOUNTING



MOTOROLA

1N5817 MBR115P
1N5818 MBR120P
1N5819 MBR130P
MBR140P

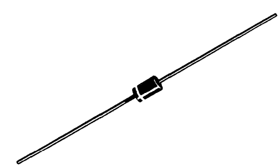
AXIAL LEAD RECTIFIERS

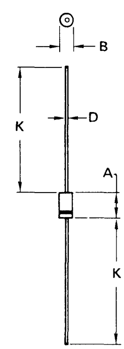
. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency

SCHOTTKY BARRIER RECTIFIERS

1 AMPERE
15, 20, 30, 40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04

*MAXIMUM RATINGS

Rating	Symbol	MBR115P	1N5817 MBR120P	1N5818 MBR130P	1N5819 MBR140P	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	15	20	30	40	V
Non-Repetitive Peak Reverse Voltage	V_{RSM}	15	24	36	48	V
RMS Reverse Voltage	$V_{R(RMS)}$	10	14	21	28	V
Average Rectified Forward Current (2) ($V_{R(equiv)} \leqslant 0.2\ V_R(dc)$, $T_L = 90^oC$, $R_{\theta JA} = 80^oC/W$, P.C. Board Mounting, see Note 2, $T_A = 55^oC$)	I_O	← 1.0 →				A
Ambient Temperature (Rated $V_R(dc)$, $P_{F(AV)} = 0$, $R_{\theta JA} = 80^oC/W$)	T_A	90	85	80	75	^oC
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, half-wave, single phase 60 Hz, $T_L = 70^oC$)	I_{FSM}	← 25 (for one cycle) →				A
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← −65 to +125 →				^oC
Peak Operating Junction Temperature (Forward Current applied)	$T_{J(pk)}$	← 150 →				^oC

*THERMAL CHARACTERISTICS (Note 2)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	80	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_L = 25^oC$ unless otherwise noted) (2)

Characteristic	Symbol	1N5817	1N5818	1N5819	MBR115P MBR120P MBR130P	MBR140P	Unit
Maximum Instantaneous Forward Forward Voltage (1)	v_F						V
($i_F = 0.1$ A)		0.320	0.330	0.340	0.350	0.350	
($i_F = 1.0$ A)		0.450	0.550	0.600	0.550	0.600	
($i_F = 3.0$ A)		0.750	0.875	0.900	0.850	0.900	
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1)	i_R						mA
($T_L = 25^oC$)		1.0	1.0	1.0	1.0	1.0	
($T_L = 100^oC$)		10	10	10	10	10	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
(2) Lead Temperature reference is cathode lead 1/32" from case.
*Indicates JEDEC Registered Data for 1N5817-19.

MECHANICAL CHARACTERISTICS

CASE . . . . Transfer molded plastic

FINISH . . . . All external surfaces corrosion-resistant and the terminal leads are readily solderable

POLARITY . . . . Cathode indicated by polarity band

MOUNTING POSITIONS . . . . Any

SOLDERING . . . . 220°C 1/16" from case for ten seconds

3

NOTE 1 — DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1).

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where $T_{A(max)}$ = Maximum allowable ambient temperature
$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest)
$P_{F(AV)}$ = Average forward power dissipation
$P_{R(AV)}$ = Average reverse power dissipation
$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2, and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2).

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2, and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2, and 3 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design, that is:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

EXAMPLE: Find $T_{A(max)}$ for 1N5818 operated in a 12-volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 0.4 A ($I_{F(AV)}$ = 0.5 A), $I_{(FM)}/I_{(AV)}$ = 10, Input Voltage = 10 $V_{(rms)}$, $R_{\theta JA}$ = 80°C/W.

Step 1. Find $V_{R(equiv)}$. Read F = 0.65 from Table 1,
$\therefore V_{R(equiv)} = (1.41)(10)(0.65) = 9.2$ V.

Step 2. Find T_R from Figure 2. Read T_R = 109°C @ V_R = 9.2 V and $R_{\theta JA}$ = 80°C/W.

Step 3. Find $P_{F(AV)}$ from Figure 4. **Read $P_{F(AV)}$ = 0.5 W @ $\frac{I_{(FM)}}{I_{(AV)}} = 10$ and $I_{F(AV)}$ = 0.5 A.

Step 4. Find $T_{A(max)}$ from equation (3).
$T_{A(max)} = 109 - (80)(0.5) = 69$°C.

**Values given are for the 1N5818. Power is slightly lower for the 1N5817 because of its lower forward voltage, and higher for the 1N5819. Variations will be similar for the MBR-prefix devices, using $P_{F(AV)}$ from Figure 7.

TABLE 1 — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

*Note that $V_{R(PK)} \approx 2.0\ V_{in(PK)}$. †Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE 1N5817/MBR115P/MBR120P

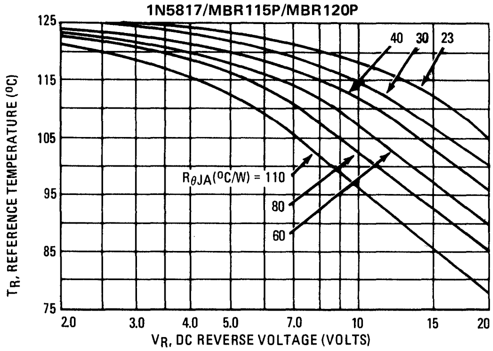


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE 1N5818/MBR130P

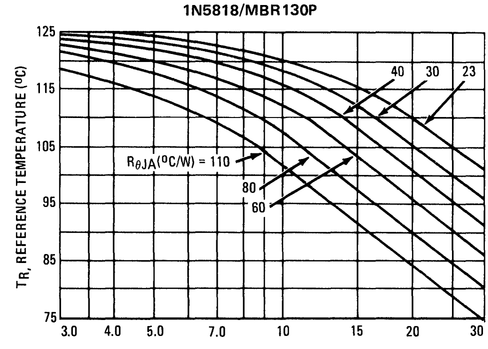


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE 1N5819/MBR140P

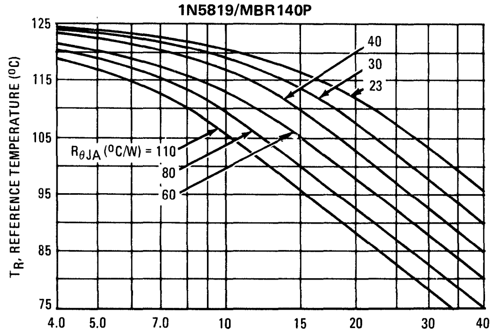
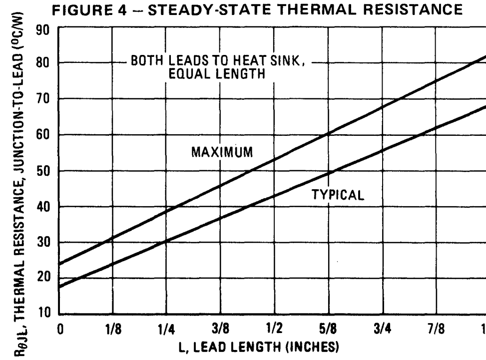


FIGURE 4 — STEADY-STATE THERMAL RESISTANCE



3

THERMAL CHARACTERISTICS

FIGURE 5 — THERMAL RESPONSE

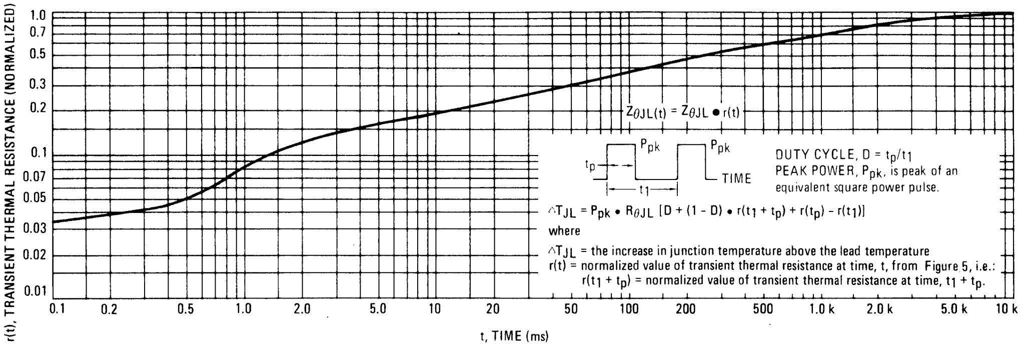


FIGURE 6 — FORWARD POWER DISSIPATION 1N5817-19

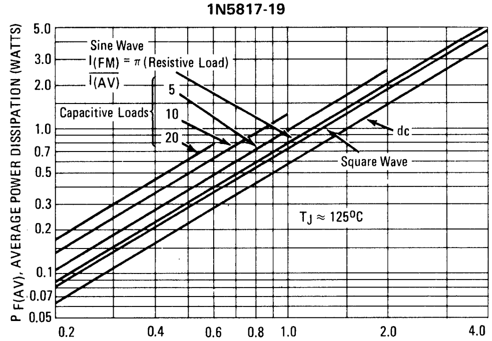
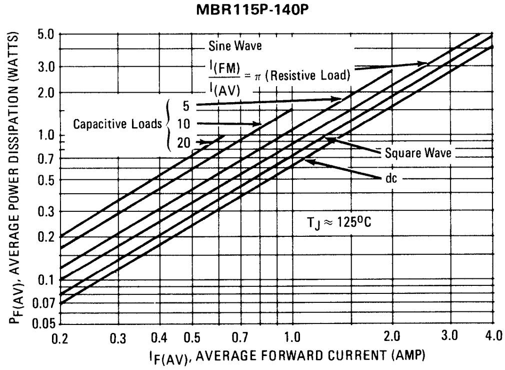


FIGURE 7 — FORWARD POWER DISSIPATION MBR115P-140P



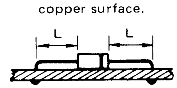
NOTE 2 — MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) 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.

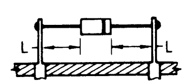
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

Mounting Method	Lead Length, L (in)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	52	65	72	85	°C/W
2	67	80	87	100	°C/W
3		50			°C/W

Mounting Method 1
P.C. Board with
1-1/2" X 1-1/2"
copper surface.

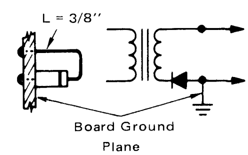


Mounting Method 2

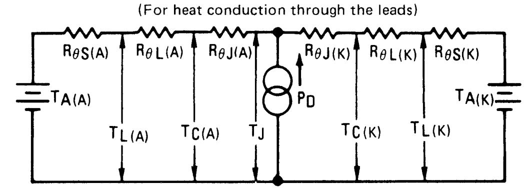


Vector Pin Mounting

Mounting Method 3
P.C. Board with
1-1/2" X 1-1/2"
copper surface.



NOTE 3 — 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 T_C = Case Temperature
T_L = Lead Temperature T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Power Dissipation
(Subscripts A and K refer to anode and cathode sides, respectively.) Values for thermal resistance components are:
$R_{\theta L}$ = 100°C/W/in typically and 120°C/W/in maximum
$R_{\theta J}$ = 36°C/W typically and 46°C/W maximum.

FIGURE 8 — TYPICAL FORWARD VOLTAGE

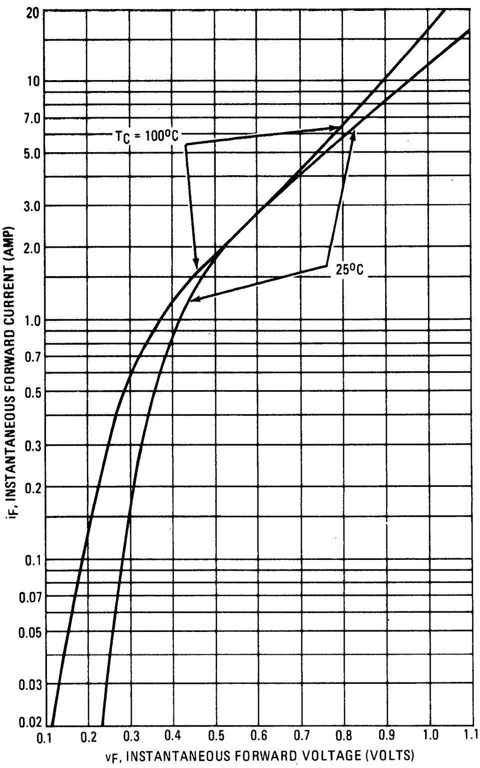


FIGURE 9 — MAXIMUM NON-REPETITIVE SURGE CURRENT

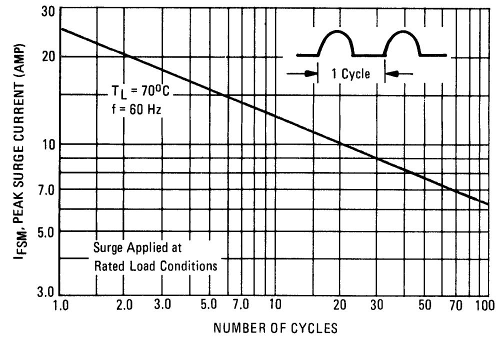


FIGURE 10 — TYPICAL REVERSE CURRENT

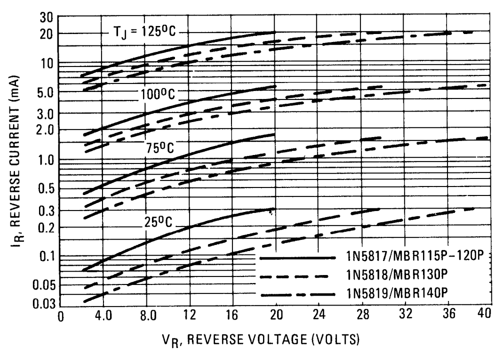
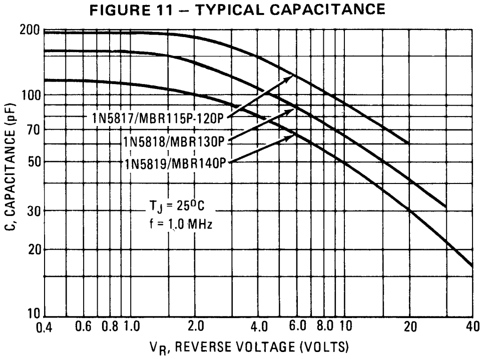


FIGURE 11 — TYPICAL CAPACITANCE



NOTE 4 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to jucntion diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss: it is simply a result of reverse current flow through the diode capactiance, which lowers the dc output voltage.

MOTOROLA

1N5820 MBR320P
1N5821 MBR330P
1N5822 MBR340P

Designer's Data Sheet

AXIAL LEAD RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

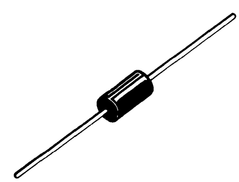
- Extremely Low v_F
- Low Power Loss/High Efficiency
- Low Stored Charge, Majority Carrier Conduction

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.

SCHOTTKY BARRIER RECTIFIERS

3.0 AMPERES
20, 30, 40 VOLTS



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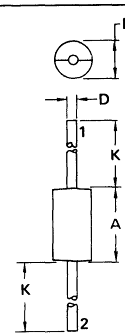


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

*MAXIMUM RATINGS

Rating	Symbol	1N5820 MBR320P	1N5821 MBR330P	1N5822 MBR340P	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	V
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	V
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	V
Average Rectified Forward Current (2) $V_{R(equiv)} \leqslant 0.2\ V_{R(dc)}$, $T_L = 95^oC$ ($R_{\theta JA} = 28^oC/W$, P.C. Board Mounting, see Note 2)	I_O	← 3.0 →			A
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 28^oC/W$	T_A	90	85	80	^oC
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, half wave, single phase 60 Hz, $T_L = 75^oC$)	I_{FSM}	← 80 (for one cycle) →			A
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS (Note 2)

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	28	$^oC/W$

*ELECTRICAL CHARACTERISTICS ($T_L = 25^oC$ unless otherwise noted) (2)

Characteristic	Symbol	1N5820	1N5821	1N5822	MBR---P	Unit
Maximum Instantaneous Forward Voltage (1)	v_F					V
(i_F = 1.0 Amp)		0.370	0.380	0.390	0.400	
(i_F = 3.0 Amp)		0.475	0.500	0.525	0.550	
(i_F = 9.4 Amp)		0.850	0.900	0.950	0.950	
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1)	i_R					mA
$T_L = 25^oC$		2.0	2.0	2.0	2.0	
$T_L = 100^oC$		20	20	20	20	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
(2) Lead Temperature reference is cathode lead 1/32" from case.
*Indicates JEDEC Registered Data for 1N5820-22.

MECHANICAL CHARACTERISTICS

CASE . . . . Transfer molded plastic
FINISH . . . . .All external surfaces corrosion-resistant and the terminal leads are readily solderable
POLARITY . . . . Cathode indicated by polarity band
MOUNTING POSITIONS . . . . Any
SOLDERING . . . . . .220°C 1/16" from case for ten seconds

NOTE 1 — DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1).

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where $T_{A(max)}$ = Maximum allowable ambient temperature
$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest)
$P_{F(AV)}$ = Average forward power dissipation
$P_{R(AV)}$ = Average reverse power dissipation
$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2, and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2).

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2, and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2, and 3 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design, that is:

$$V_{R(equiv)} = V_{(FM)} \times F \quad (4)$$

The factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

EXAMPLE: Find $T_{A(max)}$ for 1N5821 operated in a 12-volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 2.0 A ($I_{F(AV)}$ = 1.0 A), $I_{(FM)}/I_{(AV)}$ = 10, Input Voltage = 10 $V_{(rms)}$, $R_{\theta JA}$ = 40°C/W.

Step 1. Find $V_{R(equiv)}$. Read F = 0.65 from Table 1,
$\therefore V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.2 V.

Step 2. Find T_R from Figure 2. Read T_R = 108°C
@ V_R = 9.2 V and $R_{\theta JA}$ = 40°C/W.

Step 3. Find $P_{F(AV)}$ from Figure 6. **Read $P_{F(AV)}$ = 0.85 W
@ $\frac{I_{(FM)}}{I_{(AV)}}$ = 10 and $I_{F(AV)}$ = 1.0 A.

Step 4. Find $T_{A(max)}$ from equation (3).
$T_{A(max)}$ = 108 – (0.85)(40) = 74°C.

**Values given are for the 1N5821. Power is slightly lower for the 1N5820 because of its lower forward voltage, and higher for the 1N5822. Variations will be similar for the MBR-prefix devices, using $P_{F(AV)}$ from Figure 7.

TABLE 1 — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

*Note that $V_{R(PK)} \approx 2.0\, V_{in(PK)}$. †Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE 1N5820/MBR320P

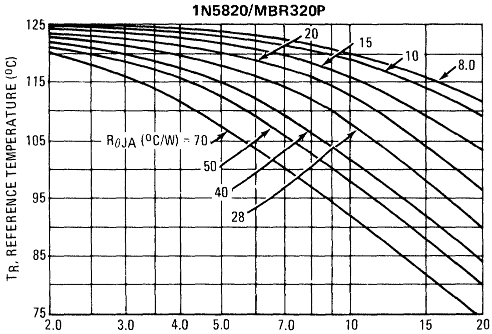


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE 1N5821/MBR330P

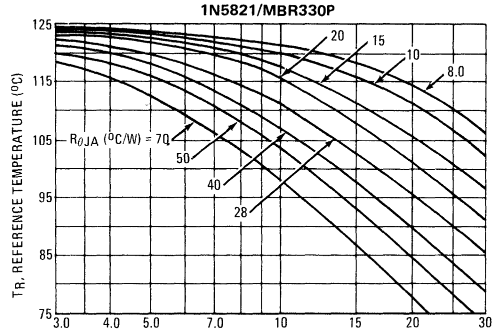


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE 1N5822/MBR340P

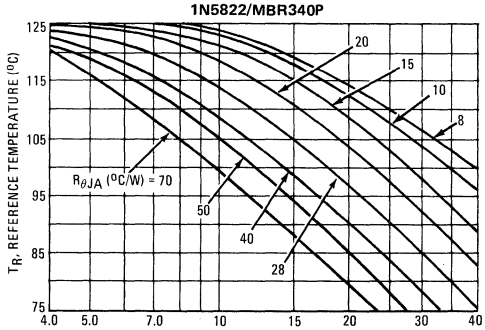


FIGURE 4 — STEADY-STATE THERMAL RESISTANCE

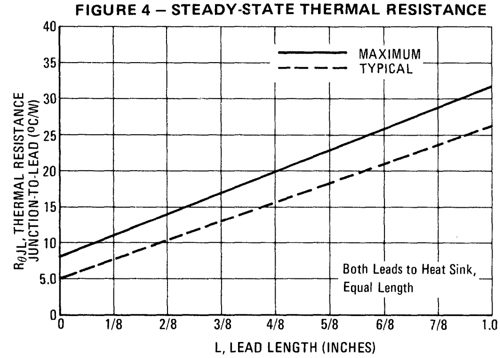


FIGURE 5 — THERMAL RESPONSE

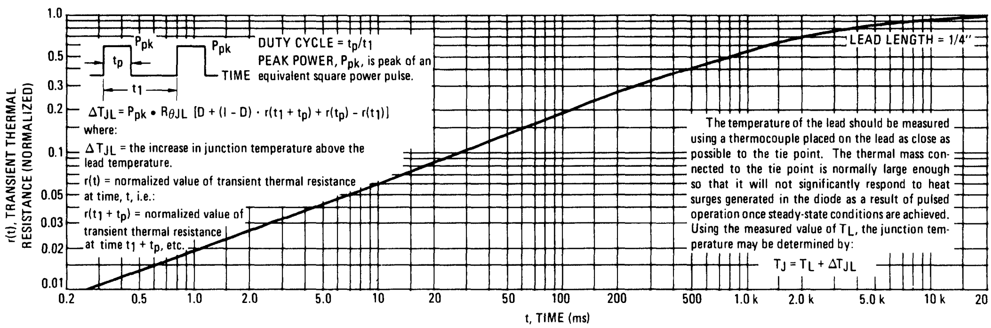


FIGURE 6 — FORWARD POWER DISSIPATION
1N5820-22

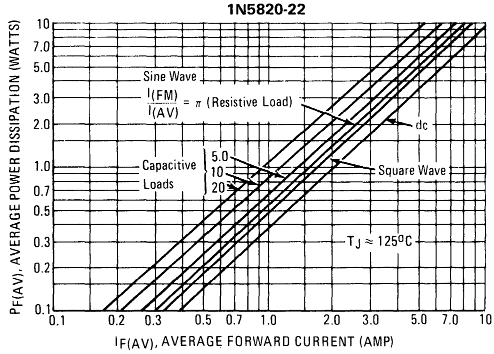
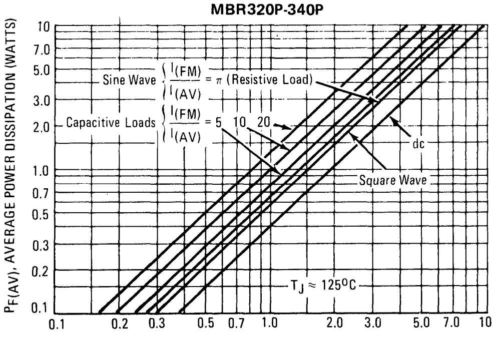
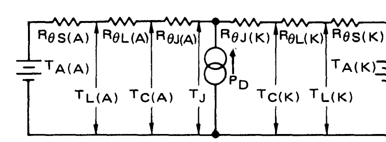


FIGURE 7 — FORWARD POWER DISSIPATION
MBR320P-340P



NOTE 3 — APPROXIMATE THERMAL CIRCUIT MODEL



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 T_C = Case Temperature
T_L = Lead Temperature T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts (A) and (K) refer to anode and cathode sides, respectively.) Values for thermal resistance components are:

$R_{\theta L}$ = 42°C/W/in typically and 48°C/W/in maximum
$R_{\theta J}$ = 10°C/W typically and 16°C/W maximum

The maximum lead temperature may be found as follows:

$$T_L = T_{J(max)} - \Delta T_{JL}$$

where $\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$

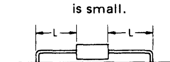
NOTE 2 — MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) 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.

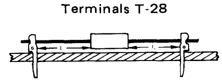
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

Mounting Method	Lead Length, L (in) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

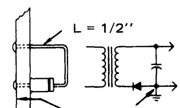
Mounting Method 1
P.C. Board where available copper surface is small.



Mounting Method 2
Vector Push-In Terminals T-28



Mounting Method 3
P.C. Board with with 2-1/2" X 2-1/2" copper surface.



Board Ground Plane

3

3

FIGURE 8 — TYPICAL FORWARD VOLTAGE

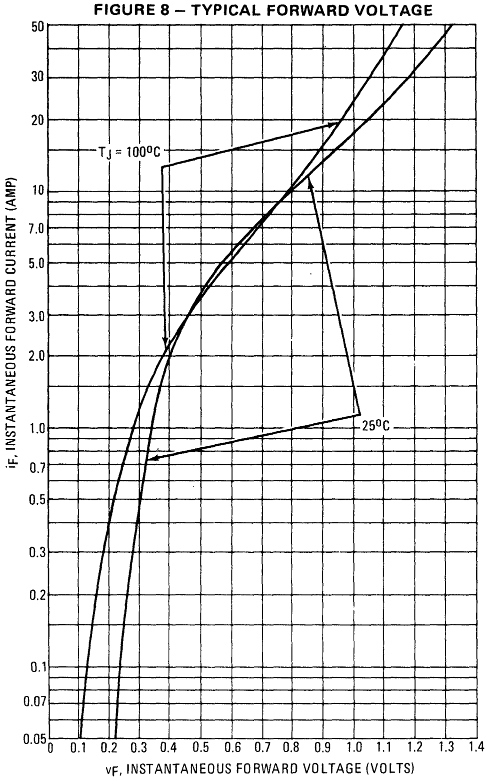


FIGURE 9 — MAXIMUM NON-REPETITIVE SURGE CURRENT

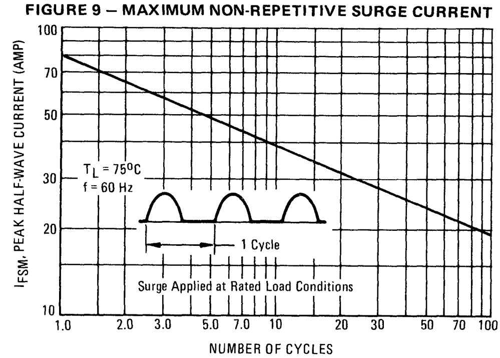


FIGURE 10 — TYPICAL REVERSE CURRENT

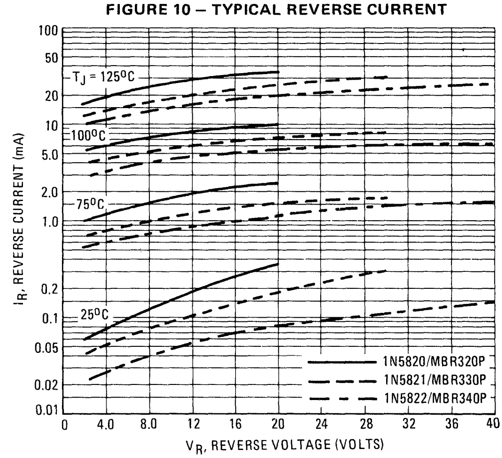
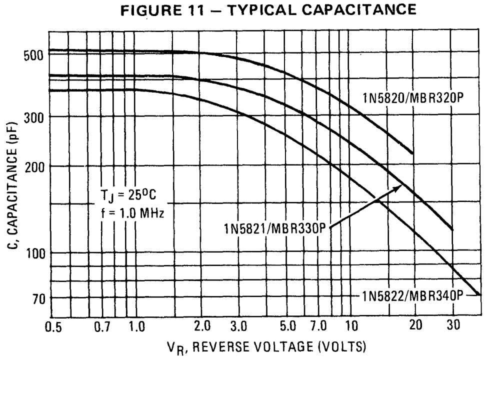


FIGURE 11 — TYPICAL CAPACITANCE



NOTE 4 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11.)

MOTOROLA

1N5823, 1N5824
1N5825
MBR5825,H, H1

Designers Data Sheet

HOT CARRIER POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

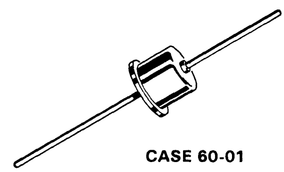
- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/ High Efficiency
- High Surge Capacity
- TX Version Available

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.

SCHOTTKY BARRIER RECTIFIERS

5 AMPERE
20, 30, 40 VOLTS



CASE 60-01

3

*MAXIMUM RATINGS

Rating	Symbol	1N5823	1N5824	1N5825 MBR5825H, H1	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	14	21	28	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R\ (dc)}$, $T_C = 75°C$ $V_{R(equiv)} \leq 0.2\ V_{R\ (dc)}$, $T_L = 80°C$ $R_{\theta JA} = 25°C/W$, P.C. Board Mounting, See Note 3)	I_O		← 15 → ← 5.0 →		Amp
Ambient Temperature Rated $V_{R\ (dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 25°C/W$	T_A	65	60	55	°C
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}		← 500 (for 1 cycle) →		Amp
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}		← −65 to +125 →		°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$		← 150 →		°C

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	°C/W

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

Characteristic	Symbol	1N5823	1N5824	1N5825 MBR5825H, H1	Unit
Maximum Instantaneous Forward Voltage (1) ($i_F = 3.0$ Amp) ($i_F = 5.0$ Amp) ($i_F = 15.7$ Amp)	v_F	 0.330 0.360 0.470	 0.340 0.370 0.490	 0.350 0.380 0.520	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage $T_C = 25°C$ $T_C = 100°C$	i_R	 10 75	 10 75	 10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0% *Indicates JEDEC Registered Data for 1N5823–1N5825

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{IN(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5825 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 10°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.2 V

Step 2: Find T_R from Figure 3. Read T_R = 113°C @ V_R = 9.2 V & $R_{\theta JA}$ = 10°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 4. **Read $P_{F(AV)}$ = 5.5 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 113-(10)(5.5) = 58°C.

**Value given are for the 1N5825. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped *†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

*Note that $V_{R(PK)} \approx 2 V_{in(PK)}$ †Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5823

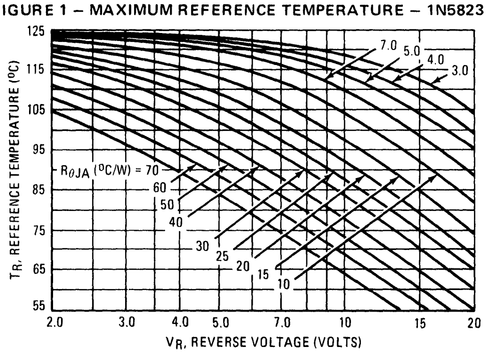


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5824

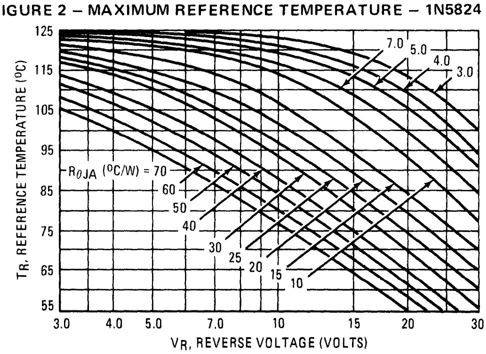


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE 1N5825 AND MBR5825H, H1

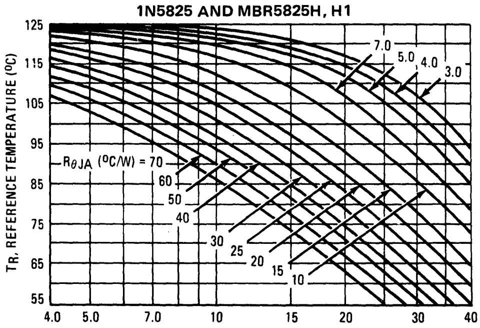
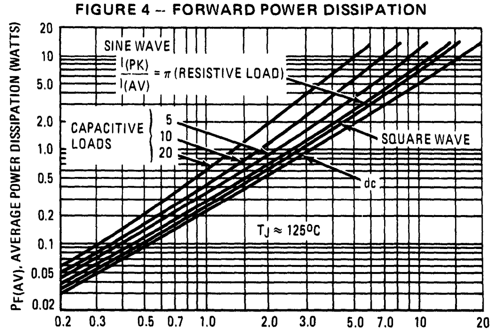
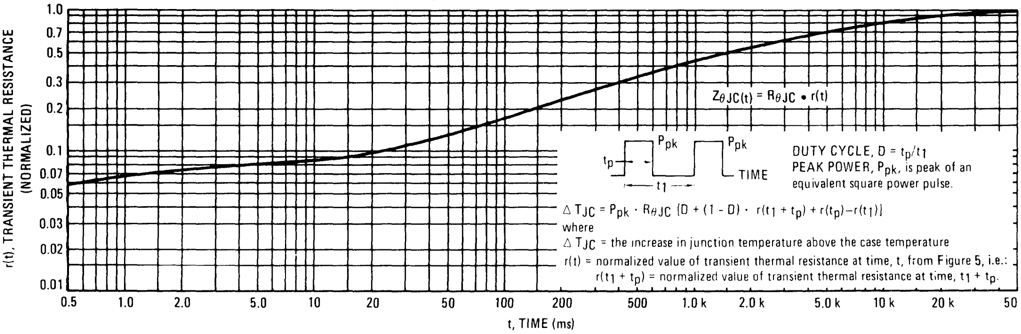


FIGURE 4 – FORWARD POWER DISSIPATION



THERMAL CHARACTERISTICS

FIGURE 5 – THERMAL RESPONSE



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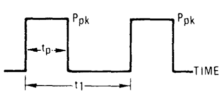
NOTE 2 – FINDING JUNCTION TEMPERATURE



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 5, i.e.:

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

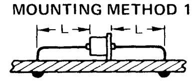
NOTE 3 – MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering.

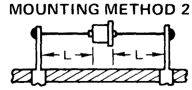
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/4	1	$R_{\theta JA}$
1	55	60	°C/W
2	65	70	°C/W
3	25		°C/W

MOUNTING METHOD 1



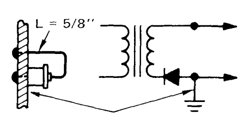
MOUNTING METHOD 2



Vector pin mounting

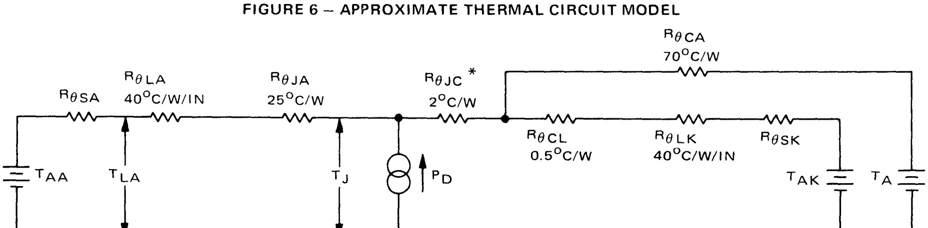
MOUNTING METHOD 3

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



Board Ground Plane

FIGURE 6 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits calculation of average junction temperature for any mounting situation. Lowest values of thermal resistance will occur when the cathode lead is brought as close as possible to a heat dissipator; as heat conduction through the anode lead is small. Terms in the model are defined as follows:

***Case temperature reference is at cathode end.**

TEMPERATURES

- T_A = Ambient
- T_{AA} = Anode Heat Sink Ambient
- T_{AK} = Cathode Heat Sink Ambient
- T_{LA} = Anode Lead
- T_{LK} = Cathode Lead
- T_J = Junction

THERMAL RESISTANCES

- $R_{\theta CA}$ = Case to Ambient
- $R_{\theta SA}$ = Anode Lead Heat Sink to Ambient
- $R_{\theta SK}$ = Cathode Lead Heat Sink to Ambient
- $R_{\theta LA}$ = Anode Lead
- $R_{\theta LK}$ = Cathode Lead
- $R_{\theta CL}$ = Case to Cathode Lead
- $R_{\theta JC}$ = Junction to Case
- $R_{\theta JA}$ = Junction to Anode Lead (S bend)

FIGURE 7 — TYPICAL FORWARD VOLTAGE

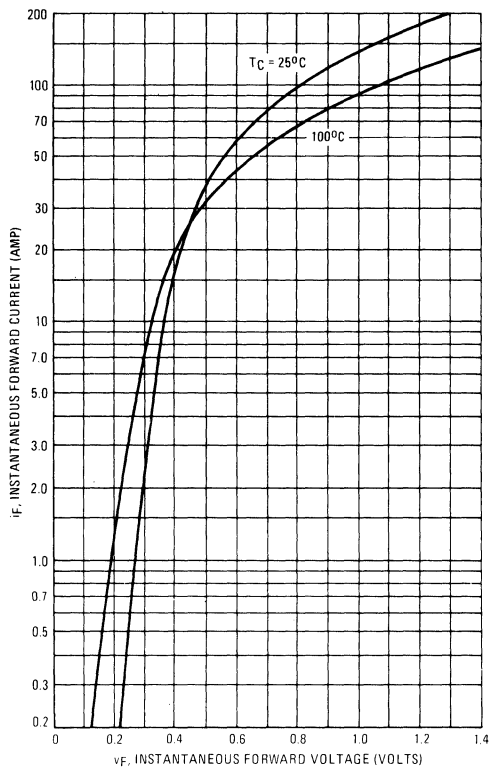


FIGURE 8 — MAXIMUM SURGE CAPABILITY

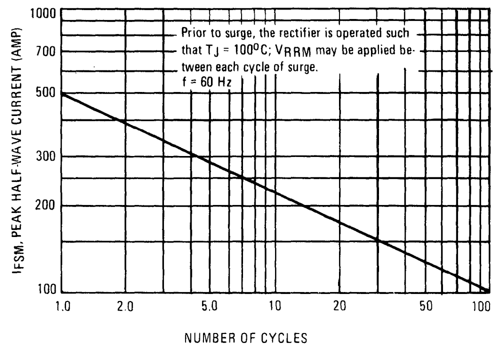


FIGURE 9 — TYPICAL REVERSE CURRENT

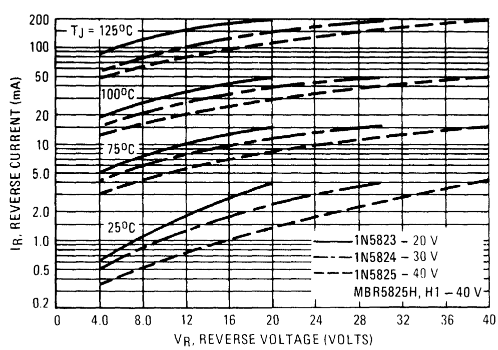
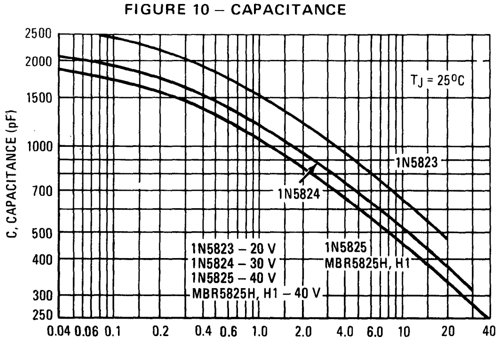


FIGURE 10 — CAPACITANCE



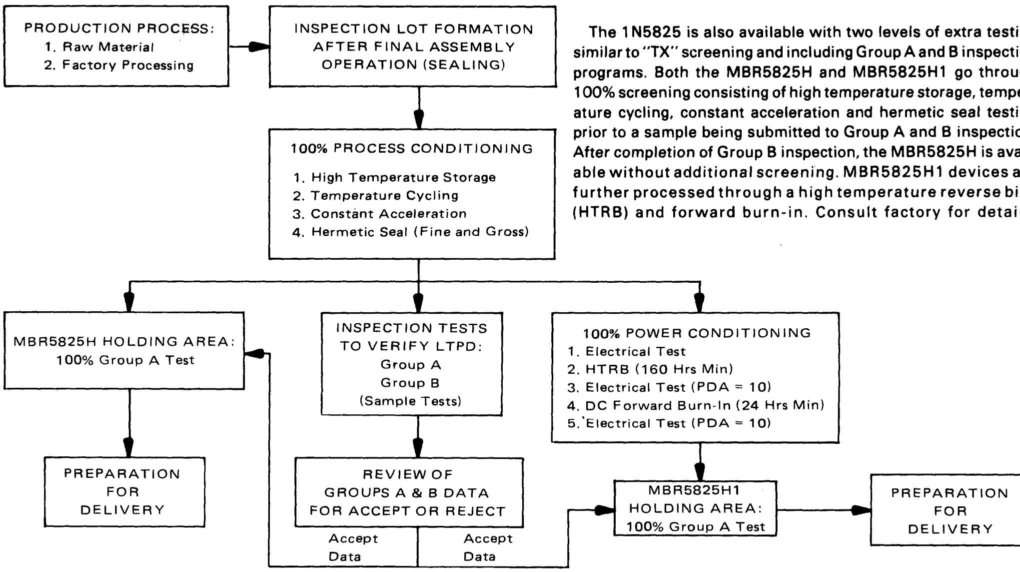
NOTE 4 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

NOTE 5 – HI-REL PROGRAM OPTIONS

The 1N5825 is also available with two levels of extra testing similar to "TX" screening and including Group A and B inspection programs. Both the MBR5825H and MBR5825H1 go through 100% screening consisting of high temperature storage, temperature cycling, constant acceleration and hermetic seal testing prior to a sample being submitted to Group A and B inspection. After completion of Group B inspection, the MBR5825H is available without additional screening. MBR5825H1 devices are further processed through a high temperature reverse bias (HTRB) and forward burn-in. Consult factory for details.



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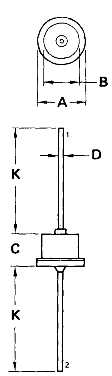
MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.
FINISH: All external surfaces corrosion-resistant and the terminal leads are readily solderable.
WEIGHT: 2.4 grams (approximately).
POLARITY: Cathode to case.
MOUNTING POSITONS: Any



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60-1

1N5826
1N5827
1N5828

MOTOROLA

Designers Data Sheet

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

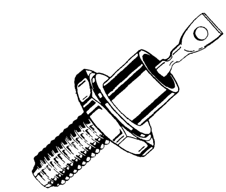
- Extremely Low V_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

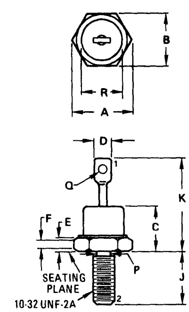
Designer's Data for "Worst Case" Conditions

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.

SCHOTTKY BARRIER RECTIFIERS

15 AMPERE
20,30,40 VOLTS





STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
DO-4

*MAXIMUM RATINGS

Rating	Symbol	1N5826	1N5827	1N5828	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 85^oC$	I_O	← 15 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 5.0^oC/W$	T_A	95	90	85	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^oC/W$

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

Characteristic	Symbol	1N5826	1N5827	1N5828	Unit
Maximum Instantaneous Forward Voltage (1)	v_F				Volts
(i_F = 8.0 Amp)		0.380	0.400	0.420	
(i_F = 15 Amp)		0.440	0.470	0.500	
(i_F = 47.1 Amp)		0.670	0.770	0.870	
Maximum Instantaneous Reverse Current @ rated dc Voltage (1)	i_R	10	10	10	mA
$T_C = 100^oC$		75	75	75	

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 15 in. lb. max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\, P_{F(AV)} - R_{\theta JA}\, P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\, P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\, P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5828 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 121°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4.** Read $P_{F(AV)}$ = 10 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 121-(5)(10) = 71°C

** Value given are for the 1N5828. Power is slightly lower for the other units because of their lower forward voltage.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped *†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

*Note that $V_{R(PK)} \approx 2\, V_{in(PK)}$

*†Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5826

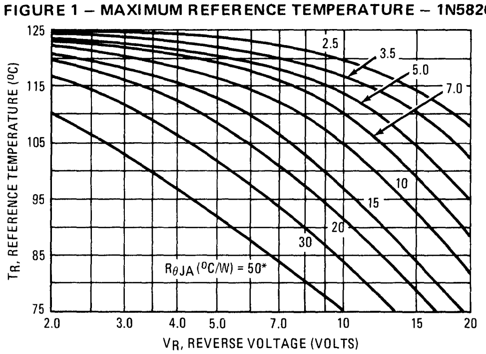


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5827

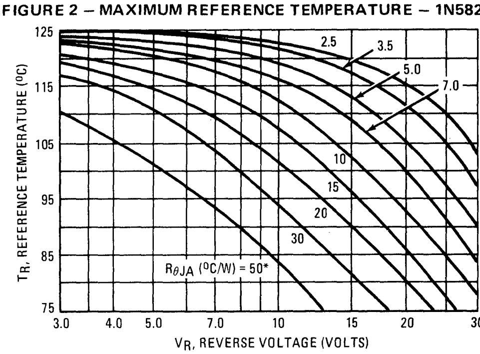


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5828

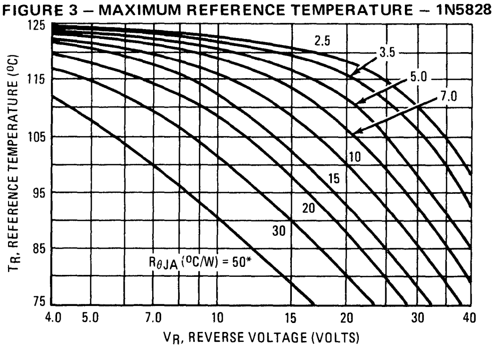
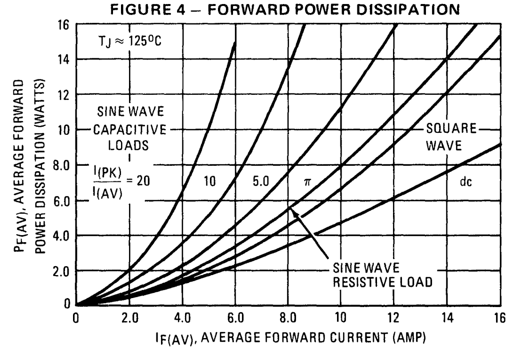


FIGURE 4 – FORWARD POWER DISSIPATION



*No external heat sink.

FIGURE 5 – TYPICAL FORWARD VOLTAGE

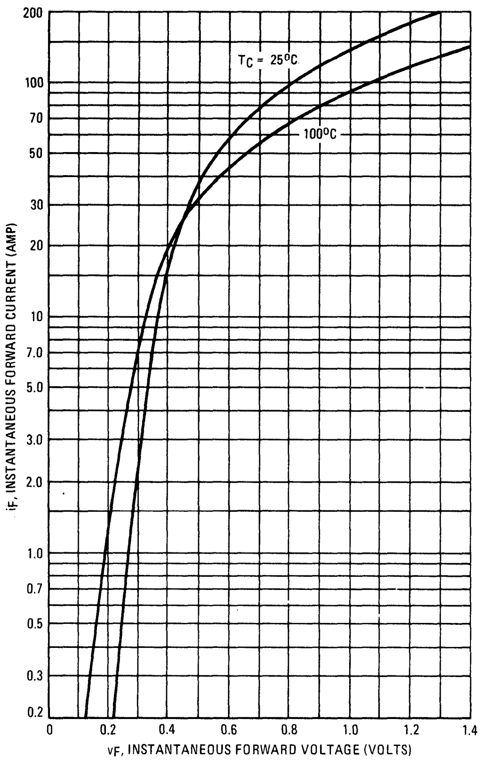


FIGURE 6 – MAXIMUM SURGE CAPABILITY

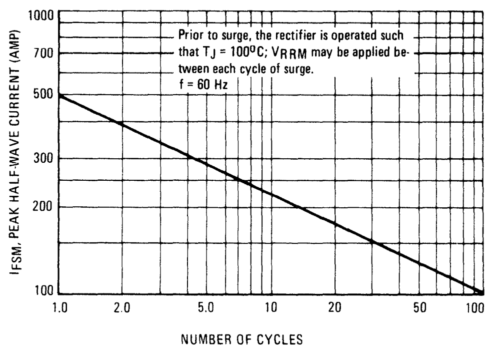


FIGURE 7 – CURRENT DERATING

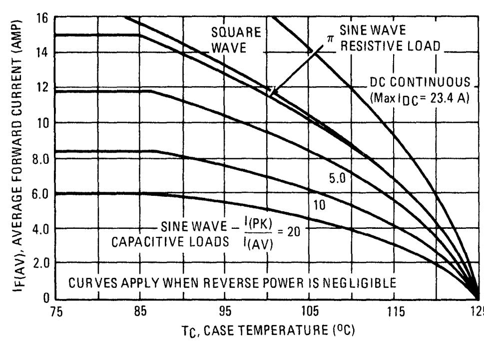


FIGURE 8 – THERMAL RESPONSE

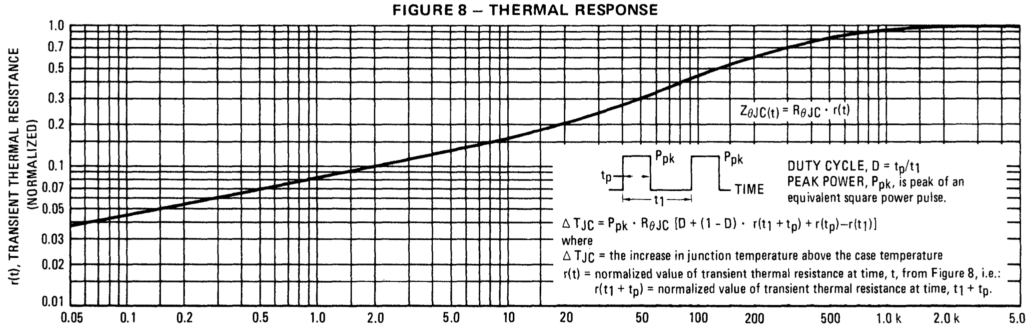


FIGURE 9 — NORMALIZED REVERSE CURRENT

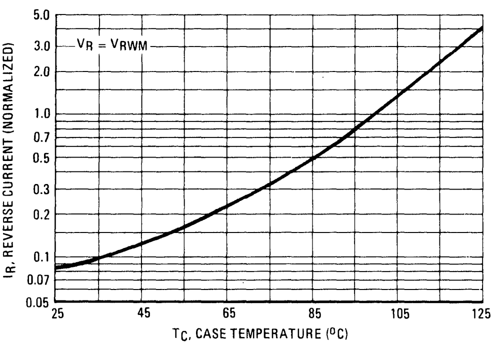


FIGURE 10 — TYPICAL REVERSE CURRENT

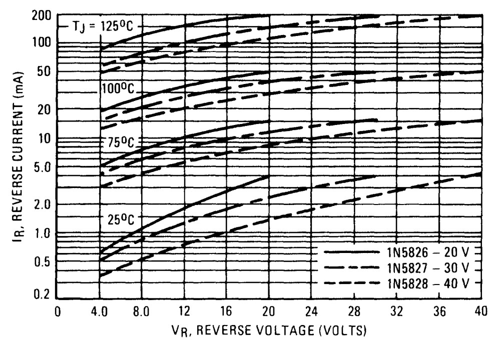
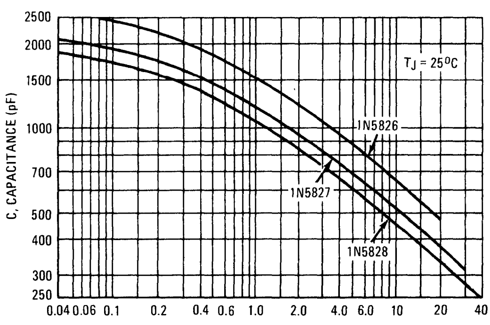


FIGURE 11 — CAPACITANCE



NOTE 2 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

3

1N5829, 1N5830
1N5831
MBR5831,H, H1

MOTOROLA

Designers Data Sheet

HOT CARRIER POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

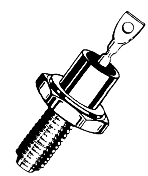
- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity
- TX Version Available

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.

SCHOTTKY BARRIER RECTIFIERS

25 AMPERE
20, 30, 40 VOLTS



*MAXIMUM RATINGS

Rating	Symbol	1N 5829	1N 5830	1N 5831 MBR 5831H,H1	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leqslant 0.2\ V_{R\ (dc)}$, $T_C = 85°C$	I_O	← 25 →			Amp
Ambient Temperature Rated $V_{R\ (dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 3.5°C/W$	T_A	90	85	80	°C
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}	800 (for 1 cycle)			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied	T_J, T_{stg}	← -65 to +125 →			°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			°C

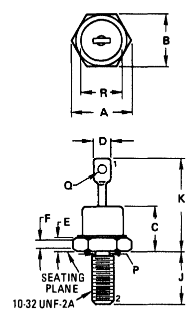
*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	°C/W

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

Characteristic	Symbol	1N 5829	1N 5830	1N 5831 MBR 5831H, H1	Unit
Maximum Instantaneous Forward Voltage (1)	v_F				Volts
(i_F = 10 Amp)		0.360	0.370	0.380	
(i_F = 25 Amp)		0.440	0.460	0.480	
(i_F = 78.5 Amp)		0.720	0.770	0.820	
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1)	i_R	20	20	20	mA
(T_C = 100°C)		150	150	150	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0% *Indicates JEDEC Registered Data for 1N5829–1N5831



STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
D0-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistant and terminal leads are readily solderable.
POLARITY: Cathode to Case
MOUNTING POSITIONS: Any
STUD TORQUE: 15 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5831 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 16 A ($I_{F(AV)}$ = 8 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 113°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4.** Read $P_{F(AV)}$ = 12.8 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 8 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 113-(5)(12.8) = 49°C

** Value given are for the 1N5828. Power is slightly lower for the other units because of their lower forward voltage.

3

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped *†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

*Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

*†Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE — 1N5829

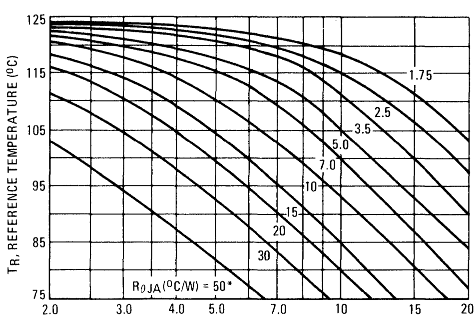


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE — 1N5830

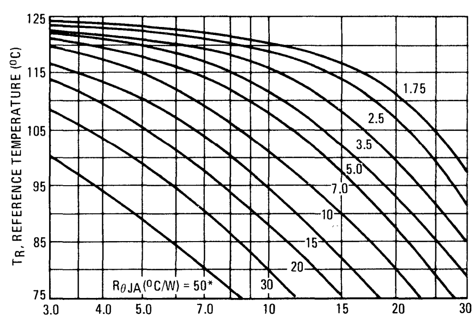
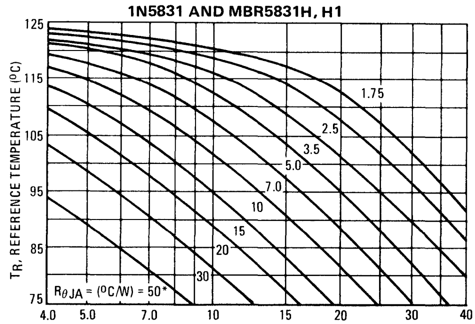


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE 1N5831 AND MBR5831H, H1



*No external heat sink.

FIGURE 4 — FORWARD POWER DISSIPATION

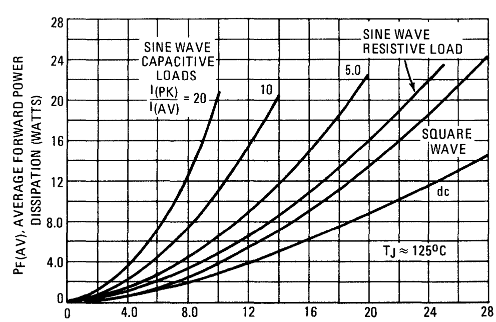


FIGURE 5 — TYPICAL FORWARD VOLTAGE

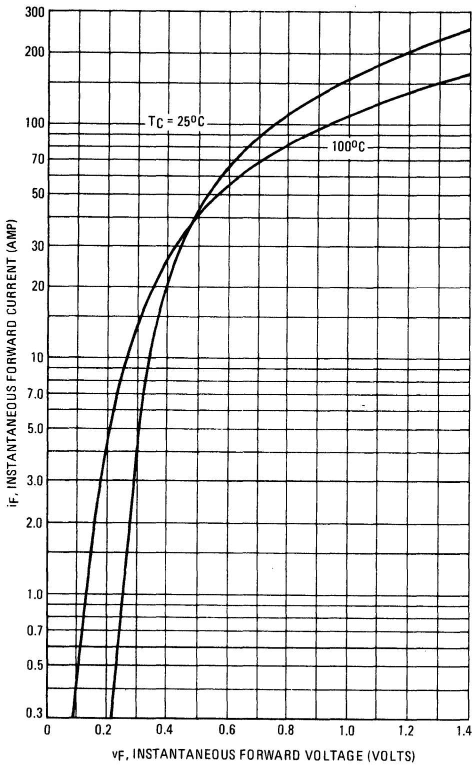


FIGURE 6 — MAXIMUM SURGE CAPABILITY

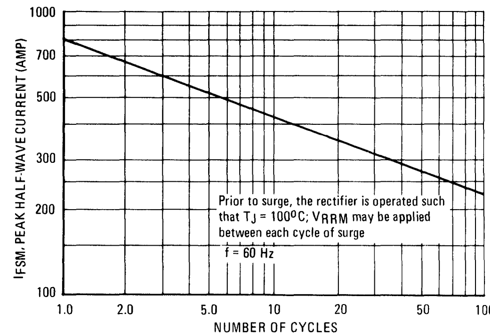


FIGURE 7 — CURRENT DERATING

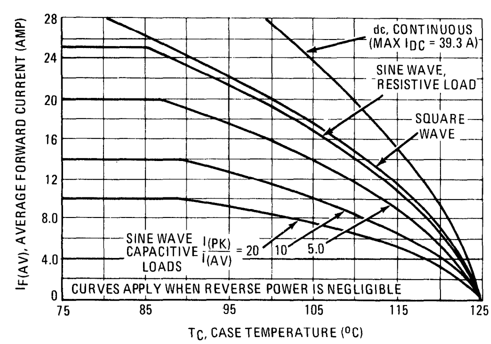


FIGURE 8 — THERMAL RESPONSE

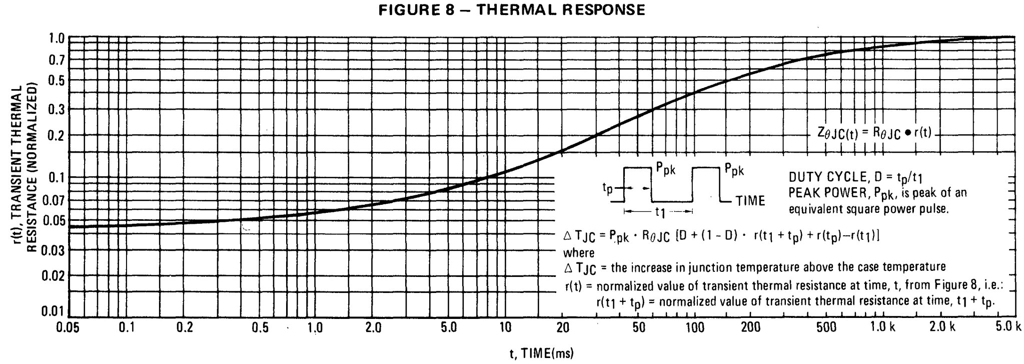


FIGURE 9 – NORMALIZED REVERSE CURRENT

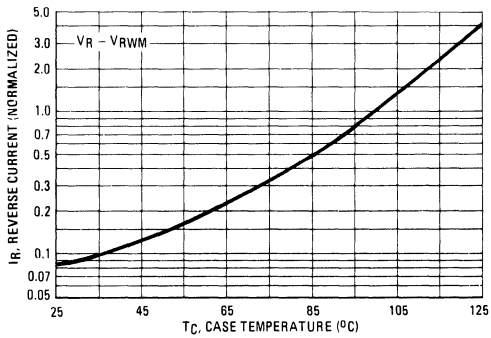


FIGURE 10 – TYPICAL REVERSE CURRENT

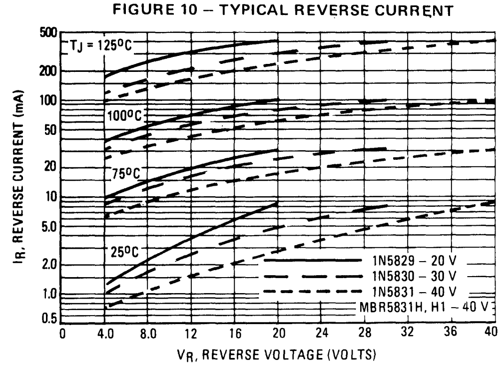
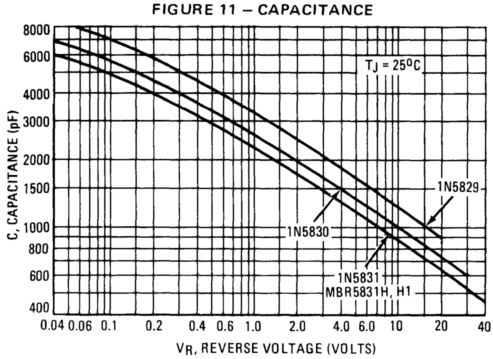


FIGURE 11 – CAPACITANCE



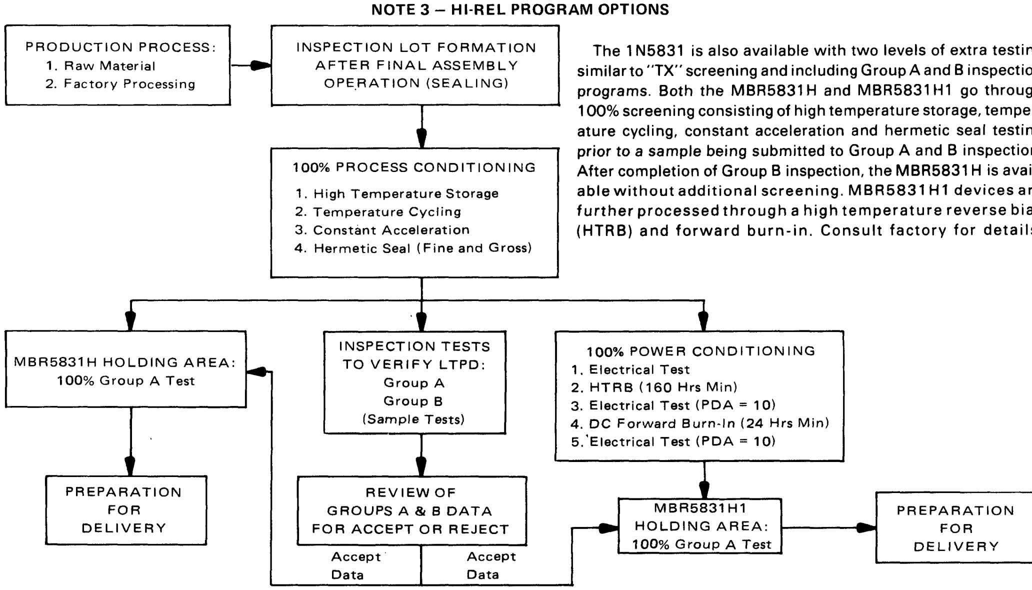
NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

NOTE 3 – HI-REL PROGRAM OPTIONS

The 1N5831 is also available with two levels of extra testing similar to "TX" screening and including Group A and B inspection programs. Both the MBR5831H and MBR5831H1 go through 100% screening consisting of high temperature storage, temperature cycling, constant acceleration and hermetic seal testing prior to a sample being submitted to Group A and B inspection. After completion of Group B inspection, the MBR5831H is available without additional screening. MBR5831H1 devices are further processed through a high temperature reverse bias (HTRB) and forward burn-in. Consult factory for details.



1N5832
1N5833
1N5834

MOTOROLA

Designers Data Sheet

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

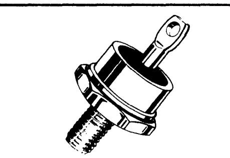
Designer's Data for "Worst Case" Conditions

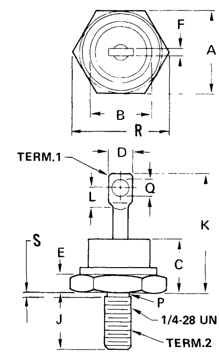
The Designers Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

3

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE
20,30,40 VOLTS





*MAXIMUM RATINGS

Rating	Symbol	1N5832	1N5833	1N5834	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}, T_C = 75^oC$	I_O	← 40 →			Amp
Ambient Temperature Rated $V_{R(dc)}, P_{F(AV)} = 0$, $R_{\theta JA} = 2.0^oC/W$	T_A	100	95	90	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

*THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	$^oC/W$

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

Characteristic	Symbol	1N5832	1N5833	1N5834	Unit
Maximum Instantaneous Forward Voltage(1) (i_F = 10 Amp) (i_F = 40 Amp) (i_F = 125 Amp)	v_F	 0.360 0.520 0.980	 0.370 0.550 1.080	 0.380 0.590 1.180	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	i_R	20 150	20 150	20 150	mA

*Indicates JEDEC Registered Data.

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

CASE 257-01

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\, P_{F(AV)} - R_{\theta JA}\, P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\, P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\, P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for 1N5834 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 3°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (10)(1.41)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 118°C @ V_R = 9.18 V & $R_{\theta JA}$ = 3°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4.†Read $P_{F(AV)}$ = 20 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 15 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 118-(3)(20) = 58°C

†Values given are for the 1N5834. Power is slightly lower for the other units because of their lower forward voltage.

3

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\, V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – 1N5832

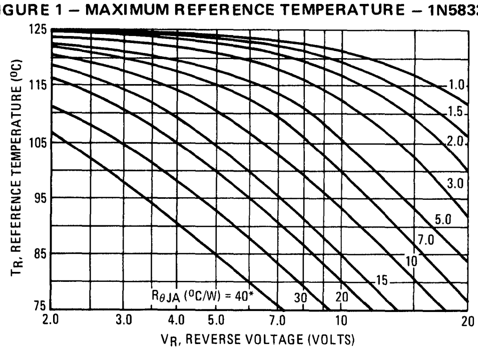


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – 1N5833

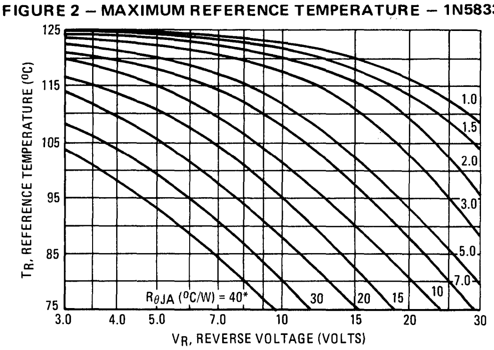


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – 1N5834

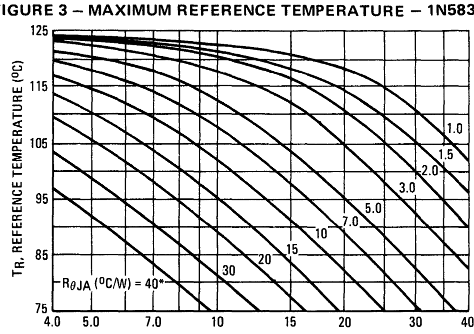
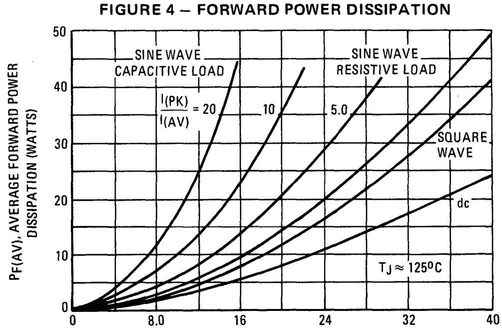


FIGURE 4 – FORWARD POWER DISSIPATION



*No external heat sink.

3

FIGURE 5 — TYPICAL FORWARD VOLTAGE

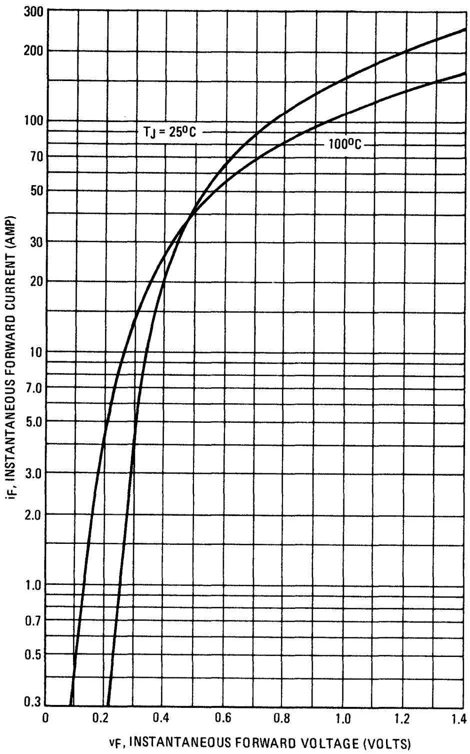


FIGURE 6 — MAXIMUM SURGE CAPABILITY

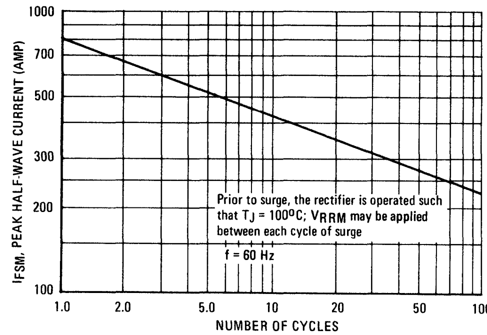


FIGURE 7 — CURRENT DERATING

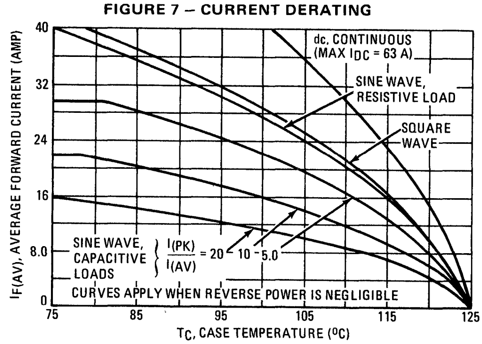


FIGURE 8 — THERMAL RESPONSE

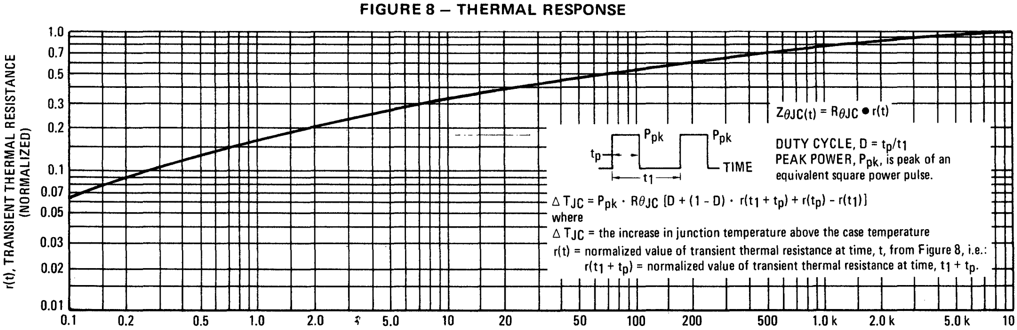


FIGURE 9 — NORMALIZED REVERSE CURRENT

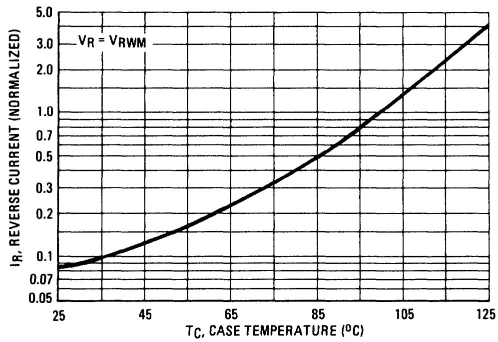


FIGURE 10 — TYPICAL REVERSE CURRENT

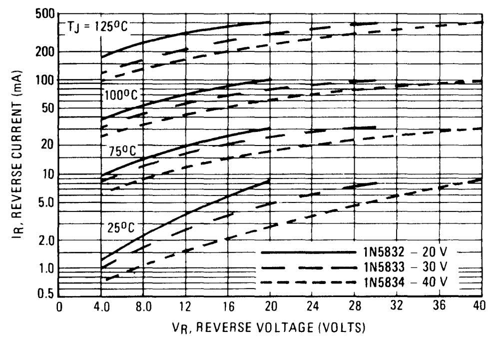
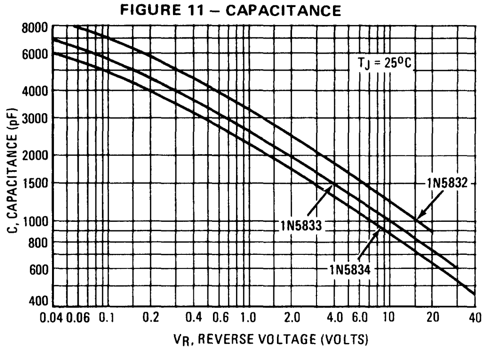


FIGURE 11 — CAPACITANCE



NOTE 2: HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in. lb. Max

SOLDER HEAT: See Note 3

NOTE 3: SOLDER HEAT

The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

1N6095
1N6096
SD41

MOTOROLA

3

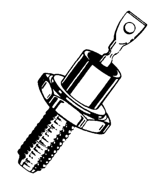
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature Capability
- Guaranteed Reverse Avalanche

SCHOTTKY BARRIER RECTIFIERS

25 and 30 AMPERES
30 to 45 VOLTS



CASE 56
D0-4

MAXIMUM RATINGS

Rating	Symbol	1N6095*	1N6096*	SD41	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	30	40	45 35 45	Volts
Average Rectified Forward Current (Rated V_R)	I_O	25 $T_C = 70°C$	25 $T_C = 70°C$	30 $T_C = 105°C$	Amps
Case Temperature (Rated V_R)	T_C	105	105	—	°C
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	400	400	600	Amp
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 10. (1)	I_{RRM}	2.0	2.0	2.0	Amps
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to + 125	-65 to + 125	-55 to + 150°C	°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	150	150	150	°C
Voltage Rate of Change (Rated V_R)	dv/dt	—	—	700	V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	1N6095*	1N6096*	SD41	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	←	2.0	→	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N6095*	1N6096*	SD41	Unit
Maximum Instantaneous Forward Voltage (2) (i_F = 30 Amp, T_C = 125°C) (i_F = 78.5 Amp, T_C = 70°C)	v_F	 — 0.86	 — 0.86	 0.55 —	Volts
Maximum Instantaneous Reverse Current (2) (Rated dc Voltage, T_C = 125°C)	i_R	250	250	125 @ V_R = 35 V	mA
Capacitance (100 kHz ≥ f ≥ 1.0 MHz)	C_t	6000 V_R = 1.0 V	6000 V_R = 1.0 V	2000 V_R = 5.0 V	pF

*Indicates JEDEC Registered Data.
(1) Not JEDEC requirement, but a Motorola product capability.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

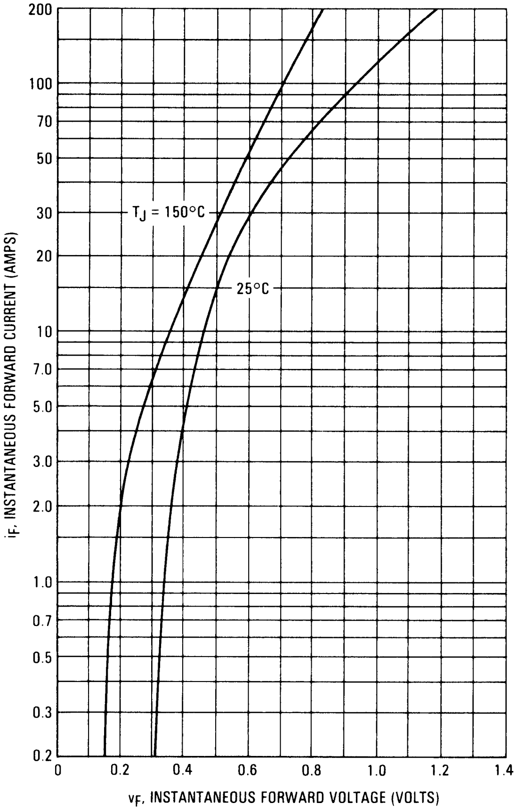


FIGURE 2 — TYPICAL REVERSE CURRENT

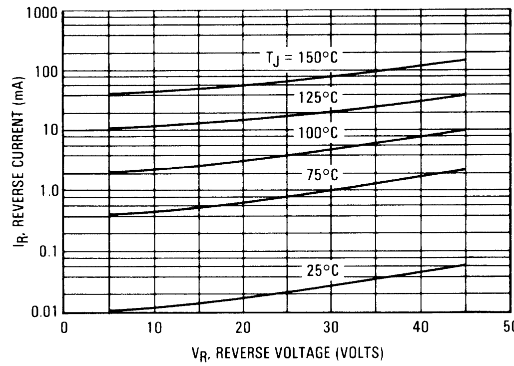
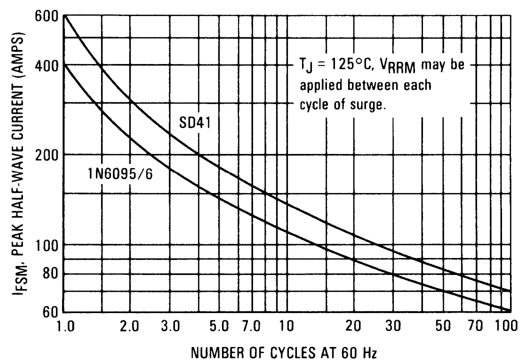


FIGURE 3 — MAXIMUM SURGE CAPABILITY



HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 4.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficieny is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 4 — CAPACITANCE

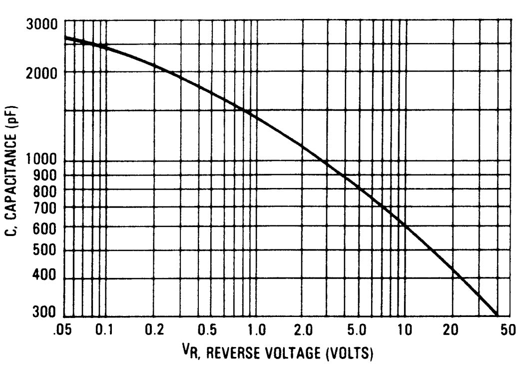


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FIGURE 5 — SD41 CURRENT DERATING

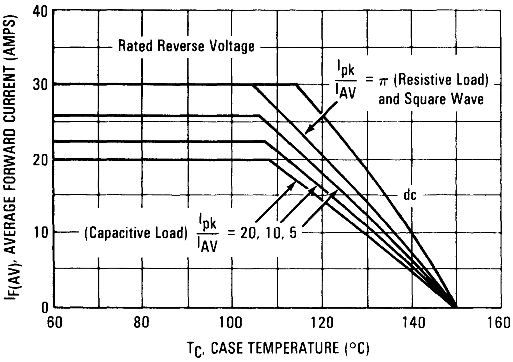


FIGURE 6 — 1N6095/6 CURRENT DERATING

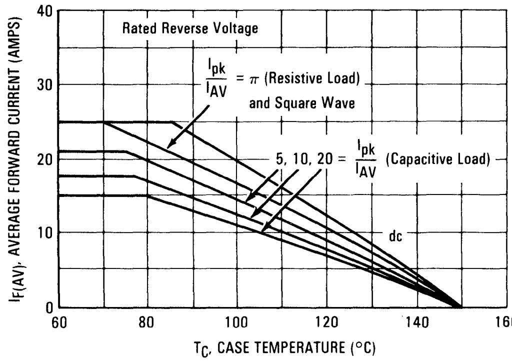


FIGURE 7 — FORWARD POWER DISSIPATION

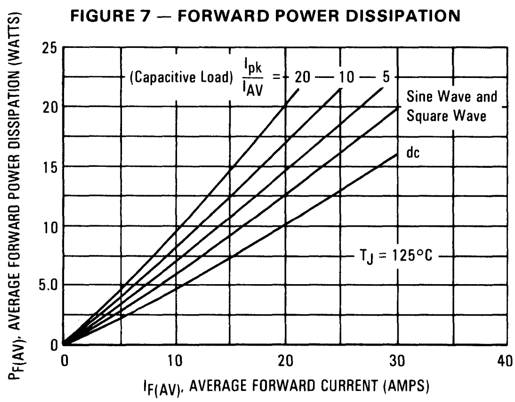


FIGURE 8 — THERMAL RESPONSE

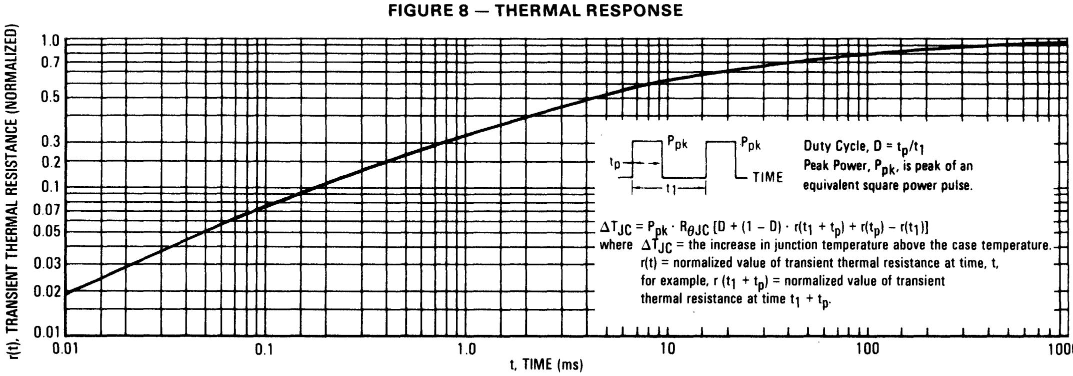
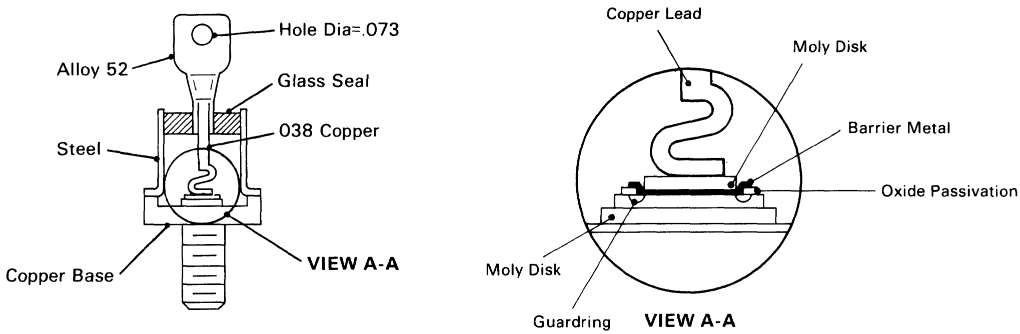


FIGURE 9 — SCHOTTKY RECTIFIER



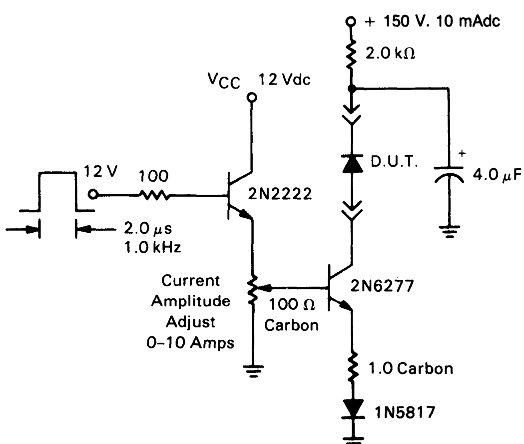
Motorola builds quality and reliability into its Schottky Rectifiers.

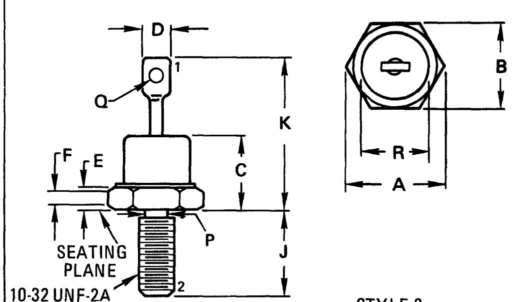
First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not required. The guardring also operates like a zener to absorb over-voltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The top copper lead is also stress-reliefed. These two features give the unit the capability of passing stringent thermal fatigue tests for 5,000 cycles. The top copper lead provides a low resistance to current and therefore does not contribute to device heating; a heat sink should be used when attaching wires.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche.

FIGURE 10 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

STYLE 2:
TERM 1. ANODE
2. CATHODE

CASE 56
D0-4

1N6097
1N6098
SD51

MOTOROLA

3

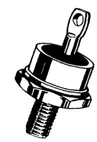
SWITCHMODE POWER RECTIFIERS

. . . using a platinum barrier metal in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Guaranteed Reverse Avalanche
- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Guardring for Stress Protection
- Low Power Loss/High Efficiency
- 150°C Operating Junction Temperature Capability
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

60 AMPERES
20 to 45 VOLTS



CASE 257
DO-5

MAXIMUM RATINGS

Rating	Symbol	1N6097*	1N6098*	SD51	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	30	40	45 35 45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz)	I_{FRM}	—	—	120 T_C = 90°C	Amps
Average Rectified Forward Current (Rated V_R)	I_O	50 T_C = 70°C	50 T_C = 70°C	—	Amps
Case Temperature (Rated V_R)	T_C	115	115	—	°C
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	←	800	→	Amps
Peak Repetitive Reverse Surge Current (2) (2.0 μs, 1.0 kHz) See Figure 10.	I_{RRM}	←	2.0	→	Amps
Operating Junction Temperature Range (Reverse Voltage Applied)	T_J	-65 to +125	-65 to +125	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +125	-65 to +125	-65 to +165	°C
Voltage Rate of Change (Rated V_R)	dv/dt	—	—	700	V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	1N6097*	1N6098*	SD51	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	←	1.0	→	°C/W

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

Characteristic	Symbol	1N6097*	1N6098*	SD51	Unit
Maximum Instantaneous Forward Voltage (2) (i_F = 157 Amp, T_C = 70°C) (i_F = 60 Amp) (i_F = 60 Amp, T_C = 125°C) (i_F = 120 Amp, T_C = 125°C)	v_F	 0.86 — — —	 0.86 — — —	 — 0.70 0.60 0.84	Volts
Maximum Instantaneous Reverse Current (2) (Rated Voltage, T_C = 125°C) (Rated Voltage, T_C = 25°C)	i_R	 250 —	 250 —	200 50 @ V_R = 35 V	mA
DC Reverse Current (Rated Voltage, T_C = 115°C)	I_R	250	250	—	mA
Maximum Capacitance (100 kHz ≤ f ≤ 1.0 MHz)	C_t	7000 V_R = 1.0 Vdc	7000 V_R = 1.0 Vdc	4000 V_R = 5.0 Vdc	pF

*Indicates JEDEC Registered Data.
(1) Not a JEDEC requirement, but of Motorola product capability.
(2) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

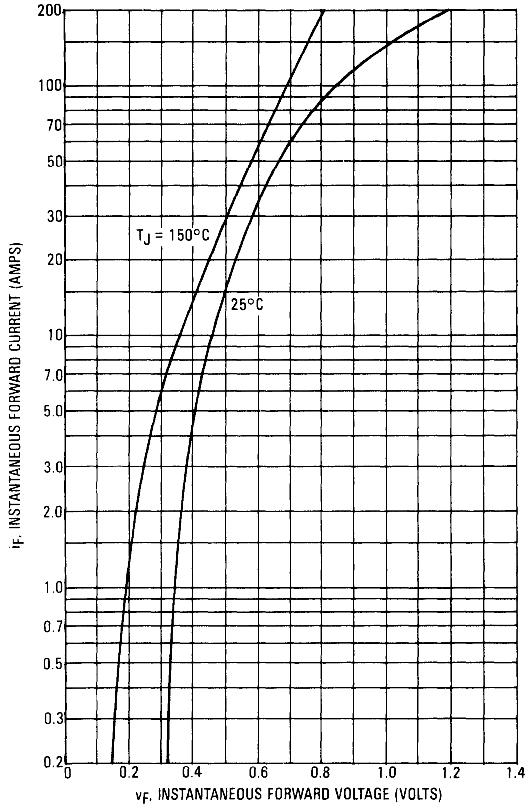


FIGURE 2 — TYPICAL REVERSE CURRENT

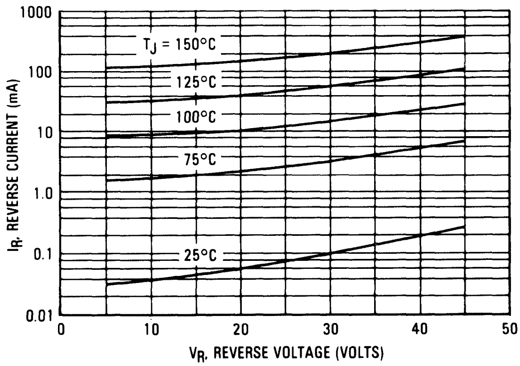


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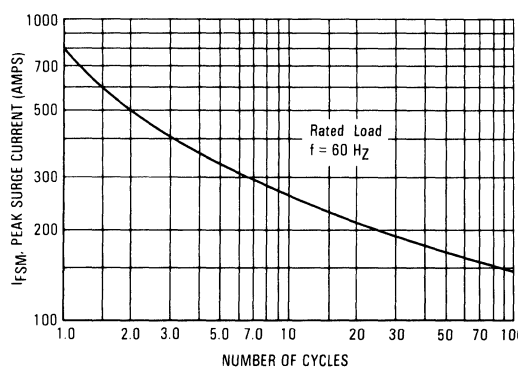
FIGURE 3 — TYPICAL SURGE CAPABILITY



NOTE 1
HIGH FREQUENCY OPERATION

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Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 4 — CAPACITANCE

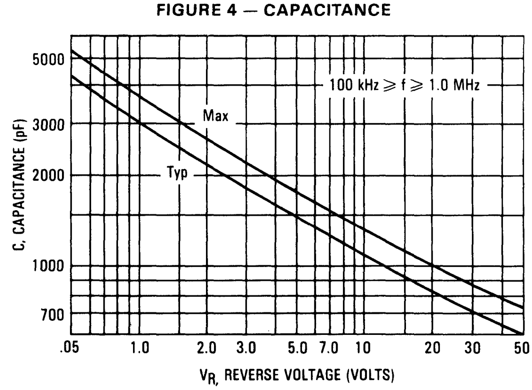

FIGURE 5 — CURRENT DERATING (SD51)

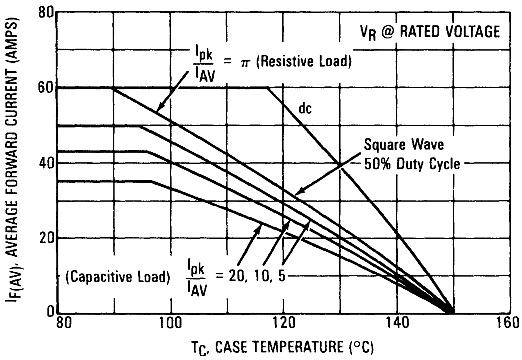

FIGURE 6 — CURRENT DERATING (1N6097/1N6098)

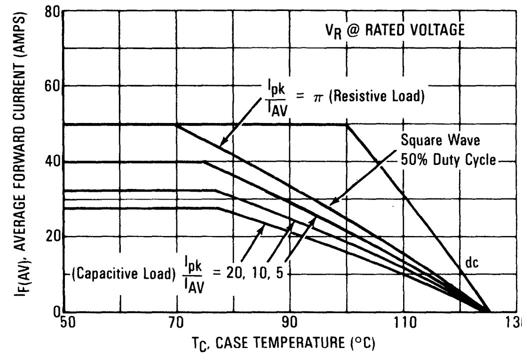

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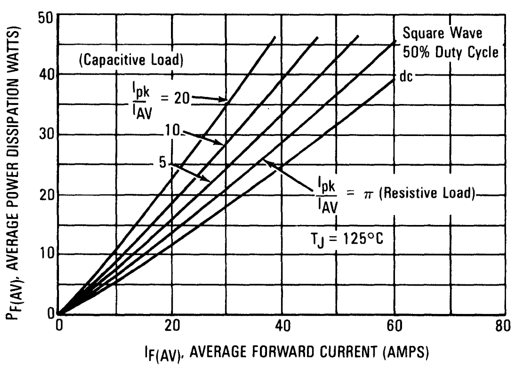
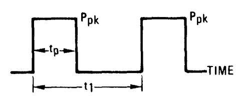
FIGURE 7 — POWER DISSIPATION



NOTE 2



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. 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_C 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 8, i.e.:

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

FIGURE 8 — THERMAL RESPONSE

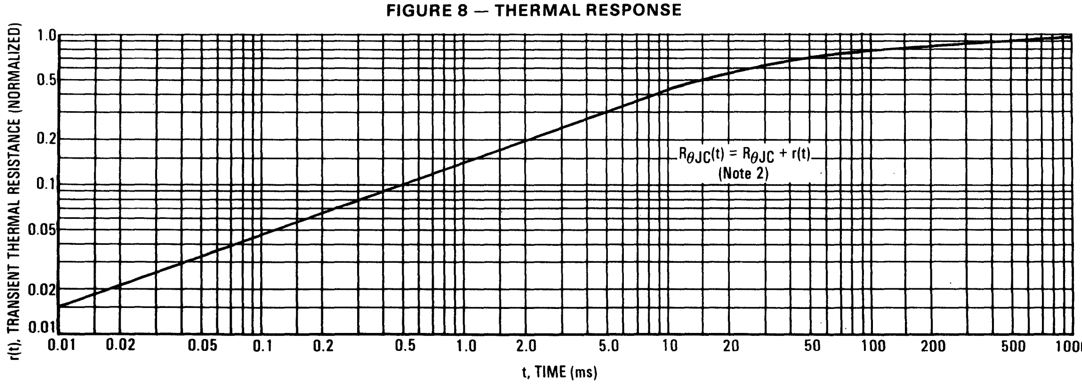
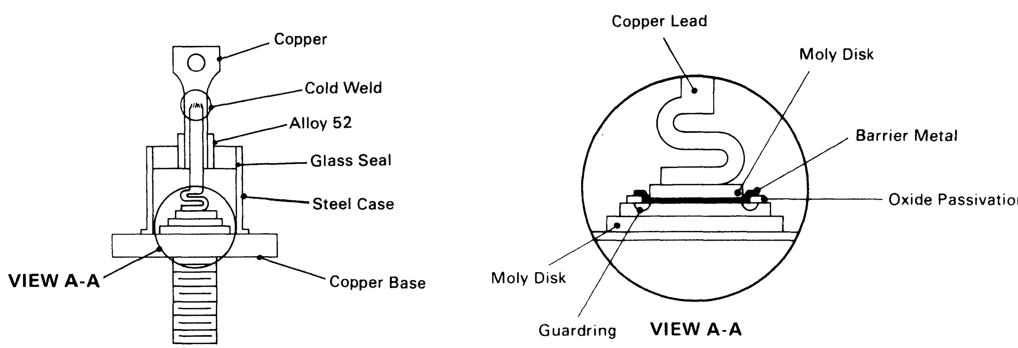


FIGURE 9 — SCHOTTKY RECTIFIER



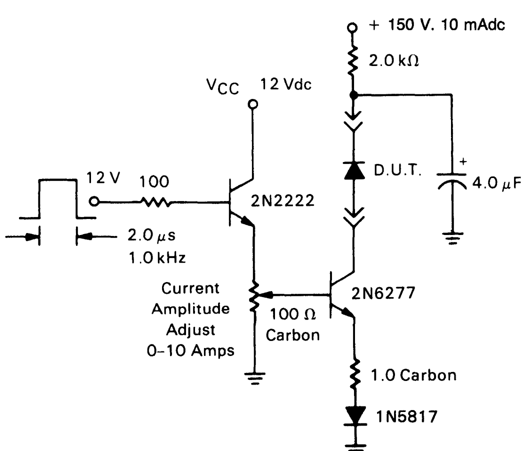
Motorola builds quality and reliability into its Schottky Rectifiers.

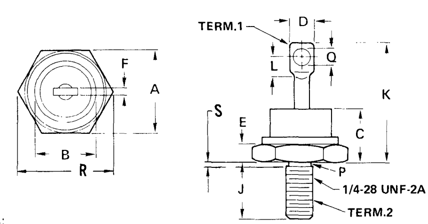
First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not mandatory. The guardring also operates like a zener to absorb overvoltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The top copper lead has a stress relief feature which protects the die during assembly. These two features give the unit the capability of passing stringent thermal fatigue tests for 5,000 cycles. The top copper lead provides a low resistance to current and therefore does not contribute to device heating; a heat sink should be used when attaching wires.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche.

FIGURE 10 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT





NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

CASE 257-01
(DO-5)

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode-to-Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in.-lb Max

SOLDER HEAT: The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

MBR030
MBR040

MOTOROLA

Advance Information

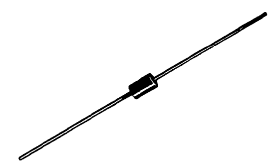
SWITCHMODE RECTIFIERS

. . . designed for use in switching power supplies, inverters, and as free wheeling diodes, these devices have the following features:

- Low Forward Voltage
- Low Leakage Current
- DO-204AH (DO-35) Glass Package

SCHOTTKY RECTIFIERS

0.5 AMPERE
30–40 VOLTS



3

MAXIMUM RATINGS

Rating	Symbol	MBR030	MBR040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	30	40	Volts
Average Rectified Forward Current (Rated V_R) T_L = 75°C, L = ⅜″ T_A = 50°C, L = ⅜″, (Mt. Method #1)	$I_{F(AV)}$	←0.5→ ←0.5→		Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	←5.0→		Amps
Operating Junction and Storage Temperature	T_J, T_{stg}	−65 to +150		

THERMAL CHARACTERISTICS

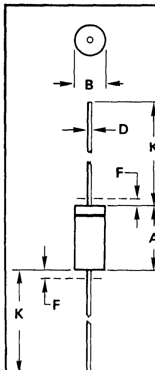
Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Lead = ⅜″	$R_{\theta JL}$	180	190	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Foward Voltage (1) (i_F = 0.1 A, T_J = 25°C) (i_F = 0.5 A, T_J = 25°C)	v_F	0.460 0.610	0.500 0.650	Volts
Reverse Current (Rated dc Voltage, T_J = 125°C) (Rated dc Voltage, T_J = 25°C)	i_R	0.6 0.003	1.0 0.005	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
Switchmode is a trademark of Motorola Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.



NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH (DO-35)

MECHANICAL CHARACTERISTICS

CASE: Glass

FINISH: External leads are plated and are readily solderable

POLARITY: Cathod indicated by polarity band.

WEIGHT: 0.2 Gram (approximately).

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, ⅛″ from case for 10 seconds.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

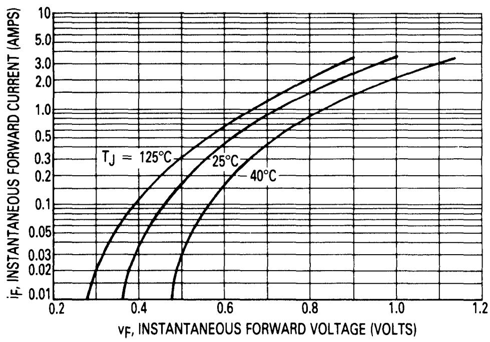


FIGURE 2 — CURRENT DERATING, PRINTED CIRCUIT BOARD MOUNTING

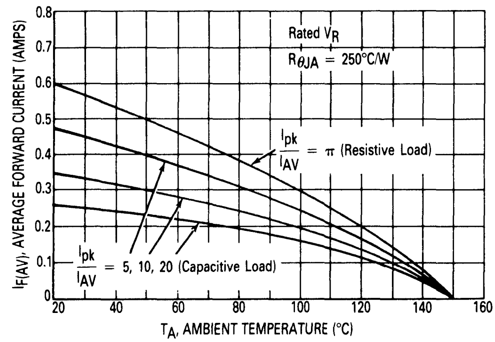


FIGURE 3 — TYPICAL CAPACITANCE

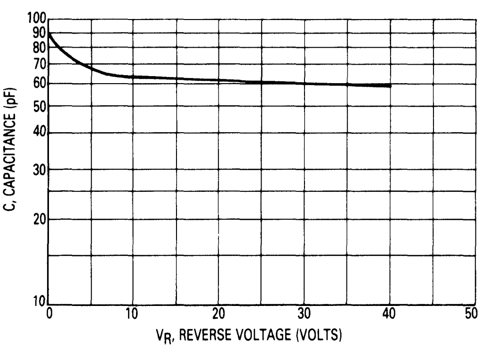


FIGURE 4 — CURRENT DERATING, LEAD TEMPERATURE

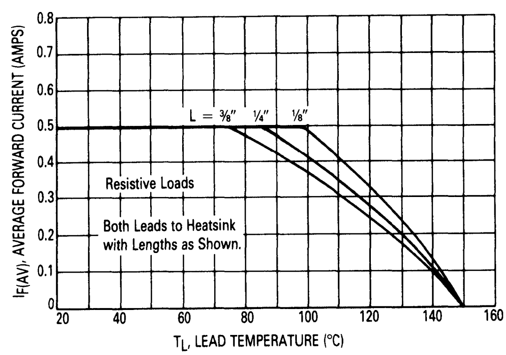
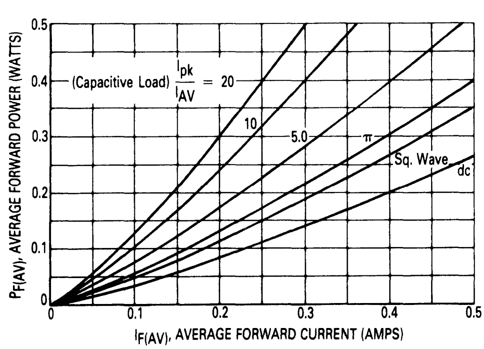


FIGURE 5 — FORWARD POWER DISSIPATION



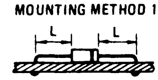
NOTE 1

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.

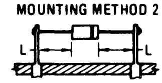
TYPICAL VALUES FOR θ_{JA} IN STILL AIR

MOUNTING METHOD	1/8	1/4	3/8	$R_{\theta JA}$
1	200	225	250	°C/W
2	210	235	260	°C/W
3		150		°C/W

MOUNTING METHOD 1



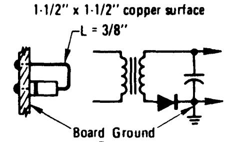
MOUNTING METHOD 2



Vector pin mounting

MOUNTING METHOD 3

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



Board Ground Plane

3

MBR320 MBR340
MBR330 MBR350
MBR360

MOTOROLA

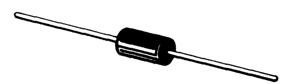
AXIAL LEAD RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Power Loss/High Efficiency
- Highly Stable Oxide Passivated Junction
- Low Stored Charge, Majority Carrier Conduction

SCHOTTKY BARRIER RECTIFIERS

3.0 AMPERES
20, 30, 40, 50, 60 VOLTS



CASE 267-01

MAXIMUM RATINGS

Rating	Symbol	MBR320	MBR330	MBR340	MBR350	MBR360	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	50	60	V
Average Rectified Forward Current T_A = 65°C ($R_{\theta JA}$ = 28°C/W, P.C. Board Mounting, see Note 3)	I_O			3.0			A
Nonrepetitive Peak Surge Current (2) (Surge applied at rated load conditions, half wave, single phase 60 Hz, T_L = 75°C)	I_{FSM}			80			A
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}			−65 to 150°C			°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$			150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient, (see Note 3, Mounting Method 3)	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS (T_L = 25°C unless otherwise noted)(2)

Characteristic	Symbol	MBR320	MBR330	MBR340	MBR350	MBR360	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 1.0 Amp) (i_F = 3.0 Amp) (i_F = 9.4 Amp)	v_F		0.500 0.600 0.850		0.600 0.740 1.080		V
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1) T_L = 25°C T_L = 100°C	i_R			0.60 20			mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.
(2) Lead Temperature reference is cathode lead 1/32″ from case.

MBR320, 330 AND 340

FIGURE 1 — TYPICAL FORWARD VOLTAGE

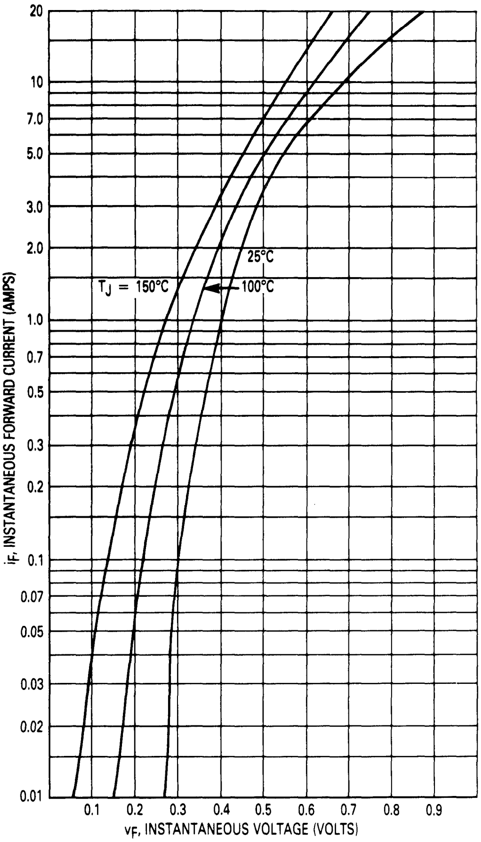
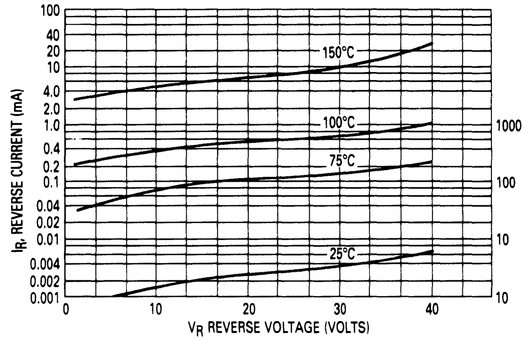


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 3)

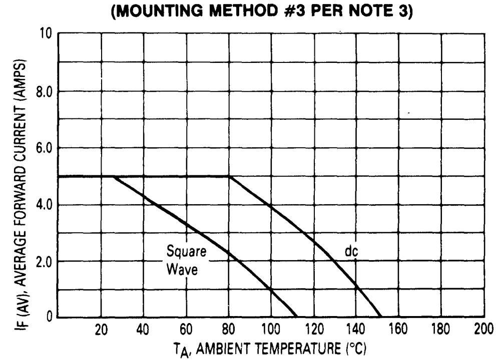


FIGURE 4 — POWER DISSIPATION

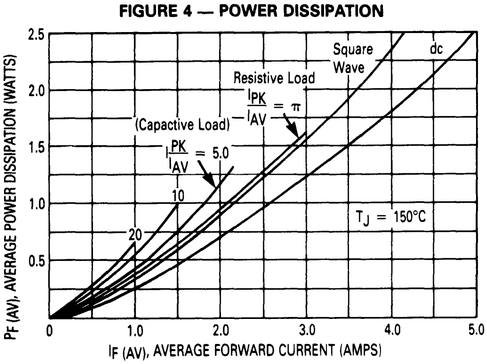
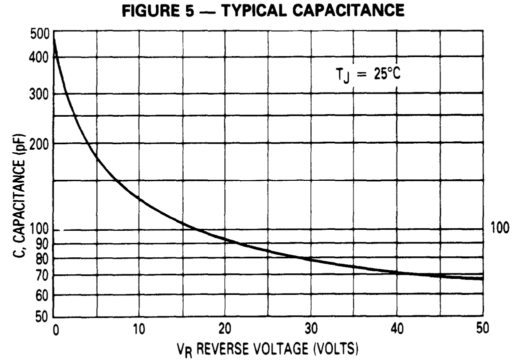


FIGURE 5 — TYPICAL CAPACITANCE



3

3

MBR350 AND 360

FIGURE 6 — TYPICAL FORWARD VOLTAGE

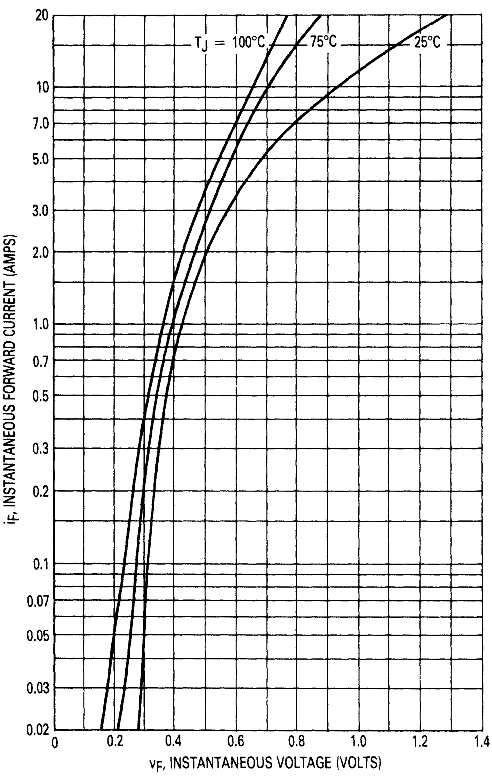


FIGURE 7 — TYPICAL REVERSE CURRENT*

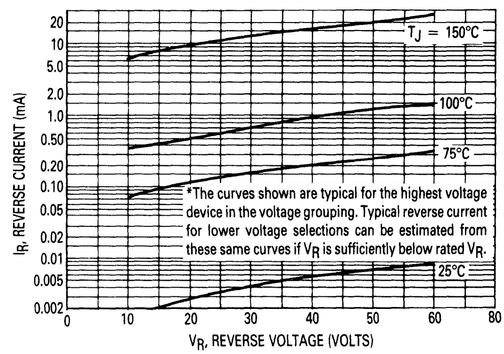


FIGURE 8 — CURRENT DERATING AMBIENT (MOUNTING METHOD #3 PER NOTE 3)

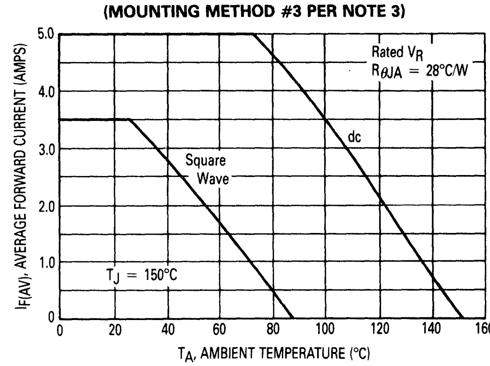


FIGURE 9 — POWER DISSIPATION

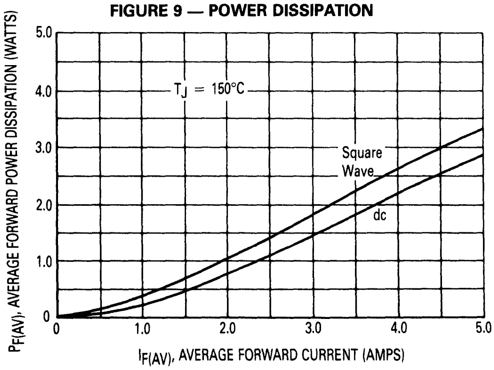
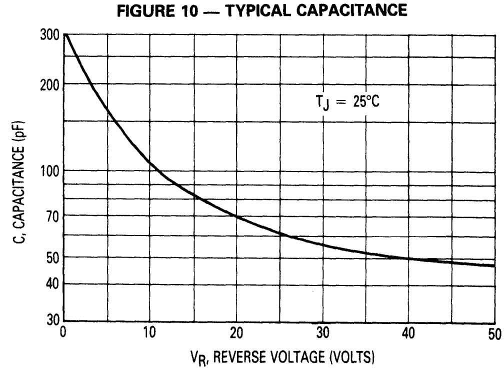


FIGURE 10 — TYPICAL CAPACITANCE



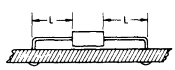
NOTE 3 — MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) 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.

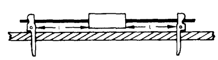
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

Mounting Method	Lead Length, L (in)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

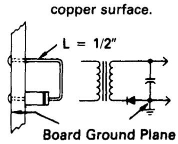
Mounting Method 1
P.C. Board where available copper surface is small.



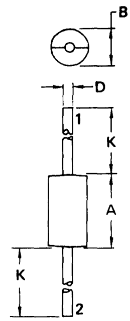
Mounting Method 2
Vector Push-In Terminals T-28



Mounting Method 3
P.C. Board with 2-1/2" × 2-1/2" copper surface.



OUTLINE DIMENSIONS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

3

MECHANICAL CHARACTERISTICS

CASE. . . . . Void free, transfer molded
FINISH. . . . . All external surfaces corrosion-resistant and the terminal leads are readily solderable
POLARITY. . . . . Cathode indicated by polarity band
MOUNTING POSITIONS. . . . . Any
SOLDERING . . . . . . 220°C 1/16" from case for ten seconds

MBR115P MBR120P
MBR130P MBR140P
See Page 3-47

MOTOROLA

MBR320M MBR330M MBR340M

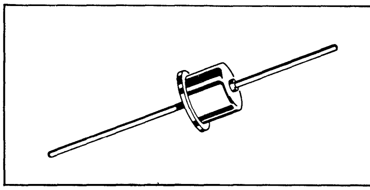
SCHOTTKY BARRIER RECTIFIERS

3 AMPERE
20, 30, 40 VOLTS

HOT CARRIER POWER RECTIFIERS

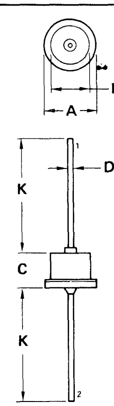
. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity



MAXIMUM RATINGS

Rating	Symbol	MBR320M	MBR330M	MBR340M	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\,V_R$ (dc), $T_C = 65^oC$ $V_{R(equiv)} \leq 0.2\,V_R$ (dc), $T_L = 90^oC$ ($R_{\theta JA} = 25^oC/W$, P.C. Board Mounting, See Note 3)	I_O	← 15 → ← 3.0 →			Amp
Ambient Temperature Rated V_R (dc), $P_{F(AV)} = 0$ $R_{\theta JA} = 25^oC/W$	T_A	65	60	55	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse Voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 5.0 Amp)	v_F	–	–	0.450	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 25^oC$ $T_C = 100^oC$	i_R	– –	– –	10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

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

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.1 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA} P_{F(AV)} - R_{\theta JA} P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA} P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA} P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{IN(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR340M operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 10°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.2 V

Step 2: Find T_R from Figure 3. Read T_R = 117°C @ V_R = 9.2 V & $R_{\theta JA}$ = 10°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 6.3 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 117-(10)(6.3) = 54°C.

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2 V_{in(PK)}$ (2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE – MBR320M

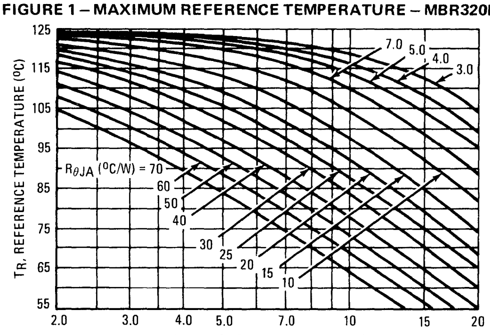


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR330M

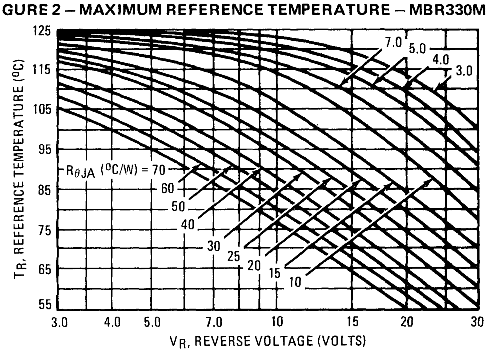


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR340M

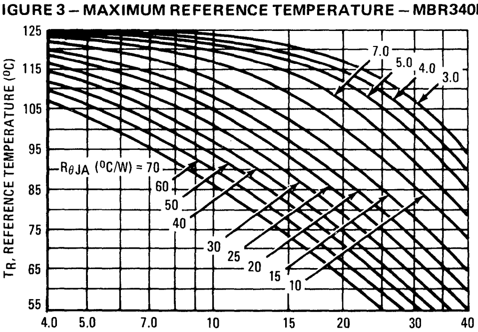
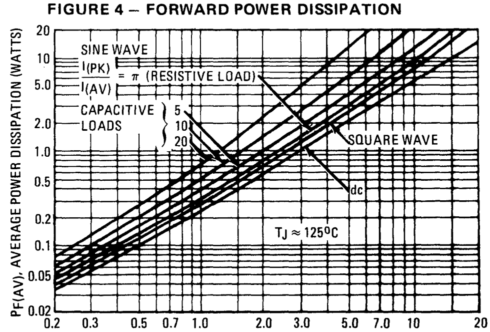
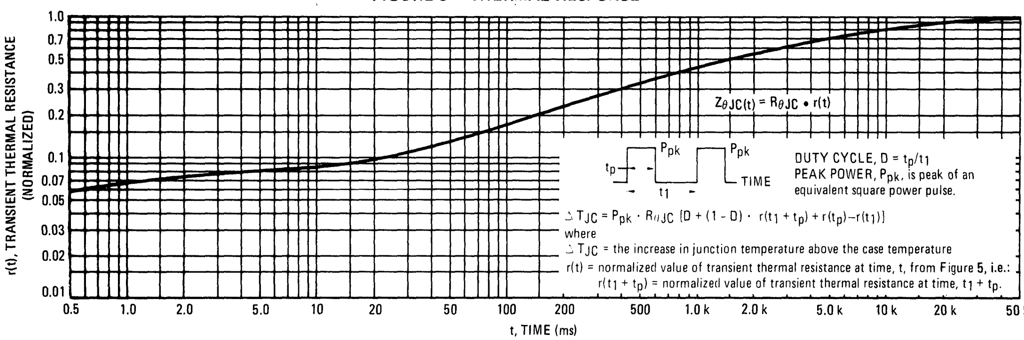


FIGURE 4 – FORWARD POWER DISSIPATION

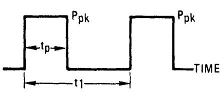


THERMAL CHARACTERISTICS

FIGURE 5 – THERMAL RESPONSE



NOTE 2 – FINDING JUNCTION TEMPERATURE



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 5 i.e.:

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

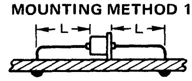
NOTE 3 – MOUNTING DATA

Data shown for the thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering.

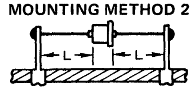
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD	LEAD LENGTH, L (IN) 1/4	1	$R_{\theta JA}$
1	55	60	°C/W
2	65	70	°C/W
3	25		°C/W

MOUNTING METHOD 1



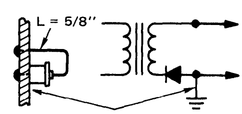
MOUNTING METHOD 2



Vector pin mounting

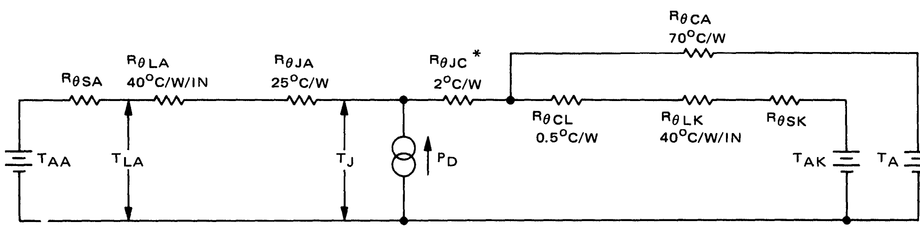
MOUNTING METHOD 3

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



Board Ground Plane

FIGURE 6 – APPROXIMATE THERMAL CIRCUIT MODEL



Use of the above model permits calculation of average junction temperature for any mounting situation. Lowest values of thermal resistance will occur when the cathode lead is brought as close as possible to a heat dissipator; as heat conduction through the anode lead is small. Terms in the model are defined as follows:

***Case temperature reference is at cathode end.**

TEMPERATURES

- T_A = Ambient
- T_{AA} = Anode Heat Sink Ambient
- T_{AK} = Cathode Heat Sink Ambient
- T_{LA} = Anode Lead
- T_{LK} = Cathode Lead
- T_J = Junction

THERMAL RESISTANCES

- $R_{\theta CA}$ = Case to Ambient
- $R_{\theta SA}$ = Anode Lead Heat Sink to Ambient
- $R_{\theta SK}$ = Cathode Lead Heat Sink to Ambient
- $R_{\theta LA}$ = Anode Lead
- $R_{\theta LK}$ = Cathode Lead
- $R_{\theta CL}$ = Case to Cathode Lead
- $R_{\theta JC}$ = Junction to Case
- $R_{\theta JA}$ = Junction to Anode Lead (S bend)

FIGURE 7 — TYPICAL FORWARD VOLTAGE

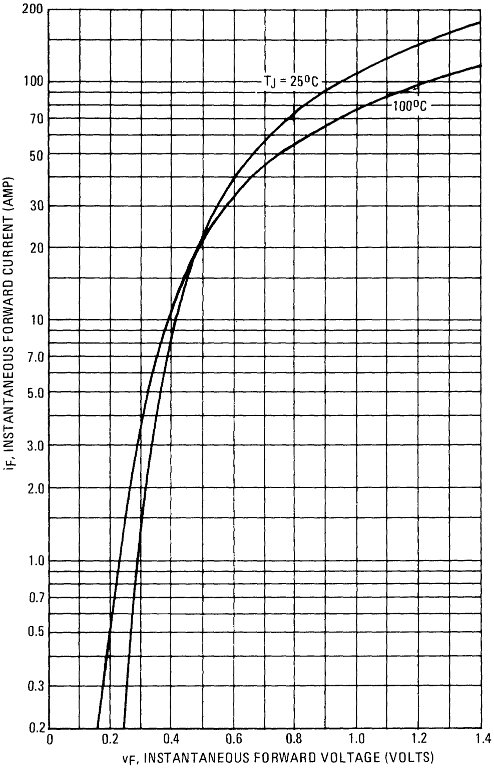


FIGURE 8 — MAXIMUM SURGE CAPABILITY

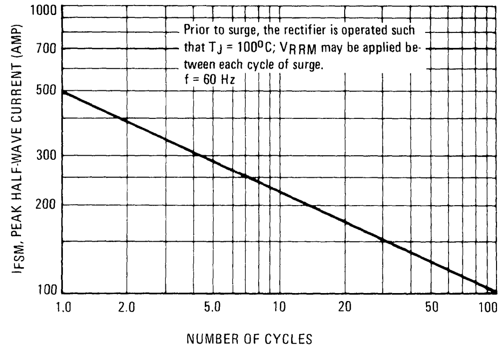


FIGURE 9 — TYPICAL REVERSE CURRENT

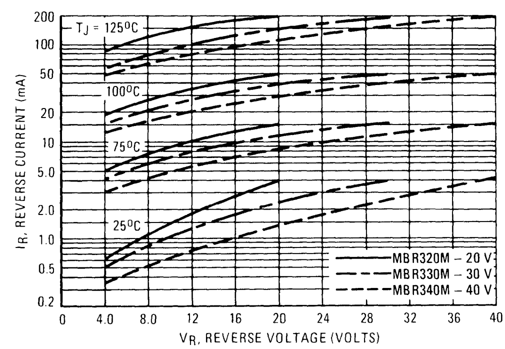


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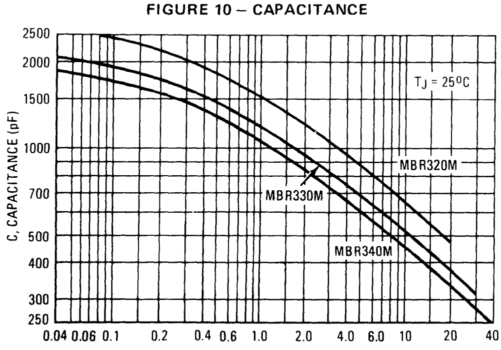
FIGURE 10 — CAPACITANCE



NOTE 4 — HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR320P MBR330P
MBR340P
See Page 3-54

MOTOROLA

MBR735 MBR745

SCHOTTKY BARRIER RECTIFIERS

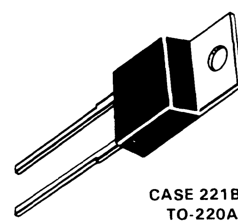
7.5 AMPERES
35 and 45 VOLTS

3

SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche
- Epoxy Meets UL94, VO at 1/8″



CASE 221B-02
TO-220AC

CROSS-REFERENCE GUIDE

MOTOROLA	GI	UNITRODE	VARO
MBR735	SB820	USD620, USD720	VSK62
MBR735	SB830	USD635, USD735	VSK63
MBR745	SB840	USD640, USD740	VSK64
MBR745	SB850	USD645, USD745	—

MAXIMUM RATINGS

Rating	Symbol	MBR735	MBR745	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 105°C$	$I_{F(AV)}$	7.5	7.5	Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) $T_C = 105°C$	I_{FRM}	15	15	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz)	I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature	T_J	-65 to +150	-65 to +150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	3.0	°C/W
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	60	60	°C/W

ELECTRICAL CHARACTERISTICS

Maximum Instantaneous Forward Voltage (1) (i_F = 7.5 Amp, T_C = 125°C) (i_F = 15 Amp, T_C = 125°C) (i_F = 15 Amp, T_C = 25°C)	v_F	 0.57 0.72 0.84	 0.57 0.72 0.84	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 15 0.1	 15 0.1	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

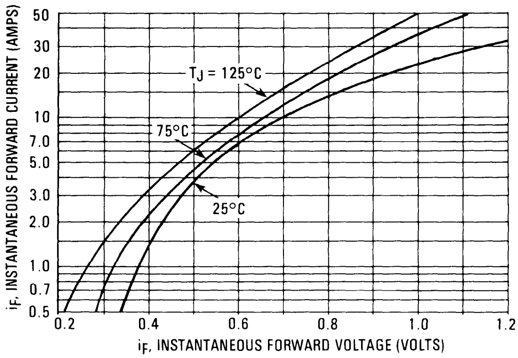


FIGURE 2 — TYPICAL REVERSE CURRENT

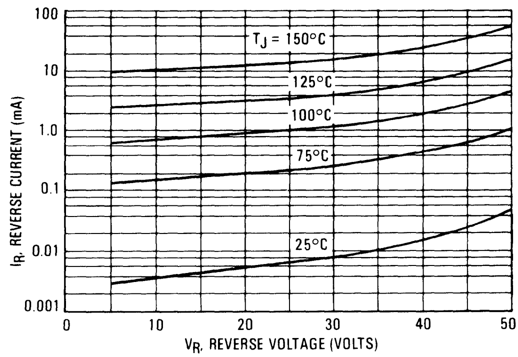


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FIGURE 3 — CURRENT DERATING, CASE

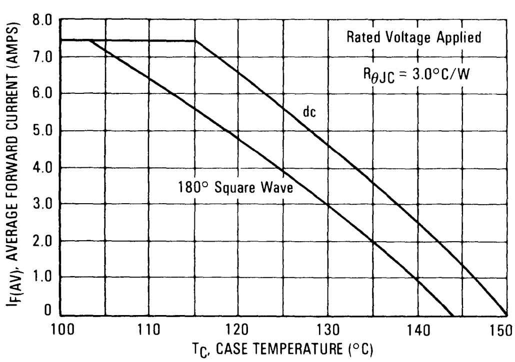


FIGURE 4 — CURRENT DERATING, AMBIENT

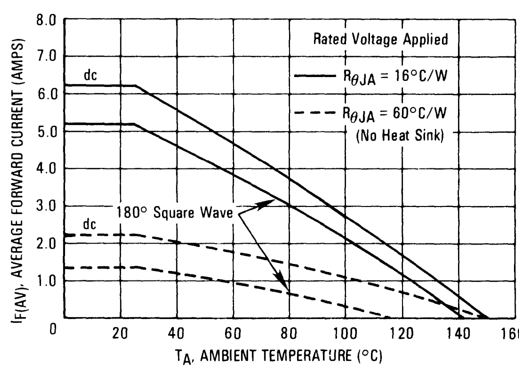
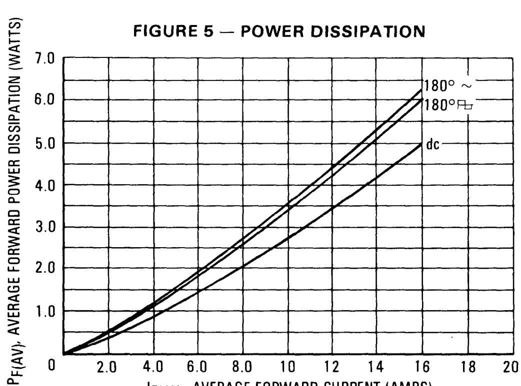
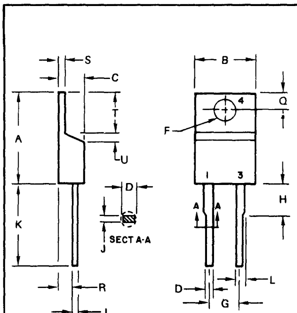


FIGURE 5 — POWER DISSIPATION





STYLE 1:
PIN 1. CATHODE
2. N/A
3 ANODE
4. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0 .56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

POLARITY: CATHODE-TO-CASE

CASE 221B-01

MBR1035
MBR1045

MOTOROLA

SWITCHMODE POWER RECTIFIERS

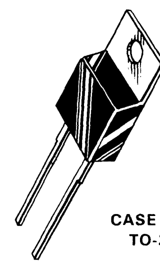
. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche
- Epoxy Meets UL94, V0 at 1/8″

3

SCHOTTKY BARRIER RECTIFIERS

10 AMPERES
20 to 45 VOLTS



CASE 221B-01
TO-220AC

MAXIMUM RATINGS

Rating	Symbol	MBR1035	MBR1045	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 135°C$	$I_{F(AV)}$	10	10	Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) $T_C = 135°C$	I_{FRM}	20	20	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 12	I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature	T_J	-65 to + 150	-65 to + 150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	MBR1035	MBR1045	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	2.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	MBR1035	MBR1045	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 10 A, T_C = 125°C) (i_F = 20 A, T_C = 125°C) (i_F = 20 A, T_C = 25°C)	v_F	 0.57 0.72 0.84	 0.57 0.72 0.84	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 15 0.1	 15 0.1	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 —MAXIMUM FORWARD VOLTAGE

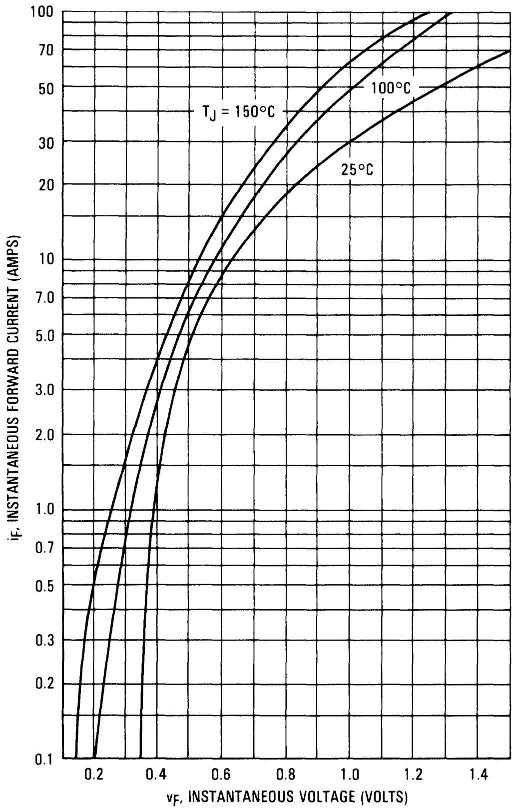


FIGURE 2 —TYPICAL FORWARD VOLTAGE

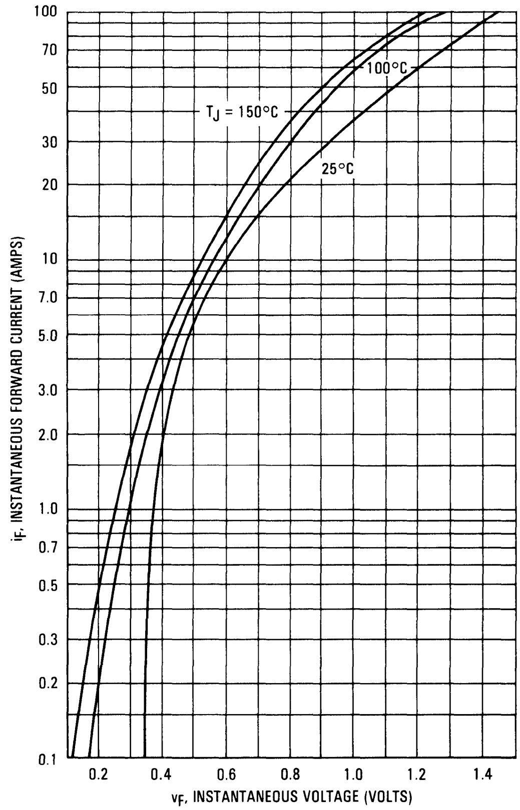


FIGURE 3 — MAXIMUM REVERSE CURRENT

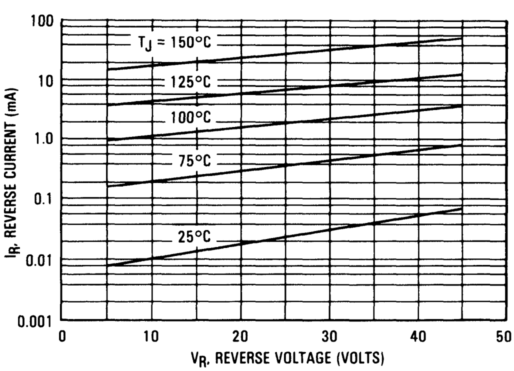
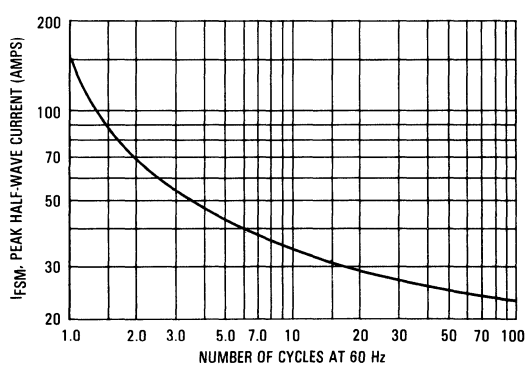


FIGURE 4 — MAXIMUM SURGE CAPABILITY



3

3

FIGURE 5 — CURRENT DERATING, INFINITE HEATSINK

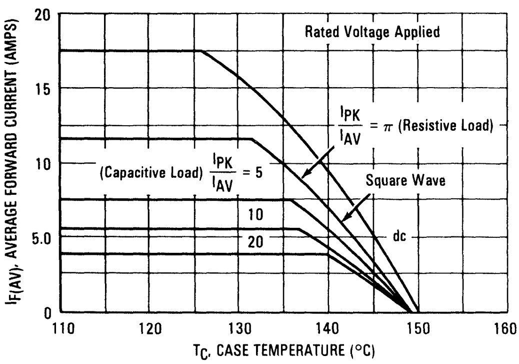


FIGURE 6 — CURRENT DERATING, $R_{\theta JA}$ = 16° C/W

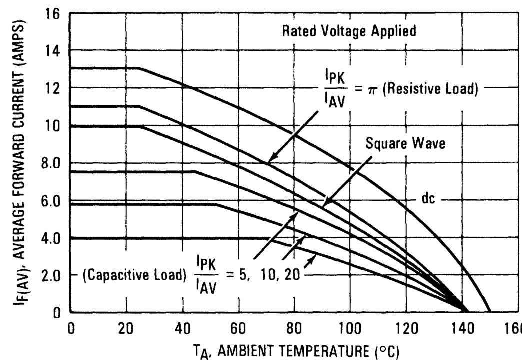


FIGURE 7 — FORWARD POWER DISSIPATION

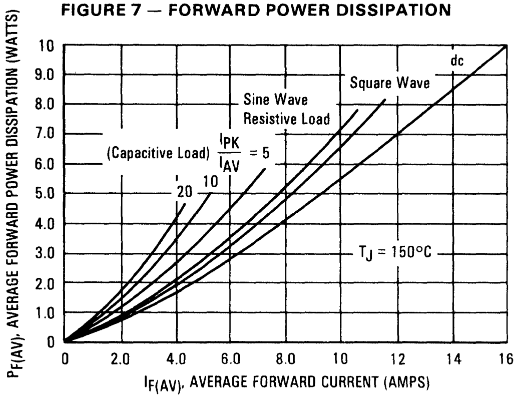


FIGURE 8 — CURRENT DERATING, FREE AIR

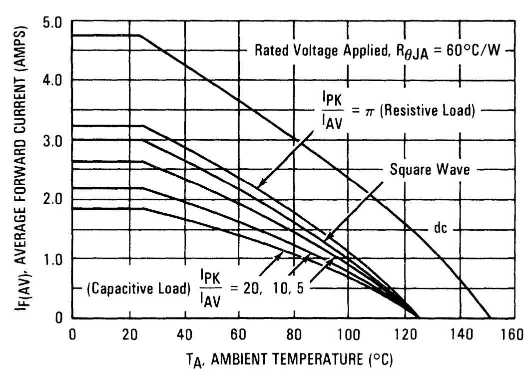
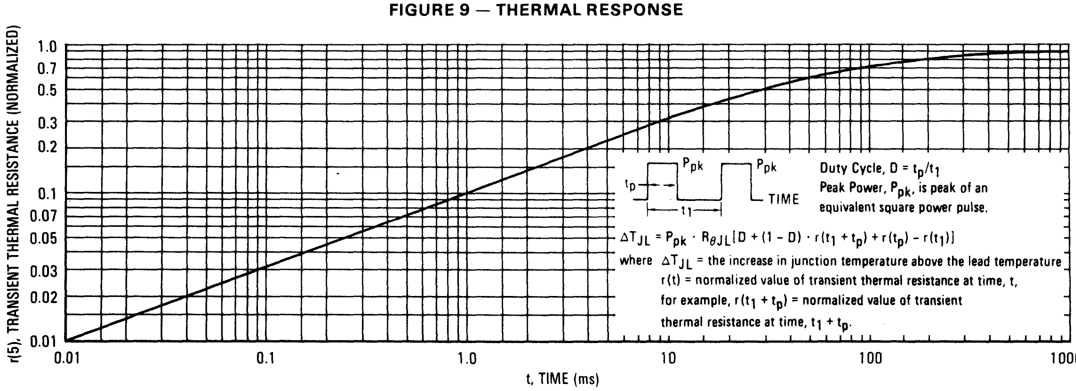


FIGURE 9 — THERMAL RESPONSE



HIGH FREQUENCY OPERATION

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FIGURE 10 — CAPACITANCE

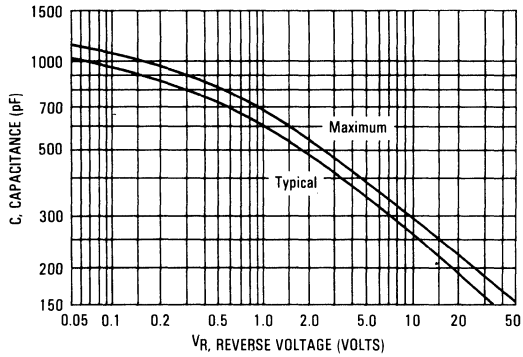
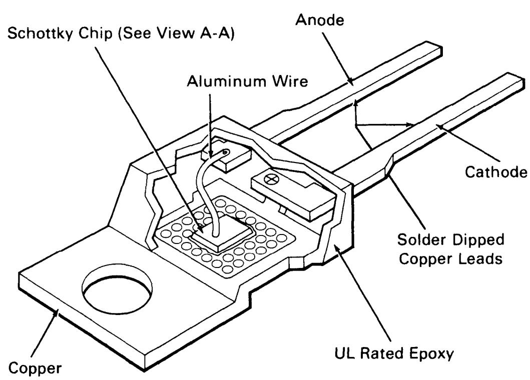
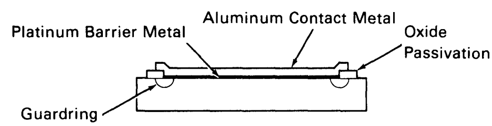


FIGURE 11 — SCHOTTKY RECTIFIER



Schottky Chip — View A-A



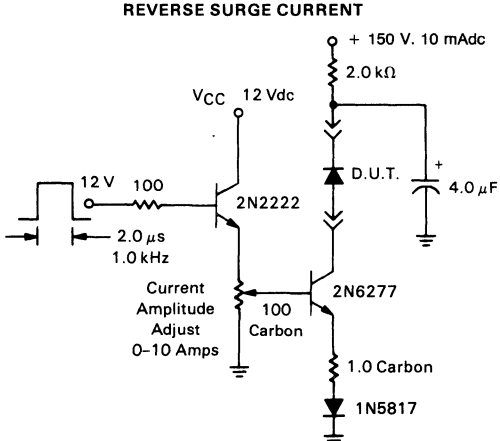
Motorola builds quality and reliability into its Schottky Rectifiers.

First is the chip, which has an interface metal between the barrier metal and aluminum-contact metal to eliminate any possible interaction between the two. The indicated guardring prevents dv/dt problems, so snubbers are not mandatory. The guardring also operates like a zener to absorb over-voltage transients.

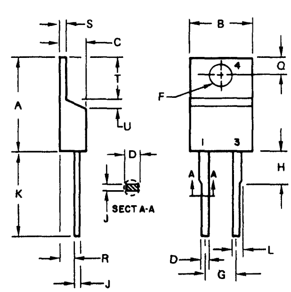
Second is the package. The Schottky chip is bonded to the copper heat sink using a specially formulated solder. This gives the unit the capability of passing 10,000 operating thermal-fatigue cycles having a ΔT_J of 100°C. The epoxy molding compound is rated per UL 94, VO @ 1/8″. Wire bonds are 100% tested in assembly as they are made.

Third is the electrical testing, which includes 100% dv/dt at 1600 V/μs and reverse avalanche as part of device characterization.

FIGURE 12 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT



OUTLINE DIMENSIONS



STYLE 1:
PIN 1. CATHODE
2. N/A
3. ANODE
4. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

CASE 221B-01
TO-220AC

3

MBR1060

MOTOROLA

3

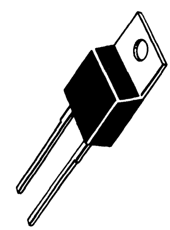
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche
- Epoxy Meets UL94, VO at 1/8″

SCHOTTKY BARRIER RECTIFIER

10 AMPERES
60 VOLTS



CASE 221B-01
TO-220AC

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	60	Volts
Average Rectified Forward Current (Rated V_R) T_C = 133°C	$I_{F(AV)}$	10	Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) T_C = 133°C	I_{FRM}	20	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz)	I_{RRM}	1.0	Amps
Operating Junction Temperature	T_J	−65 to +150	°C
Storage Temperature	T_{stg}	−65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	V/μs

THERMAL CHARACTERISTICS

Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	°C/W
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	60	°C/W

ELECTRICAL CHARACTERISTICS

Maximum Instantaneous Forward Voltage (1) (i_F = 10 Amp, T_C = 125°C) (i_F = 20 Amp, T_C = 125°C) (i_F = 20 Amp, T_C = 25°C)	v_F	 0.70 0.85 0.95	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 25 0.10	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%
Switchmode is a trademark of Motorola Inc.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

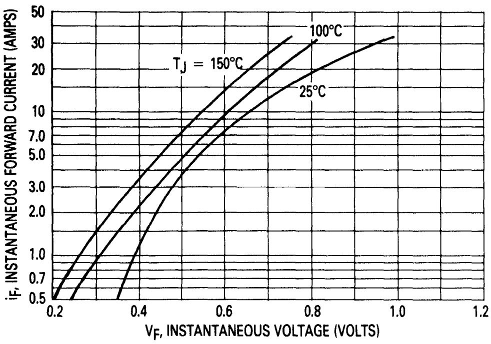


FIGURE 2 — TYPICAL REVERSE CURRENT

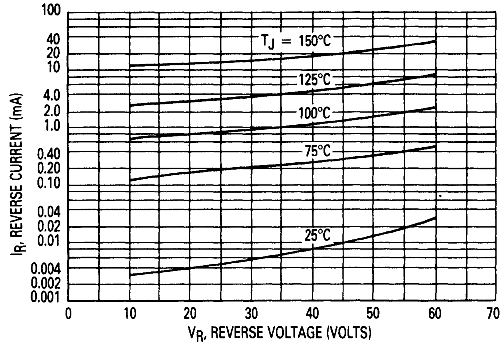


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FIGURE 3 — CURRENT DERATING, CASE

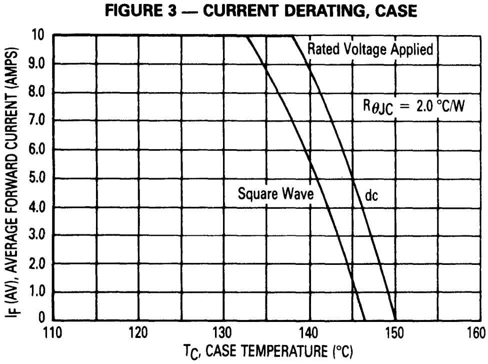


FIGURE 4 — CURRENT DERATING, AMBIENT

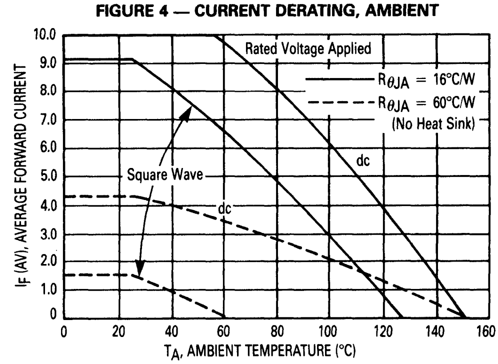
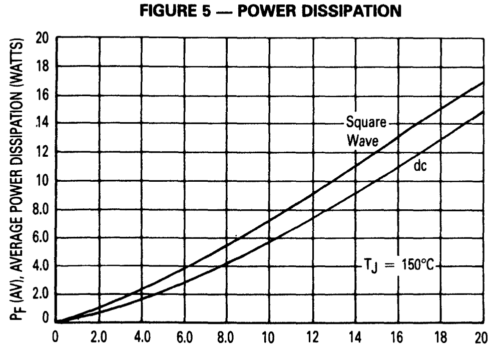
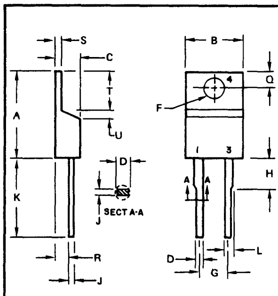


FIGURE 5 — POWER DISSIPATION





STYLE 1:
PIN 1. CATHODE
2. N/A
3. ANODE
4. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0 .56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

POLARITY: CATHODE-TO-CASE

CASE 221B-01

MBR1520
MBR1530
MBR1540

MOTOROLA

3

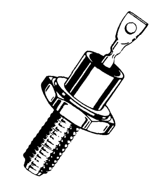
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

15 AMPERE
20,30,40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR1520	MBR1530	MBR1540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current ($V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 80^oC$)	I_O	← 15 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 5.0^oC/W$	T_A	95	90	85	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	← 500 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			^oC

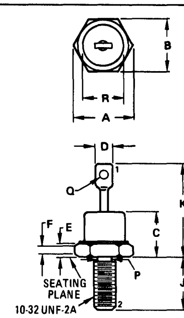
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.5	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 15 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100^oC$	i_R	– –	– –	10 75	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



STYLE 2:
TERM 1. ANODE
2. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
D0-4

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 15 in. lb. max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR1540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 10 A ($I_{F(AV)}$ = 5 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 121°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 10.5 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 5 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 121-(5)(10.5) = 68.5°C).

3

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1)(2)	
Load	Resistive	Capacitive(1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE — MBR1520

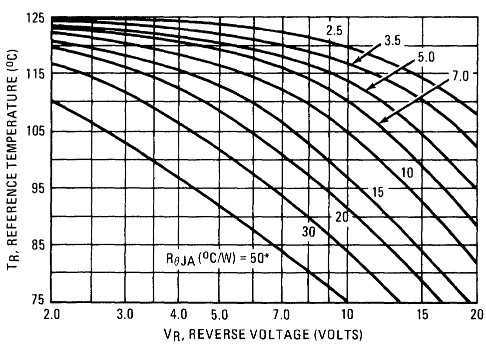


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE — MBR1530

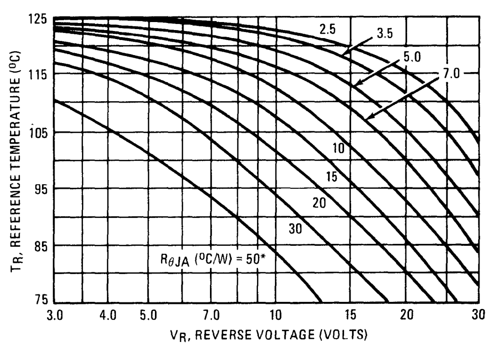
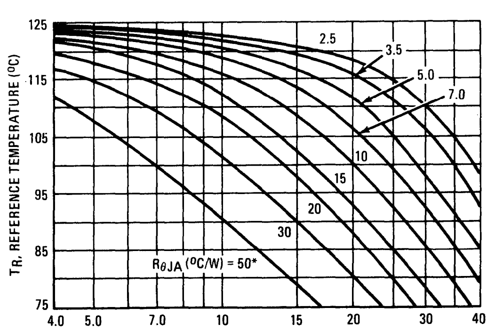


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE — MBR1540



*No external heat sink.

FIGURE 4 — FORWARD POWER DISSIPATION

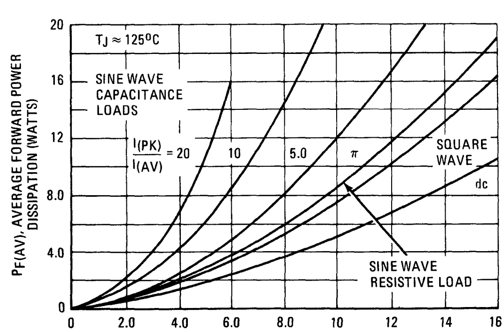


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FIGURE 5 – TYPICAL FORWARD VOLTAGE

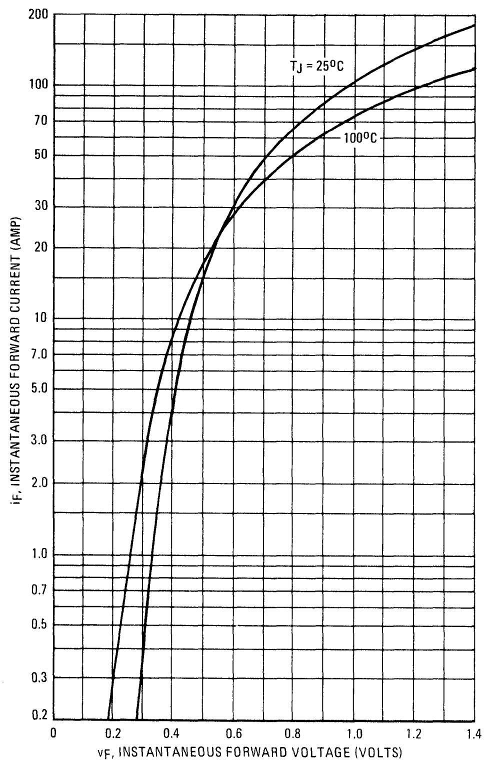


FIGURE 6 – MAXIMUM SURGE CAPABILITY

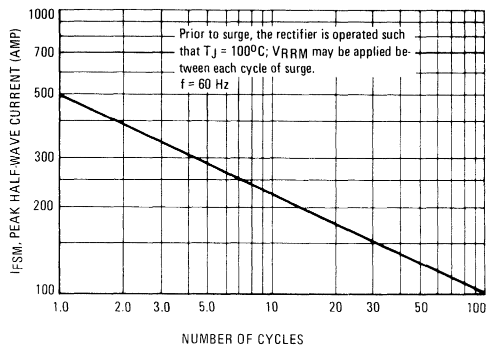


FIGURE 7 – CURRENT DERATING

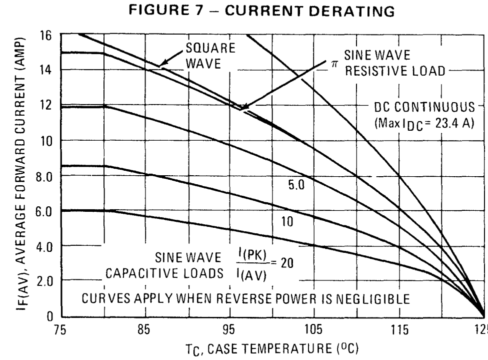


FIGURE 8 – THERMAL RESPONSE

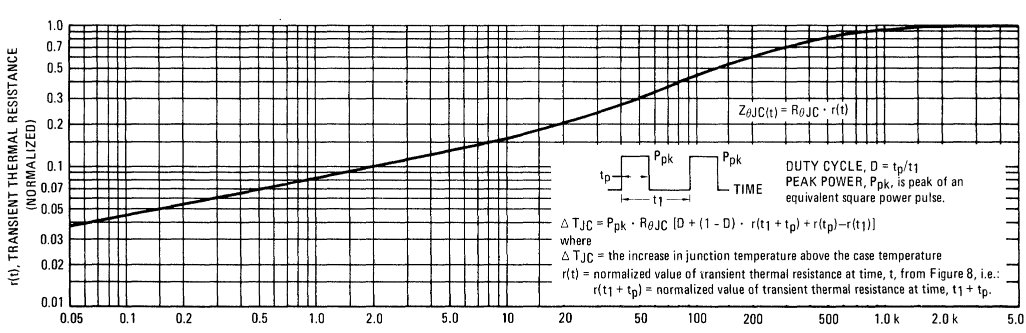


FIGURE 9 – NORMALIZED REVERSE CURRENT

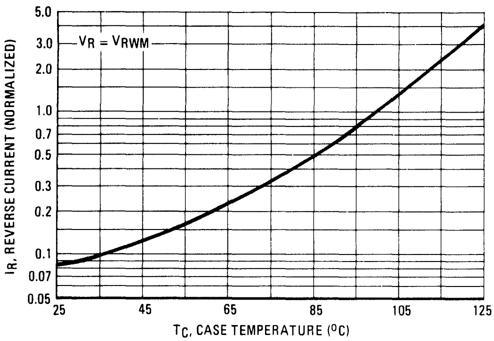


FIGURE 10 – TYPICAL REVERSE CURRENT

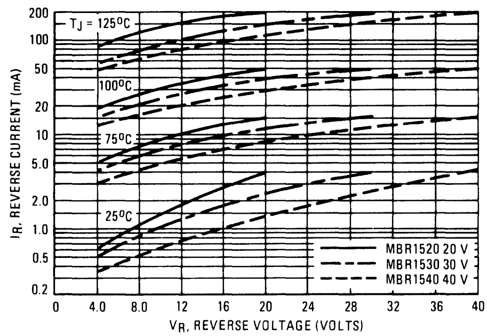
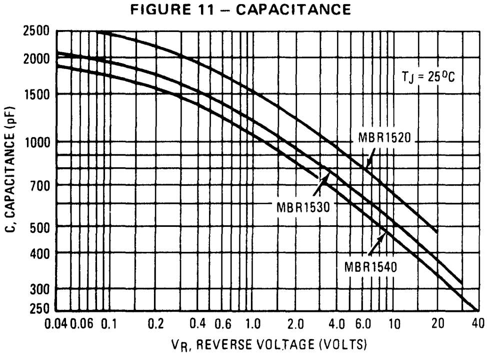


FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR1535CT
MBR1545CT

MOTOROLA

3

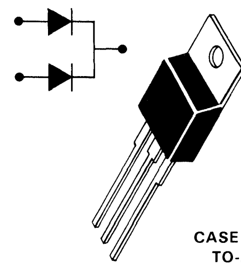
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Center-Tap Configuration
- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche
- Epoxy Meets UL94, VO at 1/8″

SCHOTTKY BARRIER RECTIFIERS

15 AMPERES
35 and 45 VOLTS



CASE 221A-02
TO-220AB

CROSS-REFERENCE GUIDE

MOTOROLA	G.I.	IR	UNITRODE	VARO
MBR1535CT	SB1620	12CTQ030	USD620, USD720C	VSK12
MBR1535CT	SB1630	12CTQ035	USD635C, USD735C	VSK13
MBR1545CT	SB1640	12CTQ040	USD640C, USD740C	VSK14
MBR1545CT	SB1645	12CTQ045	USD645C, USD745C	—

MAXIMUM RATINGS

Rating		Symbol	MBR1535CT	MBR1545CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage		V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current T_C = 105°C (Rated V_R)	Per Diode Per Device	$I_{F(AV)}$	7.5 15	7.5 15	Amps
Peak Repetitive Forward Current, T_C = 105°C (Rated V_R, Square Wave, 20 kHz) Per Diode		I_{FRM}	15	15	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz)		I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature		T_J	-65 to +150	-65 to +150	°C
Storage Temperature		T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)		dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS PER DIODE

Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	3.0	°C/W
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	60	60	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE

Maximum Instantaneous Forward Voltage (1) (i_F = 7.5 Amp, T_C = 125°C) (i_F = 15 Amp, T_C = 125°C) (i_F = 15 Amp, T_C = 25°C)	v_F	 0.57 0.72 0.84	 0.57 0.72 0.84	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 15 0.1	 15 0.1	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

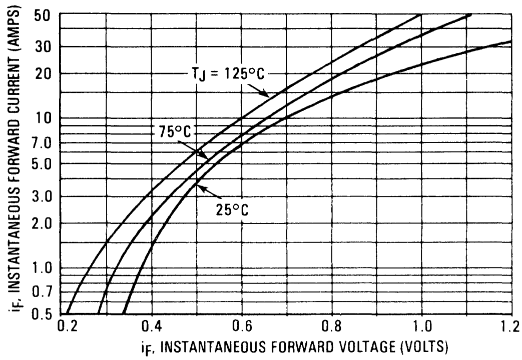


FIGURE 2 — TYPICAL REVERSE CURRENT

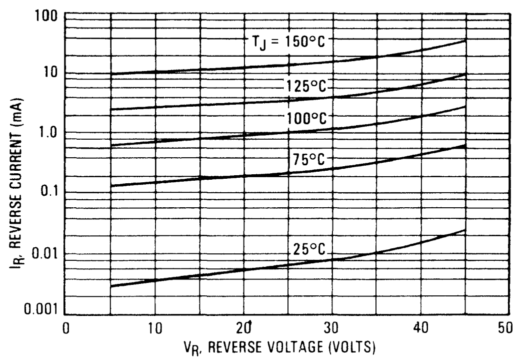


FIGURE 3 — CURRENT DERATING, CASE

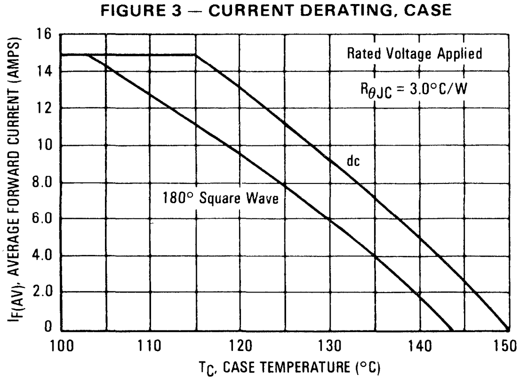


FIGURE 4 — CURRENT DERATING, AMBIENT

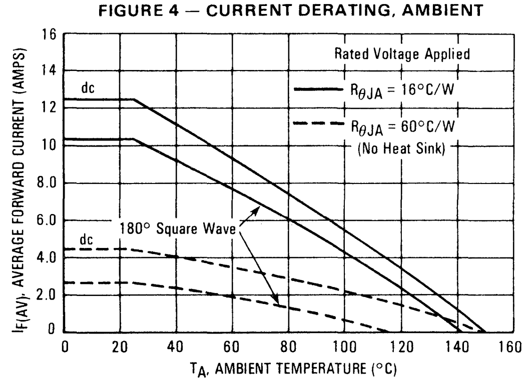
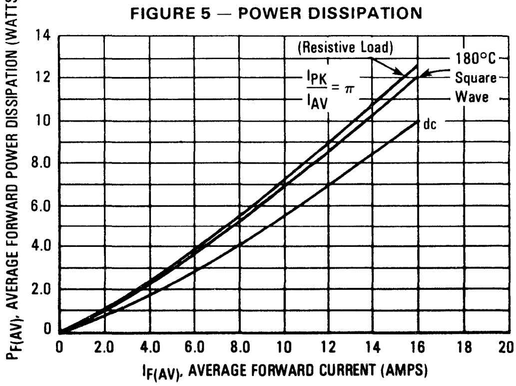
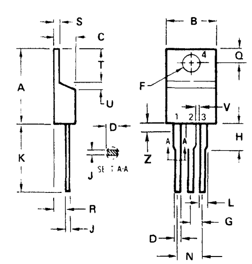


FIGURE 5 — POWER DISSIPATION





STYLE 6:
PIN 1. ANODE
2. CATHODE
3. ANODE
4. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050
V	1.14	-	0.045	-
Z	—	2.03	—	0.080

NOTES:
1. DIMENSIONS L AND H APPLIES TO ALL LEADS.
2. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5 1973.
4. CONTROLLING DIMENSION: INCH

POLARITY: CATHODE-TO-CASE **CASE 221A-02**

3

MBR1635
MBR1645

MOTOROLA

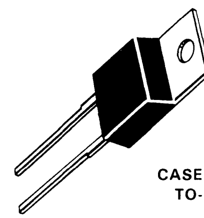
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

SCHOTTKY BARRIER RECTIFIERS

16 AMPERES
35 and 45 VOLTS



CASE 221B-01
TO-220AC

3

CROSS-REFERENCE GUIDE

MOTOROLA	UNITRODE
MBR1635	USD920
MBR1635	USD935
MBR1645	USD940
MBR1645	USD945

MAXIMUM RATINGS

Rating	Symbol	MBR1635	MBR1645	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 125°C$	$I_{F(AV)}$	16	16	Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) $T_C = 125°C$	I_{FRM}	32	32	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz)	I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature	T_J	-65 to +150	-65 to +150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Rating	Symbol	MBR1635	MBR1645	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	1.5	°C/W

ELECTRICAL CHARACTERISTICS

Rating	Symbol	MBR1635	MBR1645	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 16 Amp, $T_C = 125°C$) (i_F = 16 Amp, $T_C = 25°C$)	v_F	 0.57 0.63	 0.57 0.63	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, $T_C = 125°C$) (Rated dc Voltage, $T_C = 25°C$)	i_R	 40 0.2	 40 0.2	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

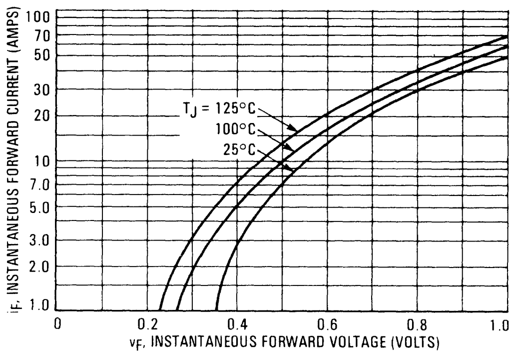


FIGURE 2 — TYPICAL REVERSE CURRENT

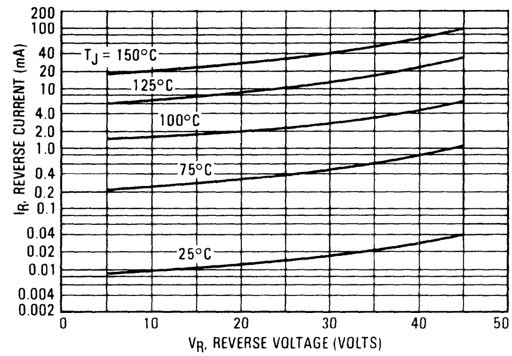


FIGURE 3 — CURRENT DERATING, CASE

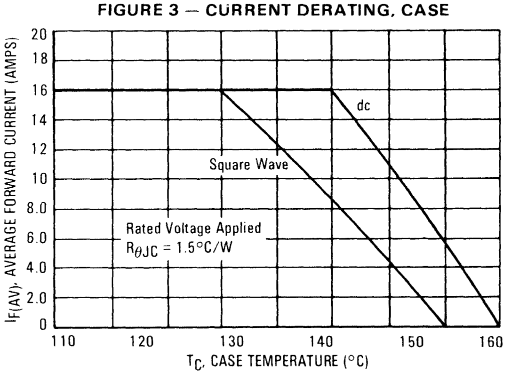


FIGURE 4 — CURRENT DERATING, AMBIENT

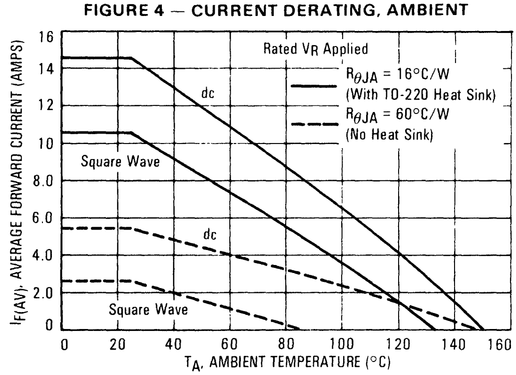
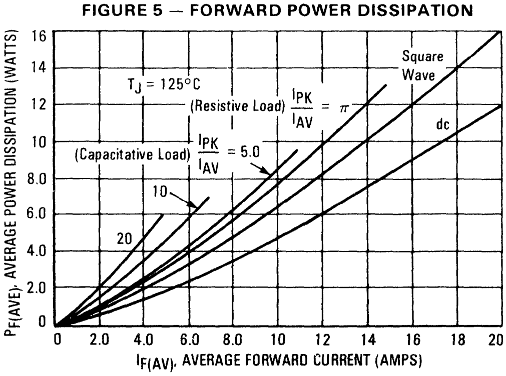
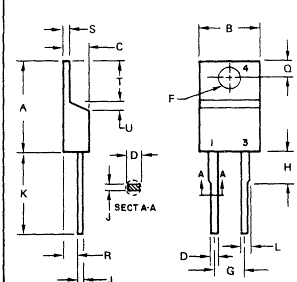


FIGURE 5 — FORWARD POWER DISSIPATION





STYLE 1:
PIN 1. CATHODE
2. N/A
3. ANODE
4. CATHODE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

CATHODE COMMON TO TAB

CASE 221B-01
(TO-220AC)
PLASTIC

3

MBR2035CT
MBR2045CT

MOTOROLA

3

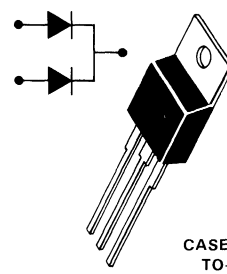
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche
- Epoxy Meets UL94, V0 at 1/8″

SCHOTTKY BARRIER RECTIFIERS

20 AMPERES
35 and 45 VOLTS



CASE 221A-02
TO-220AB

CROSS-REFERENCE GUIDE		
MOTOROLA	IR	FUJI
MBR2035CT	20CTQ030	—
MBR2035CT	20CTQ035	—
MBR2045CT	20CTQ040	ESAC83-4
MBR2045CT	20CTQ045	ESAD83-4

MAXIMUM RATINGS

Rating	Symbol	MBR2035CT	MBR2045CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 135°C$	$I_{F(AV)}$	20	20	Amps
Peak Repetitive Forward Current Per Diode Leg (Rated V_R, Square Wave, 20 kHz) $T_C = 135°C$	I_{FRM}	20	20	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 11	I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature	T_J	-65 to +150	-65 to +150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Rating	Symbol	MBR2035CT	MBR2045CT	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	2.0	2.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	MBR2035CT	MBR2045CT	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 10 Amp, $T_C = 125°C$) (i_F = 20 Amp, $T_C = 125°C$) (i_F = 20 Amp, $T_C = 25°C$)	v_F	 0.57 0.72 0.84	 0.57 0.72 0.84	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, $T_C = 125°C$) (Rated dc Voltage, $T_C = 25°C$)	i_R	 15 0.1	 15 0.1	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — MAXIMUM FORWARD VOLTAGE

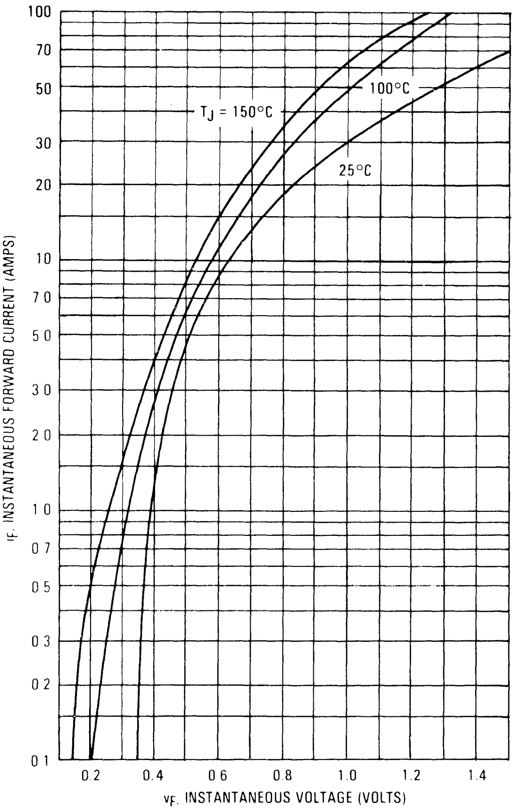


FIGURE 2 — TYPICAL FORWARD VOLTAGE

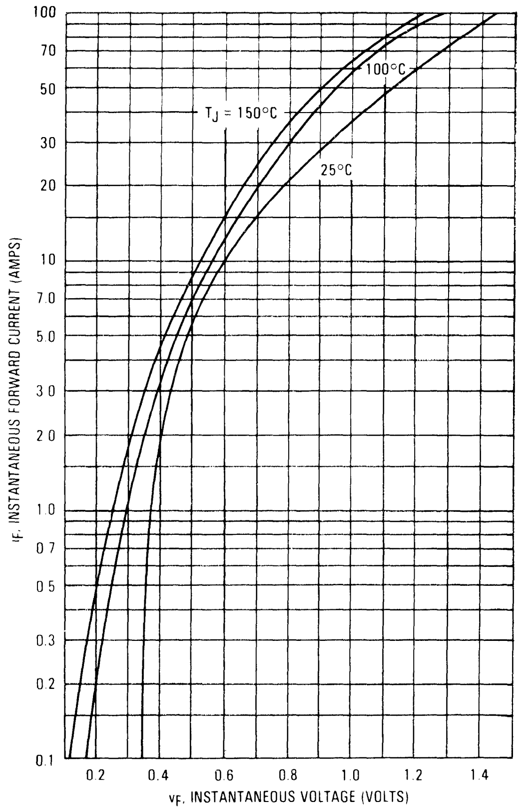


FIGURE 3 — MAXIMUM REVERSE CURRENT

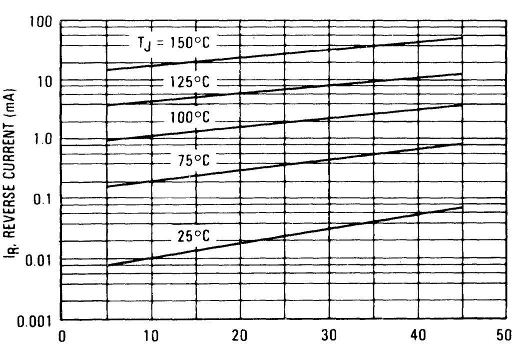


FIGURE 4 — MAXIMUM SURGE CAPABILITY

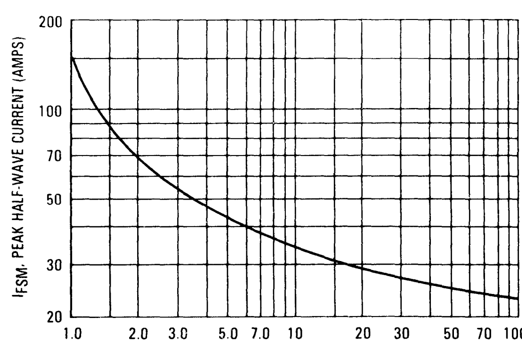


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FIGURE 5 — CURRENT DERATING, INFINITE HEATSINK

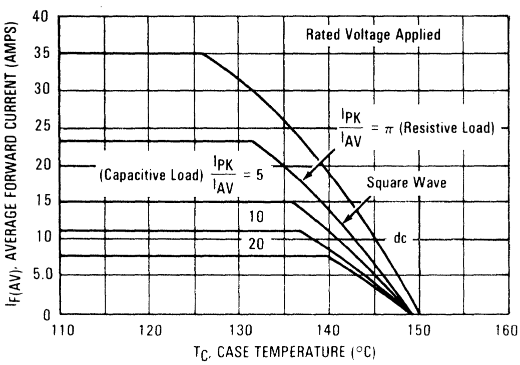

FIGURE 6 — CURRENT DERATING, $R_{\theta JA}$ = 16° C/W

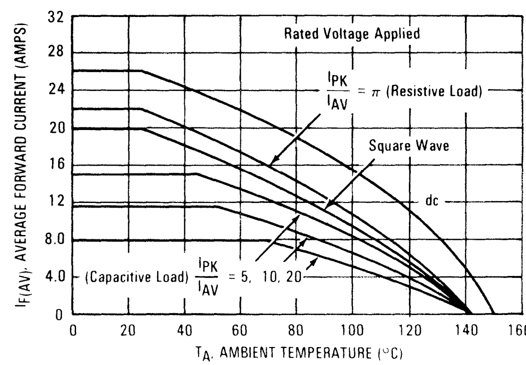

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FIGURE 7 — FORWARD POWER DISSIPATION

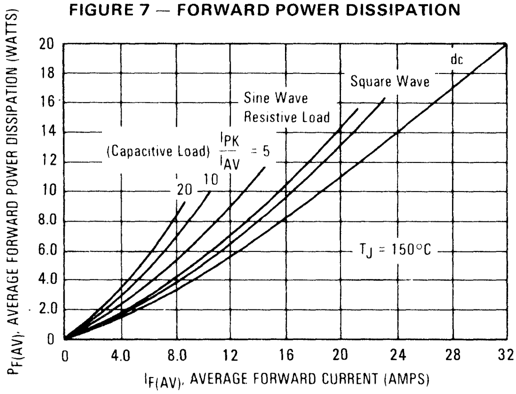


FIGURE 8 — CURRENT DERATING, FREE AIR

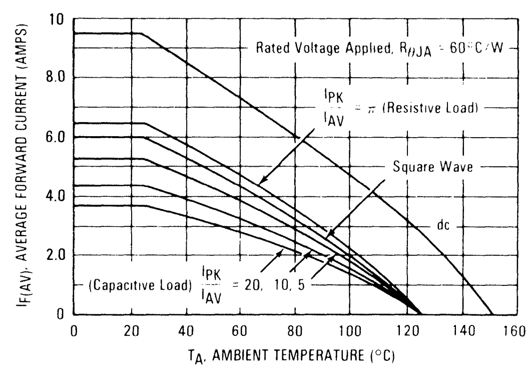
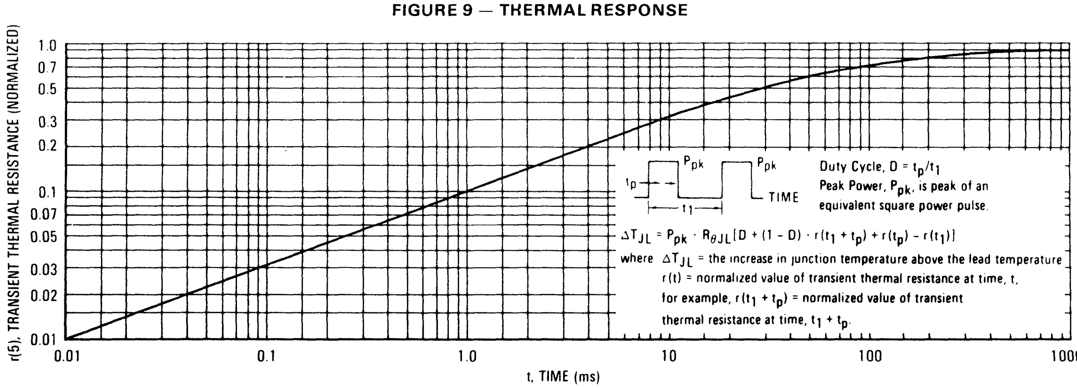


FIGURE 9 — THERMAL RESPONSE



HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 10.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficieny is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 10 — CAPACITANCE

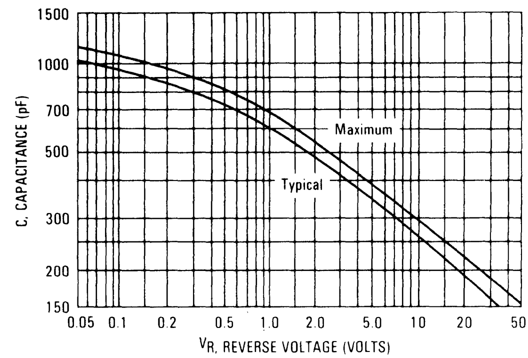


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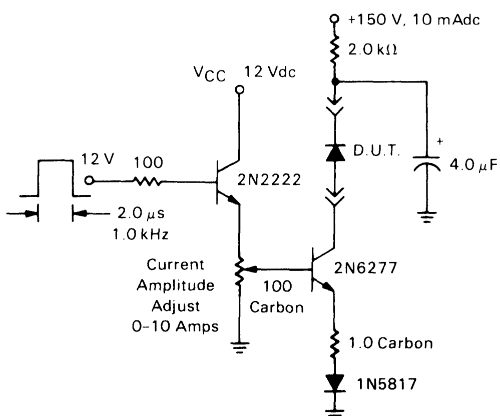
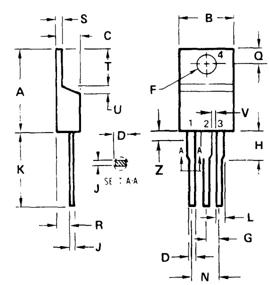
FIGURE 11 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT





NOTES:
1. DIMENSIONS L AND H APPLIES TO ALL LEADS.
2. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5 1973.
4. CONTROLLING DIMENSION: INCH.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050
V	1.14	-	0.045	-
Z	—	2.03	—	0.080

STYLE 6:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2
4. CATHODE

CASE 221A-02
TO-220AB

MBR2520
MBR2530
MBR2540

MOTOROLA

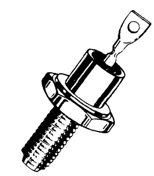
HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

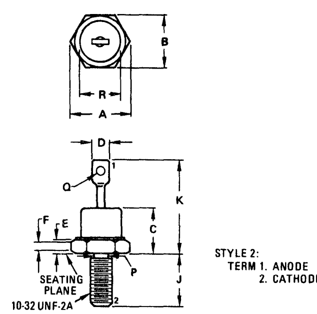
SCHOTTKY BARRIER RECTIFIERS

25 AMPERE
20, 30, 40 VOLTS



MAXIMUM RATINGS

Rating	Symbol	MBR2520	MBR2530	MBR2540	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv.)} \leqslant 0.2\ V_{R(dc)}$, $T_C = 80^oC$	I_O	← 25 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$ $R_{\theta JA} = 3.5^oC/W$	T_A	90	85	80	^oC
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← −65 to +125 →			^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J\ (pk)}$	← 150 →			^oC



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
D0-4

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.75	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 25 Amp)	v_F	–	–	0.550	Volts
Maximum Instantaneous Reverse Current @ Rated dc Voltage (1) ($T_C = 100^oC$)	i_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistance and terminal lead is readily solderable.
POLARITY: Cathode to Case
MOUNTING POSITIONS: Any
STUD TORQUE: 15 in. lb. Max

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR2540 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 16 A ($I_{F(AV)}$ = 8 A), $I_{(PK)}/I_{(AV)}$ = 20, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 5°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴
$V_{R(equiv)}$ = (1.41)(10)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 113°C @ V_R = 9.18 & $R_{\theta JA}$ = 5°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 14.8 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 20 & $I_{F(AV)}$ = 8 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 113-(5)(14.8) = 39°C

TABLE I – VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1), (2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 – MAXIMUM REFERENCE TEMPERATURE - MBR2520

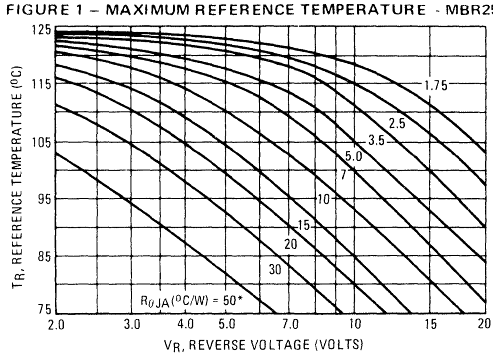


FIGURE 2 – MAXIMUM REFERENCE TEMPERATURE – MBR2530

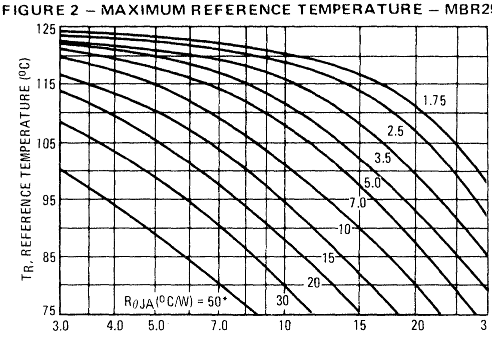


FIGURE 3 – MAXIMUM REFERENCE TEMPERATURE – MBR2540

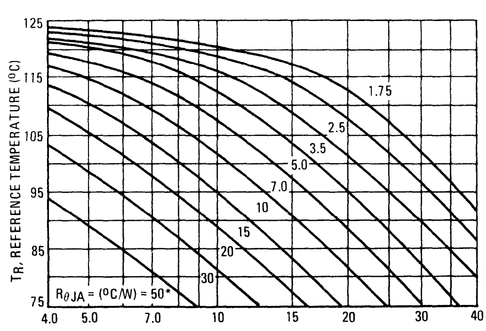
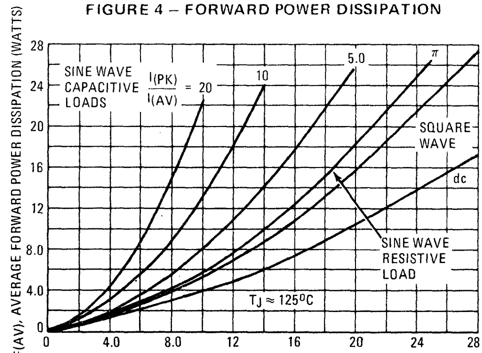


FIGURE 4 – FORWARD POWER DISSIPATION



*No external heat sink

3

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FIGURE 5 — TYPICAL FORWARD VOLTAGE

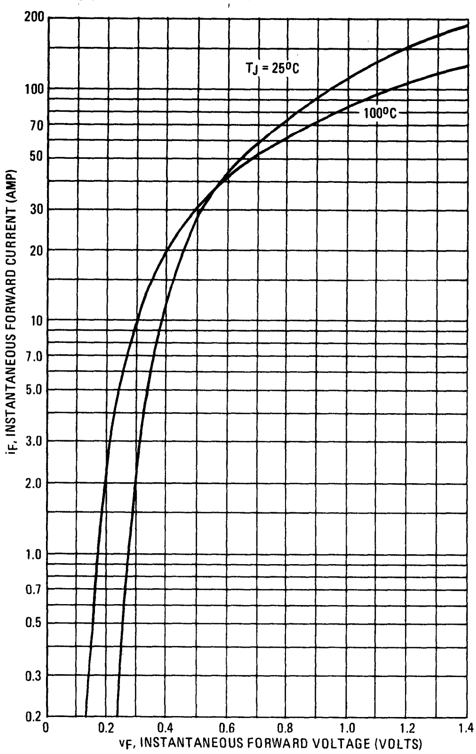

FIGURE 6 — MAXIMUM SURGE CAPABILITY

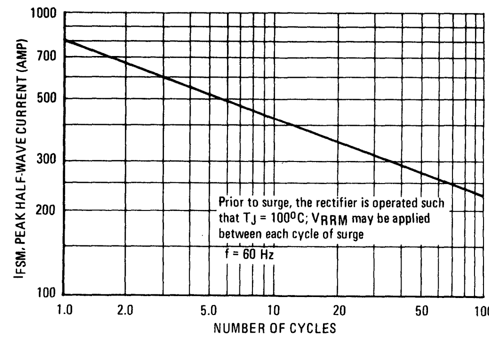

FIGURE 7 — CURRENT DERATING

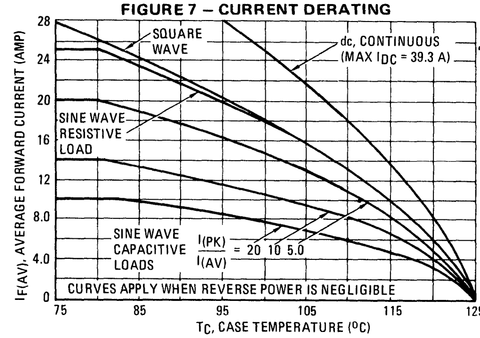

FIGURE 8 — THERMAL RESPONSE

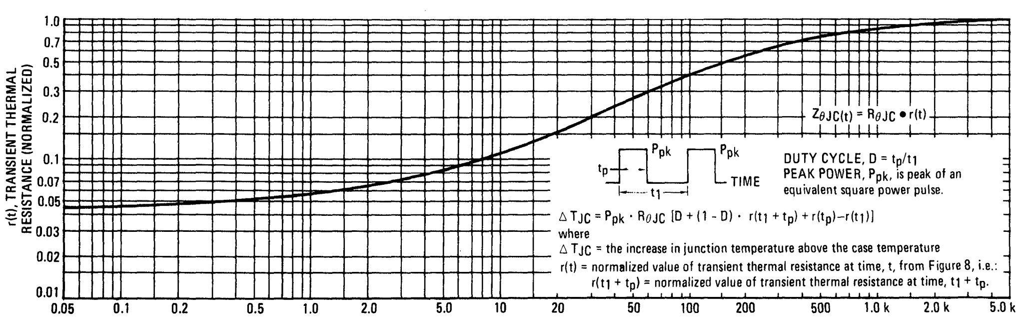

FIGURE 9 – NORMALIZED REVERSE CURRENT

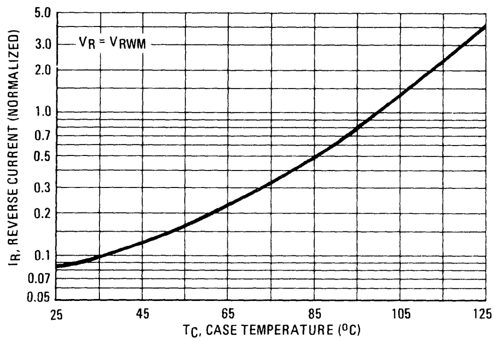

FIGURE 10 – TYPICAL REVERSE CURRENT

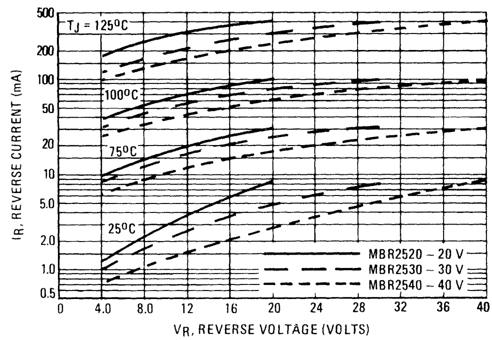

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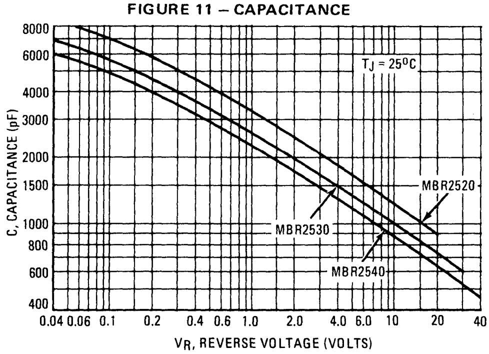
FIGURE 11 – CAPACITANCE



NOTE 2 – HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MBR2535CT
MBR2545CT

MOTOROLA

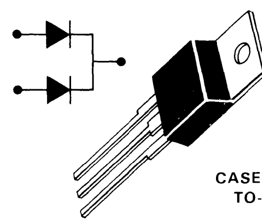
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

SCHOTTKY BARRIER RECTIFIERS

30 AMPERES
35 and 45 VOLTS



CASE 221A-02
TO-220AB

CROSS-REFERENCE GUIDE

MOTOROLA	IR	FUJI
MBR2535CT	30CTQ030	—
MBR2535CT	30CTQ035	—
MBR2545CT	30CTQ040	ESAC83-4
MBR2545CT	30CTQ045	ESAD83-4

MAXIMUM RATINGS

Rating	Symbol	MBR2535CT	MBR2545CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 130°C$	$I_{F(AV)}$	30	30	Amps
Peak Repetitive Forward Current Per Diode Leg (Rated V_R, Square Wave, 20 kHz) $T_C = 130°C$	I_{FRM}	30	30	Amps
Nonrepetitive Peak Surge Current per Diode Leg (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	150	150	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz)	I_{RRM}	1.0	1.0	Amps
Operating Junction Temperature	T_J	-65 to + 150	-65 to + 150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs
THERMAL CHARACTERISTICS PER DIODE LEG				
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	1.5	°C/W
ELECTRICAL CHARACTERISTICS PER DIODE LEG				
Maximum Instantaneous Forward Voltage (1) (i_F = 30 Amp, T_C = 125°C) (i_F = 30 Amp, T_C = 25°C)	v_F	 0.73 0.82	 0.73 0.82	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 40 0.2	 40 0.2	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

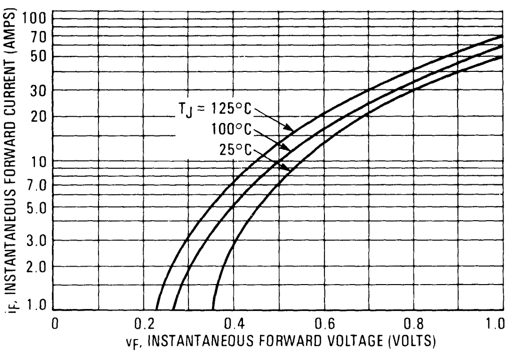
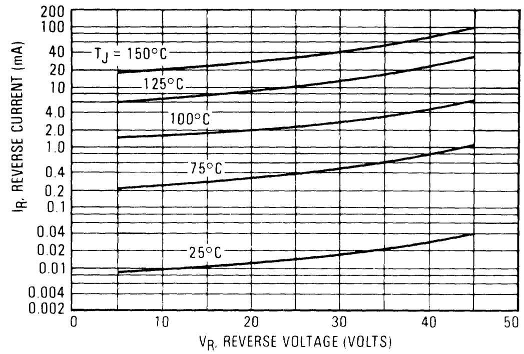


FIGURE 2 — TYPICAL REVERSE CURRENT



3

FIGURE 3 — CURRENT DERATING, CASE

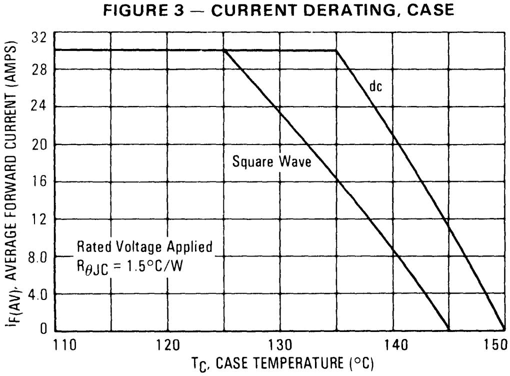


FIGURE 4 — CURRENT DERATING, AMBIENT

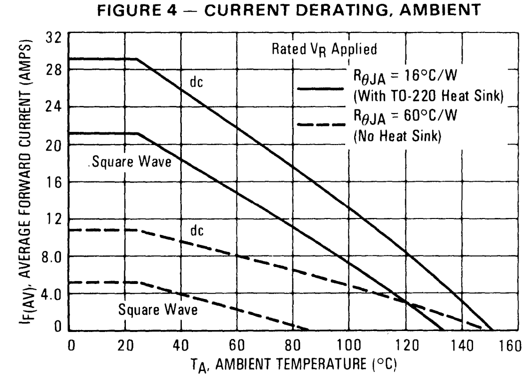
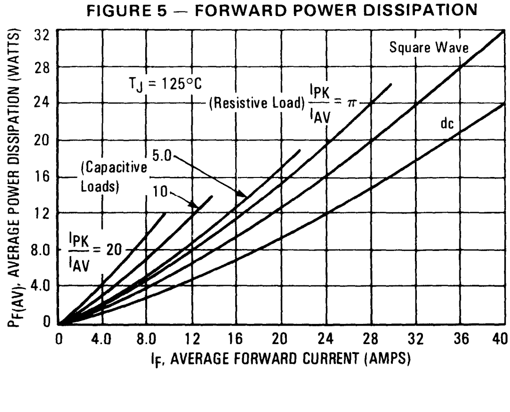
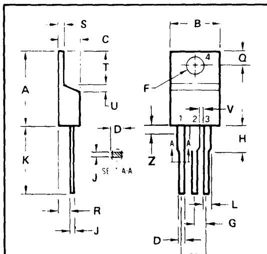


FIGURE 5 — FORWARD POWER DISSIPATION





NOTES:
1. DIMENSIONS L AND H APPLIES TO ALL LEADS.
2. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5 1973.
4. CONTROLLING DIMENSION: INCH

STYLE 6:
PIN 1. ANODE 1
2. CATHODE
3. ANODE 2
4. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050
V	1.14		0.045	
Z	—	2.03	—	0.080

CASE 221A-02

MBR3020CT
MBR3035CT
MBR3045CT
SD241

MOTOROLA

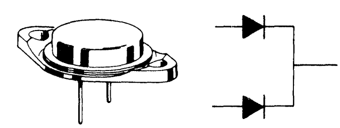
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Dual Diode Construction
- Guardring for Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

SCHOTTKY BARRIER RECTIFIERS

30 AMPERES
20 to 45 VOLTS



CASE 11-03
TO-204AA
(TO-3)

3

CROSS-REFERENCE GUIDE

MOTOROLA	TRW	UNITRODE	VARO	IR
SD241	SD241	SD241	—	—
MBR3020CT	—	—	VSK3020T	60CDQ020
MBR3035CT	—	—	VSK3030T	60CDQ035
MBR3045CT	SD241	—	VSK3040T	60CDQ045

MAXIMUM RATINGS

Rating	Symbol	MBR3020CT	MBR3035CT	MBR3045CT	SD241	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	35	45	45	Volts
Average Rectified Forward Current Per Device (Rated V_R) T_C = 105°C Per Diode	I_O	30 15	30 15	30 15	30 15	Amps
Peak Repetitive Forward Current, Per Diode (Rated V_R, Square Wave, 20 kHz)	I_{FRM}	30	30	30	30	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	400	400	400	400	Amps
Peak Repetitive Reverse Current, Per Diode (2.0 μs, 1.0 kHz) See Figure 8	I_{RRM}	2.0	2.0	2.0	2.0	Amps
Operating Junction Temperature	T_J	-65 to + 150	-65 to + 150	-65 to + 150	-65 to +150	°C
Storage Temperature	T_{stg}	-65 to +175	-65 to +175	-65 to +175	-65 to +175	°C
Peak Surge Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	175	175	175	175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	1000	1000	V/μs

THERMAL CHARACTERISTICS PER DIODE

Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	1.4	1.4	1.4	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE

Maximum Instantaneous Forward Voltage (1) (i_F = 10 Amp, T_C = 125°C) (i_F = 20 Amp, T_C = 125°C) (i_F = 30 Amp, T_C = 125°C) (i_F = 30 Amp, T_C = 25°C)	v_F	 — 0.60 0.72 0.76	 — 0.60 0.72 0.76	 — 0.60 0.72 0.76	 0.47 0.60 — —	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 60 1.0	 60 1.0	 60 1.0	 100 V_R = 35 V	mA
Capacitance	C_t	2000	2000	2000	2000	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

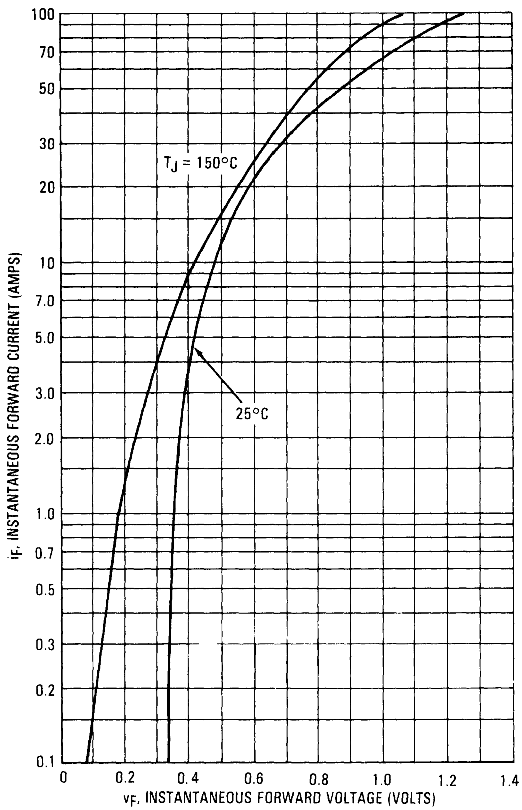


FIGURE 2 — TYPICAL REVERSE CURRENT

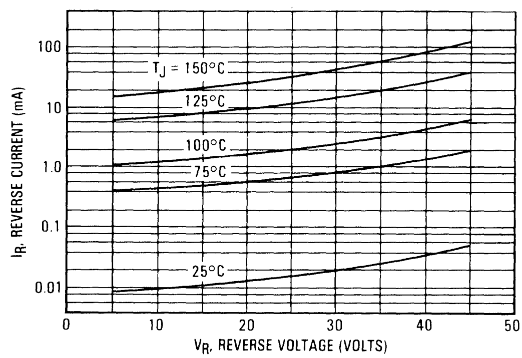


FIGURE 3 — MAXIMUM SURGE CAPABILITY

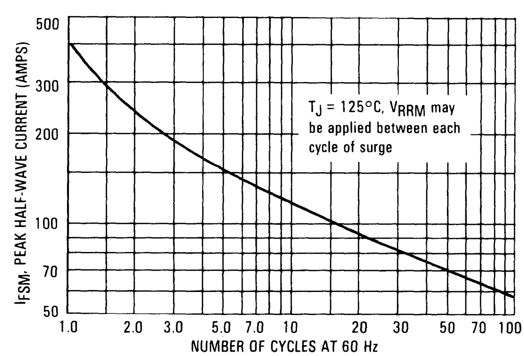


FIGURE 4 — CURRENT DERATING

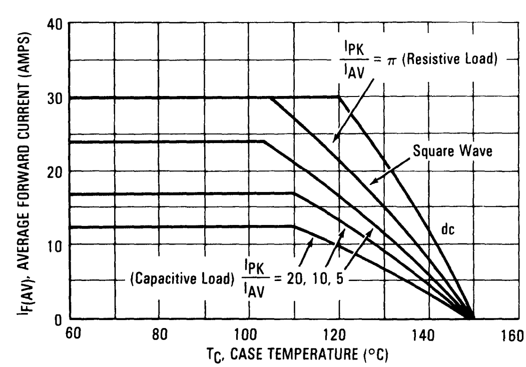


FIGURE 5 — FORWARD POWER DISSIPATION

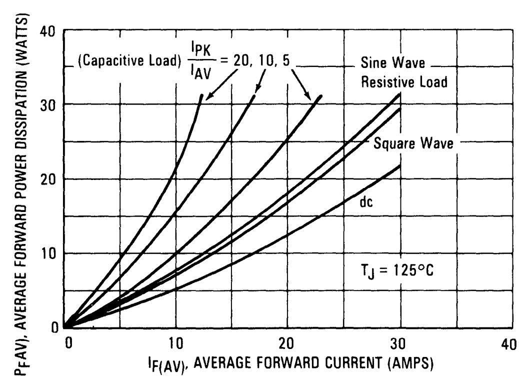
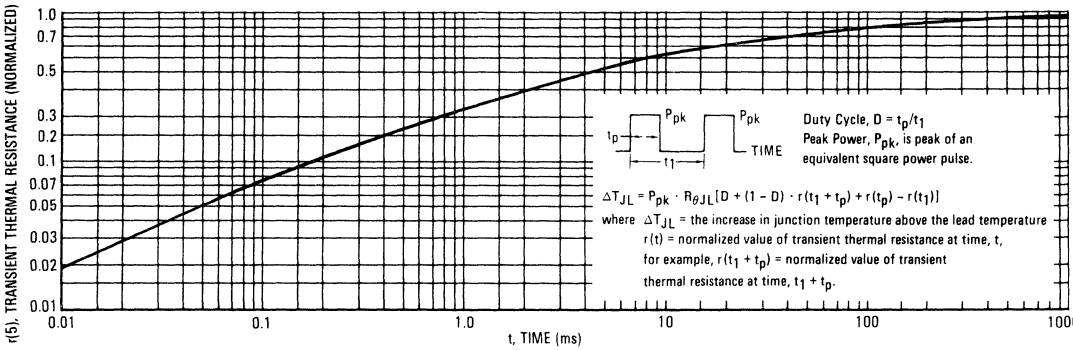


FIGURE 6 — THERMAL RESPONSE PER DIODE LEG



HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 7.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficieny is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 7 — CAPACITANCE

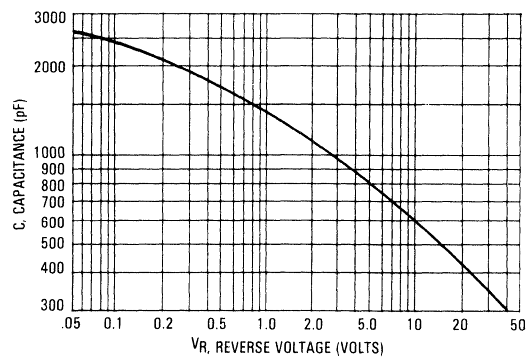


FIGURE 8 — TEST CIRCUIT FOR REPETITIVE REVERSE CURRENT

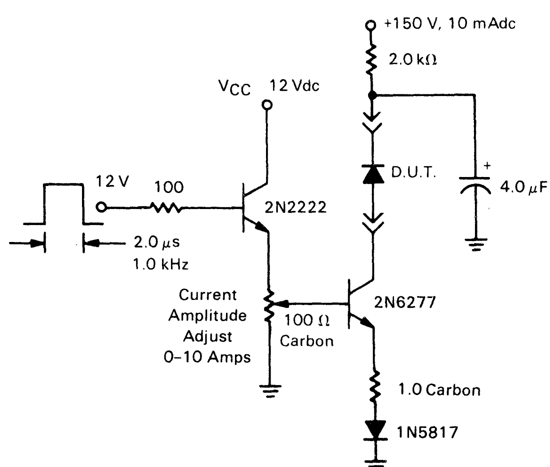
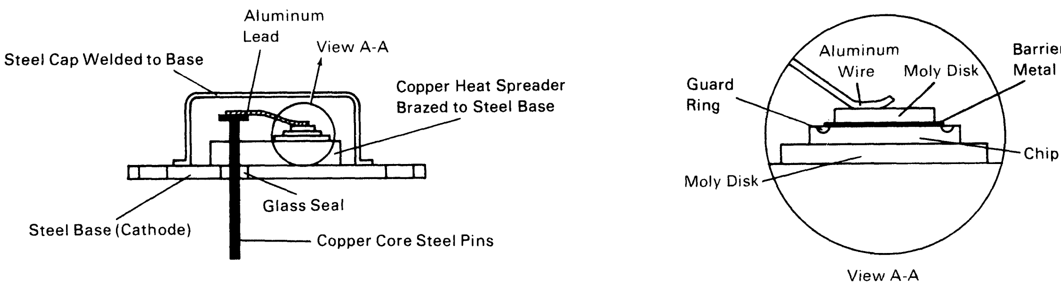


FIGURE 9 — SCHOTTKY RECTIFIER

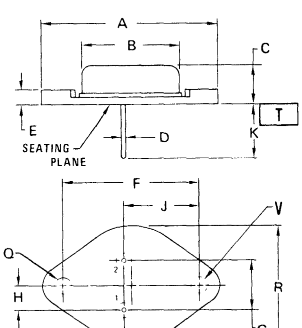


Motorola builds quality and reliability into its Schottky Rectifiers.

First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not required. The guardring also operates like a zener to absorb over-voltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The pin-to-chip aluminum leadwire provides stress relief. These two features give the unit the capability of passing stringent thermal fatigue tests for 5,000 cycles. Copper-core steel pins match the expansion coefficient of the glass and are long enough (0.440 in. min.) to reach through a heat sink to a printed circuit board.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche.



MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed.

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

POLARITY: Cathode to Case.

MOUNTING POSITION: Any.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.37	–	1.550
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	30.15 BSC		1.187 BSC	
G	10.92 BSC		0.430 BSC	
H	5.46 BSC		0.215 BSC	
J	16.89 BSC		0.665 BSC	
K	11.18	12.19	0.440	0.480
Q	3.84	4.09	0.151	0.161
R	–	26.67	–	1.050
V	3.84	4.09	0.151	0.161

CASE 11-03
TO-204AA

NOTES:
1. DIAMETERS Q, V AND SURFACE T ARE DATUMS.
2. POSITIONAL TOLERANCE FOR HOLE Q: ⊕ ∅ 0.25 (0.010) Ⓜ T V Ⓜ
3. POSITIONAL TOLERANCE FOR LEADS: ⊕ ∅ 0.30 (0.012) Ⓜ T V Ⓜ Q Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

STYLE 4:
PIN 1. ANODE 1
2. ANODE 2
CASE. COMMON CATHODE

MBR3035PT
MBR3045PT

MOTOROLA

SWITCHMODE POWER RECTIFIERS

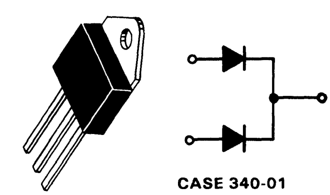
. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Dual Diode Construction — Terminals 1 and 3 May Be Connected For Parallel Operation At Full Rating
- Guardring For Stress Protection
- Low Forward Voltage
- 150°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

3

SCHOTTKY BARRIER RECTIFIERS

30 AMPERES
35 to 45 VOLTS



CASE 340-01
TO-218AC

RATINGS

Rating		Symbol	Maximum	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	MBR3035PT MBR3045PT	V_{RRM} V_{RWM} V_R	35 45	Volts
Average Rectified Forward Current (Rated V_R) T_C = 105°C	Per Device Per Diode	$I_{F(AV)}$	30 15	Amps
Peak Repetitive Forward Current, Per Diode (Rated V_R, Square Wave, 20 kHz)		I_{FRM}	30	Amps
Nonrepetitive Peak Surge Current (Surge Applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	200	Amps
Peak Repetitive Reverse Current, Per Diode (2.0 μs, 1.0 kHz) See Figure 6		I_{RRM}	2.0	Amps
Operating Junction Temperature		T_J	-65 to +150	°C
Storage Temperature		T_{stg}	-65 to +175	°C
Peak Surge Junction Temperature (Forward Current Applied)		$T_{J(pk)}$	175	°C
Voltage Rate of Change (Rated V_R)		dv/dt	1000	V/μs

THERMAL CHARACTERISTICS PER DIODE

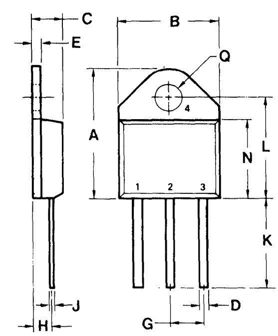
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	40	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE

Instantaneous Forward Voltage (1) (i_F = 20 Amp, T_C = 125°C) (i_F = 30 Amp, T_C = 125°C) (i_F = 30 Amp, T_C = 25°C)	v_F	 0.60 0.72 0.76	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 100 1.0	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

Switchmode is a trademark of Motorola Inc.



1. ANODE 1
2. CATHODE(S)
3. ANODE 2
4. CATHODE(S)

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
B	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

CASE 340-01
TO-218AC

FIGURE 1 — TYPICAL FORWARD VOLTAGE

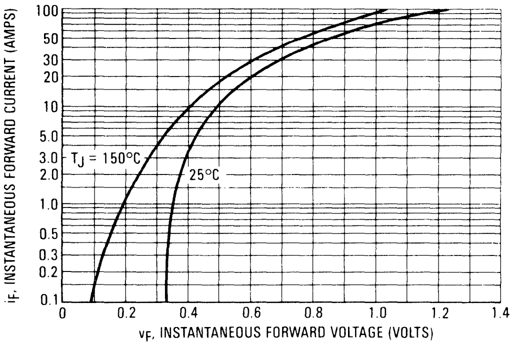
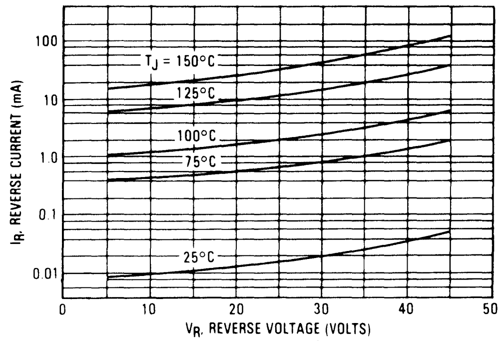


FIGURE 2 — TYPICAL REVERSE CURRENT



3

FIGURE 3 — CURRENT DERATING PER LEG

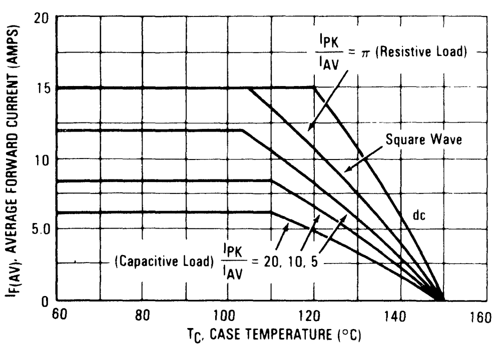


FIGURE 4 — FORWARD POWER DISSIPATION PER LEG

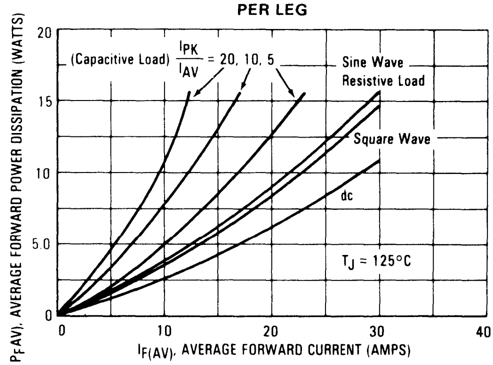


FIGURE 5 — CAPACITANCE

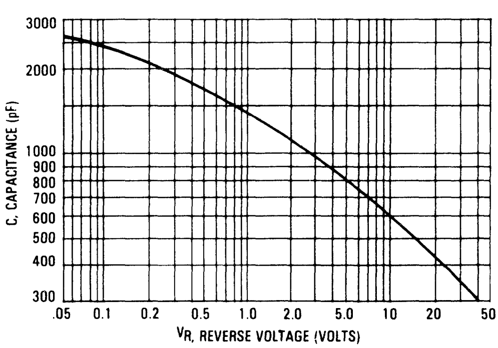
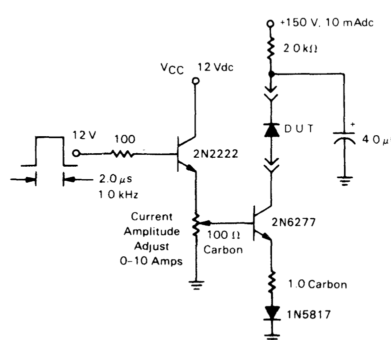


FIGURE 6 — TEST CIRCUIT FOR REPETITIVE REVERSE CURRENT



MBR3520
MBR3535
MBR3545, H, H1

MOTOROLA

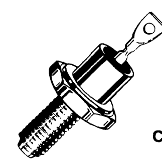
SWITCHMODE POWER RECTIFIERS

. . . using a platinum barrier metal in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Guardring for dv/dt Stress Protection
- Guaranteed Reverse Surge Current/Avalanche
- 150°C Operating Junction Temperature

SCHOTTKY BARRIER RECTIFIERS

35 AMPERES
20 to 45 VOLTS



CASE 56
D0-4

MAXIMUM RATINGS

Rating	Symbol	MBR3520	MBR3535	MBR3545, H, H1*	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	35	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz, T_C = 110°C)	I_{FRM}	← 70 →			Amps
Average Rectified Forward Current (Rated V_R, T_C = 110°C)	$I_{F(AV)}$	← 35 →			Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 8	I_{RRM}	← 2.0 →			Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 600 →			Amps
Operating Junction Temperature	T_J	← -65 to + 150 →			°C
Storage Temperature	T_{stg}	← -65 to +175 →			°C
Voltage Rate of Change (Rated V_R)	dv/dt	← 1000 →			V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	1.3	1.5	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 35 Amp, T_C = 125°C) (i_F = 35 Amp, T_C = 25°C) (i_F = 70 Amp, T_C = 125°C)	v_F	 0.49 0.55 0.60	 0.55 0.63 0.69	Volts
Instantaneous Reverse Current (1) (Rated Voltage, T_C = 125°C) (Rated Voltage, T_C = 25°C)	i_R	 60 0.1	 100 0.3	mA
Capacitance (V_R = 1.0 Vdc, 100 kHz > f > 1.0 MHz, T_C = 25°C)	C_t	3000	3700	pF

*H and H1 devices include extra testing. See Figure 10.
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 — MAXIMUM FORWARD VOLTAGE

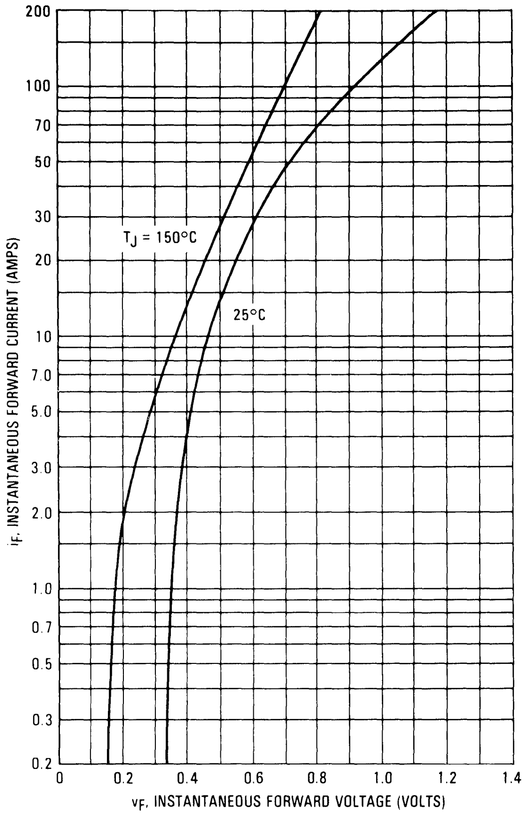


FIGURE 2 — MAXIMUM REVERSE CURRENT

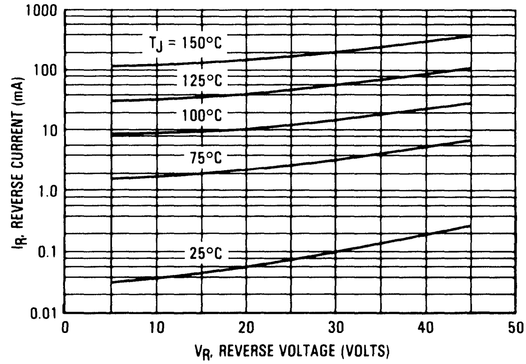


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FIGURE 3 — MAXIMUM SURGE CAPABILITY

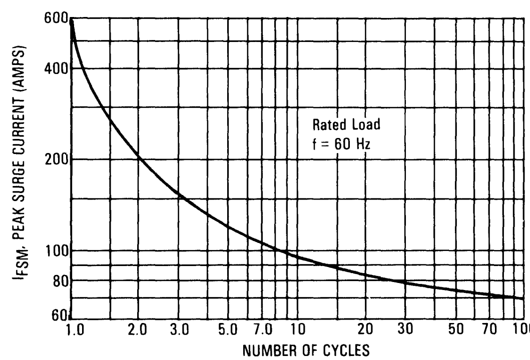


FIGURE 4 — CURRENT DERATING

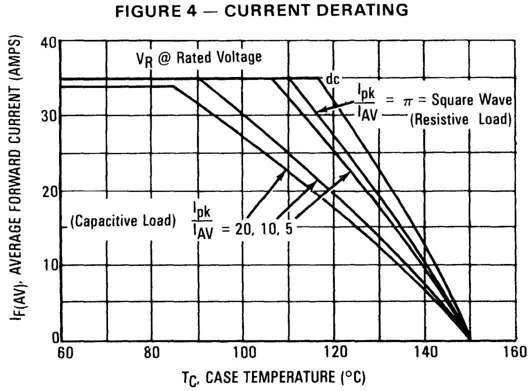


FIGURE 5 — POWER DISSIPATION

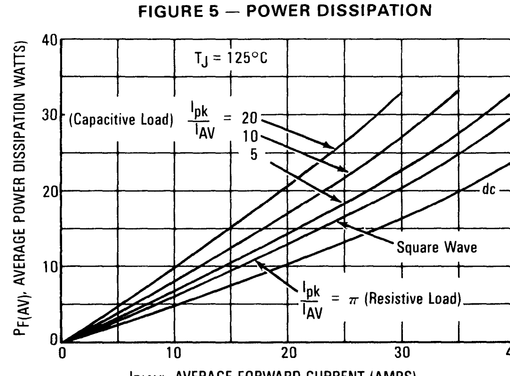
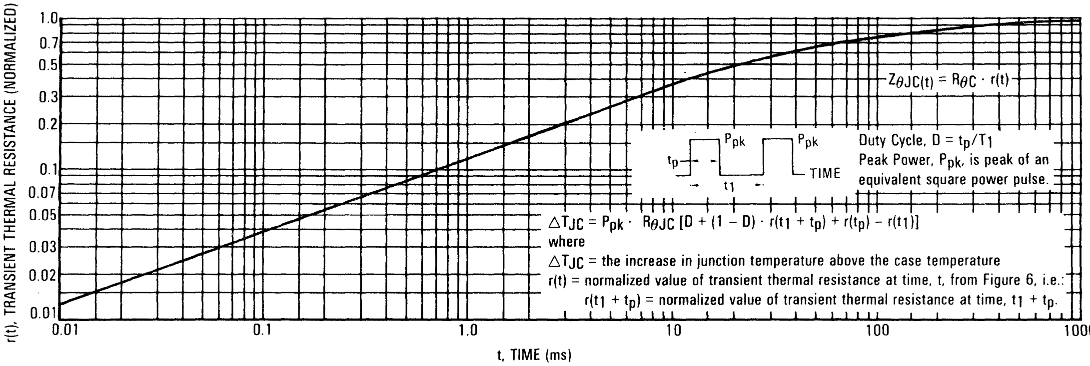


FIGURE 6 — THERMAL RESPONSE



HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 7.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 7 — CAPACITANCE

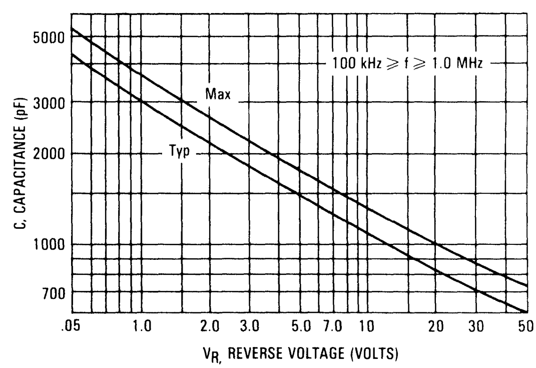
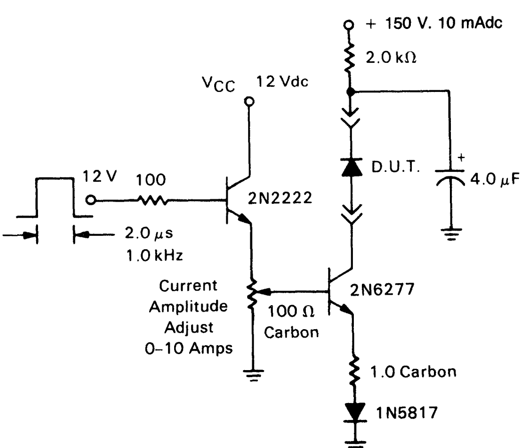
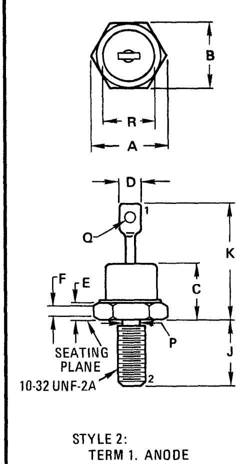


FIGURE 8 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT





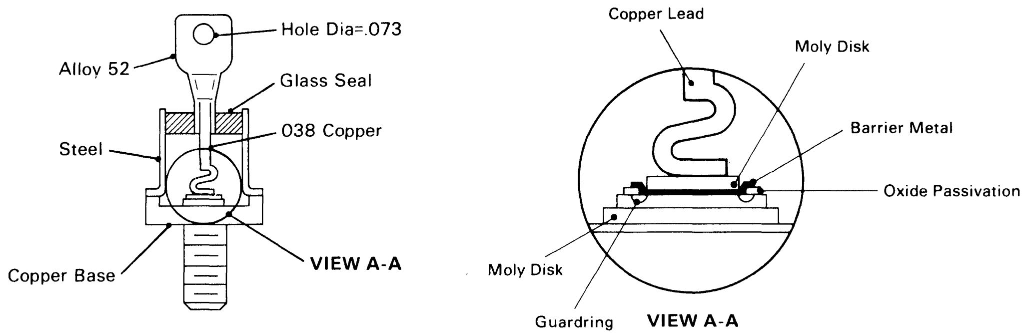
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

STYLE 2:
TERM 1. ANODE
2. CATHODE

CASE 56
DO-4

FIGURE 9 — SCHOTTKY RECTIFIER



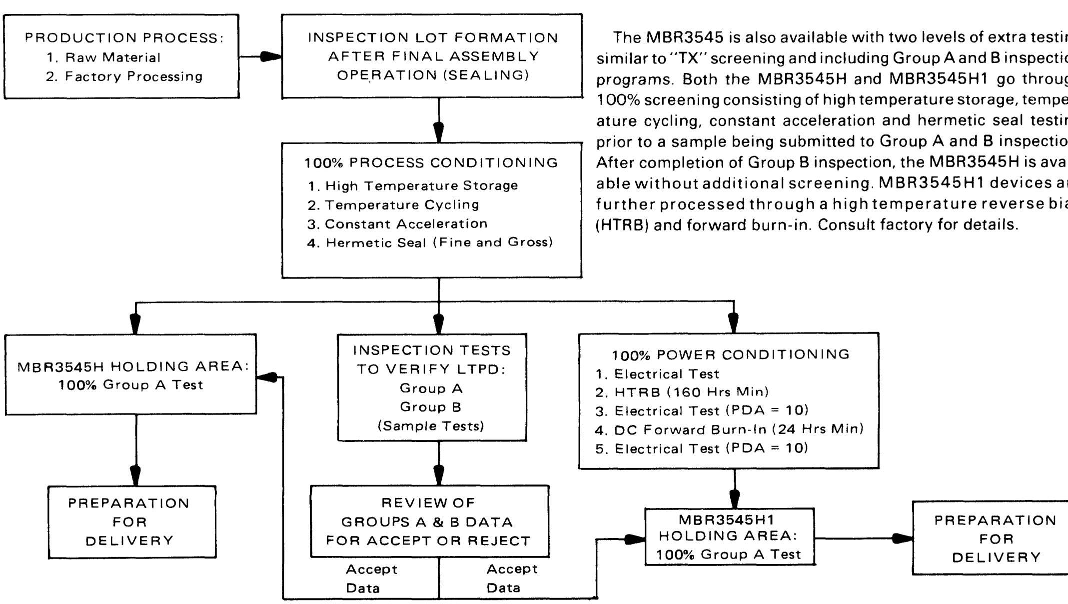
Motorola builds quality and reliability into its Schottky Rectifiers.

First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not mandatory. The guardring also operates like a zener to absorb overvoltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The top copper lead is also stress-relieved to prevent damage during assembly. These two features give the unit the capability of passing powered thermal fatigue tests for 5,000 cycles. The top copper lead provides a low resistance to current and therefore does not contribute to device heating; a heat sink should be used when attaching wires.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche. Devices are also 100% reverse scope tested for trace anomalies.

FIGURE 10 — HI-REL PROGRAM OPTIONS



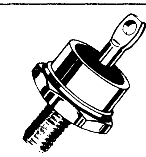
The MBR3545 is also available with two levels of extra testing similar to "TX" screening and including Group A and B inspection programs. Both the MBR3545H and MBR3545H1 go through 100% screening consisting of high temperature storage, temperature cycling, constant acceleration and hermetic seal testing prior to a sample being submitted to Group A and B inspection. After completion of Group B inspection, the MBR3545H is available without additional screening. MBR3545H1 devices are further processed through a high temperature reverse bias (HTRB) and forward burn-in. Consult factory for details.

MBR4020
MBR4030
MBR4040

MOTOROLA

SCHOTTKY BARRIER RECTIFIERS

40 AMPERE
20,30,40 VOLTS



HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free wheeling diodes, and polarity protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/High Efficiency
- High Surge Capacity

3

MAXIMUM RATINGS

Rating	Symbol	MBR4020	MBR4030	MBR4040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	40	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	24	36	48	Volts
Average Rectified Forward Current $V_{R(equiv)} \leq 0.2\ V_{R(dc)}$, $T_C = 70°C$	I_O	← 40 →			Amp
Ambient Temperature Rated $V_{R(dc)}$, $P_{F(AV)} = 0$, $R_{\theta JA} = 2.0°C/W$	T_A	100	95	90	°C
Non-Repetitive Peak Surge Current (surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 (for 1 cycle) →			Amp
Operating and Storage Junction Temperature Range (Reverse voltage applied)	T_J, T_{stg}	← -65 to +125 →			°C
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	← 150 →			°C

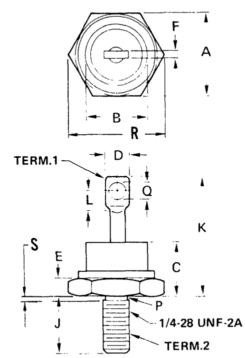
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Maximum Instantaneous Forward Voltage (1) ($i_F = 40$ Amp)	v_F	–	–	0.630	Volts
Maximum Instantaneous Reverse Current @ rated dc Voltage (1) $T_C = 100°C$	i_R	– –	– –	20 150	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

CASE 257-01
DO-5

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 0.2 V_{RWM}. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}\,P_{F(AV)} - R_{\theta JA}\,P_{R(AV)} \qquad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (125°C or the temperature at which thermal runaway occurs, whichever is lowest).

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JC}$ = Junction-to-ambient thermal resistance

Figures 1, 2 and 3 permit easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figures solve for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}\,P_{R(AV)} \qquad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}\,P_{F(AV)} \qquad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 125°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figures 1, 2 and 3 as a difference in the rate of change of the slope in the vicinity of 115°C. The data of Figures 1, 2 and 3 is based upon dc conditions. For use in common rectifier circuits, Table I indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \qquad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the reverse characteristics of Schottky diodes.

Example: Find $T_{A(max)}$ for MBR4040 operated in a 12-Volt dc supply using a bridge circuit with capacitive filter such that I_{DC} = 30 A ($I_{F(AV)}$ = 15 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 10 V(rms), $R_{\theta JA}$ = 3°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 0.65 from Table I ∴ $V_{R(equiv)}$ = (10)(1.41)(0.65) = 9.18 V

Step 2: Find T_R from Figure 3. Read T_R = 118°C @ V_R = 9.18 V & $R_{\theta JA}$ = 3°C/W

Step 3: Find $P_{F(AV)}$ from Figure 4. Read $P_{F(AV)}$ = 25 W @ $\frac{I_{(PK)}}{I_{(AV)}}$ = 10 & $I_{F(AV)}$ = 15 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 118-(3)(25) = 43°C.

3

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave, Center Tapped (1),(2)	
Load	Resistive	Capacitive (1)	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.5	1.3	0.5	0.65	1.0	1.3
Square Wave	0.75	1.5	0.75	0.75	1.5	1.5

(1) Note that $V_{R(PK)} \approx 2\,V_{in(PK)}$

(2) Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE — MBR4020

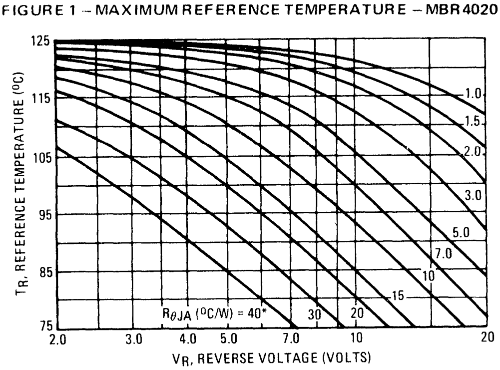


FIGURE 2 — MAXIMUM REFERENCE TEMPERATURE — MBR4030

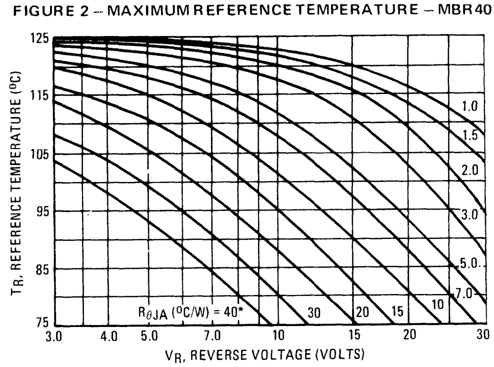
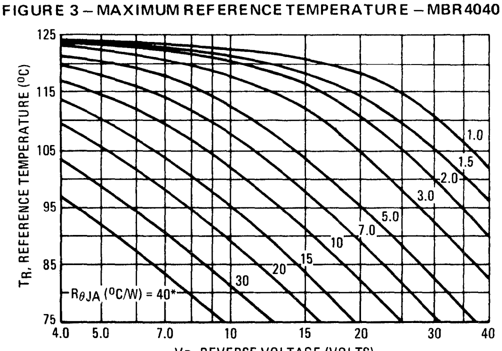


FIGURE 3 — MAXIMUM REFERENCE TEMPERATURE — MBR4040



*No external heat sink

FIGURE 4 — FORWARD POWER DISSIPATION

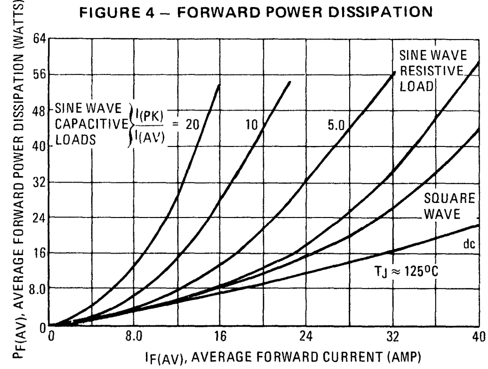


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FIGURE 5 – TYPICAL FORWARD VOLTAGE

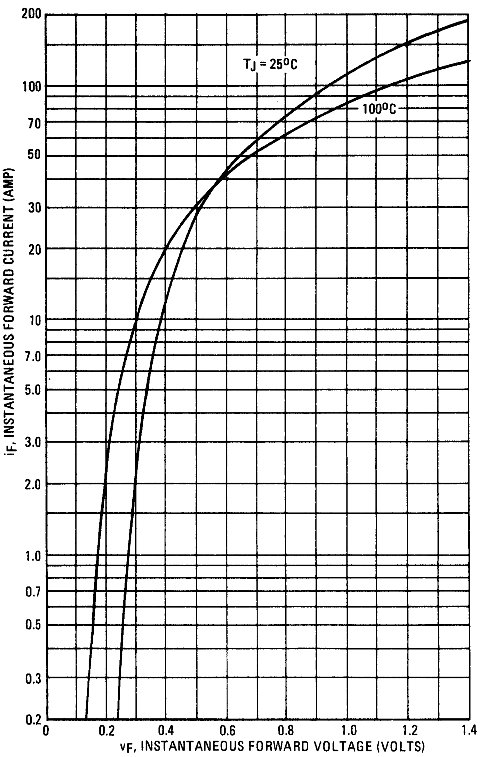


FIGURE 6 – MAXIMUM SURGE CAPABILITY

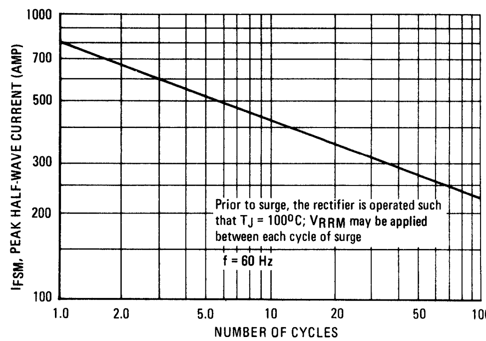


FIGURE 7 – CURRENT DERATING

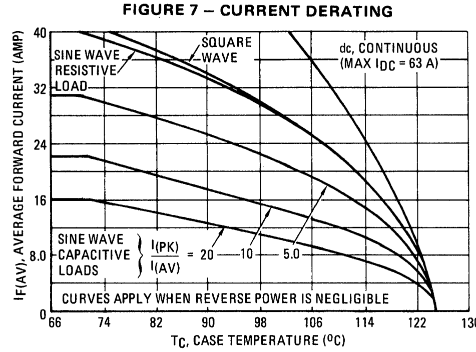


FIGURE 8 – THERMAL RESPONSE

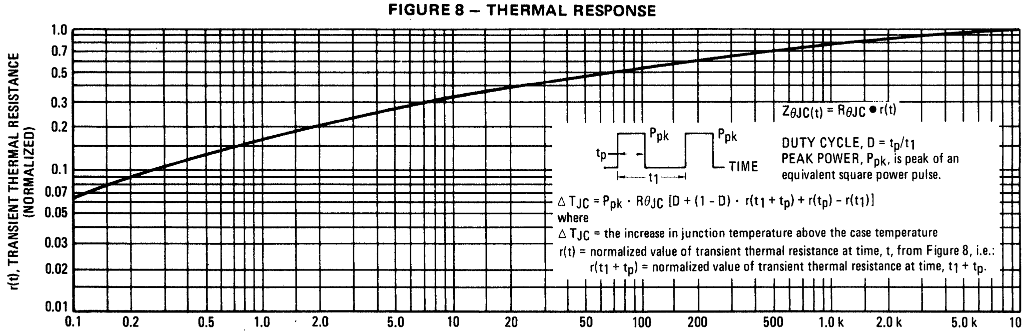


FIGURE 9 — NORMALIZED REVERSE CURRENT

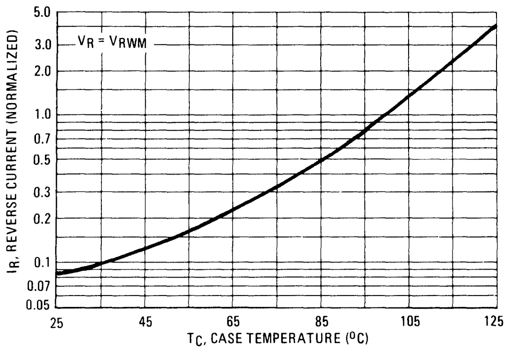


FIGURE 10 — TYPICAL REVERSE CURRENT

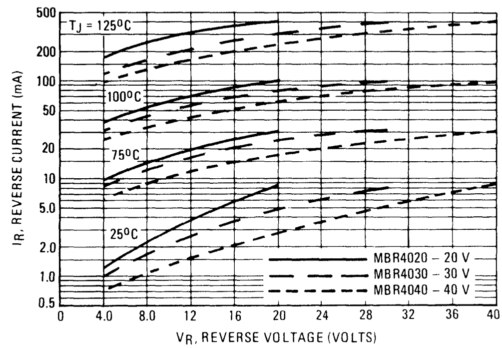
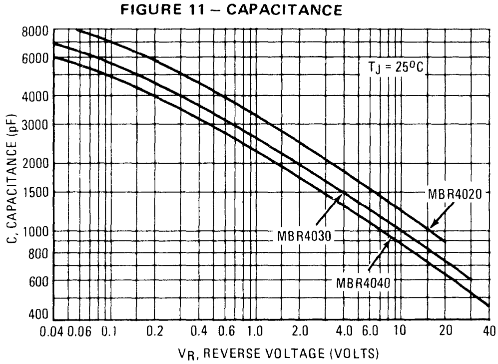


FIGURE 11 — CAPACITANCE



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NOTE 2: HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 11).

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in. lb. Max

NOTE 3: SOLDER HEAT

The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

MBR5825H, H1
See Page 3-59
MBR5831H, H1
See Page 3-64

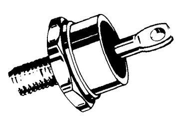
MOTOROLA

MBR6035
MBR6045, H, H1

SCHOTTKY RECTIFIERS

60 AMPERES
35 AND 45 VOLTS

CASE 257-01



SWITCHMODE POWER RECTIFIERS

. . . using a platinum barrier metal in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Guaranteed Reverse Avalanche
- Guardring for dv/dt Stress Protection
- 150°C Operating Junction Temperature
- Low Forward Voltage

MAXIMUM RATINGS

Rating	Symbol	MBR6035 MBR6035B	MBR6045, H, H1* MBR6045B	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) T_C = 100°C	I_{FRM}	120		Amps
Average Rectified Forward Current (Rated V_R) T_C = 100°C	I_O	60		Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 7	I_{RRM}	2.0		Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	800		Amps
Operating Junction Temperature	T_J	−65 to + 150		°C
Storage Temperature	T_{stg}	−65 to +175		°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000		V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	0.85	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 60 Amp, T_C = 25°C) (i_F = 60 Amp, T_C = 125°C) (i_F = 120 Amp, T_C = 125°C)	v_F	 0.65 0.57 0.70	 0.70 0.60 0.76	Volts
Instantaneous Reverse Current (1) (Rated Voltage, T_C = 25°C) (Rated Voltage, T_C = 125°C)	i_R	 0.1 55	 0.3 100	mA
Capacitance (V_R = 1.0 Vdc, 100 kHz ≤ 1.0 MHz)	C_t	3000	3700	pF

*H and H1 devices include extra testing.
(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

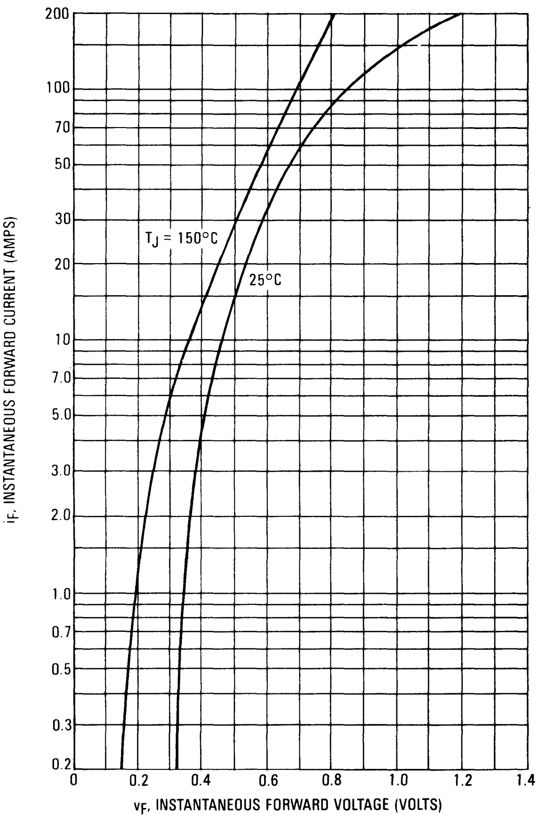


FIGURE 2 — TYPICAL REVERSE CURRENT

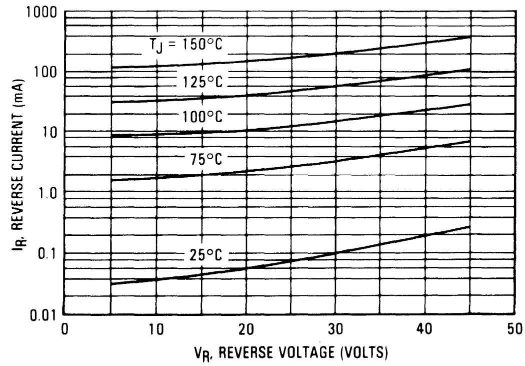
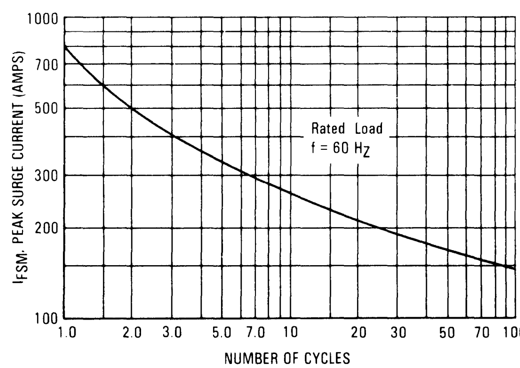


FIGURE 3 — MAXIMUM SURGE CAPABILITY



NOTE 1
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Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 4 — CAPACITANCE

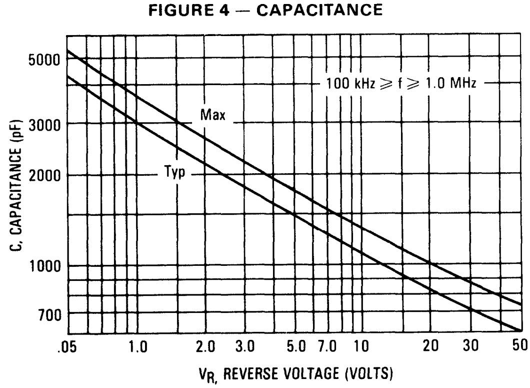

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FIGURE 5 — FORWARD CURRENT DERATING

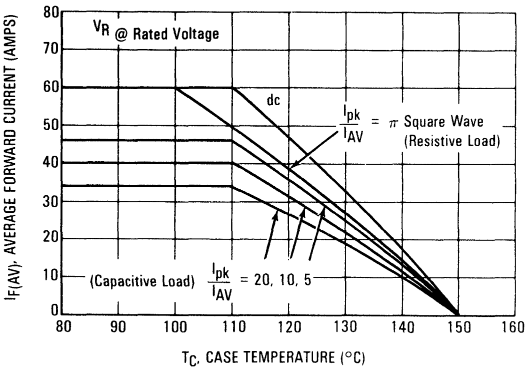
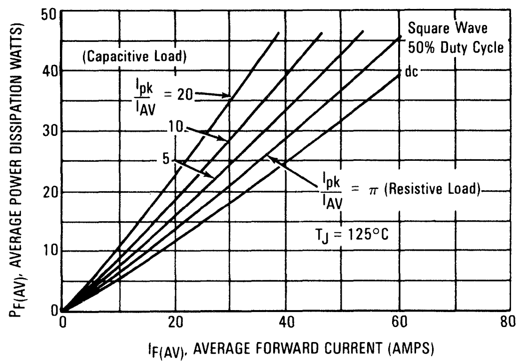


FIGURE 6 — POWER DISSIPATION



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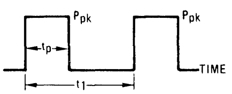
NOTE 2



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. 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_C 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 8, i.e.:
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 7 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT

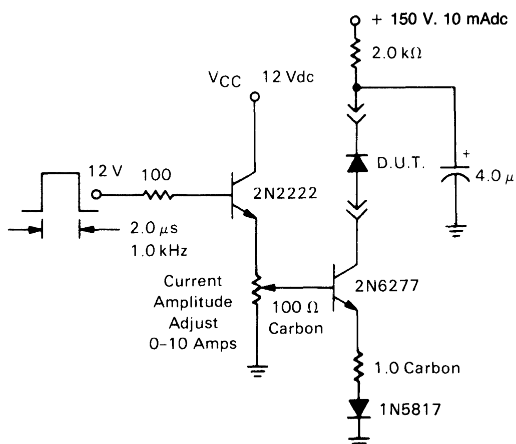


FIGURE 8 — THERMAL RESPONSE

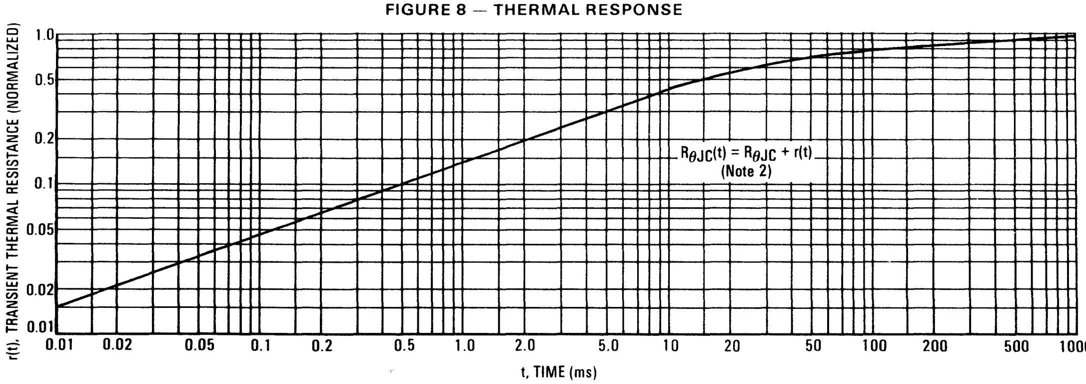
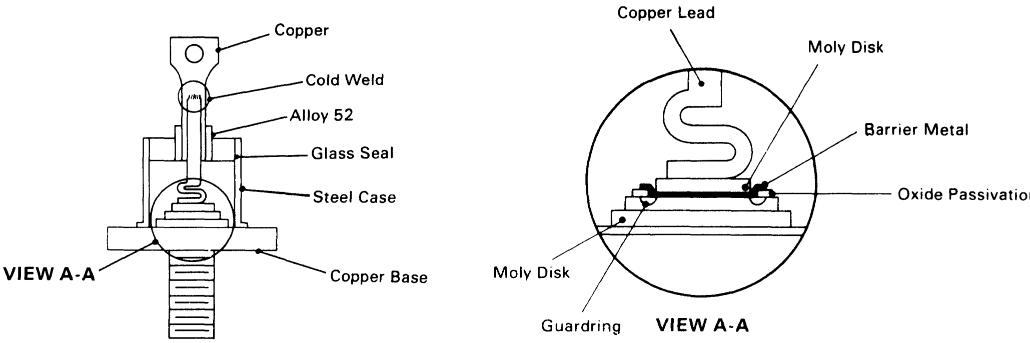


FIGURE 9 — SCHOTTKY RECTIFIER



Motorola builds quality and reliability into its Schottky Rectifiers.

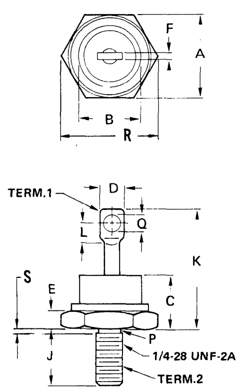
First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not mandatory. The guardring also operates like a zener to absorb over-voltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The top copper lead has a stress relief feature which protects the die during assembly. These two features give the unit the capability of passing stringent thermal fatigue tests for 5,000 cycles. The top copper lead provides a low resistance to current and therefore does not contribute to device heating; a heat sink should be used when attaching wires.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche.

HI-REL PROGRAM OPTIONS

The MBR6045 is also available with two levels of extra testing similar to "TX" screening and including Group A and B inspection programs. Both the MBR6045H and MBR6045H1 go through 100% screening consisting of high temperature storage, temperature cycling, constant acceleration and hermetic seal testing prior to a sample being submitted to Group A and B inspection. After completion of Group B inspection, the MBR6045H is available without additional screening. MBR6045H1 devices are further processed through a high temperature reverse bias (HTRB) and forward burn-in. Consult factory for details.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode-to-Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in.-lb Max

SOLDER HEAT: The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

Case 257-01
(DO-5)

MBR6035PF
MBR6045PF

MOTOROLA

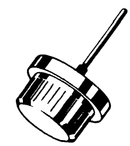
SWITCHMODE POWER RECTIFIERS

. . . using a platinum barrier metal in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectfiers in low-voltage, high frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Guaranteed Reverse Avalanche
- Guardring for dv/dt Stress Protection
- 150°C Operating Junction Temperature
- Low Forward Voltage

SCHOTTKY RECTIFIERS

60 AMPERES
35 and 45 VOLTS



CASE 43-02
(DO-21)

MAXIMUM RATINGS

Rating	Symbol	MBR6035PF	MBR6045PF	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) T_C = 100°C	I_{FRM}	← 120 →		Amps
Average Rectified Forward Current (Rated V_R) T_C = 100°C	I_O	← 60 →		Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 7	I_{RRM}	← 2.0 →		Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 800 →		Amps
Operating Junction Temperature	T_J	← −65 to + 150 →		°C
Storage Temperature	T_{stg}	← −65 to +175 →		°C
Voltage Rate of Change (Rated V_R)	dv/dt	← 1000 →		V/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.77	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 60 Amp, T_C = 25°C) (i_F = 60 Amp, T_C = 125°C) (i_F = 120 Amp, T_C = 125°C)	v_F	— 0.65 0.57 0.70	— 0.70 0.60 0.76	Volts
Instantaneous Reverse Current (1) (Rated Voltage, T_C = 25°C) (Rated Voltage, T_C = 125°C)	i_R	— 0.1 55	— 0.3 100	mA
Capacitance (V_R = 1.0 Vdc, 100 kHz ≤ 1.0 MHz)	C_t	3000	3700	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

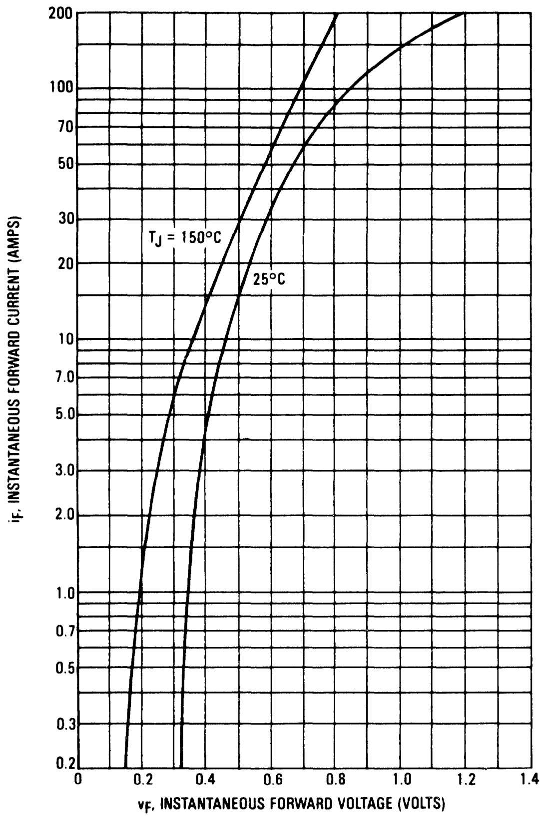


FIGURE 2 — TYPICAL REVERSE CURRENT

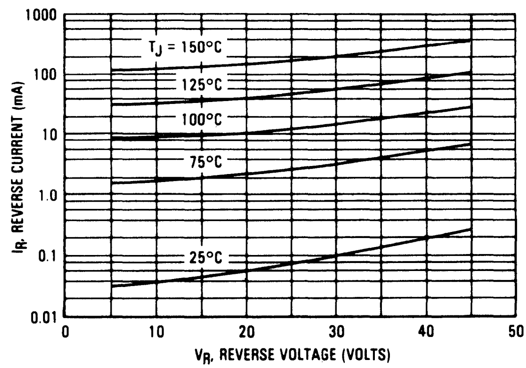


FIGURE 3 — MAXIMUM SURGE CAPABILITY

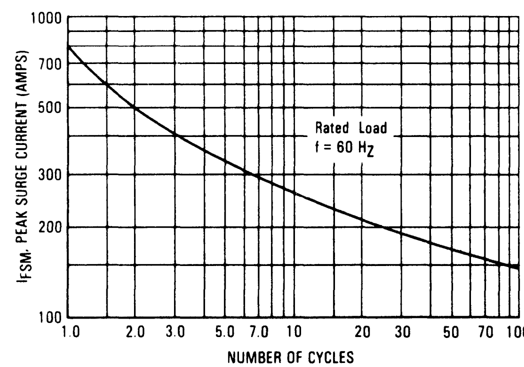
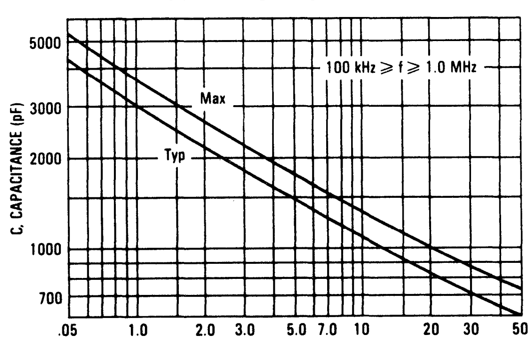


FIGURE 4 — CAPACITANCE



NOTE 1
HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 4.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 5 — FORWARD CURRENT DERATING

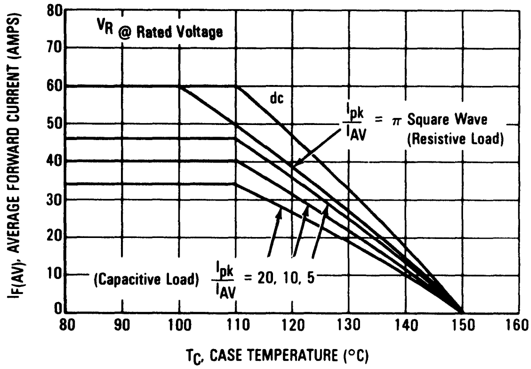
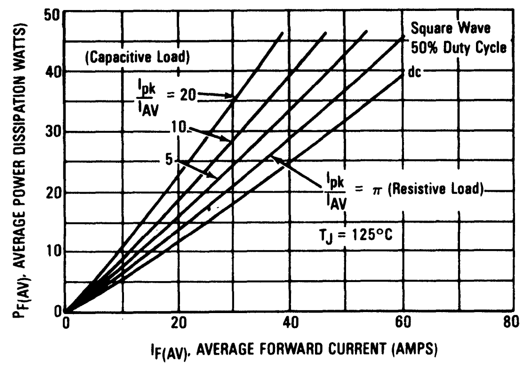


FIGURE 6 — POWER DISSIPATION



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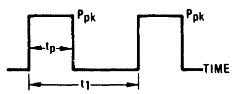
NOTE 2



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

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

where ΔT_C 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 8, i.e.:

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FIGURE 7 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT

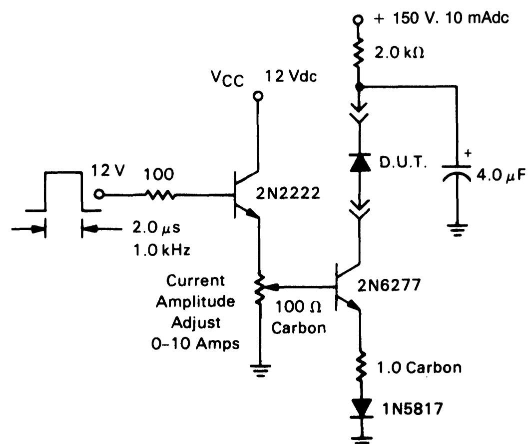
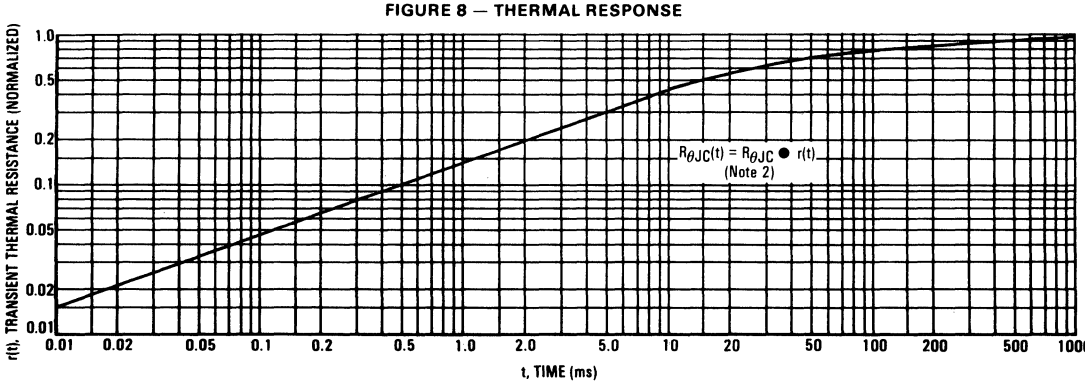


FIGURE 8 — THERMAL RESPONSE



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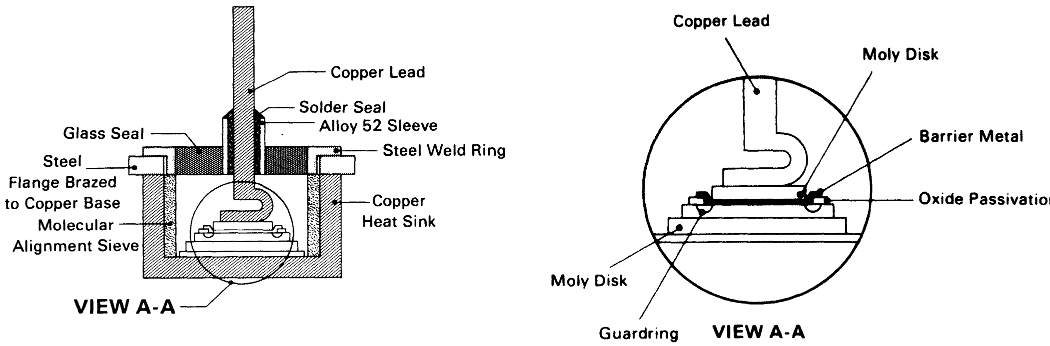

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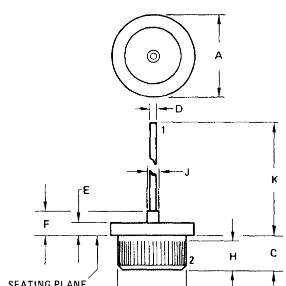


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.494	16.256	0.610	0.640
B	12.725	12.827	0.501	0.505
C	5.08	6.35	0.200	0.250
D	1.193	1.346	0.047	0.053
E	2.032	4.826	0.080	0.190
F	–	10.77	–	0.424
H	4.572	6.350	0.180	0.250
J	–	3.556	–	0.140
K	12.70	–	0.500	–

CASE 43-02
DO-21

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to Case

MOUNTING POSITION: Any

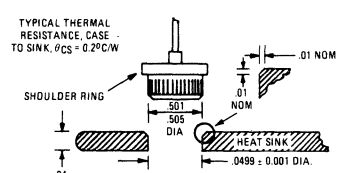
WEIGHT: 9 grams (Approximately)

MOUNTING INFORMATION

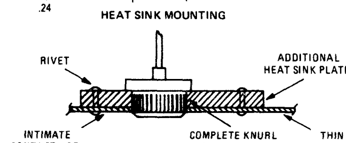
Recommended procedures for mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to provide a guide into the hole and prevent shearing off the knurled side of the rectifier.
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.
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 thermal lubricant such as D.C. 340 will be of considerable aid.

For more information see: Mounting Techniques for Metal Packaged Power Semiconductors, AN-599.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

MBR6535
MBR6545

MOTOROLA

SWITCHMODE POWER RECTIFIERS

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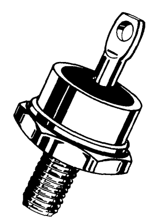
- Guaranteed Reverse Avalanche
- Guardring for dv/dt Stress Protection
- 175°C Operating Junction Temperature
- Low Forward Voltage

HIGH TEMPERATURE SCHOTTKY RECTIFIERS

65 AMPERES
35 and 45 VOLTS



CASE 257-01
DO-203AB
(DO-5)

3

CROSS-REFERENCE GUIDE

MOTOROLA	IR
MBR6535	60CDQ030
MBR6535	60CDQ035
MBR6545	60CDQ040
MBR6545	60CDQ045

MAXIMUM RATINGS

Rating	Symbol	MBR6535	MBR6545	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) T_C = 120°C	I_{FRM}	130	130	Amps
Average Rectified Forward Current (Rated V_R) T_C = 120°C	I_O	65	65	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 7	I_{RRM}	2.0	2.0	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	800	800	Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Rating	Symbol	MBR6535	MBR6545	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	MBR6535	MBR6545	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 65 Amp, T_C = 25°C) (i_F = 65 Amp, T_C = 150°C) (i_f = 130 Amp, T_C = 150°C)	v_F	 0.78 0.62 0.73	 0.78 0.62 0.73	Volts
Maximum Instantaneous Reverse Current (1) (Rated Voltage, T_C = 25°C) (Rated Voltage, T_C = 150°C)	i_R	 0.07 125	 0.07 125	mA
Capacitance (V_R = 1.0 Vdc, 100 kHz ≤ f ≤ 1.0 MHz)	C_t	3700	3700	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

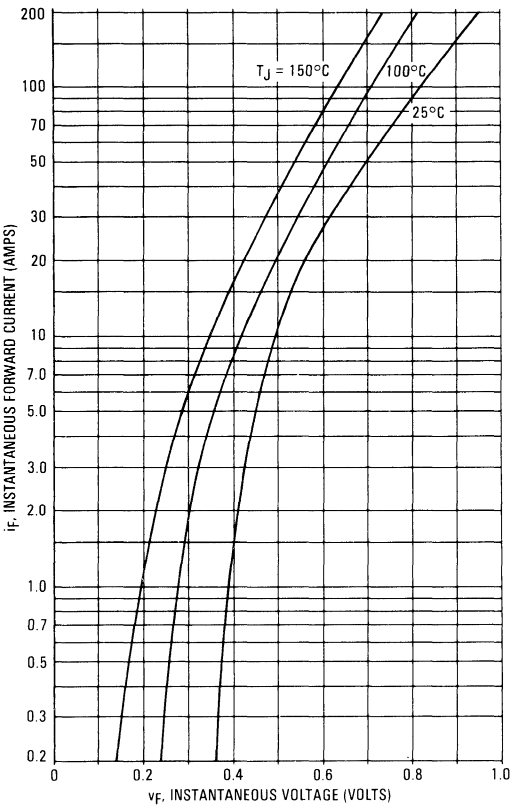


FIGURE 2 — TYPICAL REVERSE CURRENT

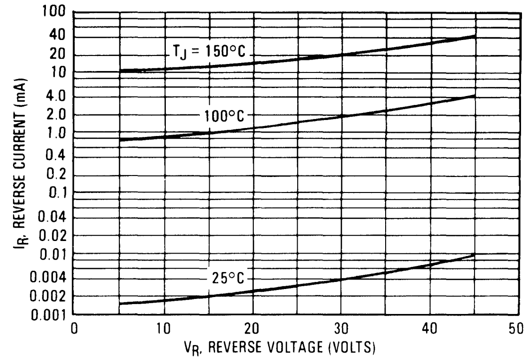
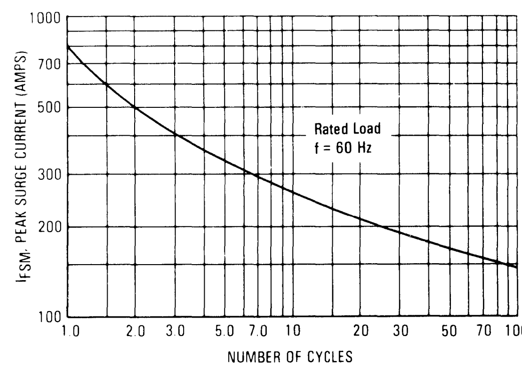


FIGURE 3 — MAXIMUM SURGE CAPABILITY



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Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 4 — CAPACITANCE

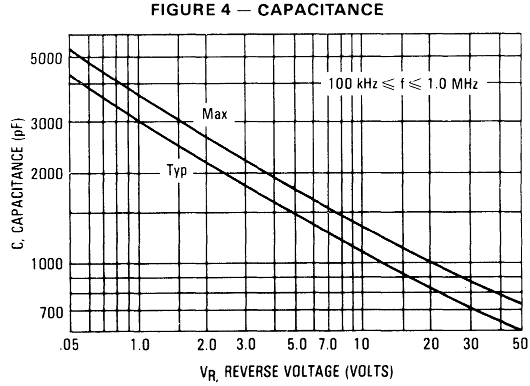

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FIGURE 5 — FORWARD CURRENT DERATING

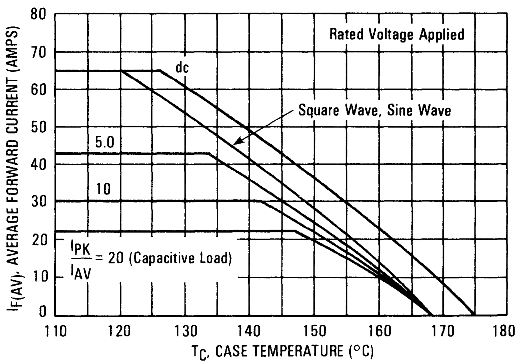
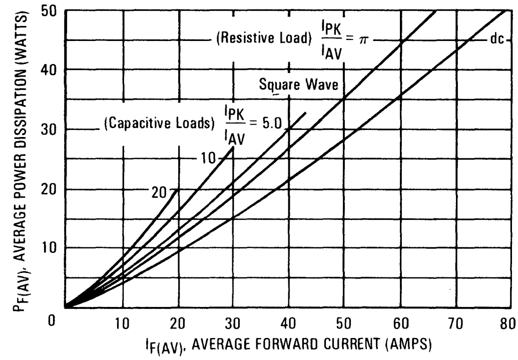
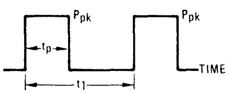


FIGURE 6 — POWER DISSIPATION



NOTE 2



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. 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_C 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 8, i.e.:

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

FIGURE 7 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT

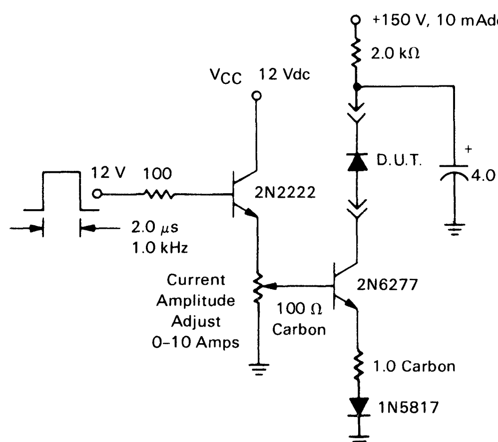


FIGURE 8 — THERMAL RESPONSE

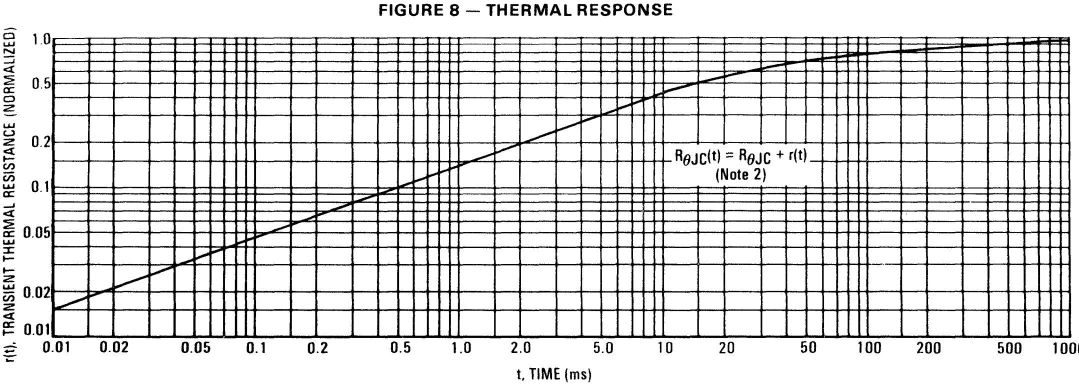
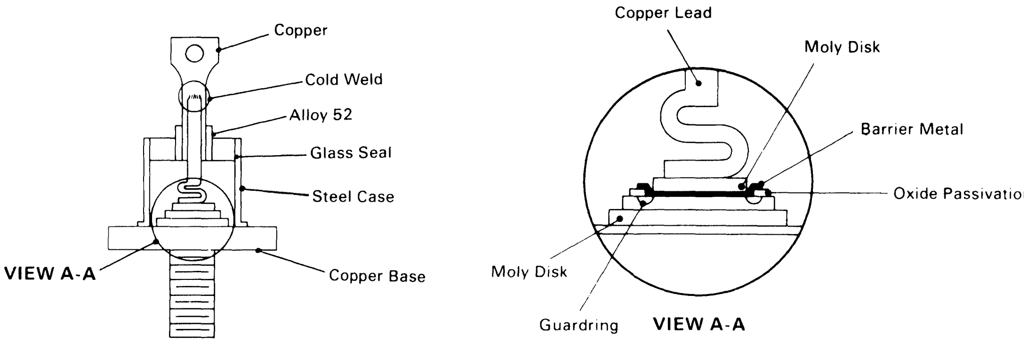


FIGURE 9 — SCHOTTKY RECTIFIER

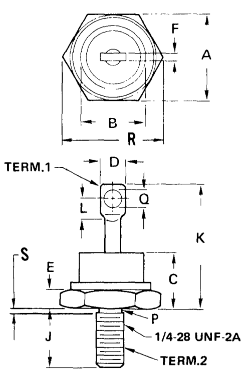


Motorola builds quality and reliability into its Schottky Rectifiers.

First is the chip, which has an interface metal between the platinum-barrier metal and nickel-gold ohmic-contact metal to eliminate any possible interaction with the barrier. The indicated guardring prevents dv/dt problems, so snubbers are not mandatory. The guardring also operates like a zener to absorb overvoltage transients.

Second is the package. There are molybdenum disks which closely match the thermal coefficient of expansion of silicon on each side of the chip. The top copper lead has a stress relief feature which protects the die during assembly. These two features give the unit the capability of passing stringent thermal fatigue tests for 5,000 cycles. The top copper lead provides a low resistance to current and therefore does not contribute to device heating; a heat sink should be used when attaching wires.

Third is the redundant electrical testing. The device is tested before assembly in "sandwich" form, with the chip between the moly disks. It is tested again after assembly. As part of the final electrical test, devices are 100% tested for dv/dt at 1,600 V/μs and reverse avalanche.



STYLE 2:
TERM. 1. ANODE
2. CATHODE (CASE)

CASE 257-01
DO-203AB
(DO-5)

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode-to-Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in.-lb Max

SOLDER HEAT: The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

3

MBR7520 MBR7530 MBR7535 MBR7540 MBR7545

MOTOROLA

SWITCHMODE POWER RECTIFIERS

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high-frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Extremely Low v_F
- Low Stored Charge, Majority Carrier Conduction
- Low Power Loss/ High Efficiency
- High Surge Capacity

SCHOTTKY BARRIER RECTIFIERS

75 AMPERES
20 to 45 VOLTS

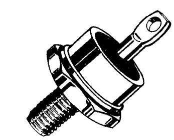
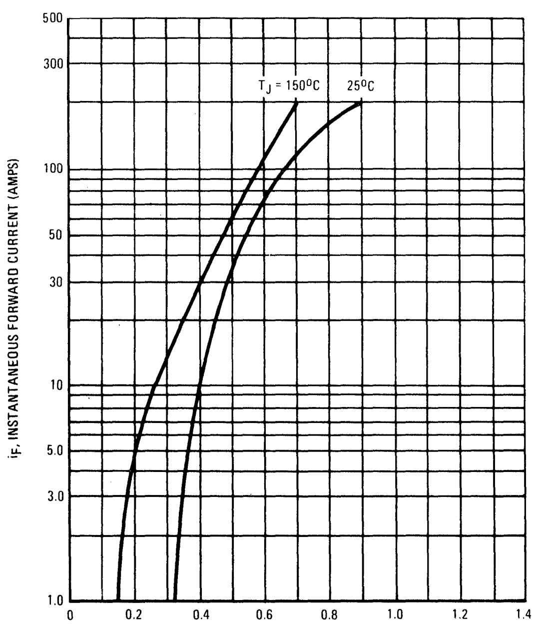
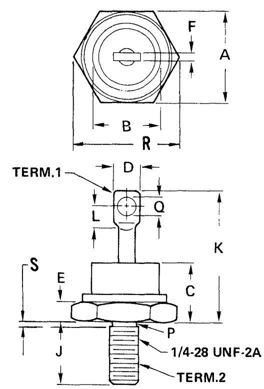


FIGURE 1 — TYPICAL FORWARD VOLTAGE





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B	–	16.94	–	0.667
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E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

CASE 257-01
DO-5

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode to case

MOUNTING POSITIONS: Any

STUD TORQUE: 25 in. lb. max

MAXIMUM RATINGS

Rating	Symbol	MBR7520	MBR7530	MBR7535	MBR7540	MBR7545	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	20	30	35	40	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz)	I_{FRM}	150 $T_C = 90^oC$					Amp
Average Rectified Forward Current (Rated V_R)	I_O	70 $T_C = 90^oC$					Amp
Non-repetitive Peak Surge Current (Surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	1000					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150					^oC
Peak Operating Junction Temperature (Forward Current Applied)	$T_{J(pk)}$	175					^oC
Voltage Rate of Change (Rated V_R)	dv/dt	1000					v/μs

THERMAL CHARACTERISTICS

Characteristic	Symbol	MBR7520	MBR7530	MBR7535	MBR7540	MBR7545	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8					$^oC/W$

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

Characteristic	Symbol	MBR7520	MBR7530	MBR7535	MBR7540	MBR7545	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 60 Amp, T_C = 125°C) (i_F = 220 Amp, T_C = 125°C)	v_F	 0.60 0.90					Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C)	i_R	100	125	150	200	250	mA
Capacitance (V_R = 5.0 Vdc, 100 kHz ≤ f ≤ 1.0 MHz)	C_t	4000					pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

FIGURE 2 – CURRENT DERATING

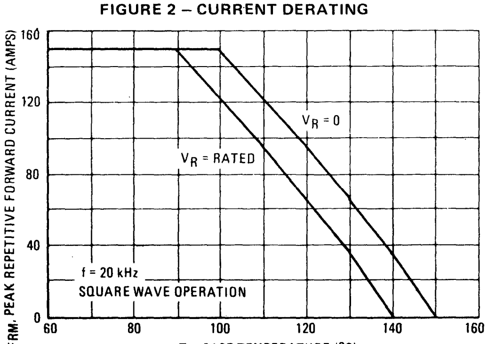
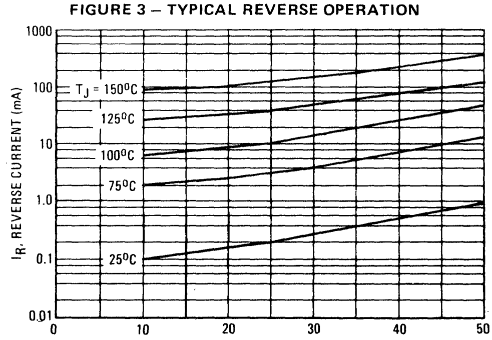


FIGURE 3 – TYPICAL REVERSE OPERATION



MBR8035
MBR8045

MOTOROLA

3

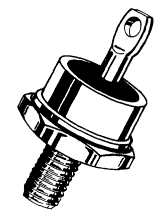
SWITCHMODE POWER RECTIFIERS

. . . using a platinum barrier metal in a large area metal-to-silicon power diode. State-of-the-art geometry features epitaxial construction with oxide passivation and metal overlap contact. Ideally suited for use as rectifiers in low-voltage, high frequency inverters, free-wheeling diodes, and polarity-protection diodes.

- Guaranteed Reverse Avalanche
- Guardring for dv/dt Stress Protection
- 175°C Operating Junction Temperature
- Low Forward Voltage

SCHOTTKY RECTIFIERS

80 AMPERES
35 and 45 VOLTS



CASE 257-01
DO-203AB
(DO-5)

CROSS-REFERENCE GUIDE

MOTOROLA	IR	TRW	UNITRODE	VARO
MBR8035	75HQ030, 85HQ030	—	USD520	—
MBR8035	75HQ035, 85HQ035	—	USD535	—
MBR8045	75HQ040, 85HQ040	SD71	USD545	VSK71
MBR8045	75HQ045, 85HQ045	SD72	—	VSK72

MAXIMUM RATINGS

Rating	Symbol	MBR8035	MBR8045	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	35	45	Volts
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz) $T_C = 120°C$	I_{FRM}	160	160	Amps
Average Rectified Forward Current (Rated V_R) $T_C = 120°C$	I_O	80	80	Amps
Peak Repetitive Reverse Surge Current (2.0 μs, 1.0 kHz) See Figure 7	I_{RRM}	2.0	2.0	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	1000	1000	Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	-65 to +175	-65 to +175	°C
Voltage Rate of Change (Rated V_R)	dv/dt	1000	1000	V/μs

THERMAL CHARACTERISTICS

Rating	Symbol	MBR8035	MBR8045	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.80	0.80	°C/W

ELECTRICAL CHARACTERISTICS

Rating	Symbol	MBR8035	MBR8045	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 80 Amp, T_C = 25°C) (i_F = 80 Amp, T_C = 150°C) (i_F = 160 Amp, T_C = 150°C)	v_F	 0.72 0.59 0.67	 0.72 0.59 0.67	Volts
Maximum Instantaneous Reverse Current (1) (Rated Voltage, T_C = 25°C) (Rated Voltage, T_C = 150°C)	i_R	 1.0 150	 1.0 150	mA
Capacitance (V_R = 1.0 Vdc, 100 kHz ≤ f ≤ 1.0 MHz)	C_t	5000	5000	pF

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

FIGURE 1 — TYPICAL FORWARD VOLTAGE

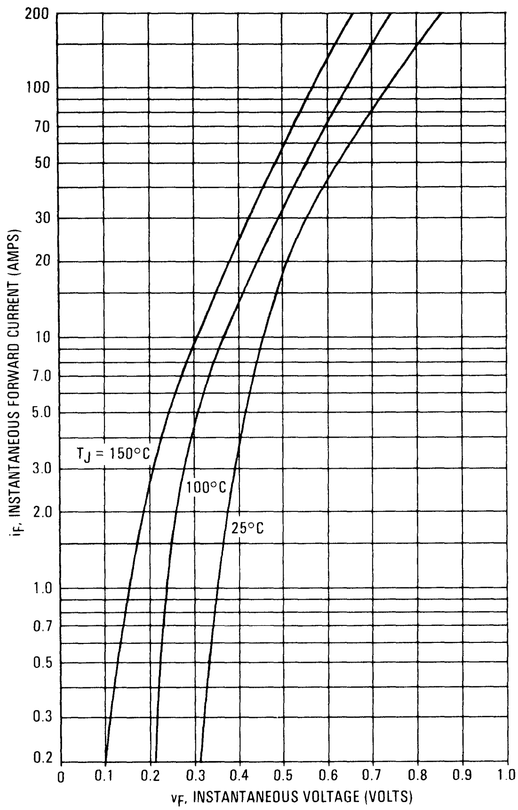


FIGURE 2 — TYPICAL REVERSE CURRENT

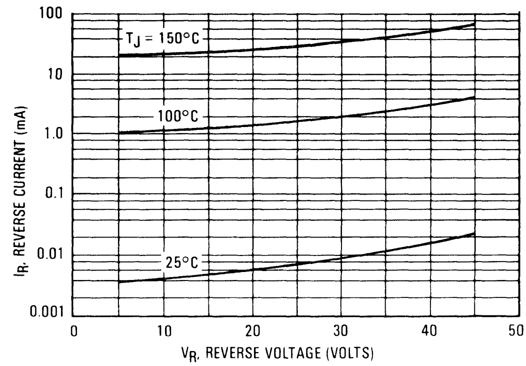
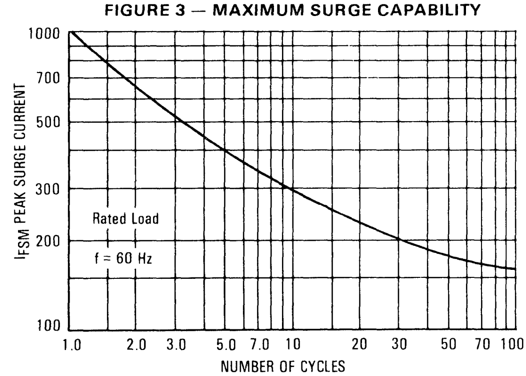


FIGURE 3 — MAXIMUM SURGE CAPABILITY

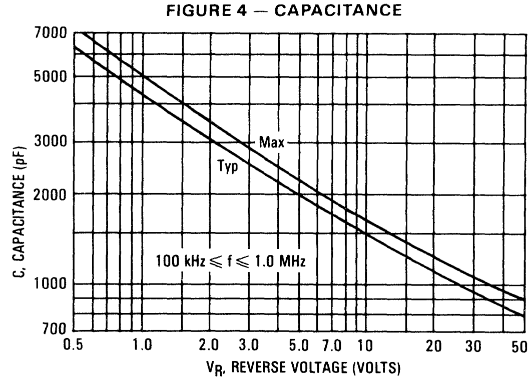


NOTE 1
HIGH FREQUENCY OPERATION

Since current flow in a Schottky rectifier is the result of majority carrier conduction, it is not subject to junction diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 4.)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance, which lowers the dc output voltage.

FIGURE 4 — CAPACITANCE



3

FIGURE 5 — FORWARD CURRENT DERATING

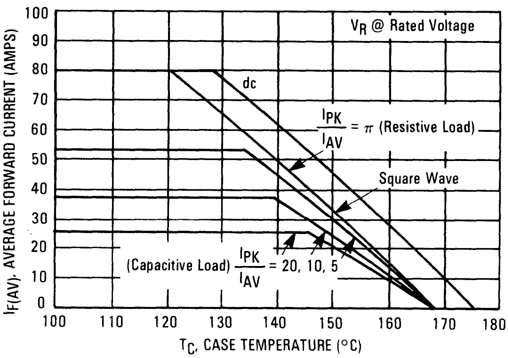
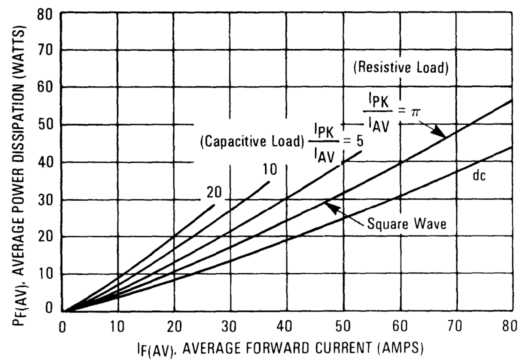
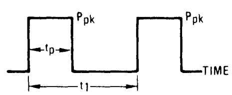


FIGURE 6 — POWER DISSIPATION



3

NOTE 2



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. 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_C 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 8, i.e.:
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 7 — TEST CIRCUIT FOR dv/dt AND REVERSE SURGE CURRENT

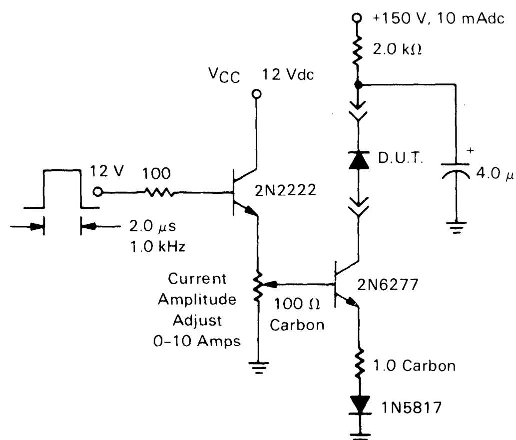
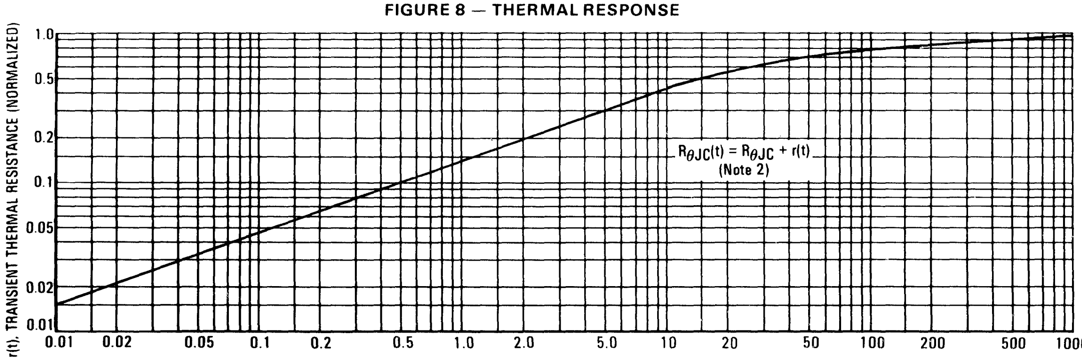


FIGURE 8 — THERMAL RESPONSE



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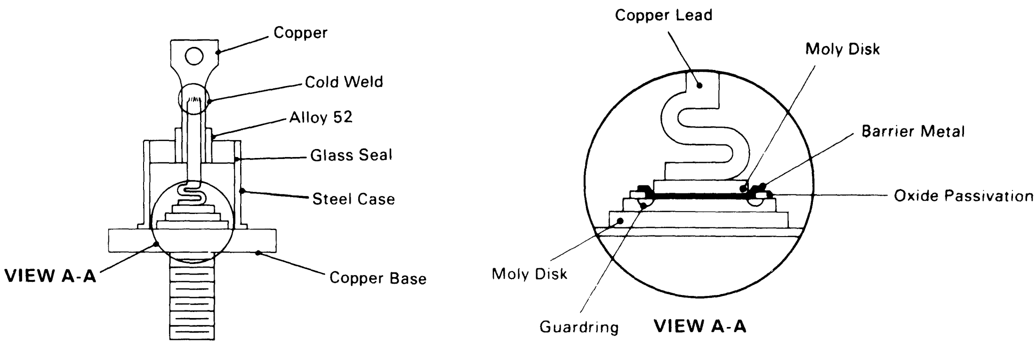

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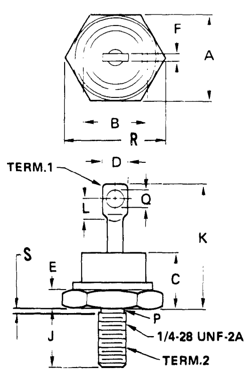

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2. CATHODE (CASE)

CASE 257-01
DO-203AB
(DO-5)

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K	–	25.40	–	1.000
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Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
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3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed

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

POLARITY: Cathode-to-Case

MOUNTING POSITION: Any

STUD TORQUE: 25 in.-lb Max

SOLDER HEAT: The excellent heat transfer property of the heavy duty copper anode terminal which transmits heat away from the die requires that caution be used when attaching wires. Motorola suggests a heat sink be clamped between the eyelet and the body during any soldering operation.

MOTOROLA

MBR12035CT
MBR12045CT
MBR12050CT
MBR12060CT

POWERTAP

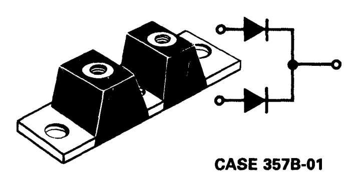
SCHOTTKY BARRIER RECTIFIERS

120 AMPERES
35 to 60 VOLTS

SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Dual Diode Construction — May Be Paralleled For Higher Current Output
- Guardring For Stress Protection
- Low Forward Voltage
- 175°C Operating Junction Temperature
- Guaranteed Reverse Avalanche



CASE 357B-01
POWERTAP

3

MAXIMUM RATINGS

Rating		Symbol	Max	Unit
Peak Repetitive Reverse Voltage	MBR12035CT	V_{RRM}	35	Volts
	MBR12045CT		45	
Working Peak Reverse Voltage	MBR12050CT	V_{RWM}	50	
DC Blocking Voltage	MBR12060CT	V_R	60	
Average Rectified Forward Current (Rated V_R) $T_C = 140°C$	Per Device	$I_{F(AV)}$	120	Amps
	Per Leg		60	
Peak Repetitive Forward Current, Per Leg (Rated V_R, Square Wave, 20 kHz), $T_C = 140°C$		I_{FRM}	120	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	800	Amps
Peak Repetitive Reverse Current, Per Leg (2.0 μs, 1.0 kHz) See Figure 6		I_{RRM}	2.0	Amps
Operating Junction and Storage Temperature		T_J, T_{stg}	−65 to +175	°C
Voltage Rate of Change (Rated V_R)		dv/dt	1000	V/μs

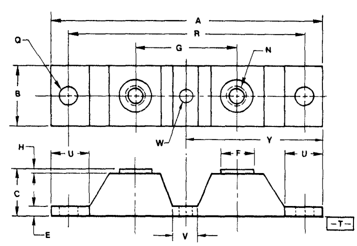
THERMAL CHARACTERISTICS PER LEG

Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.85	°C/W

ELECTRICAL CHARACTERISTICS PER LEG

Instantaneous Forward Voltage (1)	v_F		Volts
(i_F = 60 Amp, T_J = 125°C)		0.590	
(i_F = 120 Amp, T_J = 175°C)		0.620	
(i_F = 120 Amp, T_J = 125°C)		0.680	
(i_F = 120 Amp, T_J = 25°C)		0.830	
Instantaneous Reverse Current (1)	i_R		mA
(Rated dc Voltage, T_J = 125°C)		25	
(Rated dc Voltage, T_J = 25°C)		0.25	

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
PowerTap and Switchmode are trademarks of Motorola Inc.



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND -T- IS A DATUM SURFACE AND SEATING PLANE.
2. POSITIONAL TOLERANCE FOR N HOLES.
   | ⌖ | ϕ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ |
3. POSITIONAL TOLERANCE FOR Q AND W HOLES:
   | ⌖ | ϕ 0.25 (0.010) Ⓜ | T | A Ⓜ | B Ⓜ |
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	92.20	–	3.630
B	17.78	20.32	0.700	0.800
C	–	15.87	–	0.625
E	3.05	3.30	0.120	0.130
F	12.45	12.95	0.490	0.510
G	34.92 BSC		1.375 BSC	
H	–	1.27	–	0.050
N	—		1/4-20 UNC	
Q	6.86	7.11	0.270	0.280
R	80.01 BSC		3.150 BSC	
U	15.24	–	0.600	–
V	8.38	8.89	0.330	0.350
W	4.32	4.82	0.170	0.190
Y	46.10 BSC		1.815 BSC	

CASE 357B-01

Terminal Penetration	0.280 Max.
Terminal Torque	25–50 lb.-in.
Mounting Base Torque	30–40 lb.-in.

FIGURE 1 — TYPICAL FORWARD VOLTAGE PER LEG

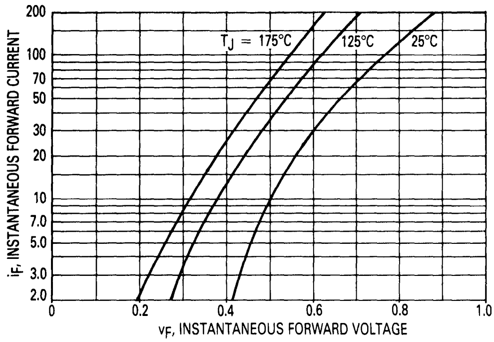


FIGURE 2 — TYPICAL REVERSE CURRENT, PER LEG*

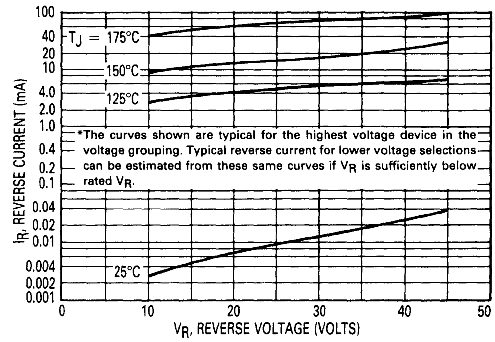


FIGURE 3 — FORWARD CURRENT DERATING, PER LEG

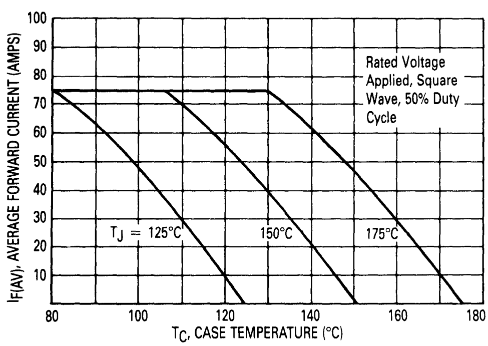


FIGURE 4 — POWER DISSIPATION PER LEG

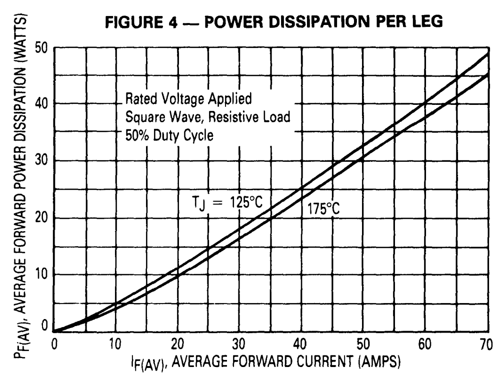


FIGURE 5 — TYPICAL CAPACITANCE, PER LEG

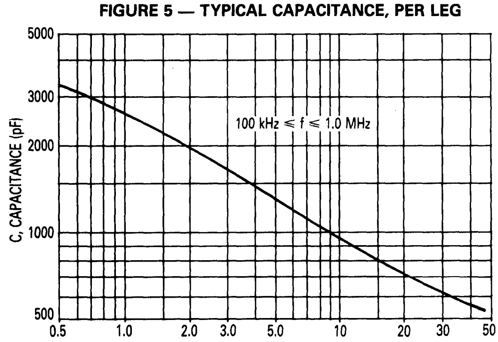
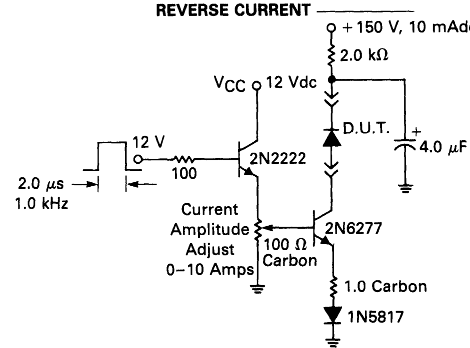


FIGURE 6 — TEST CIRCUIT FOR REPETITIVE REVERSE CURRENT



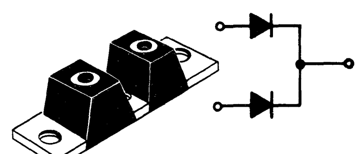
MBR20035CT
MBR20045CT
MBR20050CT
MBR20060CT

MOTOROLA

3

SCHOTTKY BARRIER RECTIFIERS

200 AMPERES
35 to 60 VOLTS



CASE 357B-01

POWERTAP®

SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Dual Diode Construction — May Be Paralleled For Higher Current Output
- Guardring For Stress Protection
- Low Forward Voltage
- 175°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

MAXIMUM RATINGS

Rating		Symbol	Max	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	MBR20035CT MBR20045CT MBR20050CT MBR20060CT	V_{RRM} V_{RWM} V_R	35 45 50 60	Volts
Average Rectified Forward Current (Rated V_R) $T_C = 140°C$	Per Device Per Leg	$I_{F(AV)}$	200 100	Amps
Peak Repetitive Forward Current, Per Leg (Rated V_R, Square Wave, 20 kHz), $T_C = 140°C$		I_{FRM}	200	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	1500	Amps
Peak Repetitive Reverse Current, Per Leg (2.0 μs, 1.0 kHz) See Figure 6		I_{RRM}	2.0	Amps
Operating Junction and Storage Temperature		T_J, T_{stg}	−65 to +175	°C
Voltage Rate of Change (Rated V_R)		dv/dt	1000	V/μs

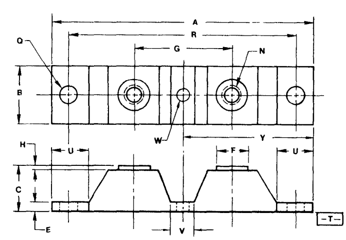
THERMAL CHARACTERISTICS PER LEG

Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.5	°C/W

ELECTRICAL CHARACTERISTICS PER LEG

Instantaneous Forward Voltage (1) (i_F = 200 Amp, T_J = 175°C) (i_F = 200 Amp, T_J = 125°C) (i_F = 100 Amp, T_J = 125°C) (i_F = 100 Amp, T_J = 25°C)	v_F	 0.650 0.825 0.710 0.800	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_J = 125°C) (Rated dc Voltage, T_J = 25°C)	i_R	 50 0.5	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
PowerTap and Switchmode are trademarks of Motorola Inc.



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE AND SEATING PLANE.
2. POSITIONAL TOLERANCE FOR N HOLES:
   ⌖ | ⌀ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ
3. POSITIONAL TOLERANCE FOR Q AND W HOLES:
   ⌖ | ⌀ 0.25 (0.010) Ⓜ | T | A Ⓜ | B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	92.20	–	3.630
B	1.77	2.32	0.700	0.800
C	–	15.87	–	0.625
E	3.05	3.30	0.120	0.130
F	12.45	12.95	0.490	0.510
G	34.92 BSC		1.375 BSC	
H	–	1.27	–	0.050
N	–	–	1/4-20 UNC	
Q	6.86	7.11	0.270	0.280
R	80.01 BSC		3.150 BSC	
U	15.24	–	0.600	–
V	8.38	8.89	0.330	0.350
W	4.32	4.83	0.170	0.190
Y	40.00 BSC		1.575 BSC	

CASE 357B-01

Terminal Penetration	0.280 in. Max.
Terminal Torque	25–75 lb.-in.
Mounting Base Torque	30–40 lb.-in.

FIGURE 1 — TYPICAL FORWARD VOLTAGE, PER LEG

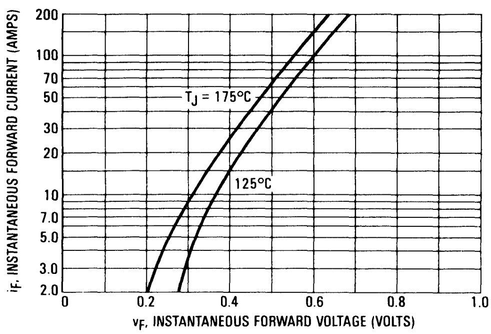


FIGURE 2 — TYPICAL REVERSE CURRENT, PER LEG

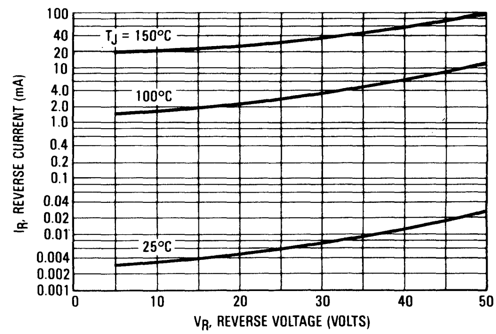


FIGURE 3 — FORWARD CURRENT DERATING, PER LEG

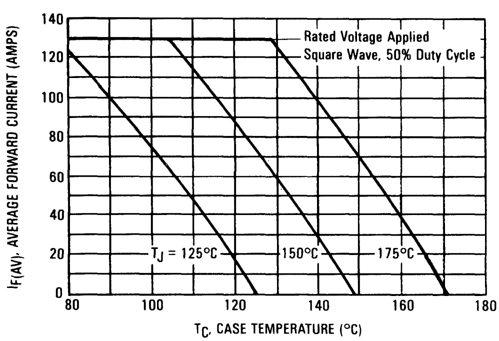


FIGURE 4 — POWER DISSIPATION, PER LEG

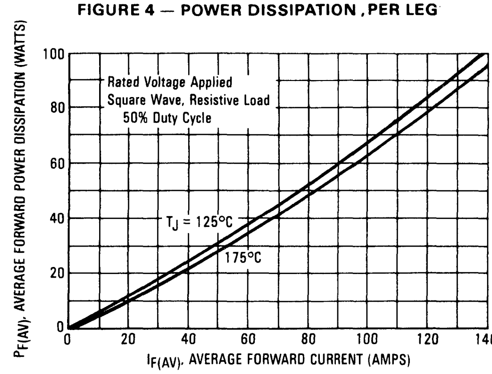


FIGURE 5 — CAPACITANCE, PER LEG

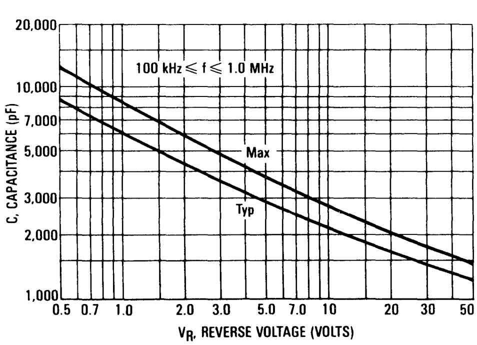
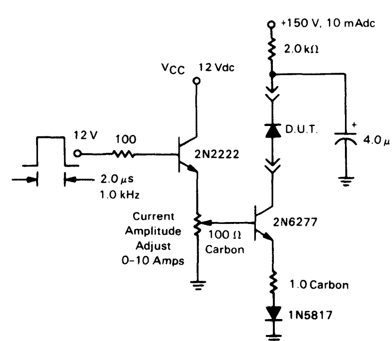


FIGURE 6 — TEST CIRCUIT FOR REPETITIVE REVERSE CURRENT



MBR30035CT
MBR30045CT

MOTOROLA

Advance Information

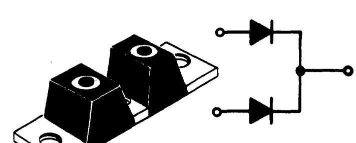
SWITCHMODE POWER RECTIFIERS

. . . using the Schottky Barrier principle with a platinum barrier metal. These state-of-the-art devices have the following features:

- Dual Diode Construction — May Be Paralleled For Higher Current Output
- Guardring For Stress Protection
- Low Forward Voltage
- 175°C Operating Junction Temperature
- Guaranteed Reverse Avalanche

SCHOTTKY BARRIER RECTIFIERS

300 AMPERES
35 to 45 VOLTS



CASE 357B-01

Power Tap®

3

MAXIMUM RATINGS

Rating		Symbol	Maximum	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	MBR30035CT MBR30045CT	V_{RRM} V_{RWM} V_R	35 45	Volts
Average Rectified Forward Current (Rated V_R) T_C = 140°C	Per Device Per Leg	$I_{F(AV)}$	300 150	Amps
Peak Repetitive Forward Current, Per Leg (Rated V_R, Square Wave, 20 kHz), T_C = 140°C		I_{FRM}	300	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	2500	Amps
Peak Repetitive Reverse Current, Per Leg (2.0 μs, 1.0 kHz) See Figure 6		I_{RRM}	2.0	Amps
Operating Junction and Storage Temperature		T_J, T_{stg}	-65 to +175	°C
Voltage Rate of Change (Rated V_R)		dv/dt	1000	V/μs

THERMAL CHARACTERISTICS PER LEG

Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.4	°C/W

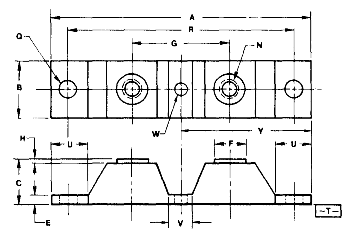
ELECTRICAL CHARACTERISTICS PER LEG

Instantaneous Forward Voltage (1) (i_F = 150 Amp, T_C = 125°C) (i_F = 300 Amp, T_C = 125°C) (i_F = 300 Amp, T_C = 25°C)	v_F	 0.570 0.615 0.780	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 75 0.8	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

Power Tap and Switchmode are trademarks of Motorola Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE AND SEATING PLANE.
2. POSITIONAL TOLERANCE FOR N HOLES: | ⌖ | ∅ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ |
3. POSITIONAL TOLERANCE FOR Q AND W HOLES: | ⌖ | ∅ 0.25 (0.010) Ⓜ | T | A Ⓜ | B Ⓜ |
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	–	92.20	–	3.630
B	1.77	2.32	0.700	0.800
C	–	15.87	–	0.625
E	3.05	3.30	0.120	0.130
F	12.45	12.95	0.490	0.510
G	34.92 BSC		1.375 BSC	
H	–	1.27	–	0.050
N	–	–	1/4-20 UNC	
Q	6.86	7.11	0.270	0.280
R	80.01 BSC		3.150 BSC	
U	15.24	–	0.600	–
V	8.38	8.89	0.330	0.350
W	4.32	4.83	0.170	0.190
Y	40.00 BSC		1.575 BSC	

CASE 357B-01

Terminal Penetration	**0.280″ Max.**
Terminal Torque	**25–75 lb.-in.**
Mounting Base Torque	**30–40 lb.-in.**

FIGURE 1 — TYPICAL FORWARD VOLTAGE (PER LEG)

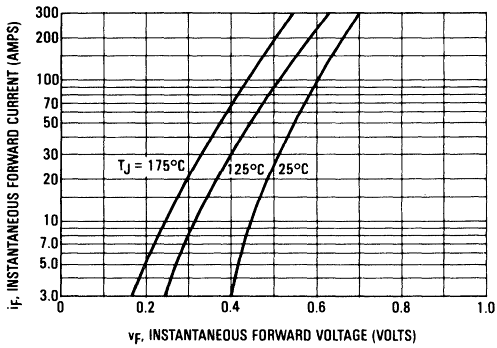


FIGURE 2 — TYPICAL REVERSE CURRENT (PER LEG)

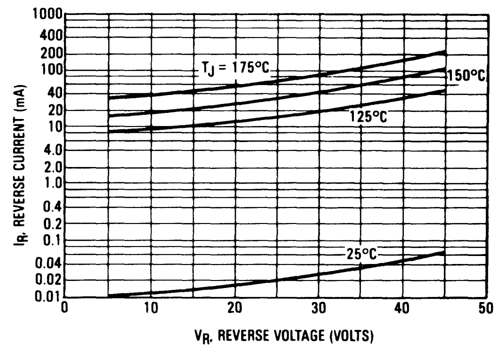


FIGURE 3 — CURRENT DERATING (PER LEG)

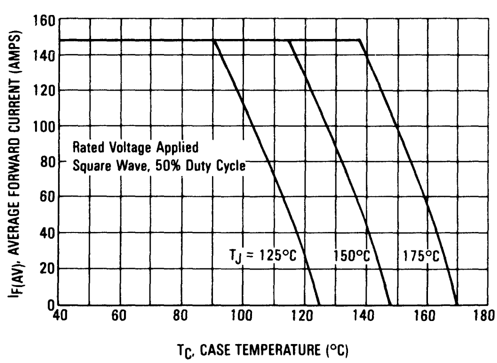


FIGURE 4 — POWER DISSIPATION (PER LEG)

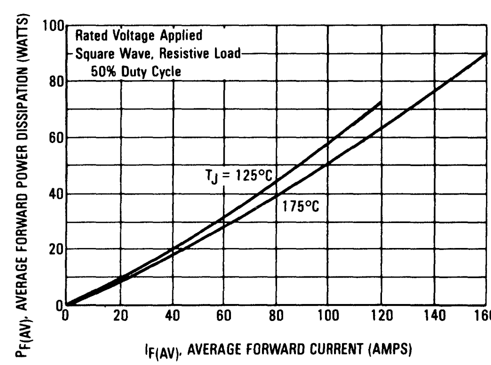


FIGURE 5 — CAPACITANCE (PER LEG)

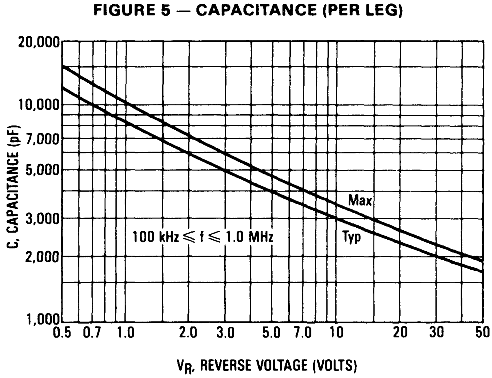
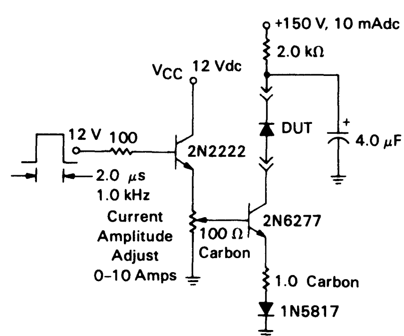


FIGURE 6 — TEST CIRCUIT FOR REPETITIVE REVERSE CURRENT



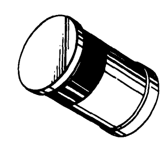
MBRL030
MBRL040

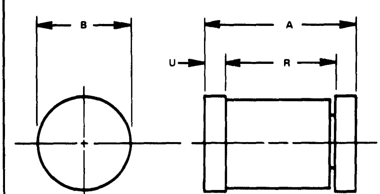
MOTOROLA

Advance Information

LEADLESS SCHOTTKY RECTIFIERS

0.5 AMPERE
30–40 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

SWITCHMODE RECTIFIERS

. . . designed for use in switching power supplies, inverters, and as free wheeling diodes, these devices have the following features:

- Low Forward Voltage
- Low Leakage Current
- Leadless Package for Surface Mount Technology

MAXIMUM RATINGS

Rating	Symbol	MBRL030	MBRL040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	30	40	Volts
Average Rectified Forward Current (Rated V_R) T_C = 75°C, T_A = 50°C, Mounting Per Note 1	$I_{F(AV)}$	 0.5 0.5		Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	5.0		Amps
Operating Junction and Storage Temperature	T_J, T_{stg}	−65 to +150		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to End Cap	$R_{\theta JC}$	180	190	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Foward Voltage (1) (i_F = 0.1 A, T_J = 25°C) (i_F = 0.5 A, T_J = 25°C)	v_F	 0.460 0.610	 0.500 0.650	Volts
Reverse Current (Rated dc Voltage, T_J = 125°C) (Rated dc Voltage, T_J = 25°C)	i_R	 0.6 0.003	 1.0 0.005	mA

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
Switchmode is a trademark of Motorola Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.

MECHANICAL CHARACTERISTICS

CASE: Glass

FINISH: End caps are plated and are readily solderable

POLARITY: Cathod indicated by polarity band.

WEIGHT: 0.2 Gram (approximately).

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, @ end cap for 10 seconds.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

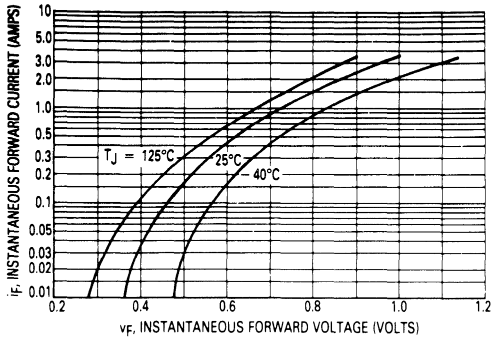


FIGURE 2 — CURRENT DERATING, PRINTED CIRCUIT BOARD MOUNTING

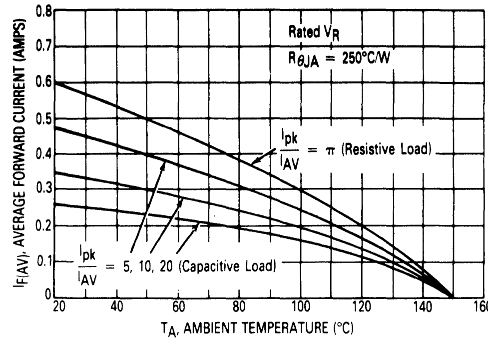


FIGURE 3 — TYPICAL CAPACITANCE

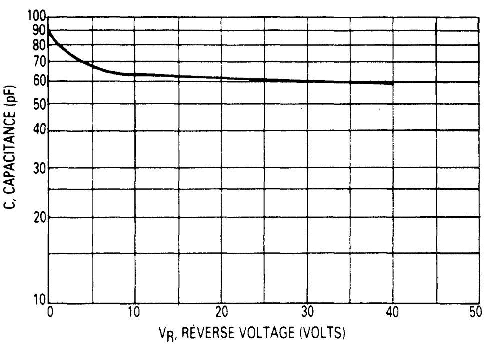


FIGURE 4 — CURRENT DERATING, END CAP TEMPERATURE

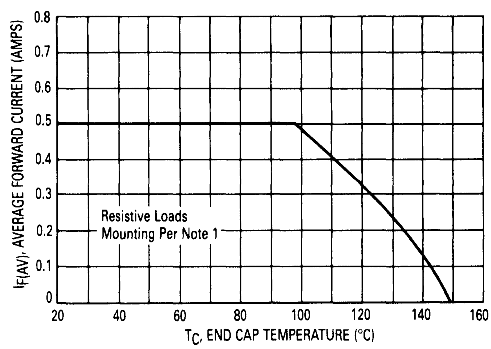
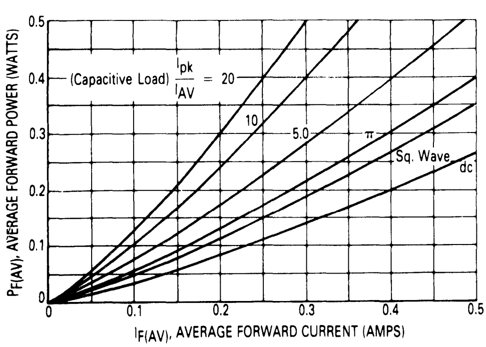


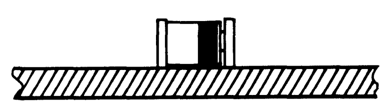
FIGURE 5 — FORWARD POWER DISSIPATION



NOTE 1

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

TYPICAL VALUES FOR θ_{JA} IN STILL AIR = 250°C/W



PC Board with 1½″ x 1½″ Copper Surface

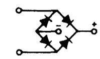
MDA100A series (3N246 thru 3N252)

MOTOROLA

MINIATURE INTEGRAL DIODE ASSEMBLIES

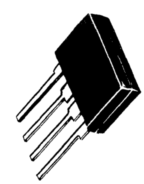
. . . with silicon rectifier chips interconnected and encapsulated into voidless rectifier bridge circuits.

- High Resistance to Shock and Vibration
- High Dielectric Strength
- Built-In Printed Circuit Board Stand-Offs
- UL Recognized
- $R\theta_{JA}$ = 60°C/W



SINGLE-PHASE FULL-WAVE BRIDGE

1.0 AMPERE
50-1000 VOLTS



3

MAXIMUM RATINGS

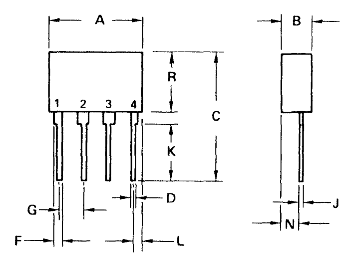
Rating (Per Diode)	Symbol	3N246 MDA100A	3N247 MDA101A	3N248 MDA102A	3N249 MDA104A	3N250 MDA106A	3N251 MDA108A	3N252 MDA110A	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 32 50	 64 100	 127 200	 255 400	 382 600	 510 800	 640 1000	 Volts Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge operation, resistive load, 60 Hz, T_A = 75°C)	I_O	← 1.0 →							Amp
Non-Repetitive Peak Surge Current (Preceded and followed by rated current and voltage, T_A = 75°C)	I_{FSM}	← 30 (for 1 cycle) →							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -55 to +150 →							°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) (i_F = 1.57 Amp, T_J = 25°C)	v_F	1.15	1.3	Volts
Reverse Current (Per Diode) (Rated V_R, T_A = 25°C)	I_R	–	10	µA

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
POLARITY: Terminal-designation on case
Pin 1 (+) for DC output
Pin 4 (–) for DC output
Pins 2 and 3 (AC) for AC input
MOUNTING POSITION: Any
WEIGHT: 1.8 grams (approx)
TERMINALS: Readily solderable connections, corrosion resistant.



STYLE 1:
TERM 1. POS
2. AC
3. AC
4. NEG

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.99	15.49	0.590	0.610
B	4.57	5.08	0.180	0.200
C	–	20.57	–	0.810
D	0.76	1.02	0.030	0.040
F	1.02	1.27	0.040	0.050
G	3.68	3.94	0.145	0.155
J	0.56	0.71	0.022	0.028
K	–	9.02	–	0.355
L	1.78	2.03	0.070	0.080
N	2.54	2.79	0.100	0.110
R	9.40	10.03	0.370	0.395

CASE 312-02

MAXIMUM RATINGS, BRIDGE OPERATION

FIGURE 1 – CURRENT DERATING

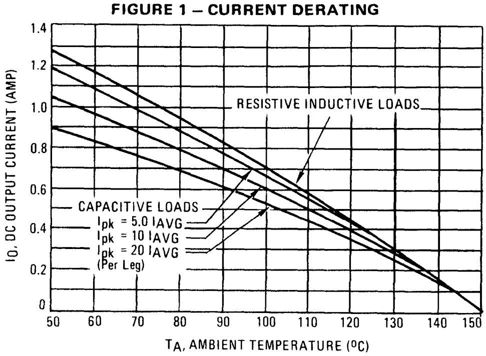


FIGURE 2 – POWER DISSIPATION

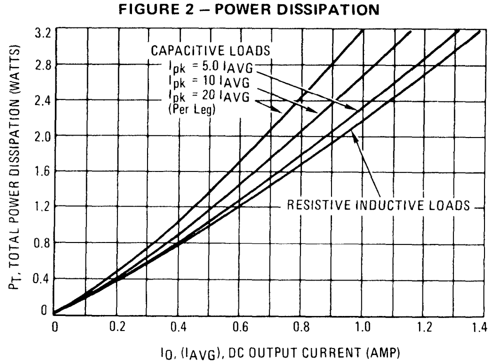
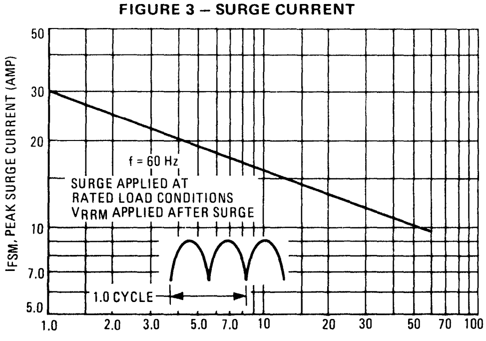


FIGURE 3 – SURGE CURRENT



SINGLE DIODE CHARACTERISTICS

FIGURE 4 – MAXIMUM FORWARD VOLTAGE

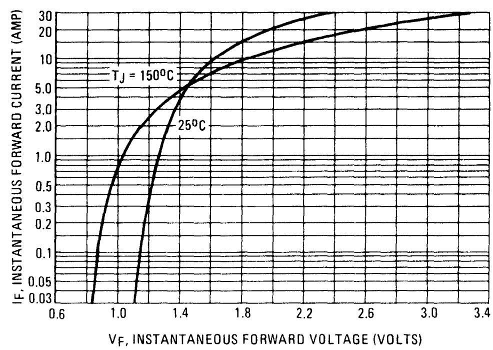


FIGURE 5 – FORWARD RECOVERY TIME

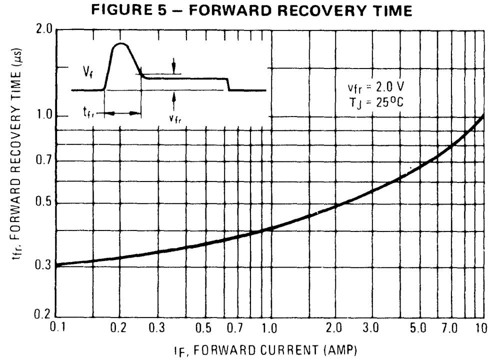
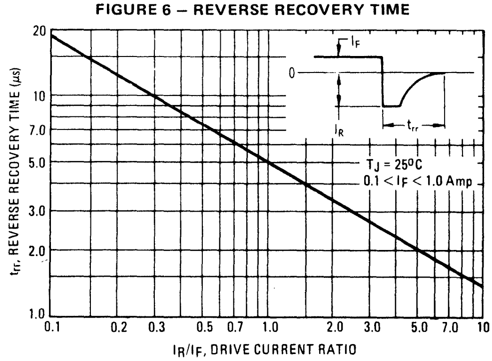


FIGURE 6 – REVERSE RECOVERY TIME



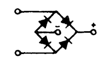
MDA200 series (3N253 thru 3N259)

MOTOROLA

MINIATURE INTEGRAL DIODE ASSEMBLIES

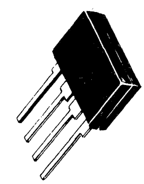
. . . with silicon rectifier chips interconnected and encapsulated into voidless rectifier bridge circuits.

- High Resistance to Shock and Vibration
- High Dielectric Strength
- Built-In Printed Circuit Board Stand-Offs
- UL Recognized
- $R\Theta_{JA} = 60°C/W$



SINGLE-PHASE FULL-WAVE BRIDGE

2.0 AMPERES
50-1000 VOLTS



3

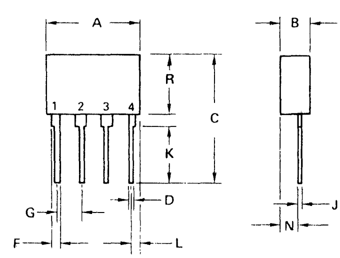
MAXIMUM RATINGS Rating (Per Diode)	Symbol	3N253 MDA200	3N254 MDA201	3N255 MDA202	3N256 MDA204	3N257 MDA206	3N258 MDA208	3N259 MDA210	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 32 50	 64 100	 127 200	 255 400	 382 600	 510 800	 640 1000	 Volts Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge operation, resistive load, 60 Hz, $T_A = 55°C$)	I_O	← 2.0 →							Amp
Non-Repetitive Peak Surge Current (Preceded and followed by rated current and voltage, $T_A = 55°C$)	I_{FSM}	← 60 (for 1 cycle) →							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -55 to +165 →							°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) ($i_F = 3.14$ Amp, $T_J = 25°C$)	v_F	1.0	1.1	Volts
Reverse Current (Per Diode) (Rated V_R, $T_A = 25°C$)	I_R	–	10	μA

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
POLARITY: Terminal-designation on case
Pin 1 (+) for DC output
Pin 4 (–) for DC output
Pins 2 and 3 (AC) for AC input
MOUNTING POSITION: Any
WEIGHT: 1.8 grams (approx)
TERMINALS: Readily solderable connections, corrosion resistant.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	14.99	15.49	0.590	0.610
B	4.57	5.08	0.180	0.200
C	–	20.57	–	0.810
D	0.76	1.02	0.030	0.040
F	1.02	1.27	0.040	0.050
G	3.68	3.94	0.145	0.155
J	0.56	0.71	0.022	0.028
K	–	9.02	–	0.355
L	1.78	2.03	0.070	0.080
N	2.54	2.79	0.100	0.110
R	9.40	10.03	0.370	0.395

CASE 312-02

MAXIMUM RATINGS, BRIDGE OPERATION

FIGURE 1 — CURRENT DERATING

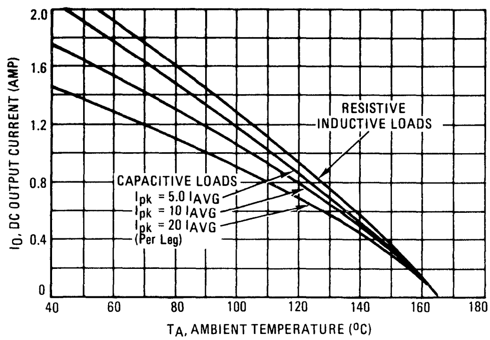


FIGURE 2 — POWER DISSIPATION

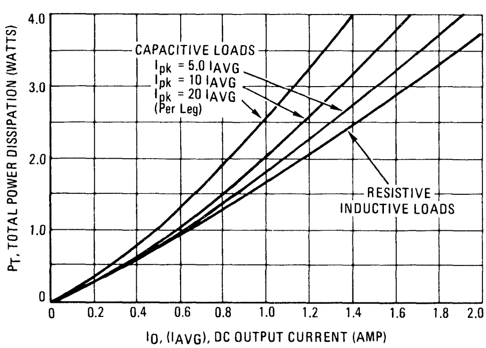
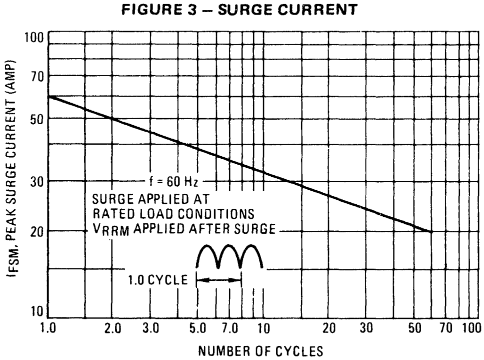


FIGURE 3 — SURGE CURRENT



SINGLE DIODE CHARACTERISTICS

FIGURE 4 — MAXIMUM FORWARD VOLTAGE

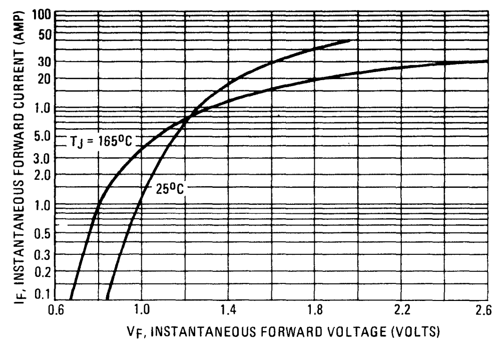


FIGURE 5 — FORWARD RECOVERY TIME

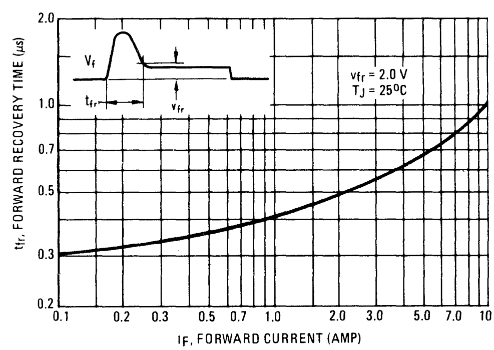
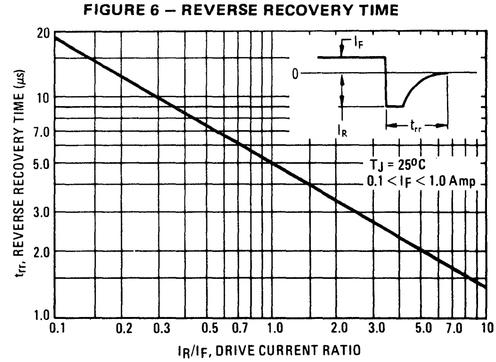


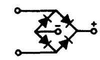
FIGURE 6 — REVERSE RECOVERY TIME



MDA920A1
thru
MDA920A9

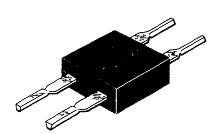
MOTOROLA

Designers Data Sheet



SINGLE-PHASE FULL-WAVE BRIDGE

1.5 AMPERES
25–1000 VOLTS



MINIATURE INTEGRAL DIODE ASSEMBLIES

. . . passivated, diffused-silicon dice interconnected and transfer molded into voidless hybrid rectifier circuit assemblies.

- Large Inrush Surge Capability – 45 A (For 1.0 Cycle)
- Efficient Thermal Management Provides Maximum Power Handling in Minimum Space

Designers Data for "Worst Case" Conditions

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

3

MAXIMUM RATINGS

Rating (Per Leg)	Symbol	A1	A2	A3	A4	A5	A6	A7	A8	A9	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	25	50	100	200	300	400	600	800	1000	Volts
DC Output Voltage Resistive Load	Vdc	15	30	62	124	185	250	380	500	620	Volts
Capacitative Load	Vdc	25	50	100	200	300	400	600	800	1000	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	18	35	70	140	210	280	420	560	700	Volts
Average Rectified Forward Current (single phase bridge resistive load, 60 Hz, see Figure 6, $T_A = 50°C$	I_O	← 1.5 →									Amp
Non-Repetitive Peak Surge Current, (see Figure 2) rated load, $T_J = 175°C$	I_{FSM}	← 45 for 1 cycle →									Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -55 to +175 →									°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (Per Leg) (i_F = 2.4 Amp, T_J = 25°C) Figure 1	v_F	1.2	Volts
Maximum Reverse Current (Rated dc Voltage across ac terminals, T_J = 25°C)	I_R	20	μA

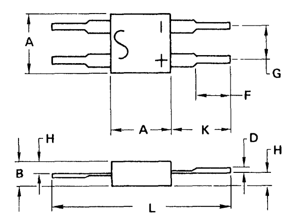
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Effective Bridge Thermal Resistance, Junction to Ambient (Full-Wave Bridge Operation, Typical Printed Circuit Board Mounting)	$R_{\theta JA}$	50	°C/W

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation.
POLARITY: Terminal-designation embossed on case +DC output
-DC output
~AC input

MOUNTING POSITION: Any
WEIGHT: 1.0 gram (approx)
TERMINALS: Readily solderable connections, corrosion resistant.



NOTES:
1. LEAD DIM "D" TO BE MEASURED WITHIN "F"
2. LEADS FORMED TO FIT INTO HOLE 0.94 mm (0.037) MIN.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	6.10	6.73	0.240	0.265
B	2.29	2.79	0.090	0.110
D	0.51	0.94	0.020	0.037
F	3.56	6.35	0.140	0.250
G	3.68	3.94	0.145	0.155
H	1.02	1.27	0.040	0.050
K	6.60	10.16	0.260	0.400
L	19.30	27.05	0.760	1.065

CASE 109-03

FIGURE 1 — FORWARD VOLTAGE (PER LEG)

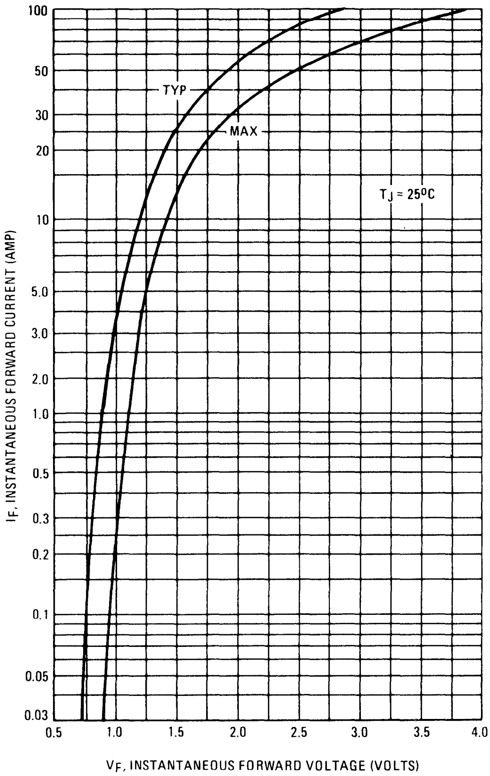


FIGURE 2 — MAXIMUM SURGE CAPABILITY

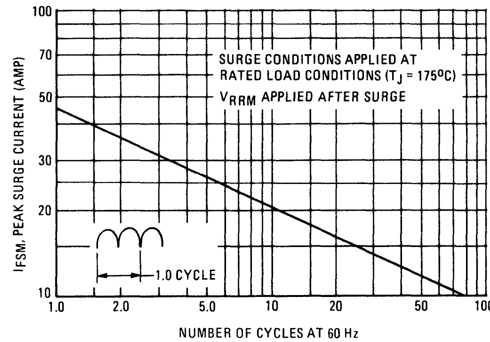


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

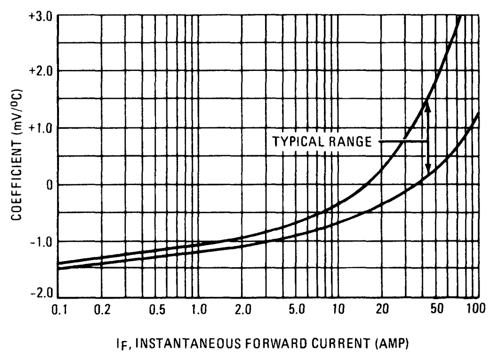


FIGURE 4 — TYPICAL THERMAL RESPONSE

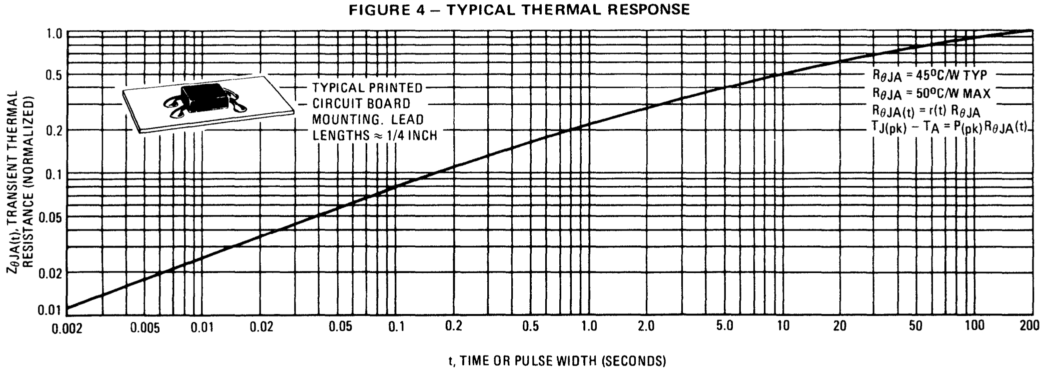


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FIGURE 5 – POWER DISSIPATION

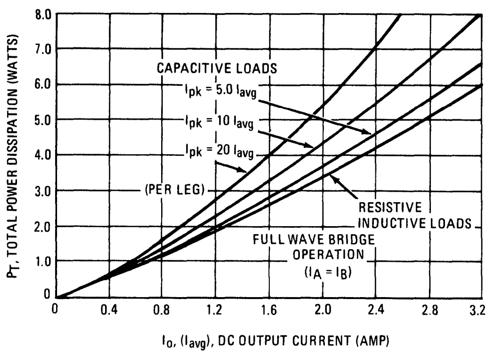


FIGURE 6 – CURRENT DERATING

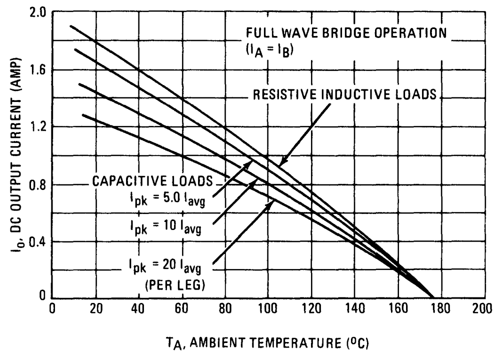
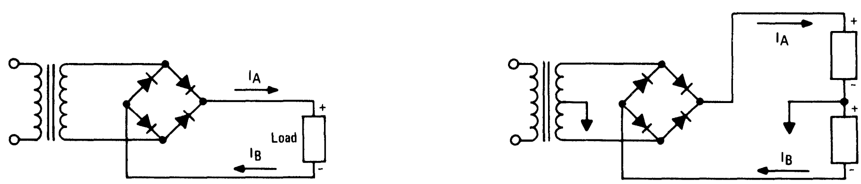


FIGURE 7 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



CIRCUIT A

CIRCUIT B

APPLICATION NOTE

The Data of Figure 4 applies for typical wire terminal or printed circuit board mounting conditions in still air. Under these or similar conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

Bridge rectifiers are used in two basic circuit configurations as shown by circuits A and B of Figure 7. The current derating data of Figure 6 applies to the standard bridge circuit (A), where $I_A = I_B$. The derating data considers the thermal response of the junction and is based upon the criteria that the junction temperature must not exceed rated $T_{J(max)}$ when peak reverse voltage is applied. However, because of the slow thermal response and the close thermal coupling between the individual semiconductor die in the MDA920A assembly, the maximum ambient temperature is given closely by

$$T_A = T_{J(max)} - R_{\theta JA}\, P_T$$

where P_T is the total average power dissipation in the assembly.

For the circuit of Figure B, use of the above formula will yield suitable rating information. For example to determine $T_{A(max)}$ for the conditions:

$$I_A = 0.5\ A,\ I_{pk} = 10\ I_{avg}$$
$$I_B = 1.0\ A,\ I_{pk} = 18\ I_{avg}$$

From Figure 5: For I_A, read $P_{TA} \approx 0.8$ W
For I_B, read $P_{TB} \approx 2.2$ W

$$P_T = (P_{TA} + P_{TB}) \div 2 = 1.5\ W$$

(Division by 2 is necessary as data from Figure 5 is for full-wave bridge operation.) $\therefore T_{A(max)} = 175^{\circ} - (50)\,(1.5) = 100^{\circ}C$.

FIGURE 8 — FORWARD RECOVERY TIME

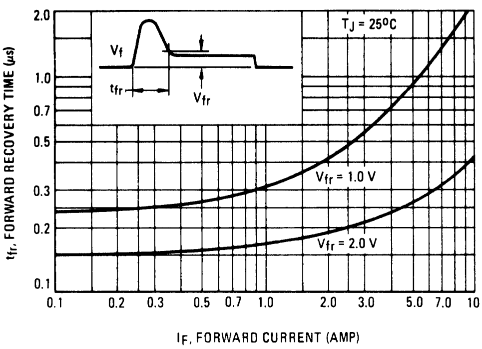


FIGURE 9 — REVERSE RECOVERY TIME

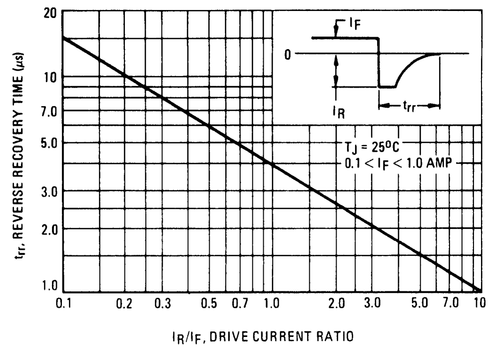


FIGURE 10 — RECTIFICATION WAVEFORM EFFICIENCY

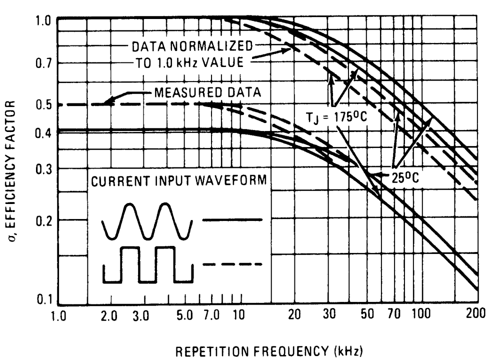
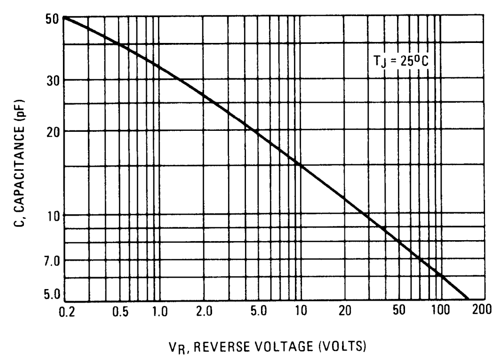
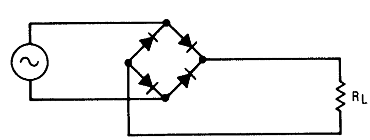


FIGURE 11 — CAPACITANCE



RECTIFIER EFFICIENCY NOTE

FIGURE 12 — SINGLE-PHASE FULL-WAVE BRIDGE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

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

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{4V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{2R_L}} \cdot 100\% = \frac{8}{\pi^2} \cdot 100\% = 81.2\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2_m}{R_L}}{\frac{V^2_m}{R_L}} \cdot 100\% = 100\% \quad (3)$$

As the frequency of the input signal is increased, the reverse recovery time of the diode (Figure 9) 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 on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

MDA970A1
thru
MDA970A6

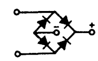
MOTOROLA

Designers Data Sheet

INTEGRAL DIODE ASSEMBLIES

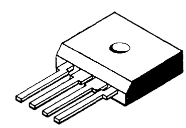
. . . diffused silicon dice interconnected and transfer molded into rectifier circuit assemblies for use in application where high output current/size ratio is of prime importance. These devices feature:

- Void-free, Transfer-molded Encapsulation to Assure High Resistance to Schock, Vibration, and Temperature Extremes
- High Dielectric Strength
- Simple, Compact Structure for Trouble-free Performance
- High Surge Capability — 100 Amps



SINGLE-PHASE FULL-WAVE BRIDGE

4 AMPERES
50-600 VOLTS



3

Designers Data for "Worst Case" Conditions

The Designers Data Sheet permits 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 (T_A = 25°C unless otherwise noted)

Rating	Symbol	MDA970A1	MDA970A2	MDA970A3	MDA970A5	MDA970A6	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
DC Output Voltage Resistive Load Capactive Load	 Vdc Vdc	 31 50	 62 100	 124 200	 248 400	 372 600	Volts
Average Rectified Forward Current T_A = 25°C T_C = 55°C	I_O	 4.0 8.0					Amp
Nonrepetitive Peak Surge Current (surge applied at rated load conditions, T_J = 150°C)	I_{FSM}	100					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150					°C

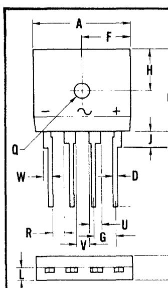
THERMAL CHARACTERISTICS

Characteristics		Symbol	Max (Per Die)	Unit
Thermal Resistance, Junction to Case	Each Die	$R_{\theta JC}$	10	°C/W
	Effective Bridge	$R_{\theta(EFF)}$	7.75	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Instaneous Forward Voltage (Per Diode) (i_F = 6.28 Amp, T_J = 25°C) (i_F = 6.28 Amp, T_J = 150°C)	v_F	— — —	 1.1 1.0	Vdc
Reverse Current (Rated V_{RM} applied to ac terminals, + and – terminals open, T_A = 25°C)	I_R	—	1.0	mA

CASE: Transfer-molded plastic encapsulation.
FINISH: All external surfaces are corrosion-resistant. Leads are readily solderable.
POLARITY: Embossed symbols
AC input = ~ DC output = + DC output = –
MOUNTING POSITION: Any
WEIGHT (Approximately): 7.5 Grams
MOUNTING TORQUE: 5 in.-lb. Max



NOTES:
1. LEADS ARE SQUARE AND OFFSET ON PACKAGE (DIM L) TO ALLOW FOR AUTOMATED EQUIPMENT LOADING.
2. DIMENSIONS G & L SHALL BE MEASURED AT THE REFERENCE PLANE.
3. DIMENSIONS R, W AND U APPLY TWO PLACES.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	22.35	23.37	0.880	0.920
B	6.35	7.37	0.250	0.290
C	18.54	19.56	0.730	0.770
D	0.89	1.14	0.035	0.045
F	11.18	11.68	0.440	0.460
G	4.57	5.59	0.180	0.220
H	8.89	9.91	0.350	0.390
J	2.79	3.81	0.110	0.150
K	14.61	–	0.575	–
L	3.18	3.43	0.125	0.135
Q	3.56	4.06	0.140	0.160
R	2.66 NOM		0.105 NOM	
U	2.66	3.17	0.105	0.125
V	2.92 NOM		0.115 NOM	
W	1.90	2.41	0.075	0.095

CASE 117A-02

FIGURE 1 – FORWARD VOLTAGE

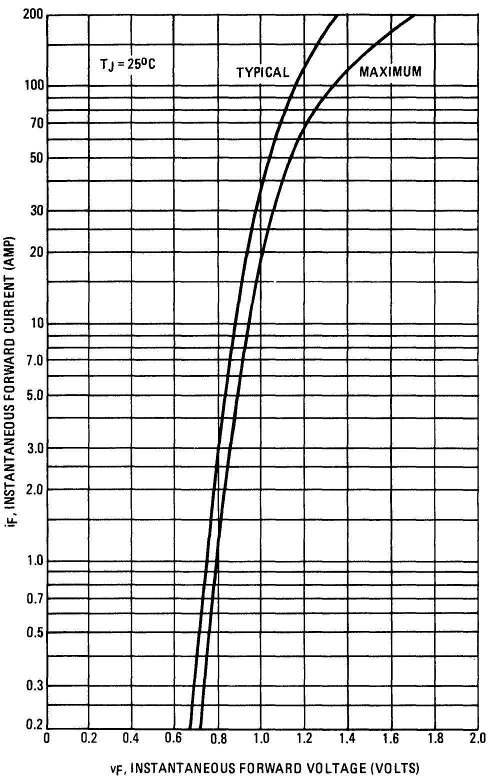


FIGURE 2 – MAXIMUM SURGE CAPABILITY

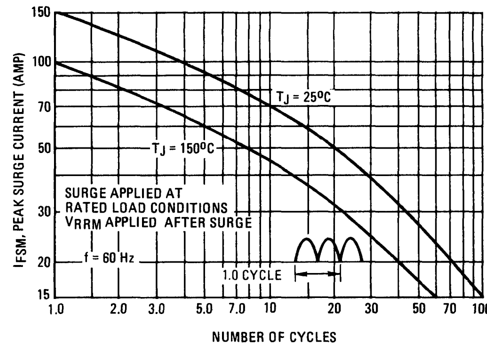


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

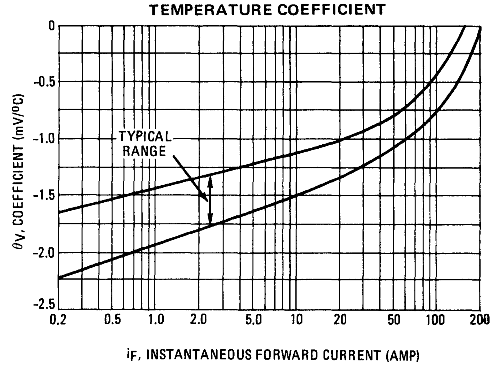


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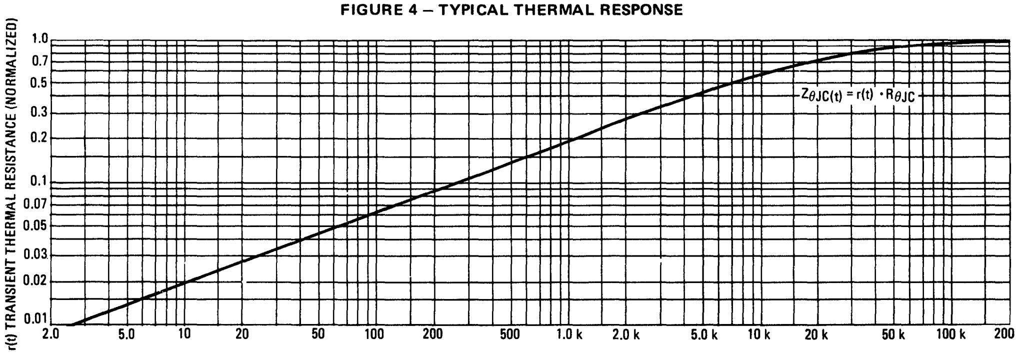
FIGURE 4 – TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – CASE TEMPERATURE DERATING

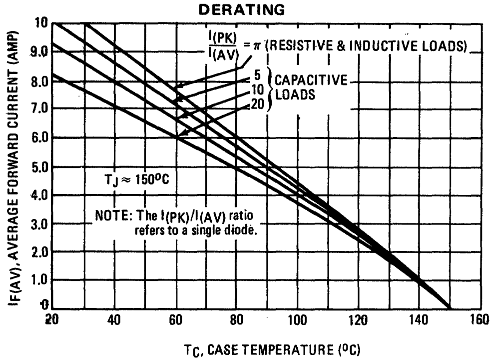
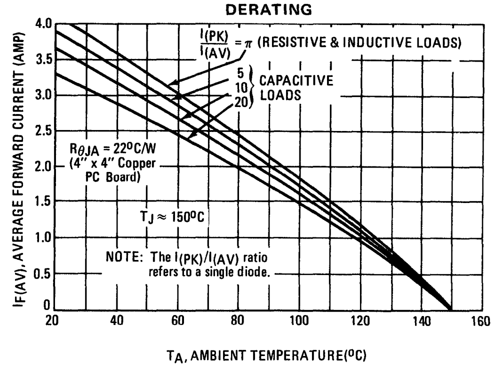


FIGURE 6 – AMBIENT TEMPERATURE DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION EFFICIENCY

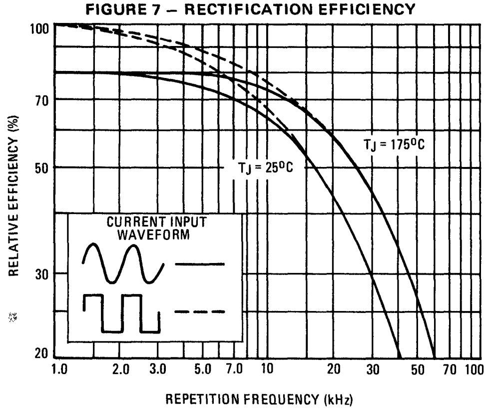


FIGURE 8 – REVERSE RECOVERY TIME

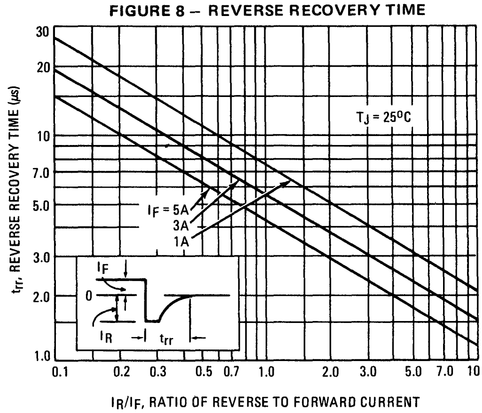


FIGURE 9 – JUNCTION CAPACITANCE

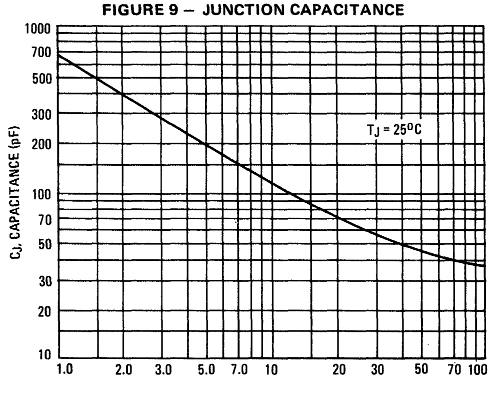


FIGURE 10 – FORWARD RECOVERY TIME

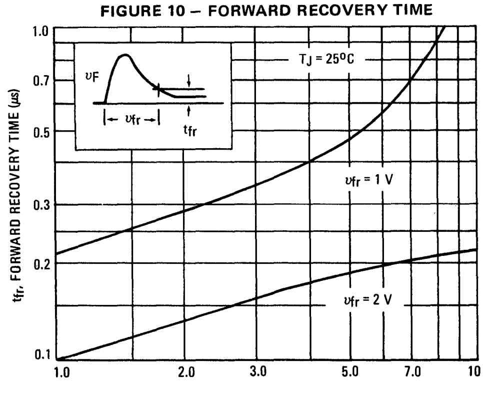


FIGURE 11 – POWER DISSIPATION

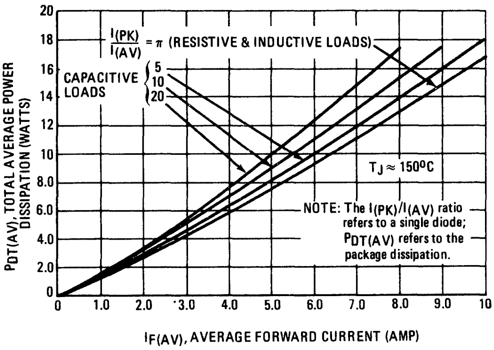
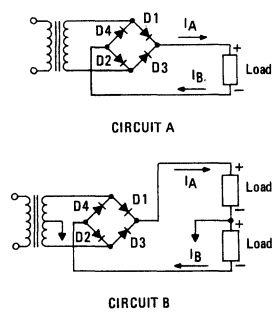


FIGURE 12 – BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



NOTE 1: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

$$(1)\ \Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$$

Where ΔT_{J1} is the change in junction temperature of diode 1
$R_{\theta 1}$ thru 4 is the thermal resistance of diodes 1 through 4
P_{D1} thru 4 is the power dissipated in diodes 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

$$(2)\ R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$$

where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

$$(3)\ \Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_D$ equation (3) can be further simplified and by substituting into equation (2) results in

$$(4)\ R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$$

For this rectifier assembly, thermal coupling between opposite diodes is 65% and between adjacent diodes is 72.5% when the case temperature is used as a reference. When the ambient temperature is used as the reference, the coupling is a function of the mounting conditions and is essentially the same for opposite and adjacent diodes.

The effective bridge thermal resistance, junction to ambient, is (from equation 4).

$$(5)\ R_{\theta(EFF)JA} = R_{\theta JA}(1 + 3K_{\theta(AV)JA})/4$$

Where: $K_{\theta(AV)JA} \approx (K_{\theta(AV)JC} R_{\theta JC} + R_{\theta CA})/R_{\theta JA}$ and $K_{\theta(AV)JC}$ is approximately 70%. $R_{\theta CA}$ is the case to ambient thermal resistance.

NOTE 2: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 12. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

$$(6)\ T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the following load conditions:

I_A = 3.1 A average with a peak of 11.2 A
I_B = 1.55 A average with a peak of 6.8 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 11.2/1.55 = 7.23 (Note that the peak to average ratio is on a per diode basis.)

From Figure 11, for an average current of 3.1 A and an $I_{(PK)}/I_{(AV)}$ = 7.23 read $P_{T(AV)}$ = 4.8 watts or 1.2 watts/diode $\therefore$ $P_{D1} = P_{D3}$ = 1.2 watts.

Similarly, for a load current I_B of 1.55 A, diode #2 and diode #4 each see 0.775 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 8.8$.

Thus, the package power dissipation for 1.55 A is 2.3 watts or 0.575 watts/diode $\therefore$ $P_{D2} = P_{D4}$ = 0.575 watts.

The maximum junction temperature occurs in diode #1 and #3. From equation (3) for diode #1 ΔT_{J1} = 9[1.2 +.65(.575) +.725 (1.2) + .725 (.575)]

$\Delta T_{J1} \approx 26°C$

Thus $T_{C(MAX)}$ = 150-26 = 124°C

The total package dissipation in this example is:

P_J = 2 X 1.2 + 2 X 0.575 $\approx$ 3.6 watts

(Note that although maximum $R_{\theta JC}$ is 10°C/watt, 9°C/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value.)

NOTE 3

Under typical wire terminal or printed circuit board mounting conditions, the thermal resistance between the diode junctions and the leads at the edge of the case is a small fraction of the thermal resistance from junction to ambient. Consequently, the lead temperature is very close to the junction temperature. Therefore, it is recommended that the lead temperature be measured when the diodes are operating in prototype equipment, in order to determine if operation is within the diode temperature ratings. The lead having the highest thermal resistance to the ambient will yield readings closest to the junction temperature. By measuring temperature as outlined, variations of junction to ambient thermal resistance, caused by the amount of surface area of the terminals or printed circuit board and the degree of air convection, as well as proximity of other heat sources cease to be important design considerations.

MDA980-1 thru MDA980-6
MDA990-1 thru MDA990-6

MOTOROLA

Designers Data Sheet

3

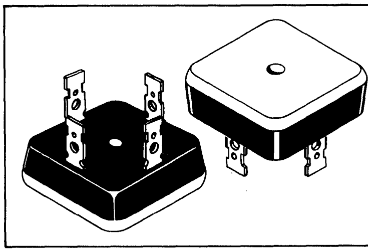
SINGLE-PHASE
FULL-WAVE BRIDGE

12 and 30 AMPERES
50 thru 600 VOLTS

RECTIFIER ASSEMBLY

. . . utilizing individual void-free molded MR2500 Series rectifiers, interconnected and mounted on an electrically isolated aluminum heat sink by a high thermal-conductive epoxy resin.

- 400 Ampere Surge Capability
- Electrically Isolated Base
- Cost Effective in Lower Current 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.

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

Rating	Symbol	-1	-2	-3	-4	-5	-6	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
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	Volts
DC Output Voltage Resistive Load Capacitive Load	 Vdc Vdc	 30 50	 62 100	 124 200	 185 300	 250 400	 380 600	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, T_C = 55°C) MDA980 MDA990	I_O	← 12 → ← 30 →						Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →						Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →						°C

THERMAL CHARACTERISTICS

Characteristic		Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	Each Die MDA980 MDA990	$R\theta_{JC}$	8.5 4.5	11 6.0	°C/W
	Effective Bridge MDA980 MDA990	$R\theta_{(EFF)}$	– –	6.05 2.28	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode)	v_F				Volts
(i_F = 18.9 A) MDA980		–	0.88	0.97	
(i_F = 47 A) MDA990		–	0.98	1.07	
(i_F = 18.9 A, T_J = 175°C) MDA980		–	–	0.85	
(i_F = 47 A, T_J = 175°C) MDA990		–	–	0.98	
Reverse Current (Rated V_{RM} applied to ac terminals, + and – terminals open)	I_R	–	–	0.5	mA

FIGURE 1 — FORWARD VOLTAGE

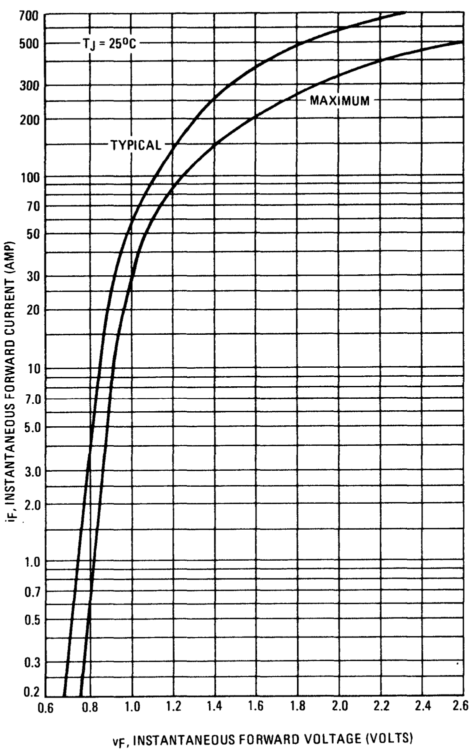


FIGURE 2 — MAXIMUM SURGE CAPABILITY

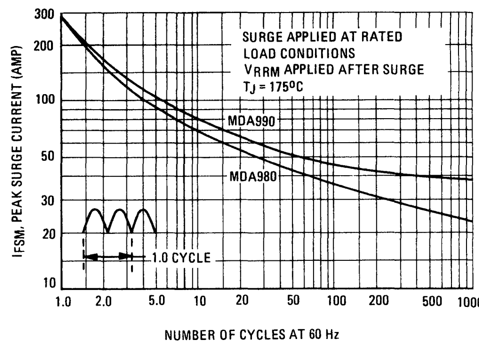


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

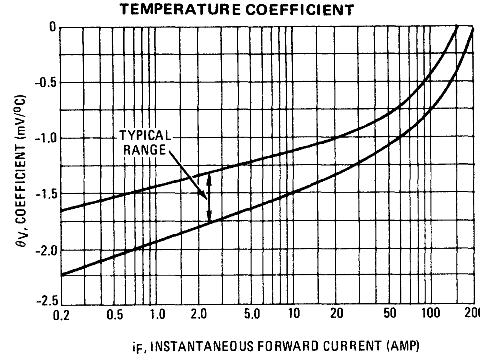
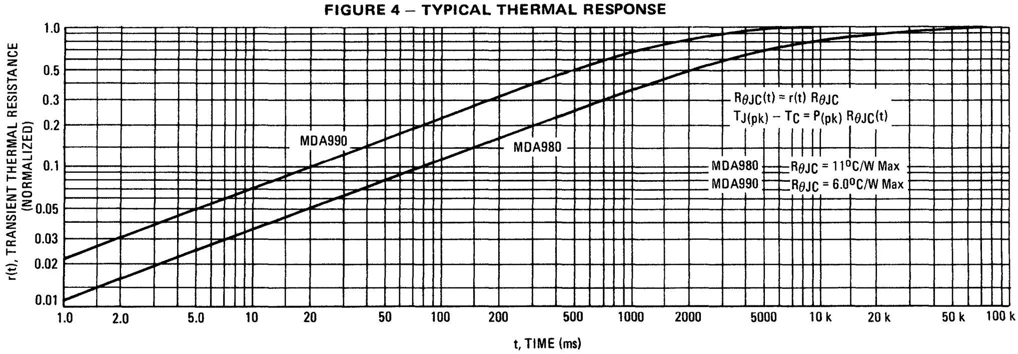


FIGURE 4 — TYPICAL THERMAL RESPONSE



MAXIMUM CURRENT RATINGS, BRIDGE OPERATION

FIGURE 5 – MDA980 CURRENT DERATING

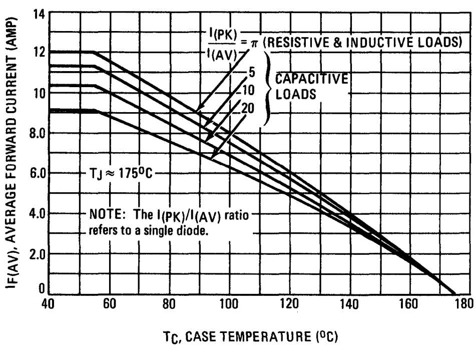
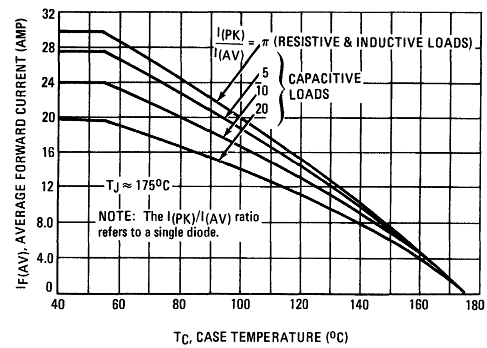


FIGURE 6 – MDA990 CURRENT DERATING



TYPICAL DYNAMIC CHARACTERISTICS (EACH DIODE)

FIGURE 7 – RECTIFICATION EFFICIENCY

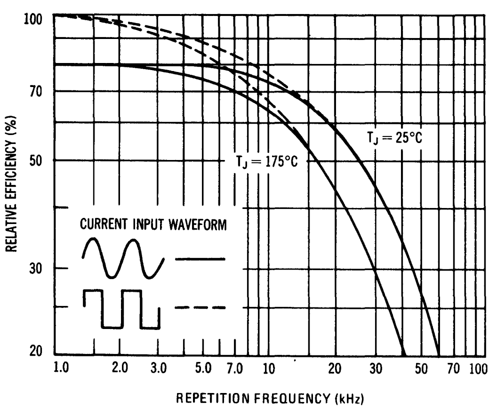


FIGURE 8 – JUNCTION CAPACITANCE

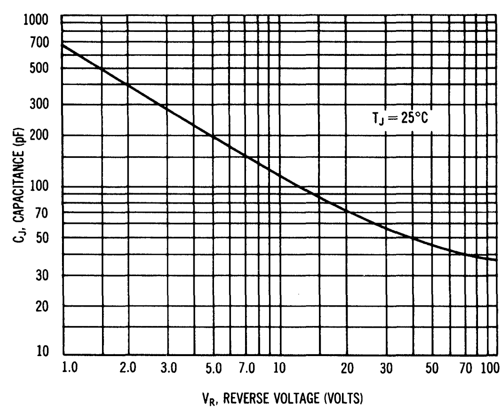


FIGURE 9 – REVERSE RECOVERY TIME

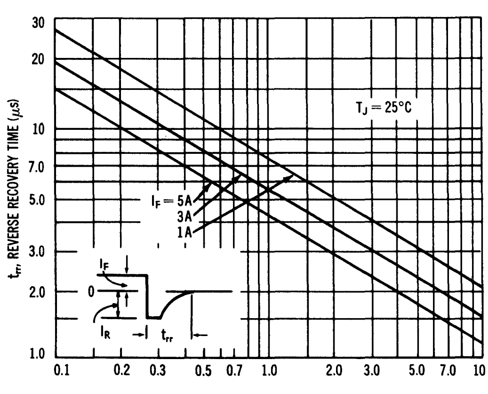


FIGURE 10 – FORWARD RECOVERY TIME

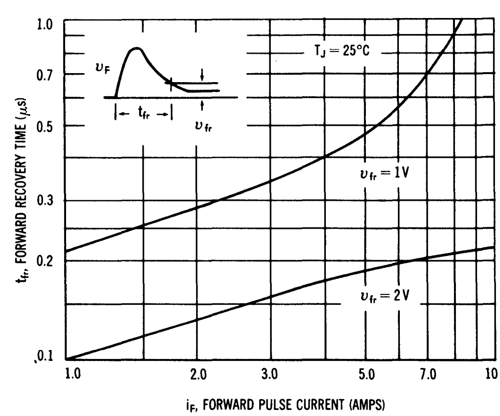


FIGURE 11 — POWER DISSIPATION

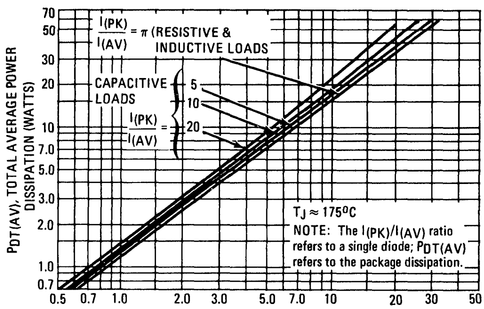
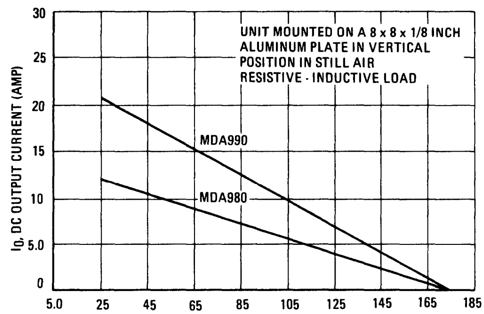


FIGURE 12 — CURRENT VERSUS AMBIENT TEMPERATURE



3

NOTE 1 — THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D2} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1}$ thru 4 is the thermal resistance of diodes 1 through 4.

P_{D1} thru 4 is the power dissipated in diodes 1 through 4

$K_{\theta 2}$ thru 4 is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condition where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4P_{D1}$ equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}\ (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

For the MDA980 rectifier assembly, thermal coupling between opposite diodes is 42% and between adjacent diodes is 50% when the case temperature is used as a reference. Similarly for the MDA990, thermal coupling between opposite diodes is 12% and between adjacent diodes is 20%.

NOTE 2 — SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown in circuits A and B of Figure 13. The current derating data of Figures 5 and 6 apply to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A \neq I_B$, derating information can be calculated as follows:

(5) $T_{R(MAX)} = T_{J(MAX)} - \Delta T_{J1}$

Where $T_{R(MAX)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 1.

For example, to determine $T_{C(MAX)}$ for the MDA990 with the following capacitive load conditions:

I_A = 20 A average with a peak of 86 A
I_B = 10 A average with a peak of 72 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 86/10 = 8.6. (Note that the peak to average ratio is on a per diode basis and each diode provides 10A average).

From Figure 11, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 8.6 read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)} \approx 14.4$

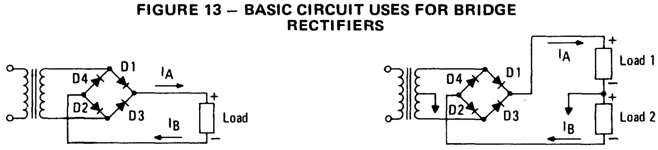
Thus, the package power dissipation for 10 A is 20.2 watts or 5.05 watts/diode. .: $P_{D2} = P_{D4}$ = 5.05 watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1 ΔT_{J1} = 5.6 [10 + 0.12 (5.05) + 0.2 (10) + 0.2 (5.05)].

$\Delta T_{J1} \approx 76^{\circ}C$
Thus $T_{C(MAX)}$ = 175-76 = 99°C
The total package dissipation in this example is:
$P_J = 2 \times 10 + 2 \times 5.05 \approx 30.1$ watts

(Note that although maximum $R_{\theta JC}$ is 6°C/W, 5.6°C/watt is used in this example and on the derating data as it is unlikely that all four die in a given package would be at the maximum value).

FIGURE 13 — BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



CIRCUIT A

CIRCUIT B

MECHANICAL CHARACTERISTICS

CASE: Transfer-molded plastic encapsulation

POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked

MOUNTING POSITION: Bolt down-highest heat transfer efficiency accomplished through the surface opposite the terminals.

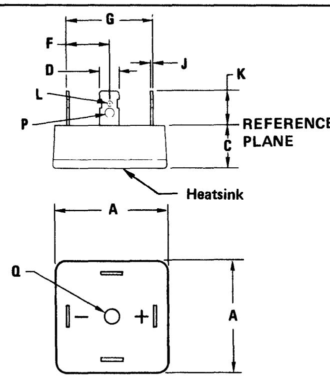
WEIGHT: 40 grams (approx.)

TERMINALS: Suitable for fast-on connections, readily solderable connections, corrosion resistant.

MOUNTING TORQUE: 20 in. lb. Max.

3

OUTLINE DIMENSIONS



NOTE:
1. DIM "Q" SHALL BE MEASURED ON HEATSINK SIDE OF PKG.
2. DIMENSIONS F AND G SHALL BE MEASURED AT THE REFERENCE PLANE.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	34.80	35.18	1.370	1.385
C	12.44	13.97	0.490	0.550
D	6.10	6.60	0.240	0.260
F	13.97	14.50	0.550	0.571
G	28.00	29.00	1.100	1.142
J	0.71	0.86	0.028	0.034
K	9.52	11.43	0.375	0.450
L	1.52	2.06	0.060	0.081
P	2.79	2.92	0.110	0.115
Q	4.32	4.83	0.170	0.190

CASE 309A-02

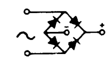
MOTOROLA

MDA2500 series

RECTIFIER ASSEMBLY

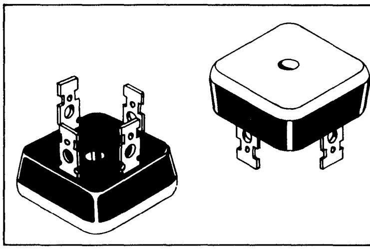
. . . utilizing individual void-free molded rectifiers, interconnected and mounted on an electrically isolated aluminum heat sink by a high thermal-conductive epoxy resin.

- 400 Ampere Surge Capability
- Electrically Isolated Base
- UL Recognized
- 1800 Volt Heat Sink Isolation



SINGLE-PHASE FULL-WAVE BRIDGE

25 AMPERES
50-600 VOLTS



3

MAXIMUM RATINGS

Rating (Per Diode)	Symbol	MDA 2500	MDA 2501	MDA 2502	MDA 2504	MDA 2506	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
DC Output Voltage Resistive Load Capacitive Load	Vdc	 30 50	 62 100	 124 200	 250 400	 380 600	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, T_C = 55°C)	I_O	← 25 →					Amp
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 400 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +175 →					°C

THERMAL CHARACTERISTICS

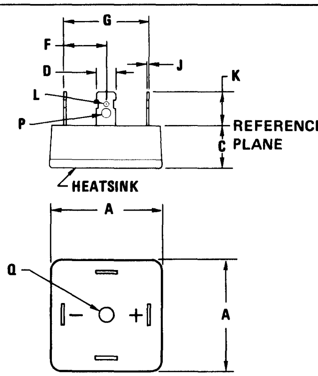
Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case Each Die Total Bridge	$R_{\theta JC}$	 8.0 2.0	 10 2.8	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) (i_F = 40 A)	v_F	—	0.95	1.05	Volts
Reverse Current (Per Diode) (Rated V_R)	I_R	—	—	0.10	mA

MECHANICAL CHARACTERISTICS

CASE:	Plastic case with an electrically isolated aluminum base.
POLARITY:	Terminal designation embossed on case: +DC output −DC output AC not marked
MOUNTING POSITION:	Bolt down. Highest heat transfer efficiency accomplished through the surface opposite the terminals. Use silicone heat sink compound on mounting surface for maximum heat transfer.
WEIGHT:	25 grams (approx.)
TERMINALS:	Suitable for fast-on connections. Readily solderable, corrosion resistant. Soldering recommended for applications greater than 15 amperes.
MOUNTING TORQUE:	20 in. lb. max.



NOTES:
1. DIMENSION "Q" SHALL BE MEASURED ON HEATSINK SIDE OF PACKAGE.
2. DIMENSIONS "F" AND "G" SHALL BE MEASURED AT THE REFERENCE PLANE.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	25.65	26.16	1.010	1.030
C	12.44	13.97	0.490	0.550
D	6.10	6.60	0.240	0.260
F	10.01	10.49	0.394	0.413
G	19.99	21.01	0.787	0.827
J	0.71	0.86	0.028	0.034
K	9.52	11.43	0.375	0.450
L	1.52	2.06	0.060	0.081
P	2.79	2.92	0.110	0.115
Q	4.42	4.67	0.174	0.184

CASE 309A-03

3

FIGURE 1 – FORWARD VOLTAGE

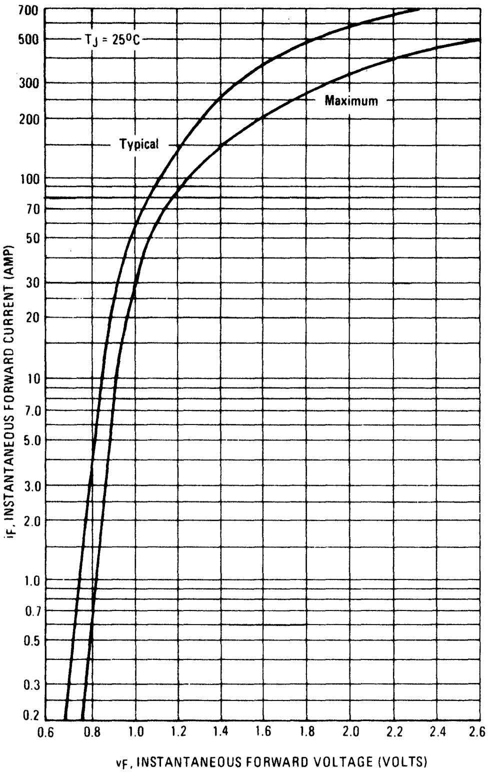


FIGURE 2 – NON REPETITIVE SURGE CURRENT

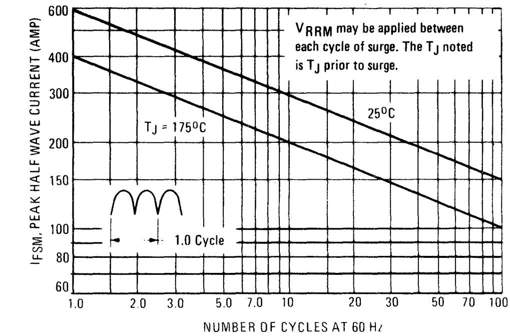


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

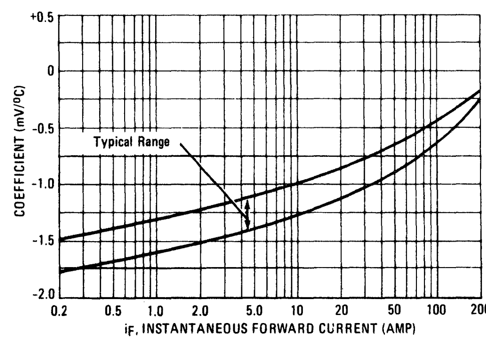


FIGURE 4 – CURRENT DERATING

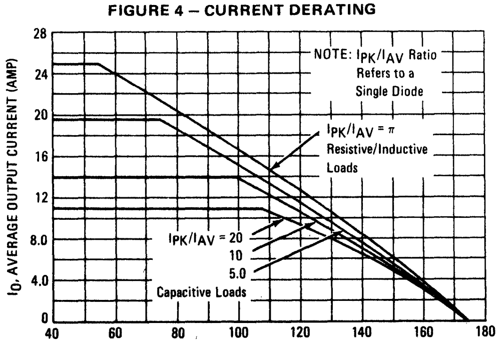


FIGURE 5 – FORWARD POWER DISSIPATION

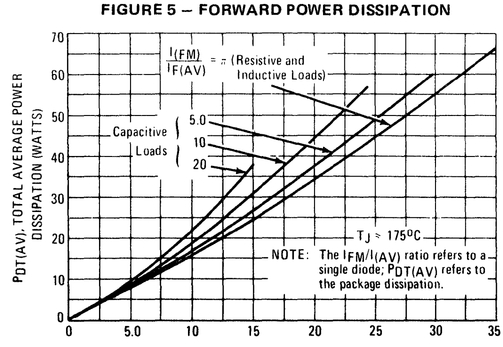
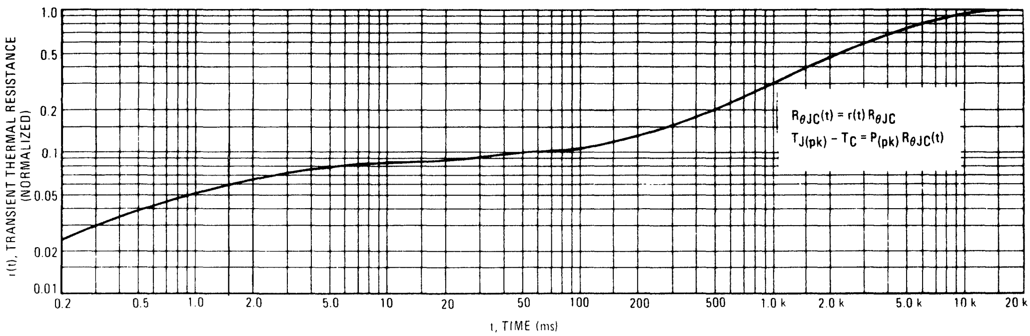
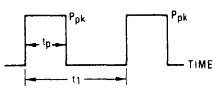


FIGURE 6 — TYPICAL THERMAL RESPONSE



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 the outline drawing on page 1). 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

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

where

r(t) = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

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

FIGURE 7 — CAPACITANCE

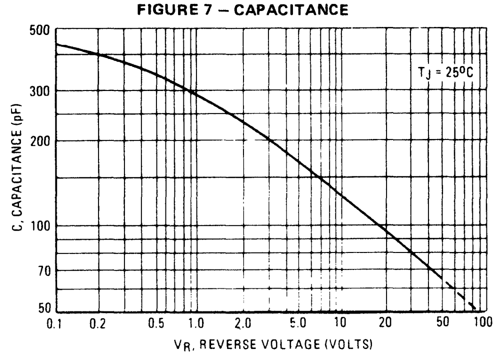


FIGURE 8 — FORWARD RECOVERY TIME

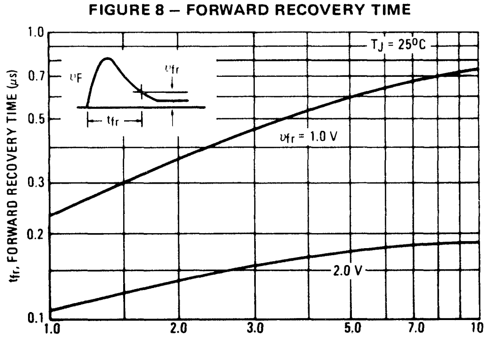
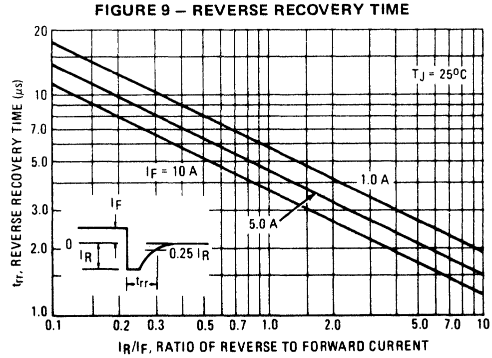


FIGURE 9 — REVERSE RECOVERY TIME



AMBIENT TEMPERATURE DERATING INFORMATION

FIGURE 10A — THERMALLOY HEAT SINK 6005B

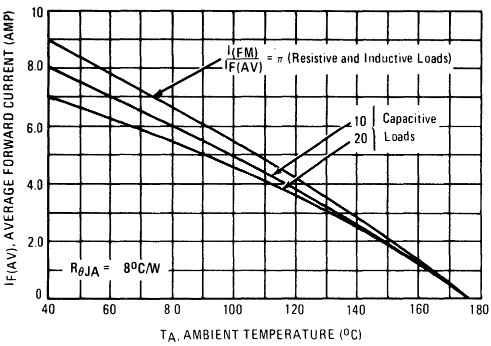
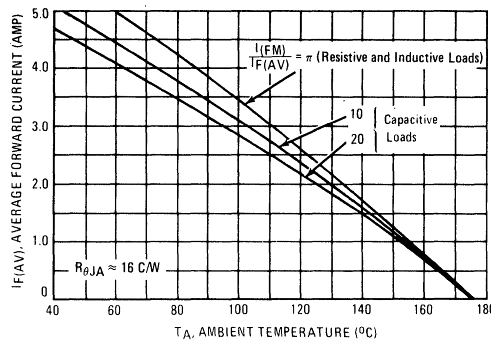


FIGURE 10B — IERC HEAT SINK UP3



NOTE 2: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1}P_{D1} + R_{\theta 2}K_{\theta 2}P_{D2} + R_{\theta 3}K_{\theta 3}P_{D3} + R_{\theta 4}K_{\theta 4}P_{D4}$

where ΔT_{J1} is the change in junction temperature of diode 1, $R_{\theta 1}$ through 4 is the thermal resistance of diodes 1 through 4, P_{D1} through 4 is the power dissipated in diodes 1 through 4, $K_{\theta 2}$ through 4 is the thermal coupling between diode 1, and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2}P_{D2} + K_{\theta 3}P_{D3} + K_{\theta 4}P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\,P_{D1}$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

When the case is used as a reference point, coupling between opposite die is negligible for the MDA2500, and coupling between adjacent die is approximately 6%.

NOTE 3: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 11. The current derating data of Figure 4 applies to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A = I_B$, derating information can be calculated as follows:

(6) $T_{R(max)} = T_{J(max)} - \Delta T_{J1}$

Where $T_{R(max)}$ is the reference temperature (either case or ambient), ΔT_{J1} can be calculated using equation (3) in Note 2.

For example, to determine $T_{C(max)}$ for the MDA2500 with the following capacitive load conditions:

I_A = 20 A average with a peak of 60 A,
I_B = 10 A average with a peak of 70 A,

first calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 60/10 = 6.0. (Note that the peak to average ratio is on a per diode basis and each diode provides 10 A average.)

From Figure 5, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 6.0, read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)}$ = 14. Thus, the package power dissipation for 10 A is 20 watts or 5.0 watts/diode. Therefore, $P_{D2} = P_{D4}$ = 5.0 watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1,

$$\Delta T_{J1} = 10[10 + 0(5) + 0.06(10) + 0.06(5)]$$
$$\Delta T_{J1} \approx 109^{\circ}C.$$

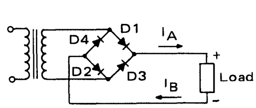
Thus, $T_{C(max)} = 175 - 109 = 66^{\circ}C$.

The total package dissipation in this example is

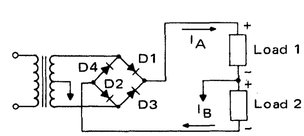
$$P_{DT(AV)} = 2 \times 10 + 2 \times 5.0 = 30 \text{ watts},$$

which must be considered when selecting a heat sink.

FIGURE 11 — BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



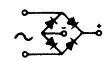
Circuit A



Circuit B

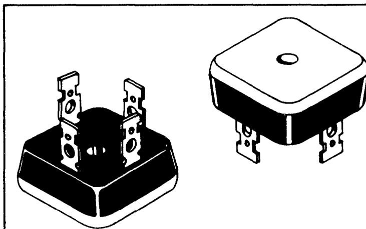
MOTOROLA

MDA2550
MDA2551



SINGLE-PHASE FULL-WAVE BRIDGE

25 AMPERES
50-100 VOLTS



RECTIFIER ASSEMBLY

. . . utilizing individual void-free molded rectifiers, interconnected and mounted on an electrically isolated aluminum heat sink by a high thermal-conductive epoxy resin.

- 400 Ampere Surge Capability
- Electrically Isolated Base — 1800 Volts

MAXIMUM RATINGS

Rating (Per Diode)	Symbol	MDA 2550	MDA 2551	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	Volts
DC Output Voltage Resistive Load Capacitive Load	Vdc	 30 50	 62 100	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, $T_C = 55°C$)	I_O	← 25 →		Amp
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 400 →		Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →		°C

THERMAL CHARACTERISTICS

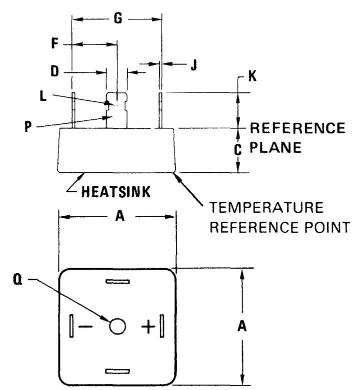
Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case Each Die Total Bridge	$R_{\theta JC}$	 8.0 2.0	 10 2.8	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) ($i_F = 55$ A)	v_F	—	0.95	1.05	Volts
Reverse Current (Per Diode) (Rated V_R)	I_R	—	—	0.50	mA

MECHANICAL CHARACTERISTICS

CASE: Plastic case with an electrically isolated aluminum base.
POLARITY: Terminal-designation embossed on case
+DC output
−DC output
AC not marked
MOUNTING POSITION: Bolt down. Highest heat transfer efficiency accomplished through the surface opposite the terminals. Use silicon heat sink compound on mounting surface for maximum heat transfer.
WEIGHT: 25 grams (approx.)
TERMINALS: Suitable for fast-on connections. Readily solderable, corrosion resistant. Soldering recommended for applications greater than 15 amperes.
MOUNTING TORQUE: 20 in. lb. max.



NOTES:
1. DIMENSION "Q" SHALL BE MEASURED ON HEATSINK SIDE OF PACKAGE.
2. DIMENSIONS "F" AND "G" SHALL BE MEASURED AT THE REFERENCE PLANE.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	25.65	26.16	1.010	1.030
C	12.44	13.97	0.490	0.550
D	6.10	6.60	0.240	0.260
F	10.01	10.49	0.394	0.413
G	19.99	21.01	0.787	0.827
J	0.71	0.86	0.028	0.034
K	9.52	11.43	0.375	0.450
L	1.52	2.06	0.060	0.081
P	2.79	2.92	0.110	0.115
Q	4.42	4.67	0.174	0.184

CASE 309A-03

3

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FIGURE 1 – FORWARD VOLTAGE

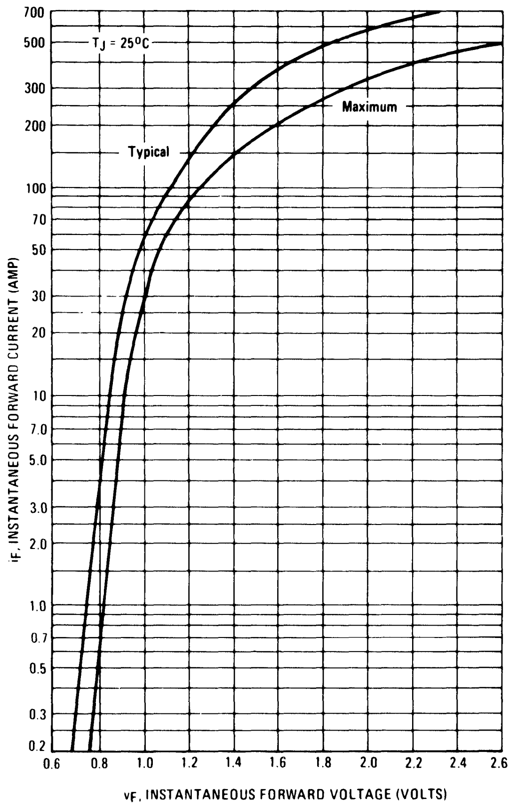


FIGURE 2 – NON REPETITIVE SURGE CURRENT

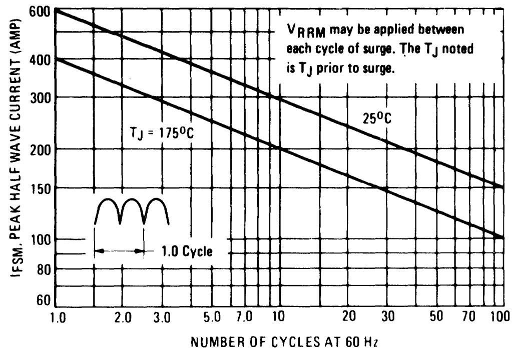


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

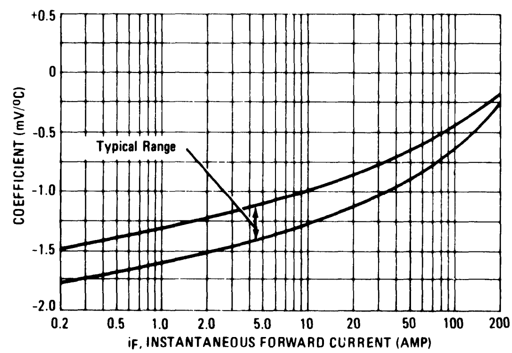


FIGURE 4 – CURRENT DERATING

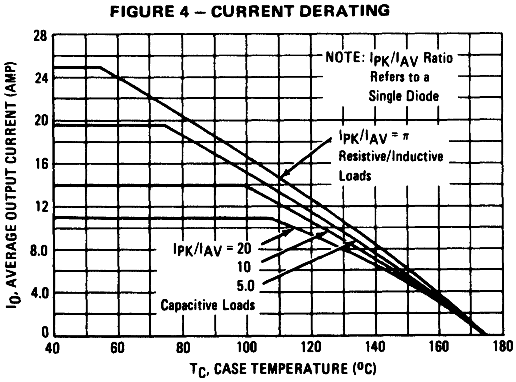


FIGURE 5 – FORWARD POWER DISSIPATION

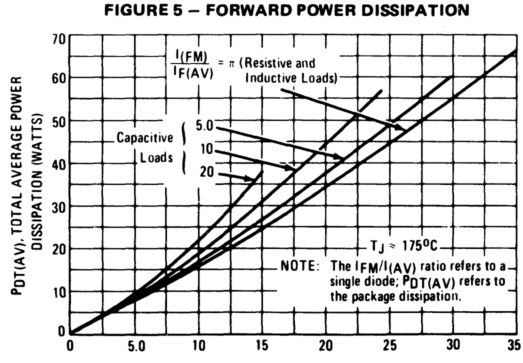
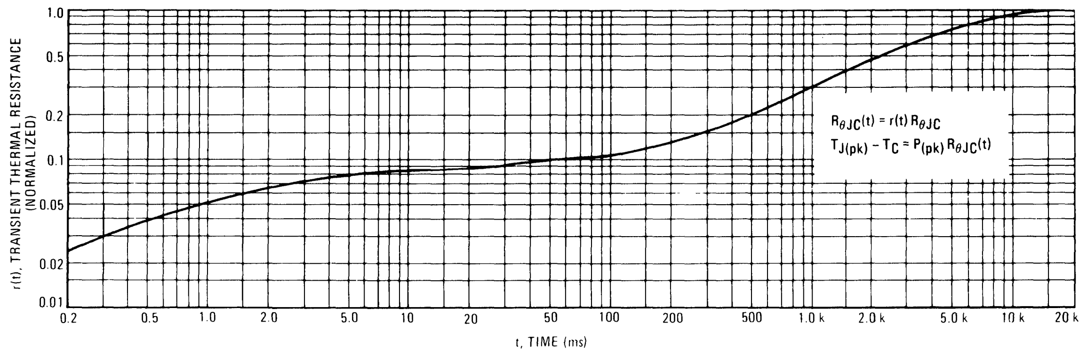
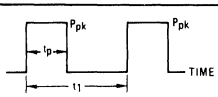


FIGURE 6 — TYPICAL THERMAL RESPONSE



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 the outline drawing on page 1*). 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:

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

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

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

FIGURE 7 — CAPACITANCE

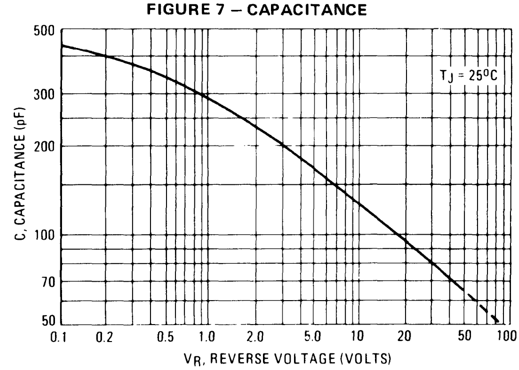


FIGURE 8 — FORWARD RECOVERY TIME

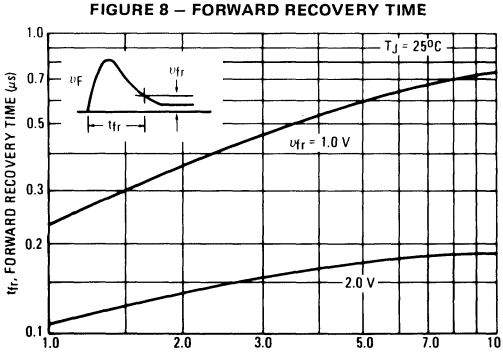
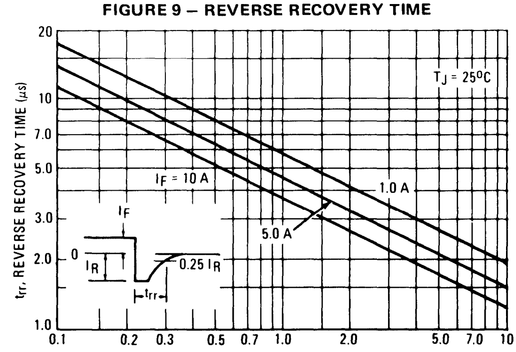


FIGURE 9 — REVERSE RECOVERY TIME



AMBIENT TEMPERATURE DERATING INFORMATION

FIGURE 10A — THERMALLOY HEAT SINK 6005B

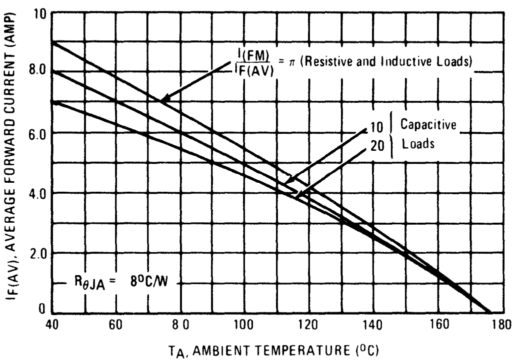
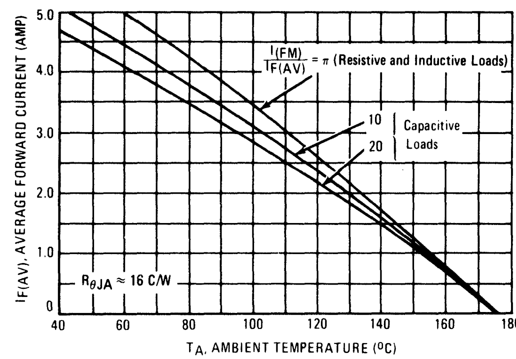


FIGURE 10B — IERC HEAT SINK UP3



NOTE 2: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1}P_{D1} + R_{\theta 2}K_{\theta 2}P_{D2} + R_{\theta 3}K_{\theta 3}P_{D3} + R_{\theta 4}K_{\theta 4}P_{D4}$

where ΔT_{J1} is the change in junction temperature of diode 1, $R_{\theta 1}$ through 4 is the thermal resistance of diodes 1 through 4, P_{D1} through 4 is the power dissipated in diodes 1 through 4, $K_{\theta 2}$ through 4 is the thermal coupling between diode 1, and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

where P_{DT} is the total package power dissipation.

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1}(P_{D1} + K_{\theta 2}P_{D2} + K_{\theta 3}P_{D3} + K_{\theta 4}P_{D4})$

For the conditions where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4\ P_{D1}$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1}(1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

When the case is used as a reference point, coupling between opposite die is negligible for the MDA2550, and coupling between adjacent die is approximately 6%.

NOTE 3: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 11. The current derating data of Figure 4 applies to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A = I_B$, derating information can be calculated as follows:

(6) $T_{R(max)} = T_{J(max)} - \Delta T_{J1}$

Where $T_{R(max)}$ is the reference temperature (either case or ambient), ΔT_{J1} can be calculated using equation (3) in Note 2.

For example, to determine $T_{C(max)}$ for the MDA2550 with the following capacitive load conditions:

I_A = 20 A average with a peak of 60 A,
I_B = 10 A average with a peak of 70 A,

first calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 60/10 = 6.0. (Note that the peak to average ratio is on a per diode basis and each diode provides 10 A average.)

From Figure 5, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 6.0, read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)}$ = 14. Thus, the package power dissipation for 10 A is 20 watts or 5.0 watts/diode. Therefore, $P_{D2} = P_{D4}$ = 5.0 watts.

The maximum junction temperature occurs in diodes #1 and #3. From equation (3) for diode #1,

$$\Delta T_{J1} = 10[10 + 0(5) + 0.06(10) + 0.06(5)]$$
$$\Delta T_{J1} \approx 109^{\circ}C.$$

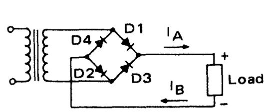
Thus, $T_{C(max)} = 175 - 109 = 66^{\circ}C$.

The total package dissipation in this example is

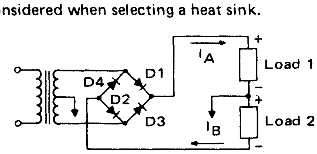
$$P_{DT(AV)} = 2 \times 10 + 2 \times 5.0 = 30 \text{ watts},$$

which must be considered when selecting a heat sink.

FIGURE 11 — BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



Circuit A



Circuit B

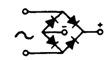
MOTOROLA

MDA3500 series

RECTIFIER ASSEMBLY

. . . utilizing individual void-free molded MR2500 Series rectifiers, interconnected and mounted on an electrically isolated aluminum heat sink by a high thermal-conductive epoxy resin.

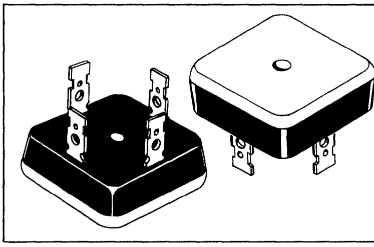
- 400 Ampere Surge Capability
- Electrically Isolated Base —1800 Volts
- UL Recognized
- Cost Effective in Lower Current Applications



SINGLE-PHASE FULL-WAVE BRIDGE

35 AMPERES
50-1000 VOLTS

3



MAXIMUM RATINGS

Rating (Per Diode)	Symbol	MDA 3500	3501	3502	3504	3506	3508	3510	Unit
Peak Repetitive Reverse Voltage	V_{RRM}								
Working Peak Reverse Voltage	V_{RWM}	50	100	200	400	600	800	1000	Volts
DC Blocking Voltage	V_R								
DC Output Voltage Resistive Load	Vdc	30	62	124	250	380	500	630	Volts
Capacitive Load	Vdc	50	100	200	400	600	800	1000	Volts
Sine Wave RMS Input Voltage	V_R (RMS)	35	70	140	280	420	560	700	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, $T_C = 55°C$)	I_O	← 35 →							Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 400 →							Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →							°C

THERMAL CHARACTERISTICS (Total Bridge)

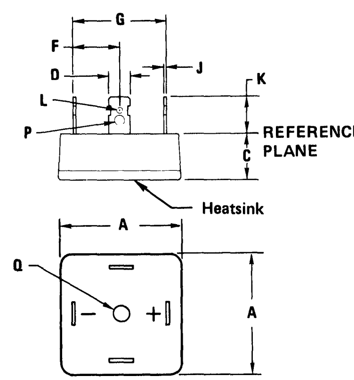
Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	1.87	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) ($i_F = 55$ A)	v_F	—	1.0	1.1	Volts
Reverse Current (Per Diode) (Rated V_R)	I_R	—	—	0.10	mA

MECHANICAL CHARACTERISTICS

CASE: Plastic case with an electrically isolated aluminum base.
POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked
MOUNTING POSITION: Bolt down. Highest heat transfer efficiency accomplished through the surface opposite the terminals. Use silicon grease on mounting surface for maximum heat transfer.
WEIGHT: 40 grams (approx.)
TERMINALS: Suitable for fast-on connections. Readily solderable, corrosion resistant. Soldering recommended for applications greater than 15 Amperes.
MOUNTING TORQUE: 20 in. lb. Max.



NOTE:
1. DIM "Q" SHALL BE MEASURED ON HEATSINK SIDE OF PKG.
2. DIMENSIONS F AND G SHALL BE MEASURED AT THE REFERENCE PLANE.

DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	34.80	35.18	1.370	1.385
C	12.44	13.97	0.490	0.550
D	6.10	6.60	0.240	0.260
F	13.97	14.50	0.550	0.571
G	28.00	29.00	1.100	1.142
J	0.71	0.86	0.028	0.034
K	9.52	11.43	0.375	0.450
L	1.52	2.06	0.060	0.081
P	2.79	2.92	0.110	0.115
Q	4.32	4.83	0.170	0.190

CASE 309A-02

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FIGURE 1 – FORWARD VOLTAGE

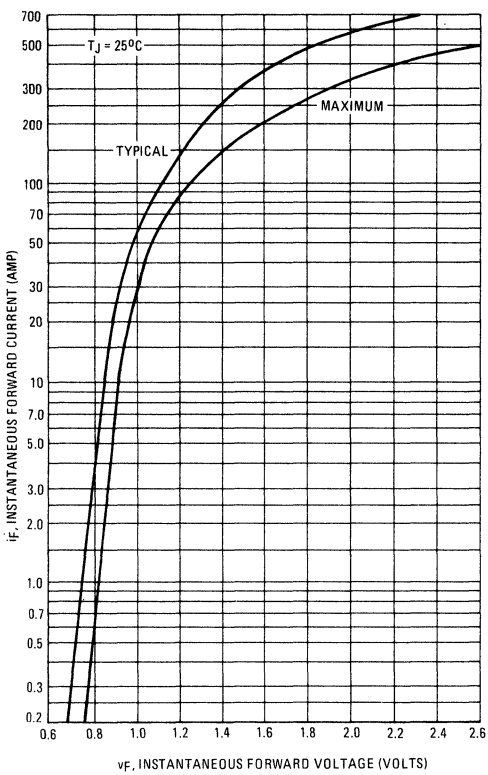


FIGURE 2 – NON REPETITIVE SURGE CURRENT

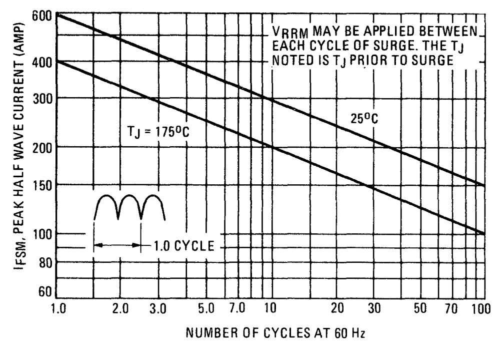


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

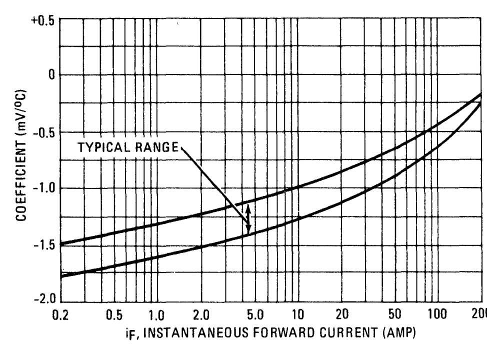


FIGURE 4 – CURRENT DERATING

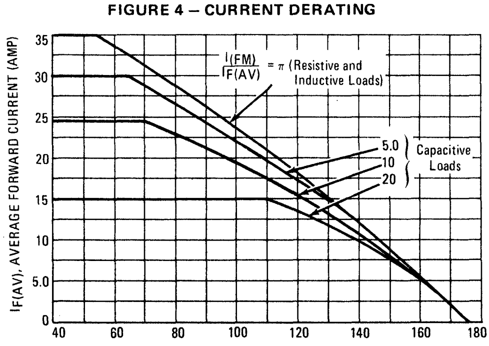


FIGURE 5 – FORWARD POWER DISSIPATION

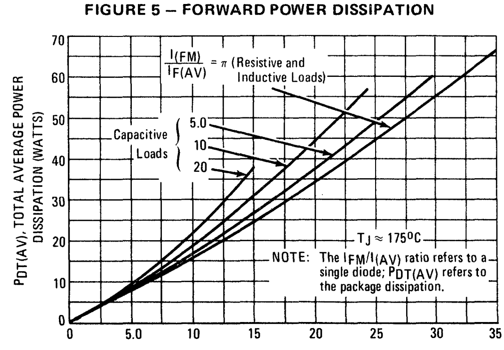
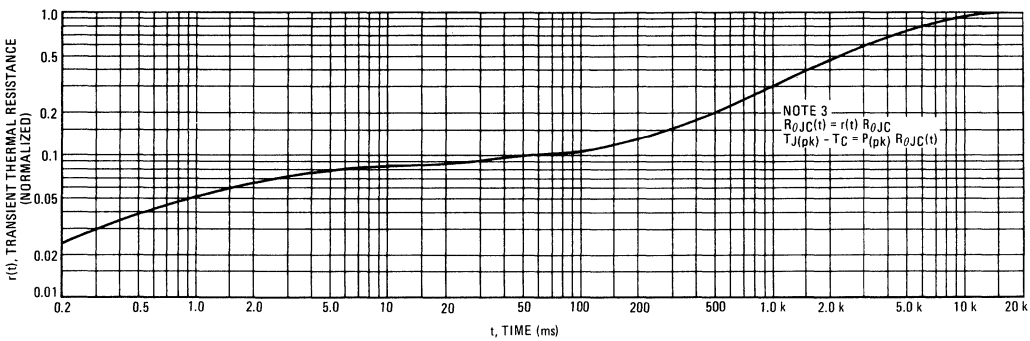
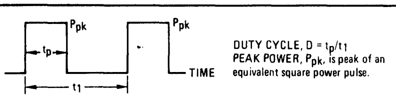


FIGURE 6 — TYPICAL THERMAL RESPONSE



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 the outline drawing on page 1). 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:

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

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

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

FIGURE 7 — CAPACITANCE

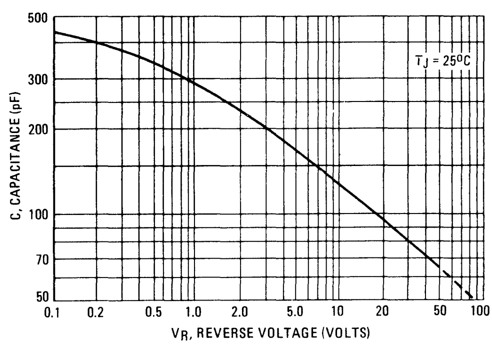


FIGURE 8 — FORWARD RECOVERY TIME

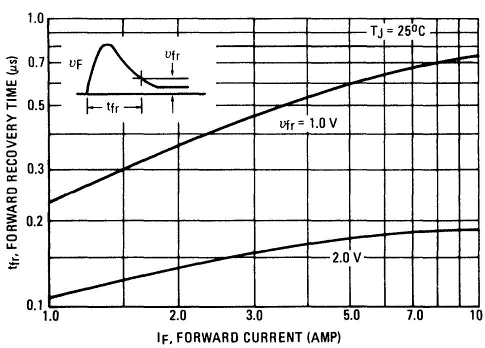
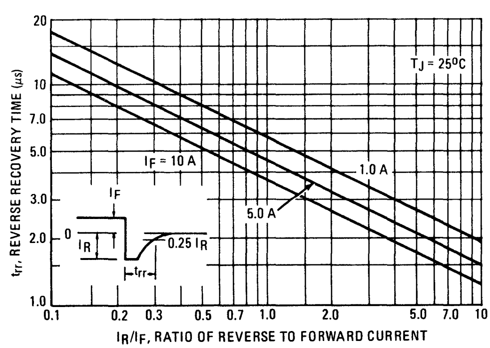


FIGURE 9 — REVERSE RECOVERY TIME



3

AMBIENT TEMPERATURE DERATING INFORMATION

FIGURE 10A – THERMALLOY HEATSINK 6005B

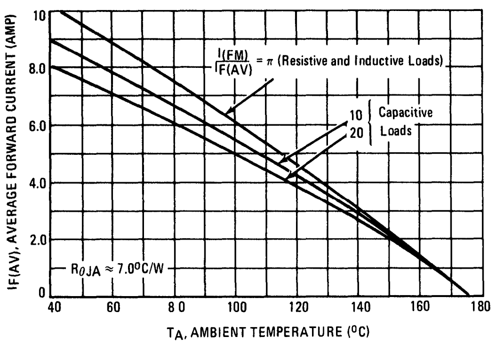
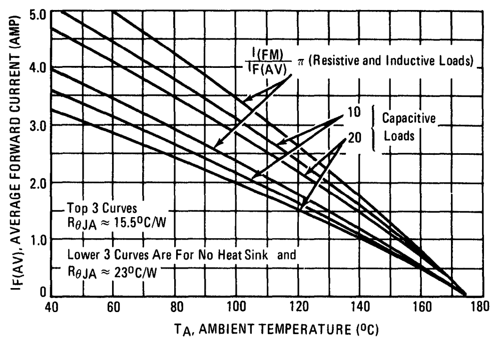


FIGURE 10B – IERC HEATSINK UP3 AND NO HEATSINK



NOTE 2: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1

$R_{\theta 1}$ thru 4 is the thermal resistance of diodes 1 through 4

P_{D1} thru 4 is the power dissipated in diodes 1 through 4

$K_{\theta 2}$ thru 4 is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condiitons where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_{D1}$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

When the case is used as a reference point, coupling between die is neglegible for the MDA3500. When the bridge is used without a heatsink, coupling between die is approximately 70% and $R_{\theta 1}$ is 30°C/W,

$\therefore R_{\theta(EFF)} = 30\ [1 + (3)\ (.7)]/4 = 23°C/W$

NOTE 3: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure11. The current derating data of Figure 4 applies to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A = I_B$, derating information can be calculated as follows:

(6) $T_{R(Max)} = T_{J(Max)} - \Delta T_{J1}$

Where $T_{R(Max)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 2.

For example, to determine $T_{C(Max)}$ for the MDA3500 with the following capacitive load condiitons.

I_A = 20 A average with a peak of 60 A

I_B = 10 A average with a peak of 70 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 60/10 = 6.0. (Note that the peak to average ratio is on a per diode basis and each diode provides 10 A average).

From Figure 5, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 6.0 read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)}$ = 14.

Thus, the package power dissipation for 10 A is 20 watts or 5.0 watts/diode $\therefore P_{D2} = P_{D4}$ = 5.0 watts.

The maximum junction temperature occurs in diode #1 and #3. From equation (3) for diode #1 ΔT_{J1} = (7.5) (10), since coupling is negligible.

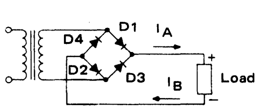
$\Delta T_{J1} \approx 75°C$

Thus $T_{C(Max)}$ = 175 -75 = 100°C

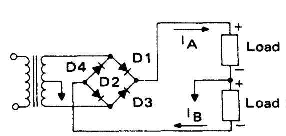
The total package dissipation in this example is:

$P_{DT(AV)}$ = 2 x 10 + 2 x 5.0 = 30 watts, which must be considered when selecting a heat sink.

FIGURE 11– BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



Circuit A



Circuit B

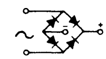
MOTOROLA

MDA3550
MDA3551

RECTIFIER ASSEMBLY

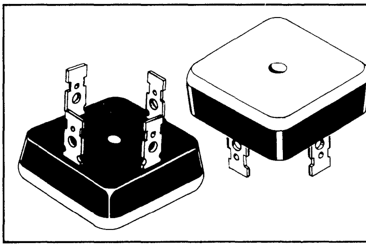
. . . utilizing individual void-free molded MR2500 Series rectifiers, interconnected and mounted on an electrically isolated aluminum heat sink by a high thermal-conductive epoxy resin.

- 400 Ampere Surge Capability
- Electrically Isolated Base — 1800 Volts
- Cost Effective in Lower Current Applications



SINGLE-PHASE FULL-WAVE BRIDGE

35 AMPERES
50-100 VOLTS



MAXIMUM RATINGS

Rating (Per Diode)	Symbol	MDA 3550	MDA 3551	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	Volts
DC Output Voltage Resistive Load Capacitive Load	Vdc	 30 50	 62 100	Volts
Sine Wave RMS Input Voltage	$V_{R(RMS)}$	35	70	Volts
Average Rectified Forward Current (Single phase bridge resistive load, 60 Hz, T_C = 55°C)	I_O	← 35 →		Amp
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 400 →		Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →		°C

THERMAL CHARACTERISTICS (Total Bridge)

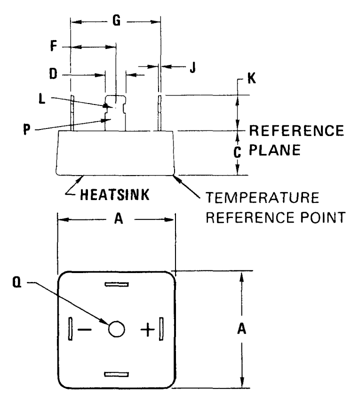
Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.4	1.87	°C/W

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

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (Per Diode) (i_F = 55 A)	v_F	—	1.0	1.1	Volts
Reverse Current (Per Diode) (Rated V_R)	I_R	—	—	0.50	mA

MECHANICAL CHARACTERISTICS

CASE: Plastic case with an electrically isolated aluminum base.
POLARITY: Terminal-designation embossed on case
+DC output
-DC output
AC not marked
MOUNTING POSITION: Bolt down. Highest heat transfer efficiency accomplished through the surface opposite the terminals. Use silicon grease on mounting surface for maximum heat transfer.
WEIGHT: 40 grams (approx.)
TERMINALS: Suitable for fast-on connections. Readily solderable, corrosion resistant. Soldering recommended for applications greater than 15 amperes.
MOUNTING TORQUE: 20 in. lb. max.



NOTES:
1. DIMENSION "Q" SHALL BE MEASURED ON HEATSINK SIDE OF PACKAGE.
2. DIMENSIONS "F" AND "G" SHALL BE MEASURED AT THE REFERENCE PLANE.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	25.65	26.16	1.010	1.030
C	12.44	13.97	0.490	0.550
D	6.10	6.60	0.240	0.260
F	10.01	10.49	0.394	0.413
G	19.99	21.01	0.787	0.827
J	0.71	0.86	0.028	0.034
K	9.52	11.43	0.375	0.450
L	1.52	2.06	0.060	0.081
P	2.79	2.92	0.110	0.115
Q	4.42	4.67	0.174	0.184

CASE 309A-03

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FIGURE 1 — FORWARD VOLTAGE

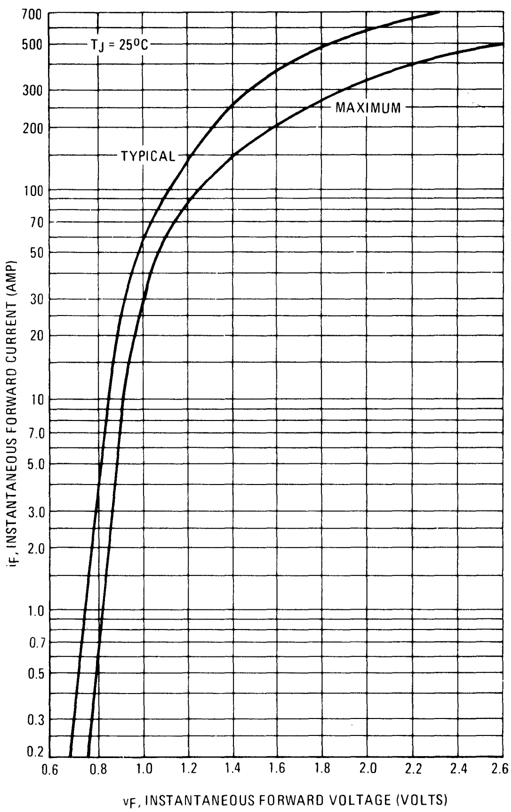


FIGURE 2 — NON REPETITIVE SURGE CURRENT

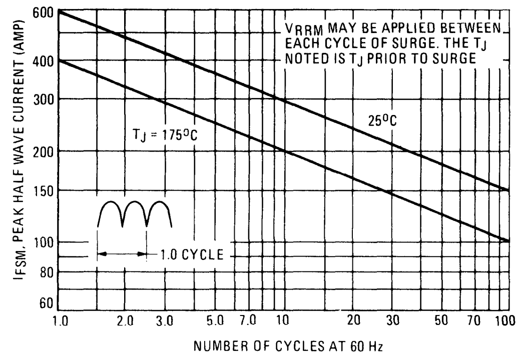


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

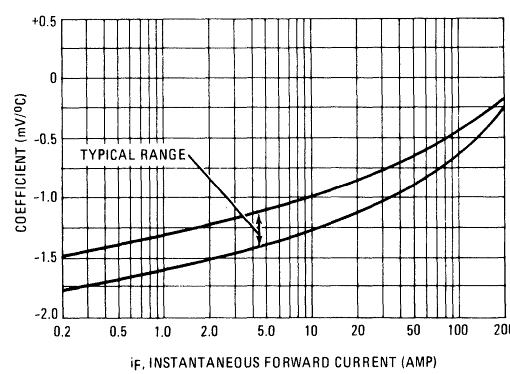


FIGURE 4 — CURRENT DERATING

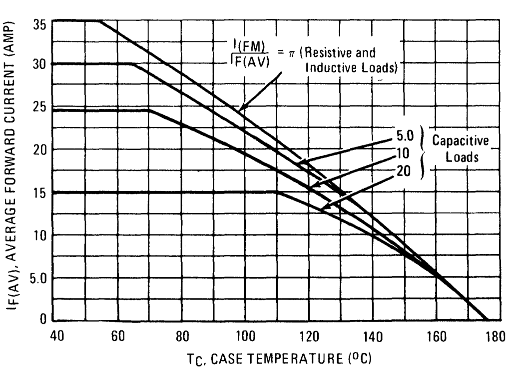


FIGURE 5 — FORWARD POWER DISSIPATION

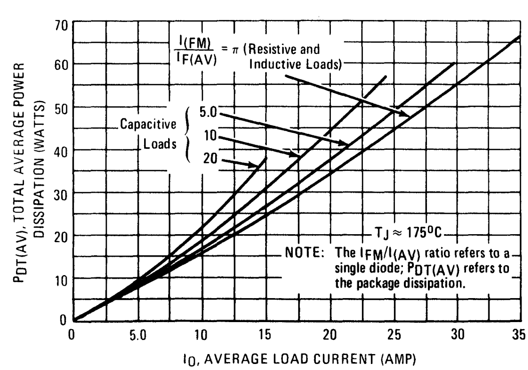
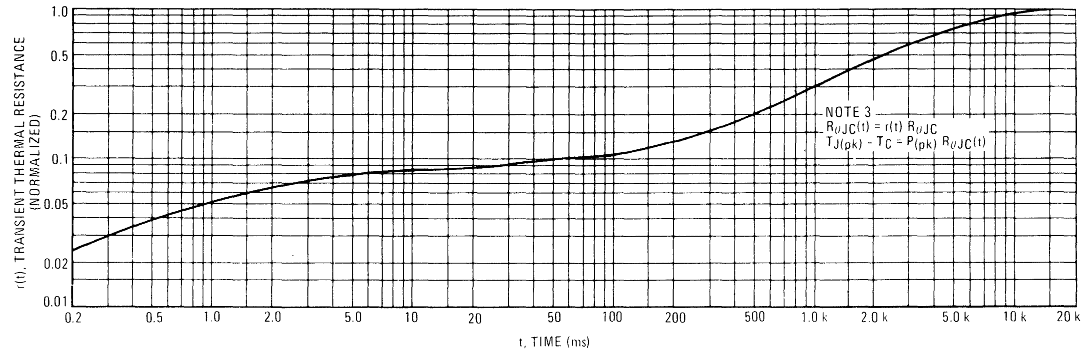
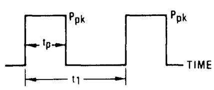


FIGURE 6 — TYPICAL THERMAL RESPONSE



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 the outline drawing on page 1). 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

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

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

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

FIGURE 7 — CAPACITANCE

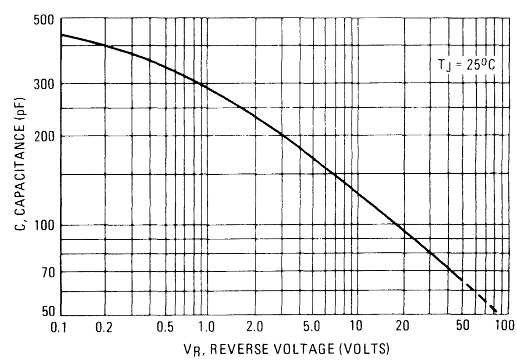


FIGURE 8 — FORWARD RECOVERY TIME

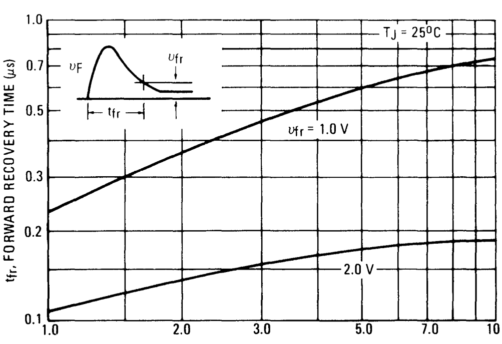
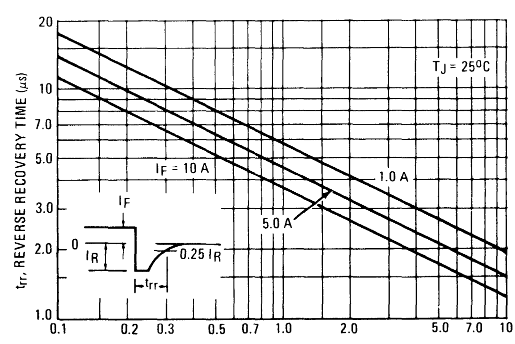


FIGURE 9 — REVERSE RECOVERY TIME



AMBIENT TEMPERATURE DERATING INFORMATION

FIGURE 10A – THERMALLOY HEATSINK 6005B

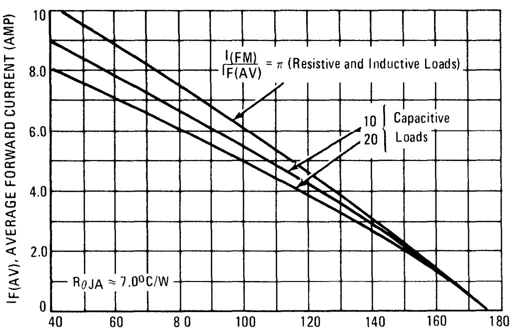
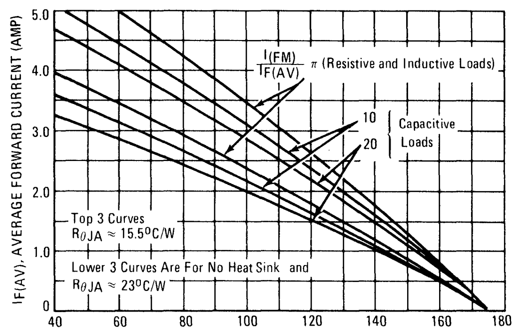


FIGURE 10B – IERC HEATSINK UP3 AND NO HEATSINK



NOTE 2: THERMAL COUPLING AND EFFECTIVE THERMAL RESISTANCE

In multiple chip devices where there is coupling of heat between die, the junction temperature can be calculated as follows:

(1) $\Delta T_{J1} = R_{\theta 1} P_{D1} + R_{\theta 2} K_{\theta 2} P_{D2} + R_{\theta 3} K_{\theta 3} P_{D3} + R_{\theta 4} K_{\theta 4} P_{D4}$

Where ΔT_{J1} is the change in junction temperature of diode 1
$R_{\theta 1}$ thru 4 is the thermal resistance of diodes 1 through 4
P_{D1} thru 4 is the power dissipated in diodes 1 through 4
$K_{\theta 2}$ thru 4 is the thermal coupling between diode 1 and diodes 2 through 4.

An effective package thermal resistance can be defined as follows:

(2) $R_{\theta(EFF)} = \Delta T_{J1}/P_{DT}$

Where: P_{DT} is the total package power dissipation

Assuming equal thermal resistance for each die, equation (1) simplifies to

(3) $\Delta T_{J1} = R_{\theta 1} (P_{D1} + K_{\theta 2} P_{D2} + K_{\theta 3} P_{D3} + K_{\theta 4} P_{D4})$

For the condiitons where $P_{D1} = P_{D2} = P_{D3} = P_{D4}$, $P_{DT} = 4 P_{D1}$, equation (3) can be further simplified and by substituting into equation (2) results in

(4) $R_{\theta(EFF)} = R_{\theta 1} (1 + K_{\theta 2} + K_{\theta 3} + K_{\theta 4})/4$

When the case is used as a reference point, coupling between die is neglegible for the MDA3550. When the bridge is used without a heatsink, coupling between die is approximately 70% and $R_{\theta 1}$ is 30°C/W,

$\therefore R_{\theta(EFF)} = 30\ [1 + (3)\ (.7)]/4 = 23°C/W$

NOTE 3: SPLIT LOAD DERATING INFORMATION

Bridge rectifiers are used in two basic configurations as shown by circuits A and B of Figure 11. The current derating data of Figure 4 applies to the standard bridge circuit (A) where $I_A = I_B$. For circuit B where $I_A = I_B$, derating information can be calculated as follows:

(6) $T_{R(Max)} = T_{J(Max)} - \Delta T_{J1}$

Where $T_{R(Max)}$ is the reference temperature (either case or ambient)

ΔT_{J1} can be calculated using equation (3) in Note 2.

For example, to determine $T_{C(Max)}$ for the MDA3550 with the following capacitive load condiitons.

I_A = 20 A average with a peak of 60 A
I_B = 10 A average with a peak of 70 A

First calculate the peak to average ratio for I_A. $I_{(PK)}/I_{(AV)}$ = 60/10 = 6.0. (Note that the peak to average ratio is on a per diode basis and each diode provides 10 A average).

From Figure 5, for an average current of 20 A and an $I_{(PK)}/I_{(AV)}$ = 6.0 read $P_{DT(AV)}$ = 40 watts or 10 watts/diode. Thus $P_{D1} = P_{D3}$ = 10 watts.

Similarly, for a load current I_B of 10 A, diode #2 and diode #4 each see 5.0 A average resulting in an $I_{(PK)}/I_{(AV)}$ = 14.

Thus, the package power dissipation for 10 A is 20 watts or 5.0 watts/diode $\therefore P_{D2} = P_{D4}$ = 5.0 watts.

The maximum junction temperature occurs in diode #1 and #3. From equation (3) for diode #1 ΔT_{J1} = (7.5) (10), since coupling is negligible.

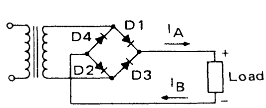
$\Delta T_{J1} \approx 75°C$

Thus $T_{C(Max)}$ = 175 -75 = 100°C

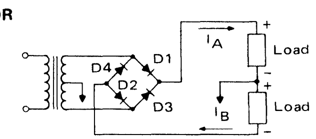
The total package dissipation in this example is:

$P_{DT(AV)} = 2 \times 10 + 2 \times 5.0 = 30$ watts, which must be considered when selecting a heat sink.

FIGURE 11– BASIC CIRCUIT USES FOR BRIDGE RECTIFIERS



Circuit A



Circuit B

MOTOROLA

MLL4001 thru MLL4004

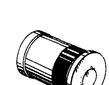
Advance Information

LEADLESS SURFACE MOUNTED RECTIFIERS

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

LEADLESS SURFACE MOUNTED SILICON RECTIFIERS

50-400 VOLTS DIFFUSED JUNCTION



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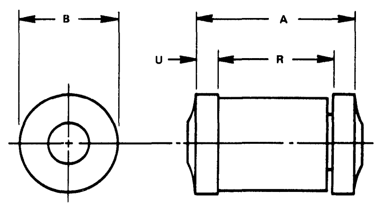
MAXIMUM RATINGS

Rating	Symbol	MLL 4001	4002	4003	4004	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	Volts
Nonrepetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, T_A = 75°C)	I_O	1.0				Amp
Nonrepetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	20 (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)	v_F	0.95	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop (I_O = 1.0 Amp, T_C = 75°C)	$V_{F(AV)}$	—	0.8	Volts
Maximum Reverse Current (rated dc voltage) T_J = 25°C T_J = 100°C	I_R	0.05 1.0	10 100	μA
Maximum Full-Cycle Average Reverse Current (I_O = 1.0 Amp, T_C = 75°C)	$I_{R(AV)}$	—	30	μA



DIM	MILLIMETERS MIN	MAX	INCHES MIN	MAX
A	4.80	5.20	0.189	0.205
B	2.44	2.54	0.096	0.100
R	3.71	4.59	0.146	0.181
U	0.36	0.50	0.014	0.020

CASE 362B-01

MECHANICAL CHARACTERISTICS

CASE: Glass

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C @ end caps for 10 seconds

FINISH: All external surfaces are corrosion-resistant, end caps are readily solderable

POLARITY: Cathode indicated by color band

This document contains information on a new product. Specifications and information herein are subject to change without notice.

MR327 MR328
MR330 MR331
See Page 3-6

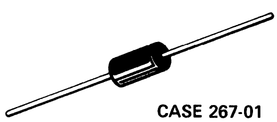
MOTOROLA

MR500 MR501 MR502 MR504 MR506 MR508 MR510

Designers Data Sheet

STANDARD RECOVERY POWER RECTIFIERS

50-1000 VOLTS
3 AMPERE



CASE 267-01

MINIATURE SIZE, AXIAL LEAD MOUNTED STANDARD RECOVERY POWER RECTIFIERS

. . . designed for use in power supplies and other applications having need of a device with the following features:

- High Current to Small Size
- High Surge Current Capability
- Low Forward Voltage Drop
- Economical Plastic Package
- Available in Volume Quantities

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.

MAXIMUM RATINGS

Rating	Symbol	MR500	MR501	MR502	MR504	MR506	MR508	MR510	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	V_{RSM}	75	150	250	450	650	850	1050	Volts
Average Rectified Forward Current (Single phase resistive load, T_Z = 95°C, PC Board Mounting) (1) (EIA Standard Conditions L = 1/32", T_L = 85°C)	I_O	← 3.0 → ← 8.0 →							Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 → (one cycle)							Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← −65 to +175 →							°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 2 on Page 4).	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (3) (i_F = 9.4 Amp, T_J = 175°C) (i_F = 9.4 Amp, T_J = 25°C)	v_F	 — —	 0.9 1.04	 1.0 1.1	Volts
Reverse Current (rated dc voltage) (3) T_J = 25°C T_J = 100°C	I_R	 — —	 0.1 2.8	 5.0 25	μA

(1) Derate for reverse power dissipation. See Note on Page 2.
(2) Derate as shown in Figure 1.
(3) Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2.0%.

MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

NOTE 1: DETERMINING MAXIMUM RATINGS

Reverse power dissipation and the possibility of thermal runaway must be considered when operating this rectifier at reverse voltages above 200 volts. Proper derating may be accomplished by use of equation (1):

$$T_{A(max)} = T_{J(max)} - R_{\theta JA}P_{F(AV)} - R_{\theta JA}P_{R(AV)} \quad (1)$$

where

$T_{A(max)}$ = Maximum allowable ambient temperature

$T_{J(max)}$ = Maximum allowable junction temperature (175°C or the temperature at which thermal runaway occurs, whichever is lowest.)

$P_{F(AV)}$ = Average forward power dissipation

$P_{R(AV)}$ = Average reverse power dissipation

$R_{\theta JA}$ = Junction-to-ambient thermal resistance

Figure 1 permits easier use of equation (1) by taking reverse power dissipation and thermal runaway into consideration. The figure solves for a reference temperature as determined by equation (2):

$$T_R = T_{J(max)} - R_{\theta JA}P_{R(AV)} \quad (2)$$

Substituting equation (2) into equation (1) yields:

$$T_{A(max)} = T_R - R_{\theta JA}P_{F(AV)} \quad (3)$$

Inspection of equations (2) and (3) reveals that T_R is the ambient temperature at which thermal runaway occurs or where T_J = 175°C, when forward power is zero. The transition from one boundary condition to the other is evident on the curves of Figure 1 as a difference in the rate of change of the slope in the vicinity of 165°C. The data of Figure 1 is based upon dc conditions. For use in common rectifier circuits, Table 1 indicates suggested factors for an equivalent dc voltage to use for conservative design; i.e.:

$$V_{R(equiv)} = V_{in(PK)} \times F \quad (4)$$

The Factor F is derived by considering the properties of the various rectifier circuits and the rectifiers reverse characteristics.

Example: Find $T_{A(max)}$ for MR510 operated in a 400 Volt dc supply using a full wave center-tapped circuit with capacitive filter such that I_{DC} = 6.0 A, ($I_{F(AV)}$ = 3.0 A), $I_{(PK)}/I_{(AV)}$ = 10, Input Voltage = 283 V(rms) (line to center tap), $R_{\theta JA}$ = 28°C/W.

Step 1: Find $V_{R(equiv)}$. Read F = 1.11 from Table 1 ∴ $V_{R(equiv)}$ = 1.41)(283)(1.11) = 444 V

Step 2: Find T_R from Figure 1. Read T_R = 167°C @ V_R = 444 V & $R_{\theta JA}$ = 28°C/W.

Step 3: Find $P_{F(AV)}$ from Figure 8. Read $P_{F(AV)}$ = 4 W @ $\frac{I_{PK}}{I_{AV}}$ = 10 & $I_{F(AV)}$ = 3.0 A

Step 4: Find $T_{A(max)}$ from equation (3). $T_{A(max)}$ = 167-(28)(4) = 55°C.

TABLE I — VALUES FOR FACTOR F

Circuit	Half Wave		Full Wave, Bridge		Full Wave Center-Tapped*†	
Load	Resistive	Capacitive*	Resistive	Capacitive	Resistive	Capacitive
Sine Wave	0.45	1.11	0.45	0.55	0.90	1.11
Square Wave	0.61	1.22	0.61	0.61	1.22	1.22

*Note that $V_{R(PK)} \approx 2\ V_{in(PK)}$

†Use line to center tap voltage for V_{in}.

FIGURE 1 — MAXIMUM REFERENCE TEMPERATURE

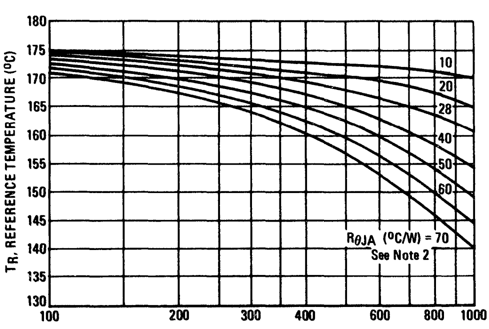
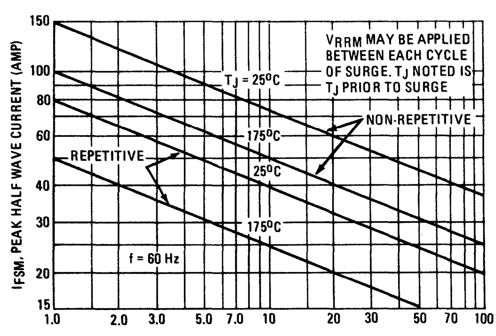


FIGURE 2 — MAXIMUM SURGE CAPABILITY



3

3

CURRENT DERATING
(Reverse Power Loss Neglected)

FIGURE 3 – PC BOARD MOUNTING

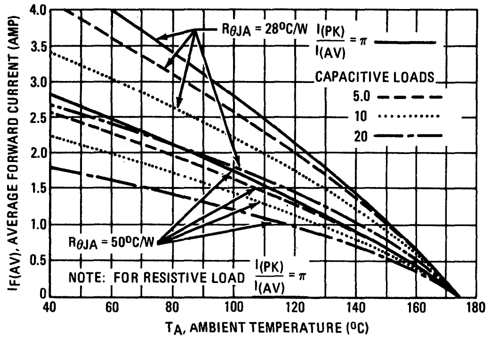


FIGURE 4 – SEVERAL LEAD LENGTHS

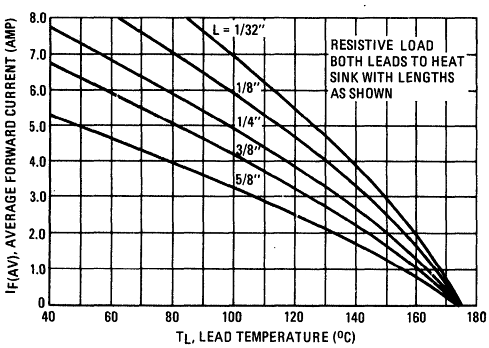


FIGURE 5 – 1/8" LEAD LENGTH

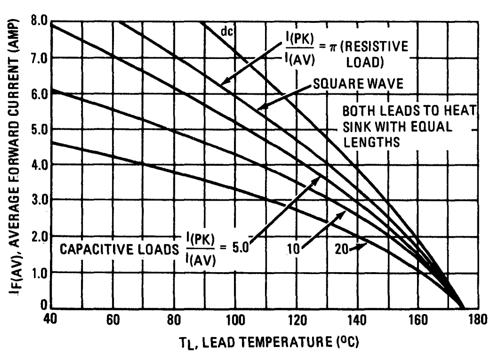


FIGURE 6 – MAXIMUM FORWARD VOLTAGE

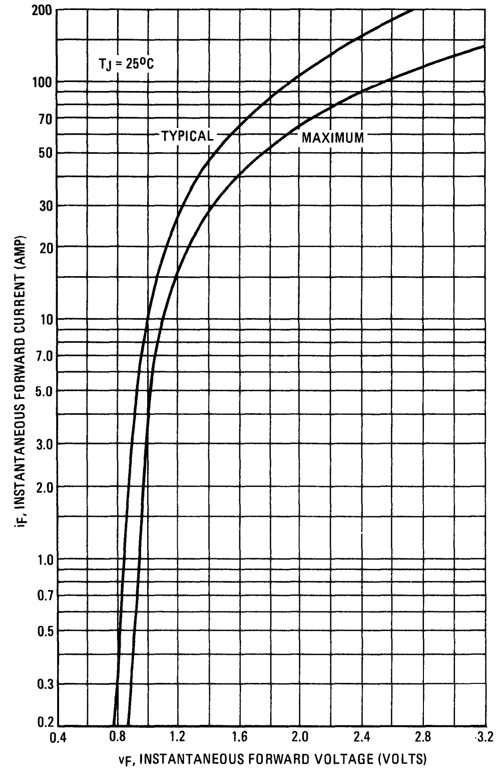


FIGURE 7 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

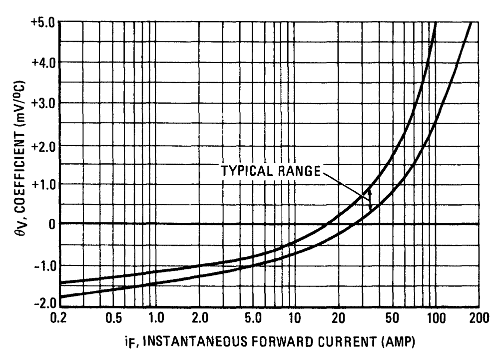


FIGURE 8 – FORWARD POWER DISSIPATION

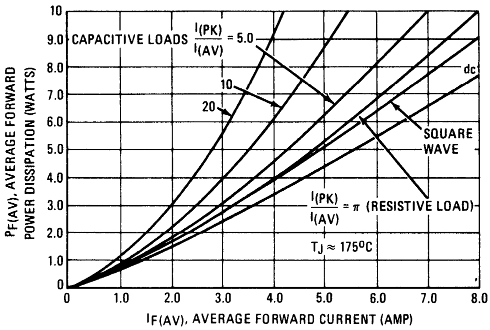
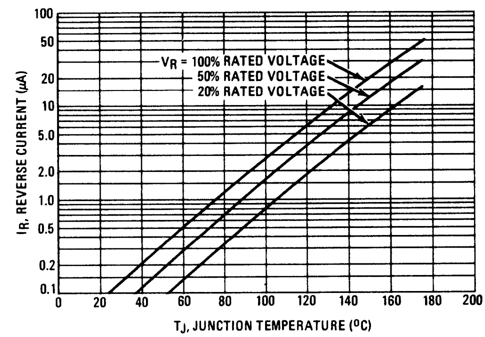


FIGURE 9 – TYPICAL REVERSE CURRENT



THERMAL CHARACTERISTICS

FIGURE 10 – THERMAL RESPONSE

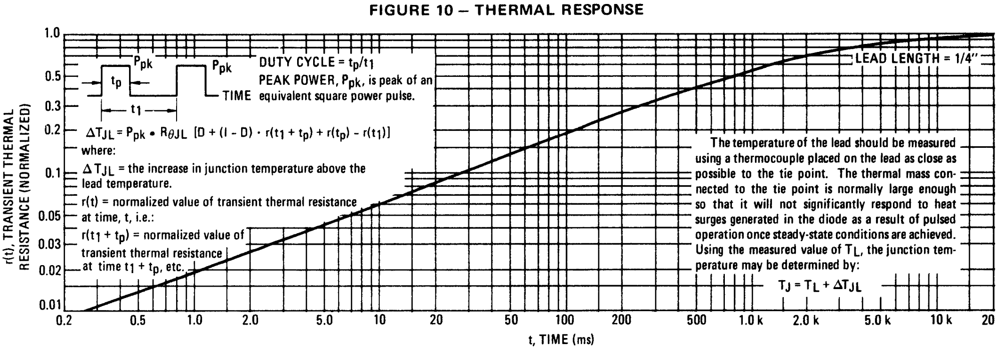
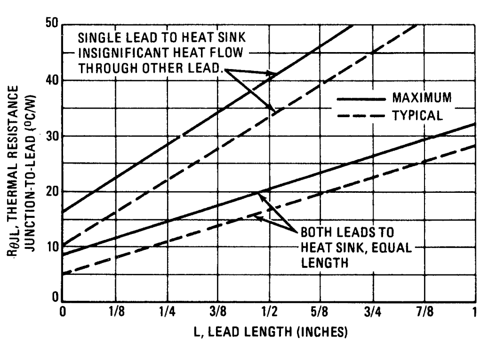


FIGURE 11 – STEADY-STATE THERMAL RESISTANCE



NOTE 2 – AMBIENT MOUNTING DATA

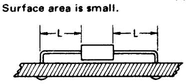
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

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

MOUNTING METHOD	LEAD LENGTH, L (IN)				$R_{\theta JA}$
	1/8	1/4	1/2	3/4	
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

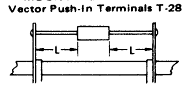
MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.



MOUNTING METHOD 2

Vector Push-In Terminals T-28



MOUNTING METHOD 3

P.C. Board with 1-1/2" x 1-1/2" Copper Surface

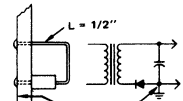
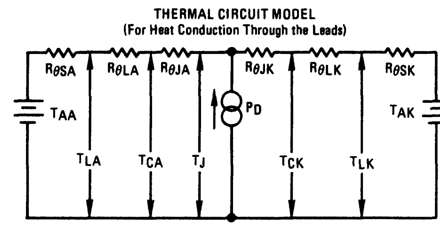


FIGURE 12 – APPROXIMATE THERMAL CIRCUIT MODEL



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
T_L = Lead Temperature
T_C = Case Temperature
T_J = Junction Temperature
$R_{\theta S}$ = Thermal Resistance, Heat Sink to Ambient
$R_{\theta L}$ = Thermal Resistance, Lead to Heat Sink
$R_{\theta J}$ = Thermal Resistance, Junction to Case
P_D = Total Power Dissipation = $P_F + P_R$
P_F = Forward Power Dissipation
P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.)
Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

$$T_L = T_{J(max)} - \Delta T_{JL}$$

where $\Delta T_{JL} \approx R_{\theta JL}$

TYPICAL DYNAMIC CHARACTERISTICS

(T_J = 25°C)

FIGURE 13 – FORWARD RECOVERY TIME

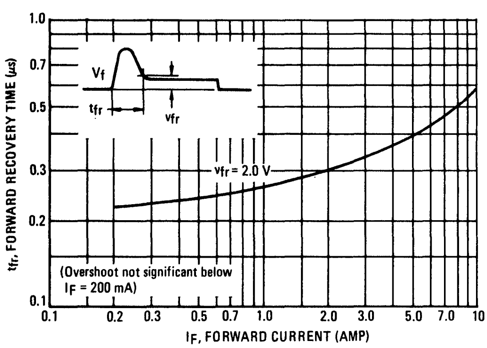


FIGURE 14 – REVERSE RECOVERY TIME

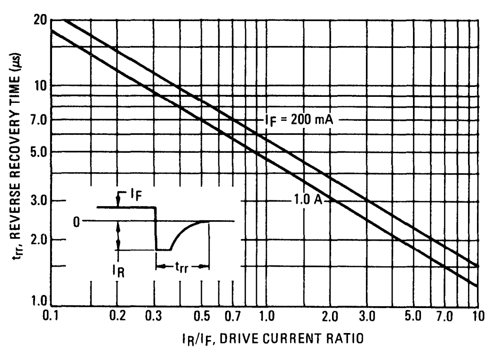


FIGURE 15 – RECTIFICATION WAVEFORM EFFICIENCY

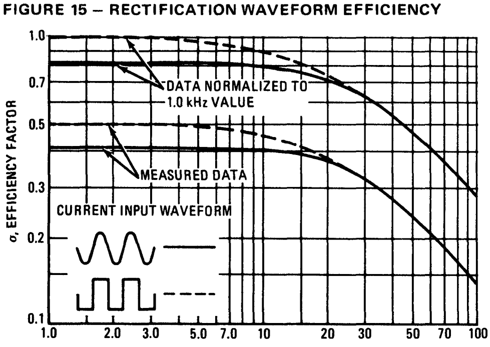
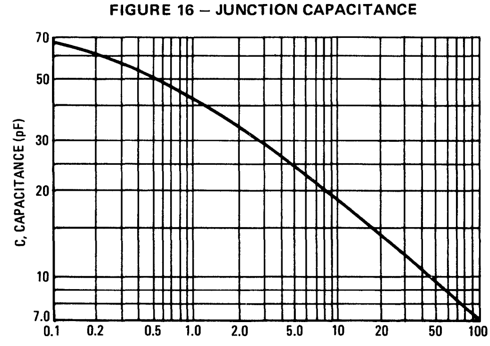


FIGURE 16 – JUNCTION CAPACITANCE



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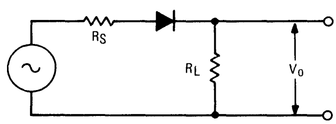
RECTIFIER EFFICIENCY NOTE

FIGURE 17 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 15 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\dfrac{V^2{}_o(dc)}{R_L}}{\dfrac{V^2{}_o(rms)}{R_L}} \cdot 100\% = \frac{V^2{}_o(dc)}{V^2{}_o(ac) + V^2{}_o(dc)} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

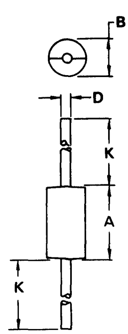
$$\sigma_{(square)} = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(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 14) 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 on Figure 15.

It should be emphasized that Figure 15 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for the figure.

OUTLINE DIMENSIONS



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

MR750
MR751 MR752
MR754 MR756

MOTOROLA

Designers Data Sheet

HIGH CURRENT LEAD MOUNTED RECTIFIERS

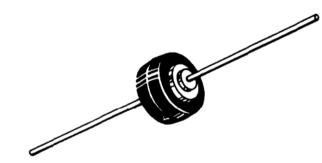
- Current Capacity Comparable To Chassis Mounted Rectifiers
- Very High Surge Capacity
- Insulated Case

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.

HIGH CURRENT LEAD MOUNTED SILICON RECTIFIERS

50-600 VOLTS DIFFUSED JUNCTION



3

MAXIMUM RATINGS

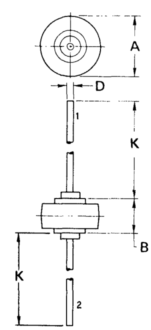
Characteristic	Symbol	MR750	MR751	MR752	MR754	MR756	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz peak)	V_{RSM}	60	120	240	480	720	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz.) See Figures 5 and 6.	I_O	← 22 (T_L = 60°C, 1/8" Lead Lengths) 6.0 (T_A = 60°C, P.C. Board mounting) →					Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 400 (for 1 cycle) →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +175 →					°C

ELECTRICAL CHARACTERISTICS

Characteristic and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage Drop (i_F = 100 Amp, T_J = 25=C)	v_F	1.25	Volts
Maximum Forward Voltage Drop (I_F = 6.0 Amp, T_A = 25°C, 3/8" leads)	V_F	0.90	Volts
Maximum Reverse Current (rated dc voltage) T_J = 25=C T_J = 100°C	I_R	0.25 1.0	mA

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350°C 3/8" from case for 10 seconds at 5.0 lbs. tension
FINISH: All external surfaces are corrosion-resistant, leads are readily solderable
POLARITY: Indicated by diode symbol
WEIGHT: 2.5 Grams (approx.)



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.43	8.68	0.322	0.342
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194-05

FIGURE 1 – FORWARD VOLTAGE

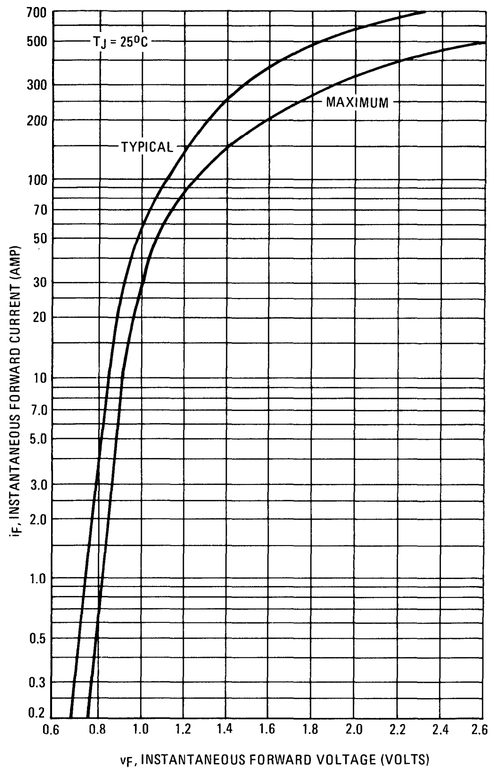


FIGURE 2 – MAXIMUM SURGE CAPABILITY

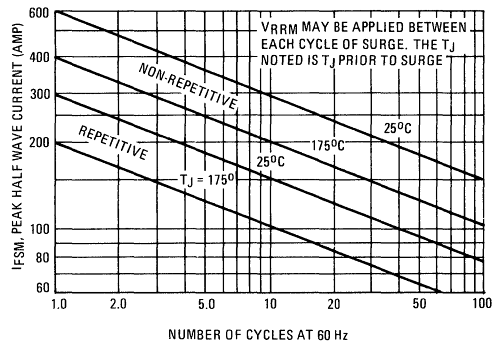


FIGURE 3 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

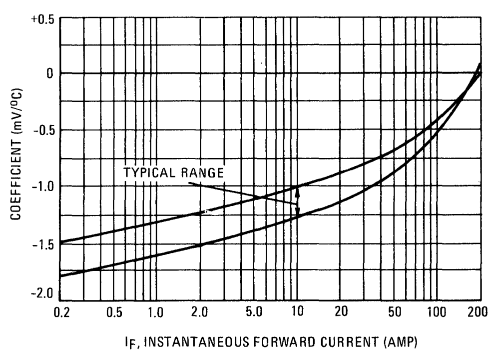


FIGURE 4 – TYPICAL TRANSIENT THERMAL RESISTANCE

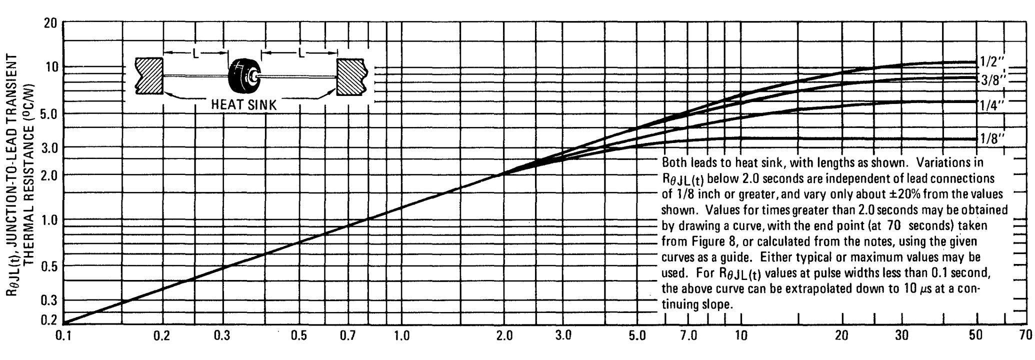


FIGURE 5 — MAXIMUM CURRENT RATINGS

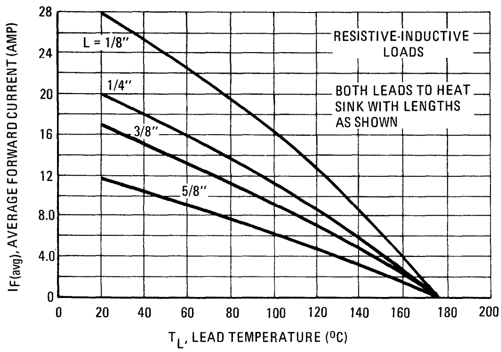


FIGURE 6 — MAXIMUM CURRENT RATINGS

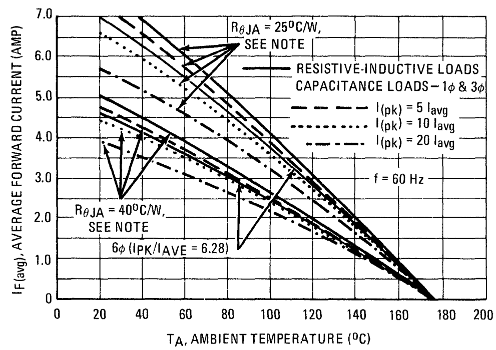


FIGURE 7 — POWER DISSIPATION

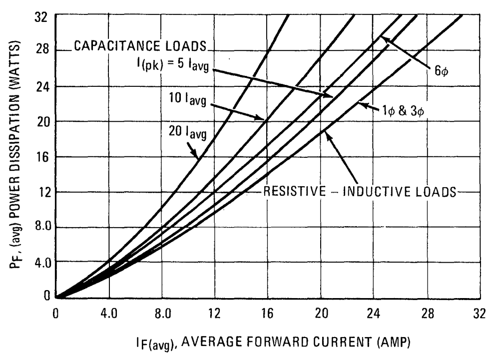
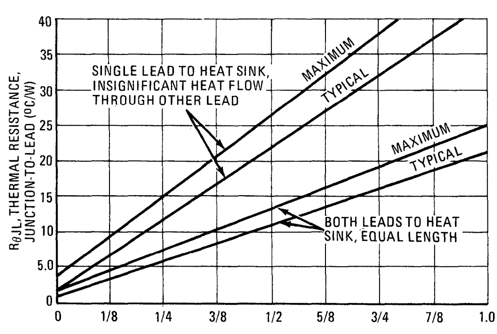


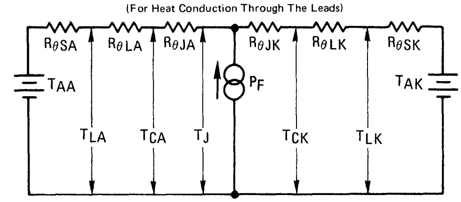
FIGURE 8 — STEADY STATE THERMAL RESISTANCE



NOTES

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. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. 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_F = Power Dissipation

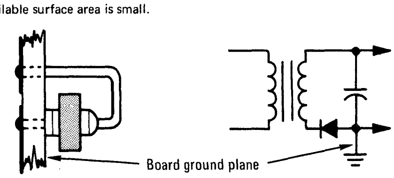
(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are:

$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AVG)}$. Therefore maximum lead temperature may be found from: $T_L = 175° - R_{\theta JL}\, P_F$. P_F may be found from Figure 7.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2" x 1-1/2" copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

3

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 9 – RECTIFICATION EFFICIENCY

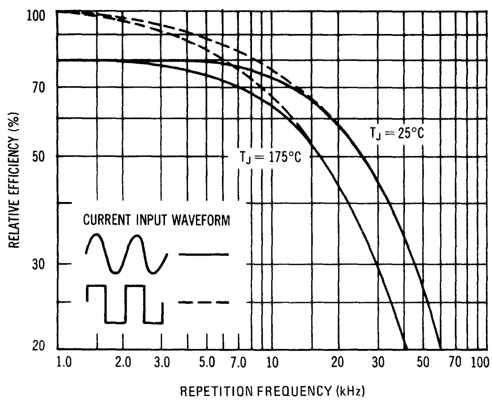


FIGURE 10 – REVERSE RECOVERY TIME

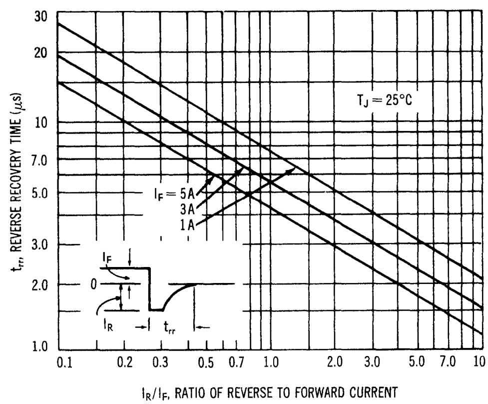


FIGURE 11 – JUNCTION CAPACITANCE

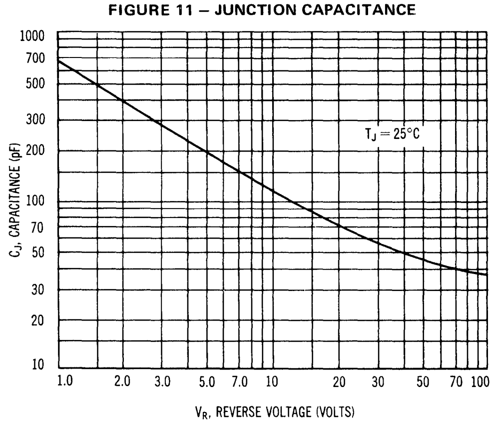


FIGURE 12 – FORWARD RECOVERY TIME

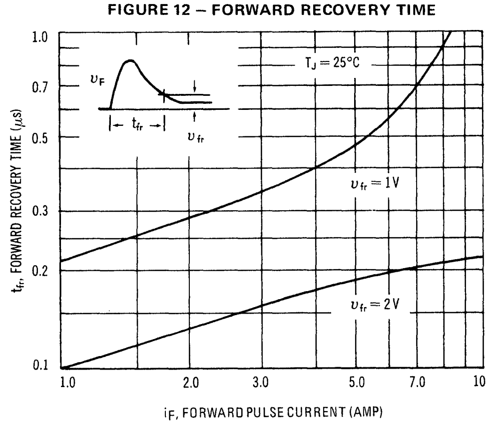
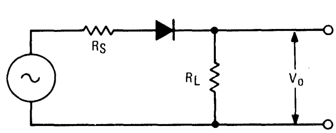


FIGURE 13 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 9 was calculated using the formula:

$$\sigma = \frac{P_{(dc)}}{P_{(rms)}} = \frac{\dfrac{V^2{}_o(dc)}{R_L}}{\dfrac{V^2{}_o(rms)}{R_L}} \cdot 100\% = \frac{V^2{}_o(dc)}{V^2{}_o(ac) + V^2{}_o(dc)} \cdot 100\% \quad (1)$$

For a sine wave input $V_m \sin(\omega t)$ to the diode, assumed lossless, the maximum theoretical efficiency factor becomes:

$$\sigma(\text{sine}) = \frac{\dfrac{V^2{}_m}{\pi^2 R_L}}{\dfrac{V^2{}_m}{4R_L}} \cdot 100\% = \frac{4}{\pi^2} \cdot 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma(\text{square}) = \frac{\dfrac{V^2{}_m}{2R_L}}{\dfrac{V^2{}_m}{R_L}} \cdot 100\% = 50\% \quad (3)$$

(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 10) 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 on Figure 9.

It should be emphasized that Figure 9 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_o with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 9.

MR810 thru MR814
MR816 thru MR818

MOTOROLA

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER 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 350 nanoseconds providing high efficiency at frequencies to 100 kHz.

FAST RECOVERY POWER RECTIFIERS

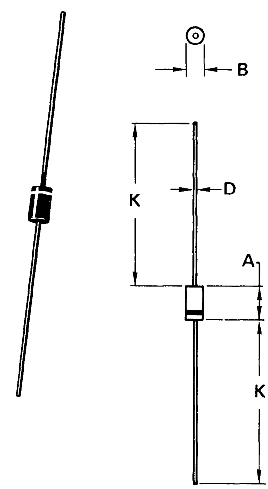
50-1000 VOLTS
1 AMPERE

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 characteristic boundaries — are given to facilitate "worst case" design.

MAXIMUM RATINGS

Rating	Symbol	MR810	MR811	MR812	MR813	MR814	MR816	MR817	MR818	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	100	200	300	400	500	800	1000	1200	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	420	560	700	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) ($T_A = 75°C$)	I_{FSM}	← 30 →								Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →								°C
Storage Temperature Range	T_{stg}	← -65 to +175 →								°C



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Typical Primted 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	–	1.1	1.2	Volts
Forward Voltage ($I_F = 1.0$ Amp, $T_A = 25°C$)	V_F	–	1.0	1.2	Volts
Reverse Current (rated dc voltage) $T_A = 25°C$ $T_A = 100°C$	I_R	– –	1.0 50	10 100	µA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc) (Figure 21) ($I_F = 20$ mA, $I_R = 2.0$ mA, Tektronix S-Plug-In) (Figure 22)	t_{rr}	– –	350 1.5	750 3.0	ns µs
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc) (Figure 21)	$I_{RM(REC)}$	–	–	3.0	Amp

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic

FINISH: External leads are plated and are readily solderable

POLARITY: Cathode indicated by Polarity band

WEIGHT: 0.4 Grams (Approximately)

FIGURE 1 — FORWARD VOLTAGE

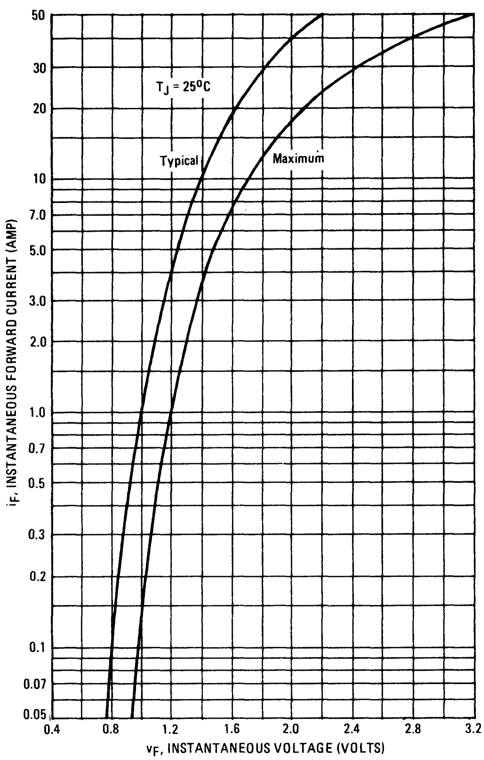


FIGURE 2 — MAXIMUM SURGE CAPABILITY

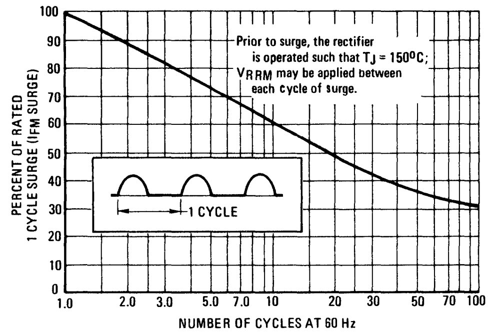


FIGURE 3 — TEMPERATURE COEFFICIENT

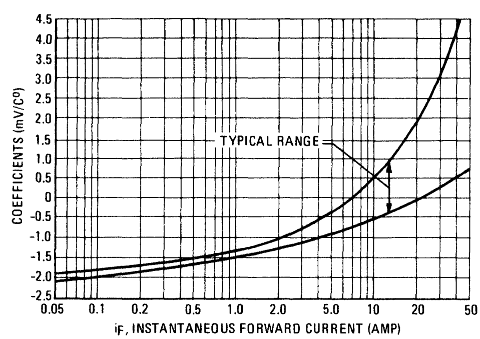


FIGURE 4 — FORWARD POWER DISSIPATION

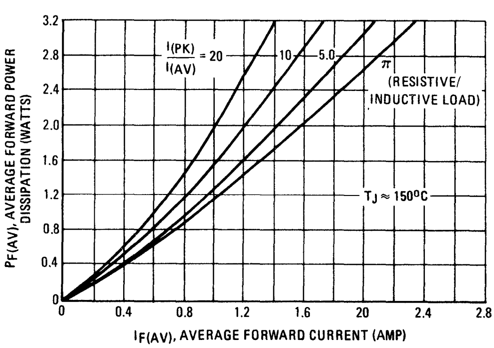
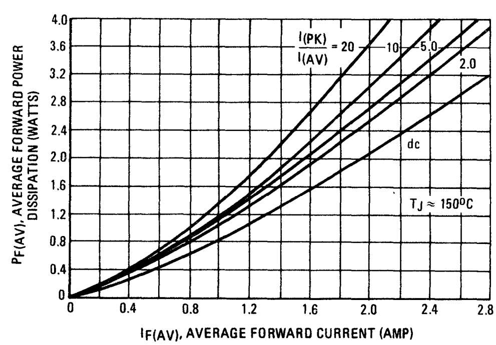


FIGURE 5 — FORWARD POWER DISSIPATION



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MAXIMUM CURRENT RATINGS
(SEE NOTES 1 and 2)

SINE WAVE INPUT

FIGURE 6 — EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

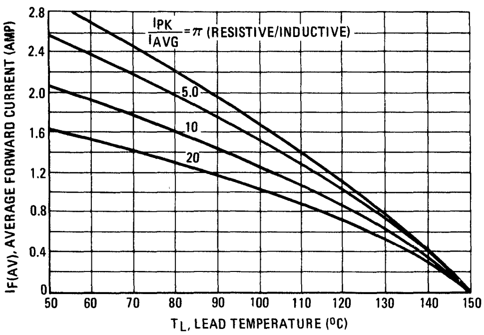


FIGURE 8 — 1/8" LEAD LENGTH, VARIOUS LOADS

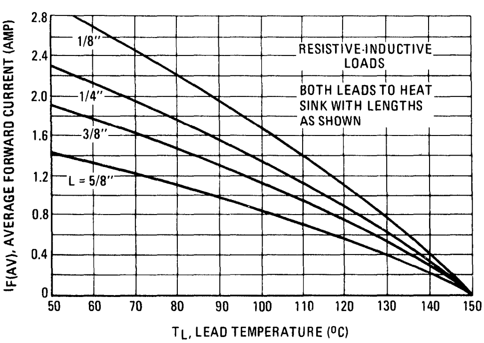
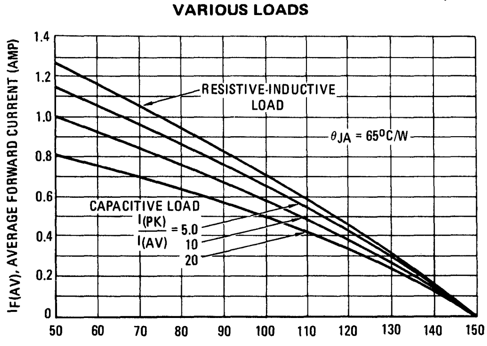


FIGURE 10 — PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUT

FIGURE 7 — EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

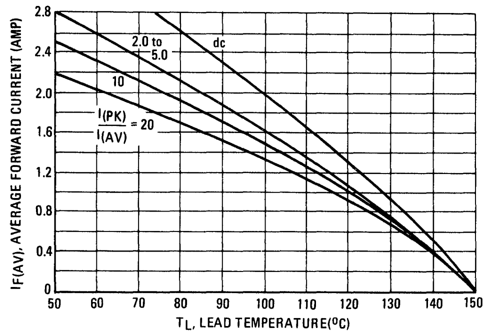


FIGURE 9 — 1/8" LEAD LENGTH, VARIOUS LOADS

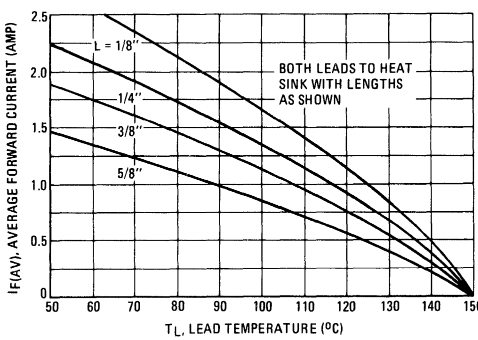


FIGURE 11 — PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

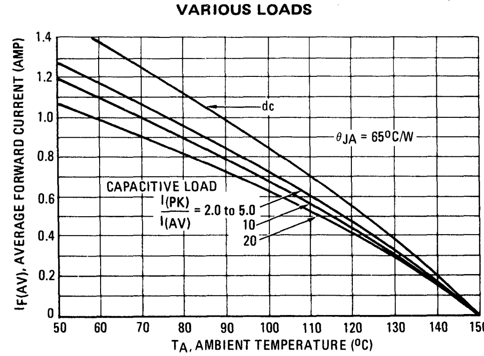


FIGURE 12 – THERMAL RESPONSE

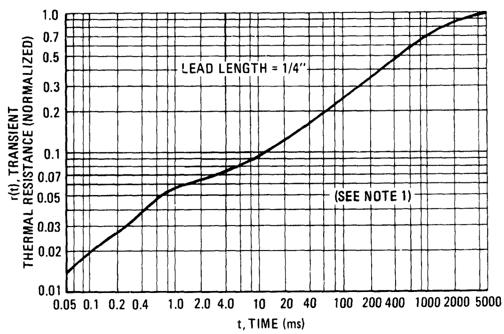
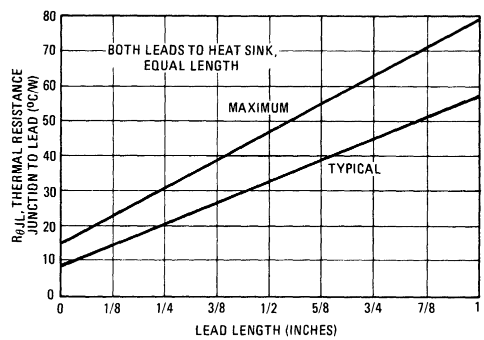
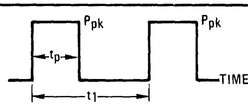


FIGURE 13 – THERMAL RESISTANCE



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 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_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:

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

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 12, i.e.:

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

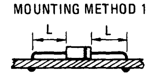
NOTE 2

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.

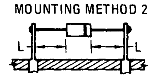
TYPICAL VALUES FOR θ_{JA} IN STILL AIR

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

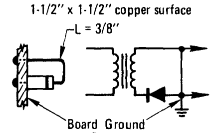
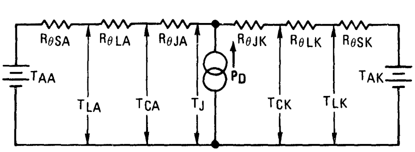


FIGURE 14 – THERMAL CIRCUIT MODEL



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:

$$T_L = 150° - \Delta T_{JL}$$

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.

3

3

TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 15 – FORWARD RECOVERY TIME

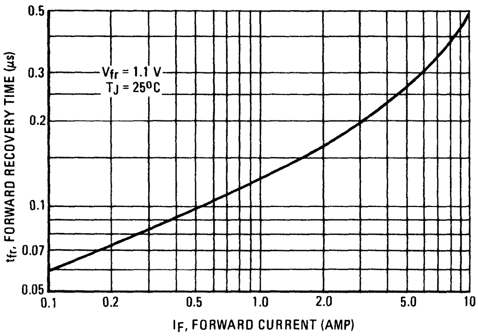
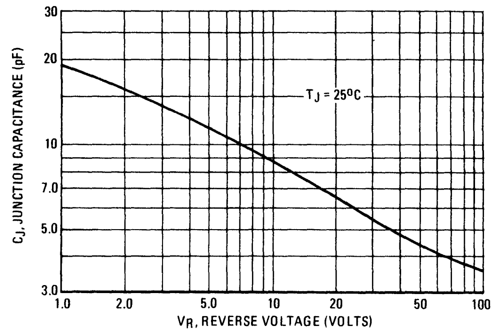


FIGURE 16 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(SEE NOTE 3)

FIGURE 17 – T_J = 25°C

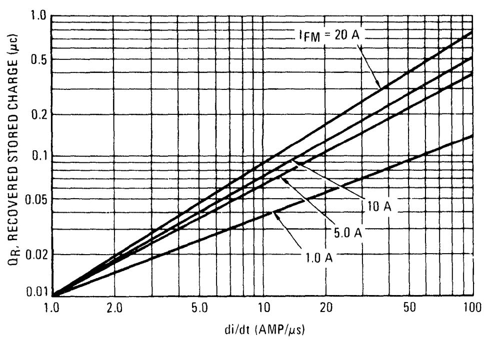


FIGURE 18 – T_J = 75°C

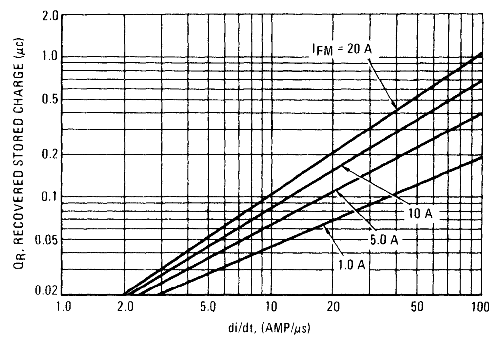


FIGURE 19 – T_J = 100°C

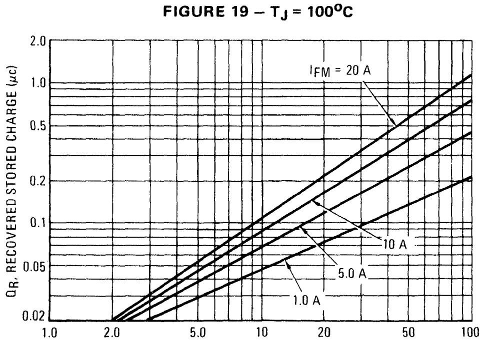


FIGURE 20 – T_J = 150°C

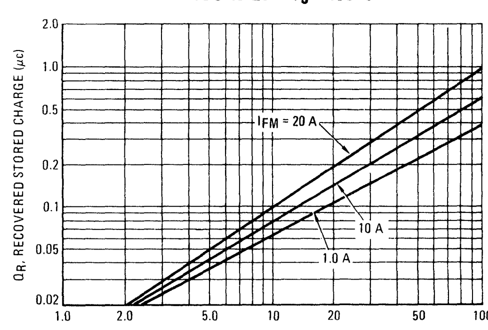


FIGURE 21 – REVERSE RECOVERY CIRCUIT

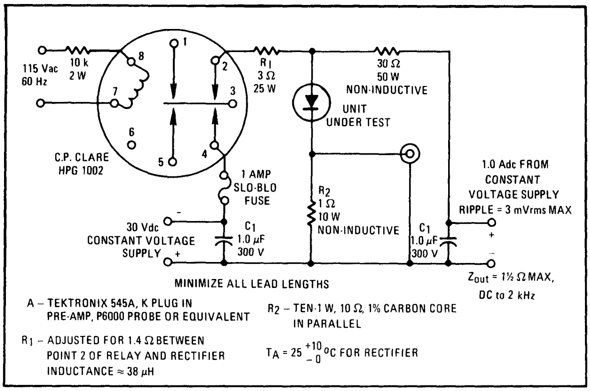
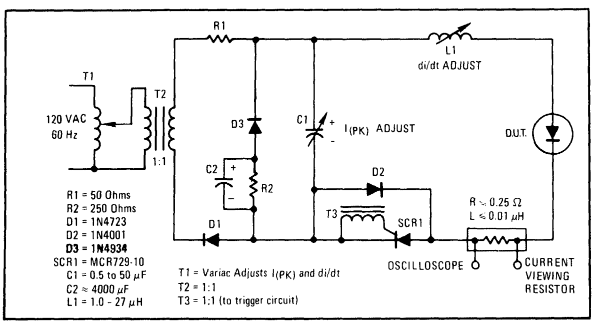


FIGURE 22 – JEDEC REVERSE RECOVERY CIRCUIT



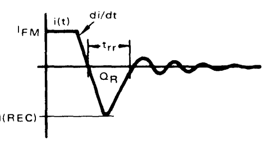
NOTE 3

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:

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

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

3

FIGURE 23 – TYPICAL REVERSE LEAKAGE

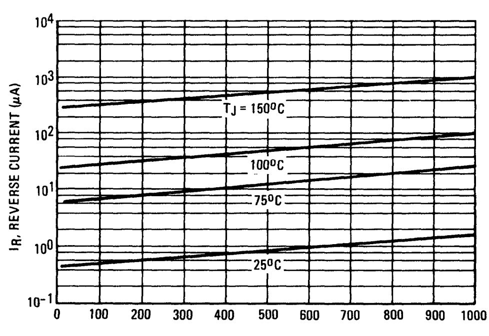
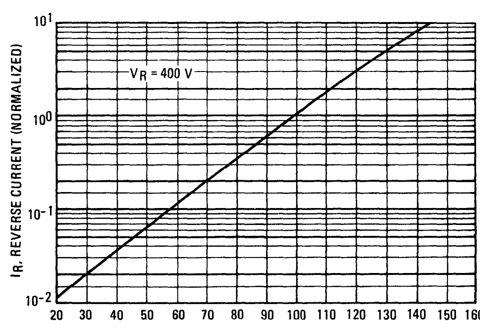


FIGURE 24 – TYPICAL REVERSE LEAKAGE



MR820 MR821 MR822 MR824 MR826

MOTOROLA

Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER 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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

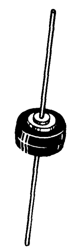
FAST RECOVERY POWER RECTIFIERS

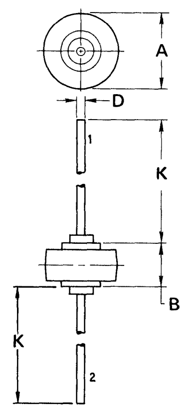
50-600 VOLTS
5.0 AMPERES

3

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.





STYLE 1:
PIN 1. CATHODE
2. ANODE
NOTE:
1. CATHODE SYMBOL ON PKG

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.43	8.69	0.332	0.342
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194-04

MAXIMUM RATINGS

Rating	Symbol	MR820	MR821	MR822	MR824	MR826	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_A = 55^oC$) (1)	I_O	← 5.0 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 300 →					Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← -65 to +175 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mounting, See Note 6, Page 8)	$R_{\theta JA}$	25	$^oC/W$

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (i_F = 15.7 Amp, $T_J = 150^oC$)	v_F	–	0.75	1.05	Volts
Forward Voltage (I_F = 5.0 Amp, $T_J = 25^oC$)	V_F	–	0.9	1.1	Volts
Maximum Reverse Current, (rated dc voltage) $T_J = 25^oC$	I_R	–	5.0	25	µA
$T_J = 100^oC$		–	0.4	1.0	mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)	t_{rr}	–	150	200	ns
(I_{FM} = 15 Amp, di/dt = 25 A/µs, Figure 26)		–	150	300	
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 25)	$I_{RM(REC)}$	–	–	2.0	Amp

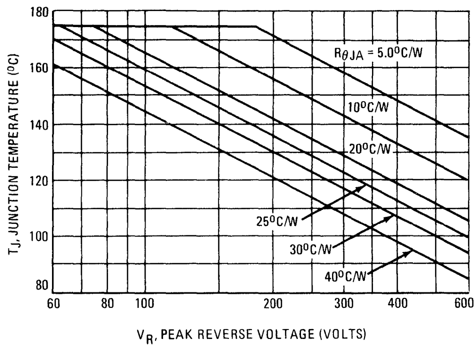
(1) Must be derated for reverse power dissipation. See Note 3
(2) Derate as shown in Figure 1.

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic
FINISH: External Surfaces are Corrosion Resistant
POLARITY: Indicated by Diode Symbol
WEIGHT: 2.5 Grams (Approximately)
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 350^oC, 3/8" from case for 10 s at 5.0 lb. tension.

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over approximately 85°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 3 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

3

RESISTIVE LOAD RATINGS
PRINTED CIRCUIT BOARD MOUNTING – SEE NOTE 6, PAGE 8

FIGURE 2 – SINE WAVE INPUT

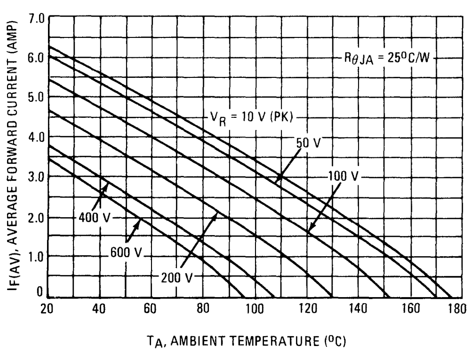


FIGURE 3 – SQUARE WAVE INPUT

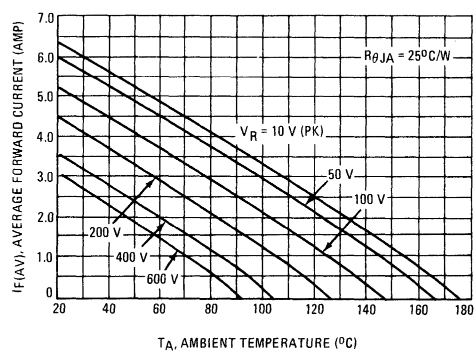


FIGURE 4 – SINE WAVE INPUT

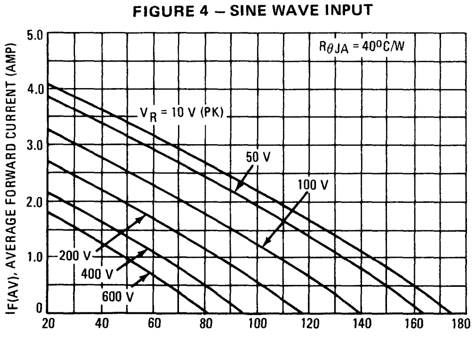
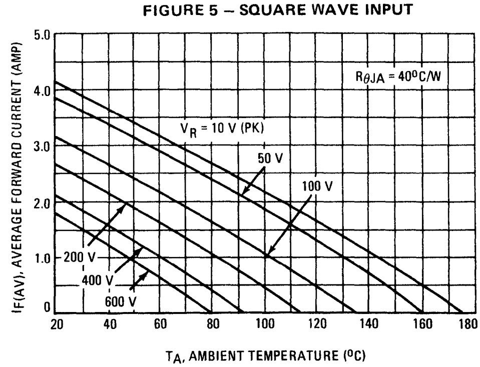


FIGURE 5 – SQUARE WAVE INPUT



3

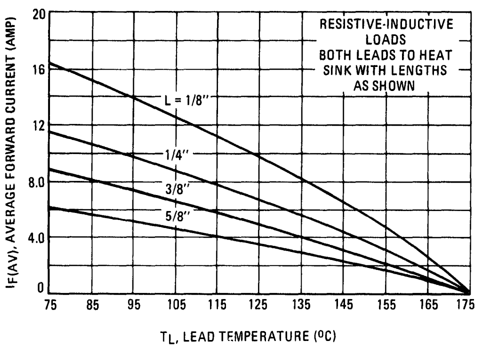
MAXIMUM CURRENT RATINGS

NOTE 2

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 3.

SINE WAVE INPUT

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD



SQUARE WAVE INPUT

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

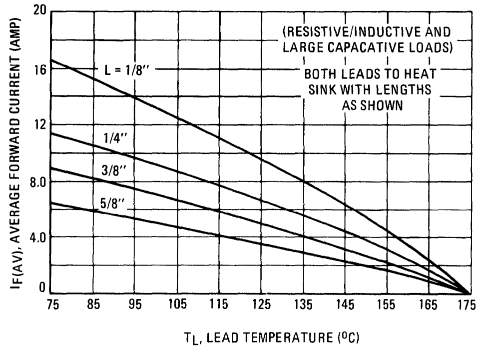


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

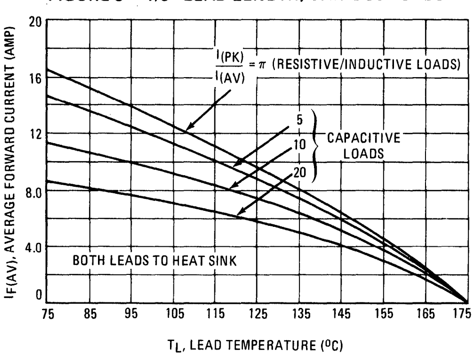


FIGURE 9 – 1/8" LEAD LENGTH, VARIOUS LOADS

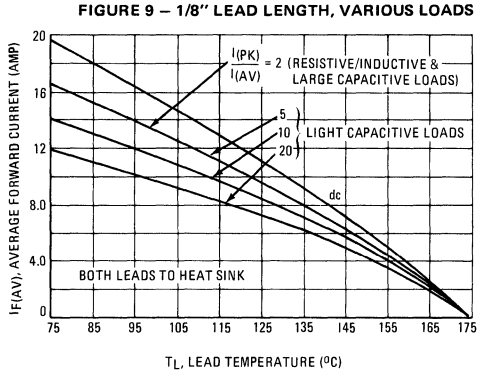


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

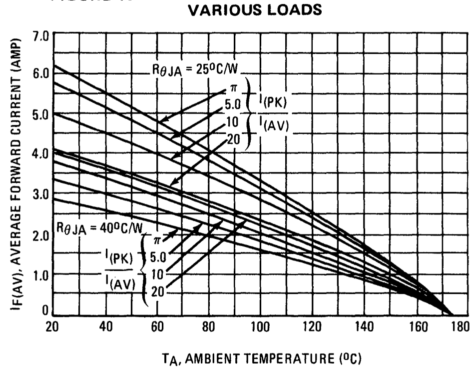
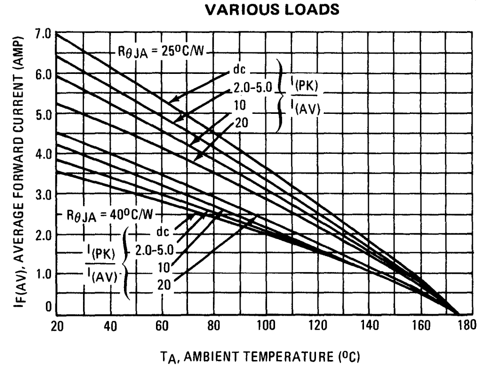


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



REVERSE POWER DISSIPATION AND CURRENT

NOTE 3
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for T_J = 150°C. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when V_P is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, V_P is the voltage across one leg of the transformer.

EXAMPLE:

Find Maximum Ambient Temperature for I_{AV} = 2 A, Capacitive Load of I_{PK}/I_{AV} = 20, Input Voltage = 120 V (rms) Sine Wave, $R_{\theta JA}$ = 25°C/W, Half Wave Circuit.

Solution 1:

Step 1: Find V_P; $V_P = \sqrt{2}\, V_{in}$ = 169 V, $V_{R(pk)}$ = 338 V
Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)}$ = 119°C.
Step 3: Find $P_{R(max)}$ from Figure 12. Read P_R = 770 mW @ 140°C
Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)}$ = 0.4
Step 5: Correct P_R to $T_{J(max)}$. $P_R = I_{R(norm)} \times P_R$ (Figure 12)
P_R = 0.4 x 770 = 310 mW.
Step 6: Find P_F from Figure 19. Read P_F = 2.4 W.
Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$
T_A = 119 - (0.31 + 2.4)(25)
T_A = 51°C

Solution 2:

Steps 1 thru 5 are as above.
Step 6: Find $T_A = T_1$ from Figure 10. Read T_A = 115°C.
Step 7: Compute T_A from $T_A = T_1 - (175 - (T_{J(max)}) - P_R R_{\theta JA}$
T_A = 115 - (175 - 119) - (0.31)(25)
T_A = 51°C

At times, a discrepancy between methods will occur because thermal response is factored into Solution 2.

3

FIGURE 12 – SINE WAVE INPUT DISSIPATION

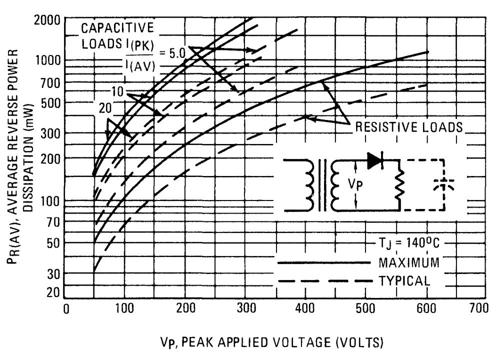


FIGURE 13 – SQUARE WAVE INPUT DISSIPATION

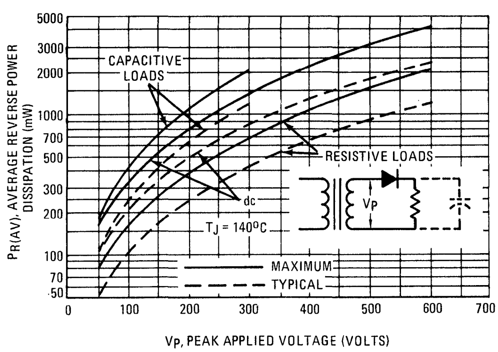


FIGURE 14 – NORMALIZED REVERSE CURRENT

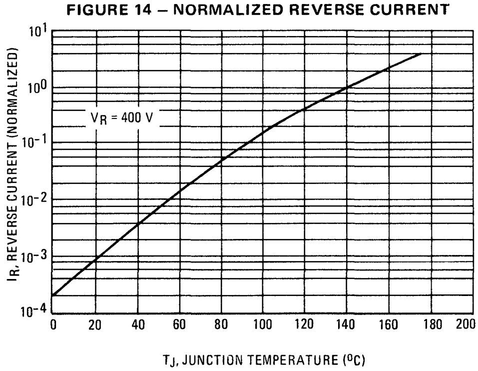
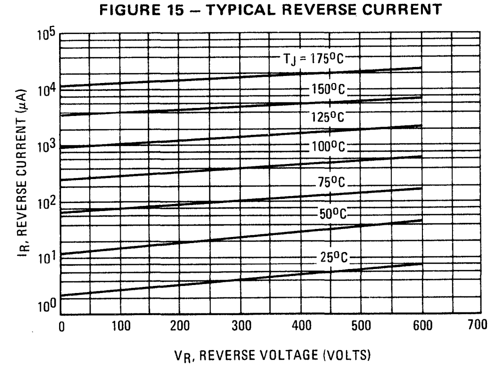


FIGURE 15 – TYPICAL REVERSE CURRENT



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STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

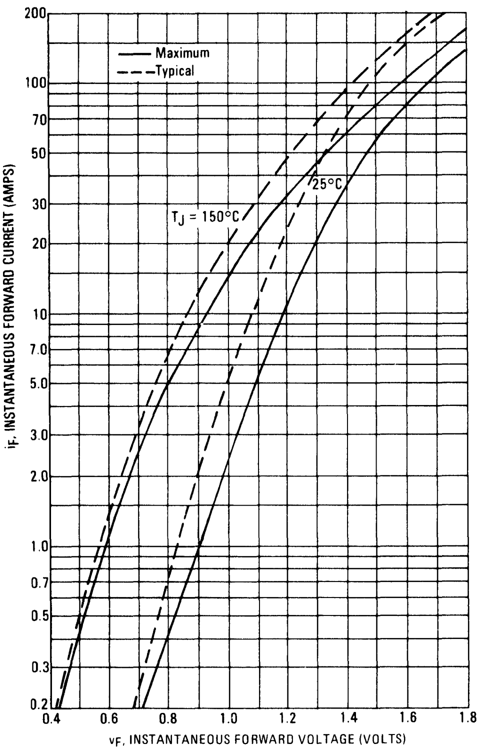


FIGURE 17 – MAXIMUM SURGE CAPABILITY

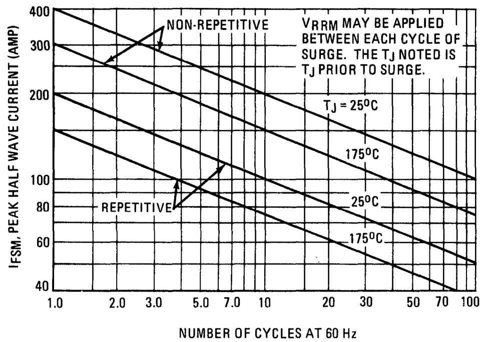
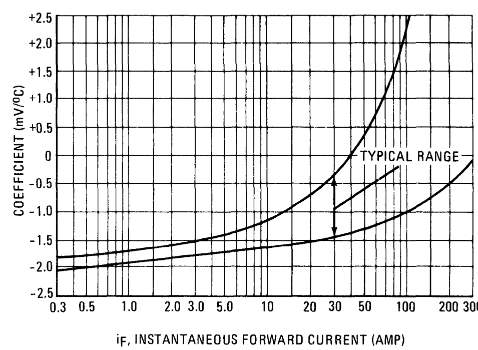


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



MAXIMUM FORWARD POWER DISSIPATION

FIGURE 19 – SINE WAVE INPUT

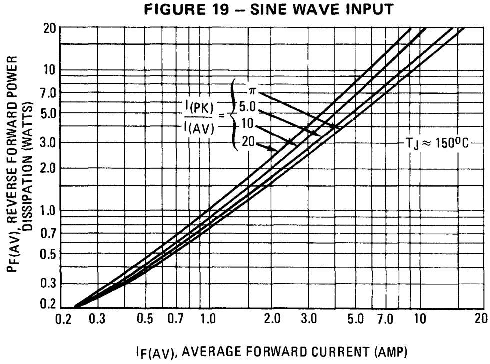
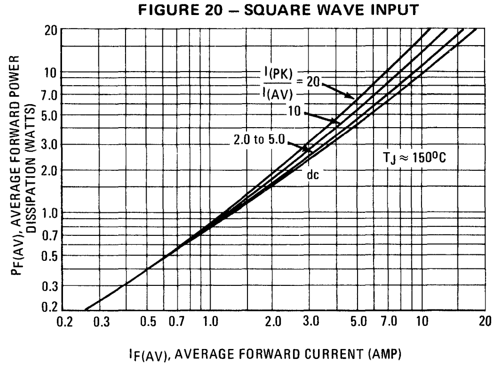


FIGURE 20 – SQUARE WAVE INPUT



TYPICAL RECOVERED STORED CHARGE DATA
(See Note 4)

FIGURE 21 — $T_J = 25°C$

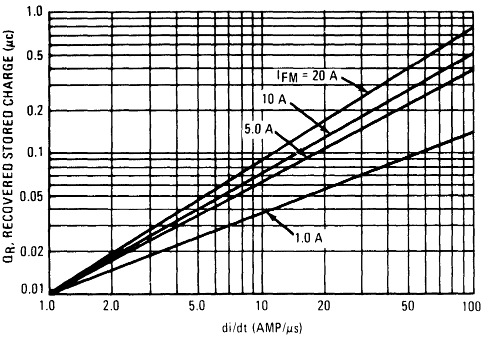


FIGURE 22 — $T_J = 75°C$

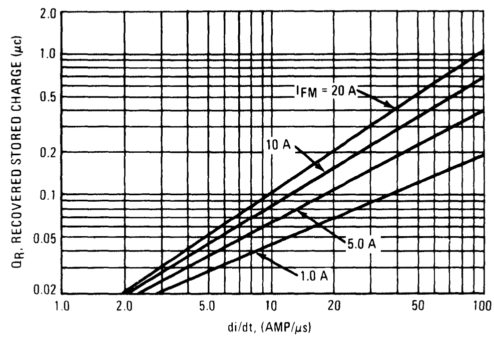


FIGURE 23 — $T_J = 100°C$

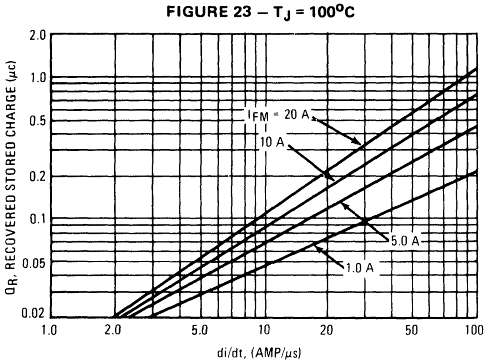
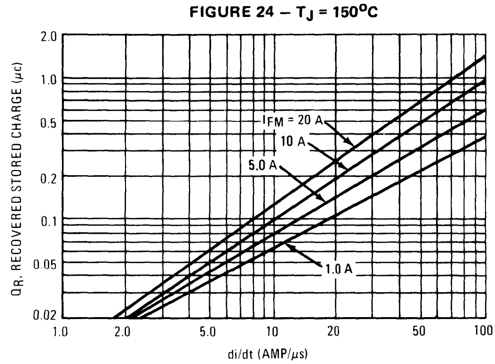


FIGURE 24 — $T_J = 150°C$



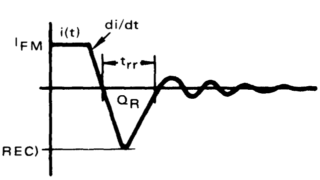
NOTE 4

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 $I_F \cong 1.0$ 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:

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

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

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT

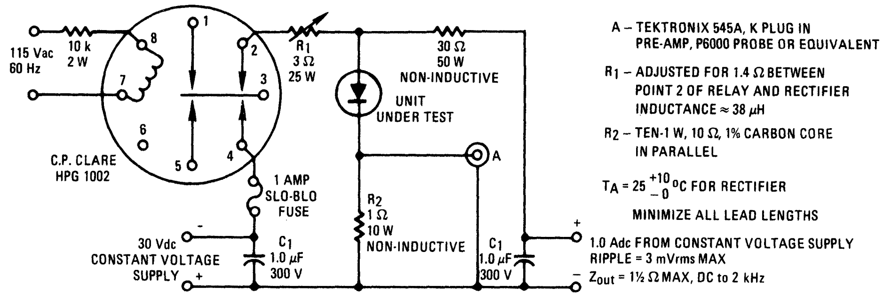


FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT

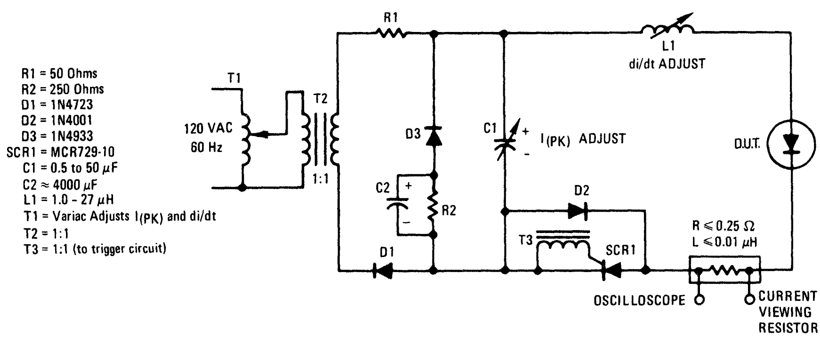


FIGURE 27 – FORWARD RECOVERY TIME

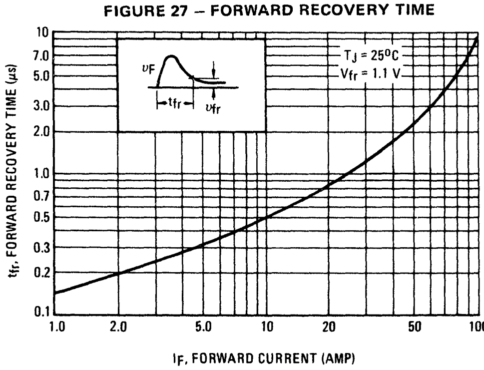
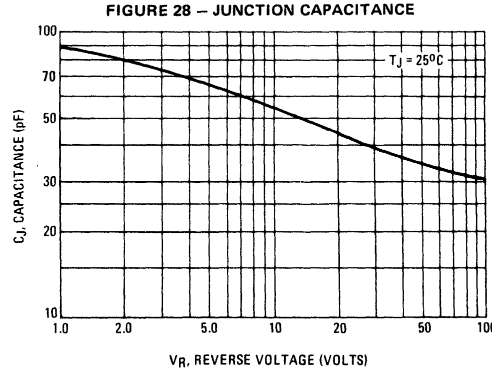
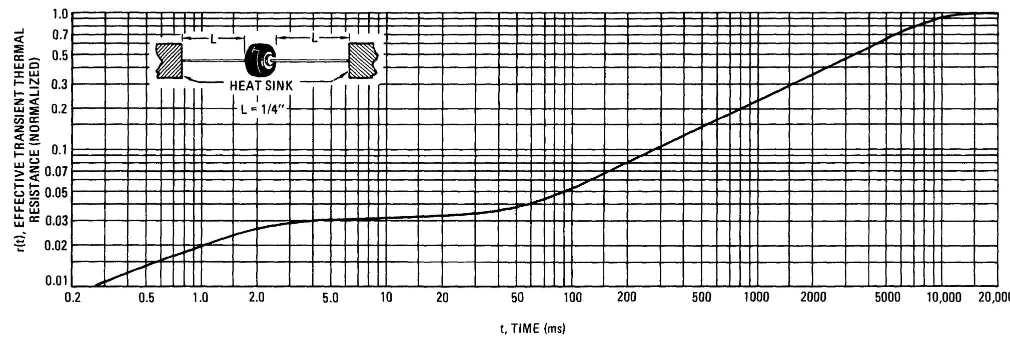


FIGURE 28 – JUNCTION CAPACITANCE



THERMAL CHARACTERISTICS

FIGURE 29 – THERMAL RESPONSE



NOTE 5

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

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:

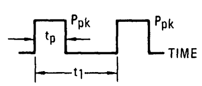
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

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

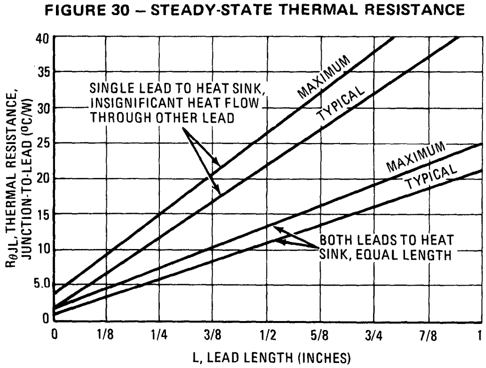
where r(t) = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

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

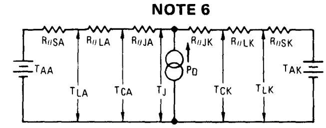


DUTY CYCLE = t_p/t_1
PEAK POWER, P_{pk}, is peak of an equivalent square power pulse.

FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 6



Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. 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 = $P_F + P_R$
	P_F = Forward Power Dissipation
	P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively). Values for thermal resistance components are:

$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum.
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum.

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C, will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AV)}$. Therefore maximum lead temperature may be found as follows:

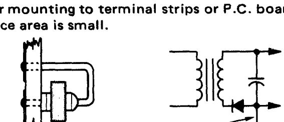
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 12 & 19 for sine wave operation and Figures 13 & 20 for square wave operation.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2" x 1-1/2" copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards where available surface area is small.



Recommended mounting for half wave circuit

MR830 MR831
MR832 MR834
MR836

MOTOROLA

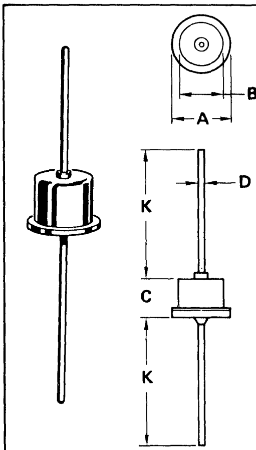
3

HERMETICALLY SEALED, AXIAL LEAD MOUNTED FAST RECOVERY POWER 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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERES



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	11.43	–	0.450
B	–	8.89	–	0.350
C	–	7.62	–	0.300
D	1.17	1.42	0.046	0.056
K	24.89	–	0.980	–

CASE 60-1

MAXIMUM RATINGS

Rating	Symbol	MR830	MR831	MR832	MR834	MR836	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100^oC$)	I_O	← 3.0 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +150 →					^oC
Storage Temperature Range	T_{stg}	← -65 to +175 →					^oC

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Forward Voltage ($I_F = 3.0$ Adc, $T_A = 25^oC$)	V_F	–	1.1	Volts
Reverse Current (rated DC Voltage) $T_A = 25^oC$	I_R	–	0.05	mA
$T_A = 100^oC$		–	1.5	

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recovery Time ($I_F = 1.0$ Amp to $V_R = 30$ Vdc)	t_{rr}	–	150	200	ns
($I_{FM} = 15$ Amp, di/dt = 25 A/μs)		–	150	300	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc)	$I_{RM(REC)}$	–	–	2.0	Amp

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistant and leads readily solderable
POLARITY: Cathode to Case
WEIGHT: 2.4 Grams (Approximately)

MOTOROLA

MR850 MR851 MR852 MR854 MR856

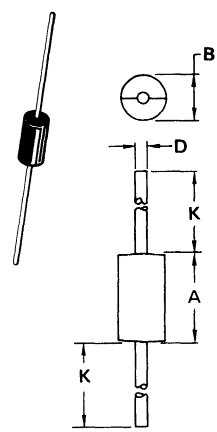
Designers Data Sheet

SUBMINIATURE SIZE, AXIAL LEAD MOUNTED FAST RECOVERY POWER 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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
3 AMPERE



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

CASE 267-01

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.

MAXIMUM RATINGS

Rating	Symbol	MR850	MR851	MR852	MR854	MR856	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase resistive load, $T_A = 90°C$) (1)	I_O	← 3.0 →					Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 100 → (one cycle)					Amp
Operating and Storage Junction Temperature Range (2)	T_J, T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Recommended Printed Circuit Board Mouting, See Note 6, Page 8)	$R_{\theta JA}$	28	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($i_F = 9.4$ Amp, $T_J = 175°C$)	v_F	–	0.9	1.1	Volts
Forward Voltage ($I_F = 3.0$ Amp, $T_J = 25°C$)	V_F	–	1.04	1.25	Volts
Reverse Current (rated dc voltage) $T_J = 25°C$	I_R	–	2.0	10	μA
$T_J = 100°C$ MR850		–	–	150	
MR851		–	60	150	
MR852		–	–	200	
MR854		–	–	250	
MR856		–	100	300	

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 25)		–	150	200	
($I_F = 15$ Amp, di/dt = 10 A/μs, Figure 26)		–	200	300	
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 25)	$I_{RM(REC)}$	–	–	2.0	Amp

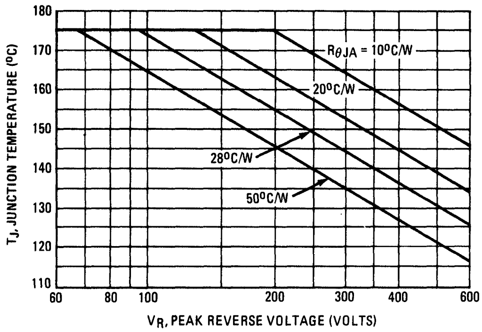
(1) Must be derated for reverse power dissipation. See Note 2, Page 4.
(2) Derate as shown in Figure 1

MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Cathode Indicated by Polarity Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8" from case for 10 s at 5.0 lb. tension

MAXIMUM CURRENT AND TEMPERATURE RATINGS

FIGURE 1 – MAXIMUM ALLOWABLE JUNCTION TEMPERATURE



NOTE 1
MAXIMUM JUNCTION TEMPERATURE DERATING

When operating this rectifier at junction temperatures over 120°C, reverse power dissipation and the possibility of thermal runaway must be considered. The data of Figure 1 is based upon worst case reverse power and should be used to derate $T_{J(max)}$ from its maximum value of 175°C. See Note 2 for additional information on derating for reverse power dissipation.

When current ratings are computed from $T_{J(max)}$ and reverse power dissipation is also included, ratings vary with reverse voltage as shown on Figures 2 thru 5.

RESISTIVE LOAD RATINGS

Printed Circuit Board Mounting – See Note 6, Page 8

FIGURE 2 – SINE WAVE INPUT

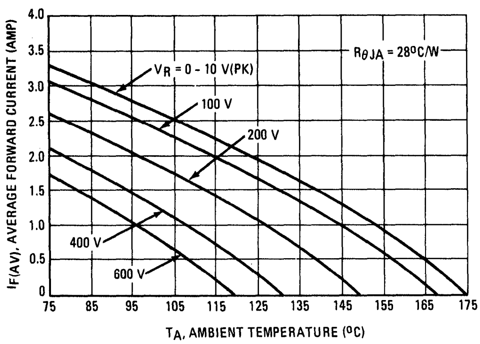


FIGURE 3 – SQUARE WAVE INPUT

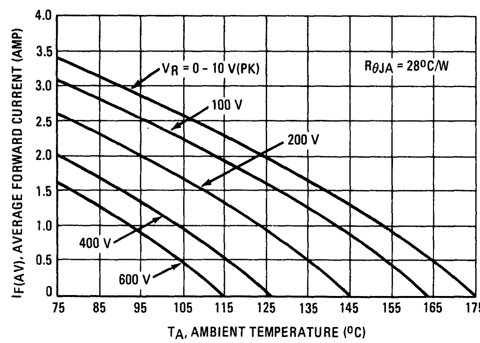


FIGURE 4 – SINE WAVE INPUT

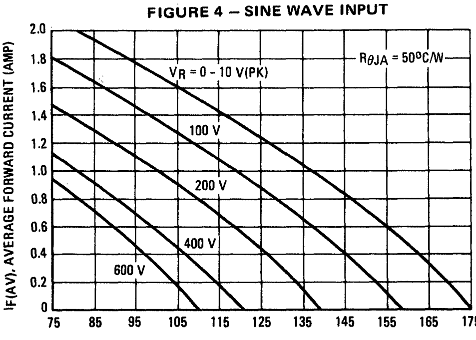
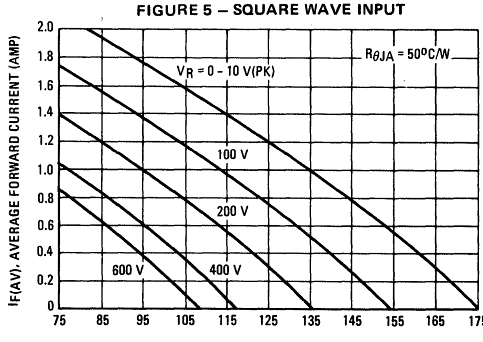


FIGURE 5 – SQUARE WAVE INPUT



MAXIMUM CURRENT RATINGS

Current derating data is based upon the thermal response data of Figure 29 and the forward power dissipation data of Figures 19 and 20. Since reverse power dissipation is not considered in Figures 6 thru 11, additional derating for reverse voltage and for junction to ambient thermal resistance must be applied. See Note 2.

SINE WAVE INPUTS

FIGURE 6 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

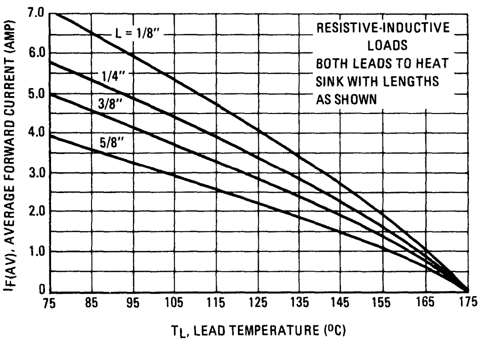


FIGURE 8 – 1/8" LEAD LENGTH, VARIOUS LOADS

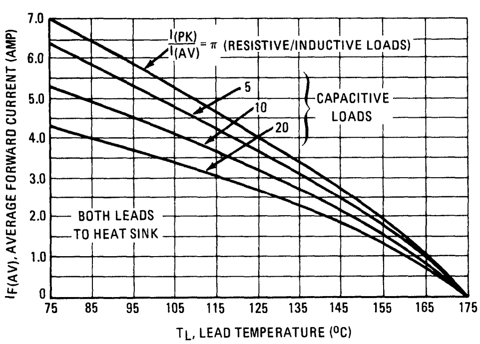
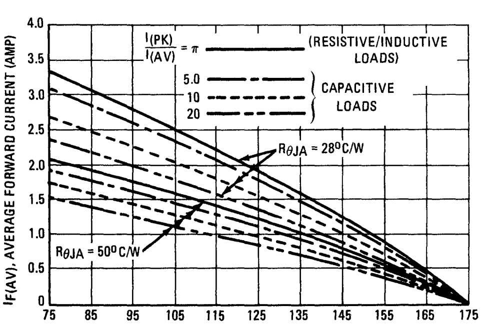


FIGURE 10 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



SQUARE WAVE INPUTS

FIGURE 7 – EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

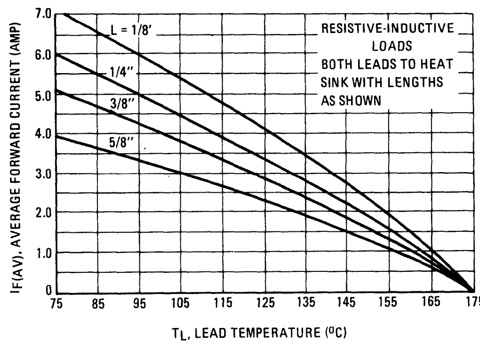


FIGURE 9 – 1/8" LEAD LENGTH, VARIOUS LOADS

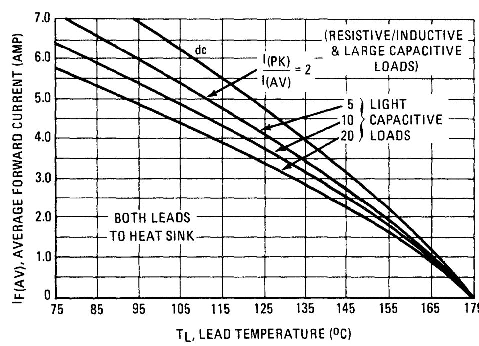
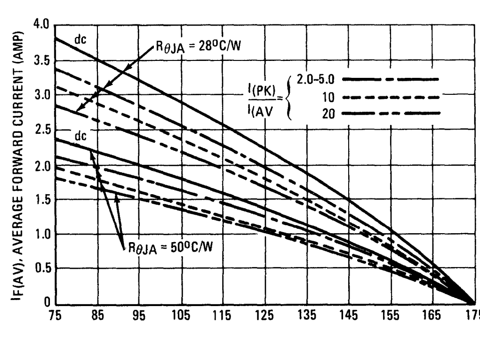


FIGURE 11 – PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS



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REVERSE POWER DISSIPATION AND CURRENT

NOTE 2
DERATING FOR REVERSE POWER DISSIPATION

In this rectifier, power loss due to reverse current is generally not negligible. For reliable circuit design, the maximum junction temperature must be limited to either 175°C or the temperature which results in thermal runaway. Proper derating may be accomplished by use of equation 1 or equation 2.

Equation 1 $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$

Where: T_1 = Maximum Allowable Ambient Temperature neglecting reverse power dissipation (from Figures 10 or 11)

$T_{J(max)}$ = Maximum Allowable Junction Temperature to prevent thermal runaway or 175°C, which ever is lower. (See Figure 1).

P_R = Reverse Power Dissipation (From Figure 12 or 13, adjusted for $T_{J(max)}$ as shown below)

$R_{\theta JA}$ = Thermal Resistance, Junction to Ambient.

When thermal resistance, junction to ambient, is over 20°C/W, the effect of thermal response is negligible. Satisfactory derating may be found by using:

Equation 2 $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$

P_F = Forward Power Dissipation (See Figures 19 & 20)

Other terms defined above.

The reverse power given on Figures 12 and 13 is calculated for T_J = 150°C. When T_J is lower, P_R will decrease; its value can be found by multiplying P_R by the normalized reverse current from Figure 14 at the temperature of interest.

The reverse power data is calculated for half wave rectification circuits. For full wave rectification using either a bridge or a center-tapped transformer, the data for resistive loads is equivalent when Vp is the line to line voltage across the rectifiers. For capacitive loads, it is recommended that the dc case on Figure 13 be used, regardless of input waveform, for bridge circuits. For capacitively loaded full wave center-tapped circuits, the 20:1 data of Figure 12 should be used for sine wave inputs and the capacitive load data of Figure 13 should be used for square wave inputs regardless of $I_{(pk)}/I_{(av)}$. For these two cases, Vp is the voltage across one leg of the transformer.

Example 1 Find maximum ambient temperature for I_{AV} = 2 A, capacitive load of I_{PK}/I_{AV} = 20, Input Voltage = 60 V (rms), sine wave, $R_{\theta JA}$ = 28°C/W, half wave circuit.

Solution 1 (using Equation 1)

Step 1: Find V_P; $V_P = \sqrt{2}\, V_{in}$ = 85 V, $V_{R(pk)}$ = 170

Step 2: Find $T_{J(max)}$ from Figure 1. Read $T_{J(max)}$ = 157°C

Step 3: Find $P_{R(max)}$ from Figure 12. Read P_R = 360 mW @ 150°C

Step 4: Find I_R normalized from Figure 14. Read $I_{R(norm)}$ = 1.5

Step 5: Correct P_R to $T_{J(max)}$. $P_R = I_{R(norm)} \times P_R$ (Figure 12) P_R = 1.5 x 360 = 540 mW

Step 6: Find $T_A = T_1$ from Figure 10. Read T_1 = 94°C

Step 7: Compute T_A from $T_A = T_1 - (175 - T_{J(max)}) - P_R R_{\theta JA}$
T_A = 94 - (175 - 157) - (0.54) (28)
T_A = 61°C

Solution 2 (using Equation 2)

Steps 1 thru 5 are as Solution 1

Step 6: Find P_F from Figure 19. Read P_F = 3.0 W

Step 7: Compute T_A from $T_A = T_{J(max)} - (P_R + P_F) R_{\theta JA}$
T_A = 157 - (0.54 + 3) 28
T_A = 58°C

The discrepancy occurs because thermal response is factored into solution 1, and advantage is taken of the cooling time after the power pulse and before reverse voltage achieves its maximum. 61°C is a satisfactory ambient temperature.

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FIGURE 12 — REVERSE POWER DISSIPATION, SINE WAVE

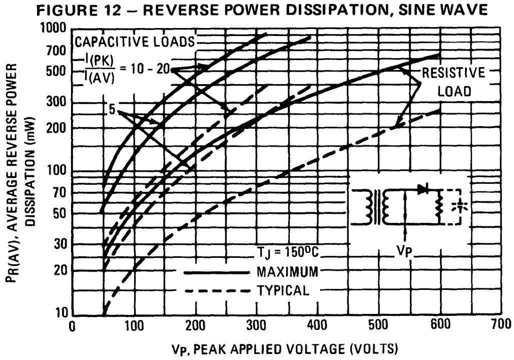


FIGURE 13 — REVERSE POWER DISSIPATION, SQUARE WAVE

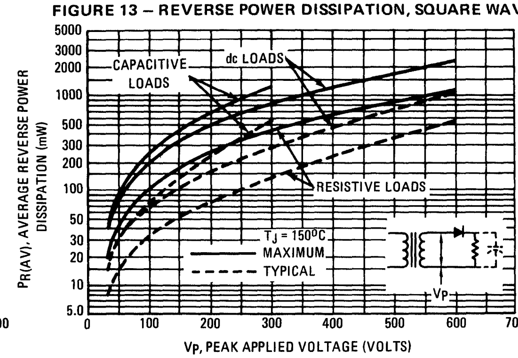


FIGURE 14 — NORMALIZED REVERSE CURRENT

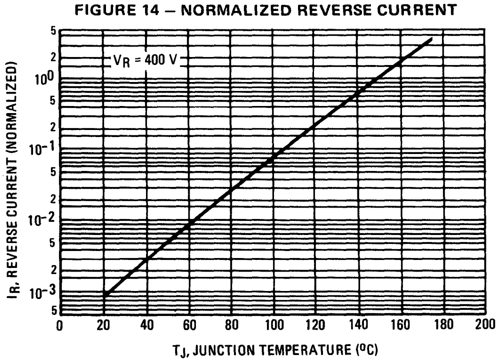
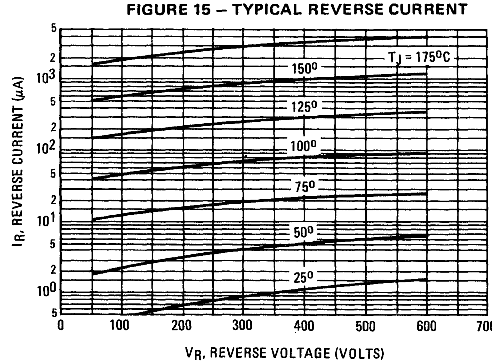


FIGURE 15 — TYPICAL REVERSE CURRENT



STATIC CHARACTERISTICS

FIGURE 16 – FORWARD VOLTAGE

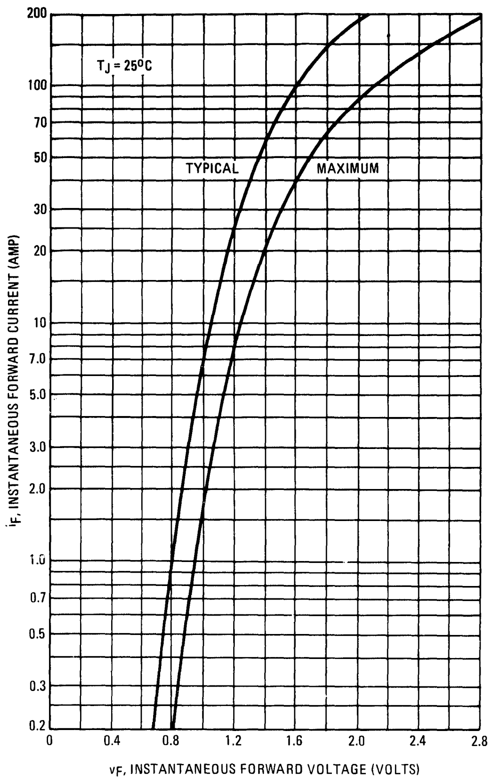


FIGURE 17 – MAXIMUM SURGE CAPABILITY

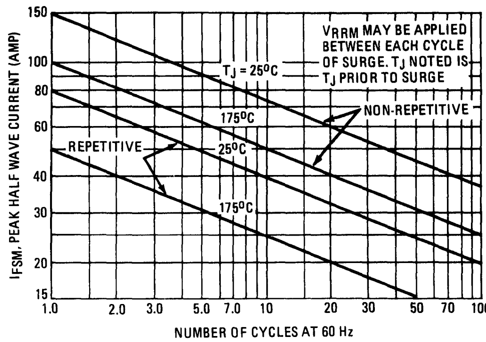
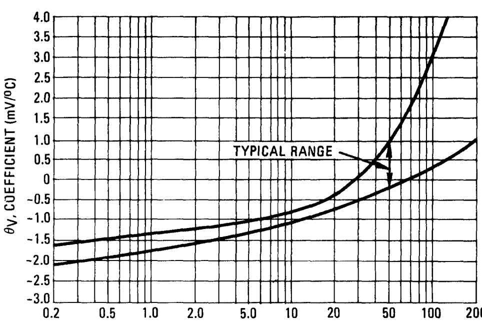
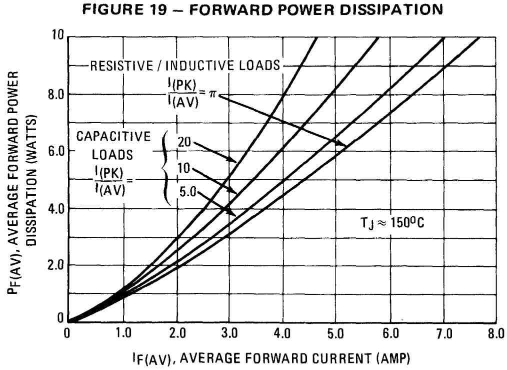


FIGURE 18 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT



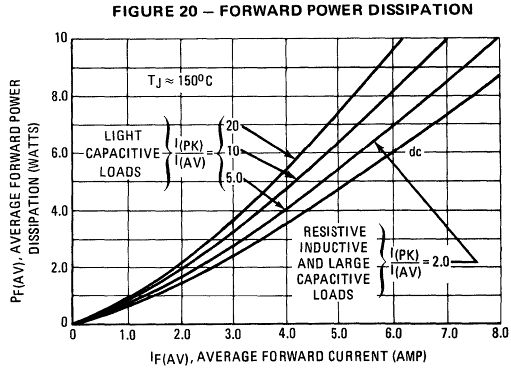
SINE WAVE INPUT

FIGURE 19 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 20 – FORWARD POWER DISSIPATION



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TYPICAL RECOVERED STORED CHARAGE DATA

(See Note 3)

FIGURE 21 — T_J = 25°C

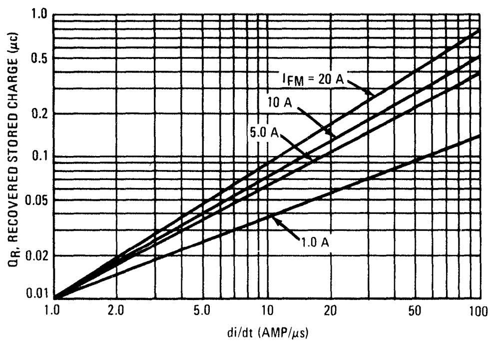

FIGURE 22 — T_J = 75°C

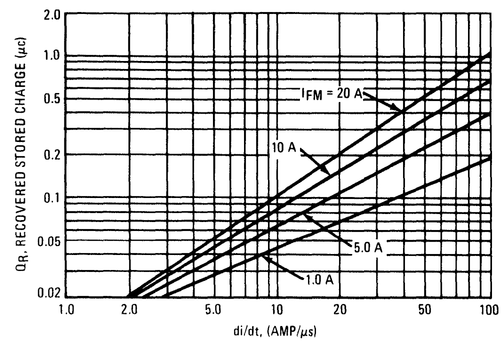

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FIGURE 23 — T_J = 100°C

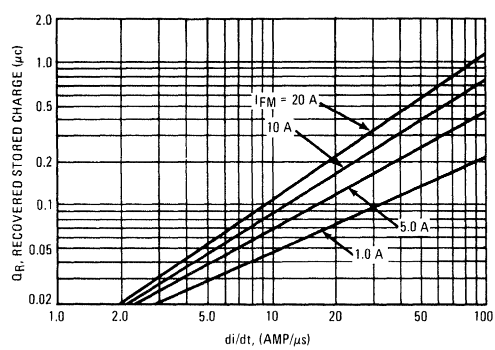
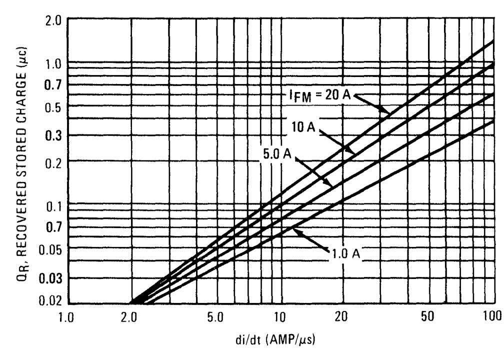


FIGURE 24 — T_J = 150°C



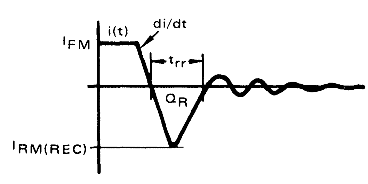
NOTE 3

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.



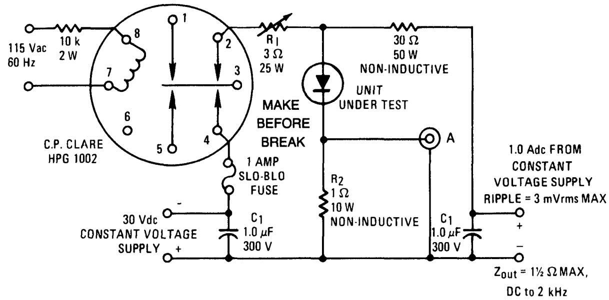
From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

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

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

DYNAMIC CHARACTERISTICS

FIGURE 25 – REVERSE RECOVERY CIRCUIT



MINIMIZE ALL LEAD LENGTHS

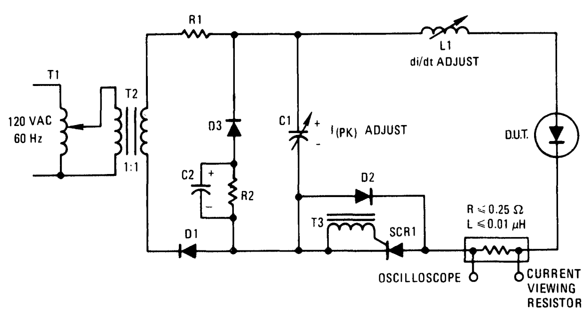
A – TEKTRONIX 545A, K PLUG IN PRE-AMP, P6000 PROBE OR EQUIVALENT

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

FIGURE 26 – JEDEC REVERSE RECOVERY CIRCUIT



R1 = 50 Ohms
R2 = 250 Ohms
D1 = 1N4723
D2 = 1N4001
D3 = 1N4934
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)

FIGURE 27 – FORWARD RECOVERY TIME

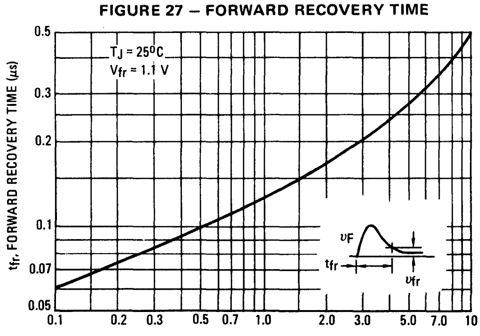


FIGURE 28 – JUNCTION CAPACITANCE

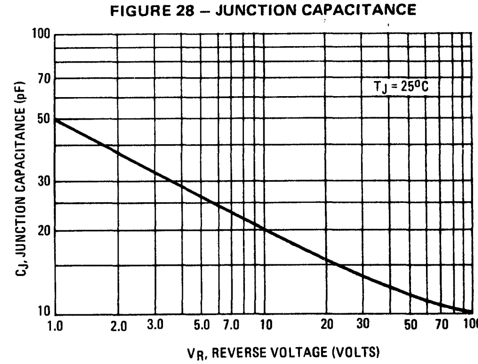


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FIGURE 29 – THERMAL RESPONSE

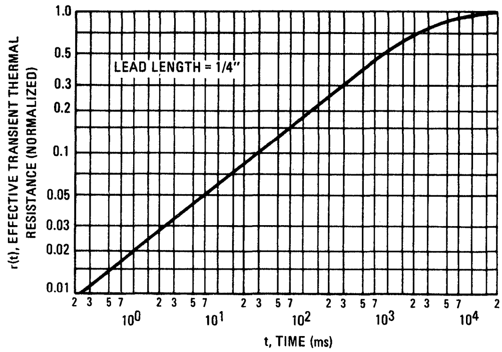
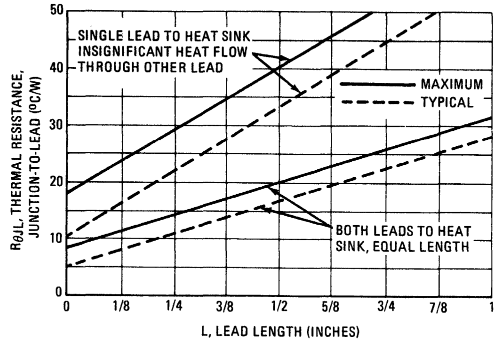


FIGURE 30 – STEADY-STATE THERMAL RESISTANCE



NOTE 4

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

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:

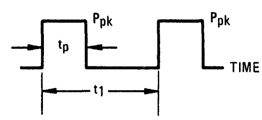
$$T_J = T_L + \Delta T_{JL}$$

where ΔT_{JL} is the increase in junction temperature above the lead temperature. It may be determined by:

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

where r(t) = normalized value of transient thermal resistance at time t from Figure 29, i.e.:

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



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

NOTE 5

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 = Total Power Dissipation = $P_F + P_R$
	P_F = Forward Power Dissipation
	P_R = Reverse Power Dissipation

(Subscripts A and K refer to anode and cathode sides respectively.) Values for thermal resistance components are:

$R_{\theta L}$ = 46°C/W/IN. Typically and 48°C/W/IN Maximum.
$R_{\theta J}$ = 10°C/W Typically and 16°C/W Maximum.

The maximum lead temperature may be found as follows:

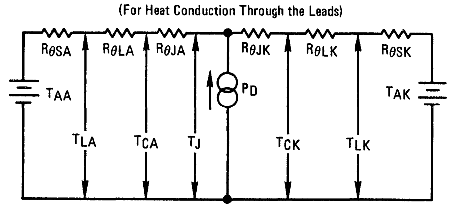
$$T_L = T_{J(max)} - \Delta T_{JL}$$

where

ΔT_{JL} can be approximated as follows:

$\Delta T_{JL} \approx R_{\theta JL} \cdot P_D$; P_D is the sum of forward and reverse power dissipation shown in Figures 2 and 4 for sine wave operation and Figures 3 and 5 for square wave operation.

THERMAL CIRCUIT MODEL
(For Heat Conduction Through the Leads)



NOTE 6

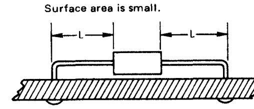
Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) for the mountings shown is to be used as typical guideline values for preliminary engineering or in case the tie point temperature cannot be measured.

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

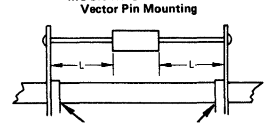
MOUNTING METHOD	LEAD LENGTH, L (IN) 1/8	1/4	1/2	3/4	$R_{\theta JA}$
1	50	51	53	55	°C/W
2	58	59	61	63	°C/W
3	28				°C/W

MOUNTING METHOD 1

P.C. Board Where Available Copper Surface area is small.

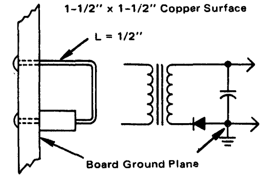


MOUNTING METHOD 2
Vector Pin Mounting



MOUNTING METHOD 3

P.C. Board with
1-1/2" x 1-1/2" Copper Surface



MOTOROLA

MR860 MR861 MR862 MR864 MR866

Designers Data Sheet

STUD MOUNTED FAST RECOVERY POWER RECTIFIERS

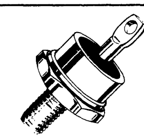
. . . designed for special applications such as dc power supplies, inverters, converters, ultrasonic systems, choppers, low RF interference, sonar power supplies and free wheeling diodes. A complete line of fast recovery rectifiers having typical recovery time of 150 nanoseconds providing high efficiency 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
40 AMPERES



3

MAXIMUM RATINGS

Rating	Symbol	MR860	MR861	MR862	MR864	MR866	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100°C$)	I_O	← 40 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 350 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →					°C
Storage Temperature Range	T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.85	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($i_F = 125$ Amp, $T_J = 150°C$)	v_F	–	1.3	1.6	Volts
Forward Voltage ($I_F = 40$ 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	 – –	 25 1.0	 50 2.0	 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}	 – –	 150 200	 200 400	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp

MECHANICAL CHARACTERISTICS

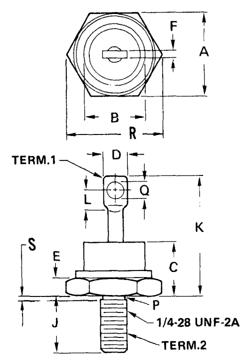
CASE: Welded, hermetically sealed

FINISH: All external surfaces corrosion resistant and readily solderable

POLARITY: Cathode to Case

WEIGHT: 17 Grams (Approximately)

STUD TORQUE: 25 in. lbs.



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

CASE 257-01
DO-5

3

FIGURE 1 – FORWARD VOLTAGE

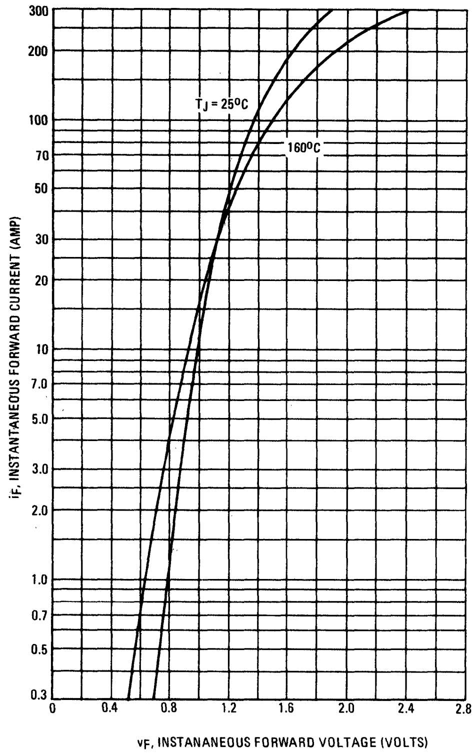
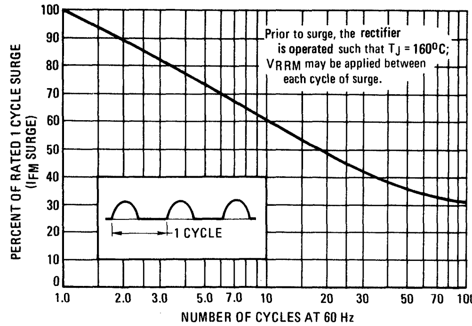
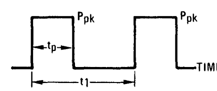


FIGURE 2 – MAXIMUM SURGE CAPABILITY



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:

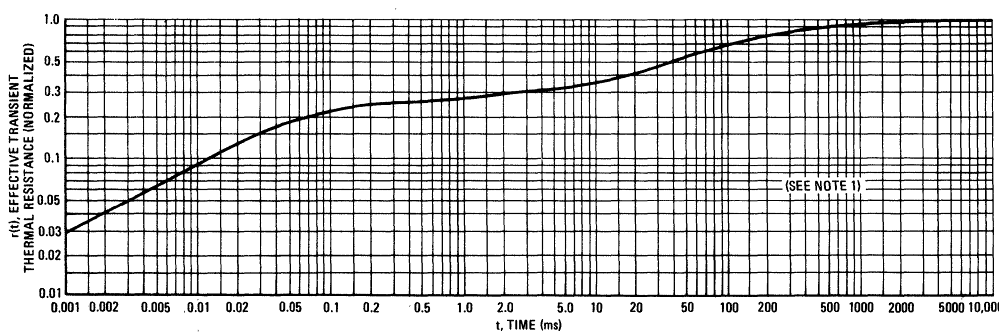
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

where

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

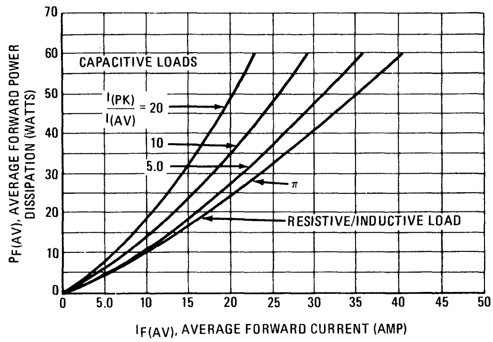
$r(t_1 + t_p)$ = normalized value of transient thermal resistance at time $t_1 + t_p$.

FIGURE 3 – THERMAL RESPONSE



SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

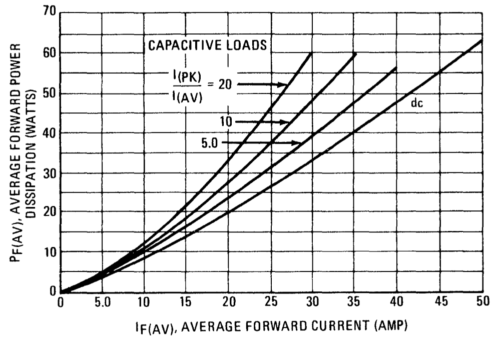


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FIGURE 6 – CURRENT DERATING

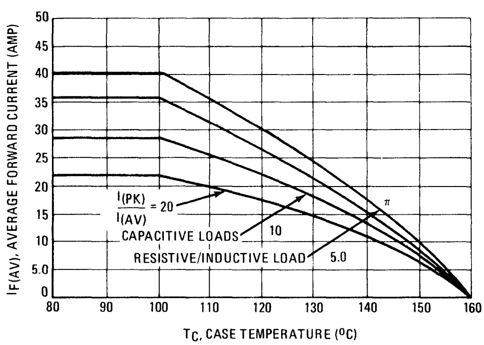


FIGURE 7 – CURRENT DERATING

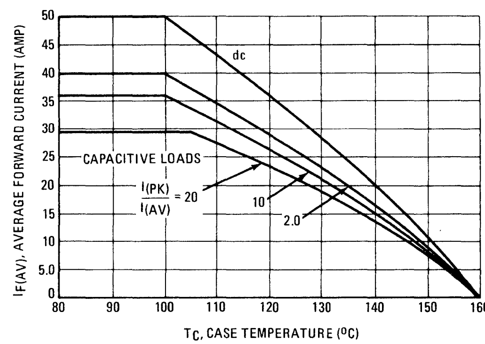


FIGURE 8 – TYPICAL REVERSE CURRENT

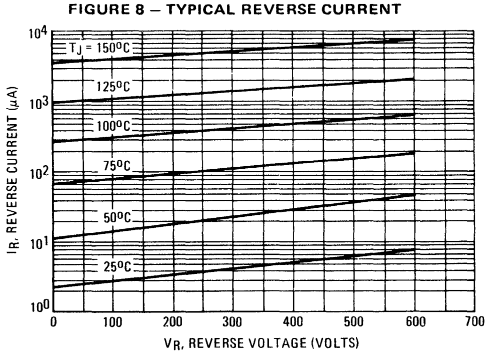


FIGURE 9 – NORMALIZED REVERSE CURRENT

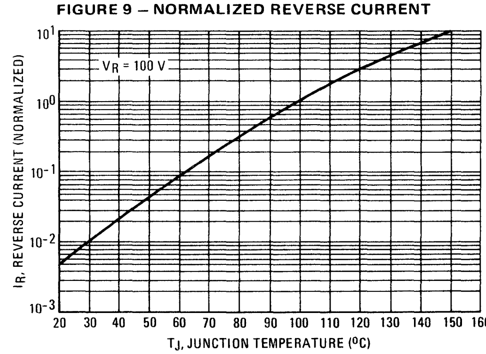


FIGURE 10 – FORWARD RECOVERY TIME

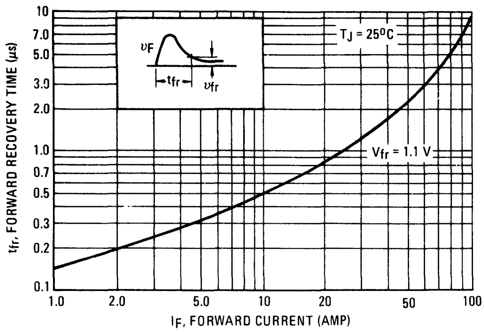
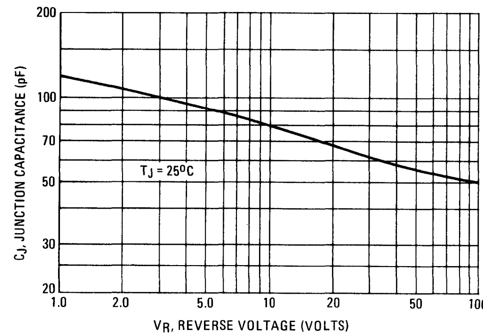


FIGURE 11 – JUNCTION CAPACITANCE



TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25^oC$

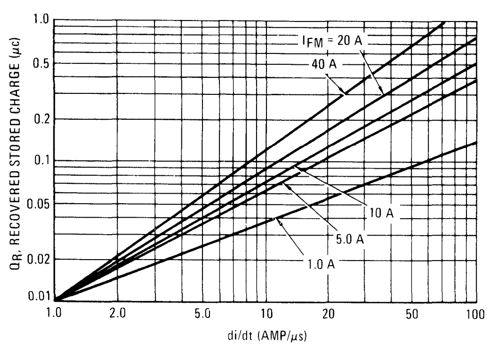


FIGURE 13 – $T_J = 75^oC$

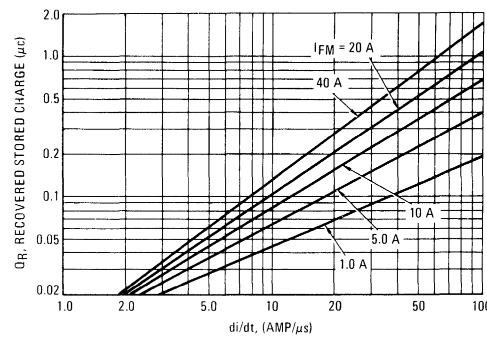


FIGURE 14 – $T_J = 100^oC$

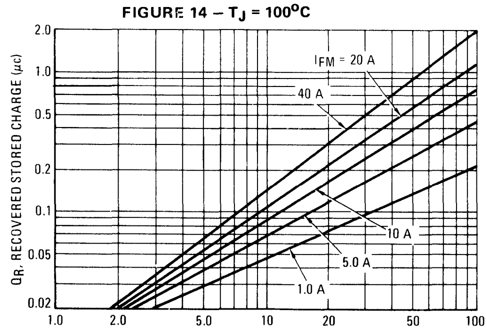


FIGURE 15 – $T_J = 150^oC$

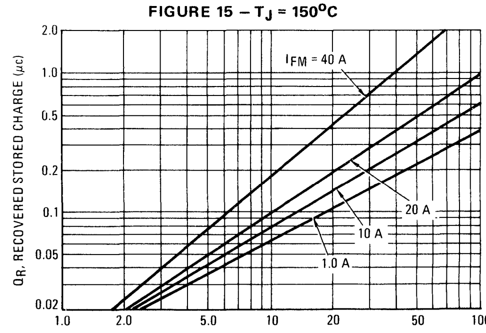
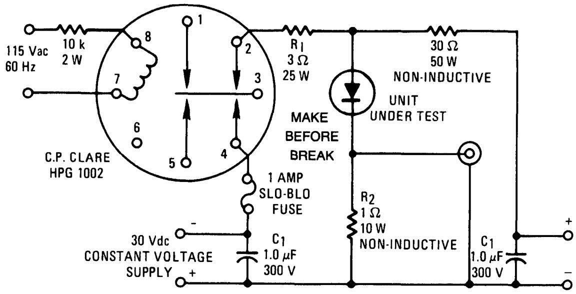


FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

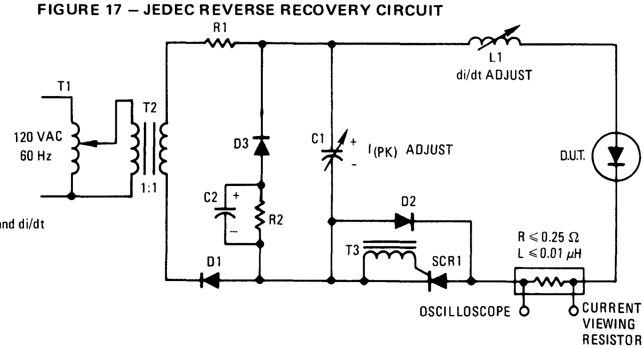
$T_A = 25 {}^{+10}_{-0}$ °C FOR RECTIFIER

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)



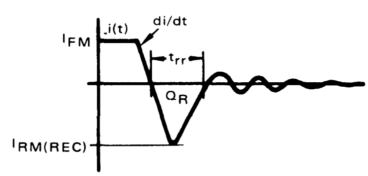
NOTE 2

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:

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

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

MR870 MR871 MR872 MR874 MR876

MOTOROLA

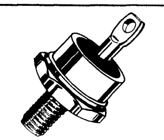
Designers Data Sheet

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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
50 AMPERES



3

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.

MAXIMUM RATINGS

Rating	Symbol	MR870	MR871	MR872	MR874	MR876	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 100°C$)	I_O	← 50 →					Amps
Non-Repetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	← 400 →					Amps
Operating Junction Temperature Range	T_J	← -65 to +160 →					°C
Storage Temperature Range	T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS

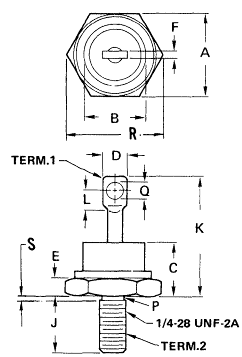
Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($i_F = 157$ Amp, $T_J = 160°C$)	v_F	–	1.3	1.6	Volts
Forward Voltage ($I_F = 50$ Amp, $T_C = 25°C$)	V_F	–	1.1	1.4	Volts
Reverse Current (rated dc voltage) $T_C = 25°C$ $T_C = 100°C$	I_R	 – –	 25 1.0	 50 2.0	 μA mA

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}	 – –	 150 240	 200 400	ns
Reverse Recovery Current ($I_F = 1.0$ Amp to $V_R = 30$ Vdc, Figure 16)	$I_{RM(REC)}$	–	2.0	3.0	Amp

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed
FINISH: All external surfaces corrosion resistant and readily solderable
POLARITY: Cathode to Case
WEIGHT: 17 grams (approximately)
STUD TORQUE: 25 in. lbs.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

CASE 257-01
DO-5

FIGURE 1 — FORWARD VOLTAGE

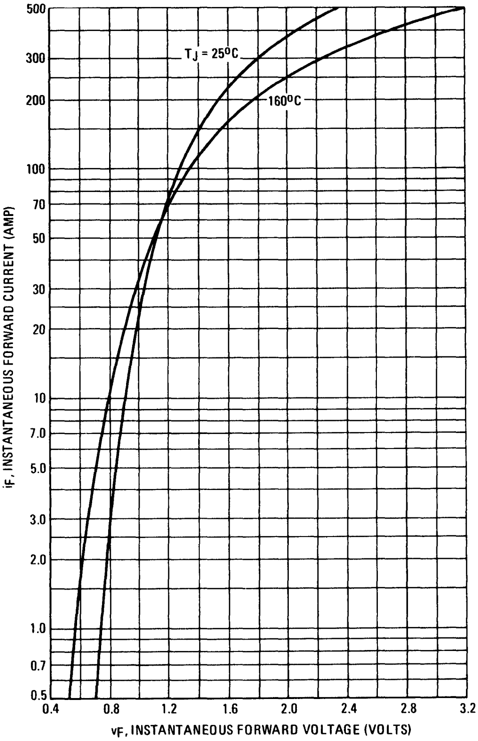
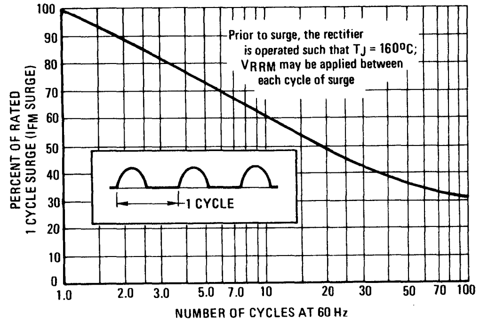
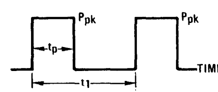


FIGURE 2 — MAXIMUM SURGE CAPABILITY



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:

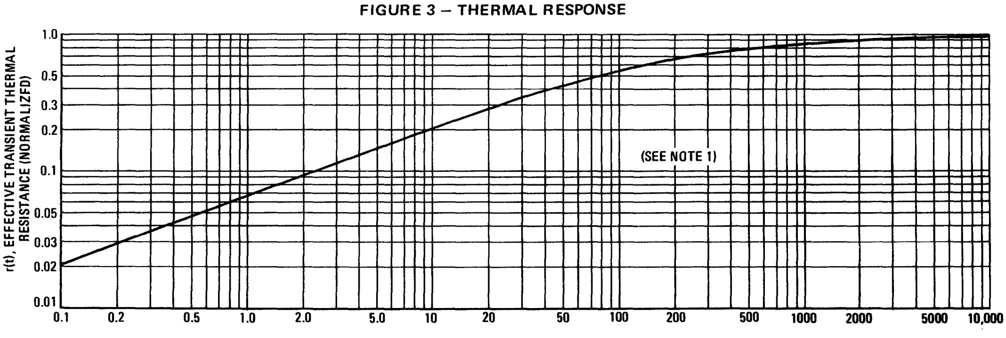
$$\Delta T_{JC} = P_{pk} \cdot R_{\theta JC} [D + (1 - D) \cdot r(t_1 + t_p) + r(t_p) - r(t_1)]$$

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



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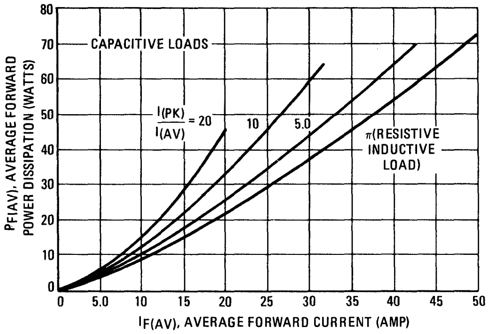
SINE WAVE INPUT

FIGURE 4 – FORWARD POWER DISSIPATION



SQUARE WAVE INPUT

FIGURE 5 – FORWARD POWER DISSIPATION

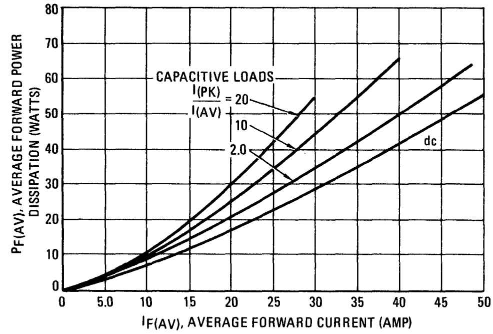


FIGURE 6 – CURRENT DERATING

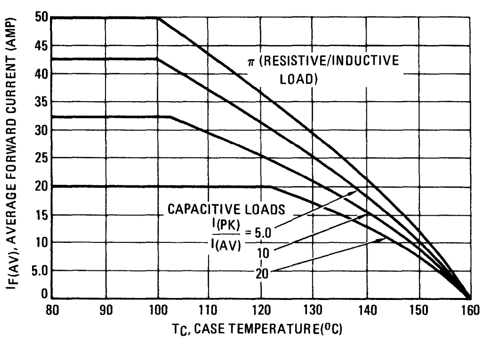


FIGURE 7 – CURRENT DERATING

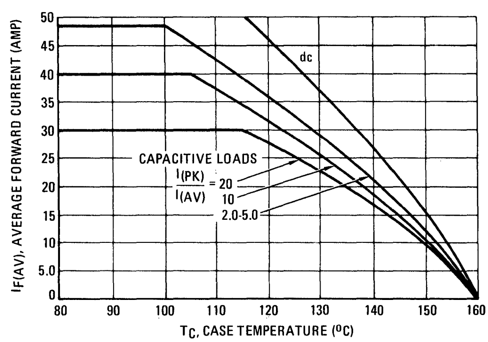


FIGURE 8 – TYPICAL REVERSE CURRENT

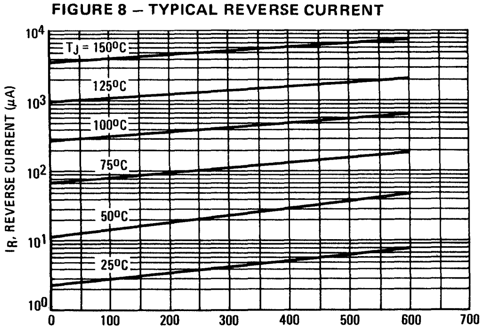
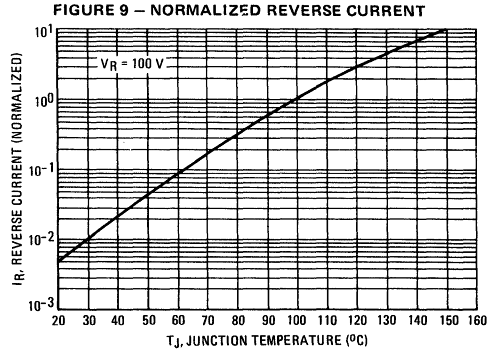


FIGURE 9 – NORMALIZED REVERSE CURRENT



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 – FORWARD RECOVERY TIME

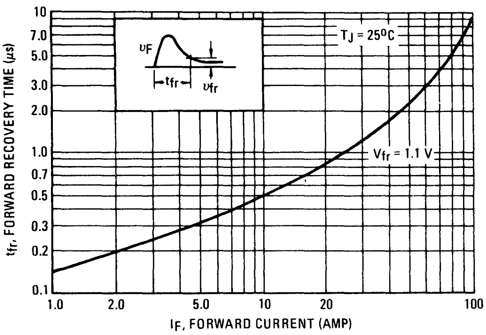
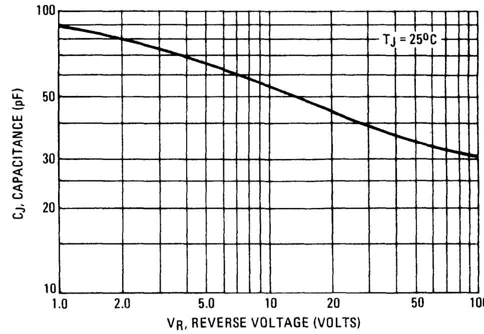


FIGURE 11 – JUNCTION CAPACITANCE



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TYPICAL RECOVERED STORED CHARGE DATA

(See Note 2)

FIGURE 12 – $T_J = 25^oC$

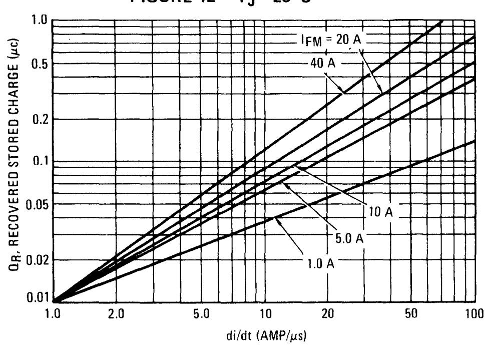

FIGURE 13 – $T_J = 75^oC$

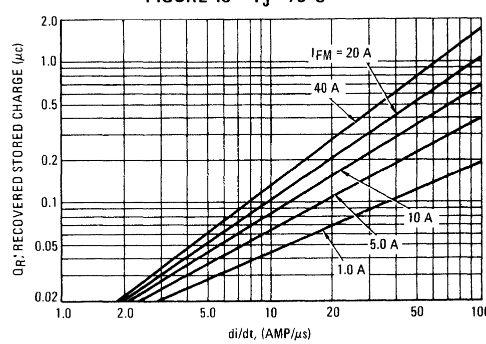

FIGURE 14 – $T_J = 100^oC$

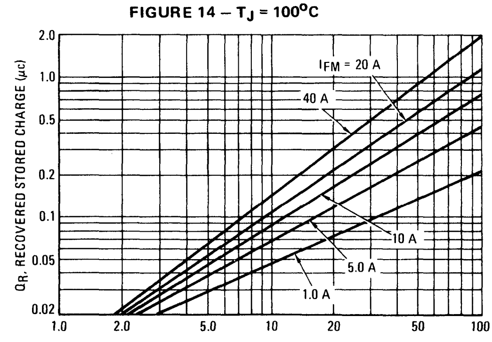

FIGURE 15 – $T_J = 150^oC$

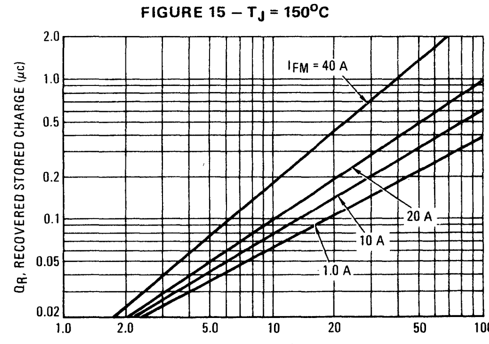

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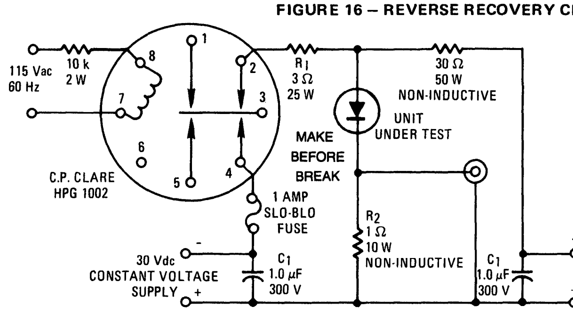
FIGURE 16 – REVERSE RECOVERY CIRCUIT



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

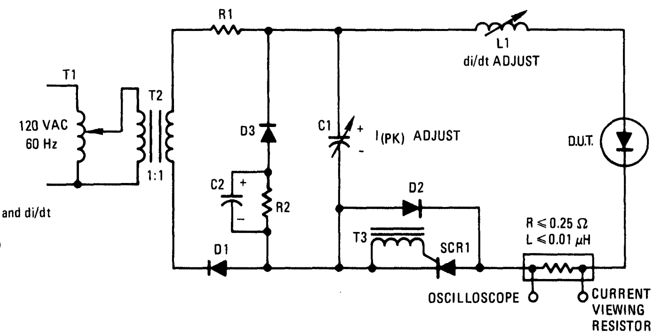
R_2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

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

MINIMIZE ALL LEAD LENGTHS

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)



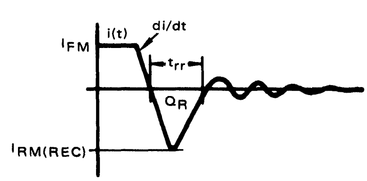
NOTE 2

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:

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

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

MOTOROLA

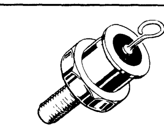
MR1120 thru MR1126
MR1128 MR1130

MEDIUM-CURRENT SILICON RECTIFIER

Medium-current silicon rectifiers feature high surge current capacity, and low forward voltage drop.

MEDIUM-CURRENT SILICON RECTIFIERS

50-1000 VOLTS
12 AMPERES



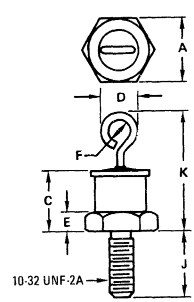
3

MAXIMUM RATINGS

Rating	Symbol	MR 1120	MR 1121	MR 1122	MR 1123	MR 1124	MR 1125	MR 1126	MR 1128	MR 1130	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 (one half-wave, single phase, 60 cycle peak)	V_{RSM}	100	200	300	400	500	600	720	100	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, T_C = 150°C)	I_O	← 12 →									Amp
Peak Repetitive Forward Current (T_C = 150°C)	I_{FRM}	← 75 →									Amp
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_C = 150°C)	I_{FSM}	← 300 (for 1/2 cycle) →									Amp
I^2t Rating (non-repetitive, 1 ms <t <8.3 ms)	I^2t	← 375 →									$A_{(rms)}{}^2s$
Maximum Junction Operating and Storage Temperature Range	T_J, T_{stg}	← -65 to +190 →									°C

ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 12 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
DC Forward Voltage Drop (I_F = 12 Adc, T_C = 25°C)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 12 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	0.5	mA



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01

THERMAL CHARACTERISTICS

Maximum Steady State DC Thermal Resistance, $R_{\theta JC}$: 2.5°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

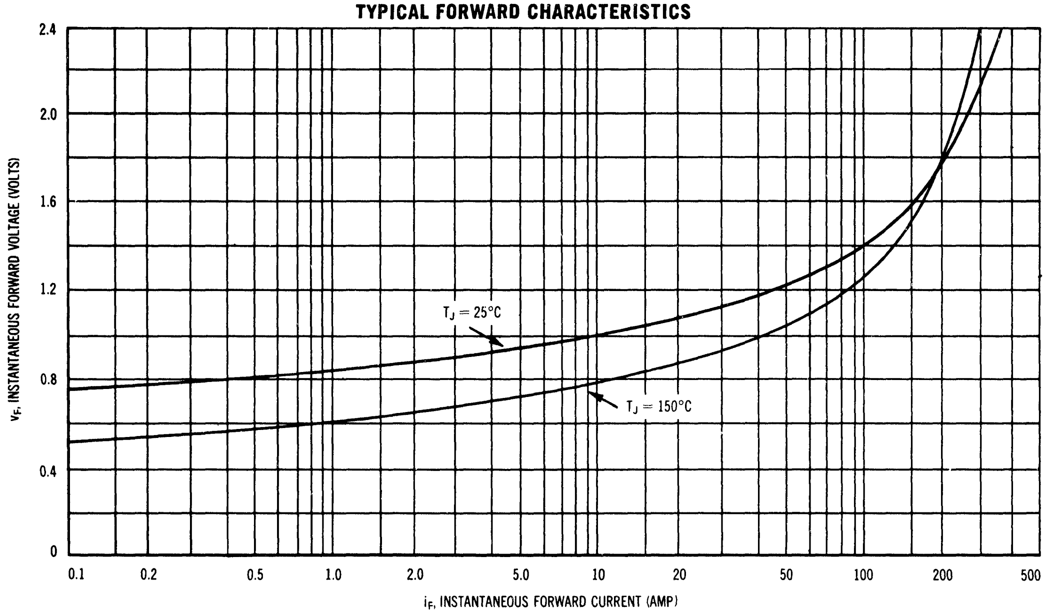
FINISH: All external surfaces corrosion-resistant and the terminal lug is readily solderable.

POLARITY: CATHODE-TO-CASE (reverse polarity units are available upon request and are designated by an "R" suffix i.e. MR1120R).

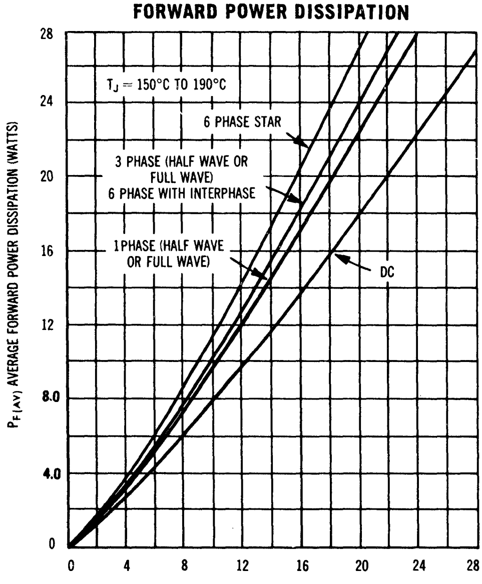
MOUNTING POSITIONS: Any

STUD TORQUE: 15 in-lbs maximum.

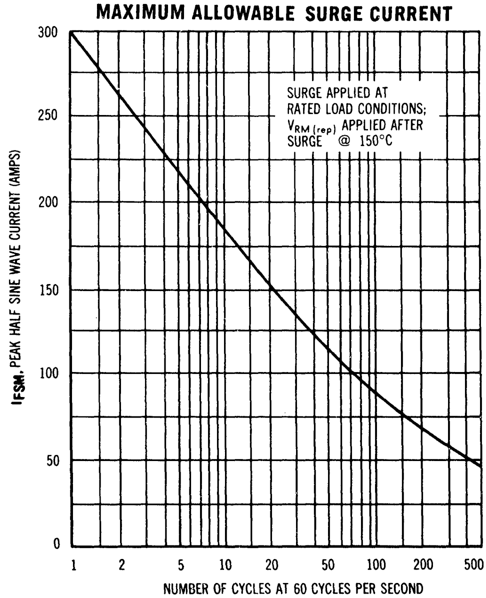
TYPICAL FORWARD CHARACTERISTICS



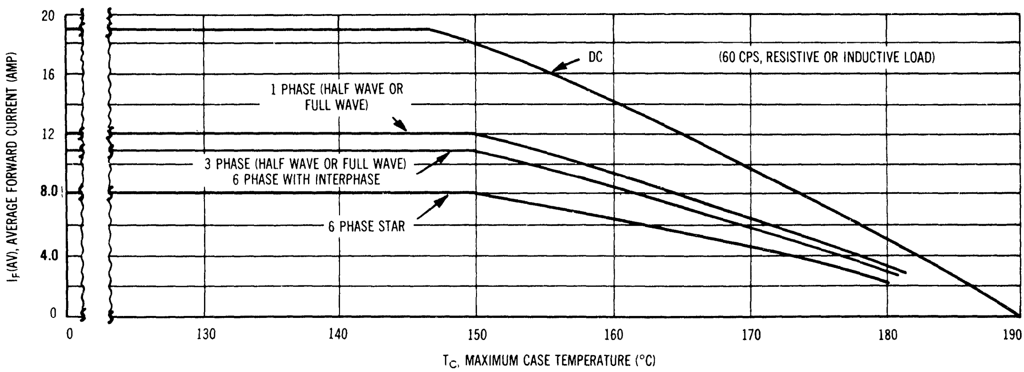
FORWARD POWER DISSIPATION



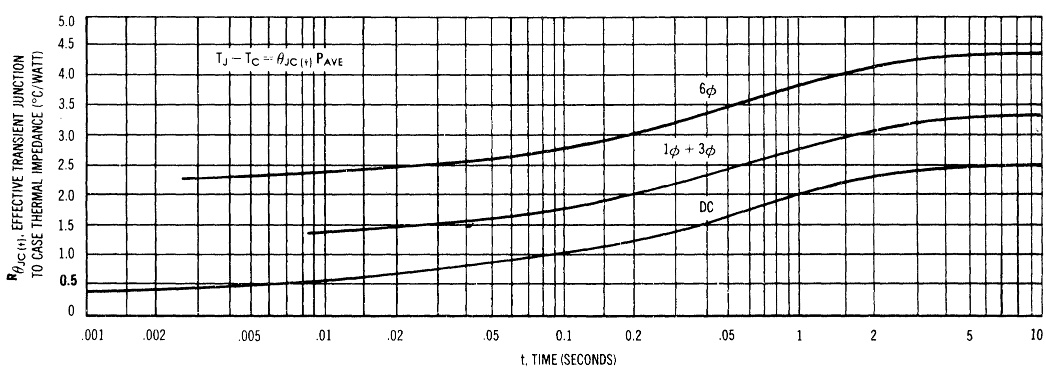
MAXIMUM ALLOWABLE SURGE CURRENT



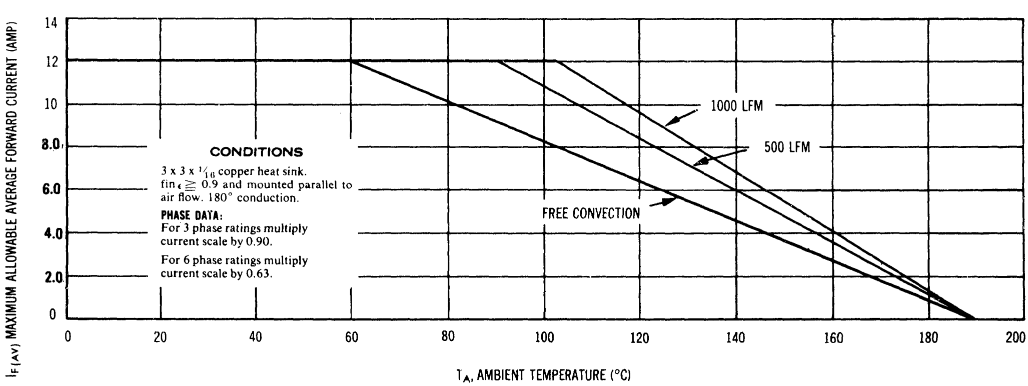
MAXIMUM CURRENT RATINGS



EFFECTIVE TRANSIENT THERMAL IMPEDANCE



CURRENT DERATING DATA



3

MR1366 See Page 3-12
MR1376 See Page 3-17
MR1386 See Page 3-22
MR1396 See Page 3-27

MOTOROLA

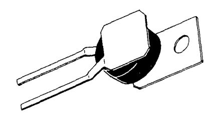
MR2400 thru MR2406

TAB-MOUNTED MEDIUM-CURRENT SILICON RECTIFIERS

. . . compact, highly efficient silicon rectifiers for medium current applications requiring:

- High Current Surge — 400 Amperes @ T_J = 175°C
- Peak Performance @ Elevated Temperature — 24 Amperes @ T_C = 150°C
- Low Cost
- Same Mounting as a TO-220AB

MEDIUM-CURRENT SILICON RECTIFIERS
50-600 VOLTS
24 AMPERES



CASE 339-02

MAXIMUM RATINGS

Rating	Symbol	MR2400	MR2401	MR2402	MR2404	MR2406	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Nonrepetitive Peak Reverse Voltage (half wave, single phase, 60 Hz peak)	V_{RSM}	60	120	240	480	720	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	24					Amp
Nonrepetitive Peak Surge Current (surge applied @ rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	400 (for 1 cycle)					Amp
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	$R_{\theta JC}$	0.8	°C/W
Thermal Resistance, Junction to Air PC Board Mount, Perpendicular to Surface	$R_{\theta JA}$	55	°C/W

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage (i_F = 75.4 Amp, T_C = 25°C)	v_F	1.18	Volts
Maximum Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	 100 500	μA

MECHANICAL CHARACTERISTICS

CASE: Plastic encapsulated, metal tabs.

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

POLARITY: Cathode to tab with hole; Reverse polarity available by adding "R" Suffix, MR2402R.

MOUNTING TORQUE: 8 in-lb max.

MAXIMUM TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8″ from case for 10 seconds.

WEIGHT: 3.6 Grams (Approximately).

FIGURE 1 — FORWARD VOLTAGE

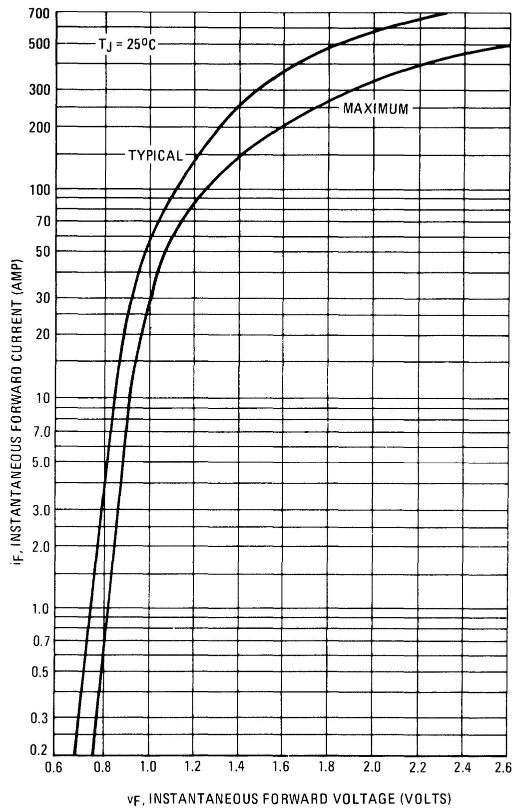


FIGURE 2 — NONREPETITIVE SURGE CURRENT

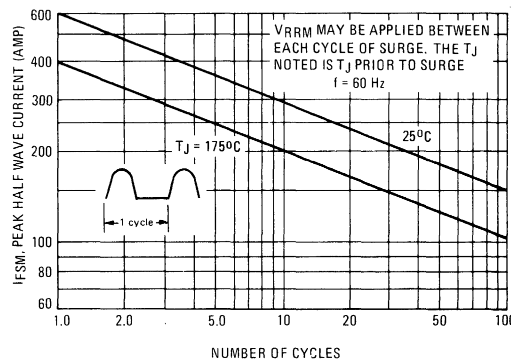


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FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

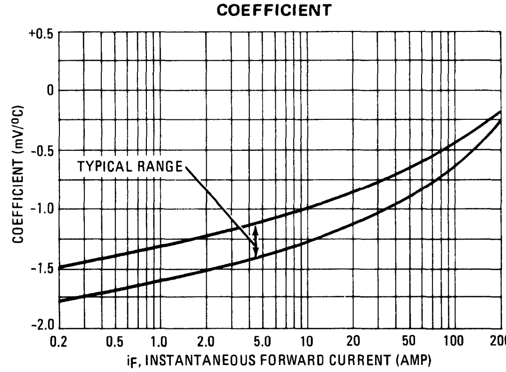


FIGURE 4 — CURRENT DERATING

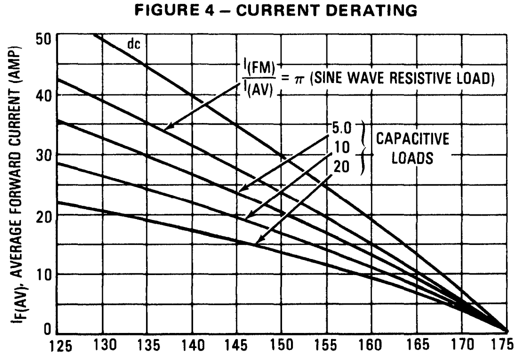


FIGURE 5 — FORWARD POWER DISSIPATION

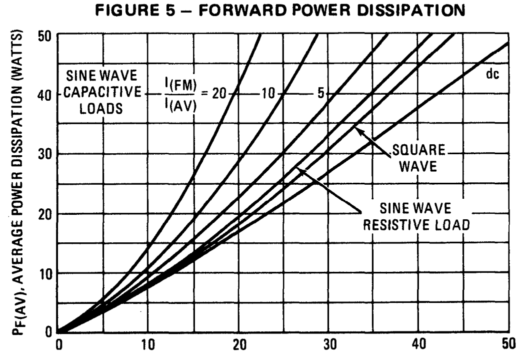
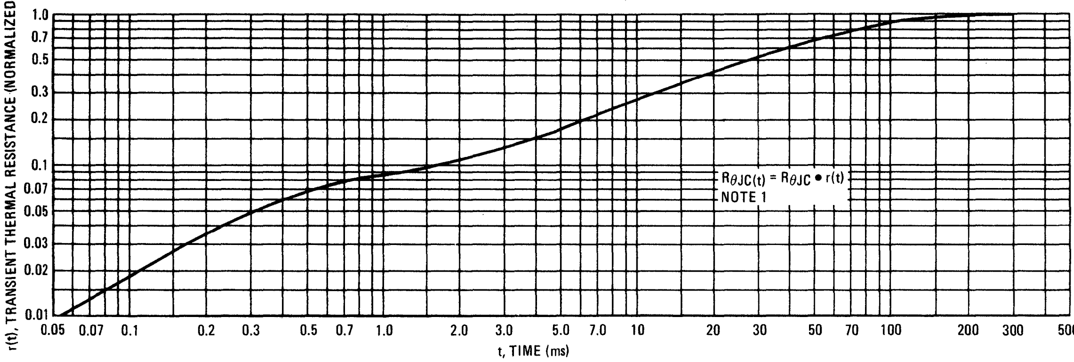


FIGURE 6 – THERMAL RESPONSE



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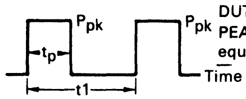
NOTE 1



DUTY CYCLE, $D = t_p/t1$
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 measureed using a thermocouple placed on the case at the temperature reference point. 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:

$$\Delta T_{JC} = P_{pk} \bullet R_{\theta JC} [D + (1 - D) \bullet r(t1 + t_p) + r(t_p) - r(t1)]$$

where

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

$r(t1 + t_p)$ = normalized value of transient thermal resistance at time $t1 + t_p$.

FIGURE 7 – CAPACITANCE

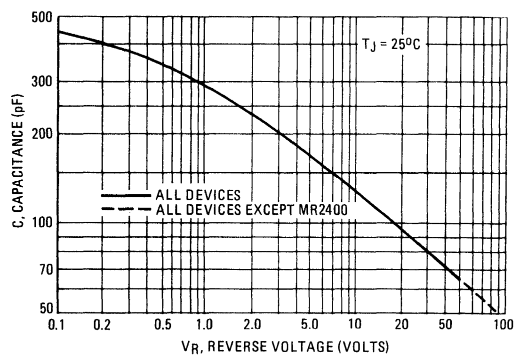


FIGURE 8 – FORWARD RECOVERY TIME

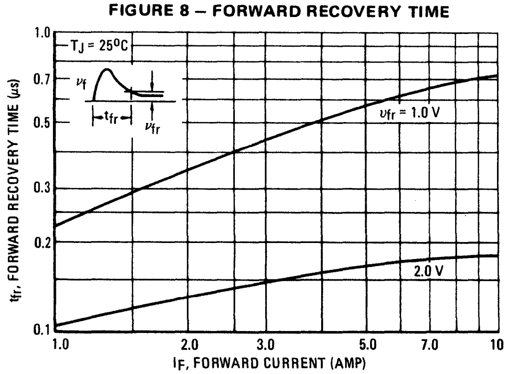


FIGURE 9 – REVERSE RECOVERY TIME

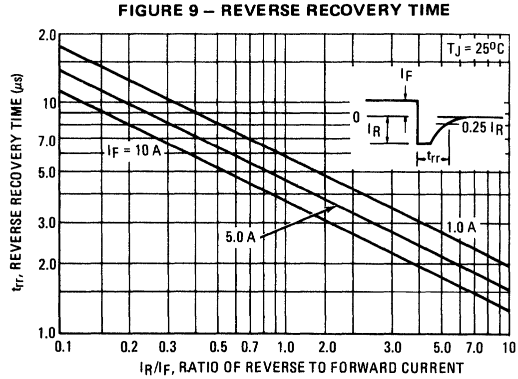
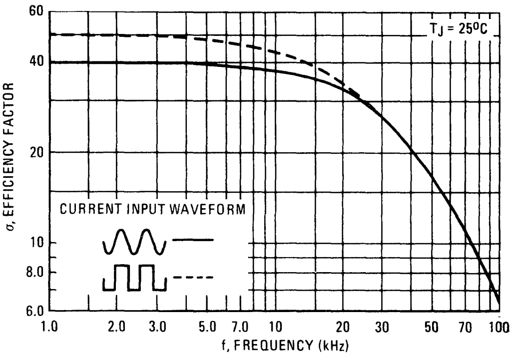
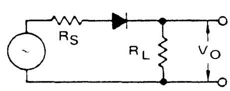


FIGURE 10 — RECTIFICATION WAVEFORM EFFICIENCY



RECTIFICATION EFFICIENCY NOTE



The rectification efficiency factor σ shown in Figure 10 was calculated using the formula:

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

For a sine wave input $V_m \sin(\omega t)$ to the diode, assume lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\dfrac{V^2_m}{\pi^2 R_L}}{\dfrac{V^2_m}{4R_L}} \bullet 100\% = \frac{4}{\pi^2} \bullet 100\% = 40.6\% \quad (2)$$

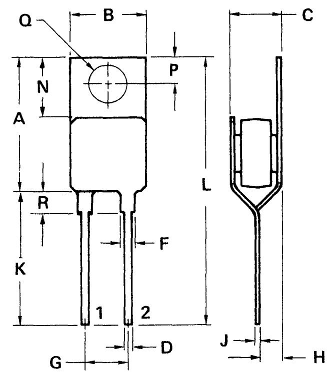
For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\dfrac{V^2_m}{2R_L}}{\dfrac{V^2_m}{R_L}} \bullet 100\% = 50\% \quad (3)$$

(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 9) 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 on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.



1-CATHODE 2-ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.22	15.88	0.560	0.625
B	9.65	10.67	0.380	0.420
C	7.21	7.87	0.284	0.310
D	0.64	1.14	0.025	0.045
F	1.52	2.29	0.060	0.090
G	4.32	5.33	0.170	0.210
H	2.03	2.92	0.080	0.115
J	0.58	0.74	0.023	0.029
K	–	14.27	–	0.562
L	–	30.15	–	1.187
N	5.84	6.86	0.230	0.270
P	2.54	3.05	0.100	0.120
Q	3.53	3.73	0.139	0.147
R	–	5.08	–	0.200

CASE 339-02
(Meets TO-220AB except dimension "C")

MR2400F thru MR2406F

MOTOROLA

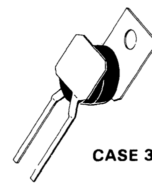
TAB-MOUNTED FAST RECOVERY POWER RECTIFIERS

. . . 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 150 nanoseconds providing high efficiency at frequencies to 250 kHz.

- Same Mounting as a TO-220AB
- Cost Effective in Low Current Applications
- Lead or Chassis Mounted
- High Surge Current Capability

FAST RECOVERY POWER RECTIFIERS

50-600 VOLTS
24 AMPERES



CASE 339-02

MAXIMUM RATINGS

Rating	Symbol	MR2400F	MR2401F	MR2402F	MR2404F	MR2406F	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	Volts
Nonrepetitive Peak Reverse Voltage	V_{RSM}	75	150	250	450	650	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	Volts
Average Rectified Forward Current (Single phase, resistive load, $T_C = 125°C$)	I_O	← 24 →					Amp
Nonrepetitive Peak Surge Current (surge applied @ rated load conditions)	I_{FSM}	← 300 (for 1 cycle) →					Amp
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	$R_{\theta JC}$	0.8	°C/W
Thermal Resistance, Junction to Air, PC Board Mount; Perpendicular to Surface	$R_{\theta JA}$	55	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage ($I_F = 75$ Amp, $T_J = 150°C$)	v_F	—	1.15	1.29	Volts
Forward Voltage ($I_F = 24$ Amp, $T_C = 25°C$)	V_F	—	1.00	1.15	Volts
Reverse Current (rated dc voltage) $T_C = 25°C$ $T_C = 100°C$ $T_C = 150°C$	I_R	— — —	10 0.5 7.0	25 1.0 10	μA mA mA

REVERSE RECOVERY CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Recover Time — Soft Recovery (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 19) (I_{FM} = 36 Amp, di/dt = 25 A/μs, Figure 20)	t_{rr}	 — —	 150 200	 200 300	ns
Reverse Recovery Current (I_F = 1.0 Amp to V_R = 30 Vdc, Figure 19)	$I_{RM(REC)}$	—	—	4.0	Amp

FIGURE 1 — MAXIMUM FORWARD VOLTAGE

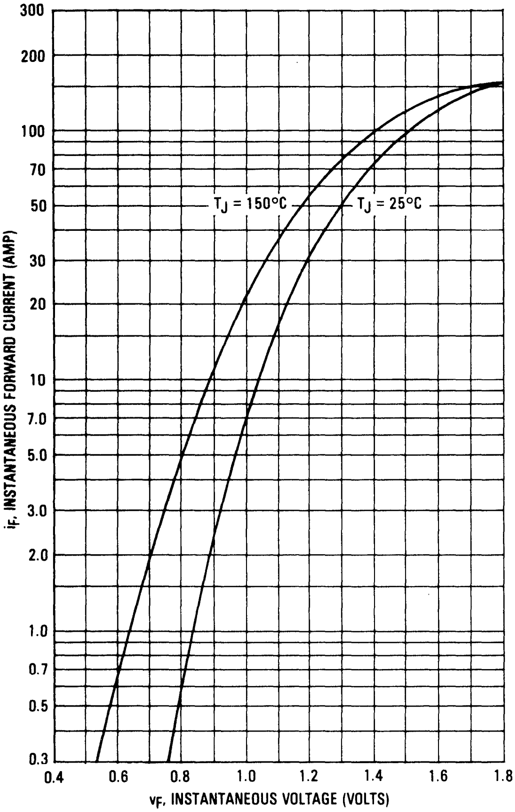
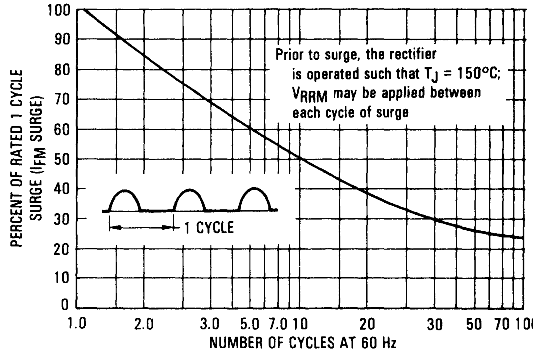
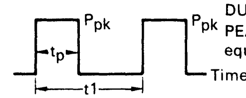


FIGURE 2 — MAXIMUM SURGE CAPABILITY



NOTE 1



DUTY CYCLE, $D = t_p/t1$

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 measureed using a thermocouple placed on the case at the temperature reference point. 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:

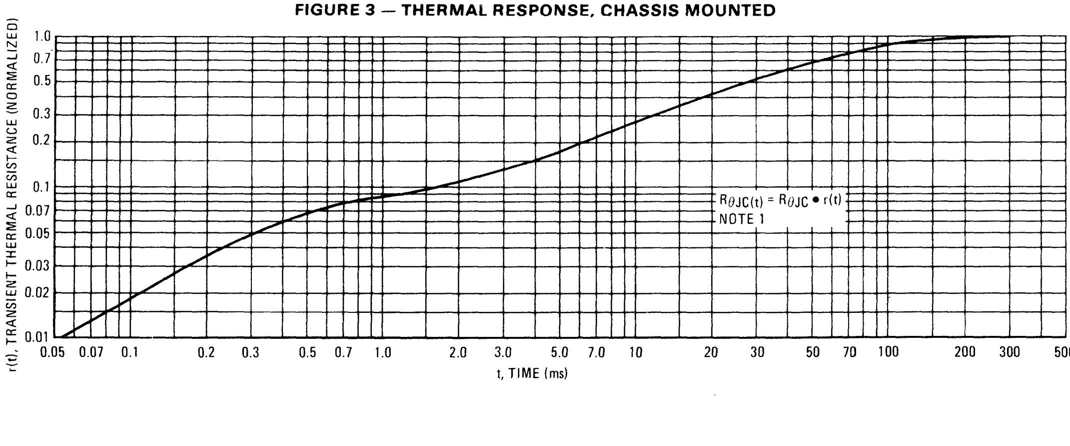
$$\Delta T_{JC} = P_{pk} \bullet R_{\theta JC} [D + (1 - D) \bullet r(t1 + t_p) + r(t_p) - r(t1)]$$

where

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

$r(t1 + t_p)$ = normalized value of transient thermal resistance at time $t1 + t_p$.

FIGURE 3 — THERMAL RESPONSE, CHASSIS MOUNTED

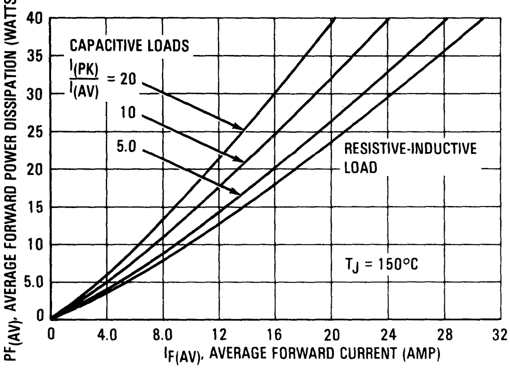


3

CHASSIS MOUNT RATING DATA

Sine Wave Input

FIGURE 4 — FORWARD POWER DISSIPATION



Square Wave Input

FIGURE 5 — FORWARD POWER DISSIPATION

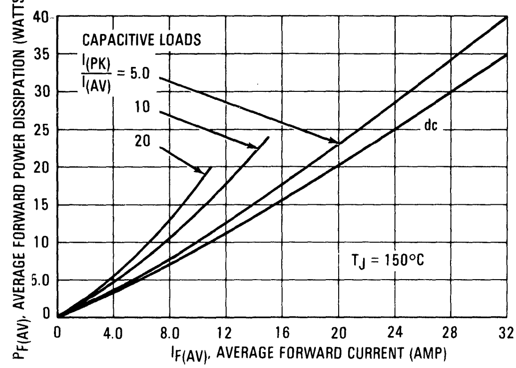


FIGURE 6 — CURRENT DERATING

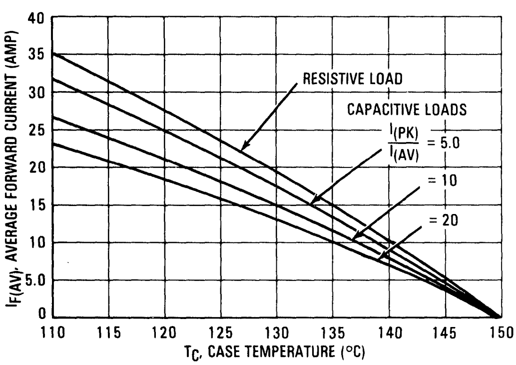
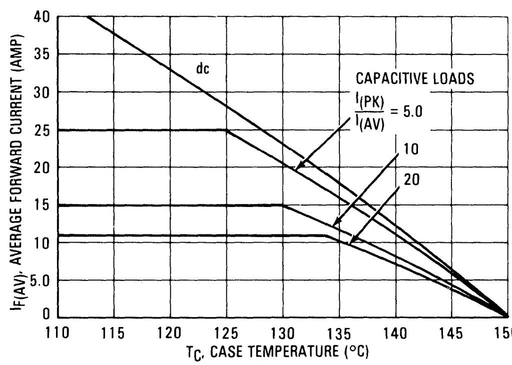


FIGURE 7 — CURRENT DERATING



PRINTED CIRCUIT BOARD RATING DATA

FIGURE 8 — FORWARD POWER DISSIPATION

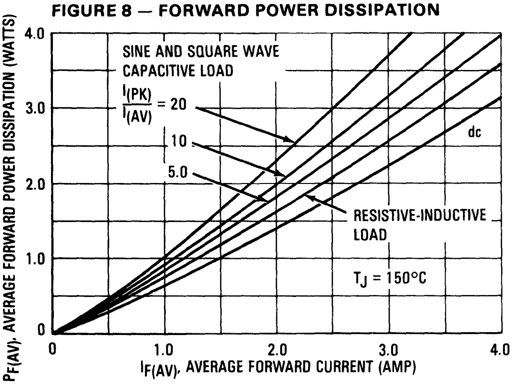
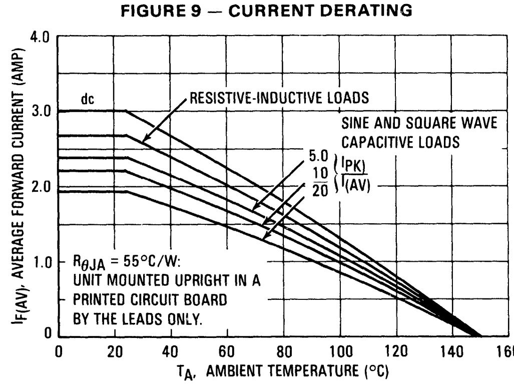


FIGURE 9 — CURRENT DERATING



TYPICAL DYNAMIC CHARACTERISTICS

FIGURE 10 — FORWARD RECOVERY TIME

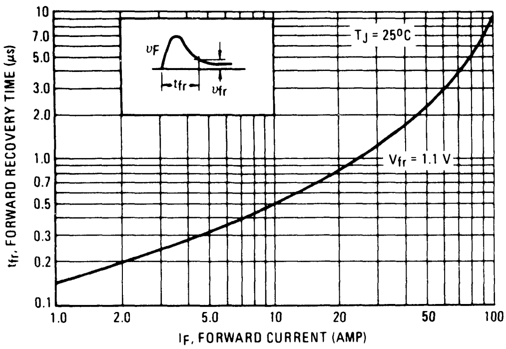


FIGURE 11 — JUNCTION CAPACITANCE

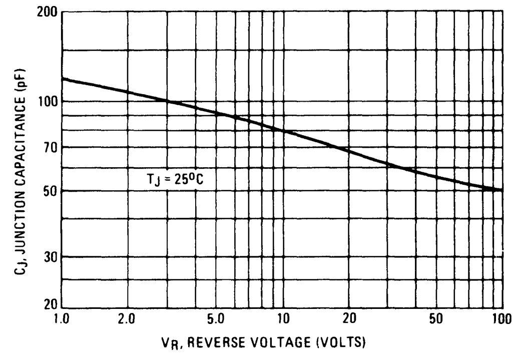


FIGURE 12 — TYPICAL REVERSE CURRENT

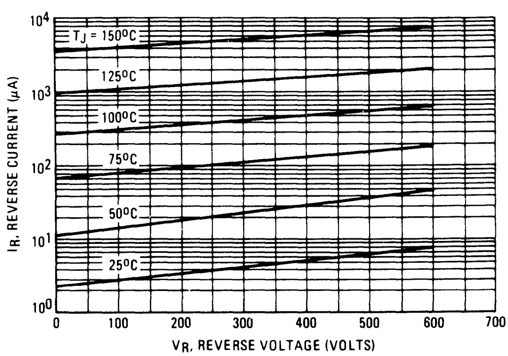
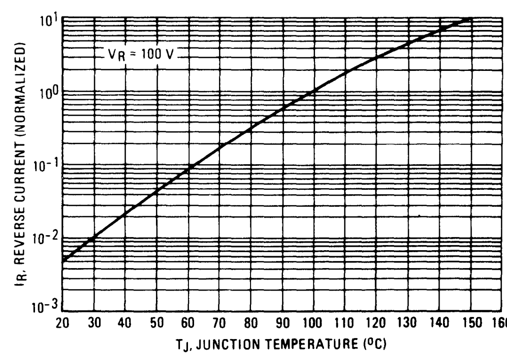
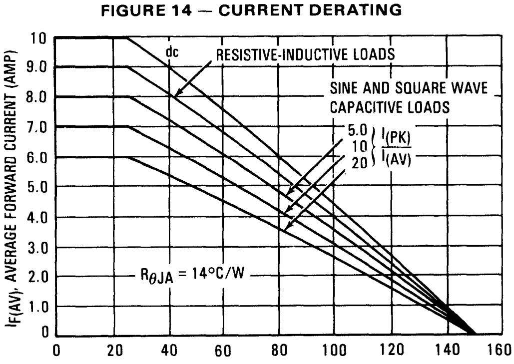


FIGURE 13 — NORMALIZED REVERSE CURRENT



TYPICAL MOUNTING DATA

FIGURE 14 — CURRENT DERATING



NOTE 2

Figure 14 shows the current carrying capability of a device mounted on a printed circuit board with a typical TO-220 type heatsink having a sink-to-air thermal resistance of 12°C/W. Allowing another 2°C/W for $R_{\theta JC}$ plus $R_{\theta CS}$ (case-to-sink) puts the total at 14°C/W as indicated. The unit and heatsink were mounted perpendicular to the printed circuit board for this data.

3

TYPICAL RECOVERED STORED CHARGE DATA
(See Note 3)

FIGURE 15 — T_J = 25°C

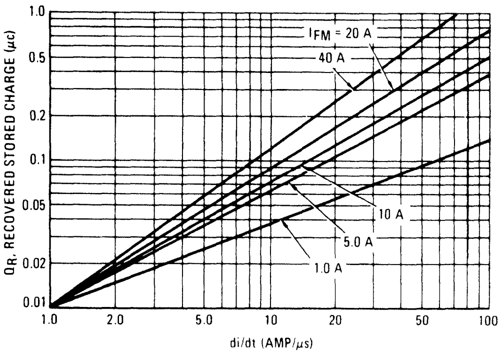


FIGURE 16 — T_J = 75°C

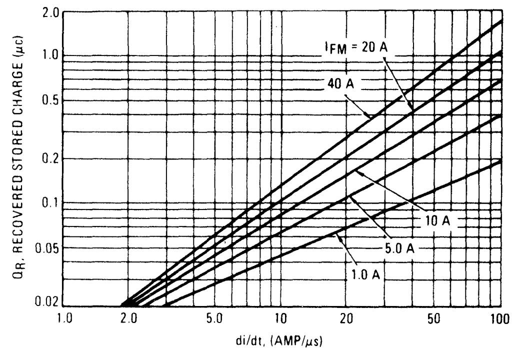


FIGURE 17 — T_J = 100°C

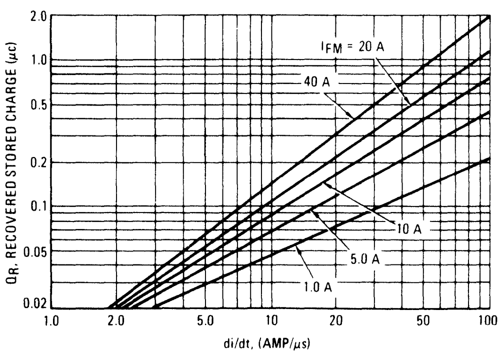
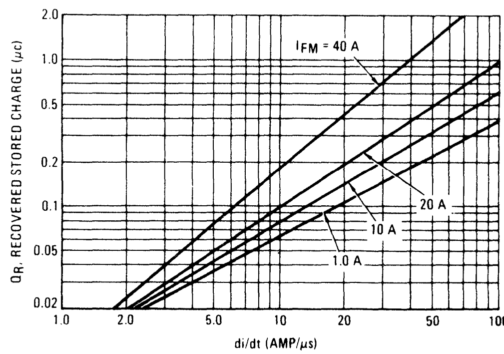


FIGURE 18 — T_J = 150°C



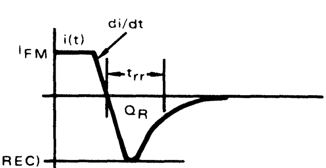
NOTE 3

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.



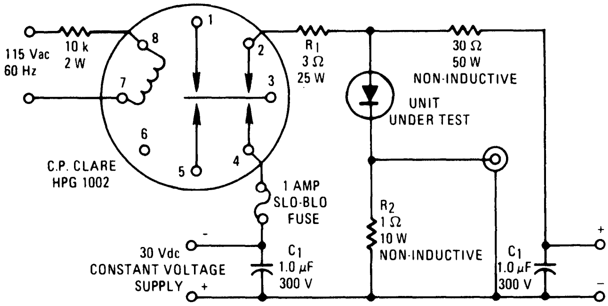
From stored charge curves versus di/dt, recovery time (t_{rr}) and peak reverse recovery current ($I_{RM(REC)}$) can be closely approximated using the following formulas:

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

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

3

FIGURE 19 — MOTOROLA REVERSE RECOVERY CIRCUIT



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

R1 – ADJUSTED FOR 1.4 Ω BETWEEN POINT 2 OF RELAY AND RECTIFIER INDUCTANCE ≈ 38 µH

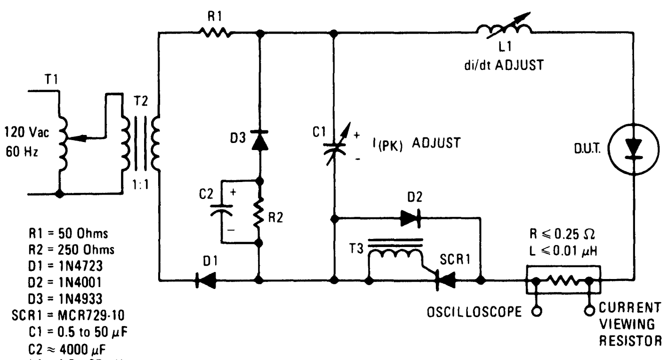
R2 – TEN-1 W, 10 Ω, 1% CARBON CORE IN PARALLEL

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

MINIMIZE ALL LEAD LENGTHS

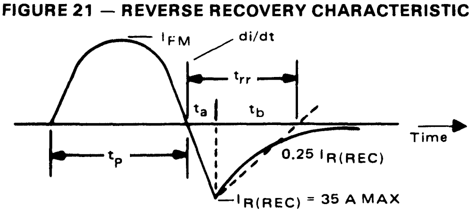
1.0 Adc FROM CONSTANT VOLTAGE SUPPLY
RIPPLE = 3 mVrms MAX
Z_{out} = 1½ Ω MAX, DC to 2 kHz

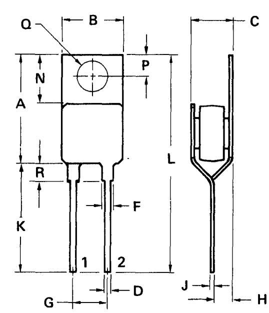
FIGURE 20 — JEDEC REVERSE RECOVERY CIRCUIT



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)

FIGURE 21 — REVERSE RECOVERY CHARACTERISTIC





1-CATHODE 2-ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.22	15.88	0.560	0.625
B	9.65	10.67	0.380	0.420
C	7.21	7.87	0.284	0.310
D	0.64	1.14	0.025	0.045
F	1.52	2.29	0.060	0.090
G	4.32	5.33	0.170	0.210
H	2.03	2.92	0.080	0.115
J	0.58	0.74	0.023	0.029
K	–	14.27	–	0.562
L	–	30.15	–	1.187
N	5.84	6.86	0.230	0.270
P	2.54	3.05	0.100	0.120
Q	3.53	3.73	0.139	0.147
R	–	5.08	–	0.200

CASE 339-02
(Meets TO-220AB except dimension "C")

MECHANICAL CHARACTERISTICS

CASE: Plastic Encapsulated, Metal Tabs.

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

POLARITY: Cathode to Tab with hole; Reverse polarity available by adding "R" Suffix, MR2402FR.

WEIGHT: 3.6 Grams (Approximately).

MOUNTING TORQUE: 8 in-lbs max.

MAXIMUM TEMPERATURE FOR SOLDERING PURPOSES: 350°C, 3/8" from case for 10 seconds.

MR2500,M Series

MOTOROLA

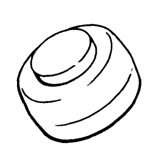
MEDIUM-CURRENT SILICON RECTIFIERS

. . . compact, highly efficient silicon rectifiers for medium-current applications requiring:

- High Current Surge — 400 Amperes @ T_J = 175°C
- Peak Performance @ Elevated Temperature — 25 Amperes @ T_C = 150°C
- Low Cost
- Compact, Molded Package — For Optimum Efficiency in a Small Case Configuration
- **Available With a Single Lead Attached**

MEDIUM-CURRENT SILICON RECTIFIERS

50 — 1000 VOLTS
25 AMPERES
DIFFUSED JUNCTION



3

MAXIMUM RATINGS

Characteristic	Symbol	MR 2500	MR 2501	MR 2502	MR 2504	MR 2506	MR 2508	MR 2510	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 peak)	V_{RSM}	60	120	240	480	720	960	1200	Volts
Average Rectified Forward Current (Single phase, resistive load, 60 Hz, T_C = 150°C)	I_O	← 25 →							Amp
Non-Repetitive Peak Surge Current (surge applied @ rated load conditions, half wave, single phase, 60 Hz)	I_{FSM}	← 400 (for 1 cycle) →							Amp
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 (Single Side Cooled)	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Maximum Instantaneous Forward Voltage (i_F = 78.5 Amp, T_C = 25°C)	v_F	1.18	Volts
Maximum Reverse Current (rated dc voltage) T_C = 25°C T_C = 100°C	I_R	 100 500	μA

MECHANICAL CHARACTERISTICS

CASE: Transfer Molded Plastic

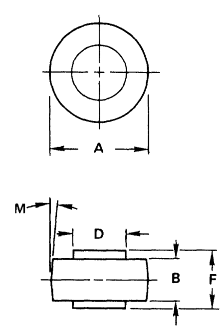
FINISH: All External Surfaces are Corrosion Resistant and the Contact Areas Readily Solderable.

POLARITY: Indicated by dot on Cathode Side

MOUNTING POSITIONS: Any

MAXIMUM TEMPERATURE FOR SOLDERING PURPOSES: 250°C

WEIGHT: 1.8 Grams (Approximately)



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.43	8.69	0.332	0.342
B	4.19	4.45	0.165	0.175
D	5.54	5.64	0.218	0.222
F	5.94	6.25	0.234	0.246
M	5° NOM		5° NOM	

CASE 193-04
MR2500M SERIES

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.03	10.29	0.395	0.405
B	4.19	4.45	0.165	0.175
D	5.54	5.64	0.218	0.222
F	5.94	6.25	0.234	0.246
M	5° NOM		5° NOM	

CASE 139-03
MR2500 SERIES

FIGURE 1 — FORWARD VOLTAGE

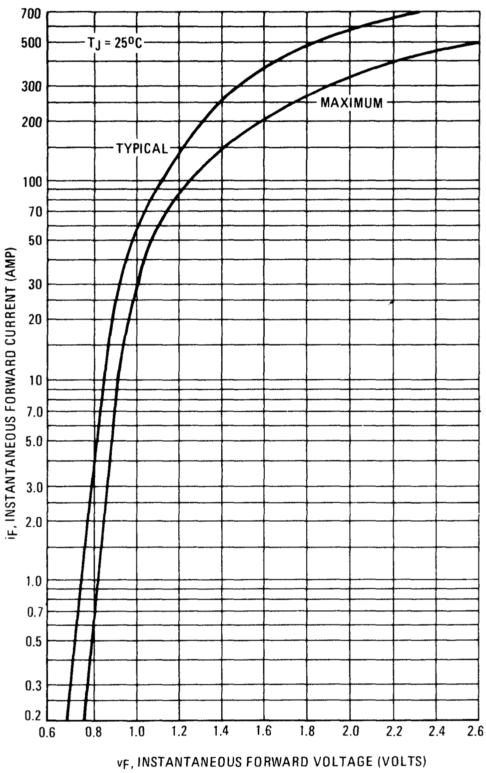


FIGURE 2 — NON-REPETITIVE SURGE CURRENT

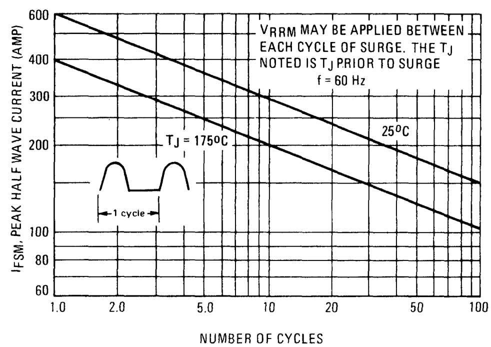


FIGURE 3 — FORWARD VOLTAGE TEMPERATURE COEFFICIENT

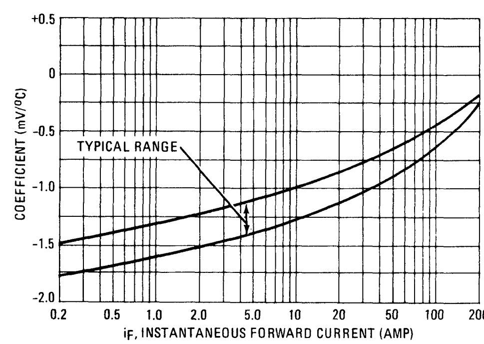


FIGURE 4 — CURRENT DERATING

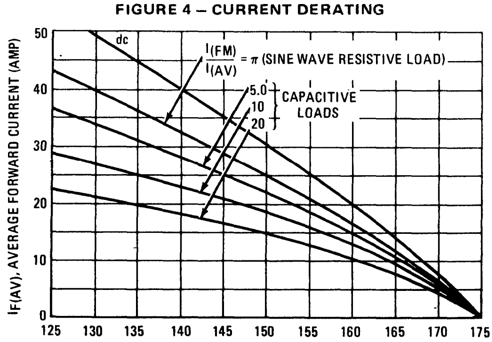


FIGURE 5 — FORWARD POWER DISSIPATION

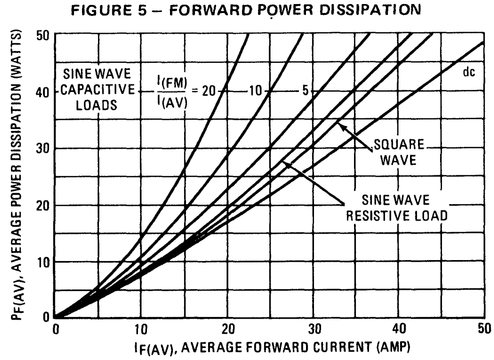


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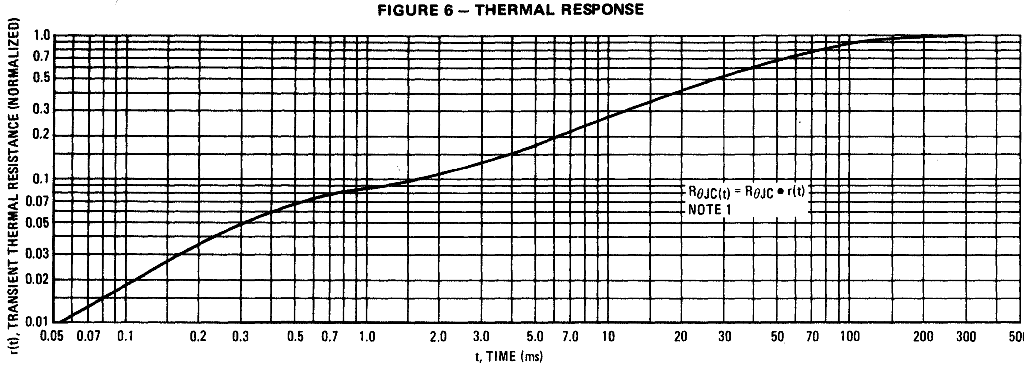
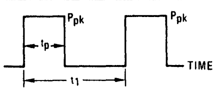
FIGURE 6 — THERMAL RESPONSE





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 the outline drawing on page 1). 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:

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

where

$r(t)$ = normalized value of transient thermal resistance at time, t, from Figure 6, i.e.,

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

FIGURE 7 — CAPACITANCE

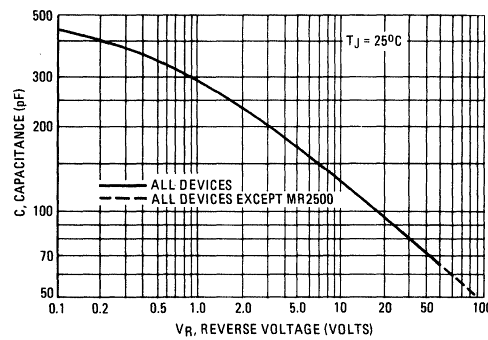


FIGURE 8 — FORWARD RECOVERY TIME

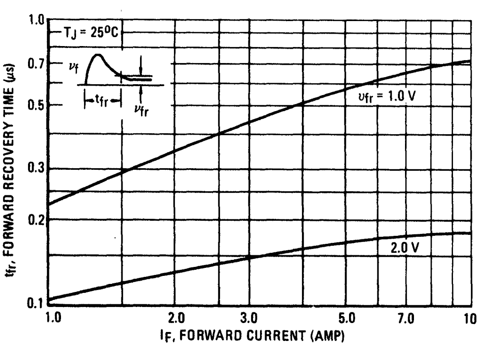


FIGURE 9 — REVERSE RECOVERY TIME

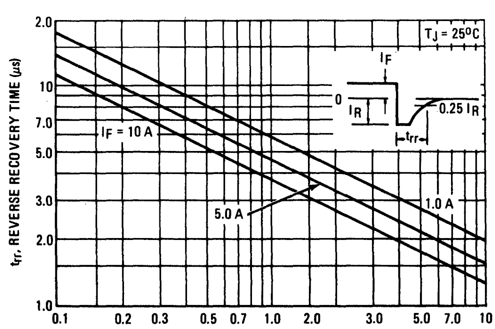
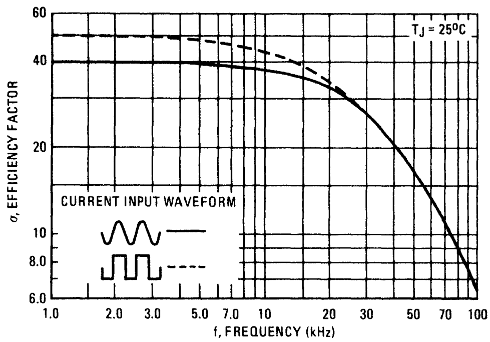


FIGURE 10 – RECTIFICATION WAVEFORM EFFICIENCY



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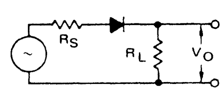
RECTIFICATION EFFICIENCY NOTE

FIGURE 11 – SINGLE-PHASE HALF-WAVE RECTIFIER CIRCUIT



The rectification efficiency factor σ shown in Figure 10 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, assume lossless, the maximum theoretical efficiency factor becomes:

$$\sigma_{(sine)} = \frac{\frac{V^2_m}{\pi^2 R_L}}{\frac{V^2_m}{4R_L}} \bullet 100\% = \frac{4}{\pi^2} \bullet 100\% = 40.6\% \quad (2)$$

For a square wave input of amplitude V_m, the efficiency factor becomes:

$$\sigma_{(square)} = \frac{\frac{V^2_m}{2R_L}}{\frac{V^2_m}{R_L}} \bullet 100\% = 50\% \quad (3)$$

(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 9) 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 on Figure 10.

It should be emphasized that Figure 10 shows waveform efficiency only; it does not provide a measure of diode losses. Data was obtained by measuring the ac component of V_O with a true rms ac voltmeter and the dc component with a dc voltmeter. The data was used in Equation 1 to obtain points for Figure 10.

ASSEMBLY AND SOLDERING INFORMATION

There are *two basic areas* of consideration for successful implementation of button rectifiers:

1. Mounting and Handling
2. Soldering

each should be carefully examined before attempting a finished assembly or mounting operation.

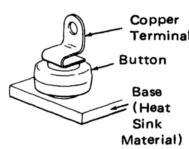
MOUNTING AND HANDLING

The button rectifier lends itself to a multitude of assembly arrangements but one key consideration must *always* be included:

One Side of the Connections to the Button Must Be Flexible!

This stress relief to the button should also be chosen for maximum contact area to afford the best heat transfer – but not at the expense of flexibility. For an annealed copper terminal a thickness of 0.015" is suggested.

Strain Relief Terminal for Button Rectifier



The base heat sink may be of various materials whose shape and size are a function of the individual application and the heat transfer requirements.

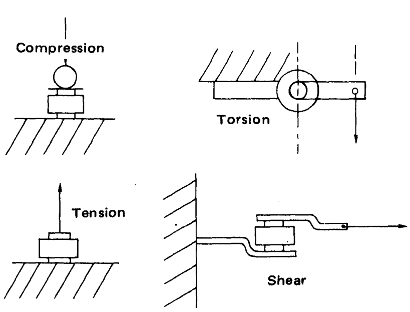
Common Materials	Advantages and Disadvantages
Steel	Low Cost; relatively low heat conductivity
Copper	High Cost; high heat conductivity
Aluminum	Medium Cost; medium heat conductivity Relatively expensive to plate and not all platers can process aluminum.

Handling of the button during assembly must be relatively gentle to minimize sharp impact shocks and avoid nicking of the plastic. Improperly designed automatic handling equipment is the worst source of unnecessary shocks. Techniques for vacuum handling and spring loading should be investigated.

The mechanical stress limits for the button diode are as follows:

Compression	32 lbs.	142.3 Newton
Tension	32 lbs.	142.3 Newton
Torsion	6-inch lbs.	0.68 Newton-meters
Shear	55 lbs.	244.7 Newton

MECHANICAL STRESS



Exceeding these recommended maximums can result in electrical degradation of the device.

SOLDERING

The button rectifier is basically a semiconductor chip bonded between two nickel-plated copper heat sinks with an encapsulating material of thermal-setting silicone. The exposed metal areas are also tin plated to enhance solderability.

In the soldering process it is important that the temperature not exceed 250°C if device damage is to be avoided. Various solder alloys can be used for this operation but two types are recommended for best results:

1. 96.5% tin, 3.5% silver; Melting point is 221°C (this particular eutetic is used by Motorola for its button rectifier assemblies).
2. 63% tin, 37% lead; Melting point 183°C (eutetic).

Solder is available as preforms or paste. The paste contains both the metal and flux and can be dispensed rapidly. The solder preform requires the application of a flux to assure good wetting of the solder. The type of flux used depends upon the degree of cleaning to be accomplished and is a function of the metals involved. These fluxes range from a mild rosin to a strong acid; e.g., Nickel plating oxides are best removed by an acid base flux while an activated rosin flux may be sufficient for tin plated parts.

Since the button is relatively light-weight, there is a tendency for it to float when the solder becomes liquid. To prevent bad joints and misalignment it is suggested that a weighting or spring loaded fixture be employed. It is also important that severe thermal shock (either heating or cooling) be avoided as it may lead to damage of the die or encapsulant of the part.

Button holding fixtures for use during soldering may be of various materials. Stainless steel has a longer use life while black anodized aluminum is less expensive and will limit heat reflection and enhance absorption. The assembly volume will influence the choice of materials. Fixture dimension tolerances for locating the button must allow for expansion during soldering as well as allowing for button clearance.

HEATING TECHNIQUES

The following four heating methods have their advantages and disadvantages depending on volume of buttons to be soldered.

1. **Belt Furnaces** readily handle large or small volumes and are adaptable to establishment of "on-line" assembly since a variable belt speed sets the run rate. Individual furnace zone controls make excellent temperature control possible.

2. **Flame Soldering** involves the directing of natural gas flame jets at the base of a heatsink as the heatsink is indexed to various loading-heating-cooling-unloading positions. This is the most economical labor method of soldering large volumes. Flame soldering offers good temperature control but requires sophisticated temperature monitoring systems such as infrared.

ASSEMBLY AND SOLDERING INFORMATION (continued)

3. **Ovens** are good for batch soldering and are production limited. There are handling problems because of slow cooling. Response time is load dependent, being a function of the watt rating of the oven and the mass of parts. Large ovens may not give an acceptable temperature gradient. Capital cost is low compared to belt furnaces and flame soldering.

4. **Hot Plates** are good for soldering small quantities of prototype devices. Temperature control is fair with overshoot common because of the exposed heating surface. Solder flow and positioning can be corrected during soldering since the assembly is exposed. Investment cost is very low.

Regardless of the heating method used, a soldering profile giving the time-temperature relationship of the particular method must be determined to assure proper soldering. Profiling must be performed on a scheduled basis to minimize poor soldering. The time-temperature relationship will change depending on the heating method used.

SOLDER PROCESS EVALUATION

Characteristics to look for when setting up the soldering process:

I Overtemperature is indicated by any one or all three of the following observations.

1. Remelting of the solder inside the button rectifier shows the temperature has exceeded 285°C and is noted by "islands" of shiny solder and solder dewetting when a unit is broken apart.
2. Cracked die inside the button may be observed by a moving reverse oscilloscope trace when pressure is applied to the unit.
3. Cracked plastic may be caused by thermal shock as well as overtemperature so cooling rate should also be checked.

II Cold soldering gives a grainy appearance and solder build-up without a smooth continuous solder fillet. The temperature must be adjusted until the proper solder fillet is obtained within the maximum temperature limits.

III Incomplete solder fillets result from insufficient solder or parts not making proper contact.

IV Tilted buttons can cause a void in the solder between the heatsink and button rectifier which will result in poor heat transfer during operation. An eight degree tilt is a suggested maximum value.

V Plating problems require a knowledge of plating operations for complete understanding of observed deficiencies.

1. Peeling or plating separation is generally seen when a button is broken away for solder inspection. If heatsink or terminal base metal is present the plating is poor and must be corrected.
2. Thin plating allows the solder to penetrate through to the base metal and can give a poor connection. A suggested minimum plating thickness is 300 microinches.
3. Contaminated soldering surfaces may out-gas and cause non-wetting resulting in voids in the solder connection. The exact cause is not always readily apparent and can be because of:
   (a) improper plating
   (b) mishandling of parts
   (c) improper and/or excessive storage time

SOLDER PROCESS MONITORING

Continuous monitoring of the soldering process must be established to minimize potential problems. All parts used in the soldering operation should be sampled on a lot by lot basis by assembly of a controlled sample. Evaluate the control sample by break-apart tests to view the solder connections, by physical strength tests and by dimensional characteristics for part mating.

A shear test is a suggested way of testing the solder bond strength.

POST SOLDERING OPERATION CONSIDERATIONS

After soldering, the completed assembly must be unloaded, washed and inspected.

Unloading must be done carefully to avoid unnecessary stress. Assembly fixtures should be cooled to room temperature so solder profiles are not affected.

Washing is mandatory if an acid flux is used because of its ionic and corrosive nature. Wash the assemblies in agitated hot water and detergent for three to five minutes. After washing; rinse, blow off excessive water and bake 30 minutes at 150°C to remove trapped moisture.

Inspection should be both electrical and physical. Any rejects can be reworked as required.

SUMMARY

The Button Rectifier is an excellent building block for specialized applications. The prime example of its use is the output bridge of the automative alternator where millions are used each year. Although the material presented here is not all inclusive, primary considerations for use are presented. For further information, contact the nearest Motorola Sales Office or franchised distributor.

MR2520L
MR2525L

MOTOROLA

3

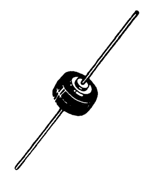
OVERVOLTAGE TRANSIENT SUPPRESSORS

. . . designed for applications requiring a diode with reverse avalanche characteristics for use as reverse power transient suppressors. Developed to suppress transients in the automotive system, these devices operate in the forward mode as standard rectifiers or reverse mode as power zener diodes and will protect expensive mobile transceivers, radios and tape decks from over-voltage conditions.

- High Power Capability
- Economical
- Increased Capacity by Parallel Operation

OVERVOLTAGE TRANSIENT SUPPRESSORS

2.5K-10K WATTS



MAXIMUM RATINGS

Rating	Symbol	Limit	Unit
DC Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	23	Volts
Repetitive Peak Reverse Surge Current MR2520L MR2525L (Time Constant = 10 ms, Duty Cycle ≤ 1.0%, T_C = 25°C)	I_{RSM}	 68 110	Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS

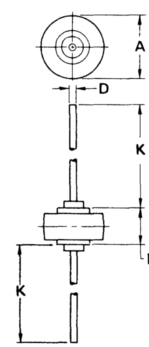
Characteristic	Symbol	Min	Max	Unit
Reverse Current (V_R = 20 Vdc, T_C = 25°C) (V_R = 20 Vdc, T_C = 100°C)	I_R	 — —	 50 300	μAdc
Breakdown Voltage (I_R = 100 mAdc, T_C = 25°C)	$V_{(BR)}$	24	32	Volts
Breakdown Voltage (1) MR2525L only (I_R = 40 Amp, T_C = 85°C)	$V_{(BR)}$	—	40	Volts

(1) Pulse Test: Pulse Width ≤ 10 ms, Duty Cycle ≤ 2.0%.

THERMAL CHARACTERISTICS

Characteristic	Lead Length	Symbol	Max	Unit
Thermal Resistance, Junction to Lead @ Both Leads to Heat Sink, Equal Length	1/4″ 3/8″ 1/2″	$R_{\theta JL}$	7.5 10 13	°C/W

(1) Pulse Test: Pulse Width ≤ 10 ms, Duty Cycle ≤ 2.0%.



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.03	10.29	0.395	0.405
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194-01
MR2525L

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	8.43	8.68	0.332	0.342
B	5.94	6.25	0.234	0.246
D	1.27	1.35	0.050	0.053
K	25.15	25.65	0.990	1.010

CASE 194-05
(MR2520L)

MECHANICAL CHARACTERISTICS:

CASE: Transfer Molded Plastic

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: Indicated by diode symbol or cathode band

WEIGHT: 2.5 Grams (approx.)

REVERSE SURGE DESIGN LIMITS

FIGURE 1 — PEAK CURRENT

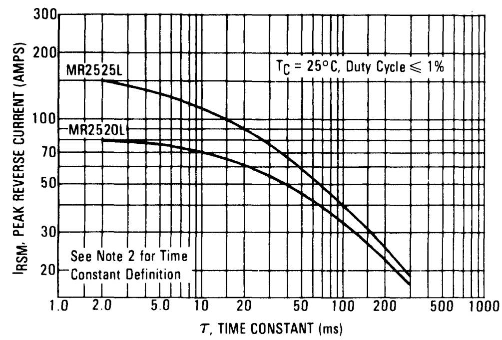


FIGURE 2 — PEAK POWER

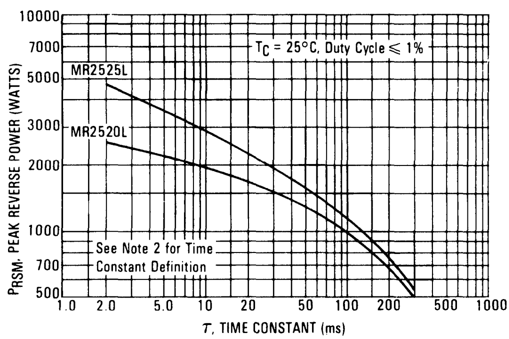
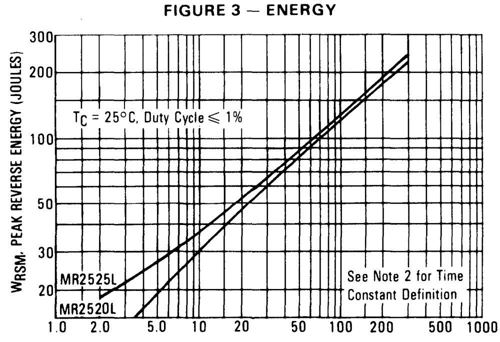


FIGURE 3 — ENERGY



NOTE 1 — TRANSIENTS IN THE AUTOMOTIVE ELECTRICAL SYSTEM

The introduction of electronics into the automobile has brought with it the interesting sidelight of characterizing the automotive electrical system for transients.

Since most electro-mechanical systems exhibit a wear-out phenomenon as electrical stresses are increased, there has been no need to separately define transients from the normal load conditions. Any transient condition was simply accounted for by increasing contact ratings, etc. The introduction of semiconductors changes the picture since they exhibit a different sensitivity to transients. Semiconductors tend to have a black and white failure characteristic when exposed to transients in that no damage is caused below a certain level and total failure results above a certain level. Unfortunately these two levels are separate and the problem is further complicated by the fact that the energy tolerance of semiconductors is normally subject to a production distribution. This leaves solid state systems open to problems which are discovered only after many units are in the field.

SUMMARY OF TRANSIENTS

Transients in the automotive electrical system have widely varying energy levels occurring over widely varing times, but most become insignificant compared to the worst transient known as "Load Dump". Load dump happens when the battery becomes disconnected while the alternator is supplying charging current, or the disconnection of some other load with no battery present. Load dump transients generally are of 200 to 500 milliseconds duration, having an exponential decay from a worst case peak voltage of 80–120 volts. A clamped load dump, it should be noted, will be of considerably shorter duration.

Although the possibility of the battery becoming disconnected while the engine is running may seem remote, it is not reasonable this occurrence should result in the total failure of the electrical system of a car.

The following table lists some of the transients the automotive electronic designer must consider and should cause him to provide some level of protection.

Power Source	Available Transients
Battery Line	1. ±200 Volts for microseconds 2. +Load Dump
Ignition Line and Accessory Line	1. –300 Volts for milliseconds 2. ±200 Volts for microseconds 3. +Load Dump
	Note: All transients are exponential decay.

The voltages and times shown are reasonable values from many on-car measurements. Since the nonload-dump transients are of low energy, but high voltage, it is recommended they be clamped rather than blocked. It is imperative that source impedances also be known to allow proper selection of clamp devices.

STOPPING THE TRANSIENTS AT THE SOURCE

Figure 4 shows the most straight forward method of preventing large negative transients from disrupting the accessory and ignition busses. At the instant the switch is opened, the current flowing in the inductance will transfer to the diode producing about 1 volt negative on that particular buss. This condition will remain until the current in the inductance decays at a rate determined by the L/R time constant for the circuit. It can be shown that the peak currents and transient durations available in the car can easily be absorbed by a 1N4003 diode.

FIGURE 4

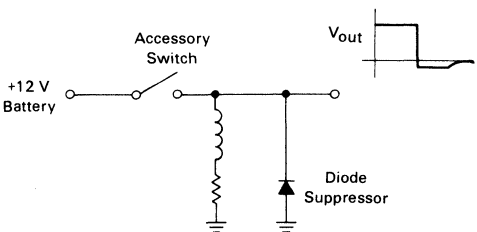
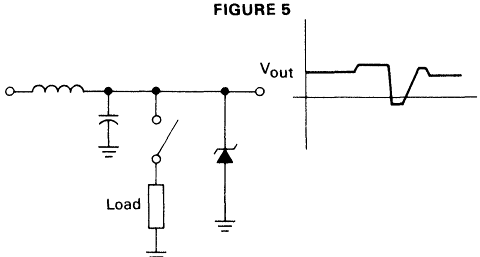


Figure 5 shows the most straight forward scheme for protecting against the series L-C type of transient. The forward biased diode action to protect the negative transient is similar to the action described for Figure 4. An avalanche device is required to clip off the positive portion.

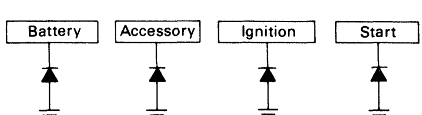
Just applying these two techniques and calling the result a master suppressor, overlooks the result of mutual coupling. Because of this effect, it becomes apparent that

FIGURE 5



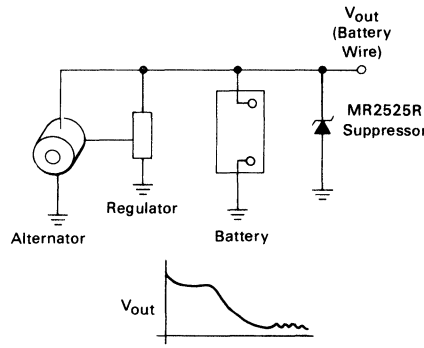
protecting against positive inductive transients at one spot is useless. Using the technique shown in Figure 5 to protect the various lines, would not be money well spent, since the same level of protection would still be required at each module anyway, due to mutual coupling. The best central suppressor for negative transients, then, is shown in Figure 6.

FIGURE 6



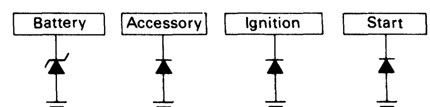
To complete the job, protection is needed against load dump. The easiest method is to simply clamp the output of the alternator with an avalanche device, as shown in Figure 7. The completed suppressor would then appear as in Figure 8. It could easily be more cost effective to incorporate the load dump suppressor into the alternator itself. The end effect would be identical to Figure 7,

FIGURE 7



however, the implementation would require placing 3 avalanche devices in place of the present 3 diodes in the ground side of the diode bridge in the alternator.

FIGURE 8



REVERSE BATTERY

Installing a battery with the terminals reversed today causes total failure of the charging system. Usually a fuse link fails, however, some cars suffer alternator failure. This condition is caused by a large current in-rush through the diode bridge which is forward biased during reverse battery condition. The master suppressor proposed in Figure 8 will suffer the same fate. While a suppressor can easily be devised, which will not drain current during −12 V condition, it is apparent that this defeats the purpose of the suppressor. In order to make this concept feasible, a circuit breaker must be inserted in series with the main battery lead.

PARALLEL OPERATION

Higher surge current capabilities can be obtained by paralleling the basic suppressor cells. Contact Motorola Semiconductor Products Division through the nearest sales office or authorized distributor for more information on number of cells required and package configurations available.

FIGURE 9 — STEADY STATE THERMAL RESISTANCE

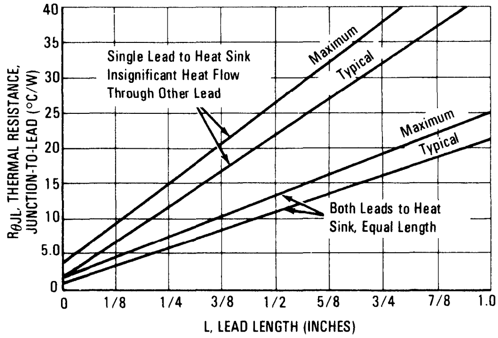
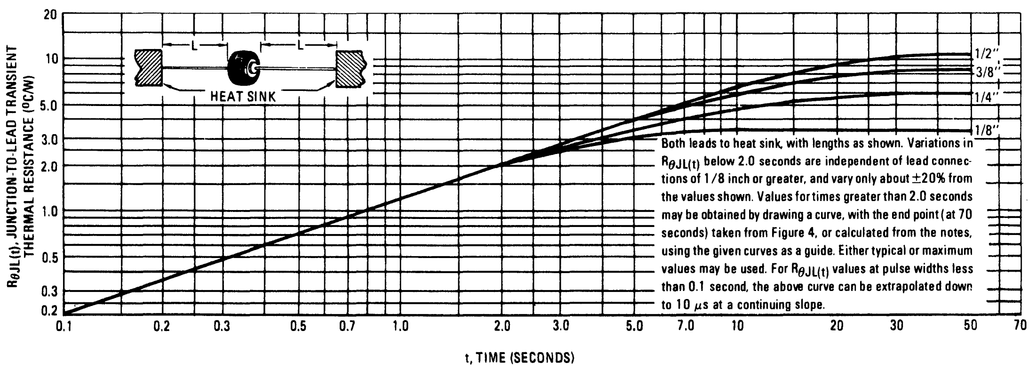
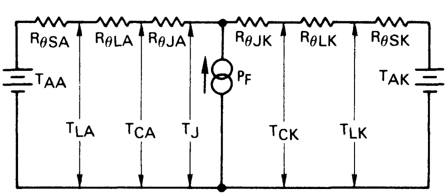


FIGURE 10 — TYPICAL TRANSIENT THERMAL RESPONSE



3

THERMAL CIRCUIT MODEL
(For Heat Conduction Through The Leads)



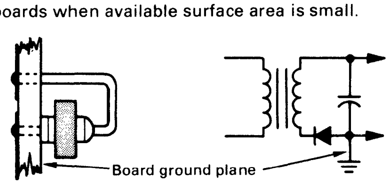
Use of the above model permits junction to lead thermal resistance for any mounting configuration to be found. Lowest values occur when one side of the rectifier is brought as close as possible to the heat sink as shown below. Terms in the model signify:

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_F = Power Dissipation
(Subscripts A and K refer to anode and cathode sides respectively.)

Values for thermal resistance components are:
$R_{\theta L}$ = 40°C/W/IN. Typically and 44°C/W/IN Maximum
$R_{\theta J}$ = 2°C/W Typically and 4°C/W Maximum

Since $R_{\theta J}$ is so low, measurements of the case temperature, T_C will be approximately equal to junction temperature in practical lead mounted applications. When used as a 60 Hz rectifier, the slow thermal response holds $T_{J(PK)}$ close to $T_{J(AVG)}$. Therefore maximum lead temperature may be found from: T_L = 175°C−$R_{\theta JL}$ P_F.

The recommended method of mounting to a P.C. board is shown on the sketch, where $R_{\theta JA}$ is approximately 25°C/W for a 1-1/2" × 1-1/2" copper surface area. Values of 40°C/W are typical for mounting to terminal strips or P.C. boards when available surface area is small.



Recommended mounting for half wave circuit

NOTE 2 — METHOD FOR CALCULATING ENERGY DISSIPATED IN A SURGE SUPPRESSOR DURING CAPACITIVE DISCHARGE TESTS

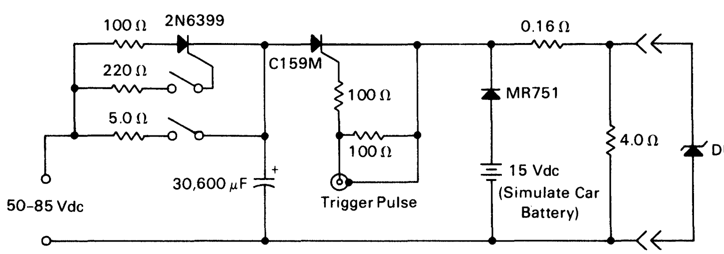
One of the major parameters of interest in the rating of a diode surge suppressor is the energy dissipated in the device during an exponentially decaying transient pulse. Surge suppressor diodes are usually characterized using a capacitive discharge test, as shown in Figures 11 and 12. Calculation of the energy, peak power and the R-C time constant of the capacitive discharge power pulse is described in the material that follows and correlates with both of the circuits.

EMPIRICAL PARAMETER DETERMINATION

Figure 13 shows the instantaneous current and voltage applied to the DUT as obtained with a dual trace memory oscilloscope during pulse testing using the circuit of Figure 11. Points on the instantaneous power curve can be found by multiplying the instantaneous current by the instantaneous voltage at various points in time.

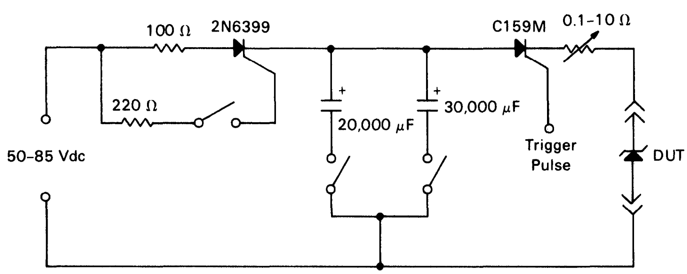
From equation (1): $p(t) = Pm\ e^{-t/\tau}$ (4)

FIGURE 11 — AUTOMOTIVE LOAD DUMP TEST CIRCUIT



$\tau = RC = 0.16 * 30.6 \times 10^{-3} = 4.896ms$

FIGURE 12 — CAPACITIVE DISCHARGE TEST CIRCUIT



THEORETICAL ENERGY CALCULATION

Assuming that the instantaneous power dissipated in the DUT (Diode Under Test) can be represented as an exponential decay represented by

$$p(t) = Pm\ e^{-t/\tau} \quad (1)$$

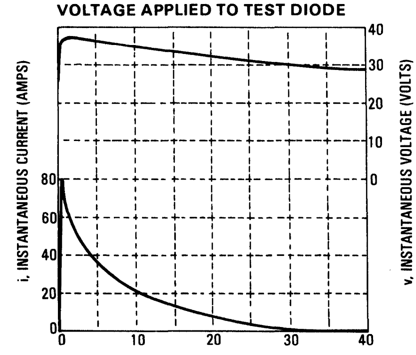
where Pm is the peak power at t = 0 and τ is the R-C time constant of the test circuit, then the energy dissipated in the DUT can be calculated as:

$$W = \int_0^{\infty} Pm\ e^{-t/\tau}\ dt \quad (2)$$

$$\therefore W = \tau\ Pm \quad (3)$$

Empirical determination of Pm and τ will allow calculation of the energy in the pulse using expression (3) above.

FIGURE 13 — REPRESENTATION OF CURRENT AND VOLTAGE APPLIED TO TEST DIODE



$$\text{thus, } \ln p(t) = \ln Pm - \frac{t}{\tau} \quad (5)$$

Calculation of p(t) and lnp(t) using data points off Figure 3 tabulates as follows:

t (ms)	v(t) (Volts)	i(t) (Amps)	p(t) (Watts)	lnp(t)
0.5	36.0	80.0	2880	7.965
1.5	37.5	54.0	2025	7.613
2.5	37.0	50.0	1850	7.523
3.5	36.5	42.0	1533	7.335
4.5	36.0	38.0	1368	7.221
9.5	34.5	22.0	759	6.632
19.5	32.0	8.0	256	5.545
29.5	30.0	2.0	60	4.094

Expression (5) is the equation form for a straight line

$$y = mx + b \quad (6)$$

Where m is the slope and b is the intercept

For expression (5) $\frac{-1}{\tau}$ is the slope and lnPm is the intercept

$$\text{thus, } \tau = \frac{-1}{m} \quad (7)$$

$$Pm = \ln^{-1}(b) \quad (8)$$

Accurately fitting a straight line to the lnp(t) vs. t data points allows determination of Pm and τ for use in equation (3).

REGRESSION APPROACH

The method of least squares can be used to determine the slope and intercept of the line which best fits the data points lnp(t) vs. t calculated above. Least squares regression routines are available on most time sharing computer systems as well as on many scientific calculators.

A least squares regression for the above data points shows the intercept and slope to be 7.8588 and -0.12429 respectively, and from (6) and (7).

$$Pm = \ln^{-1}(b) = \ln^{-1}(7.8588) = 2588.4 \text{ Watts}$$

$$\tau = \frac{-1}{m} \quad \frac{-1}{-0.12499} = 8.046 \text{ ms}$$

Finally, the energy dissipated in the DUT is:

$$W = \tau Pm = 20.825 \text{ Joules}$$

The multiple correlation coefficient of the regression for this example was 0.994 indicating a 99.4% accuracy of the fit to the theoretical equation (1). In general, accuracies above 97% can be obtained.

SUMMARY:

The energy dissipated in a diode in a capacitive discharge test can be calculated from data obtained from a dual trace memory oscilloscope using the following procedure:

1. Record the current and voltage pulses simultaneously on a dual trace memory oscilloscope using appropriate scales to utilize the entire scope to display the decay.
2. Pick off approximately five voltage and current data points across the decay (do not use t = 0 as a data point since the voltage across the DUT is initially very low, the current is at its peak and the energy dissipated is negligible).
3. Multiply these instantaneous current and voltage values and take the natural logrithm of the product.
4. Perform a least squares regression of lnp(t) vs. t to determine the slope and intercept of the "best fitting" straight line. The R^2 (correlation coefficient) should be above 90% for good accuracy.
5. Calculate τ and Pm using equations (7) and (8).
6. Calculate the energy using equation (3).

3

COMMENTS:

Using this method, **the time constant derived will be slightly larger than the R-C product of the capacitor and resistor used in the circuit.** This occurs due to the series resistance of the DUT and the Thyristor in the firing circuit. The peak energy calculated from this method will be less than what is indicated by the current and voltage traces at t = 0. This difference is of little consequence, however, because of the short duration during which it exists. In the example used, the current and voltage at t = 0 are 100 A and 30 Volts. These conditions exist for 0.5 ms or less and thus the energy dissipated is less than 1.5 Joules or 7% of the calculated energy. This 7% difference is a typical value.

Perhaps more accuracy could be obtained by adding 7% to the calculated energy, however, without the 7% "adder" this method can be used as a comparison of different transient suppressors.

MR5005 MR5010 MR5020 MR5030 MR5040

MOTOROLA

3

INDUSTRIAL PRESSFIT SILICON POWER RECTIFIERS

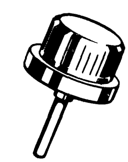
. . . designed for use in all medium-current applications or for higher current industrial alternators and chassis mounted power supply rectifiers.

- 50 Amp @ T_C = 150°C
- 600 Amp Surge Capability
- Reverse Polarity Available
- Rugged Construction

SILICON POWER RECTIFIERS

50-400 VOLTS

50 AMPERE



MAXIMUM RATINGS

Rating	Symbol	MR5005	MR5010	MR5020	MR5030	MR5040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage	V_{RSM}	75	150	250	400	450	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	210	280	Volts
Average Rectified Forward Current (Single phase, resistive load, T_C = 150°C	I_O	← 50 →					Amp
Non-Repetitive Peak Surge Current (Surge applied at rated load conditions)	I_{FSM}	← 600 →					Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +195 →					°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.8	°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Instantaneous Forward Voltage (i_F = 157 Amp, T_J = 25°C) (i_F = 50 Amp, T_J = 25°C)	v_F	 – –	 1.10 0.95	 1.18 1.00	Volts
Reverse Current (rated dc voltage) (T_C = 25°C) (T_C = 150°C)	I_R	 – –	 0.05 1.0	 0.2 2.0	mA

MECHANICAL CHARACTERISTICS

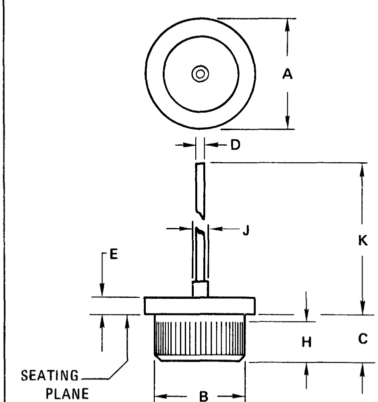
CASE: Welded hermetically sealed construction

FINISH: All external surfaces corrosion resistant, terminals readily solerable

WEIGHT: 9 grams (approx.)

POLARITY: Cathode connected to case (reverse polarity available denoted by Suffix R, i.e.: MR5030R)

MOUNTING POSITION: Any



NOTES:
1. 50 TPI STRAIGHT KNURL.
2. POLARITY, INK MARKED ON PACKAGE

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.49	16.26	0.610	0.640
B	12.73	12.83	0.501	0.505
C	5.08	6.35	0.200	0.250
D	2.46	2.62	0.097	0.103
E	2.03	4.83	0.080	0.190
H	5.08	6.35	0.200	0.250
J	–	3.56	–	0.140
K	–	15.24	–	0.600

CASE 43-04

FIGURE 1 – CURRENT DERATING

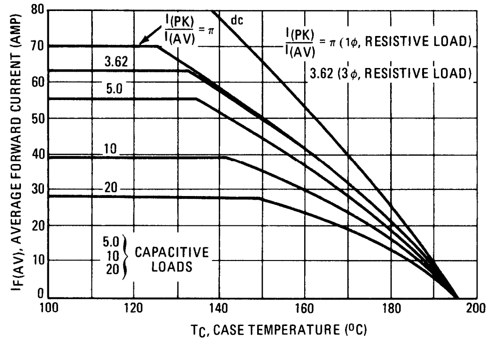


FIGURE 2 – FORWARD POWER DISSIPATION

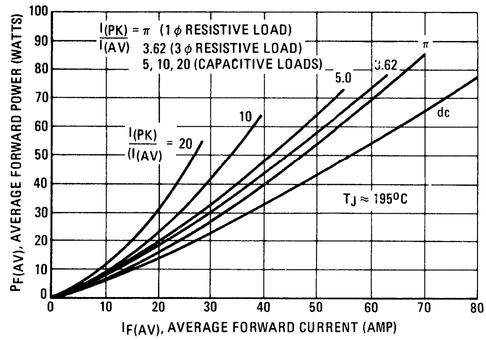


FIGURE 3 – MAXIMUM FORWARD VOLTAGE

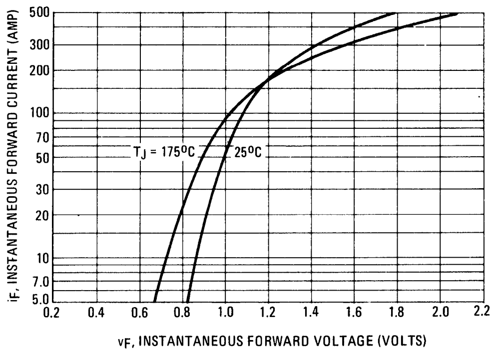


FIGURE 4 – MAXIMUM NON-REPETITIVE SURGE CAPABILITY

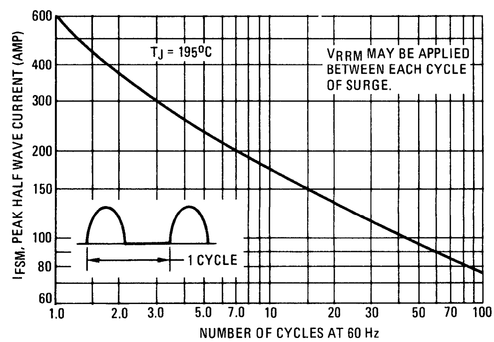
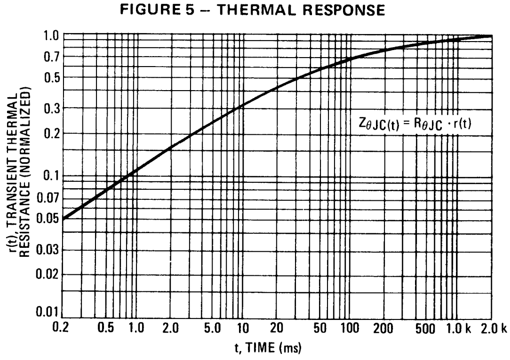
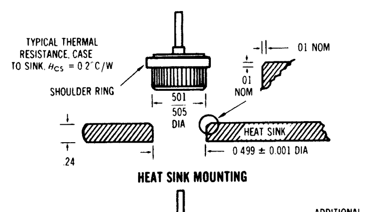


FIGURE 5 – THERMAL RESPONSE

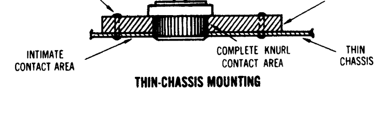


Recommended procedures for mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to provide a guide into the hole and prevent shearing off the knurled side of the rectifier.
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.
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 thermal lubricant such as D.C. 340 will be of considerable aid.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

3

MR5059
MR5060
MR5061

MOTOROLA

AVALANCHE RECTIFIERS

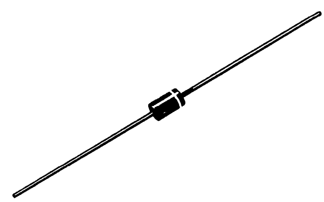
. . . subminiature size, axial lead-mounted rectifiers for general-purpose, low-power applications requiring avalanche protection.

- Avalanche power capability
  - — 1000 Watts at 20 μs
  - — 450 Watts at 100 μs
- Low Forward Voltage
- Low Cost

Cross Reference Guide		
Motorola	JEDEC	G.I.
MR5059	1N5059	1N5059GP
MR5060	1N5060	1N5060GP
MR5061	1N5061	1N5061GP

LEAD-MOUNTED AVALANCHE RECTIFIERS

200-400-600 VOLTS
1.5 AMPS



3

MAXIMUM RATINGS

Rating	Symbol	MR5059	MR5060	MR5061	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	200	400	600	Volts
Nonrepetitive Peak Reverse Voltage (Halfwave, Single Phase, 60 Hz)	V_{RSM}	300	525	800	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	420	Volts
Average Rectified Forward Current (Single Phase, Resistive Load, 60 Hz, T_L = 70°C, 1/2" From Body)	I_O		1.5	Amp	
Nonrepetitive Peak Surge Current (Surge Applied at Rated Load Conditions)	I_{FSM}		50 (for 1 cycle)		Amp
Junction & Storage Temperature Range	T_J, T_{stg}		-65 to +175		°C
Nonrepetitive Peak Reverse Surge Power (t = 20 μs)	P_{RM}		1000		Watts

ELECTRICAL CHARACTERISTICS

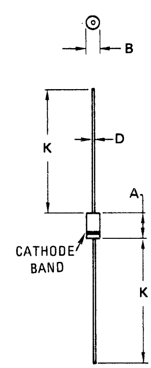
Characteristic and Conditions	Symbol	Typ	Max	Unit
Instantaneous Forward Voltage (i_f = 1.5 Amp, T_J = 25°C)	v_F	0.93	1.04	Volts
Reverse Current (Rated dc Voltage) T_J = 150°C T_J = 25°C	I_R	250 3.0	300 5.0	μA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Typ	Max	Unit
Thermal Resistance, Junction to Lead 1/4" 1/2"	$R_{\theta JL}$	 21 31	 38 50	°C/W

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded plastic
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 240°C, 1/8" 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)



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04
Dimensions Within JEDEC DO-15 Outline.

FIGURE 1 — FORWARD VOLTAGE

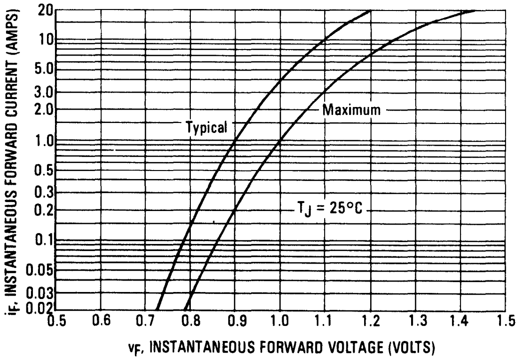


FIGURE 2 — MAXIMUM NON-REPETITIVE AVALANCHE SURGE POWER

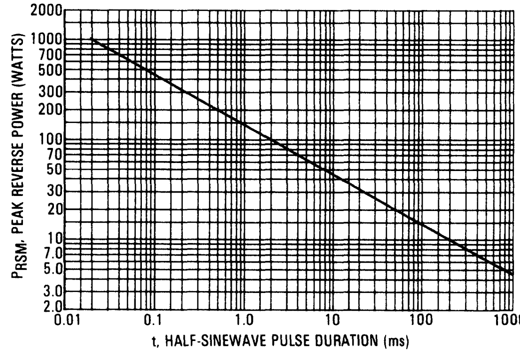


FIGURE 3 — POWER DISSIPATION

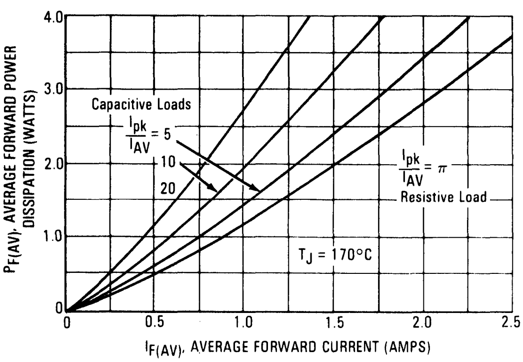


FIGURE 4 — EFFECT OF LEAD LENGTHS, RESISTIVE LOAD

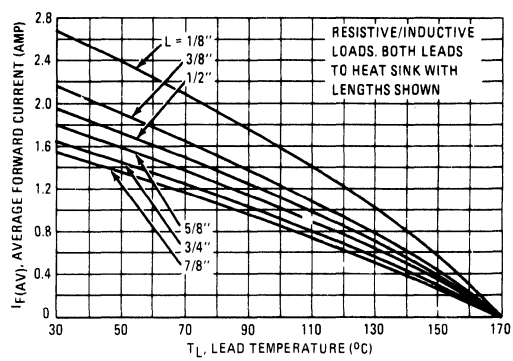
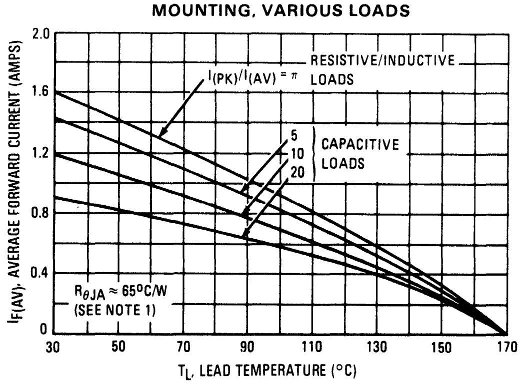


FIGURE 5 — PRINTED CIRCUIT BOARD MOUNTING, VARIOUS LOADS

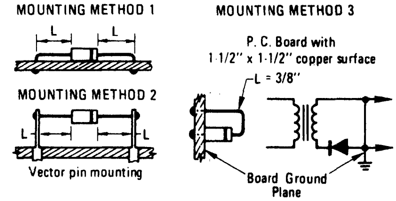


NOTE 1

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



MRL005
MRL010
MRL020
MRL040

MOTOROLA

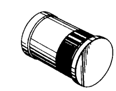
Advance Information

LEADLESS SURFACE MOUNTED RECTIFIERS

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

LEADLESS SURFACE MOUNTED SILICON RECTIFIERS

50–400 VOLTS DIFFUSED JUNCTION



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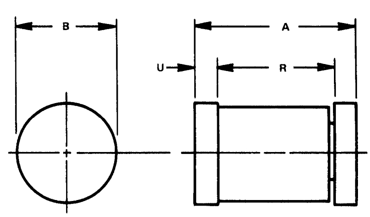
MAXIMUM RATINGS

Rating	Symbol	MRL 005	MRL 010	MRL 020	MRL 040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	Volts
Nonrepetitive Peak Reverse Voltage (halfwave, single phase, 60 Hz)	V_{RSM}	60	120	240	480	Volts
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, $T_A = 75°C$)	I_O	0.5				Amp
Nonrepetitive Peak Surge Current (surge applied at rated load conditions)	I_{FSM}	10 (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 ($i_F = 0.5$ Amp, $T_J = 25°C$)	v_F	0.95	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop ($I_O = 0.5$ Amp, $T_C = 75°C$)	$V_{F(AV)}$	—	0.8	Volts
Maximum Reverse Current (rated dc voltage) $T_J = 25°C$ $T_J = 100°C$	I_R	0.05 1.0	10 100	μA
Maximum Full-Cycle Average Reverse Current ($I_O = 0.5$ Amp, $T_C = 75°C$)	$I_{R(AV)}$	—	30	μA



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

MECHANICAL CHARACTERISTICS

CASE: Glass

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C @ end caps for 10 seconds

FINISH: All external surfaces are corrosion-resistant, end caps are readily solderable

POLARITY: Cathode indicated by color band

This document contains information on a new product. Specifications and information herein are subject to change without notice.

MOTOROLA

MUR105 MUR110 MUR115 MUR120 MUR130 MUR140 MUR150 MUR160 MUR170 MUR180 MUR190 MUR1100

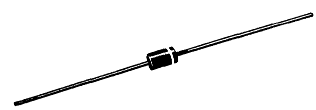
SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 25, 50 and 75 Nanosecond Recovery Times
- 175°C Operating Junction Temperature
- Low Forward Voltage
- Low Leakage Current
- High Temperature Glass Passivated Junction
- Reverse Voltage to 1000 Volts

ULTRAFAST RECTIFIERS

1.0 AMPERE
50–1000 VOLTS



CASE 59-04
PLASTIC PACKAGE

MAXIMUM RATINGS

Rating	Symbol	MUR												Unit
		105	110	115	120	130	140	150	160	170	180	190	1100	
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	700	800	900	1000	Volts
Average Rectified Forward Current (Square Wave Mounting Method #3 Per Note 1)	$I_{F(AV)}$	1.0 @ T_A = 130°C			1.0 @ T_A = 120°C					1.0 @ T_A = 95°C				Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions, halfwave, single phase, 60 Hz)	I_{FSM}	35												Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175												°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	MUR105–115	MUR120–160	MUR170–1100	Unit
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	See Note 1			°C/W

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	MUR105–115	MUR120–160	MUR170–1100	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 1.0 Amp, T_J = 150°C) (i_F = 1.0 Amp, T_J = 25°C)	v_F	 0.710 0.875	 1.05 1.25	 1.50 1.75	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_J = 150°C) (Rated dc Voltage, T_J = 25°C)	i_R	 50 2.0	 150 5.0	 600 10	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs) (I_F = 0.5 Amp, i_R = 1.0 Amp, I_{REC} = 0.25 A)	t_{rr}	 35 25	 75 50	 100 75	ns
Maximum Forward Recovery Time (I_F = 1.0 A, di/dt = 100 A/μs, I_{REC} to 1.0 V)	t_{fr}	25	50	75	ns

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%
Switchmode is a trademark of Motorola Inc.

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MUR105, 110 AND 115

FIGURE 1 — TYPICAL FORWARD VOLTAGE

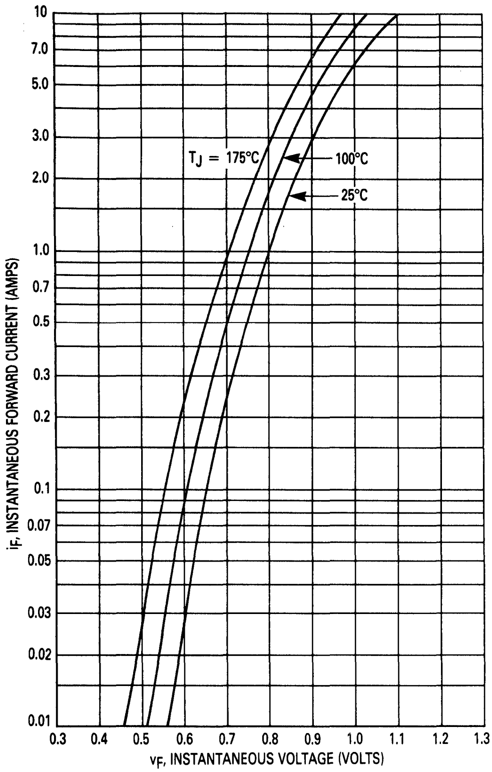


FIGURE 2 — TYPICAL REVERSE CURRENT*

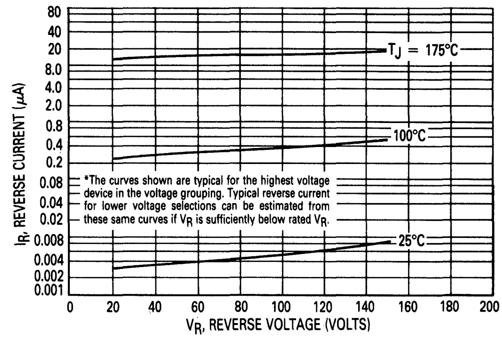


FIGURE 3 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 1)

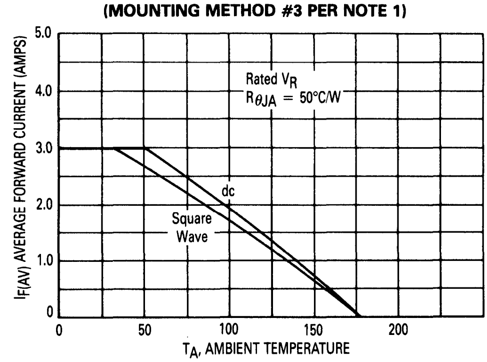


FIGURE 4 — POWER DISSIPATION

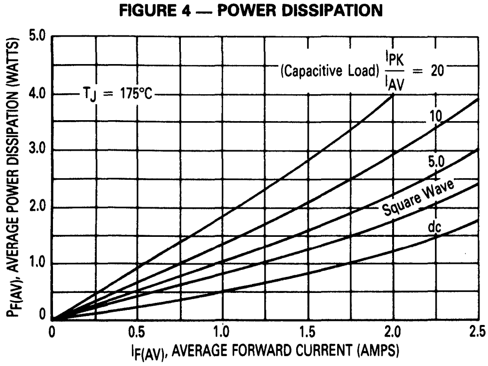
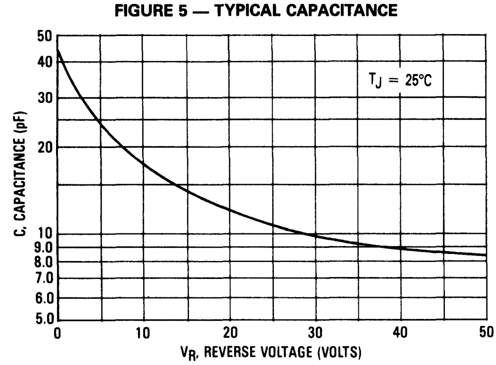


FIGURE 5 — TYPICAL CAPACITANCE



MUR120, 130, 140, 150, 160

FIGURE 6 — TYPICAL FORWARD VOLTAGE

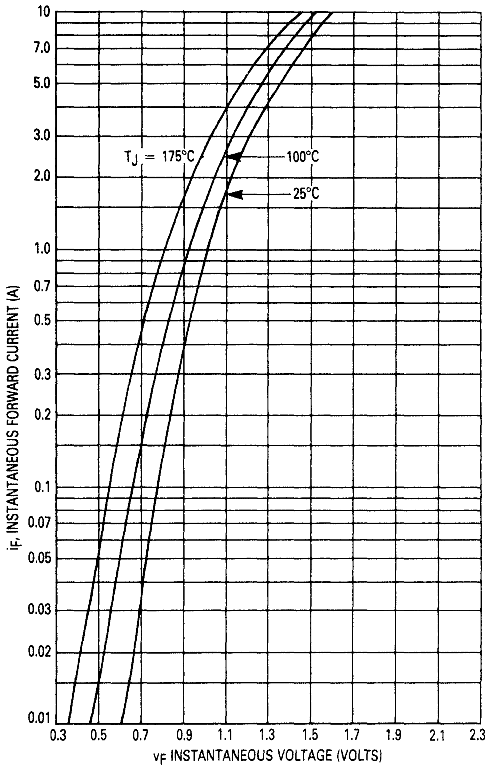


FIGURE 7 — TYPICAL REVERSE CURRENT*

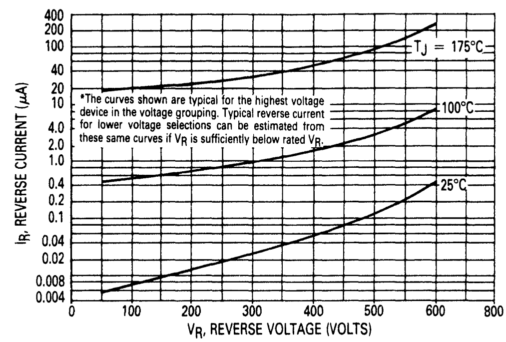


FIGURE 8 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 1)

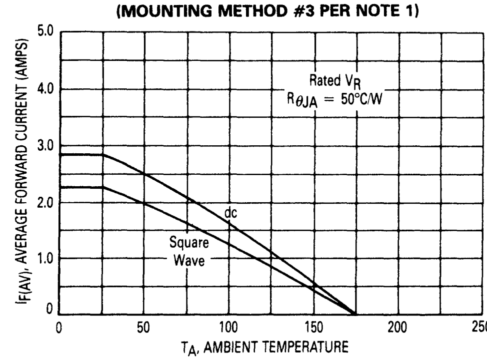


FIGURE 9 — POWER DISSIPATION

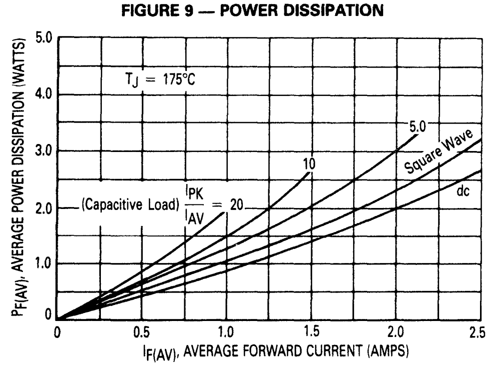
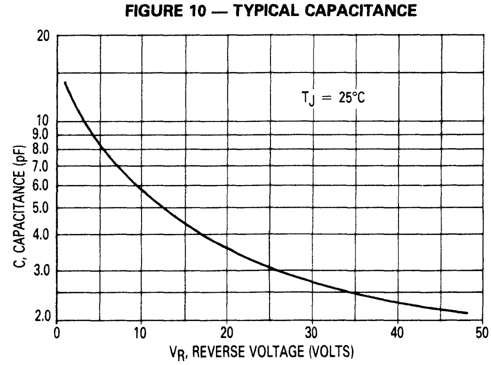


FIGURE 10 — TYPICAL CAPACITANCE



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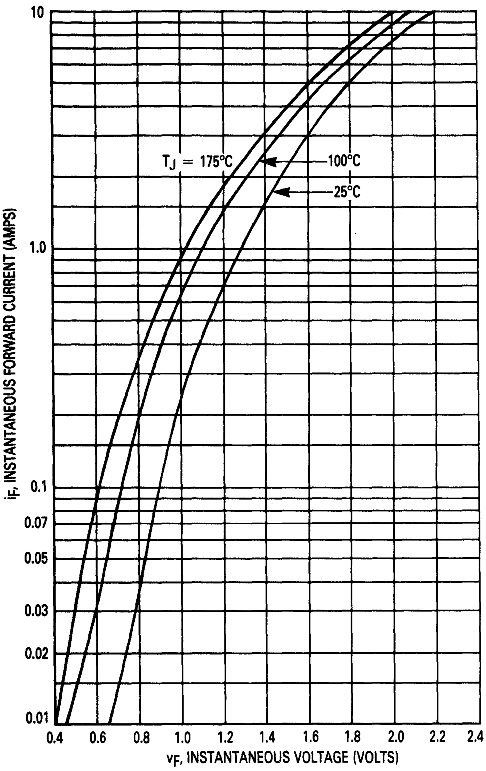


FIGURE 11 — TYPICAL FORWARD VOLTAGE

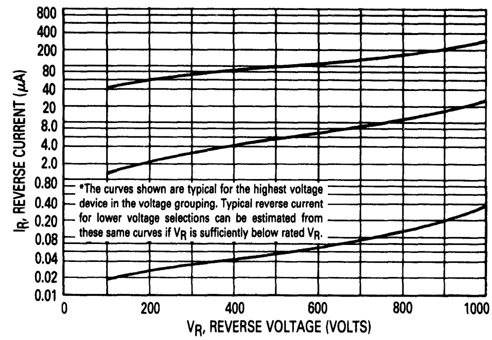


FIGURE 12 — TYPICAL REVERSE CURRENT*

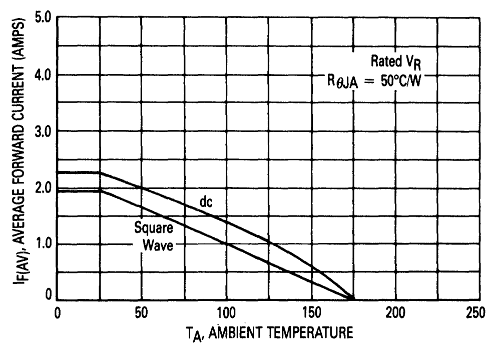


FIGURE 13 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 1)

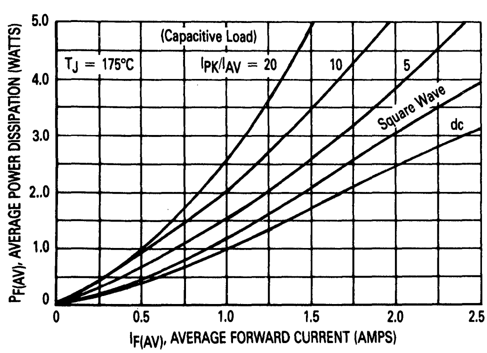


FIGURE 14 — POWER DISSIPATION

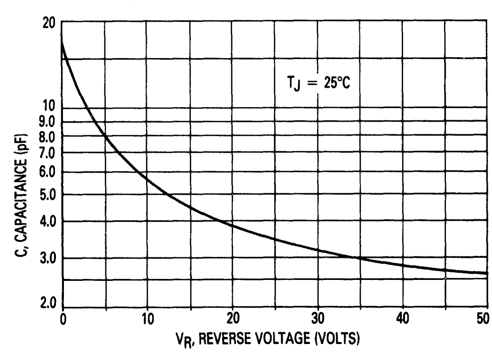


FIGURE 15 — TYPICAL CAPACITANCE

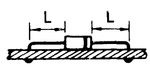
NOTE 1 — AMBIENT MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) 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.

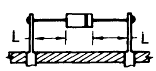
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD		LEAD LENGTH, L			
		1/8	1/4	1/2	UNITS
1	$R_{\theta JA}$	52	65	72	°C/W
2	$R_{\theta JA}$	67	80	87	°C/W
3	$R_{\theta JA}$		50		°C/W

MOUNTING METHOD 1

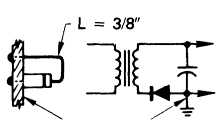


MOUNTING METHOD 2



Vector Pin Mounting

MOUNTING METHOD 3



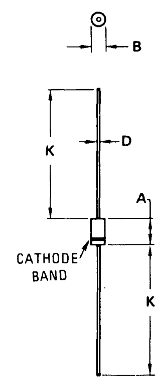
Board Ground Plane

P.C. Board with 1-1/2" x 1-1/2" Copper Surface

MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes: 240°C, 1/8" from case for 10 seconds at 5.0 lbs. tension.

OUTLINE DIMENSIONS



	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	5.97	6.60	0.235	0.260
B	2.79	3.05	0.110	0.120
D	0.76	0.86	0.030	0.034
K	27.94	–	1.100	–

CASE 59-04
PLASTIC PACKAGE

3

MUR405 MUR410 MUR415 MUR420 MUR430 MUR440 MUR450 MUR460 MUR470 MUR480 MUR490 MUR4100

MOTOROLA

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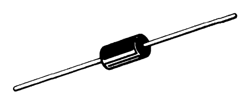
ULTRAFAST RECTIFIERS

4.0 AMPERES
50–1000 VOLTS



CASE 267-01
PLASTIC PACKAGE

SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 25, 50 and 75 Nanosecond Recovery Times
- 175°C Operating Junction Temperature
- Low Forward Voltage
- Low Leakage Current
- High Temperature Glass Passivated Junction
- Reverse Voltage to 1000 Volts

MAXIMUM RATINGS

Rating	Symbol	MUR 405	410	415	420	430	440	450	460	470	480	490	4100	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	700	800	900	1000	Volts
Average Rectified Forward Current (Square Wave) (Mounting Method #3 Per Note 1)	$I_{F(AV)}$	4.0 @ T_A = 80°C			4.0 @ T_A = 40°C					4.0 @ T_A = 35°C				Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	125			70									Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175												°C
THERMAL CHARACTERISTICS														
Maximum Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	See Note 1												°C/W
ELECTRICAL CHARACTERISTICS														
Maximum Instantaneous Forward Voltage (1) (i_F=3.0 Amp, T_J=150°C) (i_F=3.0 Amp, T_J=25°C) (i_F=4.0 Amp, T_J=25°C)	v_F	 0.710 0.875 0.890			 1.05 1.25 1.28					 1.53 1.75 1.85				Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_J=150°C) (Rated dc Voltage, T_J=25°C)	i_R	 150 5.0			 250 10					 900 25				μA
Maximum Reverse Recovery Time (I_F=1.0 Amp, di/dt=50 Amp/μs) (I_F=0.5 Amp, i_R=1.0 Amp, I_{REC}=0.25 Amp)	t_{rr}	 35 25			 75 50					 100 75				ns
Maximum Forward Recovery Time (I_F=1.0 A, di/dt = 100 A/μs, Recovery to 1.0 V)	t_{fr}	25			50					75				ns

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%
Switchmode is a trademark of Motorola Inc.

MUR405, 410 AND 415

FIGURE 1 — TYPICAL FORWARD VOLTAGE

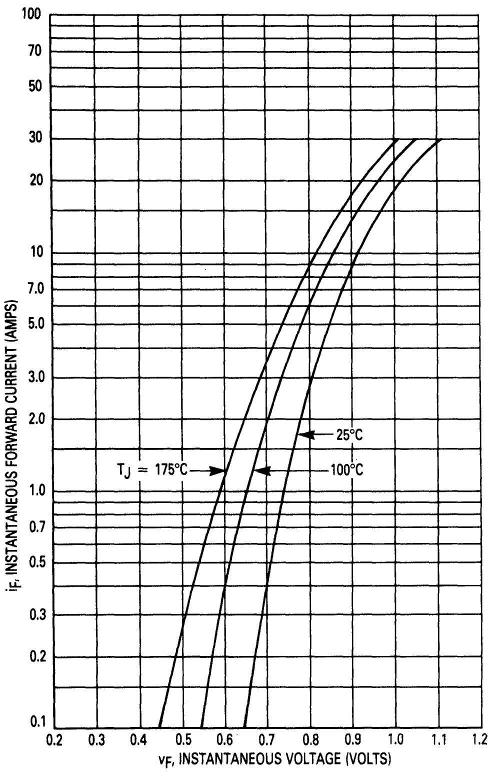


FIGURE 2 — TYPICAL REVERSE CURRENT*

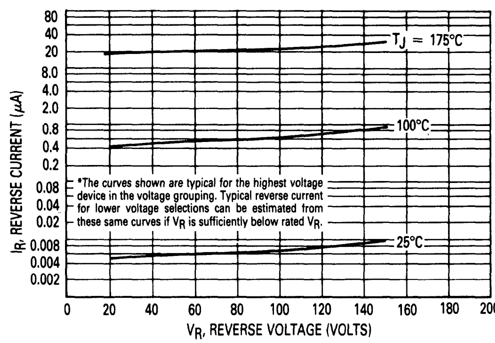


FIGURE 3 — CURRENT DERATING
(MOUNTING METHOD #3 PER NOTE 1)

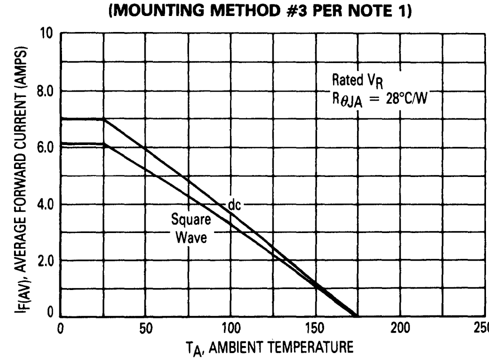


FIGURE 4 — POWER DISSIPATION

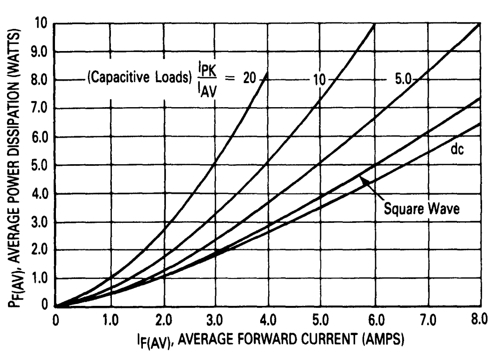
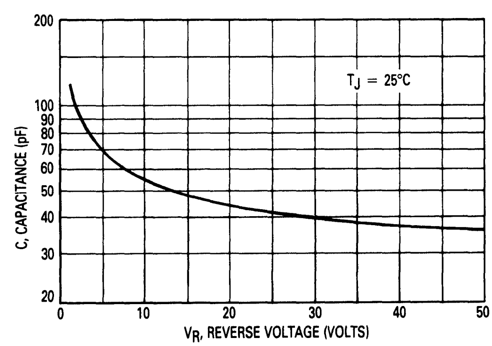


FIGURE 5 — TYPICAL CAPACITANCE



MUR420, 430, 440, 450 AND 460

3

FIGURE 6 — TYPICAL FORWARD VOLTAGE

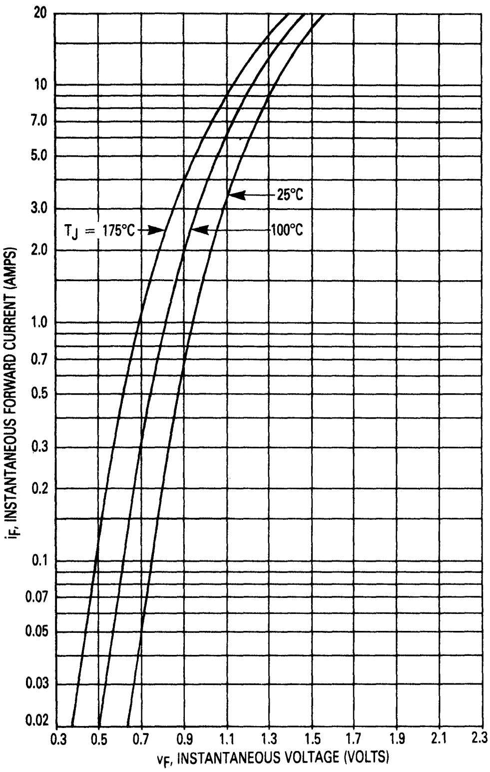


FIGURE 7 — TYPICAL REVERSE CURRENT*

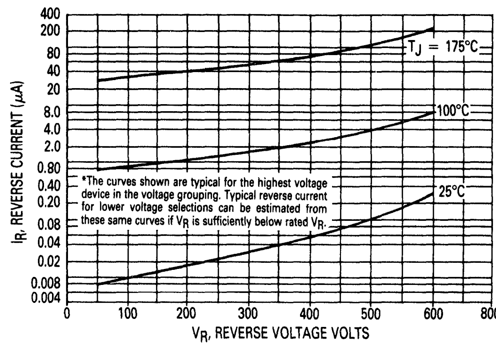


FIGURE 8 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 1)

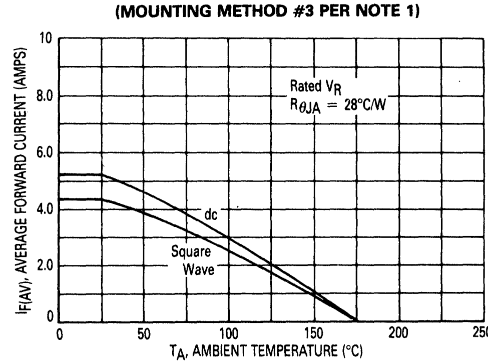


FIGURE 9 — POWER DISSIPATION

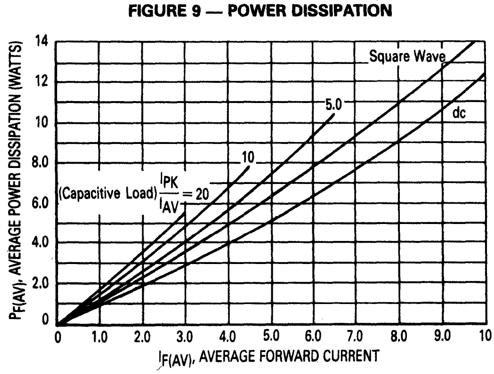
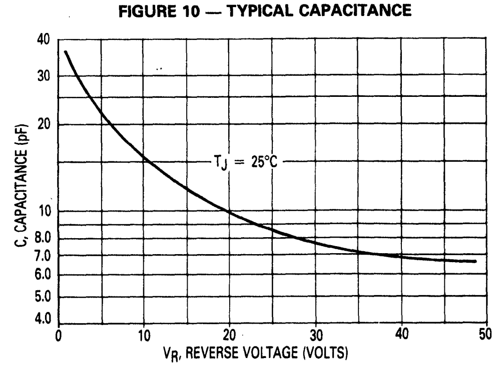


FIGURE 10 — TYPICAL CAPACITANCE



MUR470, 480, 490, 4100

FIGURE 11 — TYPICAL FORWARD VOLTAGE

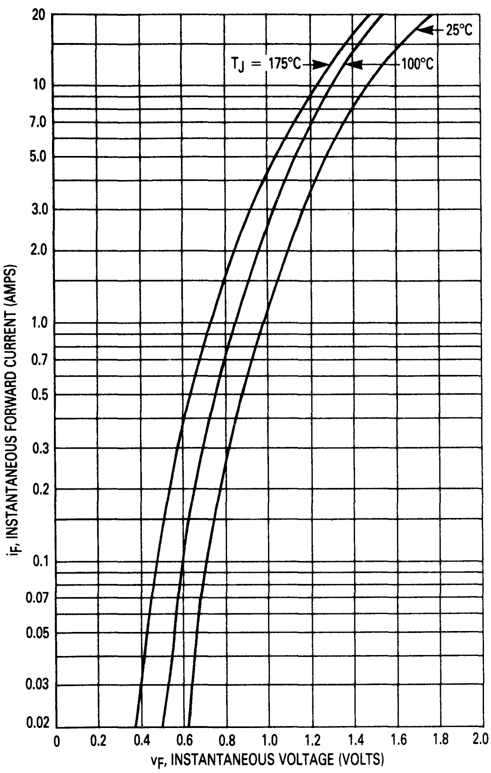
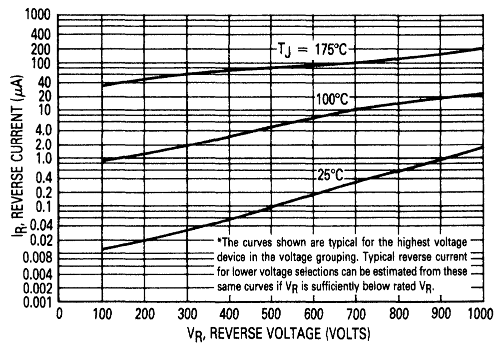


FIGURE 12 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 13 — CURRENT DERATING (MOUNTING METHOD #3 PER NOTE 1)

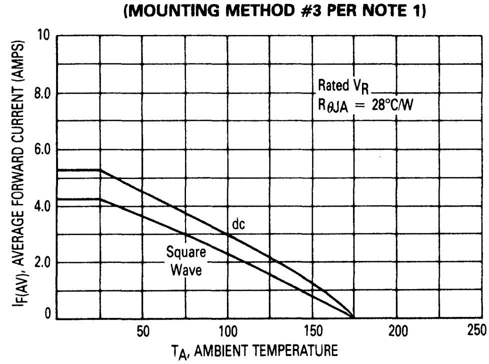


FIGURE 14 — POWER DISSIPATION

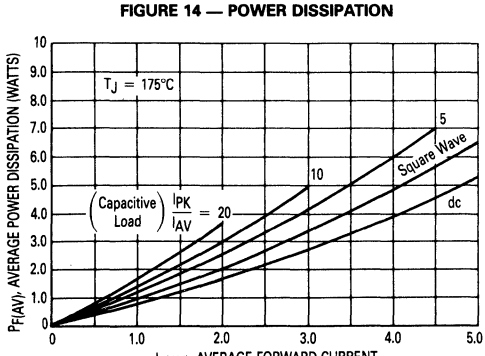
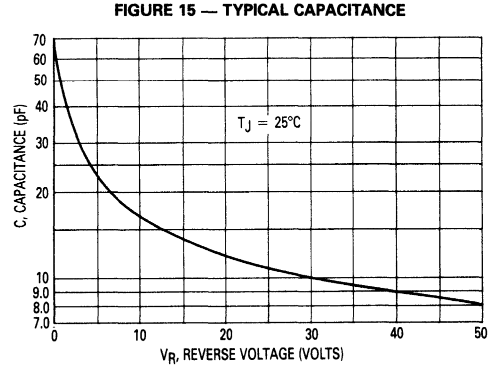


FIGURE 15 — TYPICAL CAPACITANCE



3

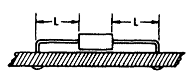
NOTE 1 — AMBIENT MOUNTING DATA

Data shown for thermal resistance junction-to-ambient ($R_{\theta JA}$) 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.

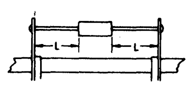
TYPICAL VALUES FOR $R_{\theta JA}$ IN STILL AIR

MOUNTING METHOD		LEAD LENGTH, L (IN)				UNITS
		1/8	1/4	1/2	3/4	
1	$R_{\theta JA}$	50	51	53	55	°C/W
2		58	59	61	63	°C/W
3		28				°C/W

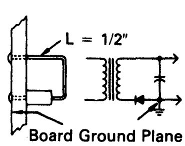
MOUNTING METHOD 1
P.C. Board Where Available Copper Surface area is small.



MOUNTING METHOD 2
Vector Push-In Terminals T-28



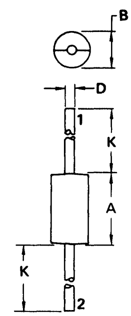
MOUNTING METHOD 3
P.C. Board with
1-1/2″ x 1-1/2″ Copper Surface



MECHANICAL CHARACTERISTICS

Case: Transfer Molded Plastic
Finish: External Leads are Plated, Leads are readily Solderable
Polarity: Indicated by Cathode Band
Weight: 1.1 Grams (Approximately)
Maximum Lead Temperature for Soldering Purposes:
300°C, 1/8″ from case for 10 s

OUTLINE DIMENSIONS



STYLE 1:
PIN 1. CATHODE
2. ANODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	9.65	0.370	0.380
B	4.83	5.33	0.190	0.210
D	1.22	1.32	0.048	0.052
K	26.97	27.23	1.062	1.072

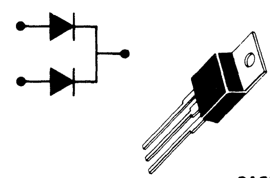
CASE 267-01
PLASTIC PACKAGE

MOTOROLA

MUR605CT
MUR610CT
MUR615CT
MUR620CT

ULTRAFAST RECTIFIERS

6 AMPERES
50–200 VOLTS



CASE 221A-02
TO-220AB

3

SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 35 Nanosecond Recovery Time
- 175°C Operating Junction Temperature
- Popular TO-220 Package

MAXIMUM RATINGS

Rating	Symbol	MUR605CT	MUR610CT	MUR615CT	MUR620CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	Volts
Average Rectified Forward Current (Rated V_R) T_C = 130°C — Per Diode Total Device	$I_{F(AV)}$	← 3.0 → ← 6.0 →				Amps
Peak Repetitive Forward Current Per Diode Leg (Rated V_R, Square Wave, 20 kHz) T_C = 130°C	I_{FRM}	← 6.0 →				Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	← 75 →				Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	← −65 to +175 →				°C

THERMAL CHARACTERISTICS PER DIODE LEG

Rating	Symbol	Typical	Maximum	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	5.0–6.0	7.0	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE LEG

Instantaneous Forward Voltage (1) (i_F = 3.0 Amp, T_C = 150°C) (i_F = 3.0 Amp, T_C = 25°C)	v_F	 0.80 0.94	 0.895 0.975	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 150°C) (Rated dc Voltage, T_C = 25°C)	i_R	 2.0–10 0.01–3.0	 250 5.0	μA
Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs)	t_{rr}	20–30	35	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
Switchmode is a trademark of Motorola Inc.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

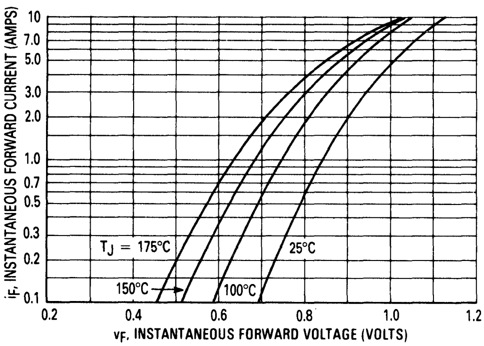


FIGURE 2 — TYPICAL REVERSE CURRENT

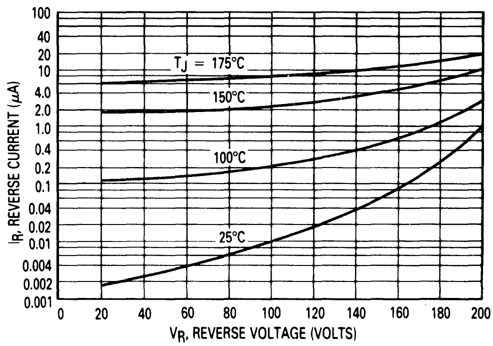


FIGURE 3 — TOTAL DEVICE CURRENT DERATING, CASE

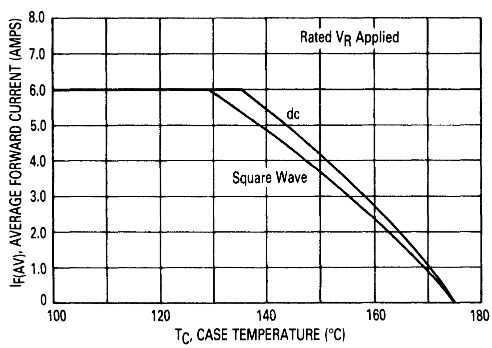


FIGURE 4 — TOTAL DEVICE CURRENT DERATING, AMBIENT

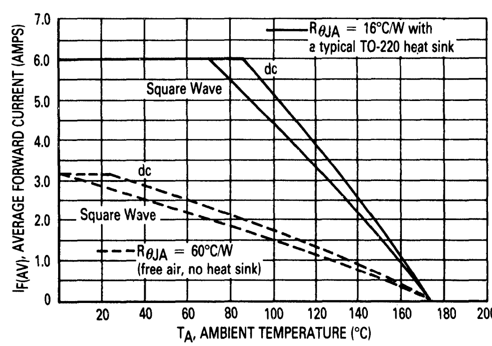
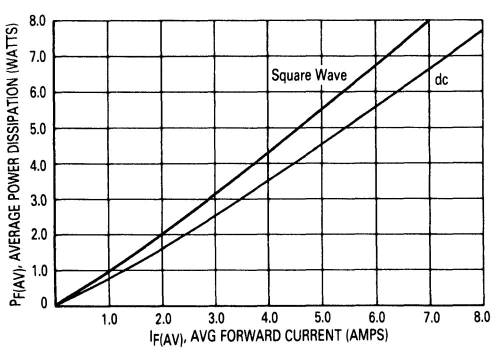
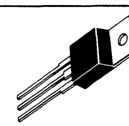


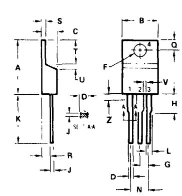
FIGURE 5 — POWER DISSIPATION



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050
V	1.14	·	0.045	·
Z	—	2.03	—	0.080



PIN 1. ANODE
2. CATHODE
3. ANODE
4. CATHODE



CASE 221A-02
(TO-220AB)

NOTES:
1. DIMENSION H APPLIES TO ALL LEADS.
2. DIMENSION L APPLIES TO LEADS 1 AND 3 ONLY.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5 1973.
5. CONTROLLING DIMENSION: INCH.

MOTOROLA

MUR805 MUR810 MUR815 MUR820 MUR830 MUR840 MUR850 MUR860 MUR870 MUR880 MUR890 MUR8100

SWITCHMODE POWER RECTIFIERS

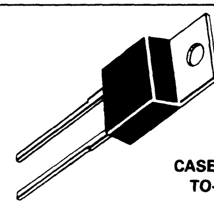
. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 25, 50 and 75 Nanosecond Recovery Time
- 175°C Operating Junction Temperature
- Popular TO-220 Package
- Epoxy meets UL94, V_O @ ⅛″
- Low Forward Voltage
- Low Leakage Current
- High Temperature Glass Passivated Junction
- Reverse Voltage to 1000 Volts

ULTRAFAST RECTIFIERS

8 AMPERES
50–1000 VOLTS

3



CASE 221B-02
TO-220AC

MAXIMUM RATINGS

Rating	Symbol	MUR 805	810	815	820	830	840	850	860	870	880	890	8100	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	700	800	900	1000	Volts
Average Rectified Forward Current Total Device, (Rated V_R), T_C = 150°C	$I_{F(AV)}$	8.0												Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz), T_C = 150°C	I_{FM}	16												Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	100												Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175												°C

THERMAL CHARACTERISTICS

Rating	Symbol	805	810	815	820	830	840	850	860	870	880	890	8100	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0			2.0									°C/W

ELECTRICAL CHARACTERISTICS

Rating	Symbol	805	810	815	820	830	840	850	860	870	880	890	8100	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 8.0 Amp, T_C = 150°C) (i_F = 8.0 Amp, T_C = 25°C)	v_F	0.895 0.975			1.00 1.30			1.20 1.50		1.5 1.8				Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 150°C) (Rated dc Voltage, T_C = 25°C)	i_R	250 5.0			500 10			500 10		500 25				μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs) (I_F = 0.5 Amp, i_R = 1.0 Amp, I_{REC} = 0.25 Amp)	t_{rr}	35 25			60 50					100 75				ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%
Switchmode is a trademark of Motorola Inc.

MUR805, 810 AND 815

FIGURE 1 — TYPICAL FORWARD VOLTAGE

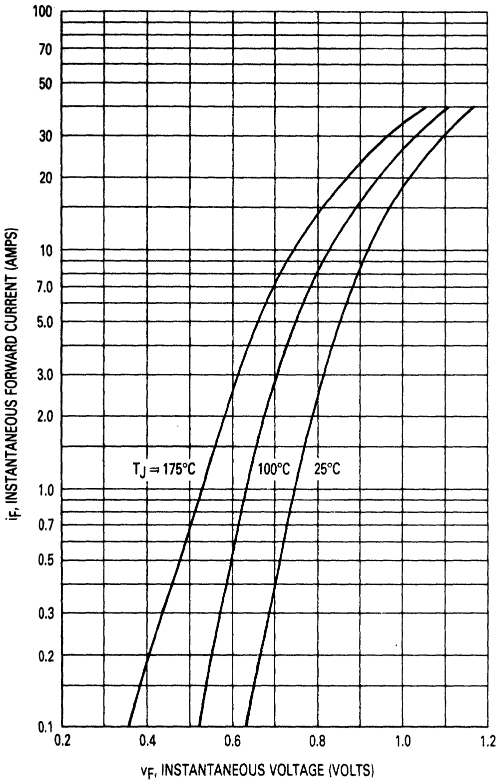


FIGURE 2 — TYPICAL REVERSE CURRENT*

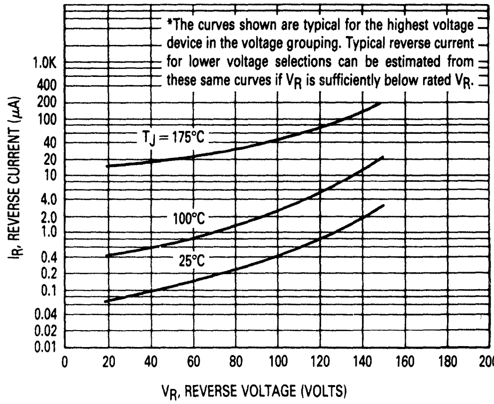


FIGURE 3 — CURRENT DERATING, CASE

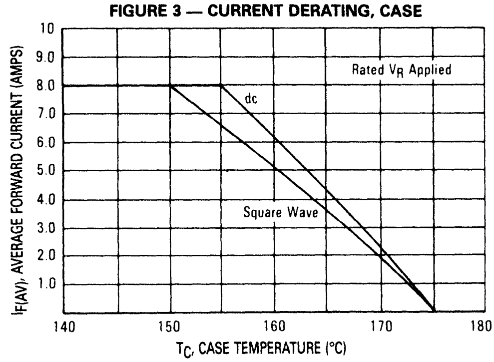


FIGURE 4 — CURRENT DERATING, AMBIENT

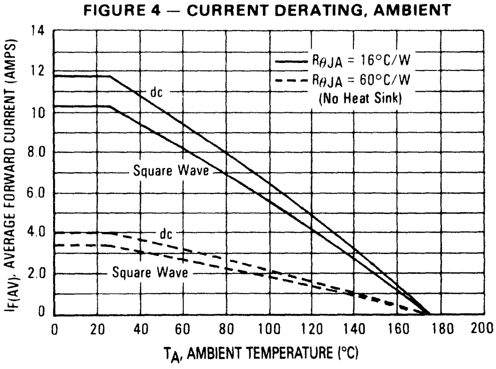
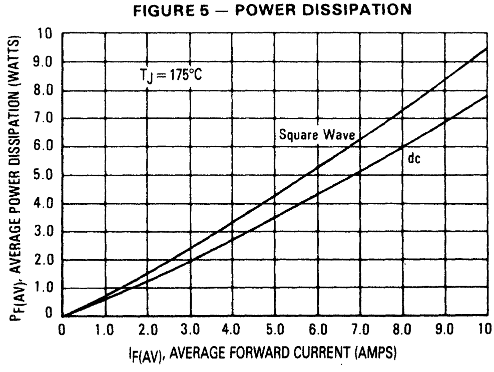


FIGURE 5 — POWER DISSIPATION



3

MUR820, 830 AND 840

FIGURE 6 — TYPICAL FORWARD VOLTAGE

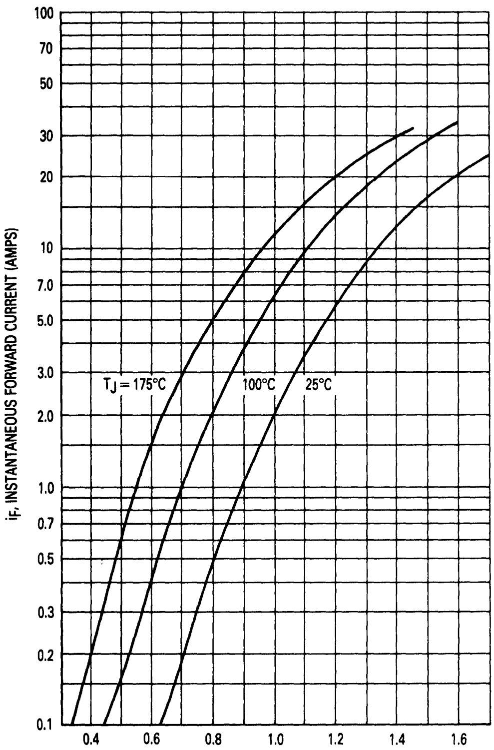


FIGURE 7 — TYPICAL REVERSE CURRENT*

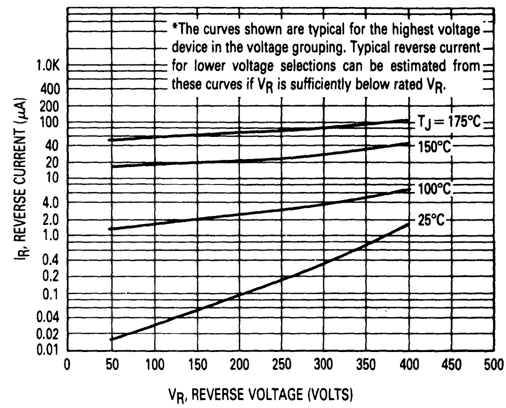


FIGURE 8 — CURRENT DERATING, CASE

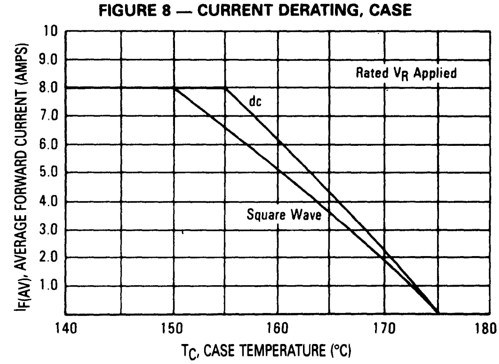


FIGURE 9 — CURRENT DERATING, AMBIENT

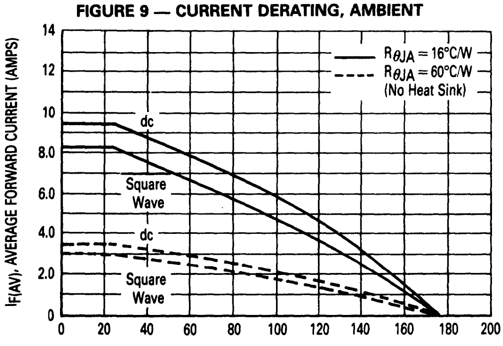
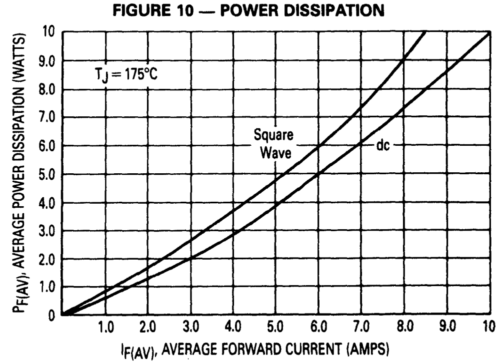


FIGURE 10 — POWER DISSIPATION



3

MUR850 AND 860

FIGURE 11 — TYPICAL FORWARD VOLTAGE

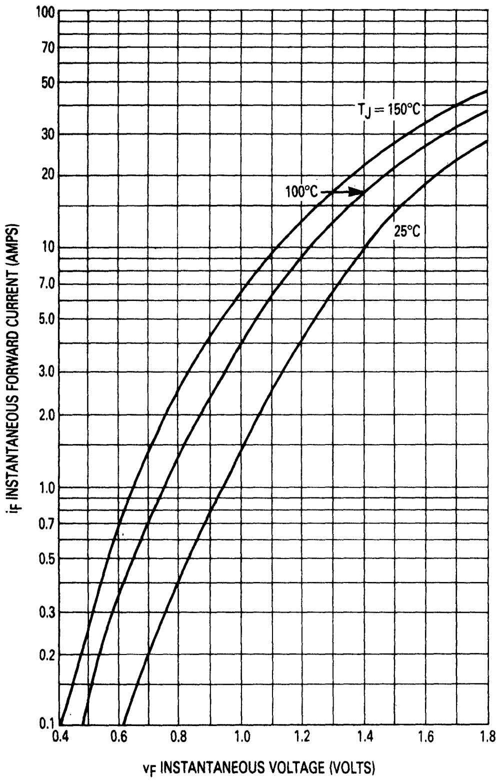


FIGURE 12 — TYPICAL REVERSE CURRENT*

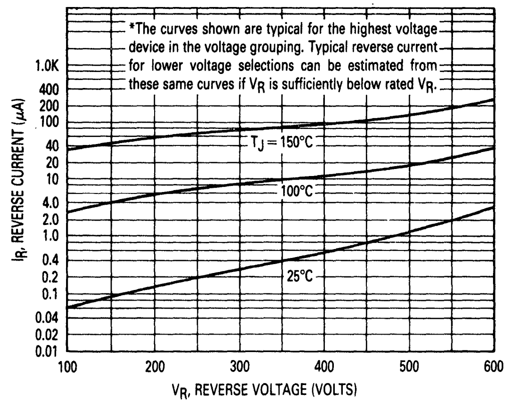


FIGURE 13 — CURRENT DERATING, CASE

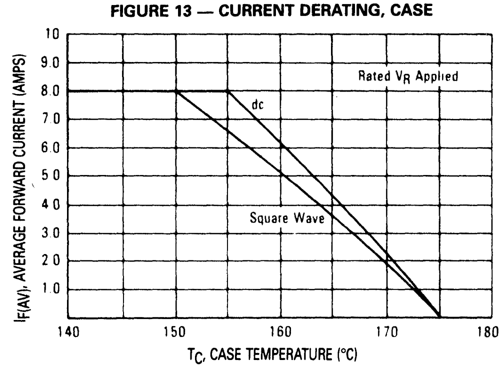


FIGURE 14 — CURRENT DERATING, AMBIENT

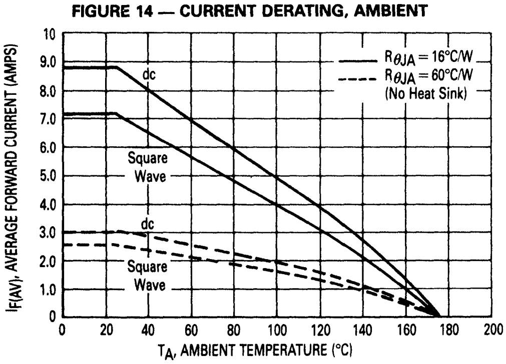
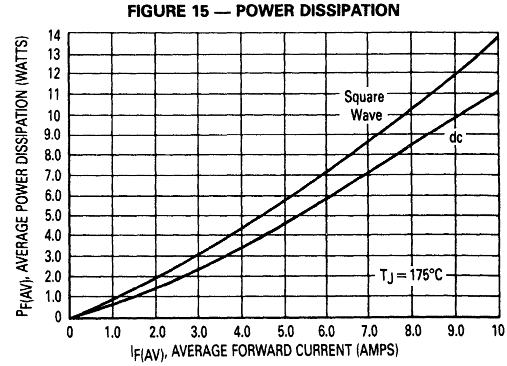


FIGURE 15 — POWER DISSIPATION



MUR870, 880, 890 AND 8100

FIGURE 16 — TYPICAL FORWARD VOLTAGE

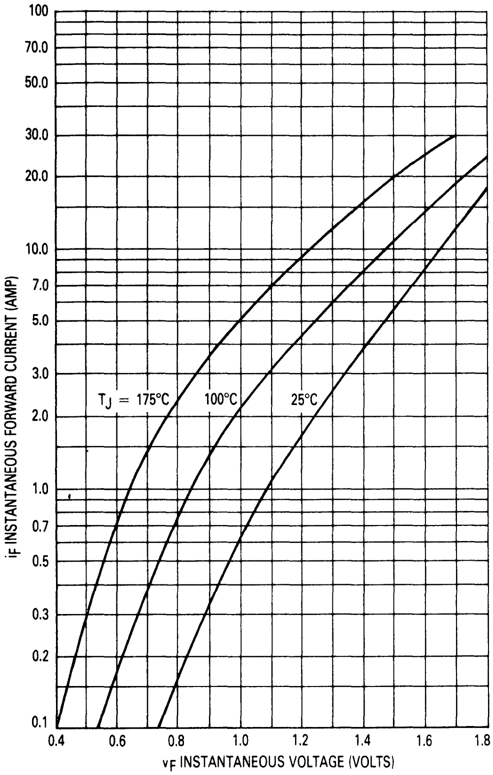


FIGURE 17 — TYPICAL REVERSE CURRENT*

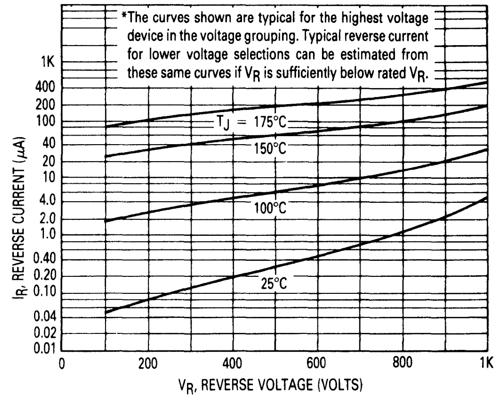


FIGURE 18 — CURRENT DERATING, CASE

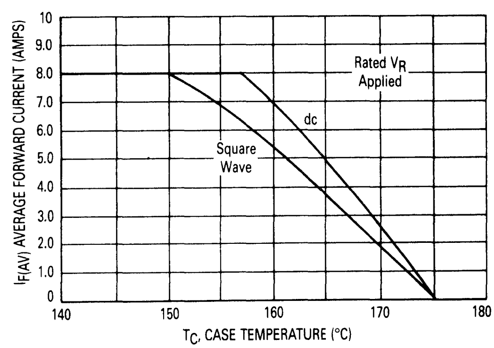


FIGURE 19 — CURRENT DERATING, AMBIENT

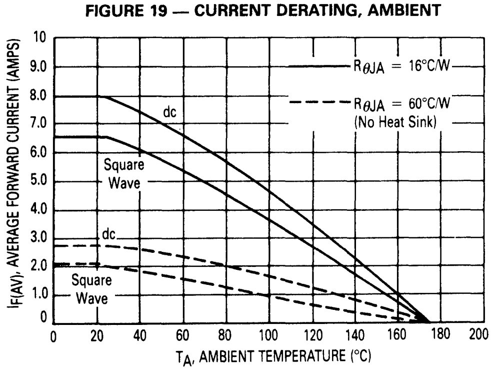


FIGURE 20 — POWER DISSIPATION

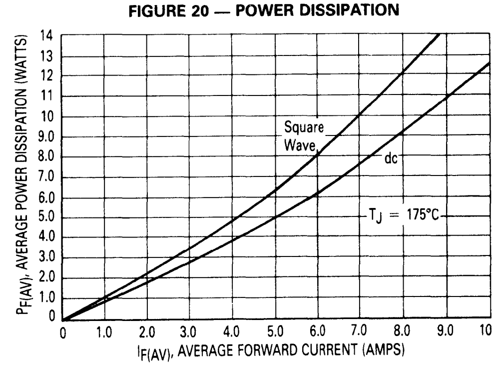


FIGURE 21 — THERMAL RESPONSE

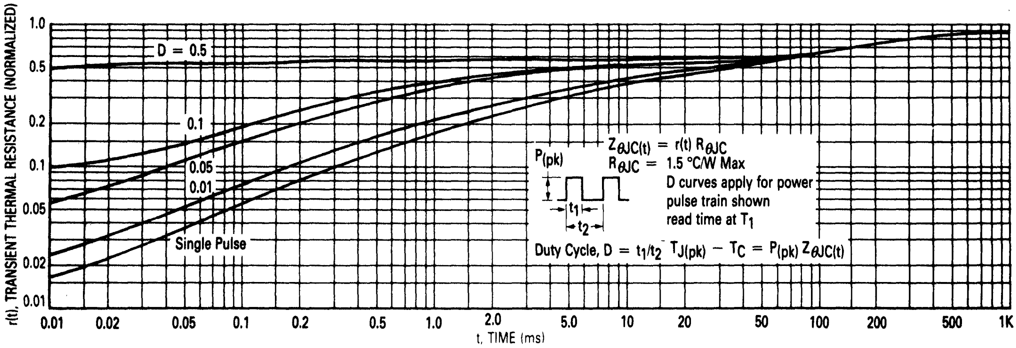


FIGURE 22 — TYPICAL CAPACITANCE

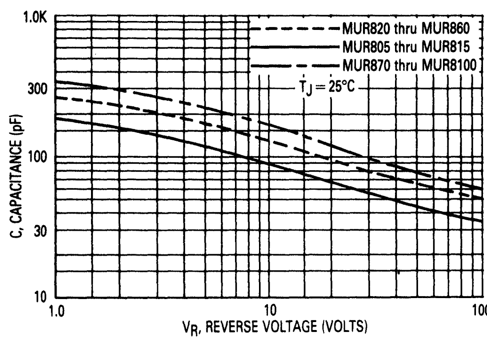
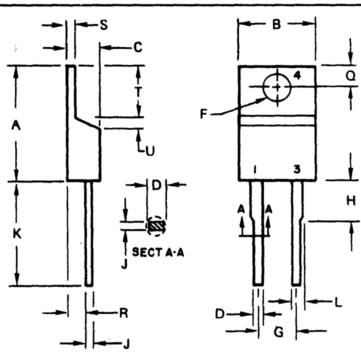


FIGURE 23 — OUTLINE DIMENSIONS



STYLE 1:
PIN 1. CATHODE
2. N/A
3. ANODE
4. CATHODE

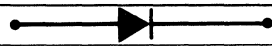
CASE 221B-01

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

3

MOTOROLA

MUR1505 MUR1510 MUR1515 MUR1520 MUR1530 MUR1540 MUR1550 MUR1560



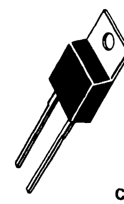
SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 35 and 60 Nanosecond Recovery Time
- 175°C Operating Junction Temperature
- Popular TO-220 Package
- High Voltage Capability to 600 Volts
- Low Forward Drop
- Low Leakage Specified @ 150°C Case Temperature
- Current Derating Specified @ Both Case and Ambient Temperatures

ULTRAFAST RECTIFIERS

15 AMPERES
50–600 VOLTS



CASE 221B-01
TO-220AC

3

MAXIMUM RATINGS

Rating	Symbol	MUR 1505	1510	1515	1520	1530	1540	1550	1560	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	Volts
Average Rectified Forward Current (Rated V_R)	$I_{F(AV)}$	15 @ T_C = 150°C						15 @ T_C = 145°C		Amps
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20 kHz)	I_{FRM}	30 @ T_C = 150°C						30 @ T_C = 145°C		Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	200			150					Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175								°C
THERMAL CHARACTERISTICS										
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5								°C/W
ELECTRICAL CHARACTERISTICS										
Maximum Instantaneous Forward Voltage (1) (i_F = 15 Amp, T_C = 150°C) (i_F = 15 Amp, T_C = 25°C)	v_F	 0.85 1.05			 1.12 1.25			 1.20 1.50		Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 150°C) (Rated dc Voltage, T_C = 25°C)	i_R	 500 10						 1000 10		μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs)	t_{rr}	35			60					ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

Switchmode is a trademark of Motorola Inc.

3

MUR1505, 1510, and 1515

FIGURE 1 — TYPICAL FORWARD VOLTAGE

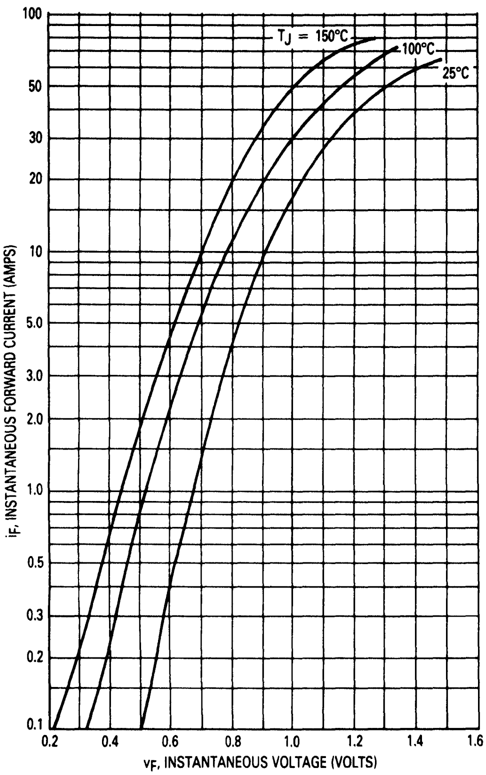
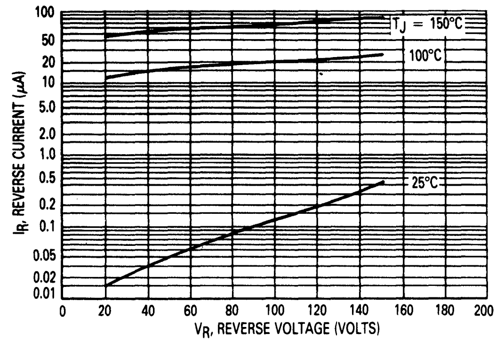


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING, CASE

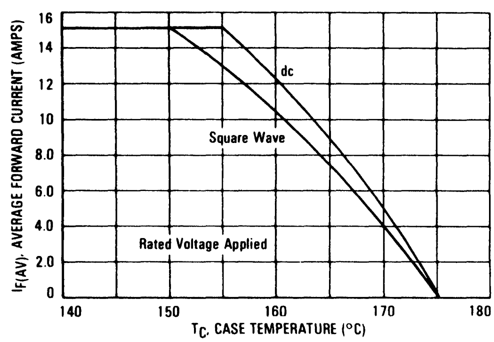


FIGURE 4 — CURRENT DERATING, AMBIENT

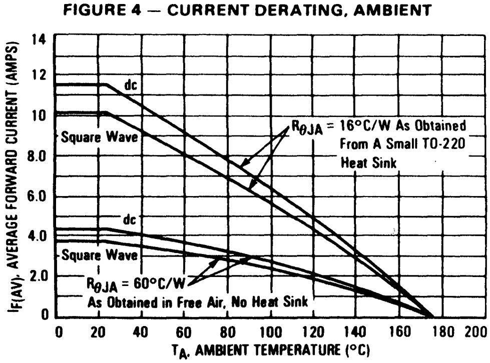
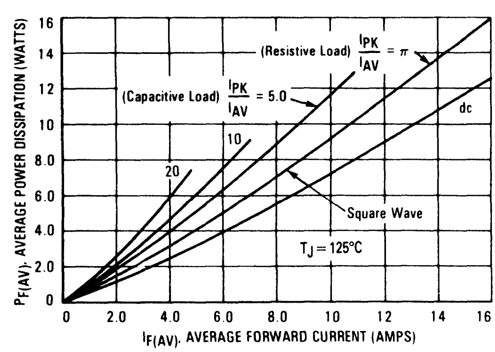


FIGURE 5 — POWER DISSIPATION



MUR1520, 1530, 1540

FIGURE 6 — TYPICAL FORWARD VOLTAGE

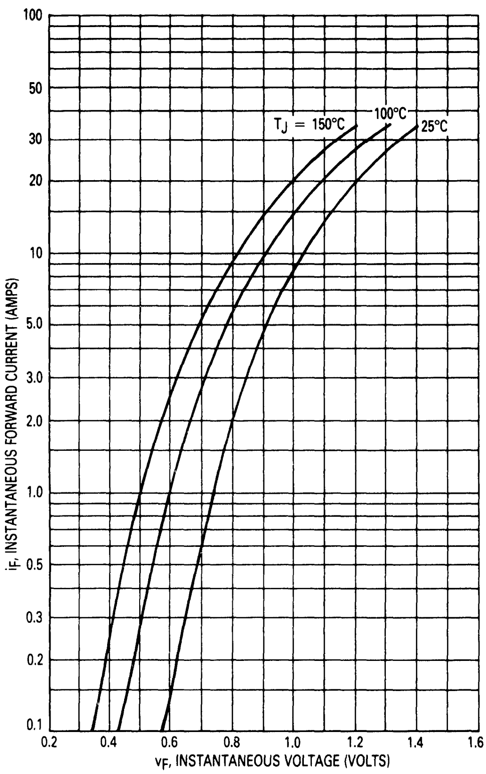
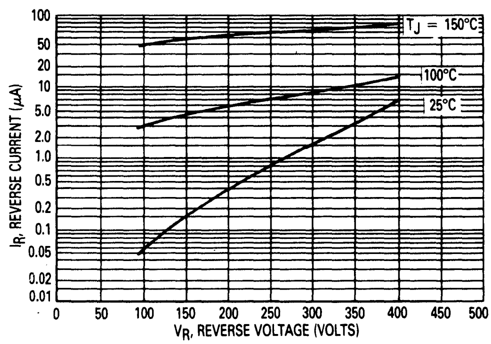


FIGURE 7 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

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FIGURE 8 — CURRENT DERATING, CASE

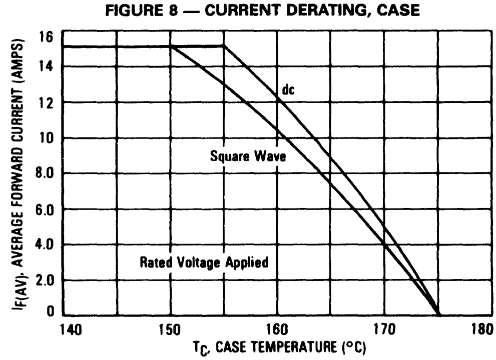


FIGURE 9 — CURRENT DERATING, AMBIENT

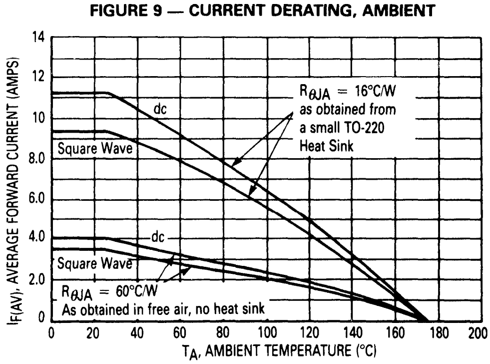
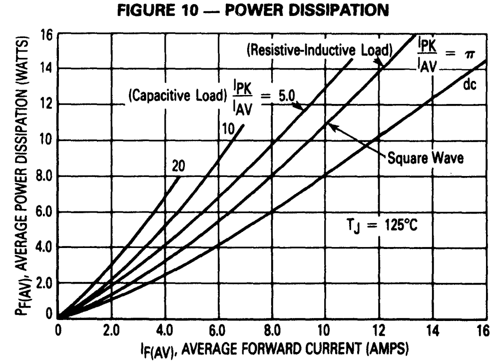


FIGURE 10 — POWER DISSIPATION



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MUR1550, 1560

FIGURE 11 — TYPICAL FORWARD VOLTAGE

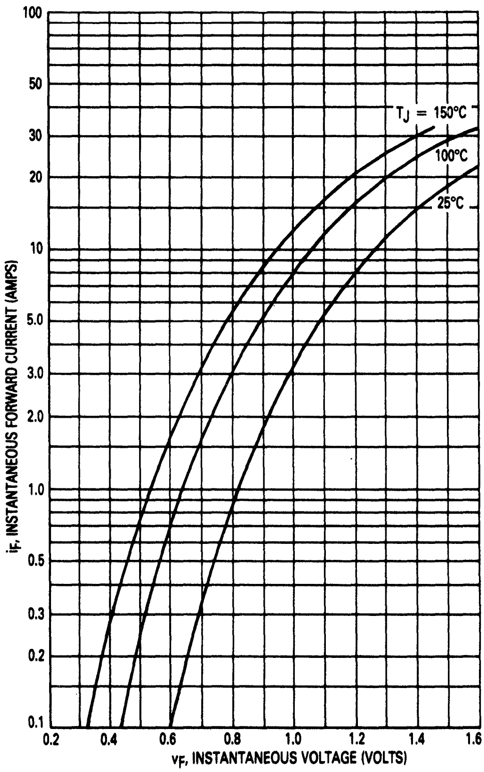
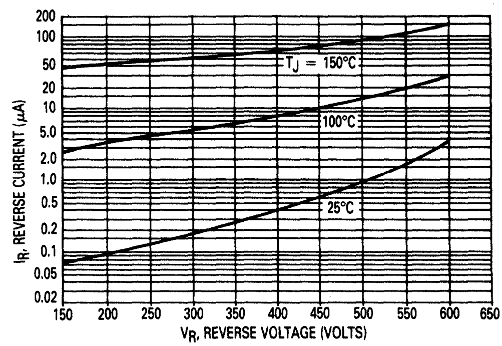


FIGURE 12 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 13 — CURRENT DERATING, CASE

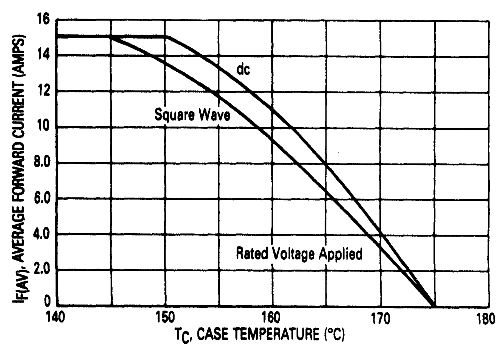


FIGURE 14 — CURRENT DERATING, AMBIENT

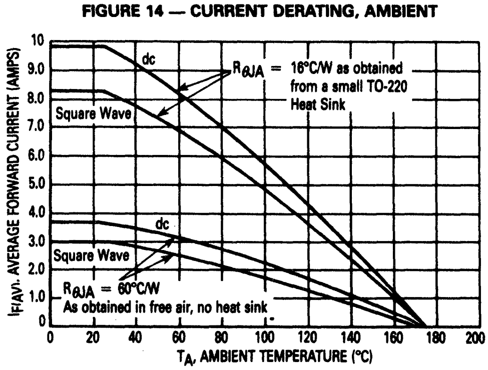


FIGURE 15 — POWER DISSIPATION

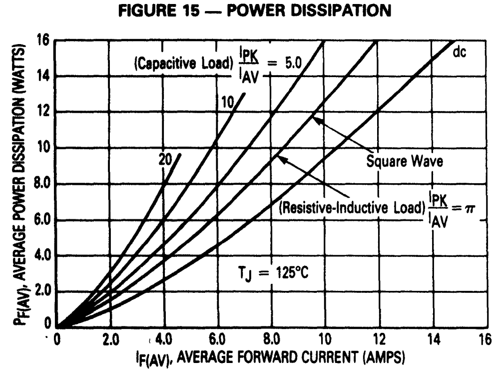


FIGURE 16 — THERMAL RESPONSE

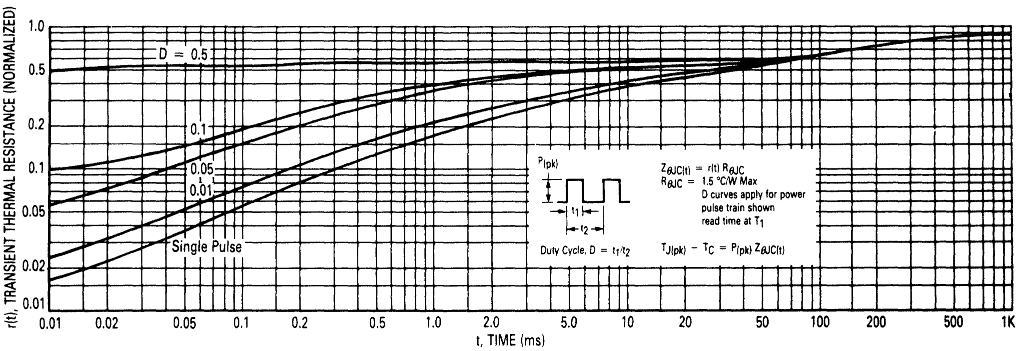


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FIGURE 17 — TYPICAL CAPACITANCE

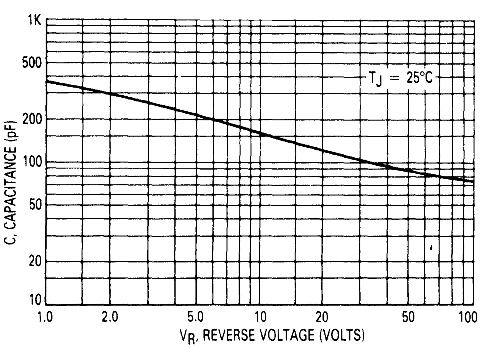
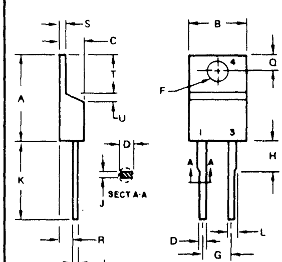


FIGURE 18 — OUTLINE DIMENSIONS



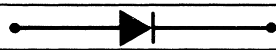
STYLE 1:
PIN 1. CATHODE
2. N/A
3. ANODE
4. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.11	15.75	0.595	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	4.83	5.33	0.190	0.210
H	2.79	3.30	0.110	0.130
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.27	0.045	0.050
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.76	1.27	0.030	0.050

CASE 221B-01

MUR1605CT MUR1630CT
MUR1610CT MUR1640CT
MUR1615CT MUR1650CT
MUR1620CT MUR1660CT

MOTOROLA



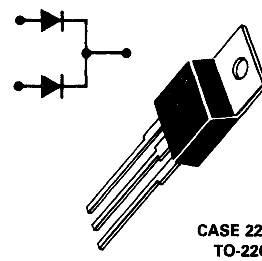
SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 35 and 60 Nanosecond Recovery Times
- 175°C Operating Junction Temperature
- Popular TO-220 Package
- Epoxy meets UL94, V_O @ ⅛″
- High Temperature Glass Passivated Junction
- High Voltage Capability to 600 Volts
- Low Leakage Specified @ 150°C Case Temperature
- Current Derating @ Both Case and Ambient Temperatures

ULTRAFAST RECTIFIERS

8 AMPERES
50–600 VOLTS



CASE 221A-02
TO-220AB

3

MAXIMUM RATINGS

Rating	Symbol	MUR 1605CT	1610CT	1615CT	1620CT	1630CT	1640CT	1650CT	1660CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	500	600	Volts
Average Rectified Forward Current Per Leg Total Device, (Rated V_R), T_C = 150°C Total Device	$I_{F(AV)}$	8.0 16								Amps
Peak Repetitive Forward Current Per Diode Leg (Rated V_R, Square Wave, 20 kHz), T_C = 150°C	I_{FM}	16								Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	100								Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175								°C

THERMAL CHARACTERISTICS, PER DIODE LEG

Characteristic	Symbol	1605CT–1615CT	1620CT–1660CT	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	3.0	2.0	°C/W

ELECTRICAL CHARACTERISTICS, PER DIODE LEG

Characteristic	Symbol	1605CT–1615CT	1620CT–1640CT	1650CT–1660CT	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 8.0 Amp, T_C = 150°C) (i_F = 8.0 Amp, T_C = 25°C)	v_F	 0.895 0.975	 1.00 1.30	 1.20 1.50	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 150°C) (Rated dc Voltage, T_C = 25°C)	i_R	 250 5.0	 500 10	 500 10	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs) (I_F = 0.5 Amp, i_R = 1.0 Amp, I_{REC} = 0.25 Amp)	t_{rr}	 35 25	 60 50		ns

(1)Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤2.0%
Switchmode is a trademark of Motorola Inc.

MUR1605CT, 1610CT AND 1615CT

FIGURE 1 — TYPICAL FORWARD VOLTAGE, PER LEG

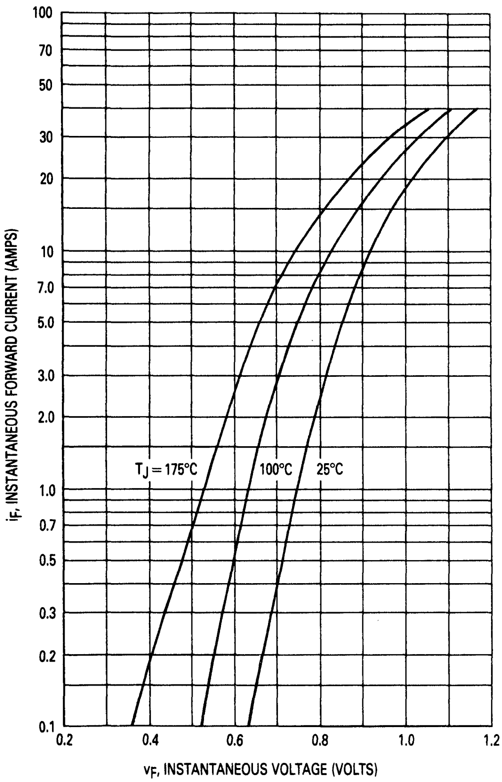


FIGURE 2 — TYPICAL REVERSE CURRENT, PER LEG*

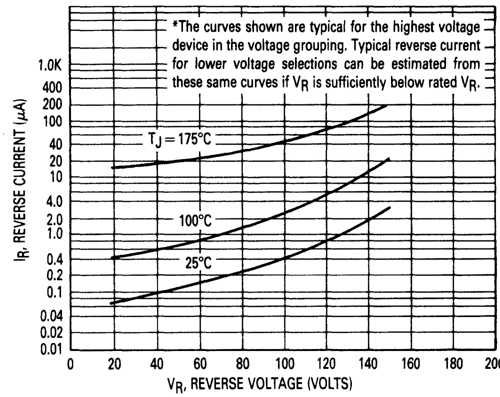


FIGURE 3 — CURRENT DERATING CASE, PER LEG

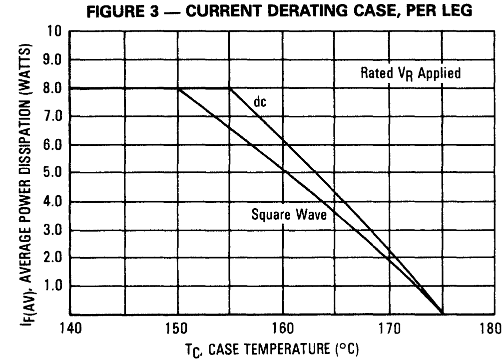


FIGURE 4 — CURRENT DERATING, AMBIENT, PER LEG

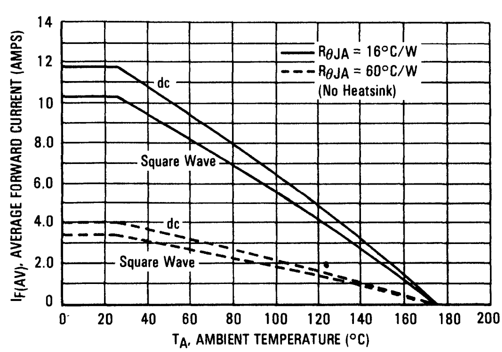
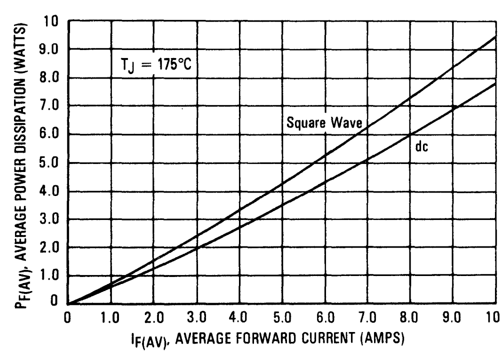


FIGURE 5 — POWER DISSIPATION, PER LEG



3

MUR1620CT, 1630CT AND 1640CT

FIGURE 6 — TYPICAL FORWARD VOLTAGE, PER LEG

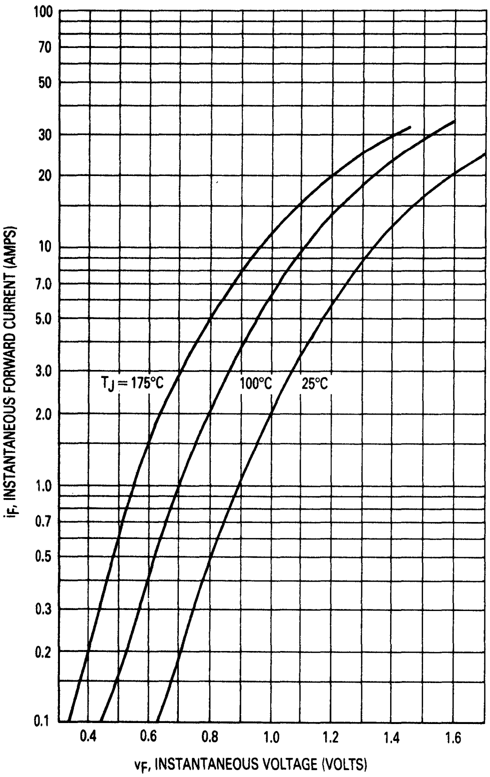


FIGURE 7 — TYPICAL REVERSE CURRENT, PER LEG*

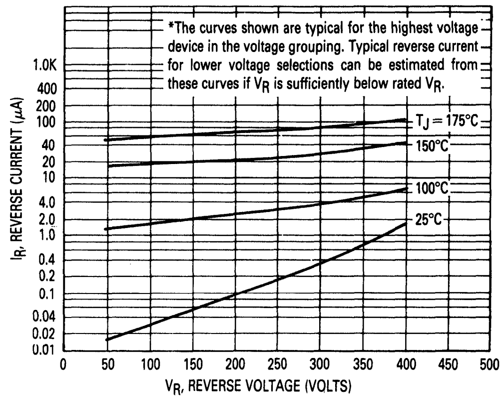


FIGURE 8 — CURRENT DERATING, CASE, PER LEG

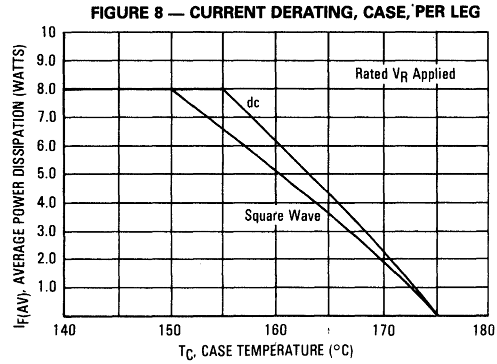


FIGURE 9 — CURRENT DERATING, AMBIENT, PER LEG

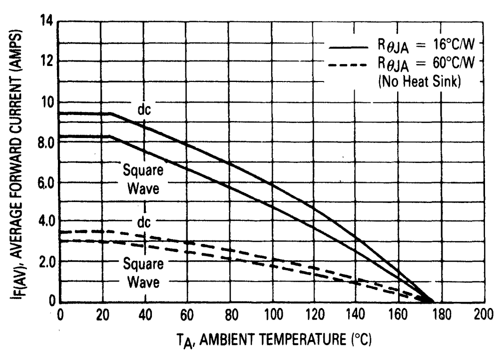
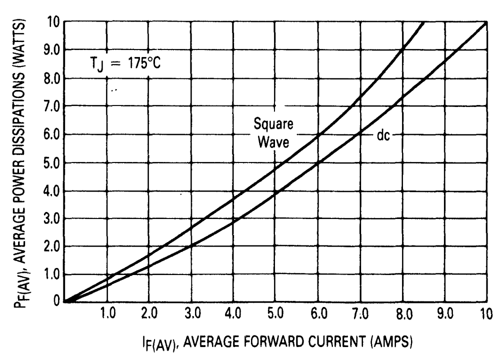


FIGURE 10 — POWER DISSIPATION, PER LEG



MUR1650CT AND 1660CT

FIGURE 11 — TYPICAL FORWARD VOLTAGE, PER LEG

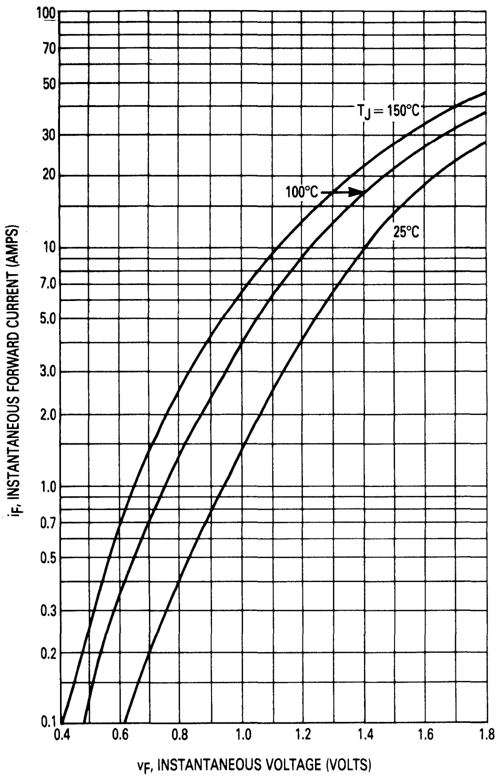


FIGURE 12 — TYPICAL REVERSE CURRENT, PER LEG*

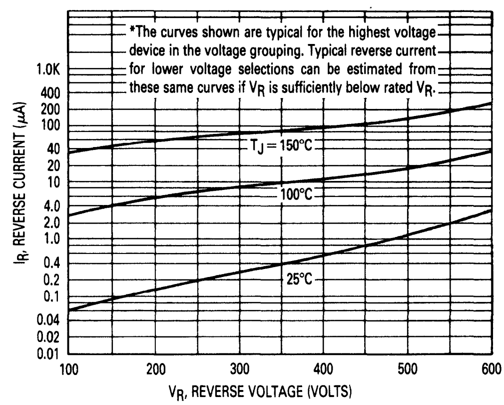


FIGURE 13 — CURRENT DERATING, CASE, PER LEG

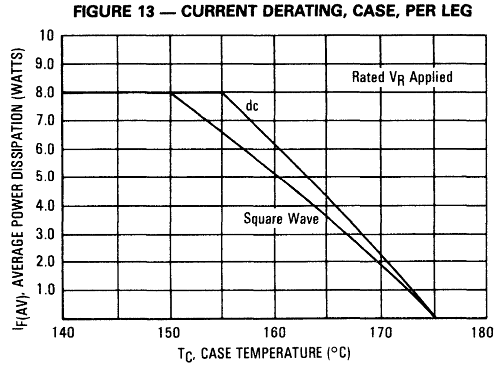


FIGURE 14 — CURRENT DERATING, AMBIENT, PER LEG

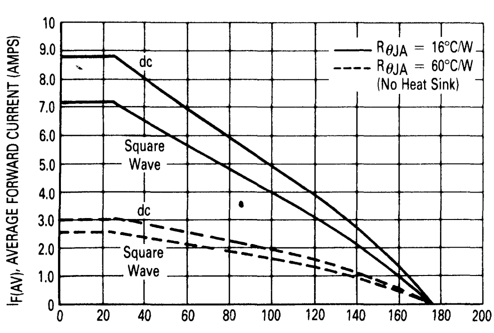
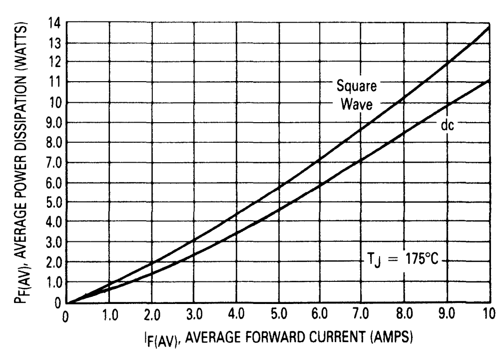


FIGURE 15 — POWER DISSIPATION, PER LEG



3

FIGURE 16 — THERMAL RESPONSE

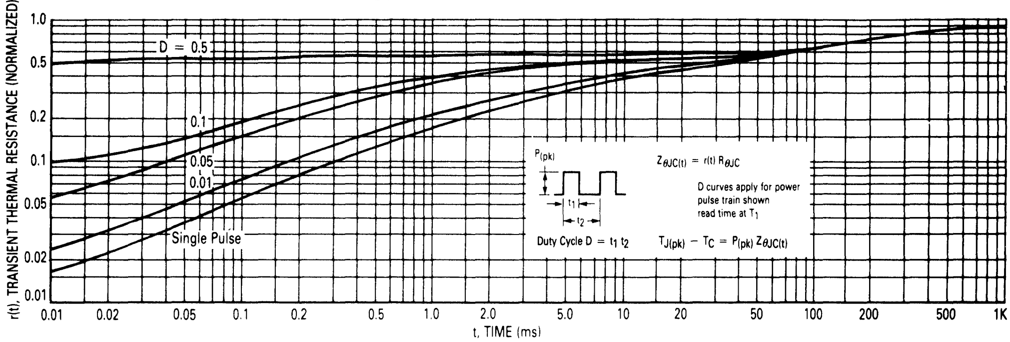
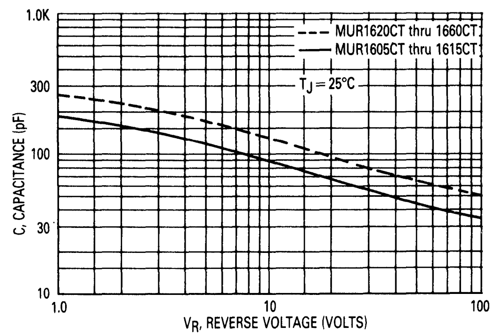
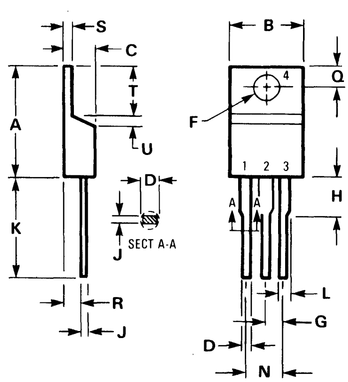


FIGURE 17 — TYPICAL CAPACITANCE, PER LEG



OUTLINE DIMENSIONS



CASE 221A-02

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

NOTES:
1. DIMENSION H APPLIES TO ALL LEADS.
2. DIMENSION L APPLIES TO LEADS 1 AND 3.
3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
5. CONTROLLING DIMENSION: INCH.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	14.60	15.75	0.575	0.620
B	9.65	10.29	0.380	0.405
C	4.06	4.82	0.160	0.190
D	0.64	0.89	0.025	0.035
F	3.61	3.73	0.142	0.147
G	2.41	2.67	0.095	0.105
H	2.79	3.93	0.110	0.155
J	0.36	0.56	0.014	0.022
K	12.70	14.27	0.500	0.562
L	1.14	1.39	0.045	0.055
N	4.83	5.33	0.190	0.210
Q	2.54	3.04	0.100	0.120
R	2.04	2.79	0.080	0.110
S	1.14	1.39	0.045	0.055
T	5.97	6.48	0.235	0.255
U	0.00	1.27	0.000	0.050
V	1.14	–	0.045	–
Z	–	2.03	–	0.080

MOTOROLA

MUR2505
MUR2510
MUR2515
MUR2520

SWITCHMODE POWER RECTIFIERS

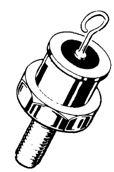
. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 50 Nanosecond Recovery Time
- Low Forward Voltage Drop
- Hermetically Sealed Metal DO-203AA (DO-4) Package

ULTRAFAST RECTIFIERS

25 AMPERES
50 to 200 VOLTS

3



MAXIMUM RATINGS

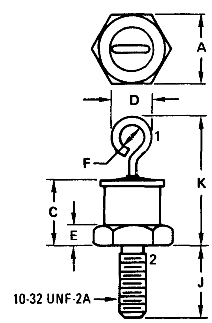
Rating	Symbol	MUR 2505	MUR 2510	MUR 2515	MUR 2520	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	Volts
Nonrepetitive Peak Reverse Voltage	V_{RSM}	55	110	165	220	Volts
Average Forward Current $T_C = 145°C$	$I_{F(AV)}$	25				Amps
Nonrepetitive Peak Surge Forward Current (half cycle, 60 Hz, Sinusoidal Waveform)	I_{FSM}	500				Amps
Operating Junction and Storage Temperature	T_J, T_{stg}	−65 to +175				°C

THERMAL CHARACTERISTICS

Rating	Symbol	All Devices	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.3	°C/W

ELECTRICAL CHARACTERISTICS

Maximum Instantaneous Forward Voltage Drop (i_F = 25 Amp, T_J = 25°C) (i_F = 25 Amp, T_J = 125°C) (i_F = 50 Amp, T_J = 125°C)	v_F	 0.95 0.80 0.88	Volts
Maximum Reverse Current @ DC Voltage (T_J = 25°C) (T_J = 125°C)	I_R	 10 1.0	 μA mA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs, V_R = 30 V, T_J = 25°C)	t_{rr}	50	ns



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800

CASE 245-01
DO-203AA
(DO-4)

MECHANICAL CHARACTERISTICS

Case: Welded, hermetically sealed

Finish: All external surface corrosion resistant and terminal leads are readily solderable

Polarity: Cathode to Case

Mounting Positions: Any

Stud Torque: 15 in/lb. Max

Switchmode is a trademark of Motorola Inc.

3

FIGURE 1 — TYPICAL FORWARD VOLTAGE

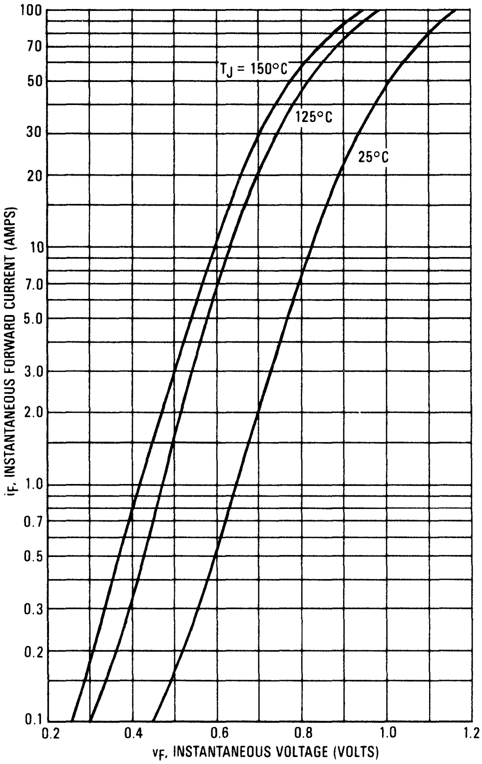
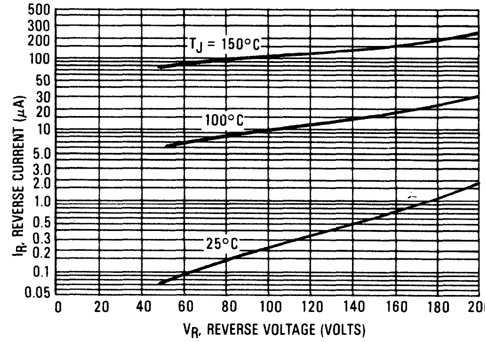


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING, CASE

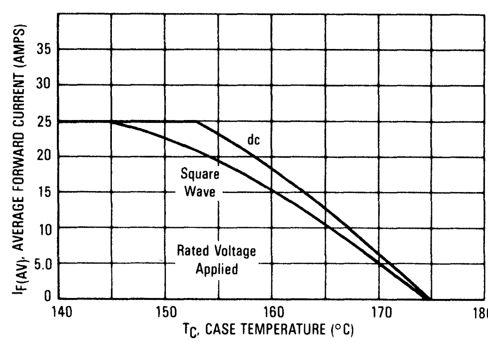


FIGURE 4 — POWER DISSIPATION

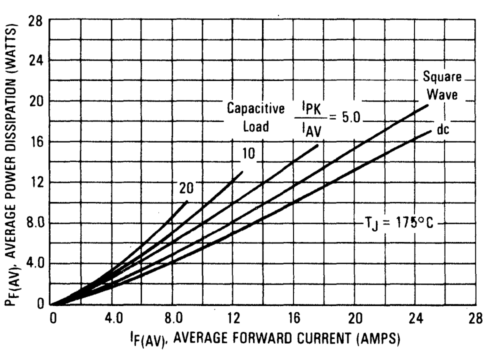


FIGURE 5 — TYPICAL CAPACITANCE

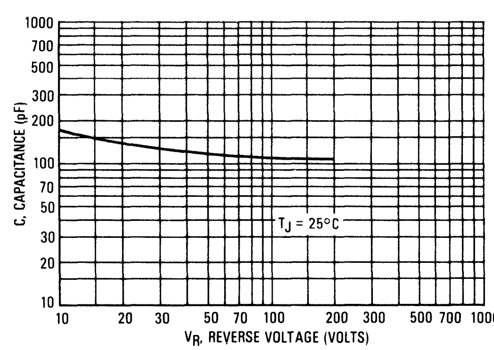
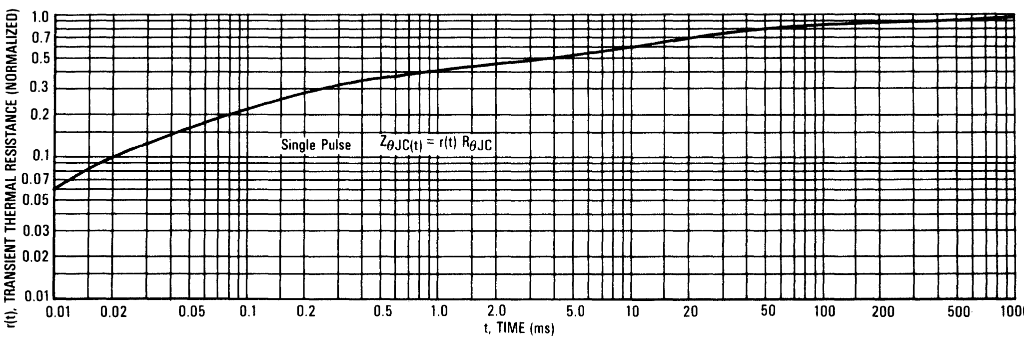


FIGURE 6 — THERMAL RESPONSE



MUR3005PT MUR3020PT
MUR3010PT MUR3030PT
MUR3015PT MUR3040PT

MOTOROLA

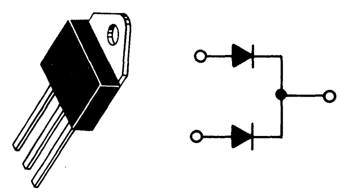
SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

- Ultrafast 35 and 60 Nanosecond Recovery Time
- 175°C Operating Junction Temperature
- Popular TO-218 Package
- High Voltage Capability to 400 Volts
- Low Forward Drop
- Low Leakage Specified @ 150°C Case Temperature
- Current Derating Specified @ Both Case and Ambient Temperatures
- Epoxy Meets UL94, V_O @ 1/8″
- High Temperature Glass Passivated Junction

ULTRAFAST RECTIFIERS

30 AMPERES 50–400 VOLTS



CASE 340-01
TO-218AC

3

MAXIMUM RATINGS

Rating	Symbol	MUR 3005PT	3010PT	3015PT	3020PT	3030PT	3040PT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	300	400	Volts
Average Rectified Forward Current (Rated V_R) Per Leg @ T_C = 150°C Per Device	$I_{F(AV)}$	15 30						Amps
Peak Repetitive Forward Current, Per Leg (Rated V_R, Square Wave, 20 kHz), T_C = 150°C	I_{FRM}	30						Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz) Per Leg	I_{FSM}	200			150			Amps
Operating Junction Temperature and Storage Temperature	T_J, T_{stg}	−65 to +175						°C

THERMAL CHARACTERISTICS PER DIODE LEG

Rating	Symbol	Value	Unit
Maximum Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W
Junction to Ambient	$R_{\theta JA}$	40	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE LEG

Characteristic	Symbol	3005PT–3015PT	3020PT–3040PT	Unit
Maximum Instantaneous Forward Voltage (1) (i_F = 15 Amp, T_C = 150°C) (i_F = 15 Amp, T_C = 25°C)	v_F	0.85 1.05	1.12 1.25	Volts
Maximum Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 150°C) (Rated dc Voltage, T_C = 25°C)	i_R	500 10		μA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs)	t_{rr}	35	60	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%

Switchmode is a trademark of Motorola Inc.

MUR3005PT, 3010PT, and 3015PT

FIGURE 1 — TYPICAL FORWARD VOLTAGE (PER LEG)

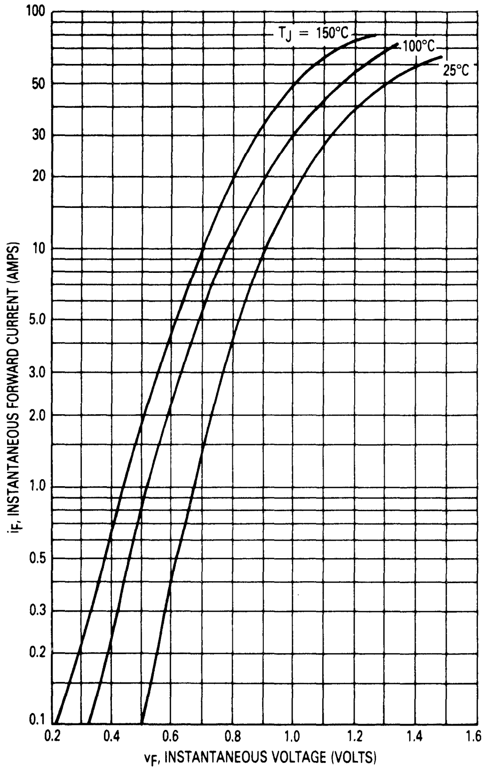
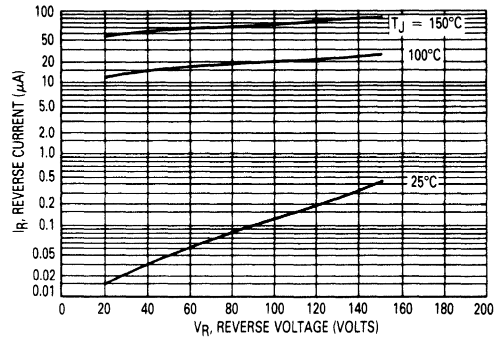


FIGURE 2 — TYPICAL REVERSE CURRENT (PER LEG)*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING, CASE (PER LEG)

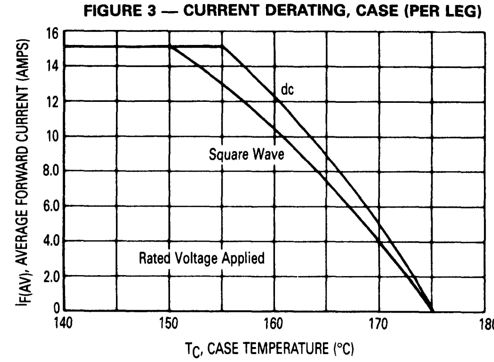


FIGURE 4 — CURRENT DERATING, AMBIENT (PER LEG)

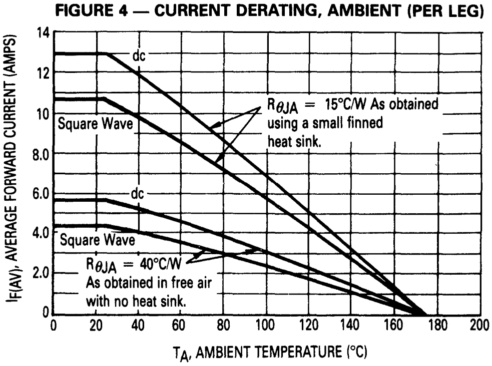
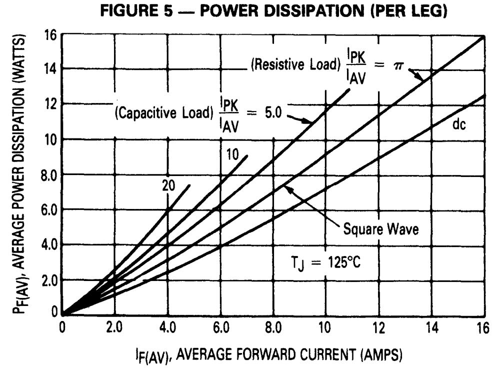


FIGURE 5 — POWER DISSIPATION (PER LEG)



MUR3020PT,3030PT, and 3040PT

FIGURE 6 — TYPICAL FORWARD VOLTAGE (PER LEG)

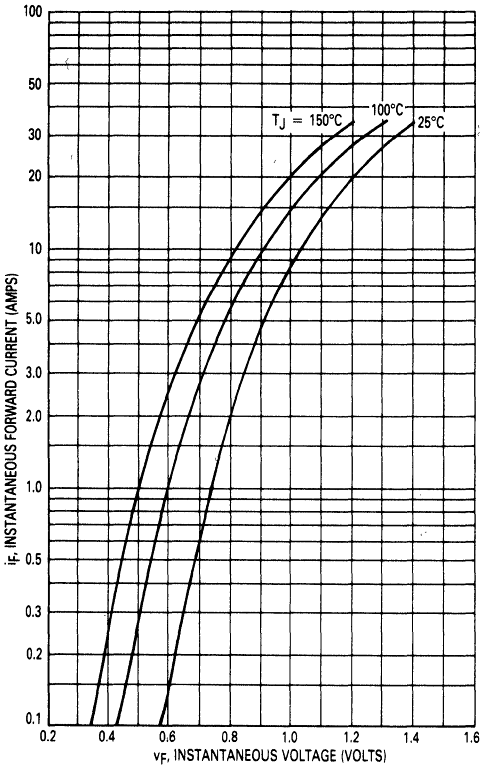
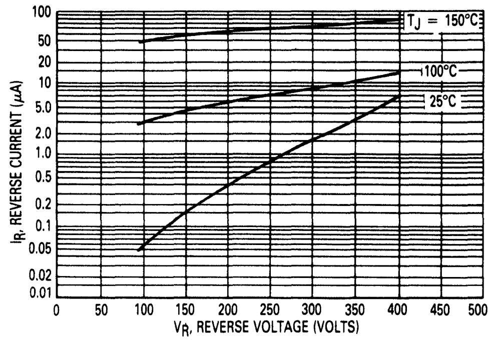


FIGURE 7 — TYPICAL REVERSE CURRENT (PER LEG)*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

FIGURE 8 — CURRENT DERATING, CASE (PER LEG)

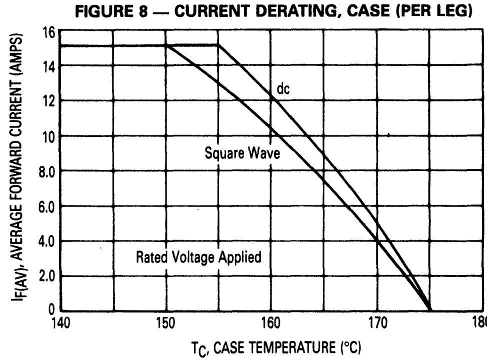


FIGURE 9 — CURRENT DERATING, AMBIENT (PER LEG)

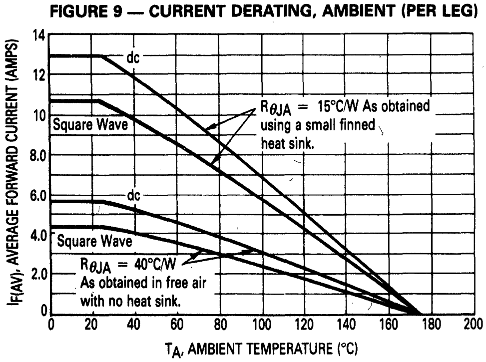


FIGURE 10 — POWER DISSIPATION (PER LEG)

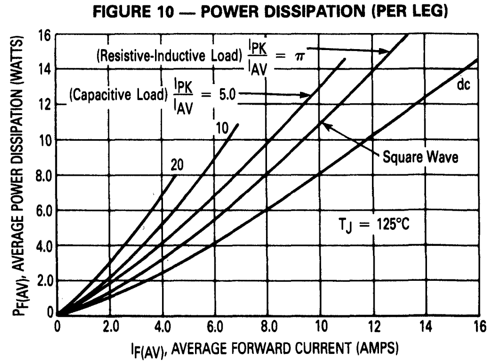


FIGURE 11 — THERMAL RESPONSE

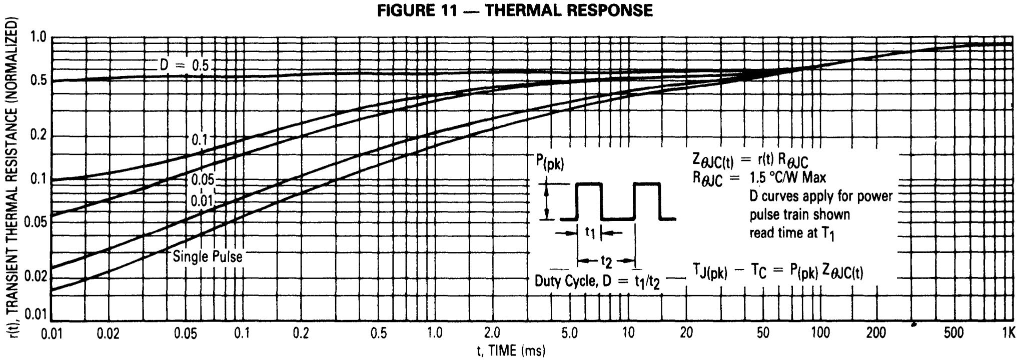
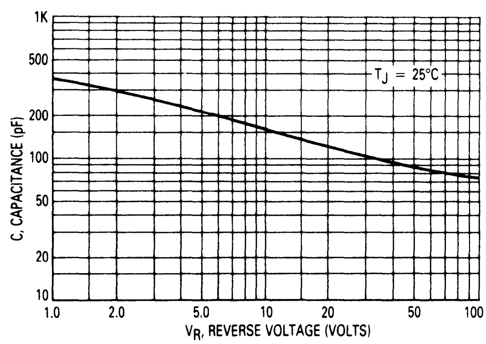
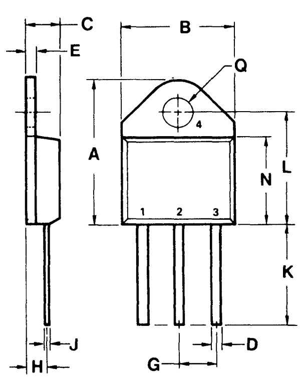


FIGURE 12 — TYPICAL CAPACITANCE (PER LEG)





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
B	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

CASE 340-01
TO-218AC

3

MUR5005
MUR5010
MUR5015
MUR5020

MOTOROLA

SWITCHMODE POWER RECTIFIERS

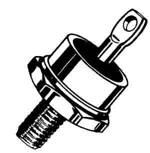
. . . designed for use in switching power supplies, inverters and as free wheeling diodes, these state-of-the-art devices have the following features:

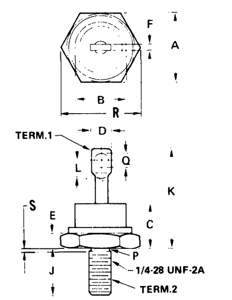
- Ultrafast 50 Nanosecond Recovery Time
- Low Forward Voltage Drop
- Hermetically Sealed Metal DO-203AB (DO-5) Package

3

ULTRAFAST RECTIFIERS

50 AMPERES
50 to 200 VOLTS





NOTES:
1. DIM "P" IS DIA.
2. CHAMFER OR UNDERCUT ON ONE OR BOTH ENDS OF HEXAGONAL BASE IS OPTIONAL.
3. ANGULAR ORIENTATION AND CONTOUR OF TERMINAL ONE IS OPTIONAL.
4. THREADS ARE PLATED.
5. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	16.94	17.45	0.669	0.687
B	–	16.94	–	0.667
C	–	11.43	–	0.450
D	–	9.53	–	0.375
E	2.92	5.08	0.115	0.200
F	–	2.03	–	0.080
J	10.72	11.51	0.422	0.453
K	–	25.40	–	1.000
L	3.86	–	0.156	–
P	5.59	6.32	0.220	0.249
Q	3.56	4.45	0.140	0.175
R	–	20.16	–	0.794
S	–	2.26	–	0.089

CASE 257-01
DO-203AB
(DO-5)

MAXIMUM RATINGS

Rating	Symbol	MUR 5005	MUR 5010	MUR 5015	MUR 5020	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	Volts
Nonrepetitive Peak Reverse Voltage	V_{RSM}	55	110	165	220	Volts
Average Forward Current $T_C = 125°C$	$I_{F(AV)}$	50				Amps
Nonrepetitive Peak Surge Forward Current (half cycle, 60 Hz, Sinusoidal Waveform)	I_{FSM}	600				Amps
Operating Junction and Storage Temperature	T_J, T_{stg}	-55 to +175				°C

THERMAL CHARACTERISTICS

Rating	Symbol	All Devices	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS

Maximum Instantaneous Forward Voltage Drop (i_F = 50 Amp, T_J = 25°C) (i_F = 50 Amp, T_J = 125°C) (i_F = 100 Amp, T_J = 125°C)	v_F	1.15 0.95 1.10	Volts
Maximum Reverse Current @ DC Voltage (T_J = 25°C) (T_J = 125°C)	I_R	10 1.0	μA mA
Maximum Reverse Recovery Time (I_F = 1.0 Amp, di/dt = 50 Amp/μs, V_R = 30 V, T_J = 25°C)	t_{rr}	50	ns

MECHANICAL CHARACTERISTICS

Case: Welded, hermetically sealed

Finish: All external surface corrosion resistant and terminal leads are readily solderable

Polarity: Cathode to Case

Mounting Positions: Any

Stud Torque: 25 in/lb. Max

Switchmode is a trademark of Motorola Inc.

FIGURE 1 — TYPICAL FORWARD VOLTAGE

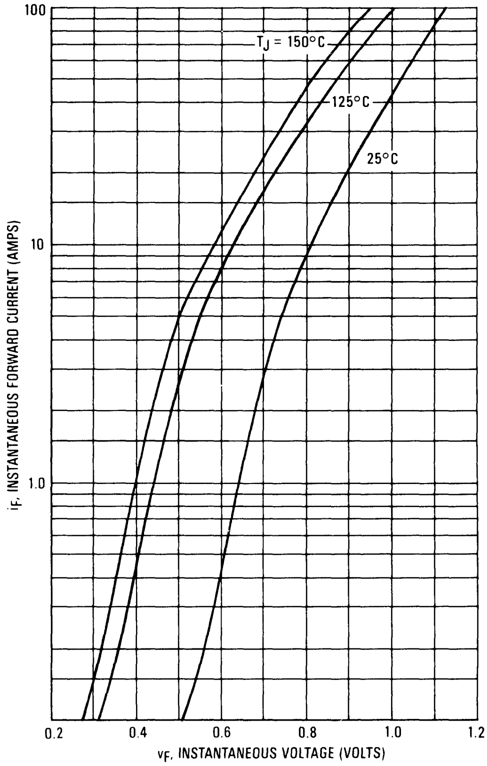
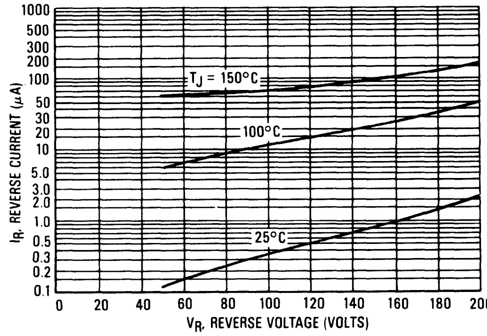


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves if V_R is sufficiently below rated V_R.

3

FIGURE 3 — CURRENT DERATING, CASE

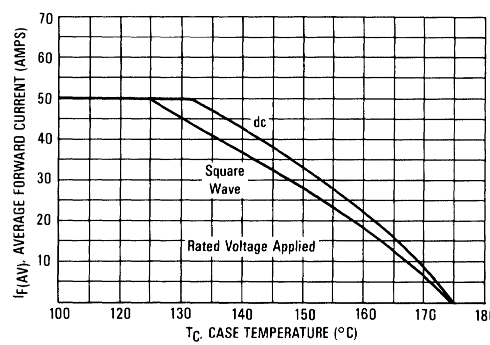


FIGURE 4 — POWER DISSIPATION

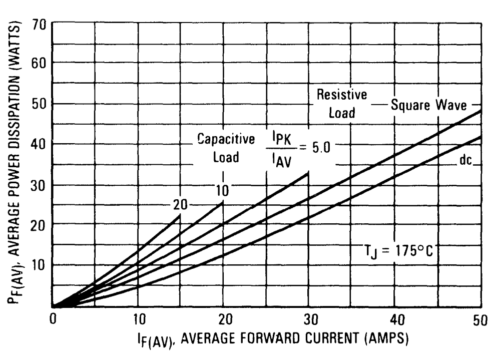


FIGURE 5 — TYPICAL CAPACITANCE

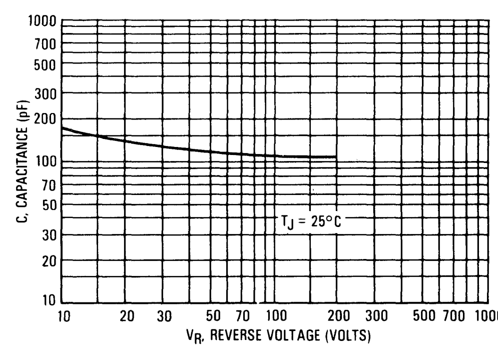
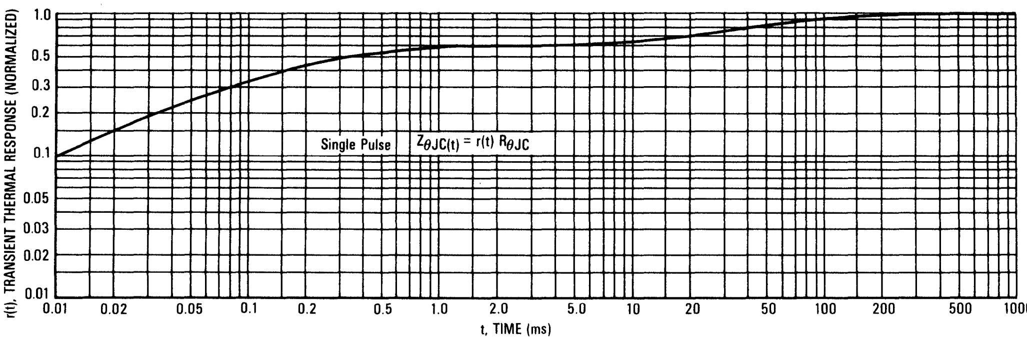


FIGURE 6 — THERMAL RESPONSE



3

MOTOROLA

MUR10005CT
MUR10010CT
MUR10015CT
MUR10020CT

Advance Information

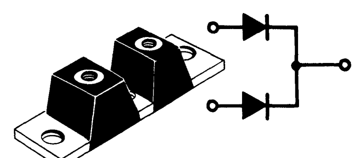
ULTRAFAST SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters, and as free wheeling diodes. These state-of-the-art devices have the following features:

- Dual Diode Construction — May Be Paralleled For Higher Current Output
- Low Leakage Current
- Low Forward Voltage
- 175°C Operating Junction Temperature
- Labor Saving POWERTAP® Package

ULTRAFAST RECTIFIERS

100 AMPERES
50 TO 200 VOLTS



CASE 357B-01
POWERTAP®

MAXIMUM RATINGS

Rating	Symbol	MUR 10005CT	MUR 10010CT	MUR 10015CT	MUR 10020CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	Volts
Average Rectified Forward Current, (Rated V_R), T_C = 140°C Per Device Per Leg	$I_{F(AV)}$	 100 50				Amps
Peak Repetitive Forward Current, Per Leg, (Rated V_R, Square Wave, 20 kHz), T_C = 140°C	I_{FRM}	100				Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}	400				Amps
Operating Junction and Storage Temperature	T_J, T_{stg}	−65 to +175				°C

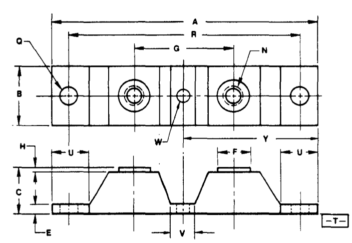
THERMAL CHARACTERISTICS PER LEG

Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.0	°C/W

ELECTRICAL CHARACTERISTICS PER LEG

Rating	Symbol	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 50 Amp, T_C = 25°C)	v_F	1.10	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 125°C) (Rated dc Voltage, T_C = 25°C)	i_R	 250 25	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amps, di/dt = 50 Amps/μs)	t_{rr}	50	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
POWERTAP and Switchmode are trademarks of Motorola Inc.
This document contains information on a new product. Specifications and information herein are subject to change without notice.



NOTES:
1. DIMENSIONS A AND B ARE DATUMS AND -T- IS A DATUM SURFACE AND SEATING PLANE.
2. POSITIONAL TOLERANCE FOR N HOLES: ⌖ | ϕ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ
3. POSITIONAL TOLERANCE FOR Q AND W HOLES: ⌖ | ϕ 0.25 (0.010) Ⓜ | T | A Ⓜ | B Ⓜ
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	92.20	–	3.630
B	17.78	20.32	0.700	0.800
C	–	15.87	–	0.625
E	3.05	3.30	0.120	0.130
F	12.45	12.95	0.490	0.510
G	34.92 BSC		1.375 BSC	
H	–	1.27	–	0.050
N	—		1/4-20 UNC	
Q	6.86	7.11	0.270	0.280
R	80.01 BSC		3.150 BSC	
U	15.24	–	0.600	–
V	8.38	8.89	0.330	0.350
W	4.32	4.82	0.170	0.190
Y	46.10 BSC		1.815 BSC	

CASE 357B-01

Terminal Penetration	0.300 Max
Terminal Torque	50–100 lb.-in.
Mounting Base Torque	30–40 lb.-in.

3

FIGURE 1 — FORWARD VOLTAGE

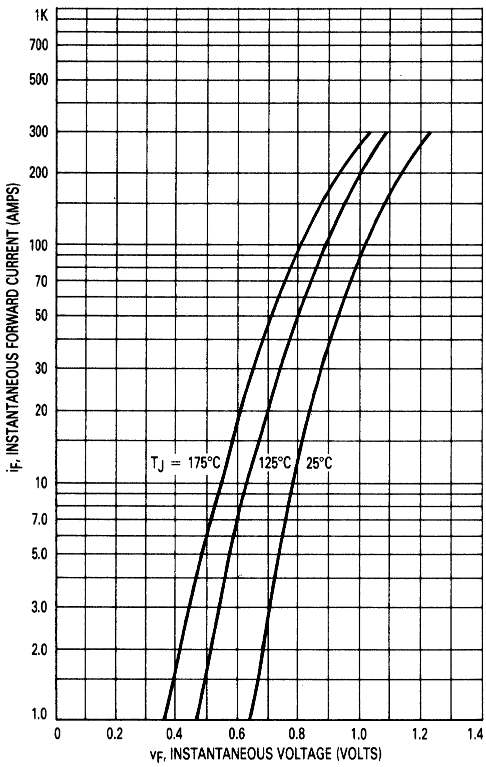
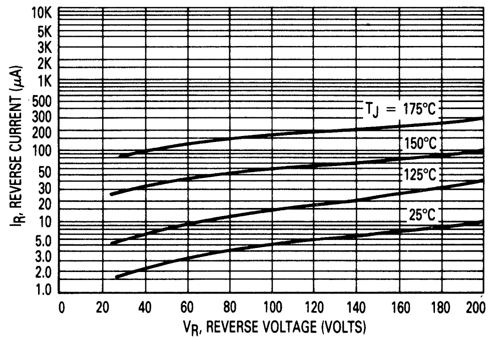


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these same curves, if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING (PER LEG)

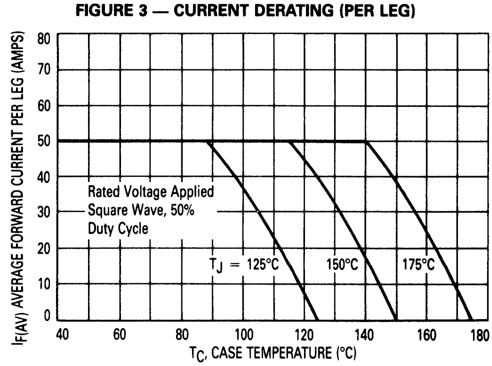


FIGURE 4 — POWER DISSIPATION (PER LEG)

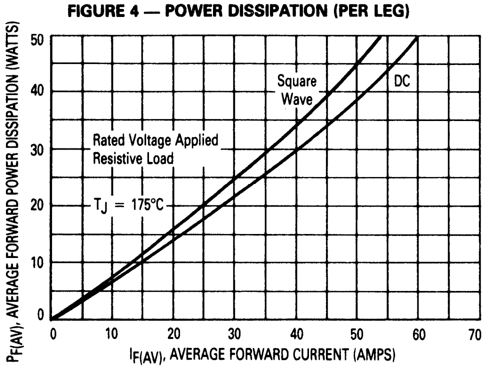
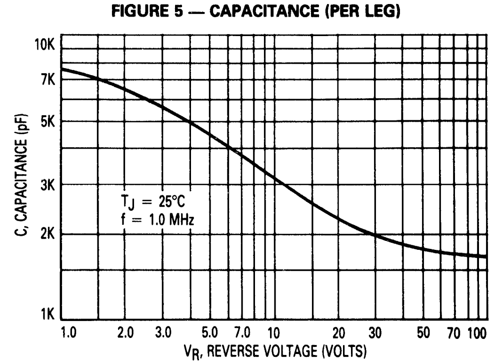


FIGURE 5 — CAPACITANCE (PER LEG)



MOTOROLA

MUR20005CT
MUR20010CT
MUR20015CT
MUR20020CT

Advance Information

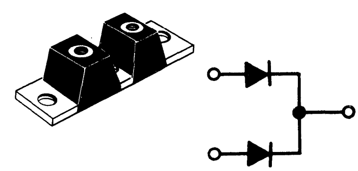
ULTRAFAST SWITCHMODE POWER RECTIFIERS

. . . designed for use in switching power supplies, inverters, and as free wheeling diodes. These state-of-the-art devices have the following features:

- Dual Diode Construction — May Be Paralleled For Higher Current Output
- Low Leakage Current
- Low Forward Voltage
- 175°C Operating Junction Temperature
- Labor Saving POWERTAP® Package

ULTRAFAST RECTIFIERS

200 AMPERES
50 TO 200 VOLTS



CASE 357B-01
POWERTAP®

3

MAXIMUM RATINGS

Rating	Symbol	MUR 20005CT	MUR 20010CT	MUR 20015CT	MUR 20020CT	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	150	200	Volts
Average Rectified Forward Current, (Rated V_R), $T_C = 95°C$ Per Device Per Leg	$I_{F(AV)}$		200 100			Amps
Peak Repetitive Forward Current, Per Leg, (Rated V_R, Square Wave, 20 kHz), $T_C = 95°C$	I_{FRM}		200			Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)	I_{FSM}		800			Amps
Operating Junction and Storage Temperature	T_J, T_{stg}		−65 to +175			°C

THERMAL CHARACTERISTICS PER LEG

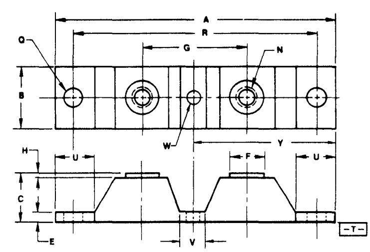
Rating	Symbol	Max	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	0.70	°C/W

ELECTRICAL CHARACTERISTICS PER LEG

Rating	Symbol	Max	Unit
Instantaneous Forward Voltage (1) (i_F = 100 Amp, $T_C = 25°C$)	v_F	1.25	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, $T_C = 125°C$) (Rated dc Voltage, $T_C = 25°C$)	i_R	 500 50	μA
Maximum Reverse Recovery Time (I_F = 1.0 Amps, di/dt = 50 Amps/μs)	t_{rr}	50	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.
POWERTAP and Switchmode are trademarks of Motorola Inc.

This document contains information on a new product. Specifications and information herein are subject to change without notice.



NOTES
1. DIMENSIONS A AND B ARE DATUMS AND -T- IS A DATUM SURFACE AND SEATING PLANE
2. POSITIONAL TOLERANCE FOR N HOLES.
   ⌖ | ϕ 0.13 (0.005) Ⓜ | T | A Ⓜ | B Ⓜ
3. POSITIONAL TOLERANCE FOR Q AND W HOLES:
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B	17.78	20.32	0.700	0.800
C	–	15.87	–	0.625
E	3.05	3.30	0.120	0.130
F	12.45	12.95	0.490	0.510
G	34.92 BSC		1.375 BSC	
H	–	1.27	–	0.050
N	—		1/4-20 UNC	
Q	6.86	7.11	0.270	0.280
R	80.01 BSC		3.150 BSC	
U	15.24	–	0.600	–
V	8.38	8.89	0.330	0.350
W	4.32	4.82	0.170	0.190
Y	46.10 BSC		1.815 BSC	

CASE 357B-01

Terminal Penetration	0.300 Max
Terminal Torque	50–100 lb.-in.
Mounting Base Torque	30–40 lb.-in.

3

FIGURE 1 — TYPICAL FORWARD VOLTAGE (PER LEG)

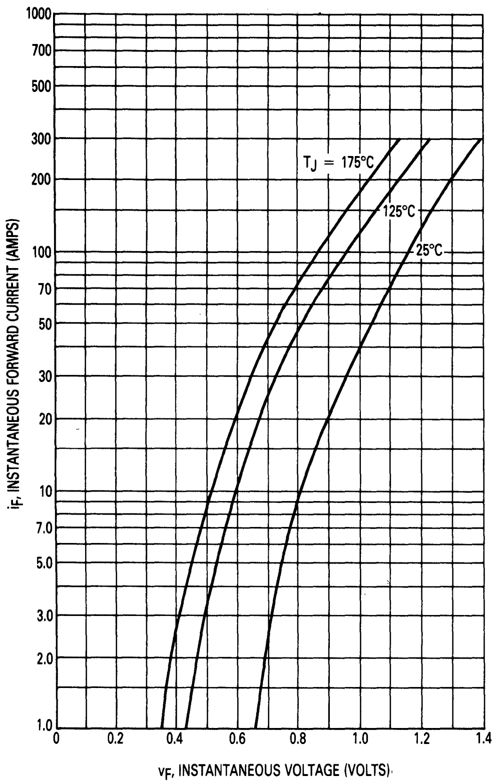
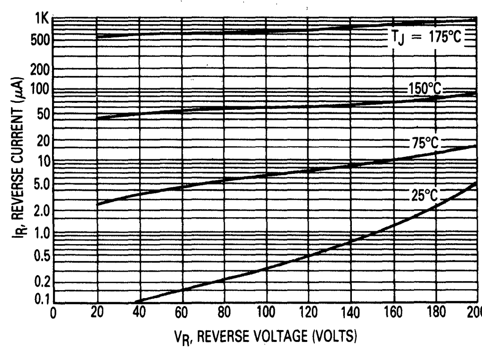


FIGURE 2 — TYPICAL REVERSE CURRENT*



*The curves shown are typical for the highest voltage device in the voltage grouping. Typical reverse current for lower voltage selections can be estimated from these curves, if V_R is sufficiently below rated V_R.

FIGURE 3 — CURRENT DERATING (PER LEG)

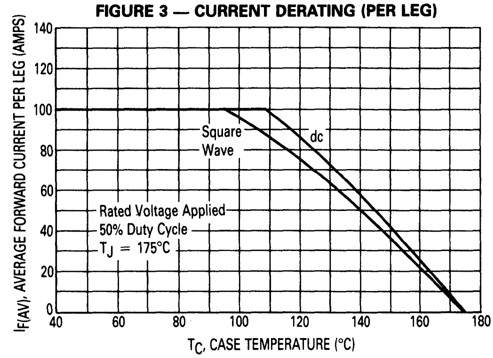


FIGURE 4 — POWER DISSIPATION (PER LEG)

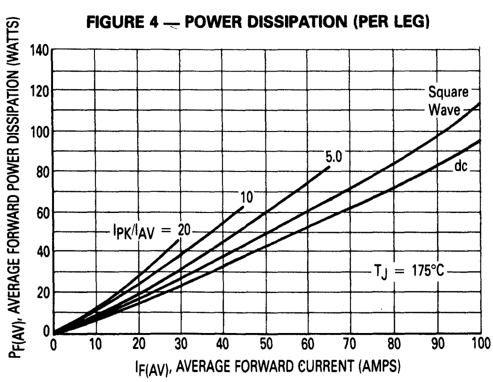
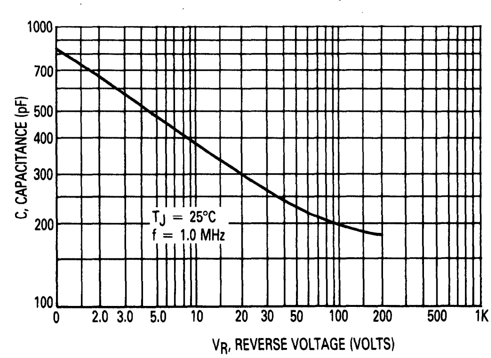


FIGURE 5 — CAPACITANCE (PER LEG)



SD41 See Page 3-72
SD51 See Page 3-76
SD241 See Page 3-116

MOTOROLA

R710XPT R712XPT R711XPT R714XPT

3

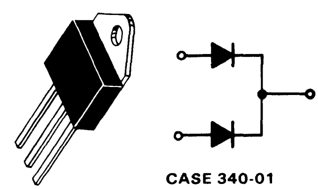
SWITCHMODE POWER RECTIFIERS

. . . 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 150 nanoseconds providing high efficiency at frequencies to 50 kHz.

- Dual Diode Construction
- 150°C Operating Junction Temperature

FAST RECOVERY RECTIFIERS

30 AMPERES
50 to 400 VOLTS



CASE 340-01
TO-218AC

CROSS-REFERENCE GUIDE	
MOTOROLA	VARO
R710XPT	—
R711XPT	R711X
R712XPT	R712X
R714XPT	R714X

MAXIMUM RATINGS

Rating		Symbol	Maximum	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	R710XPT R711XPT R712XPT R714XPT	V_{RRM} V_{RWM} V_R	50 100 200 400	Volts
Average Rectified Forward Current (Rated V_R) T_C = 100°C	Per Device Per Diode	I_O	30 15	Amps
Peak Repetitive Forward Current, Per Diode (1 Second at 60 Hz, T_C = 100°C)		I_{FRM}	50	Amps
Nonrepetitive Peak Surge Current (Surge applied at rated load conditions halfwave, single phase, 60 Hz)		I_{FSM}	150	Amps
Operating Junction and Storage Temperature		T_J, T_{stg}	-65 to +150	°C

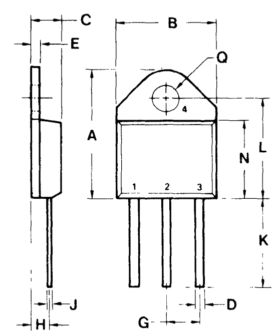
THERMAL CHARACTERISTICS PER DIODE

Characteristic	Symbol	Maximum	Unit
Thermal Resistance, Junction to Case	$R_{\theta JC}$	1.5	°C/W
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	40	°C/W

ELECTRICAL CHARACTERISTICS PER DIODE

Characteristic	Symbol	Maximum	Unit
Instantaneous Forward Voltage (1) (i_F = 15 Amp, T_C = 25°C)	v_F	1.30	Volts
Instantaneous Reverse Current (1) (Rated dc Voltage, T_C = 100°C) (Rated dc Voltage, T_C = 25°C)	i_R	 1.0 0.015	mA
Reverse Recovery Time (I_F = 1.0 Ampere to V_R = 30 Vdc)	t_{rr}	100	ns

(1) Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%
Switchmode is a trademark of Motorola Inc.



1. ANODE 1
2. CATHODE(S)
3. ANODE 2
4. CATHODE(S)

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	20.32	21.08	0.800	0.830
B	15.49	15.90	0.610	0.626
C	4.19	5.08	0.165	0.200
D	1.02	1.65	0.040	0.065
E	1.35	1.65	0.053	0.065
G	5.21	5.72	0.205	0.225
H	2.41	3.20	0.095	0.126
J	0.38	0.64	0.015	0.025
K	12.70	15.49	0.500	0.610
L	15.88	16.51	0.625	0.650
N	12.19	12.70	0.480	0.500
Q	4.04	4.22	0.159	0.166

CASE 340-01
TO-218AC

3

FIGURE 1 — TYPICAL FORWARD VOLTAGE

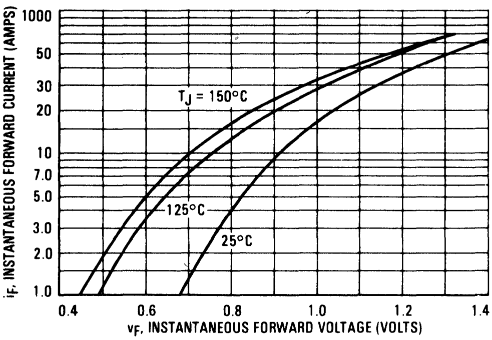


FIGURE 2 — TYPICAL REVERSE CURRENT

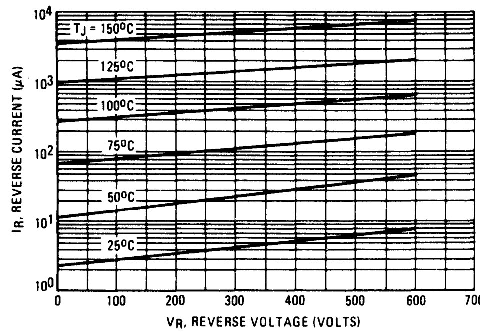


FIGURE 3 — CURRENT DERATING — TOTAL UNIT

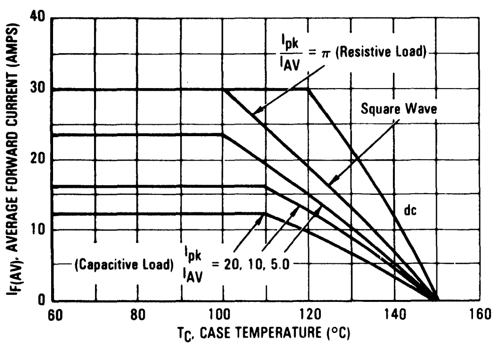


FIGURE 4 — TYPICAL CAPACITANCE

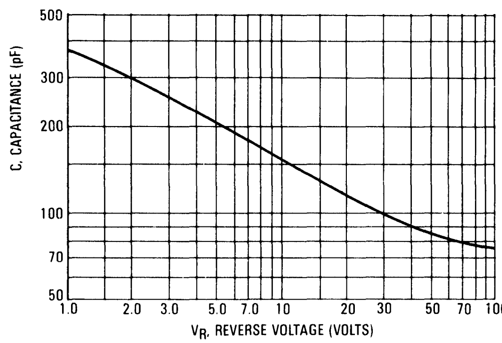


FIGURE 5 — POWER DISSIPATION — TOTAL UNIT

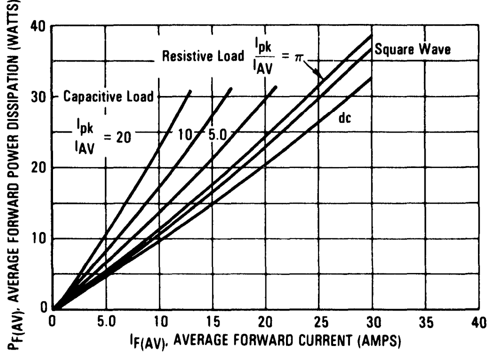
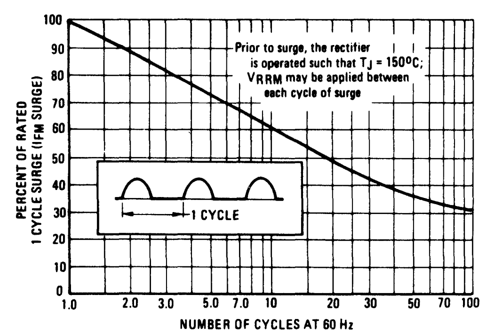


FIGURE 6 — MAXIMUM SURGE CAPABILITY



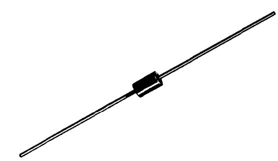
Zener Diode Data Sheets

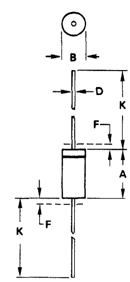
4

1/4M2.4AZ10
thru
1/4M105Z10

MOTOROLA

1/4 WATT
SILICON ZENER DIODES
2.4-105 VOLTS





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH
(DO-35)

1/4 WATT SILICON ZENER DIODES

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. These devices are in the same 400 mW glass package as the 1N746 and 1N957 Series, but designated 1/4 Watt to allow characterization at a different test current level.

4

MAXIMUM RATINGS

Junction and Storage Temperature: −65°C to +175°C
DC Power Dissipation: 1/4 Watt (Derate 1.67 mW/°C Above 25°C)

The type numbers specified have a standard voltage (V_Z) tolerance of ±10%. For closer tolerances, add suffix "5" for ±5%, (3%, 2%, 1% tolerances also available).

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA)

Type No.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Maximum Zener Impedance (Z_{ZT}) @ I_{ZT} Ohms	Maximum DC Zener Current (I_{ZM}) mA	Reverse Leakage Current I_R Max (μA)	Test Voltage Vdc* V_{R1}	Test Voltage Vdc* V_{R2}
1/4M2.4AZ10	2.4	10	60	70	75	1	1
1/4M2.7AZ10	2.7	10	60	65	75	1	1
1/4M3.0AZ10	3.0	10	55	60	50	1	1
1/4M3.3AZ10	3.3	10	55	55	50	1	1
1/4M3.6AZ10	3.6	10	50	52	50	1	1

*V_{R1} — Test Voltage for 5% Tolerance Device V_{R2} — Test Voltage for 10% Tolerance Device

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max @ 100 mA)

Type No.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Maximum Zener Impedance (Z_{ZT}) @ I_{ZT} Ohms	Maximum DC Zener Current (I_{ZM}) mA	Reverse Leakage Current I_R Max (μA)	Test Voltage Vdc* V_{R1}	Test Voltage Vdc* V_{R2}
1/4M3.9AZ10	3.9	10	50	49	25	1	1
1/4M4.3AZ10	4.3	10	45	46	25	1.5	1.5
1/4M4.7AZ10	4.7	10	35	42	10	1.5	1.5
1/4M5.1AZ10	5.1	10	25	39	5	1.5	1.5
1/4M5.6AZ10	5.6	10	20	36	5	1.5	1.5
1/4M6.2AZ10	6.2	10	15	33	5	3.5	3.5
1/4M6.8Z10	6.8	9.2	7.0	33	150	5.2	4.9
1/4M7.5Z10	7.5	8.3	8.0	30	75	5.7	5.4
1/4M8.2Z10	8.2	7.6	9.0	26	50	6.2	5.9
1/4M9.1Z10	9.1	6.9	10	24	25	6.9	6.6
1/4M10Z10	10	6.3	11	21	10	7.6	7.2
1/4M11Z10	11	5.7	13	19	5	8.4	8.0
1/4M12Z10	12	5.2	15	18	5	9.1	8.6
1/4M13Z10	13	4.8	18	16	5	9.9	9.4
1/4M14Z10	14	4.5	20	15	5	10.6	10.1
1/4M15Z10	15	4.2	22	14	5	11.4	10.8
1/4M16Z10	16	3.9	24	13	5	12.2	11.5
1/4M17Z10	17	3.7	26	12.5	5	13.0	12.2
1/4M18Z10	18	3.5	28	11.5	5	13.7	13.0
1/4M19Z10	19	3.3	30	11.0	5	14.4	13.7
1/4M20Z10	20	3.1	33	10.5	5	15.2	14.4
1/4M22Z10	22	2.8	40	9.5	5	16.7	15.8
1/4M24Z10	24	2.6	46	9.0	5	18.2	17.3
1/4M25Z10	25	2.5	50	8.0	5	19.0	18.0
1/4M27Z10	27	2.3	58	7.5	5	20.6	19.4
1/4M30Z10	30	2.1	70	7.0	5	22.8	21.6
1/4M33Z10	33	1.9	85	6.5	5	25.1	23.8
1/4M36Z10	36	1.7	100	6.0	5	27.4	25.9
1/4M39Z10	39	1.6	120	5.0	5	29.7	28.1
1/4M43Z10	43	1.5	140	4.8	5	32.7	31.0
1/4M45Z10	45	1.4	150	4.5	5	34.2	32.4
1/4M47Z10	47	1.3	160	4.3	5	35.8	33.8
1/4M50Z10	50	1.2	180	4.1	5	38.0	36.0
1/4M52Z10	52	1.2	200	4.0	5	39.5	37.4
1/4M56Z10	56	1.1	230	3.8	5	42.6	40.3
1/4M62Z10	62	1.0	290	3.3	5	47.1	44.6
1/4M68Z10	68	0.92	350	3.0	5	51.7	49.0
1/4M75Z10	75	0.83	450	2.8	5	56.0	54.0
1/4M82Z10	82	0.76	550	2.5	5	62.2	59.0
1/4M91Z10	91	0.69	700	2.3	5	69.2	65.5
1/4M100Z10	100	0.63	900	2.0	5	76.0	72.0
1/4M105Z10	105	0.60	1000	1.9	5	79.8	75.6

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

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

SPECIAL SELECTIONS AVAILABLE INCLUDE:

1 — Nominal zener voltages between those shown.

2 — Matches 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%.

1.5KE6.8,A thru 1.5KE200,A
See Page 4-74

MOTOROLA

1N746 thru 1N759
1N957A thru 1N986A
1N4370 thru 1N4372

GLASS ZENER DIODES

500 MILLIWATTS
2.4-110 VOLTS

Designers Data Sheet

500-MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 2.4 to 110 Volts
- DO-35 Package — Smaller than Conventional DO-7 Package
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die

Designer's Data for "Worst Case" Conditions

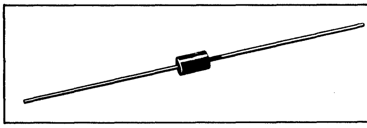
The Designer's Data sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L \leq 50^oC$, Lead Length = 3/8"	P_D		
*JEDEC Registration		400	mW
*Derate above $T_L = 50^oC$		3.2	$mW/^oC$
Motorola Device Ratings		500	mW
Derate above $T_L = 50^oC$		3.33	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}		^oC
*JEDEC Registration		-65 to +175	
Motorola Device Ratings		-65 to +200	

*Indicates JEDEC Registered Data.



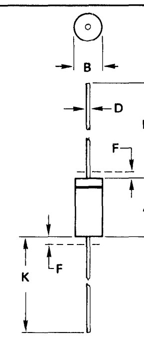
MECHANICAL CHARACTERISTICS

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16" from case for 10 seconds

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

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

MOUNTING POSITION: Any



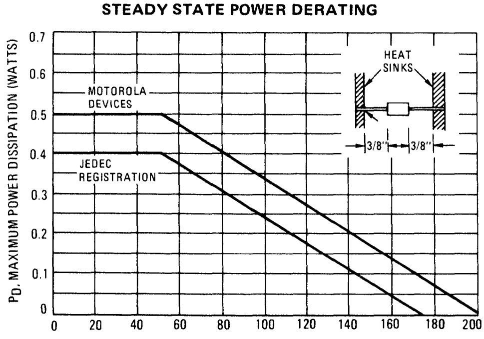
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH
(DO-35)

STEADY STATE POWER DERATING



1N746 thru 1N759, 1N957A thru 1N986A, 1N4370 thru 1N4372

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max at 200 mA for all types)

Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} (Note 2) Volts	Test Current I_{ZT} mA	Maximum Zener Impedance Z_{ZT} @ I_{ZT} (Note 3) Ohms	*Maximum DC Zener Current I_{ZM} (Note 4) 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	190	100	200
1N4371	2.7	20	30	135	165	75	150
1N4372	3.0	20	29	120	150	50	100
1N746	3.3	20	28	110	135	10	30
1N747	3.6	20	24	100	125	10	30
1N748	3.9	20	23	95	115	10	30
1N749	4.3	20	22	85	105	2	30
1N750	4.7	20	19	75	95	2	30
1N751	5.1	20	17	70	85	1	20
1N752	5.6	20	11	65	80	1	20
1N753	6.2	20	7	60	70	0.1	20
1N754	6.8	20	5	55	65	0.1	20
1N755	7.5	20	6	50	60	0.1	20
1N756	8.2	20	8	45	55	0.1	20
1N757	9.1	20	10	40	50	0.1	20
1N758	10	20	17	35	45	0.1	20
1N759	12	20	30	30	35	0.1	20

Type Number (Note 1)	Nominal Zener Voltage V_Z (Note 2) Volts	Test Current I_{ZT} mA	Maximum Zener Impedance (Note 3) Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	*Maximum DC Zener Current I_{ZM} (Note 4) mA		Maximum Reverse Current I_R Maximum μA	Test Voltage Vdc V_R 5%	10%
1N957A	6.8	18.5	4.5	700	1.0	47	61	150	5.2	4.9
1N958A	7.5	16.5	5.5	700	0.5	42	55	75	5.7	5.4
1N959A	8.2	15	6.5	700	0.5	38	50	50	6.2	5.9
1N960A	9.1	14	7.5	700	0.5	35	45	25	6.9	6.6
1N961A	10	12.5	8.5	700	0.25	32	41	10	7.6	7.2
1N962A	11	11.5	9.5	700	0.25	28	37	5	8.4	8.0
1N963A	12	10.5	11.5	700	0.25	26	34	5	9.1	8.6
1N964A	13	9.5	13	700	0.25	24	32	5	9.9	9.4
1N965A	15	8.5	16	700	0.25	21	27	5	11.4	10.8
1N966A	16	7.8	17	700	0.25	19	37	5	12.2	11.5
1N967A	18	7.0	21	750	0.25	17	23	5	13.7	13.0
1N968A	20	6.2	25	750	0.25	15	20	5	15.2	14.4
1N969A	22	5.6	29	750	0.25	14	18	5	16.7	15.8
1N970A	24	5.2	33	750	0.25	13	17	5	18.2	17.3
1N971A	27	4.6	41	750	0.25	11	15	5	20.6	19.4
1N972A	30	4.2	49	1000	0.25	10	13	5	22.8	21.6
1N973A	33	3.8	58	1000	0.25	9.2	12	5	25.1	23.8
1N974A	36	3.4	70	1000	0.25	8.5	11	5	27.4	25.9
1N975A	39	3.2	80	1000	0.25	7.8	10	5	29.7	28.1
1N976A	43	3.0	93	1500	0.25	7.0	9.6	5	32.7	31.0
1N977A	47	2.7	105	1500	0.25	6.4	8.8	5	35.8	33.8
1N978A	51	2.5	125	1500	0.25	5.9	8.1	5	38.8	36.7
1N979A	56	2.2	150	2000	0.25	5.4	7.4	5	42.6	40.3
1N980A	62	2.0	185	2000	0.25	4.9	6.7	5	47.1	44.6
1N981A	68	1.8	230	2000	0.25	4.5	6.1	5	51.7	49.0
1N982A	75	1.7	270	2000	0.25	1.0	5.5	5	56.0	54.0
1N983A	82	1.5	330	3000	0.25	3.7	5.0	5	62.2	59.0
1N984A	91	1.4	400	3000	0.25	3.3	4.5	5	69.2	65.5
1N985A	100	1.3	500	3000	0.25	3.0	4.5	5	76	72
1N986A	110	1.1	750	4000	0.25	2.7	4.1	5	83.6	79.2

4

NOTE 1. TOLERANCE AND VOLTAGE DESIGNATION

Tolerance Designation

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.
1N957 series: suffix A for ±10% units, suffix B for ±5% units.

Voltage Designation

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 variations

0.5 M 3.7 A Z 5

- 0.5 — Power Rating
- M — Motorola
- 3.7 — Nominal Voltage
- A — Low Voltage Series
- Z — Zener Diode
- 5 — Tolerance (±%)

EXAMPLE: 1N957 series variations

0.5 M 59 Z 10

- 0.5 — Power Rating
- M — Motorola
- 59 — Nominal Voltage
- Z — Zener Diode
- 10 — Tolerance (±%)

Matched Sets for Closer Tolerances or Higher Voltages

Series matched sets make zener voltages in excess of 100 volts or tolerances of less than 5% possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

For Matched Sets or other special circuit requirements, contact your Motorola Sales Representative.

NOTE 2. ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium at the lead temperature of 30°C ±1°C and 3/8" lead length.

NOTE 3. ZENER IMPEDANCE (Z_Z) DERIVATION

Z_{ZT} and Z_{ZK} are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for $I_Z(ac) = 0.1\ I_Z(dc)$ with the ac frequency = 60 Hz.

NOTE 4. MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

Maximum zener current ratings are based on the maximum voltage of a 10% 1N746 type unit or a 20% 1N957 type unit. For closer tolerance units (10% or 5%) or units where the actual zener voltage (V_Z) is known at the operating point, the maximum zener current may be increased and is limited by the derating curve.

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 1 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 3 and 4.

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.

Surge limitations are given in Figure 6. 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 6 be exceeded.

FIGURE 1 — TYPICAL THERMAL RESISTANCE

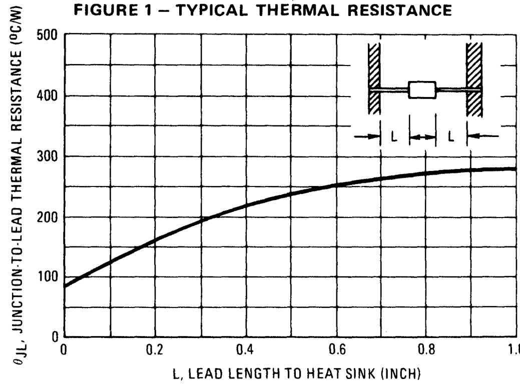


FIGURE 2 — TYPICAL LEAKAGE CURRENT

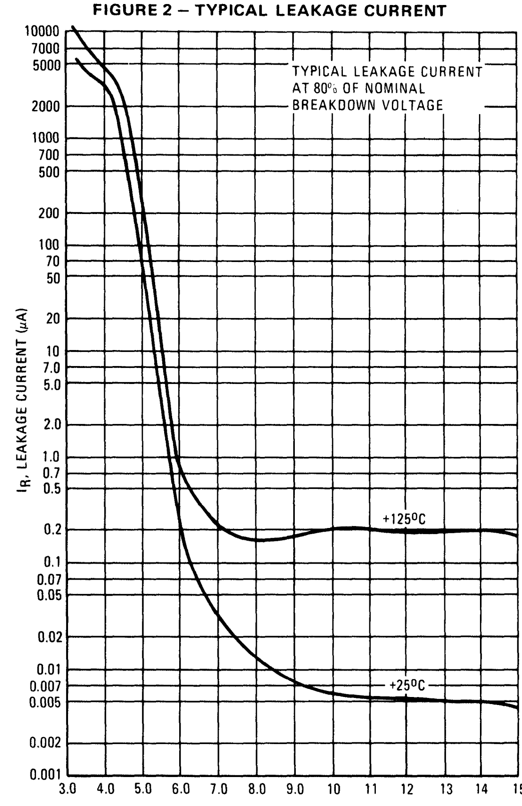
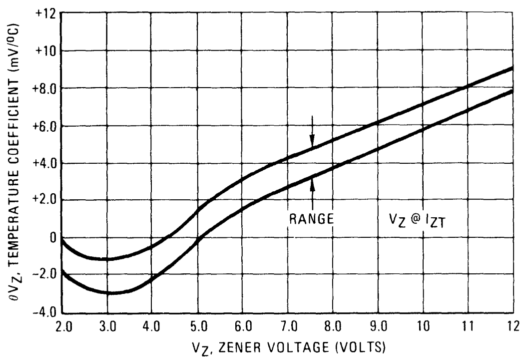


FIGURE 3 – TEMPERATURE COEFFICIENTS
(-55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

a – RANGE FOR UNITS TO 12 VOLTS



b – RANGE FOR UNITS 12 TO 100 VOLTS

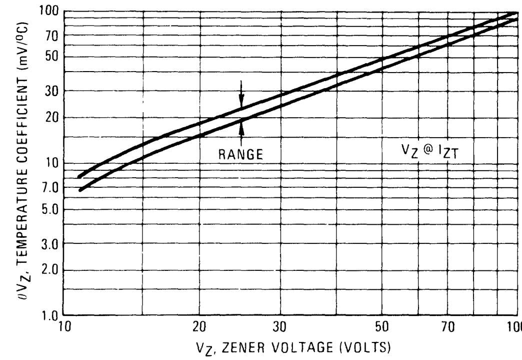


FIGURE 4 – EFFECT OF ZENER CURRENT

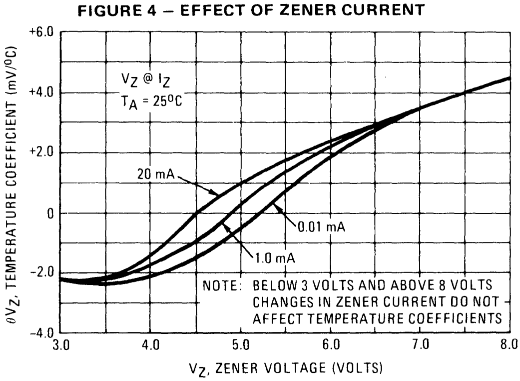


FIGURE 5 – TYPICAL CAPACITANCE

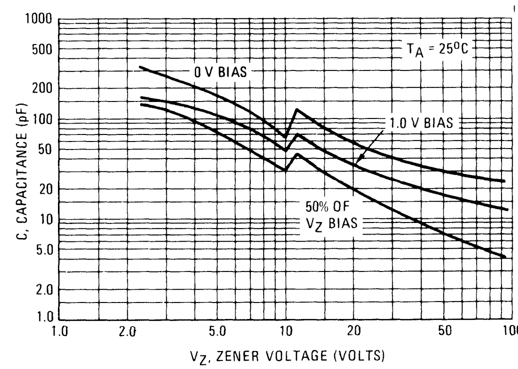
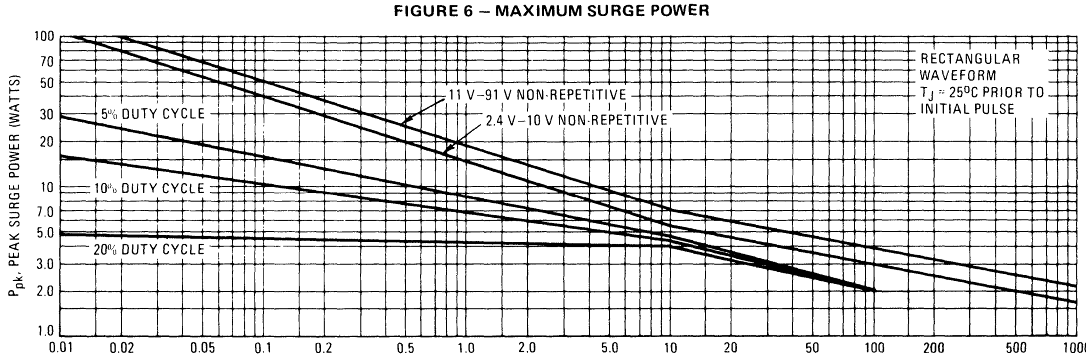


FIGURE 6 – MAXIMUM SURGE POWER



This graph represents 90 percentil data points.
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 7 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

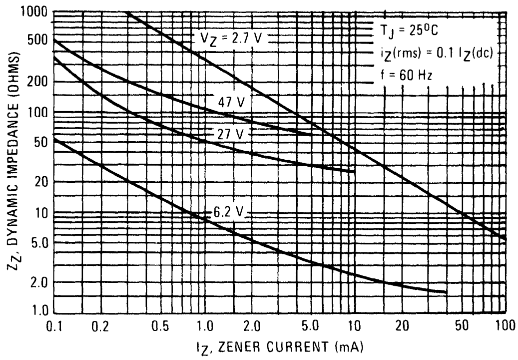


FIGURE 8 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

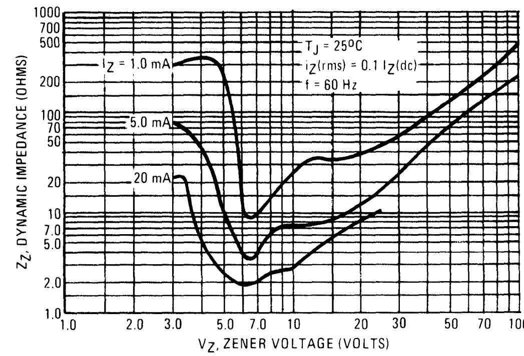


FIGURE 9 — TYPICAL NOISE DENSITY

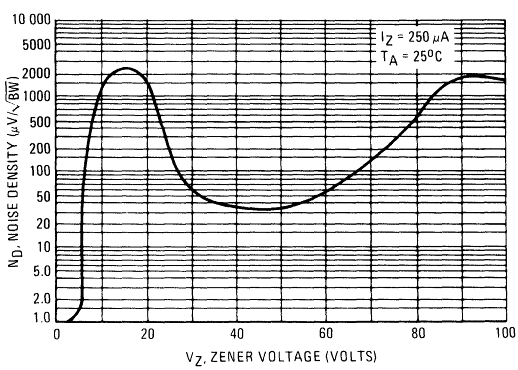
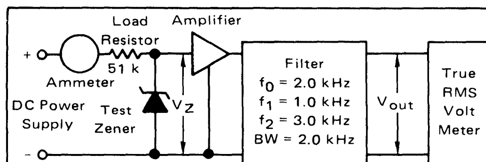


FIGURE 10 — NOISE DENSITY MEASUREMENT METHOD



Noise Density (Volts Per Square Root Bandwidth) $= \dfrac{V_{out}}{\text{Overall Gain } \sqrt{BW}}$

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 zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

FIGURE 11 — TYPICAL FORWARD CHARACTERISTICS

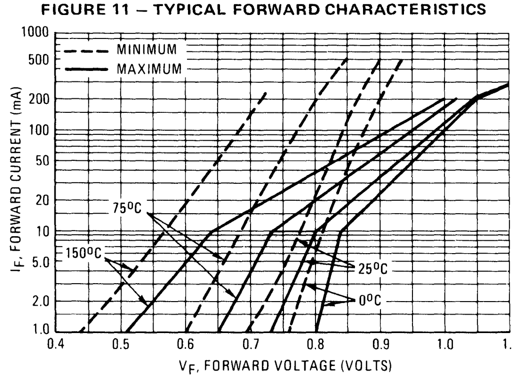


FIGURE 12 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 1 THRU 16 VOLTS

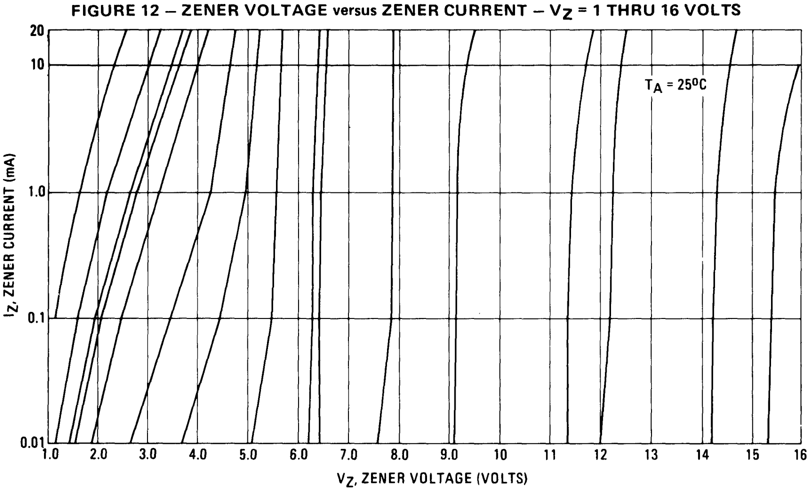


FIGURE 13 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 15 THRU 30 VOLTS

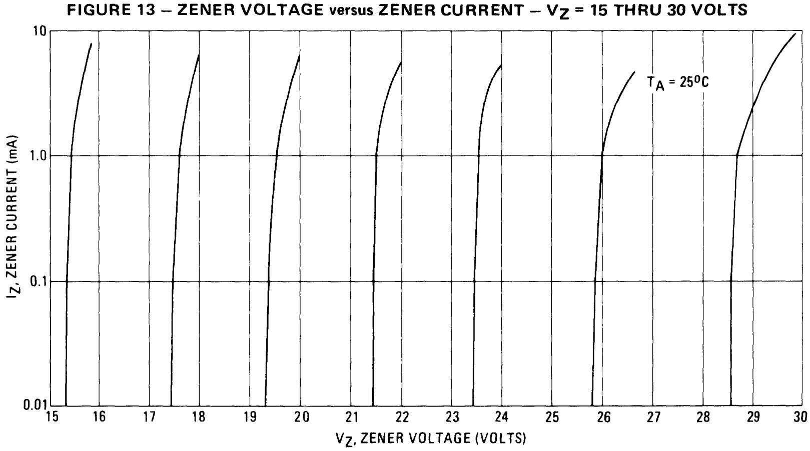
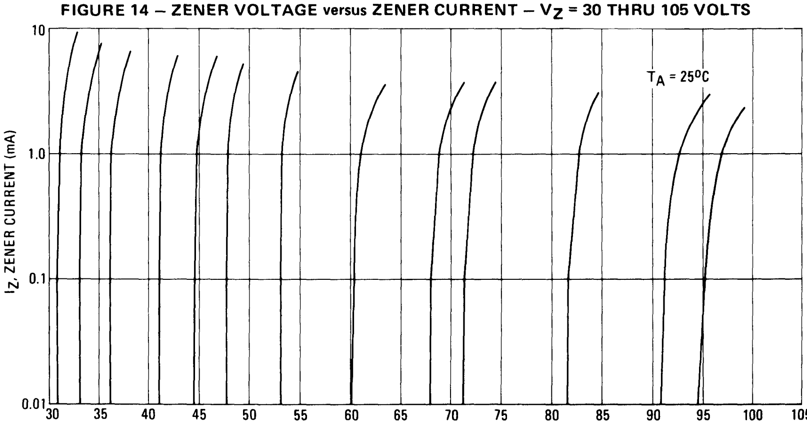


FIGURE 14 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 30 THRU 105 VOLTS



4

1N821,A 1N823,A
1N825,A 1N827,A
1N829,A

MOTOROLA

Designers Data Sheet

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Temperature-compensated zener reference diodes utilizing a nitride passivated junction for long-term voltage stability. A rugged, glass-enclosed, hermetically sealed structure.

Designer's Data for "Worst-Case" Conditions

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

4

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

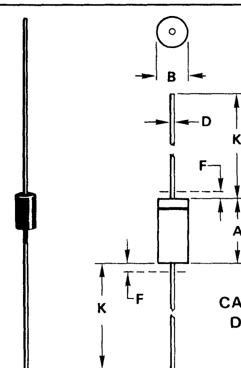
CASE: Hermetically sealed, all-glass
DIMENSIONS: See outline drawing.
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.
POLARITY: Cathode indicated by polarity band.
WEIGHT: 0.2 Gram (approx)
MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. V_Z = 6.2 V ± 5.0%* @ I_{ZT} = 7.5 mA)

JEDEC Type No.	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)
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.

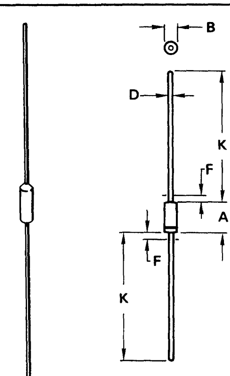
TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES
6.2 V, 400 mW



CASE 299-02
DO-204AH
(DO-35)

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.



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	38.10	1.000	1.500

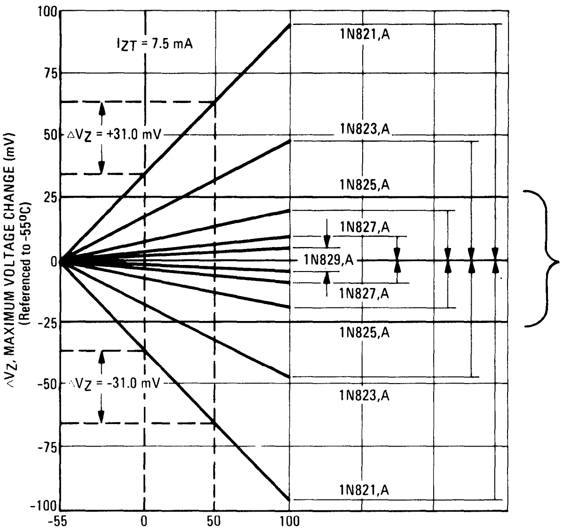
All JEDEC dimensions and notes apply

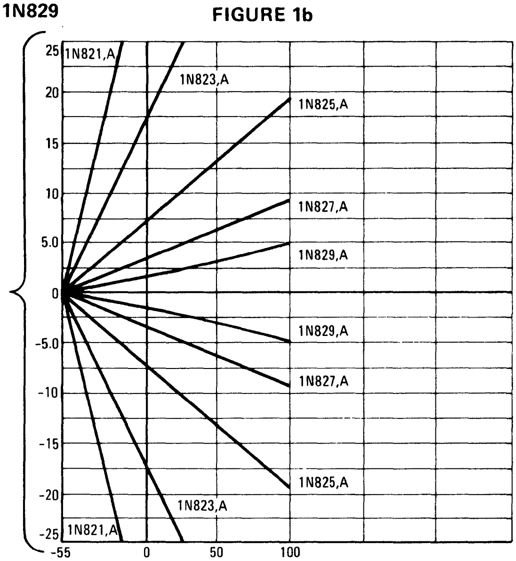
CASE 51-02
DO-204AA
(DO-7)
"A" SUFFIX ONLY

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

(with I_{ZT} = 7.5 mA ±0.01 mA) (See Note 3)

FIGURE 1a — 1N821 thru 1N829 — FIGURE 1b





T_A, AMBIENT TEMPERATURE (°C)

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.

FIGURE 2 – 1N821 SERIES

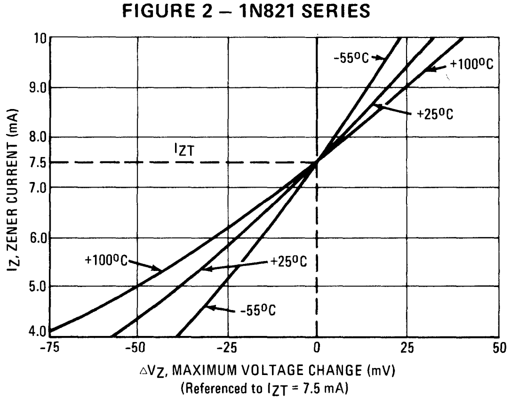
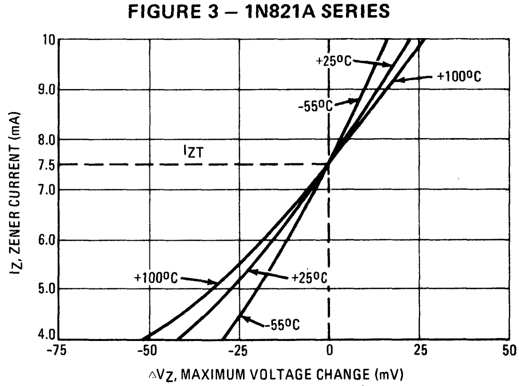


FIGURE 3 – 1N821A SERIES



MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 2)

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

FIGURE 4 – 1N821 SERIES

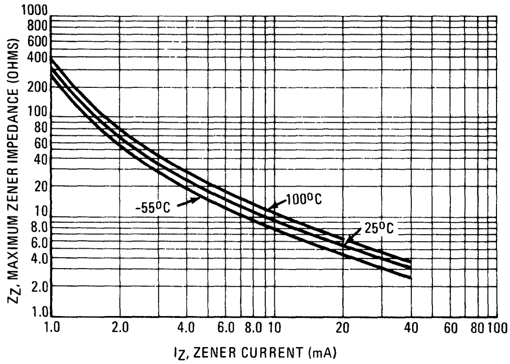
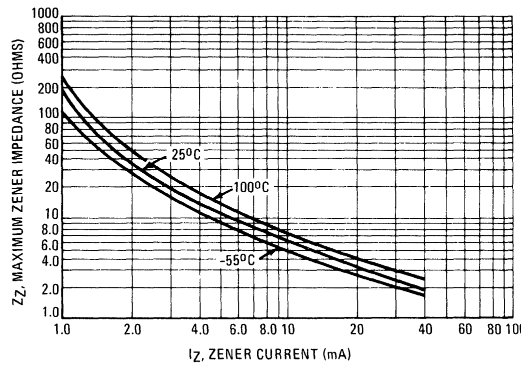


FIGURE 5 – 1N821A SERIES



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.

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}. Curves showing the variation of zener impedance with zener current for each series are given in Figures 4 and 5.

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 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 4:

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).

MOTOROLA

1N935,A,B thru 1N939,A,B

Designer's Data Sheet

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

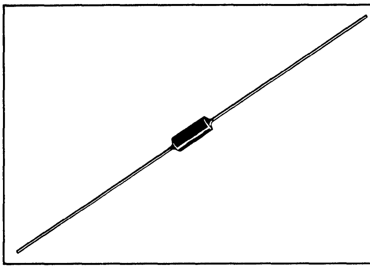
Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. A rugged, glass-enclosed, hermetically sealed structure.

Designer's Data for "Worst Case" Conditions

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

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES

9.0 V, 500 mW



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C
Storage Temperature. -65 to +175°C
DC Power Dissipation: 500 mW @ T_A = 25°C

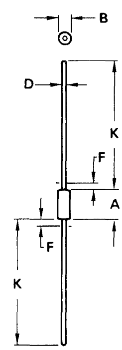
MECHANICAL CHARACTERISTICS

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 V_Z = 9.0 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)
1N935	0.067	0, +25, +75	0.01	20
1N936	0.033		0.005	
1N937	0.013		0.002	
1N938	0.006		0.001	
1N939	0.003		0.0005	
1N935A	0.139	-55, 0, +25, +75, +100	0.01	20
1N936A	0.069		0.005	
1N937A	0.027		0.002	
1N938A	0.013		0.001	
1N939A	0.007		0.0005	
1N935B	0.184	-55, 0, +25, +75, +100, +150	0.01	20
1N936B	0.092		0.005	
1N937B	0.037		0.002	
1N938B	0.018		0.001	
1N939B	0.009		0.0005	

*Tighter-tolerance units available on special request.



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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51
DO-7

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

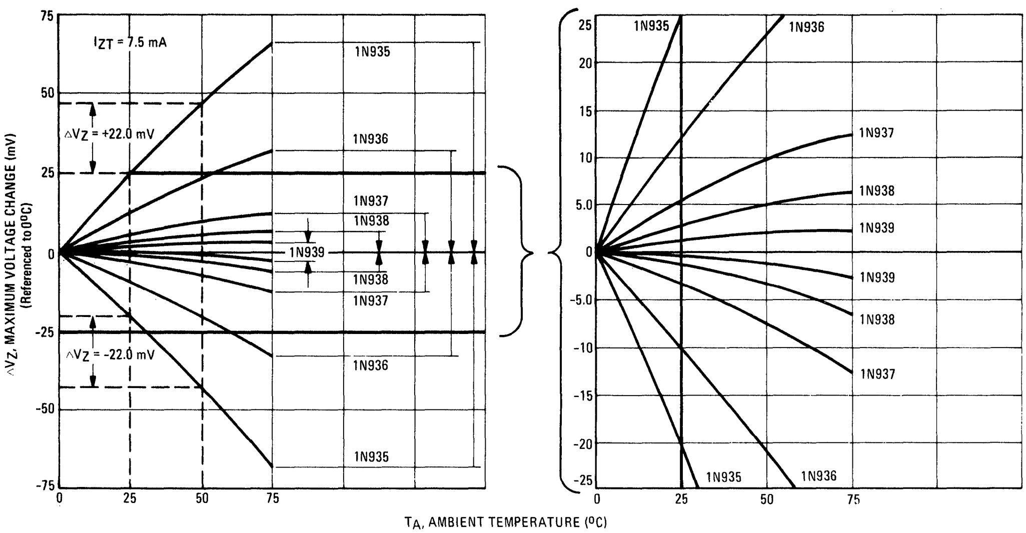
4

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

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

1N935 thru 1N939

FIGURE 1a **FIGURE 1b**

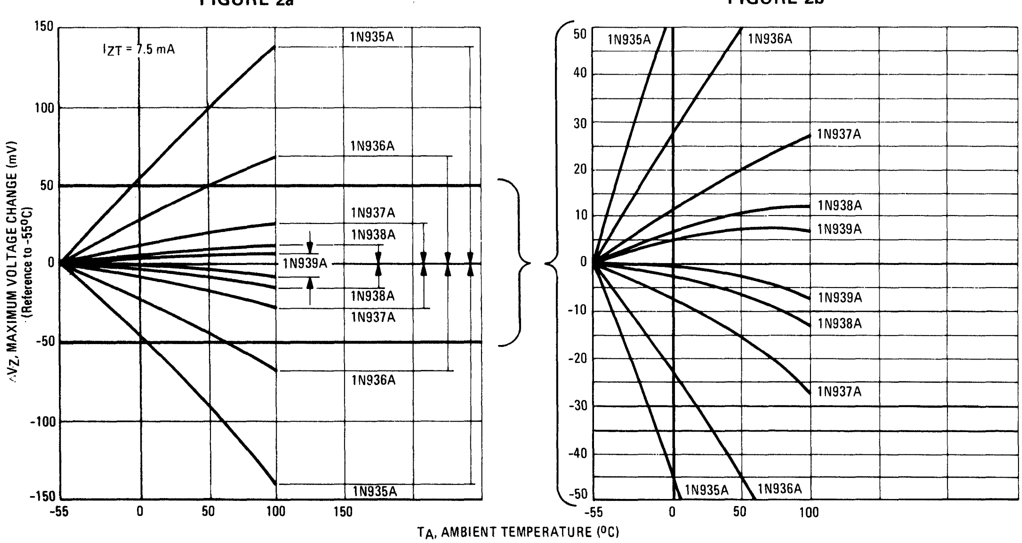


MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

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

1N935A thru 1N939A

FIGURE 2a **FIGURE 2b**



4

MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

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

1N935B thru 1N939B

FIGURE 3a **FIGURE 3b**

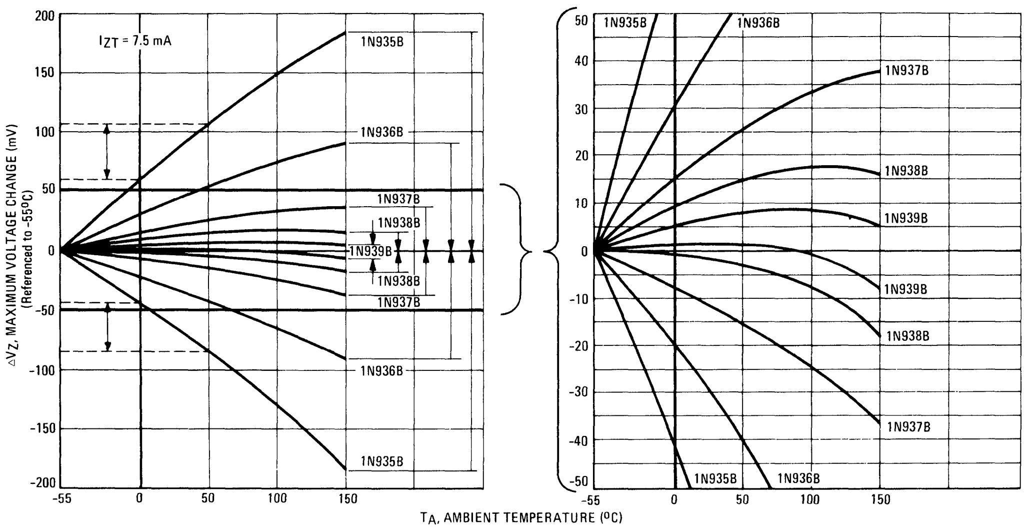


FIGURE 4 — ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)

(See Note 5)

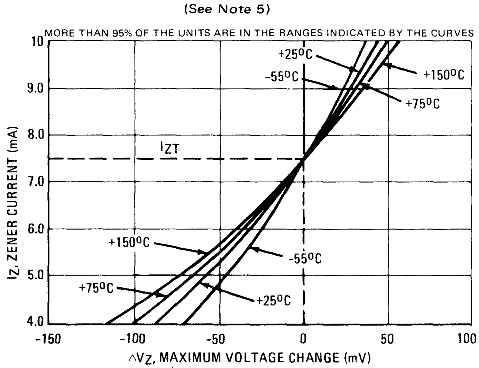
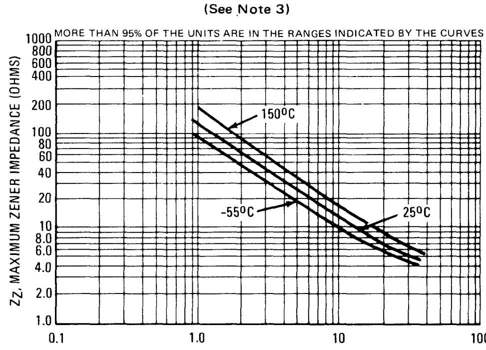


FIGURE 5 — MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)



4

NOTE 1:

Types 1N935B, 1N937B, and 1N939B are available to MIL-S-19500/156 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

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.

4

MOTOROLA

1N941,A,B thru 1N945,A,B

Designer's Data Sheet

TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

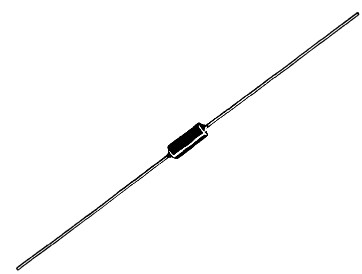
Temperature-compensated zener reference diodes utilizing an oxide-passivated junction for long-term voltage stability. A rugged, glass-enclosed, hermetically sealed structure.

Designer's Data for "Worst Case" Conditions

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

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES

11.7 V, 500 mW

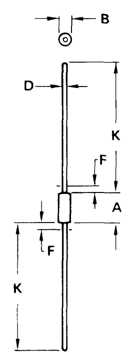


MAXIMUM RATINGS

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



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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02
DO-7

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted V_Z = 11.7 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)
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.

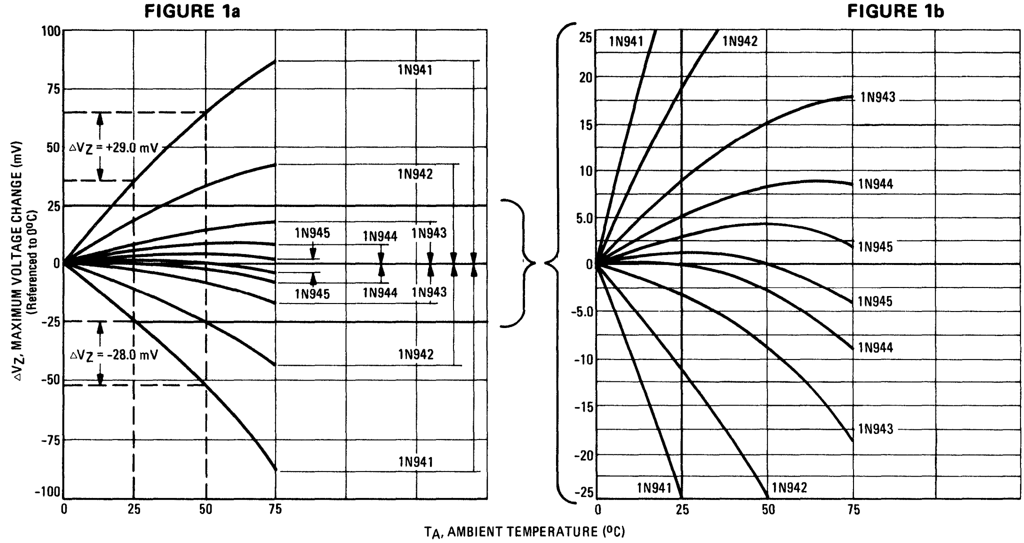
4

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**

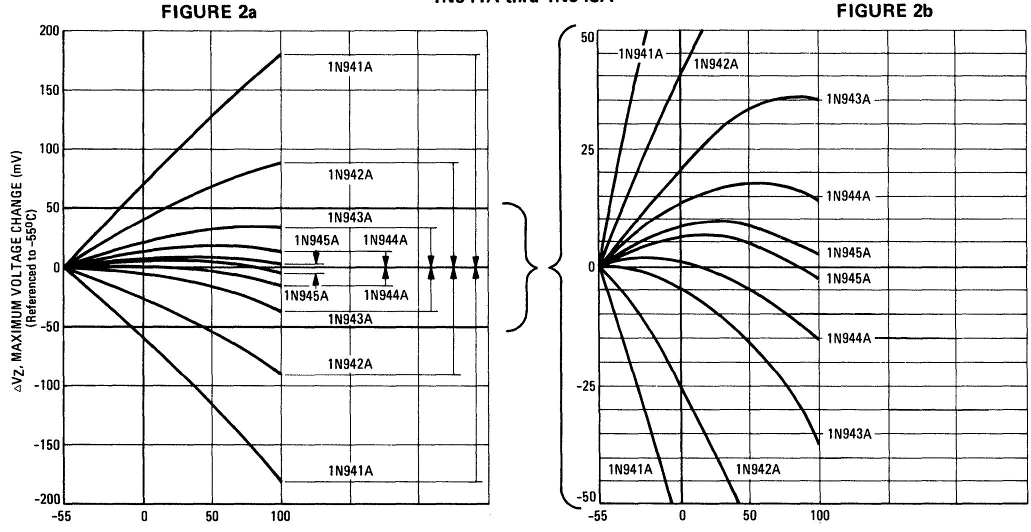


MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

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

1N941A thru 1N945A

FIGURE 2a **FIGURE 2b**



MAXIMUM VOLTAGE CHANGE versus TEMPERATURE

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

1N941B thru 1N945B

FIGURE 3a **FIGURE 3b**

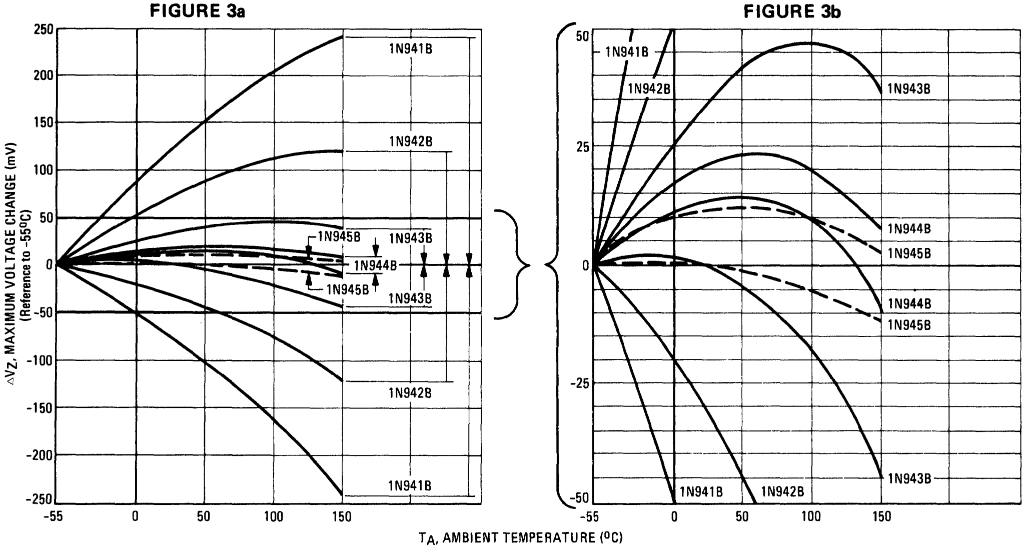


FIGURE 4 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (At specified temperatures)

(See Note 5)

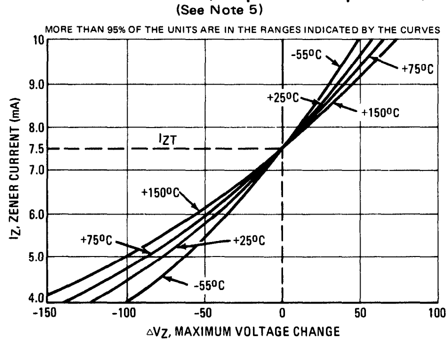


FIGURE 5 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT

(See Note 3)

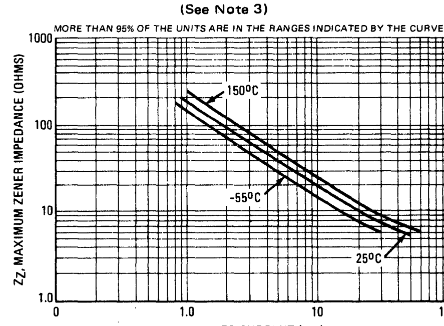


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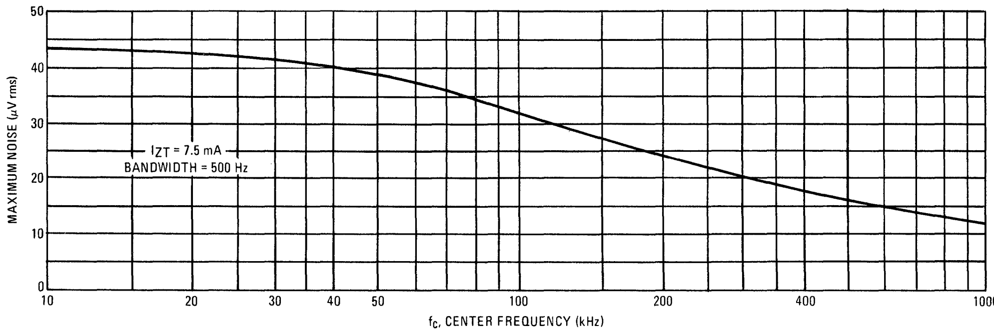
FIGURE 6 — DISTRIBUTION OF MAXIMUM GENERATED NOISE



NOTE 1:

Types 1N941B, 1N943B, and 1N944B are available to MIL-S-19500/157 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

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.

1N957A thru 1N986A
See Page 4-4

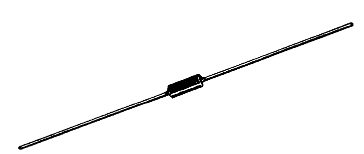
MOTOROLA

1N987A thru 1N992A

Advance Information

400-MILLIWATT

SILICON ZENER DIODES



CONSTANT-VOLTAGE REFERENCES FOR 120 thru 200-VOLT APPLICATIONS

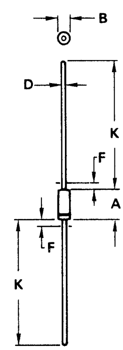
- 400-Milliwatt
- Guaranteed Low Zener Impedance
- Guaranteed Low Leakage Current
- Controlled Forward Characteristics
- Temperature Range: −65 to +175°C
- No Heat Sink Required

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 50^oC$ Derate above $T_L = 50^oC$	P_D	400 3.2	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed all glass case.
DIMENSIONS: See outline drawing.
FINISH: All external surfaces are corrosion resistant with readily solderable leads.
POLARITY: Cathode end indicated by color band. When operated in zener region, the cathode end will be positive with respect to anode end.
WEIGHT: 0.2 grams (approx.)
MOUNTING POSITION: Any



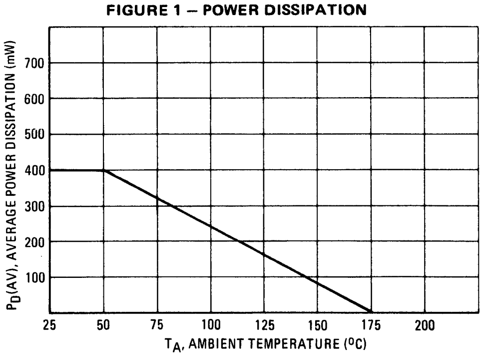
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA
(DO-7)

FIGURE 1 — POWER DISSIPATION



This document contains information on a new product. Specifications and information herein are subject to change without notice.

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max at 200 mA for all types)

Type Number (Note 1)	Nominal Zener Voltage V_Z (Note 2) Volts	Test Current I_{ZT} mA	Maximum Zener Impedance (Note 3)			Maximum DC Zener Current I_{ZM} (Note 4) mA	Maximum Reverse Current (Note 5)		
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Maximum μA	Test Voltage Vdc V_R 5%	Test Voltage Vdc V_R 10%
1N987A	120	1.0	900	4500	0.25	2.5	5.0	91.2	86.4
1N988A	130	0.95	1100	5000	0.25	2.3	5.0	98.8	93.6
1N989A	150	0.85	1500	6000	0.25	2.0	5.0	114	108
1N990A	160	0.80	1700	6500	0.25	1.9	5.0	121.6	115.2
1N991A	180	0.68	2200	7100	0.25	1.7	5.0	136.8	129.6
1N992A	200	0.65	2500	8000	0.25	1.5	5.0	152	144

NOTE 1 — TOLERANCE AND VOLTAGE DESIGNATION

Tolerance Designation

The tolerance designations are as follows:

Suffix A: ±10%
Suffix B: ±5%

Voltage Designation

To designate units with zener voltages other than those listed, a Motorola type number should be used, 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:

0.4 M 115 Z 10

Power Rating — 0.4
Motorola — M
Nominal Voltage — 115
Zener Diode — Z
Tolerance (±%) — 10

Matched Sets for Closer Tolerances or Higher Voltages

Series matched sets make zener voltages in excess of 200 volts or tolerances of less than 5% possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

For Clippers, Parallel Matched Sets or other special circuit requirements, contact your Motorola Representative.

NOTE 2 — ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium with ambient temperature of 25°C.

NOTE 3 — 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}) is superimposed on I_{ZT}.

A cathode ray oscilloscope curve test is used to insure that each zener diode breakdown region begins at a low current level and that zener voltage remains nearly constant to a current level in excess of I_{ZM}.

NOTE 4 — MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

Maximum zener current ratings are based on the maximum voltage of a 20% unit. For closer tolerance units (10% or 5%) or units where the actual zener voltage (V_Z) is known at the operating point, the maximum zener current may be increased and is limited by the derating curve.

NOTE 5 — REVERSE LEAKAGE CURRENT I_R

Reverse leakage currents are guaranteed only for 5% and 10% 400 mW silicon zener diodes and are measured at V_R as shown on the table.

1N2804 thru 1N2846
6.8V thru 200V (Case 54)

1N3305 thru 1N3350
6.8V thru 200V (Case 58)

1N4549 thru 1N4556
3.9V thru 7.5V (Case 58)

1N4557 thru 1N4564
3.9V thru 7.5V (Case 54)

ZENER DIODES

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.

50 WATTS
ZENER DIODES

MAXIMUM RATINGS

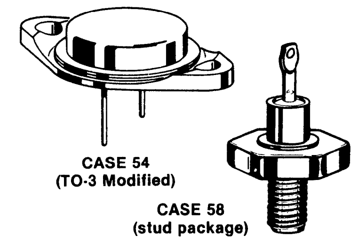
Junction and Storage Temperature: -65°C to +175°C.

DC 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.

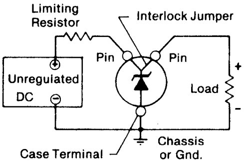
Typical circuit connections for anode-to-case and cathode-to-case polarities (standard and reverse polarities, respectively) are shown below.



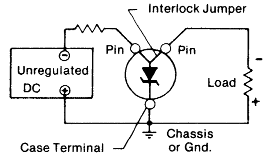
4

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 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

1N2804 thru 1N2846, 1N3305 thru 1N3350, 1N4549 thru 1N4564

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: Z_{ZT} @ I_{ZT} ohms	Max Zener Impedance: Z_{ZK} @ I_{ZK} = 5mA ohms	Max DC Zener Current 75°C Case Temp (I_{ZM})mA	Reverse* Leakage Current: I_RMax (µA)	Reverse* Leakage Current: V_{R1}	Reverse* Leakage Current: V_{R2}	Typical Zener Voltage Temp. Coeff. %/°C
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

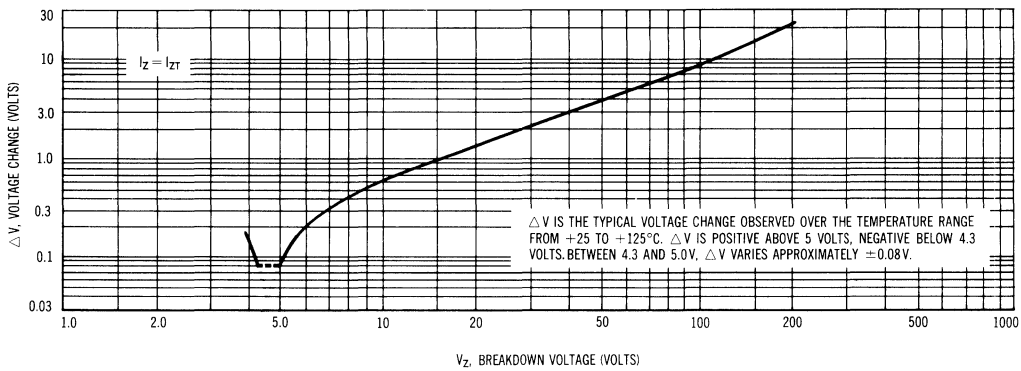


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE

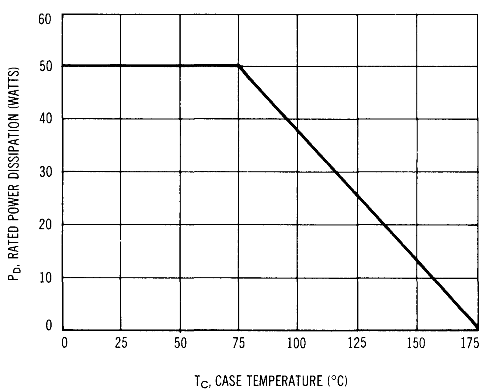


FIGURE 3 — LEAKAGE CURRENT

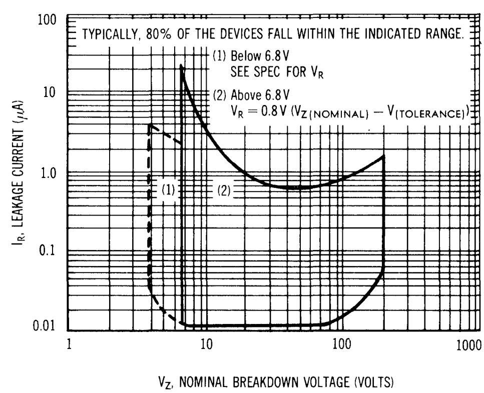
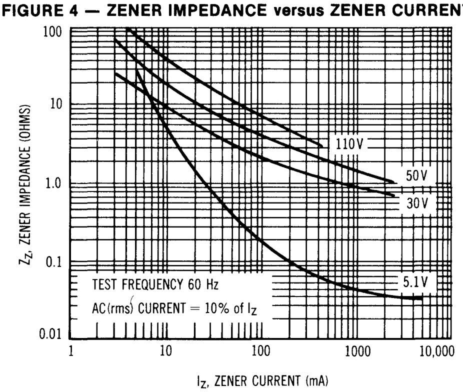
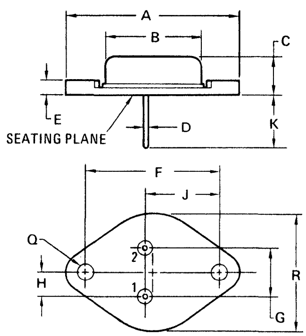


FIGURE 4 — ZENER IMPEDANCE versus ZENER CURRENT



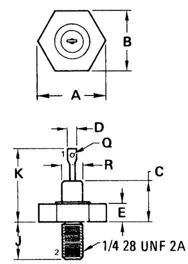


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	–	39.12	–	1.540
B	–	20.70	–	0.815
C	–	7.92	–	0.312
D	1.22	1.30	0.048	0.051
E	2.84	3.05	0.112	0.120
F	29.90	30.40	1.177	1.197
G	10.67	11.18	0.420	0.440
H	5.33	5.59	0.210	0.220
J	16.54	16.79	0.651	0.661
K	8.13	10.67	0.320	0.420
Q	3.84	4.09	0.151	0.161
R	–	26.16	–	1.030

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

STYLE 4:
PIN 1. ANODE
2. ANODE
CASE: CATHODE

CASE 54
(TO-3 Modified)



STYLE 1:
TERM. 1. CATHODE
2. ANODE
STYLE 2:
TERM. 1. ANODE
2. CATHODE

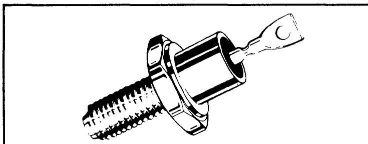
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	18.92	19.18	0.745	0.755
B	16.94	17.45	0.667	0.687
C	–	11.94	–	0.470
D	3.18	NOM	0.125	NOM
E	2.92	5.08	0.115	0.200
J	10.72	11.51	0.422	0.453
K	–	21.34	–	0.840
Q	1.78	NOM	0.070	NOM
R	–	7.11	–	0.280

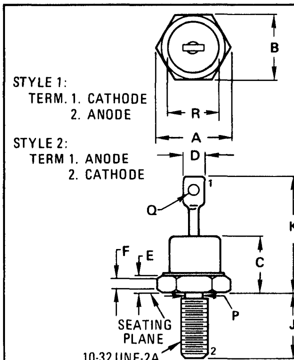
CASE 58
(stud package)

MOTOROLA

1N2970 thru 1N3015

10 WATTS ZENER DIODES





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
DO-4

ZENER DIODES

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.

DC 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 Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	Max DC Zener Current I_{ZM} mA	Max. Reverse Current* 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

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

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}
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
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

*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 — Device Description
M — Motorola
90 — Nominal Voltage
Z — Zener Diode
3 — Tolerance (±%)

Example: 10M90Z3

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: 10M51Z5B1

(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.

(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 — 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

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

1N3016 thru 1N3051
See Page 4-34

MOTOROLA

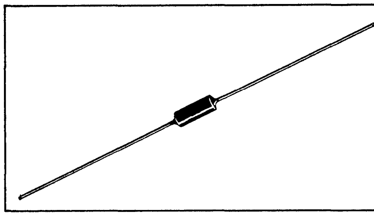
1N3154,A thru 1N3157,A

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES

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

TEMPERATURE-COMPENSATED SILICON ZENER REFERENCE DIODES

8.9 V, 500 mW



MAXIMUM RATINGS

Junction Temperature: -55 to +175°C
Storage Temperature: -65 to +175°C
DC Power Dissipation: 500 mW @ T_A = 25°C

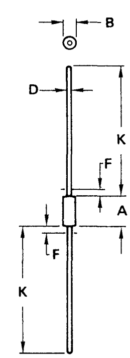
MECHANICAL CHARACTERISTICS

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 Grams (approx)
MOUNTING POSITION: Any

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted V_Z = 8.4 V ±5.0%* @ I_{ZT} = 10 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)
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



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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51
DO-7

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

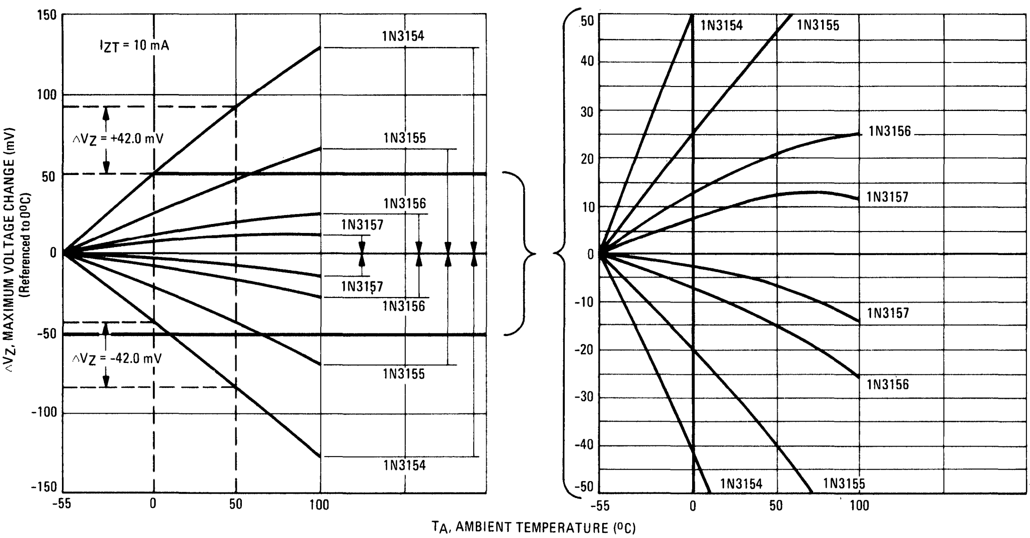
4

MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

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

1N3154 thru 1N3157

FIGURE 1a **FIGURE 1b**



MAXIMUM VOLTAGE CHANGE versus AMBIENT TEMPERATURE

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

1N3154A thru 1N3157A

FIGURE 2a **FIGURE 2b**

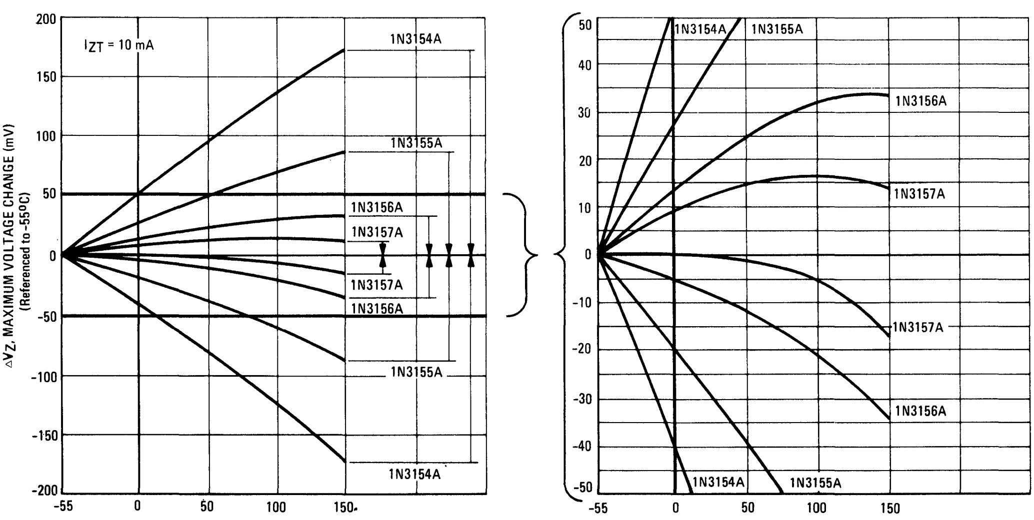


FIGURE 3 – ZENER CURRENT versus MAXIMUM VOLTAGE CHANGE (at specified temperatures)
(See Note 5)

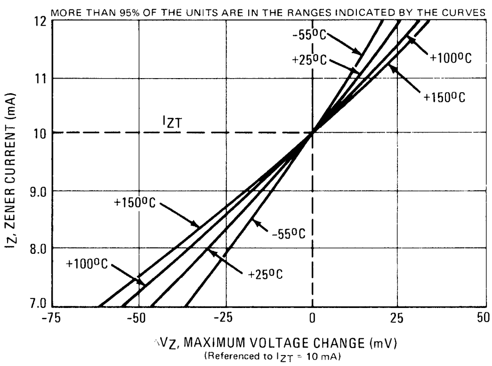


FIGURE 4 – MAXIMUM ZENER IMPEDANCE versus ZENER CURRENT
(See Note 3)

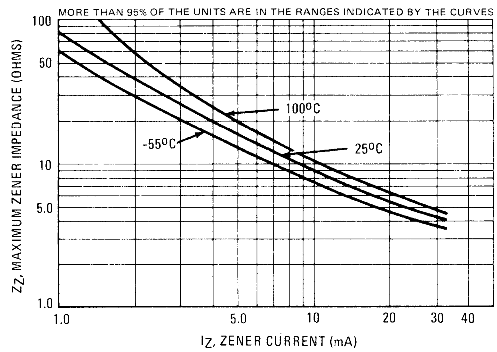
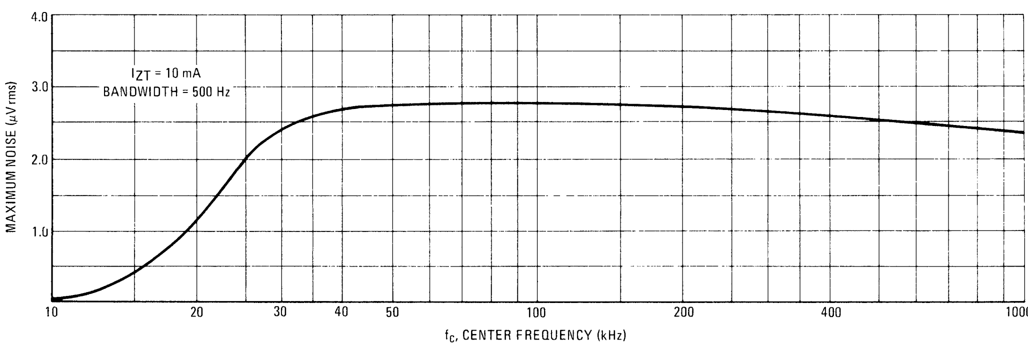


FIGURE 5 – DISTRIBUTION OF MAXIMUM GENERATED NOISE



4

NOTE 1:

Types 1N3154 thru 1N3157 are available to MIL-S-19500/158 and MEG-A-LIFE II, Levels 1, 2, & 3, specifications.

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.

1N3305 thru 1N3350
See Page 4-23

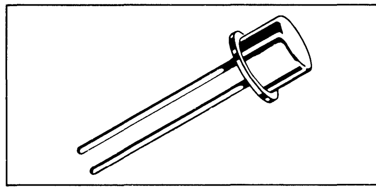
1N3785 thru 1N3820

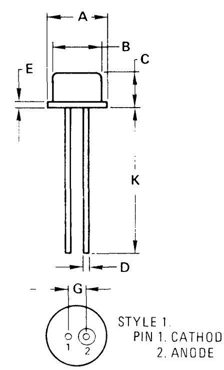
MOTOROLA

1.5 WATTS
ZENER DIODES

ZENER DIODES

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





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	--	10.59	--	0.417
B	–	8.59	--	0.338
C	–	6.50	–	0.256
D	0.99	1.09	0.039	0.043
E	–	1.19	–	0.047
G	2.92	3.43	0.115	0.135
K	22.35	25.40	0.880	1.000

CASE 55

MAXIMUM RATINGS

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

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

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			Max DC Zener Current (I_{ZM}) mA	Reverse Leakage Current*			Typical Zener Voltage Temp. Coeff. %/°C
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA		I_R Max (µA)	V_{R1}	V_{R2}	
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
SERIES
(1M3.3AZ10 thru 1M7.5AZ10)
1N3016 thru 1N3051
SERIES
(1M6.8Z thru 1M200Z)

MOTOROLA

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.

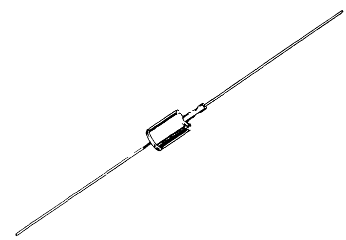
- To 100 Watts Surge Rating @ 10 ms
- Maximum Limits Guaranteed on Five Electrical Parameters
- Power Capability to MIL-S-19500 Specifications

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



4

*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.

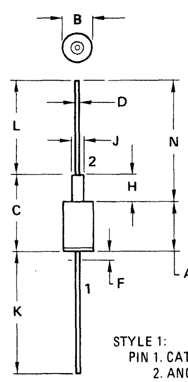
DIMENSIONS: See outline drawing.

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



STYLE 1:
PIN 1. CATHODE
2. ANODE

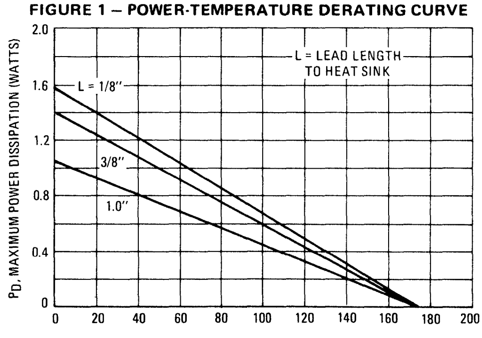
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	7.44	9.07	0.293	0.357
B	5.46	5.97	0.215	0.235
C	–	14.48	–	0.570
D	0.64	0.89	0.025	0.035
F	–	4.78	–	0.188
J	1.14	2.54	0.045	0.100
K	25.40	41.28	1.000	1.625
L	25.40	41.28	1.000	1.625

All JEDEC dimensions and notes apply

CASE 52-03
DO-13

NOTE:
1. ALL RULES AND NOTES ASSOCIATED WITH DO-13 OUTLINE SHALL APPLY.

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 – 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 – 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
1 – Overall Tolerance of set (±1%)

Code
A – Not used
B – Two devices in series
C – Three devices in series
D – Four devices in series

EXAMPLE **1M51Z5B1**

4

(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.

4

TEMPERATURE COEFFICIENTS AND VOLTAGE REGULATION

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

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

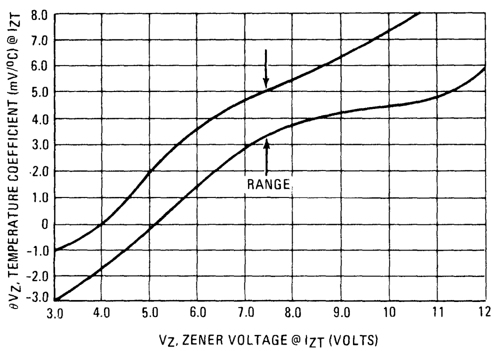


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

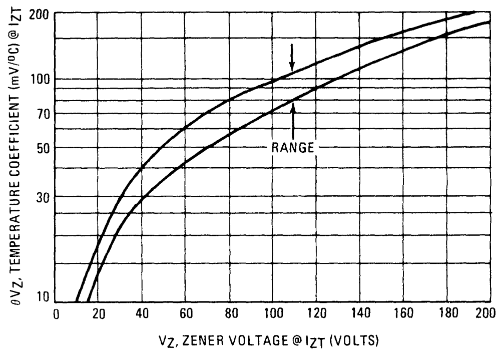


FIGURE 4 – TYPICAL VOLTAGE REGULATION

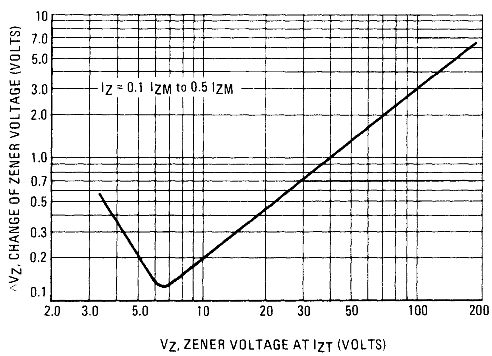


FIGURE 5 – MAXIMUM REVERSE LEAKAGE (95% OF THE UNITS ARE BELOW THE VALUES SHOWN)

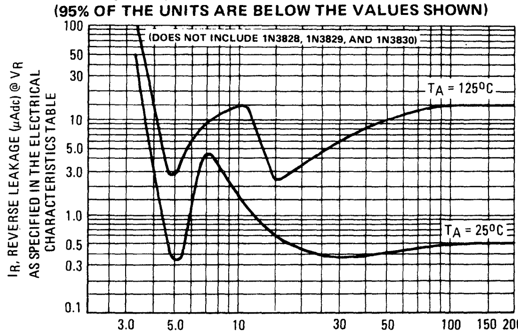


FIGURE 6 – TYPICAL THERMAL RESPONSE L, LEAD LENGTH = 3/8 INCH

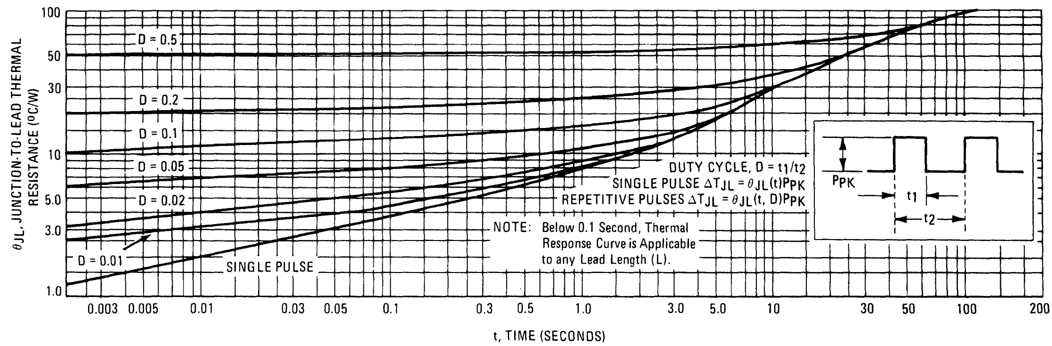


FIGURE 7 – TYPICAL THERMAL RESISTANCE

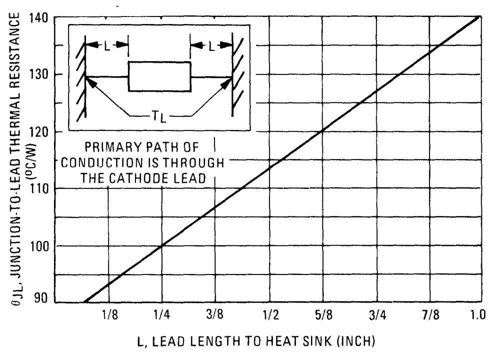


FIGURE 8 – MAXIMUM NON-REPETITIVE SURGE CURRENT

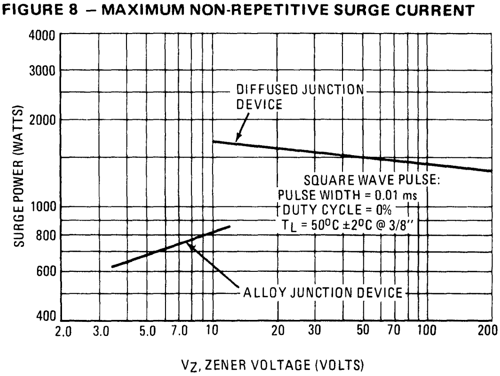


FIGURE 9 – SURGE POWER FACTOR

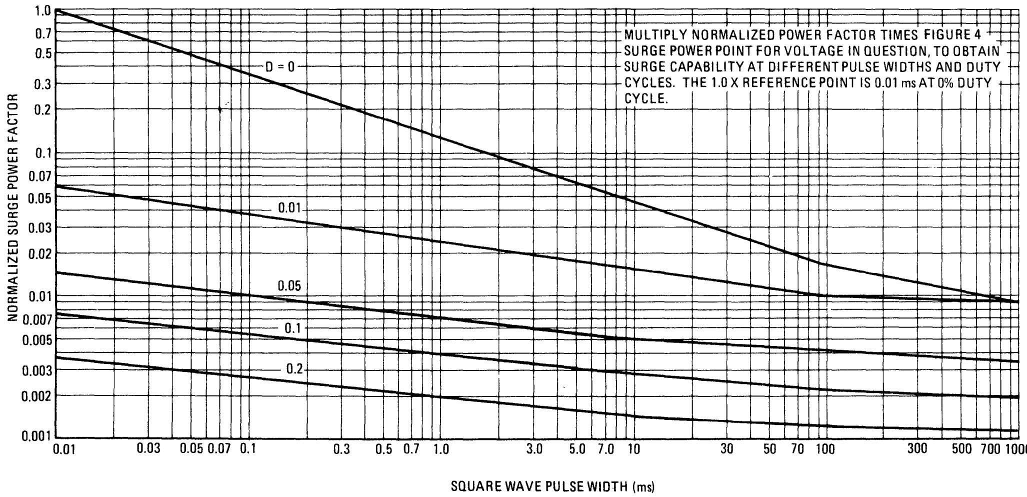
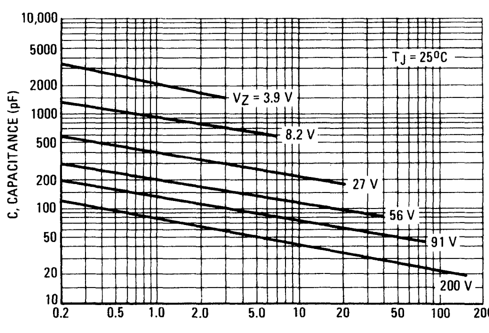


FIGURE 10 – TYPICAL CAPACITANCE



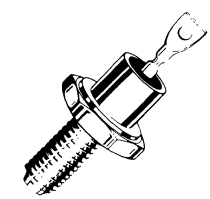
1N3993
thru
1N4000

MOTOROLA

ZENER DIODES

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

10 WATTS
ZENER DIODES

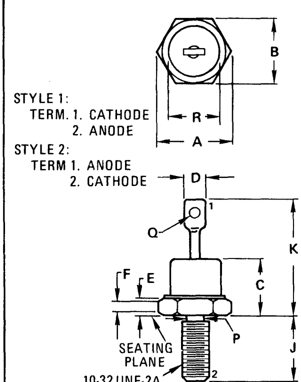


4

MAXIMUM RATINGS

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



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	11.94	12.83	0.470	0.505
B	10.77	11.10	0.424	0.437
C	–	10.29	–	0.405
D	–	6.35	–	0.250
E	1.91	4.45	0.075	0.175
F	1.52	–	0.060	–
J	10.72	11.51	0.422	0.453
K	–	20.32	–	0.800
P	4.14	4.80	0.163	0.189
Q	1.52	–	0.060	–
R	–	10.77	–	0.424

All JEDEC dimensions and notes apply

CASE 56
DO-4

ELECTRICAL CHARACTERISTICS ($T_B = 30\,°C \pm 3$, $V_F = 1.5$ 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 Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ $I_{ZK} = 1.0$ mA Ohms	Max DC Zener Current I_{ZM} mA	Reverse Leakage Current I_R µA	Reverse Leakage Current 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
Device Description	Motorola	Nominal Voltage	Alloy	Zener Diode	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
Device Description	Motorola	5.1 Volts (each device)	Alloy	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: 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
Device Description	Motorola	Nominal Voltage	Alloy	Zener Diodes	Clipper	Tolerance for each of the two Zener voltages (not a matching requirement)

Example: 10M4.7AZZ10

4

1N4099 thru 1N4135
1N4614 thru 1N4627

MOTOROLA

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

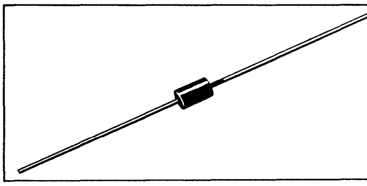
SILICON ZENER DIODES

(±5.0% TOLERANCE)

250 MILLIWATTS

1.8–100 VOLTS

SILICON OXIDE PASSIVATED JUNCTION



4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.43	mW mW/°C
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass.

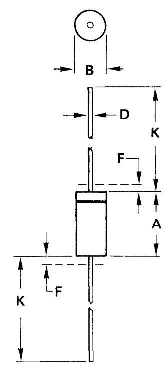
DIMENSIONS: See outline drawing.

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



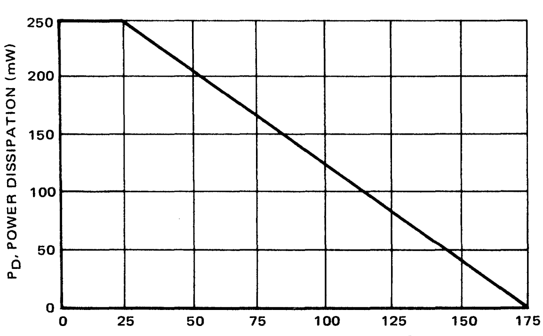
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH
(DO-35)

POWER TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS

(At 25°C Ambient temperature unless otherwise specified) 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)
1N4614	1.8	1200	7.5		1.0	1.0	120
1N4615	2.0	1250	5.0		1.0	1.0	110
1N4616	2.2	1300	4.0		1.0	1.0	100
1N4617	2.4	1400	2.0		1.0	1.0	95
1N4618	2.7	1500	1.0		1.0	1.0	90
1N4619	3.0	1600	0.8		1.0	1.0	85
1N4620	3.3	1650	7.5		1.5	1.0	80
1N4621	3.6	1700	7.5		2.0	1.0	75
1N4622	3.9	1650	5.0		2.0	1.0	70
1N4623	4.3	1600	4.0		2.0	1.0	65
1N4624	4.7	1550	10		3.0	1.0	60
1N4625	5.1	1500	10		3.0	2.0	55
1N4626	5.6	1400	10		4.0	4.0	50
1N4627	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.

4

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.

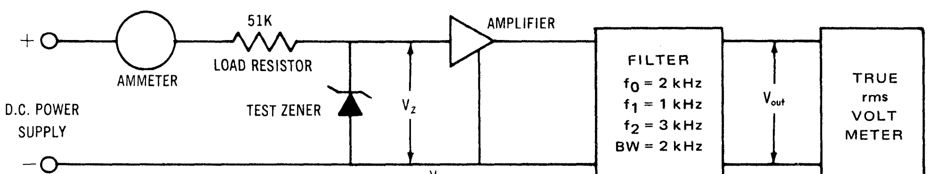
Motorola is rating this series with a maximum noise density at 250 microamperes. The rating of microvolts RMS per square root cycle enables calculation of the maximum RMS noise for any bandwidth.

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



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

WHERE: BW = FILTER BANDWIDTH (CYCLES)

V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 2 — TYPICAL NOISE DENSITY versus ZENER CURRENT

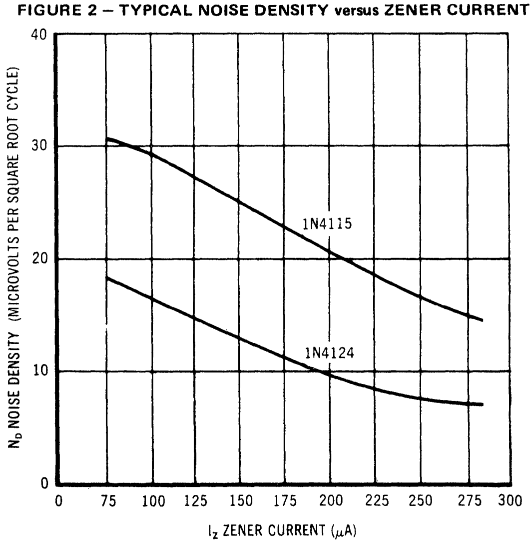


FIGURE 3 — TYPICAL CAPACITANCE

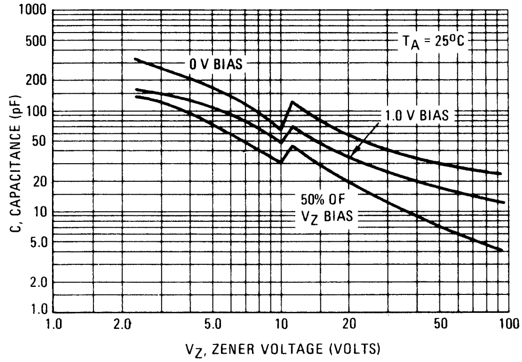
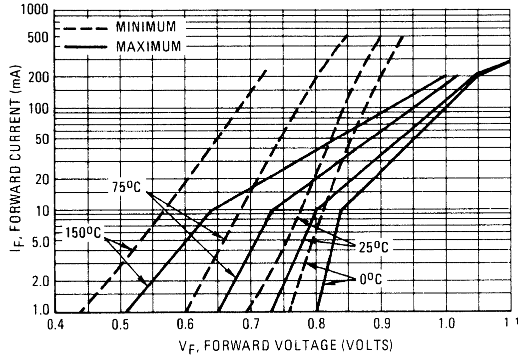


FIGURE 4 — TYPICAL FORWARD CHARACTERISTICS



4

1N4370 thru 1N4372 See Page 4-4

1N4549 thru 1N4564 See Page 4-23

MOTOROLA

1N4565 thru 1N4584
1N4765 thru 1N4784

REFERENCE DIODES

LOW LEVEL TEMPERATURE-COMPENSATED ZENER

LOW-LEVEL TEMPERATURE-COMPENSATED ZENER REFERENCE DIODES

Highly reliable reference sources utilizing a nitride/oxide-passivated junction for long-term voltage stability. Glass construction provides a rugged, hermetically sealed structure.

- **Low Power Drain Devices Specified @ 0.5 mA, 1.0 mA, 2.0 mA, and 4.0 mA**
- Maximum Voltage Change Specified over Test Temperature Range
- Temperature Compensation Guaranteed over Two Standard Operating Temperature Ranges:
  0 to 75°C
  -55 to 100°C

4

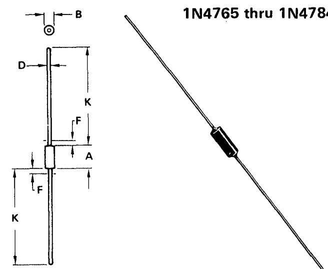
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A = 50°C$ Derate above 50°C	P_D	400 3.2	mW mW/°C
Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +175	°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

1N4765 thru 1N4784



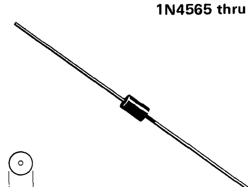
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

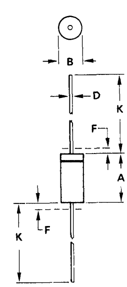
DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	5.84	7.62	0.230	0.300
B	2.16	2.72	0.085	0.107
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02 DO-204AA (DO-7)

1N4565 thru 1N4584





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02 DO-204AH (DO-35)

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		0.005	
$V_Z = 6.4$ 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.

1N4614 thru 1N4627
See Page 4-42

MOTOROLA

1N4678 thru 1N4717

ZENER REGULATOR DIODES

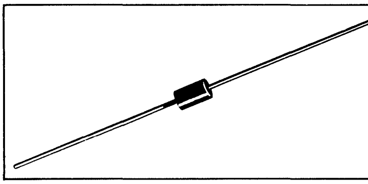
250 MILLIWATTS

ZENER REGULATOR DIODES

Low level nitride passivated zener diodes for applications requiring extremely low operating currents, low leakage, and sharp breakdown voltage.

- Zener Voltage Specified @ I_{ZT} = 50 μA
- Maximum Delta V_Z Given from 10 to 100 μA

4



ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 50°C Derate above T_A = 50°C	P_D	250 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed all glass case.

DIMENSIONS: See outline drawing.

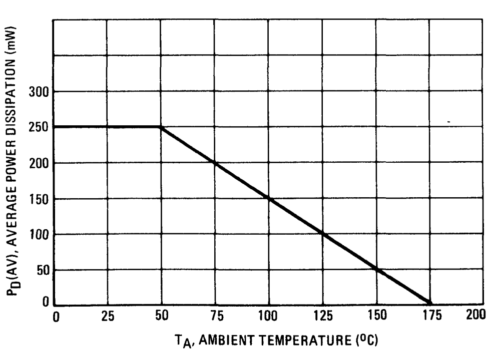
FINISH: All external surfaces are corrosion resistant with readily solerable leads.

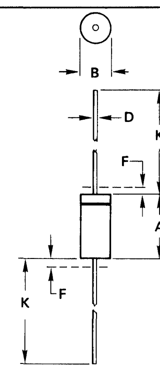
POLARITY: Cathode end indicated by color band. When operated in zener region, the cathode end will be positive with respect to anode end.

WEIGHT: 0.2 grams (approx.)

MOUNTING POSITION: Any.

FIGURE 1 — POWER TEMPERATURE DERATING CURVE





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204 AH

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max at I_F = 100 mA for all types)

Type Number (Note 1)	Zener Voltage V_Z @ I_{ZT} = 50 μA Volts Nom (Note 1)	Min	Max	Maximum Reverse Current I_R μA (Note 3)	Test Voltage V_R Volts (Note 3)	Maximum Zener Current I_{ZM} mA (Note 2)	Maximum Voltage Change ΔV_Z Volts (Note 4)
1N4678	1.8	1.710	1.890	7.5	1.0	120	0.70
1N4679	2.0	1.900	2.100	5.0	1.0	110	0.70
1N4680	2.2	2.090	2.310	4.0	1.0	100	0.75
1N4681	2.4	2.280	2.520	2.0	1.0	95	0.80
1N4682	2.7	2.565	2.835	1.0	1.0	90	0.85
1N4683	3.0	2.850	3.150	0.8	1.0	85	0.90
1N4684	3.3	3.135	3.465	7.5	1.5	80	0.95
1N4685	3.6	3.420	3.780	7.5	2.0	75	0.95
1N4686	3.9	3.705	4.095	5.0	2.0	70	0.97
1N4687	4.3	4.085	4.515	4.0	2.0	65	0.99
1N4688	4.7	4.465	4.935	10	3.0	60	0.99
1N4689	5.1	4.845	5.355	10	3.0	55	0.97
1N4690	5.6	5.320	5.880	10	4.0	50	0.96
1N4691	6.2	5.890	6.510	10	5.0	45	0.95
1N4692	6.8	6.460	7.140	10	5.1	35	0.90
1N4693	7.5	7.125	7.875	10	5.7	31.8	0.75
1N4694	8.2	7.790	8.610	1.0	6.2	29.0	0.50
1N4695	8.7	8.265	9.135	1.0	6.6	27.4	0.10
1N4696	9.1	8.645	9.555	1.0	6.9	26.2	0.08
1N4697	10	9.500	10.50	1.0	7.6	24.8	0.10
1N4698	11	10.45	11.55	0.05	8.4	21.6	0.11
1N4699	12	11.40	12.60	0.05	9.1	20.4	0.12
1N4700	13	12.35	13.65	0.05	9.8	19.0	0.13
1N4701	14	13.30	14.70	0.05	10.6	17.5	0.14
1N4702	15	14.25	15.75	0.05	11.4	16.3	0.15
1N4703	16	15.20	16.80	0.05	12.1	15.4	0.16
1N4704	17	16.15	17.85	0.05	12.9	14.5	0.17
1N4705	18	17.10	18.90	0.05	13.6	13.2	0.18
1N4706	19	18.05	19.95	0.05	14.4	12.5	0.19
1N4707	20	19.00	21.00	0.01	15.2	11.9	0.20
1N4708	22	20.90	23.10	0.01	16.7	10.8	0.22
1N4709	24	22.80	25.20	0.01	18.2	9.9	0.24
1N4710	25	23.75	26.25	0.01	19.0	9.5	0.25
1N4711	27	25.65	28.35	0.01	20.4	8.8	0.27
1N4712	28	26.60	29.40	0.01	21.2	8.5	0.28
1N4713	30	28.50	31.50	0.01	22.8	7.9	0.30
1N4714	33	31.35	34.65	0.01	25.0	7.2	0.33
1N4715	36	34.20	37.80	0.01	27.3	6.6	0.36
1N4716	39	37.05	40.95	0.01	29.6	6.1	0.39
1N4717	43	40.85	45.15	0.01	32.6	5.5	0.43

NOTES:

1. **TOLERANCE AND VOLTAGE DESIGNATION (V_Z)**
   The type numbers shown have a standard tolerance of ±5% on the nominal Zener voltage.
2. **MAXIMUM ZENER CURRENT RATINGS (I_{ZM})**
   Maximum Zener current ratings are based on maximum Zener voltage of the individual units.
3. **REVERSE LEAKAGE CURRENT (I_R)**
   Reverse leakage currents are guaranteed and measured at V_R as shown on the table.
4. **MAXIMUM VOLTAGE CHANGE (ΔV_Z)**
   Voltage change is equal to the difference between V_Z at 100 μA and V_Z at 10 μA.

1N4728,A
thru
1N4764,A

MOTOROLA

Designers Data Sheet

ONE WATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 3.3 to 100 Volts
- DO-41 Package — Smaller than Conventional DO-7 Package
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die

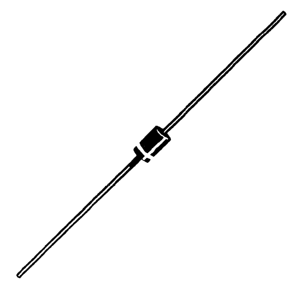
Designer's Data for "Worst Case" Conditions

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

3.3–100 VOLTS



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*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
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

MECHANICAL CHARACTERISTICS

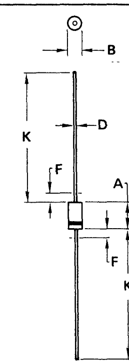
CASE: Double slug type, hermetically sealed glass

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16" from case for 10 seconds

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

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

MOUNTING POSITION: Any

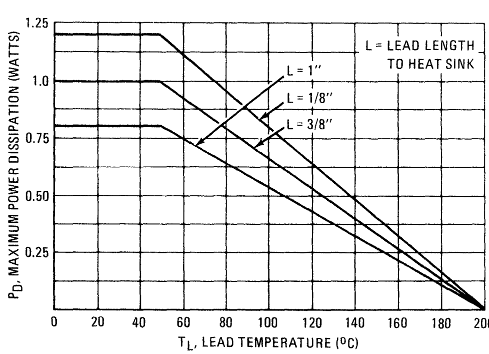


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

CASE 59-03
DO-41

NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

FIGURE 1 — POWER TEMPERATURE DERATING CURVE



*Indicates JEDEC Registered Data

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted) V_F = 1.2 V max, I_F = 200 mA for all types.

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Notes 2 and 3)	Test Current I_{ZT} mA	Maximum Zener Impedance (Note 4)			Leakage Current		Surge Current @ T_A = 25°C i_r – mA (Note 5)
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	I_R µA Max	V_R Volts	
1N4728	3.3	76	10	400	1.0	100	1.0	1380
1N4729	3.6	69	10	400	1.0	100	1.0	1260
1N4730	3.9	64	9.0	400	1.0	50	1.0	1190
1N4731	4.3	58	9.0	400	1.0	10	1.0	1070
1N4732	4.7	53	8.0	500	1.0	10	1.0	970
1N4733	5.1	49	7.0	550	1.0	10	1.0	890
1N4734	5.6	45	5.0	600	1.0	10	2.0	810
1N4735	6.2	41	2.0	700	1.0	10	3.0	730
1N4736	6.8	37	3.5	700	1.0	10	4.0	660
1N4737	7.5	34	4.0	700	0.5	10	5.0	605
1N4738	8.2	31	4.5	700	0.5	10	6.0	550
1N4739	9.1	28	5.0	700	0.5	10	7.0	500
1N4740	10	25	7.0	700	0.25	10	7.6	454
1N4741	11	23	8.0	700	0.25	5.0	8.4	414
1N4742	12	21	9.0	700	0.25	5.0	9.1	380
1N4743	13	19	10	700	0.25	5.0	9.9	344
1N4744	15	17	14	700	0.25	5.0	11.4	304
1N4745	16	15.5	16	700	0.25	5.0	12.2	285
1N4746	18	14	20	750	0.25	5.0	13.7	250
1N4747	20	12.5	22	750	0.25	5.0	15.2	225
1N4748	22	11.5	23	750	0.25	5.0	16.7	205
1N4749	24	10.5	25	750	0.25	5.0	18.2	190
1N4750	27	9.5	35	750	0.25	5.0	20.6	170
1N4751	30	8.5	40	1000	0.25	5.0	22.8	150
1N4752	33	7.5	45	1000	0.25	5.0	25.1	135
1N4753	36	7.0	50	1000	0.25	5.0	27.4	125
1N4754	39	6.5	60	1000	0.25	5.0	29.7	115
1N4755	43	6.0	70	1500	0.25	5.0	32.7	110
1N4756	47	5.5	80	1500	0.25	5.0	35.8	95
1N4757	51	5.0	95	1500	0.25	5.0	38.8	90
1N4758	56	4.5	110	2000	0.25	5.0	42.6	80
1N4759	62	4.0	125	2000	0.25	5.0	47.1	70
1N4760	68	3.7	150	2000	0.25	5.0	51.7	65
1N4761	75	3.3	175	2000	0.25	5.0	56.0	60
1N4762	82	3.0	200	3000	0.25	5.0	62.2	55
1N4763	91	2.8	250	3000	0.25	5.0	69.2	50
1N4764	100	2.5	350	3000	0.25	5.0	76.0	45

*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,

B. Matched sets.

For detailed information on price, availability, and delivery, contact your nearest Motorola representative.

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 Figure 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 to 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 as follows:

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

θ_{JL} may be determined from Figure 3 for dc power conditions. 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 Figure 2.

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.

Surge limitations are given in Figure 5. 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 5 be exceeded.

FIGURE 2 – TEMPERATURE COEFFICIENTS
(–55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

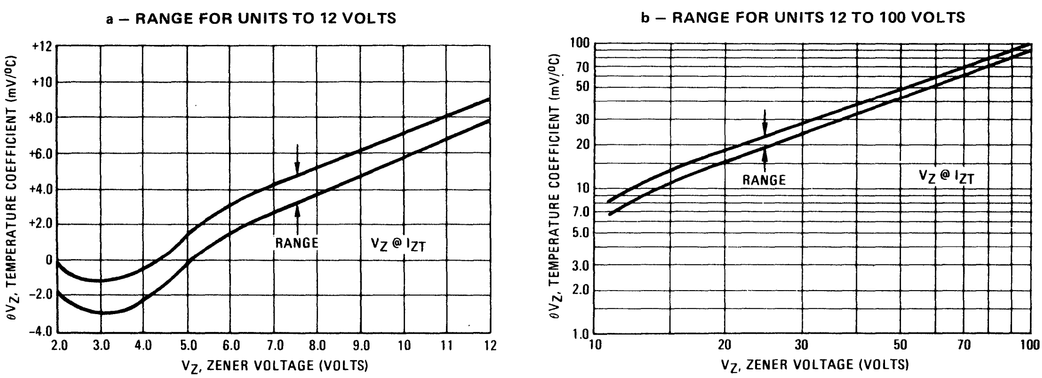


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FIGURE 3 – TYPICAL THERMAL RESISTANCE versus LEAD LENGTH

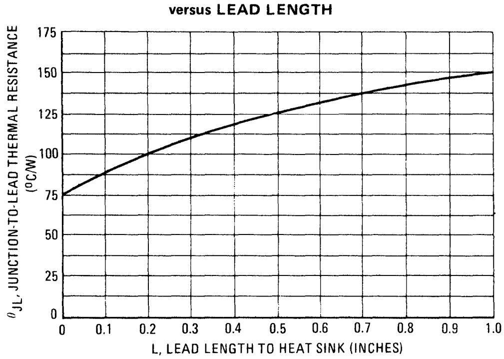


FIGURE 4 – EFFECT OF ZENER CURRENT

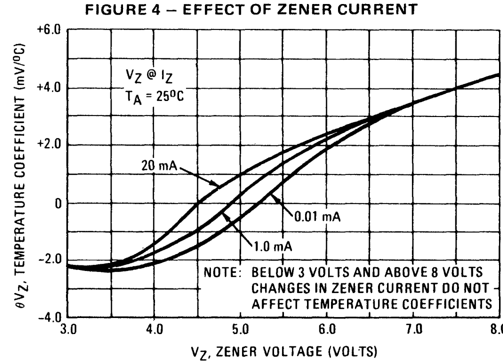
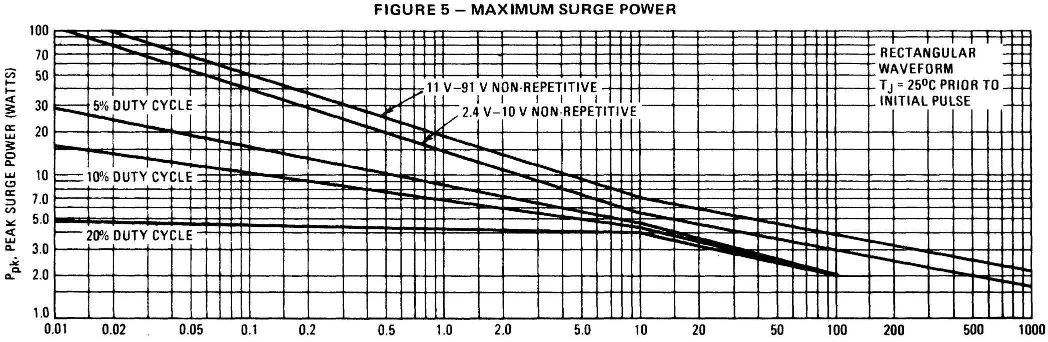


FIGURE 5 – MAXIMUM SURGE POWER



This graph represents 90 percentile data points.
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 6 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

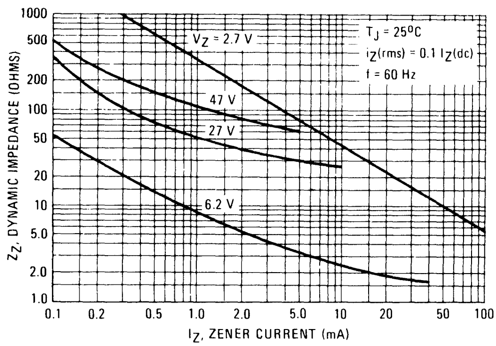


FIGURE 7 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

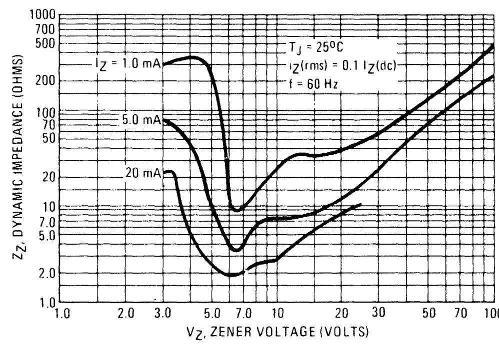


FIGURE 8 — TYPICAL LEAKAGE CURRENT

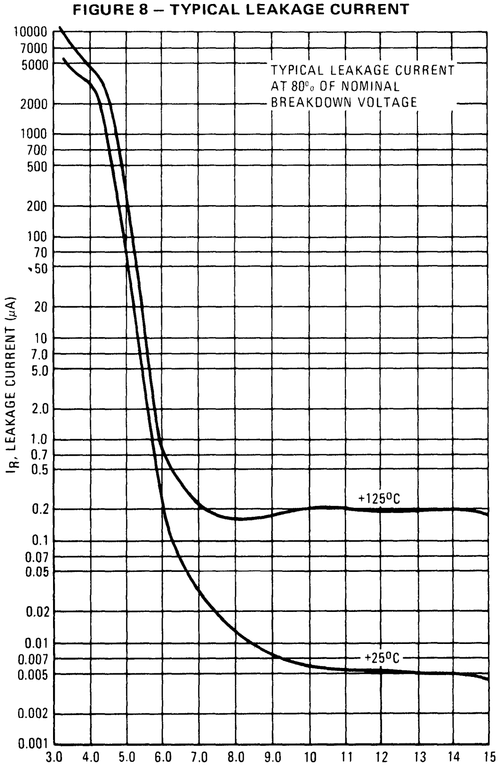


FIGURE 9 — TYPICAL CAPACITANCE versus V_Z

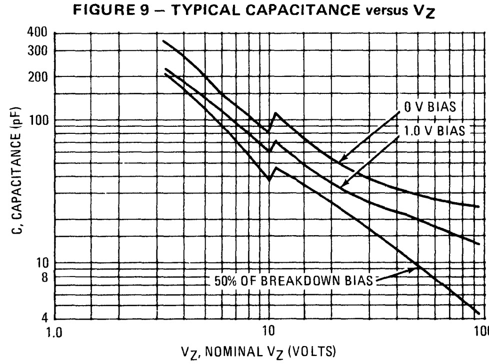
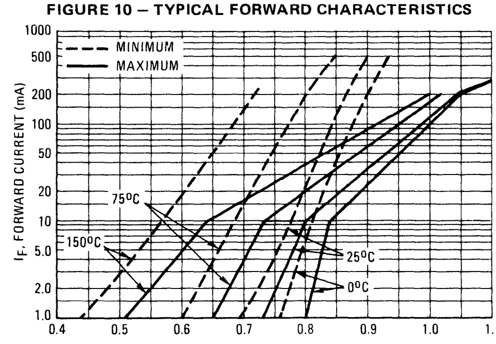


FIGURE 10 — TYPICAL FORWARD CHARACTERISTICS



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1N4765 thru 1N4784
See Page 4-46

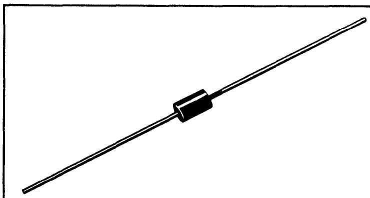
MOTOROLA

1N5221 thru 1N5272

Designer's Data Sheet

GLASS ZENER DIODES

500 MILLIWATTS
2.4-110 VOLTS



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500 MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range – 2.4 to 110 Volts**
- DO-35 Package – Smaller than Conventional DO-7 Package
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die

Designer's Data for "Worst Case" Conditions

The Designer's 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
DC Power Dissipation @ $T_L \leq 75^oC$ Lead Length = 3/8" Derate above $T_L = 75^oC$	P_D	 500 4.0	 mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data
**See 1N5273 thru 1N5281 for devices > 110 volts.

MECHANICAL CHARACTERISTICS

CASE: Double slug type, hermetically sealed glass

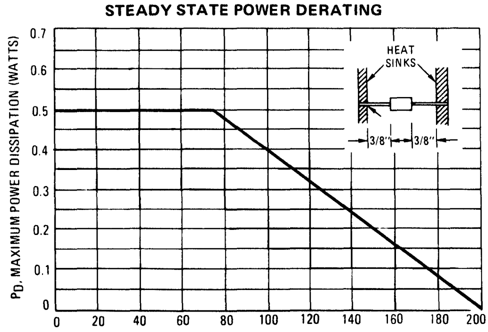
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16" from case for 10 seconds

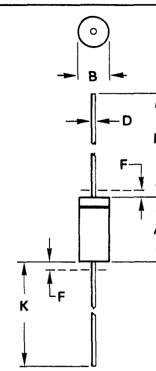
FINISH: All external surfaces are corrosion resistant with readily solderable leads

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

MOUNTING POSITION: Any

STEADY STATE POWER DERATING





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH
(DO-35)

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink = 30°C/W) V_F = 1.1 max @ I_F = 200 mA for all types.

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A and B Suffix only: Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance A and B Suffix only: Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	Max Reverse Leakage Current A and B Suffix only: I_R µA	@ V_R Volts A	@ V_R Volts B	Max Reverse Leakage Current Non-Suffix: I_R @ V_R Used for Suffix A µA	Max Zener Voltage Temperature Coeff. (A and B Suffix only) θ_{VZ} (%/°C) (Note 3)
1N5221	2.4	20	30	1200	100	0.95	1.0	200	−0.085
1N5222	2.5	20	30	1250	100	0.95	1.0	200	−0.085
1N5223	2.7	20	30	1300	75	0.95	1.0	150	−0.080
1N5224	2.8	20	30	1400	75	0.95	1.0	150	−0.080
1N5225	3.0	20	29	1600	50	0.95	1.0	100	−0.075
1N5226	3.3	20	28	1600	25	0.95	1.0	100	−0.070
1N5227	3.6	20	24	1700	15	0.95	1.0	100	−0.065
1N5228	3.9	20	23	1900	10	0.95	1.0	75	−0.060
1N5229	4.3	20	22	2000	5.0	0.95	1.0	50	±0.055
1N5230	4.7	20	19	1900	5.0	1.9	2.0	50	±0.030
1N5231	5.1	20	17	1600	5.0	1.9	2.0	50	±0.030
1N5232	5.6	20	11	1600	5.0	2.9	3.0	50	+0.038
1N5233	6.0	20	7.0	1600	5.0	3.3	3.5	50	+0.038
1N5234	6.2	20	7.0	1000	5.0	3.8	4.0	50	+0.045
1N5235	6.8	20	5.0	750	3.0	4.8	5.0	30	+0.050
1N5236	7.5	20	6.0	500	3.0	5.7	6.0	30	+0.058
1N5237	8.2	20	8.0	500	3.0	6.2	6.5	30	+0.062
1N5238	8.7	20	8.0	600	3.0	6.2	6.5	30	+0.065
1N5239	9.1	20	10	600	3.0	6.7	7.0	30	+0.068
1N5240	10	20	17	600	3.0	7.6	8.0	30	+0.075
1N5241	11	20	22	600	2.0	8.0	8.4	30	+0.076
1N5242	12	20	30	600	1.0	8.7	9.1	10	+0.077
1N5243	13	9.5	13	600	0.5	9.4	9.9	10	+0.079
1N5244	14	9.0	15	600	0.1	9.5	10	10	+0.082
1N5245	15	8.5	16	600	0.1	10.5	11	10	+0.082
1N5246	16	7.8	17	600	0.1	11.4	12	10	+0.083
1N5247	17	7.4	19	600	0.1	12.4	13	10	+0.084
1N5248	18	7.0	21	600	0.1	13.3	14	10	+0.085
1N5249	19	6.6	23	600	0.1	13.3	14	10	+0.086
1N5250	20	6.2	25	600	0.1	14.3	15	10	+0.086
1N5251	22	5.6	29	600	0.1	16.2	17	10	+0.087
1N5252	24	5.2	33	600	0.1	17.1	18	10	+0.088
1N5253	25	5.0	35	600	0.1	18.1	19	10	+0.089
1N5254	27	4.6	41	600	0.1	20	21	10	+0.090
1N5255	28	4.5	44	600	0.1	20	21	10	+0.091
1N5256	30	4.2	49	600	0.1	22	23	10	+0.091
1N5257	33	3.8	58	700	0.1	24	25	10	+0.092
1N5258	36	3.4	70	700	0.1	26	27	10	+0.093
1N5259	39	3.2	80	800	0.1	29	30	10	+0.094
1N5260	43	3.0	93	900	0.1	31	33	10	+0.095
1N5261	47	2.7	105	1000	0.1	34	36	10	+0.095
1N5262	51	2.5	125	1100	0.1	37	39	10	+0.096
1N5263	56	2.2	150	1300	0.1	41	43	10	+0.096
1N5264	60	2.1	170	1400	0.1	44	46	10	+0.097
1N5265	62	2.0	185	1400	0.1	45	47	10	+0.097
1N5266	68	1.8	230	1600	0.1	49	52	10	+0.097
1N5267	75	1.7	270	1700	0.1	53	56	10	+0.098
1N5268	82	1.5	330	2000	0.1	59	62	10	+0.098
1N5269	87	1.4	370	2200	0.1	65	68	10	+0.099
1N5270	91	1.4	400	2300	0.1	66	69	10	+0.099
1N5271	100	1.3	500	2600	0.1	72	76	10	+0.110
1N5272	110	1.1	750	3000	0.1	80	84	10	+0.110

NOTE 1. Tolerance — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.

†For more information on special selections contact your nearest Motorola representative.

NOTE 2. Special Selections† Available Include:

1. Nominal zener voltages between those shown.
2. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
3. Nominal voltages at non-standard test currents.

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NOTE 3. Temperature Coefficient (θ_{VZ}) — Test conditions for temperature coefficient are as follows:

a. I_{ZT} = 7.5 mA, T_1 = 25°C,
T_2 = 125°C (1N5221A,B through 1N5242A,B).

b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C,
T_2 = 125°C (1N5243A,B through 1N5272A, B).

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

NOTE 4. Zener Voltage (V_Z) Measurement — Nominal zener voltage is measured with the device junction in thermal equilibrium at the lead temperature of 30°C ± 1°C and 3/8″ lead length.

NOTE 5. Zener Impedance (Z_Z) Derivation — Z_{ZT} and Z_{ZK} are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for I_Z(ac) = I_Z(dc) with the ac frequency = 60 Hz.

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 to 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 1 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 3 and 4.

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.

Surge limitations are given in Figure 6. 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 6 be exceeded.

FIGURE 1 — TYPICAL THERMAL RESISTANCE

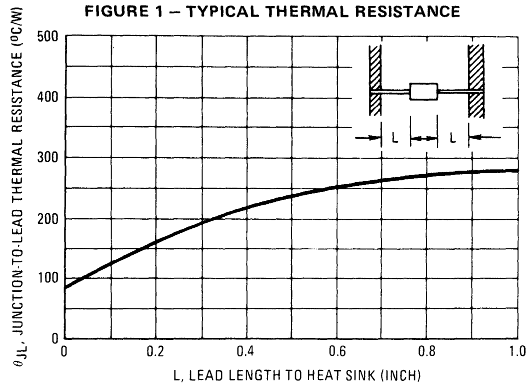

FIGURE 2 — TYPICAL LEAKAGE CURRENT

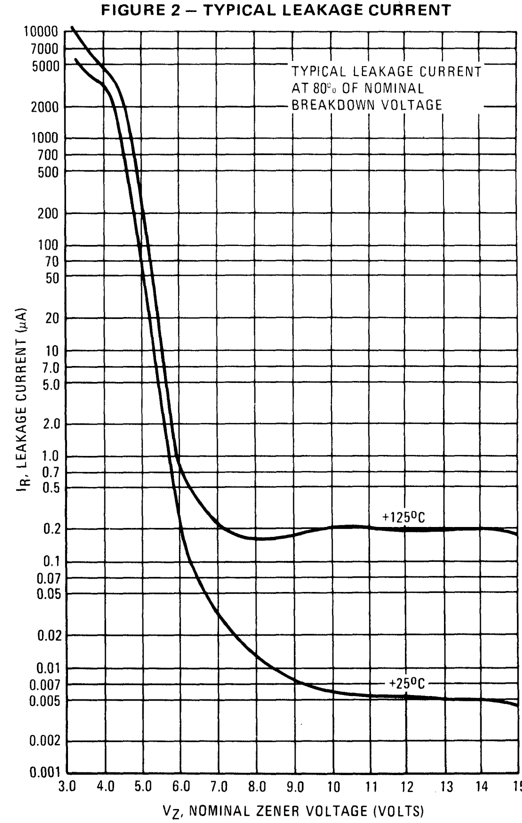

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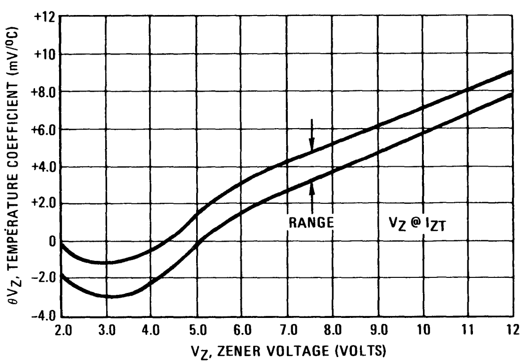
FIGURE 3 — TEMPERATURE COEFFICIENTS

(−55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

a — RANGE FOR UNITS TO 12 VOLTS



b — RANGE FOR UNITS 12 TO 100 VOLTS

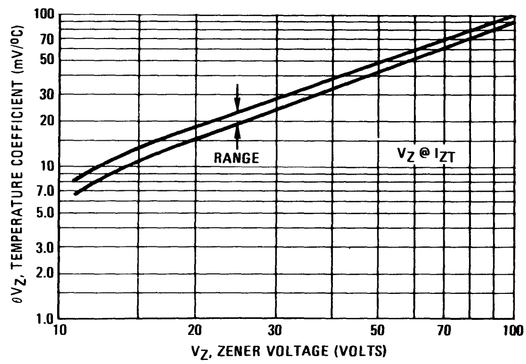


FIGURE 4 — EFFECT OF ZENER CURRENT

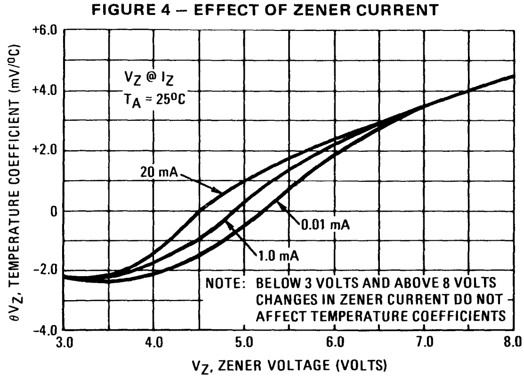


FIGURE 5 — TYPICAL CAPACITANCE

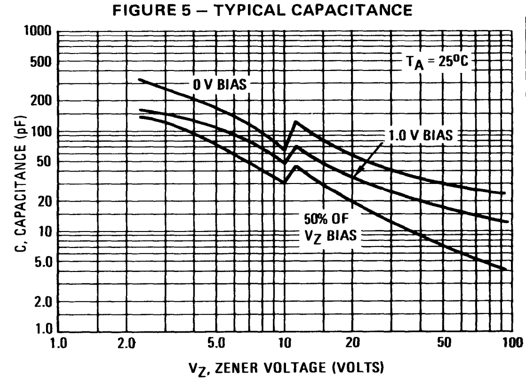


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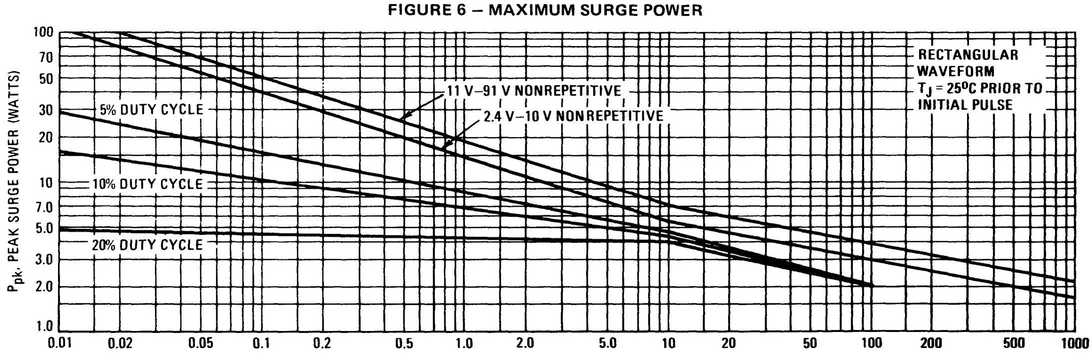
FIGURE 6 — MAXIMUM SURGE POWER



This graph represents 90 percentil data points.

For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 7 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

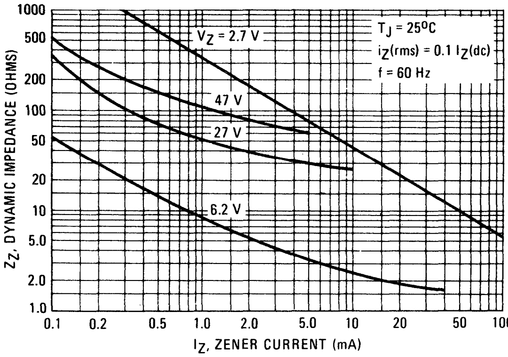


FIGURE 8 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

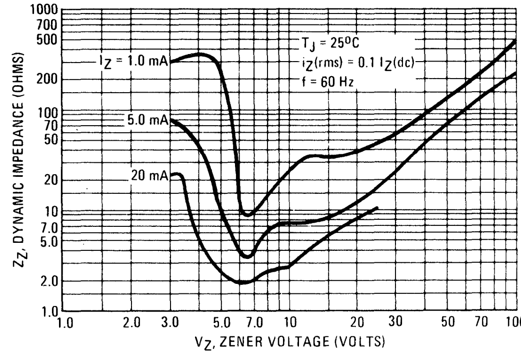


FIGURE 9 — TYPICAL NOISE DENSITY

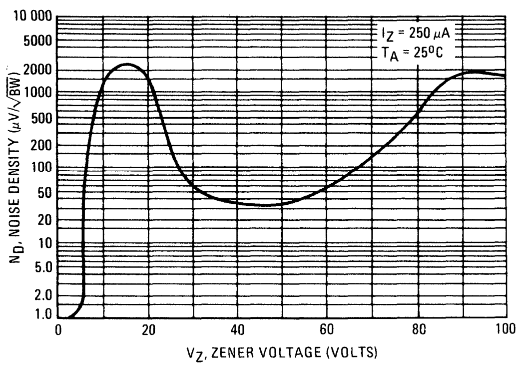
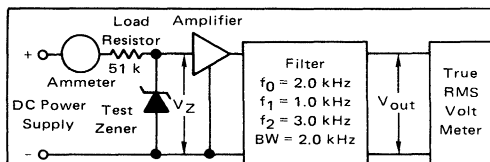


FIGURE 10 — NOISE DENSITY MEASUREMENT METHOD



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

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 zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

FIGURE 11 — TYPICAL FORWARD CHARACTERISTICS

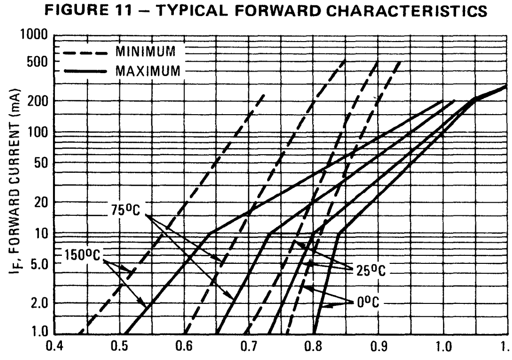


FIGURE 12 – ZENER VOLTAGE versus ZENER CURRENT – V_Z = 1 THRU 16 VOLTS

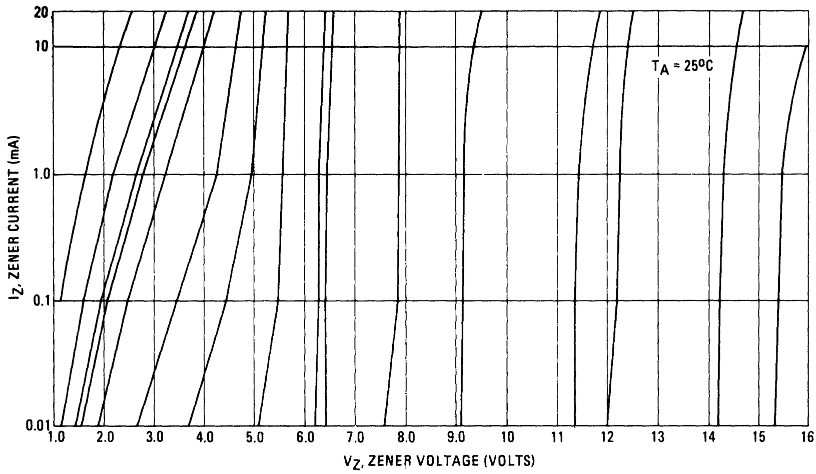


FIGURE 13 – ZENER VOLTAGE versus ZENER CURRENT – V_Z = 15 THRU 30 VOLTS

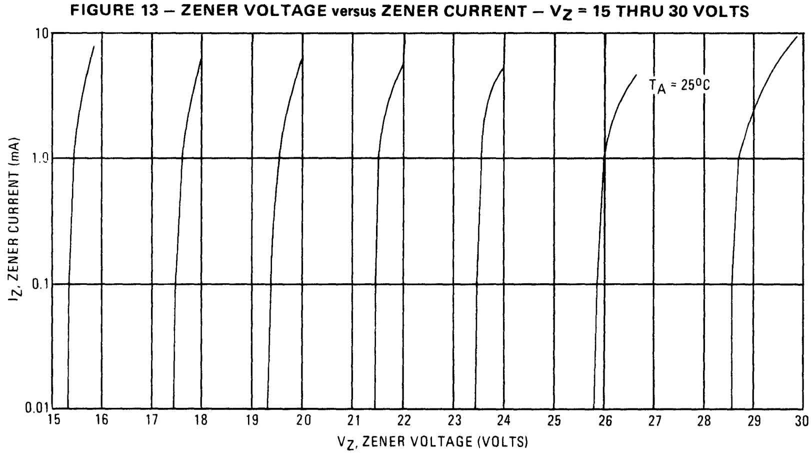
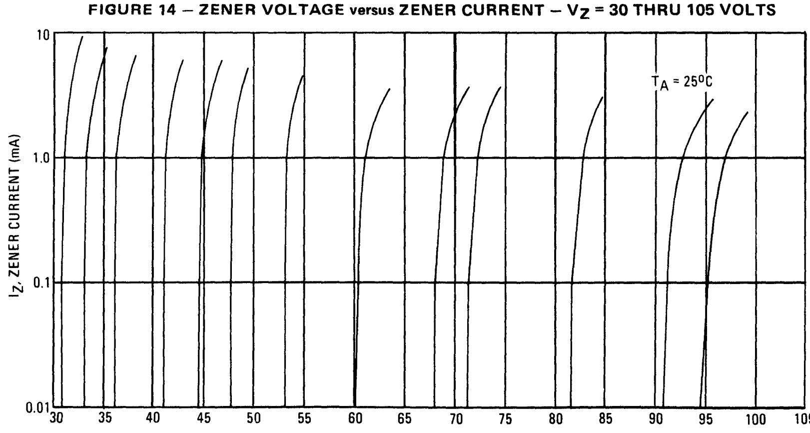


FIGURE 14 – ZENER VOLTAGE versus ZENER CURRENT – V_Z = 30 THRU 105 VOLTS



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1N5273
thru
1N5281

MOTOROLA

Advance Information

500 MILLIWATT SURMETIC 20 SILICON ZENER DIODES
(SILICON OXIDE PASSIVATED)

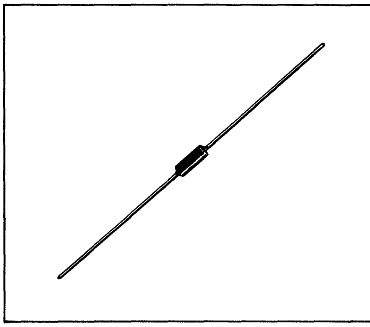
. . . in answer to the Circuit Design and Component Engineers' many requests — A complete new series of Zener Diodes in the popular DO-204AA case with higher ratings, tighter limits, better operating characteristics and a full set of designers' curves that reflect the superior capabilities of silicon-oxide-passivated junctions. All this in an axial-lead, transfer-molded plastic package offering protection in all common environmental conditions.

- Proven Capability to MIL-S-19500 Specifications
- 10 Watt Surge Rating
- Weldable Leads
- Maximum Limits Guaranteed on Six Electrical Parameters

500 MILLIWATT

ZENER REGULATOR DIODES

120-200 VOLTS



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MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 75^oC$, Lead Length = 3/8" Derate above $T_L = 75^oC$	P_D	500 4.0	mW mW/°C
Surge Power (Non-Recurrent Square Wave @ PW = 8.3 ms, $T_J = 55^oC$)	—	10	Watts
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +200	°C
Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C.			

MECHANICAL CHARACTERISTICS

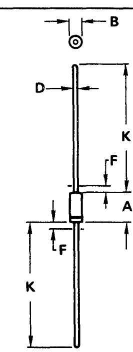
CASE: Void free, transfer molded, thermosetting plastic.

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

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

MOUNTING POSITION: Any.

WEIGHT: 0.18 gram (approximately).



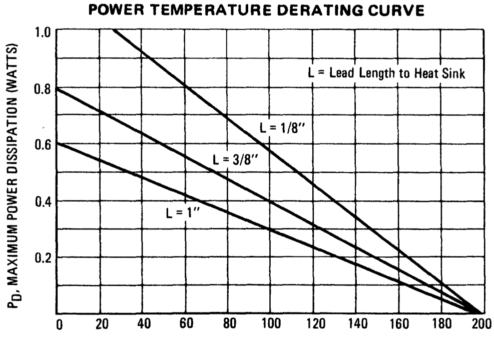
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA
(DO-7)

POWER TEMPERATURE DERATING CURVE



This document contains information on a new product. Specifications and information herein are subject to change without notice.

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 3/8"; thermal resistance of heat sink = 30°C/W). V_F = 1.1 max @ I_F = 200 mA for all types.

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Notes 2 & 4)	Test Current I_{ZT} mA	Max Zener Impedance A and B Suffix Only: Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance A and B Suffix Only: Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	Max Reverse Leakage Current, A and B Suffix Only: I_R µA	@ V_R Volts A	@ V_R Volts B	Max Reverse Leakage Current, Non-Suffix: I_R @ V_R Used For Suffix A µA	Max Zener Voltage Temperature Coefficient (A and B Suffix Only) θ_{VZ} (%/°C) (Note 3)
1N5273	120	1.0	900	4000	0.1	86	91	10	+0.110
1N5274	130	0.95	1100	4500	0.1	94	99	10	+0.110
1N5275	140	0.90	1300	4500	0.1	101	106	10	+0.110
1N5276	150	0.85	1500	5000	0.1	108	114	10	+0.110
1N5277	160	0.80	1700	5500	0.1	116	122	10	+0.110
1N5278	170	0.74	1900	5500	0.1	116	129	10	+0.110
1N5279	180	0.68	2200	6000	0.1	130	137	10	+0.110
1N5280	190	0.66	2400	6500	0.1	137	144	10	+0.110
1N5281	200	0.65	2500	7000	0.1	144	152	10	+0.110

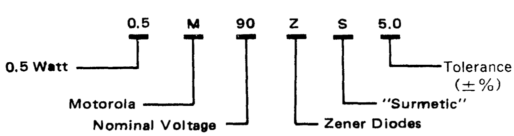
4

NOTE 1. TOLERANCE AND VOLTAGE DESIGNATION

Tolerance Designation — The JEDEC type numbers shown indicate a tolerance of ±10% with guaranteed limits on only V_Z, I_R, and V_F as shown in the above table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.

Non-Standard Voltage Designation — To designate units with zener voltages other than those assigned JEDEC numbers, the Motorola type number should be used.

EXAMPLE



NOTE 2. SPECIAL SELECTIONS AVAILABLE INCLUDE:

1. Nominal zener voltages between those shown.
2. Matched sets (standard tolerances are ±5.0%, ±2.0%, ±1.0%).

 a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing 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%.

NOTE 3. TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

I_{ZT} = Rated I_{ZT}, T1 = 25°C,
T2 = 125°C.

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

NOTE 4. 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.

1N5283
thru
1N5314

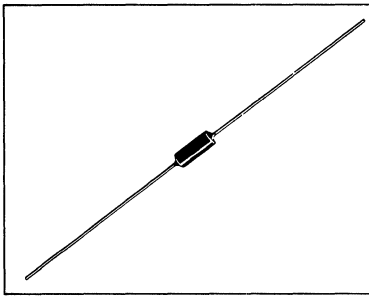
MOTOROLA

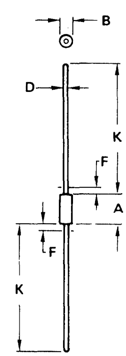
CURRENT REGULATOR DIODES

4

CURRENT REGULATOR DIODES

Field-effect current regulator diodes are circuit elements that provide a current essentially independent of voltage. These diodes are especially designed for maximum impedance over the operating range. These devices may be used in parallel to obtain higher currents.





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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51
DO-7

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

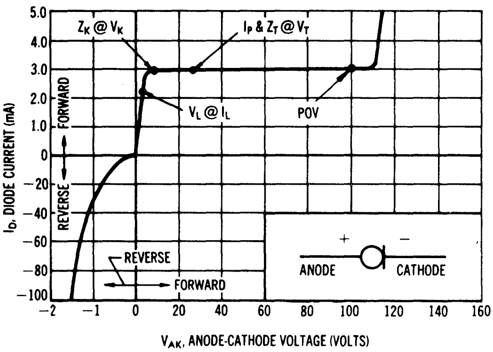
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Operating Voltage ($T_J = -55°C$ to $+200°C$)	POV	100	Volts
Steady State Power Dissipation @ $T_L = 75°C$	P_D	600	mW
Derate above $T_L = 75°C$		4.8	mW/°C
Lead Length = 3/8″ (Forward or Reverse Bias)			
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−55 to +200	°C

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

Type No.	Regulator Current I_P (mA) @ $V_T = 25$ V			Minimum Dynamic Impedance @ $V_T = 25$ V	Minimum Knee Impedance @ $V_K = 6.0$ V	Maximum Limiting Voltage @ $I_L = 0.8\ I_P$ (min)
	nom	min	max	Z_T (MΩ)	Z_K (MΩ)	V_L (Volts)
1N5283	0.22	0.198	0.242	25.0	2.75	1.00
1N5284	0.24	0.216	0.264	19.0	2.35	1.00
1N5285	0.27	0.243	0.297	14.0	1.95	1.00
1N5286	0.30	0.270	0.330	9.0	1.60	1.00
1N5287	0.33	0.297	0.363	6.6	1.35	1.00
1N5288	0.39	0.351	0.429	4.10	1.00	1.05
1N5289	0.43	0.387	0.473	3.30	0.870	1.05
1N5290	0.47	0.423	0.517	2.70	0.750	1.05
1N5291	0.56	0.504	0.616	1.90	0.560	1.10
1N5292	0.62	0.558	0.682	1.55	0.470	1.13
1N5293	0.68	0.612	0.748	1.35	0.400	1.15
1N5294	0.75	0.675	0.825	1.15	0.335	1.20
1N5295	0.82	0.738	0.902	1.00	0.290	1.25
1N5296	0.91	0.819	1.001	0.880	0.240	1.29
1N5297	1.00	0.900	1.100	0.800	0.205	1.35
1N5298	1.10	0.990	1.210	0.700	0.180	1.40
1N5299	1.20	1.08	1.32	0.640	0.155	1.45
1N5300	1.30	1.17	1.43	0.580	0.135	1.50
1N5301	1.40	1.26	1.54	0.540	0.115	1.55
1N5302	1.50	1.35	1.65	0.510	0.105	1.60
1N5303	1.60	1.44	1.76	0.475	0.092	1.65
1N5304	1.80	1.62	1.98	0.420	0.074	1.75
1N5305	2.00	1.80	2.20	0.395	0.061	1.85
1N5306	2.20	1.98	2.42	0.370	0.052	1.95
1N5307	2.40	2.16	2.64	0.345	0.044	2.00
1N5308	2.70	2.43	2.97	0.320	0.035	2.15
1N5309	3.00	2.70	3.30	0.300	0.029	2.25
1N5310	3.30	2.97	3.63	0.280	0.024	2.35
1N5311	3.60	3.24	3.96	0.265	0.020	2.50
1N5312	3.90	3.51	4.29	0.255	0.017	2.60
1N5313	4.30	3.87	4.73	0.245	0.014	2.75
1N5314	4.70	4.23	5.17	0.235	0.012	2.90

FIGURE 1 — TYPICAL CURRENT REGULATOR CHARACTERISTICS



SYMBOLS AND DEFINITIONS

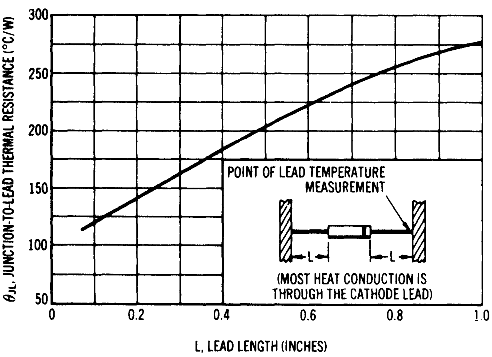
I_D — Diode Current.
I_L — Limiting Current: 80% of I_P minimum used to determine Limiting voltage, V_L.
I_P — Pinch-off Current: Regulator current at specified Test Voltage, V_T.
POV — Peak Operating Voltage: Maximum voltage to be applied to device.
θ_I — Current Temperature Coefficient.
V_{AK} — Anode-to-cathode Voltage.
V_K — Knee Impedance Test Voltage: Specified voltage used to establish Knee Impedance, Z_K.
V_L — Limiting Voltage: Measured at I_L. V_L, together with Knee AC Impedance, Z_K, indicates the Knee characteristics of the device.
V_T — Test Voltage: Voltage at which I_P and Z_T are specified.
Z_K — Knee AC Impedance at Test Voltage: To test for Z_K, a 90 Hz signal v_K with RMS value equal to 10% of test voltage, V_K, is superimposed on V_K:

$$Z_K = v_K / i_K$$

where i_K is the resultant ac current due to v_K
To provide the most constant current from the diode, Z_K should be as high as possible; therefore, a minimum value of Z_K is specified.
Z_T — AC Impedance at Test Voltage: Specified as a minimum value. To test for Z_T, a 90 Hz signal with RMS value equal to 10% of Test Voltage, V_T, is superimposed on V_T.

4

FIGURE 2 — TYPICAL THERMAL RESISTANCE



APPLICATION NOTE

As the current available from the diode is temperature dependent, it is necessary to determine junction temperature, T_J, under specific operating conditions to calculate the value of the diode current. The following procedure is recommended:

Lead Temperature, T_L, shall be determined from:

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

where θ_{LA} is lead-to-ambient thermal resistance
and P_D is power dissipation.
θ_{LA} is generally 30-40°C/W for the various clips and tie points in common use, and for printed circuit-board wiring.

Junction Temperature, T_J, shall be calculated from:

$$T_J = T_L + \theta_{JL} P_D$$

where θ_{JL} is taken from Figure 2.

For circuit design limits of V_{AK}, limits of P_D may be estimated and extremes of T_J may be computed. Using the information on Figures 4 and 5, changes in current may be found. To improve current regulation, keep V_{AK} low to reduce P_D and keep the leads short, especially the cathode lead, to reduce θ_{JL}.

FIGURE 3 — TYPICAL FORWARD CHARACTERISTICS

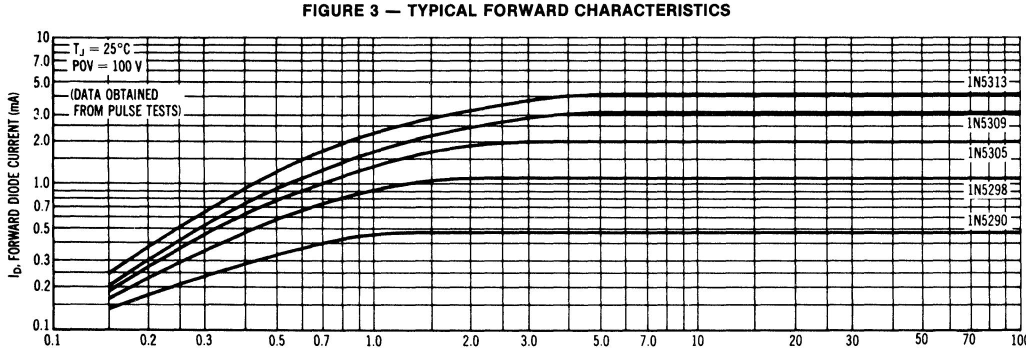


FIGURE 4 — TEMPERATURE COEFFICIENT

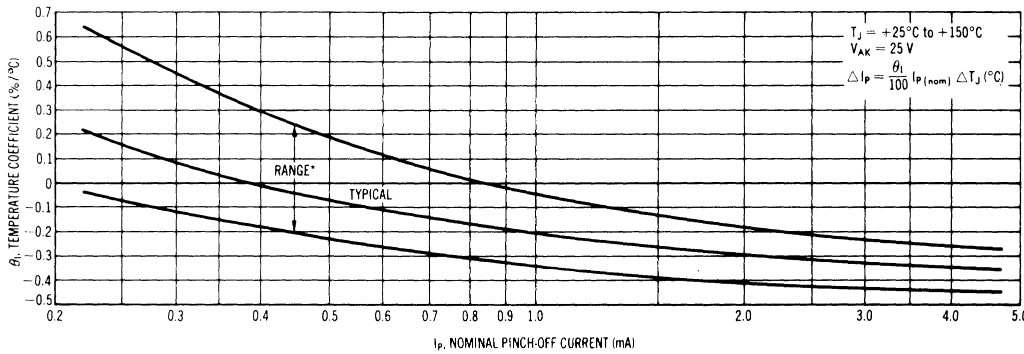


FIGURE 5 — TEMPERATURE COEFFICIENT

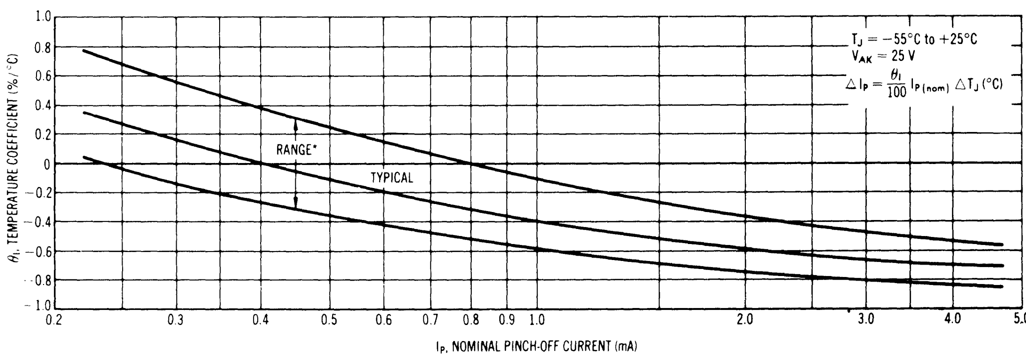
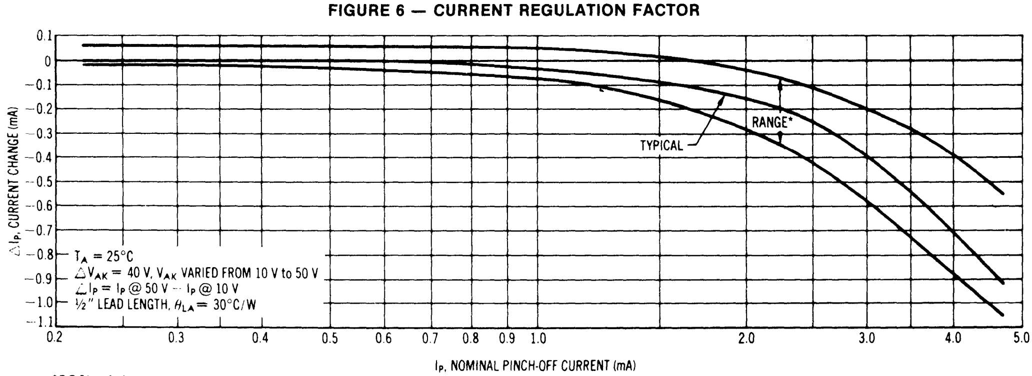


FIGURE 6 — CURRENT REGULATION FACTOR



*90% of the units will be in the ranges shown.

4

1N5333 thru 1N5388

MOTOROLA

Designers Data Sheet

5.0 WATT SURMETIC 40 SILICON ZENER DIODES (SILICON OXIDE PASSIVATED)

.... a complete series of 5.0 Watt Zener Diodes with tight limits and better 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.

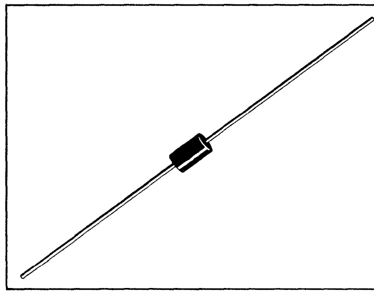
- Up to 180 Watt Surge Rating @ 8.3 ms
- Maximum Limits Guaranteed on Seven Electrical Parameters

5M3.3ZS10 thru 5M200ZS10
1N5333A thru 1N5388A

5M3.3ZS5 thru 5M200ZS5
1N5333B thru 1N5388B

5.0 WATT
ZENER REGULATOR DIODES

3.3 — 200 VOLTS



MAXIMUM RATINGS

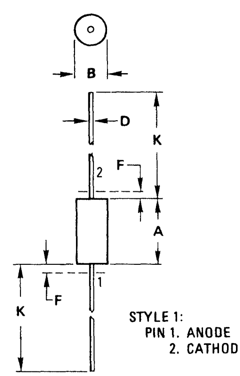
Junction and Storage Temperature: -65 to +200 °C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230 °C

DC Power Dissipation: 5.0 W @ $T_L = 75$ °C, Lead Length = 3/8"
(Derate 40 mW/°C above 75 °C)

MECHANICAL CHARACTERISTICS

CASE: Void-free, transfer-molded, thermosetting plastic
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable
POLARITY: Cathode indicated by color band. When operated in zener mode, cathode will be positive with respect to anode.
MOUNTING POSITION: Any
WEIGHT: 0.7 gram (approx)

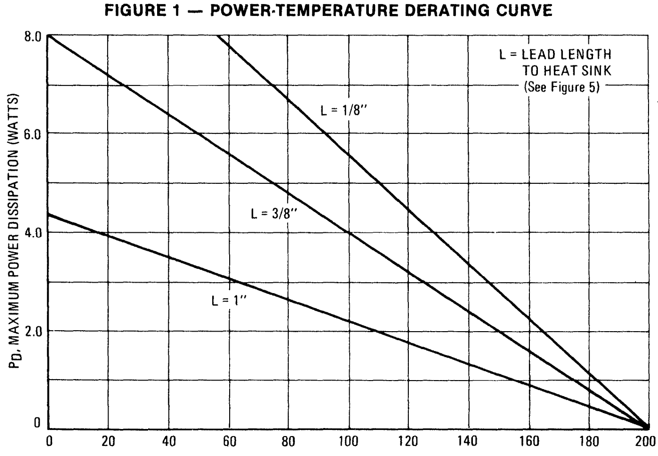


DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.38	8.89	0.330	0.350
B	3.30	3.68	0.130	0.145
D	0.94	1.09	0.037	0.043
F	–	1.27	–	0.050
K	25.40	31.75	1.000	1.250

CASE 17

NOTE:
1. LEAD DIAMETER & FINISH NOT CONTROLLED WITHIN DIM "F".

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted, $V_F = 1.2$ Max @ $I_F = 1.0$ A for all types)

JEDEC Type No. (Note 1 & 2)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 3)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only: Z_{ZT} @ I_{ZT} Ohms (Note 3)	Max Zener Impedance A & B Suffix Only: Z_{ZK} @ I_{ZK} = 1.0 mA Ohms (Note 3)	Max Reverse Leakage Current: I_R μA	Max Reverse Leakage Current: @ V_R Volts, Non & A Suffix	Max Reverse Leakage Current: @ V_R Volts, B-Suffix	Applies to all Suffix: Max Surge Current i_r, Amps (Note 4)	A & B Suffix Only: Max Voltage Regulation ΔV_Z, Volts (Note 5)	Maximum Regulator Current I_{ZM} mA (Note 6)
1N5333	3.3	380	3.0	400	300	1.0	1.0	20.0	0.85	1440
1N5334	3.6	350	2.5	500	150	1.0	1.0	18.7	0.80	1320
1N5335	3.9	320	2.0	500	50	1.0	1.0	17.6	0.54	1220
1N5336	4.3	290	2.0	500	10	1.0	1.0	16.4	0.49	1100
1N5337	4.7	260	2.0	450	5.0	1.0	1.0	15.3	0.44	1010
1N5338	5.1	240	1.5	400	1.0	1.0	1.0	14.4	0.39	930
1N5339	5.6	220	1.0	400	1.0	2.0	2.0	13.4	0.25	865
1N5340	6.0	200	1.0	300	1.0	3.0	3.0	12.7	0.19	790
1N5341	6.2	200	1.0	200	1.0	3.0	3.0	12.4	0.10	765
1N5342	6.8	175	1.0	200	10	4.9	5.2	11.5	0.15	700
1N5343	7.5	175	1.5	200	10	5.4	5.7	10.7	0.15	630
1N5344	8.2	150	1.5	200	10	5.9	6.2	10.0	0.20	580
1N5345	8.7	150	2.0	200	10	6.3	6.6	9.5	0.20	545
1N5346	9.1	150	2.0	150	7.5	6.6	6.9	9.2	0.22	520
1N5347	10	125	2.0	125	5.0	7.2	7.6	8.6	0.22	475
1N5348	11	125	2.5	125	5.0	8.0	8.4	8.0	0.25	430
1N5349	12	100	2.5	125	2.0	8.6	9.1	7.5	0.25	395
1N5350	13	100	2.5	100	1.0	9.4	9.9	7.0	0.25	365
1N5351	14	100	2.5	75	1.0	10.1	10.6	6.7	0.25	340
1N5352	15	75	2.5	75	1.0	10.8	11.5	6.3	0.25	315
1N5353	16	75	2.5	75	1.0	11.5	12.2	6.0	0.30	295
1N5354	17	70	2.5	75	0.5	12.2	12.9	5.8	0.35	280
1N5355	18	65	2.5	75	0.5	13.0	13.7	5.5	0.40	264
1N5356	19	65	3.0	75	0.5	13.7	14.4	5.3	0.40	250
1N5357	20	65	3.0	75	0.5	14.4	15.2	5.1	0.40	237
1N5358	22	50	3.5	75	0.5	15.8	16.7	4.7	0.45	216
1N5359	24	50	3.5	100	0.5	17.3	18.2	4.4	0.55	198
1N5360	25	50	4.0	110	0.5	18.0	19.0	4.3	0.55	190
1N5361	27	50	5.0	120	0.5	19.4	20.6	4.1	0.60	176
1N5362	28	50	6.0	130	0.5	20.1	21.2	3.9	0.60	170
1N5363	30	40	8.0	140	0.5	21.6	22.8	3.7	0.60	158
1N5364	33	40	10	150	0.5	23.8	25.1	3.5	0.60	144
1N5365	36	30	11	160	0.5	25.9	27.4	3.3	0.65	132
1N5366	39	30	14	170	0.5	28.1	29.7	3.1	0.65	122
1N5367	43	30	20	190	0.5	31.0	32.7	2.8	0.70	110
1N5368	47	25	25	210	0.5	33.8	35.8	2.7	0.80	100
1N5369	51	25	27	230	0.5	36.7	38.8	2.5	0.90	93.0
1N5370	56	20	35	280	0.5	40.3	42.6	2.3	1.00	86.0
1N5371	60	20	40	350	0.5	43.0	45.5	2.2	1.20	79.0
1N5372	62	20	42	400	0.5	44.6	47.1	2.1	1.35	76.0
1N5373	68	20	44	500	0.5	49.0	51.7	2.0	1.50	70.0
1N5374	75	20	45	620	0.5	54.0	56.0	1.9	1.60	63.0
1N5375	82	15	65	720	0.5	59.0	62.2	1.8	1.80	58.0
1N5376	87	15	75	760	0.5	63.0	66.0	1.7	2.00	54.5
1N5377	91	15	75	760	0.5	65.5	69.2	1.6	2.20	52.5
1N5378	100	12	90	800	0.5	72.0	76.0	1.5	2.50	47.5
1N5379	110	12	125	1000	0.5	79.2	83.6	1.4	2.50	43.0
1N5380	120	10	170	1150	0.5	86.4	91.2	1.3	2.50	39.5
1N5381	130	10	190	1250	0.5	93.6	98.8	1.2	2.50	36.6
1N5382	140	8.0	230	1500	0.5	101	106	1.2	2.50	34.0
1N5383	150	8.0	330	1500	0.5	108	114	1.1	3.00	31.6
1N5384	160	8.0	350	1650	0.5	115	122	1.1	3.00	29.4
1N5385	170	8.0	380	1750	0.5	122	129	1.0	3.00	28.0
1N5386	180	5.0	430	1750	0.5	130	137	1.0	4.00	26.4
1N5387	190	5.0	450	1850	0.5	137	144	0.9	5.00	25.0
1N5388	200	5.0	480	1850	0.5	144	152	0.9	5.00	23.6

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

TOLERANCE DESIGNATION – The JEDEC type numbers shown indicate a tolerance of ±20% with guaranteed limits on only V_Z, I_R, i_r, and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all seven parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% 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 Mfg. type number should be used.

5 M 90 Z S 3

- 5 – Device Description
- M – Manufacturer
- 90 – Nominal Voltage
- Z – Zener Diode
- S – "Surmetic"
- 3 – Tolerance (±%)

Example: **5M90ZS3**

(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.

5 M 51 Z S 5 B 1

- 5 – Device Description
- M – Manufacturer
- 51 – 51 Volts (each device)
- Z – Zener Diodes
- S – "Surmetic"
- 5 – Tolerance per device (±5%) (omit for ±20% units)
- B – Code*
- 1 – Overall Tolerance of set (±1%)

*Code:
B – Two devices in series
C – Three devices in series
D – Four devices in series
(A-Not used)

Example: **5M51ZS5B1**

(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:

5 M 20, Z Z 10

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

Example: **5M20ZZ10**

NOTE 3 – ZENER VOLTAGE (V_Z) AND IMPEDANCE (Z_{ZT} & Z_{ZK})

Test conditions for Zener voltage and impedance are as follows: I_Z is applied 40 ± 10 ms prior to reading. Mounting contacts are located 3/8" to 1/2" from the inside edge of mounting clips to the body of the diode. ($T_A = 25^oC \, ^{+8}_{-2} {}^oC$).

NOTE 4 – SURGE CURRENT (i_r)

Surge current is specified as the maximum allowable peak, non-recurrent square-wave current with a pulse width, PW, of 8.3 ms. The data given in Figure 6 may be used to find the maximum surge current for a square wave of any pulse width between 1.0 ms and 1000 ms by plotting the applicable points on logarithmic paper. Examples of this, using the 3.3 V and 200 V zeners, are shown in Figure 7. Mounting contact located as soecified in Note 3. ($T_A = 25^oC \, ^{+8}_{-2} {}^oC$).

NOTE 5 – VOLTAGE REGULATION (ΔV_Z)

Test conditions for voltage regulation are as follows: V_Z measurements are made at 10% and then at 50% of the I_Z max value listed in the electrical characteristics table. The test currents are the same for the 5% and 10% tolerance devices. The test current time duration for each V_Z measurement is 40 ± 10 ms. ($T_A = 25^oC \, ^{+8}_{-2} {}^oC$). Mounting contact located as specified in Note 3.

NOTE 6 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5% type unit, therefore, it applies only to the B-suffix device. The actual I_{ZM} for any device may not exceed the value of 5.0 watts divided by the actual V_Z of the device. $T_L = 75^oC$ at 3/8" maximum from the device body.

TEMPERATURE COEFFICIENTS

FIGURE 2 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 3.0 TO 10 VOLTS

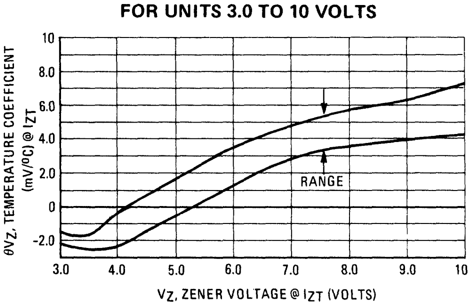


FIGURE 3 – TEMPERATURE COEFFICIENT-RANGE FOR UNITS 10 TO 220 VOLTS

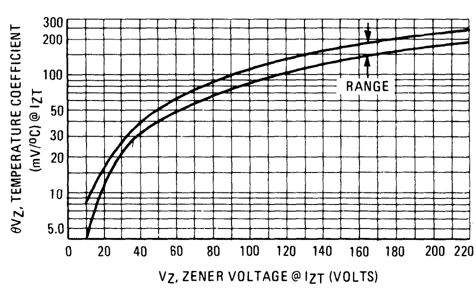


FIGURE 4 — TYPICAL THERMAL RESPONSE
L, LEAD LENGTH = 3/8 INCH

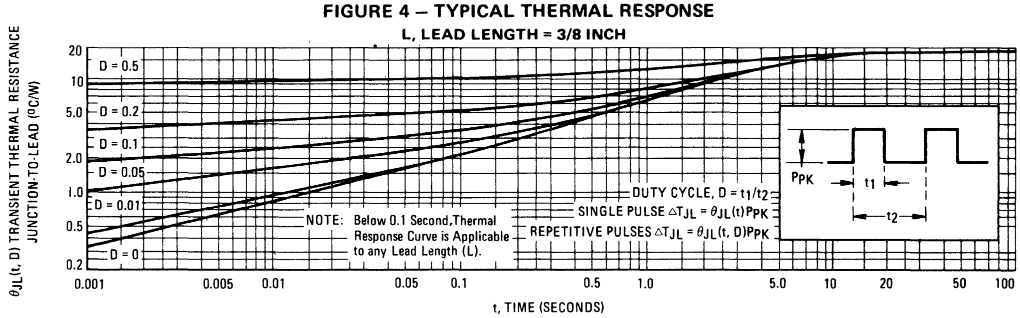


FIGURE 5 — TYPICAL THERMAL RESISTANCE

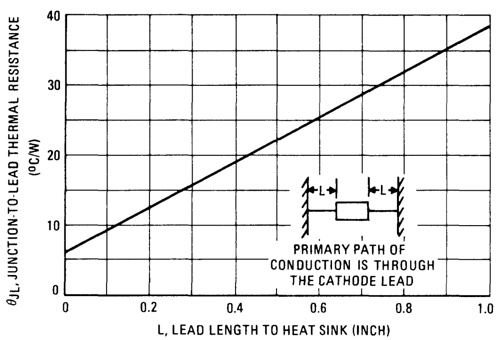
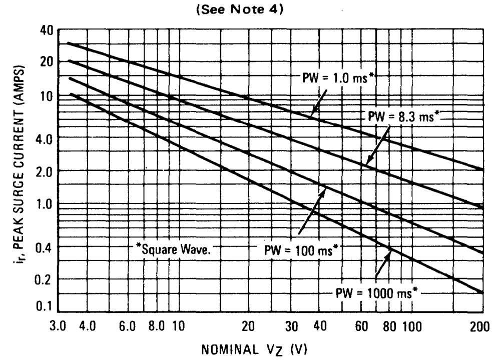


FIGURE 6 — MAXIMUM NON-REPETITIVE SURGE CURRENT versus NOMINAL ZENER VOLTAGE
(See Note 4)



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 and P_D is the power dissipation.

Junction Temperature, T_J, may be found from:

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

ΔT_{JL} is the increase in junction temperature above the lead temperature and may be found from Figure 4 for a train of power pulses or from Figure 5 for dc power.

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

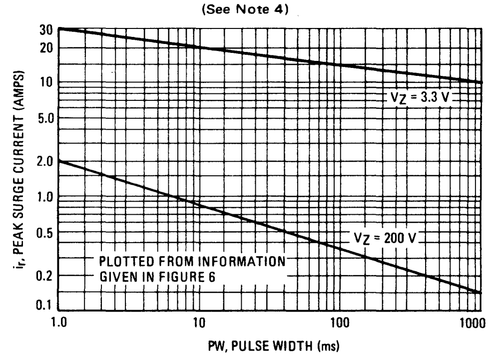
For worst-case design, using expected limits of I_Z, limits of P_D and the extremes of $T_J(\Delta T_J)$ may be estimated. Changes in voltage, V_Z, can then be found from:

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

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.

FIGURE 7 — PEAK SURGE CURRENT versus PULSE WIDTH
(See Note 4)



Data of Figure 4 should not be used to compute surge capability. Surge limitations are given in Figure 6. 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 6 be exceeded.

1N5518A,B thru 1N5546A,B

MOTOROLA

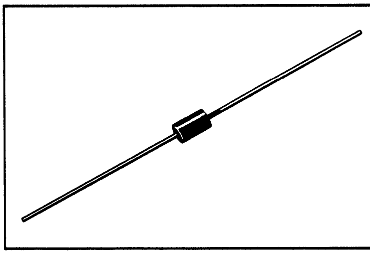
LOW VOLTAGE AVALANCHE SILICON OXIDE PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. Double slug construction provides a rugged, glass-enclosed, hermetically sealed structure.

- Low Zener Noise Specified
- Low Maximum Regulation Factor
- Low Zener Impedance
- Low Leakage Current
- Controlled Forward Characteristics
- Temperature Range: -65 to + 200°C

LOW VOLTAGE AVALANCHE ZENER DIODES

400 MILLIWATTS
3.3 THRU 33 VOLTS



4

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 50°C Derate above 50°C	P_D	400 3.2	mW mW/°C
DC Power Dissipation @ T_L = 50°C Lead Length = 1/8″ Derate above 50°C (Figure 1)	P_D	500 3.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Hermetically sealed, all-glass

DIMENSIONS: See outline drawing.

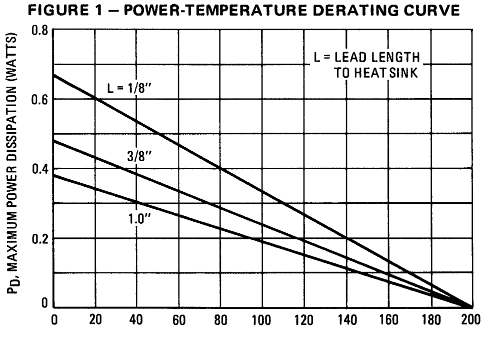
FINISH: All external surfaces are corrosion resistant and leads are readily solderable and weldable.

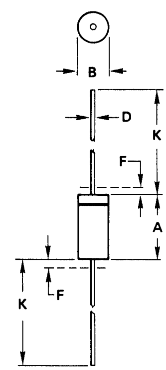
POLARITY: Cathode indicated by polarity band.

WEIGHT: 0.2 Gram (approx)

MOUNTING POSITION: Any

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE





NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204 AH

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; V_F = 1.1 Max @ I_F = 200 mA for all types)

JEDEC Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mAdc	Max Zener Impedance B-C-D Suffix Z_{ZT} @ I_{ZT} Ohms (Note 3)	Max Reverse Leakage Current I_R µAdc (Note 4)	V_R – Volts Non & A-Suffix	V_R – Volts B-C-D Suffix	B-C-D Suffix Maximum DC Zener Current I_{ZM} mAdc (Note 5)	B-C-D Suffix Max Noise Density at I_Z = 250 µA N_D (Figure 1) (micro-volts per square root cycle)	Regulation Factor ΔV_Z Volts (Note 6)	Low V_Z Current I_{ZL} mAdc
1N5518A	3.3	20	26	5.0	0.90	1.0	115	0.5	0.90	2.0
1N5519A	3.6	20	24	3.0	0.90	1.0	105	0.5	0.90	2.0
1N5520A	3.9	20	22	1.0	0.90	1.0	98	0.5	0.85	2.0
1N5521A	4.3	20	18	3.0	1.0	1.5	88	0.5	0.75	2.0
1N5522A	4.7	10	22	2.0	1.5	2.0	81	0.5	0.60	1.0
1N5523A	5.1	5.0	26	2.0	2.0	2.5	75	0.5	0.65	0.25
1N5524A	5.6	3.0	30	2.0	3.0	3.5	68	1.0	0.30	0.25
1N5525A	6.2	1.0	30	1.0	4.5	5.0	61	1.0	0.20	0.01
1N5526A	6.8	1.0	30	1.0	5.5	6.2	56	1.0	0.10	0.01
1N5527A	7.5	1.0	35	0.5	6.0	6.8	51	2.0	0.05	0.01
1N5528A	8.2	1.0	40	0.5	6.5	7.5	46	4.0	0.05	0.01
1N5529A	9.1	1.0	45	0.1	7.0	8.2	42	4.0	0.05	0.01
1N5530A	10.0	1.0	60	0.05	8.0	9.1	38	4.0	0.10	0.01
1N5531A	11.0	1.0	80	0.05	9.0	9.9	35	5.0	0.20	0.01
1N5532A	12.0	1.0	90	0.05	9.5	10.8	32	10	0.20	0.01
1N5533A	13.0	1.0	90	0.01	10.5	11.7	29	15	0.20	0.01
1N5534A	14.0	1.0	100	0.01	11.5	12.6	27	20	0.20	0.01
1N5535A	15.0	1.0	100	0.01	12.5	13.5	25	20	0.20	0.01
1N5536A	16.0	1.0	100	0.01	13.0	14.4	24	20	0.20	0.01
1N5537A	17.0	1.0	100	0.01	14.0	15.3	22	20	0.20	0.01
1N5538A	18.0	1.0	100	0.01	15.0	16.2	21	20	0.20	0.01
1N5539A	19.0	1.0	100	0.01	16.0	17.1	20	20	0.20	0.01
1N5540A	20.0	1.0	100	0.01	17.0	18.0	19	20	0.20	0.01
1N5541A	22.0	1.0	100	0.01	18.0	19.8	17	20	0.25	0.01
1N5542A	24.0	1.0	100	0.01	20.0	21.6	16	20	0.30	0.01
1N5543A	25.0	1.0	100	0.01	21.0	22.4	15	20	0.35	0.01
1N5544A	28.0	1.0	100	0.01	23.0	25.2	14	20	0.40	0.01
1N5545A	30.0	1.0	100	0.01	24.0	27.0	13	20	0.45	0.01
1N5546A	33.0	1.0	100	0.01	28.0	29.7	12	20	0.50	0.01

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

The JEDEC type numbers shown are ±10% with guaranteed limits for V_Z, I_R, and V_F. Units with guaranteed limits for all six parameters are indicated by a "B" suffix for ±5.0% units, "C" suffix for ±2.0% and "D" suffix for ±1.0%.

NOTE 2 – ZENER VOLTAGE (V_Z) MEASUREMENT

Nominal zener voltage is measured with the device junction in thermal equilibrium with ambient temperature of 25°C.

NOTE 3 – ZENER IMPEDANCE (Z_Z) DERIVATION

The zener impedance is derived from the 60 Hz 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 4 – REVERSE LEAKAGE CURRENT (I_R)

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

NOTE 5 – MAXIMUM REGULATOR CURRENT (I_{ZM})

The maximum current shown is based on the maximum voltage of a 5.0% type unit, therefore, it applies only to the "B" suffix device. The actual I_{ZM} for any device may not exceed the value of 400 milliwatts divided by the actual V_Z of the device.

NOTE 6 – MAXIMUM REGULATION FACTOR (ΔV_Z)

ΔV_Z is the maximum difference between V_Z at I_{ZT} and V_Z at I_{ZL} measured with the device junction in thermal equilibrium.

ZENER NOISE DENSITY

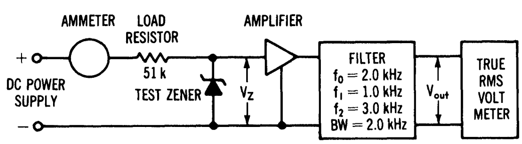
A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. To eliminate the higher frequency 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, a bandwidth of 2.0 kHz and a center frequency of 2.0 kHz.

Noise density decreases as zener current increases. The junction temperature will also change the zener noise levels, thus the noise rating must indicate frequency, bandwidth, current level and temperature.

The block diagram shown in Figure 2 represents 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 frequency and bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

FIGURE 2 – NOISE DENSITY MEASUREMENT METHOD



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

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

FIGURE 3 – TYPICAL CAPACITANCE

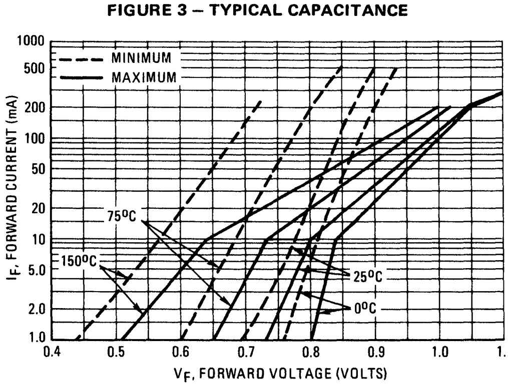


FIGURE 4 – TYPICAL FORWARD CHARACTERISTICS

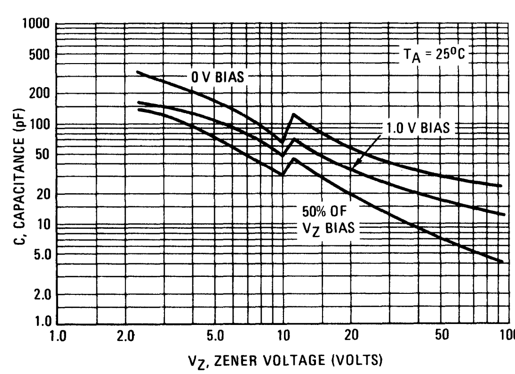
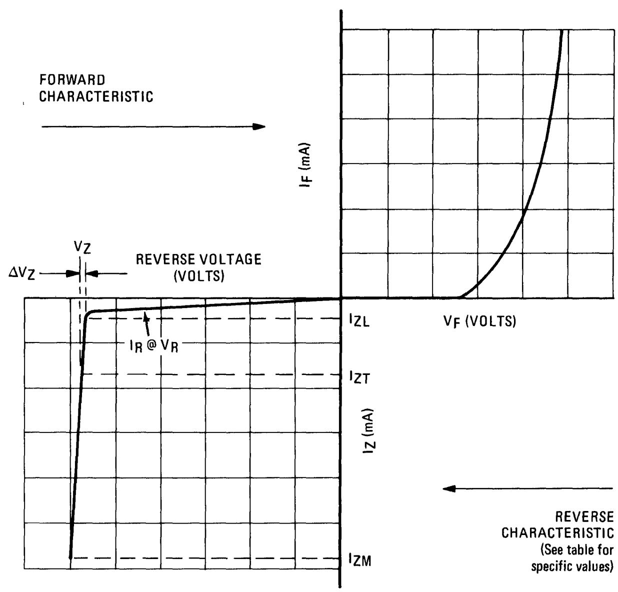


FIGURE 5 — ZENER DIODE CHARACTERISTICS AND SYMBOL IDENTIFICATION

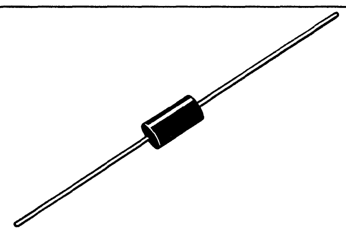


1N5908
1N6373/ICTE-5, C
MPTE-5, C
thru
1N6389/ICTE-45, C
MPTE-45, C
1N6267, A/1.5KE6.8, A
thru
1N6303, A/1.5KE200, A

MOTOROLA

MOSORBS
ZENER OVERVOLTAGE TRANSIENT SUPPRESSORS

5.0-200 VOLT
1500 WATT PEAK POWER
5.0 WATTS STEADY STATE



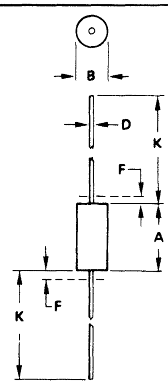
4

ZENER OVERVOLTAGE TRANSIENT SUPPRESSOR

Mosorb devices are designed to protect voltage sensitive components from high voltage, high energy transients. They have excellent clamping capability, high surge capability, low zener impedance and fast response time. These devices are Motorola's exclusive, cost-effective, highly reliable Surmetic axial leaded package and are ideally-suited for use in communication systems, numerical controls, process controls, medical equipment, business machines, power supplies and many other industrial/consumer applications, to protect CMOS, MOS and Bipolar integrated circuits.

SPECIFICATION FEATURES

- Standard Voltage Range — 5.0 to 200 V
- Peak Power — 1500 Watts @ 1.0 ms
- Maximum Clamp Voltage @ Peak Pulse Current
- Low Leakage < 5.0 μA above 10 V
- Standard Back to Back Versions Available



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

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	9.14	9.52	0.360	0.375
B	4.83	5.21	0.190	0.205
D	0.97	1.07	0.038	0.042
F	–	1.27	–	0.050
K	27.94	–	1.100	–

CASE 41-11

MAXIMUM RATINGS

Rating	Symbol	Value	Units
Peak Power Dissipation (1) @ $T_L \leq 25°C$	P_{PK}	1500	Watts
Steady State Power Dissipation @ $T_L \leq 75°C$, Lead Length = 3/8" Derated above $T_L = 75°C$	P_D	5.0 50	Watts mW/°C
Forward Surge Current (2) @ $T_A = 25°C$	I_{FSM}	200	Amps
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +175	°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

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, will be positive with respect to anode

MOUNTING POSITION: Any

NOTES: 1. Nonrepetitive Current Pulse per Figure 4 and Derated above $T_A = 25°C$ per Figure 2.
2. 1/2 Square Wave (or equivalent), PW = 8.3 ms, Duty Cycle = 4 Pulses per minute maximum.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted) V_F# = 3.5 V max, I_F** = 100 A

Device	Breakdown Voltage V_{BR} (Volts) Min	@ I_T (mA)	Maximum Reverse Stand-Off Voltage V_{RWM}*** (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Voltage @ I_{RSM}† = 120 A (Clamping Voltage) V_{RSM} (Volts)	Clamping Voltage: Peak Pulse Current @ I_{pp1}† = 30 A V_{C1} (Volts max)	Clamping Voltage: Peak Pulse Current @ I_{pp2}† = 60 A V_{C2} (Volts max)
1N5908	6.0	1.0	5.0	300	8.5	7.6	8.0

ELECTRICAL CHARACTERISTIC (T_A = 25°C unless otherwise noted) V_F# = 3.5 V max, I_F** = 100 A) (C suffix denotes standard back to back versions. Test both polarities)

JEDEC Device	Device	Breakdown Voltage V_{BR} Volts Min	@ I_T (mA)	Maximum Reverse Stand-Off Voltage V_{RWM}*** (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM}† (Clamping Voltage) V_{RSM} (Volts)	Clamping Voltage: Peak Pulse Current @ I_{pp1}† = 1.0 A V_{C1} (Volts max)	Clamping Voltage: Peak Pulse Current @ I_{pp2}† = 10 A V_{C2} (Volts max)
1N6373	ICTE-5/MPTE-5	6.0	1.0	5.0	300	160	9.4	7.1	7.5
—	ICTE-5C/MPTE-5C	6.0	1.0	5.0	300	160	9.4	8.1	8.3
1N6374	ICTE-8/MPTE-8	9.4	1.0	8.0	25	100	15.0	11.3	11.5
1N6382	ICTE-8C/MPTE-8C	9.4	1.0	8.0	25	100	15.0	11.4	11.6
1N6375	ICTE-10/MPTE-10	11.7	1.0	10	2.0	90	16.7	13.7	14.1
1N6383	ICTE-10C/MPTE-10C	11.7	1.0	10	2.0	90	16.7	14.1	14.5
1N6376	ICTE-12/MPTE-12	14.1	1.0	12	2.0	70	21.2	16.1	16.5
1N6384	ICTE-12C/MPTE-12C	14.1	1.0	12	2.0	70	21.2	16.7	17.1
1N6377	ICTE-15/MPTE-15	17.6	1.0	15	2.0	60	25.0	20.1	20.6
1N6385	ICTE-15C/MPTE-15C	17.6	1.0	15	2.0	60	25.0	20.8	21.4
1N6378	ICTE-18/MPTE-18	21.2	1.0	18	2.0	50	30.0	24.2	25.2
1N6386	ICTE-18C/MPTE-18C	21.2	1.0	18	2.0	50	30.0	24.8	25.5
1N6379	ICTE-22/MPTE-22	25.9	1.0	22	2.0	40	37.5	29.8	32.0
1N6387	ICTE-22C/MPTE-22C	25.9	1.0	22	2.0	40	37.5	30.8	32.0
1N6380	ICTE-36/MPTE-26	42.4	1.0	36	2.0	23	65.2	50.6	54.3
1N6388	ICTE-36C/MPTE-36C	42.4	1.0	36	2.0	23	65.2	50.6	54.3
1N6381	ICTE-45/MPTE-45	52.9	1.0	45	2.0	19	78.9	63.3	70.0
1N6389	ICTE-45C/MPTE-45C	52.9	1.0	45	2.0	19	78.9	63.3	70.0

JEDEC Device	Device	Breakdown Voltage V_{BR} Volts Min	Breakdown Voltage V_{BR} Volts Nom	Breakdown Voltage V_{BR} Volts Max	@ I_T (mA)	Working Peak Reverse Voltage V_{RWM} (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM} (Clamping Voltage) V_{RSM} (Volts)	Maximum Temperature Coefficient of V_{BR} (%/°C)
1N6267	1.5KE6.8	6.12	6.8	7.48	10	5.50	1000	139	10.8	0.057
1N6267A	1.5KE6.8A	6.45	6.8	7.14	10	5.80	1000	143	10.5	0.057
1N6268	1.5KE7.5	6.75	7.5	8.25	10	6.05	500	128	11.7	0.061
1N6268A	1.5KE7.5A	7.13	7.5	7.88	10	6.40	500	132	11.3	0.061
1N6269	1.5KE8.2	7.38	8.2	9.02	10	6.63	200	120	12.5	0.065
1N6269A	1.5KE8.2A	7.79	8.2	8.61	10	7.02	200	124	12.1	0.065
1N6270	1.5KE9.1	8.19	9.1	10.0	1.0	7.37	50	109	13.8	0.068
1N6270A	1.5KE9.1A	8.65	9.1	9.55	1.0	7.78	50	112	13.4	0.068
1N6271	1.5KE10	9.00	10	11	1.0	8.10	10	100	15.0	0.073
1N6271A	1.5KE10A	9.50	10	10.5	1.0	8.55	10	103	14.5	0.073
1N6272	1.5KE11	9.90	11	12.1	1.0	8.92	5.0	93.0	16.2	0.075
1N6272A	1.5KE11A	10.5	11	11.6	1.0	9.40	5.0	96.0	15.6	0.075

4

*ELECTRICAL CHARACTERISTICS (Continued)

JEDEC Device	Device	Breakdown Voltage V_{BR} Volts Min	Nom	Max	@ I_T (mA)	Working Peak Reverse Voltage V_{RWM} (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM} (Clamping Voltage) V_{RSM} (Volts)	Maximum Temperature Coefficient of V_{BR} (%/°C)
1N6273	1.5KE12	10.8	12	13.2	1.0	9.72	5.0	87.0	17.3	0.078
1N6273A	1.5KE12A	11.4	12	12.6	1.0	10.2	5.0	90.0	16.7	0.078
1N6274	1.5KE13	11.7	13	14.3	1.0	10.5	5.0	79.0	19.0	0.081
1N6274A	12.4	13	13.7	1.0	11.1	5.0	82.0	18.2	0.081	
1N6275	1.5KE15	13.5	15	16.5	1.0	12.1	5.0	68.0	22.0	0.084
1N6275A	1.5KE15A	14.3	15	15.8	1.0	12.8	5.0	71.0	21.2	0.084
1N6276	1.5KE16	14.4	16	17.6	1.0	12.9	5.0	64.0	23.5	0.086
1N6276A	1.5KE16A	15.2	16	16.8	1.0	13.6	5.0	67.0	22.5	0.086
1N6277	1.5KE18	16.2	18	19.8	1.0	14.5	5.0	56.5	26.5	0.088
1N6277A	1.5KE18A	17.1	18	18.9	1.0	15.3	5.0	59.5	25.2	0.088
1N6278	1.5KE20	18.0	20	22.0	1.0	16.2	5.0	51.5	29.1	0.090
1N6278A	1.5KE20A	19.0	20	21.0	1.0	17.1	5.0	54.0	27.7	0.090
1N6279	1.5KE22	19.8	22	24.2	1.0	17.8	5.0	47.0	31.9	0.092
1N6279A	1.5KE22A	20.9	22	23.1	1.0	18.8	5.0	49.0	30.6	0.092
1N6280	1.5KE24	21.6	24	26.4	1.0	19.4	5.0	43.0	34.7	0.094
1N6280A	1.5KE24A	22.8	24	25.2	1.0	20.5	5.0	45.0	33.2	0.094
1N6281	1.5KE27	24.3	27	29.7	1.0	21.8	5.0	38.5	39.1	0.096
1N6281A	1.5KE27A	25.7	27	28.4	1.0	23.1	5.0	40.0	37.5	0.096
1N6282	1.5KE30	27.0	30	33.0	1.0	24.3	5.0	34.5	43.5	0.097
1N6282A	1.5KE30A	28.5	30	31.5	1.0	25.6	5.0	36.0	41.4	0.097
1N6283	1.5KE33	29.7	33	36.3	1.0	26.8	5.0	31.5	47.7	0.098
1N6283A	1.5KE33A	31.4	33	34.7	1.0	28.2	5.0	33.0	45.7	0.098
1N6284	1.5KE36	32.4	36	39.6	1.0	29.1	5.0	29.0	52.0	0.099
1N6284A	1.5KE36A	34.2	36	37.8	1.0	30.8	5.0	30.0	49.9	0.099
1N6285	1.5KE39	35.1	39	42.9	1.0	31.6	5.0	26.5	56.4	0.100
1N6285A	1.5KE39A	37.1	39	41.0	1.0	33.3	5.0	28.0	53.9	0.100
1N6286	1.5KE43	38.7	43	47.3	1.0	34.8	5.0	24.0	61.9	0.101
1N6286A	1.5KE43A	40.9	43	45.2	1.0	36.8	5.0	25.3	59.3	0.101
1N6287	1.5KE47	42.3	47	51.7	1.0	38.1	5.0	22.2	67.8	0.101
1N6287A	1.5KE47A	44.7	47	49.4	1.0	40.2	5.0	23.2	64.8	0.101
1N6288	1.5KE51	45.9	51	56.1	1.0	41.3	5.0	20.4	73.5	0.102
1N6288A	1.5KE51A	48.5	51	53.6	1.0	43.6	5.0	21.4	70.1	0.102
1N6289	1.5KE56	50.4	56	61.6	1.0	45.4	5.0	18.6	80.5	0.103
1N6289A	1.5KE56	53.2	56	58.8	1.0	47.8	5.0	19.5	77.0	0.103
1N6290	1.5KE62	55.8	62	68.2	1.0	50.2	5.0	16.9	89.0	0.104
1N6290A	1.5KE62A	58.9	62	65.1	1.0	53.0	5.0	17.7	85.0	0.104
1N6291	1.5KE68	61.2	68	74.8	1.0	55.1	5.0	15.3	98.0	0.104
1N6291A	1.5KE68A	64.6	68	71.4	1.0	58.1	5.0	16.3	92.0	0.104
1N6292	1.5KE75	67.5	75	82.5	1.0	60.7	5.0	13.9	108.0	0.105
1N6292A	1.5KE75A	71.3	75	78.8	1.0	64.1	5.0	14.6	103.0	0.105
1N6293	1.5KE82	73.8	82	90.2	1.0	66.4	5.0	12.7	118.0	0.105
1N6293A	1.5KE82A	77.9	82	86.1	1.0	70.1	5.0	13.3	113.0	0.105
1N6294	1.5KE91	81.9	91	100.0	1.0	73.7	5.0	11.4	131.0	0.106
1N6294A	1.5KE91A	86.5	91	95.50	1.0	77.8	5.0	12.0	125.0	0.106
1N6295	1.5KE100	90.0	100	110.0	1.0	81.0	5.0	10.4	144.0	0.106
1N6295A	1.5KE100A	95.0	100	105.0	1.0	85.5	5.0	11.0	137.0	0.106
1N6296	1.5KE110	99.0	110	121.0	1.0	89.2	5.0	9.5	158.0	0.107
1N6296A	1.5KE110A	105.0	110	116.0	1.0	94.0	5.0	9.9	152.0	0.107
1N6297	1.5KE120	108.0	120	132.0	1.0	97.2	5.0	8.7	173.0	0.107
1N6297A	1.5KE120A	114.0	120	126.0	1.0	102.0	5.0	9.1	165.0	0.107
1N6298	1.5KE130	117.0	130	143.0	1.0	105.0	5.0	8.0	187.0	0.107
1N6298A	1.5KE130A	124.0	130	137.0	1.0	111.0	5.0	8.4	179.0	0.107
1N6299	1.5KE150	135.0	150	165.0	1.0	121.0	5.0	7.0	215.0	0.108
1N6299A	1.5KE150A	143.0	150	158.0	1.0	128.0	5.0	7.2	207.0	0.108
1N6300	1.5KE160	144.0	160	176.0	1.0	130.0	5.0	6.5	230.0	0.108
1N6300A	1.5KE160A	152.0	160	168.0	1.0	136.0	5.0	6.8	219.0	0.108

*ELECTRICAL CHARACTERISTICS (Continued)

JEDEC Device	Device	Breakdown Voltage V_{BR} Volts Min	Nom	Max	@ I_T (mA)	Working Peak Reverse Voltage V_{RWM} (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM} (Clampling Voltage) V_{RSM} (Volts)	Maximum Temperature Coefficient of V_{BR} (%/°C)
1N6301	1.5KE170	153.0	170	187.0	1.0	138.0	5.0	6.2	244.0	0.108
1N6301A	1.5KE170A	162.0	170	179.0	1.0	145.0	5.0	6.4	234.0	0.108
1N6302	1.5KE180	162.0	180	198.0	1.0	146.0	5.0	5.8	258.0	0.108
1N6302A	1.5KE180A	171.0	180	189.0	1.0	154.0	5.0	6.1	246.0	0.108
1N6303	1.5KE200	180.0	200	220.0	1.0	162.0	5.0	5.2	287.0	0.108
1N6303A	1.5KE200A	190.0	200	210.0	1.0	171.0	5.0	5.5	274.0	0.108

†Surge Current Waveform per Figure 4 and Derate per Figure 2.
*Indicates JEDEC Registered Data.
**1/2 Square Equivalent Sine Wave, PW = 8.3 ms, Duty Cycle = 4 Pulses per Minute maximum.
***A Transient Suppressor is normally selected according to the maximum reverse stand-off voltage (V_{RWM}), which should be equal to or greater than the dc or continuous peak operating voltage level.
#V_F applies to Non-C suffix devices only.
C suffix denotes standard back-to-back versions. Test both polarities.

To order clipper-bidirectional device in 1N6267 series, add a "C" suffix to 1.5KE device title, i.e., 1.5KE7.5C or 1.5KE7.5CA.

4

FIGURE 1 — PULSE RATING CURVE

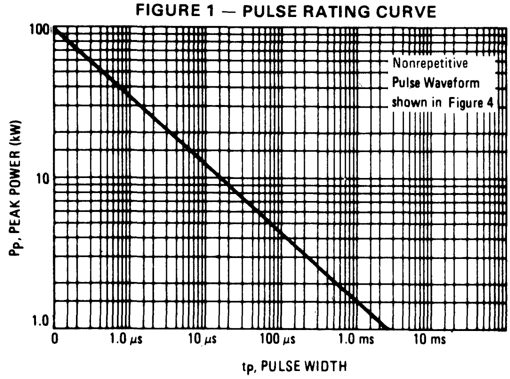


FIGURE 2 — PULSE DERATING CURVE

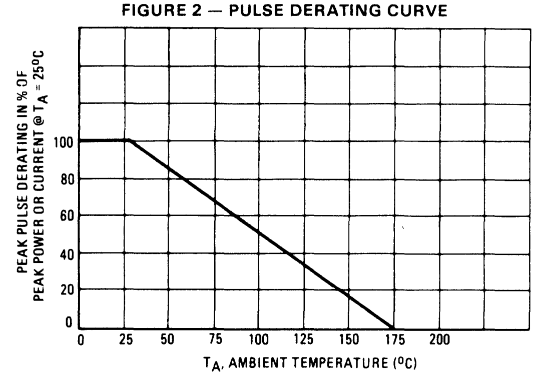
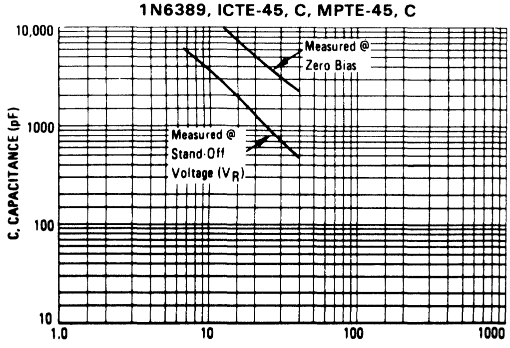


FIGURE 3 — CAPACITANCE versus BREAKDOWN VOLTAGE

1N6373, ICTE-5, C, MPTE-5, C
thru
1N6389, ICTE-45, C, MPTE-45, C



1N6267, A/1.5KE6.8, A
thru
1N6303, A/1.5KE200, A

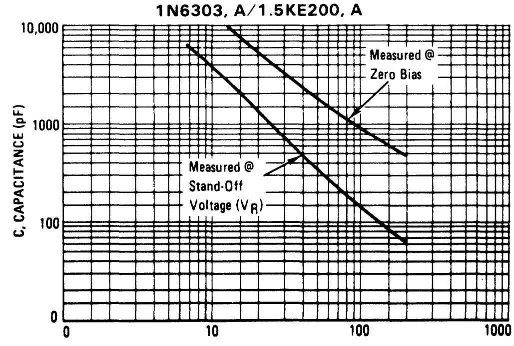


FIGURE 4 — STEADY STATE POWER DERATING

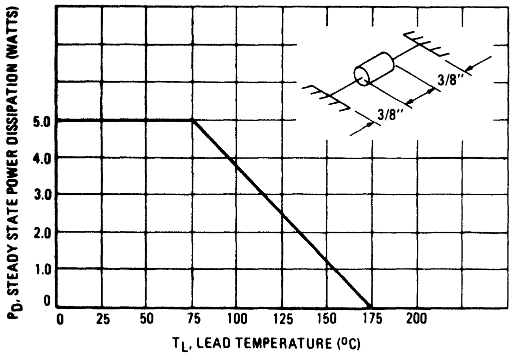


FIGURE 5 — PULSE WAVEFORM

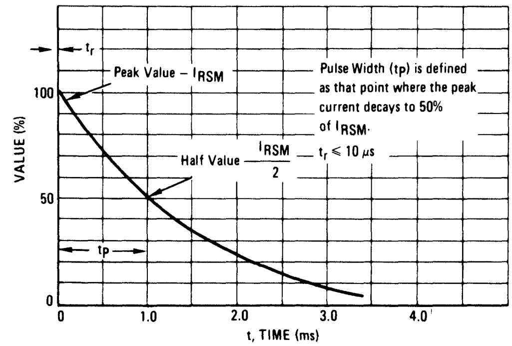
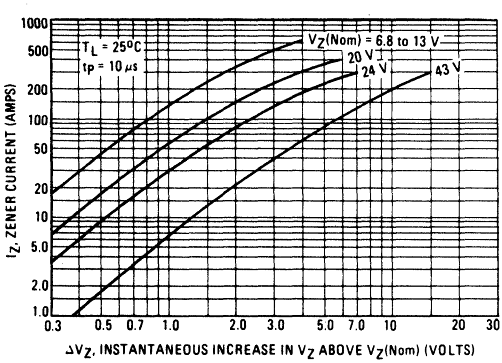
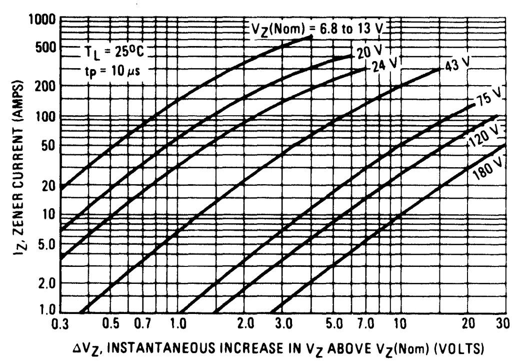


FIGURE 6 — DYNAMIC IMPEDANCE

1N6373, ICTE-5, C, MPTE-5, C
thru
1N6389, ICTE-45, C, MPTE-45, C



1N6267, A/1.5KE6.8, A
thru
1N6303, A/1.5KE200, A



APPLICATION NOTES

SPECIAL DEVICES

Matched sets and back-to-back configurations for bidirectional applications can be ordered upon special request. Contact your nearest Motorola representative.

RESPONSE TIME

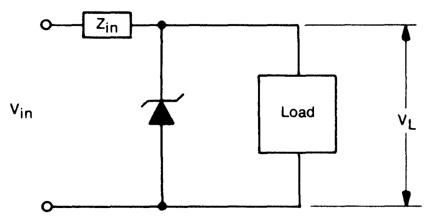
In most applications, the transient suppressor device is placed in parallel with the equipment or component to be protected. In this situation, there is a time delay associated with the capacitance of the device and an overshoot condition associated with the inductance of the device and the inductance of the connection method. The capacitive effect is of minor importance in the parallel protection scheme because it only produces a time delay in the transition from the operating voltage to the clamp voltage as shown in Figure A.

The inductive effects in the device are due to actual turn-on time (time required for the device to go from zero current to full current) and lead inductance. This inductive effect produces an overshoot in the voltage across the equipment or component being protected as shown in Figure B. Minimizing this overshoot is very important in the application, since the main purpose for adding a transient suppressor is to clamp voltage spikes. These devices have excellent response time, typically in the picosecond range and negligible inductance. However, external inductive effects could produce unacceptable overshoot. Proper circuit layout, minimum lead lengths and placing the suppressor device as close as possible to the equipment or components to be protected will minimize this overshoot.

Some input impedance represented by Z_{in} is essential to prevent overstress of the protection device. This impedance should be as high as possible, without restricting the circuit operation.

4

TYPICAL PROTECTION CIRCUIT



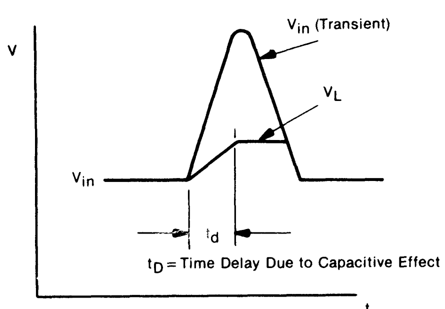


FIGURE A

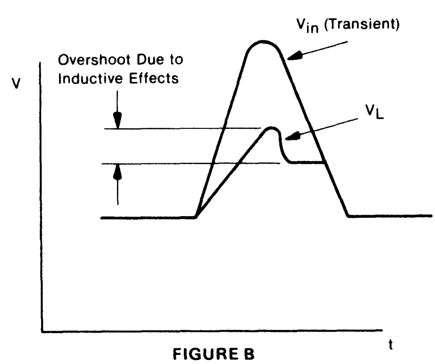


FIGURE B

1N5913A
thru
1N5956A

MOTOROLA

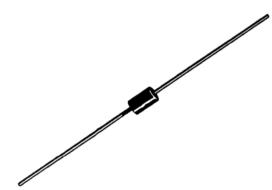
4

1.5 WATT SURMETIC 30
SILICON ZENER DIODES

. . . A complete line of 1.5-Watt Zener Diodes offering the following advantages:

- Complete Voltage Range – 3.3 to 200 Volts
- DO-41 Package – Smaller than Conventional Metal Devices
- Metallurgically Bonded Construction
- JEDEC Registered Parameters
- Oxide Passivated Diode

1.5 WATTS
ZENER DIODES
3.3 – 200 VOLTS



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_L = 75°C, Lead Length = 3/8"	P_D	1.5	Watts
Derate above 75°C		12	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	°C

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS

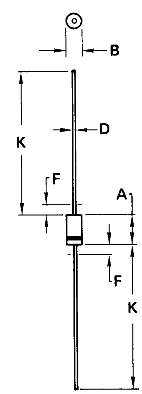
CASE: Double slug type, surmetic 30 void-free, transfer-molded, thermosetting-plastic

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16" from case for 10 seconds

FINISH: All external surfaces are corrosion resistant with readily solderable leads

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

MOUNTING POSITION: Any

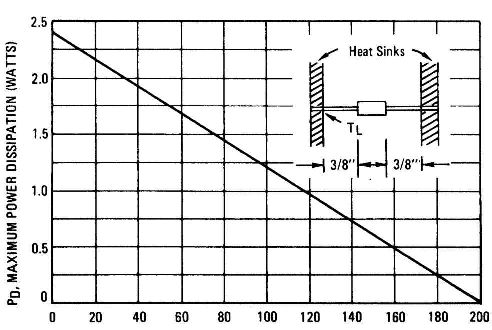


DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.07	5.20	0.160	0.205
B	2.04	2.71	0.080	0.107
D	0.71	0.86	0.028	0.034
F	–	1.27	–	0.050
K	27.94	–	1.100	–

CASE 59-03
DO-41

NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

FIGURE 1 – STEADY STATE POWER DERATING



***ELECTRICAL CHARACTERISTICS** (T_L = 30°C unless otherwise noted. V_F= 1.5 Volts Max @ I_F = 200 mAdc for all types.)

Motorola Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max. Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} Ohms	@ I_{ZK} mA	Max. Reverse Leakage Current I_R µA	@ V_R Volts	Maximum DC Zener Current I_{ZM} mAdc
1N5913A	3.3	113.6	10	500	1.0	100	1.0	454
1N5914A	3.6	104.2	9.0	500	1.0	75	1.0	416
1N5915A	3.9	96.1	7.5	500	1.0	25	1.0	384
1N5916A	4.3	87.2	6.0	500	1.0	5.0	1.0	348
1N5917A	4.7	79.8	5.0	500	1.0	5.0	1.5	319
1N5918A	5.1	73.5	4.0	350	1.0	5.0	2.0	294
1N5919A	5.6	66.9	2.0	250	1.0	5.0	3.0	267
1N5920A	6.2	60.5	2.0	200	1.0	5.0	4.0	241
1N5921A	6.8	55.1	2.5	200	1.0	5.0	5.2	220
1N5922A	7.5	50.0	3.0	400	0.5	5.0	6.8	200
1N5923A	8.2	45.7	3.5	400	0.5	5.0	6.5	182
1N5924A	9.1	41.2	4.0	500	0.5	5.0	7.0	164
1N5925A	10	37.5	4.5	500	0.25	5.0	8.0	150
1N5926A	11	34.1	5.5	550	0.25	1.0	8.4	136
1N5927A	12	31.2	6.5	550	0.25	1.0	9.1	125
1N5928A	13	28.8	7.0	550	0.25	1.0	9.9	115
1N5929A	15	25.0	9.0	600	0.25	1.0	11.4	100
1N5930A	16	23.4	10	600	0.25	1.0	12.2	93
1N5931A	18	20.8	12	650	0.25	1.0	13.7	83
1N5932A	20	18.7	14	650	0.25	1.0	15.2	75
1N5933A	22	17.0	17.5	650	0.25	1.0	16.7	68
1N5934A	24	15.6	19	700	0.25	1.8	18.2	62
1N5935A	27	13.9	23	700	0.25	1.0	20.6	55
1N5936A	30	12.5	26	750	0.25	1.0	22.8	50
1N5937A	33	11.4	33	800	0.25	1.0	25.1	45
1N5938A	36	10.4	38	850	0.25	1.0	27.4	41
1N5939A	39	9.6	45	900	0.25	1.0	29.7	38
1N5940A	43	8.7	53	950	0.25	1.0	32.7	34
1N5941A	47	8.0	67	1000	0.25	1.0	35.8	31
1N5942A	51	7.3	70	1100	0.25	1.0	38.8	29
1N5943A	56	6.7	86	1300	0.25	1.0	42.6	26
1N5944A	62	6.0	100	1500	0.25	1.0	47.1	24
1N5945A	68	5.5	120	1700	0.25	1.0	51.7	22
1N5946A	75	5.0	140	2000	0.25	1.0	56.0	20
1N5947A	82	4.6	160	2500	0.25	1.0	62.2	18
1N5948A	91	4.1	200	3000	0.25	1.0	69.2	16
1N5949A	100	3.7	250	3100	0.25	1.0	76.0	15
1N5950A	110	3.4	300	4000	0.25	1.0	83.6	13
1N5951A	120	3.1	380	4500	0.25	1.0	91.2	12
1N5952A	130	2.9	450	5000	0.25	1.0	98.8	11
1N5953A	150	2.5	600	6000	0.25	1.0	114	10
1N5954A	160	2.3	700	6500	0.25	1.0	121.6	9.0
1N5955A	180	2.1	900	7000	0.25	1.0	136.8	8.0
1N5956A	200	1.9	1200	8000	0.25	1.0	152	7.0

*Indicates JEDEC Registered Data.

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation — Device tolerances of ±10% are indicated by an "A" suffix, ±5% by a "B" suffix, ±2% by a "C" suffix, ±1% by a "D" suffix.

Non-Standard voltage designation – To designate units with zener voltages other than those assigned the Motorola type number should be used.

EXAMPLE:

M	Z	P	41	–	6.0	A
Motorola	Zener		Series		Nominal Voltage	Tolerance (±%)

NOTE 2 – SPECIAL SELECTIONS AVAILABLE INCLUDE:

(a) Nominal zener voltages between those shown.
(b) Matched sets: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%)
  a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
  b. Two or more units matched to one another with any specified tolerance.

4

TYPICAL CHARACTERISTICS

TEMPERATURE COEFFICIENTS (-55°C to +150°C temperature range)

FIGURE 2 – ZENER VOLTAGE – TO 12 VOLTS

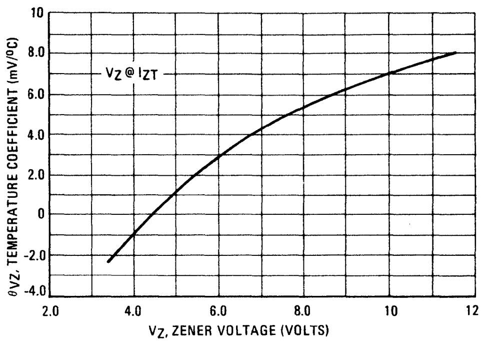
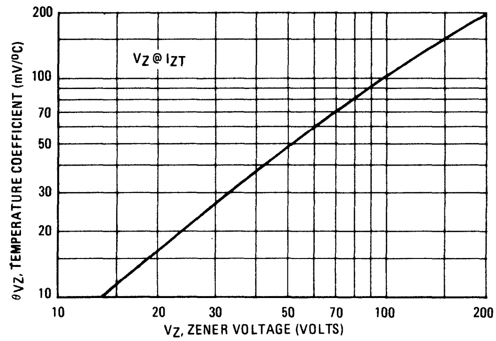


FIGURE 3 – ZENER VOLTAGE – 14 TO 200 VOLTS



ZENER IMPEDANCE

FIGURE 4 – EFFECT OF ZENER CURRENT

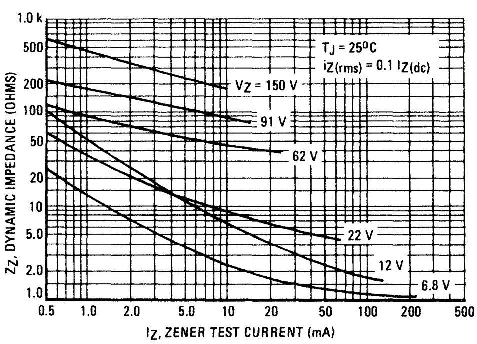
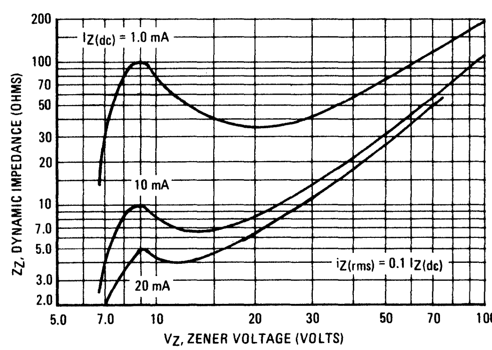


FIGURE 5 – EFFECT OF ZENER VOLTAGE



MOTOROLA

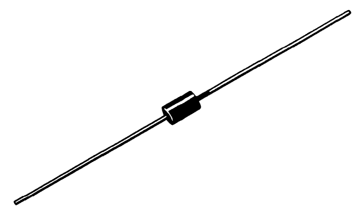
1N5985A thru 1N6025A

500 MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

. . . A complete line of 500 mW Zener Diodes offering the following advantages:

- Complete Voltage Range – 2.4 to 110 Volts
- DO-35 Package – Smaller than Conventional DO-7 Package
- Double Slug Type Construction
- Metallurgically Bonded Construction
- JEDEC Registered
- Oxide Passivated Die

500 MILLIWATT
GLASS ZENER DIODES
2.4–110 VOLTS



4

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L \leq 50^oC$, Lead Length = 3/8″	P_D	500	mW
Derate above 50^oC		3.33	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +200	^oC

*Indicates JEDEC Registered Data.

MECHANICAL CHARACTERISTICS

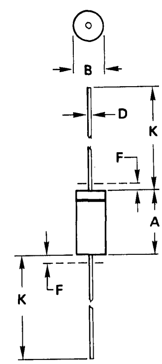
CASE: Double slug type, hermetically sealed glass

MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, 1/16″ from case for 10 seconds

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

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

MOUNTING POSITION: Any



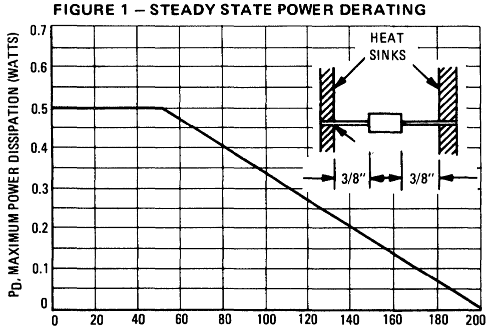
NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN A AND B. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT NOT SUBJECT TO THE MINIMUM LIMIT OF B.
2. LEAD DIAMETER NOT CONTROLLED IN ZONE F TO ALLOW FOR FLASH, LEAD FINISH BUILDUP AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.
3. POLARITY DENOTED BY CATHODE BAND.
4. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.05	5.08	0.120	0.200
B	1.52	2.29	0.060	0.090
D	0.46	0.56	0.018	0.022
F	–	1.27	–	0.050
K	25.40	38.10	1.000	1.500

All JEDEC dimensions and notes apply.

CASE 299-02
DO-204AH
(DO-35)

FIGURE 1 – STEADY STATE POWER DERATING



***ELECTRICAL CHARACTERISTICS** (T_L = 30°C unless otherwise noted.) (V_F = 1.5 Volts Max @ I_F = 100 mAdc for all types.)

Motorola Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max. Zener Impedance (Note 4) Z_{ZT} @ I_{ZT} Ohms		Max. Zener Impedance (Note 4) Z_{ZK} @ I_{ZK} = 0.25 mA Ohms		Max. Reverse Leakage Current I_R µA		@ V_R volts		Max. DC Zener Current I_{ZM} (Note 3)
			B Suffix	A, Non-Suffix	B Suffix	A, Non-Suffix	B Suffix	A, Non-Suffix	B Suffix	A, Non-Suffix	
1N5985A	2.4	5.0	100	110	1800	2000	100	100	1.0	0.5	208
1N5986A	2.7	5.0	100	110	1900	2200	75	100	1.0	0.5	185
1N5987A	3.0	5.0	95	100	2000	2300	50	100	1.0	0.5	167
1N5988A	3.3	5.0	95	100	2200	2400	25	75	1.0	0.5	152
1N5989A	3.6	5.0	90	95	2300	2500	15	50	1.0	0.5	139
1N5990A	3.9	5.0	90	95	2400	2500	10	25	1.0	1.0	128
1N5991A	4.3	5.0	88	90	2500	2500	5.0	15	1.0	1.0	116
1N5992A	4.7	5.0	70	90	2200	2500	3.0	10	1.5	1.0	106
1N5993A	5.1	5.0	50	88	2050	2500	2.0	5.0	2.0	1.0	98
1N5994A	5.6	5.0	25	70	1800	2200	2.0	3.0	3.0	1.5	89
1N5995A	6.2	5.0	10	50	1300	2050	1.0	2.0	4.0	2.0	81
1N5996A	6.8	5.0	8.0	25	750	1800	1.0	2.0	5.2	3.0	74
1N5997A	7.5	5.0	7.0	10	600	1300	0.5	1.0	6.0	4.0	67
1N5998A	8.2	5.0	7.0	15	600	750	0.5	1.0	6.5	5.2	61
1N5999A	9.1	5.0	10	18	600	600	0.1	0.5	7.0	6.0	55
1N6000A	10	5.0	15	22	600	600	0.1	0.5	8.0	6.5	50
1N6001A	11	5.0	18	25	600	600	0.1	0.1	8.4	7.0	45
1N6002A	12	5.0	22	32	600	600	0.1	0.1	9.1	8.0	42
1N6003A	13	5.0	25	36	600	600	0.1	0.1	9.9	8.4	38
1N6004A	15	5.0	32	42	600	600	0.1	0.1	11	9.1	33
1N6005A	16	5.0	36	48	600	600	0.1	0.1	12	9.9	31
1N6006A	18	5.0	42	55	600	600	0.1	0.1	14	11	28
1N6007A	20	5.0	48	62	600	600	0.1	0.1	15	12	25
1N6008A	22	5.0	55	70	600	600	0.1	0.1	17	14	23
1N6009A	24	5.0	62	78	600	600	0.1	0.1	18	15	21
1N6010A	27	5.0	70	88	600	700	0.1	0.1	21	17	19
1N6011A	30	5.0	78	95	600	700	0.1	0.1	23	18	17
1N6012A	33	5.0	88	110	700	800	0.1	0.1	25	21	15
1N6013A	36	5.0	95	130	700	900	0.1	0.1	27	23	14
1N6014A	39	2.0	130	170	800	1000	0.1	0.1	30	25	13
1N6015A	43	2.0	150	180	900	1100	0.1	0.1	33	27	12
1N6016A	47	2.0	170	200	1000	1300	0.1	0.1	36	30	11
1N6017A	51	2.0	180	225	1300	1400	0.1	0.1	39	33	9.8
1N6018A	56	2.0	200	240	1400	1600	0.1	0.1	43	36	8.9
1N6019A	62	2.0	225	265	1400	1700	0.1	0.1	47	39	8.0
1N6020A	68	2.0	240	280	1600	2000	0.1	0.1	52	43	7.4
1N6021A	75	2.0	265	300	1700	2300	0.1	0.1	56	47	6.7
1N6022A	82	2.0	280	350	2000	2600	0.1	0.1	62	52	6.1
1N6023A	91	2.0	300	400	2300	3000	0.1	0.1	69	56	5.5
1N6024A	100	1.0	500	800	2600	4000	0.1	0.1	76	62	5.0
1N6025A	110	1.0	650	950	3000	4500	0.1	0.1	84	69	4.5

*Indicates JEDEC Registered Data.

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation — Device tolerances of ±10% are indicated by an "A" suffix, ±5% by a "B" suffix, ±2% by a "C" suffix, ±1% by a "D" suffix.

Non-Standard voltage designation — To designate units with zener voltages other than those assigned the Motorola type number should be used.

EXAMPLE: M Z G 35 – 6.0 A

Motorola Zener Glass Series Nominal Voltage Tolerance (±%)

NOTE 2 – SPECIAL SELECTIONS AVAILABLE INCLUDE:

(a) Nominal Zener voltages between those shown.

(b) Matched sets: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%)

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability

b. Two or more units matched to one another with any specified tolerance.

NOTE 3:

This data was calculated using nominal voltages. In order to determine the maximum current handling capability on a worst case basis the following formula must be used:

$$I_{zm}(\text{worst case}) = \frac{500\ \text{mW}}{V_z(\text{nom}) + \text{tolerance}}$$

NOTE 4:

Z_{ZT} and Z_{ZK} are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for $I_Z(ac)$ = 0.1 $I_Z(dc)$ with the ac frequency = 1.0 kHz.

TYPICAL CHARACTERISTICS

TEMPERATURE COEFFICIENTS (-55°C to +150°C temperature range)

FIGURE 2A — ZENER VOLTAGE 2.4 to 12 VOLTS

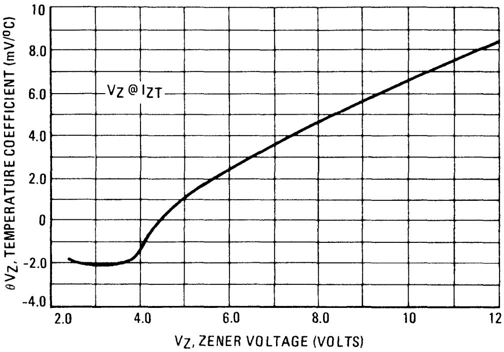


FIGURE 2B — ZENER VOLTAGE 12 to 200 VOLTS

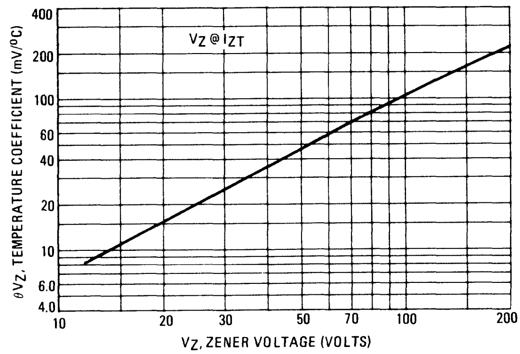


FIGURE 3 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

FIGURE 3A

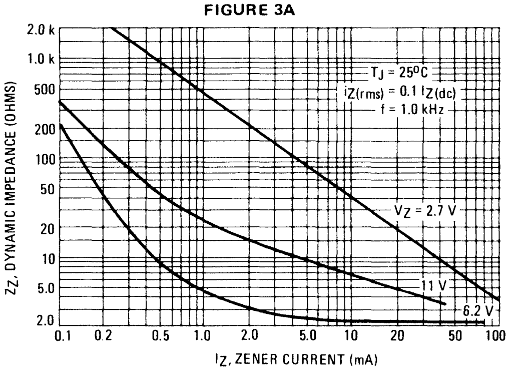


FIGURE 3B

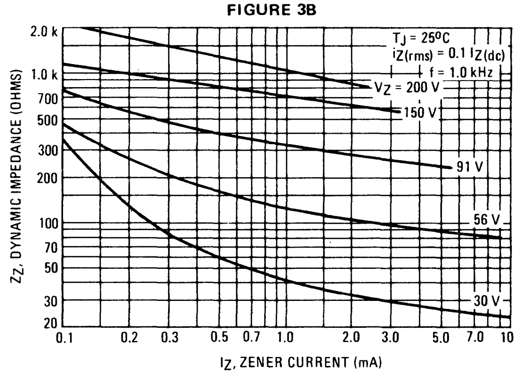
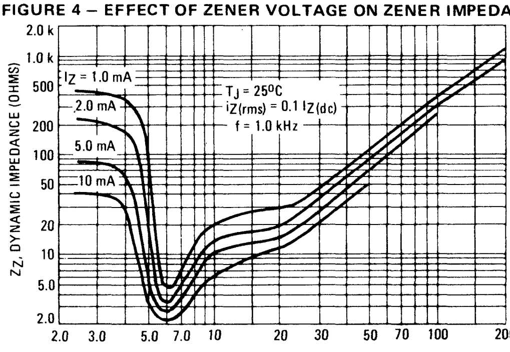


FIGURE 4 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE



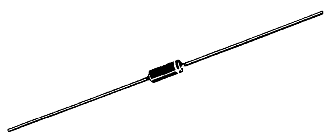
4

1N6267,A thru 1N6303,A
1N6373 thru 1N6389
ICTE-5,C
thru
ICTE-45,C
See Page 4-74

MOTOROLA

MCL1300 thru MCL1304

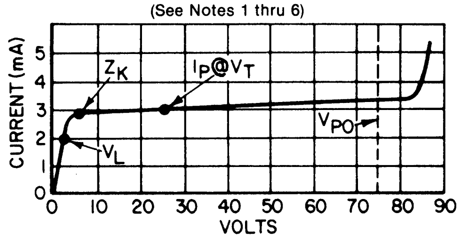
CURRENT LIMITING DIODES



CURRENT LIMITING DIODES

Field-effect current limiting diodes designed for applications requiring a current reference or a constant current over a specified voltage range.

CURRENT-LIMITER CHARACTERISTICS AND SYMBOL IDENTIFICATION
(See Notes 1 thru 6)



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

Junction and Storage Temperature: −65°C to +200°C
Peak Operating Voltage: See Table

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

Type Number	Nominal Pinch-Off Current Note 1 I_P (mA)	Tol. (mA)	Test Volt. Note 2 V_T (Volts)	Limiter Imped. Note 3 Z_T (min) (Megohms)	Knee Imped. at 6 V Note 4 Z_K (min) (Megohms)	Limiting Voltage Note 5 V_L (max) (Volts)	Peak Operating Voltage Note 6 V_{PO} (Volts)
MCL1300	0.5	±0.3	25	4.000	0.500	1.0	75
MCL1301	1.0	±0.6	25	0.800	0.200	1.5	75
MCL1302	2.0	±0.6	25	0.400	0.100	2.0	75
MCL1303	3.0	±0.6	25	0.300	0.050	2.0	75
MCL1304	4.0	±0.6	25	0.250	0.025	2.5	75

These specifications are preliminary. Selections may be made to obtain nominal currents between those shown, as well as tighter tolerance units.

SYMBOL DEFINITIONS:

NOTE 1 I_P – The pinch-off current is the guaranteed current at a specified V_T. I_P is specified as a nominal with a tolerance.

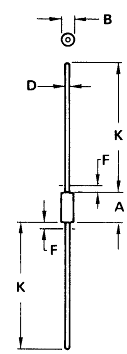
NOTE 2 V_T – The test voltage for measurement of I_P.

NOTE 3 Z_T – The impedance at the test voltage, V_T, specified. To provide the most constant current Z_T should be as high as possible; thus a minimum Z_T is specified. Z_T is derived from the 90 cycle per second current which results when an AC voltage having an RMS value equal to 10% of the test voltage (V_T) is superimposed on V_T.

NOTE 4 Z_K – Knee impedance is specified as a minimum also since again the highest value is desired. V_K is established as 6.0 V for convenience.

NOTE 5 V_L – Limiting Voltage. This specification is provided with Z_K to indicate the sharp knee of the device. The specification is analogous to I_R and Z_K of a zener diode. V_L a maximum specification is measured at 80% on I_P tolerance.

NOTE 6 V_{PO} – The peak-operating voltage is provided and indicates the maximum voltage to be applied to the device. The specification is necessary since the device is either power limited or breakdown limited beyond this specified voltage.



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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51
DO-7

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

MOTOROLA

MLL746 thru MLL759

MLL957A thru MLL986A

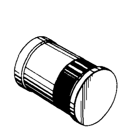
MLL4370 thru MLL4372

500 MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 2.4 to 110 Volts
- Leadless Package for Surface Mount Technology
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die
- Available in 8 mm Tape and Reel
  T1 Cathode Facing Sprocket Holes
  T2 Anode Facing Sprocket Holes

LEADLESS GLASS ZENER DIODES

500 MILLIWATTS
2.4–110 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A \leq 50°C$ Derate above $T_A = 50°C$	P_D	500 3.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Double slug type, hermetically sealed glass

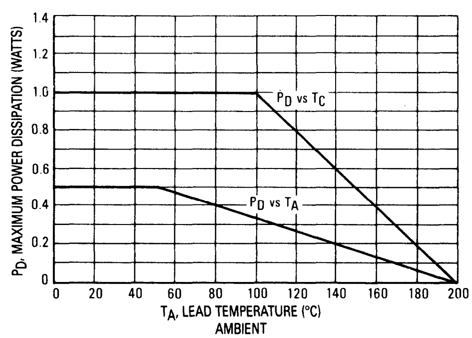
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, for 10 seconds

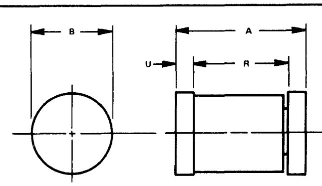
FINISH: All external surfaces are corrosion resistant and readily solderable

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

MOUNTING POSITION: Any

STEADY STATE POWER DERATING





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

4

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V Max @ 200 mA for all types)

Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} (Notes 1,2,3) Volts	Test Current I_{ZT} (Note 2) mA	Maximum Zener Impedance Z_{ZT} @ I_{ZT} (Note 4) Ohms	Maximum DC Zener Current I_{ZM} mA		Maximum Reverse Leakage Current T_A = 25°C I_R @ V_R = 1 V µA	T_A = 150°C I_R @ V_R = 1 V µA
MLL4370	2.4	20	30	150	190	100	200
MLL4371	2.7	20	30	135	165	75	150
MLL4372	3.0	20	29	120	150	50	100
MLL746	3.3	20	28	110	135	10	30
MLL747	3.6	20	24	100	125	10	30
MLL748	3.9	20	23	95	115	10	30
MLL749	4.3	20	22	85	105	2	30
MLL750	4.7	20	19	75	95	2	30
MLL751	5.1	20	17	70	85	1	20
MLL752	5.6	20	11	65	80	1	20
MLL753	6.2	20	7	60	70	0.1	20
MLL754	6.8	20	5	55	65	0.1	20
MLL755	7.5	20	6	50	60	0.1	20
MLL756	8.2	20	8	45	55	0.1	20
MLL757	9.1	20	10	40	50	0.1	20
MLL758	10	20	17	35	45	0.1	20
MLL759	12	20	30	30	35	0.1	20

Type Number (Note 1)	Nominal Zener Voltage V_Z (Notes 1,2,3) Volts	Test Current I_{ZT} (Note 2) mA	Maximum Zener Impedance (Note 4) Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} Ohms	I_{ZK} mA	Maximum DC Zener Current I_{ZM} mA		Maximum Reverse Current I_R Maximum µA	Test Voltage Vdc V_R 5%	10%
MLL957A	6.8	18.5	4.5	700	1.0	47	61	150	5.2	4.9
MLL958A	7.5	16.5	5.5	700	0.5	42	55	75	5.7	5.4
MLL959A	8.2	15	6.5	700	05	38	50	50	6.2	5.9
MLL960A	9.1	14	7.5	700	0.5	35	45	25	6.9	6.6
MLL961A	10	12.5	8.5	700	0.25	32	41	10	7.6	7.2
MLL962A	11	11.5	9.5	700	0.25	28	37	5	8.4	8.0
MLL963A	12	10.5	11.5	700	0.25	26	34	5	9.1	8.6
MLL964A	13	9.5	13	700	0.25	24	32	5	9.9	9.4
MLL965A	15	8.5	16	700	0.25	21	27	5	11.4	10.8
MLL966A	16	7.8	17	700	0.25	19	37	5	12.2	11.5
MLL967A	18	7.0	21	750	0.25	17	23	5	13.7	13.0
MLL968A	20	6.2	25	750	0.25	15	20	5	15.2	14.4
MLL969A	22	5.6	29	750	0.25	14	18	5	16.7	15.8
MLL970A	24	5.2	33	750	0.25	13	17	5	18.2	17.3
MLL971A	27	4.6	41	750	0.25	11	15	5	20.6	19.4
MLL972A	30	4.2	49	1000	0.25	10	13	5	22.8	21.6
MLL973A	33	3.8	58	1000	0.25	9.2	12	5	25.1	23.8
MLL974A	36	3.4	70	1000	0.25	8.5	11	5	27.4	25.9
MLL975A	39	3.2	80	1000	0.25	7.8	10	5	29.7	28.1
MLL976A	43	3.0	93	1500	0.25	7.0	9.6	5	32.7	31.0
MLL977A	47	2.7	105	1500	0.25	6.4	8.8	5	35.8	33.8
MLL978A	51	2.5	125	1500	0.25	5.9	8.1	5	38.8	36.7
MLL979A	56	2.2	150	2000	0.25	5.4	7.4	5	42.6	40.3
MLL980A	62	2.0	185	2000	0.25	4.9	6.7	5	47.1	44.6
MLL981A	68	1.8	230	2000	0.25	4.5	6.1	5	51.7	49.0
MLL982A	75	1.7	270	2000	0.25	1.0	5.5	5	56.0	54.0
MLL983A	82	1.5	330	3000	0.25	3.7	5.0	5	62.2	59.0
MLL984A	91	1.4	400	3000	0.25	3.3	4.5	5	69.2	65.5
MLL985A	100	1.3	500	3000	0.25	3.0	4.5	5	76	72
MLL986A	110	1.1	750	4000	0.25	2.7	4.1	5	83.6	79.2

4

NOTE 1. Tolerance Designation — The type numbers shown have tolerance designations as follows:

MLL4370 series: ±10%, suffix A for ±5% units.
MLL746 series: ±10%, suffix A for ±5% units.
MLL957 series: suffix A for ±10% units, suffix B for ±5% units.

NOTE 2. Special Selections† Available Include:

1. Nominal zener voltages between those shown.
2. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
3. Nominal voltages at non-standard test currents.

NOTE 3. Zener Voltage (V_Z) Measurement — Nominal zener voltage is measured with the device junction in thermal equilibrium at the case temperature of 30°C ±1°C.

NOTE 4. Zener Impedance (Z_Z) Derivation — Z_{ZT} is measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for $I_Z(ac) = 0.1 \times I_Z(dc)$ with the ac frequency = 1.0 kHz.

†For more information on special selections contact your nearest Motorola representative.

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:

Case Temperature, T_C, should be determined from:

$$T_C = \theta_{CA} P_D + T_A.$$

θ_{CA} is the case-to-ambient thermal resisstance (°C/W) and P_D is the power dissipation. The value for θ_{CA} will vary and depends on the device mounting method. θ_{CA} is generally 200°C/W for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the case can also be measured using a thermocouple placed at the case end 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_C, the junction temperature may be determined by:

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

ΔT_{JC} is the increase in junction temperature above the case temperature and may be found by using:

$$\Delta T_{JC} = \theta_{JC} P_D.$$

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.

Surge limitations are given in Figure 6. 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 6 be exceeded.

FIGURE 1 — TYPICAL LEAKAGE CURRENT

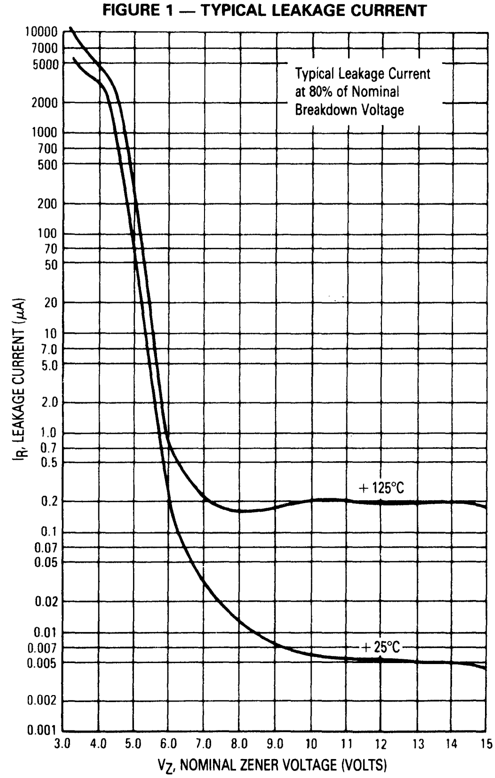


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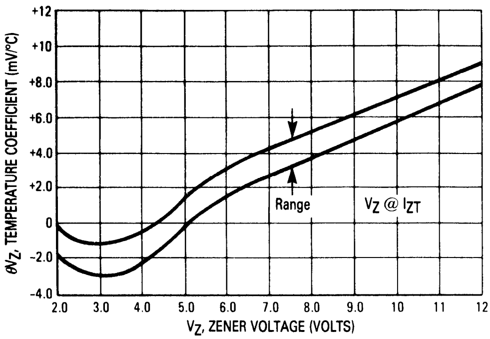
FIGURE 2 — TEMPERATURE COEFFICIENTS
(−55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

a — RANGE FOR UNITS TO 12 VOLTS



b — RANGE FOR UNITS 12 TO 100 VOLTS

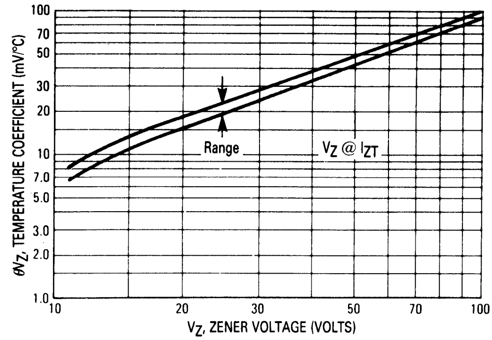


FIGURE 3 — EFFECT OF ZENER CURRENT

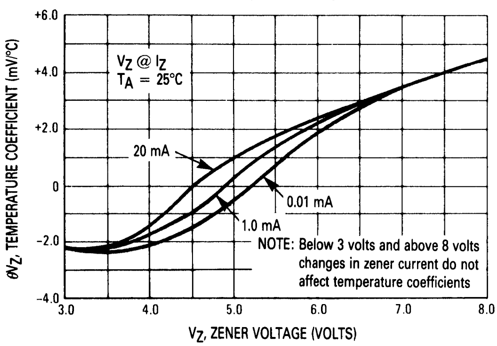


FIGURE 4 — TYPICAL CAPACITANCE

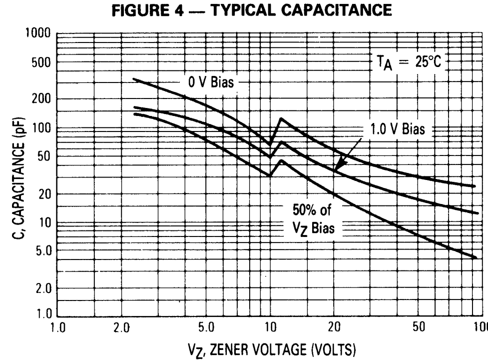
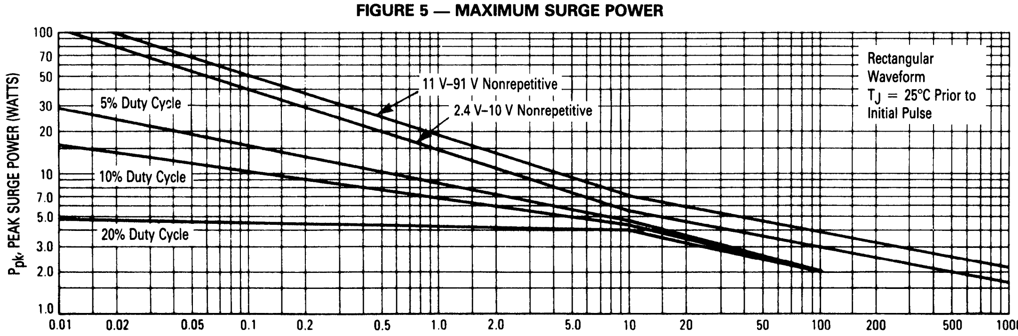


FIGURE 5 — MAXIMUM SURGE POWER



This graph represents 90 percentil data points.
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 6 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

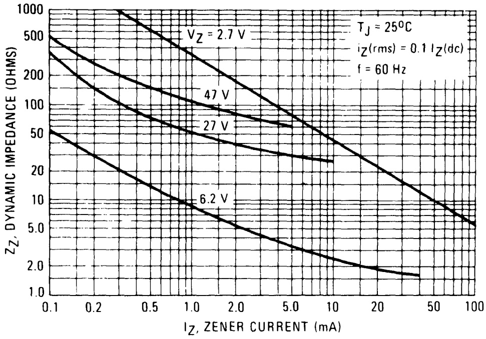


FIGURE 7 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

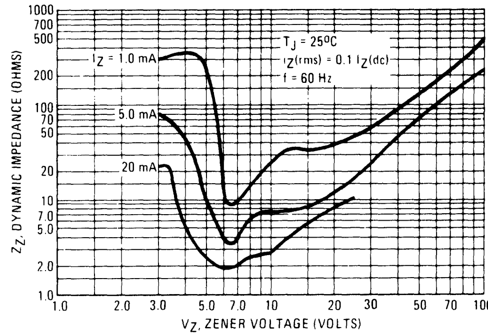


FIGURE 8 — TYPICAL NOISE DENSITY

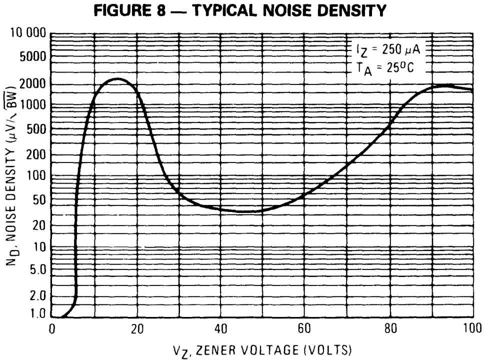
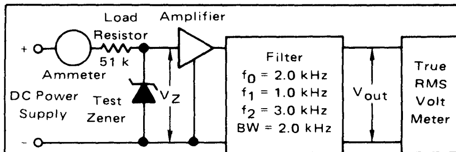


FIGURE 9 — NOISE DENSITY MEASUREMENT METHOD

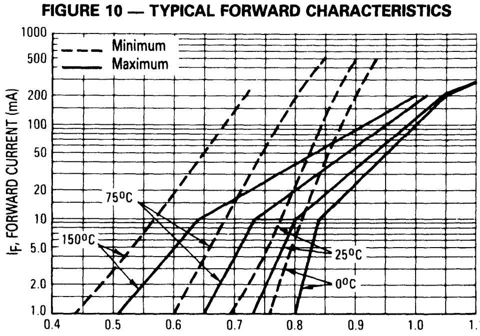


$$\text{Noise Density (Volts Per Square Root Bandwidth)} = \frac{V_{out}}{\text{Overall Gain} \sqrt{BW}}$$

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 zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

FIGURE 10 — TYPICAL FORWARD CHARACTERISTICS



MLL4099–MLL4135
MLL4614–MLL4627

MOTOROLA

4

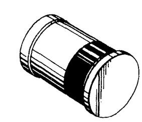
SILICON LEADLESS GLASS ZENER DIODES

(±5.0% TOLERANCE)

250 MILLIWATTS

1.8–100 VOLTS

SILICON NITRIDE PASSIVATED JUNCTION



LOW NOISE LEVEL SILICON PASSIVATED ZENER DIODES

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

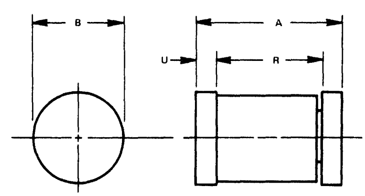
- Leadless Package for Surface Mount Technology
- Voltage Range from 1.8 to 100 Volts
- First Leadless Zener Diode Series to Specify Noise — 50% Lower than Conventional Diffused Zeners
- Zener Impedance and Zener Voltage Specified for Low-Level Operation at I_{ZT} = 250 μA
- Low Leakage Current — I_R from 0.01 to 10 μA over Voltage Range
- Available in 8mm Tape and Reel
  T1 Cathode Facing Sprocket Holes
  T2 Anode Facing Sprocket Holes

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 1.43	mW mW/°C
Junction and Storage Temperature Range	T_J, T_{stg}	−65 to +200	°C

MECHANICAL CHARACTERISTICS

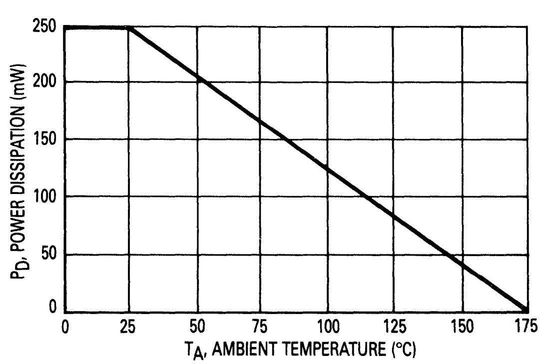
CASE: Double slug, hermetically sealed glass
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C for 10 seconds
FINISH: All external surfaces are corrosion resistant and readily solderable
POLARITY: Cathode indicated by color band. When operated in the zener mode, cathode will be positive with respect to anode
MOUNTING POSITION: Any



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

POWER TEMPERATURE DERATING CURVE



ELECTRICAL CHARACTERISTICS

(At 25°C Ambient temperature unless otherwise specified) 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 3)	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 4) (mA)
MLL4614	1.8	1200	7.5	1.0	1.0	120
MLL4615	2.0	1250	5.0	1.0	1.0	110
MLL4616	2.2	1300	4.0	1.0	1.0	100
MLL4617	2.4	1400	2.0	1.0	1.0	95
MLL4618	2.7	1500	1.0	1.0	1.0	90
MLL4619	3.0	1600	0.8	1.0	1.0	85
MLL4620	3.3	1650	7.5	1.5	1.0	80
MLL4621	3.6	1700	7.5	2.0	1.0	75
MLL4622	3.9	1650	5.0	2.0	1.0	70
MLL4623	4.3	1600	4.0	2.0	1.0	65
MLL4624	4.7	1550	10	3.0	1.0	60
MLL4625	5.1	1500	10	3.0	2.0	55
MLL4626	5.6	1400	10	4.0	4.0	50
MLL4627	6.2	1200	10	5.0	5.0	45
MLL4099	6.8	200	10	5.2	40	35
MLL4100	7.5	200	10	5.7	40	31.8
MLL4101	8.2	200	1.0	6.3	40	29.0
MLL4102	8.7	200	1.0	6.7	40	27.4
MLL4103	9.1	200	1.0	7.0	40	26.2
MLL4104	10	200	1.0	7.6	40	24.8
MLL4105	11	200	0.05	8.5	40	21.6
MLL4106	12	200	0.05	9.2	40	20.4
MLL4107	13	200	0.05	9.9	40	19.0
MLL4108	14	200	0.05	10.7	40	17.5
MLL4109	15	100	0.05	11.4	40	16.3
MLL4110	16	100	0.05	12.2	40	15.4
MLL4111	17	100	0.05	13.0	40	14.5
MLL4112	18	100	0.05	13.7	40	13.2
MLL4113	19	150	0.05	14.5	40	12.5
MLL4114	20	150	0.01	15.2	40	11.9
MLL4115	22	150	0.01	16.8	40	10.8
MLL4116	24	150	0.01	18.3	40	9.9
MLL4117	25	150	0.01	19.0	40	9.5
MLL4118	27	150	0.01	20.5	40	8.8
MLL4119	28	200	0.01	21.3	40	8.5
MLL4120	30	200	0.01	22.8	40	7.9
MLL4121	33	200	0.01	25.1	40	7.2
MLL4122	36	200	0.01	27.4	40	6.6
MLL4123	39	200	0.01	29.7	40	6.1
MLL4124	43	250	0.01	32.7	40	5.5
MLL4125	47	250	0.01	35.8	40	5.1
MLL4126	51	300	0.01	38.8	40	4.6
MLL4127	56	300	0.01	42.6	40	4.2
MLL4128	60	400	0.01	45.6	40	4.0
MLL4129	62	500	0.01	47.1	40	3.8
MLL4130	68	700	0.01	51.7	40	3.5
MLL4131	75	700	0.01	57.0	40	3.1
MLL4132	82	800	0.01	62.4	40	2.9
MLL4133	87	1000	0.01	66.2	40	2.7
MLL4134	91	1200	0.01	69.2	40	2.6
MLL4135	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 1000 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: REVERSE LEAKAGE CURRENT I_R

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

NOTE 4: MAXIMUM ZENER CURRENT RATINGS (I_{ZM})

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

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.

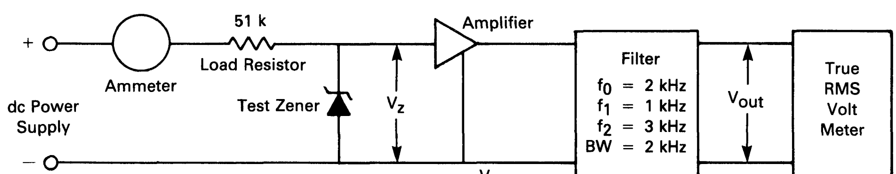
Motorola is rating this series with a maximum noise density at 250 microamperes. The rating of microvolts RMS per square root cycle enables calculation of the maximum RMS noise for any bandwidth.

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



$$\text{Noise Density (volts per square root cycle)} = \frac{V_{out}}{\text{Overall Gain} \sqrt{BW}}$$

Where: BW = Filter Bandwidth (Cycles)

V_{out} = Output Noise (Volts RMS)

FIGURE 2 — TYPICAL NOISE DENSITY versus ZENER CURRENT

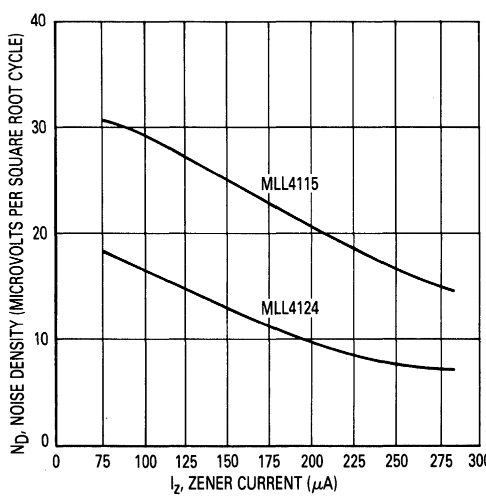


FIGURE 3 — TYPICAL CAPACITANCE

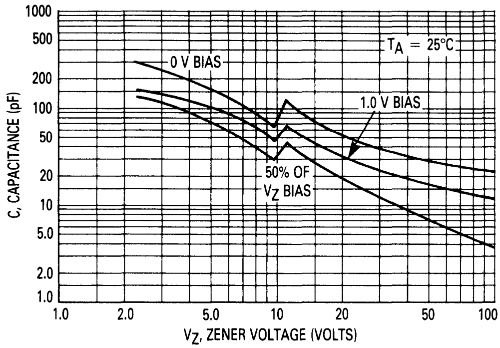
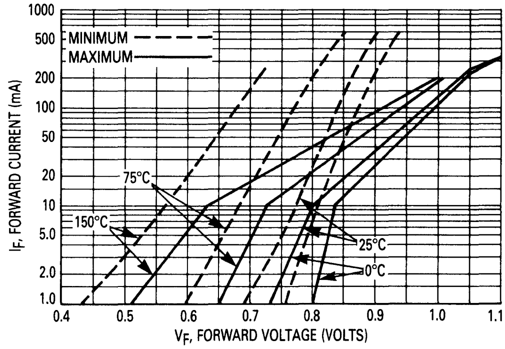


FIGURE 4 — TYPICAL FORWARD CHARACTERISTICS



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MLL4678
thru
MLL4717

MOTOROLA

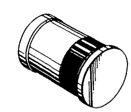
250 MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

Low level nitride passivated zener diodes for applications requiring extremely low operating currents, low leakage, and sharp breakdown voltage.

- Complete Voltage Range — 1.8 to 43 Volts
- Zener Voltage Specified @ I_{ZT} = 50 μA
- Leadless Package for Surface Mount Technology
- Maximum Delta V_Z Given from 10 to 100 μA
- Available in 8 mm Tape and Reel
  T1 Cathode Facing Sprocket Holes
  T2 Anode Facing Sprocket Holes

LEADLESS GLASS ZENER DIODES

250 MILLIWATTS



4

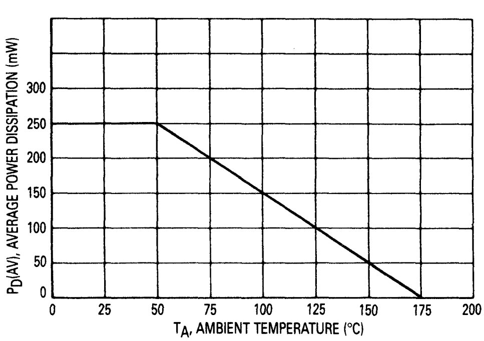
ABSOLUTE MAXIMUM RATINGS

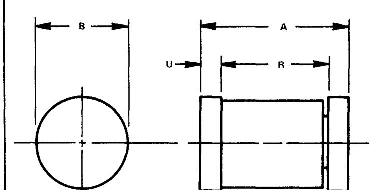
Rating	Symbol	Value	Unit
DC Power Dissipation @ T_A = 50°C Derate above T_A = 50°C	P_D	250 1.67	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

MECHANICAL CHARACTERISTICS

CASE: Double slug, hermetically sealed glass
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C for 10 seconds
FINISH: All external surfaces are corrosion resistant and readily solderable
POLARITY: Cathode end indicated by color band. When operated in zener mode, the cathode will be positive with respect to anode
MOUNTING POSITION: Any

FIGURE 1 — POWER TEMPERATURE DERATING CURVE





DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_F = 1.5 V max at I_F = 100 mA for all types)

Type Number (Note 1)	Zener Voltage V_Z @ I_{ZT} = 50 μA Volts			Maximum Reverse Current I_R μA (Note 3)	Test Voltage V_R Volts (Note 3)	Maximum Zener Current I_{ZM} mA (Note 2)	Maximum Voltage Change ΔV_Z Volts (Note 4)
	Nom (Note 1)	Min	Max				
MLL4678	1.8	1.710	1.890	7.5	1.0	120	0.70
MLL4679	2.0	1.900	2.100	5.0	1.0	110	0.70
MLL4680	2.2	2.090	2.310	4.0	1.0	100	0.75
MLL4681	2.4	2.280	2.520	2.0	1.0	95	0.80
MLL4682	2.7	2.565	2.835	1.0	1.0	90	0.85
MLL4683	3.0	2.850	3.150	0.8	1.0	85	0.90
MLL4684	3.3	3.135	3.465	7.5	1.5	80	0.95
MLL4685	3.6	3.420	3.780	7.5	2.0	75	0.95
MLL4686	3.9	3.705	4.095	5.0	2.0	70	0.97
MLL4687	4.3	4.085	4.515	4.0	2.0	65	0.99
MLL4688	4.7	4.465	4.935	10	3.0	60	0.99
MLL4689	5.1	4.845	5.355	10	3.0	55	0.97
MLL4690	5.6	5.320	5.880	10	4.0	50	0.96
MLL4691	6.2	5.890	6.510	10	5.0	45	0.95
MLL4692	6.8	6.460	7.140	10	5.1	35	0.90
MLL4693	7.5	7.125	7.875	10	5.7	31.8	0.75
MLL4694	8.2	7.790	8.610	1.0	6.2	29.0	0.50
MLL4695	8.7	8.265	9.135	1.0	6.6	27.4	0.10
MLL4696	9.1	8.645	9.555	1.0	6.9	26.2	0.08
MLL4697	10	9.500	10.50	1.0	7.6	24.8	0.10
MLL4698	11	10.45	11.55	0.05	8.4	21.6	0.11
MLL4699	12	11.40	12.60	0.05	9.1	20.4	0.12
MLL4700	13	12.35	13.65	0.05	9.8	19.0	0.13
MLL4701	14	13.30	14.70	0.05	10.6	17.5	0.14
MLL4702	15	14.25	15.75	0.05	11.4	16.3	0.15
MLL4703	16	15.20	16.80	0.05	12.1	15.4	0.16
MLL4704	17	16.15	17.85	0.05	12.9	14.5	0.17
MLL4705	18	17.10	18.90	0.05	13.6	13.2	0.18
MLL4706	19	18.05	19.95	0.05	14.4	12.5	0.19
MLL4707	20	19.00	21.00	0.01	15.2	11.9	0.20
MLL4708	22	20.90	23.10	0.01	16.7	10.8	0.22
MLL4709	24	22.80	25.20	0.01	18.2	9.9	0.24
MLL4710	25	23.75	26.25	0.01	19.0	9.5	0.25
MLL4711	27	25.65	28.35	0.01	20.4	8.8	0.27
MLL4712	28	26.60	29.40	0.01	21.2	8.5	0.28
MLL4713	30	28.50	31.50	0.01	22.8	7.9	0.30
MLL4714	33	31.35	34.65	0.01	25.0	7.2	0.33
MLL4715	36	34.20	37.80	0.01	27.3	6.6	0.36
MLL4716	39	37.05	40.95	0.01	29.6	6.1	0.39
MLL4717	43	40.85	45.15	0.01	32.6	5.5	0.43

NOTES: 1. TOLERANCE AND VOLTAGE DESIGNATION (V_Z)
The type numbers shown have a standard tolerance of ±5% on the nominal zener voltage.

2. MAXIMUM ZENER CURRENT RATINGS (I_{ZM})
Maximum Zener current ratings are based on maximum Zener voltage of the individual units.

3. REVERSE LEAKAGE CURRENT (I_R)
Reverse leakage currents are guaranteed and are measured at V_R as shown on the table.

4. MAXIMUM VOLTAGE CHANGE (ΔV_Z)
Voltage change is equal to the difference between V_Z at 100 μA and V_Z at 10 μA.

MLL4728
thru
MLL4764

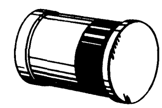
MOTOROLA

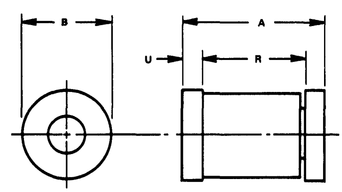
1.0 WATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 3.3 to 100 Volts
- Leadless Package for Surface Mount Technology
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die
- Available in 12 mm Tape and Reel
  T1 Cathode Facing Sprocket Holes
  T2 Anode Facing Sprocket Holes

LEADLESS GLASS ZENER DIODES

1.0 WATT
3.3–100 VOLTS





DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	4.80	5.20	0.189	0.205
B	2.44	2.54	0.096	0.100
R	3.71	4.59	0.146	0.181
U	0.36	0.50	0.014	0.020

CASE 362B-01

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A \leq 50°C$ Derate above $T_A = 50°C$	P_D	1.0 6.67	W mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Double slug type, hermetically sealed glass

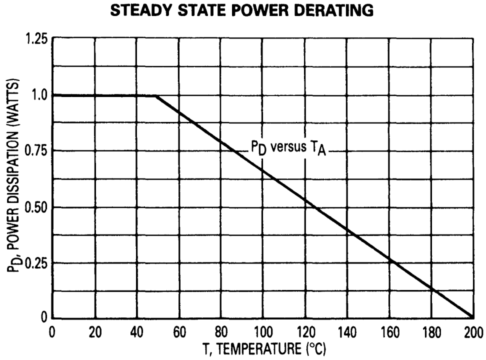
MAXIMUM TEMPERATURE FOR SOLDERING PURPOSES: 230°C, for 10 seconds

FINISH: All external surfaces are corrosion resistant and readily solderable

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

MOUNTING POSITION: Any

STEADY STATE POWER DERATING



4

ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; case temperature maintained at 30±2°C. V_F = 1.2 V max @ I_F = 200 mA for all types.)

Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Notes 2 and 3)	Test Current I_{ZT} mA	Maximum 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)
MLL4728	3.3	76	10	400	1.0	100	1.0	1380
MLL4729	3.6	69	10	400	1.0	100	1.0	1260
MLL4730	3.9	64	9.0	400	1.0	50	1.0	1190
MLL4731	4.3	58	9.0	400	1.0	10	1.0	1070
MLL4732	4.7	53	8.0	500	1.0	10	1.0	970
MLL4733	5.1	49	7.0	550	1.0	10	1.0	890
MLL4734	5.6	45	5.0	600	1.0	10	2.0	810
MLL4735	6.2	41	2.0	700	1.0	10	3.0	730
MLL4736	6.8	37	3.5	700	1.0	10	4.0	660
MLL4737	7.5	34	4.0	700	0.5	10	5.0	605
MLL4738	8.2	31	4.5	700	0.5	10	6.0	550
MLL4739	9.1	28	5.0	700	0.5	10	7.0	500
MLL4740	10	25	7.0	700	0.25	10	7.6	454
MLL4741	11	23	8.0	700	0.25	5.0	8.4	414
MLL4742	12	21	9.0	700	0.25	5.0	9.1	380
MLL4743	13	19	10	700	0.25	5.0	9.9	344
MLL4744	15	17	14	700	0.25	5.0	11.4	304
MLL4745	16	15.5	16	700	0.25	5.0	12.2	285
MLL4746	18	14	20	750	0.25	5.0	13.7	250
MLL4747	20	12.5	22	750	0.25	5.0	15.2	225
MLL4748	22	11.5	23	750	0.25	5.0	16.7	205
MLL4749	24	10.5	25	750	0.25	5.0	18.2	190
MLL4750	27	9.5	35	750	0.25	5.0	20.6	170
MLL4751	30	8.5	40	1000	0.25	5.0	22.8	150
MLL4752	33	7.5	45	1000	0.25	5.0	25.1	135
MLL4753	36	7.0	50	1000	0.25	5.0	27.4	125
MLL4754	39	6.5	60	1000	0.25	5.0	29.7	115
MLL4755	43	6.0	70	1500	0.25	5.0	32.7	110
MLL4756	47	5.5	80	1500	0.25	5.0	35.8	95
MLL4757	51	5.0	95	1500	0.25	5.0	38.8	90
MLL4758	56	4.5	110	2000	0.25	5.0	42.6	80
MLL4759	62	4.0	125	2000	0.25	5.0	47.1	70
MLL4760	68	3.7	150	2000	0.25	5.0	51.7	65
MLL4761	75	3.3	175	2000	0.25	5.0	56.0	60
MLL4762	82	3.0	200	3000	0.25	5.0	62.2	55
MLL4763	91	2.8	250	3000	0.25	5.0	69.2	50
MLL4764	100	2.5	350	3000	0.25	5.0	76.0	45

NOTE 1. Tolerance and Type Number Designation — The 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. Special Selections† Available Include:

1. Nominal zener voltages between those shown.
2. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
3. Nominal voltages at non-standard test currents.

NOTE 3. Zener Voltage (V_Z) Measurement — Nominal zener voltage is measured with the device junction in thermal equilibrium at the case temperature of 30°C ±2°C.

NOTE 4. Zener Impedance (Z_Z) Derivation — Z_{ZT} and Z_{ZK} are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for $I_Z(ac) = 0.1 \times I_Z(dc)$ with the ac frequency = 1.0 kHz.

†For more information on special selections contact your nearest Motorola representative.

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:

Case Temperature, T_C, should be determined from:

$$T_C = \theta_{CA}P_D + T_A.$$

θ_{CA} is the case-to-ambient thermal resistance (°C/W) and P_D is the power dissipation. The value for θ_{CA} will vary and depends on the device mounting method. θ_{CA} is generally 200°C/W for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the case can also be measured using a thermocouple placed at the case end 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_C, the junction temperature may be determined by:

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

ΔT_{JC} is the increase in junction temperature above the case temperature and may be found by using:

$$\Delta T_{JC} = \theta_{JC}P_D.$$

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 3 and 4.

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.

NOTE 5. Surge Current (i_r) Nonrepetitive — 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 6.

Surge limitations are given in Figure 6. 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 6 be exceeded.

FIGURE 1 — TYPICAL LEAKAGE CURRENT

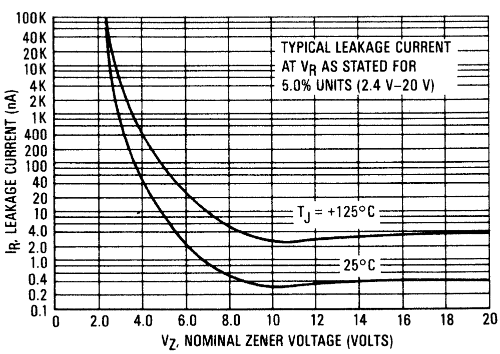


FIGURE 2 — TYPICAL LEAKAGE CURRENT

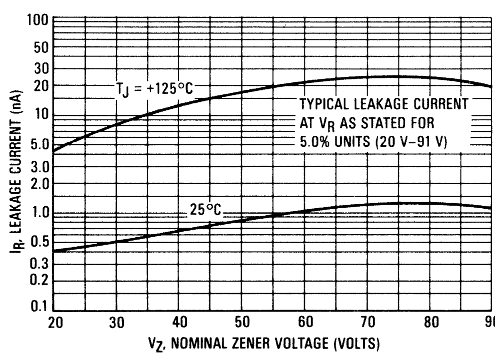


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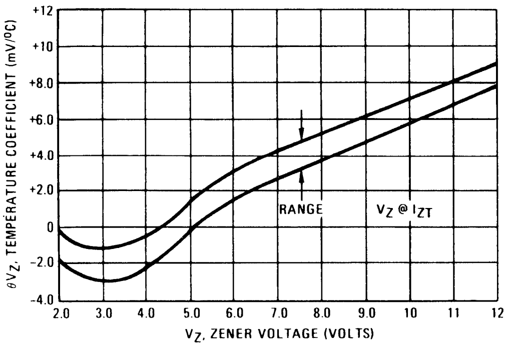
FIGURE 3 — TEMPERATURE COEFFICIENTS @ I_{ZT}

(−55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

a — RANGE FOR UNITS TO 12 VOLTS



b — RANGE FOR UNITS 12 TO 100 VOLTS

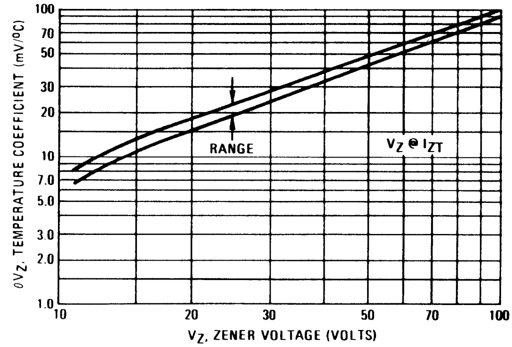


FIGURE 4 — EFFECT OF ZENER CURRENT

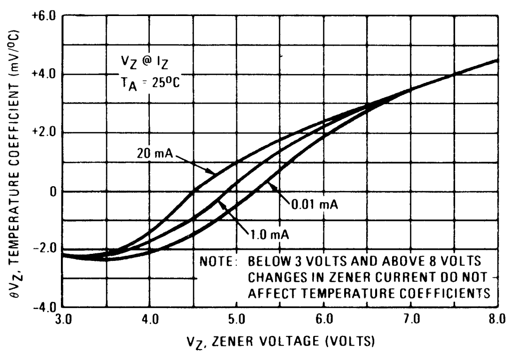


FIGURE 5 — TYPICAL CAPACITANCE

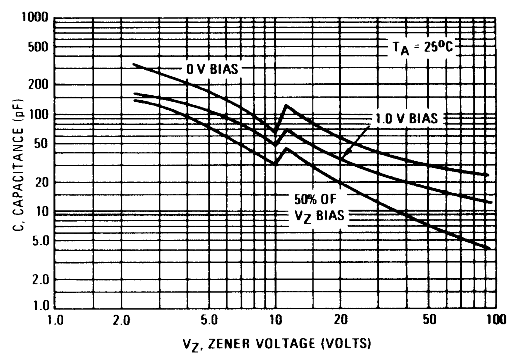
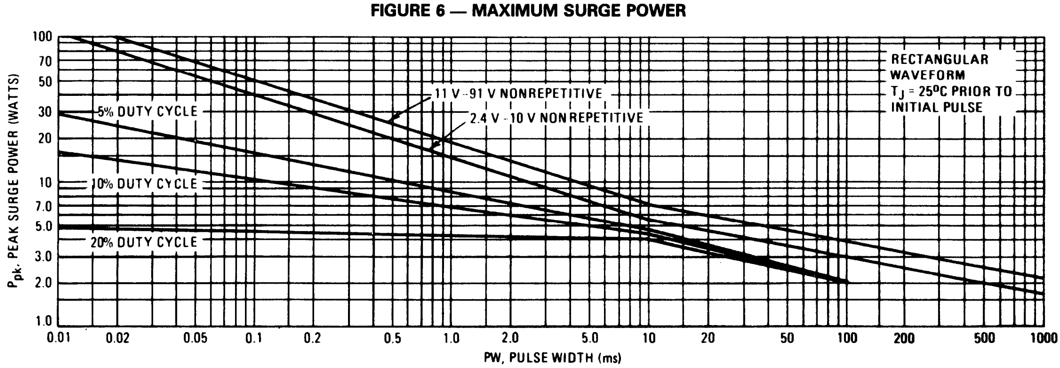


FIGURE 6 — MAXIMUM SURGE POWER



This graph represents 90 percentil data points.
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 7 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

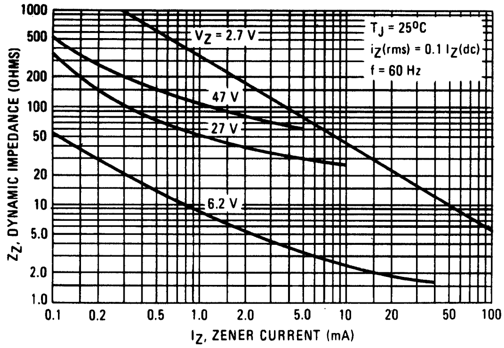


FIGURE 8 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

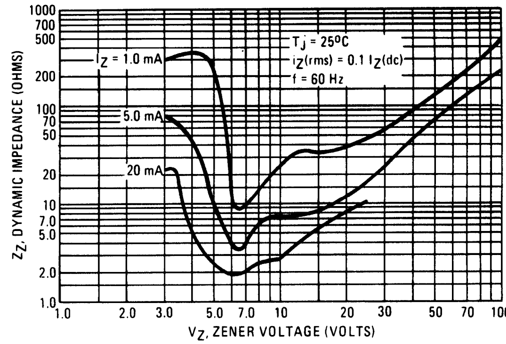


FIGURE 9 — TYPICAL NOISE DENSITY

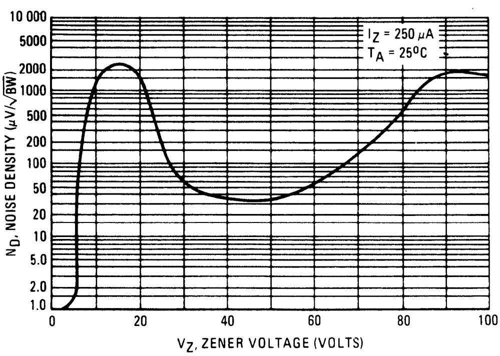
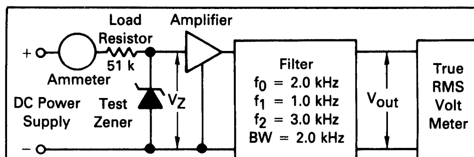


FIGURE 10 — NOISE DENSITY MEASUREMENT METHOD



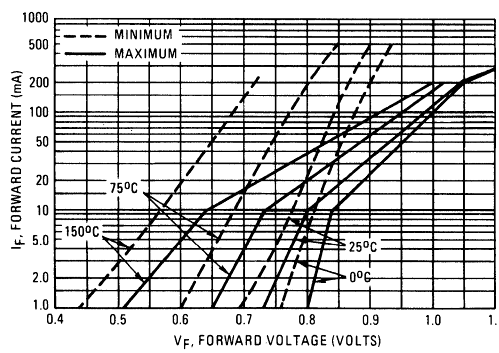
$$\text{Noise Density (Volts Per Square Root Bandwidth)} = \frac{V_{out}}{\text{Overall Gain } \sqrt{BW}}$$

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 zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

FIGURE 11 — TYPICAL FORWARD CHARACTERISTICS



MOTOROLA

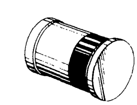
MLL5221
thru
MLL5270

500 MILLIWATT HERMETICALLY SEALED GLASS SILICON ZENER DIODES

- Complete Voltage Range — 2.4 to 91 Volts
- Leadless Package for Surface Mount Technology
- Double Slug Type Construction
- Metallurgically Bonded Construction
- Nitride Passivated Die

LEADLESS GLASS ZENER DIODES

500 MILLIWATTS
2.4-110 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A \leq 50°C$ Derate above $T_A = 50°C$	P_D	500 3.3	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

MECHANICAL CHARACTERISTICS

CASE: Double slug type, hermetically sealed glass

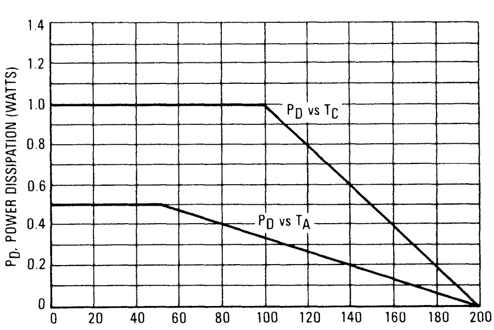
MAXIMUM LEAD TEMPERATURE FOR SOLDERING PURPOSES: 230°C, for 10 seconds

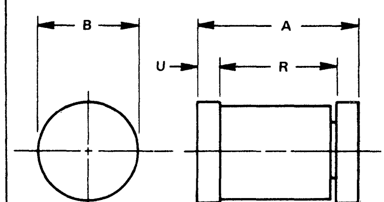
FINISH: All external surfaces are corrosion resistant and readily solderable

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

MOUNTING POSITION: Any

STEADY STATE POWER DERATING





	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	3.30	3.70	0.130	0.146
B	1.60	1.70	0.063	0.067
R	2.49	2.59	0.098	0.102
U	0.41	0.55	0.016	0.022

CASE 362-01

4

ELECTRICAL CHARACTERISTICS
(T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; case temperature maintained at 30±2°C. V_F = 1.1 max @ I_F = 200 mA for all types.)

Type No. (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A and B Suffix only		Max Reverse Leakage Current				Max Zener Voltage Temperature Coeff. (A and B Suffix only) θV_Z (%/°C) (Note 3)
					A and B Suffix only			Non-Suffix	
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	I_R µA	@ V_R Volts		I_R @ V_R Used for Suffix A µA	
						A	B		
MLL5221	2.4	20	30	1200	100	0.95	1.0	200	-0.085
MLL5222	2.5	20	30	1250	100	0.95	1.0	200	-0.085
MLL5223	2.7	20	30	1300	75	0.95	1.0	150	-0.080
MLL5224	2.8	20	30	1400	75	0.95	1.0	150	-0.080
MLL5225	3.0	20	29	1600	50	0.95	1.0	100	-0.075
MLL5226	3.3	20	28	1600	25	0.95	1.0	100	-0.070
MLL5227	3.6	20	24	1700	15	0.95	1.0	100	-0.065
MLL5228	3.9	20	23	1900	10	0.95	1.0	75	-0.060
MLL5229	4.3	20	22	2000	5.0	0.95	1.0	50	±0.055
MLL5230	4.7	20	19	1900	5.0	1.9	2.0	50	±0.030
MLL5231	5.1	20	17	1600	5.0	1.9	2.0	50	±0.030
MLL5232	5.6	20	11	1600	5.0	2.9	3.0	50	+0.038
MLL5233	6.0	20	7.0	1600	5.0	3.3	3.5	50	+0.038
MLL5234	6.2	20	7.0	1000	5.0	3.8	4.0	50	+0.045
MLL5235	6.8	20	5.0	750	3.0	4.8	5.0	30	+0.050
MLL5236	7.5	20	6.0	500	3.0	5.7	6.0	30	+0.058
MLL5237	8.2	20	8.0	500	3.0	6.2	6.5	30	+0.062
MLL5238	8.7	20	8.0	600	3.0	6.2	6.5	30	+0.065
MLL5239	9.1	20	10	600	3.0	6.7	7.0	30	+0.068
MLL5240	10	20	17	600	3.0	7.6	8.0	30	+0.075
MLL5241	11	20	22	600	2.0	8.0	8.4	30	+0.076
MLL5242	12	20	30	600	1.0	8.7	9.1	10	+0.077
MLL5243	13	9.5	13	600	0.5	9.4	9.9	10	+0.079
MLL5244	14	9.0	15	600	0.1	9.5	10	10	+0.082
MLL5245	15	8.5	16	600	0.1	10.5	11	10	+0.082
MLL5246	16	7.8	17	600	0.1	11.4	12	10	+0.083
MLL5247	17	7.4	19	600	0.1	12.4	13	10	+0.084
MLL5248	18	7.0	21	600	0.1	13.3	14	10	+0.085
MLL5249	19	6.6	23	600	0.1	13.3	14	10	+0.086
MLL5250	20	6.2	25	600	0.1	14.3	15	10	+0.086
MLL5251	22	5.6	29	600	0.1	16.2	17	10	+0.087
MLL5252	24	5.2	33	600	0.1	17.1	18	10	+0.088
MLL5253	25	5.0	35	600	0.1	18.1	19	10	+0.089
MLL5254	27	4.6	41	600	0.1	20	21	10	+0.090
MLL5255	28	4.5	44	600	0.1	20	21	10	+0.091
MLL5256	30	4.2	49	600	0.1	22	23	10	+0.091
MLL5257	33	3.8	58	700	0.1	24	25	10	+0.092
MLL5258	36	3.4	70	700	0.1	26	27	10	+0.093
MLL5259	39	3.2	80	800	0.1	29	30	10	+0.094
MLL5260	43	3.0	93	900	0.1	31	33	10	+0.095
MLL5261	47	2.7	105	1000	0.1	34	36	10	+0.095
MLL5262	51	2.5	125	1100	0.1	37	39	10	+0.096
MLL5263	56	2.2	150	1300	0.1	41	43	10	+0.096
MLL5264	60	2.1	170	1400	0.1	44	46	10	+0.097
MLL5265	62	2.0	185	1400	0.1	45	47	10	+0.097
MLL5266	68	1.8	230	1600	0.1	49	52	10	+0.097
MLL5267	75	1.7	270	1700	0.1	53	56	10	+0.098
MLL5268	82	1.5	330	2000	0.1	59	62	10	+0.098
MLL5269	87	1.4	370	2200	0.1	65	68	10	+0.099
MLL5270	91	1.4	400	2300	0.1	66	69	10	+0.099

NOTE 1. Tolerance — The type numbers shown indicate a tolerance of ±20% with guaranteed limits on only V_Z, I_R and V_F as shown in the electrical characteristics table. Units with guaranteed limits on all six parameters are indicated by suffix "A" for ±10% tolerance and suffix "B" for ±5.0% units.

NOTE 2. Special Selections† Available Include:

1. Nominal zener voltages between those shown.
2. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.
3. Nominal voltages at non-standard test currents.

NOTE 3. Temperature Coefficient (θ_{VZ}) — Test conditions for temperature coefficient are as follows:

a. I_{ZT} = 7.5 mA, T_1 = 25°C,
T_2 = 125°C (MLL5221A,B through MLL5242A,B).
b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C,
T_2 = 125°C (MLL5243A, B through MLL5270A,B).

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.

NOTE 4. Zener Voltage (V_Z) Measurement — Nominal zener voltage is measured with the device junction in thermal equilibrium at the case temperature of 30°C ±1°C.

NOTE 5. Zener Impedance (Z_Z) Derivation — Z_{ZT} and Z_{ZK} are measured by dividing the ac voltage drop across the device by the ac current applied. The specified limits are for $I_Z(ac) = 0.1 \times I_Z(dc)$ with the ac frequency = 1.0 kHz.

†For more information on special selections contact your nearest Motorola representative.

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:

Case Temperature, T_C, should be determined from:

$$T_C = \theta_{CA} P_D + T_A.$$

θ_{CA} is the case-to-ambient thermal resistance (°C/W) and P_D is the power dissipation. The value for θ_{CA} will vary and depends on the device mounting method. θ_{CA} is generally 200°C/W for the various clips and tie points in common use and for printed circuit board wiring.

The temperature of the case can also be measured using a thermocouple placed at the case end 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_C, the junction temperature may be determined by:

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

ΔT_{JC} is the increase in junction temperature above the case temperature and may be found by using:

$$\Delta T_{JC} = \theta_{JC} P_D.$$

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 3 and 4.

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.

Surge limitations are given in Figure 6. 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 6 be exceeded.

FIGURE 1 — TYPICAL LEAKAGE CURRENT

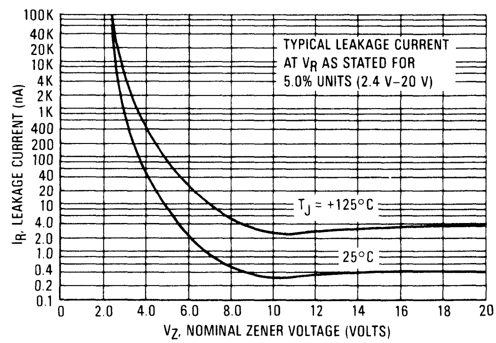
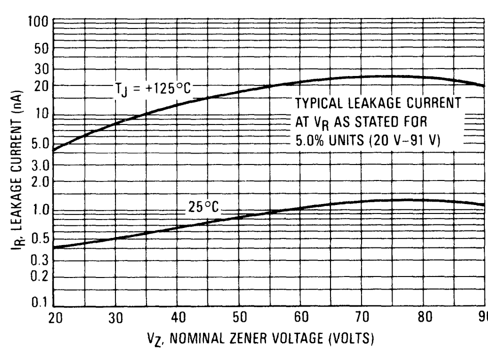


FIGURE 2 — TYPICAL LEAKAGE CURRENT



4

FIGURE 3 — TEMPERATURE COEFFICIENTS

(-55°C to +150°C temperature range; 90% of the units are in the ranges indicated.)

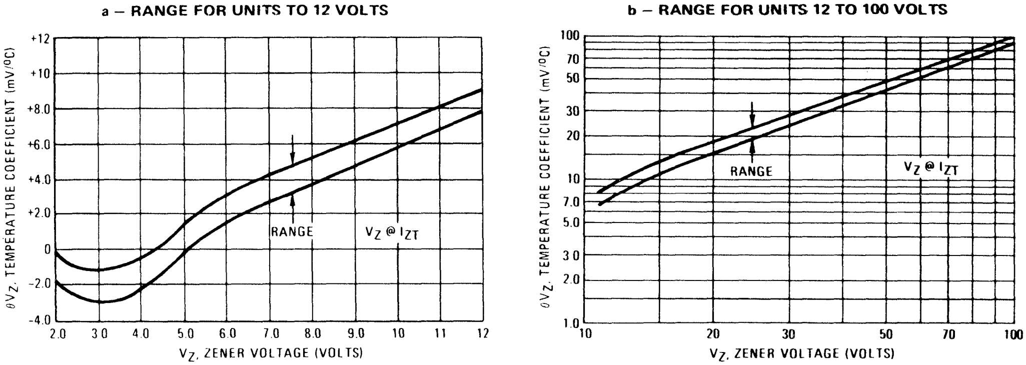


FIGURE 4 — EFFECT OF ZENER CURRENT

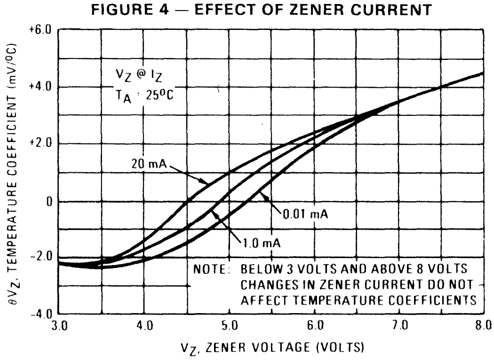


FIGURE 5 — TYPICAL CAPACITANCE

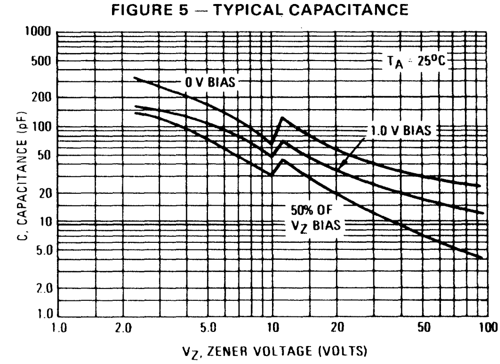
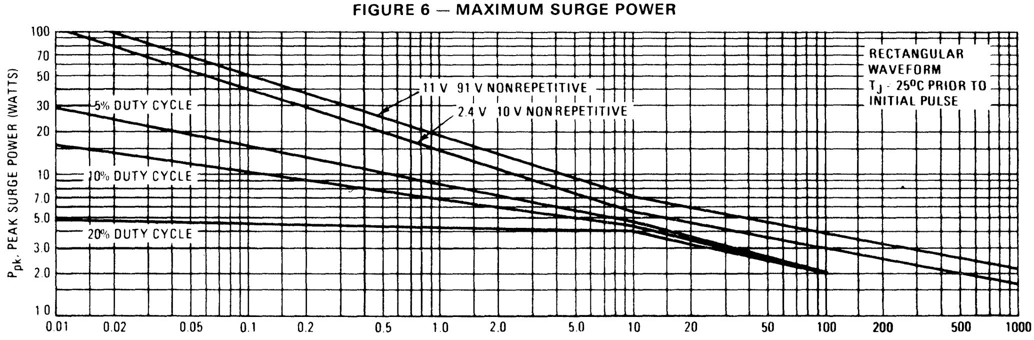


FIGURE 6 — MAXIMUM SURGE POWER



This graph represents 90 percentil data points.
For worst-case design characteristics, multiply surge power by 2/3.

FIGURE 7 — EFFECT OF ZENER CURRENT ON ZENER IMPEDANCE

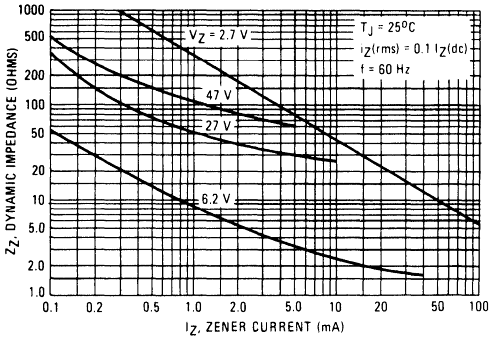


FIGURE 8 — EFFECT OF ZENER VOLTAGE ON ZENER IMPEDANCE

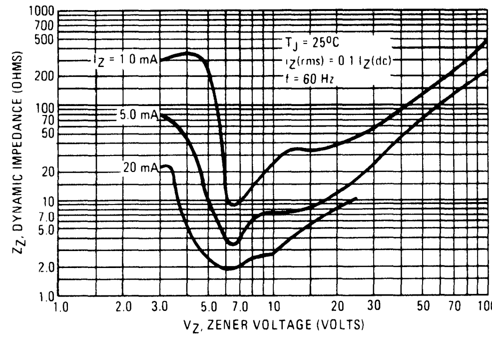


FIGURE 9 — TYPICAL NOISE DENSITY

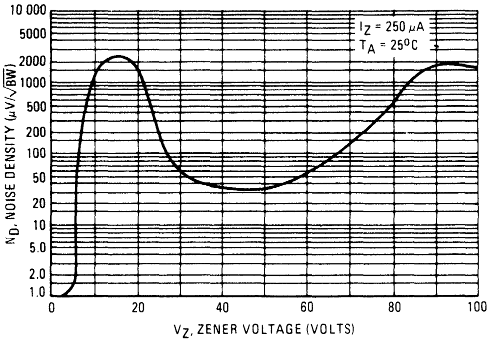
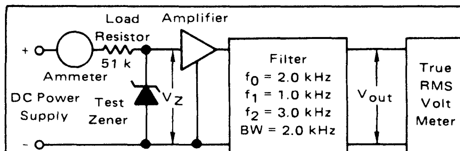


FIGURE 10 — NOISE DENSITY MEASUREMENT METHOD



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

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 zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

FIGURE 11 — TYPICAL FORWARD CHARACTERISTICS

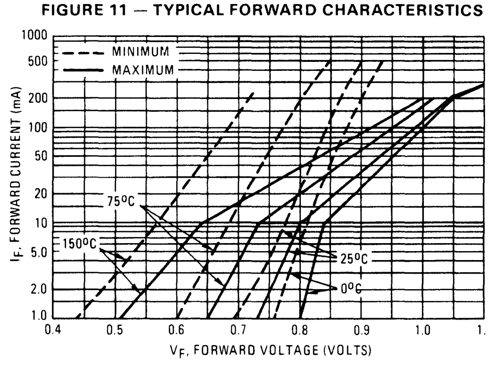


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FIGURE 12 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 1 THRU 16 VOLTS

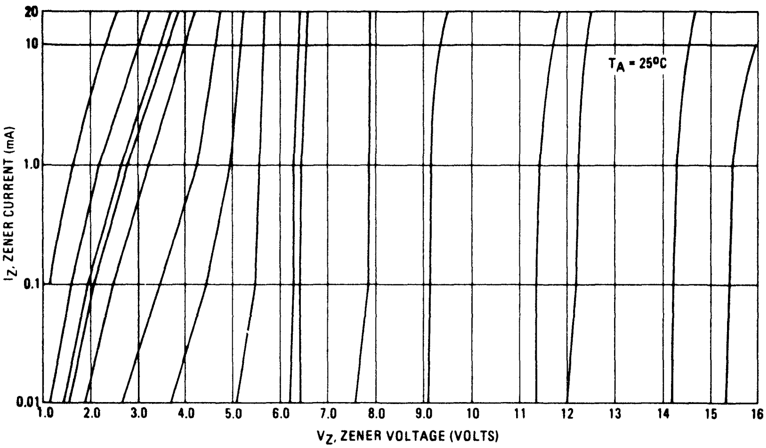


FIGURE 13 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 15 THRU 30 VOLTS

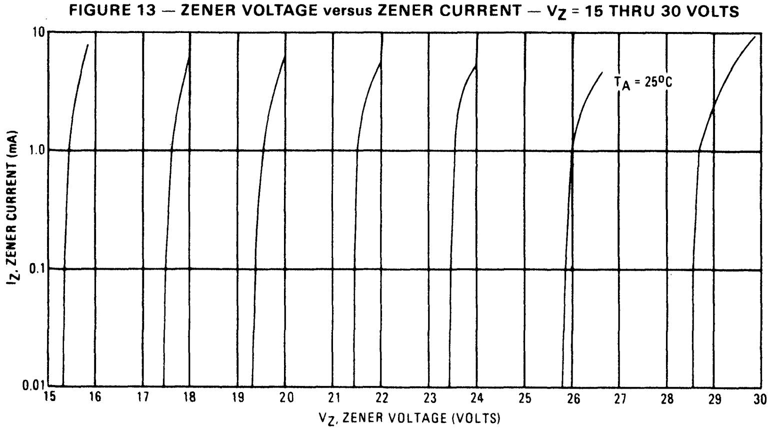
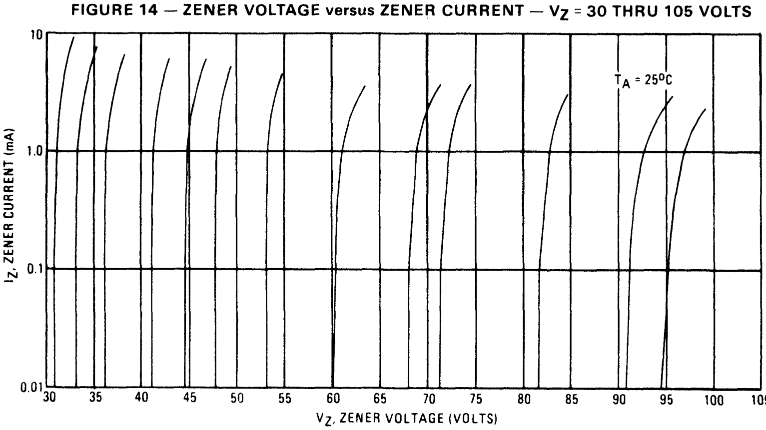


FIGURE 14 — ZENER VOLTAGE versus ZENER CURRENT — V_Z = 30 THRU 105 VOLTS



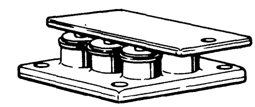
4

MPTE-5,C thru MPTE-45,C
See Page 4-74

MOTOROLA

MPZ5-16 Series
MPZ5-32 Series
MPZ5-180 Series

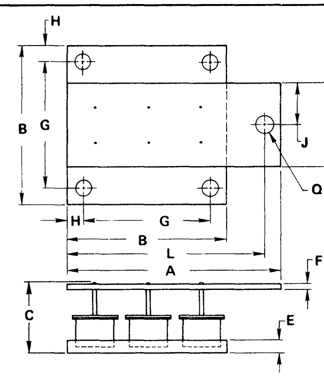
SILICON POWER TRANSIENT SUPPRESSOR



SILICON POWER TRANSIENT SUPPRESSOR

. . . designed for applications requiring protection of voltage sensitive electronic devices in danger of destruction by high energy voltage transients. Individual cells are matched to insure current-sharing under high current pulse conditions.

- Peak Surge Power Capacity Given From 0.1 ms To 10 Seconds
- Low Clamping Factor Assures Low Voltage Overshoot
- Negligible Power Loss
- Small Size and Weight
- Following Variations are Available:
  - Non-Standard Voltages
  - Higher Power Capacity
  - Other Package Configurations



DIM	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	50.29	51.31	1.980	2.020
B	37.59	38.61	1.480	1.520
C	–	16.51	–	0.650
D	20.24	21.01	0.797	0.827
E	2.92	3.43	0.115	0.135
F	1.32	1.83	0.052	0.072
G	29.97	30.99	1.180	1.220
H	3.56	4.06	0.140	0.160
J	10.06	10.57	0.396	0.416
L	46.74	47.74	1.840	1.860
Q	3.30	3.81	0.130	0.150

CASE 119-01

NOTE: DIA "Q" 5 PLACES

MAXIMUM RATINGS

Transient Power Dissipation: 40 kW
Pulse Width: 0.1ms, (See Figure 1)
DC Power Dissipation: 350 Watts @ $T_C = 25°C$
(Derate 2.33 W/°C above 25°C)
Operating Junction & Storage Temperature Range:
−65°C to +175°C

MECHANICAL CHARACTERISTICS

POLARITY: Anode-to-Case is Standard. Cathode-to-Case Available Upon Request.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$, $V_F = 1.5$ V max @ 10 A for all types)

Type	Nominal Operating Voltage (Note 1) $V_{OP(PK)}$ Vdc	$V_{OP(RMS)}$ V rms	Maximum Device Clamping Factor $CF = \frac{V_Z @ I_{Z(pulse)}}{V_Z @ I_{ZT}}$ (Note 2)	Minimum Zener Voltage $V_{Z(min)}$ Vdc	@ I_{ZT} Adc	Maximum Zener Voltage Pulse Width = 1.0 ms $V_{Z(max)}$ Vdc	@ $I_{Z(pulse)}$ Adc	Maximum Reverse Current $I_{R(max)}$ @ $V_R = V_{OP(PK)}$ μAdc	Typical Capacitance C (typ) @ $V_R = V_{OP(PK)}$ μF
MPZ5-16A	14	10	1.25	16	0.4	24	200	50	0.025
-16B	14	10	1.25	16	0.4	20	200		0.025
-32A	28	20	1.25	32	0.2	50	100		0.011
-32B	28	20	1.25	32	0.2	45	100		0.011
-32C	28	20	1.25	32	0.2	40	100		0.011
-180A	165	117	1.14	180	0.03	250	20		0.0012
-180B	165	117	1.14	180	0.03	225	20		0.0012
-180C	165	117	1.14	180	0.03	205	20	50	0.0012

FIGURE 1 – MAXIMUM NON-REPETITIVE SURGE POWER
(RECTANGULAR WAVEFORM)

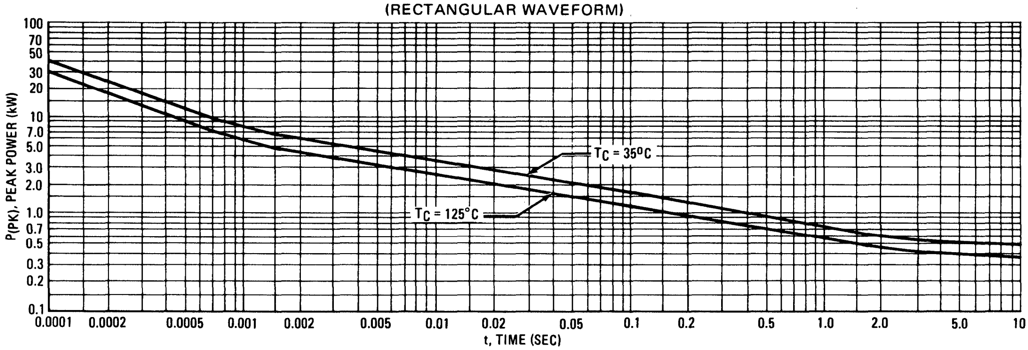


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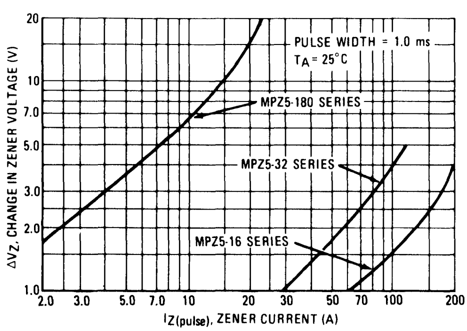
FIGURE 2 – TYPICAL DYNAMIC ZENER VOLTAGE CHARACTERISTICS (Note 2)



NOTE 1: Nominal operating voltage is defined as normal input voltage to device for non-operating condition. If non-sinusoidal wave or dc input is present, peak voltage input values $V_{OP(PK)}$ should be used to select device type.

NOTE 2: The maximum device clamping factor C_F is a ratio of V_Z measured at I_Z (pulse) given in the Electrical Characteristics Table divided by V_Z measured at I_{ZT} under steady state conditions. This value guarantees the sharpness of the voltage breakdown of individual devices. Figure 2 demonstrates the typical sharpness of the breakdown, and indicates the voltage regulation over a wide range of currents.

$$\Delta V_Z = V_Z \ @ \ I_{Z(pulse)} - V_Z \ @ \ I_{ZT}$$

MOTOROLA

MZ600 Series

6.2 VOLTS

PRECISION REFERENCE DIODES

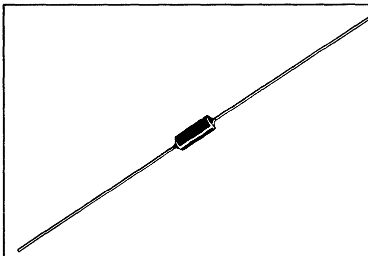
with

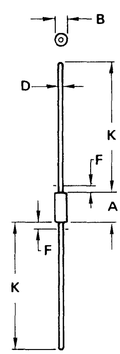
CERTIFIED ZENER VOLTAGE-TIME STABILITY

PRECISION REFERENCE DIODES

. . . designed, manufactured and tested for applications requiring a precision voltage reference with ultra-high stability of voltage with time and temperature change.

Special test laboratory uses precision measurement equipment, four-terminal (separate contacts for current and voltage) measurement techniques and voltage standards to provide calibration directly traceable to the National Bureau of Standards.





NOTES:

1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

CASE 51-02
DO-204AA
(DO-7)

Certified TEST DATA

Every Precision Reference Diode is individually serialized and its test data recorded on a Certificate of Precision that accompanies the device when shipped. This data shows:

- Actual device voltage at 168 hour intervals during verification test
- Voltage stability throughout the entire 1000 hour test period
- Certification of Precision
- All diodes are marked with the device type number and polarity band

4

OPERATING TEMPERATURE RANGE:* 25 to 100°C.

MZ600 SERIES (Voltage 6.2V ±5%, I_{ZT} = 7.5 mAdc†, ΔV_Z = 2.5 mVdc**)

Type No.	Voltage-Time Stability (μV/1000 Hours)	Parts Per Million Change (ppm/1000 Hours)
MZ605	31 Maximum	< 5
MZ610	62 Maximum	<10
MC620	124 Maximum	<20
MZ640	248 Maximum	<40

DYNAMIC IMPEDANCE: 10 Ohms at I_{ZT} = 7.5 mAdc, I_{ac} = 0.75 mA.

4

NOTES

†TEST CURRENT
For certification testing of time stability, Motorola maintains I_{ZT} constant and repeatable to ±0.05 μA tolerance. For voltage tolerance, impedance and voltage temperature stability I_{ZT} needs to be held to 0.01 tolerance only.

*Maximum limits for use as a precision reference device. Limits are well below the maximum thermal limits.

**VOLTAGE-TEMPERATURE STABILITY: Maximum allowable voltage change between voltages recorded at 25, 75 and 100°C ambient.

VOLTAGE-TIME STABILITY
(ΔV_Z/1000 Hours).

The device voltage is read and recorded initially and at 168 hour intervals through 1000 hours. The maximum change of voltage between readings, taken at any of the seven points, must be less than the maximum voltage change per 1000 hour specified as Voltage-Time Stability.

TURN-ON CHARACTERISTICS

Precision Reference Diodes have been tested to determine the behavior of the device under interrupted power operation. To insure specified performance, adequate time must be allowed for the device and its environment to reach thermal equilibrium. "Warm-up" time may range from 8 to 24 hours. Thermal equilibrium is reached when the chamber is cycling at the required temperature with the device energized.

After this '"warm-up" period, the device voltage will be between the minimum and the maximum voltage of those recorded at the seven points of the Voltage-Time Stability certification.

MOUNTING

Excellent results have been obtained by using a mechanical mounting. If necessary, the device may be soldered into a circuit using a heat sink between the heat source and the body of the diode. A low thermal EMF solder is recommended.

SPECIAL NOTE

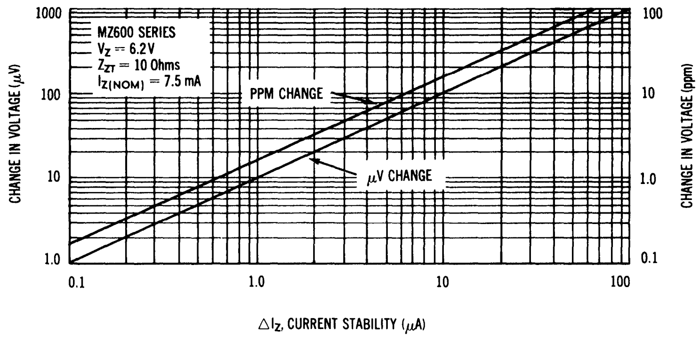
Voltage tolerance less than 5.0% is available upon special request.

Precision Reference Diodes capable of meeting special requirements for standard voltages regardless of required test current, temperature range, or test temperatures are available. Custom requirements of particular devices for specific applications are also available.

VOLTAGE-CURRENT STABILITY CHARACTERISTICS

For verification of time stability, and for repeatable operation, I_{ZT} should be maintained with a tolerance of ±0.1 μA. Figure 1 will assist in design where the supply current stability cannot be maintained to better than 0.2 μA deviation.

FIGURE 1 – MAXIMUM VOLTAGE CHANGE, IN μV AND PPM, DUE TO CURRENT SUPPLY STABILITY



VOLTAGE-TEMPERATURE CHARACTERISTICS

CHOICE OF OPERATING TEMPERATURE

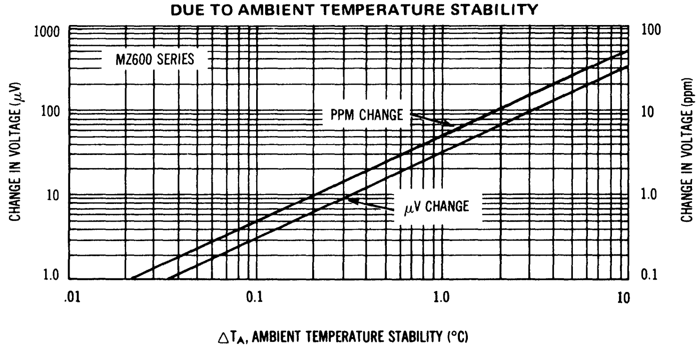
The stability certification is performed at 65°C ±0.02°C. The operating temperature can be selected within the operating temperature range. If the desired temperature is not 65°C, the precise voltage of the device will be different but the certified stability will still be observed.

VOLTAGE TEMPERATURE STABILITY

For verification of time stability and/or repeatable operation, the ambient temperature should be controlled to ±0.1°C.

Figure 2 will assist in designs where ambient temperature cannot be controlled to better than 0.2°C deviation.

FIGURE 2 – TYPICAL VOLTAGE CHANGE, IN μV AND PPM, DUE TO AMBIENT TEMPERATURE STABILITY



MZ2360
MZ2361

MOTOROLA

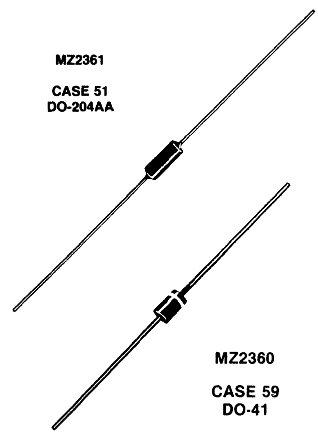
CONSTANT-VOLTAGE REFERENCE DIODES FOR LOW-VOLTAGE APPLICATIONS

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

- Guaranteed Forward Voltage Range
- Temperature Effects Provided

FORWARD REFERENCE DIODES

STABISTORS



MZ2361
CASE 51
DO-204AA

MZ2360
CASE 59
DO-41

4

MAXIMUM RATINGS

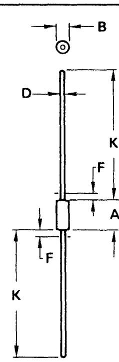
Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 30°C \pm 3°C$, Lead Length = 3/8″	P_D	400	mW
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +175	°C

MECHANICAL CHARACTERISTICS

CASE: 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

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	38.10	1.000	1.500

All JEDEC dimensions and notes apply

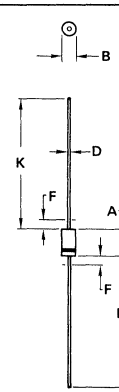


MZ2361

CASE 51
DO-204AA

NOTES:
1. PACKAGE CONTOUR OPTIONAL WITHIN DIA B AND LENGTH A. HEAT SLUGS, IF ANY, SHALL BE INCLUDED WITHIN THIS CYLINDER, BUT SHALL NOT BE SUBJECT TO THE MIN LIMIT OF DIA B.
2. LEAD DIA NOT CONTROLLED IN ZONES F, TO ALLOW FOR FLASH, LEAD FINISH BUILDUP, AND MINOR IRREGULARITIES OTHER THAN HEAT SLUGS.

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	–



MZ2360

CASE 59
DO-41

NOTES:
1. ALL RULES AND NOTES ASSOCIATED WITH JEDEC DO-41 OUTLINE SHALL APPLY.
2. POLARITY DENOTED BY CATHODE BAND.
3. LEAD DIAMETER NOT CONTROLLED WITHIN "F" DIMENSION.

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
MZ2360	0.63/0.71	10	10	5.0	Surmetic	59
MZ2361	1.24/1.38	10	10	5.0	Surmetic	51

(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.

TYPICAL FORWARD VOLTAGE CHARACTERISTICS

FIGURE 1 — MZ2360

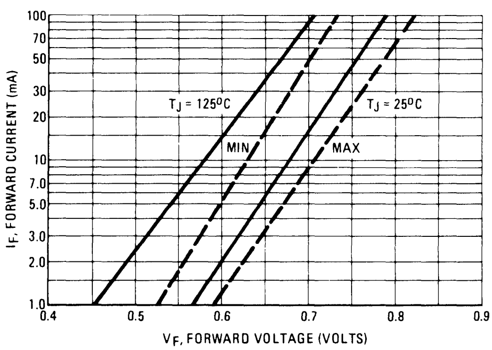
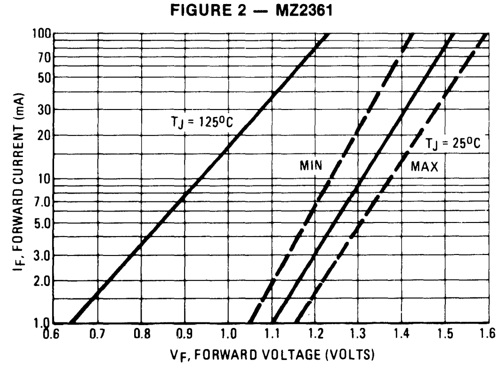


FIGURE 2 — MZ2361



TYPICAL TEMPERATURE COEFICIENT

FIGURE 3 — MZ2360

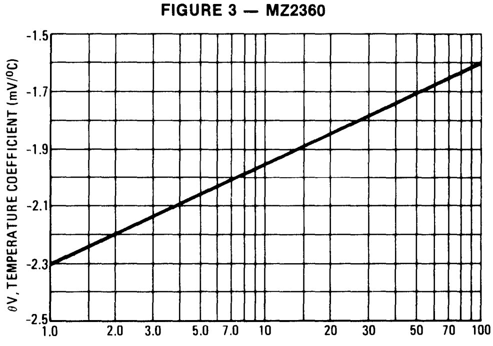
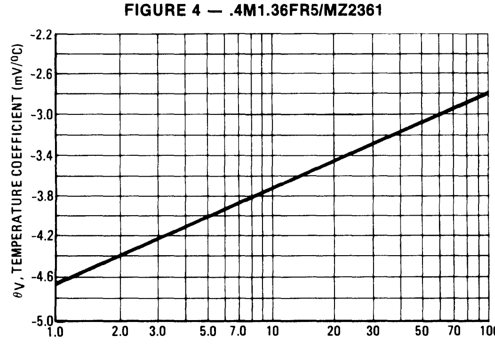


FIGURE 4 — .4M1.36FR5/MZ2361



P6KE6.8,A
thru
P6KE200,A

MOTOROLA

4

ZENER OVERVOLTAGE TRANSIENT SUPPRESSOR

The P6KE6.8 series is designed to protect voltage sensitive components from high voltage, high energy transients. They have excellent clamping capability, high surge capability, low zener impedance and fast response time. The P6KE6.8 series is supplied in Motorola's exclusive, cost-effective, highly reliable surmetic axial leaded package and is ideally-suited for use in communication systems, numerical controls, process controls, medical equipment, business machines, power supplies and many other industrial/ consumer applications.

SPECIFICATION FEATURES

- Standard Zener Voltage Range — 6.8 to 200 V
- Peak Power — 600 Watts @ 1.0 ms
- Maximum Clamp Voltage @ Peak Pulse Current
- Low Leakage < 5.0 μA above 10 V
- Maximum Temperature Coefficient Specified

ZENER OVERVOLTAGE TRANSIENT SUPPRESSORS

6.8-200 VOLT
600 WATT PEAK POWER
5.0 WATTS STEADY STATE

MAXIMUM RATINGS

Rating	Symbol	Value	Units
Peak Power Dissipation (1) @ $T_L \leq 25^oC$	P_{PK}	600	Watts
Steady State Power Dissipation @ $T_L \leq 75^oC$, Lead Length = 3/8" Derated above $T_L = 75^oC$	P_D	5.0 50	Watts mW/°C
Forward Surge Current (2) @ $T_A = 25^oC$	I_{FSM}	100	Amps
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to +175	°C

Lead Temperature not less than 1/16" from the case for 10 seconds: 230°C

MECHANICAL CHARACTERISTICS

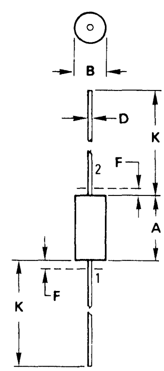
CASE: Void-free, transfer-molded, thermosetting plastic

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, will be positive with respect to anode

MOUNTING POSITION: Any

NOTES: 1. Non-Repetitive Current Pulse per Figure 4 and Derated above $T_A = 25^oC$ per Figure 2.
2. 1/2 Square Wave (or equivalent), PW = 8.3 ms, Duty Cycle = 4 Pulses per Minute maximum.



NOTE:
1. LEAD DIAMETER & FINISH NOT CONTROLLED WITHIN DIM "F".

STYLE 1:
PIN 1. ANODE
2. CATHODE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.38	8.89	0.330	0.350
B	3.30	3.68	0.130	0.145
D	0.94	1.09	0.037	0.043
F	–	1.27	–	0.050
K	25.40	31.75	1.000	1.250

CASE 17-02

ELECTRICAL CHARACTERISTIC (T_A = 25°C unless otherwise noted) V_F = 3.5 V max, I_F** = 50 A for all types.

Device	Breakdown Voltage * V_{BR} (Volts) Min	Nom	Max	@ I_T (mA)	Working Peak Reverse Voltage V_{RWM} (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (μA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM} (Clamping Voltage) V_{RSM} (Volts)	Maximum Temperature Coefficient of V_{BR} (%/°C)
P6KE6.8	6.12	6.8	7.48	10	5.50	1000	56	10.8	0.057
P6KE6.8A	6.45	6.8	7.14	10	5.80	1000	57	10.5	0.057
P6KE7.5	6.75	7.5	8.25	10	6.05	500	51	11.7	0.061
P6KE7.5A	7.13	7.5	7.88	10	6.40	500	53	11.3	0.061
P6KE8.2	7.38	8.2	9.02	10	6.63	200	48	12.5	0.065
P6KE8.2A	7.79	8.2	8.61	10	7.02	200	50	12.1	0.065
P6KE9.1	8.19	9.1	10.0	1.0	7.37	50	44	13.8	0.068
P6KE9.1A	8.65	9.1	9.55	1.0	7.78	50	45	13.4	0.068
P6KE10	9.00	10	11.0	1.0	8.10	10	40	15.0	0.073
P6KE10A	9.50	10	10.5	1.0	8.55	10	41	14.5	0.073
P6KE11	9.90	11	12.1	1.0	8.92	5.0	37	16.2	0.075
P6KE11A	10.5	11	11.6	1.0	9.40	5.0	38	15.6	0.075
P6KE12	10.8	12	13.2	1.0	9.72	5.0	35	17.3	0.078
P6KE12A	11.4	12	12.6	1.0	10.2	5.0	36	16.7	0.078
P6KE13	11.7	13	14.3	1.0	10.5	5.0	32	19.0	0.081
P6KE13A	12.4	13	13.7	1.0	11.1	5.0	33	18.2	0.081
P6KE15	13.5	15	16.5	1.0	12.1	5.0	27	22.0	0.084
P6KE15A	14.3	15	15.8	1.0	12.8	5.0	28	21.2	0.084
P6KE16	14.4	16	17.6	1.0	12.9	5.0	26	23.5	0.086
P6KE16A	15.2	16	16.8	1.0	13.6	5.0	27	22.5	0.086
P6KE18	16.2	18	19.8	1.0	14.5	5.0	23	26.5	0.088
P6KE18A	17.1	18	18.9	1.0	15.3	5.0	24	25.2	0.088
P6KE20	18.0	20	22.0	1.0	16.2	5.0	21	29.1	0.090
P6KE20A	19.0	20	21.0	1.0	17.1	5.0	22	27.7	0.090
P6KE22	19.8	22	24.2	1.0	17.8	5.0	19	31.9	0.092
P6KE22A	20.9	22	23.1	1.0	18.8	5.0	20	30.6	0.092
P6KE24	21.6	24	26.4	1.0	19.4	5.0	17	34.7	0.094
P6KE24A	22.8	24	25.2	1.0	20.5	5.0	18	33.2	0.094
P6KE27	24.3	27	29.7	1.0	21.8	5.0	15	39.1	0.096
P6KE27A	25.7	27	28.4	1.0	23.1	5.0	16	37.5	0.096
P6KE30	27.0	30	33.0	1.0	24.3	5.0	14	43.5	0.097
P6KE30A	28.5	30	31.5	1.0	25.6	5.0	14.4	41.4	0.097
P6KE33	29.7	33	36.3	1.0	26.8	5.0	12.6	47.7	0.098
P6KE33A	31.4	33	34.7	1.0	28.2	5.0	13.2	45.7	0.098
P6KE36	32.4	36	39.6	1.0	29.1	5.0	11.6	52.0	0.099
P6KE36A	34.2	36	37.8	1.0	30.8	5.0	12	49.9	0.099
P6KE39	35.1	39	42.9	1.0	31.6	5.0	10.6	56.4	0.100
P6KE39A	37.1	39	41.0	1.0	33.3	5.0	11.2	53.9	0.100
P6KE43	38.7	43	47.3	1.0	34.8	5.0	9.6	61.9	0.101
P6KE43A	40.9	43	45.2	1.0	36.8	5.0	10.1	59.3	0.101
P6KE47	42.3	47	51.7	1.0	38.1	5.0	8.9	67.8	0.101
P6KE47A	44.7	47	49.4	1.0	40.2	5.0	9.3	64.8	0.101
P6KE51	45.9	51	56.1	1.0	41.3	5.0	8.2	73.5	0.102
P6KE51A	48.5	51	53.6	1.0	43.6	5.0	8.6	70.1	0.102
P6KE56	50.4	56	61.6	1.0	45.4	5.0	7.4	80.5	0.103
P6KE56A	53.2	56	58.8	1.0	47.8	5.0	7.8	77.0	0.103
P6KE62	55.8	62	68.2	1.0	50.2	5.0	6.8	89.0	0.104
P6KE62A	58.9	62	65.1	1.0	53.0	5.0	7.1	85.0	0.104
P6KE68	61.2	68	74.8	1.0	55.1	5.0	6.1	98.0	0.104
P6KE68A	64.6	68	71.4	1.0	58.1	5.0	6.5	92.0	0.104
P6KE75	67.5	75	82.5	1.0	60.7	5.0	5.5	108.0	0.105
P6KE75A	71.3	75	78.8	1.0	64.1	5.0	5.8	103.0	0.105
P6KE82	73.8	82	90.2	1.0	66.4	5.0	5.1	118.0	0.105
P6KE82A	77.9	82	86.1	1.0	70.1	5.0	5.3	113.0	0.105
P6KE91	81.9	91	100.0	1.0	73.7	5.0	4.8	131.0	0.106
P6KE91A	86.5	91	95.50	1.0	77.8	5.0	4.8	125.0	0.106

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ELECTRICAL CHARACTERISTICS (continued)

Device	Breakdown Voltage V_{BR} (Volts) Min	Nom	Max	@ I_T (mA)	Working Peak Reverse Voltage V_{RWM} (Volts)	Maximum Reverse Leakage @ V_{RWM} I_R (µA)	Maximum Reverse Surge Current I_{RSM}† (Amps)	Maximum Reverse Voltage @ I_{RSM} (Clamping Voltage) V_{RSM} (Volts)	Maximum Temperature Coefficient of V_{BR} (%/°C)
P6KE100	90.0	100	110.0	1.0	81.0	5.0	4.2	144.0	0.106
P6KE100A	95.0	100	105.0	1.0	85.5	5.0	4.4	137.0	0.106
P6KE110	99.0	110	121.0	1.0	89.2	5.0	3.8	158.0	0.107
P6KE110A	105.0	110	116.0	1.0	94.0	5.0	4.0	152.0	0.107
P6KE120	108.0	120	132.0	1.0	97.2	5.0	3.5	173.0	0.107
P6KE120A	114.0	120	126.0	1.0	102.0	5.0	3.6	165.0	0.107
P6KE130	117.0	130	143.0	1.0	105.0	5.0	3.2	187.0	0.107
P6KE130A	124.0	130	137.0	1.0	111.0	5.0	3.3	179.0	0.107
P6KE150	135.0	150	165.0	1.0	121.0	5.0	2.8	215.0	0.108
P6KE150A	143.0	150	158.0	1.0	128.0	5.0	2.9	207.0	0.108
P6KE160	144.0	160	176.0	1.0	130.0	5.0	2.6	230.0	0.108
P6KE160A	152.0	160	168.0	1.0	136.0	5.0	2.7	219.0	0.108
P6KE170	153.0	170	187.0	1.0	138.0	5.0	2.5	244.0	0.108
P6KE170A	162.0	170	179.0	1.0	145.0	5.0	2.6	234.0	0.108
P6KE180	162.0	180	198.0	1.0	146.0	5.0	2.3	258.0	0.108
P6KE180A	171.0	180	189.0	1.0	154.0	5.0	2.4	246.0	0.108
P6KE200	180.0	200	220.0	1.0	162.0	5.0	2.1	287.0	0.108
P6KE200A	190.0	200	210.0	1.0	171.0	5.0	2.2	274.0	0.108

†Surge Current Waveform per Figure 4 and Derate per Figure 2.
**1/2 Square or Equivalent Sine Wave, PW = 8.3 ms, Duty Cycle = 4 Pulses per Minute maximum.
*V_{BR} measured after I_T applied for 300 µs, I_T = Square Wave Pulse or equivalent.

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FIGURE 1 — PULSE RATING CURVE

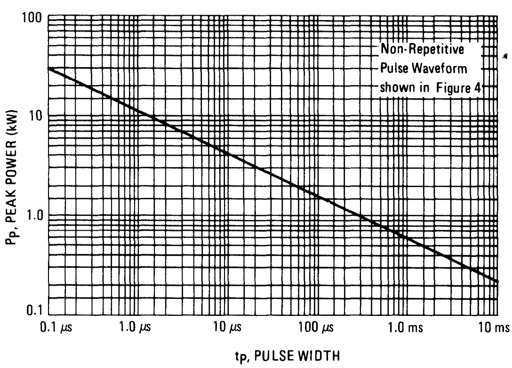


FIGURE 2 — PULSE DERATING CURVE

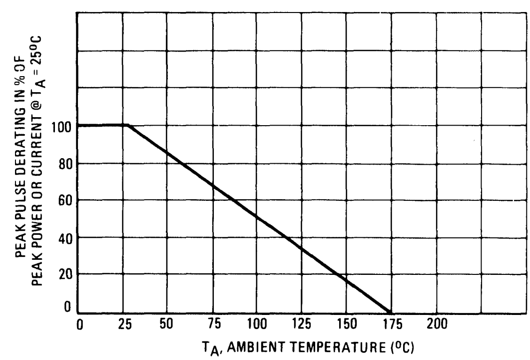


FIGURE 3 — CAPACITANCE versus BREAKDOWN VOLTAGE

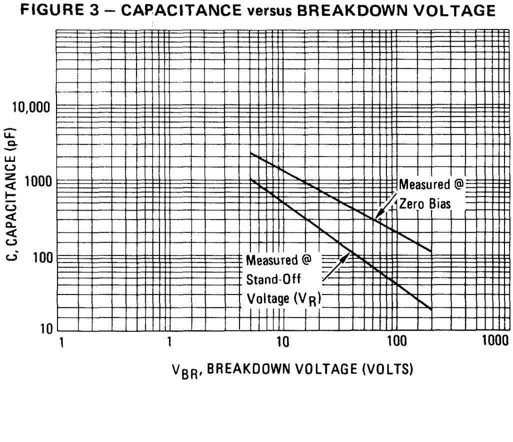


FIGURE 4 — PULSE WAVEFORM

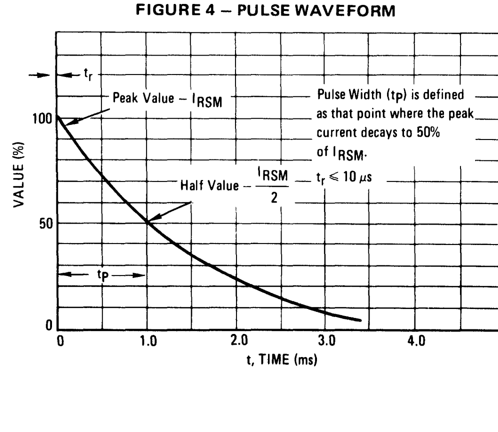
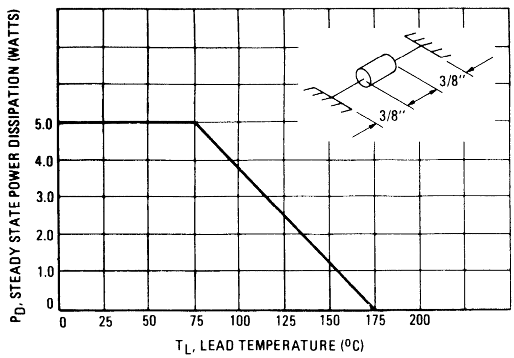


FIGURE 5 — STEADY STATE POWER DERATING



APPLICATION NOTES

SPECIAL DEVICES

Matched sets and back-to-back configurations for bidirectional applications can be ordered upon special request. Contact your nearest Motorola representative.

For a bidirectional device use a C or CA suffix (i.e. P6KE6.8CA). Electrical characteristics apply in both directions except for V_F.

RESPONSE TIME

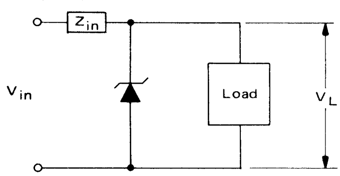
In most applications, the transient suppressor device is placed in parallel with the equipment or component to be protected. In this situation, there is a time delay associated with the capacitance of the device and an overshoot condition associated with the inductance of the device and the inductance of the connection method.

The capacitive affect is of minor importance in the parallel protection scheme because it only produces a time delay in the transition from the operating voltage to the clamp voltage as shown in Figure A.

The inductive affects in the device are due to actual turn-on time (time required for the device to go from zero current to full current) and lead inductance. This inductive affect produces an overshoot in the voltage across the equipment or component being protected as shown in Figure B. Minimizing this overshoot is very important in the application, since the main purpose for adding a transient suppressor is to clamp voltage spikes. The P6KE6.8 series has very good response time, typically < 1.0 ns and negligible inductance. However, external inductive affects could produce unacceptable overshoot. Proper circuit layout, minimum lead lengths and placing the suppressor device as close as possible to the equipment or components to be protected will minimize this overshoot.

Some input impedance represented by Z_{in} is essential to prevent overstress of the protection device. This impedance should be as high as possible, without restricting the circuit operation.

TYPICAL PROTECTION CIRCUIT



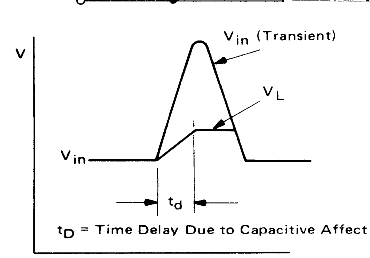


FIGURE A

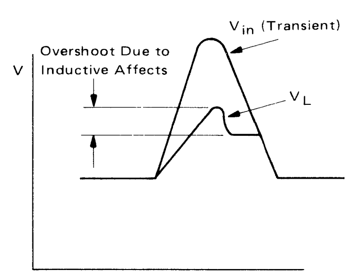


FIGURE B

NOTES

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