EK-PT110-UG-001

PDT-11/110 and PDT-11/130 User Guide

digital equipment corporation • maynard, massachusetts

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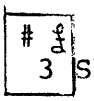

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CHAPTER 1
INTRODUCTION

This guide contains information dealing with two configurations of the PDT-11 series of products: the PDT-11/110 and PDT-11/130 systems. Contained within this document is information required to unpack, inspect, install, verify proper operation and describe the hardware programming considerations of these programmable data entry terminals.

Chapter 1 contains a general description of the PDT-11/110 and PDT-11/130 systems. The PDT-11 system options, supplies, and related documentation are also discussed within this chapter. All necessary ordering information has been supplied.

Chapter 2 defines the controls and indicators used by the system operator, as well as, program loading instructions, system maintenance and troubleshooting.

Chapter 3 provides detailed procedures used to unpack, pack, inspect and install the PDT-11 systems. This chapter also includes detailed interfacing and system specifications for both the PDT-11/110 and PDT-11/130 systems.

Chapter 4 supplies hardware programming information and considerations required for the development of the application program.

GENERAL DESCRIPTION

The PDT-11 family of products are terminal-based computer systems which are programmed to meet the specific requirments of the user. The systems operate in an ordinary office environment without the need for extensive cabling, air conditioning or special electrical fixtures. The PDT-11 systems provide programmable data processing, local file storage and communications capabilities which were previously found only in large computer systems. The PDT-11 intelligent data terminals are based on the powerful LSI-11 microprocessor. The LSI-11 microcomputer allows distributed data processing, therefore the user can access programming and data locally without host computer intervention. Because of their intelligence, the PDT-11 products may pre-process data to reduce the volume of data transmitted to the host computer, reducing communication costs and processing overhead of the host computer.

The PDT-11/110 and PDT-11/130 systems are shown in Figure 1-1. These intelligent data entry terminals combine the functionality of a VT100 video display terminal, the power of the LSI-11 microprocessor and (in the case of the PDT-11/130) a mass storage device. The PDT-11/130's mass storage is in the form of a dual DECtape II tape cartridge drive held within the video monitor. Figure 1-2 provides a general block diagram of the PDT-11 systems.

The PDT-11 terminal-based systems operate under the control of an application program. The application program must be developed on a larger and possibly faster host computer and then loaded into the PDT-11 system using terminal resident program loading routines.

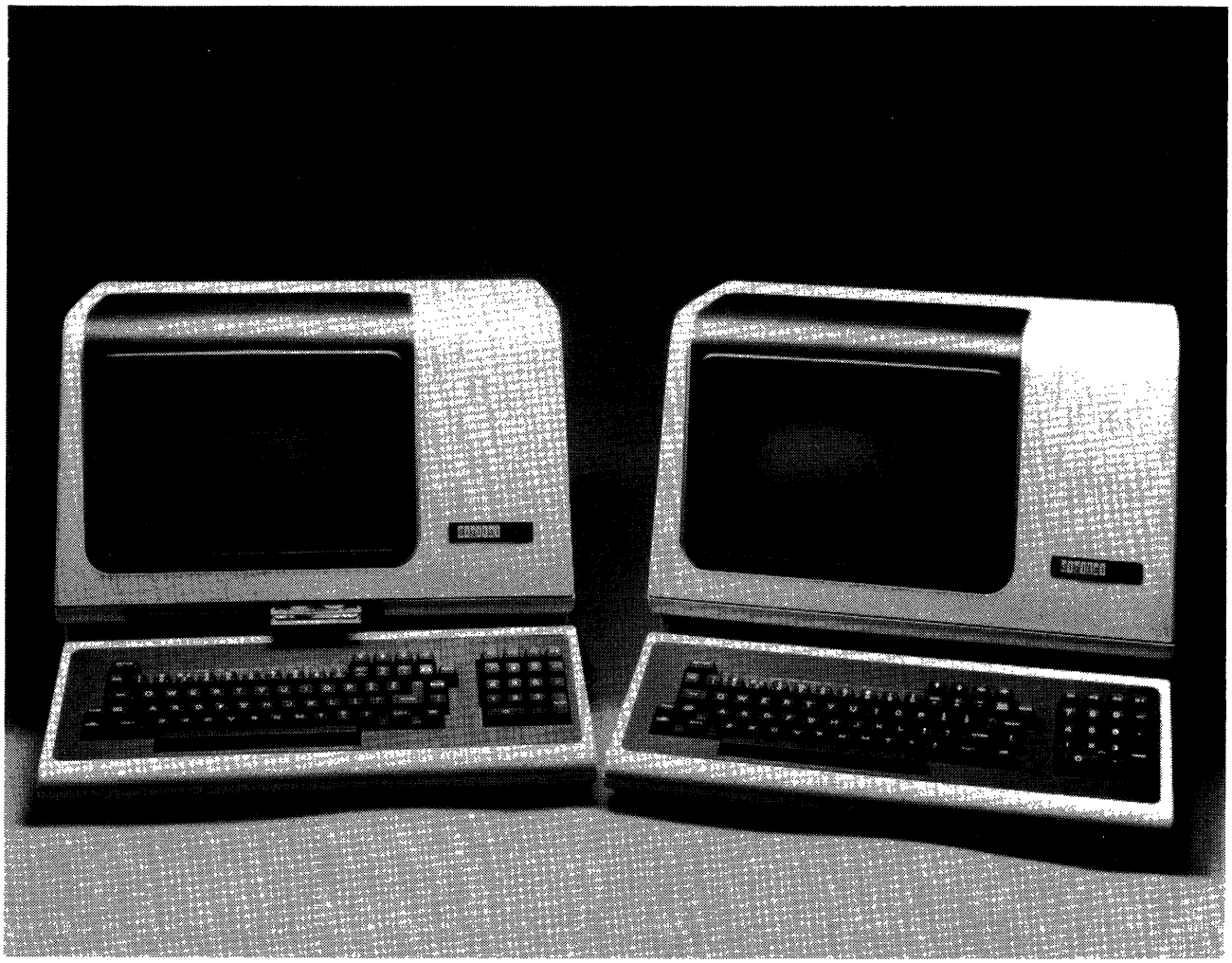


Figure 1-1 PDT-11/110 and PDT-11/130 Systems

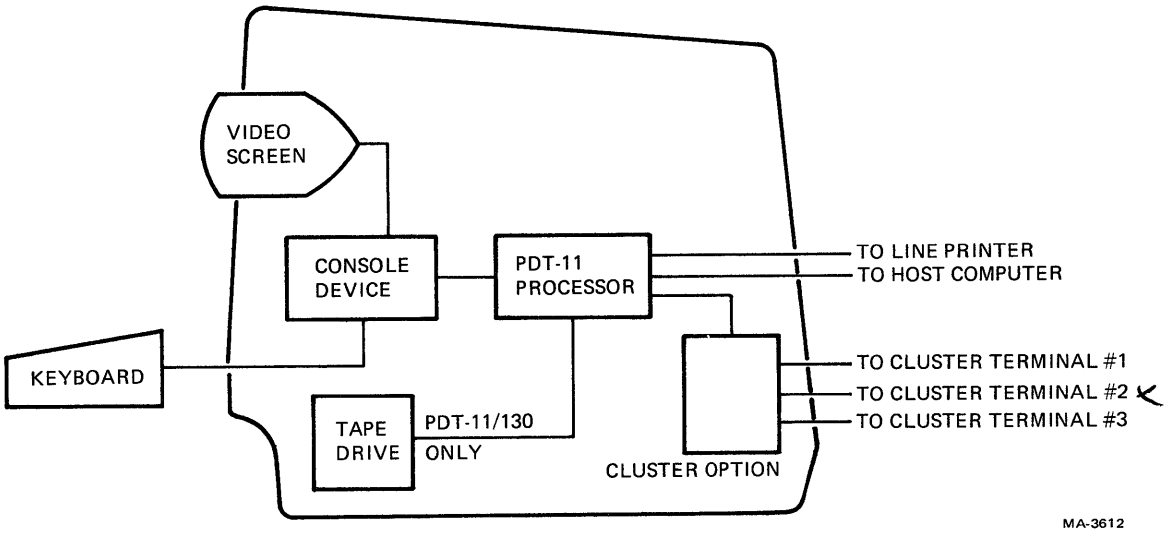


Figure 1-2 General Block Diagram

The PDT-11 systems utilize the basic instruction set of the PDP-11 computer. This allows a vast number of existing PDP-11 programs to be used with the PDT-11 systems. Also, programmers developing software for PDP-11 computers can directly apply their expertise to programming the PDT-11 systems.

SYSTEM CONFIGURATIONS

Figure 1-3 lists the model numbers assigned to each of the PDT-11/110 and PDT-11/130 systems. The systems are available with varying memory sizes and options.

SYSTEM OPTIONS

The PDT-11/110 and PDT-11/130 systems have a number of options and accessories which may be ordered with the system or added by a field service representative. The options currently available are listed in Table 1-1.

TABLE 1-1
System Options

OPTION NUMBER	DESCRIPTION
DFT11-AC	Cluster option
VT1XX-AB	Advanced video option
MST11-BB	PDT-11/110 Processor memory (16 kb)
MST11-BC	PDT-11/110 Processor memory (32 kb)
MST11-BD	PDT-11/110 Processor memory (60 kb)
MST11-CB	PDT-11/130 Processor memory (16 kb)
MST11-CC	PDT-11/130 Processor memory (32 kb)
MST11-CD	PDT-11/130 Processor memory (60 kb)

Cluster Option (DFT11-AC)

The Cluster Option expands the capacity of the system to include three additional serial line terminals. The clustered terminals operate asynchronously at speeds ranging from 50 to 2400 bits per second.

Advanced Video Option (VT1XX-AB)

The Advanced Video Option adds the following features:

* 10 additional lines of 132 column display - this capability is added by providing additional display memory. The AVO option gives the screen the ability to display a total of 24 lines using either 80 or 132 column line widths.

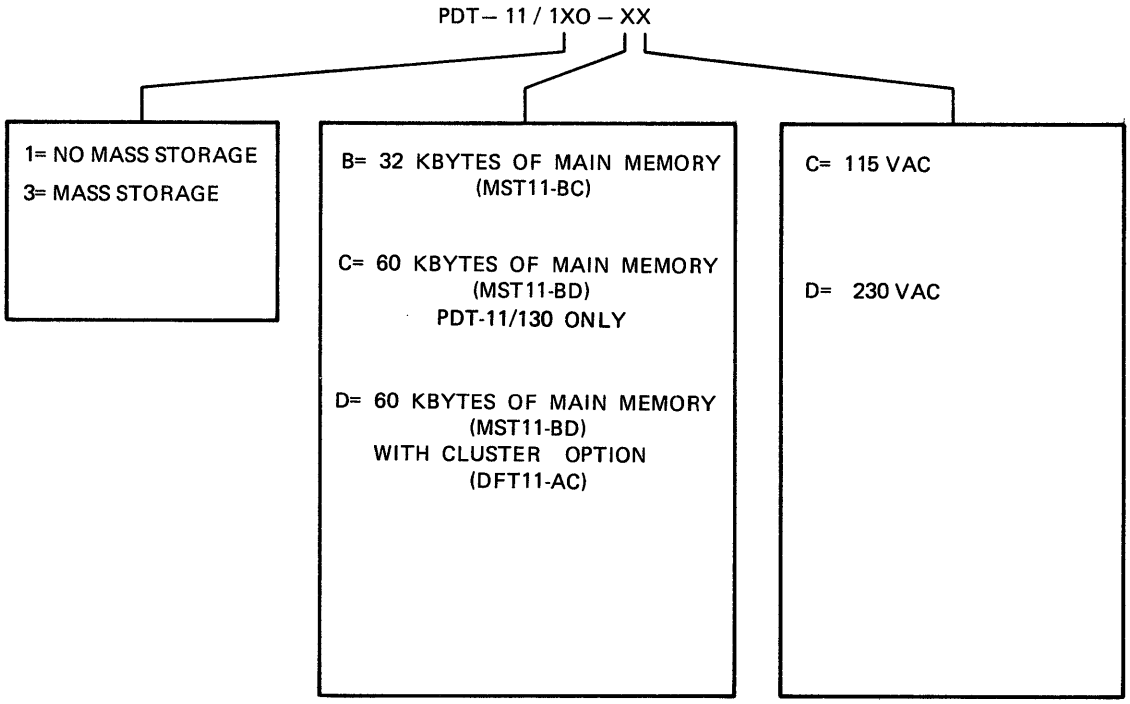


Figure 1-3 PDT-11/11Ø and PDT-11/13Ø System Designations

* Additional character attributes - the capability of highlighting any character(s) on the screen in any of the following methods:

  Standard character attributes (chosen using cursor selection)
  - Underline
  - Reverse

  Additional character attributes
  - Bold
  - Blink
  - Any combination of character attributes

* Capability of using an additional character generator ROM - this capability is provided by additional user supplied programming held within read only memories mounted on the AVO board.

Memory Options (MST11-XX)
The PDT-11 memory options expand the capacity of the system to permit substantial programming to reside locally. These memory options are installable by a field service representative, therefore, system memory upgrades are both fast and inexpensive.

SOFTWARE LICENSES

The PDT-11/130 is sold with a RT2/PDT software license which provides a single-job (SJ) or foreground/background (FB) execute-only environment for application programs developed on a RT-11 system. The RT2/PDT license allows the use of a specified subset of RT-11 to be used on PDT-11 based systems. The license-only option allows the duplication of special PDT monitors (included in the RT2/PDT software) as well as the specified subset of RT-11 for the PDT-11 systems. It is the user's responsibility to integrate his application(s) with the PDT monitor and transport the resulting runtime system from the RT-11 system to the target PDT-11 system.

The PDT-11/110 has no software license associated with it at the time of sale. However, the system is able to run under RSX-11S software. RSX-11S is the execute-only member of the RSX-11 family of software used for dedicated real-time multiprogramming applications which require a host RSX-11M or VMS system.

Consult your local DIGITAL sales office for detailed information on PDT-11 software.

RELATED DOCUMENTATION

The related documentation referenced throughout this manual is provided within the following sections with all necessary ordering information.

RELATED DIGITAL SOFTWARE DOCUMENTATION

The documents listed in Table 1-2 are supplied within the documentation packages of the particular operating system. They are listed here to direct the new user to the proper starting point when learning the operating system. All purchase orders for DIGITAL software documentation should be forwarded to:

Digital Equipment Corporation
Software Distribution Center
146 Main Street
Maynard, Massachusetts 01754

or

Digital Equipment Corporation
Software Distribution Center
1400 Terra Bella
Mountain View, California 94043

TABLE 1-2
Related DIGITAL Software Documentation

DOCUMENT	CONTENTS
RT-11 Documentation Directory	This document describes the software manual set for the RT-11 operating system. It gives a brief sysnopsis of each manual and a suggested reading path for RT-11 users.
RSX-11M/RSX-11S Documentation Directory	This document is a guide of the software manual set for the RSX-11M/RSX-11S operating systems. The exact contents of the set is dependent on the license purchased.

The application program of the PDT-11/110 system may be loaded using the Terminal Boot Loader routine. This routine allows the program to be loaded in a character-by-character fashion from a time-sharing host computer. To aid the user in formating the application program properly for character-by-character transmission, a program has been made available to the user through DECUS. All requests for this programm should be forwarded to:

DECUS
Digital Equipment Corporation
146 Main Street
Maynard Ma. 01754

RELATED DIGITAL HARDWARE DOCUMENTATION

Table 1-3 lists the related publications that are available from DIGITAL for the PDT-11/110 and PDT-11/130 systems. All purchase orders for DIGITAL publications should be forwarded to:

DIGITAL Equipment Corporation
Accessories and Supplies
Cotton Road
Nashua N.H. 03060

Purchase orders must show shipping and billing addresses and state whether a partial shipment will be accepted.

All correspondence and invoicing inquiries should be directed to the above address.

Contact your local sales office or call DIGITAL Direct Catalog Sales toll free 800-258-1710 from 8:30 am to 5:00 pm eastern standard time (U.S. customers only). New Hampshire customers should dial (603)-884-6660. Terms and conditions include net 30 days and F.O.B. DIGITAL plant. Freight charges will be prepaid by DIGITAL and added to the invoice. Minimum order is $35.00. Minimum does not apply when full prepayment is sudmitted with an order. Checks and money orders should be made out to Digital Equipment Corporation.

TABLE 1-3
Related DIGITAL Hardware Documentation

DOCUMENT	DOCUMENT NUMBER	
PDT-11 Series Technical Manual	EK-PT110-TM-001	This document provides an overview of the entire PDT-11 family. It references all related documents and supplies any additional information not contained within the documents cited.
TU58 DECTape II Technical Manual	EK-0TU58-TM-001	This document provides a detailed discussion of the operation and repair of the tape drive and controller.
VT100 Technical Manual	EK-VT100-TM-001	This document provides a detailed discussion of the operation and repair of the VT100 (PDT-11 console device.
VT100,PDT-11 Mini Maintenance Hardware Guide	EK-VT100-J1-002	This document describes the procedures used to isolate and repair the VT100, PDT-11/110 and PDT-11/130 systems to the field replacable unit.
Microcomputer Processors (Microcomputer Handbook Series)	EB-15115-78	Provides a complete, detailed description of the LSI-11 microprocessor. This includes the instruction set, processor architecture and processor operation.
PDT-11/110 IPB (Illustrated Parts Break-down)	EK-11110-IP	This document shows a detailed breakbown of the PDT-11/110 system. All orderable parts are indentified and their placement within the assembly illustrated.

PDT-11/130 IPB (Illustrated Parts Breakdown)	EK-11130-IP	This document shows a detailed breakbown of the PDT-11/130 system. All orderable parts are indentified and their placement within the assembly illustrated.
11110 &11130 Field Maintenance Print Set	MP00715	This print set holds schematics, assembly drawings and part lists for both the PDT-11/110 and PDT-11/130 systems.

RELATED EIA DOCUMENTATION
Table 1-4 provides the title and designation of the EIA publications related to the PDT-11 products. These publications may be ordered by forwarding requests for documentation to the following address:

EIA Engineering Department
2001 Eye Street, N.W.
Washington, D.C. 20006

TABLE 1-4
Related EIA Documentation

DOCUMENT TITLE	DOCUMENT DESIGNATION
Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange	EIA RS-232-C
Electrical Performance Standards for Monochrome Television Studio Facilities	EIA RS-170

RELATED ANSI DOCUMENTATION
Table 1-5 contains the title and designation of the American National Standards documents which pertain to the PDT-11 systems. These documents may be purchased from ANSI by writing the following address:

Sales Department ANSI
1430 Boardway
N.Y., N.Y. 10018

TABLE 1-5
Related ANSI Documentation

DOCUMENT TITLE	DOCUMENT DESIGNATION
American National Standard Code For Information Interchange	ANSI X3.4
American National Standard Code Extension Techniques For Use With The 7-bit Coded Character Set Of American National Standard Code For Information Interchange	ANSI X3.41
American National Standard Additional Controls For Use With ASCII	ANSI X3.64

RELATED CCITT DOCUMENTATION
Table 1-6 contains the title and designation of the applicable International Telegraph and Telephone Consultive Committee recommendations adhered to by the PDT-11 products. A copy of these recommendations may be ordered by writing the following address:

UN Bookstore
United Nations Building
New York, New York 10017

or

NTIS
Department of Commerce
Springfield, Virginia

TABLE 1-6
Related CCITT Documentation

DOCUMENT TITLE	DESIGNATION
List of Definitions for Interchange Circuits Between Data Terminal Equipment and Data Circuit Terminating Equipment	CCITT V.24
Electrical Characteristics for Unbalanced Double-current Interchange Circuits	CCITT V.28

Note: When ordering from NTIS, the PB270814 order number will provide both documents.

ACCESSORIES AND SUPPLIES

A wide variety of supplies and accessories are available for the PDT-11 products. The following sections provide a brief description of the products available. All purchase orders for supplies and accessories should be forwarded to:

DIGITAL Equipment Corporation
Accessories and Supplies
Cotton Road
Nashua N.H. 03060

Purchase orders must show shipping and billing addresses and state whether a partial shipment will be accepted.

All correspondence and invoicing inquiries should be directed to the above address.

Contact your local sales office or call DIGITAL Direct Catalog Sales toll free 800-258-1710 from 8:30 am to 5:00 pm eastern standard time (U.S. customers only). New Hampshire customers should dial (603)-884-6660. Terms and conditions include net 30 days and F.O.B. DIGITAL plant. Freight charges will be prepaid by DIGITAL and added to the invoice. Minimum order is $35.00. Minimum does not apply when full prepayment is sudmitted with an order. Checks and money orders should be made out to Digital Equipment Corporation.

PDT-11/130 TAPE SUPPLIES

Table 1-7 lists all tape supplies used with the PDT-11/130 system.

TABLE 1-7
Tape Supplies

PART NUMBER	DESCRIPTION
TU58-K	Mini-tape Cartridges
TUC-01	Cleaning Kit

COMMONLY USED CABLE ASSEMBLIES

Table 1-8 lists the cable assemblies most commonly used with the PDT-11 products. See chapter 3 for detailed information on the cables listed in the table.

TABLE 1-8
Available Cable Assemblies

CABLE #	CABLE LENGTH	CONNECTOR 1	CABLE TYPE	CONNECTOR 2
BC22B-XX	XX= 10 or 25'	RS-232 (male)	Extension	RS-232 (female)
BC05D-XX	variable	RS-232 (male)	Extension	RS-232 (female)
BC03Z-XX	variable	RS-232 (female)	Null Modem	RS-232 (female)
BC22A-XX	XX= 10 or 25'	RS-232 (female)	Null Modem	RS-232 (female)
BC03M-XX	variable	RS-232 (female)	Null Modem	RS-232 (female)

ADDITIONAL SUPPLIES
VT1XX-ST Terminal stand offers ease of use for the PDT-11 video products, and is styled to give a contemporary look of elegance to any office or computer environment. The unit requires minimal floor space. The stand consists of a keyboard/monitor base plate that is securely mounted to a tubular steel center pole, which is attached to five pedestal legs providing excellent stability. The stand raises the terminal 26 inches to provide for typing comfort and accuracy.

VT1XX-AE screen filter reduces glare from overhaed lighting, while softening the monitor display without dulling the sharpness of the image itself. The light grey filter adheres directly to the face of the screen, thereby avoiding image distortion and maintaining high character resolution and contrast. The filter has a non-glare matte finish and a hard coating that is both abrasion and chemical resistant.

ZJ-288-XX system exerciser is used with the PDT-11/110 and PDT-11/130 systems to verify proper system operation. The exerciser is used to test the PDT-11 processor's ability to operate with the system peripherals. The software operates in interrupt mode with emphasis on PDT-11/130 tape drive operation.

Loopback connector set part number 70-17047 contains five loopback plugs used by the system exerciser when placed in external loopback mode. This mode is not used during acceptance testing.

CHAPTER 2
OPERATOR INFORMATION

This chapter has been provided for the operator and programmer to become familiar with the operating controls, indicators and procedures used with the PDT-11/110 and PDT-11/130 systems.

The operator chapter has been structured to allow the reader to become familiar with all the controls and indicators before applying power to the system. The specific step-by-step procedure used to apply power to the system has been provided within the Power Up Procedure section of this chapter.

The PDT-11 console device is equipped with a unique operational mode called SET-UP Mode. This mode allows the operator to select operating parameters of the system through keyboard entries after the system is powered. A complete explaination of this operational mode has been provided within this chapter.

The PDT-11 systems are equipped with self test and program loading routines. The instructions for the operation of these routines is provided in this chapter. All operator actions which may be preformed as a result of the self test and program loading routine indications are listed at the end of the chapter.

CONTROLS AND INDICATORS

The PDT-11/110 and PDT-11/130 systems are equipped with a wide variety of controls and indicators which are used by the operator to monitor and direct system operation. The controls and indicators of the PDT-11 systems are described in the following categorizes:

Keyboard Controls
Keyboard Indicators
Monitor Controls
Audible Indicators

KEYBOARD CONTROLS

The PDT-11 systems are equipped with two keypads on a single keyboard. The main keyboard has a key arrangement and sculptured style which resembles a standard office typewriter. The auxiliary keypad allows numeric data or special function codes to be entered in a calculator fashion.

The operator uses the keyboard to transmit codes to the system processor. Some keys transmit one or more codes immediately when typed. Other keys such as CTRL and SHIFT keys do not transmit codes when typed, but modify the codes transmitted by other keys. If two code-transmitting keys are pressed together, two codes will be transmitted according to the order in which the keys were typed. The console will not wait for the keys to be lifted, but will transmit both codes as soon as possible after the keys are typed. If three code-transmitting keys are pressed simultaneously, the codes from the first two keys are transmitted immediately; the code for the third key will be transmitted when the first key is lifted.

The PDT-11 keyboard keys are divided by functionality. The key functions are:

Standard Keys
Special Function Keys
Set-Up Mode Keys

Standard Keys
Figure 2-1 identifies those keys which usually operate as standard typewriter and calculator keys. The operator uses these keys to generate codes which are transmitted by the PDT-11 console (the specific codes generated by the standard keys can be found in Table 4-30).

The console generates lowercase codes unless one or both of the SHIFT keys are depressed, or the CAPS LOCK key is pressed. The SHIFT keys are pressed to allow the console to generate uppercase codes for the alphabetic, numeric and special symbol keys. The SHIFT key does not affect the keys of the auxiliary keypad.

The CAPS LOCK key enables the console to generate uppercase alphabetic character codes regardless of the position of the SHIFT key. The numeric and special symbol keys are not affected by the CAPS LOCK key. The CAPS LOCK key locks into position during operation. To release the CAPS LOCK key, press it again.

The minus, comma, period and numeric keys of the auxiliary keypad normally generate the same codes as the corresponding unshifted keys of the main keyboard. However, when the console is placed in Keypad Application Mode, the keys of the auxiliary keypad generate predetermined codes (as listed in Tables 4-36 or 4-39). The codes generated may have special meaning to the application program.

Some of the standard typewriter keys, when used in conjunction with special function keys may generate control codes which may also have special meaning to the application program.

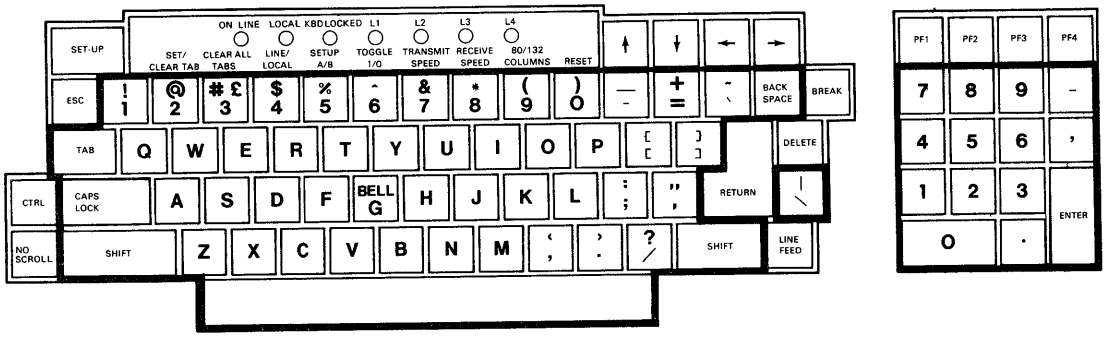


FIGURE 2-1 Standard Typewriter and Calculator Keys

Special Function Keys

Figure 2-2 identifies the special function keys of the PDT-11 keyboard. When in Keypad Application Mode, the shaded keys shown in Figure 2-2 provide additional special function keys. The special function keys are used to transmit codes which may have a special meaning to the application program. A general description of each special function key is provided in Table 2-1.

When Keypad Application Mode is not selected the shaded keys in Figure 2-2 generate the same codes as the corresponding unshifted keys of the main keyboard.

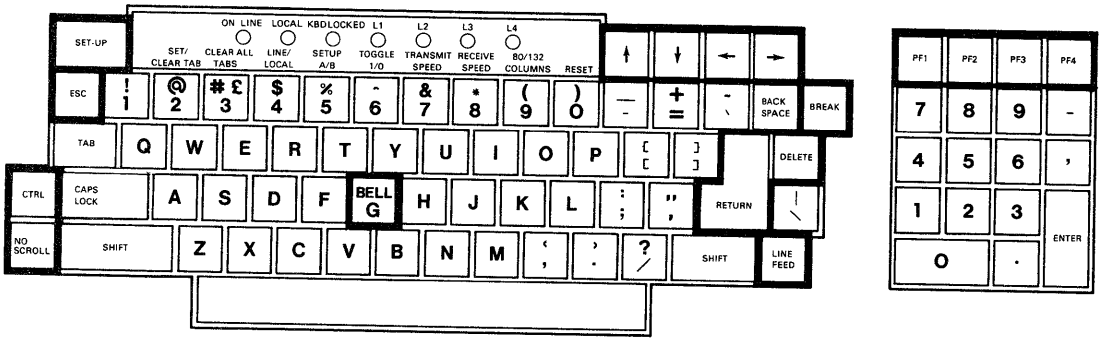


FIGURE 2-2 Special Function Keys

TABLE 2-1
Special Function Keys
(General Description)

KEY	ASSOCIATED FUNCTION
SET-UP Key	- The SET-UP key is used to enter and exit the SET-UP Mode (a detailed description of the SET-UP Mode is provided later in this chapter).
ESC Key	- The ESC key causes the console to generate an Escape code (octal 033).
CTRL Key	- When used in combination with other keys, the CTRL key causes the console to generate control codes. (The control codes generated by the console are listed in Table 4-32).
BELL G Key	- When used in combination with the CTRL key, the G key causes the console to generate a bell code (octal 007).
NO SCROLL Key	- When the NO SCROLL key is pressed it generates the XOFF (DC3, octal 023) control code and inhibits further scrolling. When pressed again, the XON (DC1, octal 021 control code is generated and scrolling may resume.
← → ↓ ↑ Keys	- These keys cause the console to generate sequences whose function is determined by the application program. These keys are usually associated with cursor control commands. (The specific codes generated by these keys are listed in Table 4-35 or 4-38).
BREAK Key	- The BREAK key has no affect on the system unless ODT (HALT mode) operation is enabled. (ODT operation is normally not used by the operator).
DELETE Key	- The DELETE key causes the console to generate a delete code (octal 177).
LINE FEED Key	- The LINEFEED key causes the console to generate a linefeed (LF) code (octal 012).
RETURN Key	- The operation of the RETURN key is dependent on the New Line SET-UP feature setting (discussed in the SET-UP Mode section of this chapter). The New Line feature enables the RETURN key of the console to generate both a carriage return (CR) code (octal 015) and linefeed (LF) code (octal 012). When the New Line feature is disabled the RETURN key generates a carriage return (CR) code (octal 015).

ENTER Key - The ENTER key of the auxiliary keypad causes the console to generate the same code(s) as the RETURN key.

When the console is placed in Keypad Application Mode, the ENTER key generates predetermined codes which may have special meaning to the application program. (Table 4-36 or 4-39 lists the predetermined codes generated).

PF1 PF2 PF3 PF4 Keys - These keys of the auxiliary keypad cause the console to generate predetermined codes which may have special meaning to the application program. (Table 4-36, 4-37, 4-39, or 4-40 list the predetermined codes generated).

0 - 9 / - , . Keys - These keys of the auxiliary keypad generate the same code as the corresponding unshifted key of the main keyboard. The SHIFT key of the main keyboard does not affect these keys.

When the console is placed in Keypad Application Mode, these keys generate predetermined codes which may have special meaning to the application program. (Table 4-36 or 4-39 list the predetermined codes generated).

SET-UP Mode Keys

Figure 2-3 identifies the keys which have special meaning to the system when operating in SET-UP Mode. The shaded keys are used to position the cursor while in SET-UP Mode. There are two SET-UP Modes, SET-UP A Mode and SET-UP B Mode. A detailed description of the SET-UP mode is supplied later in this chapter and should be read prior to using the SET-UP keys listed in Table 2-2.

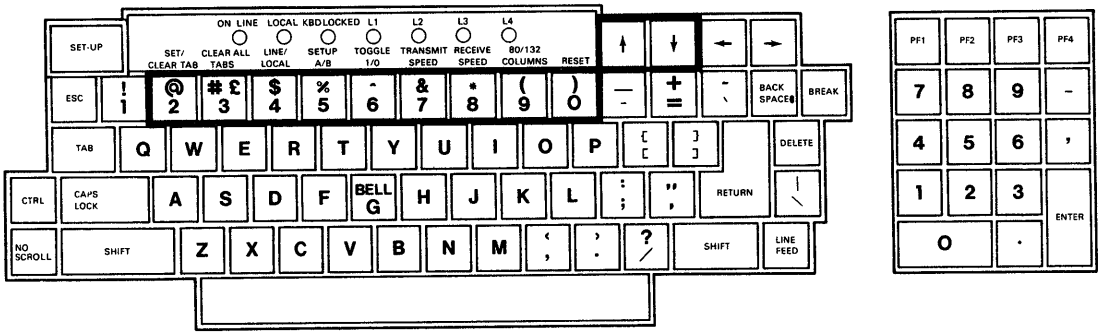


FIGURE 2-3 SET-UP Mode Keys

TABLE 2-2
SET-UP Mode Keys
(General Description)

KEY	ASSOCIATED FUNCTION
[↑] [↓] Keys	- When in SET-UP Mode, these keys increase and decrease the brightness of the video screen. [↑] = Increase [↓] = Decrease
SET/ CLEAR TAB [@ 2] Key	- When in SET-UP A Mode, the [@ 2] key alternately sets or clears individual horizontal tabs.
CLEAR ALL TABS [# £ 3] Key	- When in SET-UP A Mode, the [# £ 3] key clears all tabs.
LINE/ LOCAL [$ 4] Key	- When in SET-UP Mode, the [$ 4] key alternately places the console "on line" or "local" to the PDT-11 processor. "On Line" - The console is "on line" and can receive or transmit characters with the PDT-11 processor. The On Line condition is shown by the lighting of the ON LINE indicator. "Local" - The console is "local (off line)" and can not receive or transmit characters. When operating locally, the console remains active and all characters typed on the keyboard are displayed on the video screen. The Local condition is shown by the lighting of the LOCAL indicator.
SET-UP A/B [% 5] Key	- When in SET-UP Mode, the [% 5] key alternately places the system in SET-UP A or SET-UP B mode.

TOGGLE 1/0

[^ 6] Key

- When in SET-UP B Mode, the [^ 6] key toggles the feature selected by the cursor between two selectable conditions.

TRANSMIT SPEED

[& 7] Key

- PDT-11/110 only. When in SET-UP B Mode, the [& 7] key steps the system through the transmit and receive baud rate settings of the communications port in ascending order.

RECEIVE SPEED

[* 8] Key

- This key has no direct effect on PDT-11 systems.

80/132 Column

[(9] Key

- When in SET-UP A Mode, the [(9] key alternately selects a display line size of either 80 or 132 characters per line.

RESET

[) 0] Key

- When in SET-UP Mode, the [) 0] key causes the generation of a master reset.

NOTE

A master reset will invoke the power up sequence as described later in this chapter.

KEYBOARD INDICATORS

Figure 2-4 shows the location of the keyboard indicators of the PDT-11 system. Table 2-3 describes each of the keyboard indicators.

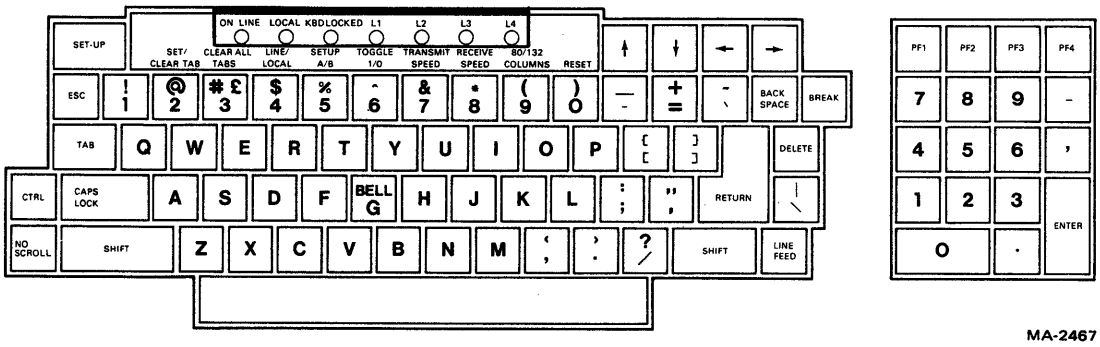


FIGURE 2-4 Keyboard Indicators

TABLE 2-3
Keyboard Indicators

INDICATOR	FUNCTION
ON LINE Indicator	- This indicator lights to show that the console is "on line" and can transmit or receive characters.
LOCAL Indicator	- This indicator lights to show that the console is "local (off line)" and cannot transmit or receive characters. When operating in the "local" condition, the console remains active and all characters typed on the keyboard are displayed on the video screen. **NOTE** **The presence of AC power is shown by the lighting of either the ON LINE or LOCAL indicator. If neither indicator is lit see the Operator Troubleshooting section of this chapter.**
KBD LOCKED Indicator	- This indicator lights to show that the keyboard has been prevented from sending characters. However, the console can still receive and display data. The operator may clear this condition by entering and exiting SET-UP Mode.
L1-L4 Indicators	- These indicators are turned ON and OFF by the applications program. These indicators are also used during the power up sequence to indicate self test failures. For further information on the meaning of these indicators during self test, refer to the Operator Troubleshooting section of this chapter.

MONITOR CONTROLS

The PDT-11 monitor is equipped with two monitor controls which are mounted on the rear panel of the monitor: the AC Voltage ON/OFF switch and the AC Voltage Selector switch. These controls are shown in Figure 2-5 and discussed in Table 2-4.

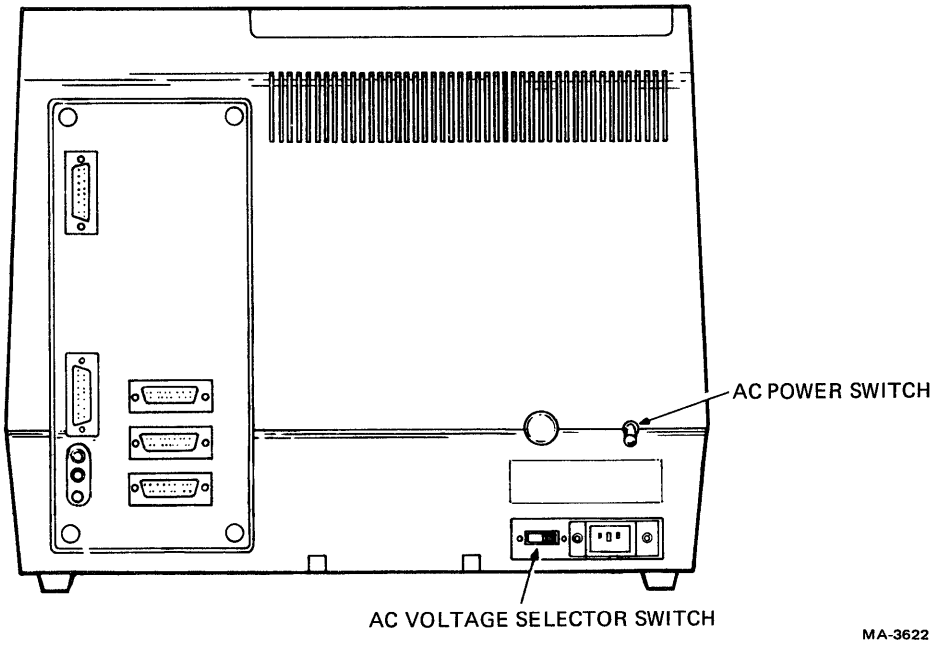


FIGURE 2-5 Monitor Control Locations
(Monitor Rear View)

TABLE 2-4
Monitor Controls

CONTROL	ASSOCIATED FUNCTION
AC Voltage ON/OFF Switch	The AC Voltage ON/OFF switch turns ON and OFF the AC voltage to the system. The AC ON condition is indicated by the lighting of either the ON LINE or LOCAL indicator. **POSITION AC VOLTAGE** Up ON Down OFF Turning the AC Voltage Switch ON causes the power up sequence to begin. See the Power Up Sequence section of this chapter for details on the proper indications.
AC Voltage Selector Switch	The AC Voltage Selector switch is used to adapt the system to the available AC input voltage range. **POSTION / VISABLE INDICATION / OPERATING RANGE** Right: 115 VOLT: 90-128 VOLTS RMS Left: 230 VOLT: 180-256 VOLTS RMS **NOTE** **AC Line frequency is selected using the Power Selection SET-UP feature.**

AUDIBLE INDICATORS

There are three audible indicators associated with the PDT-11 console: a short tone (click), a long tone (bell) and a series of long tones. Table 2-5 describes the function of each audible indicator.

TABLE 2-5
Audible Indicators

AUDIBLE INDICATION	CAUSE
SHORT TONE (click)	- The short tone (click) is sounded by the PDT-11 console whenever a key is pressed with the following exceptions: - SHIFT or CTRL keys do not generate a key click. - KBD LOCKED indicator light is ON; in which case no keyclick is sounded and all characters typed are lost. - The Keyclick feature has been turned OFF in SET-UP Mode.
LONG TONE (bell)	- The long tone (bell) is sounded by the console to indicate one of the following conditions: - A bell code is received by the PDT-11 console. - The Margin Bell feature has been enabled in SET-UP Mode and the cursor is eight character positions from the end of the current line.
SERIES OF LONG TONES	- The PDT-11 console will sound the long tone several times in succession to indicate that the console has had difficulty in reading or writing the SET-UP features. (When this occurs, see the Operator Troubleshooting section of this chapter).

POWER UP SEQUENCE

The PDT-11 systems are equipped with several permanently resident programs which are run during a power up sequence. These programs verify the proper operation of the PDT-11 system and then load the application program.

POWER UP PROCEDURE

The procedure used to initiate a power up sequence in the PDT-11 systems is described below:

1) Verify that the AC Voltage Selection Switch is set to the proper voltage. The location of the AC Voltage Switch is shown in the Monitor Controls section of this chapter.

2) Ensure that the AC power cord and communication cables are connected to their proper recepticals.

3) Place the AC voltage ON/OFF switch into the ON position.

   The power up sequence may also be initiated when AC power is applied by generating a master reset from the keyboard. This is done by placing the console in SET-UP mode and pressing the Reset (0) key.

   The PDT-11 processor may generate a power up sequence by sending a reset sequence to the console device. Refer to chapter 4 for specifics on console programming considerations.

SELF TEST PROGRAMS

The self test programs of the PDT-11 systems are initiated during the power up sequence to verify the proper operation of the system hardware and isolate equipment malfunctions.

When a failure is found, the PDT-11 systems will attempt to display a failure message on either the keyboard indicators or video screen as shown in Table 2-6. When no equipment failures are found in the PDT-11/110 system, the "check ok" message is displayed and the program loading procedure may begin. If no self test failures are found in the PDT-11/130, the system will automatically attempt to load the application program.

TABLE 2-6
Self Test Failure Indications

Light the local indicator and one or more of the L1 through L4 indicators.

Display one of the following codes on the video screen.

1	6	;	@	E	J	O
2	7	<	A	F	K	
3	8	=	B	G	L	
4	9	>	C	H	M	
5	:	?	D	I	N	

I/O ERROR xx **

Where xx can be any number.

xxxxxx
@

Where xxxxxx can be any number.

NVRAM Fault

Tape error

Refer to the Operator Troubleshooting section of this chapter for operator actions when any other indications are encountered before the completion of the self test.

PROGRAM LOADING ROUTINES

After successful completion of the self test, the PDT-11 system loads the application program using permanently held program loading routines. The system operates under the resident programs only until the application program is loaded. Once loaded, the application program determines the operation of the system.

Program Loading The PDT-11/110

The PDT-11/110 system is equipped with two types of program loading routines: the Terminal Boot Loader and the Maintenance Operation Protocol (MOP) Loader. The program loaders are entered from the Terminal Mode and Message Mode, respectively. Both program loaders are used to receive application programs down-line from a host computer system. The program loader used by the PDT-11/110 system must be compatible with the application program loading format of the host computer. The proper program loader must be specified by the operator using the Boot Select SET-UP feature.

Procedure for Program Loading the PDT-11/110 in Terminal Mode - The Terminal Boot loader, entered from Terminal Mode, is employed when receiving the application program in a character-by-character fashion from a timesharing host computer. The Terminal Mode causes the PDT-11/110 system to emulate a dumb terminal, thus permitting the operator to perform any "log-on" procedures required and manually initiate the program load as specified by the operating system of the host computer.

To load the application program from a host computer into the PDT-11/110 using the Terminal Boot program loader, the following procedure is performed (the numbered paragraghs identify operator procedures):

1. Initiate a power up sequence using one of the following procedures.

   - The system's AC Power Switch is turned ON.

   - The system is placed in SET-UP mode and the Reset feature is invoked by pressing the RESET (0) key.

   The PDT-11/110 will automatically run the internal self test programs to verify proper hardware operation. Upon successful completion of the self test programs, the "Check Ok" message will be displayed on the video screen.

   The PDT-11/110 system then checks for the reception of both the Data Set Ready and Clear To Send signals from the modem. When received the "Ready" message is displayed.

2. The PDT-11/110 system will now operates as an interactive terminal with no local data processing. This allows the operator to perform any log-on procedures required and initiate the loader request (as specified by the operating procedures of the host computer).

   To load the application program, the host computer must request the use of the Terminal Boot program loader (the request is in the form of a two character sequence) and transmit the program.

   When the system has successfully loaded the program, the "Load Ok" message is displayed.

Refer to the Operator Troubleshooting section of this chapter if any other indications are encountered.

Procedure for Program Loading the PDT-11/110 in Message Mode - The Maintenance Operation Protocol (MOP) loader, entered from the Message Mode, allows the PDT-11/110 application program to be loaded from a DECNET host computer. The MOP loader is initiated automatically, during the power up sequence.

To load the application program from a host computer into the PDT-11/110 using the MOP loader, the following procedure is used (the numbered paragraghs identify operator procedures):

1. Initiate a power up sequence using one of the following procedures.

   - The system's AC Power Switch is turned ON.

   - The system is placed in SET-UP mode and the Reset feature is invoked by pressing the RESET (0) key.

   The PDT-11 will automatically run the internal self test programs to verify proper hardware operation. Upon successful completion the self test programs, the "Check Ok" message will be displayed on the video screen.

   The PDT-11/110 system then checks for the reception of both the Data Set Ready and Clear To Send signals from the modem. When received the "Loading" message is displayed and the L4 keyboard indicator is turned ON.

The PDT-11 system will automatically request a down-line load from the host computer (in the form of a Maintenance Operation Protocol message).

The PDT-11 system can then load a secondary bootstrap routine which is used to load more extensive programming. When the secondary bootstrap routine has been loaded correctly, the L4 keyboard indicator is turned OFF.

The secondary loader is then run to load a tertiary and/or application program.

When the application program has been successfully loaded, the system will display a program identifier within the application program. The format of this identifier is dependent on the application program.

Refer to the Operator Troubleshooting section of this chapter if any other indications are encountered.

Program Loading the PDT-11/130
The application program is loaded into a PDT-11/130 system using the mass storage tape drive.

Procedures For Loading The PDT-11/130 - To load the PDT-11/130 from the tape drive use the following procedure (the numbered paragraghs identify operator procedures):

1. Initiate a power up sequence using one of the following procedures.

   - The system's AC Power Switch is turned ON.

   - The system is placed in SET-UP mode and the Reset feature is invoked by pressing the RESET (0) key.

   The PDT-11 will automatically run the internal self test programs to verify proper hardware operation. Upon successful completion the self test programs, the system will display:

   Read error

   Type start unit 0 or 1

2. The operator must install the tape cartridge into one of the two tape drives shown in Figure 2-6 and type the number of the tape drive selected and the RETURN key.

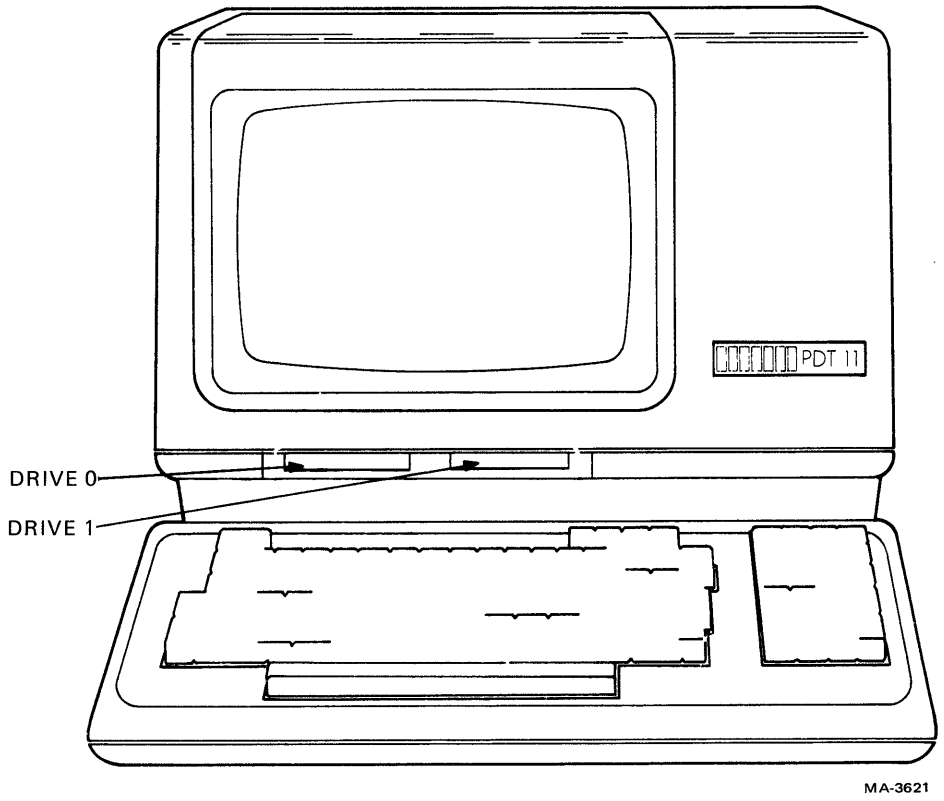


FIGURE 2-6 PDT-11/130 Tape Drive Locations

When the program is loaded successfully, the system will display a program identifier within the application program. The format of this identifier is dependent on the application program.

It is possible to power up the PDT-11/130 system with a tape cartridge installed in tape drive 0. This will cause the PDT-11/130 system to run the self test programs and automatically load the application program. No operator intervention is required and the "Read error type start unit 0 or 1" message will not be displayed.

Refer to the Operator Troubleshooting section of this chapter if any other indications are encountered.

PDT-11/130 TAPE DRIVE

The PDT-11/130 system is equipped with a mass storage device in the form of two miniature tape cartridge drives mounted within the video monitor. The dual tape drives are accessable from the front of the video monitor directly below the video display.

The tape cartridges used by the PDT-11/130 are file structured to allow block accessing and replacement of data or programs within the system. The tapes used by the system are DECtape II miniature cartridges which hold 262 kbytes of data in 512 byte blocks. The tape cartridge has two tracks each holding 256 blocks of data.

TAPE CARTRIDGE STORAGE AND CARE

When not in use, the tape cartridges should be removed from the tape drive and stored in the containers provided. Keep the tapes away from magnetism, dust, heat and direct sunlight; never touch the surface of the tape. If the tape cartridge is exposed to temperature less than 0C(32F) or greater than 50C(122F), the tape should be rewound once in both directions before using.

System and program tapes should always be copied to ensure against data loss due to tape cartridge malfunction.

TAPE CARTRIDGE INSERTION AND REMOVAL PROCEDURE

To load the tape cartridge into the PDT-11/130 system, push the cartridge into the tape drive opening with the label side facing upward, as shown in Figure 2-7. The tape drive opening, placed below the video screen, is covered by a spring mounted protective door which swings upward into the monitor whenever a tape is inserted.

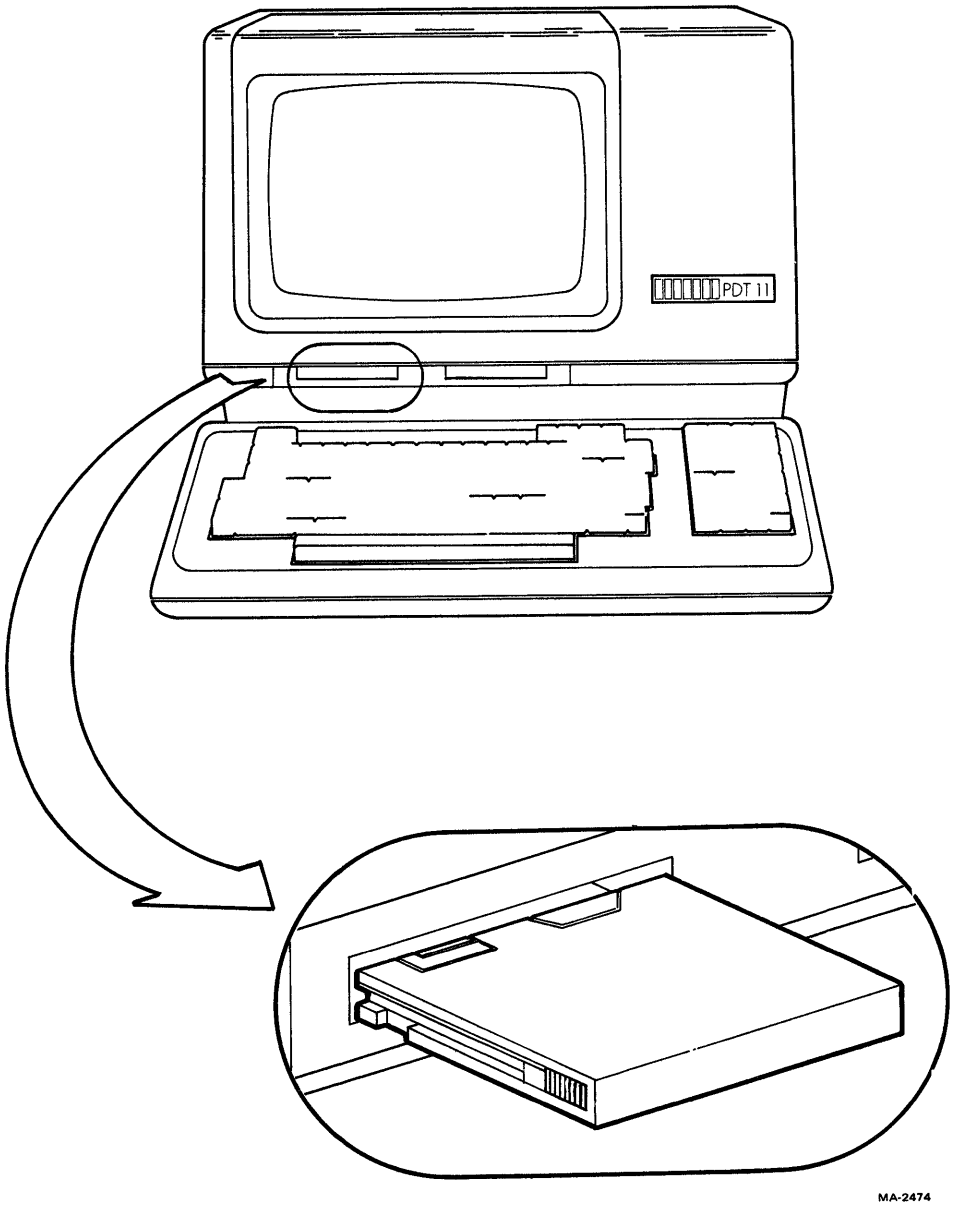


FIGURE 2-7 Tape Insertion and Removal

To remove the tape, wait for tape motion to stop and pull the cartridge out of the tape drive opening.

CAUTION
If the tape is removed when the tape is in motion, a tape error message will be sent to the PDT-11 processor. The visual display to the operator is dependent on the application program. Data may be lost if the tape is removed during a write operation.

WRITE PROTECTING TAPES
Each cartridge is equipped with a movable write protection tab. The tab may be placed in one of two positions: write permit position and write protect position, as shown in Figure 2-8.

Write protect position - When in this position the write protect tab prevents the accidental destruction of data by preventing the PDT-11/130 system from writing onto the tape cartridge.

Write permit position - When the write protect tab is in the write permit position the PDT-11/130 system may write onto the tape cartridge.

To ensure against accidental data loss, the write protect tab can be completely removed to eliminate the possibility of overwriting important data or programming on the tape cartridge. To remove the write protect tab, move the tab into the write protect position and lift the tab as shown in Figure 2-9. Write protect tabs should be saved after removal from the tape cartridge, because the tabs are re-installable.

To replace the write protect tab, place the tab into the tab slot over the write protect position and press down firmly until the tab clicks into place.

SET-UP MODE
The PDT-11 system is equipped with a variety of selectable, built-in features. These features are designed to provide compatibility to a computer communication system, adapt to local power conditions, increase operator comfort and create software (programming) compatibility by altering some of the operational characteristics of the PDT-11 system. The operator may select, alter and store these features from the PDT-11 keyboard using main keyboard entries, when the console is in SET-UP Mode. The SET-UP features of the system may also be altered by the application program. (For specific programming information refer to chapter 4). The SET-UP Mode features are divided into two groups: SET-UP A Mode and SET-UP B Mode.

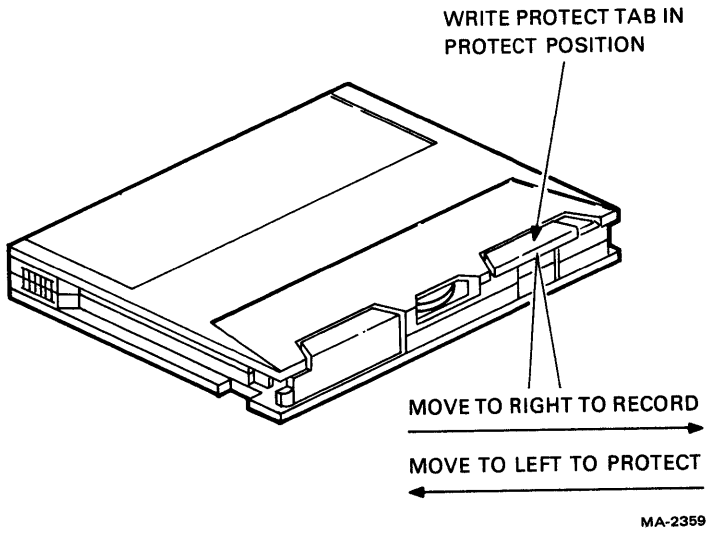


FIGURE 2-8 Write Protection Tab

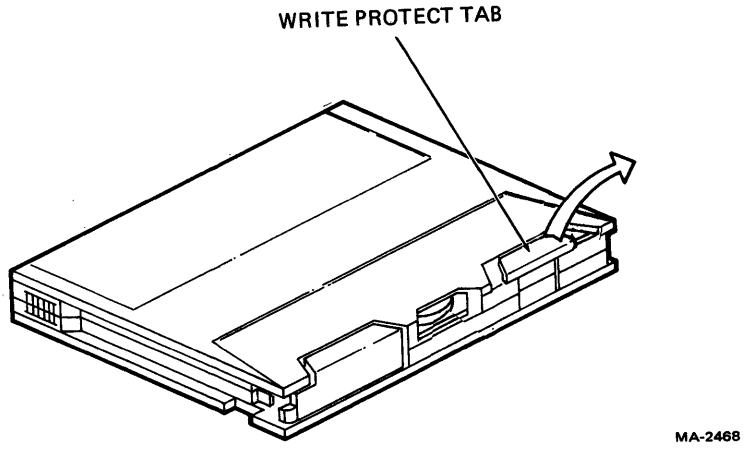


FIGURE 2-9 Write Protection Tab Removal

SET-UP A MODE
The SET-UP A Mode is entered by pressing the SET-UP key. When entered the screen will display a summary of the current SET-UP A feature status as shown in Figure 2-10. For a detailed description of these SET-UP features see the Definition Of The SET-UP Features section of this chapter. To exit SET-UP Mode press the SET-UP key again.

SET-UP B MODE
The SET-UP B Mode may only be entered from the SET-UP A Mode by pressing the SET-UP A/B (5) key. When entered, the screen will display a summary of the current status of the SET-UP B features as shown in Figure 2-11. Figure 2-12 summarizes the meaning of the SET-UP B presentation. For a detailed description of these SET-UP features see the Definition Of The SET-UP Features section of this chapter. To exit SET-UP Mode press the SET-UP key again.

SET-UP FEATURE CATEGORIES
Table 2-7 lists all the SET-UP features of the system in alphabetical order and classifies each using the following general categories:

Installation
Communication Compatibility
Operator Comfort
Software Compability

The installation category SET-UP features are used during the initial installation of the system and any optional equipment. If system options are added or removed, or the physical location of the system is changed, verify these SET-UP features for the proper setting.

The communication compatibility category of SET-UP features are those features which must be set correctly to allow the PDT-11/110 system to communicate with a host computer. An error in these settings may prevent communication or cause incorrect data to be exchanged between the PDT-11 and the host computer system. These settings would normally change only when communicating with a different computer or software package.

The operator comfort category of SET-UP features are designed exclusively for the operator. These features allow the operator to tailor the console to fit individual preferences. These features only alter the operation of the console and do not affect any other operations of the system.

The software compatibility category of SET-UP features allow the PDT-11 console to communicate with the PDT-11 system processor. An error in these settings may prevent the operator from executing the application program.

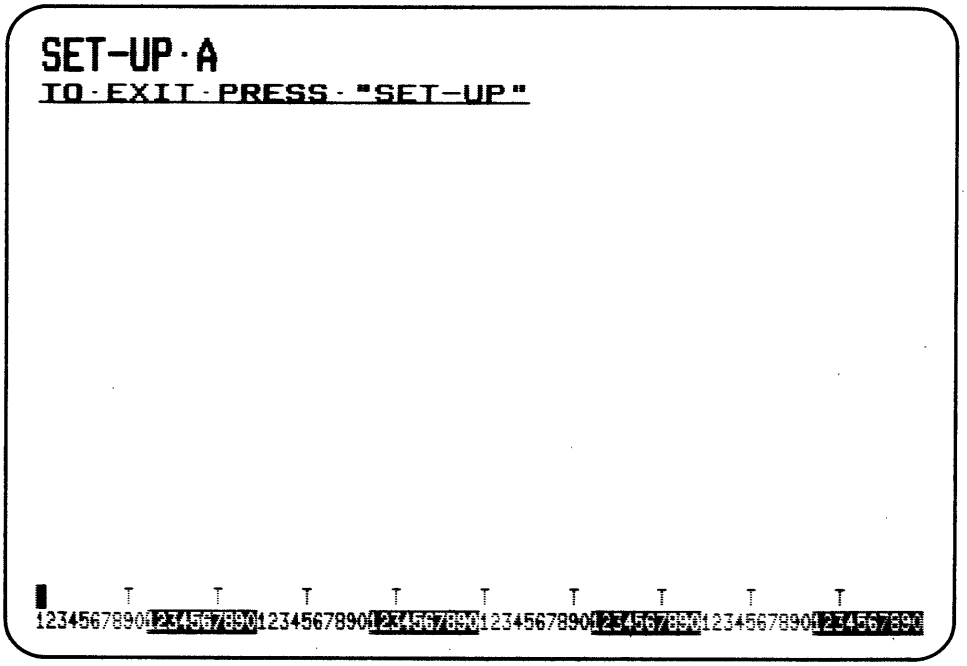


FIGURE 2-10 SET-UP A Mode Presentation

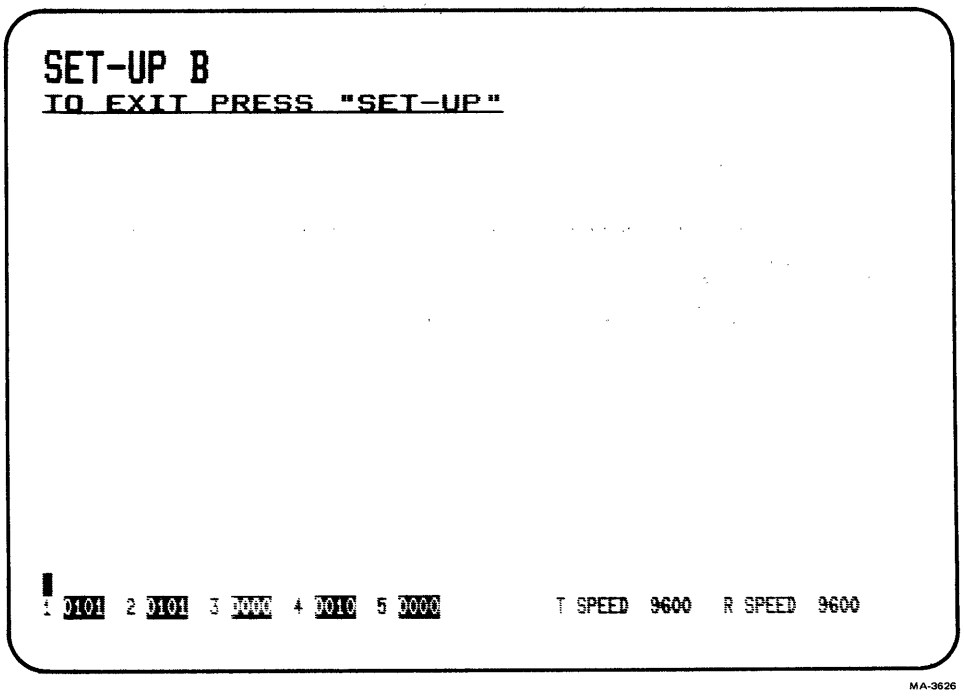


FIGURE 2-11 SET-UP B Presentation

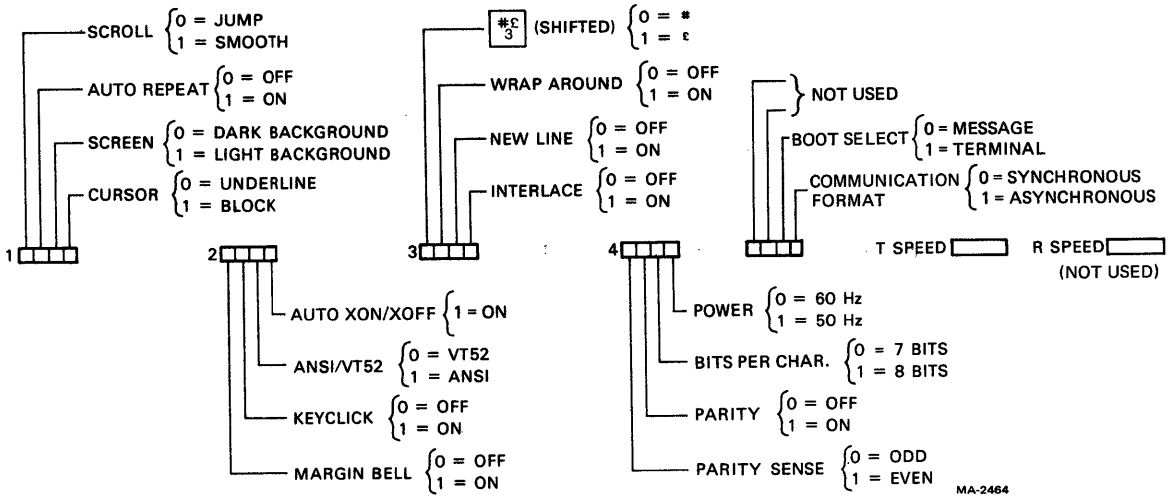


FIGURE 2-12 SET-UP B Summary

TABLE 2-7
SET-UP Features Categories
(Set-Up Features are listed in alphabetical order)

SET-UP FEATURE	INSTALLATION	COMMUNICATION (PDT-11/110 only)	OPERATOR COMFORT	SOFTWARE COMPATABILITY
ANSI/VT52 MODE				X
ANSWERBACK		X		
AUTO REPEAT			X	
AUTO XON/XOFF				X
BITS/CHARACTER		X		
BOOT SELECT		X		X
BRIGHTNESS			X	
CHARACTERS/LINE				X
COMM. FORMAT		X		
CURSOR			X	
INTERLACE	X			
KEYCLICK			X	
LINE/LOCAL				X
MARGIN BELL			X	
NEW LINE				X
PARITY		X		
PARITY SENSE		X		
POWER	X			
RECALL			X	
RECEIVE SPEED		X		
RESET			X	
SAVE			X	
SCREEN			X	
SCROLL			X	
TABS				X
TRANSMIT SPEED		X		
WRAPAROUND				X
# ≠ 3 SHIFTED				X

CHANGING A SET-UP FEATURE
To change a SET-UP feature from the PDT-11 console, use the following general procedure:

1) Place the PDT-11 console in SET-UP Mode. Press the SET-UP Key.

2) Select the proper SET-UP Mode. The SET-UP A/B (5) key is used to select SET-UP A or SET-UP B Mode.

3) Position the cursor above the feature to be changed using one or more of the following keys:

SPACE BAR
TAB
RETURN
←
→

NOTE
Some features do not require this step because specific keys have been dedicated to the feature, see Table 2-8 for the specific feature and key.

4) Change the appropriate SET-UP feature. Features may be changed by pressing the key indicated on Table 2-8. Each time the key is depressed, the feature status will be changed.

When changing communication SET-UP features within the PDT-11/110 (as indicated in Table 2-7), the Save feature MUST be used, followed by a system reset (initiated by the Reset feature). Refer to the Reset and Save SET-UP features described in the SET-UP feature definitions.

5) Exit SET-UP Mode. Press the SET-UP key again.

Keys used to change the SET-UP features are located on the main keyboard. The auxiliary keypad keys can not change the SET-UP feature settings.

Keys used to change the SET-UP features are located on the main keyboard. The auxiliary keypad keys can not change the SET-UP feature settings.

TABLE 2-8
Changing SET-UP Features
(SET-UP features are listed in alphabetical order)

FEATURE	MODE SET-UP A	MODE SET-UP B	CURSOR POSITIONING	KEY ON MAIN KEYBOARD
ANSI/VT52 ***		X	YES	6
ANSWERBACK *		X	NO	SHIFT and A
AUTO REPEAT		X	YES	6
AUTO XON/XOFF	(this feature cannot be altered)			
BITS/CHARACTER		X	YES	6
BOOT SELECT **		X	YES	6
BRIGHTNESS *	X		NO	↑ or ↓
CHARCTERS/LINE	X		NO	9
COMM. FORMAT		X	YES	6
CURSOR		X	YES	6
INTERLACE		X	YES	6
KEYCLICK		X	YES	6
LINE/LOCAL	X	X	NO	4
MARGIN BELL		X	YES	6
NEW LINE		X	YES	6
PARITY		X	YES	6
PARITY SENSE		X	YES	6
POWER		X	YES	6
RECALL *	X	X	NO	SHIFT and R
RECEIVE SPEED	(this feature is controlled by the Transmit Speed feature setting)			
RESET	X	X	NO	0
SAVE *	X	X	NO	SHIFT and S
SCREEN		X	YES	6
SCROLL		X	YES	6
TABS *	X		YES	3 or 2
TRANSMIT SPEED		X	NO	7
WRAPAROUND		X	YES	6
# £ 3 SHIFTED		X	YES	6

* See Definition Of The SET-UP Features for the entire key sequence.

** Only used by the PDT-11/110 to select the type of program loading routine.

*** The PDT-11/110 system is left in ANSI Mode after the application program is loaded into the system regardless of the SET-UP feature setting. To enter VT52 Mode with the VT52 Mode selected and Saved, use the Recall feature. The VT52 Mode may also be selected by the application program (see chapter 4 for details).

DEFINITION OF THE SET-UP FEATURES
This section describes each SET-UP feature (listed in alphabetical order) in detail and explains how each feature affects the system operation.

Unless otherwise stated, entering either SET-UP Mode and changing the features does not result in the loss of data displayed on the screen.

ANSI/VT52 Mode
The PDT-11 console may follow one of two programming standards - American National Standards Institute (ANSI) or DEC private (VT52) code. In ANSI Mode, the console will generate and respond to sequences coded per ANSI standards X3.4 - 1977, X3.41 - 1974 and X3.64 - 1977. In the VT52 Mode, the console is compatible with previous DIGITAL software used by the VT52 video terminal. Both the ANSI and VT52 Modes are outlined in chapter 4 of this document.

The PDT-11/110 console is left in ANSI Mode after the application program is loaded, regardless of the ANSI/VT52 Mode feature setting. If the VT52 Mode selection has been saved by the Save SET-UP feature, the Recall SET-UP feature will place the console back into the VT52 Mode. The application program can change this feature if required.

ANSWERBACK
The Answerback message feature provides a 20 character message sequence which allows the PDT-11 console to identify itself. When the PDT-11/110 system is placed in Terminal Mode, the Answerback message is transmitted to the host computer (which in some systems may provide a "Log-on" sequence). The host computer issues a request for the PDT-11 system to identify itself and the PDT-11 system responds by transmitting a unique identifier (or Answerback) message. This sequence takes place automatically without operator intervention or affecting the video screen.

The Answerback message may also be manually transmitted by the operator by pressing the CTRL and BREAK keys simultaneously.

The Answerback message is entered into the PDT-11 system using the following procedure:

1) Place the PDT-11 console in SET-UP B Mode.

2) Press the SHIFT and A keys simultaneously. The console will respond with "A=" on the video screen.

   The SHIFT key is required, the CAPS LOCK key will not activate the Answerback message feature.

3) Type the message delimiter character. The message delimiter character is any character not used within the Answerback message text. The message delimiter character does not become part of the Answerback message.

4) Type the Answerback message. The message may be up to 20 characters (as illustrated in Figure 2-13), including space and control characters. Control characters will be displayed as a ( ) character to indicate their presence. If a mistake is made when entering the message, type the delimiter character (used in step 3) again and repeat the procedure starting with step 2. This is the only way to correct errors or change the Answerback message.

5) Type the delimiter character (used in step 3) to end the Answerback message. Once the message delimiter is typed or 20 characters are typed, the Answerback message will disappear from the screen. The Answerback message cannot be viewed by the operator after being entered. The console will then return to SET-UP A Mode.

6) After changing the Answerback message the Save feature must be used; otherwise the message will be erased from memory during a master reset or power up sequence.

AUTO REPEAT

The Auto Repeat feature allows a pressed key to automatically repeat at a rate of about 30 characters per second, when the key is held down more than one-half second. The Auto Repeat feature affects all the keyboard keys except the following:

SET-UP
ESC
NO SCROLL
TAB
RETURN
ENTER
CTRL used with any key

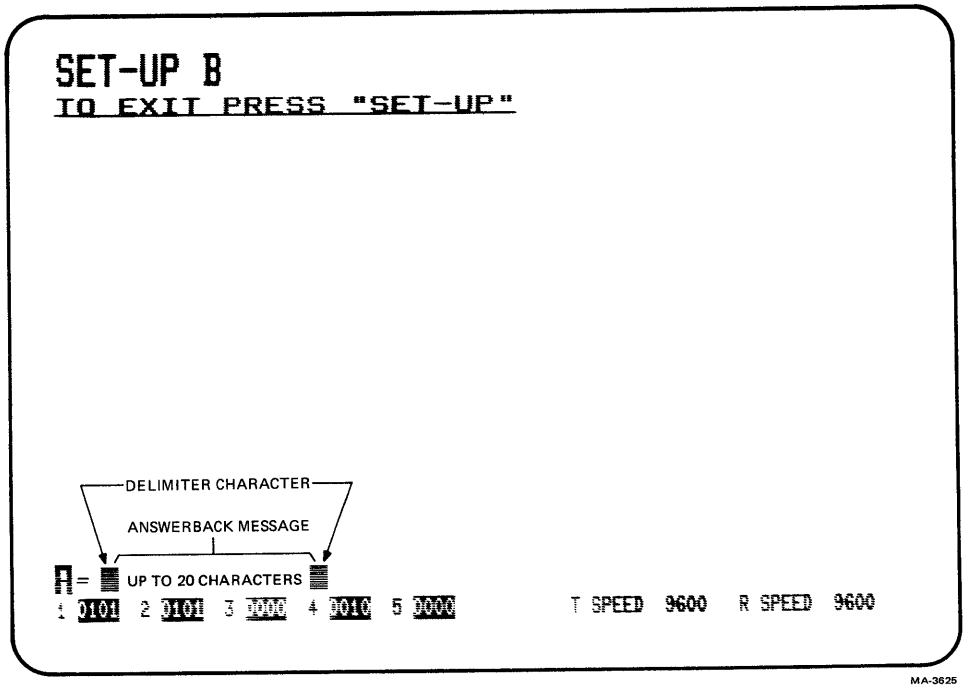


FIGURE 2-13 Answerback Message Summary

AUTO XON/XOFF
The PDT-11 console device supports the synchronizing control codes XON (DC1, octal 021) and XOFF (DC3, octal 023). The XOFF control code is used to stop the transmission of data to the console under the following conditions:

- The internal buffer of the console is nearly full
- The NO SCROLL key is pressed
- The CTRL and S keys are pressed simultaneously

The XON control code is used to resume the data transmission under the following conditions:

- The internal buffer of the console is nearly empty
- The NO SCROLL key is pressed again
- The CTRL and Q keys are pressed simultaneously

This feature must always be used, therefore it has been forced to the ON or one state in the SET-UP B presentation and cannot be changed from the keyboard or by the application program.

BITS PER CHARACTER (PDT-11/110 only)
This feature is used by the PDT-11/110 system to select either seven or eight bit character operation for the communication (modem) port during program loading. The Maintenance Operation Loader (MOP) requires the use of eight bit characters. The Terminal Boot Loader may use either seven or eight bit characters depending on the requirements of the host computer system. The application program may select 5, 6, 7 or 8 bit characters after the program is loaded. Refer to chapter 4 for details on character length selection using the application program.

BOOT SELECT (PDT-11/110 only)
The application program is loaded into the PDT-11/110 system with a program loading routine permanently residing in system memory. The Boot Select feature of the PDT-11/110 system allows the operator to select the proper loading routine for the application program. The PDT-11/110 system may load the program in one of two operational modes: the Terminal Mode or Message Mode. These modes are only significant before the application program is loaded; after the program is loaded, the application program determines system operation.

Refer to the Program Loading Routines section of this chapter for application program loading instructions. The application program and host system requirements determine the proper setting of this feature.

BRIGHTNESS
The PDT-11 console uses this feature to electronically control the screen brightness. The feature allows the operator to select the desired level of brightness for maximum comfort under varied lighting conditions.

↑ = Increased brightness
↓ = Decreased brightness

CHARACTERS PER LINE
The PDT-11 console is capable of displaying either 80 or 132 characters per line as defined below:

80 characters per line - A line contains 80 characters and the screen can hold 24 lines as shown in Figure 2-14.

132 characters per line - A line contains 132 characters and the screen can hold 14 lines. In 132 character per line operation, the displayed lines are physically the same height and width on the screen as in the 80 character per line display but the characters are spaced closer together.

If the Advanced Video Option is installed, a line may contain 132 characters with the screen holding 24 lines as shown in Figure 2-15.

The use of double width characters reduces the number of characters per line by half.

CAUTION
When changing between the 80 and 132 characters per line displays, the current contents of the screen are lost.

COMMUNICATION FORMAT (PDT-11/110 only)
The PDT-11 system has the ability to communicate with the host computer in one of two data formats: synchronous and asynchronous.

Synchronous format - Information is transmitted between the PDT-11 system and the host computer using an externally (modem) generated timing signal. Synchronization of data is accomplished with the use of characters inserted into the data stream at the begining of each message.

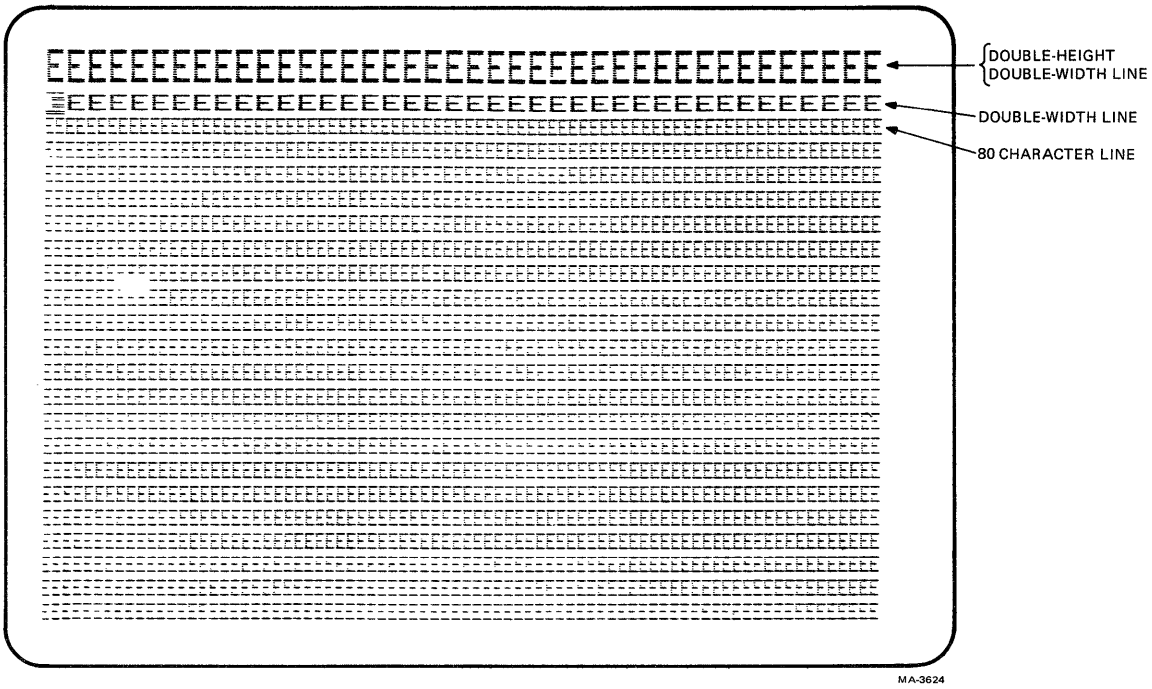


FIGURE 2-14 80 Column Presentation (with all E's)

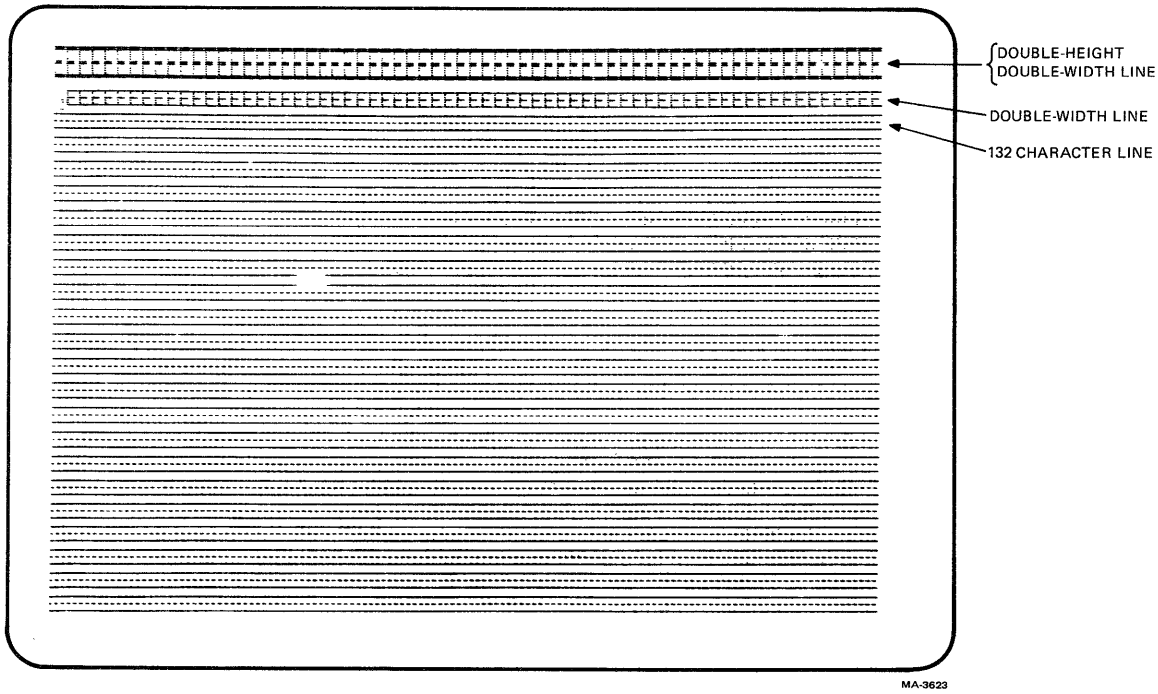


FIGURE 2-15 132 Column Presentation (with all E's)

Asynchronous format - Information is transmitted between the PDT-11 system and the host computer using an internally generated timing signal. Data synchronization is accomplished through the use of start and stop bits inserted into each character sent.

CURSOR
The operator has a choice of two cursor display modes to indicate the active position (or where the next character will be placed) on the screen. The cursor may be displayed as either a blinking underline character (_) or a blinking block character (▮).

INTERLACE
This feature is used with high resolution video devices. Screen flicker will be produced if the Interlace feature is selected and a high resolution video device is not installed.

KEYCLICK
Keyclick is a tone which is generated by the PDT-11 console every time a key is depressed (with the exception of the SHIFT and CTRL keys). The keyclick may be turned ON or OFF to suit the operator's preferance. However, experience has shown that many operators type more accurately when there is an audible feedback from the keyboard. The keyclick tone volume is not adjustable.

LINE/LOCAL
The Line/Local feature allows the operator to place the PDT-11 console in either an "on line" or "local (off line)" condition.

"On Line" - When the console is placed in the "on line" condition (the keyboard ON LINE indicator is ON) all characters typed on the keyboard are transmitted to the PDT-11 system processor. Messages received by the PDT-11 console are displayed on the video screen.

"Local" - When the console is placed in the "local" condition (the keyboard LOCAL indicator is ON) the console is electrically disconnected from the PDT-11 system processor. Messages cannot be exchanged between the PDT-11 console and any other device; however, all characters typed on the keyboard will be displayed on the video screen.

MARGIN BELL
The margin bell of the PDT-11 system operates the same as the margin bell on a typewriter. While typing, if the cursor reaches eight (8) characters from the end of the current line, a tone sounds to alert the operator.

NEW LINE
The New Line feature enables the RETURN key of the PDT-11 console to function as the RETURN key of an electric typewriter. The RETURN key generates both a carriage return (CR) and linefeed (LF) code. When the New Line feature is enabled, the reception of a carriage return (CR) will cause the cursor to return to the left margin and advance one line.

When the New Line feature is disabled, the RETURN key only generates a carriage return (CR) code. When a carriage return is received by the console the cursor moves to the left margin.

The New Line feature should be set to match the requirements of the application program. Some programs are not compatible with the New Line feature.

PARITY (PDT-11/110 Terminal mode only)
The Parity feature is used to check the correctness of data transmitted between the PDT-11/110 and host computer system during application program loading. If Parity is used to detect data errors, both the host computer and the PDT-11/110 system must interpret Parity and check for correct Parity Sense. If the Parity feature is enabled, the Parity Sense feature must be set to be compatible with the host computer. The Parity Sense feature determines whether the parity expected is odd or even. When the Parity feature is disabled, the parity bit is not transmitted and is ignored when received.

PARITY SENSE (PDT-11/110 Terminal mode only)
The Parity Sense feature defines whether parity checking, odd or even, is being used by the PDT-11/110 system and the host computer when loading the application program. If the Parity feature is enabled, the Parity Sense feature must match the parity sense expected by the host computer. If the Parity feature is disabled, the Parity Sense feature selection is ignored.

POWER
During installation, the PDT-11 Power feature must be set to the proper power line frequency. The user sets this feature immediately after powering up the system. (In the U.S. this is generally set to 60 hz.)

RECALL
The volatile memory may hold SET-UP features that differ from those held within the non-volatile memory (see the Save feature definition for the meaning of volatile and non-volatile). To return the system to the settings held within the non-volatile memory, the Recall feature may be used as follows:

1) Place the console into SET-UP Mode. Press the SET-UP key.

2) Press the SHIFT and R keys simultaneously. The screen will clear and the "Wait" message will appear on the screen.

   After a brief pause, the console will return to SET-UP A mode.

CAUTION
When the Recall feature is used the contents of the screen are destroyed.

RECEIVE SPEED (PDT-11/110 only)
The receive speed of the PDT-11/110 system must be set to match the transmit speed of the host computer. The Receive Speed is determined by the Transmit Speed SET-UP feature. The PDT-11/110 system transmits and receives data at the same baud rate (speed). When the Communication Format SET-UP feature is set for synchronous communication, the receive and transmit baud rates are determined by an external clock supplied by the modem.

RESET
The Reset feature is used to re-initialize the entire PDT-11 system. This feature invokes the power up sequence of the system. (The power up sequence of the system is descibed in the Power Up Sequence section of this chapter).

CAUTION
The contents of the volatile memory in both the PDT-11 console and processor are lost. The contents of the screen is lost and any options present may be affected.

SAVE
The PDT-11 console is equipped with two types of memory: volatile random access memory and non-volatile random access memory (NVR). The characteristics of each are:

Volatile - This memory is erased whenever the Reset or Recall feature is used and whenever the system power is turned OFF.

Non-volatile - This memory may only be altered by the Save feature.

Selecting the Save feature moves the SET-UP feature settings of the console's volatile memory into the non-volatile memory (NVR). To store the SET-UP features in non-volatile memory, perform the following steps:

1) Place the console in SET-UP Mode. Press the SET-UP key.

2) Press the SHIFT and S keys simultaneously. The screen will clear and the message "Wait" will be displayed.

   After a brief wait, the console will return to the SET-UP A Mode.

The Save feature may only be initiated from the PDT-11 keyboard. The application program cannot perform this operation, although it can modify the feature settings held in volatile memory.

SCREEN
The Screen feature allows the operator to select either a dark or light video screen background.

Dark Background - The display contains light characters on a dark background as shown in Figure 2-16.

Light Background - The display contains dark characters on a light background as shown in Figure 2-17.

SCROLL
Scrolling is the upward or downward movement of existing lines on the screen to make room for new lines to be displayed. It can be performed in two ways: Jump Scroll or Smooth Scroll.

Jump Scroll - The new lines appear on the screen as fast as the console receives the data. However, data may be difficult to read due to the rapid movement of the lines.

Smooth Scroll - The speed at which the console will accept data is limited, therefore the movement of the lines on the screen occurs at a smooth, steady rate. This allows data to be read more easily. The Smooth Scroll feature limits a maximum of six lines of data per second to be added to the screen.

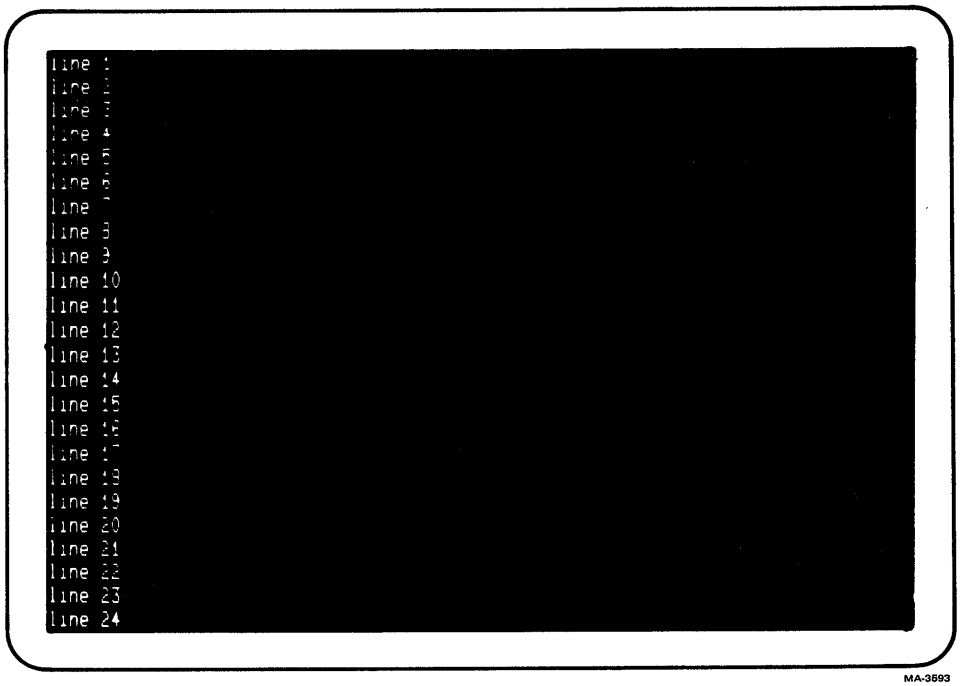


FIGURE 2-16 Dark Background Presentation

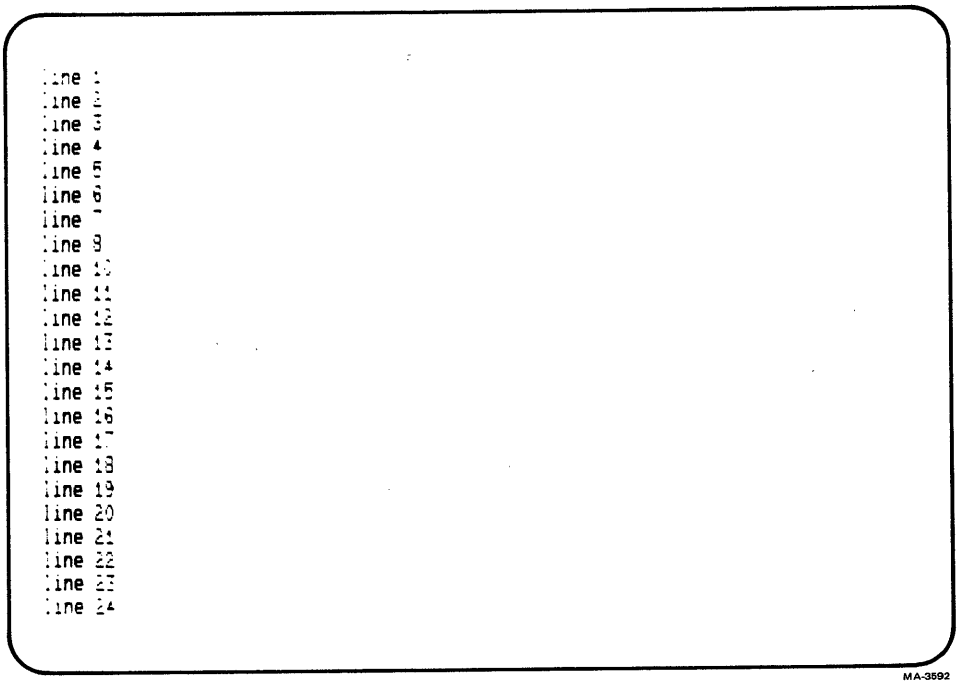


FIGURE 2-17 Light Background Presentation

TABS

Just like a typewriter, the console can jump or tab to preselected points on the current writing line. The tabs selected must match the tab positions expected by the application program. These tab stops can be individually changed, or totally cleared and set using the following procedure:

1) Place the PDT-11 console in SET-UP A mode. Press the SET-UP key.

2) Position the cursor at the desired tab location using one or more of the following keys:

   SPACE BAR
   TAB
   RETURN
   ←
   →

   Cursor positioning is not necessary when clearing all tabs.

3) Set or clear appropriate tabs using the following keys:

   3 = clear all tabs
   2 = set or clear individual tabs at current cursor position

4) Select Save feature (optional) if the tab positions selected are to be held in non-volatile memory (see the Save feature description).

5) Exit SET-UP Mode. Press the SET-UP key again.

TRANSMIT SPEED (PDT-11/110 only)
The Transmit Speed SET-UP feature determines the transmit and receive speed used by the PDT-11/110 system during application program loading. Split baud rates are not allowed. The PDT-11 system is capable of transmitting and receiving data at any one of the following transmission baud rates:

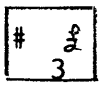
DISPLAYED	SPEED OF OPERATION
50	50
75	75
110	110 (assumes two STOP bits)
134	134.5
150	150
200	150
300	300
600	600
1200	1200
1800	1800
2000	2000
2400	2400
3600	3600
4800	4800
	* 7200
9600	9600
19200	19200

* The 7200 baud rate can be selected only by the application program, and can not be set by the keyboard.

When the Communication Format SET-UP feature is set for synchronous communication, the transmit and receive baud rates are determned by an external clock provided by the modem.

WRAPAROUND
When this feature is enabled, the 81st or 133rd character (depending on the line size selected) is placed automatically in the first position of the next line, without the generation of the carriage return (CR) or linefeed (LF) code. If the wraparound feature is not enabled, the 81st or 133rd characters will be overwritten into the last character position of the current writing line.

The use of double width characters reduces the number of characters per line by half.



Shifted
The PDT-11 console contains two character sets: the United States and the United Kingdom character sets. The difference between the two character sets is the shifted 3 key on the main keyboard. When using the standard U.S. character set, the shifted 3 key will display the (#) symbol; when using the U.K. character set the (£) symbol is displayed.

OPERATOR MAINTENANCE

The PDT-11/110 system requires no periodic maintenance. However, it may be desirable to occasionally clean the external surfaces of the PDT-11 systems to maintain a suitable appearance. The PDT-11/130 system requires periodic maintenance of the tape drive components. The tape drive components require cleaning (usually once a week) to minimize both tape cartridge and drive wear.

CLEANING THE EXTERIOR OF THE PDT-11

The PDT-11 monitor and keyboard may be cleaned with a moist cloth and any mild detergent. Although the system's exterior provides superior resistance to damage from detergents; cleaners with solvents should not be used. To clean the keys, rub with a dry or barely moist cloth. Do not remove the keycaps to clean them more thoroughly; damage may result to the key switch contacts if the keycaps are replaced incorrectly.

NOTE

Avoid using excessive amounts of water when cleaning the system's exterior.

The PDT-11 system's exterior is not meant to be weatherproof. There are several ventilation openings in the case which will allow liquids, coins, paper clips and other small objects to fall into the monitor. Such objects will disturb the electronic operation of the system. For this reason, never put drinks or metal objects on top of the video monitor.

CLEANING THE PDT-11/130 TAPE DRIVE

The PDT-11/130 tape drive should be cleaned at regular and frequent intervals (usually once a week). Regular cleaning of the tape drive components will minimize tape and head wear, thus preventing possible tape damage and data errors caused by contamination. Cleaning the tape drive consists of cleaning the tape head and drive capstan as shown in Figure 2-18. To clean these components, use a cotton tipped applicator moistened with DEC cleaning fluid, both contained within the cleaning kit (DEC part number TUC-01). Clean the entire surface of the drive capstan by rotating it with the cotton tipped applicator.

OPERATOR TROUBLESHOOTING

If it appears that there is a problem in the system, perform the checks listed in Table 2-9. When performing these checks it may be necessary to refer to Figure 2-19 for the location of the items mentioned.

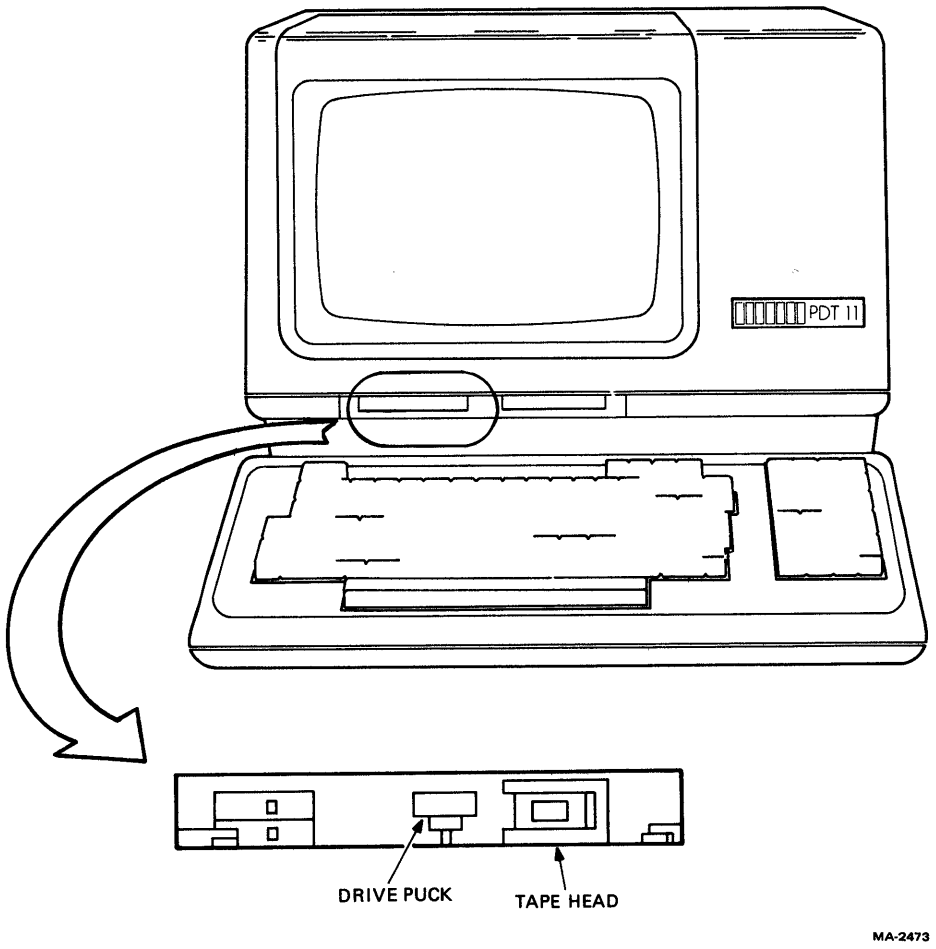


FIGURE 2-18 PDT-11/130 Tape Drive Components

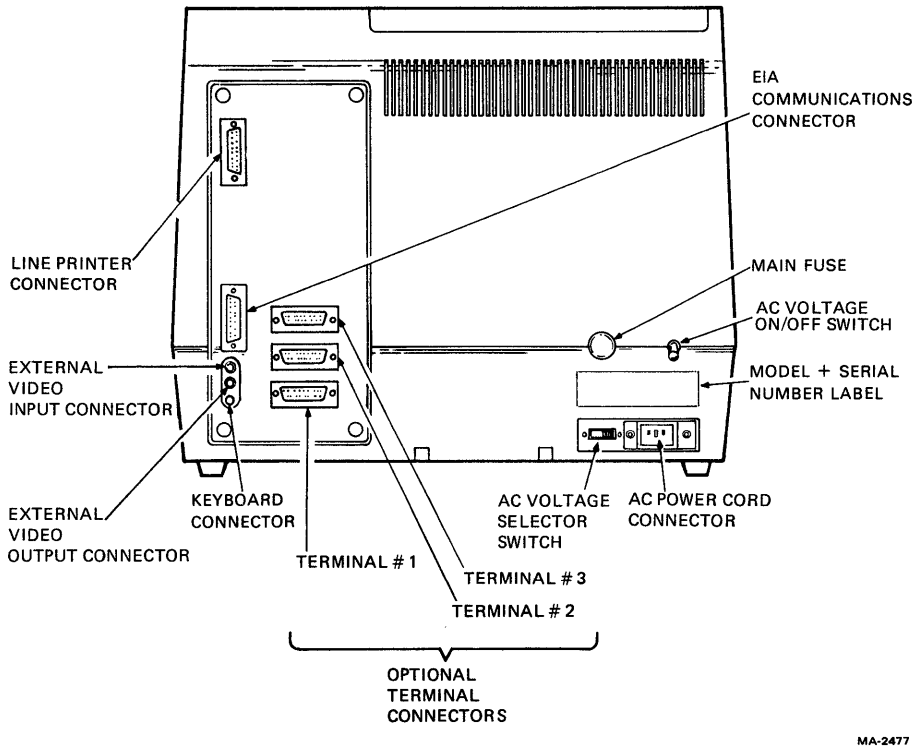


FIGURE 2-19 PDT-11 Rear View

TABLE 2-9
Problem Checklist

SYMPTOM	POSSIBLE CAUSE AND CORRECTION
System LINE or LOCAL indicators will not turn ON when the Power switch is set to ON position. No cursor present on screen.	AC power cord not plugged into AC outlet; place the AC Power switch in the Off position and plug in cord. AC power cord not plugged into PDT-11 system; place the AC Power switch in the OFF position and plug in cord. Power is not coming from the wall outlet; check the outlet with a known working electrical device (such as a lamp). AC line fuse blown; turn OFF the AC Power switch and unplug the PDT-11 system; replace the fuse.
Keyboard indicator LINE or LOCAL ON with no cursor on the screen.	Screen brightness set to low, enter SET-UP Mode and increase brightness.
No keyboard response and no keyboard indicators ON, with cursor present on video screen.	Keyboard cable not plugged into monitor; plug in keyboard cable.
Garbled characters	Incorrect SET-UP feature selection; correct SET-UP feature. Suggested SET-UP features which may be in error: ANSI/VT52 Mode Bits Per Character Receive/Transmit Speed If the problem remains, initiate the power up seqeunce and make a note of any indications. If error indications are found, turn off the system and contact your local service representative.
Double Linefeeds occur consistently	The system program is performing the New Line SET-UP feature operation within the applications program. Turn off the New Line SET-UP feature of the PDT-11 console.

The (■) character is displayed on the video screen.	The (■) character indicates that the console data buffer is overflowing. This only occurs when the XON/XOFF control codes are not supported correctly by the application program.
Excessive tape read operation retries (PDT-11/130 only)	Soft errors occurring; clean tape drive (tape head and drive capstan) components refer to the operator troubleshooting section of this chapter. If problem persists, load the backup tape cartridge into the tape drive and operate the system. If the condition is corrected the original tape cartridge is old and should be replaced. If the problem persists, contact your local service representative.

The PDT-11 systems are equipped with permanent resident programs which may be used to verify the proper operation of the system hardware and load the application program. These programs may be used by the operator to detect failures within the system and load the application program.

SELF TEST PROGRAM INDICATIONS

The self test programs of the systems check the console, the PDT-11 processor and the tape drive controller for failures. The self test programs provide a specific indication of the failure encountered. These programs are automatically run whenever the power up sequence is initiated. This sequence is started whenever one of the following procedures is performed.

- The system's AC Power Switch is turned ON.
- The system is placed in SET-UP mode and the Reset feature is selected (by pressing the RESET 0 key).
- The system processor issues a Reset command to the console device.

Upon finding a failure, the PDT-11 system attempts to display a message on either the keyboard indicators or video screen. A list of messages used by the PDT-11 system are provided in Table 2-10. If failure conditions are detected during the operation of the self test programs, additional procedures may be required to locate the problem. Make a note of the failure indication and contact your local service representative.

There are two board categories of failures (errors) reported by the self test programs: fatal and non-fatal.

Fatal errors - A fatal error of a PDT-11 console device causes the system to immediately stop all operations. No intelligible information is displayed on the screen; however, the screen will most likely contain a random pattern of characters. The only indication (in addition to the random characters) is a possible error code displayed on the keyboard indicators L1-L4.

A fatal error of the PDT-11/130 tape drive will cause the "Tape error" indication to be displayed.

Non-fatal errors - Non-fatal errors may be detected by the console or PDT-11 processor. Console non-fatal errors force the console into the local mode and an error code character is displayed on the screen. The console non-fatal error codes displayed are shown in Table 2-10.

The non-fatal errors found by the PDT-11 processor will be indicated as either an I/O error or a six digit number followed by an "@" character on the video screen. The format of these error indications is shown in Table 2-10.

If no errors are found during self test on the PDT-11/110, the message "Check ok" is displayed. This indicates the system is ready to enter the program loader.

If no errors are found in the PDT-11/130, the system automatically loads the application program.

TABLE 2-10
Self Test Indications/Repair Actions

INDICATIONS	POSSIBLE CAUSE AND OPERATOR ACTION
One or more of the keyboard indicators L1-L4 are ON.	A fatal error has been found by the self test. No intelligible information can be displayed on the video screen; however, the screen most likely will contain some random pattern of characters. Make a note of the indication displayed on the keyboard indicators and re-initiate the power up sequence. If a fatal error is found once again, turn off the system and contact your local service representative. If no error condition is found continue to operate the system.
KBD LOCKED indicator ON.	System processor has turned off the keyboard due to the application program. This action is usually performed when the console data buffer is full. The operator may attempt to clear the condition by entering and exiting the SET-UP mode.
Several Successive Long Tones and "NVRAM Fault" is displayed.	The PDT-11 console has had difficulty reading or writing the SET-UP features stored in non-volatile memory. Attempt to use the Save, Recall or Reset the SET-UP features of the system, this will cause the PDT-11 to read the SET-UP features. If the error indication is repeated, initiate the power up sequence and make a note of any error indications displayed. If the error condition is not repeated continue system operation.

One of the following error indications are displayed on the video screen: 1 @ 2 A 3 B 4 C 5 D 6 E 7 F 8 G 9 H : I ; J < K = L > M ? N O	A non-fatal error has been found within the PDT-11 console device. The console will be forced into "local" mode and the self test will be halted. Make a note of the indication displayed on the video screen and re-initiate the power up sequence. If the error is found again, turn off the system and contact your local service representative. If no error is found, continue to operate the system. The console will display "4" on the video screen to indicate a keyboard failure. Verify that the keyboard cable is plugged into the video monitor and re-initiate the power up sequence. If "4" is displayed again, note the indication and turn off the system power. Contact your local service representative for further instructions. If the system completes the self test successfully, continue system operation.
The following error indication is displayed on the video screen: "I/O ERROR xx **" Where xx can be any number.	The system processor has found an error during the self test program. Make a note of the entire error indication displayed on the video screen and re-initiate the power up sequence. If the error indication is displayed again, turn off the system power and contact your local service representative. If no error condition is found continue to operate the system.
Video screen displays: "xxxxxx" @ Where xxxxxx can be any number.	The system processor has found an error during the self test program. Make a note of the error indication on the video screen and re-initiate the power up sequence. If the error persists, turn off the system and contact your local service representative. If no error indication is found continue to operate the system.

Video screen displays: "Check Ok" (PDT-11/110 only)	The PDT-11/110 system has completed the self test programs successfully.
Video screen displays: "Tape error"	The PDT-11/130 system processor has had difficulty communicating with the tape drive. Re-initiate the power up sequence and make a note of any error indications. If the error persists, turn off the system and contact your local service representative. If no error condition is found, continue to operate the system.

PROGRAM LOADING ROUTINE INDICATIONS

The PDT-11 systems contain program loading routines within permanent system memory. Table 2-11 provides a list of the indications which can be displayed while executing the program loading routines.

TABLE 2-11
Program Loader Indications

INDICATIONS	POSSIBLE CAUSE AND OPERATOR ACTION
PDT-11/110	
Video screen displays: "Loading" in Message Mode.	The PDT-11/110 system is attempting to load the application program from the host computer. If the "Loading" message appears repeatedly, the PDT-11/110 system has had trouble communicating with the host computer for one or more of the following reasons. Host computer is not operating. Communication link is not suitable for reliable communication.
Keyboard indicator L4 ON when "Loading" is displayed on the video screen when in Message Mode.	The PDT-11/110 system is attempting to load the secondary boot from a DECNET host computer. When the secondary boot program is loaded successfully, the L4 indicator will turn OFF.
Video screen displays: "READY" in Terminal Mode.	The PDT-11/110 system is in terminal emulation mode. Continue to operate the system as required by the host operating procedures.

Video screen displays: "Load bad"	Message Mode- The PDT-11 system has had difficulty receiving the program. The system will automatically try to load the program again. Terminal Mode- the PDT-11/110 system has had difficulty receiving the application program. the system will return to Terminal Emulation Mode. Initiate the program load as required by the host operating system. Possible causes of the "Load bad" indication are: Excessive data errors Communication facility problems Host computer problems

PDT-11/130

Video screen displays: "Read error type start unit 0 or 1" (PDT-11/130 only)	The PDT-11/130 system has had difficulty loading the applications program. The system will automatically try to load the applications program again. Possible causes of the "Read error" indiations are: Dirty tape drive Old and worn tape Broken tape Wrong tape drive specified Tape removed during a program load sequence The PDT-11/130 system has attempted to load the application program from tape drive 0, and no tape was inserted.
Video screen displays: "No boot on volume type start unit 0 or 1"	The PDT-11/130 has tried to boot from a tape which is not the system tape.

TAPE CARTRIDGE REPAIR

Under unusual circumstances of controller failure or cartridge mishandling, the tape may come free from the tape hub. The tape is not fastened to the tape hub, but is held in place by the drive belt and the tape wrapping around itself on the tape hub. The procedure for threading the tape back onto the hub is given here to help the user prevent important data loss. This procedure is not a substitute for the customary precautions of proper tape handling and backup copying. Two procedures are given here, one is for the metal base cartridge and the other is for the plastic base cartridge.

These are moderately difficult procedures requiring the use of small tools. Tools required:

#1 phillips screwdriver

a small probe (a straightened paperclip can be used)

Tweezers

NOTE

Keep magnetized tools (if staples stick to a tool, it is magnetized) away from the bulk of the tape and do not touch the tape surface except at the ends. Fingerprints may cause data loss.

Metal Base Cartridge Tape Rethreading Procedure

1. Open the cartridge by removing the four baseplate phillips head screws and lift off the cover as shown in Figure 2-20.

2. Thread the end of the tape around the tape guides as shown in Figure 2-21.

3. Moisten the end of the tape with water to cause the tape to stick to the tape hub and insert the loose end of the tape between the tape hub and drive belt. Rotate the drive roller while gently pulling back on the tape (to provide back tension on the tape). The back tension will keep the tape feeding straight into the tape hub.

4. Continue to wind the drive roller a few more turns while alppying back tension to the tape.

5. Hold the empty tape hub and drive roller fixed and rotate the supply hub to take up any slack in the tape.

6. Continue rotating the the drive roller about twenty turns before reassembling the cartridge.

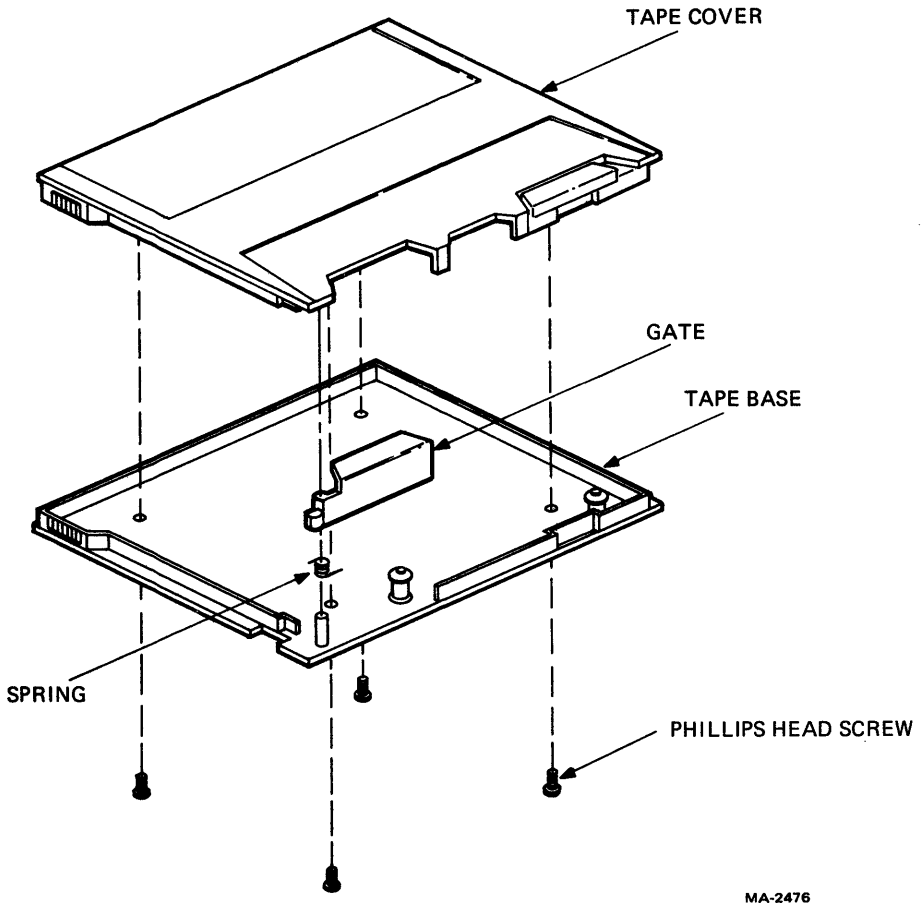


Figure 2-20 Tape Disassembly

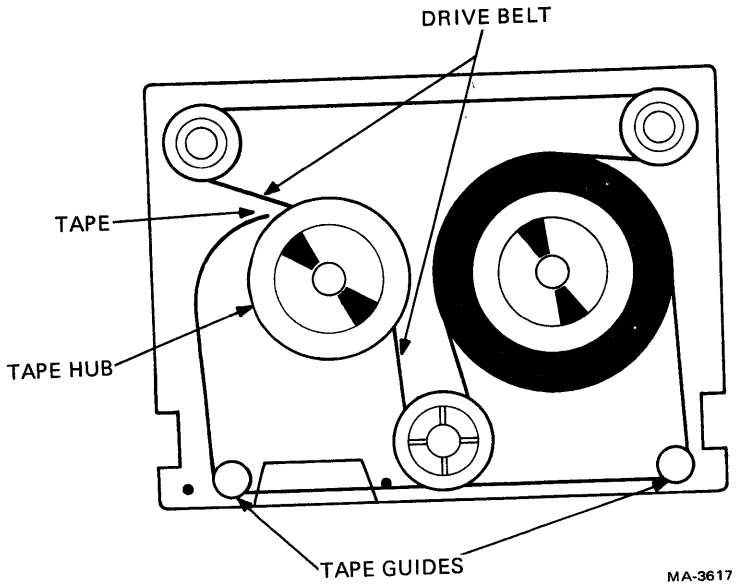


Figure 2-21 Metal Base Tape Threading

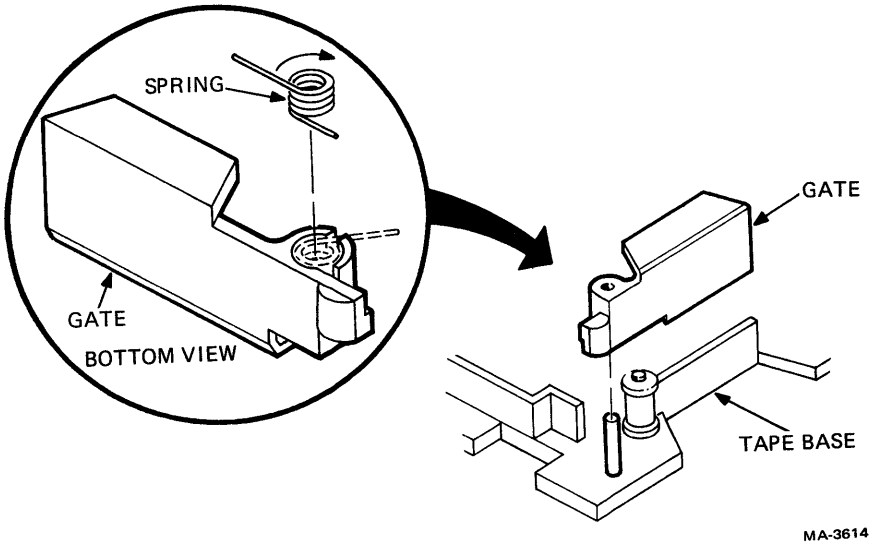


Figure 2-22 Tape Gate Installation

7. To reassemble the cartridge, ensure that the head gate is in proper position. If the gate has been removed, reinstall it by aligning the long and short ends of the spring with the long and short ends of the head gate, as in Figure 2-22.

8. Place the spring into the well in the head gate. Holding the spring down with a thumbnail or probe; rotate the long end of the spring to the slot which is at a right angle to the long dimension of the head gate. Push the end of the spring into the slot; the spring should stay in place by itself.

9. Hold the head gate halfway open so that the gate and the spring end will not touch the tape. Slowly press the gate down onto the appropriate pin on the cartridge base plate. Reach in with the probe and press the spring down. The spring will clear the holding slot of the gate and snap into position, closing the gate.

10. Carefully lower the cartridge cover into place and reinstall the the four phillips head screws.

Plastic Base Cartridge Tape Rethreading Procedure

1. Open the cartridge by removing the four baseplate phillips head screws and lift off the cover as shown in Figure 2-20.

NOTE

The four rollers and tape hubs in the plastic base cartridge are held in their operating plain by the top and bottom of the case. When the top is removed, the various parts tend to creep out of position.

2. To organize the parts for threading, remove the empty tape hub and floating roller from the case as shown in Figure 2-23.

3. Reinstall the floating roller and use it to stretch the drive belt (Figure 2-24).

5. Put the empty tape hub on the appropriate pin of the case base.

6. Hold the floating roller and belt in place, and push the empty tape hub into position, use a probe to guide the drive belt around the empty tape hub. The hub should seat against the cartridge base with the belt around it as shown in Figure 2-25.

7. Pull several centimeters (a few inches) of tape off the full tape hub and thread the tape through the tape guides.

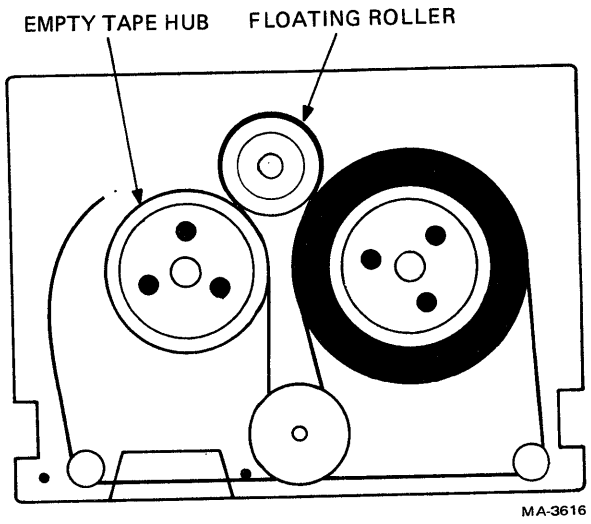


FIGURE 2-23 Plastic Base Tape Preparation

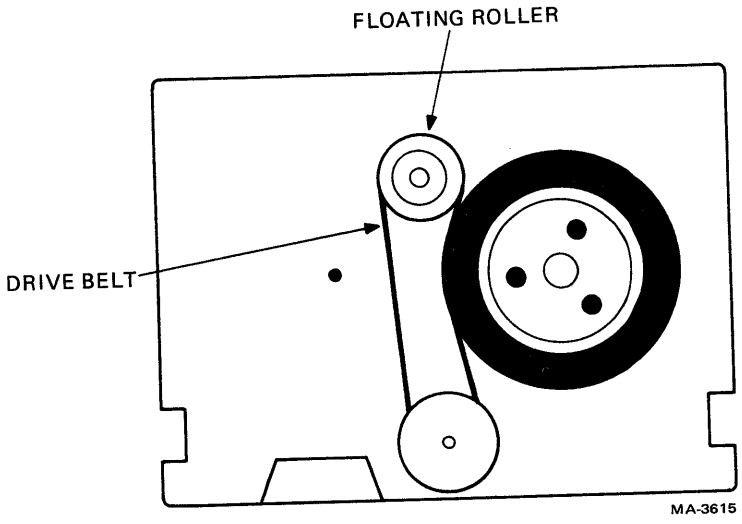


FIGURE 2-24 Plastic Base Tape Roller Installation

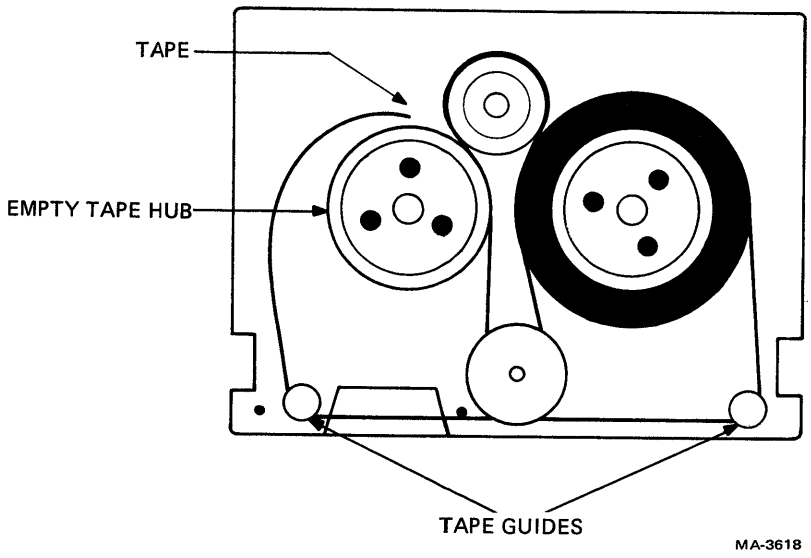


FIGURE 2- 25 Plastic Base Tape Threading

NOTE

Hold all parts down when moving them. Otherwise, the hubs will creep up the pins and cause the belt to slip. Then the procedure must be restarted from step 2.

8. Moisten the end of the tape with water to cause the tape to stick to the tape hub and insert the loose end of the tape between the tape hub and drive belt. Rotate the drive roller while gently pulling back on the tape (to provide back tension on the tape). The back tension will keep the tape feeding straight into the tape hub.

9. Continue to wind the drive roller a few more turns while applying back tension to the tape.

10. Hold the takeup hub, drive and floating rollers fixed and rotate the supply hub to take up any slack in the tape.

11. Continue rotating the the drive roller about twenty turns before reassembling the cartridge.

12. To reassemble the cartridge, ensure that the head gate is in proper position. If the gate has been removed, reinstall it by aligning the long and short ends of the spring with the long and short ends of the head gate, as in Figure 2-22.

13. Place the spring into the well in the head gate. Holding the spring down with a thumbnail or probe; rotate the long end of the spring to the slot which is at a right angle to the long dimension of the head gate. Push the end of the spring into the slot; the spring should stay in place by itself.

14. Hold the head gate halfway open so that the gate and the spring end will not touch the tape. Slowly press the gate down onto the appropriate pin on the cartridge base plate. Reach in with the probe and press the spring down. The spring will clear the holding slot of the gate and snap into position, closing the gate.

15. Carefully lower the cartridge cover into place and reinstall the the four phillips head screws.

CHAPTER 3
PACKING, UNPACKING, INSTALLATION AND SPECIFICATIONS

The PDT-11/110 and PDT-11/130 systems are free standing, self enclosed units that can be placed on a desk or table. The modem, printers, terminals and external video monitors which may operate with the unit are attached by cables to the rear panel. The peripheral devices can be located adjacent to the unit or at a remote location.

The PDT-11 products are shipped in reinforced cartons. Optional equipment such as terminals, printers, etc. are shipped in separate containers.

This chapter supplies information necessary to unpack, pack and install the PDT-11/110 and PDT-11/130 systems. Included in the chapter is detailed interface information for each peripheral device connector of the system. Product specifications are also supplied within the chapter.

UNPACKING, PACKING AND INSPECTION

UNPACKING AND INSPECTION PROCEDURE

The PDT-11 system is packaged within a reinforced carton containing the following items:

- Video Monitor
- Detached Keyboard
- AC Power Cord
- SET-UP Label
- User Guide

Figure 3-1 shows the packaging used with the PDT-11 system. To unpack the unit from the shipping container use the following procedure:

1. Cut the two plastic straps and carton sealing tape used to hold the carton closed.

2. Lift the keyboard packing material out of the carton and place it on a flat work surface. Remove the AC power cord and keyboard from the keyboard packing material.

3. Lift the video monitor packing material and the video monitor out of the carton using the handles provided in the packing material. Place on a flat work area and remove the packing.

4. Visually inspect the unit for physical damage.

NOTE

If physical damage is evident, notify your local DIGITAL Sales Office.

5. Install the system as described in the Installation Procedure section of this chapter.

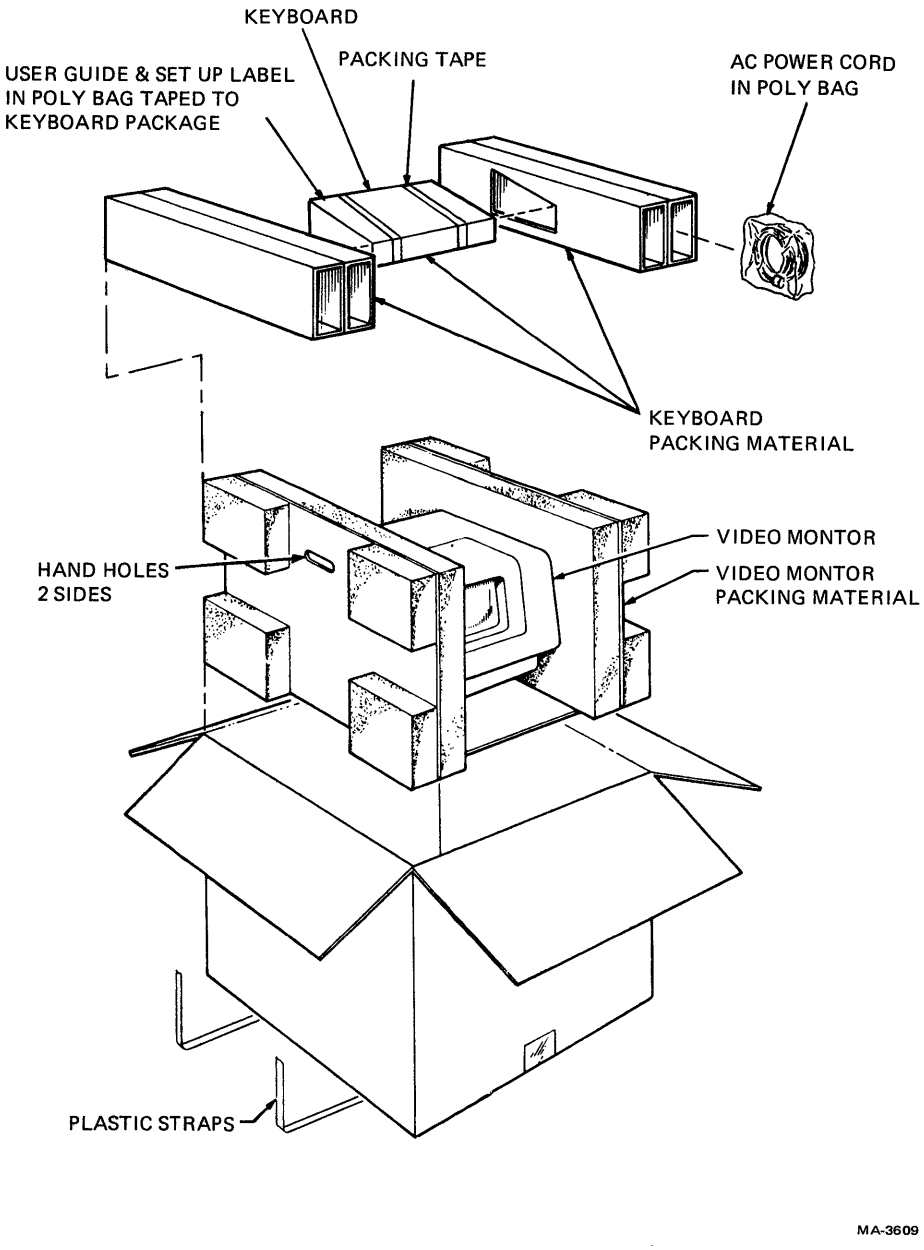


Figure 3-1 PDT-11 Packing

PACKING PROCEDURE
When packing the PDT-11 system for reshipment, use the following procedure (refer to Figure 3-2 for switch and cable locations):

1. Place the AC Voltage ON/OFF Switch in the OFF position.

POSITION	AC VOLTAGE
Up	ON
Down	OFF

2. Disconnect all cables at the rear of the monitor.

3. Place the video monitor packing material on a flat work surface (with the monitor cutouts facing up) and place the video monitor in the center.

4. Fold the packing material around the monitor and lift by the handles provided. The package is then placed into the shipping carton (refer to Figure 3-1).

5. Wrap the keyboard in the keyboard packing material with the keyboard cable extending out the end. Secure the keyboard by wrapping the package with tape. Place the remainder of the keyboard cable into the remaining keyboard package and slide the package around the end of the keyboard as shown in Figure 3-1. The keyboard package is then placed on top of the video monitor package in the shipping carton.

6. Fold the carton flaps and tape the shipping carton closed with sealing tape.

INSTALLATION

SITE CONSIDERATIONS
The PDT-11 system consists of a video monitor and a detached keyboard which may be placed on a desk or table top. The dimensions of these devices are shown in Figure 3-3.

The PDT-11 systems provide few constraints on the selection of a place to install the unit. Areas which experience extremes in temperature and humidity or are subject to high levels of industrial contaminants should be avoided. The guaranteed operating conditions and system specifications are provided at the end of this chapter.

When installing the equipment, care must be taken not to block the monitor air vents, thus hindering the flow of air.

The system monitor controls and cable connections are located on the rear panel of the monitor. When installing the unit allow adequate area for the operator to gain access to the rear panel of the monitor.

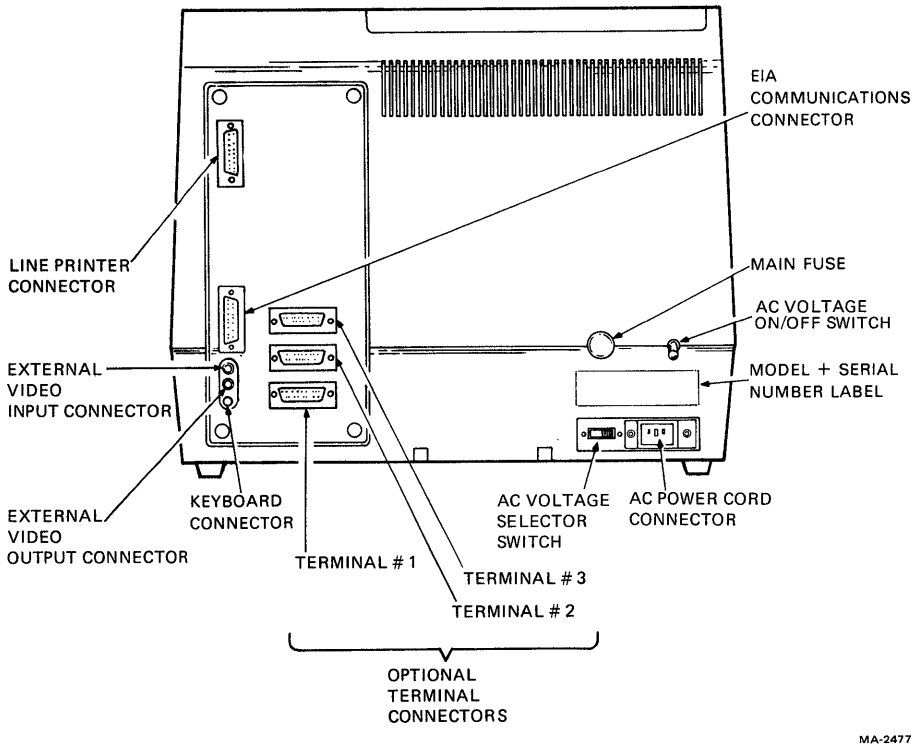
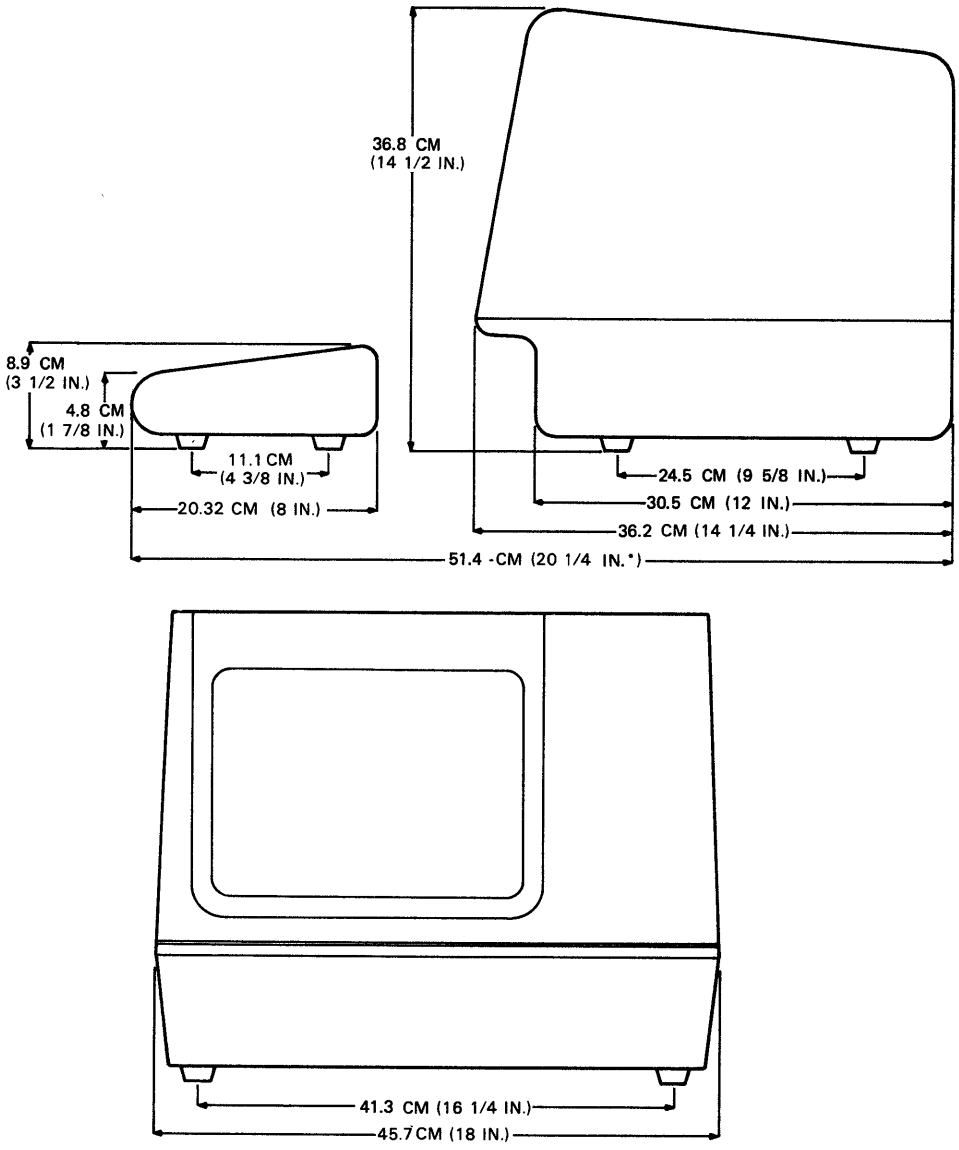


Figure 3-2 PDT-11 Rear View



*MEASUREMENT TAKEN WITH THE KEYBOARD PLACED FLUSH TO FRONT OF TERMINAL UNDER UNDERCUT.

MA-1991

Figure 3-3 PDT-11 System Dimensions

NOTE

When installing the system, all power and signal cables should be free from obstructions, sharp bends and stress.

INSTALLATION PROCEDURE

To install the PDT-11 system use the following general procedure (refer to Figure 3-2 for the switch and cable locations):

1. Remove the system from the shipping carton and place it in the desired work area; examine the unit for physical damage. Refer to the Unpacking and Inspection Procedure of this chapter for details on removing the PDT-11 system from the shipping carton.

2. Verify that the AC Voltage Selector switch shows the proper voltage. PDT-11 products are able to operate with either 115 VAC or 230 VAC input power. The AC voltage frequency is selected using the Power SET-UP feature after the system has AC voltage applied.

CONTROL	ASSOCIATED FUNCTION
AC Voltage Selector Switch	The AC Voltage Selector switch is used to adapt the system to the available AC input voltage range.

POSTION	OPERATING RANGE
115 VOLT	90-128 VOLTS RMS
230 VOLT	180-256 VOLTS RMS

CAUTION

Plugging the PDT-11 into a 230 V outlet with the AC Voltage Selector Switch set for 115 V will damage the equipment.

3. Connect the cables to the appropriate connectors at the rear of the monitor. Refer to the Interface Information section of this chapter for details on connector usage and signal/pin definitions. Verify that the AC Voltage Switch is in the OFF position before connecting the AC power cord.

CONTROL	ASSOCIATED FUNCTION
AC Voltage ON/OFF Switch	The AC Voltage ON/OFF switch turns ON and OFF the AC voltage to the system.

POSITION	AC VOLTAGE
Up	ON
Down	OFF

4. Place the AC Voltage Switch in the ON position. The system will run the internal self-test programs, and attempt to load an application program.

   Refer to chapter 2 of this guide for a detailed description of the power up sequence and indicators.

5. Select SET-UP parameters as discussed in chapter 2 of this guide.

   The Power SET-UP feature must be set to the proper power line frequency. The user sets this feature to either 50 or 60 Hz, immediately after powering up the system. (In the U.S. this is generally set to 60 hz.)

6. Once the SET-UP features have been entered, record the selected features on the SET-UP label and attach the label to the underside of the keyboard.

INTERFACE INFORMATION

SERIAL LINE DEVICE CONNECTORS

Two, 25-pin miniature "D" (EIA RS-232-C type) connectors are mounted on the rear panel of the PDT-11 monitor as standard equipment. Three additional, 25-pin miniature "D" connectors may be added to the PDT-11 system as an option. The placement of the connectors is shown in Figure 3-2. The pin numbering used on the connectors is shown in Figure 3-4. Table 3-1 lists the types of devices which may be used on each connector.

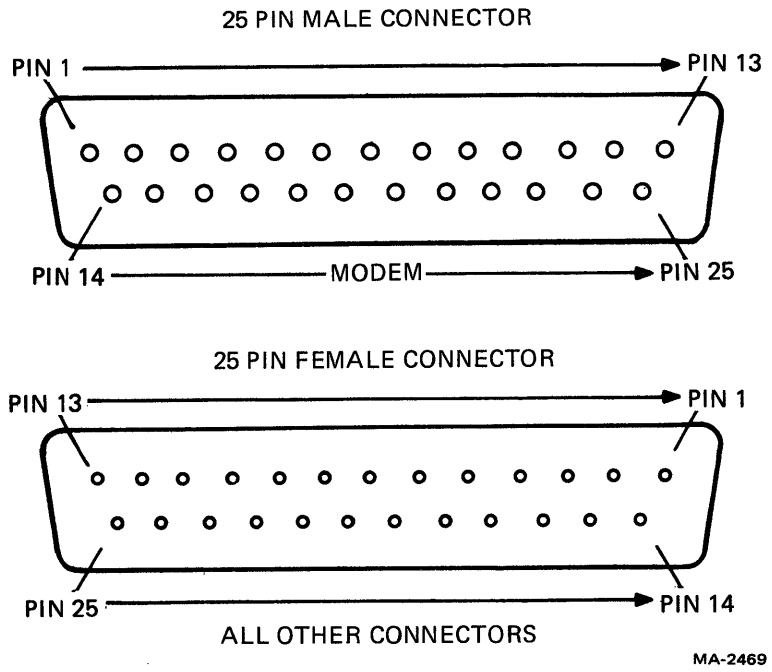


FIGURE 3-4 Serial Line Connector Pin Assignments

TABLE 3-1
Rear Panel Device Connector Assignments

STANDARD PORTS	DEVICE TYPES
Communications	Bell 103, 113, 202, 212 or equivalent modem
Line Printer	LA120, LA36, LS120, LA34, LA180 with the LAXX-NW option or equivalent printer
OPTIONAL PORTS	**DEVICE TYPES**
Terminals #1-3	LA36 DECWriter II, LA120 DECWriter III, VT52, VT100 or equivalent terminal

Electrical Characteristics
The signal levels of the PDT-11 serial line connectors are compatible with Electronics Industries Association (EIA) STD RS-232-C and International Telegraph and Telephone Consultive Committee (CCITT) Recommendation V.28.

Input Voltages - All signals designated "to PDT-11" are interpreted as follows:

VOLTAGE	PDT-11 INTERPRETATION
-25.0 V to +0.75 V or an open circuit	Mark, OFF or unasserted state
+.75 to +2.25 V	Undefined, not allowed using EIA RS-232-C specifications
+25.0 V to +2.25 V or a shorted circuit	Space, ON or asserted state

Voltages greater in magnitude than $\pm$25 V are not allowed.

Output Voltages - All signals designated "from PDT-11" are output as follows:

VOLTAGE	INTERPRETATION
-6.0 V to -12.0 V	Mark, OFF or unasserted state
-6.0 V to +6.0 V	Not used by the system
+6.0 V to +12.0 V	Space, ON or asserted state

Communications Connector Signal and Pin Assignments

The communications connector is mounted on the rear of the monitor and is the only male miniature "D" (EIA RS-232-C) connector of the system. The signal and pin assignments are compatible with equipment conforming to EIA RS-232-C specifications and CCITT recommendation V.24; however, not all signals defined within these specifications are used by the PDT-11 unit.

Table 3-2 lists pins which are used by the PDT-11 communications connector. A list defining each of the signals used by the PDT-11 communications port has also been provided. Pins not specified in Table 3-2 are not used by the PDT-11 equipment.

TABLE 3-2
Communication Connector Signal and Pin Assignments

PIN NUMBER	INTERCHANGE CIRCUIT	CCITT EQUIVALENT CIRCUIT	SIGNAL DESIGNATION
1	AA	101	Protective Ground (chassis)
2	BA	103	Modem Receive Data
3	BB	104	Modem Transmit Data
4	CA	105	Request to Send
5	CB	106	Clear to Send
6	CC	107	Data Set Ready
7	AB	102	Signal Ground (common return)
8	CF	109	Receive Line Signal Detector (carrier detect)
11		111	Secondary Request to Send (Speed Select/ Secondary Transmit) Same as pins 19 & 23
12		112	Secondary Received Line Signal Detector (Speed Indicator/Secondary Receive)
15	DB	114	Transmission Signal Element Timing (SYN CLK T)

17	DD	115	Receiver Signal Element Timing (SYN CLK R)
19			Same as pins 11 & 23
20	CD	108.2	Data Terminal Ready
22	CE	125	Ring Indicator
23			Same as pins 11 & 19

Protective Ground - Pin 1
This conductor is electrically bonded to the PDT-11 chassis. Use of this circuit for reference potential purposes is not allowed.

Modem Received Data (from PDT-11) - Pin 2
PDT-11 transmits serially encoded characters and break signals on this circuit, which is held in the mark state when neither characters nor break signals are being transmitted.

Modem Transmit Data (to PDT-11) - Pin 3
PDT-11 receives serially encoded characters and break signals generated by the host computer equipment on this circuit.

Request to Send (from PDT-11) - Pin 4
This control line, when asserted (ON), places the modem in the transmit mode. When unasserted (OFF), the modem is placed in receive mode.

Clear to Send (to PDT-11) - Pin 5
This circuit monitors the Clear To Send signal generated by the modem in response to Request To Send . This signal is required by the PDT-11/110 before loading programs.

Data Set Ready (to PDT-11) - Pin 6
This line, when asserted (ON), indicates that the modem is powered and is not in the test, talk, or dial mode. This signal is required by the PDT-11/110 before loading programs.

Signal Ground (common return) - Pin 7
This circuit establishes the common ground reference potential for all voltages on the interface. It is permanently connected to the PDT-11 chassis.

Received Line Signal Detector - Carrier Detect (to PDT-11) - Pin 8
This circuit, when asserted (ON), indicates the reception of the data carrier signal by the modem. It also indicates either the end of the current transmission activity or an error condition.

Secondary Request To Send - Speed Select (from PDT-11) - Pin 11
Supervisory data may be transmitted on this line with modems capable of supporting a secondary channel. As a control line, this circuit can be used to acknowledge messages.

This control line may be used to select the speed on modems capable of dual speed operation. (Generally, the asserted (ON) condition selects the higher baud rate; the unasserted (OFF) condition selects the lower baud rate).

Secondary Receive Line Signal Detector - Speed Indicator (to PDT-11) - Pin 12
This line may be used to receive supervisory data when used with modems capable of supporting a secondary channel. As a control line it can be used to acknowledge messages.

This control signal is supplied by the two speed modem to indicate the current operating speed selected. This signal is supplied only when the modem is capable of dual speed operation. (Generally, the asserted (ON) condition indicates that the higher baud rate has been selected; the unasserted (OFF) condition indicates that the lower baud rate has been selected).

Transmission Signal Element Timing - SYN CLK T - (to PDT-11) Pin 15
A control signal for the transmission of synchronous data. The transition from the OFF to ON condition of this signal indicates to the PDT-11 that a data bit may be placed on the transmit data circuit.

Receiver Signal Element Timing - SYN CLK R - (to PDT-11) - Pin 17
A control signal for the receiving of synchronous data. The transistion from the ON to OFF condition of this signal indicates that a valid data bit is present on the received data circuit.

Data Terminal Ready (From PDT-11) - Pin 20
This control signal is generated by the PDT-11 system to indicate the ability to transmit and receive data. It also is used to disconnect the PDT-11 system from the communication channel.

Ring Indicator (to PDT-11) - Pin 22
This signal indicates that a RINGING signal is being received by the modem. The RINGING signal is not a level but an EIA control with the cycle time as shown in Figure 3-5.

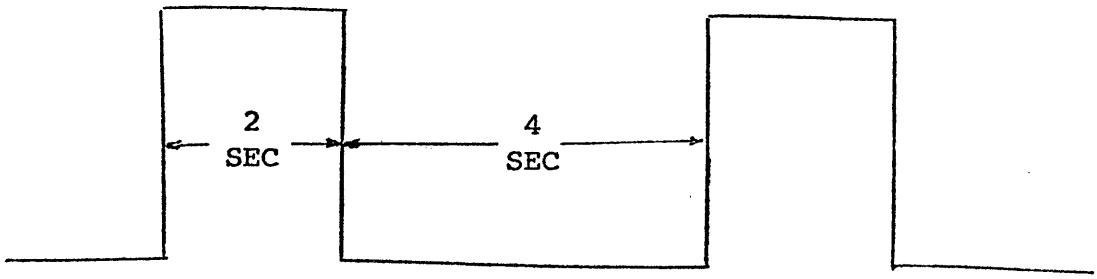


FIGURE 3-5 Ring Signal Timing

Line Printer Connector Signal and Pin Assignments
A hard copy printer may be attached to a dedicated 25 pin miniature "D" (EIA RS-232-C type) connector mounted on the rear of the PDT-11 monitor. The pin assignments of the printer connector are listed in Table 3-3. Pins not specified in Table 3-3 are not used by the PDT-11 equipment. A description of each signal used by the PDT-11 printer port is also provided.

TABLE 3-3
Printer Connector Signal and Pin Assignments

PIN NUMBER	SIGNAL DESIGNATION
1	Protective Ground (Chassis)
2	Printer Transmit Data
3	Printer Receive Data
7	Signal Ground (common return)
18	Halt (ODT) Mode Enable
20	Data Terminal Ready

Protective Ground - Pin 1
This connector is electrically bonded to the system chassis. The use of this connector for reference potential purposes is not allowed.

Printer Received Data (from PDT-11) - Pin 3
The PDT-11 transmits serially encoded characters on this circuit which is held in the mark state when characters are not being transmitted.

Printer Transmitted Data (to PDT-11) - Pin 2
The PDT-11 receives serially encoded XON and XOFF control characters on this circuit, all other characters will be ignored.

Signal Ground (common return) - Pin 7
This conductor establishes the common ground reference potential for all voltages on the interface. It is permanently connected to the PDT-11 chassis.

Halt (ODT) Mode Enable - PIN 18
This circuit is connected to pin 1 when Halt mode operation is desired. This mode is generally used by the application programmer to debug programs during development.

Data Terminal Ready (to PDT-11) - Pin 20
The PDT-11 monitors this circuit to determine if the printer is ready for operation. This control circuit is unasserted (OFF) to indicate the unit is out of paper, not powered or off line.

Optional Cluster Connector Signal and Pin Assignments
The PDT-11 System may be equipped with three optional 25-pin miniture "D" (EIA RS-232-C type) connectors. The connectors support additional terminals, which may be connected to the rear of the PDT-11 monitor. The connector pin assignments and signal definitions are the same for all three connectors.

The connector pin assignments for the cluster option are shown in Table 3-4. Pins not specified in Table 3-4 are not used by the PDT-11 equipment. A description of each signal of the PDT-11 optional cluster is also provided.

TABLE 3-4
Optional Cluster Connectors Pin and Signal Assignments

PIN NUMBER	SIGNAL DESIGNATION
1	Protective Ground (Chassis)
2	Cluster Terminal Received Data
3	Cluster Terminal Transmitted Data
7	Signal Ground (common return)
20	Data Terminal Ready

Protective Ground - Pin 1
This connector is electrically bonded to the terminal chassis. The use of this connector for reference potential purposes is not allowed.

Cluster Terminal Transmit Data (to PDT-11) - Pin 2
The PDT-11 receives serial encoded characters and break signals on this circuit.

Cluster Terminal Receive Data (from PDT-11) - Pin 3
The PDT-11 transmits serially encoded data on this circuit which is held in the mark state when characters are not being transmitted.

Signal Ground (common return) - Pin 7
This conductor establishes the common ground reference potential for all voltages on the interface.

Data Terminal Ready (to PDT-11) - Pin 20
The PDT-11 monitors this circuit to determine if the terminal is ready for operation.

TYPICAL CABLE ASSEMBLIES

All cables used to connect the PDT-11 system to serial line devices require miniature "D" (EIA RS-232-C type) connectors. Cables used with the PDT-11 products must be less than 15.24 meters (50 feet) in length. The PDT-11 printer port and cluster option ports are wired as modems to allow the use of extension cables.

Null Modem Cables
The following is a list of null modem cables which may be ordered from DIGITAL (refer to chapter 1 for ordering information).

BC22A-10
BC22A-25
BC03M-XX
BC03Z-XX

BC22A-XX - The BC22A is a six conducter (including shield) cable with two female miniature "D" (EIA RS-232-C type) connectors. The cable is available in two standard lengths, 10 and 25 feet. The cable is wired in a null modem configuration and can be used to connect a PDT-11/130 system to a local computer. Figure 3-6 provides a schematic of the BC22A cable.

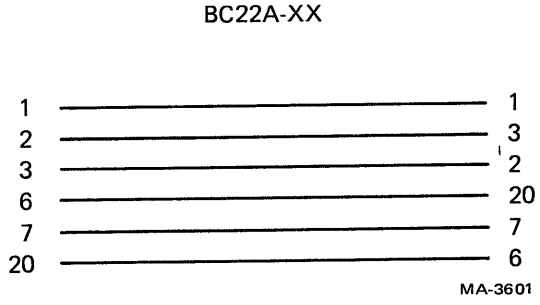


FIGURE 3-6 BC22A-XX Cable Schematic

BC03M-XX - The BC03M cable is used to replace the BC22A when cable length requirements exceed 25 feet.

BC03Z-XX - The BC03Z is a six conductor cable (including shield) with two female miniature "D" (EIA RS-232-C type) connectors. This cable is wired in a null modem configuration and can be used to connect a PDT-11/110 to a local computer. Figure 3-7 provides a schematic of the BC03Z cable.

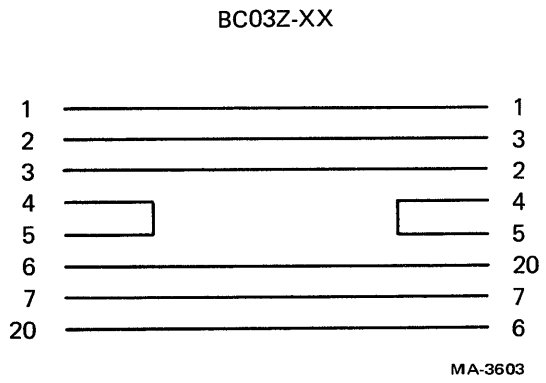


FIGURE 3-7 BC03Z-XX Cable Schematic

Extension Cables
The following is a list of extension cables available from DIGITAL.

BC22B-10
BC22B-25
BC05D-XX

BC22B-XX - The BC22B is a fourteen conductor cable (including shield) with one male and one female miniature "D" (EIA RS-232-C type) connector. This cable is available in 10 and 25 foot lengths and is wired in a one to one extension configuration. The BC22B cable can be used to connect a PDT-11 to a line printer, optional cluster terminal or data set (modem). Figure 3-8 provides a schematic of the BC22B-XX cable.

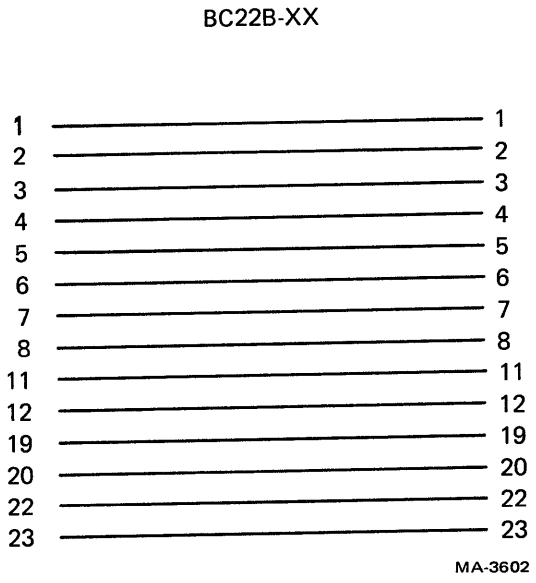


FIGURE 3-8 BC22B-XX Cable Schematic

BC05D-XX - This cable is used to replace the BC22B when cable length requirements exceed 25 feet or a full 25 connector cable is required.

EXTERNAL VIDEO CONNECTIONS

In addition to the EIA RS-232-C interface, the PDT-11 console can be easily interfaced to an external video device. The external video device may act either as a slave to the PDT-11 console video section when connected to the composite video output or as the controller of the PDT-11 console video screen when connected to the video input. The external video connectors are two female BNC connectors located on the rear panel of the PDT-11 monitor just below the communications connector. The upper connector is the video input, while the lower connector is the video output as shown in Figure 3-2.

Video Input

An analog signal applied to the video input will be "ORed" with the internal video signal in such a way that the beam intensity at any point on the screen will correspond to the intensity of that signal which would tend to make the beam brighter at that point. A video signal on this input affects only the console screen and does not appear on the composite video output. This input has the following nominal characteristics.

Input impedance = 75 ohms, DC-coupled
Black level = 0 V
White level = 1.0 V
Maximum continuous input = +2.0 V

NOTE

The external video source must be synchronized to the terminal, it may do this by referencing the composite synchronization signal on the composite video output.

Composite Video Output

The composite video provides EIA STD RS-170-like output (see the following note), generated by combining the video signal with a composite synchronization signal. This output contains all video data appearing on the video screen except that video which comes from the video input. The output has the following nominal characteristics (refer to Figure 3-9).

Output impedance = 75 ohms. DC-coupled
Sync level = 0 Volts
Black level = approximately 0.3 Volts when loaded with 75 ohms
White level - approximately 1.0 V with a 75 ohm load

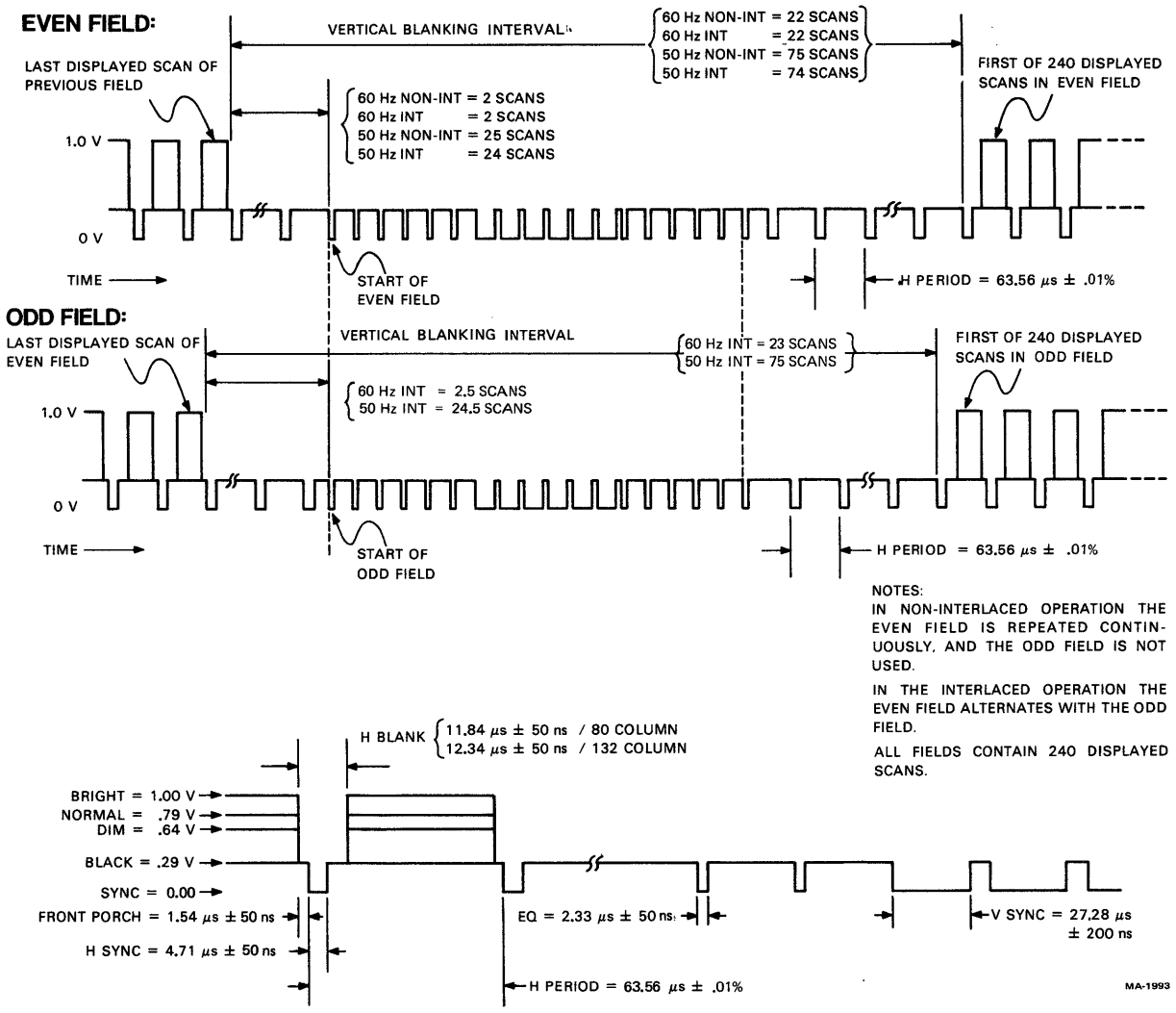


FIGURE 3-9 Composite Video Signal

The composite sync waveform conforms to EIA STD RS-170 standards. The vertical interval is composed of six equalizing pulses, six vertical synchronization pulses, and six more equalizing pulses. The timing is as follows:

Equalizing pulse width	=	2.33	us ±50	ns
Vertical pulse width	=	27.28	us ±200	ns
Horizontal pulse width	=	4.71	us ±50	ns
Horizontal blank width	=	11.85	us ±50	ns/80 column mode
Horizontal blank width	=	12.34	us ±50	ns/132 column mode
Front Porch	=	1.54	us ±50	ns

NOTE

The use of decoupling is not in strict agreement with EIA RS-170. To agree with EIA RS-170, the output load of the console requires a 10 pF capacitor in series with the output. Failing to do so, the 20 mA DC short circuit current requirement is violated. This presents no problem with most auxiliary monitors which are in fact AC-coupled.

SPECIFICATIONS

The system specifications presented in this section indicate the hardware capabilities of the systems. Due to system programming considerations many of these parameters are not practical expectations for the systems. Consult chapter 4 when choosing operating parameter settings.

PDT-11/110 SPECIFICATIONS

Dimensions

Monitor	Height: 36.83 cm(14.5 inch) Width: 45.72 cm (18 inch) Depth: 36.2 cm (14.25 inch)
Keyboard	Height: 8.89 cm (3.5 inch) Width: 45.72 cm (18 inch) Depth: 20.32 cm (8 inch) Minimum table depth: 51.4 cm (20.25 inch)

Weight

Monitor	17.2 kg (38 lb)
Keyboard	2.0 kg (4.5 lb)
Shipping Weight	25.6 kg (56.5 lb)

Environmental

Operating	Temperature: 10 C (50F) to 40 C (104F) Relative Humidity: 10% to 90% Maximum wet bulb: 28 C (82 F) Minimum dew point: 2 C (36 F) Altitude: 2.4Km (8,000 ft)
Non-operating	Temperature: -40C (-40F) to 66C (151F) Relative humidity: 0 to 95% Altitude: 9.1 km (30,000 ft)

Power

Line Voltage	90-128 V RMS single phase, 2 wire 180-256 V RMS single phase, 2 wire (switch selectable)
Line Frequency	47-63 Hz, keyboard selectable to 50 or 60 Hz.

Current	3.0 A RMS maximum @ 115 V RMS 1.5 A RMS maximum @ 230 V RMS
Current Limiting	3 A normal blow fuse
Power Cord	3 prong, 1.9 m (6 ft)

Display

CRT	12 inch diagonal measure, P4 phosphor
Format	24 lines X 80 characters or 14 lines X 132 characters (keyboard selectable)
Character	7 X 9 dot matrix with descenders
Character size	3.35 mm (0.132 inch) X 2 mm (0.073 inch) in 80 column mode, 3.35 mm (0.132 inch) X 1.3 mm (.051 inch) in 132 column mode
Active Display Size	202 mm (8 inch) X 115 mm (4.5 inch)
Character Set	96 character displayable ASCII subset (upper and lowercase, numeric and punctuation)
Cursor Type	Blinking block character or blinking underline. (Keyboard selectable)

Keyboard

General	83-key detachable unit with a 1.9 m (6 ft) coiled cord attached
Key Layout	65-key arrangement with sculpturing similar to standard typewriter keyboard with an 18-key auxiliary keypad.
Auxiliary Keypad	18-key numeric keypad with period, comma, minus, enter, and four user-programmable function keys
Visual Indicators	Seven indicators; three indicators are dedicated to ON LINE, LOCAL and KBD LOCKED, four indicators are user-programmable.
Audible Signals	Key-click: sound simulates typewriter. Bell: 1) sounds upon receipt of BELL code; 2) sounds eight characters from right margin (keyboard selectable).

	Multiple Bell: sounds upon detection of error when reading SET-UP features.
Memory	
Main Memory	16, 32 60 kbytes of Random Access Memory with 2 Kbytes of ROM memory containing self test diagnostics and program loaders.
Communications Port	
Type	EIA RS-232-C (CCITT V.28 and V.24)
Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, *7200, 9600, 19200 (keyboard selectable) *NOTE this setting may only be selected by the applications software, it may not be set from the keyboard. An external clock setting is automatically invoked when using the synchronous communication mode.
Code	ACSII
Character Format	Asynchronous/Synchronous (Keyboard selectable)
Character Size	7 or 8 bits (Keyboard selectable); 5 or 6 bits selectable by the program
Parity	Even, odd or no parity during program loading (Keyboard selectable)
Printer Port	
Type	EIA RS-232-C (CCITT V.28 and V.24)
Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19200
Code	ASCII
Character Format	Asynchronous
Character Size	5, 6, 7 or 8 bits

Parity	Even, odd or no parity

External Video Port

Type	EIA RS-170

Optional Terminal Ports

Type	EIA RS-232-C (CCITT V.28 and V.24)
Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 1000, 2400, 4800, 7200, 9600, 19200
Code	ASCII
Character Format	Asynchronous
Character Size	5, 6, 7 or 8 bits
Parity	Even, odd or no parity

PDT-11/130 SPECIFICATIONS

Dimensions

Monitor	Height: 36.83 cm (14.5 inch) Width: 45.72 cm (18 inch) Depth: 36.195 cm (14.25 inch)
Keyboard	Height: 8.89 cm (3.5 inch) Width: 45.72 cm (18 inch) Depth: 20.32 cm (8 inch) Minimum table depth: 51.4 cm (20.25 inch)

Weight

Monitor	18 kg (39 lb)
Keyboard	2.0 kg (4.5 lbs)
Shipping Weight	26 kg (57.5 lb)

Environmental

Operating	Temperature: 15C (59F) to 32C (90F) Relative Humidity: 20% to 80% Maximum wet bulb 25 C (77 F) Maximum dew point 2 C (77 F) Altitude: 2.4 Km (8,000 ft)
Non-operating	Temperature: -40C (-40F) to 66C (151F) Relative Humidity: 95% maximum Altitude: 9.1 Km (30,000 ft)

Power

Line Voltage	90-128 V RMS single phase, 2 wire 180-256 V RMS single phase, 2 wire (switch selectable)
Line Frequency	47-63 Hz, keyboard selectable to 50 or 60 Hz.
Current	3.0 A RMS maximum @ 115 V RMS 1.5 A RMS maximum @ 230 V RMS
Current Limiting	3 A normal blow fuse
Power Cord	3 prong, 1.9 m (6 ft)

Display

CRT	12 inch diagonal measure, P4 phosphor
Format	24 lines X 80 characters or 14 lines X 132 characters (keyboard selectable)
Character	7 X 9 dot matrix with descenders
Character size	3.35 mm (0.132 inch) X 2 mm (0.073 inch) in 80 column mode, 3.35 mm (0.132 inch) X 1.3 mm (.051 inch) in 132 column mode
Active Display Size	202 mm (8 inch) X 115 mm (4.5 inch)
Character Set	96 character displayable ASCII subset (upper and lowercase, numeric and punctuation)
Cursor type	Blinking block character or blinking underline. (Keyboard selectable)

Keyboard

General	83-key detachable unit with a 1.9 m(6 ft) coiled cord attached
Key Layout	65-key arrangement with sculpturing similar to standard typewriter keyboard with an 18-key auxiliary keypad.
Auxiliary Keypad	18-key numeric keypad with period, comma, minus, enter, and four user-programmable function keys
Visual Indicators	Seven indicators; three indicators are dedicated to ON LINE, LOCAL and KBD LOCKED, four indicators are user-programmable.
Audible Signals	Key-click: sound simulates typewriter. Bell: 1) sounds upon receipt of BELL code; 2) sounds eight characters from right margin (keyboard selectable). Multiple Bell: sounds upon detection of error when reading SET-UP features.

Memory

Main Memory	16, 32 60 kbytes of Random Access Memory with 2 Kbytes of ROM memory containing self test diagnostics, program loaders and Tape drive Input/Output pirimitive routines.
Mass storage	See media specifications

Tape Drive

Drive	Single motor, head integrally cast into a molded chassis
Drives per controller	Two, Only one may operate at a time.
Data transfer rate Read/write on tape	41.7 us per data bit, 24 kbps
Data reliability Search error rate (failure to find block after 8 tries)	1 in 10^{6} searches
Soft data error rate	1 in 10^{7} bits read

NOTE

Soft data errors are usually attributable to random effects in the head/tape interface, such as electrical noise, dirt or dust. Soft errors are defined as recoverable within eight retries. Hard errors connot be recovered.

Hard error data rate (Unrecoverable within 8 tries)	1 in 10^9 bits read
Error checking	Checksum with rotation
Average access time	9.3 seconds
Maximum access time	28 seconds
Read/write tape speed	75 cm/sec (30 ips)
Search tape speed	105 em/sec (60 ips)
Bit density	315 bits/cm (800 bpi)
Flux reversal density	945 fr/cm (2400 frpi)
Recording method	Ratio encoding

Communications Port

Type	EIA RS-232-C (CCITT V.28 and V.24)
Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19200 An external clock setting is automatically invoked when using the synchronous communication mode.
Code	ASCII
Character Format	Asynchronous/Synchronous
Character Size	5, 6, 7 or 8 bits
Parity	Even, odd or no parity

Printer Port

Type	EIA RS-232-C (CCITT V.28 and V.24)

Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 1000, 2400, 3600, 4800, 7200, 9600, 19200
Code	ASCII
Character Format	Asynchronous
Character Size	5, 6, 7 or 8 bits
Parity	Even, odd or no parity

External Video Port

Type	EIA RS-170

Optional Terminal Ports

Type	EIA RS-232-C (CCITT V.28 and V.24)
Speeds	Half/Full duplex: 50, 75, 110 (two stop bits), 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, 9600, 19200
Code	ASCII
Character Format	Asynchronous
Character Size	5, 6, 7 or 8 bits
Parity	Even, odd or no parity

MEDIA SPECIFICATIONS

Cartridge	DEC Tape cartridge Part Number: TU58-K with 42.7 meters (140 feet) of 3.81 mm (0.150 in) tape Size: 6.1 x 8.1 x 1.3 cm 2.4 x 3.2 x 0.5 in
Capacity per cartridge	262,144 bytes, formatted in 512 blocks of 512 bytes each

Track format (See Programming chapter for details)	2 tracks, each containing 1024 individually numbered, firmware interleaved 'records'. Firmware manipulates 4 records at each operation to form 512 byte blocks.

Environmental

Non operating	Temperature:0C(32F) to 50C (122F) Relative Humidity: 10% to 80%

CHAPTER 4

PROGRAMMING INFORMATION

This programming chapter describes the hardware characteristics of the PDT-11/110 and PDT-11/130 systems. These characteristics must be considered when creating application programs. The PDT-11 systems are intended to run host system generated, real-time programs that have been developed to satisfy the specific needs of the end user. PDT-11 systems are not designed to be a software development systems. Another larger and possibly faster PDP-11 system is used for application program development. It is possible, however, to debug the application program on the PDT-11 system with the use of console On-line Debugging Technique (ODT).

SYSTEM ARCHITECTURE

The PDT-11/110 and PDT-11/130 systems are programmable data entry terminals which provide local data processing abilities within a desk top device. Figure 4-1 shows a general block diagram of these intelligent terminals. The systems are composed of a VT100 video console device, a PDP-11 compatible processor (containing up to 60k bytes of Random Access Memory) and a serial line interface controller (which may communicate with up to five serial line devices). The PDT-11/130 is equipped with an additional mass storage device in the form of a TU58 dual DECtape II mini-cartridge tape drive and controller. The following paragraphs provide a brief description of the major components of the PDT-11/110 and PDT-11/130 systems.

VT100 VIDEO CONSOLE DEVICE

The VT100 console device consists of a keyboard and video screen. The console translates operator keyboard entries into ASCII characters and transmits them to the PDT-11 system processor. Data on the video screen is received as ASCII characters from the PDT-11 system processor and displayed by the video portion of the console. The transmit and receive functions of the console are totally independent. Therefore, to display keyboard entries onto the video screen, the application program must echo the ASCII characters received from the keyboard to the video screen.

The console operates at 4800 baud with XON/XOFF control character support. XON/XOFF control characters require a minimum of software support and ensure that every character or command sent to the console will be processed in the correct order. For further details on XON/XOFF support see the Synchronization section of this chapter.

The VT100 type console contains, as standard equipment, an external video interface which adheres to EIA RS-170 standards. An optional external video device may act either as a slave to the console device or as a controller of the video section of the console.

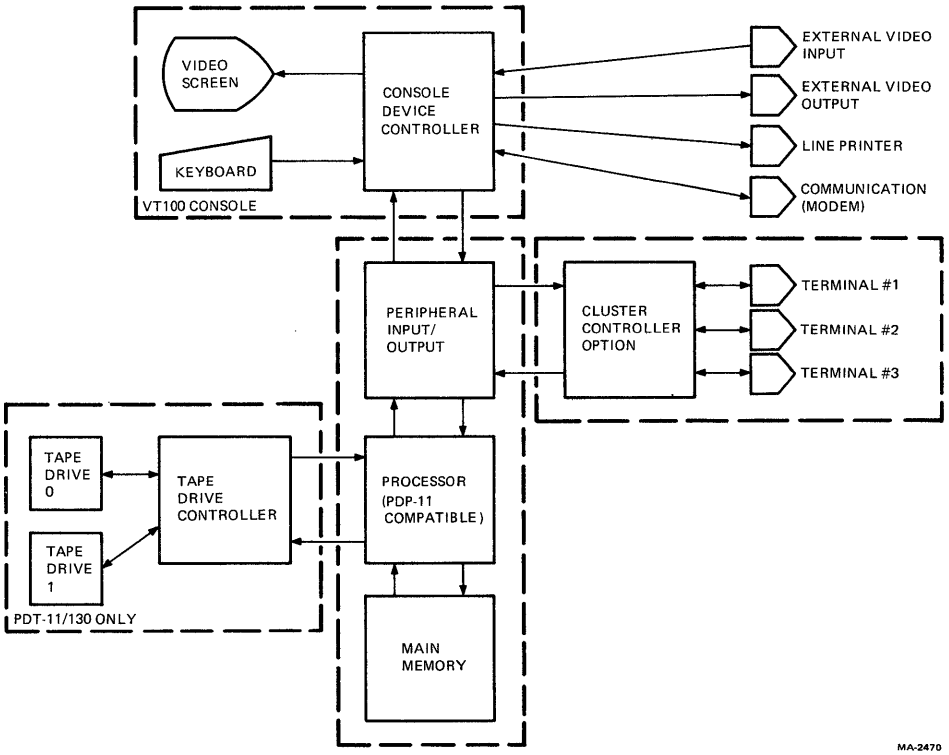


Figure 4-1 General System Block Diagram

PDT-11 PROCESSOR

The PDT-11 systems are LSI-11 microprocessor-based and operate under the control of a run-time application program. The processor is programmed using the basic PDP-11 instruction set. The use of this instruction set allows sophisticated programs developed for larger PDP-11 computers to be run on the PDT-11 products.

For details on the instruction set and LSI-11 processor architecture, see the DIGITAL Microcomputer Processors Handbook and related publications (refer to chapter 1 for a complete list of related documents).

PDT-11 PROCESSOR MEMORY

The processor main memory may contain 16, 32 or 60 Kbytes of Random Access Memory (RAM) in which to store programming and data. This provides the system with substantial memory which may contain operating systems, communication software or application programming. The processor memory also holds the Input/Output (I/O) page and Self Test/ Program Loading routines of the system. Figure 4-2 illustrates the memory organization of the PDT-11 systems.

PERIPHERAL INTERFACE

The standard peripheral interface controller of the PDT-11 system is able to interface with two serial line devices, usually a line printer and a communication modem. An optional cluster controller allows the addition of three serial line devices (for a total of five serial line devices). The additional devices are usually video or hardcopy terminals. Figure 4-3 shows a system configuration which includes the maximum number of serial line devices that can operate as part of the PDT-11 system.

The PDT-11 serial line interfaces meet Electronic Industry Association (EIA) RS-232-C and International Telephone and Telegraph Consultive Committee (CCITT V.24) specifications. Therefore, a wide variety of devices are directly compatible with the PDT-11 products.

The communication (modem) port allows full or half duplex operation in either a synchronous or asynchronous character format. The communication port has full modem control enabling use in a wide variety of communication systems. (The PDT-11 systems can operate with dual speed modems, supervisory channels, etc.) For dedicated applications using software service routines developed specifically for modem control, the maximum half-duplex baud rate during synchronous or asynchronous data transfers is 9600 baud. For applications using software operating systems, such as RT-11 (capable of servicing several devices), the typical full-duplex baud rates are 4800 baud for asynchronous and 2400 baud for synchronous data transfers. The resident program loading routines of the PDT-11/110 system will operate reliably at a maximum speed of 4800 baud.

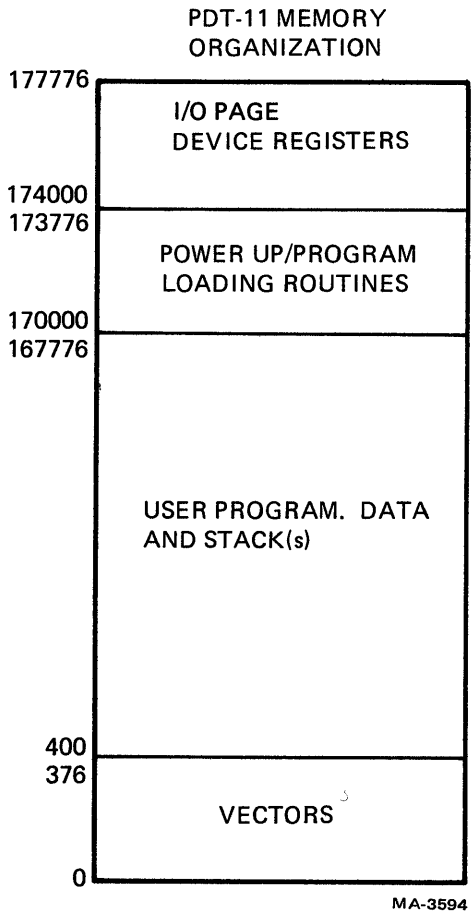


FIGURE 4-2 PDT-11. MEMORY ORGANIZATION

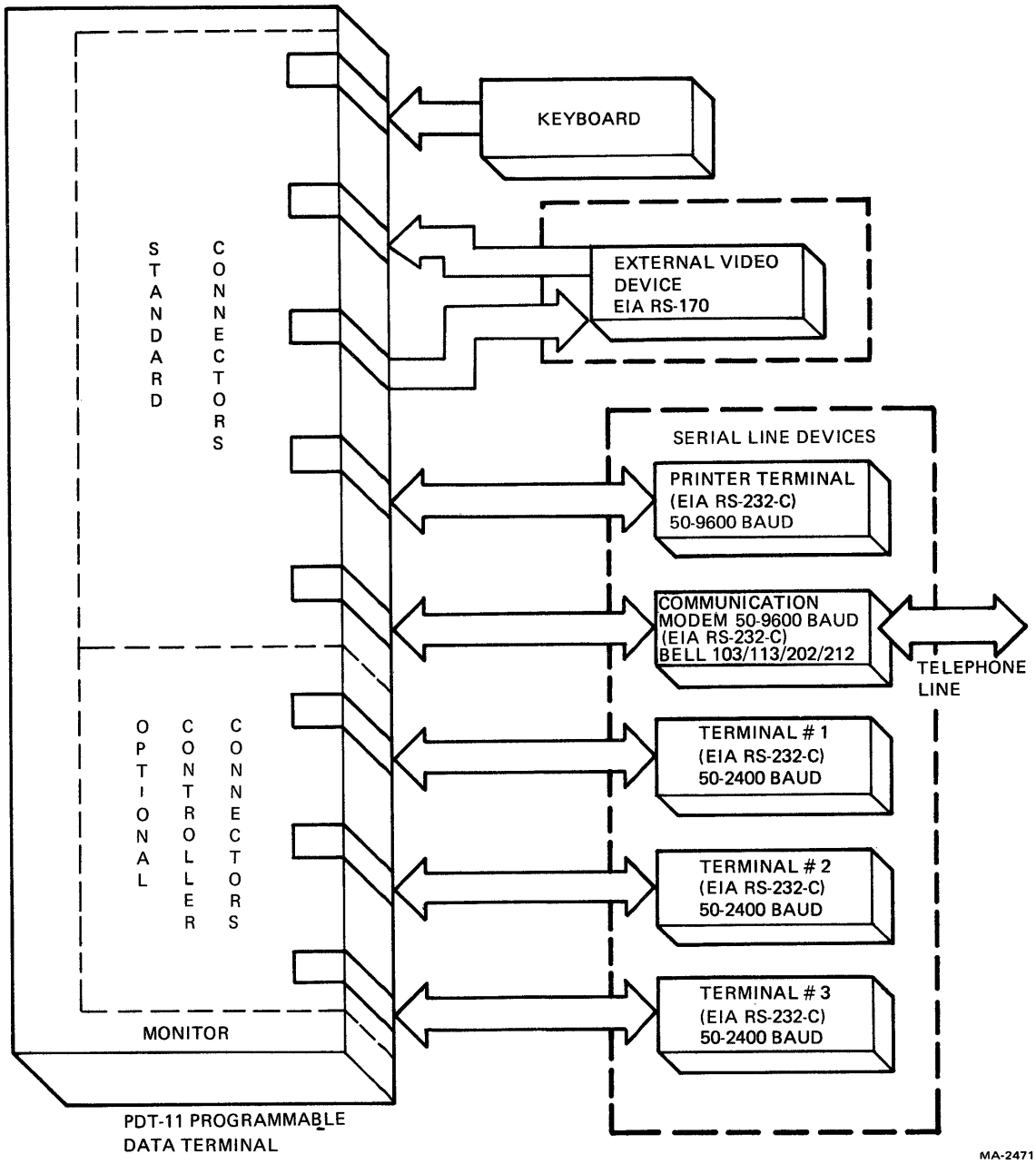


Figure 4-3 System Configuration

The printer port is used to interface an optional line printer to the PDT-11 system, thus providing hardcopy capabilities. The printer port operates asynchronously at baud rates ranging from 50 to 9600 bits per seconds with full XON/XOFF control character support.

A cluster controller expands the capacity of the system to include three additional serial line devices which can be equipped with a keyboard. The cluster devices operate asynchronously at speeds ranging from 50 to 2400 bits per second when used with the standard ASCII character set. When the terminal contains buffered data storage or special function keys (such as cursor controls, etc.), the baud rate should be reduced to a maximum of 2000 baud.

PDT-11/130 MASS STORAGE

The PDT-11/130 system has a mass storage device in the form of a TU58 dual DECtape II mini-cartridge drive and controller. The PDT-11 processor communicates with the tape drive controller using DIGITAL's Radial Serial Protocol (RSP) which is explained in the PDT-11/130 Tape Drive Programming Considerations section of this chapter. RSP removes all primitive tape handling considerations from the PDT-11 processor causing a reduction in the LSI-11 processing load.

The mass storage tape cartridge is file structured to allow block addressing and replacement of data or programming. Each cartridge holds a maximum of 262 kbytes of data in 512 byte blocks. There are 256 blocks on each of two tracks which may be accessed by the controller under the direction of the PDT-11 processor.

The tape cartridges used by the system are preformatted with inter-record marks to allow random access of specific blocks of data. The PDT-11/130 system does not have the ability to format these tapes. However, the preformatted tapes are available from DIGITAL. Refer to the ordering information contained in chapter 1 of this guide for further information.

SYSTEM CHARACTERISTICS

The PDT-11 systems are LSI-11 microprocessor-based and are programmed using the basic PDP-11 instruction set. The use of this instruction set allows programs developed for larger PDP-11 computers to be run on the PDT-11 products. The PDT-11 processor is a "bounded bus" system as opposed to the "open bus" of the PDP-11 computer. The bus is completely buried within the terminal, and a separate 8-bit microprocessor acts as an interface between the CPU and the peripheral devices. A word transfer to the I/O page takes approximately 90 us. Any byte transfer to the I/O page will automatically cause a dual transfer (read/write) and double the access time to 180 us.

SERIAL LINE DEVICE PROGRAMMING CONSIDERATIONS

The PDT-11 systems are available with several serial line devices which have user programmable baud rates. The baud rate setting determines the speed at which a character will be moved to or from the serial line device. The baud rate does not indicate the throughput of the PDT-11 system. The throughput determines the speed which a string of continuous characters may be moved to or from the serial line device. When programming any system which must service multipule peripheral devices, the system programmer must be careful not to demand a throughput rate faster than the system can provide. To determine the system throughput refer to Appendix B.

The PDT-11 is equipped with a USART parameter control register used to provide software control of serial line device parameters. The serial line ports of the system include the communication (modem) port, the line printer port and three clustered terminals. Additional devices which interface to the PDT-11 processor are the Line Time Clock, the console and in the case of the PDT-11/130 a mass storage tape drive. The communication (modem) port has an additional PARCSR register used to define synchronous communication parameters.

INTERRUPTS

Interrupts are requests for service from devices external to the LSI-11 processor. The interrupt requests are recognized whenever the processor is in RUN mode and the processor priority is set to zero. When the processor priority is raised or the processor is in HALT (ODT) mode, all interrupt requests will not be recognized. The I/O microprocessor will store unrecognized interrupts until the processor is again able to process interrupts. The I/O microprocessor stores an interrupt request each time a device interrupts, therefore several interrupt requests may be stored for a single device.

Data may be transmitted to the serial line devices using either programmed I/O instructions or through interrupt device routines. When transmitting data to a device using interrupt routines, the interrupt enable bit of the associated CSR must be set. If it is desired to end the data transmission, the interrupt enable bit must be cleared prior to the last data word transferred.

NOTE

When clearing an interrupt enable bit, first set the processor to its highest priority (Processor Status Word PSW bit 7=1). After the interrupt enable bit is cleared, the processor may be returned to its normal priority (PSW bit 7=0).

For example:

```
MTPS #200
BIC #100, CSR
MTPS #0
EXIT
```

CONSOLE ODT

Console ODT commands are executed by the LSI-11 processor when the processor is in the HALT mode. These commands allow the programmer to examine and alter the contents of memory and registers through the console device. The HALT mode is entered when the printer port pins 1 and 18 are connected and the BREAK key is pressed. Refer to the On-line Debugging Technique Considerations for more detailed console ODT information.

PROGRAMMED RESET INSTRUCTION

If a reset instruction is issued during programmed operation, an INIT signal is generated, all device registers will be reset and any operation in process will be terminated. The serial line device parameters will not be altered by the programmed reset instruction. If the INT ENB (bit 06) of the Line Time Clock was previously set, the reset instruction will clear the bit.

POWER UP AND MASTER RESET CONDITIONS

When the AC power is applied or a master reset is generated from the console keyboard, the serial line device parameters will be set to a preselected condition. Table 4-1 lists the preselected conditions of the serial line devices set by the firmware held within Read Only Memory (ROM). Additionally, the Line Time Clock will be disabled by the clearing of the interrupt enable bit.

TABLE 4-1
Power Up and Master Reset Conditions

	CONSOLE	PRINTER	TERMINAL CLUSTER	COMM PORT
PDT-11/110				
Mode	Async	Async	Async	
Character Length (#bits)	8	8	8	
Parity	None	None	None	Set by selection of the SET-UP features
Baud Rate (bps)	4800	1200	300	
#Stop bits	1	1	1	
PDT-11/130				
Mode	Async	Async	Async	Async
Character Length (#bits)	8	8	8	8
Parity	None	None	None	None
Baud Rate (bps)	4800	1200	300	9600
#Stop bits	1	1	1	1

When the PDT-11/110 system is initialized, the communication port is set to the preselected SET-UP features held within the console's Non-Volatile Random Access Memory (NVR). The communication (modem) port operation may be altered by changing the SET-UP features and reinitiatizing the system. (See the chapter 2 for details on the SET-UP features).

The interface for each device is initialized at power up time and if different conditions are required must be programmed for operating conditions after initialization. In both the PDT-11/110 and PDT-11/130 systems, the USART Parameter Register is used to select and modify the operating parameters of the serial line devices and the processor peripheral board lights (which cannot be seen by the operator). The USART parameter control register should not be used to alter the operating parameters of the console device.

DEVICE REGISTER ADDRESSES, INTERRUPT VECTORS AND WORD FORMATS

The Input/Output (I/O) page of the PDT-11 system is reserved by convention for handling interrupts and traps, and for accessing peripheral device registers. The device registers of the PDT-11 system are associated with either a serial line device interface, a tape drive interface or the Line Time Clock. The I/O page is 2k bytes in length and is contained in the highest memory locations. The device registers of the PDT-11 system are accessed through the I/O page of the system using specific addresses which are fixed and may not be altered by the program. All device interfaces which can generate device interrupt requests are assigned unique vector addresses. The vector addresses locate device service routines which may be held in main memory. The interrupt vectors of the PDT-11 system are fixed and may not be altered by the program. Figure 4-4 shows the relationship of the control and buffer registers within the PDT-11 system. Figure 4-5 provides a brief summary of the device register formats, addresses and interrupt vectors.

UNIVERSAL SYNCHRONOUS/ASYNCHRONOUS RECEIVER TRANSMITTER (USART) PARAMETER CONTROL REGISTER

The USART Parameter Control Register is used to select the operational parameters of both the standard and optional serial line device interfaces. The standard serial line device interfaces of the PDT-11 system are:

the console device (whose operating parameters should never be altered)

the printer port

the communication (modem) port

The optional serial line devices are the clustered terminals which may be attached to the PDT-11 system.

The address of the USART Parameter Register is shown in Table 4-2. Figure 4-6 shows the word format and Table 4-3 describes the function of the bits. This register is write-only and must be programmed as a full 16-bit word before data is transferred to the interface device. A separate write instruction is performed to the USART Parameter Register for each device programmed.

TABLE 4-2
USART Parameter Control Register Device Address

DEVICE REGISTER	ADDRESS
USART Parameter Control/ Status Register (UPCSR)	177420

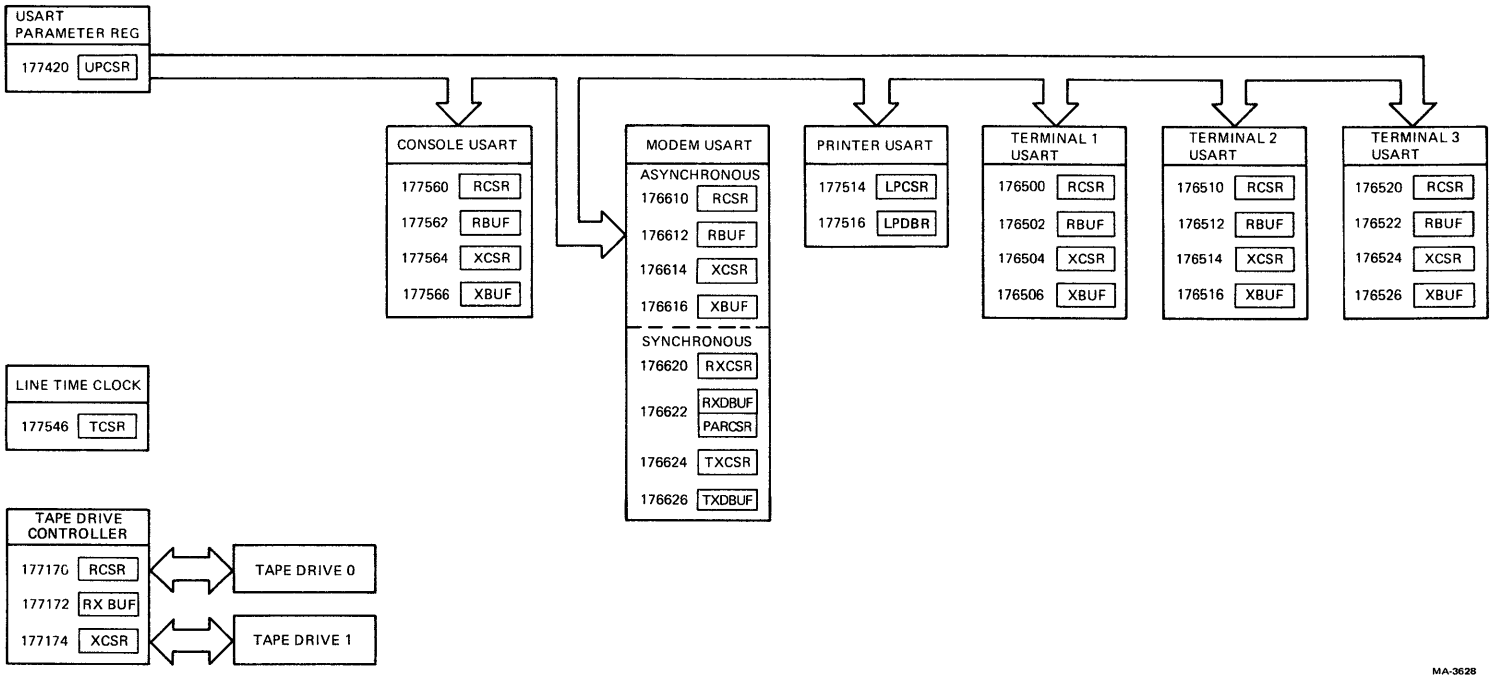
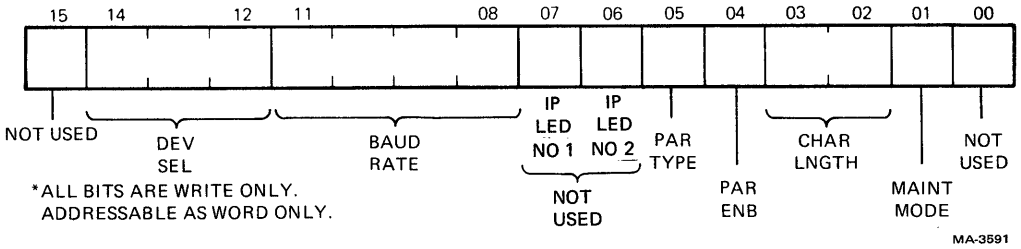


Figure 4-4 PDT-11 Control and Address Register, Buffer Assignments

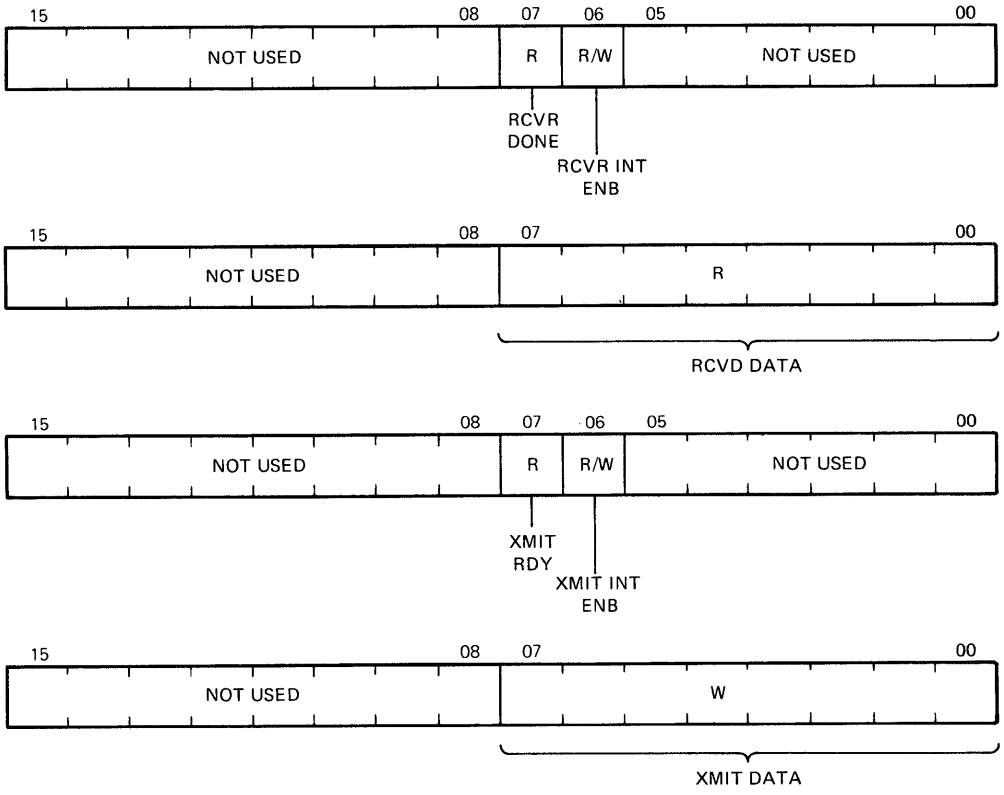
USART PARAMETER CONTROL REGISTER

MNEMONIC	ADDRESS
UPCSR	177420



CONSOLE DEVICE INTERFACE REGISTERS

MNEMONIC	ADDRESS	VECTOR
RCSR	177560	
		RECEIVE 060
RBUF	177562	
XCSR	177564	
		TRANSMIT 064
XBUF	177566	



LINE TIME CLOCK REGISTER

MNEMONIC	ADDRESS	VECTOR
TCSR	177546	100

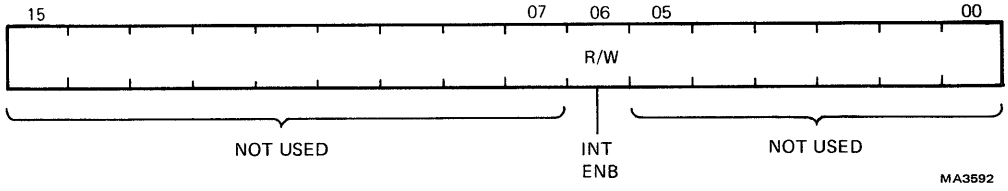
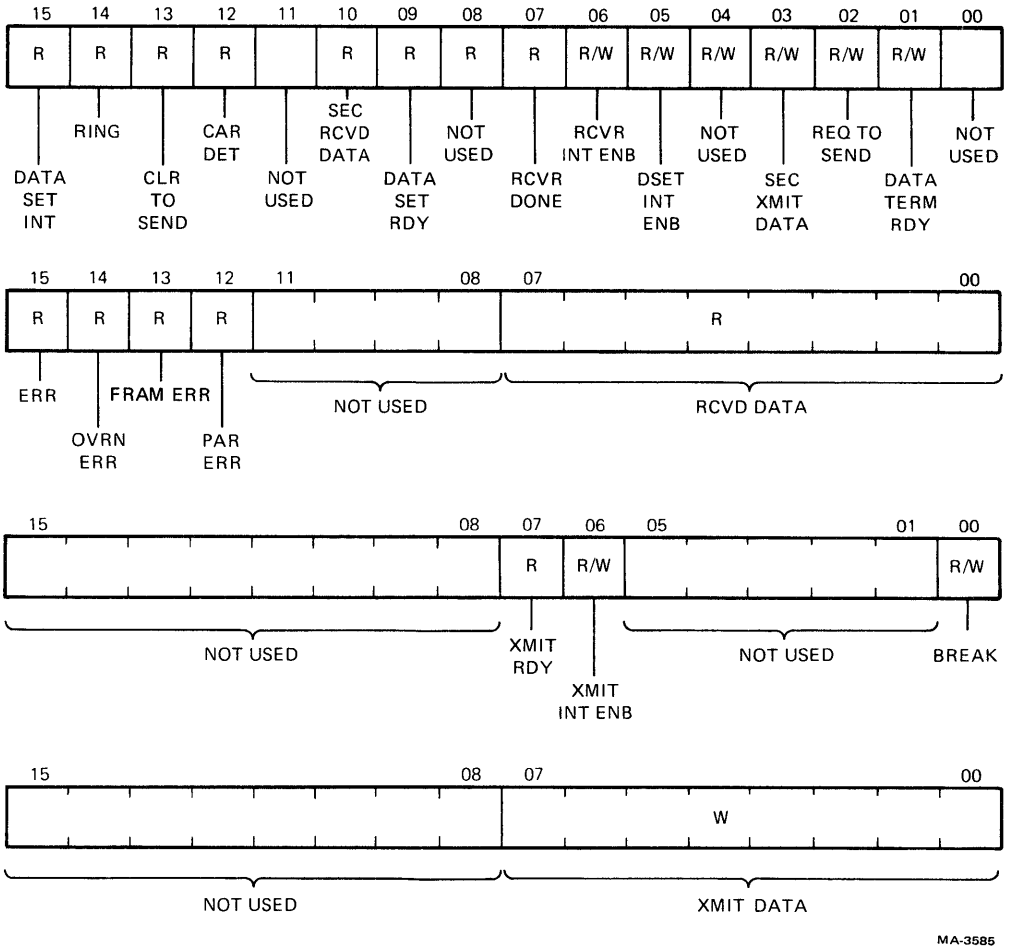


Figure 4-5 Device Register Summary

COMMUNICATIONS INTERFACE REGISTERS

ASYNCHRONOUS

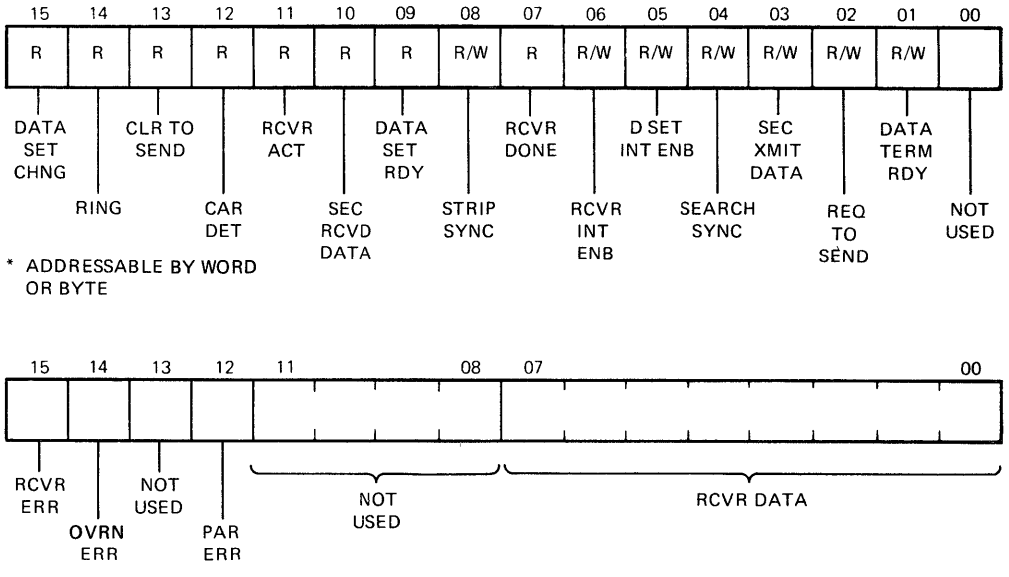
MNEMONIC	ADDRESS	VECTOR
RCSR	176610	
		RECEIVE 330
RBUF	176612	
XCSR	176614	
		TRANSMIT 334
XBUF	176616	



MA-3585

SYNCHRONOUS

MNEMONIC	ADDRESS	VECTOR
RXCSR	176620	
		RECEIVE 340
RXDBUF	176622	

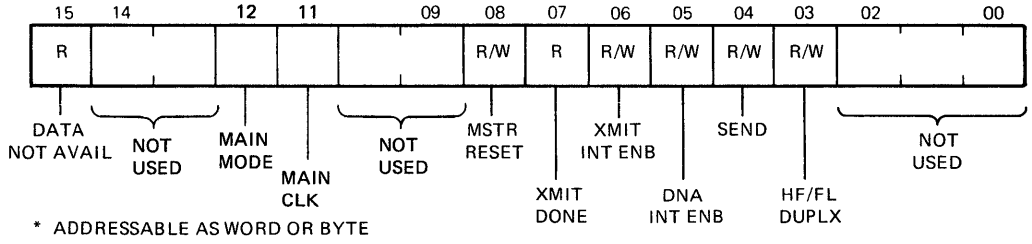


*ALL BITS READ ONLY, ADDRESSABLE BY WORD OR BYTE

MA-3586

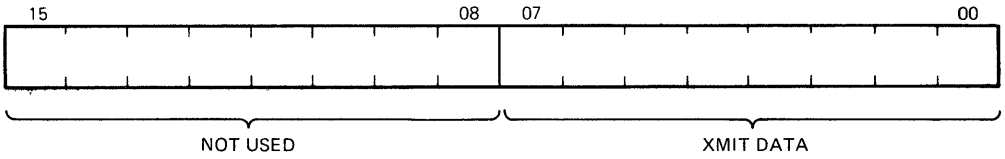
TXCSR 176624

TRANSMIT 344



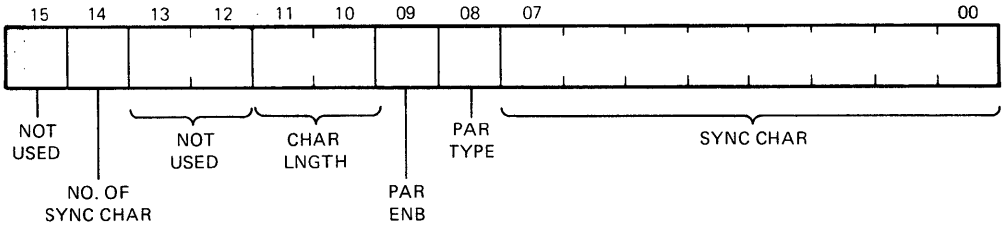
* ADDRESSABLE AS WORD OR BYTE

TXDBUF 176626



*ADDRESSABLE AS WORD OR BYTE TO EVEN ADDRESS ONLY

PARCSR 17662

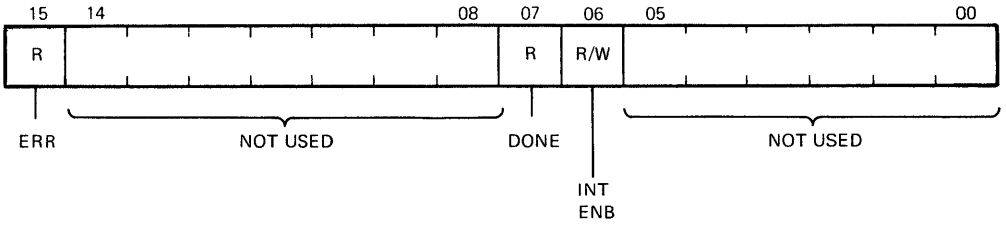


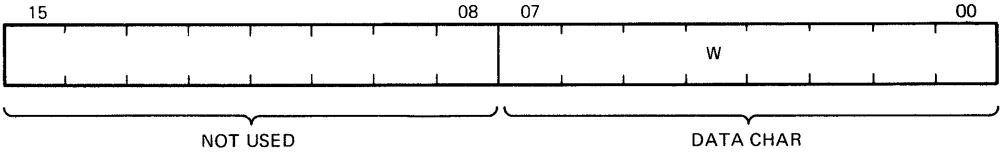
*ALL BITS ARE WRITE ONLY
ADDRESSABLE AS WORD ONLY

MA-3589

RINTER TERMINAL INTERFACE REGISTERS

MNEMONIC	ADDRESS	VECTOR
LPCSR	177514	
		RECEIVE 200
LPDBR	177516	

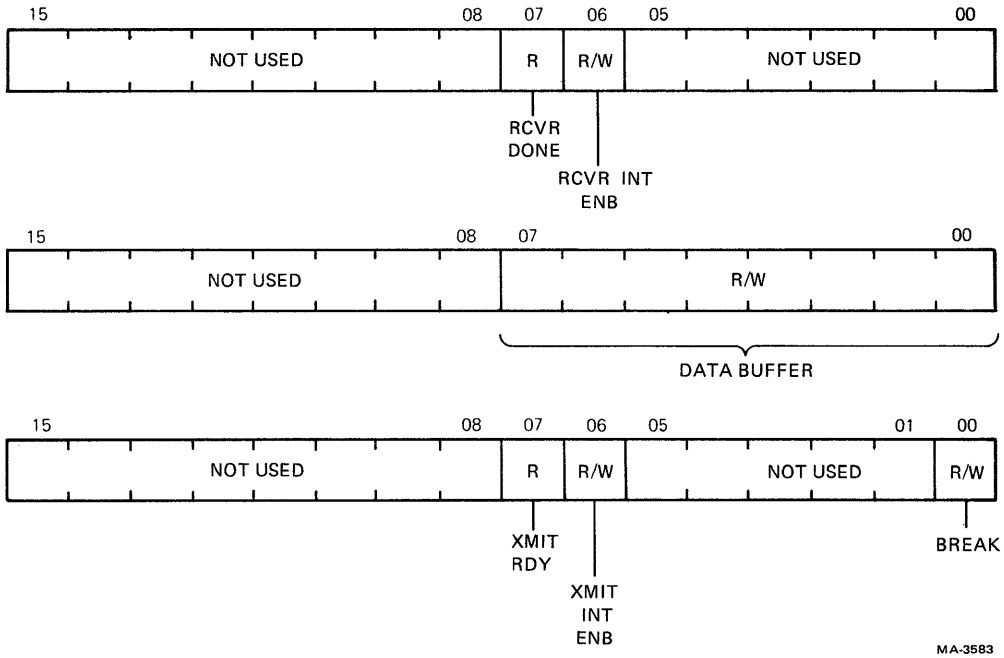




MA-3590

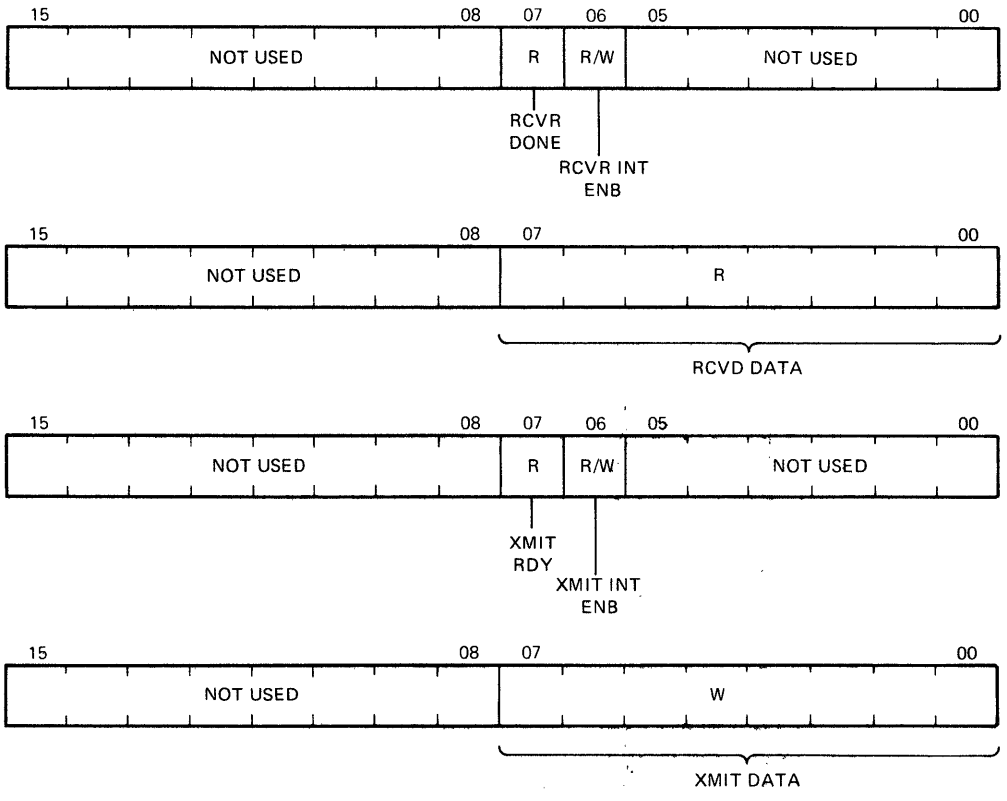
TAPE DRIVE INTERFACE REGISTERS (PDT11/130 ONLY)

MNEMONIC	ADDRESS	VECTOR
RCSR	177170	RECEIVE 260
RXBUF	177172	TRANSMIT 264
XCSR	177174	



TERMINAL #1 INTERFACE REGISTERS (OPTIONAL)

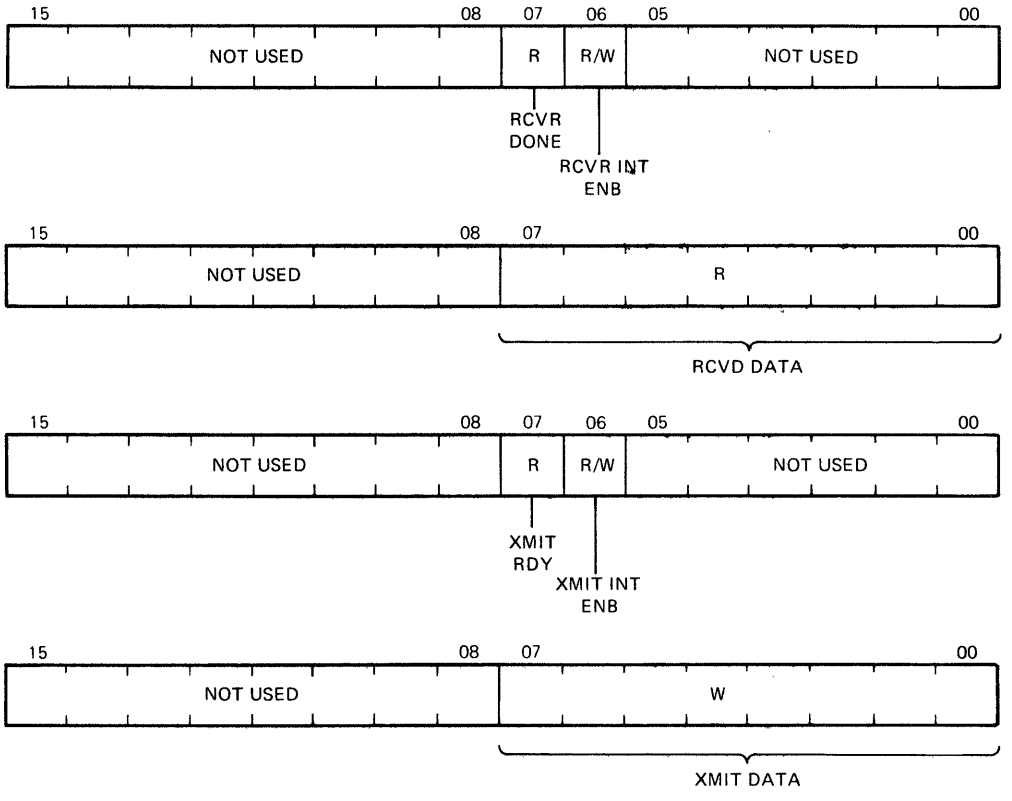
MNEMONIC	ADDRESS	VECTOR
RCSR	176500	
		RECEIVE 300
RBUF	176502	
XCSR	176540	
		TRANSMIT 304
XBUF	176506	



MA-3587

TERMINAL #2 INTERFACE REGISTERS (OPTIONAL)

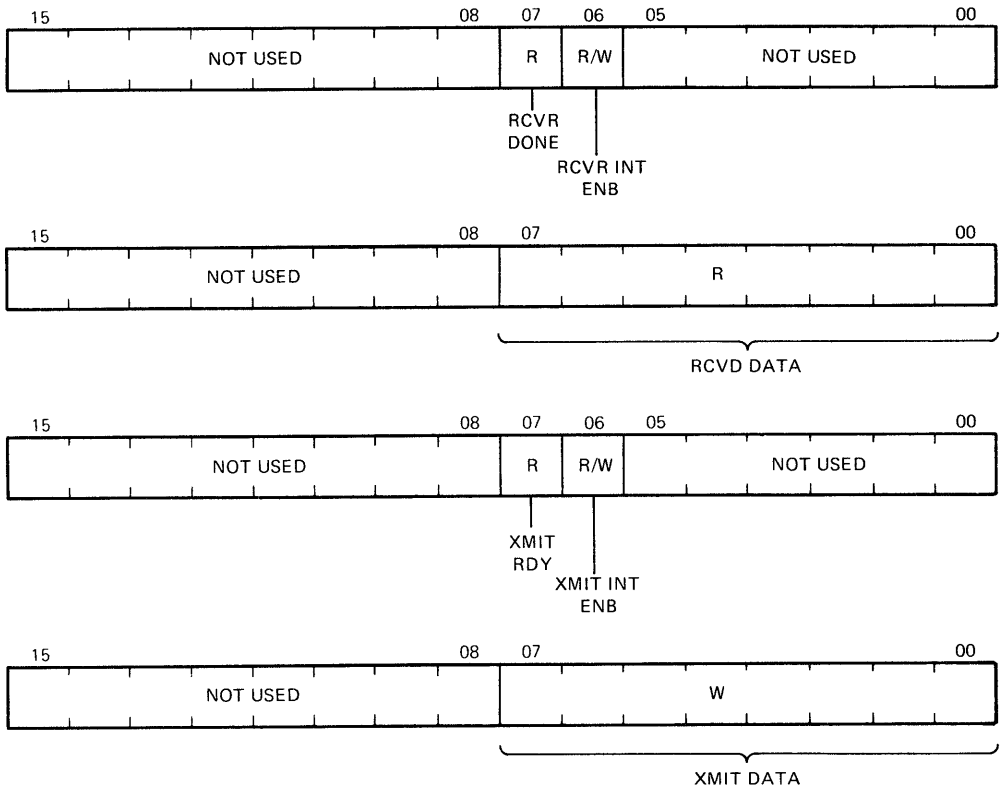
MNEMONIC	ADDRESS	VECTOR
RCSR	176510	
		RECEIVE 310
RBUF	176512	
XCSR	176514	
		TRANSMIT 314
XBUF	176516	



MA-3588

TERMINAL #3 INTERFACE REGISTERS (OPTIONAL)

MNEMONIC	ADDRESS	VECTOR
RCSR	176520	
		RECEIVE 320
RBUF	176522	
XCSR	176524	
		TRANSMIT 324
XBUF	176526	



MA-3584

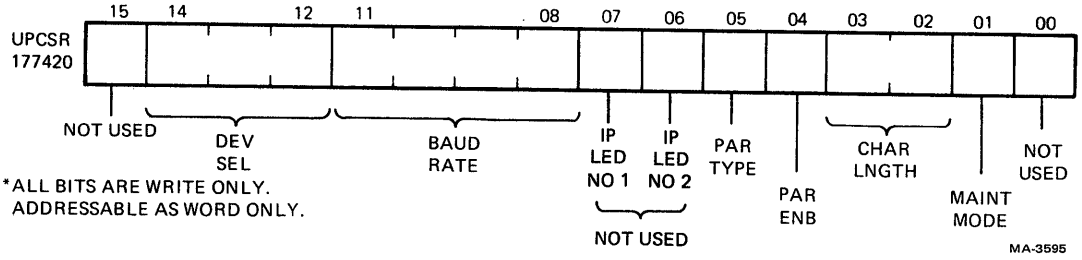


FIGURE 4-6 USART Parameter Control Register UPCSR Format

TABLE 4-3
USART Parameter Control Register, Bit Descriptions

BIT	NAME	DESCRIPTION
15	Not Used	Reserved for future use.
14-12	DEV SEL (Device Select)	Selects one of the six standard or optional device interfaces for parameter information as follows:

BITS 14 13 12	INTERFACE SELECTED
0 0 0	Cluster terminal #1 (option)
0 0 1	Console terminal*
0 1 0	Printer Terminal
0 1 1	Communications (modem)
1 0 0	Selects user lights on PDT-11 processor peripheral board
1 0 1	Cluster Terminal #2 (option)
1 1 0	Cluster Terminal #3 (option)

* Console parameters are selected by firmware, do not change these parameters.

11-08	BAUD RATE (Baud Rate)	Selects the desired transmit and receive baud rates for interface selected as follows (Split baud rates are not allowed):

BITS				BAUD RATE	BITS				BAUD RATE
11	10	09	08		11	10	09	08	
0	0	0	0	50	1	0	0	0	1800
0	0	0	1	75	1	0	0	1	2000
0	0	1	0	110*	1	0	1	0	2400
0	0	1	1	134.5	1	0	1	1	3600
0	1	0	0	150	1	1	0	0	4800
0	1	0	1	300	1	1	0	1	7200
0	1	1	0	600	1	1	1	0	9600
0	1	1	1	1200	1	1	1	1	19200

*Baud rate 110 assumes two stop bits. All other baud rates assume one stop bit.

07	LED No. 2	Internal indicator, Set to light the "2" LED on the peripheral board of the PDT-11 processor. This indicator is not visable to the operator.
06	LED No. 1	Internal indicator, Set to light the "1" LED on the peripheral board of the PDT-11 processor. This indicator is not visable to the operator.
05	PAR TYPE (Parity Type)	Selects odd or even parity when enabled by PAR ENB (bit 04) as follows: 1 = even parity 0 = odd parity
04	PAR ENB (Parity Enable)	Enables or disables parity check function as follows: 1 = enable parity 0 = disable parity

03-02	CHAR LNGTH (Character Length)	Selects the number of bits in each character transferred as follows:

BIT 03	BIT 02	CHARACTER LENGTH (BITS)
0	0	five
0	1	six
1	0	seven
1	1	eight

01	MAINT MODE (Maintenance Mode)	Set when selecting maintenance mode. Used during diagnostic programs to loop back data through the communication and cluster option interfaces. The maintenance mode can be disabled by a switch mounted on the processor peripheral board.
00	Not Used	Reserved for future use.

CONSOLE DEVICE REGISTERS

Information, is transfered between the operator and the PDT-11 processor using the console device and interface. Four registers are associated with the console device interface. The addresses and interrupt vectors assigned to these registers are listed in Table 4-4. The content and format of the registers is shown in Figure 4-7 and described in the following paragraphs.

TABLE 4-4
Console Device Addresses and Interrupt Vectors

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Receiver Control Status Register (RCSR)	177560	
		Receive 060
Receiver Data Buffer Register (RBUF)	177562	
Transmitter Control/ Status Register (XCSR)	177564	
		Transmit 064
Transmitter Data Buffer Register (XBUF)	177566	

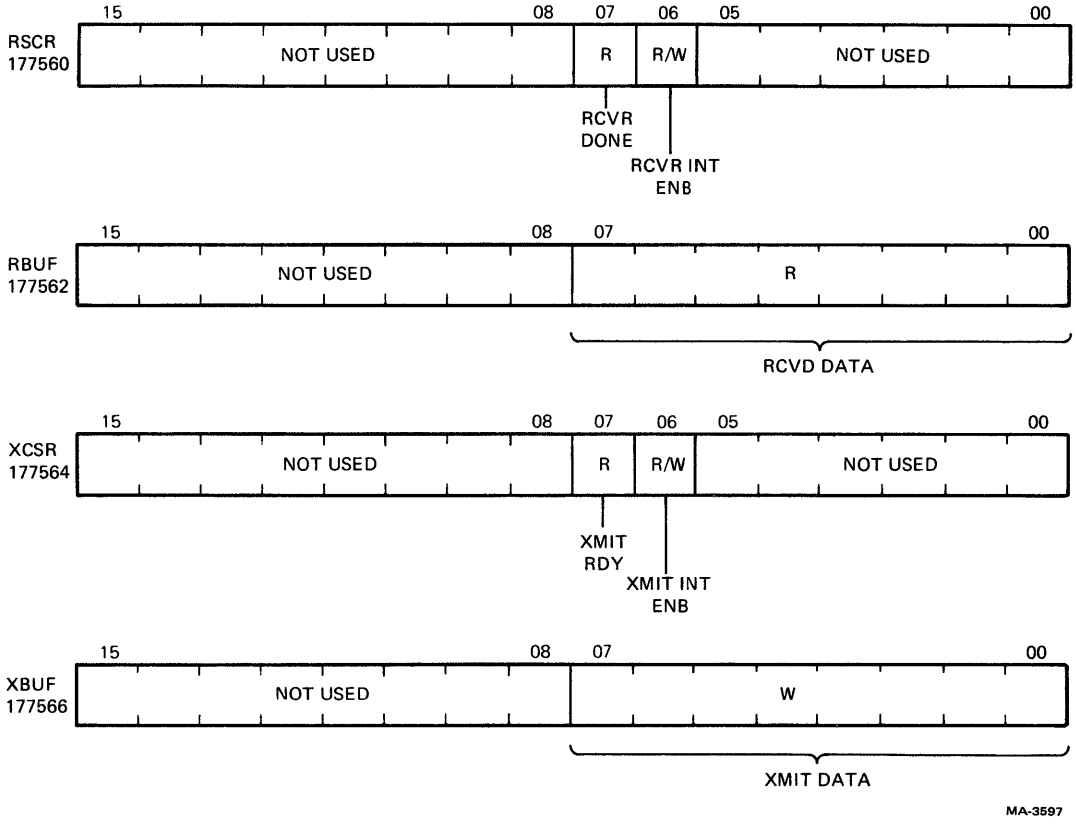


Figure 4-7 Console Device Interface Register Formats

Receiver Control/Status Register (RCSR)
The RCSR provides control and status information for data transferred to the PDT-11 processor from the console device. Table 4-5 describes the functions of the bits of the RCSR.

TABLE 4-5
Console Interface, RCSR Bit Description

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07	RCVR DONE (Receiver Done)	A read-only bit set when an incomming character is available in the receive data register (RBUF). If the RCVR INT ENB (bit 06) is set an interrupt request will be generated. Cleared by the INIT signal or when the character is read.
06	RCVR INT ENB (Receiver Interrupt Enable)	A read/write bit, set by program to allow the RCVR DONE (bit 07) to generate an interrupt request. Cleared by the INIT signal or under program control.
5-00	Not Used	Reserved for future use.

Receiver Data Buffer (RBUF)
The RBUF stores the data character received by the PDT-11 processor from the console device. Table 4-6 lists and defines the function of the bits in the RBUF.

TABLE 4-6
Console Interface, RBUF Bit Description

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	RCVD DATA (Receive Data)	Read-only bits which are the last character, from the console, assembled by the USART.

Transmitter Control/Status Register (XCSR)
The XCSR provides control and status information during information transfers from the PDT-11 processor to the console. Table 4-7 describes the functions of the bits of the XCSR.

TABLE 4-7
Console Interface, XCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07	XMIT RDY (Transmitter Ready)	A read-only bit, set when the transmit buffer is ready to accept a character. Also set by INIT signal. If the XMIT INT ENB (bit 06) is set an interrupt request will be generated. Cleared when a character is loaded into the buffer.
06	XMIT INT ENB (Transmitter Interrupt Enable)	A read/write bit set by the program to allow the XMIT RDY (bit 07) to generate an interrupt request. Cleared by the INIT signal or under program control.
05-00	Not Used	Reserved for future use.

Transmitter Data Buffer (XBUF)
The XBUF stores the data character for transmission to the console from the PDT-11 processor. Table 4-8 lists the bit assignments and describes their function.

TABLE 4-8
Console Interface, XBUF Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	XMIT DATA (Transmit Data)	Write-only bits which are the data character to be transmitted serially to the console.

LINE TIME CLOCK (LTC)
The Line Time Clock whose address and vector are shown in Table 4-9, provides a real-time indication to the program every 16.6 ms. The Line Time Clock initiates an interrupt request to provide the real time indication, when the INT ENB (bit 06) of the TCSR shown in Figure 4-8 is set. During a power up sequence, master reset or program reset instruction, the LTC is disabled by clearing the INT ENB bit. Table 4-10 defines the bits associated with the TCSR. The LTC can be disabled by a switch mounted on the PDT-11 processor peripheral board.

TABLE 4-9
Line Time Clock Device Address and Interrupt Vector

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Time Control/Status Register (TCSR)	177546	100

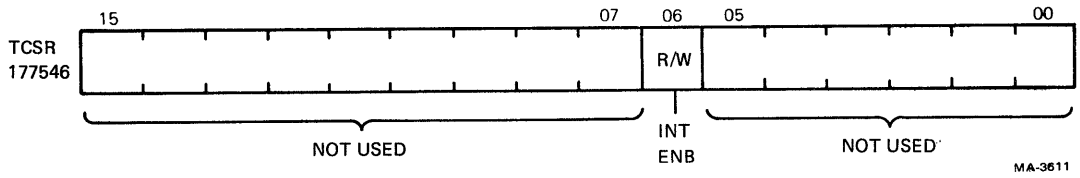


FIGURE 4-8 Line Time Clock (TCSR) Register Format

TABLE 4-10
Line Time Clock, TCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15-07	Not Used	Reserved for future use.
06	INT ENB (Interrupt Enable)	Set by the program to allow an interrupt request to be generated every 16.6 ms.
05-00	Not Used	Reserved for future use.

LINE PRINTER TERMINAL INTERFACE

The line printer terminal interface transfers EIA compatible serial line data to the printer unit at a maximum rate of 9600 baud. To prevent the loss of data when the printer buffer is full, an XOFF (023 octal) ASCII command should be issued by the printer to stop the data transfers. The XON (021 octal) ASCII command indicates that the printer buffer can accept additional data. These control codes are seen by the LSI-11 processor as a change in status of DONE (bit 07) in the LPCSR.

The addresses of the two registers, control/status register and data buffer are shown in Table 4-11. The content and format of the registers are shown in Figure 4-9 and described in the following paragraphs.

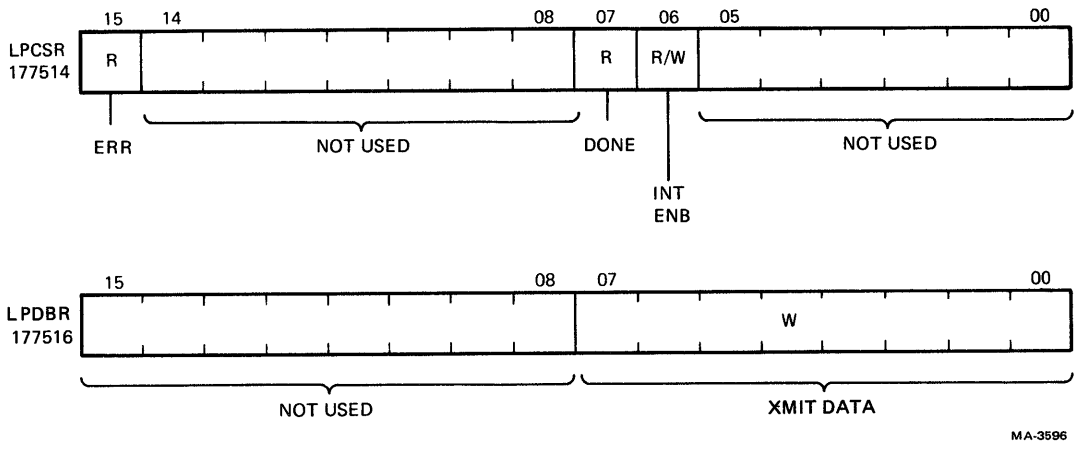


Figure 4-9 Printer Terminal Interface, Register Formats

TABLE 4-11
Line Printer Device Addresses and Interrupt Vector

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Control/Status Register (LPCSR)	177514	Transmit 200
Printer Data Buffer (LPDSR)	177516	

Line Printer Control/Status Register (LPCSR)
The word format is shown in Figure 4-9 and bits are defined in Table 4-12.

TABLE 4-12
Line Printer Interface LPCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15	ERR (Error)	A read-only bit, set when the Data Terminal Ready line (pin 20 of PDT printer port) from the printer is negated. This condition occurs when the printer terminal paper is depleted or the printer is not powered. Cleared when paper is supplied or when power is applied.
14-08	Not Used	Reserved for future use.
07	DONE (Done)	A read-only bit set when the printer is ready to accept a character. An interrupt request will be generated provided the INT ENB (bit 06) is set. The DONE bit is set by the INIT signal or when the XON control code is received. Cleared by loading a character into the data register (LPDSR) or by receiving the XOFF control code.
06	INT ENB (Interrupt Enable)	A read/write bit, set or cleared under program control. When set, an interrupt request will be generated provided the ERR (bit 15) or DONE (bit 07) is set. Cleared by the INIT signal.
05-00	Not Used	Reserved for future use.

Line Printer Data Buffer (LPDBR)
The LPDSR format is shown on Figure 4-9 and the bits are defined in Table 4-13.

TABLE 4-13
Line Printer Interface LPDBR, Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	DATA CHAR (Data Character)	Write-only bits which are the data character to be transfered to the printer (on the PDT-11 printer port pin 3). Bit 07 is the most significant bit of the 8-bit character.

PDT-11/130 TAPE DRIVE INTERFACE
The PDT-11/130 system is equipped with an integral DECtape II minicartridge tape drive which communicates with the system processor through three device registers. The addresses and interrupt vectors of these three device registers are shown in Table 4-14. Figure 4-10 shows the word format of the device registers. A description of the registers is provided in the following paragraghs.

TABLE 4-14
Tape Drive Controller Device Addresses and Interrupt Vectors

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Receiver Control/ Status Register (RCSR)	177170	
		Receive 260
Receive/Transmit Data Buffer (RXBUF)	177172	
		Transmit 264
Transmit Control/ Status Register (XCSR)	177174	

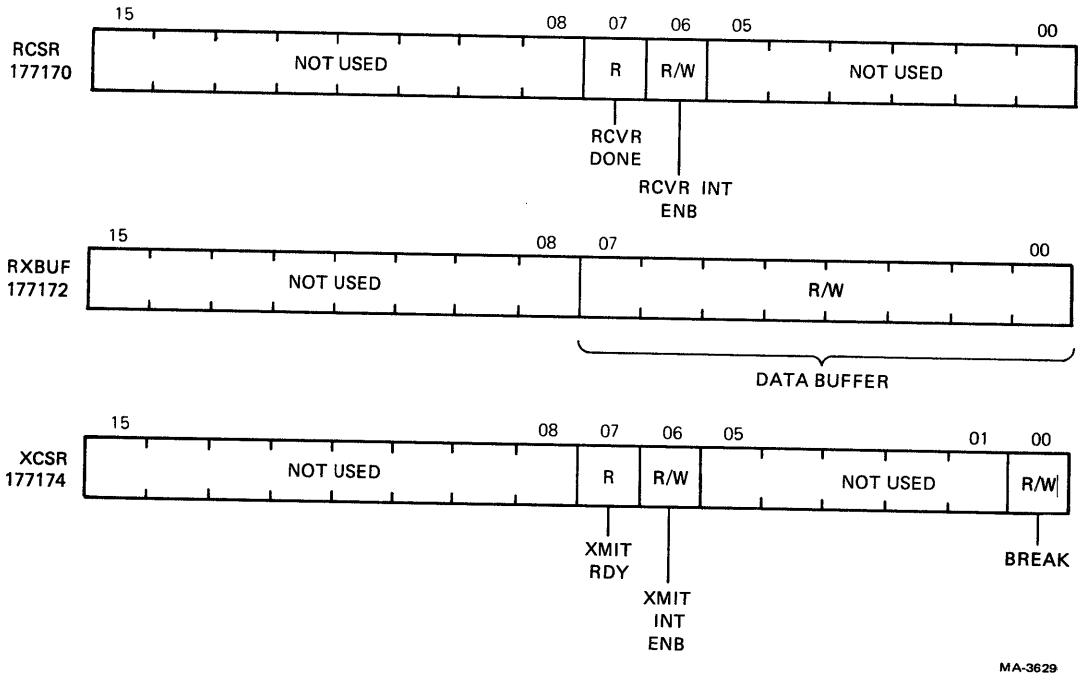


FIGURE 4-10 Tape Drive Interface Register Formats

Receiver Control/Status Register (RCSR)

The RCSR provides control and status information for data transferred to the PDT-11/130 processor from the tape drive controller. Table 4-15 describes the functions of the bits of the RCSR.

TABLE 4-15
Tape Drive Controller Interface, RCSR Bit Description

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07	RCVR DONE (Receiver Done)	A read-only bit set when an incoming character is available in the receive data register (RXBUF). If the RCVR INT ENB (bit 06) is set, an interrupt request will be generated. Cleared by the INIT signal or when the character is read.
06	RCVR INT ENB (Receiver Interrupt Enable)	A read/write bit, set by program to allow the RCVR DONE (bit 07) to generate an interrupt request. Cleared by the INIT signal or under program control.
5-00	Not Used	Reserved for future use.

Receive/Transmit Data Buffer (RXBUF)

The RXBUF on a read operation stores the data character received by the PDT-11/130 processor from the tape drive controller. The RXBUF on a write operation stores the data character for transmission to the tape drive controller from the PDT-11/130 processor. Table 4-16 lists and defines the function of the bits in the RXBUF.

TABLE 4-16
Tape Drive Controller Interface, RXBUF Bit Description

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	RCVD DATA (Receive Data)	Bits which when read are the last character, from the tape drive.
	XMIT DATA (Transmit Data)	Bits which when written are the data character to be transmitted to the tape drive.

Transmitter Control/Status Register (XCSR)
The XCSR provides control and status information during information transfers from the PDT-11/130 processor to the tape drive controller. Table 4-17 describes the functions of the bits of the XCSR.

TABLE 4-17
Tape Drive Controller Interface, XCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07	XMIT RDY (Transmitter Ready)	A read-only bit, set when the transmit buffer is ready to accept a character. Also set by INIT signal. If the XMIT INT ENB (bit 06) is set an interrupt request will be generated. Cleared when a character is loaded into the buffer.
06	XMIT INT ENB (Transmitter Interrupt Enable)	A read/write bit set by the program to allow the XMIT RDY (bit 07) to generate an interrupt request. Cleared by the INIT signal or under program control.
05-01	Not Used	Reserved for future use.
00	BREAK (Break)	A read/write bit, when set by program, . This will cause the tape drive controller to reinitialize. Cleared under program control or by the INIT signal.

COMMUNICATIONS INTERFACE
The communications (modem) interface in the PDT-11 system transmits and receives standard EIA signal levels from a Bell 103, 113, 202 or 212 data set or equivalent. The communication port contains full modem control providing the ability to operate in a wide variety of communication systems. (The PDT-11 systems can operate with dual speed modems, supervisory channels, etc.) The communications interface is programmable and may operate using either synchronous or asynchronous data transmissions. The communication may be in either a half or full duplex mode, using one of a variety of baud rates from 50 to 19200 bits per second.

ASYNCHRONOUS MODEM INTERFACE
Four registers whose addresses are shown in Table 4-18 are associated with the asynchronous communication USART. Two registers provide data control and status information during the receiver functions and two registers during transmit functions. Figure 4-11 shows the bit formats for each of the registers associated with the interface and the following paragraphs describe the purpose of each register.

TABLE 4-18
Asynchronous Communication (Modem) Device Addresses and Interrupt Vectors

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Receiver Control/ Status Register (RCSR)	176610	Receiver 330
Receiver Data Buffer (RBUF)	176612	
Transmitter Control/ Status Register (XCSR)	176614	Transmit 334
Transmitter Data Buffer (XBUF)	176616	

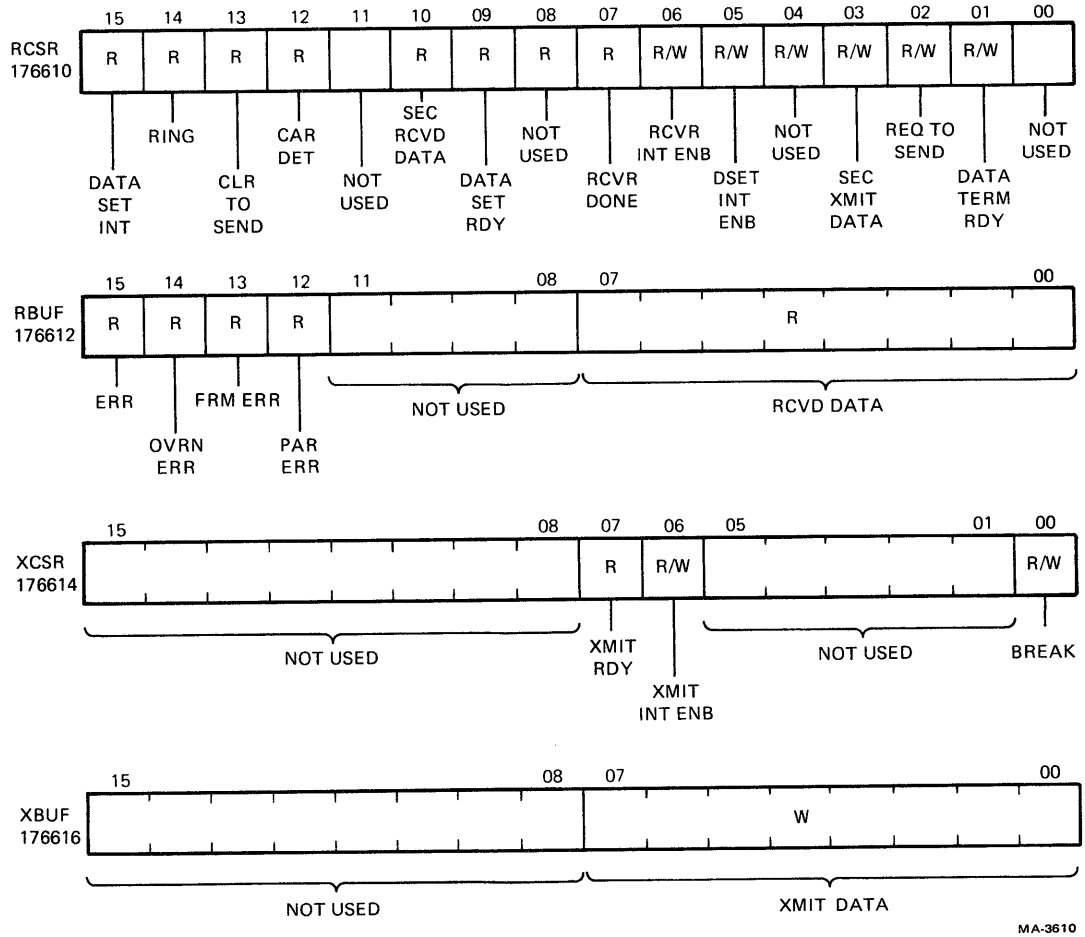


FIGURE 4-11 Asynchronous Communication Interface Register Formats

Asynchronous Receiver Control/Status Register (RCSR)
The RCSR provides control and status information during all operations. Table 4-19 lists and defines the function of each bit of the RCSR shown in Figure 4-11.

TABLE 4-19
Asynchronous Communication Interface, RCSR BIT Descriptions

BIT	NAME	DESCRIPTION
15	DATA SET CHNG (Data Set Change)	A read-only bit initiates an interrupt sequence provided the DATA SET CHNG ENB bit (05) is also set. Set whenever one or more of the following PDT-11 communication port signals changes state in a 0-to-1 or 1-to-0 transition: CAR DET (pin 8 of PDT) CLR TO SEND (pin 5 of PDT) DATA SET RDY (pin 6 of PDT) SEL CAR DET (pin 12 of PDT) Also set when RING (pin 22 of PDT) changes from 0 to 1. Cleared by the INIT signal or by reading the RCSR.
14	RING (Ring)	A read-only bit, when set, indicates that a RING signal is being received from the data set (on pin 22 of PDT comm port). The RINGING signal is an EIA control with the cycle time as shown. A change in the status of this bit will cause the DATA SET CHNG bit to be asserted.
13	CLR TO SEND (Clear to Send)	A read-only bit. Which is dependent on the state of the CLEAR TO SEND signal from the data set (received on pin 5 of PDT comm port). When set, indicates the ON Condition; when clear, indicates the OFF condition. A change in the status of this bit will cause the DATA SET CHNG bit to be asserted.
12	CAR DET (Carrier Detect)	A read-only bit. Set when the data carrier is received (received on pin 8 of PDT-11 comm port). When clear, indicates either the end of the current transmission activity or an error condition. A change in the status of this bit will cause the DATA SET CHNG bit to be asserted.
11	Not Used	Reserved for future use.

10	SEC REC (Secondary Receive) or SPEED IND (Speed Indicator)	A read-only bit that reflects the state of the Secondary Receive Line Signal Detector (Sec Car Det) pin 12 of the PDT-11 comm port. This line can be used to receive supervisory data on certain modems. As a control line, it can be used to acknowledge messages. The Secondary Receive Line Signal Detector also may be used as a control line to indicate the modem baud rate of dual speed modems. A change in the status of this bit will cause the DATA SET CHNG bit to be asserted.
09	DATA SET RDY (Data Set Ready)	A read-only bit that is a direct reflection of the Data Set Ready (or interlock) lead from the modem (received on pin 6 of PDT-11 comm port). This line, when asserted, indicates that the modem is powered up and is not in the test, talk, or dial mode. Any transition of this bit will cause the DATA SET CHNG bit to be asserted.
08	Not Used	Reserved for future use.
07	RCVR DONE (Receiver Done)	A read-only bit that is set when an entire character has been received and is ready for transfer to the LSI-11. When set, initiates an interrupt sequence provided RCVR INT ENB (bit 06) is also set. Cleared whenever the receiver buffer (RBUF) is addressed and the INIT signal.
06	RCVR INT ENB (Receiver Interrupt Enable)	A read/write bit. When set, allows an interrupt sequence to start when RCVR DONE (bit 07) is set. Cleared by the INIT signal.
05	DSET CHNG ENB (Data Set Change Enable)	A read/write bit. When set, allows an interrupt sequence to start when DATA SET CHNG (bit 15) is set. Cleared by the INIT signal.
04	Not Used	Reserved for future use.

03	SEC XMIT (Secondary Transmit) or SPEED SEL (Speed Select)	A read/write bit, which indicates the status of the Secondary Request To Send line (pin 11 of the PDT-11 comm port). Supervisory data may be transmitted on this line with certain modems. As a control line it can be used to acknowledge messages. This line can operate as a control line with dual speed modems to select a desired baud rate. Cleared by INIT.
02	REQ TO SEND (Request to Send)	A read/write bit used in the control of the data set transmitted data (pin 4 of PDT-11 comm port). Cleared by the INIT signal.
01	DTR (Data Terminal Ready)	A read/write bit. When set permits the connection of the communications channel to the data set. This signal is sent on pin 20 of PDT-11 comm port. When clear, disconnects the interface from the channel. Cleared by the INIT signal.
00	Not Used	Reserved for future use.

Asynchronous Receiver Data Buffer (RBUF)
The RBUF register stores the data bits received from the modem and indicates any error conditions associated with the data received. Table 4-20 lists and describes the bit functions shown in Figure 4-11.

TABLE 4-20
Asynchronous Communications Interface, RBUF Bit Descriptions

BIT	NAME	DESCRIPTION
15	ERR (Error)	A read-only bit that indicates an error condition is present. This bit is the "Logical OR" of OVRN ERR, FRM ERR, and PAR ERR (bits 14, 13 and 12, respectively). Whenever one of these bits is set, it causes ERR to set. This bit is not connected to the interrupt logic. Cleared when the error producing condition is removed. Error indications remain present until the next character is received, at which time the error bits are updated. Cleared by the INIT signal.

14	OVRN ERR (Overrun Error)	A read-only bit which, when set, indicates that reading of the previously received character was not completed (RCVR DONE not cleared) prior to receiving a new character. Cleared by the INIT signal.
13	FRM ERR (Framing Error)	A read-only bit which, when set, indicates that the character that was read had invalid STOP bit(s). Cleared by the INIT signal.
12	PAR ERR (Parity Error)	A read-only bit which, when set, indicates that the parity received does not agree with the expected parity. This bit is always 0 if no parity is selected.
11-08	Not Used	Reserved for future use.
07-00	RCVD DATA (Received Data)	Read-only bits which is the character just read from pin 3 of PDT-11 comm port. If less than eight bits are selected, the buffer is right-justified into the least significant bit positions. The higher unused bit or bits are read as 0's. Cleared by the INIT signal. If parity is selected for a character length less than 8 bits, bit 7 is the parity bit. No parity is present for 8 bit characters.

Asynchronous Transmit Control/Status Register (XCSR)
The XCSR provides control and status information during the transmitting of data. Table 4-21 describes the function of each bit in the register.

TABLE 4-21
Asynchronous Communications Interface, XCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07	XMIT RDY (Transmit Ready)	A read-only bit, set when the transmitter buffer is ready to accept a character. This condition initiates an interrupt sequence when the XMIT INT ENB (bit 06) is set. Also set by INIT signal.
06	XMIT INT ENB (Transmit Interrupt Enable)	A read/write bit, when set allows an interrupt sequence to start provided the XMIT RDY, bit 07, is also set. Cleared by Init.

05-01	Not Used	Reserved for future use.
00	BREAK (Break)	A read/write bit, when set by the program, transmits a continuous space character to the external device. Cleared by the INIT signal. The duration of the space character transmission must be controlled by the program using software timers.

Asynchronous Transmitter Data Buffer (XBUF)
The XBUF stores the data and control information for transmission to the line. The bit functions are described in Table 4-22 and shown in Figure 4-11.

TABLE 4-22
Asynchronous Communications Interface, XBUF Bit Descriptions

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	XMIT DATA (Transmit Character)	Write-only bits which store a data character for serial transfer to the modem on pin 2 of PDT-11 comm port. If the character is less than eight bits, it must be loaded right justified from the least significant bit. If parity is selected, the parity bit is appended to the highest order bit of the character.

SYNCHRONOUS MODEM INTERFACE
The communiication port contains two registers associated with the receive operation of the USART and two registers associated with the transmit operations. A programmable Parameter Control register is provided to specify the transmission characteristics of the synchronous mode. Figure 4-12 shows the formats for each of the five registers. The device addresses and interrupt vectors are shown in Table 4-23.

To enter the synchronous mode of operation, set the MASTER RESET bit in the Transmit Control/Status Register (TXCSR) bit 8 of the register at location 176624, (e.g., MOV #400, @ #176624) and enter the operational parameters in the PARCSR register (location 176622). The MASTER RESET bit is then cleared. Note that the USART parameter register does not affect the characteristics of the synchronous communications operation, a separate control/status register (PARCSR) is provided for this purpose.

NOTE

Changing the mode of communication is not generally performed within one installation, however, if desired ensure that all communication activity has ceased before switching communication modes.

TABLE 4-23
Synchronous Communication (Modem) Device, Addresses and Interrupt Vectors

DEVICE REGISTER	ADDRESS	INTERRUPT VECTOR
Receiver Control/ Status Register (RXCSR)	176620	Receive 340
Receiver Data Buffer (RXDBUF)	176622	
Parameter Control/ Status Register (PARCSR)	176622	
Transmitter Control/ Status Register (TXCSR)	176624	Transmit 344
Transmitter Data Buffer (TXDBUF)	176626	

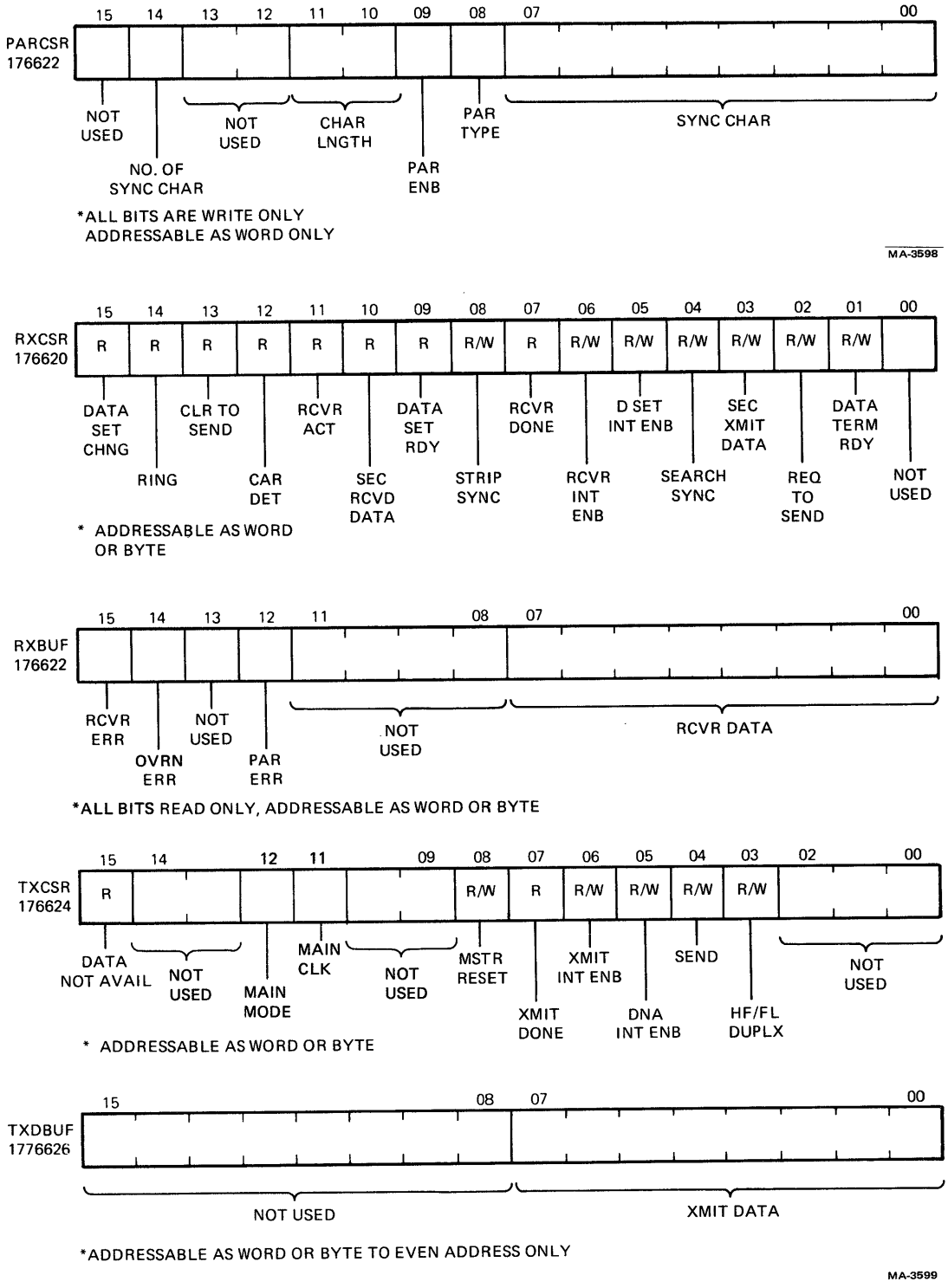


Figure 4-12 Synchronous Communications Interface Register Format

Parameter Control Register (PARCSR)
Figure 4-12 shows the word format of the PARCSR and Table 4-24 lists the bit assignments.

TABLE 4-24
Parameter Control Register, PARCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15	Not Used	Reserved for future use.
14	NO. OF SYNC CHAR (Number of Sync Characters	A write-only bit that selects either one or two sync characters as follows: 1 - selects two sync. characters 0 - selects one sync. characters
13-12	Not Used	Reserved for future use.
11,10	CHAR LNGTH (Character Length)	Write-only bits that select the number of bits associated with each character as follows: BIT 11 10 — CHARACTER LENGTH 0 0 — 5 0 1 — 6 1 0 — 7 1 1 — 8
09	PAR ENB (Parity Enable)	Enables or disables parity check function as specified by PAR TYPE (bit 08) as follows: 1 = enable parity generation 0 = disable parity generation
08	PAR TYPE (Parity Type)	A write-only bit used to select odd or even parity generation when enabled by PAR ENB (bit 09) as follows: 1 = even parity 0 = odd parity Parity is added to transmitted character and a parity check is performed on received character.

07-00	SYNC CHAR (Sync Character)	Write-only bits. Used for character synchronization prior to transmitting a serial character stream. Character format and number of characters transmitted is dependent on command mode. Refer to PARCSR register bit 14 for information on number of sync characters. The sync character will be all ones after a master reset. Character length right justified from bit 00.

Synchronous Receiver Control/Status Register (RXCSR)
The RXCSR is programmed and monitored during receive data operations. The register is addressable as a word or byte and contains control and status information from the modem. Table 4-25 lists and defines the function of each bit.

TABLE 4-25
Synchronous Communications, RXCSR Bit Descriptions

BIT	NAME	DESCRIPTION
15	DATA SET CHNG (Data Set Change)	A read-only bit, set to indicate a level transition on one of the following: ^Ring ^Secondary ^Clear to Send Received Data ^Carrier Detect ^Data Set Ready If D SET INT ENB (bit 05) is set, the level transition will cause an interrupt request by the receiver. Cleared by the INIT signal or when the RXCSR is read.
14	RING (Ring Indicator)	A read-only bit, set to indicate that a ring signal is being received from the modem (on pin 22 of PDT). Any transition of this bit will also assert the DATA SET CHNG (bit 15).
13	CLR TO SEND (Clear to Send)	A read-only bit, set to indicate that the modem is ready to receive data from the interface (received by PDT on pin 5 of the comm port). Any transition of this bit will also assert the DATA SET CHNG (bit 15).

12	CAR DET. (Carrier Detect)	A read-only bit set by the modem whenever an acceptable carrier is on the communications line (received by PDT on pin 8 of the comm port). Any transition of this bit will also assert the DATA SET CHNG (bit 15).
11	RCVR ACT. (Receiver Active)	A read-only bit that is set when the selected number of continuous sync characters (either one or two) from the modem has been received. Cleared by the INIT signal.
10	SEC RCVD DATA (Secondary Receive Data)	A read-only bit that reflects the state of the Secondary Received Data line from the modem (pin 11 of PDT comm port). Supervisory data can be received over this line when operating with some modems. As a control line, it can also be used to acknowledge a message.
	SPEED IND (Speed Indicator)	The Secondary Receive Line Signal Detector also may be used to indicate the modem baud rate of dual speed modems. Any transition of this bit will also assert the DATA SET CHNG (bit 15).
09	DATA SET RDY (Data Set Ready)	A read-only bit that reflects the state of the Data Set Ready line (pin 6 of PDT comm port) received from the modem. When asserted, the line indicates that the modem is powered up and is not in the test, talk, or dial mode. Any transition of this bit will also assert the DATA SET CHNG (bit 15).
08	STRIP SYNC. (Strip Sync.)	A read/write bit which, when set, prevents the receive characters, which match the contents of the sync register from causing an RCVR interrupt provided no errors are detected in the RXDBUF. Cleared by the INIT signal.
07	RCVR DONE (Receiver Done)	A read-only bit, normally set when a character is transferred into the receive buffer. If the character received is a sync character and the STRIP SYNC (bit 08) and RCVR ACT (bit 11) are set the RCVR DONE bit will not be asserted. Cleared by reading the RXBUF or by the INIT signal.

06	RCVR INT ENB (Receiver Interrupt Enable)	A read/write bit which, when set, allows a receiver interrupt request to be generated, provided RCVR DONE (bit 07) is set. Cleared by the INIT signal.
05	D SET INT ENB (Data Set Interrupt Enable)	A read/write bit which, when set, allows a receiver interrupt request to be generated provided the DATA SET CHNG (bit 15) is asserted. Cleared by the INIT signal.
04	SEARCH SYNC (Search Sync)	A read/write bit which, when set, enables the comparison of the received data with the sync code stored in the sync register. After the selected number of sync characters are detected (refer to PARCSR bit 14) and RCVR ACT (bit 11) is asserted. Cleared by the INIT signal.
03	SEC XMIT DATA (Secondary Transmit)	A read/write bit, which indicates the status of the Secondary Request To Send line (pin 11 of the PDT comm port). Supervisory data may be transmitted on this line with certain modems. As a control line it can be used to acknowledge messages.
	SPEED SEL (Speed Select)	This line can operate as a control line with dual speed modems to select a desired baud rate. Cleared by INIT.
02	REQ TO SEND (Request to Send)	A read/write bit which, when set, causes the request to send line (pin 4 of PDT comm port) sent to the modem to be asserted. This line is asserted prior to transmitting serial data to the modem. Cleared by the INIT signal.
01	DATA TERM RDY (Data Terminal Ready)	A read/write bit which, when set, causes the Data Terminal Ready line (pin 20 of PDT comm port) sent to the modem to be asserted. During Auto Dial and manual call origination, asserting the line maintains the established call. For Auto Answer, it allows handshaking in response to a RING signal. Cleared by the INIT signal.
00	Not Used	Reserved for future use.

Synchronous Receiver Data Buffer (RXDBUF)

The RXDBUF stores the character received from the modem and indicates error conditions associated with the received data. Table 4-26 lists and describes the function of the RXDBUF bits.

TABLE 4-26
Synchronous Communications RXDBUF Bit Descriptions

BIT	NAME	DESCRIPTION
15	RCVR ERR (Receiver Error)	A read-only bit set when either or both the PAR ERR (bit 12) and OVRN ERR (bit 14) are set. Cleared when both the PAR ERR and OVRN ERR bits are cleared.
14	OVRN ERR (Overrun Error)	A read-only bit, set to indicate a data overrun in the receiver. When the RCVR DONE (bit 07) of the RXCSR is set, the processor must read the RXDBUF within a specified time or the overrun error will occur. The time specified is: Tsec = (1/baud rate) X bits per character The detection of an overrun error will cause the RCVR ERR (bit 15) to be set. Cleared by the INIT signal or when the RXDBUF low byte is read.
13	Not Used	Reserved for future use.
12	PAR ERR (Parity Error)	A read-only bit. If parity detection is enabled, the bit is set when the parity of the received character is different from the parity selected by PAR TYPE (bit 08) of the PARCSR. A detected parity error will also set RCVR ERR (bit 15). Cleared by the INIT signal or when the RXDBUF low byte is read.
11-08	Not Used	Reserved for future use.
07-00	RCVR DATA (Receiver Data)	Read-only bits which contain the data character from the modem (received on pin 3 of PDT comm port) and are stored in the RXDBUF. Characters can be 5 to 8 bits in length and are always right justified. Parity, if selected, always appears after the most significant bit (MSB) except for 8-bit characters where no parity will be indicated. Cleared by reading low byte of RXDBUF which also clears RCVR DONE (bit 07) of the RXCSR.

Synchronous Transmit Control / Status Register (TXCSR)
The TXCSR is programmed and monitored to provide control and status operations. Table 4-27 describes the function of each bit.

TABLE 4-27
Synchronous Communications TXCSR Bit Assignments

BIT	NAME	DESCRIPTION
15	DATA NOT AVAIL (Data Not Available)	A read-only bit set to indicate a character has been transmitted from the sync register to the modem. A sync character is transmitted if a new character is not loaded into the TXDBUF within a specified time after the XMIT DONE (bit 07) is set. The time interval is: Tsec = (1/baud rate) X (bits per character - 1/2 bit time) If the DNA INT ENB (bit 05) is set when DATA NOT AVAIL is asserted, a transmitter interrupt request will be generated. Cleared by the INIT signal or when a character is transmitted.
14-09	Not Used	Reserved for future use.
08	MSTR. RESET (Master Reset)	A read/write bit which, when set, causes the receiver and transmitter to enter an idle state. The transmitter idle, state results in: 1. Internal timing is reset 2. Transmitter sync register is set to all ones (1) 3. All bits ofthe TXCSR are cleared

The receiver state results in:

1. Internal timing is reset
2. The following RXCSR bits are cleared

BIT	NAME
15	DATA SET CHNG
11	RCVR ACT
08	STRIP SYNC
07	RCVR DONE
06	RCVR INT ENB
05	DSET INT ENB
04	SEARCH SYNC
03	SEC XMIT DATA
02	REQ TO SEND
01	DATA TERM RDY

07	XMIT DONE (Transmitter Done)	A read-only bit set to indicate that the TXDBUF is ready to receive a data character. If the XMIT INT ENB (bit 06) is set when XMIT DONE is asserted, a transmitter interrupt request is generated. Cleared by the INIT signal or when the TXDBUF receives a character.
06	XMIT INT ENB (Transmitter Interrupt Enable)	A read/write bit set to allow a transmitter interrupt request to be generated when the XMIT DONE (bit 07) is asserted. Cleared by the INIT signal.
05	DNA INT ENB (Data Not Available Interrupt Enable)	A read/write bit set to allow a transmitter interrupt request to be generated when DATA NOT AVAIL (bit 15) is asserted. Cleared by the INIT signal.
04	SEND (Send)	A read/write bit, set to enable data transfer from the transmitter. The SEND bit must be asserted for the entire message or only the current character will be transferred and the transmitter will enter the idle state. Cleared by the INIT signal.

03	HF/FL DUPLEX (Half or Full Duplex)	A read/write bit used to select half or full duplex transmission. 1 = half duplex 0 = full duplex The receiver will be disabled if the SEND (bit 04) is asserted during half duplex operation.
02-00	Not Used	Reserved for future use.

Synchronous Transmit Data Buffer (TXDBUF)
The TXDBUF contains eight bits of data to be transmitted serially to the modem and is addressable as a word or byte to an even address only. The remaining eight bits in the word are not used. Table 4-28 describes the character formats for the eight data bits.

TABLE 4-28
Synchronous Communication TXDBUF Bit Assignments

BIT	NAME	DESCRIPTION
15-08	Not Used	Reserved for future use.
07-00	XMIT DATA (Transmit Data)	Write-only bits which contain the data character stored in the TXDBUF for transfer (on pin 2 of PDT comm port) to the modem. Character length is from 5 to 8 bits and right justified at bit 00. The parity bit, if enabled by PAR ENB (bit 09) of the PARCSR is appended to the last bit of the data character transferred. The INIT signal sets all ones (1) in the TXDBUF.

OPTIONAL CLUSTER TERMINALS
The Cluster option enables the PDT-11 to operate with three additional serial line devices. The interface parameters are selected by the USART Parameter Register. The register formats are identical to the console terminal as described previously.

Table 4-29 lists the device address and interrupt vector assignments for the I/O registers associated with each of the three optional devices that operate with the PDT-11. The address and vector assignments are nonchangeable.

TABLE 4-29
Cluster Terminal Addresses and Interrupt Vectors

DEVICE TYPE	ADDRESS	INTERRUPT VECTOR
TERMINAL NO. 1		
Receiver Control/ Status Register (RCSR)	176500	Receive 300
Receiver Data Buffer (RBUF)	176502	
Transmitter Control/ Status Register (XCSR)	176504	Transmit 304
Transmitter Data Buffer (XBUF)	176506	
TERMINAL NO. 2		
Receiver Control/ Status Register (RCSR)	176510	Receive 310
Receiver Data Buffer (RBUF)	176512	
Transmitter Control/ Status Register (XCSR)	176514	Transmit 314
Transmitter Data Buffer (XBUF)	176516	
TERMINAL NO. 3		
Receiver Control/ Status Register (RCSR)	176520	Receive 320
Receiver Data Buffer (RBUF)	176522	
Transmitter Control/ Status Register (XCSR)	176524	Transmit 324
Transmitter Data Buffer (XBUF)	176526	

CONSOLE PROGRAMMING CONSIDERATIONS

This section of the user guide discusses the data flow between the PDT-11 (VT100 type) console and the PDT-11 system processor. Included are the codes generated by the keyboard; the transmission protocol followed by the console; and the actions and reactions of the console when receiving control functions.

The PDT-11 console normally performs a two-part function. It is an input device to the system processor; such that, information entered through the keyboard is sent to the processor. It is simultaneously an output device for the processor; that is data coming from the processor is displayed on the video screen as shown in Figure 4-13. The transmit and receive functions of the console are totally independent. Therefore, to display keyboard entries onto the video screen, the application program must echo the characters generated by the keyboard.

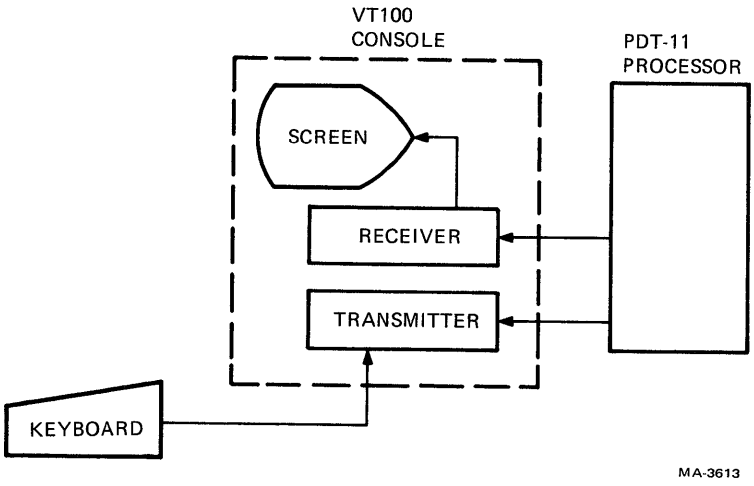


Figure 4-13 Console Data Flow

CHARACTER SETS

The console device may contain up to five character sets. Two character sets can be considered to be active at any one time. The two active character sets are designated as G0 or G1 by the select character set (SCS) sequence defined later in this section. These designations may be changed as often as required by the application program.

To select a designated character set, either G0 or G1, the SO (Shift Out 016 octal) or SI (Shift In 017 octal) control codes are used.

The standard PDT-11 console device is capable of sending and receiving (displaying) three distinct character sets, two character sets are undefined. The character sets used by the standard PDT-11 console are the United States ASCII character set (USASCII), the United Kingdom character set (UK) and a Special Graphics character set.

USASCII/UK Character Sets

The USASCII and UK character sets contain both control characters and displayable characters. The character sets differ only by one character. The "#" character of the USACII code is replaced by the "£" character of the UK character set. The USASCII and UK character sets are shown in Table 4-30.

TABLE 4-30
USASCII/UK Character Set

Octal Code	Char	Octal Code	Char	Octal Code	Char	Octal Code	Char
000	NUL	040	SP	100	@	140	`
001	SOH	041	!	101	A	141	a
002	STX	042	"	102	B	142	b
003	ETX	043	#	103	C	143	c
004	EOT	044	$	104	D	144	d
005	ENQ	054	%	105	E	145	e
006	ACK	046	&	106	F	146	f
007	BEL	047	'	107	G	147	g
010	BS	050	(	110	H	150	h
011	HT	051	)	111	I	151	i
012	LF	052	*	112	J	152	j
013	VT	053	+	113	K	153	k
014	FF	054	,	114	L	154	l
015	CR	055	-	115	M	155	m
016	SO	056	.	116	N	156	n
017	SI	057	/	117	O	157	o
020	DLE	060	0	120	P	160	p
021	DC1	061	1	121	Q	161	q
022	DC2	062	2	122	R	162	r
023	DC3	063	3	123	S	163	s
024	DC4	064	4	124	T	164	t
025	NAK	065	5	125	U	165	u
026	SYN	066	6	126	V	166	v
027	ETB	067	7	127	W	167	w
030	CAN	070	8	130	X	170	x
031	EM	071	9	131	Y	171	y
032	SUB	072	:	132	Z	172	z
033	ESC	073	;	133	[	173	{
034	FS	074	<	134	\	174	|
035	GS	075	=	135	] or ↑	175	}
036	RS	076	>	136	^	176	~
037	US	077	?	137	_ or ←	177	DEL

Special Graphics Character Set

If the Special Graphics set is selected, the graphics for ASCII/UK codes 113_8 through 176_8 will be replaced according to Table 4-31.

TABLE 4-31
Special Graphics Character Set

OCTAL CODE	GRAPHIC WITH US OR UK SET	GRAPHIC WITH "SPECIAL GRAPHICS" SET
137	—	Blank
140	\	♦ Diamond
141	a	▒ Check Board (error indicator)
142	b	HT (horizontal tab)
143	c	FF (form feed)
144	d	CR (carriage return)
145	e	LF (line feed)
146	f	° Degree symbol
147	g	± Plus/Minus ±
150	h	NL (new line)
151	i	VT (vertical tab)
152	j	┘ Lower-right corner
153	k	┐ Upper-right corner
154	l	┌ Upper-left corner
155	m	└ Lower-left corner
156	n	┼ Crossing lines
157	o	⎺ Horizontal line - Scan 1
160	p	⎻ Horizontal line - Scan 3
161	q	─ Horizontal line - Scan 5
162	r	⎼ Horizontal line - Scan 7
163	s	⎽ Horizontal line - Scan 9
164	t	├ Left "T"
165	u	┤ Right "T"
166	v	┴ Bottom "T"
167	w	┬ Top "T"
170	x	⎪ Vertical Bar
171	y	≤ Less than or equal to
172	z	≥ Greater than or equal to
173	{	π PI (mathematical)
174	|	≠ Not equal to
175	}	£ UK pound sign
176	~	· Centered dot

NOTES

Codes 152-156, 161, and 164-170 are used to draw rectangular grids; each piece of this line drawing set is contiguous with others so that the lines formed are unbroken.

Codes 157-163 give better vertical resolution then dashes and underlines when drawing graphs; using these segments 120 X 132 resolution may be obtained in 132 column mode with the Advanced Video Option installed.

CONTROL FUNCTIONS

A control function provides control of the displaying, processing, transmission and representation of data. Control functions are both sent and received by the console device. Control functions are implemented through the use of either a control character, escape sequence, control sequence and control string. In this way, the processor can command the console to move the cursor, change modes, ring the bell, select character sets, etc.

The PDT-11 console is compatible with both the previous DEC standard private control functions and the new ANSI standard control functions. Application programmers may use existing DEC software designed around the DEC private control functions or use new software generated using ANSI control functions. When using existing DEC software designed around the VT52, the console must be placed in a "VT52 compatible" mode. In this mode, the console responds to DEC private control functions like a VT52. However, most of the new features of the console can not be used with VT52 software.

Throughout this section of the user manual references will be made to "VT52 mode" or "ANSI mode". These two terms are used to indicate the console's software compatibility. New software should be designed around "ANSI mode" as future DEC terminals will not necessarily be committed to VT52 compatibility. The ANSI standards have been established to create a flexible and comprehensive system of transmitting format and editing information. The ANSI standards provide the following major advantages:

1. The standards are well defined and documented. This greatly decreases the chances of incompatible implementations.

2. The standards have ample provisions for future expansion without sacrificing compatability with older programs. The syntax used in ANSI controls allow a large number of new controls to be added with little difficulty.

3. The standards are compatible with all frequently used communication protocols. In contrast, many other standards use control codes that are reserved for communications functions. In these other standards, codes used for line turnaround, disconnect and synchronization get confused with those used to send parameter values.

Control Characters

A control character is a single character whose occurence in a particular context initiates, modifies or stops a control function. The value of a control character is in the octal range of 0 through 37 and 177.

Control Characters Generated - The console has the ability to generate all of the control characters listed in Table 4-32. These characters are generated by the operator from the console keyboard. The operator may use the CTRL key simultaniously with another key or a dedicated key. The dedicated key allows the operator to generate commonly used characters with a single key depression.

TABLE 4-32
Generated Control Characters

CONTROL CHARACTER	CHARACTER MNEUMONIC	OCTAL CODE TRANSMITTED	KEY USED WITH CTRL KEY	DEDICATED
Null	NUL	000	Space Bar	
Start Of Heading	SOH	001	A	
Start Of Text	STX	002	B	
End Of Text	ETX	003	C	
End Of Transmission	EOT	004	D	
Enquiry	ENQ	005	E	
Acknowledge	ACK	006	F	
Bell	BEL	007	G	
Back Space	BS	010	H	BACK SPACE
Horizontal Tabulation	HT	011	I	TAB
Line Feed	* LF	012	J	LINE FEED
Vertical Tabulation	VT	013	K	
Form Feed	FF	014	L	
Carriage Return	* CR	015	M	RETURN (ENTER)
Shift Out	SO	016	N	
Shift In	SI	017	O	
Data Link Escape	DLE	020	P	
Device Control 1	DC1 or XON	021	Q	
Device Control 2	DC2	022	R	
Device Control 3	DC3 or XOFF	023	S	
Device Control 4	DC4	024	T	
Negitive Acknowledge	NAK	025	U	
Synchronous Idle	SYN	026	V	
End Of Transmission Block	ETB	027	W	
Cancel Previous Word Or Character	CAN	030	X	
End Of Medium	EM	031	Y	
Substitute	SUB	032	Z	
Escape	ESC	033	!	
File Separator	FS	034	\	

Group Separator	GS	035	{	
Record Separator	RS	036	~	
Unit Separator	US	037	?	
Delete	DEL	177		DELETE

* The New Line feature of the console may alter the way in which the Line Feed and Carriage Return control characters are generated. When the New Line feature is enabled the RETURN key causes the generation of both a line feed and carriage return; when disabled the RETURN key only generates a carriage return.

  The ENTER key transmits the same codes as the RETURN key when the console is in keypad numeric mode.

The control characters are generated independently of the <SHIFT> and <CAPS LOCK> keys. There are three control characters which are generated differently than in previous DEC terminals. The generation of these control characters is shown in Table 4-33.

TABLE 4-33
NUL, RS and US Control Character Generation

CONTROL CHARACTER	CHARACTER MNEMONIC	OCTAL CODE	PDT-11 CONSOLE KEY USED	PREVIOUS DEC TERMINAL KEY USED
Null	NUL	000	Press CTRL and Space Bar	Press CTRL, SHIFT and [@ 2]
Record Separator	RS	036	Press CTRL and [~ \]	Press CTRL, SHIFT and [^ 6]
Unit Separator	US	037	Press CTRL and [? /]	Press CTRL, SHIFT and [_ -]

Control Characters Received - The control characters recognized by the console are shown in Table 4-34. All other control codes cause no action to be taken.

TABLE 4-34
Received Control Characters

CONTROL FUNCTION	FUNCTION MNEMONIC	OCTAL CODE	ACTION TAKEN
Null	NUL	000	Ignored on input (not stored in input buffer)
Enquiry	ENQ	005	Request for transmission of the answerback message.
Bell	BEL	007	Sound console bell tone from keyboard.
Back Space	BS	010	Move the cursor to the left one character position, unless it is at the left margin, in which case no action occurs.
Horizontal Tabulation	HT	011	Move the cursor to the next tab stop, or to the right margin if no further tab stops are present on the line.
Line Feed	LF	012	This code causes a line feed or a new line operation (a carriage return and line feed). When used the ANSI New Line Mode causes the reception of a line feed to be interpeted as a line feed and carriage return.
Vertical Tabulation	VT	013	Interpreted as LF.
Form Feed	FF	014	Interpreted as LF.
Carriage Return	CR	015	Move cursor to left margin on the current line.
Shift Out	SO	016	Activates G1 character set, as designated by the SCS sequence.
Shift In	SI	017	Activates GO character set as designated by the SCS sequence.
Device Control 1	DC1,XON	021	Causes console to resume transmission.

Device Control 3	DC3,XOFF	023	Causes console to stop transmitting all codes except XOFF and XON.
Cancel	CAN	030	If sent during a control or escape sequence, the sequence is immediately terminated and not executed. It also causes the error character to be displayed.
Substitute	SUB	032	Interpreted as CAN.
Escape	ESC	033	The initial delimiter of a control or escape sequence - interpert the following characters from the PDT-11 processor as a command, rather than displaying them.
Delete	DEL	177	Ignored on input (not stored in input buffer).

Control and Escape Sequence Formats

The following paragraphs define the basic elements of the control functions sequences used by the PDT-11 console. Appendix A provides detailed definitions of ANSI terms and notations used within this chapter.

^ Escape character (ESC) - The ESC control character is the initial delimiter in a sequence. It is a prefix effecting the interpretation of a limited number of contiguous characters

^ Control Sequence Introducer (CSI) - A control sequence that provides supplementary controls and is itself a prefix affecting the interpretation of a limited number of contiguous characters. In the PDT-11 the CSI is **ESC [** (octal 033 133).

^ Intermediate Character - A character whose bit combination precedes a final character in a control or escape sequence.

^ Parameter - A string of zero or more transmitted characters which represent a single value, leading zeros are ignored. The PDT-11 console uses two types of parameters:

1) Numeric Parameter (Pn) - A numeric parameter is a decimal number represented as a string of ASCII characters. The decimal numbers have a range of 0 (octal 60) to 9 (octal 71).

2) Selective Parameter (Ps) - A parameter that selects a subfunction from a specified list of subfunctions, designated by Ps. In general, a control sequence with more than one selective parameter causes the same effect as several control sequences, each with one selective parameter, e.g., CSI Psa; Psb; Pse F is identical to CSI Psa F CSI Psb F CSI Psc F.

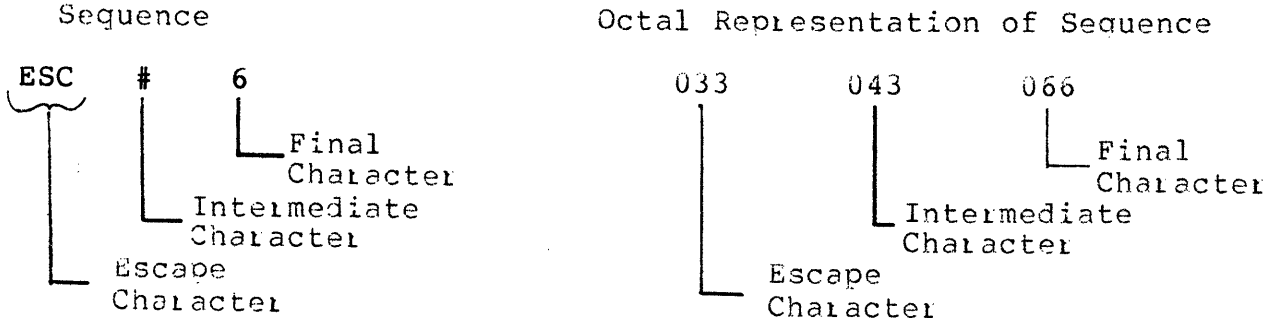
^ Default - A function-dependent value that is assumed when no explicit value, or a value of 0, is specified.

^ Delimiter - A character used to fix the boundries of an entity.

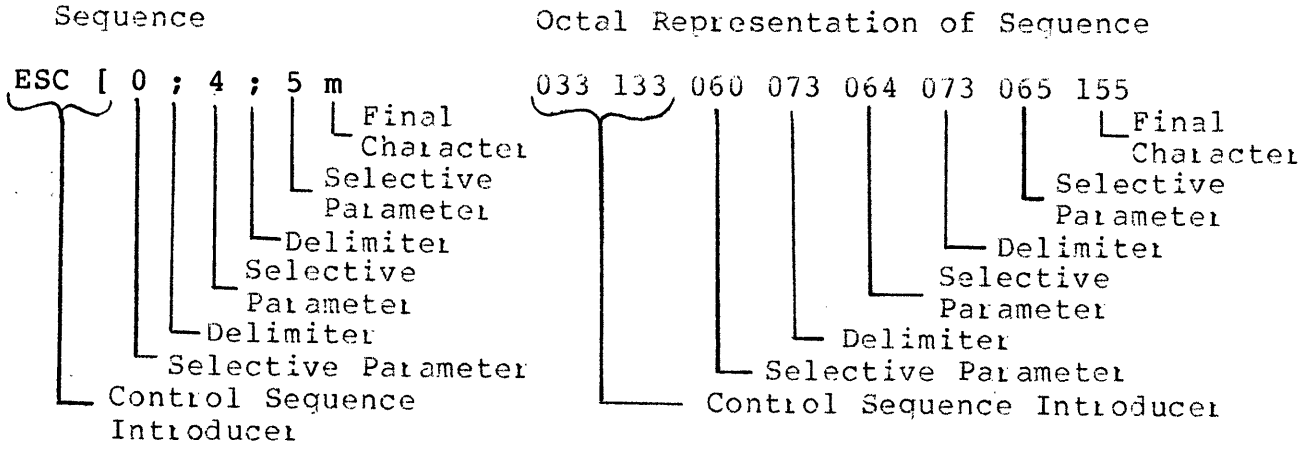
^ Final Character - A character whose bit combination terminates an escape or control sequence.

Examples:

Sequence used to create a double width line DECDWL



Sequence used to turn off all character attributes and turn on the underscore and blink character attributes.



Alternate sequences which operate as the above example:

ESC [; 4 ; m	033 133 073 064 073 115
ESC [m	033 133 115
ESC [4 m	033 133 064 115
ESC [5 m	033 133 065 115
ESC [0 ; 0 4 ; 0 0 5 m	033 133 060 073 060 064 073 060 060 065 115

In the list of control functions contained within this chapter, the graphic characters are shown using the ASCII character set. The ASCII characters are followed by the octal representation for the character used. The case of the characters sent is significant and must be sent exactly as documented. These characters are spaced apart for clarity only. The space character, octal 040, never appears in any control or escape sequence. The escape character, octal 033, is designated as ESC. Parameters are shown explicitly or are designated as Pn or Ps. The parameter characters never contain + or - signs. The "***" character is used to indicate variable parameters within the octal representation of the control sequence.

Each control and escape sequence has been assigned a mnemonic which is a short abbreviation of the name. In general, the mnemonic has been formed by taking the first letter of each significant word of the name. Control functions designated as private by ANSI and ISO code extension standards (X3.41 1974 and ISO 2022 1973, respectively) are not yet standardized. Therefore, DIGITAL has assigned functions to these sequences and prefixed their mnemonic with "DEC". All other mnemonics are specified by the ANSI standards.

Detailed Definitions Of ANSI Mode Sequences

All of the control functions used by the PDT-11 console are a subset of those specified in ANSI X 3.64 1977, ANSI X 3.4 1977 and ANSI X 3.41 1974. If a control function is received by the console that it does not support, it is ignored. The following escape and control sequences are transmitted to the console unless otherwise noted. Control functions may also be entered from the keyboard when in local mode.

The following control and escape sequences are arranged by functionality. Within each functional group the sequences are arranged in alphabetical order using the assigned mnemonic. The functional groups are as follows:

Scrolling Region
Cursor Control Commands
Line Size Commands
Erasing
Programmable Keyboard LEDs
Selecting Character Sets
Tab Stops
Modes
Reports
Confidence and Alignment
Reset

Scrolling Region - Scrolling is the upward or downward movement of existing lines on the video screen. Scrolling is performed to make room for additional lines to be added at either the top or bottom of the screen. The scrolling region is the area of the screen which may contain data. This area is defined by the top and bottom margins.

DECSTBM Set Top and Bottom Margins (DEC Private)

ESC	[	Pn	;	Pn	r
033	133	***	073	***	162

default values: see below

This control sequence sets the top and bottom margins to define the scrolling region. The first parameter is the line number of the first line in the scrolling region; the second parameter is the line number of the bottom line in the scrolling region. Default is the entire screen (no margins). The minimum size of the scrolling region allowed is two lines, i.e., the top margin must be less than the bottom margin. The cursor is placed in the home position (see origin mode DECOM in the reports section of this chapter).

Cursor Control Commands - The cursor is used to provide a visual indication of the active position (the cursor is either a blinking reverse-video or underline character). The active position is defined as the active column and active line position into which the next displayable character will be placed. The active line is the line containing the cursor; the active column is the position within the active line indicated by the cursor. The displaying of a character normally increments the active column position.

CUB Cursor Backward - Processor to Console and Console to Processor

ESC	[	Pn	D
033	133	***	104

default value : 1

The CUB sequence moves the active position to the left, the distance moved is determined by the parameter. If the parameter value is zero or one, the active position is moved one position to the left. If the parameter value is n, the active position is moved n positions to the left. If an attempt is made to move the cursor to the left margin, the cursor stops at the left margin. Editor Function.

CUD Cursor Down - Processor to Console and Console to Processor

ESC	[	Pn	B
033	133	***	102

default value : 1

The CUD sequence moves the active position downward without altering the column position. The number of lines moved is determined by the parameter. If the parameter value is zero or one, the active position is moved one line downward. If the parameter value is n, the active position is moved n lines downward. If an attempt is made to move the cursor below the bottom margin, the cursor stops at the bottom margin. Editor Function.

CUF Cursor Forward - Processor to Console and Console to Processor

ESC	[	Pn	C	defalut value : 1
033	133	***	103	

The CUF sequence moves the active position to the right, the distance moved is determined by the parameter. A parameter value of zero or one moves the active position one position to the right. A parameter value of n moves the active position n positions to the right. If an attempt is made to move the cursor to the right of the right margin, the cursor stops at the right margin. Editor Function.

CUP Cursor Position

ESC	[	Pn	;	Pn	H	default value : 1
033	133	***	073	***	110	

The CUP sequence moves the active position to the position specified by the parameters. This sequence has two parameter values, the first specifying the line position and the second specifying the column position. The parameter value of zero or one for the first or second parameter moves the active position to the first line or column in the display, respectively. The default condition with no parameters present is equivalent to a cursor to home action. In the console, this control behaves identically with its format effector counterpart, HVP. Editor Function.

The numbering of lines and columns depends on the reset or set state of the origin mode (DECOM).

CUU Cursor Up - Processor to Console and Console to Processor

ESC	[	Pn	A	default value : 1
033	133	***	101	

The CUU sequence moves the active position upward without altering the column position, the number of lines moved is determined by the parameter. A parameter value of zero or one moves the active position one line upward. A parameter value of n moves the active position n lines upward. If an attempt is made to move the cursor above the top margin, the cursor stops at the top margin. Editor Function.

DECRC Restore Cursor (DEC Private)

ESC	8
033	070

The DECRC sequence causes the previously saved cursor position, graphic rendition, and character set to be restored.

DECSC Save Cursor (DEC Private)

ESC	7
033	067

The DECSC sequence causes the cursor position, graphic rendition, and character set to be saved. (See DECRC in this section).

HVP Horizontal and Vertical Position

ESC [Pn ; Pn f **default value : 1**

033 133 *** 073 *** 146

The HVP sequence moves the active position to the position specified by the parameters. This sequence has two parameter values, the first specifying the line position and the second specifying the column. A parameter value of either zero or one causes the active position to move to the first line or column in the display, respectively. The default condition with no parameters present moves the active position to the home position. In the console this control behaves identically with its editor function counterpart, Cursor Up Position (CUP). The numbering of lines and columns depends on the reset or set state of the origin mode (DECOM). Format Effector.

IND Index

ESC D

033 104

The IND sequence causes the active position to move downward one line without changing the column position. If the active position is at the bottom margin, a scroll up is performed. Format Effector.

NEL Next Line

ESC E

033 105

The NEL sequence causes the active position to move to the first position on the next line downward. If the active position is at the bottom margin, a scroll up is performed. Format Effector.

RI Reverse Index

ESC M

033 115

The RI sequence moves the active position to the same horizontal position on the preceding line. If the active position is at the top margin, a scroll down is performed. Format Effector.

Line Size Commands - The console device has the ability to alter the contents of the active line (which contains the cursor) when one of the following sequences is received.

DECDHL Double Height Line (DEC Private)

Top Half: ESC # 3
033 043 063

Bottom Half: ESC # 4
033 043 064

These sequences cause the line containing the active position to become the top or bottom half of a double-height double-width line. The sequences must be used in pairs on adjacent lines and the same character output is sent to both lines to form a full double-height character. If the line was single-width single-height, all characters to the right of the center of the screen are lost. The cursor remains over the same character position unless it would be moved to the right of the right margin, in which case the cursor is moved to the right margin.

NOTE
The use of double wide characters reduces the number of characters per line by half.

DECDWL Double-Width Line (DEC Private)
ESC # 6
033 043 066

The DECDWL sequence causes the line that contains the active position to become double-width single-height. If the line was single-width single-height, all characters to the right of the center of the screen are lost. The cursor remains over the same character position unless it would be to the right of the right margin, in which case, it is moved to the right margin.

NOTE
The use of double wide characters reduces the number of characters per line by half.

DECSWL Single-width Line (DEC Private)
ESC # 5
033 043 065

The DECSWL sequence causes the line which contains the active position to become single-width single-height. The cursor remains on the same character position. This is the default condition for all new lines on the screen.

Character Attributes - The following sequence is used to specify the character attributes which are assigned to the characters to be displayed by the console device.

SGR Select Graphic Rendition
ESC [Ps ; ... ; Ps m **default value : 0**
033 133 *** 073 ---- 073 *** 155

Invokes the graphic rendition specified by the parameter(s). All following characters transmitted to the console are rendered according to the parameter(s) until the next occurrence of SGR.

PARAMETER (Ps)	PARAMETER MEANING
0	Attributes off
1	Bold or increased intensity
4	Underscore
5	Blink
7	Negative (reverse) image

All other parameter values are ignored.

Without the advanced video option, only one character attribute is possible as determined by the Cursor selection SET-UP feature; in that case specifying either the underscore or the reverse video (block) will activate the currently selected attribute. See the Cursor SET-UP feature in the operator chapter.

Erasing Commands - The erasing function performed by the console device allows some or all of the displayed characters to be erased (removed) from the video screen. The erasing function is invoked by the following sequences.

ED Erase in Display
ESC [Ps J **default value : 0**
033 133 *** 112

This feature erases some or all the characters in the display according to the parameter. Any complete line erased by this sequence will return that line to single-width mode.

PARAMETER (Ps)	PARAMETER MEANING
0	Erase from the active position to the end of the screen, inclusive (default)
1	Erase from start of the screen to the active position, inclusive
2	Erase all of the display - all lines are erased, changed to single-width and the cursor does not move.

EL Erase in Line
ESC [Ps K **default value : 0**
033 133 *** 113

Erases some or all characters in the active line according to the parameter.

PARAMETER (Ps)	PARAMETER MEANING
0	Erase from the active position to the end of the line, inclusive (default)
1	Erase from the start of the screen to the active position, inclusive
2	Erase all of the line, inclusive

Programmable Keyboard Indicators - The keyboard has seven light emitting diodes (LEDs) of which two are committed to the complementary ON-LINE/LOCAL function. The power on condition is implicitly shown by one of the two LEDs being on; that is, if the keyboard is connected and power is on, one of these LEDs will be on.

A third LED indicates a "keyboard locked" condition. In this condition, the keyboard has been "turned off" automatically by the console due to a full buffer or by the processor through the transmission of an XOFF to the console.

The four remaining LEDs are programmable and can be assigned any meaning for specific applications. These indicators are controlled through the use of the following sequence.

DECLL Load LEDs (DEC Private)
ESC [Ps q **default value : 0**
033 133 *** 161

Load the four programmable LED indicators on the keyboard according to the following parameter(s).

PARAMETER (Ps)	MEANING
0	Clear indicator L1 through L4
1	Light indicator L1
2	Light indicator L2
3	Light indicator L3
4	Light indicator L4

Indicator designations are shown on the keyboard.

Designating Character Sets - The console may contain up to five character sets. Two character sets can be considered active at any one time. The two active character sets are designated using the SCS sequence. These designations may be changed as often as required by the software.

SCS Select Character Set
The appropriate G0 and G1 character sets are designated from two of the five character sets of the console. The G0 and G1 sets are invoked by the control codes S1 (shift in 017 octal) and S0 (shift out 016 octal) respectively.

G0 SETS SEQUENCE	G1 SETS SEQUENCE	CHARACTER SET
ESC (A 033 050 101	ESC) A 033 051 101	United Kingdom Set
ESC (B 033 050 102	ESC) B 033 051 102	USASCII Set
ESC (0 033 050 060	ESC) 0 033 051 060	Special Graphics
ESC (1 033 050 061	ESC) 1 033 051 061	Alternate Character ROM Standard Character Set
ESC (2 033 050 062	ESC) 2 033 051 062	Alternate Character ROM Special Graphics

The United Kingdom and ASCII sets conform to the "ISO international register of character sets to be used with control functions". The other sets are private character sets. Special graphics means that the graphic characters for the codes 137_8 to 176_8 are replaced with other characters. The specified character set will be used until another SCS is received.

NOTE
Additional information concerning the SCS sequence may be obtained in ANSI standard X3.41 1974.

Tab Stops - The console device has the capability of designating one tab stop for each column position. Each tab stop may be set or cleared independently, with the cursor positioned at the proper column. Additionally, all tabs may be cleared without cursor positioning.

HTS Horizontal Tabulation Set
ESC H
033 110

Set one horizontal stop at the active position.

TBC Tabulation Clear **default value : 0**
ESC [Ps g
033 133 *** 147

PARAMETER (Ps)	PARAMETER MEANING
0	Clear the horizontal tab stop at the active position (the default case).
3	Clear all horizontal tab stops.

Any other parameter values are ignored.

Modes - The console has the ability of operating in several modes. These modes alter the format of the transmitted information, the interpretation of received information and the operation of the console.

The following modes, which are specified in the ANSI X 3.64 standards, may be considered to be permanently set, permanently reset, or not applicable, as noted. Refer to that standard for further information concerning these modes.

MODE MNEMONIC	MODE FUNCTION	STATE
CRM	Control representation	Reset
EBM	Editing boundary	Reset
ERM	Erasure	Set
FEAM	Format effector action	Reset
FETM	Format effector transfer	Reset
GATM	Guarded area transfer	NA
HEM	Horizontal editing	NA
IRM	Insertion-replacement	Reset
KAM	Keyboard action	Reset
MATM	Multiple area transfer	NA
PUM	Positioning unit	Reset
SATM	Selected area transfer	NA
SRTM	Status reporting transfer	Reset
TSM	Tabulation stop	Reset
TTM	Transfer termination	NA
VEM	Vertical editing	NA

Many modes of the console may be changed using ANSI control functions. Several of the modes, when in SET-UP mode, may be changed by the operator. The modes which may be changed by the operator or by the ANSI control functions are listed below. The appropriate ANSI control or escape sequence mneumonic is indicated in parentheses.

SET-UP FEATURE OR MACHINE MODE	CHANGEABLE USING CONTROL FUNCTIONS	CHANGABLE FROM KEYBOARD (AND MAY BE STORED IN NVR) BY THE OPERATOR
Alternate keypad mode	Yes (DECPAM/DECKPNM)	No
ANSI/VT52	Yes (DECANM)	Yes
Auto Repeat	Yes (DECARM)	Yes
Characters per line	Yes (DECCOLM)	Yes
Cursor key mode	Yes (DECCKM)	No
Interlace	Yes (DECINLM)	Yes
New Line	Yes (LNM)	Yes
Origin mode	Yes (DECOM)	No
Screen	Yes (DECSCNM)	Yes
Scroll	Yes (DECSCLM)	Yes
Tabs	Yes (HTS/TBC)	Yes
Wraparound	Yes (DECAWM)	Yes
# 3 (shifted)	Yes (SCS)	Yes

When changing one or more machine modes, the set and reset control functions are used. The general format for the set and reset control functions are shown below followed by each mode's selective parameter. A detailed description of each mode has also been provided.

RM Reset Mode
ESC [Ps ; Ps ; ... ; Ps l **default value: none**

Resets one or more console modes as specified by each selective parameter in the parameter string. Each mode to be reset is specified by a separate parameter. (See Set Mode (SM) sequence).

SM Set Mode
ESC [Ps ; ... ; Ps h **default value: none**

Causes one or more modes to be set within the console as specified by each selective parameter in the parameter string. Each mode to be set is specified by a separate parameter. A mode is considered set until it is reset by a reset mode (RM) sequence.

The following is a list of console modes which may be changed with set mode (SM) and reset mode (RM) controls.

ANSI Specified Modes

PARAMETER (Ps)	MODE MNEMONIC	MODE FUNCTION
0		Error (ignored)
20	LNM	Line feed new line mode

DEC Private Modes

PARAMETER (Ps)	MNEMONIC	MODE FUNCTION
0		Error (ignored)
1	DECCKM	Cursor Key
2	DECANM	ANSI/VT52
3	DCCOLM	Column
4	DECSCLM	Scrolling
5	DECSCNM	Screen
6	DECOM	Origin
7	DECAWM	Auto wrap
8	DECARM	Auto repeating
9	DECINLM	Interface

Any other parameter values are ignored.

DECANM ANSI/VT52 Mode (DEC Private)

Set Mode **ESC [2 h** (033 133 062 150) Reset Mode **ESC [2 l** (033 133 062 154)

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes only VT52 compatible sequences to be interpreted and executed. Refer to the VT52 Control Function section of this chapter for further details on the VT52 mode. The set state causes only ANSI "compatible" sequences to be interpreted and executed.

DECARM Auto Repeat Mode (DEC Private)

Set Mode	ESC [8 h	Reset Mode	ESC [8 l
	033 133 070 150		033 133 070 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes no keyboard keys to auto-repeat. The set state causes all keyboard keys to auto-repeat exceptthe following:

SET-UP
ESC
NO SCROLL
TAB
RETURN
ENTER
CTRL used with any other key

DECAWM Autowrap Mode (DEC Private)

Set Mode	ESC [7 h	Reset Mode	ESC [7 l
	033 133 067 150		033 133 067 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes any displayable characters received when the cursor is at the right margin to replace any previous characters there. The set state causes these characters to advance to the start of the next line, doing a scroll up if required and permitted.

DECCKM Cursor Keys Mode (DEC Private)

Set Mode	ESC [1 h	Reset Mode	ESC [1 l
	033 133 061 150		033 133 061 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. This mode is only effective when the console is in keypad application mode (see DECKPAM) and the ANSI/VT52 mode (see DECANM) is set. Under these conditions, if the cursor key mode is reset, the four cursor function keys will send ANSI cursor control commands. If cursor key mode is set, the four cursor function keys will send application functions.

The keyboard contains four keys labeled with arrows in each of four directions.

If the processor echoes these sequences back to the console device, the cursor will move one character up, down, right, or left. Table 4-35 shows the sequences generated by each key.

TABLE 4-35
Cursor Control Key Codes

ANSI MODE AND CURSOR KEY MODE SET	ANSI MODE AND CURSOR KEY MODE RESET	CURSOR KEY ARROW
ESC O A 033 177 101	ESC [A 033 133 101	Up
ESC O B 033 177 102	ESC [B 033 133 102	Down
ESC O C 033 133 103	ESC [C 033 133 103	Right
ESC O D 033 133 104	ESC [D 033 133 104	Left

DECCOLM Column Mode (DEC Private)

Set Mode					Reset Mode				
	ESC	[	3	h		ESC	[	3	l
	033	133	063	150		033	133	063	154

This is a private parameter applicable to the set mode (SM) and reset mode (RM) sequences. The reset mode allows a maximum of 80 columns on the screen; the set mode allows a maximum of 132 columns on the screen.

DECINLM Interlace Mode (DEC Private)

Set Mode					Reset Mode				
	ESC	[	9	h		ESC	[	9	l
	033	133	071	150		033	133	071	154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state (non-interlace) causes the video processor to display 240 scan lines per frame. The (interlace) set state causes the video processor to display 480 scan lines per frame. There is no increase in character resolution.

DECKPAM Keypad Application Mode (DEC Private)
ESC =
033 075

The Keypad Application Mode is useful to distinguish between the pressing of a key on the auxiliary keypad and the pressing of a key on the main keyboard. The PDT-11 processor can send the console a command to place it in Keypad Application Mode. In Keypad Application Mode all keys on the auxiliary keypad cause the generation of sequences which may be used by the application program for user-defined functions.

The auxiliary keypad keys transmit control sequences as defined in Table 4-36. None of the keys are affected by pressing the SHIFT , CAPS LOCK or CTRL keys.

TABLE 4-36
ANSI Application Mode Keypad Codes

ANSI MODE AUXILIARY KEYPAD CODES	SYMBOL ON KEY
ESC O p 033 117 160	0
ESC O q 033 117 161	1
ESC O r 033 117 162	2
ESC O s 033 117 163	3
ESC O t 033 117 164	4
ESC O u 033 117 165	5
ESC O v 033 117 166	6
ESC O w 033 117 167	7
ESC O x 033 117 170	8
ESC O y 033 117 171	9

ESC O m 033 117 155	-
ESC O l 033 117 154	,
ESC O n 033 117 156	.
ESC O M 033 117 115	ENTER
ESC O P 033 117 120	PF1
ESC O Q 033 117 121	PF2
ESC O R 033 117 122	PF3
ESC O S 033 117 123	PF4

NOTE

ANSI mode, if the codes are echoed back to the console, or if the console is in local mode, the last character of the sequence will be displayed on the screen; e.g., PF1 will display a "P".

DECKPNM Keypad Numeric Mode (DEC Private)
ESC >
033 076

The auxiliary keypad keys will send ASCII codes corresponding to the characters shown in Tables 4-37.

The keys on the auxiliary keypad transmit the codes for the numeric, comma and decimal point when the console is placed in Keypad Numeric Mode. The processor cannot tell if these keys were typed on the auxiliary keypad as opposed to the numeric, comma and decimal point keys on the main keyboard. In addition, the key labeled ENTER transmits the same code as the RETURN key (either a CR or CR LF). Therefore, programs which require considerable numeric data entry need not be rewritten to use the auxiliary keypad.

None of the keys are affected by pressing the SHIFT, CAPS LOCK or CTRL keys.

TABLE 4-37
ANSI Numeric Mode Keypad Codes

ANSI MODE AUXILIARY KEYPAD CODES	SYMBOL ON KEY
060	0
061	1
062	2
063	3
064	4
065	5
066	6
067	7
070	8
071	9
055	-
054	,
056	.
Same as RETURN	ENTER
ESC O P 033 117 120	PF1
ESC O Q 033 117 121	PF2
ESC O R 033 117 122	PF3
ESC O S 033 117 123	PF4

NOTE

In ANSI mode, if the codes are echoed back to the console, or if the console is in local mode, the last character of the sequence will be displayed on the screen; e.g., PF1 will display a "P".

DECOM Origin Mode (DEC Private)

Set Mode	ESC [6 h	Reset Mode	ESC [6 l
	033 133 066 150		033 133 066 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes the origin to be at the upper-left character position on the screen. Line and column numbers are, therefore, independent of current margin settings.

The cursor may be positioned outside the margins with a cursor position (CUP) or horizontal and vertical position (HVP) control.

The set state causes the origin to be at the upper-left character position within the margins. Line and column numbers are therefore relative to the current margin settings. The cursor is not allowed to be positioned outside the margins.

The cursor is moved to the new home position when this mode is set or reset.

Lines and columns are numbered consecutively, with the origin being line 1, column 1.

DECSCLM Scrolling Mode (DEC Private)

Set Mode	ESC [4 h	Reset Mode	ESC [4 l
	033 133 064 150		033 133 064 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes scrolls to "jump" instantaneously. The set state causes scrolls to be "smooth" at a rate of six lines per second.

DECSCNM Screen Mode (DEC Private)

Set Mode	ESC [5 h	Reset Mode	ESC [5 l
	033 133 065 150		033 133 065 154

This is a private parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes the screen to be black with white characters. The set state causes the screen to be white with black characters.

LNM New Line Mode

Set Mode	ESC [2 0 h	Reset Mode	ESC [2 0 l
	033 133 062 060 150		033 133 062 060 154

This is a parameter applicable to set mode (SM) and reset mode (RM) sequences. The reset state causes the interpretation of the line feed (LF), defined in ANSI Standard X3.4 1977, to imply only vertical movement of the active position and causes the return key (CR) to send the single code CR. The set state causes the LF to imply movement to the first position of the following line and causes the return key to send the two codes (CR, LF). This is the New Line (NL) option.

This mode does not affect the index (IND), or next line (NEL) format effectors.

Reports - The console device has the ability to generate reports to indicate the types of options installed, cursor information, console status and console parameters. The console parameter report may be solicited or unsolicited by the PDT-11 processor. The unsolicited reports are enabled by requesting a parameter report using the proper selective parameter. See the detailed definitions held under the DECREQTPARM report. Unsolicited reports are generated when the console leaves SET-UP mode.

CPR Cursor Position Report - Console to Processor

ESC	[	Pn	R	default value : 1
033	133	***	122	

The CPR sequence reports the active position by means of the parameters. This sequence has two parameter values, the first specifying the vertical line and the second specifying the horizontal column. The default condition with no parameters present or parameters of 0, is equivalent to a cursor at home position.

The numbering of lines and columns depends on the reset or set state of the origin mode (DECOM).

This sequence is solicited by the device status report (DSR).

DA Device Attributes
ESC [Pn c **default value : 0**

1. The processor requests the console to send a device attributes (DA) sequence to identify itself. This form is derived by the DA sequence with either no parameter or a parameter of 0 (processor to console).

2. Response to the request described above (console to processor) by the console as a DA sequence with the numeric parameters listed as follows:

OPTION PRESENT	SEQUENCE SENT
No options	**ESC [? 1 ; 0 c** 033 133 077 061 073 060 143
Processor option (STP)	**ESC [? 1 ; 1 c** 033 133 077 061 073 061 143
Advanced video option (AVO)	**ESC [? 1 ; 2 c** 033 133 077 061 073 062 143
AVO and STP	**ESC [? 1 ; 3 c** 033 133 077 061 073 063 143
Graphics processor option (GPO)	**ESC [? 1 ; 4 c** 033 133 077 061 077 064 143
GPO and AVO	**ESC [? 1 ; 6 c** 033 133 077 061 077 066 143
GPO, STP, and AVO	**ESC [? 1 ; 7 c** 033 133 077 064 073 067 143

DECID Identify Terminal (DEC Private)
ESC Z
033 132

This sequence causes the same response as the ANSI device attributed (DA). This sequence may not be supported in future DEC terminals, therefore, DA should be used by any new software.

DECREPTPARM Report Terminal Parameters
ESC [<sol> ; <par> ; <nbits> ; <xspeed> ; <rspeed> ;
033 133 *** 073 *** 073 *** 073 *** 073 *** 073

<clkmul> ; <flags> x
*** 073 *** 170

These sequence parameters are explained in the DECREQTPARM sequence.

DECREQTPARM Request Terminal Parameter
ESC [<sol> x
033 133 *** 170

The sequence DECREPTPARM is sent by the console controller to notify the processor of the status of selected console parameters. The status sequence may be sent when:

1) requested by the processor. DECREPTPARM is sent by the console upon receipt of a DECREQTPARM.

2) the console exits SET-UP mode. This is an unsolicited DECREPTPARM report which must be enabled by the system processor as discussed below.

The <XXXX> representation is used to indicate a sequence numeric parameter as follows:

PARAMETER	ASCII CHARACTER	MEANING
<sol>	0 or none	This message is a request (DECREQTPARM) and the console will be allowed to send unsolicited reports.
	1	This message is a request; from now on the console may only report in response to a request.
	2	This message is a report (DECREPTPARM).
	3	This message is a report and the console is only reporting on request.
<par>	1	No parity set
	4	Parity is set and odd
	5	Parity is set and even
<nbits>	1	8 bits per character
	2	7 bits per character
<xspeed>		Bits per second

<rspeed>	8	50
	16	75
	24	110
	32	134.5
	40	150
	56	300
	64	600
	72	1200
	80	1800
	96	2400
	104	3600
	112	4800
	120	9600
	128	19200
<clkmul>	1	The bit rate multiplier is 16.
<flags>	0-15	This value communicates four bits to the option. These bits may be assigned in an STP device dependent fashion. The default value for these four bits is 0.

DSR Device Status Report
ESC [Ps n **default value : 0**
033 133 *** 156

Requests and reports the general status of the console according to the following parameter(s).

PARAMETER (Ps)	PARAMETER MEANING
0	Response from console - Ready, No malfunctions detected (default)
3	Response from console - Malfunction-retry
5	Command from processor - Please report status (using a DSR control sequence)
6	Command from processor - Please report active position (using a CPR control sequence)

DSR with a parameter value of 0 or 3 is always sent as a response to a requesting DSR with a parameter value of 5.

Confidence and Alignment Tests - The console is equipped with several tests used to isolate hardware failures in the serial line interface drivers. Also included is a command used to align and focus the screen. These tests have been provided for the terminal service representative.

DECTST Invoke Confidence Test
ESC [2 ; Ps y
033 133 062 073 *** 171

Ps is the parameter indicating the test to be done. Ps is computed by taking the weight indicated for each desired test and adding them together.

TEST	WEIGHT
Power up self-test (ROM checksum, RAM, NVR, and keyboard)	1
Data loop back	2 (loop-back connector required)
EIA modem control test	4 (loop-back connector required)
Repeat selected test(s) indefinitely	8

DECALN Screen Alignment Display (DEC Private)
ESC # 8
033 043 070

This command fills the entire screen area with uppercase Es for screen focus and alignment. This command is used by DEC manufacturing and Field Service personnel.

Reset - The reset command is used to initiate a power up sequence.

RIS Reset To Initial State
ESC c
033 143

Reset the PDT-11 system to its initial state, i.e., the state it has after it is powered on. This also causes the execution of the power-up self-test and signal INIT H to be asserted briefly.

NOTE
This sequence will distroy the contents of console volatile memory and PDT-11 processor memory.

Detailed Description Of VT52 Mode Seqences

The following sequences are arranged by functionality. Within each functional group the sequences are arranged in alphabetical order using the assigned mnemonic. The functional groups are as follows:

Cursor Control Commands
Erasing
Modes
Reports

Cursor Control Commands - The cursor is used to provide a visual indication of the active position (the cursor is either a blinking reverse-video or underline character). The active position is defined as the active column and active line position into which the next displayable character will be placed. The active line is the line containing the cursor; the active column is the position within the active line indicated by the cursor. The displaying of a character normally increments the active column position. Table 4-38 lists the sequences generated by the cursor control keys of the console keyboard.

TABLE 4-38
VT52 Cursor Control Key Codes

CODES	CURSOR KEY (ARROW)
ESC A 033 101	Up
ESC B 033 102	Down
ESC C 033 103	Right
ESC D 033 104	Left

Cursor Up
ESC A
033 101

Move the active position upward one position without altering the horizontal position. If an attempt is made to move the cursor above the top margin, the cursor stops at the top margin.

Cursor Down
ESC B
033 102

Move the active position downward one position without altering the horizontal position. If an attempt is made to move the cursor below the bottom margin, the cursor stops at the bottom margin.

Cursor Right
ESC C
033 103

Move the active position to the right. If an attempt is made to move the cursor to the right of the right margin, the cursor stops at the right margin.

Cursor Left
ESC D
033 104

Move the active position one position to the left. If an attempt is made to move the cursor to the left of the margin, the cursor stops at the left margin.

Cursor to Home
ESC H
033 110

Move the cursor to the home position.

Reverse Line Feed
ESC I
033 111

Move the active position upward one position without altering the column position. If the active position is at the top margin (on line 1), a scroll down is performed.

Direct Cursor Address
ESC Y Pn Pn
033 131 *** ***

Move the cursor to the specified line and column. The line and column numbers are sent as ASCII codes whose values are the number plus 037_8; e.g., 040_8 refers to the first line or column, 050_8 refers to the eighth line or column, etc.

Erasing Commands - The erasing function performed by the console device allows some or all of the displayed characters to be erased (removed) from the video screen. The erasing function is invoked by the following sequences.

Erase to End of Screen
ESC J
033 112

Erase all characters from the activity position to the end of the screen. The active position is not changed.

Erase to End of Line
ESC K
033 113

Erase all characters from the active position to the end of the current line. The active position is not changed.

Modes - In VT52 mode, the console may operate in either numeric mode (out of keypad application mode) or in keypad application mode.

Enter Alternate Keypad Mode
ESC =
033 075

The optional auxiliary keypad keys will send unique identifiable sequences for use by applications programs as shown in Table 4-39.

TABLE 4-39
VT52 Alternate Keypad Mode Key Codes

CHARACTER	SYMBOL ON KEY
ESC ? p 033 077 160	0
ESC ? q 033 077 161	1
ESC ? r 033 077 162	2
ESC ? s 033 077 163	3
ESC ? t 033 077 164	4

ESC ? u 033 077 165	5
ESC ? v 033 077 166	6
ESC ? w 033 077 167	7
ESC ? x 033 077 170	8
ESC ? y 033 077 171	9
ESC ? m 033 077 155	-
ESC ? l 033 077 154	,
ESC ? n 033 077 156	.
ESC ? M 033 077 115	ENTER
ESC P 033 120	PF1
ESC Q 033 121	PF2
ESC R 033 122	PF3
ESC S 033 123	PF4

Exit Alternate Keypad Mode
ESC >
033 076

The optional auxiliary keypad keys send the ASCII codes for the functions or characters engraved on the key as shown in Table 4-40.

TABLE 4-40
VT52 Numeric Mode Keypad Codes

CHARACTERS SENT	SYMBOL ON KEY
060	0
061	1
062	2
063	3
064	4
065	5
066	6
067	7
070	8
071	9
055	-
054	,
056	.
Same as RETURN	ENTER
ESC P 033 120	PF1
ESC Q 033 121	PF2
ESC R 033 122	PF3
ESC S 033 123	PF4

Enter ANSI Mode
ESC <
033 074

All subsequent control functions will be interpreted according to the ANSI Standard X 3.64. The VT52 control functions defined in this section will not be recognized.

Reports - The console, when in VT52 mode, has the ability to identify itself by transmitting a sequence in response to the identify request.

Identify
ESC Z
033 132

This sequence causes the console to send its identifier escape sequence to the processor. This sequence is:

ESC / Z
033 057 132

NOTE
Information regarding options must be obtained in ANSI mode, using the device attributes (DA) sequence.

FULL DUPLEX SYNCHRONIZATION

The console exchanges EIA compatible serial line data with the PDT-11 processor at a transmission speed of 4800 baud. The console stores incoming characters in a 64-character buffer and processes them on a first-in/first-out basis. However, the console may not be able to keep up with the processing of incoming data, therefore, when the contents of the buffer reaches 32 characters, the console will transmit the XOFF or DC3 (023_8) control code. When receiving this control code, the PDT-11 processor should suspend the transmission of chaiaters to the console. Eventually, if the processor stops transmitting, the console will process characters out of the buffer until 16 characters remain in the buffer. At that time, the console will transmit the XON or DC1 (021_8) control code to signal the PDT-11 processor that character transmission may resume. If the processor fails to respond to the XOFF control code from the console in a timely manner, the buffer will continue to fill. When the 64-character capacity of the buffer is exceeded, the console interface will discard incoming characters and the error character (■) will be displayed on the video screen.

The PDT-11 processor must respond to the XOFF or DC3 (023_8) control code in 30.2 mseconds to prevent the overflow of the console buffer thus causing a loss of data.

The XOFF/XON synchronization scheme has an advantage over requiring the processor to insert delays or filler characters in its data stream. Requiring a minimum of software support, XON/XOFF synchronization ensures that every character or command sent to the console will be processed in the correct order. It frees interface programs from all timing considerations and results in more reliable system operation.

In addition to the buffer-filled condition, there are two other means of transmitting XOFF and XON; the <NO SCROLL> key and the <CTRL> <S>/<CTRL> <Q> key sequences. The XON/XOFF feature will coordinate these three sources of XOFF and XON so that the desired effect occurs. For example, if the buffer-filling condition has caused an XOFF to be sent, and then the operator types the <NO SCROLL> key, a second XOFF is not sent. Instead of sending an XON when the silo empties, the console waits until the operator types the <NO SCROLL> key again before sending XON.

Use of <CTRL> <S> and <CTRL> <Q> will also be synchronized with the <NO SCROLL> key.

If the operator transmits an XOFF to the processor (by <CTRL> <S> or <NO SCROLL> keys), the processor cannot echo any further code transmission until the operator transmits an XON (by <CTRL> <Q> or <NO SCROLL> keys).

The console also recognizes received XOFF and XON control codes. Reception of the XOFF code will inhibit the console from transmitting any codes except XOFF and XON. After the receiving an XOFF code, three to seven keystrokes on the keyboard can be stored in a keyboard buffer (some keys transmit two or three codes, e.g., cursor controls) before the keyboard buffer is filled. When the keyboard buffer overflows, keyclicks will stop and the KYB LOCKED indicator will be turned on. The transmission of characters is resumed upon reception of the XON code.

PDT-11/130 TAPE DRIVE PROGRAMMING CONSIDERATIONS

The TU58 DECtape II tape drive is a mass storage device used by the PDT-11/130 system to provide random access of block addressable data. The mass storage tape system uses fixed length data blocks on preformatted tape cartridges. Each cartridge contains 262 kbytes of data in 512 byte blocks. The data blocks are accessed by the PDT-11 processor using a high level instruction set which removes primitive tape handling considerations from the LSI-11 processor. The TU58 controller uses a dedicated microprocessor to control all tape handling with firmware subroutines activated by strings of command bytes. These command strings adhere to Radial Serial Protocol (RSP) specifications (explained later in this section) and contain the numerical code for the operation to be performed as well as the location and size of the data files to be transfered, if applicable.

RADIAL SERIAL PROTOCOL (RSP)

Radial Serial Protocol is a byte oriented high level message protocol used to transfer error free data between a processor and peripheral device. This protocol provides an envelope used by the PDT-11 processor and the TU58 tape drive to transfer data and commands.

MESSAGE PACKETS

All communication between the tape drive controller and PDT-11 processor are broken up into message packets, which are groups of bytes arranged in a fixed order. The type of message packet determines the position of the bytes within the packet as well as the meaning of each individual byte. There are three general categories of Radial Serial Protocol message packets: command packets, data packets and single byte command packets.

A data transfer operation uses three or more message packets. The first packet is the command packet sent from the PDT-11 processor to the tape drive controller identifying the type of transaction to be performed, i.e. read or write. Next, the data is transferred in 128 byte packets. After all data is transferred, the tape controller sends an end command packet to the PDT-11 processor indicating the status of the operational data (successful, unsuccessful, etc.). If the tape drive controller encounters a failure before all data has been transferred, the end packet is sent as soon as the failure occurs. The end packet informs the PDT-11 processor of the error condition which has been detected.

A summary of the message packet formats used in the Radial Serial Protocol are shown in Figure 4-14.

COMMAND MESSAGE PACKET

BYTE NUMBER	MNEMONIC
0	FLAG BYTE
1	MESSAGE BYTE COUNT
2	INSTRUCTION-OP CODE-
3	INSTRUCTION MODIFIER
4	UNIT NUMBER
5	
6	-NOT USED (ALWAYS ZERO)
7	
8	DATA BYTE COUNT (LOW)
9	DATA BYTE COUNT (HIGH)
10	BLOCK NUMBER (LOW)
11	BLOCK NUMBER (HIGH)
12	CHECKSUM (LOW)
13	CHECKSUM (HIGH)

END MESSAGE PACKET

BYTE NUMBER	MNEMONIC
0	FLAG BYTE
1	MESSAGE BYTE COUNT
2	INSTRUCTION-OP CODE-
3	SUCCESS CODE
4	UNIT NUMBER
5	
6	-NOT USED (ALWAYS ZERO)
7	
8	DATA BYTE COUNT (LOW)
9	DATA BYTE COUNT (HIGH)
10	SUMMARY STATUS (LOW)
11	SUMMARY STATUS (HIGH)
12	CHECKSUM (LOW)
13	CHECKSUM (HIGH)

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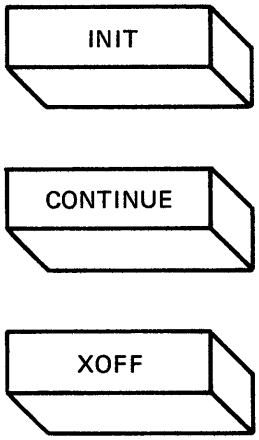
Figure 4-14a Serial Message Packet Summary

SINGLE BYTE COMMANDS



DATA MESSAGE PACKET

BYTE NUMBER	MNEMONIC
0	FLAG BYTE
1	BYTE COUNT
2	FIRST DATA BYTE
—	
—	
—	
—	
M	
M+1	LAST DATA BYTE
M+2	CHECKSUM (LOW)
M+3	CHECKSUM (HIGH)

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Figure 4-14b Radial Serial Protocol Message Pocket Summary

Command Message Packet

The command (control) message packet is transmitted by the PDT-11 processor to specify the type of transaction to be implemented by the tape drive controller. Table 4-41 indicates the byte structure of the command message packet. Each byte is discussed in the following paragraphs.

TABLE 4-41
Command Packet Structure

	BYTE #	BYTE NAME
	0	FLAG
	1	MESSAGE BYTE COUNT
Message Bytes Transfered	2	INSTRUCTION (OP CODE)
	3	INSTRUCTION MODIFIER
	4	UNIT NUMBER
	5	NOT USED ⎫
	6	NOT USED ⎬ Always Zero
	7	NOT USED ⎭
	8	DATA BYTE COUNT - LOW
	9	DATA BYTE COUNT - HIGH
	10	BLOCK NUMBER - LOW
	11	BLOCK NUMBER - HIGH
	12	CHECKSUM - LOW
	13	CHECKSUM - HIGH

Flag Byte (BYTE 0) - Each packet begins with the flag byte which identifies the type of message packet to be transmitted. The flag byte will be the same for all command message packets as follows:

OCTAL CODE	MESSAGE PACKET IDENTIFIER
002	The flag byte is set to 002_8 to indicate that the message packet is a command message packet.

Message Byte Count (BYTE 1) - The message byte count is the number of message characters in the packet; excluding the flag byte (byte 0), message byte count (byte 1) and checksum (bytes 12 and 13). The message byte count used will be the same for all command message packets as follows:

OCTAL CODE	DECIMAL BYTE COUNT
012	Ten (bytes 2-11 inclusive)

Instruction Byte -OP CODE- (BYTE 2) - The instruction byte (or operational code) informs the tape drive controller of the transaction to be performed. To allow for future development, certain instructions (opcodes) in the command set have been reserved; these commands have unpredictable results and should not be used. The use of instructions (opcodes) not listed in this section will result in the return of an end packet with the "bad instruction (opcode)" success code. The instructions which may be performed by the tape drive controller are listed below.

OCTAL CODE	OP CODE	INSTRUCTION
000	0	NOP
001	1	INIT
002	2	READ
003	3	WRITE
004	4	(reserved)
005	5	POSITION
006	6	(reserved)
007	7	DIAGNOSE
010	8	GET STATUS
011	9	SET STATUS
012	10	(reserved)
013	11	(reserved)
100		End Message Packet (This is a special case command packet, see the end packet section of this chapter for further details)

Refer to the Detailed Instruction Set Description of this chapter for additional information on each instruction.

Instruction Modifier (BYTE 3) - The instruction modifier byte is used to alter the execution of the instruction specified by byte 2 of the command message packet. Refer to the Detailed Instruction Set Description of this chapter for additional information on each instruction.

Unit Number (BYTE 4) - The unit number specifies which of the two tape drives is to be used during the transaction.

OCTAL CODE	SELECTED TAPE DRIVE
000	Drive 0
001	Drive 1

Not Used (BYTES 5, 6 and 7) - Not used, always equal to zero.

Data Byte Count (BYTES 8 and 9) - The data byte count indicates the number of data bytes to be transfered by a read or write instruction. The data byte count is ignored when using other instructions.

Block Number (BYTES 10 and 11) - The block number bytes indicate the data block number to be used by all instructions which require tape positioning. The block number bytes are ignored by instructions not requiring tape positioning.

Checksum (BYTES 12 and 13) - The last two bytes of the command message packet contain a 16 bit checksum used in detecting bit errors in the reception of the message packet. The checksum is formed by summing successive byte pairs taken as sixteen bit words using an end around carry from bit 15 to bit 0. The sixteen bit words are created using successive byte pairs of the command packet from byte 0 through byte 11, inclusive.

End Packets

The end packet (which is a special case of the command message packet category) is sent to the PDT-11 processor by the tape drive controller. The end packet is sent after the completion or termination of an operation, or on the detection of an error condition. When an error condition is detected, the tape controller sends an end packet before the current packet is completely transferred by the PDT-11 processor. The reception of the premature end packet (with a command flag 002_8 instead of a data flag 001_8) informs the PDT-11 processor that the tape drive controller has detected an error condition. Table 4-42 illustrates the format and byte positions of the end packet. A detailed description of each byte is provided in the following paragraphs.

TABLE 4-42
End Packet Structure

	BYTE #	BYTE NAME	
	0	FLAG	
	1	MESSAGE BYTE COUNT	
Message Bytes Transfered	2	INSTRUCTION (OP CODE)	
	3	SUCCESS CODE	
	4	UNIT NUMBER	
	5	NOT USED	Always Zero
	6	NOT USED	
	7	NOT USED	
	8	DATA BYTE COUNT L	
	9	DATA BYTE COUNT H	
	10	NOT USED	Always Zero
	11	NOT USED	
	12	CHECKSUM L	
	13	CHECKSUM H	

Flag Byte (BYTE 0) - Each packet begins with the flag byte which identifies the type of message packet to be transmitted. The flag byte will be the same for all command message packets as follows.

OCTAL CODE	MESSAGE PACKET IDENTIFIER
002	The flag byte is set to 002_8 to indicate that the packet is command packet.

Message Byte Count (BYTE 1) - The message byte count is the number of message characters in the packet; excluding the flag byte (byte 0), message byte count (byte 1), and checksum (bytes 12 and 13). The message byte count used will be the same for all end message packets.

OCTAL CODE	DECIMAL BYTE COUNT
012	Ten (bytes 2-11 inclusive)

Instruction Byte -OP CODE- (BYTE 2) - The instruction byte (or operational code) informs the PDT-11 processor of the transaction which was performed. The instruction for an end packet is listed below:

OCTAL CODE	INSTRUCTION
100	End Packet Op Code

Success Code (BYTE 3) - The success code byte is transmitted by the tape drive controller to the PDT-11 processor to indicate the status of the transaction just completed, or the cause of an interrupted operation. The success codes which may be transmitted by the tape drive controller are listed below.

OCTAL CODE	SUCCESS CODE	DEFINITION
000	normal success	Operation completed as defined by the instruction byte (byte 2).
001	success but with retries	Operation completed as defined by the instruction byte (byte 2) but success was obtained only after repeated attempts.

377	failed self test	The tape drive controller failed to pass the internal self test initiated during a power up sequence, during a master reset instruction or init instruction.
376	partial operation (end of media)	Operation defined in the instruction byte (byte 2) has not been totally completed due to having reached the end of the tape cartridge.
370	bad unit number	The unit number specified by byte 4 of the command message packet was incorrect. (i.e. non-existant drive unit, etc.)
367	no cartridge	No tape cartridge is installed in the tape drive specified in byte 4 of the command message packet.
365	write protected	The tape cartridge located in the tape drive specified by byte 4 of the command message packet has been write protected, therefore data may not be written onto the tape.
357	data check error	Message checksums did not match.
340	seek error	The tape drive (block not found) controller is unable to locate the data block specified by bytes 10 and 11 of the command message packet.

337	motor stopped	Tape motion has stopped due to a tape drive logic problem or a bad tape cartridge.
320	bad instruction	The instruction in byte 2 of the command message packet cannot be performed by the tape drive.
311	bad block number	The data block specified in bytes 10 and 11 are not possible.

Unit Number (BYTE 4) - The unit number specifies which of the two tape drives was used during the transaction.

OCTAL CODE	SELECTED TAPE DRIVE
000	Drive 0
001	Drive 1

Not Used (BYTES 5, 6 and 7) - Not used, always equal to zero.

Data Byte Count (BYTES 8 and 9) - The data byte count indicates the number of data bytes transfered by the read or write operation. In a good transaction this byte should be the same as the data byte count of the command packet which initiated the transfer. This byte is ignored by other commands.

Not Used (BYTES 10 and 11) - Not used, always equal to zero.

Checksum (BYTES 12 and 13) - The last two bytes of the end packet contain a 16 bit checksum used in detecting bit errors in the end command message packet. The checksum is formed by summing successive byte pairs taken as sixteen bit words using an end around carry from bit 15 to bit 0. The sixteen bit words are created using successive byte pairs of the end packet from byte 0 through byte 11, inclusive.

Single Byte Commands
The tape drive controller reacts to a set of single byte control commands which are listed in Table 4-43.

Table 4-43
Single Byte Commands

OCTAL CODE	COMMAND NAME
004	INIT
020	CONTINUE
023	XOFF

INIT - The INIT control command when issued by the PDT-11 processor causes the execution of the tape drive controller's power up sequence. Upon the completion of the self test program, the tape controller will send the continue command.

The INIT control command when issued from the tape drive controller indicates protocol errors, an invalid command or the end of the tape controller initialization procedure. In these instances, the tape controller will send 261 INIT commands because the PDT-11 processor will not interpret the INIT until the end of the expected message packet is received. The PDT-11 processor should respond by issuing a break signal (see device register descriptions), two INIT commands and a command packet.

CONTINUE - After the PDT-11 processor sends a message packet to the tape drive controller, the processor must wait for a continue command from the tape drive before sending further messages. This permits the tape drive to control the transfer of data thus avoiding buffer overflows and the possibility of data loss.

XOFF - The tape drive controller supports the XOFF command. When the tape controller receives the XOFF command, it stops transmitting immediately and waits until the reception of the continue command. Upon the reception of the continue command, the tape controller will, when ready, complete the data transfer.

Data Message Packets

The data message packet may be transmitted between the PDT-11 processor and tape drive controller in either direction, depending on the type of instruction being executed (i.e. read or write). One data message packet may transfer between 1 and 128 data bytes. For data transfers larger than 128 bytes, the transaction is broken up into multiple data packets and sent 128 bytes at a time.

During a read instruction, the tape drive controller does not wait for a continue flag between message packets as shown in Figure 4-15. The PDT-11 processor is assumed to have enough buffer capacity to accept the entire transaction.

During write commands, the PDT-11 processor must receive the continue command from the tape drive controller before sending the next message packet as shown in Figure 4-16. This condition occurs because the tape drive controller has 128 bytes of buffer space and must finish all data processing before accepting additional message packets.

The data message packet format is shown in Table 4-44 and a description of each byte is provided in the following paragraphs.

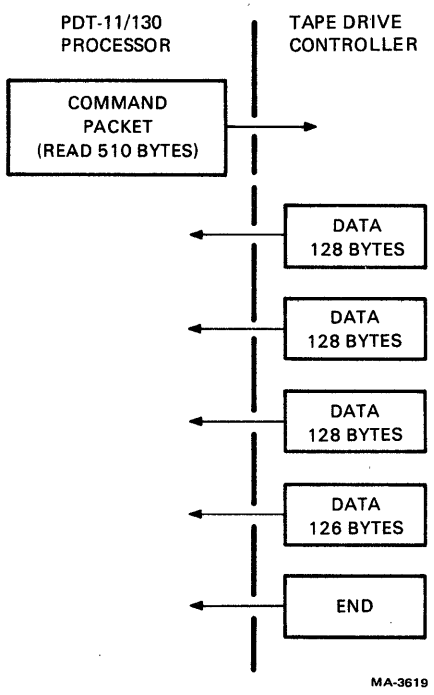

Figure 4-15 Read Command Packet Exchange

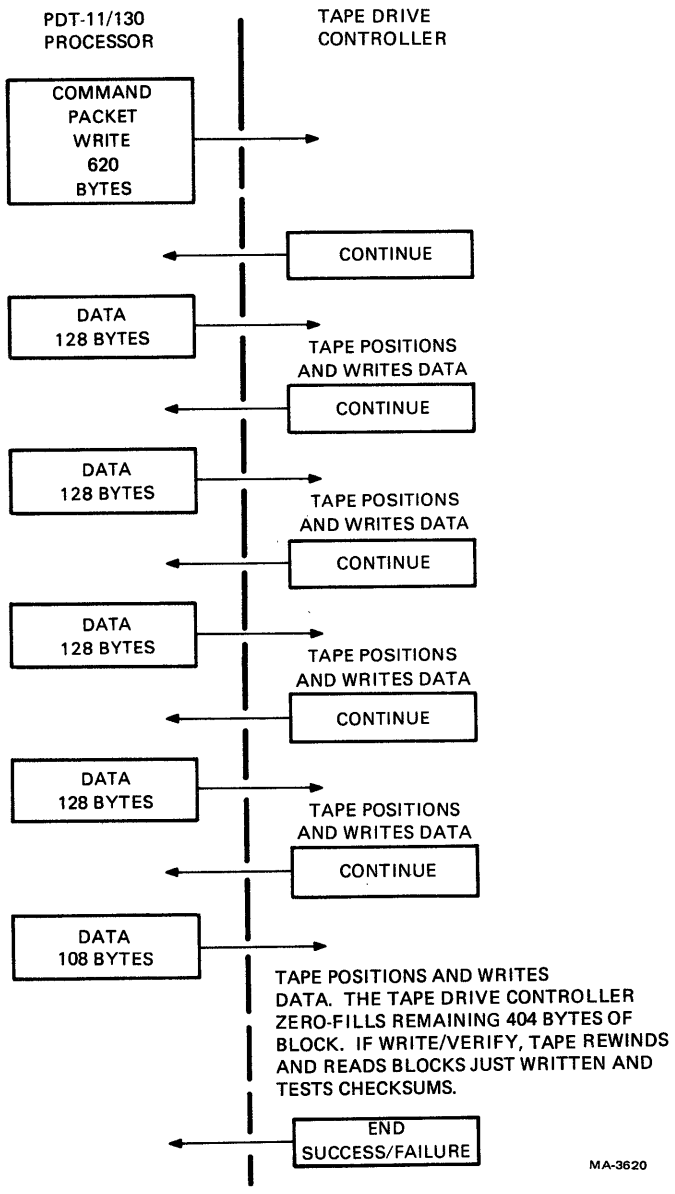

Figure 4-15 Write Command Packet Exchange

TABLE 4-44
Data Packet Structure

	BYTE #	BYTE NAME
	0	FLAG
	1	MESSAGE BYTE COUNT = M (the number of bytes tranfered)
Message Bytes Transfered	2	FIRST DATA BYTE
	3	DATA
	"	"
	"	"
	"	"
	M	"
	M+1	LAST DATA BYTE
	M+2	CHECKSUM L
	M+3	CHECKSUM H

Flag Byte (BYTE 0) - Each packet begins with the flag byte which identifies the type of message packet to be transmitted. The flag byte will be the same for all data message packets.

OCTAL CODE	MESSAGE PACKET IDENTIFIER
001	This flag when set to 001_8 informs the receiver that data rather than commands are arriving. The receiver loads the incoming bytes into a buffer area in memory and should not wait for an instruction to execute.

Message Byte Count (BYTE 1) - The message byte count is the number ("M") of message characters in the packet; excluding the flag byte (byte 0), message byte count (byte 1), and checksum (bytes 12 and 13).

Data Bytes (BYTES 2 THROUGH M+1) - Between 1 and 128 data bytes may be transfered within one data message packet. For data transfers larger than 128 bytes, the transaction is broken up into multiple data packets and sent 128 bytes at a time.

Checksum (BYTES M+2 and M+3) - The last two bytes of the data message packet are a 16 bit checksum used in detecting bit errors in the reception of the data packet. The checksum is formed by summing successive byte pairs taken as sixteen bit words using an end around carry from bit 15 to bit 0. The sixteen bit words are created using successive byte pairs of the data packet from byte 0 through M+1 (the end of the transmitted data), inclusive.

DETAILED INSTRUCTION SET DESCRIPTION

The instruction byte (or operational code) informs the tape drive controller of the transaction to be performed. To allow for future development, certain instructions (opcodes) in the command set have been reserved; these commands currently have unpredictable results and should not be used. The use of instructions (opcodes) not listed in this section will result in the return of an end packet with the "bad instruction (opcode)" success code. A detailed description of the tape drive instruction set and their operational codes are provided in the following paragraphs.

NOP Op Code 0 - The no operation instruction causes the tape drive controller to return an end packet. There are no modifiers to the NOP instruction. The NOP command message packet is shown below.

BYTE #	OCTAL CODE	BYTE NAME
0	002	FLAG
1	012	MESSAGE BYTE COUNT
2	000	INSTRUCTION (OP CODE)
3	000	INSTRUCTION MODIFIER
4	00X	UNIT NUMBER
5	000	NOT USED
6	000	NOT USED
7	000	NOT USED
8	000	BYTE COUNT L (NO DATA INVOLVED)
9	000	BYTE COUNT H
10	000	BLOCK NUMBER L (NO TAPE POSITIONING)
11	000	BLOCK NUMBER H
12	01X	CHECKSUM L
13	012	CHECKSUM H

The Tape drive returns the following end packet:

0	002	FLAG
1	012	MESSAGE BYTE COUNT
2	000	INSTRUCTION (OP CODE)
3	000	INSTRUCTION MODIFIER
4	00X	UNIT NUMBER
5	000	NOT USED
6	000	NOT USED
7	000	NOT USED
8	000	DATA BYTE CNT L (NO DATA INVOLVED)
9	000	DATA BYTE CNT H
10	000	SUMMARY STATUS L
11	XXX	SUMMARY STATUS H
12	0XX	CHECKSUM L
13	XXX	CHECKSUM H

X = A variable number from 0 to 7 (octal)

INIT Op Code 1 - The INIT instruction causes the tape drive controller to reset itself to a known state. No tape motion results from this operation. The command packet is the same as for NOP except for the instruction byte -op code- (byte 2) and the resultant change to the low order checksum byte (byte 12). The tape drive controller returns the same end packet as described for the NOP instruction. There is no instruction modifier to INIT.

READ Op Code 2 - The read instruction causes the tape drive controller to position the tape in the drive selected by the unit number byte (command byte 4) to the block designated by the block number byte (command bytes 10 and 11). The tape drive controller reads the data starting at the first block and continues reading until the byte count (command bytes 8 and 9) is satisfied. After the data has been sent, the tape drive controller sends an end packet.

Byte 3 of the end packet will indicate the read operation's success, success with retries, or failure. In the event of failure, the end packet will be sent at the time of failure without filling up the data count. The end packet can be recognized by the PDT-11 processor by the flag byte (byte 0) containing a command flag byte (octal 002) instead of a data flag (octal 001)

Read With Increased Threshold Modified Op Code 2 - There is one modifier to the read command. A modifier of octal 001 in byte 3 of a read command packet will cause the tape drive controller to read the tape with an increased threshold in the data recovery circuit. This command is used to verify data integrity.

WRITE Op Code 3 - The write instruction causes the tape drive controller to position the tape in the tape drive selected by the unit number byte (command byte 4) to the block specified by the block number byte (command bytes 10 and 11). The tape drive controller will write data into one or more blocks until the byte count (command bytes 8 and 9) is satisfied. The controller will automatically zero-fill any remaining bytes in a 512 byte block.

Write and Verify Modified Op Code 3 - There is one modifier write permitted with the write command. A modifier of octal in 001 byte 3 of a common packet will cause the tape drive controller to write all of the data contained in the data packet. To verify the data written, the tape drive controller will return to the newly written data and perform a read operation. The checksum of each record will then be tested to verify the data. If all of the checksums are correct, the tape drive controller will send an end packet with the success code set to octal 000 (or octal 001 if retries were necessary to read the data) to the PDT-11 processor.

During the write operation the tape drive controller may only buffer 128 bytes of data. Therefore, it is necessary for the PDT-11 processor to send a data packet and wait for the write operation to be completed before sending the next data packet. This is accomplished using the continue flag. The continue flag is a single byte response of octal 020 from the tape drive controller to the PDT-11 processor.

(reserved) Op Code 4 - Reserved for future use.

Position Op Code 5 - The position command causes the tape drive controller to position the tape on the selected drive (indicated by command byte 4) to the block designated by command bytes 10 and 11. After reaching the selected block, the tape controller sends an end packet to the PDT-11 processor. No modifiers are used.

(reserved) Op Code 6 - Reserved for future use.

Diagnose Op Code 7 - The diagnose command causes the tape drive controller to run its internal diagnostic program. Upon completion, the tape drive controller sends an end packet with the appropriate success code.

Get Status Op Code 8 - Treated as a NOP, The tape drive controller returns an end packet containing the current tape drive controller status.

Set Status Op Code 9 - Treated as a NOP, the tape drive controller returns an end packet.

(reserved) Op Code 10 - Reserved for future use.

(reserved) Op Code 11 - Reserved for future use.

GENERAL PROGRAMMING CONSIDERATIONS

Some device-related functions required during operation are not dealt with directly by the TU58 firmware or the Radial Serial Protocol commands. Suggestions and considerations related to these device-related functions are listed below:

1) A short routine should be included in the tape drive device handler to provide a complete wind-rewind procedure for new or environmentally stressed tape cartridges. To accomplish this, position the a data tape block to at each end of the tape cartridge (see Figure 4-17). This procedure will bring the tape cartridge to the proper tape tension and also prevent tape sticking (which causes data errors).

	78.7 b/cm 200 b/in	315 b/cm 800 b/in						
	INTER RECORD MARK	HEADER SYNC.	RECORD NUMBER	COMPL OF RCD. NUMBER	DATA SYNC.	DATA SPACE 128 BYTES	CHECK SUM	END SPACE ALL ZEROS
TRK1		000...01	N + 1024	$\overline{N + 1024}$	00 00 00 00....01			
TRK0		000...01	N	$\overline{N}$	00 00 00 00...01			

TAPE DRIVE ARRANGES FOUR RECORDS AS ONE BLOCK

Single Record on Tape

BOT	#128 200	#384 600	#129 201	#385 601	#130 202	#386 602	#131 203	#254 376	#510 776	#255 377	#511 777	EOT
BOT	#0 0	#256 400	#1 1	#257 401	#2 2	#258 402	#3 3	#126 176	#382 576	#127 177	#383 577	EOT

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Figure 4-17 Block Locations on Tape

2) The tape drive device handler should check the success code (byte 3 of the radial serial protocol end packet) for the presence of soft errors (temporary data loss). This will enable action to be taken before hard errors (permanent data loss) occur. For example, if the number of retries on a particular cartridge reaches some specified value, a message like "TAPE MAINTENANCE REQUIRED" could be displayed to prompt the operator to copy the tape or clean the tape drive components.

3) A short routine should be included in the tape drive device handler to allow the operator to easily create back up copies of a tape cartridge to prevent data loss due to cartridge malfunction.

4) File structured data should be organized with the use of a file directory contained in the first few data blocks of the tape cartridge. The file directory need only contain the number of the first block of the file and the file's byte count. If the file is larger than the 512 byte block, the data is held in additional sequential blocks. During read or write operations the TU58 will use as many byte blocks as needed to fill the specified byte count.

When positioning files on the tape cartridge, care must be taken to avoid crossing certain block addresses as follows:

127-128
255-256
383-384

Crossing these addresses cause a full rewind operation to be performed. This will drastically impact system performance. Insofar as possible, avoid placing multiblock files within these addresses.

APPLICATION PROGRAM LOADING

The PDT-11 systems operate under the control of an application program. The application program is normally developed on a larger and possibly faster computer and then loaded into the PDT-11 main memory using bootstrap programs. A bootstrap program is a brief set of instructions which command the system to read other programs into main memory and execute them when successfully assembled. The primary bootstrap program of a PDT-11 system is held in non-volatile read only memory (ROM). The ROM resident routines are generally used to load a secondary bootstrap program which must follow an expected format (as defined later in this chapter). The bootstrap program controls the system operation until the secondary bootstrap program is fully assembled. When successfully loaded into the PDT-11 main memory, the secondary bootstrap program can be used to load a tertiary program and/or application program as specified and supported by the system programmer. After a program is successfully loaded and if the self start feature of the host computer assembler is used, the processor will automatically jump to the transfer address of each program loaded and execute the program. The programs loaded into the PDT-11 memory may use all locations with an address less than 170000, memory locations with an address in the range of 170000 to 173776 contain ROM resident programs or Input/Output device registers.

PROGRAM LOADING THE PDT-11/130

The PDT-11/130 system loads the application program from the mass storage DECtape II dual tape drive using Radial Serial Protocol (RSP is described in the Tape Drive Programming Considerations section of this chapter). Program loading is initiated by either a power up sequence or master reset instruction (generated from the system keyboard). The PDT-11/130 executes a ROM resident bootstrap program which attempts to load a secondary bootstrap program from tape drive 0 (the operator has the option of specifying drive 1 in place of drive 0 from the console keyboard). The ROM resident program addresses block 0 of the selected tape drive and reads the first data block. The first byte of the block read must be octal 240. This code indicates that a system program tape is present in the selected tape drive and the secondary bootstrap program is contained within the data block read. The secondary bootstrap program when executed loads either a tertiary bootstrap program and/or the application program.

PROGRAM LOADING THE PDT-11/110

The PDT-11/110 system is equipped with two types of program loading routines; the Terminal Boot Loader and the Maintenance Operation Protocol (MOP) Loader. The program loaders are entered from the Terminal Mode and Message Mode, respectively. Each of these loaders is used to receive down-line program loads from the host computer.

The Terminal Boot Loader, entered from the Terminal Mode, is used to receive bootstrap programs which are transmitted in a character-by-character fashion from a general time sharing host computer. This technique of program loading is implemented by transmitting properly encoded uppercase ASCII character strings with elementary error checking procedures.

The Maintenance Operation Protocol (MOP) Loader, entered from the Message Mode, allows the bootstrap programs to be loaded from a DECNET host computer which supports Maintenance Operation Protocol. Maintenance Operation Protocol is a byte oriented packet protocol utilizing Digital Data Communications Message Protocol (DDCMP) message framing, link management and CRC error checking.

TERMINAL MODE

The Terminal Mode is selected by the operator when specifing the Boot Selection SET-UP feature of the PDT-11/110 (see the operator chapter for specific operator procedures). When selected, this operational mode is entered automatically after a power up sequence or master reset operation (initiated from the console keyboard). The Terminal Mode causes the PDT-11/110 system to emulate a dumb terminal, allowing the operator to perform any "log-on" procedures required and then manually initiate the down-line program load as specified by the operating system of the host computer.

The PDT-11/110 system will function as a dumb terminal until a Terminal Boot Loader Request is received from the host computer in the form of Altmode L or } L (octal characters 175 and 114). The PDT-11/110 then enters the Terminal Boot Loader to receive the secondary bootstrap program. The secondary bootstrap program is used to load a tertiary bootstrap program and/or application program.

When using the Terminal Boot Loader specific SET-UP features of the PDT-11/110 system are assumed to be set as follows:

* The Boot Select feature is set for Terminal Mode.

* The ANSI/VT52 feature is ignored and the PDT-11/110 system is automatically placed in the ANSI Mode regardless of the SET-UP feature setting.

* The Communication Format feature used by the communication port will operate in the Asynchronous Mode reguardless of the SET-UP feature setting.

* The Transmit Speed feature (which also selects the receive speed) baud rate must be set for 4800 baud or less.

Terminal Boot Protocol

The Terminal Boot Loader uses a character-by-character loading sequence. The loader will accept properly encoded ASCII character strings containing uppercase printable characters and symbols (040 through 137 octal). The host computer encodes these ASCII characters into six bit binary format within eight bit bytes for transmission to the PDT-11/110 (the host computer program is available from DIGITAL, refer to chapter 1 for ordering information). The encoded bytes are broken up into data blocks, which are groups of bytes arranged in a fixed order. The meaning of each individual byte in the data block is determined by the byte position held. When the encoded bytes are received, the Terminal Boot Loader decodes them and loads main memory with the ASCII characters. The error checking techniques of the Terminal Boot Loader are elementary, therefore the data block size should not be greater than 512 bytes. The data block format expected by the PDT-11/110 Terminal Boot Loader is determined by the position of the data block within the data block string as summarized in Figure 4-18.

If the message is received successfully, execution of the program starts at Transfer Address specified in bytes 4 and 5 of the last data block transmitted. The PDT-11/110 will transmit Altmode G (two octal characters 175 107) to indicate a successful data transfer. If an error is detected by the Terminal Boot Loader program, the PDT-11/110 will transmit Altmode B (two octal characters 175 102) to indicate a checksum error. The PDT-11 will return to the Terminal Emulation mode to allow the program load sequence to be restarted.

Character Coding and Decoding - The ASCII characters of the program to be transferred are encoded into six bit binary format in eight bytes for transmission to the PDT-11/110. This is done to allow the host computer to transmit characters which are unrecognizable to the PDT-11 communication port handler. This eliminates the chance of processing data before the program is fully assembled. When the encoded bytes are received, the Terminal Boot Loader decodes the six bit binary format and loads main memory with the ASCII characters. The encoding and decoding scheme used in the transfer of the program is shown in Figure 4-19. The detailed byte conversion technique used by the Terminal Boot Loader is shown pictorially in Figure 4-20.

First Data Block Format - The byte positions within the first data block are shown Table 4-45. A detailed description of the byte sequence and the meaning of each byte in the first data block received is provided in the following paragraphs.

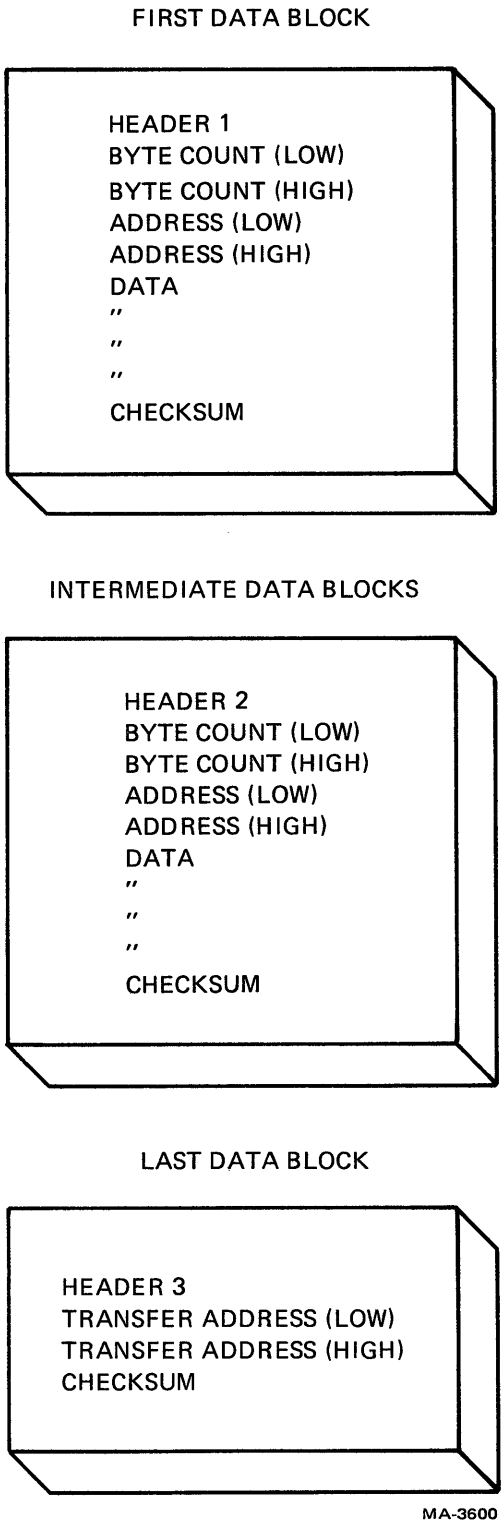


Figure 4-18 Terminal Boot Loader Block Format

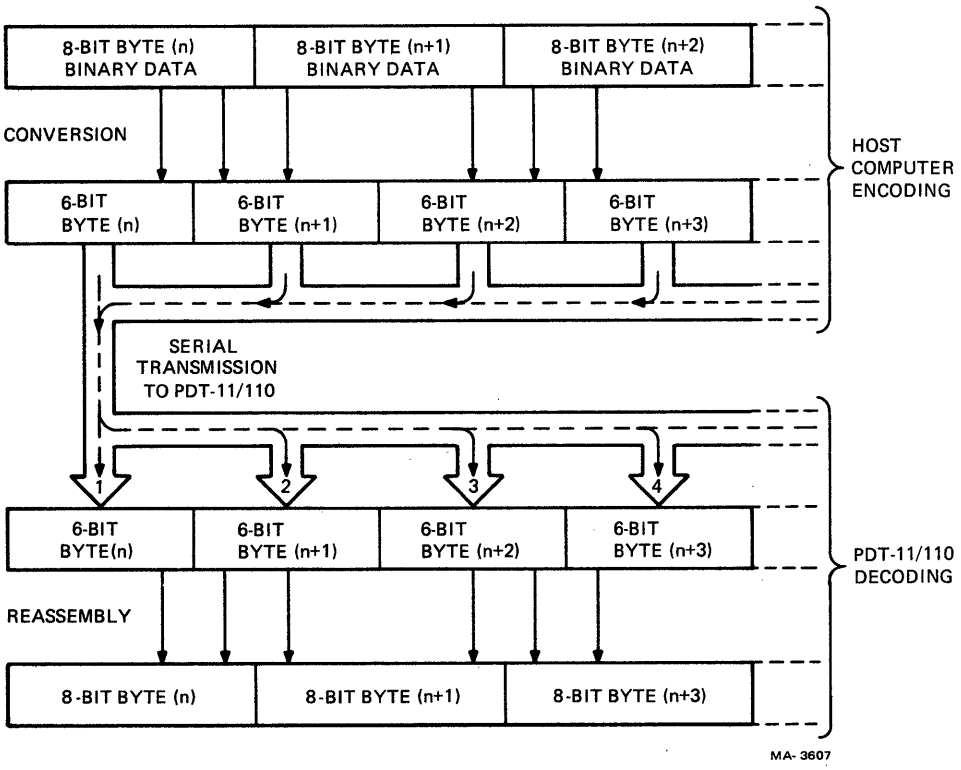


Figure 4-19 Character Encoding and Decoding of the Terminal Boot Loader

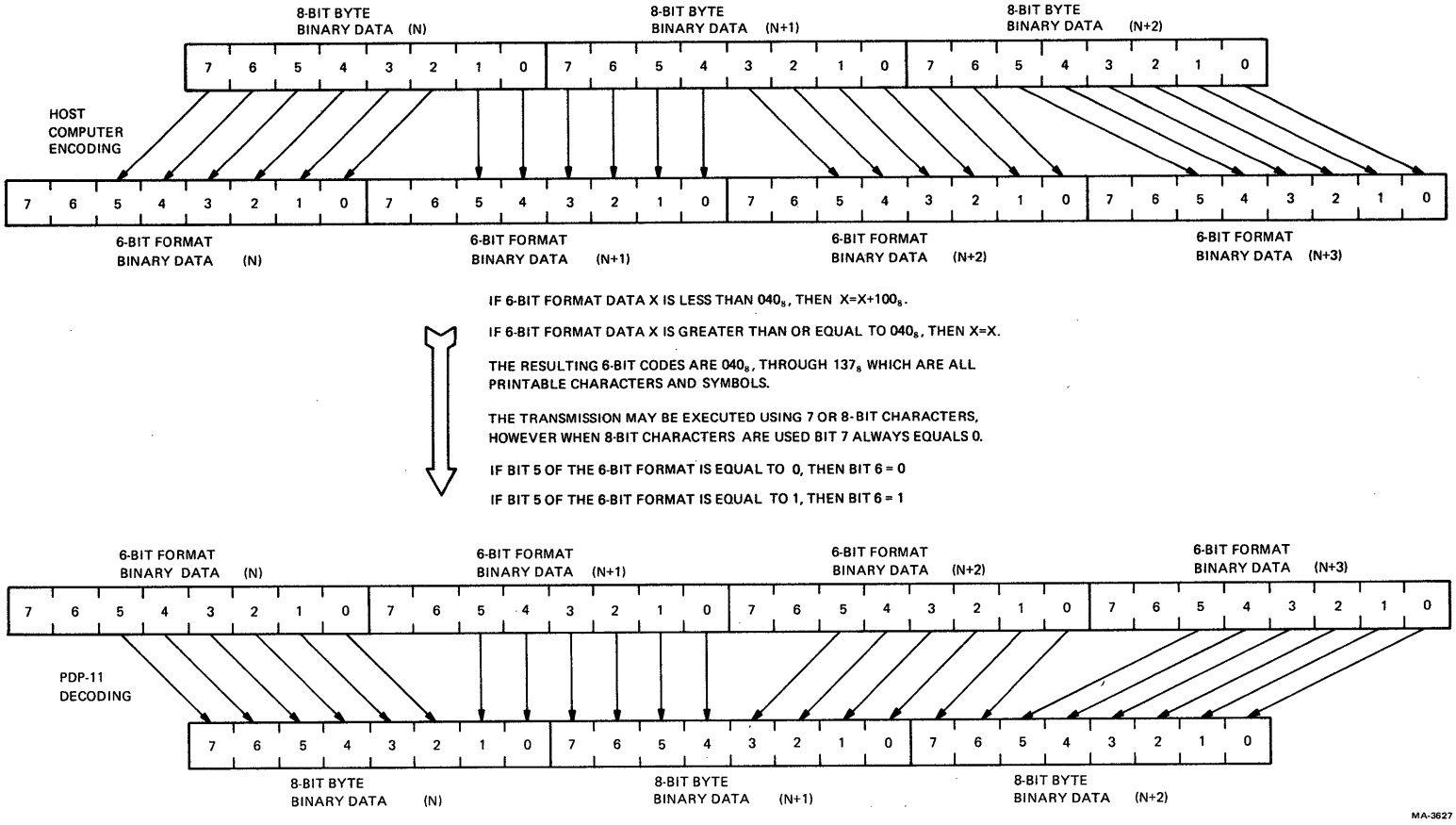


Figure 4-20 Byte Conversion of Terminal Boot Loader

TABLE 4-45
First Data Block Structure

	BYTE #	BYTE NAME
	0	HEADER 1
	1	
	2	
	3	DATA BYTE COUNT (Low) = N - 6
	4	DATA BYTE COUNT (High)
	5	ADDRESS (Low)
	6	ADDRESS (High)
Data Bytes Transferred	7	FIRST DATA BYTE
	.	
	.	
	.	
	N	LAST DATA BYTE
	N + 1	CHECKSUM

Header 1 (BYTES 0, 1 and 2) - Contains three bytes used to indicate the type of data block. The header bytes of the first data block are as follows:

BYTE #	OCTAL VALUE
0	000
1	001
2	000

Data Byte Count (Low) (BYTE 3) - The lower 8 bits of the data byte count. The data byte count is the number of 8 bit data bytes transferred in the data block.

Data Byte Count (High) (BYTE 4) - The higher 8 bits of the 8 bit data byte count.

Address (Low) (BYTE 5) - The lower 8 bits of the first memory address into which the program is to be loaded.

Address (High) (BYTE 6) - The higher 8 bits of the first memory address into which the program is to be loaded.

Data Bytes (BYTE 7 through N) - The data bytes which contain the program to be loaded into memory.

Checksum (BYTE N+1) - A checksum of the entire transmitted data block.

Intermediate Data Block Formats - The positions of the bytes within the intermediate data blocks received are shown in Table 4-46. The following paragraphs describe the byte sequence and meaning of each byte expected in all intermediate data blocks received.

TABLE 4-46
Intermediate Data Block Structure

	BYTE #	BYTE NAME
	0	HEADER 2
	1	
	2	DATA BYTE COUNT (Low) = P - 5
	3	DATA BYTE COUNT (High)
	4	ADDRESS (Low)
	5	ADDRESS (High)
Data Bytes Transferred	6	FIRST DATA BYTE
	.	
	.	
	.	
	P	LAST DATA BYTE
	P + 1	CHECKSUM

Header 2 (BYTES 0 and 1) - Two bytes used to indicate the type of data block. The header bytes of the intermediate data block are as follows:

BYTE #	OCTAL VALUE
0	000
1	001

Data Byte Count (Low) (BYTE 2) - The lower 8 bits of the data byte count. The data byte count is the number of 8 bit data bytes transferred in the data block.

Data Byte Count (High) (BYTE 3) - The higher 8 bits of the 8 bit data byte count.

Address (Low) (BYTE 4) - The lower 8 bits of the first memory address into which the program is to be loaded.

Address (High) (BYTE 5) - The higher 8 bits of the first memory address into which the program is to be loaded.

Data Bytes (BYTES 6 through P) - The data bytes of the program to be loaded into main memory.

Checksum (BYTE P+1) - A checksum of the entire transmitted data block.

Last Data Block Format - Table 4-47 shows the order of the bytes contained within the last data byte received. The following paragraphs describe the byte sequence and byte meaning expected in the last data block received.

TABLE 4-47
Last Data Block Structure

BYTE #	BYTE NAME
0	HEADER 3
1	
2	
3	
4	TRANSFER ADDRESS (Low)
5	TRANSFER ADDRESS (High)
6	CHECKSUM

Header 3 (BYTES 0, 1, 2 and 3) - Four bytes used to indicate the type of data block. The header bytes of the last data block are as follows:

BYTE #	OCTAL VALUE
0	001
1	000
2	006
3	000

Transfer Address (Low) (BYTE 4) - The lower 8 bits of the program address used to start the transmitted program.

Transfer Address (High) (BYTE 5) - The higher 8 bits of the program address used to start the transmitted program.

Checksum (BYTE 6) - A checksum of the entire transmitted data block.

MESSAGE MODE

The Maintenance Operational Protocol (MOP) Loader of the PDT-11/110 system allows the application program to be loaded from a DECNET host computer supporting Maintenance Operation Protocols. The MOP loader utilizes a subset of a high level communication message protocol, DDCMP, which operates in one of two modes; the on-line or normal running mode and the off-line or maintenance mode. The maintenance mode of DDCMP is used by the PDT-11/110 system to load program. The MOP loader provides a basic envelope compatible with DDCMP framing, link management, and CRC error checking. The MOP loader does not support error recovery or sequence checks; these functions, if desired, must be handled within the data field.

When the MOP loader is entered from the power-up sequence or a master reset (initiated from the console device), the PDT-11/110 automatically sends a message to the host computer requesting a down-line load. In the DECNET environment, the host computer will respond by sending a secondary loader within a single message (which contains a memory image and transfer address), which in turn will load a tertiary loader, which then loads the application program. If

the secondary loader is received successfully, execution of the secondary loader begins at location 6 and keyboard LED L4 is turned off. If the secondary loader is received in error, the PDT-11/110 restarts the load sequence by retransmitting the request program message automatically.

The specified SET-UP features of the PDT-11 system must be selected as follows:

* The Boot Select feature must be set to Message mode.

* The Bits Per Character feature must be set to 8 data bits per character when using the MOP loader.

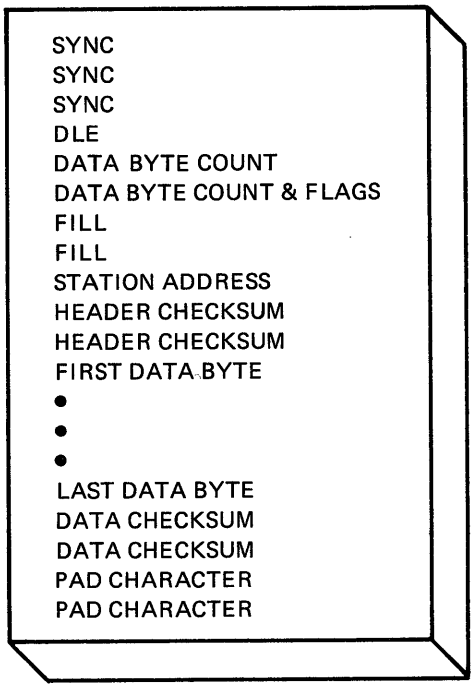
* The Transmit Speed baud rate setting must be set for 4800 baud or less.

MOP Message Protocol
The MOP protocol is a byte oriented, high level message protocol within DDCMP used to transmit error free data over communications links. The format of the MOP messages for both the synchronous and asynchronous communication are shown in Figure 4-21.

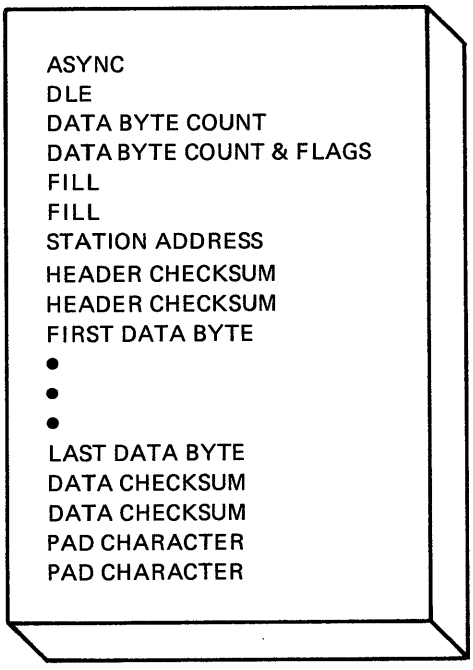
MOP Protocol with Synchronous Communication - The format of the MOP message using synchronous communication is in Table 4-48 and described in the following paragraphs.

TABLE 4-48
MOP Message Format with Synchronous Communication

	BYTE #	BYTE NAME
	0	SYNC
	1	SYNC
	2	SYNC
	3	DLE
	4 + 5	DATA BYTE COUNT and FLAGS
Header Bytes		(DATA BYTE COUNT = Q - 10)
	6 + 7	FILL BYTES
	8	STATION ADDRESS
	9 + 10	HEADER CHECKSUM
	11	FIRST DATA BYTE
Data Bytes Transferred	.	
	.	
	.	
	Q	LAST DATA BYTE
	Q + 1	DATA CHECKSUM
	Q + 2	DATA CHECKSUM
	Q + 3	PAD CHARACTER
	Q + 4	PAD CHARACTER



MOP MESSAGES WITH SYNCHRONOUS COMMUNICATION



MOP MESSAGES WITH ASYNCHRONOUS COMMUNICATION

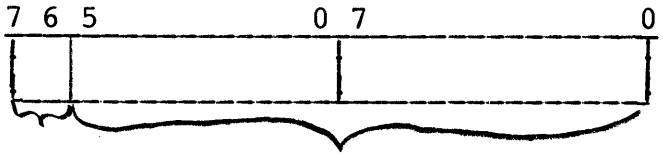
MA-3606

FIGURE 4-21 MOP Message Formats

SYNC (BYTES 0, 1 and 2) - Bytes which are used to synchronize the communication message; each SYNC byte is octal 226.

DLE (BYTE 3) - Maintenance message identifier, has the value 220 octal.

Data Byte Count and Flags (BYTES 4 and 5) - The data byte count specifies the number of eight bit bytes transferred in the data field of the message, the value of zero is not allowed (14 bits). The flags are always ones in maintenance messages (2 bits).



Fill Bytes (BYTES 6 and 7) - Two fill bytes with a value of 000 octal (8 bits) are used as position holders for the protocol.

Station Address (BYTE 8) - This byte specifies the station address (8 bits) of the system when using a multi-drop communication network. When not using a multi-drop network this byte is always equal to one.

Header Checksum (BYTES 9 and 10) - Header block check on data from DLE to STATION ADDRESS; block checks are performed using CRC-16.

Data Bytes (BYTES 11 through Q) - The data field of the message; uses 8 bit bytes.

Data Checksum (BYTES Q+1 and Q+2) - A data block check on data field only, block checks are performed using CRC-16. One CRC-16 checksum is used to detect errors within the program load, therefore the data load should be limited to under 1000 bytes to insure error free program loading.

Pad Characters (BYTES Q+3 and Q+4) - Two pad characters must be added to the message format due to timing considerations of the data communication port.

MOP Loader Request and Reply for Synchronous Communication - The PDT-11 system transmits the Maintenance Operation Protocol Message to request a program load from the DECNET host computer system when using the synchronous communication format, as shown in Table 4-49.

TABLE 4-49
MOP Synchronous Communication Loader Request

MNEMONIC		OCTAL
SYN		226
SYN		226
SYN		226
DLE		220
DATA BYTE COUNT		004
FLAGS		300
FILL		000
FILL		000
STATION ADDRESS		001
HEADER CHECKSUM		021 120
DATA	CODE	010
	DEVICE	002
	VERSION	001
	TYPE	000
DATA CHECKSUM		242 060
PAD CHARACTERS		XXX XXX

XXX may be any number 0-7

Note: HEADER CHECKSUM is computed on DLE thru STATION ADDRESS (16 bit CRC-16). DATA CHECKSUM is computed on the DATA sent (CODE thru TYPE) (16 bit CRC-16).

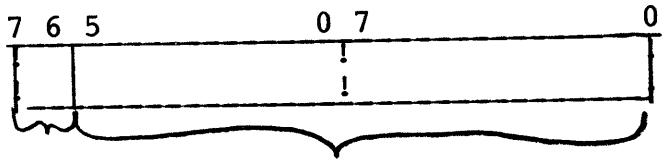
The DECNET host computer will respond with the message shown in Table 4-50.

TABLE 4-50
MOP Synchronous Communication Loader Response

MNEMONIC		OCTAL
SYN		226
SYN		226
SYN		226
DLE		220
DATA BYTE COUNT		NOTE 1
FLAGS		NOTE 1
FILL		000
FILL		000
STATION ADDRESS		001
HEADER CHECKSUM		NOTE 2
DATA	CODE	000
	LOADNUM	000
	LOADADDR	000 000 000 000
	DATA	NOTE 3
	TRANSFER ADDR	006 000 000 000
DATA CHECKSUM		NOTE 4
PAD CHARACTERS		XXX XXX

XXX may be any number 0-7

Note 1: DATA BYTE COUNT and FLAGS bytes specify the number of bytes to be transferred as DATA (CODE through TRANSFER ADDRESS). This equals number of data bytes transered. Contents of the DATA BYTE COUNT and FLAGS bytes are:



Note 2: HEADER CHECKSUM is computed on DLE thru STATION ADDRESS (16 bit CRC-16).

Note 3: Image Data. Each byte represents one memory byte. Least significant byte transferred first. The communications must be 8 data bits per character for MOP loader.

Note 4: DATA CHECKSUM is computed on the DATA BYTES (CODE thru TRANSFER ADDRESS) (16 bit CRC-16).

MOP Protocol with Asynchronous Communication - The format of the MOP message using asynchronous communication is shown in Table 4-51 and described in the following paragraphs.

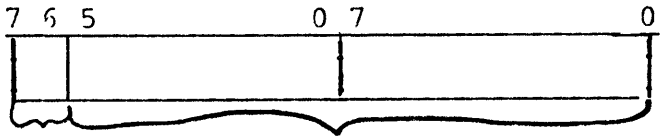
TABLE 4-51
MOP Message Format with Asynchronous Communication

	BYTE #	BYTE NAME
	0	ASYN
Header Bytes	1	DLE
	2 + 3	DATA BYTE COUNT and FLAGS (DATA BYTE COUNT = R - 8)
	4 + 5	FILL BYTES
	6	STATION ADDRESS
	7 + 8	HEADER CHECKSUM
Data Bytes Transferred	9	FIRST DATA BYTE
	.	
	.	
	.	
	R	LAST DATA BYTE
	R + 1	DATA CHECKSUM
	R + 2	DATA CHECKSUM
	R + 3	PAD CHARACTER
	R + 4	PAD CHARACTER

ASYN (BYTE 0) - A byte which is used to synchronize the communication message; each ASYN byte is always octal 377.

DLE (BYTE 1) - Maintenance message identifier, has the value 220 octal.

Data Byte Count and Flags (BYTES 2 and 3) - The data byte count specifies the number of eight bit bytes in the data field of the message, the value of zero is not allowed (14 bits). The flags are always ones in maintenance messages (2 bits).



Flags Data Byte Count

Fill Bytes (BYTES 4 and 5) - Two fill bytes with a value of 000 octal (8 bits) are used as position holders for the protocol.

Station Address (BYTE 6) - This byte specifies the station address (8 bits) of the system when using a multi-drop communication network. When not using a multi-drop network this byte is always equal to one.

Header Checksum (BYTES 7 and 8) - header block check on data from DLE to STATION ADDRESS, block checks are performed using CRC-16.

Data Bytes (BYTES 9 through R) - The data field of message, uses 8 bit bytes.

Data Checksum (BYTES R+1 and R+2) - A data block check on data field only, block checks are performed using CRC-16. One CRC-16 checksum is used to detect errors within the program load, therefore the data load should be limited to under 1000 bytes to insure error free program loading.

Note:

Pad Characters (BYTES R+3 and R+4) - Two pad characters must be added to the message format due to timing considerations of the data communication port.

MOP Loader Request and Reply for Asynchronous Communication - The PDT-11/110 system may use either synchronous or asynchronous communication formats, as specified by the operator in SET-UP mode, when loading the application program using the MOP loader. The PDT-11 system transmits the Maintenance Operation Protocol message to request a program load from the DECNET host computer system when using the asynchronous communication format, as shown in Table 4-52.

TABLE 4-52
MOP Asynchronous Communication Loader Request

MNEMONIC		OCTAL
ASYN		377
DLE		220
DATA BYTE COUNT		004
FLAGS		300
FILL		000
FILL		000
STATION ADDRESS		001
HEADER CHECKSUM		021 120
DATA	CODE	010
	DEVICE	004
	VERSION	001
	TYPE	000
DATA CHECKSUM		061
PAD CHARACTERS		XXX XXX

XXX may be any number 0-7

HEADER CHECKSUM is computed on DLE thru STATION ADDRESS (16 bit CRC-16). DATA CHECKSUM is computed on the data transferred (CODE thru TYPE) (16 bit CRC-16).

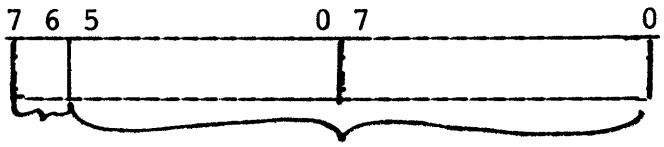
The DECNET host computer responds with the Maintenance Operation Protocol message shown in Table 4-53.

TABLE 4-53
MOP Asynchronous Communication Loader Response

MNEMONIC		OCTAL
ASYN		377
DLE		220
DATA BYTE COUNT		NOTE 1
FLAGS		NOTE 1
FILL		000
FILL		000
STATION ADDRESS		001
HEADER CHECKSUM		NOTE 2
DATA	CODE	000
	LOADNUM	000
	LOADADDR	000 000 000 000
	DATA	NOTE 3
	TRANSFER ADDR	006 000 000 000
DATA CHECKSUM		NOTE 4
PAD CHARACTERS		XXX XXX

XXX may be any number 0-7

Note 1: DATA BYTE COUNT and FLAGS bytes specify number of data bytes to be transferred (CODE through TRANSFER ADDRESS). This equals number of Data bytes sent. Contents of the DATA BYTE COUNT and FLAGS bytes are:



Flags Data Byte Count

Note 2: HEADER CHECKSUM is computed on DLE thru STATION ADDRESS (16 bit CRC-16).

Note 3: Image Data. Each byte represents one memory byte. Least significant byte transferred first. The communications must be 8 data bits per character for MOP loader.

Note 4: DATA CHECKSUM is computed on the data bytes sent (CODE thru TRANSFER ADDRESS) (16 bit CRC-16).

ON-LINE DEBUGGING TECHNIQUE CONSIDERATIONS

The LSI-11 microprocessor can operate in either a Run or Halt Mode. When in Halt Mode, normal program operation is suspended and the processor executes console ODT microcode. Console ODT microcode operation is useful for program development because it allows the programmer to examine and alter the contents of memory and device registers through the console device. After a Halt, the system can be restarted without having to reboot (system rebooting destroys the present contents of memory). When in Halt mode, the processor will perform memory refresh in a normal fashion.

The Halt Mode is entered in one of the following ways:

The LSI-11 processor executes a halt instruction.

The LSI-11 processor encounters a fatal trap (double bus error, time out when fetching a vector, etc.).

The BREAK key is pressed with the BREAK Enable jumper installed in the printer port (from pin 1 to pin 18). If the pressing of the BREAK key does not cause the processor to enter the HALT mode, press the BREAK key again.

The system is powered up with the BREAK Enable jumper installed in the printer port (from pin 1 to pin 18).

NOTE

When using ODT on the PDT-11 system, the Scroll SET-UP feature must be set for Jump Scroll.

When operating using ODT microcode, the last BREAK signal processed by the LSI-11 processor with the ODT enable jumper installed determines the system controller. Therefore, if a BREAK signal is received on the communication port for example, system control will be shifted from the console device to the host computer. Data will then be transmitted to the host system and will not be displayed on the console device video display. To avoid losing system control to the host computer during ODT operation, disconnect the communication cable.

For further information on console ODT refer to the Microcomputer Processor Handbook.

APPENDIX A
ANSI DEFINITIONS AND NOTATION

This appendix has been provided as a reference to the American National Standards Institute (ANSI) terms and notations used throughout this document. The following definitions have been paraphrased from the ANSI publications X3.64, X3.4 and X3.41. The definitions provided are not taken directly from the ANSI standards to provide the reader with two sources of information when learning these terms.

ANSI DEFINITIONS

Active position - The character position on the visual console display that is to display the graphic symbol representing the next graphic character.

ANSI mode - A mode in which console device recognizes and responds only to control functions whose syntax and semantic are in accordance with ANSI specifications.

Character - A sequence of 7 or 8 bits that represent a control or graphic entity. In serial-by-bit transmission, the character is transfered from low-order bit to high-order bit.

Character position - That portion of a visual display which is displaying or is capable of displaying a graphic symbol.

Control - The term "control" refers to a "control function". A control function is implemented through the use of a control character, escape sequence, control sequence or control string.

Control character - A single character whose occurrence in a particular context initiates, modifies, or stops a control function. The value of a control character is in the range of 0 through 37 and 177 octal in a 7-bit environment.

Control function - An action that affects the recording, processing, transmission, or interpretation of data. This term refers to either a control character, escape sequence, control sequence or control string.

Control sequence - A sequence of characters that is used for control purposes to perform a control function. A control sequence is a string of characters that begins with the control sequence introducer (CSI) and ends with the first occurence of a final character (100-176 octal). A control sequence may contain 0 or more parameter characters (060-077 octal) and/or intermediate characters (040-057 octal).

Control sequence introducer (CSI) - A prefix to a control sequence that provides supplementary control functions. The CSI for the PDT-11 console is **ESC [** (033 133 octal).

Control string - A string of characters that is used to perform a control function and that is delimited by an opening and closing delimiter control.

Cursor - A visual representation of the active position which is either a blinking reverse-video or blinking underline. The active position is defined as the active column and active line position in which the next displayable character will be placed. The active line is the line in which the cursor is presently located. The active column is the cursor location on the active line.

Cursor control - An editor function that moves the active position indicated by the cursor.

Default - A function-dependent value that is assumed when no explicit value, or a value of 0, is specified.

Display - The current active area of the screen, i.e., the area inside the scrolling region, or the entire screen, depending on the origin mode.

Editor function - A control that affects the layout or positioning of previously entered or received information. This information is to be interperted and executed without remaining in the data stream. (See format effector).

Escape character (ESC) - A control character that provides supplementary characters (code extension) and that is itself a prefix affecting the interpretation of a limited number of contiguous characters.

Escape sequence - A sequence of characters that is used for control purposes to perform a control function. The sequence begins with an Escape (ESC 033 octal) control character and ends with the first occurrence of a final character (060-176 octal). An escape sequence may have 0 or more intermediate characters (040-057 octal) preceding the final character.

Final character - A character whose bit combination terminates an escape or control sequence designated by "F" in the Control Function Notation section of this appendix.

1) The final character in an escape sequence is in the range 060-176 octal, inclusive.

2) The final character in a control sequence in in the range 100-176 octal, inclusive.

Format effector - A control that affects the layout or positioning of information on the screen. It may remain in the data stream subsequent to interpretation and processing. (See editor function).

Graphic character - A character, other than a control character, that has a visual representation.

Home - The character position at the origin. [See origing mode (DECOM)].

Intermediate character - A character whose bit combination precedes a final character in an escape or control sequence. The character "I" in the Control Function Notation section of this appendix is from 040-057 octal, inclusive.

Numeric parameter - A string of bit combinations in a control sequence that represents a decimal number, designated by Pn. Pn is in the range of 0 (060 octal) to 9 (071 octal).

Parameter - (1) A string of one or more characters that represent a single value: (2) The value so represented.

Parameter string - A string of characters that represent one or more parameter values.

Selective parameter - A string of bit combinations in a control sequence that selects a subfunction from a specified list of subfunctions, designated by Ps. In general, a control sequence with more than one selective parameter causes the same effect as several control sequences, each with one selective parameter, e.g., CSI Psa ; Psb ; Psc F is identical to CSI Psa F CSI Psb F CSI Psc F.

VT52 mode - A mode in which the console recognizes and responds only to DEC private escape sequences which DEC VT52 type terminals use.

CONTROL FUNCTION NOTATION

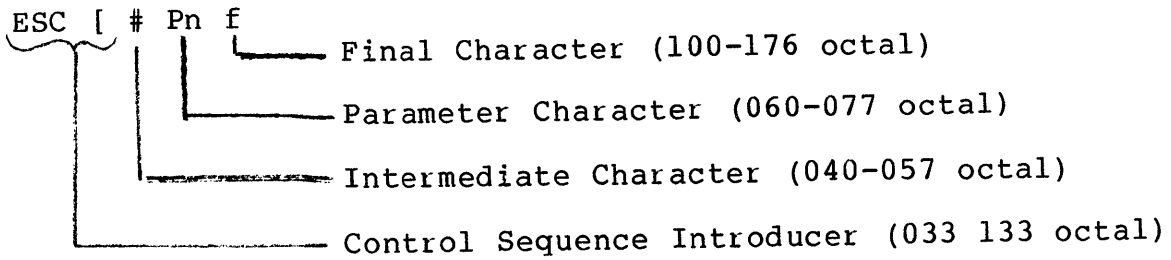
The abbreviations or notations used in defining the control functions for the PDT-11 console device are in accordance with ANSI standard X3.41 - 1974 which defines control function terminology.

Control Sequence Notation

The control sequence notation is defined by ANSI as follows:

ESC [I Pn ; Pn .... Pn F

Example:



Where:

1) ESC [is the control sequence introducer (033 133 octal) for a 7-bit environment

2) I - An intermediate character in a control sequence, where I is from 40_8 to 57_8 inclusive. There may be 0 or more intermediate characters in a control sequence.

3) P - A parameter in a control sequence. There may be 0 or more parameter characters in a control sequence. Parameter characters are separated by a semicolon (073 octal).

   a) Pn is a numeric parameter within the range of 0 (060 octal) to 9 (071 Octal).

   b) Ps is a selective parameter selected from a specified list of parameters.

4) F - A Final character in a control sequence, where F is from 100_8 to 176_8, inclusive.

5) The occurrence of characters in the inclusive ranges of 0_8 to 37_8 is technically an error condition whose recovery is to execute immediately the function specified by the character and then continue with the control sequence execution. The exceptions are:

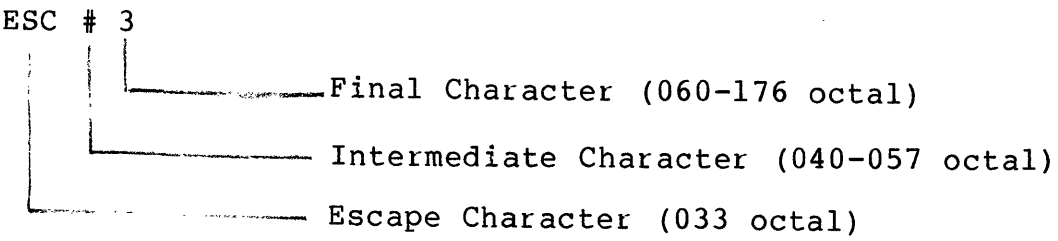
   a) If the character ESC occurs, the current control sequence is aborted, and a new one commences, beginning with the ESC just received.

   b) If the character CAN (30_8) or the character SUB (32_8) occurs, the current control sequence is aborted.

Escape Sequence Notation
The format of an escape sequence as defined in American National Standard X 3.41-- 1974 as follows:

ESC I...I F

Example:



Where:

1) ESC is the introducer control character (033_8) that is named escape.

2) I...I are the intermediate characters that may or may not be present. I characters are in the range of 40_8 to 57_8 inclusive in both 7-and 8-bit environments.

3) F is the final character. F characters are bit combinations 60_8 to 176_8 inclusive in escape sequences in both 7-and 8-bit environments.

4) The occurrence of characters in the inclusive ranges of 0_8 to 37_8 is technically an error condition whose recovery is to execute immediately the function specified by the character and then continue with the escape sequence execution. The exceptions are:

   a) If the character ESC occurs, the current escape sequence is aborted, and a new one commences, beginning with the ESC just received.

   b) If the character CAN (30_8) or the character SUB (32_8) occurs, the current escape sequence is aborted.

APPENDIX B
SYSTEM THROUGHPUT CONSIDERSTIONS, CALCULATIONS AND INSTRUCTION TIMES

This appendix has been provided to aid the system programmer in determining the throughput limitations of the PDT-11 products. Throughput is an indication of the speed at which a string of contiguous characters may be transmitted or received between the PDT-11 processor and any of it's peripheral devices. All throughput considerations presented in this appendix are based on worst case conditions.

SYSTEM THROUGHPUT CONSIDERATIONS AND CALCULATIONS

When programming any system which must service multiple peripheral devices, the programmer must be careful not to demand a throughput rate faster than the system can provide. If the throughput limitations of the system are violated, overrun errors will occur and characters are lost. An overrun error will occur whenever the PDT-11 software fails to fetch a character from a receive data buffer of a peripheral device before the next character is received.

Interrupts are requests from peripheral devices external to the LSI-11 processor. The PDT-11 systems are available with several devices which may generate up to a maximum fourteen interrupts. The devices which can generate interrupts are listed in Table B-1:

TABLE B-1
Interruptable Devices

	Console Video Screen
	Console Keyboard
*	Terminal #1 Printer/display
	Terminal #1 Keyboard
*	Terminal #2 Printer/display
	Terminal #2 Keyboard
*	Terminal #3 Printer/display
	Terminal #3 Keyboard
*	Line Printer
	Line Time Clock
	Tape Drive Transmit (PDT-11/130 only)
	Tape Drive Receive (PDT-11/130 only)
*	Communication Transmit
	Communication Receive

* Baud rate is user programmable

When calculating throughput it is important to distinguish between those ports which receive characters at a throughput rate determined by a peripheral device and ports which obtain characters under the control of the PDT-11 software. Only the receive data buffers of the PDT-11 which have a throughput rate controlled by a peripheral device are susceptable to overrun errors. These receive data buffers are:

three cluster terminal keyboard receive buffers
communication receive buffer
console keyboard receive buffer

The throughput rate is related to the baud rate of the peripheral device. The baud rate setting selected for a device determines the speed at which a single character is transmitted or received. (Split baud rates are not allowed in the PDT-11 products). The maximum time available to fetch a character from the receive data buffer to avoid an overrun error is shown in Table B-2. Table B-2 was generated using worst case conditions as follows:

receiving a string of contiguous characters at a throughput rate equal to the baud rate.

each character contains the maximum number of bits/character (11 bits/character). The each character received contains two stop bits.

TABLE B-2
Maximum Service Time/Character

BAUD RATE SETTING	SEC/CHARACTER
9600	1145 us
7200	1527 us
4800	2291 us
2400	4583 us
2000	5500 us
1800	6111 us
1200	9166 us
600	18.33 ms
300	36.66 ms
150	73.33 ms
134.5	81.78 ms
110	100 ms
75	146.6 ms
50	220 ms

SYSTEM THROUGHPUT CALCULATIONS

I/O instructions in the PDT-11 systems take more time than in a standard PDP-11 because of the PDT-11 I/O microprocessor. The PDT-11 word I/O takes 90 us to execute, a byte I/O takes 180 us. During an interrupt sequence an interrupt acknowledge (IAK) is executed automatically, this takes 90 us. For any device, the interrupt latency (the time from the interrupt request to the time when the request is serviced) plus the time to service the interrupt must be less than the time allowed before an overrun may occur. This relationship is shown in equation #1.

Equation #1 System Throughput Calculation

Interrupt Latency	+ 90 us (IAK)	+ Service Routine Until Interrupt Enabled	+ 90 us (To Get Character)	+ Service Routine End	< Sec/Char (refer to Table B-1)

NOTE
When using byte I/O transactions, an additional 90 us is added to the left hand side of the above equation.

The left side of the equation must be less than the right side or characters will be lost. The closer the left side of the equation is to the right side, the greater the chance of overrun errors occuring.

Interruptable Service Routines

Interruptable service routines may improve the interrupt latency by deferring the fetching of a character to a later time. The character may be fetched at times when the processor is idle. Equation #2 shows the interrupt latency calculation for interruptable service routines.

Equation #2 Interrupt Latency Calculation for Interruptable Service Routines

$$\text{Interrupt Latency} = \left[\left[\begin{array}{l}\text{\# of Devices}\\ \text{That can}\\ \text{Interrupt}\end{array}\right] - 1\right] \times \left[90\text{ us} + \begin{array}{l}\text{Time Within Service}\\ \text{Routine before}\\ \text{Interrupted}\end{array}\right]$$

Non-interruptable Service Routines

Non-interruptable service routines are used when the interrupts occur so rapidly that defering the character time will not aid in reducing the interrupt latency. This occurs when the system is not idle long enough to fetch the defered characters. Equation #3 shows the calculation for the interrupt latency for non-interruptable service routines.

Eqaution #3 Interrupt Latency Calculation for Non-interruptable Service Routines

$$\text{Interrupt Latency} = \left[\text{\# Of Devices That Can Interrupt} - 1\right] \times \left[180\ \text{us} + \text{Average Processor Code Execution Time for a Service Routine}\right]$$

NOTE

The 180 us includes 90 us to do the IAK and 90 us to get the character. The Processor instruction exection time is found in the second section of this appendix.

Example:
In some applications, characters typed on the console keyboard must be echoed on the video screen with the line time clock running (causing an interrupt every 16.6 ms). Human typing is generally less than 110 baud except for the generation of control functions (which is a worst case condition). Control function characters will be transmitted at a throuthput rate equal to the baud rate of the device. The baud rate of the console device is set at 4800 baud. Therefore, the service routine must fetch a character prior to every 2291 us to avoid an overrun error.

Equation #3

$$\text{Interrupt Latency} = \left[\text{2 devices (Video + LTC)}\right] \times \left[180\ \text{us} + 250\ \text{us}\ *\right] = 860\ \text{us}$$

* 250 us assumes that the average service routine for both the video screen and line time clock (LTC) are 25 instructions with an average execution time of 10 us per instruction.

Equation #1

860 us (Interrupt Latency) + 90 us (IAK KYB) + 90 us (CHAR Fetch) + 250 us (Service Routine Execution) = 1290 us

1290 us < 2291 us (characters will not be dropped)

INSTRUCTION TIMING

The execution time for an instruction depends on the type of instruction and the mode of addressing implemented. In most cases, the instruction execution time is a sum of the Basic Time, a Source Address Time (SRC) and a Destination (DST) Time.

Instruction Time = Basic Time + SRC Time + DST Time

(Basic time = fetch time + decode time + execute time)

The source and destination times of the LSI-11 processor are shown in Table B-3.

TABLE B-3
Source and Destination Time

MODE	SRC TIME (W)	SRC TIME (B)	DST TIME (W)	DST TIME (B)
0	0	0	0	0
1	1.52	1.14	2.28	1.90
2	1.52	1.14	2.28	1.90
3	3.80	3.42	4.56	4.56
4	2.28	1.90	3.04	2.66
5	4.56	4.18	5.32	5.32
6	4.56	4.18	5.32	4.94
7	6.84	6.46	7.22	7.60

(All times in microsceonds) NOTE: For mode 2 and mode 4 if R6 or R7 used with byte operation add 0.38 usec to SRC time and 0.76 used to DST time.

The basic times of the LSI-11 double and single operand instructions are listed in Table B-4.

TABLE B-4
Basic Times

INSTRUCTION	DM0	DM1-7
DOPS (double operand)		
MOV	3.42	2.28
ADD, XOR, SUB, BIC, BIS	3.42	4.18
CMP, BIT	3.42	3.04
MOVB	3.80	3.80
BICB, BISB	3.80	3.80
C,[B. BITB	3.04	2.66

SOPS (single operand)

CLR	3.80	4.18
INC, ADC, DEC, SEC	4.18	4.94
COM, NEG	4.18	4.56
ROL, ASL	3.80	4.56
TST	4.18	3.80
ROR	5.32	6.08
ASR	5.70	6.46
CLRB, COMB, NEGB	3.80	4.18
ROLB, ASLB	3.80	4.18
INCB, DECB, SBCB, ADCB	3.80	4.56
TSUB	3.80	4.56
RORB	4.18	4.94
ASRB	4.56	6.08
SWAB	4.18	3.80
SXT	6.08	6.84
MFPS (1067DD)	4.94	6.84
MTPS (1064SS)	7.22	7.22

For MTPS use Byte DST time not SRC time.
Add 0.35 us to instruction time if Bit 7 of effective OPR = 1

Table B-5 provides the destination times of the JMP/JSR instructions.

TABLE B-5
JMP/JSR Instruction Destination Times

JMP/JSR MODE	DST. TIME
1	0.76
2	1.52
3	1.90
4	1.52
5	2.66
6	2.66
7	4.56

Table B-6 lists the basic times of the Branch, Control, Trap, Jump and Miscellaneous Instructions.

TABLE B-6
Branch, Control, Trap, Jump and Miscellaneous Instructions

INSTRUCTION	TIMES
JMP	3.52
JSR (FC=LINK)	5.32
JSR (FC≠LINK)	8.74
All branches	3.42 (condition MET or net MET)
SOB (Branch)	4.94
SOB (NO Branch)	4.18
SET CC	3.42
CLEAR CC	3.42
NOP	3.42
RTS	5.32
MARK	12.16
RTI	9.88*
RTT	9.88*+
TRAP, EMT	17.86*
IOT, BPT	19.76*
WAIT	6.46
HALT	6.08
RESET	6.46 + 11.4uSEC for INIT+99.0uSEC
MAINT INST (00021R)	22.04
RSRVC INST (00022X)	6.46 (To get to ADDRESS 3000)

* If new PS has bit 7 set, add 0.35 us for each
*+ If new PS has bit 4 (T bit) set add 2.10 us

APPENDIX C
KEY CODE GENERATION

This appendix has been provided to aid the reader in equating a console key to the octal code generated. The octal codes generated by the console keyboard are shown in Figure C-1. The shaded keys indicate the keys used in conjunction with the keyboard keys to generate shifted codes.

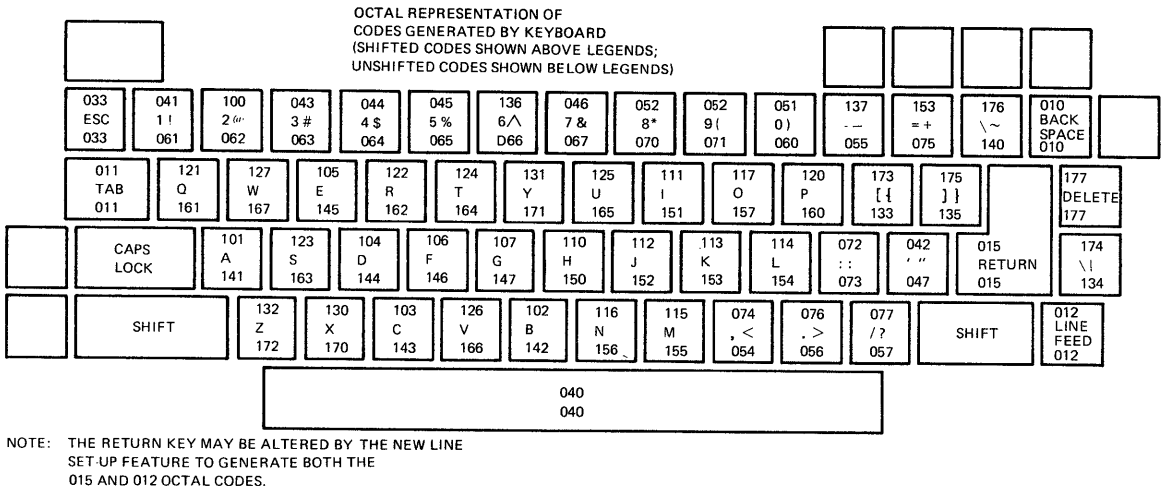


FIGURE C-1 Key Code Generation

ACCEPTANCE TESTING

The PDT-11 products are equipped with internal self test programs used to verify the proper operation of the system hardware. The internal self test programs are run automatically whenever a power up sequence is initiated. In addition to the self test programs, the PDT-11/130 system may use a system exerciser program contained on the system exerciser tape, part number ZJ-288. The system exerciser is used to test the interaction between the system components with emphasis on the tape drive. The system self test programs must be completed successfully before the system exerciser is run, refer to the PDT-11/110, and PDT-11/130 User Guide for further information on the self test programs.

The system exerciser tests the interaction between the PDT-11 processor and its peripheral devices. When an error is found the exerciser will halt operation, ring the bell and display an error code in blinking bold characters (refer to the System Exerciser Error Messages section of this document for further information on error codes). One complete pass of the system exerciser program is required during the acceptance testing procedure. No errors are allowable during the running of the acceptance test. If errors are found, further repair action is required.

The system exerciser checks the interaction of the following devices:

the PDT-11 main memory

the console device

the optional line printer (if installed)

the line time clock (used within the PDT-11 processor)

the tape drives

the synchronous comm port

the asynhronous comm port

the optional clustered terminals (if installed)

When using the system exerciser, two scratch tape cartridges (part number TU58-K) are required.

Running The PDT-11 System Exerciser

To run the PDT-11 system exerciser in the PDT-11/130 system, use the following procedure:

1. Place the write protected system exerciser tape (part number ZJ-288) in to tape drive Ø.

2. Enter SET-UP mode and use the Reset feature.

   Press the SET-UP key

   Press the Ø key of the main keyboard

   The system will load a portion of the system exerciser into the PDT-11 main memory. This takes approximately two minutes. The system will then display:

   ```
   CLEARING MEMORY
   CHMPDAØ XXDP+ PD MONITOR (Memory size)
   BOOTED VIA UNIT (Ø OR 1)

   ENTER DATE (DD-MM-YY):
   ```

3. Press the RETURN key. The system will display:

   ```
   RESTART ADDRESS: XXXXXX
   ```

   (XXXXXX = is a variable number dependent on the system memory size)

   ```
   5Ø HZ? N
   ```

4. If the power supplied to the system is 5Ø Hz, press the Y and RETURN keys. If the power is 6Ø Hz, press the RETURN key. The system will display:

   ```
   LSI? N
   ```

5. Press the Y and RETURN keys. The system will display:

   ```
   THIS IS XXDP+  TYPE H OR H/L FOR DETAILS
   .
   ```

6. Type the following on the main keyboard:

   R VKDBAØ and press the RETURN key.

The system exerciser will be loaded from the tape to the PDT-11 main memory. This takes approximately one minute. The system will then display:

```
CVKDBAØ PDT-11 11Ø/13Ø SYS. EX.   Ø PASS  Ø TOTAL ERRORS ( Ø SOFT)

SWR = ØØØØØØ  NEW =
```

7. Type 152ØØØ and press the RETURN key. The system will display:

```
$DEVM = ØØØØ17  NEW =
```

8. Press the RETURN key. The system will display:

```
XX  MEMORY SIZE        ( XX equals the memory size of the system)
```

any devices not present such as line printer, etc. will be printed on the screen here.

```
INSERT SCRATCH CASSETTES, TYPE  P  TO PROCEED
ØØ2374
@
```

9. Remove the system exerciser tape from tape drive Ø. Insert the scratch tapes (which are not write protected) into the two tape drives. Press the P and RETURN keys.

NOTE
Before running the system exerciser, ensure that both scratch tapes are not write protected and are fully inserted into the tape drives.

10. The exerciser will start running the interaction tests. As each test is passed, the system will display a passed test message on the top half of the screen. The bottom half of the screen contains data used to test console interaction. The exerciser tests take approximately eleven minutes to complete. If an error is found, the system will halt, ring the bell and display an error code in blinking bold characters. If no errors are found, the exerciser will run continuously. (One complete pass of the system exerciser is required for acceptance testing.) At the end of each pass the system displays an END PASS message as follows:

```
END PASS     TOTAL ERRORS THIS PASS  XX   (XX equals number of
                                           errors found)
             SOFT ERRORS THIS PASS   XX   (XX equals number of
                                           errors found)
```

The system will then update the message at the top of the screen as follows:

CVKDBA0 PDT-11 110/130 SYS. EX. X PASS 0 TOTAL ERRORS (0 SOFT)

(Where X equals the number of passes completed)

The execiser automatically begins the next pass.

11. Remove both scratch tapes from the tape drives and use the Reset SET-UP feature of the system to finish running the system exerciser.

System Exerciser Error Messages

If the PDT-11 system exerciser encounters an error it will halt operation (hold the present console test dsts on the screen), ring the bell and display an error code in blinking bold characters. The system exerciser uses several display formats to indicate the detection of errors. Typical examples of the error displays are shown in Figure 1. The display formats are used to indicate hardware malfunctions within the system. Hardware malfunctions within the system cannot be fixed by the operator and further repair action by a field service representative is required.

Example #1 (with a cluster terminal data error detected):

```
CLUSTER TERM #3 DATA COMP ERR
ERROR #    ERR PC     EXPECTED     RECVD
XXXXXX     XXXXXX     XXXXXX       XXXXXX
```

Example #2 (with a tape drive error detected):

```
TU58 DEVICE ERROR
ERROR #    ERR PC     ERR WRD      OP CODE     UNIT #
XXXXXX     XXXXXX     XXXXXX       XXXXXX      XXXXXX
```

FIGURE 1 System Exerciser Error Displays

XXPD+/SUPER USER'S MANUAL

MAIN DEC # CHQUSB REV B

TO BE RELEASED IN THE 80-01

PDP-11 DIAGNOSTIC UPDATE

PDT-11 110/130

SYSTEMS EXERCISER

MAIN DEC # CVKDBA Ø

TO BE RELEASED IN THE 80-01

PDP-11 DIAGNOSTIC UPDATE