DIGITAL Facility, Albuquerque, N.M.

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part I terminals

part II communication

part III quick reference
NOTE

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**We read every single** response card and carefully consider every suggestion you make!

Thank you,

THE AUTHORS
terminals and communications handbook
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This handbook is a comprehensive overview of and a general reference about terminals and communications interfaces. Since this handbook is an overview, you will find that it cannot include the same degree of technical detail as a document dedicated to a particular product. It should provide enough information to allow you to determine if you would like additional information about a particular terminal or communications interface.
# CONTENTS

## PART I — TERMINALS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION TO TERMINALS</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>THE DECwriter II (LA36)</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>THE DECwriter IV (LA34/38)</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>THE DECwriter III (LA120)</td>
<td>27</td>
</tr>
<tr>
<td>5</td>
<td>THE VT100 VIDEO TERMINAL</td>
<td>43</td>
</tr>
<tr>
<td>6</td>
<td>THE VT55 GRAPH DRAWING TERMINAL</td>
<td>59</td>
</tr>
<tr>
<td>7</td>
<td>THE PDT-11 INTELLIGENT TERMINALS</td>
<td>65</td>
</tr>
</tbody>
</table>

## PART II — COMMUNICATION

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>BASIC CONCEPTS OF DATA COMMUNICATION</td>
<td>83</td>
</tr>
<tr>
<td>9</td>
<td>ASYNCHRONOUS SINGLE LINE COMMUNICATION</td>
<td></td>
</tr>
<tr>
<td>DL11</td>
<td></td>
<td>105</td>
</tr>
<tr>
<td>10</td>
<td>ASYNCHRONOUS MULTILINE COMMUNICATION</td>
<td></td>
</tr>
<tr>
<td>DZ11</td>
<td></td>
<td>115</td>
</tr>
<tr>
<td>COMM IOP-DZ</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td>DH11</td>
<td></td>
<td>137</td>
</tr>
<tr>
<td>DZV11</td>
<td></td>
<td>152</td>
</tr>
<tr>
<td>11</td>
<td>SYNCHRONOUS SINGLE LINE COMMUNICATION</td>
<td></td>
</tr>
<tr>
<td>DUP11</td>
<td></td>
<td>163</td>
</tr>
<tr>
<td>DQ11</td>
<td></td>
<td>171</td>
</tr>
<tr>
<td>DMC11</td>
<td></td>
<td>179</td>
</tr>
<tr>
<td>DUV11</td>
<td></td>
<td>193</td>
</tr>
<tr>
<td>CHAPTER 12</td>
<td>SYNCHRONOUS MULTILINE COMMUNICATION INTERFACES</td>
<td>199</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>COMM IOP-DUP</td>
<td></td>
<td>199</td>
</tr>
<tr>
<td>CHAPTER 13</td>
<td>SYNCHRONOUS/ASYNCHRONOUS MULTILINE COMMUNICATION INTERFACES</td>
<td>207</td>
</tr>
<tr>
<td>DV11</td>
<td></td>
<td>207</td>
</tr>
<tr>
<td>CHAPTER 14</td>
<td>AUXILIARY COMMUNICATION PROCESSORS</td>
<td>219</td>
</tr>
<tr>
<td>KMC11-A</td>
<td></td>
<td>219</td>
</tr>
<tr>
<td>CHAPTER 15</td>
<td>COMPUTER SPECIAL SYSTEMS</td>
<td>225</td>
</tr>
<tr>
<td>CS11-M</td>
<td></td>
<td>225</td>
</tr>
<tr>
<td>IMP11-A</td>
<td></td>
<td>231</td>
</tr>
<tr>
<td>PCL11-B</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>VTV30-H</td>
<td></td>
<td>244</td>
</tr>
<tr>
<td>CHAPTER 16</td>
<td>TRADITIONAL PRODUCTS PROFILE</td>
<td>249</td>
</tr>
</tbody>
</table>

PART III — QUICK REFERENCE

APPENDIX A QUICK REFERENCE FOR THE DECwriter IV (LA34/38) .................................. 255
DETAILED SPECIFICATIONS ........................................ 256
PROGRAMMING INFORMATION ......................................... 260

APPENDIX B QUICK REFERENCE FOR THE DECwriter III (LA120) .................................. 265
DETAILED SPECIFICATIONS ........................................ 266
OPTIONS ......................................................... 270
ACCESSORIES ...................................................... 271
PROGRAMMING INFORMATION ........................................ 273
SUMMARY OF MODEM CONTROL FEATURES .......................... 279

APPENDIX C QUICK REFERENCE FOR THE VT100 ...................... 281
OPTIONS ......................................................... 282
PROGRAMMING INFORMATION ........................................ 283
COMMUNICATION CABLES ............................................ 297
FILL CHARACTER REQUIREMENTS .................................... 299
part I terminals
CHAPTER 1

INTRODUCTION

DIGITAL is one of the world’s leading terminal manufacturers, producing over one quarter million computer terminals a year. Our leadership is not in numbers alone, but rather in the practical application engineering that has made DIGITAL terminals so popular. Because we are leaders in interactive computer systems and pioneers in distributed systems, we truly understand interactive terminals and their use. In fact, we are one of our own biggest customers for terminals.

GENERAL PURPOSE INTERACTIVE TERMINALS
DIGITAL offers a wide variety of terminals. This handbook will present DIGITAL’s general purpose interactive terminals.

General Purpose
As the term implies, general purpose terminals are not limited to any specific host system or application. They can be connected to a variety of host computer systems and are suited for a wide range of interactive applications.

You don’t have to own a DIGITAL computer system to use DIGITAL terminals.

Hundreds of thousands of DIGITAL terminals are currently in use communicating with computers built by other manufacturers.

ALL DIGITAL general purpose terminals can communicate using:
• American Standard Code for Information Interchange—ASCII code
• EIA RS-232C compatible or 20 mA current loop interface
• Asynchronous communications
• Odd, even or no parity

Interactive
Interactive terminals let you carry on a “conversation” with the computer and get individual responses to inquiries, statements and commands. You can enter requests as fast as you can type. The computer processes your requests as they are received and sends the response to your terminal. Of course, if you are using a timesharing system, you may have a short wait in the queue before the computer starts to process your request.

HARDCOPY TERMINALS
The DECwriter II (LA36) was a truly outstanding terminal success story. For years, the DECwriter II was the standard against which other
hardcopy terminals were judged. Now there are new standards for hardcopy terminal performance—the DECwriter III and the DECwriter IV. Both add the latest LSI microprocessor technology to proven DECwriter printing performance.

The DECwriter IV takes the DECwriter down off its pedestal and puts it in an attractive desktop unit. The DECwriter IV also has an attractively low price.

The DECwriter III is a wise selection because it’s smart:
- Smart enough to print bidirectionally at 180 cps
- Smart enough to give you an unparalleled range of over 45 keyboard selectable print and communication features

VIDEO TERMINALS
The VT100 set a new standard in video terminal versatility with a combination of features never before available in a compact desktop terminal. It has proven to be one of the most popular, and most imitated, video terminals ever offered.

The VT55 DCEscope is three devices in one—a graph drawing terminal, an alphanumeric programmer’s terminal and an electrolytic printer/plotter which prints line-for-line images of the entire screen.

INTELLIGENT TERMINALS
PDT-11 intelligent terminals give you the power, versatility and programmable flexibility of a small computer right in your own office or department. When your application needs computing power right at the source of the information, your probably need a PDT-11.

Typical PDT-11 applications include local error checking and preprocessing of order entry, inventory control, billing and scheduling information. PDT-11 intelligent terminals may also be used for remote data entry and small business computation with immediate access to locally stored files without host computer intervention, and data capture and storage for later transmission to the host.

The PDT-11/110 terminal is a user-programmable intelligent terminal that adds the power of an LSI-11 microprocessor to the video versatility of the VT100. Among its features are PDP-11 code compatibility and up to 60K bytes of down-line loadable Random Access Memory.

The PDT-11/130 terminal adds 512K bytes of additional storage on handy dual cassettes to all the features of the PDT-11/110. The tape units are an integral part of the compact, PDT-11 terminal which fits easily on the top of a desk.
The PDT-11/150 terminal is also a small stand-alone business system in a terminal package. It can put the executive in touch with every part of the company as the intelligent node in a network and operate as a small, independent computer. The PDT-11/150 includes three system expansion ports for adding up to four terminals, making it a powerful remote workstation. Any of DIGITAL's LA series of printers can be connected to the second port for hardcopy capability and the third port provides an EIA link to a host computer.

SPECIAL PURPOSE TERMINALS
In addition to the general purpose terminals presented in this handbook, DIGITAL also offers special purpose terminals. Many of these special purpose terminals are modified versions of general purpose terminals. However, some require special software packages and may only be used with DIGITAL computers. For more information about DIGITAL's special purpose terminals, contact your local DIGITAL sales office.
CHAPTER 2
THE DECwriter II (LA36)

INTRODUCTION

THE STANDARD OF THE INDUSTRY
The DECwriter II (LA36) set a new standard and established DIGITAL as a leading supplier of hardcopy terminals. Its rugged reliability and continued performance even after years of hard use is almost legendary. This is combined with common sense human engineering for practical operator convenience and comfort. For these reasons, the DECwriter II (LA36) is one of the most popular hardcopy terminals in the world today.

MAJOR FEATURES AND BENEFITS

FEATURES | BENEFITS
---|---
100 Million Character print head | Proven reliability and durability
16 character buffer and 60 cps catch-up mode | True 30 cps throughput
7 × 7 dot matrix impact printing | Prints up to six-part forms (.020 in. maximum pack thickness)
Variable width forms handling | 7.6 cm-37.8 cm (3 in.-14 7/8 in.) wide forms via adjustable tractor feed
Fine vertical adjustment for accurate forms placement | Accurate alignment of data on printed media
Communication flexibility | Half- or full-duplex
Parity check on output | 20 mA current loop interface standard on most models
| EIA interface with modem control available
Set to odd, even, or no parity with mark or space using internal jumper straps
FEATURES
Automatic LCV (Last Character View)

Pedestal design with ANSI-standard multi-key rollover keyboard

14-key numeric pad (optional on some models)

BENEFITS
The print head moves four columns to the right when you pause in your typing so you can see the last character you typed and returns automatically when you type the next character

The typewriter-like keyboard is at proper height for operator comfort

Industry-standard adding machine keyboard for efficient number entry

SUMMARY DESCRIPTION
The DECwriter II is a pedestal mounted 30 cps interactive dot-matrix impact printing terminal. It has a 16 character buffer and a 60 cps catch-up mode for true 30 cps throughput. It accepts 1- to 6-part forms from 7.6 cm to 37.6 cm (3 in.-14 7/8 in.) wide via an adjustable tractor feed. The integral stand design provides a comfortable height for the typewriter-style keyboard. It has a wide variety of options and accessories and is built for a long, reliable lifetime of heavy use.

RELIABILITY
The DECwriter II has a well deserved reputation for outstanding reliability. It has stood up to years of heavy usage in hostile environments (to which it never should have been subjected). DECwriter II reliability has become the standard against which other hardcopy terminals are compared.

The famous 100 million character print head uses a jeweled head bearing to guide the seven solenoid-driven print wires that make up the 7 X 7 character matrix. The curvature of the print wire guide tubes matches the natural curvature of the print wire. It is not unusual for a print head to last five to seven years under average use.

OPTIONS
LAXX-LG—EIA/CCITT Interface Option
This option provides an EIA RS-232C or CCITT V.24 interface for any LA36. The option includes auto answer, timed disconnect, and half/full-duplex logic to provide earlier LA36s with half-duplex. A 9-foot cable with 25-pin modem type connector is also supplied with this option.
**LAXX-PK**—APL/ANSI Dual Character Set
The APL/ANSI dual character set option allows the DECwriter II to be used as a bit-paired ASCII APL terminal. With this option installed, the DECwriter II has two character sets, and selection of the desired set is possible via the receipt of Shift In (SI) and Shift Out (SO) ASCII control codes or via the ALT CHAR SET switch on the operator's control panel. The character set lock switch is used to lock out either manual control or host computer control of character set selection.

**1.0.1 Accessories**

**LAXX-KA**—Caster, Paper Tray and Shelf Kit
This accessory provides a DECwriter II with two rear casters to allow the terminal to be moved easily; a paper stacking tray to catch the printer paper behind the DECwriter II; and a right and/or left shelf area to provide operator work space.

**LAXX-KB**—Caster Kit for DECwriter II
Kit of two casters as described in the LAXX-KA option.

**LAXX-KC**—Shelf for DECwriter II
This accessory provides the operator work area as described in the LAXX-KA option. Two shelves can be mounted on the DECwriter II at one time.

**LAXX-KD**—Paper Tray for DECwriter II
This accessory provides only the paper catcher as described in the LAXX-KA.

**LAXX-NC**—Deep Paper Basket for DECwriter II and DECprinter I

**H981-A** — Adjustable Position Document Holder
This accessory provides the operator of a DECwriter with an adjustable position document holder.
Figure 2-1  DECwriter III  LA120
DIGITAL HAS TAKEN THE MOST POPULAR FEATURES FROM THE DECwriter II AND INCORPORATED THEM IN TWO NEW DECwriters WITH THE SAME RUGGED RELIABILITY.

The DECwriter III (LA120) — a 180 cps smart printing terminal with an outstandingly flexible range of over 45 standard keyboard-selectable features.

The DECwriter IV (LA34/38) — a 30 cps desktop terminal which is as easy to use as an electric typewriter and weighs only 10 kg (22 lbs.). It has a 130 character buffer, eight switch-selectable communication features, and keyboard- or software-selectable print control features including: left/right margins; horizontal tabs; four character sizes and six line spacings. The DECwriter IV is available with a roll paper holder or tractors.
CHAPTER 3

THE DECwriter IV (LA34/38)

INTRODUCTION

WE'VE TAKEN THE DECWRITER DOWN OFF ITS PEDESTAL
Now you can get DECwriter convenience and reliability in a rugged tabletop terminal. The DECwriter IV (LA34/38) looks and feels like an electric typewriter, but it's loaded with a surprising range of practical terminal features.

THE TABLETOP TERMINAL WITH A TYPEWRITER TOUCH
If you have ever used an electric typewriter, you'll like the DECwriter IV. The comfortably contoured keyboard is designed to feel like a typewriter keyboard. It has a convenient snap-in cartridge ribbon—no spools to thread, no mess. The print head moves aside for LCV (Last Character View) at the touch of the VIEW key. For added convenience, all alphanumeric keys and the space bar repeat automatically when you hold them down for more than one-half second.

The DECwriter IV even has a typewriter style friction roll platen. You're not limited to chemically treated papers or any so called "standard" paper size. The DECwriter IV will accept blank paper or forms of any width from 7.6 cm to 37.8 cm (3 in. - 14 7/8 in.). You can manually feed cut sheets (typewriter paper), attach the roll paper holder\(^1\) to print on roll feed paper, or attach the tractor\(^2\) to print fanfolded sprocket feed computer paper and multipart forms.

THE TABLETOP TERMINAL WITH A TOUCH OF CLASS
The DECwriter IV is designed to be at home wherever there's a job to be done...in the office, the computer room...for timesharing, message networks, system console...anywhere you have room for an electric typewriter and need an interactive hardcopy terminal. Its sleek modern styling fits in with any decor. And it's surprisingly light, just 10 kg (22 lbs.).

THE TRUSTWORTHY TABLETOP TERMINAL
The DECwriter IV may be the most reliable hardcopy terminal DIGITAL has ever offered. Just ask about the low cost DIGITAL service con-

1 The roll paper holder is optional on all models.
2 Tractors are optional on the LA34 and standard on the LA38.
TRACT. Circuitry has been reduced to a single logic board with a custom LSI (Large Scale Integrated) microprocessor for the latest in solid state reliability. A special circuit instantly senses print head jams and cuts power to the print head drive—no more motor overloads or blown fuses. The print head is designed to print at least 100 million characters.

THE ECONOMICAL TABLETOP TERMINAL
The DECwriter IV the lowest cost hardcopy terminal DIGITAL has ever offered. This low purchase price is combined with outstanding reliability for the lowest overall cost of ownership of any DIGITAL hardcopy terminal. When you compare the DECwriter IV’s convenient desktop styling and practical performance features with its surprisingly low price, you’ll see that the DECwriter IV gives you a price/performance ratio that’s hard to match.

THE TALENTED TABLETOP TERMINAL
The DECwriter IV (LA34/38) may look and feel like a typewriter, but it packs a powerful practical flexibility no other desktop terminal can touch. Despite it’s convenient desktop size and modern styling, the DECwriter IV definitely acts like a heavyweight.

What other desktop terminal could give you all these practical features?

Keyboard- or software-settable print control features — left/right margins, unlimited horizontal tabs, variable character sizes and line spacings.

Switch-selectable internal communication features — Local Echo, Auto Line Feed, Auto XON/XOFF, ANSI New Line, and parity (odd, even or no parity).

Operator convenience features — sculptured typewriter-style keyboard, multi-key rollover protection, manual LCV Auto Repeat on all alphanumeric keys and the space bar, even a bell to warn you when you are eight characters away from the right margin.

MAJOR FEATURES AND BENEFITS

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractive typewriter styling</td>
<td>Desktop convenience</td>
</tr>
<tr>
<td>Typewriter-style keyboard</td>
<td>Easy transition from typewriter to terminal</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Paper or forms from 7.6 cm to 37.8 cm (3 in. - 14 7/8 in.)</td>
<td>You’re not limited to a preset paper width or a special type of paper</td>
</tr>
<tr>
<td></td>
<td>Use sheets, roll paper, fanfold computer paper or preprinted forms</td>
</tr>
<tr>
<td>160 character buffer</td>
<td>Efficient communications—no fill characters required under normal operating conditions</td>
</tr>
<tr>
<td>30 cps (characters per second) print speed with a 45 cps catch-up mode</td>
<td>True 30 cps throughput</td>
</tr>
<tr>
<td>7 × 9 dot matrix impact printing</td>
<td>Prints plain paper and up to four-part forms</td>
</tr>
<tr>
<td></td>
<td>Permanent easy-to-read characters</td>
</tr>
<tr>
<td>Print Format Controls</td>
<td>Set the printer control features at the keyboard</td>
</tr>
<tr>
<td>Left/right margins anywhere on the page</td>
<td>Or include print control commands in your programs to automatically format the printed output for each program</td>
</tr>
<tr>
<td>Horizontal tabs anywhere on the line</td>
<td>Use larger pitches for attention-getting headers and messages</td>
</tr>
<tr>
<td></td>
<td>Use condensed pitches to save paper</td>
</tr>
<tr>
<td></td>
<td>Print 132 columns on an 8½ in. sheet, 216 columns on a full width sheet</td>
</tr>
<tr>
<td>Four different horizontal pitches (characters per inch)</td>
<td>Vary vertical spacing to a wide variety of preprinted forms.</td>
</tr>
<tr>
<td></td>
<td>Print superscripts and subscripts</td>
</tr>
</tbody>
</table>

**SUMMARY DESCRIPTION**

The DECwriter IV is a low-cost, lightweight desk-top terminal with contemporary styling. It is microprocessor-driven and capable of processing data at rates up to 30 cps. It has a 7 × 9 dot matrix impact print head and can print plain paper or preprinted forms in sheets, rolls or continuous fanfolds with widths from 7.6 cm to 37.8 cm (3 in. - 14 7/8 in.).
The DEWriter IV communicates over full-duplex, asynchronous lines at 300 or 110 baud. It interfaces to EIA devices with a 25-pin connector that meets the requirements of EIA specification RS-232C (Bell 103 type modems). A 20 mA loop interface is optional. Switch-selectable communication features include Local Echo, Auto Line Feed, Auto XON/XOFF, ANSI New Line, and Parity (odd, even or no parity). Keyboard- and software-selectable features include left/right margins, horizontal tabs, horizontal pitch, and vertical pitch.

Available options include roll paper holder, tractors (standard on some models), 18-key numeric keypad (also standard on some models), 20 mA interface, terminal stand, low paper detector (roll paper feed only), and paper out detector (tractor feed only).

HUMAN ENGINEERING
The DEWriter IV was designed to be an exceptionally convenient terminal whether you’re a typist who is using a terminal for the first time or an experienced terminal user. It’s also an extremely practical terminal. All of the print control features are keyboard-selectable, so you can easily reset them. But the internal communication features are switch-selectable for your protection.

CONVENIENT AND COMFORTABLE
The DEWriter IV was designed to “feel right” to the experienced typist. All of the contoured alphanumeric keys are just where you expect them to be and all the alphanumeric keys and the space bar repeat automatically when you hold them down for more than one-half second. There’s even a warning bell eight characters from the right margin. And if you’re either a very good or very poor typist, you’ll appreciate the N-key rollover feature. You won’t lose any characters even if you accidently type one or more keys before you’ve released the previous key.

Another convenient feature is the Manual LCV. The print head moves four columns to the right when you press the VIEW key. This lets you clearly see the last character you typed. Manual LCV eliminates distracting print head motion every time you pause in your typing. The VIEW key also resets your terminal after an error condition, such as a print head jam, has been corrected.

EASY TO USE
The DEWriter IV is easy for you or your host computer to set up, or you can let it set itself automatically. When you turn the terminal on, it assumes a standard setup of 10 characters per inch, 6 lines per inch, tab stops every 8 columns, the left margin at column 1 and the right margin at column 132. It will maintain these settings until you or your
host computer temporarily reset them. Your terminal automatically returns to the standard settings when you turn it off.

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Tab Stops</td>
<td>1, 9, 17, 25, 33, 41, 49, 57, 65, 73, 81, 89, 97, 105, 113, 121, 129</td>
</tr>
<tr>
<td>Left Margin</td>
<td>1</td>
</tr>
<tr>
<td>Right Margin</td>
<td>132</td>
</tr>
<tr>
<td>Horizontal Pitch</td>
<td>10 cpi</td>
</tr>
<tr>
<td>Vertical Pitch</td>
<td>6 lpi</td>
</tr>
</tbody>
</table>

Figure 3-1 Permanently stored SETUP parameters

CONVENIENT SETUP MODE—  
(for the Keyboard-Selectable Print Control Features)
Setup Mode was designed to help you quickly and easily reset the print control features from the keyboard. You can put your terminal in Setup Mode by pressing the SETUP key while you are holding down the CONTROL key. The red SETUP indicator light flashes when your terminal is in Setup Mode. You can then easily reset any of the print control features.

For example: suppose you wanted to change your terminal’s horizontal pitch setting (the number of characters per inch). You could type the H key then the RETURN key. Your terminal would then print a message which tells you the command for each possible horizontal pitch setting, as well as what the current setting is.

To set the print size to 16.5 characters per inch, you would type H = D and press the RETURN key. Then, when you left Setup Mode by pressing the SETUP key, your terminal could print a full 132-character line on a standard 8½ in. wide page. All of the other print control features are just as easy to reset.

If you ever want a printed summary of all the current settings, just press the labeled STATUS key while your terminal is in Setup Mode. Your terminal will automatically print a status message telling you the vertical and horizontal pitches, communications settings, and the positions of the left and right margins. Then your terminal will automatically leave Setup Mode.
While your terminal is in Setup Mode, you can run several different terminal self-tests.

Figure 3-2  Status message

Figure 3-3  Ripple pattern self-test

Figure 3-4  Character self-test

Figure 3-5  Vertical bar self-test

APPLICATION ENGINEERING
The DECwriter IV has a surprising range of application flexibility. You can set the print control features from the keyboard or include print control commands in your programs to automatically format the printed output. The 18-key numeric keypad4 includes four user-defined special function keys. And you have your choice of printing on plain or preprinted cut sheets, roll paper, or pin feed computer paper.5

4 The 18-key numeric keypad is optional on some models.

5 Tractors are optional on some models. The roll paper holder is optional on all models.
PRACTICAL PRINT CONTROL FEATURES

The DECwriter IV gives you a number of very useful print control features. You can set these print control features from the terminal keyboard. Or you can write print control commands into your programs to automatically format reports and printouts.

Margins

You can set left and right margins anywhere on the page. You can change either or both margins at any time.

Horizontal Tabs

You can set horizontal tab stops anywhere on the page. You can increase the number of tab stops whenever you want to. Or you can decrease the number of horizontal tab stops. Or even eliminate them entirely if you want to.

Horizontal Pitch (Characters Per Inch)

The DECwriter IV gives a choice of 10, 12, 13.2, or 16.5 cpi (Characters Per Inch). You can vary the horizontal pitch to make your reports and printouts easier to read.

SAMPLE HEADER AT 10 CPI

You can use 10 cpi pitch for headers and important messages, but use 13.2 cpi for general text.
And since the DECwriter IV backspaces, you can repeat the same characters several times for bold headers.

And you can use the condensed pitch of 16.5 cpi to print a full 132 columns on paper 8.5 inches wide, the width of standard typing
DEWriter IV

Paper. This lets you file full length computer reports in standard-sized files, yet, as you can see, the condensed pitch is easy to read. You can also use condensed pitch to save paper by printing 216 columns on full width (37.8 cm., 14.875 in.) paper where single pitch terminals could print only 132 columns.

Vertical Pitch (Lines Per Inch)

The DEWriter IV gives you a choice of 2, 3, 4, 6 or 12 lpi (Lines Per Inch). You can vary the vertical spacing to accommodate a variety of pre-printed forms. Or you can use the 12 lpi setting with double-spacing to allow superscripts and subscripts.

As you can see, the DEWriter IV print control features truly are practical.

COMMUNICATION

Your DEWriter IV must be compatible with the equipment and program at the other end of the line if you are to successfully send and receive data. The DEWriter IV has a flexible range of switch-selectable communications features. Once you set the communications features to match your host system, you rarely have to worry about them again. These features include:

Parity — enables your terminal to test for parity errors in characters it receives. It also causes your terminal to set the parity bits in the characters it sends so your computer can test the parity of those characters when it receives them. If your host computer tests for parity errors, the Parity feature should be enabled.

If the Parity feature is enabled and your terminal detects a parity error in a character it receives, it will print an error character in place of the character which was changed in transmission.

Parity Sense — this feature serves two functions:

1. If the Parity feature is enabled the Parity Sense Feature determines how your terminal will set the parity bit on transmitted characters and check the parity of received characters. You can set the parity sense to odd or even depending on the parity sense your host computer uses.

6 For an explanation of parity, see page 93.
2. **If the Parity feature is disabled** the Parity Sense will determine if your terminal will always set the parity bit on transmitted characters to a space or a mark (a one or a zero). You can set this feature according to what your host computer expects.

**Auto XON/XOFF** — enables your terminal to automatically generate the XON (DC1) and XOFF (DC3) codes. The XOFF code asks the host computer to stop transmitting data to your terminal. This prevents buffer overflow when the computer sends data faster than your terminal can print it. The XON code tells the host computer to resume transmission of data. If your host computer recognizes the XON and XOFF codes, this feature should be enabled.

**ANSI New Line** — causes an automatic carriage return as well as a line feed when your terminal receives a line feed (LF) character from your host computer. Some host computers expect this automatic carriage return, others send a separate carriage return (CR) character after the line feed (LF) character. The software on your host computer determines whether you should enable or disable the ANSI New Line feature.

**Auto New Line** — lets the carriage return on your terminal act like a carriage return on a standard typewriter. When the Auto New Line feature is enabled, the terminal will automatically perform a line feed (as well as a carriage return) whenever you press the **RETURN** key.

Some computers generate a line feed (LF) for the terminal when they receive a carriage return (CR) character. If your host computer does, you will notice a double line feed when you press the **RETURN** key. In that case you should disable this feature.

**Local Echo** — causes your terminal to print each character as it is typed. Most host computers echo back characters as they are received. This provides added assurance that your computer has correctly received the characters you typed. The characters are not actually printed at your terminal until they are echoed back by the computer. If the character printed at your terminal is not the character you typed, then you know that something went wrong during transmission. However some computers do not echo back characters.

If your host computer does not echo characters, you will want to **enable** the Local Echo feature so you can see what you have typed. If you select the Local Echo feature and your computer does echo back characters, you will see double characters. In that case you should **disable** this feature.

**Paper Low/Paper Out Features** — the Paper Low Detector (for roll paper only) and the Paper Out Detector (for tractor feed only) are
optional on the DECwriter IV. If you have installed one or both of these options, the Paper Low/Paper Out Features should be set appropriately.

RELIABILITY
The DECwriter II (LA36) set the old standard in hardcopy terminal reliability, the DECwriter IV will set the new standard. Each unit is carefully and thoroughly tested before it is shipped. These exhaustive tests include a comprehensive 24-hour operational test.

The real secret of the DECwriter IV's outstanding reliability is that there are simply fewer things that can go wrong. All the electronic components are contained in a single board with an LSI microprocessor. Print head jams are sensed instantly, so blown fuses and motor overloads are headaches of the past. And, of course, the print head meets the famous DECwriter 100 million character standard.

MAINTAINABILITY
The DECwriter IV is extremely easy to maintain, especially since it's so reliable. However, in case a problem does occur, the four different self-tests which have been incorporated in the basic design of the DECwriter IV will help you quickly determine the nature of the problem. Whatever the problem is, you can fix it quickly since the entire terminal can be disassembled in minutes without special tools. In addition, the new ribbon cartridge makes routine ribbon changes a snap.

OPTIONS
ROLL PAPER HOLDER
The Roll Paper Holder option allows your DECwriter IV to accept roll paper up to 37.8 cm (14-7/8 in.) wide. The roll may have a maximum diameter of 11.3 cm (4.5 in.) and should have a core diameter of 2.5 cm (1 in.).

NOTE:
1. Cut sheet paper may also be used
2. Multipart forms are not recommended
3. Impact paper is not recommended
4. Card stock is not recommended

TRACTOR FEED (STANDARD ON SOME MODELS)
The Tractor Feed option allows your DECwriter IV to accept sprocket-fed paper from 7.6 cm to 37.8 cm (3 in. - 14 7/8 in.) wide, including multipart forms.
NOTE:
1. Cut sheet paper may also be used
2. Multipart forms may have up to four parts
3. Only one card part may be used and it must be the last part
4. First-surface impact paper is not recommended

NUMERIC KEYPAD (STANDARD ON SOME MODELS)
The 18-key numeric key pad lets you enter numbers in calculator or adding machine fashion. It includes four user-defined special function keys which generate unique escape sequences.

PAPER LOW DETECTOR (ROLL PAPER ONLY)
PAPER OUT DETECTOR (TRACTOR FEED ONLY)
When either or both of these options are installed and the terminal senses either the Paper Low or the Paper Out condition, the bell sounds, the Power/Fault indicator flashes and the terminal either sends the computer a break signal or drops the data terminal ready signal, depending upon how you set the Paper Low/Paper Out features.

20 mA LOOP INTERFACE
This option enables your DECwriter IV to communicate over a 20 mA current loop.

TERMINAL STAND OPTION
The handsome terminal stand lets you feed fan-folded paper up from the bottom of the terminal if your terminal has paper tractors. The optional castors for the terminal stand let you wheel your DECwriter IV from workstation to workstation.

NOTE
DIGITAL is constantly developing new options in response to customer needs. Please ask your DIGITAL representative for information about new options as they become available.
Figure 3-6 LA38 on Optional Terminal Stand
SUMMARY SPECIFICATIONS

PRINTER
Printing technique
Impact dot matrix
Print matrix
7 × 9
Maximum print speed
45 cps
Maximum throughput
30 cps
Paper type
Cut sheets, roll feed or fanfold, up to four parts
Paper feed
Friction-feed, platen drive (all models)
Tractor drive (standard on some models)
Roll paper holder (optional)
Vertical pitch
2, 3, 4, 6, 8, or 12
(lines per inch)
Horizontal pitch
10, 12, 13.2, 16.5
(characters per inch)
Margins
Left, right
Tabs
Up to 217 horizontal tab stops
Character set
ASCII upper/lowercase set
Other printer features
Snap-in cartridge ribbon, cover open interlock, self test, status message, terminal reset, manual last character view, optional paper low/paper out detection

KEYBOARD
Keyboard
Typewriter style with multikey rollover
Numeric keypad
18 keys including 4 user-defined special function keys
(standard on some models)
Other keyboard features
Local form feed, local line feed, auto repeat on all alphanumeric keys
COMMUNICATION
Data transfer
Serial, asynchronous

Baud rates
110 or 300
(bits per second)

Input buffer
160 characters

Switch-selectable
Parity: odd, even, or none (8th bit mark or space transmitted)
Auto XON/XOFF
ANSI New Line
Auto Line Feed
Local Echo

Interface
Full EIA standard

PHYSICAL CHARACTERISTICS
Dimensions
Length
55.9cm (22 in.)

Width
39.4cm (15.5 in.)

Height
16.4cm (6.5 in.)

Terminal weight
10 kg (22 lbs.)

Power
Voltage
90-128 Vac
180-256 Vac
(switch-selectable)

Printing
45 W maximum

Non-printing
45 W maximum

PAPER REQUIREMENT
Roll Feed
Width
7.6 cm-37.8 cm (3 in.-14 7/8 in.)

Weight
6.8 kg (15 lb.) paper minimum

Single-part

Roll diameter
11.3 cm (4-1/2 in.) maximum

Core diameter
1 in.

NOTES:
1. Cut sheet or roll paper may be used
2. Multipart forms are not recommended
3. Impact paper is not recommended
4. Card stock is not recommended
Pin Feed

Width 7.6 cm-37.8 cm (3 in.-14 7/8 in.)

Weight
Single-part 6.8 kg (15 lb.) paper minimum 0.25 mm (0.010 in.) thick card stock maximum

Multipart 1 to 4 parts (see notes) 0.50 mm (0.020 in.) thick maximum

NOTES:
1. Multipart forms may have only one card part; the card must be the last part
2. First-surface impact paper is not recommended
3. Dot or line glue margins are acceptable (if line is on one margin only)
4. Split forms (forms with each side containing a different number of sheets) are not recommended
CHAPTER 4
THE DECwriter III (LA120)

INTRODUCTION

AN INTERACTIVE SMART PRINTING TERMINAL
The DECwriter III (LA120) is the most powerful and flexible hardcopy terminal DIGITAL has ever offered. It has the proven reliability of the DECwriter II (LA36) with six times the printing speed. But that's not all. The DECwriter III is smart enough to give you an outstanding range of over 45 keyboard-selectable standard features which make the DECwriter III flexible enough to meet your specific application requirements.

Flexible Because It's Smart
Only a terminal as smart as the DECwriter III could give you such a flexible range of standard features — more than 45 communication, form control, print format control and convenience features you can set quickly and easily right at the terminal keyboard. (No wires to cut or jumpers to connect!) Form control and print formatting features can also be set automatically by your host computer using standard ANSI escape sequences.

You can set any or all features on a temporary basis or store all the features in non-volatile memory so the DECwriter III won't forget your settings when you turn it off. You can recall the stored settings at any time.

THE DECwriter III IS FLEXIBLE IN MORE WAYS THAN ONE
Flexible Communications — All the communications features you need to quickly and easily configure your terminal to communicate with your host computer system. The communications features are so flexible and so easy to reconfigure that you can use a DECwriter III to communicate with one system, then reset it to communicate with a totally different system.
For additional flexibility, the Auto Answerback feature lets you use your DECwriter III as an unattended remote printer when you don’t need an interactive terminal. If your host computer is communicating over a telephone line, the Auto Answerback will answer the phone when it rings, and give your computer the identifying answerback message. The Auto Disconnect feature will hang up the phone when your host computer sends an EOT (End of Transmission) signal.

**Flexible Forms and Formatting Controls** — A full range of printer control features which include form length; upper/lower and left/right margins; unlimited vertical and horizontal tabs; type size (characters per inch); and line spacing (lines per inch).

These printer control functions are all independent, so you can select any combination you want and you can change any or all of the print characteristics at any time. For example, you can compress 132 columns of type into an 8½”-wide sheet. At the same time you can use double-width characters for headings or attention-getting messages. You can select any form length up to 14 inches, and position left/right and top/bottom margins anywhere within that form. You can then put any number of horizontal and vertical tabs in any position on the form.

You can set the printer control features at the keyboard or you can include print control commands in your programs to automatically format the printed output for that program.

**Fast Because It’s Smart**
The DECwriter III can greatly reduce the time you spend waiting for printed output. It can print a typical full page memo in under 20 seconds. It prints in both directions at 180 cps (characters per second) and “looks ahead” to find the shortest path to the next print position (no time wasted on unnecessary print head movement). It accelerates for high speed skipping over white space. The 1K character buffer (expandable to 4K characters) makes fill characters unnecessary when your DECwriter III is communicating at speeds of up to 1200 baud.

**Smart Because It’s So Cost Effective**
Despite its outstanding flexibility, the DECwriter III is about the same price as a conventional terminal! You know it’s reliable because it’s a DECwriter with the famous 100 million character print head. You can easily pay more for a terminal which only has a few of these features. For additional cost efficiency, the DECwriter III has such a comprehensive range of standard features that no options are required for most applications.
MAJOR FEATURES AND BENEFITS

FEATURES

Smart 180 cps bidirectional printing

14 data rates plus 8 split data rates with 5 different half- or full-duplex protocols

1K character buffer (expandable to 4K characters)

Nonvolatile memory

Auto Answerback & Auto Disconnect

Comprehensive forms and print formatting controls

Eight different font sizes
Six different line spacings

Over 45 keyboard-selectable features

BENEFITS

FAST printed output
SMART printing means no wasted motion, no wasted time

Can communicate with just about any host system

Uses communications lines efficiently by storing data received at rates exceeding print speed
Fill characters are not needed under most operating conditions

Store your feature settings in nonvolatile memory, operate the terminal temporarily with different settings, then recall the stored settings at any time

Also functions as an unattended remote terminal

Tailor output to fit preprinted forms (up to six-part fan-folded)

Typeset-like printed output set from the terminal or set by your host computer
Expanded fonts for labels and messages
Condensed printing to save paper

Unparalleled flexibility in communications and printing control
Change any or all settings in minutes using the terminal keyboard

SUMMARY DESCRIPTION

The DECwriter III is a pedestal mounted interactive high speed smart printing terminal. It has a 1K character buffer (standard) and can print bidirectionally at 180 cps. Over 45 standard keyboard-selectable features give the DECwriter III unparalleled application flexibility. Options
include a numeric key pad (available either with the order or as an add-on kit), a 3K character additional buffer (for 4K character total), special character sets (APL, foreign language), and a 20 mA interface.

HUMAN ENGINEERING
The DECwriter III was designed with you in mind. It's fast so you won't have to stand around waiting for output. If you've ever waited for a two or three page report from a 30 cps terminal, you'll really appreciate the difference. It's so fast that you'll be able to print some reports locally that you used to send to the line printer.
The DECwriter III Is Both Comfortable And Easy To Use.

COMFORTABLE
The DECwriter III is so comfortable it's a pleasure to use. You'll like the contoured keyboard. All of the standard keys are exactly where your fingers expect them to be, and you'll appreciate how easy the contoured keys are on your fingers. No matter how fast (or how poorly) you type, you can't jam or confuse the DECwriter III by pressing several keys at the same time. Each key will be automatically typed in the order it was pressed, because you have multi-key rollover protection.

EASY TO USE
The DECwriter III is so easy to use you can quickly and easily set or reset any or all of the over 45 standard features using the terminal keyboard. (You don't have to rewire the terminal every time you want to change a setting.) Even the little extra features add up to a lot of convenience.

For example, the LED (Light Emitting Diode) display tells you the exact column position of the print head while you are using the terminal interactively. Eight indicator lights give you a constant reminder of terminal status and warn you about such error conditions as paper out, print head jam, or buffer overflow.

OVER 45 CHOICES, YET IT'S EASY TO SET UP
The DECwriter III is designed with a Setup Mode to help you use the terminal keyboard to quickly and easily select the features you need. You enter the Setup Mode by simply typing the SETUP key while holding down the CONTROL key. Since you must use two keys at the same time there is little danger of accidentally entering Setup Mode. (You can also set one feature at a time by pressing the appropriate key while holding down the SETUP key.) A blinking indicator light tells you when the terminal is in Setup Mode. Other indicator lights give you a constant summary of the most important settings.

Once the terminal is in Setup Mode, you can set the most frequently used features by typing clearly labeled function keys. Other features are set by pressing one or two keys. An LED (Light Emitting Diode) display greatly simplifies feature selection. For example, if you are in Setup Mode and you want to set the form length, you press the F key. The LED display will indicate the current form length setting. If you hold the F key down, the LED display will increment the form length setting until it reaches 168, then it will start again from 1. When it displays the form length you want to set, just release the F key and the new form length is set. You can get a printed summary of all the current terminal settings by pressing the status key.
Even though you have more than 45 settable features, all of the setup commands are summarized on a small decal which you may attach to the terminal. An informative Users Guide gives you step-by-step examples of how to set each feature. Finally, a pocket-sized operator’s card provides yet another summary of procedures for selecting features.

**Operator Convenience Features**

**MANUAL OR AUTOMATIC LAST CHARACTER VIEWING**

LCV (Last Character Viewing) is a DIGITAL feature which causes the print head to move out of the way so you can view the last character printed. When you select automatic LCV, the print head will move four spaces to the right whenever you pause more than 1.3 seconds in your typing. When you select manual LCV, the print head will move out of the way when you press the **VIEW** key. People who type slowly sometimes prefer the manual mode. The print head automatically returns to the current character position when you type the next character.

**LARGE OR SMALL BUFFER**

The DECwriter III has a 1K character buffer (expandable to 4K characters) which enables it to accept characters faster than it can print them. This buffer lets the terminal “look ahead” to find the shortest path to the next print position and eliminates the need for fill characters when operating at 1200 baud. This both improves throughput and utilizes the communication line efficiently.

However, because of the size of the buffer there may be a noticeable delay between a typed command and the response. You can eliminate this delay by selecting the small “apparent” buffer of 256 characters. Thus, you have a choice of a large buffer for efficiency while printing and a small buffer for quick response time when you are using the terminal interactively.

**KEY CLICK AND BELL VOLUME**

Some people find it reassuring to hear a “click” every time a key is pressed, especially when a long distance communication path results in a delay after you type a character and before the echo is printed. Other people find the key click distracting. You can select either an audible key click or a silent keyboard.

In the same way a loud bell tone is needed in a noisy environment, but may be unpleasantly jarring in quiet surroundings. You can select either a loud or a soft bell tone.

**LOCAL ECHO**

Most computers echo back characters as they are received, but some do not. If your host computer does not echo characters, you can select
the Local Echo feature so the terminal will print each character as you type it. Of course, if your host computer does echo each character, you can disable the Local Echo feature.

AUTO REPEAT
The Auto Repeat feature causes all alphanumeric keys and the space bar to repeat when you hold them down for more than half a second. Most people find this a useful convenience. But some slow typists hold each key down long enough to get unintentional repetitions. You can select or disable this feature according to your preference.

AUTO LINE FEED
This feature enables the RETURN key to act like the return key on a standard typewriter. So when you press the RETURN key it causes both a carriage return and a line feed. Some host computers automatically send a line feed when you press the RETURN key, others do not. If your computer generates a line feed for you, you can disable the Auto Line Feed feature to prevent a double line feed.

AUTO NEW LINE AT RIGHT MARGIN
This feature causes an automatic carriage return and line feed when the print head reaches the right margin. This is extremely useful in a message network where the accidental omission of a carriage return code could result in the partial loss of a message. It is also convenient when you are using the terminal interactively. Again, some host computers perform this function for you and, if your computer does, you may want to disable this feature.

APPLICATION ENGINEERING
The DECwriter III was designed to be as practical as it is convenient. The exceptional range of keyboard-selectable features let you configure your terminal to precisely meet the needs of a given application and then quickly reconfigure your terminal to meet the needs of a different application. When your needs change, the DECwriter III gives you the flexibility to meet those changing needs in minutes without having to install expensive options.

Communications
The wide range of communications features allow the DECwriter III to perform well in any communications environment. The DECwriter III communications features are so flexible, you can consider the DECwriter III to be a backup terminal for one system even while you are using it on another.

ANSWERBACK
The Answerback feature lets you program a short identifying message of up to 30 characters, which the terminal will send in response to a
control code or when you press the **HERE IS** key on the terminal keyboard. For added security, an Answerback jumper has been installed on the terminal control circuit board. After you have entered and tested the Answerback message you can remove this jumper to insure that the Answerback message cannot be altered or erased.

**UNATTENDED REMOTE PRINTING**

You do not need to have an operator in attendance to use your DECwriter III as a printer—a major convenience if you have an electronic mail system. The Auto Answerback feature generates an identifying message when the terminal detects a telephone ringing signal. In other words, your DECwriter III will automatically answer the phone and tell the host computer which terminal it is. The Auto Disconnect will automatically hang up the phone when it receives an EOT (End of Transmission) from the host computer, or if your terminal becomes inoperable (most often due to a paper out condition).

The DECwriter III has many other communications features. You can select:

- Any one of 14 line rates from 50 to 9600 baud or any one of 8 split line rates.
- One of two full-duplex or three half-duplex protocols with or without a secondary channel (used for restraint mode for full-duplex and a reverse channel for half-duplex).
- Seven parity states for seven-data-bit communications and three parity states for eight-data-bit communications.
- Automatic generation of XON (DC1) and XOFF (DC3) codes. XOFF asks the host computer to stop transmitting data while XON asks the host to resume transmission.
- One of three different ways the DECwriter III can respond to the line feed and carriage return codes it receives.
- Either normal or alternate keypad mode. This allows the optional numeric keypad to generate either characters or escape sequences.

The Auto Line Feed, Auto New Line at Right Margin and Local Echo features also provide communications flexibility as well as operator convenience.

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1 The DECwriter III is designed for light duty printing. Large volume reports should always be directed to a line printer.
This was printed on the **LA120 DECwriter III**.

The **LA120** has over 45 features in all. It prints up to 180 characters per second bidirectionally. And it's smart about it, too! The **LA120** figures out the shortest path to the next print position without returning to the margin for each new line.

It has eight font sizes so you can select **BIG LETTERS** for report headings or little ones if you want 132 columns on an 8 1/2 inch wide sheet or **ANY** mix that you want on one line.

**LA120** font sizes include:

```
$Z2*0123?@ABCD  5 CPI
$Z2*0123?@ABCD`  6 CPI
$Z2*0123?@ABCD`a  6.6 CPI
$Z2*0123?@ABCD`abcd{1}  8.25 CPI
$Z2*0123?@ABCD`abcd{1}`$%&  10 CPI
$Z2*0123?@ABCD`abcd{1}`$%&0123  12 CPI
$Z2*0123?@ABCD`abcd{1}`$%&0123?@A  13.2 CPI
$Z2*0123?@ABCD`abcd{1}`$%&0123?@ABC  16.5 CPI
```
You can change vertical line spacing. The full range of choices is: 2, 3, 4, 6, 8 and 12 lines per inch.

You can even print superscripts:

\[ E = MC^2 \]
or subscripts, or both:

\[ F_i = F_{i-1} + F_{i-2} \]

Would you like tabs? You can put a tab here tab here

or anywhere on the paper. You can use vertical as well as horizontal tabs.

Options include APL and several European character sets and keyboards:

Special European Characters: £ Á Ö Å Ú É
                                 ã ô à ü ë à ë ç ü ë õ

APL Characters: ^ ~ < > ] v ^ < + , / 0 1 2 3 4 5 6 7 8
                  ( [ ; i ; \ - _ a u n e \ a \ o ' ] [ o t g * ] [ ~ u w ] [ c e t ] [ z - ]
                  A B C D E F G H I J K L M N O P Q R S T U V W X Y Z { ] $

This is only a small sample of what the LA120 can do.
RELIABILITY
Over the years, DECwriter terminals have been proven reliable in millions of hours of customer use. The DECwriter III carries on this tradition with the famous 100 million character print head.2

Before any DECwriter is shipped, it is subjected to 24 hours of continuous operational testing. The DECwriter III also has automatic self-test diagnostics that check the circuitry every time the terminal is powered up. A diagnostic code in the LED display indicates the presence and nature of any failure. You can run two additional self-tests from the terminal keyboard.

2 100 million characters is approximately 200 hours of continuous printing at 180 cps.
MAINTAINABILITY
When your DECwriter III finally does require some attention, you'll find all the electronic components easily accessible on a single logic board that uses a custom LSI (Large Scale Integration) chip to reduce component count and increase circuit reliability. This single board is mounted for easy access behind the rear door of the pedestal.

The print head servo-motor/encoder is permanently packaged inside a sealed housing, eliminating the need for servo-motor/encoder adjustment. The print head itself can be easily replaced without the need for special tools or complicated alignment procedures.

OPTIONS
Because so many important features are standard in the LA120, options have been reduced to a minimum.

3K Character Additional Buffer
The 4K character extended buffer offers several advantages:

1. If your host computer does not recognize the XON and XOFF signals, the extended buffer could allow you to run your DECwriter III at 1200 baud without buffer overflow.

2. If your host computer does recognize the XON and XOFF signals, but you are communicating over long distances (which often involves a satellite link), there may be a delay after the XOFF is sent by your terminal and before it is received by the host computer. This could result in an overflow of the 1K buffer.

3. If you want to get a hardcopy printout from a video terminal, the extended buffer lets you “fast dump” from the video terminal without synchronization.

Other Available Options
- 20 mA loop interface
- Separate numeric keypad which can be used to generate either character or escape codes

NOTE
The numeric keypad may be standard on some models.

- APL character set
- Foreign character sets: Finland, Denmark, France, Germany, Norway and Sweden (other character sets can be provided on special order)
## SUMMARY SPECIFICATIONS

### Printer
- Printing technique: Impact dot matrix, smart bidirectional
- Print matrix (width by height): 7 × 7
- Maximum print speed: 180 cps
- Paper type: Fanfold, up to six parts (see paper requirements)
- Forms length: 1 to 168 lines
- Vertical pitch (lines per inch): 2, 3, 4, 6, 8, 12
- Horizontal pitch (characters per inch):
  - 180 cps
  - 90 cps
- Margins: Left, right, top, bottom
- Tabs: Up to 217 horizontal tab positions, Up to 168 vertical positions
- Forms storage: True nonvolatile memory (no batteries)
- Positioning commands: Horizontal and vertical, absolute and relative
- Character set: ASCII upper/lowercase set
- National character sets
  - Standard: United States, United Kingdom
  - Optional: Finland, Denmark, Sweden, Germany, Norway, France
- APL character set: Optional
DECwriter III

Other printer features
Paper out and cover open interlocks, manual and automatic last character view, selectable auto new line, self-test, status message, 4-digit numeric display used as column counter and to set parameters

Keyboard
Typewriter style with multi-key rollover

Selectable Auto LF
Standard

Optional numeric keypad
18 keys including 4 function keys

Feature selection
Keyboard entry to nonvolatile memory

Other keyboard features
Local form feed key, local line feed key, auto repeat on all alphanumeric keys, and selectable key click

Communication
Serial, asynchronous

Data transfer

Baud rates
50, 75, 110, 134, 134.5, 150, 300, 600, 1200, 1800, 2400, 4800, 7200, 9600

(bits per second)

Split speeds
600 or 1200 receive, with 75 or 150 transmit; 2400 or 4800 receive, with 300 or 600 transmit

(bits per second)

Parity
Odd, even, or none (8th bit mark or space transmitted, or data bits only)

Input buffer
1024 characters standard, 4096 characters optional

Interface
Full EIA standard (includes auto answer/disconnect)
### Physical

**Dimensions**
- **Width**: 69.9 cm (27.5 in.)
- **Height**: 85.1 cm (33.5 in.)
- **Depth**: 61.0 cm (24.0 in.)

**Weight**
- Uncrated: 46.4 kg (102 lb.)
- Shipping: 63.7 kg (140 lb.)

**Power**
- **Voltage**: 90-128 V or 180-256 V
- **Frequency**: 47-63 Hz
- **Input current**: 4.2A max. at 115V
- **Heat dissipation — printing**: 440 W max.

### Paper Requirements

**General**
- Continuous, fanfold, pin-feed forms

**Width**
- 7.6 cm-37.8 cm (3 in.-14 7/8 in.)

**Single part**
- 15 lb. paper minimum, 0.25 mm (0.010 in.) card stock maximum

**Multipart**
- Up to six parts, 0.50 mm (0.020 in.) maximum
CHAPTER 5
THE VT100 VIDEO TERMINAL

INTRODUCTION

THE VERSATILE VIDEO TERMINAL
The VT100 set a new standard in video terminal versatility with a combination of features never before available in a compact desktop terminal. It has proven to be one of the most popular, and most imitated, video terminals ever offered. You can quickly and easily set the display format and terminal features from the moveable terminal keyboard. Or, you can let your host computer set the terminal features for you by writing either ANSI control functions or VT52 commands into your application programs.

Video Versatility
The VT100 provides a wide variety of user- and program-controllable character and screen attributes that let you “customize” the viewing screen for your particular interactive application. Then you (or your host computer) can quickly and easily reset your VT100 for the next application. These features, along with limited graphics and line drawing characters, let you use your VT100 for a full range of interactive terminal applications. These attributes include:

Full screen attributes — reverse video, two screen widths (80- or 132-column lines) and either jump or smooth bidirectional scrolling.

When you select reverse video your terminal displays black characters against a white background, which gives the screen the appearance of a printed page. The 132-column line feature lets you display standard lineprinter reports without reformatting. The smooth bidirectional scrolling feature allows the text to “float” up or down the screen at a steady rate, like movie credits. Smooth scrolling is easier to read than conventional jump scrolling.

Line by line attributes — double-width or double-size (double width X double height) characters and split screen scrolling.

Large characters emphasize formatted text and can make complex forms easier to read. Double-size characters can be read from a distance for important messages. You can select any group of adjacent lines anywhere on the screen for a split screen scrolling area. The remaining non-scrolling (fixed) lines can be used for displaying headers, prompts, menu selections or status information.
Character by character attributes — The standard VT100 gives you a choice of normal or one alternate character attribute (either reverse or underline) depending on the SETUP parameters.

The Advanced Video Option lets you select normal or any combination of four attributes: bold, blink, underline and reverse. For example, you could select reversed blinking characters or blinking bold underlined characters.

Versatile Communication
The VT100 lets you set and reset the full-duplex communication features from the terminal keyboard, so you can use one VT100 with a number of host systems. You can set the transmission reception speeds independently in a range of 50 to 19,200 baud.

Composite video output (compatible with standard RS170) lets you use your VT100 to drive an auxiliary monitor—useful for computer-aided instruction and other applications where you want to display the screen image to a group of people.

MAJOR FEATURES AND BENEFITS

FEATURES
Double-width and double size (double-width × double-height) character lines
80 or 132 characters per line
Bidirectional smooth scrolling
Split screen scrolling capability
Limited line drawing and special graphic characters
Full-duplex transmission and reception speeds up to 19,200 bits per second
Two programming modes
   VT52
   ANSI

BENEFITS
Large characters emphasize formatted text
Important messages stand out
Display 132-character wide computer printouts without reformatting
Easier to read than jump scrolling
Allows constant data to remain on the screen
Allows simple graphics and forms display
Provides for a flexible range of split speeds to meet varying line requirements
Responds to software written for a VT52 terminal
Responds to software based on ANSI standards
FEATURES

Nonvolatile memory holds feature settings
Single alternate character attribute standard, up to four alternate attributes available as an option
Automatic self-test diagnostics on power-up

BENEFITS

Change settings easily
VT100 retains settings when power is off
Data may be highlighted on the screen on a character-by-character basis
Assures that terminal is fully functional before you start

SUMMARY DESCRIPTION

The VT100 is a high performance general purpose interactive video display desk-top terminal. The moveable keyboard is connected with a coiled cord 1.9 m (6 ft.) long so it can be placed for operator comfort and convenience. The keyboard can be disconnected from the terminal for receive-only applications.

The wide variety of user- and program-controllable character and screen attributes can be easily set for specific applications. Feature settings are stored in nonvolatile memory. These features include double-width and double-height character lines, 80- or 132-column lines, smooth scrolling, and split screen.

The VT100 has two programming modes:
1. Responds to software written for the DIGITAL VT52 terminal
2. Responds to software based on ANSI standards 1

The VT100 communicates asynchronously over full-duplex lines. Transmit and receive speeds can be set independently at sixteen different rates from 50 to 19,200 baud. An EIA RS-232C compatible interface is standard. A 20 mA current loop interface is optional. The composite video output allows the VT100 to drive an auxiliary monitor.

An Advanced Video Option is available which lets you use any combination of four alternate character attributes—bold, underline, reverse, and blink. This same option provides extra memory so your terminal can display a total of 24 lines of 132 characters and also allows an alternate character set to reside in the terminal.

1 ANSI X3.4-1977, X3.41-1974, X3.64-1979
HUMAN ENGINEERING
Many of the same features which make the VT100 such a versatile terminal also make it an extremely pleasant terminal to use. Certainly the simple SET-UP modes which put full control of the terminal at your fingertips are as convenient as they are practical—no more fumbling for hidden controls or switches.

Designed to Reduce Eye Fatigue
Most people find the flicker-free black/white VT100 screen easy on their eyes. You have a choice of white characters on a black background (normal video) or black characters against a white background (reverse video). The $7 \times 9$ dot matrix characters are crisp and have two-dot descenders on lower-case characters. The VT100 has smooth scrolling at a steady rate, which is much easier to read than the variable speed jump scrolling used in most video terminals. The VT100 also has double-width and double-size character lines, programmable individual character attributes, simple line drawing and graphics characters, even split screen capabilities, for easy-to-read formatted text.

Moveable Keyboard for Comfort
The VT100 keyboard is comfortably contoured and designed to feel like a typewriter keyboard. It is attached to the terminal by a 1.9m (6 ft.) coiled cord, so you can position it for maximum comfort. You may select a reassuring keyclick and/or auto-repeat on any key which is held down for more than one-half second.

In addition to the standard typewriter keys, the VT100 keyboard has an 18-key numeric keypad which can be used as user-defined special function keys (Alternate Keypad Mode). Seven LED (Light Emitting Diode) indicators, four of which are software controlled, provide terminal and program status information.

Easy to Set Up From the Keyboard
The VT100 has convenient SET-UP modes which let you select display format and terminal features from the keyboard. You place your terminal in a SET-UP mode simply by pressing the SET-UP key. For added convenience, the VT100 has both a temporary memory and a nonvolatile memory which always remembers what features you have selected even if the terminal is reset or turned off. The nonvolatile memory is as permanent as if you had physically set switches.

The VT100 has two SET-UP modes. SET-UP A mode controls the settable tab and the characters per line setting (80 or 132). SET-UP B mode controls terminal features (machine states). The SET-UP key will always place your terminal in SET-UP mode. You can switch your
terminal from SET-UP A mode to SET-UP B mode and back by pressing the 5 key on the main keyboard.

**SET-UP A mode** — displays status information about format features such as the number of columns per line, the position of tab stops, and the screen brightness setting. You can change any of these settings by pressing the appropriate key while your terminal is in SET-UP A mode.

![SET-UP A](image)

Figure 5-1  SET-UP A mode—display format features

**SET-UP B mode** — displays status information about terminal features such as communication parameters. You can change any of these features while your terminal is in SET-UP B mode.
Figure 5-2  SET-UP B mode—terminal features

Once you have selected the format and terminal features you want, you can store them temporarily by simply pressing the SET-UP key. Or you can permanently store your SET-UP parameters by pressing the SHIFT and the $ key at the same time while your terminal is in either SET-UP mode.
Operator Convenience Features

CURSOR
The VT100 offers a choice of two cursor displays 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 ( _) or a blinking block (■).

In standard terminals (without the Advanced Video Option) this feature also selects the alternate character attribute—underline or reverse.

KEYCLICK
Some people find it reassuring to hear a "click" every time a key is pressed. Other people find the keyclick distracting. You can select either an audible keyclick or a silent keyboard.

MARGIN BELL
The margin bell feature functions just like the margin bell in a typewriter. If you select this feature, your VT100 will sound a tone whenever the cursor is eight characters from the end of the current line.

SCREEN BACKGROUND (NORMAL OR REVERSE VIDEO)
In the normal screen mode, the display contains light characters on a dark background; in the reverse screen mode, the display contains dark characters on a light background.

SCREEN BRIGHTNESS
Screen brightness is controlled from the keyboard in SET-UP mode and this setting may be saved like any other feature in the terminal.

APPLICATION ENGINEERING
The VT100 was designed with the versatility to serve a full range of interactive applications. You have the display flexibility to design easy-to-read screen formats for just about any application.

- Limited graphics and line drawing characters
- Double-width and double-size character lines
- Alternate character attributes
- Split screen scrolling
- Advanced Video Option which gives you even greater flexibility with any combination of four alternate character attributes

The 18-key numeric keypad includes four user-defined special function keys so you can write your programs to execute application-specific functions at the touch of a key. The keypad application mode allows all 18 keys to serve as user-defined function keys.
Communication and Host Computer Compatibility Features

ANSI/VT52 MODE
The VT100 terminal responds to two different programming standards:
- In ANSI (American National Standards Institute) mode, the VT100 will respond to software based on ANSI standards—ANSI X3.4-1977, X3.41-1974, X3.64-1979.
- In VT52 mode, the VT100 terminal will respond to software written for use with the DIGITAL VT52 video terminal.

ANSWERBACK MESSAGE
The VT100 answerback feature provides the terminal with the ability to identify itself by sending a message to the host. The entire answerback sequence can take place automatically without affecting the screen. The answerback message will be transmitted when you type the BREAK key while holding down the CTRL key or when the host computer sends an ENQ (005_e).

AUTO XON/XOFF
The VT100 is capable of automatically generating the synchronizing codes XON (DC1) and XOFF (DC3). The XOFF code tells the computer to stop the transmission of data. The XON code tells the computer to resume transmission.

The VT100 will always stop transmission when an XOFF (DC3) code is received and will resume transmission when an XON (DC1) code is received regardless of the auto XON/XOFF feature setting.

BITS PER CHARACTER
This feature allows the terminal to transmit and receive either 7- or 8-bit characters. When set for 8-bit characters, bit 8 is set to a space (or 0) for characters transmitted and is ignored for all characters received.

CHARACTERS PER LINE
The VT100 is capable of displaying either 80 or 132 characters per line. In the 80-character-per-line mode, the screen is 80 characters wide by 24 lines high. In the 132-character-per-line mode, the screen is 132 characters wide by 14 lines high (24 lines if the VT100 is equipped with the Advanced Video Option). In the 132-character-per-line mode, the displayed lines are physically the same width as in the 80-character-per-line mode, but the characters are more compact.
When changing from 80- to 132-character-per-line mode or vice-versa, the current contents of the screen are lost.

LINE/LOCAL
The line/local feature lets you place the terminal in either an on-line or a local (off-line) condition. When the terminal is on-line (ON-LINE indicator on the keyboard is lit), all characters typed on the keyboard are sent directly to the computer and messages from the computer are displayed on the screen. In the local condition (LOCAL indicator on the keyboard is lit), the terminal is electrically disconnected from the computer, and characters typed on the keyboard are echoed on the screen directly.

NEW LINE
The new line feature enables the RETURN key on the terminal to function like the RETURN key on an electric typewriter. When the new line feature is enabled, pressing the RETURN key generates the carriage return (CR) and line feed (LF) codes. When a line feed code is received, the code is interpreted as a carriage return and line feed.
When the new line feature is disabled, the RETURN key generates only the CR code and a received LF code causes the terminal to perform a line feed only.

PARITY
Parity, when enabled, checks for single bit errors in data transmission. If a transmission error occurs, the VT100 can often detect it and indicate its presence by placing a checkerboard character on the screen in place of the character with the error. The parity sense feature determines if the parity is even or odd. When parity is disabled, no parity bit is transmitted or received.

PARITY SENSE
The parity sense feature defines which of the two methods of parity checking, odd or even, is being used by the VT100. If the parity is turned off, the parity sense selection will be disregarded.

POWER
During the initial installation, the terminal display must be set to the power line frequency (50 Hz or 60 Hz).
RECEIVE SPEED
The VT100 is capable of receiving at any one of the following pre-selected speeds: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 9600, or 19,200 bits per second.

The receive speed is independent of the transmit speed; the terminal may receive data at one speed and transmit data at a different speed.

TRANSMIT SPEED
The VT100 is capable of transmitting at any one of the following pre-selected transmit speeds: 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 9600, or 19,200 bits per second.

SCROLL
Scrolling is the upward or downward movement of existing lines on the screen to make room for new lines at the bottom or top of the screen or split screen scrolling area. It can be performed in two ways, jump scroll or smooth scroll. In jump scroll mode, new lines appear on the screen as fast as the computer sends them to the terminal. At the higher data rates, the data is very difficult to read because of the rapid movement of the lines.

In smooth scroll mode, a limit is placed on the speed at which new lines of data may be sent to the terminal. The movement of lines occurs at a smooth steady rate, allowing the data to be read as it appears on the screen. Smooth scroll mode allows a maximum of six lines of data per second to be added to the screen. The Auto XON/XOFF feature must be enabled and supported by the host computer to ensure that data is not lost when smooth scroll mode is enabled.

tabs
Just like a typewriter, the VT100 can jump or tab to preselected points on a line. These tab stops may be changed individually, or totally cleared and then reset.

WRAPAROUND
When this feature is enabled, characters which would otherwise appear beyond the right margin are automatically placed in the first character position of the next line. If the wraparound feature is not enabled, all such characters will be overwritten into the last character position of the current line.
U.K./U.S. CHARACTER SET SELECTION
The VT100 contains character sets for the U.S. and the United Kingdom. The difference between the two character sets is one character, the # or £ symbol. When the standard U.S. character set is selected, the uppercase 3 key on the main keyboard displays the # character. The £ character is displayed when the U.K. character set is selected.

RELIABILITY
The VT100 is exceptionally reliable because it has just two mechanical switches—ON/OFF and 110V/220V. All other terminal functions are controlled by a single logic board that uses custom LSI (Large Scale Integration) chips to reduce component count and increase circuit reliability. The power supply is also a single unit.

MAINTAINABILITY
The VT100’s modular design makes it exceptionally easy to service. The outside shell has pop fasteners for easy access to the modules. Built-in self-test diagnostics run automatically when the terminal is powered on or upon command from the keyboard or the host computer. These same diagnostics, when run in maintenance mode, guide the service technician to any defective modules. Modules can be replaced in minutes.

OPTIONS

Advanced Video Option
A single module which provides:

1. Four alternate character attributes—bold, underline, reverse, and blink—which can be selected in any combination on a character by character basis.

2. Extra memory to display a total of 24 lines of 132 characters. (14 132-column lines are standard.)

3. Provision for alternate character sets. Alternate characters may be selected on a character by character basis.

20 mA Current Loop Adapter
This plug-in adapter provides a switch-selectable active or passive 20 mA current loop interface complete with cable.
SUMMARY SPECIFICATIONS

Dimensions

Monitor:
  Height: 36.8cm (14.5 in.)
  Width: 45.7cm (18 in.)
  Depth: 36.2cm (14.2 in.)

Keyboard:
  Height: 8.9cm (3.5 in.)
  Width: 45.7cm (18 in.)
  Depth: 20.3cm (8 in.)
  Minimum table depth: 51.4cm (20.2 in.)

Weight
  Monitor: 13.6 kg (30 lbs.)
  Keyboard: 2.0 kg (4.5 lbs.)
  Shipping weight: 18.6 kg (41 lbs.)

Environment

Operating:
  Temperature: 10° to 40° C (50° to 104° F)
  Relative humidity: 10% to 90%
  Maximum wet bulb: 28°C (36°F)
  Altitude: 2.4 km (8,000 ft)

Non-operating:
  Temperature: −40° to 66° C (−40° to 151° F)
  Relative humidity: 0 to 95%
  Altitude: 9.1 km (30,000 ft.)

Power
Line voltage: 90-128V RMS single phase, 2 wire
180-256V RMS single phase, 2 wire
(switch-selectable)

Line frequency: 47-63 Hz
Current: 3.0 A RMS maximum at 115V RMS
1.5 A RMS maximum at 230V RMS
Input power: 300 W maximum
Current limiting: 3 A normal blow fuse
Power cord: Detachable, 3 prong, 1.9 m (6 ft.)

Display
CRT: 12 in. diagonal measure, P4 phosphor
Format: 24 lines × 80 characters or 14 lines × 132 characters (selectable)
Character: 7 × 9 dot matrix with descenders
Character size: 3.35mm × 2.0mm (0.132 in. × 0.078 in.) in 80-column mode
3.35mm × 1.3mm (0.132 in. × 0.051 in.) in 132-column mode
Active display size: 202mm × 115mm (8 in. × 4.5 in.)
Character set: 96-character displayable ASCII subset (upper/lowercase, numeric and punctuation)
Cursor type: Keyboard-selectable, blinking block character or blinking underline

Keyboard
General: 83-key detachable unit with a 1.9 m (6 ft.) coiled cord attached
Key layout: 65-key arrangement and sculpturing similar to standard typewriter keyboard with an 18-key auxiliary keypad
Auxiliary keyboard: 18-key numeric pad with period, comma, minus, enter, and four general purpose function keys
Visual indicators: Seven LEDs; three LEDs dedicated to ON LINE, LOCAL and KBD LOCKED, four LEDs user-programmable
Audible signals:
1. Keyclick: sound simulates typewriter
2. Bell:
   a) Sounds upon receipt of BEL code
   b) Sounds eight characters from right margin (keyboard-selectable)
3. Multiple bell: sounds upon detection of error in SET-UP save or recall operation

**Communication**
Type: EIA RS-232C (subset)
Speeds: Full-duplex: 50, 75, 110 (two stop bits), 134.5, 150, 200, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 9600, 19,200 bits per second.
Code: ASCII
Character format: Asynchronous
Character size: 7 or 8 bits; keyboard-selectable (Note: if 8-bit character is selected, 8th bit is always space)
Parity: Even, odd, or none—keyboard-selectable
Synchronization: Keyboard-selectable via automatic generation of XON and XOFF control codes
CHAPTER 6
VT55 GRAPH DRAWING VIDEO TERMINAL

INTRODUCTION

A GRAPH DRAWING TERMINAL WITH AN INTEGRAL COPIER
The VT55 is three devices in one: a graph drawing terminal, an alphanumeric terminal, and a printer/plotter. It starts with waveform and histogram graphics capabilities which are extremely useful for a wide range of applications involving data acquisition, monitoring, trending, simulations—anywhere results can be improved by extending traditional methods of output with rapid graphics display. It then adds DECscope alphanumericics in any combination with the graphics. And, to complete the picture, it even has a built-in electrolytic copier, so you can get a permanent record of the entire screen display just by pressing a key.

A Graph Drawing Terminal
The VT55 can display one or two point-to-point (smooth curve) graphs or shaded histograms. Each graph or histogram can have a maximum of 512 data points each and is displayed with a screen resolution of 512 horizontal by 236 vertical points. You can place vertical and/or horizontal grid lines at any position\(^1\) and program graph markers (short vertical bars) to facilitate data editing and graph generation.\(^2\)

An Alphanumeric Terminal
The VT55 allows the simultaneous display of any combination of text and graphics. And, when you don't need graphics, you can take advantage of the VT55's DECscope alphanumeric capabilities—full ANSI compatible keyboard plus a numeric keypad—to use your VT55 as a 24-line programmer's terminal.

A Printer/Plotter
The electrolytic copier, built into the side of the VT55, prints line-for-line images of the entire screen—text and graphics. To copy all the lines currently being displayed, just press the COPY key. You can also write COPY commands into your programs.

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1 Except the 24th (bottom) line of the screen, which is positioned below any graphs and reserved for labeling the X-axis.
2 One vertical marker per data point.
MAJOR FEATURES AND BENEFITS

FEATURES
Integral copier
Direct entry of alphanumerics and graphics

BENEFITS
Saves space by combining terminal and copier in one compact desktop unit
Saves programming time
Allows VT55 to be used as a programming terminal
Add labels and comments from the keyboard for easy-to-read graphs and reports
Allows easy access to data
Simplifies multiple graph comparison and analysis

SUMMARY SPECIFICATION

Video Display
Size: 30.5cm (12 in.) diagonal
Active screen size: 20.3cm × 12.7cm (8 in. × 5.0 in.)
Method: Raster scan, roll-free

Alphanumerics
Character lines: 24
Character columns: 80
Control: Blinking alphanumeristic cursor
Character set: 96-character upper/lowercase ASCII subset; 32 control characters, and graphic characters
Special features: Upward and downward scroll, bell, erase, tabulate, cursor control
Graphics
Resolution: 512 horizontal × 236 vertical points
Graphs or histograms: Two single-valued functions of x, each individually controlled
Grid: 512 vertical lines and 236 horizontal lines, each individually controlled
Graph markers: 512 per graph, (1024 total) Each graph marker is individually controlled
Special features: Individual blanking and unblanking of all graph features, clear all graphs

User Controls
Intensity: Variable to adjust character and graph brightness
Power/logic reset: Turns line voltage on and off and resets unit to alphanumeric mode
Data rate/interface mode: Allows choice of data rate, full-duplex, full-duplex with local copy, or local mode

Copier
Image copied: Display on screen (without the alphanumeric cursor)
Time to print: Approximately 25 seconds/copy
Copy size: Approximately 76.2mm (3 in.) high × 177.8mm (7 in.) wide
Paper roll size: 36.5m (120 ft.) long × 216mm (8½ in.) wide
Character format: 7 × 7 dot matrix

Communications
Full-duplex with local copy: 110, 150, 300, 600, 1200, 2400, 4800, and 9600 bits per second
Full-duplex, split speeds: Transmission at 75, 150, 300, or 4800 bits per second with reception at 110, 600, 1200, 2400, 4800, or 9600 bits per second
Parity: Generated on transmission as odd or even parity or a mark. (Parity suppression is switch-selectable.) Parity is not checked on reception.
VT55

Physical
Width: 53cm (20.9 in.)
Height: 36cm (14.1 in.)
Depth: 69cm (27.2 in.)
Minimum table depth: 45cm (17.7 in.)
Weight (with copier) 25.8kg (57 lb)
CHAPTER 7

INTELLIGENT TERMINALS
PDT-11 FAMILY

OVERVIEW/PDT-11 INTELLIGENT TERMINALS
PDT-11 programmable data terminals are DIGITAL's new family of PDP-11 based intelligent terminals. These terminals have been designed to be fully compatible with existing PDP-11 systems, and offer excellent expansion capabilities. Intelligent terminals are capable of relieving the host computer of many time-consuming tasks. The built-in LSI-11 microprocessor enables the PDT-11 family to perform many tasks locally, such as error checking and execution of application software. Transmission of error-free, preprocessed data greatly reduces the workload and communication costs of the host computer. PDT-11 systems, which include the PDT-11/110, 130, and 150, can also support a local database. Local data bases give the user quick access to data entry applications without having to poll the host computer.
## FEATURES

<table>
<thead>
<tr>
<th>Feature</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDP-11 code compatibility.</td>
<td>Offers the current PDP-11 user the ability to run pre-existing programs on an intelligent PDT-11 terminal to save time and decrease cost.</td>
</tr>
<tr>
<td>Powerful instruction set.</td>
<td>Enables the user to write programs that can do sophisticated processing at the terminal level.</td>
</tr>
<tr>
<td>Up to 60K bytes of Random Access Memory.</td>
<td>Provides dynamic memory allocation for enhanced computational capabilities and program accommodation; the upper limit of 60K bytes provides room to support operating systems, communications, and applications software.</td>
</tr>
<tr>
<td>Asynchronous/synchronous host communication port.</td>
<td>Supports a variety of data communications protocols. Utilizes standard RS-232-C port with modem control.</td>
</tr>
<tr>
<td>EIA port for local printer.</td>
<td>Permits standard EIA hookup for printer to provide hard copy data if needed. EIA compatibility means that a wide variety of printers may be used.</td>
</tr>
<tr>
<td>Optional clustering of up to three additional workstations.</td>
<td>Enables the user to add up to three printing or video display terminals to a host PDT-11, thus lowering the cost of intelligence per terminal.</td>
</tr>
<tr>
<td>Ideal for network applications.</td>
<td>Specially designed to facilitate efficient remote or network terminal processing (utilizing the clustering capability).</td>
</tr>
<tr>
<td>Automatic program load.</td>
<td>Provides quick, easy, automatic bootstrapping via built-in ROM to enhance overall operating efficiency in start-up procedures.</td>
</tr>
</tbody>
</table>
FEATURES

Built-in self-test diagnostics.

Field upgradable via module swap.

BENEFITS

Maximizes terminal uptime and minimizes service costs.

Additional memory (up to 60 K bytes) and/or a cluster controller can be added quickly on-site via module swapping.

PRODUCT PROFILE/PDT-11 SERIES

General Description
The PDT-11/110 terminal is a down-line loadable, user-programmable, intelligent terminal. It provides all of the features of the VT100, the power of a PDP-11 compatible microcomputer, varying increments of memory, and an asynchronous or synchronous communication port.

The PDT-11/130 is the basic PDT-11/110 terminal with the addition of a dual drive DECTape II minicartridge unit.

The PDT-11/150 is a marriage of the RX01 flexible disk drive and the PDT-11 intelligence module in a single system. Any EIA terminal such as the VT100, LA120, or LA36 can connect to the PDT-11/150 as a console.

PDT-11 Series Common Functions
The PDT-11 intelligent terminals utilize a modular concept of engineering design. They combine an LSI-11 microprocessor with the display and features of the VT100 video terminal. The three-board LSI-11 housed in the VT100 provides up to 60K bytes of random access memory (RAM) space, allowing large programs to reside locally. Optionally available are 16K and 32K byte memories for smaller system configurations.

PDT-11 systems use the same instruction set as the PDP-11 family of minicomputers. This means that many programs developed on the PDT-11 are capable of running on a variety of PDP-11 processors, and vice versa. Instruction set compatibility between the PDP-11 and PDT-11 families also permits a great savings in software development—PDP-11 programming expertise can readily be adapted to PDT-11 systems.

The PDT-11s feature an interface port allowing the connection of any EIA RS-232-C compatible printer with support for XON/XOFF control codes from the printer; the printer is limited to 9600 bits per second.
asynchronous operation. In addition, a standard EIA interface is supplied with the PDT-11 terminals. This feature can be used to connect a low-cost printer where hard copy for archives or business forms is required. Optionally available are interface ports that enable the PDT-11s to support up to three additional workstations in a cluster configuration. This provision allows standard video or printing terminals to share the same "intelligence" as the PDT-11. These intelligent workstations also share the same communications line, which results in lower network support costs.

The PDT-11s operate on half- or full-duplex synchronous or asynchronous communication lines at rates from 50 to 19,200 bits per second.

**PDT-11 Processor**

The PDT-11 processor is constructed on three boards, collectively called the Terminal Intelligence Module, or TIM. The CPU board contains the standard 4-chip LSI-11 processor, and an 8-bit microprocessor which handles all communication with the dedicated I/O ports and the VT100. The peripheral board contains USARTs (Universal Synchronous/Asynchronous Receiver/Transmitters) and peripheral control circuitry. The memory board contains both dynamic RAM and 1 kiloword of ROM.

The PDT-11 series features "bounded bus" architecture, as opposed to the open or exposed bus architecture of the PDP-11s. This means that the LSI-11 bus is completely buried in the terminal, and a separate 8-bit microprocessor acts as the interface between the CPU and all peripherals.

The PDT-11 CPU has a 400-nanosecond memory access time and a 490-nanosecond single instruction cycle time. The PDT-11 I/O latency is 30 to 125 microseconds, depending on the operation involved.

**The PDT-11 Intelligence Module Set**

The Terminal Intelligence Module set is made up of three modules. The main board is a module containing the functions of the CPU (an LSI-11 chip set) and an I/O processor. Attached to this board by stacking connectors is the memory module, which can be 8, 16, or 30 kilowords of dynamic RAM memory plus 1 kiloword of ROM memory. The memory board is 5.25" x 10.1". Also attached to the main board by stacking connectors is the I/O module. This module contains the three (optionally six) serial line units. This module is also 5.25" x 10.1".

These three modules, when interconnected via the stacking connectors, give the appearance of two 10.5" x 10.1" modules with .5" center-to-center spacing between them.
PDT-11/TIM-VT100 Communications

On the PDT-11/110 and 130, communications between the TIM and the VT100 are via the console Universal Asynchronous Receiver/Transmitter on the TIM and the VT100 side of the Standard Terminal Port (STP). Communications are performed under the following parameters:

- **Data Rate:** 9600
- **Bits/Character:** 8
- **Parity:** None
- **Stop Bits:** 1
- **XON/XOFF:** Must be supported in both directions
- **Mode:** Asynchronous

The above parameters, except for data rate, are specified for the VT100 by asserting Option Present on the STP board, and are not alterable from the VT100 set-up mode. Data rate is provided to the VT100 UART from the STP board as Internal Transmitter Clock (TCLK) and Internal Receiver Clock (RCLK), at 16 times bit rate. The TIM side of the interface is established as part of the power-up cycle by initialization code resident in the 8085 microprocessor chip in the Terminal Intelligence Module. Specifically, the Initialize TIM-VT100 ROM program is designed to initialize the TIM's console UART according to the above parameters.

Communications on the PDT-11/150 are established via software and not through the VT100's console Universal Asynchronous Receiver/Transmitter.

**PDT-11/TIM-Host Communications**

In the PDT-11/110, communications between the terminal intelligence module and the computer are initialized by the Initialize TIM-HOST routine in the TIM's LSI-11 chip at power-up time. In the PDT-11/130, communications are initialized by software that must access the necessary parameters from the VT100 Non-Volatile Random Access Memory (NVRAM). The PDT-11/150 initializes communications via software which must establish the parameters. Because of a difference in the basic capabilities of the VT100 and the TIM set, the TIM-HOST data rates do not all map directly between VT100 NVRAM and the TIM's USART. Specifically, the VT100 can select and display a 200-bit-per-second communication rate. If this is selected by the operator, the TIM firmware will default it to 150 bits per second. Additionally, the
VT100 NVRAM cannot select 7200 bits per second, although the TIM set can. If this data rate is desired, it must be specified directly through the application software within TIM.

PDT-11/VT100 Terminal
The VT100 is a basic building block for the PDT-11 series. It is a high performance video terminal offering features not found in other entry-level terminals. Among these features are a detached keyboard for user convenience; double-width, double-size, and reverse underline video characters for emphasis in formatted text; up to 132 characters per line for viewing standard line printer format on the video screen without reformatting files; and split screen and smooth scrolling capability for easy viewing of text and operator prompts or status information. The advanced video option adds selectable blinking, underline, reverse and dual intensity characters—in any combination the user chooses.

The PDT-11 Terminal Controller
The terminal controller is a module 10.5” x 10.5”. Its function is to send keyboard inputs to the TIM set or to accept ASCII information and act upon it in two ways. If the information is meant for display, it will be placed in the controller’s internal memory to be displayed on the CRT monitor. If the information is control information, the controller will perform the appropriate function without storing the control data.

The PDT-11 Keyboard
The keyboard is an alphanumeric key array used by the operator to communicate with the CPU. When a key is depressed on the keyboard, the key closure is translated by the terminal controller module into an ASCII character and transmitted to the intelligence module.

PDT-11 Display
The PDT-11 display is a 12” diagonal cathode ray tube plus the electronics necessary to accept control and data information from the terminal controller and to present alphanumeric character information to the operator.

PDT-11 Power Supply
The power supply is a 95 watt supply of the switching variety. It is mounted on a module 11.464” long x 5.625” high. This module supplies direct current power at the proper voltages for the entire system.

Standard Terminal Port
The standard terminal port provides a means of interfacing terminal
options. Logically, this interface is very similar to that of a serial line splice, which is accomplished by breaking the serial line from terminal to host and inserting the option. These options may include communications, graphics, a terminal processor, mass storage devices, etc.

PDT-11 Cluster Option
The cluster option provides three additional serial line units, which are intended to be used as terminal ports.

A cluster interface module, containing three female 25-pin sub-miniature “D” connectors and EIA interface circuitry, is interconnected to the TIM I/O board by a cluster data cable. Three USART chips located on the TIM I/O module are also added to support this option.

PDT-11 DIAGNOSTICS
Diagnostics resident in the VT100 and the Terminal Intelligence Module ROM will assess that the PDT-11/110 and 130 are generally functional at power-on time. At power-on, each module will execute its own diagnostic routines independently. The PDT-11/150 utilizes TIM diagnostics exclusively.

If the VT100 fails, its normal failure reporting will be used. If TIM fails, it will attempt to display, via console, a report of the failure. The diagnostics will isolate hard failures to the module (board) in 85%-95% of the cases. This capability will allow the service technician to isolate a possible hardware problem quickly to minimize downtime.

PDT-11 ROM Layout
The LSI-11 ROM in the PDT11/110 includes the following:

- customer space
- MOP loader
- terminal boot
- initialization
- diagnostics
- start-up sequencing

The section labeled customer space can be used for a down-line loader or other applications. The user can also choose to omit the MOP loader, terminal boot, and/or terminal mode if more space is needed.

Since the LSI-11 ROM can be a programmable read only memory (PROM) chip, users can “blast” or produce their own chips, replacing those shipped with the PDT-11 from DIGITAL. If the user does this, the start-up sequencing, diagnostics, and initialization routines should be included as specified in the appropriate PDT-11 documentation. The
ROM in a PDT-11/130 includes a self-test and a DECtape II boot. The DECtape II boot will automatically load from Drive 0 after completion of self-test at power-on or re-boot.

PDT-11/Terminal Boot
The capability to down-line load programs to a PDT-11/110 from the host in a character-by-character mode is provided by the terminal boot. This LSI-11 routine in the Terminal Intelligence Module is called upon receipt of a specific message sequence from the host.

PDT-11 Re-boot Capability
The ability to re-boot the PDT-11 is available by executing the reset function while in set-up mode. This is accomplished by entering SET-UP, per VT100 specification, and pressing "0". The result is a complete re-start, as if power were just turned on.

PRODUCT PROFILE/PDT-11/110

PDT-11/110 Applications
The PDP-11/110 is designed for network applications where local software is under the control of the central computer. In a network environment the PDT-11/110 provides both low-cost intelligence where local mass storage is not needed and the ability to cluster terminals to lower the per-terminal cost of intelligence even further.

Applications for the 110 include inquiry/response, local program execution, and intelligent data capture.

Typical inquiry/response applications are airline, hotel/motel and car rental reservation desks; ticket agencies, inventory status checking; credit checking; and other programmed screen format applications. Storing the screen formats in the terminal reduces host overhead and communication line overhead. Only relevant data is sent between terminal and host.

Intelligent data capture means that the terminal prompts the user and checks errors in keyed data before transmission to the host. For example, the terminal processor can perform interfield computation and checking of screen format data before it is transmitted. It may also provide editing functions.

Local program execution reduces the data processing load of the host. The local terminal can preprocess and condense data to reduce communication overhead and lower network expenses.

The PDT-11/110 can also be configured with a local hard copy device to provide a complete local workstation whose programs are down-line loaded from the host.
PDT-11/110 Features and Benefits
The PDT-11/110 intelligent terminal has all of the features and benefits described previously in the general PDT-11 series product profile.
PRODUCT PROFILE/PDT-11/130
The aspect of the PDT-11/130 which distinguishes it from the PDT-11/110 is the use of DECtape II minicartridges for local storage. DECtape II is a random access tape subsystem capable of reading and writing 512K bytes of data on block-addressable, preformatted cartridges at 800 bits per inch. The average search time to any record is 10 seconds. Low cost, low maintenance, and high reliability are assured by the simple transport mechanisms. Each transport has a high-quality read/write head with an integral erase-gap. The system stores information at fixed positions on magnetic tape as in magnetic disk or floppy disk storage devices, rather than at unknown or variable positions as in conventional magnetic tape systems. This feature allows replacement of blocks of data on tape in a random fashion, without disturbing information recorded previously.

Supporting Software
The PDT-11/130 series uses RT²/PDT software, a subset of the RT-11 interactive operating system. RT²/PDT applications can be developed in the MACRO-11, FORTRAN IV, or BASIC-11 languages. When the application is developed, it is combined with RT²/PDT, and transported via tape cartridge to the PDT-11/130 to be booted. Thus, the user is provided with a turnkey load module that boots from the local mass storage device. This run-time only production system provides a high level of system security by preventing applications operators from modifying (or even accessing) program source or object code.

PDT-11/130 Applications
The primary application of the PDT-11/130 is source data collection, in which local software prompts the operator and checks input for errors. Information gathered for transmission to a remote computer can be processed before transmission. Simultaneously, a local journal of all entries can be made on the minicartridges. In addition, screen formats can be stored locally.

With respect to hardware, the PDT-11/130 can be used as a stand-alone desktop computer system, especially if a printer is added. In addition, the PDT-11/130 is suited for text editing and word processing applications.
**PDT-11/130 Features and Benefits**

<table>
<thead>
<tr>
<th>FEATURES</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual minicartridge drive.</td>
<td>Block addressable, block replaceable data format allows quick reading and writing of data. Permits local storage of both programs and data. Allows more efficient usage of communications lines by storing local data for block transmission. Small cartridges may easily be stored and mailed.</td>
</tr>
<tr>
<td>Single enclosure design.</td>
<td>The power of a complete computer, with CPU, terminal, and mass storage, can be placed on a desk or typing stand. Has no bulky cabling between processor, storage, and terminal.</td>
</tr>
</tbody>
</table>
PDT-11

PRODUCT PROFILE/PDT-11/150
The PDT-11/150 systems are entry-level, user-programmable, intelligent terminals with local disk storage. PDT-11/150 systems combine the features of any DIGITAL hard copy or video terminal with the power of a PDP-11 compatible processor. They provide up to 60K bytes of random access memory, an asynchronous and synchronous host communication port, and single or dual floppy disks with up to 512K bytes of mass storage. The PDT-11/150 mass storage and intelligence modules are contained in a separate enclosure that complements the design of DIGITAL's terminals. The floppy disk module and terminal can fit easily on an office desk, providing a compact, efficient workstation.

Floppy Disk Storage
The PDT-11/150 uses floppy disk media for local mass storage. Floppy disks are thin, flexible, oxide-coated disks similar in size to a 45-rpm phonograph record. The floppy is recorded on one side, and is permanently contained in an 8-inch-square flexible envelope. The floppy disk is an ideal storage, interchange, and software distribution medium. The thin, flat design of the floppy disk enables large amounts of data to be stored conveniently in a small space.

The simple mechanical construction of the drive, and the use of a microprogrammed controller that reduces hardware complexity, contribute to the exceptional reliability of floppy disks. Each sector of a diskette has a Cyclic Redundancy Check (CRC) character recorded as part of the header field, and another CRC character as part of the data field to ensure data integrity.

Supporting Software
The PDT-11/150 series uses RT²/PDT software, a subset of the RT-11 interactive operating system. RT²/PDT provides a single job or foreground/background execute-only environment for applications that are developed on any RT-11 system. RT²/PDT can be developed on a wide range of PDP-11 minicomputers—from the microprocessor-based PDP-11/03 to the larger PDP-11/60 with cache memory. RT²/PDT applications can be developed in the MACRO-11, FORTRAN IV, or BASIC-11 languages. Once the application is developed, it is combined with RT²/PDT, transported via floppy diskette to the PDT-11/150 and is then ready to be booted. Thus, the user is provided with a turnkey load module that boots from the local mass storage device. This run-time-only production system provides a high level of system security by preventing applications operators from modifying (or even accessing) program source or object code.
PDT-11/150 Features and Benefits

FEATURES

Terminal independence.

Stand-alone compatibility.

Modularity.

Single or dual floppy.

Field upgradable.

Single enclosure design.

BENEFITS

Any EIA compatible terminal may be used with the PDT-11/150. The user may configure a system with a single hard copy terminal, doing away with the need for a separate printer and console device.

The PDT-11/150 series is a set of complete stand-alone computers, with terminal, CPU, and mass storage. In addition to their use in networks, they can form small independent systems.

The design of the PDT-11/150, with separate terminal and separable floppy drives, provides flexibility in configuring and ease of repair.

Offers users a choice of storage capacity to meet different needs. A second drive can be added later.

Memory, a cluster controller, and a second flexible disk drive can each be added in minutes.

Fits on table top or desk in any office environment.
PDT-11/150 Applications

The PDT-11/150 series is suited for applications requiring a small stand-alone computer which is linked to a remote data base and/or computer network. For example, an automobile driver, a local insurance office, and a warehouse inventory control station all might need local data processing, yet all are part of a larger data transfer system.
PDT-11

The 11/150 series is also well suited to small stand-alone functions, such as word processing or small business applications. Since it is terminal-independent, the console terminal can be a hard copy terminal. This does away with the need for both CRT and hard copy devices. And the cluster controller option means that the 11/150 can form the nucleus of a set of non-intelligent workstations.
part II communication
CHAPTER 8

BASIC CONCEPTS OF DATA COMMUNICATIONS

INTRODUCTION
One of the essential properties of all electronic data processing systems is that they communicate. Certainly a computer would be of little use if it had no way of accepting commands and information from you and then letting you know the results of its computations. Computers must be able to communicate with peripheral devices such as terminals or disk drives. In an increasing number of applications, computers must also be able to communicate directly with other computers.

The Basic Elements of Communication
All communication involves the same basic elements, whether you're studying human communication or data communication. Each of these basic elements contribute both potentials and limitations to the process of communication. It is the interaction of all these elements which shapes each communication process.

1. **SENDER (transmitter)** — a device or person with a message to communicate. For example, the author of this handbook.

2. **RECEIVER** — a device or person capable of receiving or accepting a message. For example, you, the reader.

3. **MEDIUM (of transmission)** — a way of getting the message from the sender to the receiver. In this case, the handbook itself is the medium.

4. **NOISE** — anything which interferes with the process of communication. Unfortunately noise is always present in all communications. Noise can introduce errors in communication which cause the message received to be different from the message transmitted. As a result, various error checking procedures have been developed for data communications.

5. **EFFICIENCY** — usually expressed in terms of cost effectiveness. Often a secondary consideration in human communications, efficiency tends to be the deciding factor in data communications. In most applications you will try to select the technique which will communicate the most data at the lowest overall cost.
BINARY CODES
Digital computers understand only binary numbers—powers of 2 which can be represented by combinations of the two digits “1” and “0.” Each “1” or “0” is called a bit (Binary digiT). Since digital computers understand only binary numbers, they must send and receive binary numbers when they communicate.

But people find binary numbers difficult to read and understand. So people developed codes to translate the characters people understand—the letters of the alphabet (A-Z), the digits (1-9), and punctuation marks(,:!,...)—into the binary bits—1s and 0s—computers understand. Each character is represented by a unique combination of a fixed number of bits, usually 6, 7 or 8, depending upon the particular binary code which is used.

Several codes have been standardized so that computers made by different manufacturers can communicate with each other. One of the most commonly used standard codes is the ASCII (American Standard Code for Information Interchange) code. The ASCII code uses seven bits to represent each character plus an eighth bit, called the parity bit, which is reserved for error checking.

NOTE
All the examples shown in this book will use 7-bit ASCII code with odd (mark) parity.
PARALLEL TRANSMISSION
In parallel transmission, the medium consists of one wire for each bit in a character plus an additional wire for a clock or strobe signal. The clock or strobe tells the receiver to read the character which is ready on the other wires. An entire character plus the strobe is transmitted in the time it takes to transmit a single bit, so parallel transmission is very efficient and capable of extremely high speeds.

Computers and other high-speed digital systems use parallel transmission internally, so it often makes sense to use parallel transmission between these devices whenever they are in close physi-

1 Some parallel connections consist of the strobe plus one wire for each bit in a byte or in a word, so an entire byte or even an entire word is transmitted in a single bit time.
Figure 8-3 Parallel transmission can transmit an entire character in the time it takes to transmit a single bit.

...cal proximity. However, as the distance between these devices increases, so does the cost of the multiple wire connections. Also, there is always some signal loss as an electric signal is transmitted down a wire (due to the resistance of the wire). This loss increases with the length of the wire. After a certain distance, the signal must be amplified or it will be lost beyond recovery. But amplification of parallel signals can be very complicated due to phase and timing problems. So parallel connections are usually limited to the maximum distance the signal can be transmitted without needing amplification.

SERIAL TRANSMISSION

In serial transmission, the medium consists of a pair of wires—one wire to transmit the data and one wire to act as a common signal ground. Any of the standard binary codes can be used, but the bits are transmitted serially—one after the other. So instead of multiple parallel signals, only a single serial signal is transmitted.

Since serial transmission requires only a single signal transmitted over a single pair of wires it is more practical than parallel transmission for longer distance communications. The cost of the wire itself is considerably lower than for parallel transmission and a single signal is easier to work with. (Remember, as distance increases noise becomes more and more of a problem.)
Basic Concepts of Data Communication

Figure 8-4 Serial Transmission—an interface converts the multiple parallel signals from the sender into a single serial signal for transmission

In addition, longer distance data communication often requires the use of wires which are leased or rented from a common carrier. Most common carriers, such as the telephone company, have designed their networks to meet the requirements of voice transmission, not data communications. It is not practical to use parallel transmission over telephone lines.

Modems
Computers communicate binary data which allows only two choices. If a bit is not a "1," it must be a "0" and vice versa. There is no in-between in binary communication. But, as stated above, most common carriers have designed their networks to meet the requirements of voice transmission. Voice transmission is analog—a continuous range of possibilities. A typical telephone circuit can transmit a continuous range of sounds from 300 to 3000 Hz.

Figure 8-5 Binary data has only two possibilities—1 or 0
Analog data has a continuous range of possibilities
Basic Concepts of Data Communication

A *modem* (modulation/demodulation unit) or *data phone* is a device which:

1. Converts the binary data from the sender into an analog sound signal which can be transmitted over a telephone circuit. This is called *modulation*.
2. Converts the analog telephone signal back into a binary signal for the receiver. This is called *demodulation*.

Some modems have special cradles in which you can place the handset of an ordinary telephone. These are called *acoustic couplers*. Some modems may also perform special functions such as automatic dialing, automatically answering, and automatically disconnecting the line when the communication is completed.

![Diagram of modem components](image)

**Figure 8-6** The *sender* needs a modem to *modulate* the binary signal for transmission.

The *receiver* needs a modem to *demodulate* the analog signal back into a binary signal.

### 20 mA and EIA Transmission

There are two common techniques used to transmit binary data along serial lines. One technique varies the *current* and the other varies the *voltage* to communicate the binary 1's and 0's.

**20 mA (milliAmpere) CURRENT LOOP**

This technique communicates binary data by turning on and off a 20 mA current flowing through both the sender and the receiver. The sender turns the current on to communicate a "mark" or "1" bit and turns the current off to communicate a "space" or "0" bit.
Although they are much less susceptible to noise than voltage varying techniques, 20 mA loops do have several drawbacks. The major drawback is that 20 mA loops cannot be used with modems. Current loops were designed for use in telegraph circuits and they do not have enough wires to carry modem control information.

Since current is directly proportional to voltage and resistance, the voltage required to drive 20 mA of current through the loop may be quite high. Therefore, optical isolators must be used to protect delicate and valuable logic circuits. Of course, if the loop is modified in any way, that will change the resistance, so the voltage must be readjusted to maintain the 20 mA current. Finally, there can be only one source of the 20 mA current, therefore there must be two types of 20 mA interfaces—an active interface to supply the current and a passive interface for other devices connected in the loop.

EIA (Electronics Industry Association) SYSTEM
This technique communicates binary data by reversing the polarity of the voltage on a dc serial line. The sender transmits a positive voltage to communicate a “0” bit and a negative voltage to communicate a “1” bit.

Voltage varying systems are more susceptible to noise than current loop systems but they do have several significant advantages. The EIA system is based on standards prepared by the Electronics Industry Association and includes the definition of modem control signals. Most modems manufactured in the United States are compatible with EIA standard RS-232C. In the EIA system, senders and receivers have male connectors and modems have female connectors, so you must use a device called a null modem when you want to directly connect two EIA devices.

The CCITT system is another voltage varying system with modem controls based on standards prepared by the International Consultative Committee on Telephony under the auspices of the United Nations.

Modes of Transmission
The three modes of transmission correspond to the three types of circuits available. But bear in mind that a circuit is not always used to

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2 An optical isolator is a light-tight box with a light source and a photoresistor. When the 20 mA current is flowing, the light is on. This affects the photoresistor. The binary data can be communicated without a direct electrical connection between logic boards and the loop.
its fullest potential. For example, if you use a half-duplex modem on a full-duplex circuit, the data will be communicated in half-duplex mode.

1. **Simplex** — One-way communication
   One side can only send and the other side can only receive. I can talk to you, but you can never talk back to me. (Simplex circuits are used for telemetry communication such as from a satellite to a ground station.)

2. **Half-Duplex (HDX)** — One-way-at-a-time communication
   Both sides can either send or receive, but at any given moment one side is only sending and the other side is only receiving. I can talk to you, and, when I am done, you can talk back to me.

3. **Full-Duplex (FDX)** — Two-way communication
   Both sides can both send and receive at the same time. I can talk to you while you are talking to me—and we don’t have to be talking about the same subject or even related subjects.

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**Figure 8-7** Simplex, half-duplex and full-duplex communication
Rate of Transmission
The sender and receiver must agree upon the speed or rate at which they will communicate. This is accurately measured as bps (bits per second). The rate of transmission is also, less accurately, expressed as the baud rate.³

Obviously, the higher the rate of transmission, the more data which can be communicated in a given period of time. The length of a bit time is determined by the rate of transmission. But, as the rate of transmission increases, so do the effects of noise. Higher speed lines require special conditioning to cut down on noise and are, therefore, more expensive to install or lease.

ASYNCHRONOUS SERIAL TRANSMISSION
A CHARACTER-ORIENTED COMMUNICATION TECHNIQUE

In asynchronous transmission, the sender transmits a character whenever one is ready. It may transmit characters one right after the other or there may be some time between characters. For example, if you are typing a command at a terminal which is communicating asynchronously, the terminal will transmit a character each time you type a key. The terminal then has nothing to send until you type the next key.

Each character is, in effect, a complete self-contained message by itself. So, each character transmitted must also contain information telling the receiver when a character begins and when that character has ended. The part of the message which tells the receiver that a character is about to begin is called the start bit. The part of the message which tells the receiver that an entire character has been transmitted is called the stop bit(s). There may be more than one stop bit per character.⁴ The start and stop bits serve the same function as the blank spaces between words in printed English.

³ Technically, the baud rate refers to the number of signal elements per second. There are some data communication techniques which communicate more than one bit every time the signal changes. Thus the baud rate could be less than the number of bits per second (bps). In reality, the baud rate is almost always equal to bits per second.

⁴ Older electro-mechanical printers required the extra stop bits to give them time to set up for the next character and this tradition is sometimes carried over in modern equipment.
During the period that no characters are being sent, the line is said to be *idling*. By convention, there is current flowing through the line while it is idling.\(^5\) Also by convention this is called the "mark" or "1" state because it is the line state used to transmit a "1" bit. When the current (or voltage for EIA type techniques) drops down to the "space" or "0," the receiver knows that a character is being sent. Thus when the line changes from a constant "1" to a "0," that is the start bit.

![Asynchronous transmission diagram](image)

**Figure 8-8** Asynchronous transmission—each character is a complete message by itself with a start bit, character and parity bits, and one or more stop bits

As soon as the receiver senses the start bit, it starts a clock which measures bit times. It then samples the next eight bits (a 7-bit character plus parity) and places them in a register for transfer to memory. The next bit (or bits) is the stop bit, which *must* be a "1" bit.\(^6\)

Asynchronous technique is easy to implement and is almost universal. It can communicate characters as they are ready, so it doesn't require any buffering or temporary storage of data. But it does not use the communication line very efficiently. At least 2 out of every 10 bits (for ASCII code) serve as start and stop bits, which do not communicate any data.

5 This acts as a failsafe circuit check on the line, since if the current stops flowing for more than eight bit times, it means that the circuit has been broken.

6 Since the receiver uses the idle to space ("1" state to "0" state) transition to detect a new character, the line must return to the idle state for at least one bit time.
Error Checking—Parity

Parity is a test which is used to detect single bit errors in transmission. Sometimes a bit gets changed by noise or interference during transmission—a "1" gets sent, but a "0" is received, or vice versa. Since each character is represented by a unique combination of bits (seven bits for ASCII characters), this makes it look as though a different character has been sent.

![Diagram of parity error]

Figure 8-9 A single bit error in transmission can change the letter “K” to the letter “C”

Parity checking guards against single bit errors by counting the number of “1s” in the character and setting the parity bit (the eighth bit in ASCII characters) so that the total number of “1s” is either odd or even. (It doesn’t matter which, but both the sender and the receiver have to agree.)

If odd, or mark, parity is selected, the parity bit is set so the total number of “1s” in a character is always odd. If the binary representation of a character has an even number of “1s,” the parity bit is set to “1” to make the total number of “1s” odd. If the character has an odd number of “1s,” the parity bit is set to “0” so the number of “1s” remains odd.

If even, or space, parity is selected, the parity bit is set to “1” or “0” to make the total number of “1s” an even number.

Examples of odd or mark parity:

- The ASCII code for the letter “K” is 1001011. Since there are an even number of “1s,” the parity bit is set to “1.”
The ASCII code for the letter “C” is 1000011. It has an odd number of “1s,” so the parity bit is set to “0” for odd parity.

When a character is received, the receiver counts the number of “1s” and then checks the parity bit. If the parity bit is a “1” but it expects a “0” or vice versa, it sends a special parity error character.

Figure 8-10 Parity—if the letter “K” was changed to the letter “C” by an error in transmission, the parity bit would still be set to “1” so the receiver would detect the error

SYNCHRONOUS SERIAL TRANSMISSION
A MESSAGE OR BLOCK-ORIENTED DATA COMMUNICATION TECHNIQUE

In synchronous communication, the sender sends an entire block of characters at a time. Special synchronization characters are sent before and after each block to coordinate or synchronize both the sender and the receiver. Since the entire block of characters is synchronized, there is no need for separate start and stop bits before and after each character. So synchronous technique uses the line more efficiently than asynchronous transmission—it can transmit more data in a given period of time. Synchronous technique is almost always used when higher speed communication is required. 7

7 Speeds above 5,600 bps (bits per second)
SYNCHRONOUS PROTOCOLS
Data communication requires the use of a grammar or protocol to assure both the correct sequencing and the integrity of the data being communicated. The protocol for asynchronous technique is composed of the start and stop bits. There are a number of different protocols in common use for synchronous technique. Commonly used protocols include:

- DDCMP (DIGITAL Data Communications Message Protocol)
- HDLC (High level Data Link Controls)—developed by ISO (International Standards Organization)
- ADCCP (Advanced Data Communication Control Procedures)—developed by ANSI (American National Standards Institute)
- BISYNC (Binary Synchronous communication protocol)
- SDLC (Synchronous Data Link Control)

Synchronous protocols are composed of control characters and text.

Control characters Special bit sequences which are used to carry information about the communication process itself. For example, DDCMP uses the synchronization character SYN to synchronize the receiver with the sender. In ASCII code, SYN has the bit pattern 0010110. SDLC has only one control character, called a flag character, which always has the bit pattern 01111110.

Text Refers to the data being communicated. The only function of a protocol is to communicate the text.

Data communication protocols are similar in many ways to the grammar which is used in this book. In written languages, sequence is maintained through both positioning and numbering. Characters are organized into blocks called words. Words are organized into sentences. Blank spaces are used to block off letters into words. In addition to blank spaces, there are a number of other control characters which are called punctuation marks. Normally, we do not pay much attention to the grammar unless something goes wrong somewhere.

Synchronous Protocol Functions
SYNCHRONIZATION
Both the sender and receiver must be synchronized—they must agree exactly when one bit ends and the next bit begins. In synchronous technique, this is accomplished through the use of a special synchronization character called SYN. The receiver searches for the unique bit pattern of the SYN character and uses it to lock into phase with the control and data characters which will follow.
FORMATTING
Certain positions or fields in each message block are reserved for specific types of information. For example, each block might have a header followed by the text itself and then a trailer. The text is the payload and the header and trailer are merely the vehicle for communicating the text.

| HEADER OR CONTROL FIELD | BODY OR TEXT FIELD | TRAILER OR ERROR CHECKING FIELD |

Figure 8-11 A typical synchronous protocol format

The header carries addressing, block sequence and control flag information which ensures that the data arrives at the correct receiver in the proper sequence and is interpreted correctly.

The text contains the block of data being communicated.

The trailer carries error checking information which the receiver will use to test for errors in transmission.

LINE UTILIZATION
The protocol often determines the maximum efficiency with which the communications line can be used—the maximum amount of data which can be transmitted in a given period of time. For example, the protocol BISYNC cannot take advantage of a full-duplex line because the receiver can only answer with acknowledgments. But the protocol DDCMP (DIGITAL Data Communications Message Protocol) is designed so each device can both send and receive data at the same time. The DDCMP format has a field set aside so a device can acknowledge receipt of a message while sending a message of its own.

HANDSHAKING
Synchronous communication technique involves a constant dialogue between the communicating devices. The terms sender and receiver do not apply because the "receiver" must often become the "sender" and send back acknowledgements so the "sender" knows that the "receiver" has indeed received the message. This dialogue—which establishes and maintains synchronization and lets the receiver acknowledge a good block of data or request retransmission of a bad block—is often called handshaking.
Basic Concepts of Data Communication

Some of the handshaking is done by the protocol and some by the modems. For example, when a device is ready to send, it first sends a request-to-transmit character. The receiver then transmits a clear-to-send character. The sender then sends the SYN characters to establish synchronization. After each block has been sent, the receiver checks for errors and then either sends an acknowledgement or a negative acknowledgement.

In half-duplex (one-way-at-a-time) communication, the “receiver” must turn the line around to send back the appropriate acknowledgement. The “sender” must then turn the line around again to continue sending.

ERROR CHECKING AND RECOVERY
The protocol must also ensure that the text which is received is complete and free from errors. Remember, noise is a basic element in all communications. Noise can, and often does, cause errors during transmission. So each protocol incorporates error checking procedures involving an algorithm which is applied to each block of text to generate an error checking field. The error checking field is communicated with the text block. The receiver applies the same algorithm to each text block and compares the field it generates with the error checking field which was sent with the text. If the check field the receiver generates is not exactly the same as the check field sent with the text block, then the entire text block is rejected and must be retransmitted.

Each protocol must provide a way for the receiver to acknowledge the receipt of an acceptable text block or request the retransmission of an unacceptable text block. This is part of the handshaking procedure.

NOTE
Synchronous transmission is a block-oriented technique. If a transmission error occurs anywhere in a block, the entire block must be retransmitted.

Data Transparency — Synchronous protocols use special bit patterns to represent control characters. But there are many different ways of representing data and some codes use these same bit patterns to represent data which are not control characters. For example, one CPU may want to communicate the contents of certain memory locations to another CPU, or a measuring station may want to communicate digital representation of analog data. So every protocol has to have a way of transmitting text which may contain bit patterns that could look like control characters to the receiver. This is called transparency.
SUMMARY
Data communication can be as simple or as complex as you want it to be. This chapter touches on only the most basic concepts of data communications. The next several chapters will present an overview of DIGITAL's communication interfaces including features, benefits and general programming information.
interfaces

Since digital computers use parallel transmission for internal communication, they require interfaces to convert internal parallel signals into serial signals for transmission and to convert incoming serial signals back into parallel signals during reception. This, of course, is the absolute minimum function of an interface.

Interfaces are usually designed for either asynchronous or synchronous communication, but a few are capable of both. Some interfaces handle only a single line, but other interfaces can handle multiple lines. Some interfaces have modern control capabilities ranging from auto dial and auto answer to auto disconnect. Others are capable of multiplexing or combining several signals so they can be transmitted over the same line. A few interfaces are intelligent, so they can relieve the computer of much of the workload involved in communications.

DIGITAL offers a tremendous range of interfaces so you can select the interface or interfaces which are best suited to your particular communication requirements.
**ASYNCHRONOUS COMMUNICATIONS INTERFACES**

<table>
<thead>
<tr>
<th>SINGLE LINE</th>
<th>MULTI LINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DZ11</td>
</tr>
<tr>
<td></td>
<td>COMM IOP-DZ</td>
</tr>
<tr>
<td>DL11</td>
<td>DH11</td>
</tr>
<tr>
<td></td>
<td>DZV11</td>
</tr>
</tbody>
</table>

**SYNCHRONOUS/ASYNCHRONOUS**

|             | DV11        |

---

**Asynchronous Transmission**

Transmission in which time intervals between transmitted characters may be of unequal length. Transmission is controlled by start and stop elements at the beginning and end of each character. Also called start/stop transmission.
ASYNCHRONOUS TRANSMISSION

The programming logic that provides for asynchronous transmission stipulates the sequence of instructions required to send a data character over communications lines to a receiving device. Before transmission of a data character may occur, however, a buffer containing the count of characters in a message must be initialized. It is from this buffer that characters will be individually moved or "fetched" and framed with start and stop bits. Each bit of each character is moved and counted in a transmit bit buffer until the end of the bit string is reached. When all bits are processed, the end of the character string is also reached, and the transmit bit buffer is reinitialized to send additional data characters.
ASYNCHRONOUS RECEPTION

The programming logic that provides for asynchronous reception stipulates the sequence of instructions required to receive and process data characters. Before data characters can be received, the communications line must be tested for a signal from the transmitting end that data characters will follow. This signal is the start bit. Once the start bit character is received, half a bit time will elapse before the bit counter is set to zero. And exactly one bit time after the counter is set, each incoming bit on the line is examined and then appended into a data character which increments the bit counter. Upon completion of moving a bit stream into a data character, the actual processing takes place, the program logic looks for another start bit, and the bit counters are set back to zero.
CHAPTER 9
ASYNCHRONOUS SINGLE LINE INTERFACES
DL11

OVERVIEW/DL11
The DL11 series of asynchronous single line interfaces handles full- or half-duplex communication between a wide variety of serial communication channels and a PDP-11 computer.

With a DL11 interface, a PDP-11 computer can communicate with a local terminal such as a console DECookie, with a remote terminal via modems and private line or public switched telephone facilities, or with another local or remote PDP-11 computer.

DL11 systems provide wide flexibility. The user can specify the data rate from a selection of standard rates between 40 and 9600 bits per second. The interface can offer split-speed operation for faster, more efficient handling of computer output.

For additional flexibility, character size, parity checking (even, odd, or none), and stop code length (1, 1.5, or 2 bits) are switch or strap selectable.
Asynchronous Single Line Interfaces

**DL11**

**FEATURES**

Double-character-buffered receiver and transmitter.

Speeds from 40 to 9600 bits per second.

Strap-selectable character size (5, 6, 7, or 8 bits), parity generation on transmit and checking on receive (even, odd, or none), stop length 1, 1.5, or 2 bits.

Standard interfacing.

**BENEFITS**

Allows a full character time for interrupt service.

Can handle a variety of terminals and communication lines at varying data rates.

Offers the ability to handle a wide range of terminals.

EIA RS-232-C/CCITT V.24, 20mA active current loop electrical interface available.

**PRODUCT PROFILE**

**General Description**

Each DL11 module represents one unit to the UNIBUS and plugs into a standard small-peripheral controller slot in a PDP-11 system.

There are three DL11 models: the DL11-WA, DL11-WB, and DL11-E.

Model DL11-WB is a serial line EIA/CCITT interface and real-time line frequency clock. It is capable of handling either local or remote terminals (data only). With local devices, this model requires a null modem; in private line communication, modems are required. Switches allow modification to replace DL11-B and DL11-D in most applications. The DL11-WB gives the same wide range of operating parameters as the DL11-WA.
Model DL11-E meets the EIA and CCITT interface specifications cited for Models B and D. This interface provides the user with the full range of data rates as well as with complete modem control for remote communication with either a terminal or another PDP-11 computer.

Model DL11-WA is a serial line 20mA interface and real-time line frequency clock. It provides the flexibility of a wide choice of speeds, character size, and stop bit configurations. Switches allow modification to replace the DL11-A and DL11-C in most applications.

OPERATION

General
The DL11 is a interface between a single asynchronous serial communication channel and the PDP-11. It performs serial-to-parallel and parallel-to-serial conversion of serial start/stop data with a double-character-buffered circuit called a UART (for Universal Asynchronous Receiver/Transmitter). This 40-pin dual-in-line package includes all of the circuitry necessary to double-buffer characters in and out, serialize/deserialize data, provide selection of character length and stop code configuration, and present status information about the unit and each character.

Receiver
The receiver section performs serial to parallel conversion of 5-, 6-, 7- or 8-level codes. The character length is selectable by split-lug jumpers on the DL11-E and by switches on the DL11-WA and DL11-WB, and is specified by the customer at the time of the order. Each character appears right-justified in the receiver data buffer register (RBUF), stripped of start, stop, and parity bits.

The data rate may lie anywhere in the range between 40 bits per second and 10,000 bits per second, and in many cases need not necessarily be the same for the receiver as for the transmitter. The receiver samples the line at 16 times the data rate.

A complete character is formed in the UART and is transferred to the receiver data buffer register (RBUF) at the time the center of the first stop bit is sampled. At that time, the Receiver Done bit (bit 7) is set in the receiver status register (RCSR). If the Receiver Interrupt Enable bit (bit 6) is also set in RCSR, an interrupt request is generated. The BR level is set by jumper plug. BR4 is standard.

The program then reads the RBUF. The character appears right-justified in bits 7-0 of RBUF, stripped of start, stop and parity (if odd or even is selected) bits. Unused high order bits (6 and 7 in the case of a
6-level code) are zero-filled. Bits 8-11 are always zero and bits 12-15 contain status information about the character supplied by the UART.

Transmitter
The transmitter section performs parallel-to-serial conversion of data supplied to it from the UNIBUS. The character length and stop code (number of units of mark at the end of each character) are the same as for the receiver section. The transmitter section is also fully double buffered. Any time the Transmitter Ready bit (bit 7) is set in the transmitter status register (XCSR), the program may load the low-order eight bits of the transmitted data buffer register (XBUF) with a right-justified data character. The Transmitter Ready bit will be set any time the XBUF is available, whether or not a character is currently being transmitted. This is a natural result of the double buffering and means that if a character is not currently being transmitted and XBUF is empty, the program may provide two characters in succession (within less than one character time) to the transmitter.

PROGRAMMING

General
The interface between a program running in the PDP-11 processor and DL11 is via four device registers. They are: 1) receiver status register (RCSR); 2) receiver data buffer register (RBUF); 3) transmitter status register (XCSR); and 4) transmitter data buffer register (XBUF). Each register is assigned an 18-bit memory address, and may be read from or written into using any processor instruction that references these addresses, with the exceptions noted.

Interrupts
The DL11 has two channels of interrupts: one for the receiver section (vector = XX0) and one for the transmitter section (vector = XX4). These two circuits operate independently, except that receiver takes priority on simultaneous interrupt requests (is closer to the processor on the bus).

However, it is very important to note that in the DL11-E (modem operation), the receiver section handles a multiple source interrupt: RCVR DONE and DST INT. Furthermore, DST INT is set by several conditions (RING, CARRIER, etc.). If while servicing an interrupt for one condition, a second interrupt condition occurs, a unique second interrupt (and all subsequent ones as well) may not occur. To prevent this 1) all possible interrupt conditions should be checked after servicing one particular condition, or 2) both Interrupt Enables (bits 5 and 6) should
be cleared upon entry to the service routine for vector XXO, and set again at the end of service.

**Address and Vector Assignments**
The DL11-WA and DL11-WB follow the same address and vector assignments as the DL11-A and DL11-B.

**SPECIFICATIONS**

**Function:** Provides an interface between the PDP-11 UNIBUS and a single asynchronous bit-serial communications channel.

**Mechanical:** The DL11 consists of one Quad module and a connecting cable terminated in a plug appropriate to the data communications equipment to be connected.

**Operating Mode:** Full- or half-duplex under program control.

**Data Format:** Asynchronous, serial by bit. One start and 1, 1.5 (5-level codes only), or 2 stop bits, supplied by the hardware. The DL11-WA, WB, and E will accommodate characters of 5, 6, 7 or 8 bits, with or without even or odd parity. The data format must be the same for transmitted and received data. The data format must be specified at the time of order.

A one (1) presented by the program to any bit in the transmitted data register will cause a Marking (logical 1) condition to appear on the Transmitted Data lead during the corresponding bit interval. A zero (0) presented by the program will cause a Spacing (logical 0) condition to appear. A Marking condition on the Received Data lead during any data bit sampling interval will be presented to the program as a one (1) in the received data register, and a Spacing condition will be presented as a zero (0).

**Order of Bit Transmission:** Low order bit first.
Asynchronous Single Line Interfaces

DL11

Distortion: The DL11 receiver will operate properly in the presence of 40% space-to-mark or mark-to-space distortion between any two received data bits, and up to ± 4.5% long-term speed distortion, provided the data format contains at least one and one-half stop units. If the data format contains only one stop unit, the speed tolerance is ± 4%. The DL11 transmitter operates with less than 3% bit-to-bit or long term distortion.

Bus Loading: One DL11 presents one unit load to the PDP-11 UNIBUS.

Standard Interface: The DL11-WB provides a voltage level interface and connector whose signal levels and connector pinning conform to EIA Standard RS-232-C and CCITT Recommendation V.24. The leads supported are:

<table>
<thead>
<tr>
<th>Circuit</th>
<th>EIA RS-232-C</th>
<th>CCITT V.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protective Ground</td>
<td>1</td>
<td>AA</td>
</tr>
<tr>
<td>Signal Ground Transmitted</td>
<td>7</td>
<td>AB</td>
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<tr>
<td>Data</td>
<td>2</td>
<td>BA</td>
</tr>
<tr>
<td>Received Data</td>
<td>3</td>
<td>BB</td>
</tr>
<tr>
<td>Data Terminal Ready</td>
<td>20</td>
<td>CD</td>
</tr>
<tr>
<td>Request to Send</td>
<td>4</td>
<td>CA</td>
</tr>
</tbody>
</table>

Asynchronous Single Line Interfaces

DL11

The DL11-E provides a voltage level interface as described above for the DL11-WB but in addition supports the following leads, giving full modem control capability to the computer program:

Data Terminal Ready, Circuit CD, pin 20.
Clear to Send, Circuit CB, pin 5.
Request to Send, Circuit CA, pin 4.
Received Line Signal Detector (Carrier), Circuit CF, pin 8.
Ring Indicator, Circuit DE, pin 22.
Secondary Transmitted Data, Circuit SBA, pin 11.**
Secondary Received Data, Circuit SBB, pin 12.**


DL11-WA provides a 20mA active current loop for both Send and Receive leads for connection to local teleprinters.

The DL11-WA is supplied with a 2 1/4-foot, 6-conductor cable terminated with a female Mate-n-Lok connector.

* These leads are held ON (logical 1) by the hardware.

** Note that the pin assignment of these two leads conforms to that of the Bell 202 Data Set, rather than to the cited EIA/CCITT standard.

Power Requirements: The DL11 requires 1.8 amps of +5V, 0.05 amps of +15V, and .15 amps of -15V.

DL11-WA, WB
2.0 amps at +5V
0.05 amps at +15V
0.15 amps at -15V

DL11-E
1.8 amps at +5V
0.05 amps at +15V
0.15 amps at -15V
Asynchronous Single Line Interfaces

**DL11**

**Data Rate:**

The DL11-E is supplied to customer order with 13 standard data rates in four groups:

- **Group 1:** 110 bits per second receive and transmit.
- **Group 2:** 134.5 bits per second receive and transmit.
- **Group 3:** Following 8 speeds, which may be different for receive and transmit: 50, 75, 150, 300, 600, 1200, 1800, 2400 bits per second.
- **Group 4:** Following 8 speeds, which may be different for receive and transmit: 200, 300, 600, 1200, 2400, 4800, 7200, 9600 bits per second.

The DL11-WA, WB is supplied with eight switch-selectable speeds: 110, 150, 300, 600, 1200, 2400, 4800, 9600 bits per second.

**ORDERING INFORMATION**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL11-WB</td>
<td>Single asynchronous serial line EIA/CCITT interface and real-time line frequency clock.</td>
</tr>
<tr>
<td>DL11-E</td>
<td>Single asynchronous serial line interface. Supports full modem control interface, including Data Terminal Ready, Clear to Send, Request to Send, Carrier, Ring, Secondary Received and Secondary Transmitted leads.</td>
</tr>
<tr>
<td>DL11-WA</td>
<td>Single asynchronous serial line 20mA interface and real-time line frequency clock.</td>
</tr>
</tbody>
</table>
Asynchronous Single Line Interfaces

NOTE
See Communications Programming Card for register information.
CHAPTER 10
ASYNCHRONOUS MULTILINE INTERFACES
DZ11, COMM IOP-DZ, DH11, DZV11

OVERVIEW/DZ11
The DZ11 is a program-controlled asynchronous multiplexer that connects a PDP-11 or VAX-11/780 processor to 8 or 16 asynchronous serial lines. It is ideally suited to applications needing a low-cost method of connecting multiple local remote terminals at moderate throughput. DZ11s can be used with PDP-11 or VAX-11/780 systems in a variety of applications, including communications processing, timesharing, transaction processing and real-time processing. The PDP-11 or VAX-11/780 may be a stand-alone computer system, a front-end or remote concentrator to a larger system, or part of a network of computers performing distributed processing.
Asynchronous Multiline Interfaces

FEATURES

8- and 16-line asynchronous multiplexer.

Local operation at speeds up to 9600 bits per second.

Programmable data rate and formats on a per line basis.

Character interrupt output transfers.

Standard interfacing.

Single Hex board, 8-line modularity.

16-line cable distribution panel.

BENEFITS

Low-cost solution for connecting PDP-11 or VAX-11/780 to terminals or other computers.

Enables CRT terminals to achieve maximum response time.

Flexibility to handle wide range of terminals or communication lines.

Low-cost hardware implementation.

Versions available for EIA, RS-232-C/CCITT V.24, and also 20mA.

Reduces system space requirements.

Permits the user to expand easily from 8 to 16 lines.

PRODUCT PROFILE

General Description

DZ11 is a buffered, multiplexed interface between asynchronous serial communications channels and the PDP-11 or VAX-11/780. Modularity is on an 8-channel basis. The DZ11 performs serial-to-parallel and parallel-to-serial conversion of serial start/stop data with circuits called UARTs (Universal Asynchronous Receiver/Transmitters). These circuits double-buffer characters in and out, serialize/deserialize data, provide selection of character length and stop code configuration under program control, and present the necessary status information. Separate timing signals are generated for each line from a common crystal oscillator, permitting the speed of operation of each line to be controlled individually by the program. A 64-character first-in/first-out buffer is provided in the hardware (for each 8 lines) to hold characters as they are received. DZ11 models with EIA RS-232-C/CCITT V.24 interfaces include modem control, permitting the program to sense the state of two control lines and to control the state of one modem control line for each channel.
Local
Applications needing a few terminals benefit from the small size and 8-line modularity of the DZ11, while applications needing more terminals on a single system can use multiple DZ11s. Up to 128 asynchronous lines can be connected to a PDP-11/VAX-11/780 system, with the number in a particular case determined by the system software, hardware configuration, and application. The DZ11 can also be used in applications requiring asynchronous links between computer systems. Local operation to terminals or computers is possible at speeds up to 9600 bits per second. The higher speeds will enhance the responsiveness of CRT terminals. Local operation can use either EIA RS-232-C/CCITT V.24 interfaces or 20mA current loop signaling, depending on the DZ11 model selected. Local operation using EIA/CCITT interfaces is particularly convenient, because it permits a single DZ11 to serve a mixture of local and remote devices.

Remote—Dial-up
Remote operation using the public switched telephone network is possible with DZ11 models offering EIA RS-232-C/CCITT V.24 interfaces. These DZ11 models contain sufficient modem control as a standard feature to permit dial-up (auto-answer) operation with modems capable of full-duplex operation (such as the Bell models 103 or 113 or equivalent). The speed of operation will be limited by the modem and communications line, typically to 300 bits per second (Bell 103 or 113). The standard DZ11 modem control does not support half-duplex dial-up operation or the secondary transmit and receive channels available with some modems (such as Bell model 202.)

Remote—Leased Lines
Remote operation over private lines is possible with DZ11 models offering EIA RS-232-C/CCITT V.24 interfaces. These models are suitable for full-duplex point-to-point operation or full-duplex multipoint operation as a control (master) station. In some applications, a DZ11 can also be used as a multipoint tributary (slave) station or in half-duplex point-to-point operation by connecting modems to the DZ11 with specially wired cables. The standard DZ11 modem control will not support half-duplex applications requiring secondary channels. Remote operation using the Bell model 202 modem can be supported for private-line operation with the above restrictions.

BASIC OPERATION
Receiver
The receiver section performs serial-to-parallel conversion of 5-, 6-, 7-
or 8-level codes. The duration of the stop element may be 1 or 1½ bit times for characters with 5 data bits and 1 or 2 bit times for characters with 6, 7, or 8 data bits. The receiver can check for even or odd character parity, or, alternatively, no parity checking may be performed. If parity is selected, the total character length is the sum of the start bit, plus the number of data bits selected, plus the parity bit, plus the number of stop bits selected. The data rate is program-selected from among 15 standard speeds. The above parameters are controlled separately for each channel by the program and are the same for that channel’s transmitter and receiver. They are controlled by writing into the line parameter register (LPR). The line parameter register is also used to selectively enable reception on each line. The DZ11 is initialized by setting the CLR bit in the control and status register (CSR) or by the INIT signal on the UNIBUS. Initialization resets all line parameters, clears the 64-character buffer, and disables all transmitters and receivers. Following initialization, the program must specify the desired character format and speed of operation and enable the receiver for each line on which it desires to receive data. It should also enable receiver interrupts, if desired (by using the CSR). It must set the Master Scan Enable (MSE) bit in the CSR so the DZ11 receiver and transmitter will function.

As each character is received, the start and stop bits are stripped off and the data bits are placed, together with the 3-bit number of the line it came from and the three bits of status information, in a 16-bit-wide by 64-word-deep first-in/first-out hardware buffer, called a silo. The character is stored at the time the center of the first stop bit of the character is sampled. Each complete character is loaded into the top of the silo and falls automatically toward the bottom of the silo, until it comes to rest against the bottom, or against the last previous character stored in the silo. The bottom of the silo is actually the receiver buffer register (RBUF) and is seen by the program as a device register on the UNIBUS.

Silo Status Bits
In addition to the character and line number, a silo entry (and hence RBUF entry) contains several status bits.

The Parity Error bit will be set if parity is enabled and a character is received on the serial line with incorrect parity. If parity is enabled, the DZ11 receiver will strip off and check the incoming parity bit, placing only the data portion of the character in the silo entry.

The Framing Error bit will be set if the serial line is in the spacing state (0) at the time of the first stop bit. The Framing Error bit can be used to
detect break. Following a framing error, the serial line must return to
the mark state (1) for at least 1/16 bit time before the DZ11 receiver
will resume assembling characters.

The Overrun bit will be set if one or more characters for this line had to
be discarded because the silo was full. The UARTs are double charac-
ter buffered so this will occur only if the program fails to service the
silo for an extended period of time or falls behind in servicing the silo.
The character assembled in the entry with the Overrun bit set was
received correctly. One or more previous characters were discarded.

The RBUF has one additional status bit, Data Valid. This bit indicates
that a character is in the RBUF. The bit will be clear when the silo is
empty or if characters are propagating down the silo but no character
is available at the bottom. The program must ignore the contents of
bits 0-14 of RBUF if Data Valid (bit 15) is not set. The status of these
bits is undefined unless Data Valid is set. For example, initializing the
DZ11 will clear the Data Valid bit but not the other bits of RBUF.

Interrupt Conditions
The Receiver Interrupt Enable (RIE) and Silo Alarm Enable (SAE) bits
in the CSR control the circumstances upon which the DZ11 receiver
interrupts the processor.

Transmitter
The transmitter section performs parallel-to-serial conversion of data
supplied by the program. The line parameter register (LPR) enables
the program to specify speed, character size, stop code and parity on
a per-line basis. The speed and character format for any given line are
the same for the receiver and transmitter.

The transmitter for each line is double character buffered. The pro-
gram has a full character time to respond to the Transmit Ready
(TRDY) flag from any line and still transmit data on that line at the
maximum character rate.

The program controls the DZ11 transmitter through five registers on
the UNIBUS: the control and status register (CSR) previously men-
tioned, the line parameter register (LPR) previously mentioned, the
transmitter control register (TCR), the transmitter buffer (TBUF) and
the break register (BRK). Following DZ11 initialization, the program
must use the LPR to specify the speed and character format for each
line to be used and must set the Master Scan Enable (MSE) bit in the
CSR. The program should set the Transmitter Interrupt Enable (TIE)
bit in the CSR if it wants the DZ11 transmitter to operate on a program
interrupt basis. If enabled, the DZ11 will interrupt the processor and
Asynchronous Multiline Interfaces

DZ11

vector to the transmitter interrupt address when the Transmitter Ready (TRDY) bit in the CSR is set, indicating that the DZ11 is ready to accept a character to be transmitted.

The Transmitter Control Register (TCR) is used to enable and disable transmission on each line. One bit in this 8-bit register is associated with each line. The program can set and clear bits in this register by using MOV, MOVB, BIS, BISB, BIC and BICB instructions. (If word instructions are used, the TCR and DTR registers will be accessed simultaneously.)

The DZ11 transmitter is controlled by a scanner which is constantly looking for an enabled line (TCR bit set) which has an empty UART transmitter buffer. When the scanner finds such a line, it loads the number of the line into the 3-bit Transmit Line Number (TLINE) field of the CSR and sets the TRDY bit, interrupting the processor if the TIE bit is set. The program can clear the TRDY bit by moving a character for the indicated line into the TBUF or by clearing the TCR bit for the line. Clearing the TRDY bit frees the scanner to resume its search for lines needing services.

To terminate transmission on a line, the program should load the last character normally and wait for the scanner to request an additional character for the time. The program clears the TCR bit at this time instead of loading the TBUF.

MODEM CONTROL

DZ11 models with EIA/CCITT interfaces include modem control as a standard feature. The program may sense the state of the carrier and ring indicator signals from each modem and may control the state of the Data Terminal Ready signal to each modem. These signals enable the DZ11 to interface to full-duplex modems used for switched network operation, such as the Bell models 103 and 113, or equivalent.

Modem Control Registers

The program uses three 8-bit registers to access the DZ11 modem control logic. One bit in each register is associated with each of the 8 lines. There are no hardware interlocks between the modem control logic and the receiver and transmitter logic. Any required coordination should be done under program control.

The data terminal ready (DTR) register is a read/write register. Setting or clearing a bit in this register will return the appropriate Data Terminal Ready signal on or off. The program may access this register with word or byte instructions. (If word instructions are used, the DTR and
TCR registers will be accessed simultaneously.) The DTR register is cleared by the INIT signal on the UNIBUS but is not cleared if the program clears the DZ11 by setting the CLR bit of the CSR.

The carrier register (CAR) and ring register (RING) are read-only registers. The program can determine the current state of the carrier signal for a line by examining the appropriate bit of the CAR register. It can determine the current state of the ring signal by examining the appropriate bit of the RING register. The program can examine these registers separately by using MOV B or BIT B instructions or can examine them as a single 16-bit register by using MOV or BIT instructions. The DZ11 modem control logic does not interrupt the processor when a carrier or ring signal changes state. The program should periodically sample these registers to determine the current status. Sampling at a high rate is not necessary.

ELECTRICAL INTERFACE
The distribution panel supplied with the DZ11-A and DZ11-E includes 16 cinch DB25P plugs for connection to modems or local terminals. For connection to modems, an extension cable is required with a DB25S socket at one end and a DB25P plug at the other. The DB25S socket connects to the DB25P plug on the DZ11 distribution panel and the DB25P plug connects to the modem. The BC05D-25 is such a cable and is 25 feet long. The maximum cable length between the DZ11 and a modem must not exceed 50 feet to ensure that operation conforms to the EIA RS-232-C/CCITT V.24 interface specifications.

Local Terminals
The distribution panel supplied with the DZ11-A and DZ11-E includes 16 cinch DB25P plugs for connection to modems or local terminals. For connection to modems, an extension cable is required with a DB25S socket at one end and a DB25P plug at the other. The DB25S sockets connect to the DB25P plugs on the DZ11 distribution panel and the terminal. The BC03M null-modem cable is such a cable and is available in lengths from 25 to 1000 feet. An alternate wiring approach is to use a BC05D extension cable together with an H312-A null modem.

Operation Over Long Cables
Operation beyond 50 feet does not conform to the EIA RS-232-C or CCITT V.24 specifications. However, operation will often be possible at long distances depending on the terminal equipment, type of cable, speed of operation and electrical environment. Reliable communication over long cables depends on the absence of excessive electrical
noise. For these reasons, DIGITAL can not guarantee error-free communication beyond 50 feet. However, the EIA/CCITT versions of the DZ11 may be connected to local DIGITAL terminals (and most other terminals) at distances beyond 50 feet with satisfactory results if the terminal and computer are located in the same building, in a modern office environment. Shielded twisted pair cable (Belden 8777 or equivalent) is recommended and is used in the BC03M cable.

20mA Line Interface
The distribution panel supplied with the DZ11-C and DZ11-F includes 16 four-screw terminal strips for connection to local terminals having a 20mA interface. Two types of cable are often used to connect 20mA terminals to a DZ11, quad station wire #22 AWG (DEC Part Number 91-5856-04) and 3-shielded twisted pair cable (Belden 8777, DEC Part Number 91-07723). The cables can connect directly to the DZ11 screw terminals. A pair of Mate-N-Lok connectors (Order Numbers 959-A and 959-B) may be inserted at convenient points in the cable for quick connection and disconnection.

The DZ11 transmitter and receiver have an active interface for connection to devices such as terminals which have a passive transmitter and receiver. An active interface supplies current to the loop and must be connected to a passive interface. For example, the DZ11 can be connected directly to computer interfaces such as the DL11-WA which can be strapped for passive operation. To connect a DZ11 to an interface not capable of passive operation, such as another DZ11, a pair of H319 20mA receivers should be used to convert from active to passive.

MAINTENANCE FEATURES
The DZ11 has a number of features that ensure reliable operation and easy maintenance. The DZ11 circuitry makes extensive use of large scale integration (LSI), minimizing the number of components and reducing the likelihood of failure. Data rate and format parameters are program-controlled, reducing the number of switches on the module, thereby speeding installation and reducing the chance of an incorrect switch setting. A single module contains the complete logic for 8 lines, permitting fault isolation to the module level on the basis of function.

The Maintenance (MAINT) bit of the CSR (control and status register) permits a diagnostic program to loop back each transmitter to the associated receiver. This feature enables the program to diagnose 90% of the DZ11 logic without changing any cables. The BRK register does not function while the MAINT bit is set.
Two special test connectors are supplied with the EIA/CCITT models of the DZ11 and are used to check out the remaining portions of the DZ11. An 8-line turnaround connector (H327) can be connected to the DZ11 logic module in place of the ribbon cable to the distribution panel. This connector loops back lines in pairs (0 to 1, 2 to 3, 4 to 5, 6 to 7) and permits a complete check of DZ11 logic. A single-line turnaround connector with DB24S socket (H325) can be connected to the distribution panel or the modem end of a BC05D cable and permits a complete check of the distribution panel and associated cabling.

**PROGRAMMING**

**General**
The DZ11 is controlled through nine device registers. In some cases, two registers share the same UNIBUS address, with register selection determined by whether the program is writing data to the DZ11 (DATAO UNIBUS cycle) or reading data from the DZ11 (DATAI UNIBUS cycle). Some of the registers are 8 bits wide, others are 16 bits wide. The 16-line models of the DZ11 have a separate set of device registers for each 8 lines.

The DZ11 uses 8 bytes of floating address space. The relative position of the DZ11 within the floating address system is number eight, directly following DMC11.

The registers are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Address Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control and Status Register (CSR)</td>
<td>76XXX0</td>
<td>word read/write</td>
</tr>
<tr>
<td>Line Parameter Register (LPR)</td>
<td>76XXX2</td>
<td>word write-only</td>
</tr>
<tr>
<td>Receiver Buffer Register (RBUF)</td>
<td>76XXX2</td>
<td>word read-only</td>
</tr>
<tr>
<td>Transmitter Control Register (TCR)</td>
<td>76XXX4</td>
<td>byte read/write</td>
</tr>
<tr>
<td>Data Terminal Ready Register (DTR)</td>
<td>76XXX5</td>
<td>byte read/write</td>
</tr>
<tr>
<td>Transmitter Buffer (TBUF)</td>
<td>76XXX6</td>
<td>byte write-only</td>
</tr>
<tr>
<td>Break Register (BRK)</td>
<td>76XXX7</td>
<td>byte write-only</td>
</tr>
<tr>
<td>Ring Register (RING)</td>
<td>76XXX6</td>
<td>byte read-only</td>
</tr>
<tr>
<td>Carrier Register (CAR)</td>
<td>76XXX7</td>
<td>byte read-only</td>
</tr>
</tbody>
</table>

**Vector Assignment**
The DZ11 uses two interrupt vectors: XX0 for the receiver section and XX4 for the transmitter section. If both interrupts occur simultaneously, the receiver has priority (is closer to the processor on the UNIBUS). The interrupt priority for both vectors is controlled by one standard priority connector. The priority can be changed by sub-
Asynchronous Multiline Interfaces

DZ11

stituting the appropriate connector. DZ11s will be shipped with a priority 5 connector.

MODELS AVAILABLE
DZ11 models are available with EIA/CCITT or current loop interfaces in 8- or 16-line configurations. An 8-line configuration consists of a single Hex-sized printed circuit board module and a 5¼" high cable distribution panel. The printed circuit board module plugs into any Hex-sized small peripheral controller (SPC) slot in processor back planes or expansion system units. The cable distribution panel contains connectors terminating 16 lines. Cables from the panel to modems or local devices must be ordered separately.

A 16-line DZ11 configuration consists of two printed circuit board modules connected by two 15-foot ribbon cables to a single distribution panel. The two Hex SPC slots required do not have to be adjacent. A 16-line DZ11 configuration appears to the programmer as two 8-line multiplexers. A 16-line configuration saves cabinet space and cost. It is possible to field-expand an 8-line configuration to 16-line by adding an additional interface module and ribbon cable.

The DZ11-A is an 8-line configuration with EIA RS-232-C/CCITT V.24 interface. It can be expanded to 16 lines (all EIA/CCITT) by adding a DZ11-B. The DZ11-E is a 16-line EIA/CCITT configuration. The distribution panel supplied with EIA/CCITT configurations has 16 cinch DB25P connectors for connection to modems or local devices.

The DZ11-C is an 8-line configuration with 20mA current loop interfaces. It can be expanded to 16 lines (all 20mA) by adding a DZ11-D. The DZ11-F is a 16-line 20mA configuration. The distribution panel supplied with 20mA configurations has 16 four-screw terminal strips for connection to local devices.

SPECIFICATIONS
Function: The DZ11 provides an interface between the UNIBUS and 8 or 16 asynchronous bit serial communications channels, depending on the model:

DZ11-A, DZ11-B, DZ11-C, DZ11-D
DZ11-E, DZ11-F

8 channels 16 channels

Operating Mode: Full-duplex.
Asynchronous Multiline Interfaces

Data Format: Asynchronous, serial by bit. One start and 1, 1½ (5-level codes only), or 2 stop bits supplied by the hardware. The DZ11 will accommodate characters of 5, 6, 7 or 8 bits with or without even or odd parity. The data format is the same for transmitted and received data on any line. The data format is program controlled separately for each line.

Order of Bit Transmission and Reception: Low order bit first.

Data Rate: Program-controlled on an individual line basis with the following speeds available: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200 and 9600 bits per second. The receiver and transmitter of a given line operate at the same speed. Timing is provided by a crystal oscillator accurate to ±.01%. However, the nominal speed at 134.5 bits per second is 0.016% fast; at 2000 bits per second, 0.253% fast.

Distortion: The DZ11 receiver operates properly in the presence of 40% (38% at 2000 bits per second) space-to-mark or mark-to-space distortion between any two received bits and with up to ±4.5% (4.3% at 2000 bits per second) long-term speed distortion provided the data format contains at least 1.5 stop units. If the data format contains only one stop unit, the speed tolerance is ±4% (3.8% at 2000 bits per second). The DZ11 transmitter operates with less than 3% bit-to-bit distortion.

DZ11-E, DZ11-F: two UNIBUS loads.
Mounting Space:

DZ11-A, DZ11-C: one Hex-sized SPC slot in a DD11 backplane or processor backplane plus one small panel (5¼") space in a cabinet.

DZ11-B, DZ11-D: one Hex-sized SPC slot.

DZ11-E, DZ11-F: two Hex-sized SPC slots (not necessarily adjacent) plus one small panel space.

Standard Interface:

DZ11-A, DZ11-B, DZ11-E:

These models provide a voltage level interface whose levels and connector pinnings conform to EIA Standard RS-232-C and CCITT recommendation V.24. The leads supported are:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Protective Ground</th>
<th>Signal Ground Transmitted Data</th>
<th>Received Data</th>
<th>Data Terminal Ready</th>
<th>Ring Indicator</th>
<th>Carrier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 AA</td>
<td>7 AB</td>
<td>2 BA</td>
<td>103</td>
<td>22 CE</td>
<td>8 CF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Circuit Pin**

<table>
<thead>
<tr>
<th>EIA RS-232-C</th>
<th>CCITT V.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>103</td>
<td>104</td>
</tr>
<tr>
<td>108.2</td>
<td>125</td>
</tr>
<tr>
<td>109</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:**

Signal Ground and Protective Ground are connected together at the distribution panel.

**NOTE:**

Request to Send, pin 4, circuit CA, CCITT 105, is connected to Data Terminal Ready through a removable jumper on the distribution panel.
Asynchronous Multiline Interfaces

DZ11

DZ11-C, DZ11-D, DZ11-F:
These models provide a 20mA current loop interface terminated by four-screw terminal blocks. The transmitter has an active interface and is balanced. The receiver has an active interface which is pseudo-differential for improved noise immunity. The maximum permissible loop resistance is:

Transmitter: 560 ohms
Receiver: 750 ohms

Power Requirements (amps):

<table>
<thead>
<tr>
<th></th>
<th>+5V</th>
<th>-15V</th>
<th>+15V</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ11-A</td>
<td>2.5</td>
<td>.15</td>
<td>.13</td>
</tr>
<tr>
<td>DZ11-B</td>
<td>3.0</td>
<td>.3</td>
<td>.13</td>
</tr>
<tr>
<td>DZ11-C</td>
<td>5.0</td>
<td>.3</td>
<td>.26</td>
</tr>
<tr>
<td>DZ11-D</td>
<td>6.0</td>
<td>.6</td>
<td>.26</td>
</tr>
</tbody>
</table>

Heat Dissipation:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ11-A</td>
<td>57 BTU/hr.</td>
</tr>
<tr>
<td>DZ11-B</td>
<td>74 BTU/hr.</td>
</tr>
<tr>
<td>DZ11-C</td>
<td>114 BTU/hr.</td>
</tr>
<tr>
<td>DZ11-D</td>
<td>148 BTU/hr.</td>
</tr>
</tbody>
</table>

Environment

Operating Temperature: +5° to +50°

Humidity: 10% to 95%

Reference: DEC STD 102—Class C device

ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Option</th>
<th>Prerequisite</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZ11-A</td>
<td>PDP-11/VAX-11/780</td>
<td>8-Line Async Mux EIA/CCITT</td>
</tr>
<tr>
<td>DZ11-B</td>
<td>DZ11-A</td>
<td>8-Line Expander EIA/CCITT</td>
</tr>
<tr>
<td>DZ11-C</td>
<td>PDP-11/VAX-11/780</td>
<td>8-Line Async Mux (20mA)</td>
</tr>
<tr>
<td>DZ11-D</td>
<td>DZ11-C</td>
<td>8-Line Expander (20mA)</td>
</tr>
<tr>
<td>DZ11-E</td>
<td>PDP-11/VAX-11/780</td>
<td>16-Line Async Mux EIA/CCITT</td>
</tr>
<tr>
<td>DZ11-F</td>
<td>PDP-11/VAX-11/780</td>
<td>16-Line Async Mux (20mA)</td>
</tr>
<tr>
<td>Related Options</td>
<td>Option No.</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>BC05D-25</strong></td>
<td>Modem cable (25 ft.) 25-conductor cable terminated in cinch DB25S socket at one end and DB25P plug at the other end for connection of one line from DZ11-A or DZ11-E distribution panel to modem, or null modem, listed below.</td>
<td></td>
</tr>
<tr>
<td><strong>BC03M-XX</strong></td>
<td>Null modem cable 3-shielded twisted pair cable terminated in cinch DB25S sockets at each end for connecting local terminals with EIA/CCITT interfaces to the DZ11-A or DZ11-E distribution panel. This cable is supplied in standard lengths of 25 feet (BC03M-25), 100 feet (BC03M-A0), 250 feet (BC03M-B5), 500 feet (BC03m-E0), and 1000 feet (BC03M-L0).</td>
<td></td>
</tr>
<tr>
<td><strong>H312-B</strong></td>
<td>Null modem for connecting local terminals with EIA/CCITT interfaces to DZ11-A and DZ11-E distribution panels when BC05D modems cables are used.</td>
<td></td>
</tr>
<tr>
<td><strong>H319</strong></td>
<td>20mA current loop receiver. Converts a 20mA active interface into a 20mA passive interface. A pair of H319s should be used when connecting one line of a 20mA DZ11 to one line of another DZ11 or to another 20mA interface with active transmitter and receiver.</td>
<td></td>
</tr>
</tbody>
</table>
Asynchronous Multiline Interfaces

DZ11

NOTE
See Communications Programming Card for register information.
OVERRIDE/COMM IOP-DZ
The COMM IOP-DZ is an intelligent, asynchronous Direct Memory Access (DMA) line controller. It is based on the KMC11-A auxiliary processor, which controls the DZ11 asynchronous multiplexer over the PDP-11 UNIBUS. This arrangement of KMC11-A and DZ11 provides an asynchronous interface with DMA capability for input and output, which relieves the CPU of the time-consuming tasks associated with handling asynchronous communication lines and terminals. It is particularly suitable for high-performance terminal applications in an inquiry/response environment.
Asynchronous Multiline Interfaces

FEATURES

Uses the KMC11-A general purpose, high-speed auxiliary processor for intelligent DMA capability.

Line characteristics can be changed dynamically on a line-by-line basis without affecting any other line.

BENEFITS

Includes simplified software interface for easy customer programming.

Off-loads from the CPU time-consuming tasks which are normally associated with handling multiple asynchronous lines.

Provides high degree of flexibility and redundancy with use of KMC11-A auxiliary processor.

Allows diverse mix of terminals or communications lines to be handled.

Capable of message handling under DDCMP, SDLC, ADCCP, HDLC, BDL, X.25, and SNAP protocols.

Represents low-cost upgrade for existing DZ11 users.

PRODUCT PROFILE

General Description

The COMM IOP-DZ is an intelligent, asynchronous DMA line controller for use on PDP-11 computer systems. It comprises a KMC11-A auxiliary processor and multiple DZ11 asynchronous multiplexers. The KMC11-A runs the COMM IOP-DZ microprogram, which controls up to six 8-line DZ11s via the UNIBUS. Therefore, up to 48 asynchronous communication lines can be handled in full-duplex or echoplex mode at data rates up to 9600 bits per second. These lines can be either EIA/CCITT or 20mA, or a mix of both. The actual interface configuration is a function of the DZ11 only and is not affected by the KMC11 or the COMM IOP microprogram. COMM IOP-DZ is designed to implement high-performance terminal and communications network systems which can provide a small, low-cost, but extremely powerful front-end capability.

COMM IOP-DZ can provide low-cost and efficient application terminal support in such areas as transaction processing systems, reservation systems, and credit validation systems. In addition, COMM IOP-DZ is
ideal for local and remote command terminal operations under the various DIGITAL operating systems.

Since there is no direct electrical connection between the KMC11-A and the DZ11, the COMM IOP-DZ system is very easy to configure. Furthermore, because the KMC11-A can be reloaded, it is possible to have a number of these devices on a system for redundancy where high reliability is a goal. In the event of failure, the operating system can reload another KMC11 for continued operation.

Software interfacing to the COMM IOP-DZ is straightforward and simple. Communication between the CPU-resident driver and COMM IOP-DZ is accomplished by a series of commands and responses. Commands are initiated by the PDP-11, and responses by the COMM IOP-DZ. Therefore, users need not be concerned with the details of the KMC11-A microcode operation.

The KMC11-A is loaded with the COMM IOP-DZ microprogram via the UNIBUS by a dedicated resident loader operating in the main PDP-11 CPU. This loader transfers an image of the COMM IOP-DZ microprogram from the system's mass storage media to the KMC11-A control memory at system start-up time. Operation of the COMM IOP-DZ microprogram is initiated and directed from a software driver in the PDP-11 CPU. This driver can be either user-written, or part of a DIGITAL-supplied operating system. The microprogram operates each DZ11 with interrupts disabled. It periodically scans the status register to determine whether the device is ready to accept a character for transmission or has assembled a received character. This procedure substantially reduces the interrupt overhead associated with this type of device and allows overall I/O throughput to be increased. All data transfers are therefore under the total control of the KMC11-A without the involvement of the PDP-11 CPU. The scanning rate can be varied using the interval timer on the KMC11-A; this avoids monopolizing the UNIBUS.

SYSTEM OPERATION
This interface between the PDP-11 and COMM IOP-DZ has been designed to provide a very simple structure which considerably reduces the complexity of the associated operating system driver or handler. Communication between the device driver and a COMM IOP-DZ is provided by four UNIBUS device registers that are integral to the KMC11-A auxiliary processor. These four 16-bit registers are used for control input, status output, and data input and output. Since COMM IOP-DZ is basically an input-output device, the command set for this
COMM IOP-DZ

device can be categorized as input commands and output commands. Input commands allow the driver to initialize and set up the parameters associated with each communication line. Output commands allow COMM IOP-DZ to convey information pertinent to the normal completion of data transfers, or forced completion of data transfers due to detection of an error condition.

Commands to COMM IOP-DZ are issued from the driver by storing the command in the four control and status registers (CSRs). The commands are then interpreted by the COMM IOP-DZ. Similarly, commands are issued from the COMM IOP to the driver by storing the command in the CSRs and posting a completion to the driver. The driver has the option of selectively operating either in the non-character processing (binary) mode or character processing mode on each communication line under control of COMM IOP-DZ.

Driver-defined buffer descriptor lists identify buffers for each communication line; this allows memory buffers to be chained. A list consists of 3-word entries, where each entry identifies an I/O buffer. Lists can be any arbitrary length, and the driver can assign up to two buffer descriptor lists to each COMM IOP-DZ controlled terminal line. In addition to the buffer descriptor list, COMM IOP-DZ also uses 128-byte functional mode control tables defined by the driver in main memory space. These tables enable the driver to control how the COMM IOP-DZ processes any given input character. As many as eight functional mode control tables can be assigned to a given line, enabling the COMM IOP-DZ to recognize and process multiple-character sequences. Tables can be shared by multiple lines. Each entry in a table corresponds to a unique character in the ASCII character set. The purpose of the functional mode control tables is to provide COMM IOP-DZ character detection capability to determine how a given received character is to be processed. COMM IOP-DZ accesses these tables by Direct Memory Access (DMA) control. To permit sequential accessing, the functional mode control tables must occupy contiguous addresses in main CPU memory. Since these tables are never written into COMM IOP-DZ, they can be shared by multiple lines.

SYSTEM APPLICATIONS
COMM IOP-DZ is designed to implement high-performance terminal and communication network systems for the user who does not have a sufficient number of lines to justify the additional cost of a large-scale front-end. In effect, COMM IOP-DZ is a small, low-cost, but extremely powerful front-end. COMM IOP-DZ can provide low-cost and efficient application terminal support in such areas as transaction processing
COMM IOP-DZ

systems, data base management systems, inquiry/response systems, reservation systems, and credit validation systems. In addition, COMM IOP-DZ is ideal for implementing local and remote command terminal operation under the various Digital Equipment Corporation operating systems, including RSX-11D, IAS, and RSTS-E.

Terminal Support
A COMM IOP-DZ operating in an application terminal support capacity can employ up to six DZ11 interfaces, which function as asynchronous multiplexers capable of handling up to 48 terminals connected by either EIA RS-232-C/CCITT V.24 or 20mA lines. The data transfer rate for each terminal can be programmed in the range 50 to 9600 bits per second. The COMM IOP-DZ microprogram can support the following functions, which in more conventional systems are provided by a terminal driver:
1. Metacharacter detection
2. Character echoing
3. Character deletion
4. Transmit on and off (XON, XOFF) recognition
5. Escape sequence detection
6. Buffer chaining

COMM IOP-DZ supports the following terminals on a multiple-buffered basis operating either in half- or full-duplex mode:
1. LA35/36 DECwriter II
2. ASR/KSR33, 35 Teletype units
3. VT50/52 Alphanumeric terminals
4. VT61/62 Alphanumeric terminals
5. VT05 Alphanumeric terminal
6. VT100

These terminals are logically and electrically compatible with COMM IOP-DZ, and they can be implemented as application or command terminals. The use of terminals other than those listed is not precluded but could require user-installed modifications of the software and/or hardware interfaces.

ASSOCIATED SOFTWARE
The COMM IOP-DZ microprogram is supplied as an image file on the following media: 9-track magnetic tape, RK04 disk, RK06 disk, and floppy disk. It is loaded into the KMC11-A control Random Access Memory (RAM) by a utility loader which is supplied as part of the
COMM IOP-DZ

COMM IOP-DZ microcode package and runs as a privileged task under RSX-11M, RSX-11D, and IAS.

The KMC11-A loading can be implemented in one of two ways. The utility loader can be run as a task by the pertinent operating system, or the required portions of the utility loader can be incorporated in a user program. The COMM IOP-DZ is available in both binary and source versions.

ORDERING INFORMATION

COMM IOP-DZ:
The following key (D, E, R, T, Y, Z) represents the distribution media for the product and must be specified at the end of the “Q” number, e.g., QJ733-CD = binaries on 9-track magnetic tape.

D = 9-track Magnetic Tape
E = RK05 Disk
R = Microfiche
T = RK06 Disk
Y = Floppy Disk
Z = No software dependency

QJ733-C_- Single-use license, binaries, documentation, no support services Media D, E; Y, T
QJ733-DZ Single-use license only
QJ733-M_- All sources, plus listings on microfiche Media D, E, Y, T
QJ733-FR Microfiche listing
Asynchronous Multiline Interfaces

COMM IOP-DZ

Comm IOP-DZ COMPRISÉS
- KMC11-A
- DZ11-A/B/E
- QJ733 MICROCODE

KMC11-A CONTROLS UP TO 48 LINES OR 6 DZ11s

H317-E

16-LINE DISTRIBUTION PANEL

Comm IOP-DZ
48-LINE ASYNCHRONOUS DMA CONTROLLER

NOTE
See Communications Programming Card for register information.
OVERVIEW/DH11
The DH11 asynchronous multiplexer connects the PDP-11 with 16 serial communications lines operating with individually programmable parameters.

The DH11 multiplexer uses 16 double-buffered receivers to assemble the incoming characters. An automatic scanner takes each received character and the line number and deposits that information in a first-in/first-out buffer memory referred to as the silo. The bottom of the silo is a register which is addressable from the UNIBUS.

The transmitter in the DH11 also uses double-buffered units. They are loaded directly from message tables in the PDP-11 memory by means of single cycle direct memory transfers.
Asynchronous Multiline Interfaces

**FEATURES**

Program-selectable speeds up to 9600 bits per second.

Complete control of each line for: data rate, character size, stop code length, transmission mode.

Program-controlled hardware echo of received characters.

64-character hardware buffer for received characters.

Direct Memory Access for data transfer.

Split-speed transmitter and receiver on each line.

Hardware break detection and program-controlled break generation.

**BENEFITS**

Enables the user to attain higher speeds on private or leased lines.

Offers flexibility to handle wide range of terminal or communication lines.

Relieves program of echo function.

Prevents data overrun and subsequent loss of valuable data.

Offers high data throughput and increased flexibility.

More efficient use of communications facilities, and less software demand for receiver.

Enables terminal operator to terminate output or raise attention on half-duplex circuits.

**PRODUCT PROFILE**

**General Description**

The DH11-AA consists of a double system unit, all modules necessary to implement a 16-line asynchronous multiplexer, an externally mounted 14 cm (5 ¼ inch) level conversion and distribution panel with its own power supply that can be mounted on the rear of the rack, and a data cable between the logic in the double system unit and the level-conversion/distribution panel.

The modules for level conversion are not included, so that the type and quantity of lines may be chosen by the customer.

The DH11-AC is the same as the DH11-AA, except that the power supply for the level-conversion/distribution panel is arranged for 240 V, 50 Hz operation.

All of the above versions of the DH11 include pre-wired slots in the double system unit for the insertion of the DM11-BB modem control (not included in the basic DH11).

The DH11-AD consists of a double system unit, all modules necessary to implement a 16-line asynchronous multiplexer, including modem
control (programming is same as DM11-BB programming), necessary level converters for EIA RS-232-C/CCITT V.24 interfacing and an externally mounted distribution panel. This is a self-contained unit for applications where line interfacing flexibility is not needed.

The DH11-EA is the same as the DH11-AD except it does not include modem control. Includes EIA/CCITT level conversion for data leads only.

Receiver
Reception on each line is effected by means of Universal Asynchronous Receiver/Transmitters (UARTs). These are circuits which perform all the necessary functions for double-buffered asynchronous character assembly.

The receiver section of the UART samples the line at 16 times the bit rate of the signals to be received on that line. Upon detection of a mark-to-space transition, the UART counts 8 clock pulses and checks the line. This sampling will occur in the center of a normal start bit. If the sample is a mark, the receiver returns to its idling state, ready to detect another mark-to-space transition. If the sample is a space, the receiver samples the line at subsequent sample points spaced 16 clock ticks from the center of the start bit. The number of samples taken is determined by the character length information entered into the UART via the line parameter register. If parity checking has been enabled for this line, the receiver logic computes the parity of the character just received and compares it with the parity sense specified for reception on that line. If the parity sense differs, the parity error bit will be set.

The character length, parity sense, and number of stop bits that will be used by the UART to perform the above operations are stored within each UART in a control bits holding register. The control bits holding register is addressable on a write-only basis from the UNIBUS, by first setting the line selection bits of the system control register and then loading the desired line parameters into the line parameter register. They will then be transferred automatically to the control bits holding register of the designated UART. It is important that no interrupt handling routine intervene and change the contents of the system control register during the above operation.

Characters enter the DH11 and are stored in a buffer that is 16 bits wide and 64 words deep, called a silo. A 16-bit word is entered at the top, and automatically shifted down to the lowest location that does not already contain an entry. The bottom of the silo is the next received character register.
Asynchronous Multiline Interfaces

There are three registers associated with the silo. The next received character register is a read-once register and is the bottom of the silo. Reading it extracts a character from the silo and causes all other entries to shift down one more position.

The other two registers are byte-size registers and are contained within the silo status register. The high byte is read-only and contains the status of an up-down counter giving the actual fill level of the silo. The low byte (bits 7-0) is read/write, and contains the number of characters that must be loaded into the silo before an interrupt request will be generated.

Transmitter
Transmission on each line is also effected by means of UARTs. These devices perform all the necessary functions for double-buffered asynchronous character transmission. The transmitter section of the UART holds the serial output line to a marking state when idle. When the transmitter loading leads have been conditioned with the character to be transmitted and the data strobe lead has been brought high (these functions are performed by the Direct Memory Access (DMA) control), the UART will generate a start space within one sixteenth of a bit time. The start space and all subsequent data bits are a full bit time each. The start space is followed by 5, 6, 7, or 8 data bits, as determined by the control bits hold register. The data bits are presented to the lines least significant bit first. The parity bit, if parity generation is enabled, is calculated by the transmitter and affixed after the last data bit, but before the stop marks.

The number of stop bits depends upon the setting of the control word. If the transmission of 6, 7, or 8 bits has been selected, the program may select either one or two stop bits. If the transmission is in 5-bit code, the program may select either one or one and a half stop bits.

If the transmitter’s holding register has been loaded while a character was being transmitted, that second character will have its start bit commence immediately at the end of the preceding character’s stop bit(s).

The transmitter timing circuit is driven by the same clock as the receiver, and is accurate to .05%.

The Auto-Echo Feature
The DH11 hardware is capable of echoing received characters without software intervention. The feature may be enabled on any line by conditioning the line selection bits in the system control register and then setting the appropriate bits in the line parameter register.
The auto-echo hardware is part of the receiver scanner. It should be noted that it is not advisable to transmit messages on a line and auto-echo characters received on that line simultaneously. The auto-echo hardware will interlock these functions to some degree, but if more than two characters are received on a line while the scanner is waiting for the transmitter holding buffer to become available, a data overrun will occur and characters will be lost. In short, auto-echo and software-driven transmission should not be attempted on the same line simultaneously if input from that line is expected.

Modem Control Multiplexer DM11-BB

In cases where the DH11 is used on public switched networks, the modem control multiplexer DM11-BB should be used. The control multiplexer provides the necessary control leads to interface with the Bell 103 and 202 type modems or equivalent. All leads meet EIA RS-232-C and CCITT V.24 electrical specifications. The DM11-BB is not required with the DH11-AD and cannot be used with the DH11-AE.

Slots A6 through A21 are used for level conversion and slots B6 through B21 are used for cabling out. Other slots provide inputs or special purpose outputs. The unit mounts on the standard 48.3 cm (19 in.) cabinet and connects to the PDP-11 via the BC08-S data cable.

Power for the distribution panel is provided by the H751-C power supply mounted on the rear door of the cabinet.

The H751-C provides the following voltages:

+ 5 V at 4 A
+ 15 V at 2 A
- 15 V at 2 A
*LEVEL CONVERSION OF CONTROL LEADS, ONE SLOT PER LINE. USE M594 ONLY WHEN DM11-BB IS IMPLEMENTED.

IF DM11-DB IS USED REPLACE M594 WITH W404-A (SUPPLIED WITH DM11-DB). IF DM11-DA IS USED LEAVE BLANK.

**USE M594 FOR DM11-DB

***USE M596 FOR DM11-DA

*USE ONLY IF DM11-BB IS IMPLEMENTED

**DATA CABLE FROM DM11-AA CONTROL LOGIC

▲CABLE SLOTS ONE PER LINE FOR DM11-DA USE M973, FOR DM11-DB USE BC01R-25

▲▲JUMPER CARD USED FOR DIAGNOSTIC PROGRAMS ONLY, REMOVE FOR NORMAL OPERATION.
Asynchronous Multiline Interfaces

Power drain of the distribution panel depends on the type of level conversion used. The maximum consumption occurs when EIA/CCITT levels are used with modem control (DM11-BB is implemented).

For this configuration the following power is used:

+15 V at 1.4 A
-15 V at 1.4 A
+5 V at 1.7 A

Note that level converter types can be mixed on a 4-line basis by using different converters in slots A4, A5, B4, and B5. Also, level converter types can be mixed on a single-line basis by using slots A6 through A21 for level conversion on a single-line basis.

PROGRAMMING

Zero Data Rate
A speed selection of zero is provided so that the program may turn off any line. This is useful if excessive circuit noise on an unused line causes annoying quantities of extraneous characters.

BREAK Signals
When the break control register has been conditioned to transmit a break signal on a particular line, DH11 logic immediately forces the output on that line to the space (0) condition. The duration of this signal may be timed as described below.

The generation of a transmitter interrupt occurs when the last character of a message is loaded into a UART transmitter from a message table in PDP-11 memory. At that time the program sets up a new message in memory and loads the appropriate current address and byte count so that the new message can begin when the old one is finished.

It is important to note that the former message is not finished when the transmitter interrupt is given. Rather, the use of the memory table is finished. In terms of the serial communications line, there are two more characters left. One of these characters is in the UART transmitter’s shift register; the other is in the UART transmitter’s holding register.

Therefore, sending a break signal requires loading two nulls and waiting for a transmitter interrupt before setting the appropriate bit in the break control register. In this way, generation of a break will not interrupt the transmission of any valid characters. In like manner, nulls
should be used to time the transmission of a break signal so that when the break condition is terminated, no valid characters will be produced from the UART shift and holding registers.

Interrupts
There are two kinds of receiver interrupts:

Receiver Interrupt (System Control Register, bit 7): This interrupt, when enabled, occurs whenever the number of entries in the silo exceeds the silo status alarm level. (The program can determine the actual silo fill at any time by examining the high byte of the silo status register.)

Storage Overflow Interrupt (System Control Register, bit 14): This interrupt, when enabled, occurs whenever the character storage silo is full and the DH11 hardware needs to store an additional character. This does not necessarily mean that data has been lost.

There are two kinds of transmitter interrupts; both are enabled by bit 13 of the system control register.

Transmitter Interrupt (System Control Register, bit 15): This interrupt, if enabled, occurs when one or more lines finish the transmission of a complete string of characters. Specifically, it occurs after the Direct Memory Access (DMA) cycle that loads the last character to be transmitted (and hence increments the byte count to zero).

Non-Existent Memory Interrupt (System Control Register, bit 19): This interrupt, when enabled, occurs whenever the DH11 addresses non-existent memory; specifically, this interrupt occurs if the DH11 enters the Direct Memory Access (DMA) cycle, places an address on the UNIBUS, and fails to receive a slave sync response for that request within 20 microseconds.

Address and Vector Assignment
The DH11 uses floating addresses and is located after DJ11s in the floating address space that begins at location 760 010. Because the DH11 has eight registers, it must be assigned an address that is a multiple of 20 (octal). All DH11s in a system should have consecutive addresses.

Example #1: A system with no DJ11s but two DH11s:

<table>
<thead>
<tr>
<th>Address</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>760 010</td>
<td>Cannot use for DH11s because not multiple of 20.</td>
</tr>
<tr>
<td>760 020</td>
<td>First DH11</td>
</tr>
<tr>
<td>760 040</td>
<td>Second DH11</td>
</tr>
<tr>
<td>760 060</td>
<td>DH11 Gap (Indicates that there are no more DH11s.)</td>
</tr>
</tbody>
</table>
Example #2: A system with one DJ11, two DH11s:
760 010    First DJ11
760 020    DJ11 Gap (Indicates that there are no more DJ11s.)
760 030    Cannot use for DH11s because not multiple of 20.
760 040    First DH11
760 060    Second DH11
760 100    DH11 Gap (Indicates that there are no more DH11s.)

The DH11 vectors (2) follow those of the DJ11 in the floating vector-space that starts at address 300. The vectors starting at 300 are used in the following order: DC11; DL11-WA/DL11-A; DL11-WB/DL11-B; DP11; DN11; DM11-BB; DR11-C; PA611 readers; PA611 punches; DT11; Dx11; DL11-C, D, E; DJ11; DH11.

The receiver vector is the lower number vector. The priorities of the receiver and transmitter interrupts are individually selectable by means of two standard PDP-11 priority jumper plugs. BR level 5 is standard.

**SPECIFICATIONS**

Function: The DH11 is a program-controlled interface between the PDP-11 UNIBUS and 16 asynchronous bit-serial communications channels. The DH11 receiver section provides conversion of binary serial asynchronous (start/stop) signals to parallel binary data, and temporary buffering of that data. The DH11 transmitter section provides retrieval of parallel binary data from PDP-11 memory and conversion of that data to binary serial asynchronous (start/stop) signals for transmission over data communications channels.

Operating Modes: Each individual channel may be set to operate in half- or full-duplex mode, under program control. In half-duplex, the receiver for a channel is disabled during transmission of a character on that channel.

Any individual channel may be set, under program control, to echo (retransmit) received characters automatically.

Individual receivers may be continuously disabled under program control.
Data Format: Asynchronous, serial-by-bit to/from the communications channel. Parallel-by-character to/from the UNIBUS. The serial data format is one start bit; 5, 6, 7, or 8 data bits; none or 1 parity bit (odd or even); and 1, 1½ (5-level codes only), or 2 stop bits per character. All data format parameters are individually program-selectable for each channel. The data format for the receiver and transmitter on a given channel, however, is the same.

A 1 in any bit of a character presented by the program to the DH11 for transmission will cause a marking (logical 1) condition to appear on the Transmitted Data lead during the corresponding bit interval. A 0 presented by the program will cause a spacing (logical 0) condition to appear. A marking condition on the Received Data lead during any data bit sampling interval will be presented to the program as a 1 in the next received character register, and a spacing condition will be presented as a 0.

Order of Bit Transmission and Reception: Low-order bit first.

Data Rates: The operating data rate of the receiver and transmitter on each channel is independently program-selectable from among the following 14 rates:

0, 50, 75, 110, 134.5, 150, 200, 300, 600, 1200, 1800, 2400, 4800, and 9600 bits per second. In addition, any two other speeds between 40 and 110 bits per second and between 312.5 and 9600 bits per second may be added as options, by ordering an M405 or M401 clock module at the proper frequency (desired bit rate × 16).
Distortion: The DH receiver will operate properly in the presence of up to 43% distortion between any two code elements (intersymbol distortion). The long-term (within any one character) speed variation of the received data may not exceed ± 4.3%, provided that the auto-echo feature is not used. If auto echo is used, the long-term (greater than one character time) speed variation of the received data may not exceed 0 to –4%. The DH11 receiver clock is accurate to within ± 0.05% of the nominal data rate. The DH11 transmitter will introduce less than 2% intersymbol distortion, with a long-term stability of ± 0.05%.

Physical Arrangement: The DH11-AA and DH11-AC comprise a prewired, double PDP-11 system unit and all logic cards necessary to implement a 16-line multiplexer. Also included is an externally mounted distribution panel, 14 cm by 48.3 cm (5½ in. × 19 in.), with separate power supply for individual channel termination. The DH11-AA and -AC system unit and distribution panel are prewired for plug-in installation of the DM11-BB 16-line modem control multiplexer.

Environmental Information: The DH11 will operate at temperatures between +5° and +45° C, and at relative humidity between 0% and 95%, noncondensing.

Bus Loading: Each DH11 presents 2 unit loads to the PDP-11 UNIBUS. The DM11-BB modem control multiplexer, if present, represents one additional unit load.

The DH11-AD is three loads and the DH11-AE is two loads.
Asynchronous Multiline Interfaces

Power Consumption: The DH11 logic draws 8.5 A of +5 VDC, and 240 mA of -15 VDC. If the DM11-BB modem control multiplexer is added, the total current drain is 11.2 A at +5 VDC. The DH11-AD and DH11-EA use 10.8 A at +5 V, 0.4 A at +15 V, and 0.65 A at -15 V.

Electrical Interface: Connection between the DH11 logic and the distribution panel is via a cable containing 16 input and 16 output data lines at Transistor-Transistor Logic levels (0, +5 VDC). The logic levels are: Mark (logical 1) = 0 V, Space (logical 0) = +3 V. Input leads from the distribution panel are equipped with pull-up resistors which clamp open input lines in a logical 0 (space) condition. However, logic in the DH11 receiver section prevents this from assembling continuous all-zero characters.

The electrical and physical interface to the external channels is provided by optional level conversion module sets (DM11-DA, -DB, -DC) that plug into the distribution panel. These options are described in the next section.

MODELS

Connection to Switched Network Modems

<table>
<thead>
<tr>
<th>DEC No.</th>
<th>PREREQUISITE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH11-AA</td>
<td>PDP-11</td>
<td>Programmable 16-line asynchronous serial line multiplexer and distribution panel, includes space for mounting up to four line adapters (16 line interfaces). Power requirement is 115 VAC, 60 Hz, 600 W.</td>
</tr>
<tr>
<td>DH11-AC</td>
<td>PDP-11</td>
<td>Same as DH11-AA except 230 V, 50 Hz, 600 W.</td>
</tr>
</tbody>
</table>
Asynchronous Multiline Interfaces

**DM11-BB**  **DH11-AA or DH11-AC**  16-line modem control multiplexer provides program operation of control leads for 103, 202 or equivalent modems. Mounting in DH11-AA or DH11-AC.

**DH11-DC**  **DM11-BB**  Line adapter which implements four EIA/CCITT-compatible lines equipped with modem control features. Includes 25-foot modem cables.

**DH11-AD**  **PDP-11**  Programmable 16-line asynchronous multiplexer and distribution panel with built-in conversion for EIA/CCITT compatible lines equipped with modem control features. (Cables are not included.)

**Private Line Modems (No Control) or Local EIA/CCITT Terminals**

**DH11-AA**  **PDP-11**  See above -AA

**DH11-AC**  **PDP-11**  See above -AC

**DM11-DB**  **DH11-AA or DH11-AC**  Line adapter which implements four EIA/CCITT lines (data only). Includes four 25-foot modem cables.

Note that the -DB can be used on a switched network system. This requires that the modem have Auto Answer strapped on. The modem will answer a call automatically. Not provided in this type of operation is the ability **not** to answer a call, the ability to initiate a disconnect by the computer, and the ability to sense an intermittent carrier.
### DH11

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DH11-AE</td>
<td>Programmable 16-line asynchronous serial line multiplexer and distribution panel with built-in level conversion for EIA/CCITT compatible lines (data only). (Cables are not included.)</td>
</tr>
</tbody>
</table>

#### Local Teletypes

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD11-AA</td>
<td>See above DH11-AA</td>
</tr>
<tr>
<td>DH11-AC</td>
<td>See above DH11-AC</td>
</tr>
<tr>
<td>DM11-DA</td>
<td>Line adapter for four 20mA Teletype lines.</td>
</tr>
</tbody>
</table>
Asynchronous Multiline Interfaces

DH11

16-Line Asynchronous Multiplexer

NOTE
See Communications Programming Card for register information.
OVERVIEW/DZV11

The DZV11 is an asynchronous multiplexer that interconnects the LSI-11 bus with up to four asynchronous serial data communications channels. It can be used with the LSI-11 in a variety of applications that include data concentration, real-time processing, and cluster controlling. The DZV11 provides an EIA RS-232-C/CCITT V.24 interface and sufficient modem control signals to permit dial-up (auto-answer) operation with modems using full-duplex operations such as Bell models 103, 113, 212, or equivalent. Remote operation on private wires or leased lines is also possible, for full-duplex point-to-point or full-duplex multipoint operation as control (master) station. The DZV11-B includes a BC11U cable assembly for interconnection to the communication devices.
<table>
<thead>
<tr>
<th>FEATURES</th>
<th>BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-line multiplexer.</td>
<td>Low-cost solution for connecting LSI-11 or PDP-11/03 to terminals or other computers.</td>
</tr>
<tr>
<td>Speeds up to 9600 bits per second.</td>
<td>Each line of the DZV11 may run at program-selectable speeds up to 9600 bits per second.</td>
</tr>
<tr>
<td>Programmable data rate and formats on per-line basis.</td>
<td>Flexibility to handle wide range of terminals and communication lines.</td>
</tr>
<tr>
<td>64-character hardware buffer for received characters.</td>
<td>Can handle up to 28 lines on an LSI-11 (depending on system software).</td>
</tr>
<tr>
<td>Modem control.</td>
<td>Full-duplex dial-up operation with Bell 103 or 113 modems or equivalent.</td>
</tr>
<tr>
<td>Compact single Quad four-line module.</td>
<td>Reduces system space requirements.</td>
</tr>
</tbody>
</table>

**PRODUCT PROFILE**

**General Description**
The DZV11-B interface consists of the M7057 module and a 4-line BC11U 25-foot interface cable, and two necessary test connectors (H329 and H325). The H329 connector permits a staggered loopback. The H325 connector is used with the BC11U cable to provide a single-link loopback.

Data from the LSI-11 is sent to the DZV11 transmit data register. There it is converted from parallel data to serial data and sent to the communication line via the EIA/CCITT transmitters.

Data coming in from the communication line is converted from serial to parallel and is stored in the receiver silo buffer. From there it is transferred via multiplexers to the LSI-11.

An interrupt service request is generated when a transmitter buffer is empty or when a character appears at the output of the receiver buffer register and the silo alarm is disabled. When it is enabled, sixteen entries are allowed in the receiver buffer before an interrupt request is made.
The transmitter control determines which of the four possible lines is to be used and controls the loading of the data.

The receiver control scans the receiver status and controls the loading and unloading of the silo.

The speed and format control generates clock signals for the Universal Asynchronous Receiver/Transmitters (UARTs). Under program control, it selects data rate, stop bit, parity bit, and character length parameters.

The break feature inhibits output data to create a break signal. The four lines operate independently under program control.

The maintenance mode data selector provides the capability of switching the data outputs and the data inputs. This is used to verify correct operation.

Receive
The DZV11 receives three modem signals for each of the four communication lines it interfaces: Carrier Detect, Ring Indicator, and Received Data, which are converted from EIA/CCITT levels to TTL levels. The carrier and ring signals go to the modem status register. The received data signals go to the RBUF (in the UARTs).

Transmit
The DZV11 can control up to three modem control signals for each of the four communication lines it interfaces. Control bits from the transmitter control register are converted from TTL levels to EIA/CCITT levels to drive modem control lines. For each line there is a single control bit that is always connected to Data Terminal Ready. In addition, these signals may be jumpered to control Request To Send also. If this is done, they may then be further jumpered to control Forced Busy (for Bell model 103E and 113B modems with the forced burst option).

Data to be transmitted from the LSI-11 to the lines moves from the transmitter data buffer to the EIA/CCITT transmitters, where it is converted from TTL levels to EIA/CCITT levels and placed on the lines.

Maintenance Mode
The DZV11 can be switched to receive the data that it is transmitting. The four serial data lines leaving the UARTs are applied to both a data selector and the EIA/CCITT transmitters. The data selector controls the inputs to the UART receivers. During normal operation, data from
the EIA receivers is routed through the data selector to the UART receivers. In the maintenance mode the data selector ignores the inputs from the EIA/CCITT receivers. Instead, it routes the output data to the UART receivers. This internal "wraparound" feature is enabled by setting the Maintenance bit in the CSR. Setting CSR bit 3 asserts MAINTENANCE H, which switches the data selector.

**SPECIFICATIONS**

**Function:** The Quad-sized DZV11 provides an interface between the LSI-11 or PDP-11/03 and four asynchronous bit-serial communications channels.

**Operating Mode:** Full-duplex.

**Data Format:** Asynchronous, serial by bit. One start and 1, 1½ (5-level codes only), or 2 stop bits supplied by the hardware. The DZV11 will accommodate characters of 5, 6, 7, or 8 bits with or without even or odd parity. The data format is the same for transmitted and received data on any line. The data format is under program control separately for each line.

The transmitted data lead may be held in the zero state under program control.

**Order of Bit Transmission and Reception:** Low-order bit first.

**Data Rate:** Program-controlled on an individual line basis with the following speeds available: 50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 3600, 4800, 7200, and 9600 bits per second.

**Bus Loading:** One DC load and 4.1 AC loads

**Standard Interface:** EIA RS-232-C/CCITT V.24 Standard
The leads supported are:

<table>
<thead>
<tr>
<th>Circuit</th>
<th>EIA RS-232-C</th>
<th>CCITT V.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective Ground</td>
<td>1 AA</td>
<td>101</td>
</tr>
<tr>
<td>Signal Ground</td>
<td>7 AB</td>
<td>102</td>
</tr>
<tr>
<td>Transmitted Data</td>
<td>2 BA</td>
<td>103</td>
</tr>
<tr>
<td>Received Data</td>
<td>3 BB</td>
<td>104</td>
</tr>
<tr>
<td>Data Terminal Ready</td>
<td>20 CD</td>
<td>108.2</td>
</tr>
<tr>
<td>Ring Indicator</td>
<td>22 CE</td>
<td>125</td>
</tr>
<tr>
<td>Carrier</td>
<td>8 CF</td>
<td>109</td>
</tr>
</tbody>
</table>

Power:  
+5 VDC at 1.15 A  
+12 VDC at 0.39 A
NOTE
See Communications Programming Card for register information.
Synchronous Transmission
Transmission in which the data characters and bits are transmitted at a fixed rate with the transmitter and receiver synchronized. This eliminates the need for start/stop elements, thus providing greater efficiency.
SYNCHRONOUS TRANSMISSION

The programming logic that provides for synchronous transmission stipulates the sequence of instructions required to send a data character over communications lines to a receiving device. Before data can be transmitted, however, control or sync characters must be sent to achieve line synchronization with the receiving end. Once these sync characters are sent, a message buffer, which contains a character string count, must be initialized. From this message buffer, data characters will be moved, accumulated or calculated into an error check and repeatedly moved until the end of the character string is reached. When the last character string is moved an "End-of-Text" control character is sent along with the error check characters.
SYNONYMOUS RECEPTION

The programming logic that provides for synchronous reception stipulates the sequence of instructions required to receive and process data characters. Before data characters can be received for processing, however, the communications line must achieve a state of synchronization. Sync or control characters that form a signal pattern are received on-line from the transmitting end and are compared or analyzed to establish line synchronization. Once the line is synchronized, a bit counter is set to zero and incremented when each received bit is appended to a character. Upon completion of moving a bit string, a character is formed and likewise appended into a data message. When the data message or character string is finally processed, the program logic clears the line for receiving another message.
CHAPTER 11
SYNCHRONOUS SINGLE LINE INTERFACES
DUP11, DQ11, DMC11, DUV11

OVERVIEW/DUP11
The DUP11 is a single-line, program-controlled, double-buffered communications device designed to interface the PDP-11 processor to a serial synchronous line. The self-contained unit is capable of handling a wide variety of protocols, including byte-oriented protocols, such as DDCMP and BISYNC, and bit-oriented protocols, such as SDLC, HDLC, ADCCP, and X.25.

The DUP11 is ideally suited for interfacing the PDP-11 to medium-speed synchronous lines for remote batch, remote data collection, remote concentration and network applications. Multiple DUP11s on a PDP-11 allow its use in applications requiring several synchronous lines.

The DUP11 can also be used in conjunction with a KMC11 auxiliary processor, using either DIGITAL-supplied microcode as used in IOP-DUP, or customized code for unique applications.
FEATURES

Speeds up to 9600 bits per second.

Double-character-buffered receive and transmit.

Full modem control.

Byte-oriented operation.

Bit-oriented operation.

CRC-16 generation and checking for use with DDCMP protocol, or CRC/CCITT generation and checking for use with bit-oriented protocols.

Secondary address recognition for bit-oriented operation.

SYNC stripping on receive operations under program control.

Auto-answering capability.

BENEFITS

Enables use of higher speeds attainable on private-wire or leased lines.

Maximizes data throughput.

Allows operation over switched or unswitched communication lines.

Supports protocols such as DIGITAL’s DDCMP and IBM’s BISYNC.

Supports “zero bit insertion” protocols such as IBM’s SDLC, ISO’s HDLC, and ANSI’s ADCCP.

Allows transmission errors to be detected readily and provides positive indication to program in event of an error.

Allows use in networks where multipoint operation is required. Helps to eliminate unnecessary program overhead.

Improves efficiency of processing operation and frees buffer space for use of data characters.

Allows operation as a remote unattended station when used on Public Switched Telephone Networks.

PRODUCT PROFILE

General Description

The DUP11 is a character-buffered, synchronous serial-line interface capable of two-way simultaneous communications. The DUP11 translates between serial data and parallel data. Output characters are transferred in parallel from the UNIBUS into the DUP11 where they are
serially shifted to the communications line. Input characters from the 
modem are shifted into the DUP11 and made available to the UNIBUS 
on an interrupt basis.

This allows a full character time in which to service transmitter and 
receiver interrupts. The clocking necessary to serialize the data is 
provided by the associated synchronous modem.

Modem control is a standard feature of the DUP11. The signals need-
ed to establish communications with the Bell Series 200 synchronous 
modems are present in the receive status register (RxCSR).

The DUP11 is capable of transmitting data at the maximum speed of 
either 19,200 bits per second when used in conjunction with KMC11-
A, or 9600 bits per second when used by itself (limited by modem 
interface level converters).

**OPERATION**

**General**
The operation of the DUP11 depends on whether it must handle a 
byte-oriented protocol, such as DDCMP or BISYNC, or a bit-oriented 
protocol, such as SDLC, HDLC, ADCCP, or X.25. This is determined by 
bit 15 (DEC Mode) of the parameter status register.

**Byte-Oriented Transmitter**
The transmitter operation of the DUP11 performs parallel-to-serial 
conversion of 8-bit bytes supplied to it from the UNIBUS and optional-
ly calculates and sends CRC-16 block check characters.

After initialization, the program must set the DEC Mode bit in the 
parameter status register (PARCSR) to indicate that a byte-oriented 
protocol is in use. The program should also specify if CRC calculation 
is desired and set the CRC Inhibit bit of the PARCSR if it is not desired. 
For byte-oriented protocols, the DUP11 uses the CRC-16 polynomial. 
Protocols such as DDCMP can make efficient use of the DUP11 CRC 
capability. This protocol is characterized by the fact that all characters 
within the message are included in the CRC. For other byte-oriented 
protocols such as BISYNC, the CRC capability of the DUP11 must 
usually be inhibited.

Before transmitting, any necessary handshaking with the modem 
should be completed. Once this has been done, the program can 
enable the transmitter by setting the Send bit of the transmitter status 
register (TxCSR).

The program begins transmission by loading the desired sync charac-
Synchronous Single Line Interfaces

**DUP11**

Ter into the transmitter data buffer register (TxDBUF) and setting the Transmit Start of Message (TSOM) bit. All transmitted sync characters must be loaded into the TxDBUF.

When Transmitter Done (TxDONE) is set after the last sync character has been loaded, the program should load the first data character into the TxDBUF and clear the TSOM bit. This character and all subsequent data characters will be included in the CRC calculation.

**Byte-Oriented Receiver**

The receiver operation of the DUP11 performs serial-to-parallel conversion of 8-bit bytes and optionally calculates and checks the CRC-16 block check characters.

After initialization, the program must set the DEC Mode bit of the parameter status register (PARCSR) and set the CRC Inhibit bit of the PARCSR if it does not wish the DUP11 to perform CRC verification. These bits affect both the transmitter and receiver. In addition, the program must load the desired sync character into the PARCSR. This sync character affects only the DUP11 receiver.

Before enabling the receiver, any necessary handshaking with the modem should be completed. Once this has been done, the program can enable the receiver by setting the Receiver Enable (RCVEN) bit in the receiver status register (RxCSR). Setting RCVEN causes the receiver to search the data stream for two consecutive sync characters. When two successive syncs have been recognized, the receiver is considered synchronized and subsequent information will be assembled as 8-bit characters.

Whenever a character is assembled, it will be transferred into the receiver data buffer register (RxDBUF). If the character is not a sync character, or if a non-sync character has been assembled subsequent to receiver resynchronization, then RxDONE will be set. If the character is a leading sync character, the RxDONE will be set unless the STRIP SYNC bit of the RxCSR is set. The program can bypass leading sync characters by setting STRIP SYNC.

**Bit-Oriented Transmitter**

The transmitter section of the DUP11 generates FLAG and ABORT sequences, performs parallel-to-serial conversion of 8-bit bytes supplied to it from the UNIBUS, and optionally generates and sends the CRC/CCITT block check characters. Whenever the data stream between two flags contains five consecutive 1 bits, the transmitter logic automatically inserts a 0 bit to distinguish data and block check characters from FLAG and ABORT sequences.
After initialization, the program should clear the DEC Mode bit in the parameter status register (PARCSR). The program should also specify if CRC calculation is desired and set or clear the CRC Inhibit bit of the PARCSR as desired. The DUP11 calculates and sends the block check characters as described above. For protocols calculating the block check differently, the CRC capability of the DUP11 should be inhibited and the program should generate the required block check characters.

Before transmitting, any necessary handshaking with the modem should be completed. Once this has been done, the program can enable the transmitter by setting the Send bit of the TxCSR.

The program begins transmission by setting the TSOM bit in the TxDBUF. This initial access momentarily clears the TxDONE bit, which was initially set by the initialize pulse or reset. The transmitter will remain inactive for a period equal to two bit times and then the transmitter will become active. The TxACT (Transmit Active) and TxDONE bits will be set and a flag sequence will begin on the serial line.

Some devices that communicate with the DUP11 require that sixteen 0 bits precede the flag character beginning the first frame sent after enabling the transmitter. To accommodate these devices, the program should set TEOM together with TSOM immediately after setting the send bit. TxDONE and TxACT will set when the 0 bit sequence begins. When TXDONE sets for the first time, the program should respond by clearing TEOM. This will clear TxDONE. TxDONE will set again when the sixteen 0 bits have been sent and a flag character has begun. Note that TEOM and TSOM can be used this way only immediately after the transmitter has been enabled.

**Bit-Oriented Receiver**

The receiver section of the DUP11 detects FLAG and ABORT sequences, performs serial-to-parallel conversion of 8-bit bytes of data, and optionally calculates and checks the CRC/CCITT block check characters. Whenever the data stream between two flags contains five consecutive 1 bits followed by a 0 bit, the receiver section automatically deletes the 0 bit from the data stream being assembled into characters and checked in the CRC calculation. This restores the original transmitted data stream.

After initialization or device reset pulse, the program must clear the DEC Mode bit out of the parameter status register (PARCSR) and set or clear the CRC Inhibit bit of the PARCSR. These bits affect both the transmitter and receiver. In addition, the program can set the
Secondary Mode Select bit of the PARCSR if the DUP11 is operating as a secondary station with a protocol which uses the first data character as a secondary address. In this case, the program must load the desired secondary address into the PARCSR.

Before enabling the receiver, any necessary handshaking with the modem should be completed. Once this is done, the program can enable the receiver by setting the RCVEN bit in the RxCSR. The receiver will begin to search for a flag sequence.

Multiple flags at the beginning of a frame are simply ignored. A frame begins following the last initial flag.

Subsequent characters will be loaded into the RxDBUF and presented to the program by setting RxDONE. The program should read the RxDBUF and assemble the incoming frame. If the program does not read the RxDBUF by the time the next character has been assembled, the Overrun bit in the RxDBUF will set, indicating an error condition.

The DUP11 receiver will recognize the end of frame when it sees a terminating flag. The RxAkt bit will be cleared and the REOM bit will be set in the RxDBUF. The RxDONE bit in the RxCSR will be set. If CRC Inhibit is not set and the completed CRC calculation indicates an error, then the RCRC Error + Zero bit will be set in the RxDBUF to inform the program of the error.

Half-Duplex Operation
The program may specify half-duplex operation by setting the Half Duplex bit in the TxCSR.

In this mode of operation, the receiver will be completely disabled while the Send bit is set in the TxCSR. All other characters of the interface are maintained. This action is required only for half-duplex modems which provide local copy.

SPECIFICATIONS
Function: The DUP11 provides an interface between the PDP-11 UNIBUS and a single, synchronous, bit-serial communications channel. It is capable of handling a wide variety of protocols, including bit-oriented protocols (such as SDLC, HDLC, ADCCP, and X.25) and byte-oriented protocols (such as DDCMP and BISYNC.)
Synchronous Single Line Interfaces

**DUP11**

**Mechanical:**
The DUP11-DA consists of one Hex-size (15 3/4 inch × 8 3/8 inch) module, a 16-inch flat ribbon cable, and a 25-foot (7.6-meter) connecting cable. It requires one Hex slot in a DD11-B mounting panel or equivalent. Only slots 2 and 3 of the DD11-B can be utilized with this device. Two DUP11-DAs can be mounted in one DD11-B.

**Operating Mode:**
The DUP11 operates in half- or full-duplex mode, under program control.

**Environmental**

**Temperature:**
+10°C to +40°C

**Relative Humidity:**
10% to 90%, non-condensing

**Power Requirements**
+5 V @ 3.6A
+15 V @ .0A
-15 V @ .9A

**Bus Loads**
The DUP11 presents one unit load to the PDP-11 UNIBUS.

**Ordering Information**

**DUP11-DA**
Full-/half-duplex synchronous-line Hex module. Termination suitable for use with Bell Series 200 synchronous modems or equivalent. Supplied with 25-foot modem cable.

Prerequisite: DD11 system unit.
Figure 8-1  Synchronous Line Interface, DUP11

NOTE
See Communications Programming Card for register information.
OVERVIEW/DQ11
The DQ11 is a high-speed, double-buffered communications device mounted on a single system unit and designed to interface the PDP-11 processor to a serial synchronous communications channel. This interface allows the PDP-11 to be used for remote batch and remote concentrator applications. With the DQ11, the PDP-11 can also be used as a front-end synchronous line controller to handle remote and local synchronous terminals.

The DQ11 provides parallel-to-serial and serial-to-parallel data conversion, voltage or current level conversion, character recognition, error detection, and modem control for half- or full-duplex operation.
FEATURES

Direct Memory Access (DMA) transfers for transmit and receive.

Transmission speeds up to 1,000,000 bits per second when utilizing an appropriate protocol.

Full modem control.

Programmable parity (VRC) checking. Parity (odd or even) is switch-selectable.

Switch-selectable (one or two) sync characters to character frame.

Programmable sync character.

Programmable character size; up to 16 bits per character with double character transfers for characters containing 8 bits or less.

Double-buffered.

BENEFITS

Offers high data throughput, and concurrent autonomous processor operation.

Enables high speed point-to-point data link configuration to be established.

Gives the user capabilities of selecting full-or half-duplex operation over switched or unswitched communications lines.

Provides programming flexibility.

Provides flexibility in compensating for line quality in achieving synchronization.

Offers flexibility where protocol demands a special synchronizing character.

Ability to handle various protocols with differing character sizes.

Maximizes data throughput.

PRODUCT PROFILE

General Description

Data transfers between the PDP-11 UNIBUS and the DQ11 are handled on a DMA (Direct Memory Access) basis. These are data transfers without processor supervision. As a DMA device, the DQ11 provides extremely fast access to the PDP-11 UNIBUS, and can transfer data at exceptionally high rates once it gains control. The PDP-11 processor state is not affected by these types of transfers, since they occur on a cycle-steal basis.

The DQ11-DA is capable of transmitting data at speeds up to 10,000 bits per second. The DQ11-EA is designed for current mode operation, using the Bell System 303, or an equivalent modem, and may transmit data at speeds up to 1,000,000 bits per second.
The DQ11 is a single system unit. It consists of a double-buffered character count register, a double-buffered bus address register, transmitter, receiver, and three switch-selectable characters (receive only) for character recognition. The character count and bus address registers are maintained in the hardware, enabling data transfer rates up to 125,000 characters per second.

**OPERATION**

**General**
The DQ11 is a double-buffered synchronous serial line interface capable of two-way simultaneous communications. It translates between serial data and parallel data. Output characters are transferred in parallel from the PDP-11 UNIBUS into the DQ11 where they are serially shifted to the communication line. Input characters from the modem are shifted into the DQ11 and made available to the PDP-11 on an interrupt basis.

Synchronization between the DQ11 and the transmitting device is established by a sync character code. Once synchronization is achieved, serial data can be transmitted and received continuously. Both the receiver and transmitter are double-buffered. Since the character count register is also double-buffered, a full buffer time is available to service character count overflow interrupts. The clocking necessary to serialize the data may be provided by the associated high-speed synchronous modem.

**Transmitter**
The transmitter section of the DQ11 performs parallel-to-serial conversion of data supplied to it from the PDP-11 UNIBUS.

After the initialization, the program must set the miscellaneous register (bits 11 through 8) for the desired character length (1 to 16 bits), and a desired word count and current address for transmit and receive. Before any required handshaking with the modem, the program may load the sync register with the desired sync character. When the sync register is loaded, the sync character will be used for both receiver and transmitter operations.

Any required handshaking to establish connection with the modem may be done at this time. Once handshaking is complete, the program can assert the Transmit Go (Tx GO) bit in the transmit status register (Tx STAT) to commence data transfer.

The transmitter section of the DQ11 allows the sending of IDLE characters whenever Tx GO is zero. In the non-transparent mode, the IDLE character is the content of the sync register.
Receiver
The receiver section of the DQ11 performs serial-to-parallel conversion of incoming data arriving from the modem.

After any required handshaking with the modem, data transfers and framing will commence when the Receive Go (Rx GO) bit in the receive status register is asserted by the program. The receiver becomes synchronized with the incoming data when it recognizes one or two consecutive sync characters.

Once synchronization is established and when the Receive Active (Rx Active) bit in the receive status register is asserted, receiver data transfers commence. Clearing the Rx Active bit while Rx GO is asserted forces new sync characters. Receive Active may be set following synchronization or on the first non-sync character following synchronization. When the DQ11 leaves the factory, it is set up with two consecutive sync characters, followed by Active on the first non-sync character.

PROGRAMMING
General
The address assigned to the DQ11 is the floating address space reserved for PDP-11 peripherals. The DQ11 address assignment starts at 170010 and follows the DH11 in the order of assignments.

Each DQ11 requires four addresses to accommodate the following device registers:

Receive Status Register (Rx STAT)
Address: 76XXX0 (Addressable by word or byte)

Transmit Status Register (Tx STAT)
Address: 76XXX2 (Addressable by word or byte)

REG/ERR Register
Address: 76XXX4 (Addressable by word or byte)

Secondary Registers (SEC REG)
Address: 76XXX6 (Addressable by word only)

Sixteen secondary registers are provided for read/write operations. These registers are:

Receive Bus Address (BA)—Primary
Receive Character Count (CC)—Primary
Transmit Bus Address (BA)—Primary
Transmit Character Count (CC)—Primary
Receive Bus Address (BA)—Secondary
Receive Character Count (CC)—Secondary
Transmit Bus Address (BA)—Secondary
Transmit Character Count (CC)—Secondary
Sync
Miscellaneous
Transmit Buffer (Tx BUF)

**Interrupts and Vector Assignment**
The interrupt service routine should service all flags within the interrupting vector before returning to the mainline program.

All interrupts are under two vectors, where vector A is XX0 and vector B is XX4. These interrupts are as follows:

Receive Status Register (XX0):
- Receive Done Primary (Rx Done P)
- Receive Done Secondary (Rx Done S)
Character Flag

Transmit Status Register (XX4):
- Transmit Done Primary (Tx Done P)
- Transmit Done Secondary (Tx Done S)
Error Flag
Modem Flag

The DQ11 follows the DH11 in the floating vector assignment area. Vector assignment is from 300 to 777.

**SPECIFICATIONS**

**Function:**
The DQ11 provides a two-way communications interface between the PDP-11 UNIBUS and a serial synchronous transmission line.

**Type:**
Double-buffered, transmit and receive, serializer/deserializer.

**Operating Mode:**
Full- or half-duplex.

**Transmission Speeds:**
EIA RS-232-C/CCITT V.24—Up to 10,000 bits per second; Current Mode Operation—up to 1,000,000 bits per second.

**Clocking:**
Synchronous clock from the modem (internal crystal clock optional).

**Sync Character:**
Program-selectable.
Synchronous Single Line Interfaces

**Sync Detection:** Activates on first non-sync character following one or two successive sync characters, or immediately upon detecting one or two successive sync characters (switch-selectable).

**Order of Bit Transmission:** Low order bit first.

**Error Detection:** VRC (odd or even) for transmit and receive; jumper-selectable. VRC (ON/OFF) is a program function.

**Character Recognition:** Three switch-selectable characters for generating program interrupts.

**Program Interrupts:** Program interrupts on RING, Carrier Detect, Clear to Send, Transmit/Receive Done, Character Flag, and errors.

**Character Size:** Up to 16 bits per character, program-selectable.

Double-character transfers when eight bits (or fewer) per character are selected.

**Bus Address:** Bus Address (BA) may be set to any 128K word address.

**Character Count:** Character Count (CC) may be set for up to 65,536 characters.

**UNIBUS Loads:** The DQ11 System Unit presents one load to the PDP-11 UNIBUS.

**Power Requirements:** +5 V at 6.0 A
+15 V at .04 A
-15 V at .07 A

**Temperature and Humidity Range:** 10 to 50° C with up to 90% non-condensing relative humidity.
# Synchronous Single Line Interfaces

## ORDERING INFORMATION

<table>
<thead>
<tr>
<th>DEC No.</th>
<th>Description</th>
<th>Prerequisite</th>
</tr>
</thead>
<tbody>
<tr>
<td>DQ11-DA</td>
<td>Full-/half-duplex synchronous line. EIA/CCITT termination suitable for direct use with Bell System 201 or equivalent modems. Transmission speeds up to 10,000 bits per second. Modem control included. Supplied with 7.6m (25-foot) modem cable.</td>
<td>PDP-11</td>
</tr>
<tr>
<td>DQ11-EA</td>
<td>Full-/half-duplex synchronous line. TTL to Bell System 303 or equivalent modems. Transmission speeds up to 1,000,000 bits per second. Modem Control included. Supplied with 7.6m (25-foot) modem cable.</td>
<td>PDP-11</td>
</tr>
</tbody>
</table>
NOTE
See Communications Programming Card for register information.
OVERVIEW/DMC11

The DMC11 Network Link is designed for high-performance interconnection of PDP-11 or VAX-11/780 computers in network applications where the computers are located in the same facility. DMC11s can be configured for high-speed operation (56,000 or 1,000,000 bits per second) over inexpensive coaxial or triaxial cable. The necessary modems are built in. Where the computers are located remotely and connected via common carrier facilities, DMC11s can be configured to interface to synchronous modems such as the Bell Models 208 and 209, or Bell 500A LI/5 and equivalent synchronous modems.
FEATURES

DDCMP communications protocol implemented by hardware.

Local or remote interconnection of computers over a serial synchronous link.

Pipelined operation.

BENEFITS

Ensures reliable data transmission, high throughput, low processor overhead, and easy programming.

Allows a user to enhance computing power by utilizing multiprocessors.

High data throughput by overlapping data transmissions, program operations and propagation delays.

Local Operation

56,000 bits per second (full- or half-duplex) over coaxial or triaxial cable up to 6,000 meters long.

1 million bits per second (full- or half-duplex) over coaxial or triaxial cable up to 2,000 meters long.

Remote Operation

Over synchronous leased or private modems at speeds up to 19,200 bits per second (full- or half-duplex) using EIA/CCITT interface.

Also speeds up to 250,000 bits per second (full- or half-duplex) using CCITT V.35 suitable for use on Bell’s DDS (Data Phone Digital Service) or certain European networks.

Flexibility in the choice between distance and speed.

Allows the user to choose appropriate interface to suit network requirements.
FEATURES
Versatile interface.

BENEFITS
Communication between
DMC11s or between a DMC11
and other synchronous interfaces
that can support the DDCMP pro-
tocol.

Down-line loading of remote
computer systems. Ability to ini-
tialize an incorrectly functioning
satellite computer system by
command over the link (Remote
Load Detect).

Same PDP-11 software support-
ing local or remote, full- or half-
duplex configurations.

PRODUCT PROFILE
General Description
Two UNIBUS computers can be connected by a pair of DMC11s. For
remote operation, a DMC11 can communicate with a different type of
synchronous interface or even a different type of computer, provided
that the remote system has implemented the DDCMP (Digital Data
Communication Message Protocol) protocol.

The DMC11 ensures reliable data transmission by implementing the
DDCMP protocol in hardware using a high-speed microprocessor. The
DDCMP protocol detects errors on the channel interconnecting
the systems by using a 16-bit Cyclic Redundancy Check (CRC-16).
Errors are corrected, when necessary, by automatic retransmissions.
Sequence numbers in message headers ensure that messages are
delivered in proper order with no omissions or duplications.

Errors are commonplace on cables or other communications chan-
nels more than a few feet in length. Reliable data transmission re-
quires a protocol. The DMC11 takes care of the details of protocol
operation, including character and message synchronization, header
and message formatting, error checking and retransmission control.
The program need not worry about these details.

The DMC11 offers a number of advantages over conventional inter-
faces that require a combination of hardware and software to
implement a protocol. For example: programming is greatly simplified
and does not require extensive communications expertise; memory
and processor time are not wasted with instructions implementing the
protocol; throughput is enhanced because the DMC11 microprocessor operates at high speed and is not delayed when the processor has to perform high-priority tasks.

**OPERATION**

**General**

All communications between the processor and the DMC11 are through eight bytes of control and status registers. Four bytes of these registers are multipurpose. Their meaning is controlled by the other registers and their use is governed by the DMC11 microprocessor. All commands, command completions and status information pass through these registers.

The PDP-11 program is completely insulated by the DMC11 from the communications link and the DDCMP protocol. When the program initializes the DDCMP protocol, it defines the characteristics of the link with a single command. From that point on, the DMC11 will perform all data link control activities, notifying the user of failures only after an error threshold has been exceeded.

The program initializes the DMC11 by supplying the address of a memory area which the DMC11 uses to keep a snapshot of protocol activity for power fail recovery and defining the characteristics of the data link.

From that point on, all the program need do is request and then use the multiprogram registers to provide the bus address and byte count of messages to be transmitted or buffers to be filled on reception. The DMC11 is multiple buffered. Up to seven messages for the transmitter and seven buffers for the receiver can be queued by the DMC11.

After a bus address/byte count has been assigned, the DMC11 assures error-free sequential message transfer by use of the DDCMP protocol. Transmit commands will be reported as completed when successfully acknowledged. Receive commands will be reported as completed when an entire message has been successfully received in correct sequence. Successful command completion will interrupt the processor, if enabled.

**Full-Duplex Operation**

The DMC11 supports full- or half-duplex operation. Full-duplex operation offers the highest throughput and is used when the communications facilities permit two-way simultaneous operation. Data and/or control messages can be exchanged between the two computer sys-
tems simultaneously in both directions. The DDCMP protocol permits continuous simultaneous transmission of data messages in both directions when buffers are available and there are no errors on the channel.

In order to take advantage of this pipeline capability, the DMC11 permits the program to queue as many as seven buffers containing messages for transmission and as many as seven empty buffers for reception. By queuing up multiple buffers, the programs can effectively overlap processing with data transmission.

Transmissions do not have to stop while the program responds to an end-of-message interrupt. The DMC11 will interrupt the processor when a message has been successfully transmitted or received. At this time the program can supply a new buffer to keep the pipeline filled.

**Half-Duplex Operation**

Half-duplex operation is used where throughput requirements do not justify the added cost of cables or communications lines capable of simultaneous operation in both directions. Local operation requires two coaxial cables for full-duplex operation but only one coaxial cable for half-duplex operation. This is particularly important for dial-up operation when two calls would need to be placed for full-duplex operation.

The program does not have to worry about the details of half-duplex operation. All it needs to do is specify half-duplex operation at device initialization. The DMC11 ensures that both ends of the link are coordinated: one listening while the other is transmitting. The program queues transmit and receive buffers exactly as for full-duplex operation. The same program can be used for local and remote operations, private-wire and dial-up operation, because of this feature.

**Down-Line Loading and Remote Load Detect**

The DMC11 supports down-line loading of computer system software. Down-line loading is used when software is centrally stored (in a host system) and distributed over the network links to other systems (the satellite systems). These satellites are often small systems with no peripherals available for program loading. Sometimes the satellite systems have disks, but down-line loading is desired to maintain central control over the software.

The DMC11 can send and receive down-line loading messages in the DDCMP maintenance format. DMC11s can be used for down-line loading at the host, satellite, or both ends of a link. A special ROM
Synchronous Single Line Interfaces

DMC11

(read-only memory) bootstrap is needed for down-line loading when a DMC11 is used at the satellite end of a link (M9301-YJ).

Unattended operation of satellite systems in a network requires the host systems to be able to initialize an incorrectly functioning satellite system and force it to execute a new program loaded down the communications link. A special DDCMP maintenance message is used for this purpose. A DMC11 at the satellite end of a link can recognize this message and initialize the associated computer system.

Powerfail Recovery
The DMC11 may be programmed either to cold-start or to warm-start on powerfail recovery. Cold-starting initiates the DDCMP startup sequence to make certain that the remote system is aware of the restart. A cold start resets all the DDCMP sequence numbers so the status of previously transmitted but unacknowledged messages is undetermined.

To warm-start, the DMC11 uses the snapshot of protocol operation kept in memory. Restarting proceeds at the state indicated. Messages being transmitted at the time of power failure will be retransmitted as necessary. By using the DDCMP sequence numbers (stored in the memory area), correct recovery of all messages without loss or duplication is assured, providing that neither end of the link does a cold start. Should only one end of a link experience a lengthy power failure, the other end will exceed an error threshold and cause a status interrupt. However, a remote DMC11 will not initiate a cold start unless commanded by the remote program. Recovery from lengthy power failures or communications outages is possible.

Programming
Programming the DMC11 is best described at two levels. The first level describes how a program uses the DMC11 control and status registers together with the interrupt system for transfer of control and status information between the PDP-11 program and the DMC11 microprogram. The second level describes details of these transactions, including formats, details of device and protocol initialization, data transfer and unusual cases.

In order to program the DMC11 successfully, it is not necessary to be familiar with the details of DDCMP protocol operation. These are handled by the DMC11 microprogram. However, some familiarity with the protocol operation will be useful in interpreting the significance of the various error counters provided to assess the quality of the circuit connecting the two computers. If a DMC11 is to communicate with a
DMC11

different interface which uses a software implementation of DDCMP, the person programming the software implementation should consult the DDCMP protocol standard document.

Physical Description
A DMC11 consists of two modules, a microprocessor module and a line unit module. The two modules are interconnected by a one-foot cable. The microprocessor and line unit modules are ordered separately. Two versions of the microprocessor module are available. Four versions of the line unit module are available:

- local operation at 1,000,000 bits per second
- local operation at 56,000 bits per second
- remote operation up to 19,200 bits per second (EIA/CCITT compatible)
- remote operation up to 250,000 bits per second (CCITT/V.35/DDS compatible)

The DMC11-AR/AL microprocessor modules are single Hex-sized boards that fit into a Hex small peripheral controller (SPC) slot. They include a 300ns bipolar microprocessor, a Read-Only Memory implementing the DDCMP protocol, local scratch pad memory (RAM), and a UNIBUS interface.

The DMC11-AL microprocessor is used with local line units DMC11-MA and DMC11-MD. The DMC11-AR microprocessor is used with remote line units DMC11-DA and DMC11-FA.

The DMC11-MA, DMC11-MD, DMC11-DA, and DMC11-FA line unit modules are Hex-sized boards for use in SPC slots. They have a cutout to fit over a UNIBUS connector so they can also be located in the end slots of a DD11 system unit, but not in the case where an 8½-inch-high UNIBUS terminator or cable connector is used. Each includes a one-foot cable for connection to the microprocessor module.

The DMC11-MA line unit module includes serial-to-parallel conversion and a built-in modem for local operation at 1,000,000 bits per second over coaxial cable up to 2,000 meters long. Coaxial cables are not included.

The DMC11-MD line unit module includes serial-to-parallel conversion and a built-in modem for local operation at 56,000 bits per second over coaxial cable up to 6,000 meters long. Coaxial cables are not included.

The DMC11-DA line unit module includes serial-to-parallel conversion and a CCITT V.24/EIA/CCITT RS-232-C interface for use with Bell 208
and 209 synchronous modems or equivalent. Clocking is supplied by the modem and speeds up to 19,200 bits per second can be used. The DMC11-DA includes modem control for full-duplex or half-duplex, private wire or switched operation. A 25-foot cable with 25-pin EIA/CCITT connector is included.

The DMC11-FA line unit module includes serial-to-parallel conversion and a CCITT V.35/DDS interface for use with Bell 500 A LI/5 synchronous modems or equivalent. Clocking is supplied by the modem and speeds up to 250,000 bits per second can be used. The DMC11-FA includes modem control for full-duplex or half-duplex private wire operation. A 25-foot cable with connector is included.

Configurations
Where two systems are to be interconnected locally by coaxial or triaxial cable, a DMC11 is required at each end of the link. For operation at 1,000,000 bits per second, each DMC11 would include a DMC11-AL and a DMC11-MA. For operation at 56,000 bits per second, each DMC11 would include a DMC11-AL and a DMC11-MD.

When two systems are to be interconnected remotely by synchronous modems and common carrier facilities, DMC11s can be used at each end of a link. Each DMC11 would include a DMC11-AR and a DMC11-DA or a DMC11-FA.

A PDP-11 or VAX-11/780 can be interconnected remotely to another computer system that can interface to synchronous modems and support the DDCMP protocol. The configuration would include a DMC11-AR, DMC11-DA, or a DMC11-FA, synchronous modems and compatible communications facilities. At the remote end would be the appropriate communication interface and the computer system software implementing the DDCMP protocol.

Cables
Local operation uses inexpensive coaxial or triaxial cable and standard connectors. One cable is used for half-duplex operation, two for full-duplex operation. The required cable, complete with connectors, is available from DIGITAL in a 100-foot length (BC03N-A0). When longer lengths are needed, or the systems are not located in the same room, the customer is responsible for supplying and installing the cable. It is suggested that the cable be installed well before delivery of the DMC11s.

Maintenance Features
The DMC11 contains a number of features that ensure reliable opera-
tion and easy maintenance. During normal operation, the DMC11 keeps count of communication errors and retransmissions. These counts are recorded in main processor memory. Occasional retransmissions are handled automatically by the DMC11, but repeated errors will result in an interrupt to the main processor to inform the program that action is needed (such as calling the common carrier).

The DMC11-AR/AL microprocessors can be single-stepped by a diagnostic program to verify correct operation. The diagnostic program can supply special microinstructions to exercise the DMC11 thoroughly. It can also verify the contents of the ROM program.

The DMC11-MA, DMC11-MD, DMC11-DA, and DMC11-FA line units can be single-stepped by a diagnostic program to verify correct operation. Programmable loopback prior to the built-in modem or level converters, together with a free-running maintenance clock, enable most of the DMC11 circuits to be exercised without disconnecting any cables. Special turnaround connectors are supplied to provide a complete test of a DMC11.

Vector Assignment
The DMC11 uses two vectors (mod 10) XX0 and XX4. Interrupts are vectored to XX0 for RDY1 and to XX4 for RDYO if the respective Interrupt Enable is set. The vector assignment is within the floating vector system—relative position is number 25 directly following DWUN.

Program Interrupt Priority
The DMC11 interrupt priorities for vectors XX0 and XX4 are controlled by one standard priority connector. The priority can be changed by substituting the appropriate priority connectors. DMC11s will be delivered from the factory with a priority 5 connector.

SPECIFICATIONS
DMC11-AR/AL—DDCMP Microprocessor Module
Protocol: DDCMP
Type of Operation: Full-duplex or half-duplex, point-to-point.
Data Format: 8-bit bytes, DDCMP message formats.
Data Transfers: 16-bit DMA (8-bit DMA at beginning or end of buffers where required).
Mounting Space: One Hex SPC slot in DD11-C or DD11-D back-plane.
Synchronous Single Line Interfaces

**DMC11**

- **Bus Loading:** One UNIBUS load
- **Power Consumption:** 5.0 amps at +5V
- **Operating Temperature:** +10°C to +40°C
- **Humidity:** 10% to 90%
- **Reference:** DEC STD 102—Class C device

**DMC11-MA, DMC11-MD—Line Unit Modules (Local)**

- **Operating Mode:** Half-duplex (single cable), full-duplex (two cables).
- **Data Format:** Synchronous, serial by bit, LSB first.
- **Character Size:** 8 bits
- **Block Check:** 16-bit CRC-16 polynomial.
- **Data Rate:**
  - 1,000,000 bits per second (DMC11-MA)
  - 56,000 bits per second (DMC11-MD)
- **Maximum Distance:**
  - 2,000 meters (DMC11-MA)
  - 6,000 meters (DMC11-MD)
- **Modulation:** Diphase (double freq.) NRZ (Non-Return-to-Zero).
- **Transmitter Timing:** RC Osc., trimmable ±5%
- **Receiver Timing:** From received signal
- **Line Interface:** Transformer coupled
- **Common Mode Rejection:** 500 to 1
- **Transmitter Signal:** 4 volts P-P
- **Receiver Signal:** 150 mv (min.) P-P
- **Cable Type:** Belden 8232 or equivalent (not supplied)
- **Connector Type:** AMP 20606 series
- **Mounting Space:** One Hex SPC slot (DD11-C or D); cutout also permits use in end slots of backplane.
Synchronous Single Line Interfaces

**DMC11**

**Power Consumption:**
- 3.0 amps at +5V
- 0.046 amps at -15V
- 0.018 amps at +15V

**DMC11-DA/FA—Line Unit Module (remote)**

**Operating Mode:** Full- or half-duplex.

**Communications Channel:** Private-wire or switched.

**Data Format:** Synchronous, serial by bit, LSB first.

**Character Size:** 8 bits

**Block Check:** 16-bit CRC-16 polynomial.

**Data Rate:**
- Up to 19,200 bits per second (clocked by modem) (DMC11-DA only).
- Up to 250,000 bits per second (clocked by modem) (DMC11-FA only).

**Standard Interface:**
- CCITT V.24/EIA RS-232-C compatible (DMC11-DA only).
- CCITT V.35 or DDS compatible (DMC11-FA only).

**Modems:**
- Bell 208, 209 or equivalent (DMC11-DA only).
- Bell 500A LI/5 or GTE Lenkurt L500 A-5 or equivalent (DMC11-FA only).

**Signals Supported:**

<table>
<thead>
<tr>
<th>Circuit</th>
<th>EIA RS-232-C</th>
<th>CCITT V.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmitted Data</td>
<td>2 BA</td>
<td>103</td>
</tr>
<tr>
<td>Serial Clock Transmit (SCT)</td>
<td>DB</td>
<td>114</td>
</tr>
<tr>
<td>Received Data</td>
<td>3 BB</td>
<td>104</td>
</tr>
<tr>
<td>Serial Clock Receive (SCR)</td>
<td>17 DD</td>
<td>115</td>
</tr>
</tbody>
</table>
**Synchronous Single Line Interfaces**

<table>
<thead>
<tr>
<th>Command</th>
<th>DEC No.</th>
<th>Prerequisite</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMC11-AR/AL</td>
<td>PDP-11/VAX-11/780</td>
<td>DDCMP microprocessor</td>
<td></td>
</tr>
<tr>
<td>DMC11-MA</td>
<td>DMC11-AL</td>
<td>1,000,000-bit-per-second local line unit</td>
<td></td>
</tr>
<tr>
<td>DMC11-MD</td>
<td>DMC11-AL</td>
<td>56,000-bit-per-second local line unit</td>
<td></td>
</tr>
<tr>
<td>DMC11-DA</td>
<td>DMC11-AR</td>
<td>Remote EIA/CCITT line unit</td>
<td></td>
</tr>
<tr>
<td>DMC11-FA</td>
<td>DMC11-AR</td>
<td>Remote V.35/DDDS line unit</td>
<td></td>
</tr>
</tbody>
</table>

**DMC11**

- Data Set 6 CC 107
- Ready
- Data Terminal 20 CD 108.2
- Ready
- Request to Send 4 CA 105
- Clear to Send 5 CB 106
- BA Transmit Data
- DB Serial Clock Transmit (SCT)
- BB Receive Data
- DD Serial Clock Receive (SCR)
- CC Data Set Ready
- CD Data Terminal Ready
- CA Request To Send
- CB Clear To Send

**Cable:**
25-foot with connector supplied.

**Mounting Space:**
One Hex SPC slot (DD11-C or D), cutout permits use in end slots of backplane as well.

**Power Consumption:**
- 3.0 amps at +5V
- 0.31 amps at -15V
- 0.03 amps at +15V
Synchronous Single Line Interfaces

DMC11

BC03N-A0 DMC11-MA or MD 100-foot coaxial cable

CABLE CONNECTOR PARTS

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>DIGITAL PART NO.</th>
<th>AMP PART NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable Clamp</td>
<td>12-11430</td>
<td>206062-1</td>
</tr>
<tr>
<td>Male Housing</td>
<td>12-12527</td>
<td>206153-1</td>
</tr>
<tr>
<td>Male Pin</td>
<td>12-12001</td>
<td>66589-2</td>
</tr>
<tr>
<td>Female Housing</td>
<td>12-12526</td>
<td>206060-1</td>
</tr>
<tr>
<td>Female Pin</td>
<td>12-12000</td>
<td>66590-2</td>
</tr>
<tr>
<td>14-Guage Male Pin</td>
<td>12-12001-01</td>
<td>66587-2</td>
</tr>
<tr>
<td>Crimping Tool</td>
<td></td>
<td>90277-1</td>
</tr>
<tr>
<td>Pin Extractor</td>
<td></td>
<td>305183</td>
</tr>
</tbody>
</table>

DMC11 REMOTE NETWORK LINK
NOTE
See Communications Programming Card for register information.
OVERVIEW/DUV11
The DUV11 is a single-line, program-controlled, double-buffered communications device designed to interface the LSI-11 processor to a serial synchronous line. The self-contained unit is fully programmable with respect to sync character, character length (5 to 8 bits), and parity selection.

This interface will allow one of two modes of data transmission. Either synchronous or isochronous transmission can be selected by the program.

The DUV11 can be used in many commercial, industrial, or scientific applications, such as remote data collection, remote batch processing, and remote concentration.
FEATURES

Speeds up to 9600 bits per second.

Double-buffered program interrupt.

Full modem control.

Programmable sync character.

Programmable character size (5, 6, 7, or 8 bits).

Receiving sync character stripping program-selectable.

Standard interfacing.

Auto-answering capability.

Parity checking and generation.

BENEFITS

Enables the user to use higher speeds attainable on private-wire or leased lines.

Maximizes data throughput.

Gives the user capability of selecting full- or half-duplex operation over switched or unswitched lines.

Offers flexibility where protocol demands a special synchronization character.

Offers the ability to handle a variety of systems.

Improves efficiency of processing operation and frees buffer space for use of data characters.

Electrical interface conforms to EIA RS-232-C/CCITT V.24, suitable for connection to Bell 200 synchronous modems or equivalent.

Allows operation as a remote unattended station when used on Public Switched Telephone Networks.

Provides programming flexibility.

PRODUCT PROFILE

General Description

The DUV11 is ideally suited for interfacing the LSI-11 to high-speed synchronous lines for remote batch, remote data collection, and remote concentration applications. Multiple DUV11s on an LSI-11 allow its use as a synchronous line concentrator or front-end synchronous controller to a large computer.

The DUV11 provides serial-to-parallel and parallel-to-serial data con-
version, voltage level conversion and modem control for half- or full-duplex operation. The Bell Series 200 synchronous modems or equivalent may be used with the DUV11.

Modem control is a standard feature of the DUV11. The signals needed to establish communications with the Bell Series 200 synchronous modems are present in the receive status register (RxCSR). No transition of control lines coming from the modem directly causes a change in the state of the transmitter or receiver logic.

OPERATION

General
The DUV11 is a character-buffered synchronous serial line interface capable of two-way simultaneous communications. The DUV11 translates between serial data and parallel data. Output characters are transferred in parallel from the LSI-11 into the DUV11, where they are serially shifted to the communication line. Input characters from the modem are shifted into the DUV11 and made available to the LSI-11 on an interrupt basis.

Synchronization between the DUV11 and the transmitting device is established by a sync character code. Both the receiver and transmitter are double-buffered. This allows a full character time in which to service transmitter and receiver interrupts. The clocking necessary to serialize the data is provided by the associated high-speed synchronous modem.

The DUV11 consists of five registers: two status registers, two data buffer registers, and a parameter control register which is used to control characteristics of the interface such as mode of operation (synchronous internal or external), number of bits per character, parity selection, and the sync character.

For local connection (no modem) or for use with a modem without a clock, an external clock source is required. When using the H312-A null modem, pin 24 of the A selection is provided for an external clock connection.

Transmitter
The transmitter section of the DUV11 performs parallel-to-serial conversion of data supplied to it from the LSI-11.

After initialization, the program must set the parameter control register for the mode of operation (in this case synchronous), the desired character length (5, 6, 7, or 8 bits—parity not included), and the mode of parity.
Before any necessary handshaking with the modem, the program may load the sync register with the desired character. When the sync register is loaded, the character will be used for both the receiver and transmitter operations. Any handshaking required to establish connection with the modem may be done at this time.

**Receiver**
Receiver operation is initiated by asserting Search Sync. This action enables the receiver to compare incoming characters with the Sync register. When a compare is detected the receiver will frame on the number of bits per character selected and Receiver Active will be asserted when either one or two Sync characters are received. Additional characters will cause Receiver Done to be asserted unless additional Sync characters are received and the strip Sync function is asserted. Furthermore, if the program fails to service the RDSBUF before the next character is framed, an overrun error occurs.

**Isochronous Operation**
Isochronous operation is essentially asynchronous data transmission over a synchronous modem. Character synchronization is achieved by the use of start and stop bits attached to each character. These start and stop bits are added to and removed from the character by the transmitter and receiver logic. The advantage of isochronous transmission over asynchronous is higher data rates.

After initialization, the program must load the parameter status register with the information used in controlling the operation and selection of parity.

For transmitter or receiver operation, the following parameters must be specified: isochronous mode, character length, and parity. If the receiver is being set up, the sync register must also be loaded and the Search Sync bit set.

When the required handshaking, if any, with the modem is complete, transmission of data can begin after the assertion of Send. As soon as the first character bit is placed on the communication line by the transmitter, Transmit Done is asserted, and remains like this until the transmitter services the transmitter buffer or clears the Send bit.

Receiver operation is initiated by the assertion of Search Sync (SCH SYNC). When this happens, Receiver Active sets and the receiver starts framing characters upon receipt of the Start bit from the transmitter. When the selected number of character bits is received, the
receiver tests the line for a valid Stop bit, transfers the received character into the receiver data buffer (RxDBUF) minus the Start and Stop bits, and sets Receiver Done. A framing error occurs if a Stop bit is not detected. Furthermore, if the program fails to service the RxDBUF before the next character is framed, an overrun error occurs.

**PROGRAMMING**
The five registers and their addresses are listed below:

1. Receiver Status Register (RxCSR) 16XXX0
2. Receiver Data Buffer Register (RxDBUF) 16XXX2
3. Parameter Control Register (PARCSR) 16XXX2
4. Transmitter Status Register (TxCSR) 16XXX4
5. Transmitter Data Buffer Register (TxDBUF) 16XXX6

All information is transmitted between the DUV11 and the LSI-11 in parallel fashion by byte or word. The RxCSR and TxCSR are addressable by word or byte. The PARCSR is write-only by word operation. The RxDBUF is read-only by word or byte. The TxDBUF is write-only by word or byte to the even address only.

Data transfer is under program control. All data is transferred by the program (not a DMA device). Four contiguous LSI-11 addresses are required in the floating address area. Two contiguous interrupt vector addresses are required in the floating vector address area. The first vector of the set will have priority over the second if two interrupt requests are made simultaneously. The first vector will deal with conditions in the RxCSR. The second vector will deal with conditions in the TxCSR.

The initialize signal from the processor will generate a Master Reset in the DUV11.

**SPECIFICATIONS**

Function: Provides an interface between the LSI-11 processor and a single serial synchronous communications channel.

Mechanical: The DUV11 consists of one Quad (8½" x 10½") etched circuit card, and a 25-foot connecting cable terminating in a plug appropriate to the data communications equipment to be connected.

Operating Mode: Full- or half-duplex under program control.
Synchronous Single Line Interfaces

DUV11

Environmental: +5°C to +50°C with a relative humidity of 10% to 95% (without condensation).

Power Requirements: +5 V at 1.2 A max.
+12 V at 0.45 A max.

UNIBUS Loads: The DUV11 presents one unit load to the LSI-11 bus.

ORDERING INFORMATION
DUV11-DA Full-/half-duplex synchronous line module. Double-buffered, 5-, 6-, 7-, or 8-bit characters. EIA/CCITT termination suitable for use with Bell Series 200 synchronous modems or equivalent. Includes 7.6m (25-foot) modem cable.

NOTE
See Communications Programming Card for register information.
CHAPTER 12
SYNCHRONOUS MULTILINE INTERFACES
COMM IOP-DUP

OVERVIEW/COMM IOP-DUP
The COMM IOP-DUP is an intelligent, synchronous Direct Memory Access (DMA) line controller. It is based on the KMC11-A auxiliary processor, which controls the DUP11 synchronous interface over the PDP-11 UNIBUS. This arrangement of KMC11-A and DUP11 provides a synchronous interface with DMA capability for input and output, which relieves the CPU of the time-consuming tasks associated with handling synchronous communication lines. It is particularly suitable for high performance computer networking applications.
## FEATURES

- Uses KMC11-A general purpose, high-speed auxiliary processor.

## BENEFITS

- Provides intelligent DMA capability.
- Off-loads from the CPU time-consuming tasks normally associated with handling multiple asynchronous lines.
- Provides a high degree of flexibility and redundancy.
- Simplifies software interface for easy custom programming.
- Line parameters can be changed dynamically on a line-by-line basis without affecting any other line.
- Allows diverse mix of terminals or communication lines to be handled.

### Bit- or byte-oriented controller.

- Capable of message handling under DDCMP, SDLC, ADCCP, HDLC, BDLC, X.25, and SNAP protocols.

### Built-in expansion capability.

- Minimum COMM-IOP configuration easily upgraded with no recabling required.

### Standard interfacing.

- Electrical interface conforms to EIA RS-232-C/CCITT V.24 suitable for connection to Bell 200 Series or equivalent synchronous modems.

## PRODUCT PROFILE

### General Description

The COMM IOP-DUP is an intelligent, synchronous DMA line controller for use on PDP-11 computer systems. It comprises a KMC11-A auxiliary processor and multiple DUP11 synchronous interfaces. The KMC11-A runs the COMM IOP-DUP microprogram which controls up to 16 single-line DUP11s via the UNIBUS. Each DUP11 can be pro-
COMM IOP-DUP

grammed to operate in full- or half-duplex mode controlling a single communication line capable of message handling under DDCMP protocol or one of the following bit-oriented protocols: SDLC, ADCCP, HDLC, BDLC, X.25, SNAP, and similar protocols. The actual interface configuration is a function of the DUP11 only and is not affected by the KMC11-A or the COMM IOP microprogram. COMM IOP-DUP is designed to implement high-performance communications network systems. It can provide a small but extremely powerful front-end, and is ideal for message switching applications, where high efficiency can be achieved at substantial cost savings over the more conventional methods.

A flexible buying approach has been adopted towards the COMM IOP-DUP product. This allows each of the component parts to be acquired individually as the need arises. If, for example, DUP11s already exist on a system, then only the purchase of the KMC11-A and COMM IOP-DUP microcode software is necessary to upgrade to a higher-performance system. Hence the investment in the existing DUP11s is preserved.

Since there is no direct electrical connection between the KMC11-A or the DUP11, other than via the UNIBUS, the COMM IOP-DUP system is very easy to configure. Further, because the KMC11-A can be reloaded, it is possible to have a number of these devices on a system for redundancy in cases where high reliability is a goal. In the event of failure, the operating system can reload another KMC11-A for continued operation.

Software interfacing to the COMM IOP-DUP is straightforward and simple. Communication between the CPU-resident driver and COMM IOP-DUP is accomplished by a series of commands and responses. Commands are initiated by the PDP-11, and responses by the COMM IOP-DUP. Therefore, users need not be concerned with the details of the KMC11-A microcode operation.

The KMC11-A is loaded with the COMM IOP-DUP microprogram via the UNIBUS by a dedicated resident loader operating in the main PDP-11 CPU. This loader transfers an image of the COMM IOP-DUP microprogram from the system’s mass storage medium to the KMC11-A control memory at system start-up time. Operation of the COMM IOP-DUP microprogram is initiated and directed from a software driver in the PDP-11 CPU. This driver can be either user-written, or part of a DIGITAL-supplied operating system. The microprogram operates each DUP11 with interrupts disabled. It periodically scans the status registers to determine whether the device is ready to accept
COMM IOP-DUP

a character for transmission, or has assembled a received character. This procedure substantially reduces the interrupt overhead associated with this type of device, and allows overall I/O throughput to be increased. All data transfers are therefore under the total control of the KMC11-A without the involvement of the PDP-11 CPU. To avoid monopolizing the UNIBUS, the scanning rate can be varied using the interval timer on the KMC11-A.

SYSTEM OPERATION

The interface between the PDP-11 and COMM IOP-DUP has been designed to provide a very simple structure that considerably reduces the complexity of the associated operating system driver or handler. Communication between the device driver and a COMM IOP-DUP is provided by four UNIBUS device registers that are integral to the KMC11-A auxiliary processor. These four 16-bit registers are used for control input, status output, and data input and output. Since COMM IOP-DUP is basically an input-output device, the command set for this device can be categorized as input commands and output commands. Input commands allow the driver to initialize and set up the parameters associated with each communication line. Output commands allow COMM IOP-DUP to convey information pertinent to the normal completion of data transfers, or forced completion of data transfers due to detection of an error condition.

Commands to COMM IOP-DUP are issued from the driver by storing the command in the four control and status registers (CSRs). The commands are then interpreted by the COMM IOP-DUP. Similarly, commands are issued from the COMM IOP to the driver by storing the command in the CSRs and posting a completion to the driver.

Transmit and receive operations under both DDCMP and bit-oriented protocols require the assignment of buffer descriptor lists. These lists are driver-defined and serve to identify buffers for each communication line; this allows memory buffers to be chained. A list consists of 3-word entries, where each entry identifies an I/O buffer. Lists can be any arbitrary length, and the driver can assign up to two buffer descriptor lists to each COMM IOP-DUP controlled communication line.

SYSTEM APPLICATIONS

COMM IOP-DUP is designed to implement high performance communication network systems for the user who does not have a sufficient number of lines to justify the additional cost of a large-scale front-end. In effect, COMM IOP-DUP is a small, low-cost, but extremely powerful front-end and is ideal for implementing large, highly effi-
efficient message-switching systems at substantial cost savings over the more conventional approaches.

Protocol Support
A COMM IOP-DUP operating as a synchronous communications line controller can support multiple-buffered DMA (Direct Memory Access) interfaces for up to 16 DUP11 devices. Each DUP11 handles one full- or half-duplex synchronous communications line. The maximum aggregate throughput for all communications lines in a COMM IOP-DUP system, including both input and output lines, is 19,200 characters per second. When operating half duplex, the maximum aggregate throughput is 9600 characters per second. Data rates for 4, 8, and 16 lines operating either full or half duplex are as follows:

- Data rate for 16 lines is 4800 bits per second.
- Data rate for 8 lines is 9600 bits per second.
- Data rate for 4 lines is 19,200 bits per second.

The speed of the fastest line in a given configuration determines the number of lines that can be supported by that configuration. This throughput rate assumes a UNIBUS bandwidth of 500,000 Hz and relates to the speed of the KMC11-A only to the extent that the associated PDP-11 supplies sufficient transmit and receive buffers and responds promptly to completion postings by the COMM IOP-DUP. The throughput rate for a COMM IOP-DUP has no relationship to the throughput rate for the associated PDP-11 software, since this throughput rate depends on such factors as CPU model, memory type, buffering capability, and the overall efficiency of the specific software.

The COMM IOP-DUP supports DDCMP protocol or one of six bit-oriented protocols, such as SDLC, ADCCP, HDLC, BDLC, X.25, SNAP and other similar protocols. In addition, the protocol assignment for a given line can be switched under user program control. In a COMM IOP-DUP implemented synchronous communications network, user program responsibilities are minimal; they are limited mainly to command interpretation, protocol-related functions such as half-duplex control, error recovery, and header control.

COMM IOP-DUP performs all modem control functions, with the exception of ring and carrier monitoring, and checks and initiates the sending of CRC characters during the respective transmit and receive data operations. Under DDCMP, COMM IOP-DUP performs the following time-critical tasks, which in conventional installations tend to limit the number of DDCMP lines available for simultaneous servicing:
COMM IOP-DUP

- Identification of numbered versus unnumbered message headers to permit retrieval of the byte count from numbered headers for use in determining message length.
- Automatic receiver resynchronization through analysis of the DDCMP Quick Sync (Q) bit.
- Automatic receiver resynchronization upon detection of block check errors and header errors.
- Recognition of slave station addresses in the multidrop line environment so that the main CPU is interrupted only for messages having the proper station address.

Under the bit-oriented protocols, COMM IOP-DUP controls the flag character generation and detection, secondary station selection, frame check sequence generation and checking, and error and abort detection.

ASSOCIATED SOFTWARE
The COMM IOP-DUP microprogram is supplied as an image file on the following media: 9-track magnetic tape, RK05 disk, RK06 disk, and floppy disk. It is loaded into the KMC11-A control Random Access Memory (RAM) by a utility loader which is supplied as part of the COMM IOP-DUP microcode package and runs as a privileged task under RSX-11M, RSX-11D, and IAS.

The KMC11-A loading can be implemented in one of two ways. The utility loader can be run as a task by the pertinent operating system, or the required portions of the utility loader can be incorporated in a user program. The COMM IOP-DUP is available in both binary and source versions.

ORDERING INFORMATION
COMM IOP-DUP:
The following key (D, E, R, T, Y, Z) represents the distribution media for the product and must be specified at the end of the “Q” number, e.g., QJ733-CD = binaries on 9-track magnetic tape.

D = 9-track Magnetic Tape
E = RK05 Disk
R = Microfiche
T = RK06 Disk
Y = Floppy Disk
Z = No hardware dependency
Synchronous Multiline Interfaces

COMM IOP-DUP

QJ734-C_ Single-use license, binaries, documentation, no support
QJ734-DZ Single-use license only
QJ734-M_ All sources, plus listings on microfiche
QJ734-FR Microfiche listing

Media D, E, T, Y

NOTE
See Communications Programming Card for Register Information.
CHAPTER 13
SYNCHRONOUS/ASYNCHRONOUS
MULTILINE INTERFACES
DV11

OVERVIEW/DV11
The DV11 is a communications preprocessor that permits eight or sixteen synchronous and/or asynchronous lines to be interfaced to a PDP-11. It is designed to relieve the PDP-11 processor of almost the entire overhead associated with interrupt handling, character processing, and CRC/LRC calculations.

It provides very high throughput (up to 38,400 characters per second total for all 16 lines) and extremely flexible handling of special data link characters. High throughput is achieved by use of direct memory access transfers on both transmission and reception. Flexibility is achieved, without committing hardware to any specific protocol, through the use of control bytes stored in core tables. The program can specify parameters in each control byte, thus providing flexibility for requirements within a specific application.
FEATURES

8- or 16-line synchronous/asynchronous multiplexer for use with PDP-11 family.

Direct Memory Access (DMA) transfers on transmission and reception.

Control table scheme.

Open-ended flexible design.

128-character, first-in/first-out receiver buffer (SILO).

Program-selectable block checks (LRC-8, CRC-16, CRC/CCITT) calculated by the hardware.

Two program-selectable sync characters for each line.

Full modem control.

BENEFITS

Permits the user to select a mix of synchronous or asynchronous lines on one interface.

Provides for high data throughput.

Provides programming flexibility, particularly for special characters and protocol handling.

Hardware is not committed to any specific protocol.

Improves character handling latency.

Provides improved error detection.

Offers flexibility where protocol demands a special synchronizing character.

Gives the user capability over switched or unswitched communication lines of selecting full- or half-duplex operation.

PRODUCT PROFILE

General Description

The DV11 consists of a 9-slot double system unit (DV11-AA) which contains the basic modules, plus a choice of three line groups. The DV11-BA consists of a distribution panel and line cards for eight synchronous lines. The DV11-BB consists of a distribution panel and line cards for eight asynchronous lines. The DV11-BC consists of a distribution panel and line cards for four synchronous and four asynchronous lines.

A total of two DV11-BAs, DV11-BBs and DV11-BCs can be used with one DV11-AA.

The DV11 hardware can perform block check calculations for longitudinal redundancy checks (LRC) and cyclic redundancy checks (CRC-16 and CRC/CCITT).
For synchronous lines, the character size (5, 6, 7, or 8 bits) and character format (no parity, even, or odd parity) are switch-selectable for each 4-line group (0-3, 4-7, 8-11, 12-15). Two sync characters may be manually pre-selected for each 4-line group. Then the program can select from either of those two sync characters for each individual line. For transmission, the same sync character is used as the transmitter fill character or an "all 1s" condition can be sent. For asynchronous lines, the character size (5, 6, 7, or 8 bits) and speed (50, 75, 110, 134.5, 150, 300, 600, 1200, 1800, 2000, 2400, 4800, 7200, and 9600 bits per second) are program-selectable for each line. The DV11 can calculate LRCs for all character sizes, and CRCs for 8-bit characters.

**BASIC OPERATION**

Sixteen LSI receiver circuits (synchronous and/or asynchronous depending on configuration) assemble characters received from serial communications lines and assert a flag as each character is received. Sixteen LSI transmitters disassemble characters and transmit them on serial communications lines and assert a flag whenever they can accept another character for transmission. The master scanner sequentially checks the receivers and transmitters for each line to see if a flag exists.

The microprocessor handles all characters received or transmitted by the DV11. It controls all non-UNIBUS data transfers and steps the master scanner. Except for those occasions where a UNIBUS instruction or Direct Memory Access (DMA) transfer involving the DV11 is taking place, the microprocessor never stops.

The microprocessor system includes a 128-character first-in/first-out storage buffer. While most characters received by the DV11 will propagate through this buffer and be transferred directly to PDP-11 memory by means of a Direct Memory Access (DMA) transfer, the occasion may arise when the attention of the PDP-11 program is required before this is done. To prevent the receivers from experiencing data overruns during the interval that the DV11 is awaiting program attention, the microprocessor will continue to load the received characters into the first-in/first-out buffer, but the action of the microprocessor in withdrawing characters from the buffer will cease until the PDP-11 program responds to the interrupt caused by the special character at the bottom of the silo buffer. The character which requires PDP-11 program attention is copied into the receiver interrupt character register at the time the interrupt is generated.

The receiver interrupt character register is a UNIBUS-addressable
register used by the microprocessor to show the PDP-11 program any received character, along with line number and error flags, for which the control logic requires assistance in processing.

![Diagram showing DV11 Basic Operation](image)

Figure 10-1  DV11 Basic Operation

The receiver control byte storage register is a UNIBUS-addressable secondary register used to instruct the microprocessor how to process the character in the receiver interrupt character register.

The NPR control is the Direct Memory Access (DMA) hardware which is used to gain control of the UNIBUS in order to store received characters, obtain characters for transmission, and to obtain control bytes that direct the character processing.

The microprocessor read/write random access memory (RAM) contains current addresses and 2's complement byte counts used in DMA transfers. The initial values are subsequently updated by the microprocessor. The RAM also contains a line protocol word for each line by
which the PDP-11 program can specify what action is to be taken when the byte count reaches zero and what type of block check polynomial should be used. In addition, a line state word is stored for each line, providing a snapshot of what microprocessor activity is in the program at a particular line.

**Receiver**

For synchronous lines, line synchronization and character assembly are accomplished by LSI synchronous receivers which initially compare groups of eight bits received on each line with the preselected sync character to achieve synchronization. Subsequently received characters are placed into a first-in/first-out, 128-character silo storage buffer. Each line receiver appends the line number (four bits) and any error flags (two bits—parity error, overrun error) to the character prior to placing it in the receiver storage buffer.

For asynchronous lines, character assembly is performed by the receiver portions of LSI circuits called Universal Asynchronous Receiver/Transmitters (UARTs). The UARTs automatically obtain line synchronization on the start bit of each received character. When a character has been assembled, it is placed into the 128-character silo storage buffer together with the line number (four bits) and any error flags (parity error, overrun error, framing error).

The DV11 microprocessor removes characters from the silo along with their line number and error flags. If there is an error flag (as a result of the parity error, framing error, or overrun error detected by the receiver), the character is placed in a UNIBUS-addressable register called the receiver interrupt character register, and an interrupt request is generated.

If there is no error flag, the DV11 processing depends on whether a character-oriented protocol (example: BISYNC) or a byte-count-oriented protocol (example: DDCMP) is being used.
Figure 10-2 DV11 Receiver
The receiver throughput in the DV11 is dependent on the number of characters identified in the control bytes as being special (interrupt generating) and the size of the message buffers for received characters. The ability of control bytes to accomplish reception mode changes makes it unnecessary for received special characters to generate an interrupt. When a receiver interrupt is generated, received characters are accumulated in a 128-character first-in/first-out (silo) storage buffer until the interrupt is handled. Assuming arrival of characters at a 19,200 character-per-second rate, it would take approximately 6.6 milliseconds for a silo overflow to occur. Thus, substantial worst-case interrupt latency can be accommodated.

In response to a receiver interrupt indication, the PDP-11 program should set the system control register (bit 8) indicating that the DV11 microprocessor may resume processing the character in the receiver interrupt character register and resume withdrawing characters from the receiver silo storage buffer.

If the program so desires, it may alter the receiver control byte stored in the receiver control byte storage register before setting bit 8 in the system control register.

Transmitter
For each line there is a double-buffered serial transmitter. Transmitters for synchronous lines share UARTs with the receivers. Whenever the transmitter buffer is empty, a flag is raised. The microprocessor scans for transmitter flags and when it finds one, it checks a "work sheet" to determine whether any special action must be taken (e.g., send a block check character). If no special action is required, the microprocessor checks to see if the transmitter "GO" bit for the line is set. If it is set, the microprocessor uses the transmitter current address register to perform a DMA transfer and obtain—from a message buffer—a character to be transmitted. (The DV11 processing of this character depends on whether a character-oriented protocol (example: BISYNC) or a byte-count-oriented protocol (example: DDCMP) is being used.)
Figure 10-3 DV11 Transmitter
The microprocessor loads the character to be transmitted into the appropriate line transmitter and increments the byte count. It then checks the byte count to determine whether it has reached zero. If it has, a check is made to determine whether a mode change has been requested. (Such a change is indicated by the byte count register's being loaded initially with bit 15 cleared.) The new mode is stored by the PDP-11 program in the high byte of the line progress secondary register in approximately the same format as the control byte. Having accomplished any actions requested in this pseudo control, the microprocessor will switch to the other set of tables (i.e., from principal to alternate or vice versa). If the byte count that was just exhausted did not request a mode change via bit 15 on the byte count register, the microprocessor will switch from principal to alternate (or vice versa) without reference to the upper byte of the line progress secondary register.

If, after the switch in registers, the microprocessor finds the new byte count is also zero, it will clear Transmit Go in the line state register and idle the line. On synchronous lines, the Idle Mark bit in the line protocol parameters register determines whether sync characters or 1s are idled. On asynchronous lines, 1s are always idled (Mark Hold).

On synchronous lines, the transmitter serializes each character, appending a parity bit if parity is enabled. On asynchronous lines, the transmitter serializes each character, adding a start bit, parity bit if parity is enabled, and the stop bit(s).

PROGRAMMING

System Addresses
The DV11 uses the same address space as the DM11-A. The first DV11 in a system would be at 775000; the next at 775040; the third at 775140. If there are DM11-As in the system already, the first DV11 would be at 775040. The DV11 data handling and modem control use a total of ten registers.

Interrupt Vectors
Each DV11 requires three interrupt vectors—two for the data handling section and one for the modem control. The interrupt vectors are in the floating vector space that starts at 300. The DV11 modem control follows the DM11-BB, which follows the DN11. The DV11 data handling section follows the DUP11, which in turn follows the DU11.

Timing Considerations
The modem control timing considerations consist of scan control and
CLR SCAN operations. Scan control through the CSR allows the scan either to run free (SCAN EN) or to be stepped through the line counter sequentially line by line (STEP bit of CSR). The read/write cycles of the modem control scan logic force the program to wait, after issuing CLR SCAN, until it has cycled through the memories. Also, the scan's read/write cycles prevent halting the scan and changing the line number with one machine cycle.

Programs should not spin on flags in the DV11 secondary registers using loops less than 30 (octal) instructions; to do so may interfere with DV11 RAM microprocessor/UNIBUS access interlocks.

**SPECIFICATIONS**

**Function:** The DV11 is a communications preprocessor that permits 8 or 16 synchronous or asynchronous lines to be interfaced to a PDP-11.

**Space Requirements:**
- DV11-AA: two system units (SUs)
- DV11-BA: 5¼ inches of cabinet space (SM PAN)
- DV11-BB: 5¼ inches of cabinet space (SM PAN)
- DV11-BC: 5¼ inches of cabinet space (SM PAN)

**Bus Loads:** Two bus loads

**Power Consumption:**

<table>
<thead>
<tr>
<th></th>
<th>+5V</th>
<th>-15V</th>
<th>+15V</th>
</tr>
</thead>
<tbody>
<tr>
<td>DV11-AA</td>
<td>12.3</td>
<td>.444</td>
<td>.420</td>
</tr>
<tr>
<td>DV11-BA</td>
<td>2.6</td>
<td>.148</td>
<td>.540</td>
</tr>
<tr>
<td>DV11-BB</td>
<td>4.0</td>
<td>.148</td>
<td>.540</td>
</tr>
<tr>
<td>DV11-BC</td>
<td>3.3</td>
<td>.148</td>
<td>.540</td>
</tr>
</tbody>
</table>

**Environmental:** +10° to +50°C with a relative humidity of 20% to 95%.

**Cables:** Order BC05D-25 modem cables. 7.6m 25-conductor cable terminated in cinch DB25S socket at one end and cinch DB25P plug at the other.
Internal Clock (synchronous line only):
The DV11 synchronous line units include an internal clock which can be used when two PDP-11s are connected locally without modems. It is also useful for diagnostic purposes. The clock speed can be set at 1200, 2400, 4800, or 9600 bits per second, switch-selectable for each 4-line group (0-3, 4-7, 8-11, 12-15).

ORDERING INFORMATION

DV11-AA Double system unit contains all DV11 logic except the line cards and distribution panels. A total of two DV11-BAs, DV11-BBs, and DV11-BCs may be used with a DV11-AA. No lines are implemented.

DV11-BB Line cards and distribution panel for eight asynchronous lines.

DV11-BC Line cards and distribution panel for four asynchronous lines and for four synchronous lines.
NOTE
See Communications Programming Card for register information.
CHAPTER 14
AUXILIARY COMMUNICATIONS PROCESSORS
KMC11-A

OVERVIEW/KMC11-A
The KMC11-A is an auxiliary processor, complete with memory, that interfaces to the PDP-11 UNIBUS. The KMC11-A improves the performance of PDP-11 computer systems by performing time-consuming system functions in parallel with the PDP-11 CPU, thereby offloading the main CPU. It is especially suited to controlling I/O operations, such as data communications and analog I/O, that require extensive intelligence.

FEATURES
Direct Memory Access UNIBUS interface provides 8- or 16-bit direct memory access to data buffers or control blocks located in PDP-11 memory under microprogram control.

Up to 16 KMC11-As may be connected to a PDP-11 computer system.

High speed LSI microprocessor (300 nsec instruction time) uses 16-bit microinstructions and 8-bit data paths.

1024 16-bit word Random Access Memory contains the microprogram.

1024 8-bit byte data memory stores frequently used information.

8 bytes of control and status registers (CSRs) and associated interrupt logic provide communication between the PDP-11 program and the KMC11-A microprogram.

BENEFITS
By providing access to control, status, and data registers of one or more peripherals on the UNIBUS, it enables low-cost programmed I/O devices to operate as if they had an intelligent DMA capability.

Provides for easy expansion, improved performance, and redundancy.

Offers efficient data throughput.

Provides flexible program loading by the PDP-11 processor and allows use as a general purpose controller.

Permits high-speed access by the microprogram.

Assists in debugging microprograms.
FEATURES

An external connector allows the KMC11-A to be connected directly to a high-speed peripheral such as a DMC11 synchronous line unit.

The KMC11-A is complete on a single printed circuit module and includes the microprocessor, control memory, data memory, UNIBUS interface and external connector.

BENEFITS

Well suited to custom designed interfacing.

Offers a space-saving compact design.

PRODUCT PROFILE

General Description

The KMC11-A is an auxiliary processor designed for use on PDP-11 computer systems. It operates in parallel with the main CPU and has an architecture specifically suited to data movement, character processing, address arithmetic, and other functions necessary for controlling I/O devices, formatting data, and processing communications protocols. The KMC11-A can be used in conjunction with all UNIBUS-based PDP-11 processors, from the PDP-11/04 to the PDP-11/70.

The functions performed by the KMC11-A are determined primarily by the microprogram in the KMC11-A control memory. This control memory is volatile and may be changed whenever desired by the PDP-11 processor. In normal operation, the PDP-11 operating system would load the microprogram into the KMC11-A control memory as part of system initialization; it would remain in the control memory until the system is subsequently reinitialized.

Software support of the KMC11-A by a PDP-11 operating system consists of two parts:

1. the PDP-11 operating system driver
2. the KMC11-A microprogram

The microprogram must be tailored to the specific processing to be performed by the KMC11-A. The operating system driver interfaces the microprogram to the rest of the PDP-11 software. Communication between the microprogram and the operating system uses the KMC11-A control status registers and is entirely defined by the software. Different applications may require different types of micro-
code/software interfaces. Operating system support for the KMC11-A should always be considered in terms of the specific KMC11-A micro-program employed.

**Controlling Peripherals over the UNIBUS**
A typical application of the KMC11-A is the control of several peripheral devices attached to the UNIBUS. These devices, for example the DZ11 8-line asynchronous multiplexer, typically operate by programmed I/O, interrupting the PDP-11 processor for each character input or output. However, with the addition of a KMC11-A, this processor overhead can be substantially reduced and I/O throughput increased.

The PDP-11 processor communicates with the KMC11-A on a message basis, with the KMC11-A interrupting the processor at the end of each message. The KMC11-A has direct memory access to message buffers in PDP-11 memory by means of Direct Memory Access (DMA) transfers. Data is transferred between the KMC11-A and associated peripherals on a character-by-character basis through NPR transfers that address the peripherals' control, status, and data registers (CSRs). NPR transfers are conducted over the UNIBUS with no direct connection between the KMC11-A and associated peripherals. The peripherals are operated with their interrupts disabled. The KMC11-A periodically scans the peripheral status register to determine when characters may be transferred. A single KMC11-A can simultaneously control many transfers between peripherals and memory, keeping track of their status by using its 1024-byte data memory.

In addition to assembling and disassembling messages, the KMC11-A microprogram can perform formatting, special character recognition, error checking, and other protocol functions.

For high-speed operation, the KMC11-A can be connected directly to a specially designed peripheral, such as a DMC11 serial synchronous line unit. The peripheral is located adjacent to the KMC11-A and connects to the external connector with a short over-the-top cable.

In this mode of operation, the KMC11-A communicates with the PDP-11 processor and memory as described above, but has a direct path to the high-speed peripheral. PDP-11 CPU and UNIBUS interference are reduced to one cycle per 16-bit word. Throughput of 50-100,000 characters per second will often be possible, depending on the design of the peripheral, the system configuration, the extent of KMC11-A processing and the efficiency of the microprogram.
The external connector implements a simple bidirectional data port. Transfers are entirely under microprogram control. It will often prove convenient to design special devices to interface to the KMC11-A connector, since much complex logic can be replaced by a KMC11-A microprogram.

**KMC11-A Software Tools**

The KMC11-A microprogramming tools are used to aid a programmer in developing and debugging a KMC11-A microprogram; the tools enable the programmer to assemble, load and debug the new microprogram.

The KMC11-A software tools consist of three parts:

1. A MACRO-11 prefix file consisting of macro definitions of KMC11-A instructions. The prefix file is assembled using MACRO-11 together with a file containing customer-written microinstructions in the form of macro calls.

2. A utility program to load the Random Access Memory of a KMC11-A from a file containing an image of a KMC11-A microprogram. The utility program runs as a privileged task under the supporting operating system. The input to the program is a file created by the operating system task builder from the output of the MACRO-11 assembly.

3. A utility program to enable a programmer to debug interactively a microprogram running on a KMC11-A. The utility program runs as a privileged task under the supporting operating system and utilizes the maintenance features of the KMC11-A hardware. The user may examine and modify the contents of the microprocessor internal registers, data memory and control memory. The user may start, stop, or single-step the microprogram; or he may direct the KMC11-A to execute a single microinstruction from the console. The user may optionally set up to eight breakpoints in the microprogram. Breakpoints are user-selected locations at which microprogram execution is to be halted temporarily to permit interaction between the microprogram and the user. If breakpoint support is to be used, the 16 highest locations in the KMC11-A control memory must be reserved for the utility program. All addresses and data input and output to the user are in octal.

**MICROPROGRAM DEVELOPMENT CONSIDERATIONS**

Software support of a KMC11-A by a PDP-11 operating system consists of two parts: the KMC11-A microprogram and the PDP-11 operating system. The operating system driver interfaces the micropro-
gram with the rest of the PDP-11 software. The microprogram must be tailored to the specific processing to be performed by the KMC11-A.

Development or acquisition of the microprogram can be done in the following ways:

1. Users can use DIGITAL-developed microprograms and drivers supplied with DIGITAL's PDP-11 operating systems.
2. Users can use DIGITAL-developed microprograms in their own software environment. These users will develop their own operating system drivers.
3. Users can develop their own microprograms tailored to specific applications. These users can also develop their own operating system drivers. They may utilize the DIGITAL software tools as outlined above.
4. DIGITAL's Computer Special Systems (CSS) can design and develop custom microprograms for KMC11-A. CSS services avoid the need to develop in-house expertise and experience in the details of KMC11-A microprogramming, yet provide the benefits of customer microcode.

If KMC11-A microcode is to be developed by the user, personnel should be senior-level and should have experience in programming I/O routines in several different minicomputer or microprocessor assembly languages. In addition, the personnel should be familiar with the problems of correctly synchronizing multiple processors.
CHAPTER 15
COMPUTER SPECIAL SYSTEMS
CS11-M, IMP11-A, PC11-B, VTV30-H

OVERVIEW/CS11-M
The CS11 family of switch options provides facilities for switching communication lines from one set of communication interfaces to another. These switch options are particularly useful in multiprocessor configurations where one computer backs up another.

The CS11 switches are offered for EIA standard RS-232-C, Bell Type 303, and four-wire 20mA current loop lines. These switches are compatible with either synchronous or asynchronous data lines and devices operating up to 460.8 KB/s.

An important CS11 feature is the use of special switches with bifurcated, gold-plated contacts that have been specifically designed for telephone and data line applications where maximum reliability and minimum signal degradation are important.

Figure 12-1 CS11 Switch Implemented in a Multiprocessor Configuration

225
FEATURES

Manual communications line switch options.

Standard interfacing.

Specially designed gold-plated contacts.

BENEFITS

Provide facilities for switching communications lines from one set of communication interfaces to another.

CS11 switches are offered for EIA standard RS-232-C and 20mA current loop lines.

Provide for maximum reliability and minimum signal degradation on telephone and data lines.

PRODUCT PROFILE

General Description

The CS11 manually operated switches are constructed from basic building block modules (48.3cm x 13.3cm) which are rack-mounted in a standard 19 in. x 5¼ in. mounting panel. Unused space in the mounting panel is filled with blank panels.

The four-wire 20mA current loop switches have screw-type terminal blocks on the rear panel, while the EIA standard RS-232-C switches are equipped with 25-pin interface connectors. The units are supplied with the appropriate additional cables to connect to user-specified devices.

Environmental requirements for the CS11 switch options are the same as those specified for the PDP-11 computer system in the PDP-11 maintenance literature.

CABLES

The CS11 manual switch options are designed to connect either of two PDP-11 line interfaces to one communications terminal. The cable descriptions for the 20mA current loop line options (CS11-MA/MB), EIA RS-232-C options (CS11-MC/MC), Bell Type 303 options (CS11-ME/MF) and DC14 switch (CS11-MH/MJ) are given separately in the following paragraphs.

CS11-MA/MB SWITCH OPTIONS

The CS11-MA/MB switch options for the 20mA current loop lines are provided with three cables as shown in Figure 12-2. The 18-foot cable, terminated in a male Mate-N-Lok connector, allows this option to connect to a PDP-11 line interface. The interface can be mounted in the
same or adjacent cabinet and must be terminated in a female Mate-N-Lok connector. The 2-foot (.6m) cable allows the option to be connected to any communications terminal which is terminated in a male Mate-N-Lok connector. Therefore, with both female and male connectors available to the user, any interfaces and terminals with Mate-N-Lok connectors may be incorporated into a CS11 manual switch configuration by redirecting the existing cables. No additional or alternate cables are required.

![Diagram of CS11-MA/MB Cable Connections](image)

**Figure 12-2 CS11-MA/MB Cable Connections**

**CS11-MC/MD SWITCH OPTIONS**
The CS11-MC/MD switch options for the EIA standard RS-232-C interface lines are provided with two 25-pin (female) connectors. The CS11-MC/MD female connectors mate with the EIA standard male connector DB-25S which is provided at the end of an EIA cable associated with a PDP-11 line interface. Each CS11-MC/MD option is equipped with a 25-foot (7.6m) cable which provides the interconnection to the modem. Figure 12-3 illustrates the cable arrangement of the CS11-MC/MD options.
CS11-MH/MJ SWITCH OPTIONS
The CS11-MH/MJ switch options for BC14L type lines are provided with three cables shown in Figure 12-4. Two cables, terminated in male 6-pin connectors, allow the switch to be connected to DC14-CE channel interfaces. One cable, terminated in a female 6-pin connector, connects the switch with a DC14 controller interface through a BC14L cable. Four controller interfaces may be switched per CS11-MH/MJ.
CS11-M

CS11-ME/MF SWITCH OPTIONS
The CS11-ME/MF switch options for Bell Type 303 lines are provided with three 12-pin (female) coaxial connectors. These connectors mate with a Burndy P/N MD 12 MXP-17TC plug. Each CS11-ME/MF option is equipped with a 20-foot (6.1m) cable which provides the intercon-nection to the modem.

Figure 12-5 CS11-ME/MF Cable Connections

CONTROLS AND INDICATORS
One manual switch is associated with each communication line controlled by the CS11 options. The switches are contained on a mounting panel located on the front of an H960 cabinet. Each CS11-MA/MB and CS11-MH/MJ option contains four switches, providing the facility to switch four communication lines. The CS11-MC/MD, CS11-ME/MF options contain one switch and control one line. The positions on all switches are marked A and B, indicating which line interface is connected to the terminal device.

PROGRAMMING
No programming procedures are associated with the CS11 manual switch options. The operator must inform the operating software of any change in the switch settings.

MAINTENANCE TESTS
No special tools or test equipment is required for maintaining the CS11 manual switch options. Margin tests are not performed on this device. Maintenance tests performed on the line interface units and
the terminal devices through the CS11 switches verify the switch operation.

MAINTENANCE TECHNIQUES
If a problem develops on a communication line associated with a CS11 manual switch, the user should check to see if the switch has the proper line interface selected and all cables properly installed. If the CS11 option is still suspect after making these visual checks, the switch may be removed from the communication line. The cable from the line interface under test and the cable from the communication terminal can be removed from the switch and connected together directly. If the communication device then works properly, the problem is due to the CS11 option. Performing the checkout and acceptance procedure should isolate the problem area.
OVERVIEW/IMP11-A
The IMP11-A interface provides a direct connection between PDP-11 computer systems and the Interface Message Processor (IMP) used to connect host computers to the Advanced Research Projects Agency (ARPA) network. This UNIBUS option allows the user (with the addition of appropriate software) to communicate via the network with other host systems, and is supplied with level conversion modules to connect to either the local or distant host interface of network IMPs.

The IMP11-A is supplied in a BA11-ES mounting box, complete with power supply, UNIBUS cable and Light Emitting Diode (LED) indicator panel, and includes all the logic elements required to implement the full-duplex bit serial signal interchange defined for IMP-to-host connections. Diagnostic and exerciser software is also included to facilitate acceptance and maintenance procedures. The IMP11-A is available in the U.S. only.
FEATURES

Versatile connecting interface.

Diagnostic and exerciser software.

Supplied in BA11-ES mounting box.

BENEFITS

Allows host computers to be connected to the ARPA network and other host computers.

Facilitates acceptance and maintenance procedures.

Contains all the logic elements necessary to implement full-duplex interchange.

PRODUCT PROFILE

General Description
The IMP11-A is a PDP-11 family device for interfacing a PDP-11 to the Advanced Research Projects Agency Network (ARPANET). The IMP11-A is designed to connect to the Interface Message Processor (IMP) which is the communications processor in the ARPANET. The signaling scheme conforms to the specifications in the Bolt, Beranek, and Newman Report 1822, “Specifications for Interconnection of a Host and an IMP.”

Figure 12-6 IMP11-A Simplified Logic Diagram

The interface to the UNIBUS is through two DR11-Bs. Associated with the DR11-B is an interface logic assembly. This logic controls the DR11-Bs, serializes and de-serializes the data, and generates the control signals required by the host interface in the IMP.
INTERFACE LEVELS
The IMP11-A is capable of operating in two modes, Local Host or Distant Host. The Local Host signals (out of the IMP) are standard TTL levels of 0 and +3 V to ground driven by high current drivers. The Distant Host signals are differential levels as follows:

<table>
<thead>
<tr>
<th>Logic 1</th>
<th>Logic 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal Line</td>
<td>+0.5 V</td>
</tr>
<tr>
<td>Pair</td>
<td>-0.5 V</td>
</tr>
</tbody>
</table>

TRANSMIT LOGIC
The transmit section of the interface logic assembly consists of a 16-bit shift register, a 4-bit counter, and a number of flip-flops for status and control bits.

The transmitting sequence is initiated when the Go bit is set and the DR11-B Ready signal goes low. This removes the reset from the transmit logic. The Ready bit’s going low causes a pulse on Tx Ready Fall and a request is sent to the DR11-B for the first word. The DR11-B performs an NPR cycle, inputting the first word from computer memory and passing it to the transmit shift register of the interface logic assembly. The data is shifted out according to the four-way handshaking protocol of the host interface of the IMP.

The four-way handshaking sequence associated with each data bit proceeds as follows. The assertion of Ready-for-Next-Bit (RFNB) from the host interface in the IMP is detected in the IMP11-A and the next data bit is shifted onto the data line. After a short delay, the IMP11-A asserts There’s-Your-Bit (TYB). The host interface uses this signal to strobe in the data bit and then drops RFNB. The negation of RFNB at the IMP11-A results in the dropping of TYB. The interface logic in the IMP11-A starts on the next four-transition cycle when RFNB signal is re-asserted by the host interface.

Figure 12-7 shows a simplified diagram of this sequence.
Figure 12-7  Four-Way Handshaking Sequence

The 4-bit counter is incremented and the shift register is shifted during each cycle. When the counter overflows (16 bits transmitted), a new word request is given to the DR11-B and further transfers are inhibited until that word has been received from the DR11-B and loaded into the shift register.

NOTE
The counter is incremented by one as soon as the word is loaded, since the first bit is present on the data lines at that time.

The Tx Last Word flip-flop is set as soon as the last word is being transmitted (indicated by the assertion of the DR11-B Ready signal). On the last bit of the last word, the Last Bit (LB) signal is transmitted along with the data if the Enable Last Bit was set in the DR11-B status register. The Last Word flip-flop is cleared automatically following the transmitting of this bit so that it will be initialized for the next block of data. As soon as the Last Word signal is cleared, the Reset signal is asserted and the logic is disabled until the next block transfer.

RECEIVE LOGIC
The basic operation of the receive logic is very similar to the transmit logic with several minor differences and additional features. One of the differences is that the 4-bit counter starts at 0 rather than 1 because the first bit must be shifted in before it is counted.

When the Last Bit signal has been recognized by the IMP11-A logic, it is not presented to the processor as an interrupt until the word has been transferred by the DR11-B. Therefore, if it is sent before all 16 bits have been received, the interrupt will not occur until all 16 bits have been received.
IMP11-A

If the Last Bit signal is received by the IMP11-A before a full data word has been received, the IMP11-A will fill the remainder of the shift register with 0s to complete the word.

A relay is included in the logic to signify to the IMP that the host PDP-11 is ready. The two sides of the relay contacts are brought out to the IMP as signal lines. The normal way to implement these lines is to ground one side and sample the output of the other side. The side being sampled will then be switched between an open circuit and ground depending on the state of the relay. The relay is set by setting the Host Ready bit in the RxCSR. Naturally, if power is lost to the IMP11-A, the relay will open and indicate to the IMP that it is not ready.

A flip-flop (Ready Line Error) has been included in the logic to store the fact that either Host Not Ready or IMP Not Ready has been asserted.

DR11-B LOGIC
The DR11-Bs are standard and have not been modified. Refer to the DR11-B Maintenance Manual for a thorough analysis of the DR11-B logic. Since some of the normal DR11-B signals have different names in the IMP11-A, Table 12-1 is provided to show the correlation of the standard DR11-B signal names and the names given to the signals in the IMP11-A logic.

NOTE
The protocol of the ARPANET requires that bits be shifted out by byte with the most significant bit first. Therefore, the order of shifting is bits 07, 06, 05, 04, 03, 02, 01, 00, then bits 15, 14, 13, 12, 11, 10, 09, 08. The data lines from the DR11-B have been wired into the shift register to provide this order.
<table>
<thead>
<tr>
<th>IMP11-A RECEIVE SECTION NAME</th>
<th>NAME IN RECEIVE DR11-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUND</td>
<td>C0 CONTROL H</td>
</tr>
<tr>
<td>WRITE ENABLE</td>
<td>C1 CONTROL H</td>
</tr>
<tr>
<td>CYCLE REQUEST AH</td>
<td></td>
</tr>
<tr>
<td>RX WORD READY</td>
<td>CYCLE REQUEST BH</td>
</tr>
<tr>
<td>+3 V</td>
<td>WC INC ENB H</td>
</tr>
<tr>
<td>+3 V</td>
<td>BA INC ENB H</td>
</tr>
<tr>
<td>GROUND</td>
<td>A00 H</td>
</tr>
<tr>
<td>RX END OF MESSAGE</td>
<td>DSTAT A H</td>
</tr>
<tr>
<td>IMP NOT READY</td>
<td>DSTAT B H</td>
</tr>
<tr>
<td>READY LINE ERROR</td>
<td>DSTAT C H</td>
</tr>
<tr>
<td>RX ATTN H</td>
<td>ATTN H</td>
</tr>
<tr>
<td>+3 V</td>
<td>SINGLE CYCLE H</td>
</tr>
<tr>
<td>RX WRITE ENABLE</td>
<td>FNCT 3 H</td>
</tr>
<tr>
<td>HOST READY</td>
<td>FNCT 2 H</td>
</tr>
<tr>
<td>RX CLEAR STATUS</td>
<td>FNCT 1 H</td>
</tr>
<tr>
<td>RX INACTIVE</td>
<td>READY H</td>
</tr>
<tr>
<td>RX CYCLE BUSY</td>
<td>BUSY H</td>
</tr>
<tr>
<td>RX WORD ACCEPT</td>
<td>END CYCLE H</td>
</tr>
<tr>
<td>RX GO H</td>
<td>GO H</td>
</tr>
<tr>
<td>NO LOCK H</td>
<td>INIT H</td>
</tr>
<tr>
<td>RX BIT 08</td>
<td>DAT15 IN H</td>
</tr>
<tr>
<td>RX BIT 09</td>
<td>DAT14 IN H</td>
</tr>
<tr>
<td>RX BIT 10</td>
<td>DAT13 IN H</td>
</tr>
<tr>
<td>RX BIT 11</td>
<td>DAT12 IN H</td>
</tr>
<tr>
<td>RX BIT 12</td>
<td>DAT11 IN H</td>
</tr>
<tr>
<td>RX BIT 13</td>
<td>DAT10 IN H</td>
</tr>
<tr>
<td>RX BIT 14</td>
<td>DAT09 IN H</td>
</tr>
<tr>
<td>RX BIT 15</td>
<td>DAT08 IN H</td>
</tr>
<tr>
<td>RX BIT 00</td>
<td>DAT07 IN H</td>
</tr>
<tr>
<td>RX BIT 01</td>
<td>DAT06 IN H</td>
</tr>
<tr>
<td>RX BIT 02</td>
<td>DAT05 IN H</td>
</tr>
<tr>
<td>RX BIT 03</td>
<td>DAT04 IN H</td>
</tr>
<tr>
<td>RX BIT 04</td>
<td>DAT03 IN H</td>
</tr>
<tr>
<td>RX BIT 05</td>
<td>DAT02 IN H</td>
</tr>
<tr>
<td>RX BIT 06</td>
<td>DAT01 IN H</td>
</tr>
<tr>
<td>RX BIT 07</td>
<td>DAT00 IN H</td>
</tr>
</tbody>
</table>
### IMP11-A

<table>
<thead>
<tr>
<th>TRANSMIT SECTION NAME</th>
<th>NAME IN TRANSMIT DR11-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAT15 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT14 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT13 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT12 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT11 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT10 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT09 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT08 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT07 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT06 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT05 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT04 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT03 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT02 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT01 OUT H</td>
<td></td>
</tr>
<tr>
<td>DAT00 OUT H</td>
<td></td>
</tr>
<tr>
<td>GROUND</td>
<td>C0 CONTROL H</td>
</tr>
<tr>
<td>GROUND</td>
<td>C1 CONTROL H</td>
</tr>
<tr>
<td>WORD REQUEST</td>
<td>CYCLE REQUEST AH</td>
</tr>
<tr>
<td></td>
<td>CYCLE REQUEST BH</td>
</tr>
<tr>
<td>+3 V</td>
<td>WC INC ENB H</td>
</tr>
<tr>
<td>+3 V</td>
<td>BA INC ENB H</td>
</tr>
<tr>
<td>GROUND</td>
<td>A00 H</td>
</tr>
<tr>
<td></td>
<td>DSTAT A H</td>
</tr>
<tr>
<td></td>
<td>DSTAT B H</td>
</tr>
<tr>
<td></td>
<td>DSTAT C H</td>
</tr>
<tr>
<td>TX ATTN H</td>
<td>ATTN H</td>
</tr>
<tr>
<td>+3 V</td>
<td>SINGLE CYCLE H</td>
</tr>
<tr>
<td></td>
<td>FNCT 3 H</td>
</tr>
<tr>
<td>TX ENABLE LAST BIT</td>
<td>FNCT 2 H</td>
</tr>
<tr>
<td>TX CLEAR STATUS</td>
<td>FNCT 1 H</td>
</tr>
<tr>
<td>TX READY</td>
<td>READY H</td>
</tr>
<tr>
<td>TX CYCLE BUSY</td>
<td>BUSY H</td>
</tr>
<tr>
<td>TX WORD VALID</td>
<td>END CYCLE H</td>
</tr>
<tr>
<td></td>
<td>GO H</td>
</tr>
<tr>
<td></td>
<td>NO LOCK H</td>
</tr>
<tr>
<td></td>
<td>INIT H</td>
</tr>
<tr>
<td>TRANSMIT SECTION NAME</td>
<td>NAME IN TRANSMIT DR11-B</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>DAT15 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT14 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT13 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT12 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT11 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT10 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT09 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT08 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT07 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT06 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT05 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT04 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT03 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT02 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT01 IN H</td>
<td></td>
</tr>
<tr>
<td>DAT00 IN H</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TX</th>
<th>BIT 08</th>
<th>NAME IN TRANSMIT DR11-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>09</td>
<td>DAT14 OUT H</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>DAT13 OUT H</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>DAT12 OUT H</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>DAT11 OUT H</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>DAT10 OUT H</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>DAT09 OUT H</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>DAT08 OUT H</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>DAT07 OUT H</td>
<td></td>
</tr>
<tr>
<td>01</td>
<td>DAT06 OUT H</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>DAT05 OUT H</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>DAT04 OUT H</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>DAT03 OUT H</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>DAT02 OUT H</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TX</th>
<th>BIT 06</th>
<th>NAME IN TRANSMIT DR11-B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DAT01 OUT H</td>
<td></td>
</tr>
</tbody>
</table>
**SPECIFICATIONS**

**Mechanical**
Mounting Box: One, type BA11-ES  
Dimensions: 10½ in. h, × 19 in. w, × 24 in. d (26.7cm × 48.3cm × 61cm)  
Weight: 130 lbs. (58.9kg)  
Prerequisites: None

**Electrical**
Input Power: 120 VAC +/-10%, 47-63 Hz  
Power Supply: One, type H720-E  
Logic: M-series modules, TTL levels

**Operational**
Capacity: One IMP Host Interface  
Transfer: Full duplex, NPR  
UNIBUS Loads: Two  
Data Rate: Nominal 500,000 bits/sec., full duplex  
Interrupt: Receive Section:  
1) Receipt of Last Bit from IMP  
2) Receive word count overflow  
Transmit Section: Word count overflow

Output Levels: Local host—single ended 0 VDC to 5 VDC  
Distant host—differential /-1.0 VDC  
Signaling: Bit asynchronous with re-quest/acknowledge handshake per bit  
Indicators: 12 front panel Light Emitting Diodes displaying major IMP11-A functions  
Cabling: Connector only supplied for terminating customer-supplied IMP-Host cable
OVERVIEW/PCL11-B

The Parallel Communications Link (PCL11-B) is a high performance computer link used for interconnecting multiple PDP-11 computers in a local distributed processing network. Up to 16 processors may be connected to the PCL11-B network. Each computer may send or receive messages or data blocks to or from any other computer in the network. Communications occur in a DMA block transfer mode over a time division multiplexed (TDM) 16-bit parallel bus. Because of the TDM nature of the PCL11-B bus, up to 16 conversations may be conducted concurrently. Data transferred is error-checked by the PCL11-B hardware using CRC and parity detection techniques.

![PC11-B Block Diagram]
FEATURES

Hardware-controlled error checking in communications.

Block CRC-16 and word parity.

Both receiver and transmitter have FIFO (first in/first out) data silo buffers for the data being transferred.

The receiver may reject or terminate messages it does not wish to complete.

Time division multiplexing.

PCL11-B units connect to the TDM bus in a T-junction.

Units may be powered down without halting bus operation.

BENEFITS

Ease of use with low software overhead.

Offers error-free data.

Permits smooth data flow and avoids the need for special data codes.

Gives receiver control of the data it receives.

Offers the flexibility to use only a certain percentage of the bus bandwidth.

Provides for ease of maintenance in reconfiguration.

Provides for ease of maintenance.

PRODUCT PROFILE

General Description

The PCL11-B includes many fail-safe features which make it ideal for building high reliability into multi-CPU networks. Computers may be powered up or down and added to or removed from the system by attaching to or detaching from the PCL11-B bus. Units may be removed from the TDM bus for maintenance functions without breaking or disabling the bus.

The above figure shows a general block diagram for a PCL11 communications system. Each computer that is part of the network has a PCL11-B interface unit attached to its UNIBUS. This unit is the heart of the communications system, as it provides an interface between the UNIBUS and the TDM bus. Each PCL11-B may control transfer of parallel 16-bit data words to another PCL11-B over the bus. The PCL11-B contains independent logic to control both transmission and reception of messages simultaneously. The transmit logic may retrieve data directly from memory via DMA access to transfer to another PCL11-B on the TDM bus. Similarly, the receive section may receive data from any unit on the bus and transfer it directly to memory via DMA transfers.
PCL11-B

The PCL11-B bus is a time division multiplexed bus. This means each transmitter is assigned a certain “timeslice” by a bus controller within which one data word of a message may be sent to a receiver. In a PCL11 communication system this controller is called the TDM Bus Master. Each PCL11-B contains master logic and any one unit on the bus is designated as TDM Bus Master. A different unit may be assigned to be Secondary Master. This secondary unit becomes master automatically in the event that the first master is powered down or otherwise disabled.

Software
PCL11-B communications interfaces are supported with an RSX-11M device driver.

SPECIFICATIONS

Mechanical
Mounting: PCL11-B interface requires space for a 9-slot double system unit backplane (supplied with unit) in standard PDP-11 processor box or PDP-11 mounting box (except BA11-L).

Modules: PCL11-B contains 7 Hex-sized modules and 1 Quad-sized module.

Cables: Each PCL11-B is shipped with 1 BC20K cable to implement the T-junction. BC20P-xx cables are required to connect together units that are further than 10 ft. apart.

Max. no. of PCL11-B units on TDM bus: 16

Electrical
Voltage/Current: Powered from PDP-11 mounting box:
- 14 amps @ +5 volts
- .5 amps @ -15 volts
**Operational**

TDM Bus Bandwidth: This depends on bus length as per the following table:

<table>
<thead>
<tr>
<th>Bus Length</th>
<th>50’</th>
<th>100’</th>
<th>240’</th>
<th>300’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Bandwidth (Kbytes/sec)</td>
<td>1000</td>
<td>800</td>
<td>500</td>
<td>400</td>
</tr>
</tbody>
</table>

Message Length: 64 K bytes maximum

Error Detection: Parity checked on each word. CRC character checked after 400 (octal) bytes.
OVERVIEW/VTV30-H

The VTV30-H Graphics Display Controller enables a color television monitor to be connected to a DIGITAL LSI-11 microprocessor. A wide variety of alphanumeric and pictorial data, mimics, graphs, engineering diagrams, and other patterns can be presented on a monitor screen in up to seven colors.
FEATURES
Graphics display controller.

Picture store.

Versatile character set.

Flexible formatting.

BENEFITS
Enables a color television monitor to be connected to a DEC LSI-11 microprocessor.
Can present up to seven colors and a wide variety of alphanumerical and pictorial data.
Serves as an additional memory in the controller to store information on data characters.
Offers 128 user-defined characters.
Provides for software-selectable display format and character size matrix.

PRODUCT PROFILE
General Description
Information is displayed on the screen in the form of rows of characters. A character is composed of a pattern of dots that form a character matrix. The size of this character matrix, and hence the number of characters per row and the number of character rows on the screen, is defined by the setting or clearing of bits in the device’s control and status register. Each character matrix is assigned an area of memory within the controller into which the software may write the desired pattern to define the character. One hundred and twenty-eight characters may be defined in this way; typically, the standard ASCII character set, together with special symbols, line and arc segments, may be held in this memory, termed the character store.

The controller also holds within itself another memory, the picture store. This picture store has one location for each position on the screen and in each location is held:

a) the address in the character store of the character to be displayed in that position

b) the colors of the character to be displayed in that position

c) the blink status of the character to be displayed in that position

Thus, the character store holds the character set information, whereas the picture store holds the information for the current display on the screen.
The above figure shows a block diagram of the VTV30-H controller.

**Communication Between LSI-11 Computer and VTV30-H**
The LSI-11 computer communicates with the VTV30-H via the LSI bus, by means of a number of registers:

1. **Control and Status Register (CSR):** General control and status information is conveyed via this register.
2. **Data Buffer Register (DBUF):** This is the means by which the program loads and reads the picture store.
3. **Cursor Address Register (CAR):** The program can operate directly on the X and Y addresses of the cursor via this register.
4. **Character Store Register (CHSR):** This is the means by which the program loads and reads the character store.

Data to be displayed on the T.V. screen is output to the controller through an 8-bit port, DBUF. Into this data port may be written:

(a) 0-177; this loads one of the 128 user-defined characters into the picture store at the cursor address.

(b) 200-277; this defines the foreground and background colors for the ensuing characters.

(c) 300-377; various codes within this range are specified to be commands, such as blink control, cursor control, etc.

The character store can be read and written into by use of CHSR. The program may set the address port of this register to the desired character within the character store, and then may load or read that character by using the data port of the register. This allows full user definition of the character set.

The VTV30-H can, under specified conditions, interrupt the processor to advise it of events. This is achieved via an interrupt vector address, which is fixed by jumpers on the module.

**Operation of the VTV30-H**
The picture store contains sufficient information to display one complete screen. When set to display, the controller performs the following:

(a) reads data from the picture store in a sequential manner

(b) uses the data so obtained
   - as an address to the character store
   - as color information

(c) routes the color data through the output circuitry, so that at the appropriate instant on the T.V. raster, the correct color is displayed
The reading of the data from the picture store and subsequent processing is, once enabled, entirely invisible to the programmer, and the manipulation of data in the various memories is the means by which the display is updated by software.

To position the cursor at any point on the screen, the X and Y coordinates are loaded into the cursor address register, with the Cursor Enable bit in the CSR set. When the scan coincides with the cursor position, the character in that position flashes black and white at a pre-specified frequency.

Any character loaded into the picture store is loaded at the cursor position; thus, the cursor address register acts as the loading address of the picture store, as well as a facility to aid interaction between the computer and the operator.

**SPECIFICATIONS**

**Hardware Supplied**

**Modules:**

One Hex and one Quad module to fit into two adjacent LSI-11 backplane slots.

**Cables:**

1. One 50-way and one 40-way berg-to-berg cable to connect the modules together.
2. Four 75-ohm coaxial cables to connect the T.V. monitor.

**NOTE:** These cables are approximately 50cm long to facilitate easy removal of the modules from the mounting box used. Four standard coaxial cable lengths with B.N.C. connectors on each end will normally be required to connect to the T.V. monitor.

**Electrical Requirements**

**D.C. Power:**

<table>
<thead>
<tr>
<th>Maximum</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5V @ 6A</td>
<td>+5V @ 4A</td>
</tr>
<tr>
<td>+15V @ 0.75A</td>
<td>+15V @ 0.25A</td>
</tr>
<tr>
<td>-15V @ 3mA</td>
<td>-15V @ 2mA</td>
</tr>
</tbody>
</table>

Typical figures are those obtained by measurements on units in an idle state (no program-initiated memory cycles) with a character matrix of 8 x 8 and in 625-line mode.
**VTV30-H**

**Logic:** Transistor-Transistor Logic (TTL) with TTL-compatible Metal-Oxide Semiconductor (MOS) memories.

**Operation Specifications**

<table>
<thead>
<tr>
<th>Character Set:</th>
<th>128 user-defined characters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Format and</td>
<td>Software selectable.</td>
</tr>
<tr>
<td>Character Size Matrix:</td>
<td></td>
</tr>
<tr>
<td>Number of Colors:</td>
<td>Seven, plus black.</td>
</tr>
<tr>
<td>Interrupt Vector:</td>
<td>Vector defined by jumpers: normally 170. Priority defined by position on LSI bus.</td>
</tr>
<tr>
<td>Bus Loading:</td>
<td>The controller imposes two unit loads on the LSI-11 I/O bus.</td>
</tr>
<tr>
<td>Video Output Signals:</td>
<td>Hardware selectable to either:</td>
</tr>
<tr>
<td></td>
<td>a) CCIR 625-line T.V. standard OR</td>
</tr>
<tr>
<td></td>
<td>b) NTSC 525-line T.V. standard</td>
</tr>
</tbody>
</table>
CHAPTER 16
TRADITIONAL PRODUCTS PROFILE

GENERAL DESCRIPTION

The purpose of this appendix is to provide a reference guide to DIGITAL products that have made a major impact in the marketplace, but are currently being enhanced or replaced with new products.

TERMINALS

VT52

The VT52 is an upper- and lower-case ASCII video terminal whose display holds 24 lines of 80 characters.

The VT52's human-engineering features include a clicking sound which provides feedback to the operator when keys are typed, a roll-over feature that lets the terminal get the message straight even if two or three keys are pressed at once, and a standard typewriter keyboard layout.

The VT52 also provides a "two-way" keypad. In one mode, the keypad is used to generate program-compatible numeric codes. Applications which require much numeric input can use the VT52 without modifying hardware or software, while the operator uses the convenient "numeric pad." Or software may place the VT52 in the alternate mode, in which each key on the keypad transmits a unique Escape sequence. This allows the host computer to distinguish between keys typed on the auxiliary keypad and similar keys on the main keyboard. In this mode, each key on the keypad can be used to invoke a user-defined function.

The VT52 has a wide range of cursor-positioning functions. As well as moving the cursor one position in any direction, software can move the cursor to any position on the screen with a Direct Cursor Addressing command which specifies the destination of the cursor. The VT52 also offers fixed horizontal tabs, a Cursor-to-Home command, and two screen-erasure functions. Data on the screen scrolls up when a line feed function is performed with the cursor on the bottom line; it scrolls down when a reverse line feed function is performed with the cursor on the top line.

DATA COMMUNICATIONS EQUIPMENT

DJ11

The DJ11 consists of a single system unit with all the necessary mod-
ules to implement a 16-line data-only multiplexer. In addition, an H317
distribution panel is also furnished to provide the appropriate line
termination.

The distribution panel mounts either in an H960 and H9600 19-inch
cabinet or to a wall. Connections are made to the panel by cinch EIA
connectors or 20mA screw-type connectors.

**DF01-A Acoustic Telephone Coupler**
The DF01-A acoustic coupler can be used to connect DIGITAL and
other terminals to remote computing systems via ordinary telephone
sets and the public switched telephone network.

Both 0-20 milliamp Teletype current loop and EIA RS-232-C interfaces
are standard in the DF01-A.

Through slide switches, the user may choose either full- or half-duplex
operation.

"Sound-seal" cushions on the DF01-A hold the telephone handset
firmly in position and provide excellent acoustic shielding. Good dura-
bility is provided by an injection-molded case made of special impact-
resistant material. All electronic circuitry, switches and connectors are
mounted on a single printed circuit board.

**DN11 Automatic Calling Unit Interface**
The DN11 and the Bell 801 Automatic Calling Unit (ACU) will allow any
PDP-11 to dial any telephone number in the Direct Distance Dial
Network and establish a data link. The DN11 is a digit-buffered inter-
face, and digits to be dialed are presented as four-bit binary numbers.
The interface drives the ACU with EIA RS-232-C voltages and is con-
ected via a standard 25-pin plug.

The programmer has access to all lines of the 801 through the DN11.
The 801 presents the following leads to the DN11: Power Indicator,
Data Line Occupied, Abandon Call and Retry, Data Set Status and
Present Next Digit. The DN11 provides the following leads to the 801:
Digit Present, Call Request and four digit leads.

Because the PDP-11 UNIBUS serves as a multiplexer, multiple au-
tomatic calling units can be added to the PDP-11. One PDP-11 system
unit accepts up to four 801 ACU interfaces. Each interface looks like
one device to the UNIBUS.

**DU11**
The DU11 is a single-line, program-controlled, double-buffered com-
munications device designed to interface the PDP-11 processor to a
serial synchronous line. The self-contained unit is fully programmable with respect to sync character, character length (5 to 8 bits), and parity selection. The DU11 is ideally suited for interfacing the PDP-11 to high-speed synchronous lines for remote batch, remote data collection, and remote concentration applications. Multiple DU11s on a PDP-11 allow its use as a synchronous line concentrator or front-end synchronous controller to a larger computer. The DU11 provides serial-to-parallel and parallel-to-serial data conversion, voltage level conversion, and modem control for half- or full-duplex operation. The Bell Series 200 synchronous modems or equivalent may be used with the DU11. Modem control is a standard feature of the DU11. The signals needed to establish communications with the Bell Series 200 synchronous modems are present in the Receive Status Register (RxCSR). No transition of control lines emanating from the modem directly causes a change in the state of the transmitter or receiver logic. The DU11 is capable of transmitting data at the following speed:

EIA/CCITT: 9600 bits per second maximum (limited by modem interface level converters).

The DU11 conforms to Electronic Industries Association (EIA) specification RS-232-C and CCITT Recommendation V.24.

H312-A Asynchronous Null Modem
The H312-A null modem allows a user to connect a terminal device to a computer without the use of two modems as would normally be required. It consists of two female 25-pin data-phone sockets mounted on a printed circuit board with the 15 most commonly used wires brought out to split lugs in the center board. The split lug allows users to interconnect the two sockets in any way they wish as long as the pins used are on the split lug interconnection points.

KG11-A Communications Arithmetic Option
The KG11-A is attached to the UNIBUS and is used to compute a cyclic redundancy check (CRC) or longitudinal redundancy check (LRC) for detecting errors in serially transmitted data. It is used with a DU11 serial synchronous line interface to compute the block check character(s) (BCC) appearing at the end of a block of data transmitted over a serial synchronous line.
part III quick reference
APPENDIX A
QUICK REFERENCE FOR
THE DECwriter IV (LA34/38)

Detailed Specifications .............................................. 256
Programming Information ............................................ 260
**LA34/38 SPECIFICATIONS**

**Printer**
- Printing technique: Impact dot matrix
- Print matrix: $7 \times 9$
- Maximum print speed: 45 cps
- Maximum throughput: 30 cps
- Horizontal slew rate: 50 ips
- Single line feed time: 50 msec.
- Vertical slew rate: 5 ips
- Paper type: Cut sheets, roll feed or fanfold, up to four parts
- Paper feed:
  - Friction-feed, platen drive (all models)
  - Tractor drive (standard on some models)
  - Roll paper holder (optional)
- Vertical pitch (lines per inch): 2, 3, 4, 6, 8, or 12
- Horizontal pitch (characters per inch): 10, 12, 13.2, 16.5

**Maximum line length (varies with horizontal pitch)**
- 10 cpi: 132 columns
- 12 cpi: 158 columns
- 13.2 cpi: 168 columns
- 16.5 cpi: 216 columns

**Margins**
- Left, right

**Tabs**
- Up to 217 horizontal tab stops

**Character set**
- ASCII upper/lowercase set

**Other printer features**
- Snap-in cartridge ribbon, cover open interlock, self test, status message, terminal reset, manual last character view, optional paper low/paper out detection
<table>
<thead>
<tr>
<th><strong>Keyboard</strong></th>
<th><strong>Communication</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Typewriter style with multikey rollover</em></td>
<td><strong>Data transfer</strong></td>
</tr>
<tr>
<td><em>18 keys including 4 user-defined special function keys</em></td>
<td>Serial, asynchronous</td>
</tr>
<tr>
<td><em>Local form feed, local line feed, auto repeat on all alphanumerics keys</em></td>
<td><strong>Baud rates</strong></td>
</tr>
<tr>
<td><em>(bits per second)</em></td>
<td>110, 300</td>
</tr>
<tr>
<td><em>Input buffer</em></td>
<td><strong>Switch selectable:</strong></td>
</tr>
<tr>
<td>160 characters</td>
<td>Parity—odd, even, or none (8th bit mark or space transmitted)</td>
</tr>
<tr>
<td><em>Auto XON/XOFF</em></td>
<td><strong>ANSI New Line</strong></td>
</tr>
<tr>
<td><em>Auto Line Feed</em></td>
<td><strong>Local Echo</strong></td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td><strong>Full EIA standard</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Physical Characteristics</strong></th>
<th><strong>Dimensions</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>55.9cm (22 in.)</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>39.4cm (15.5 in.)</td>
</tr>
<tr>
<td><strong>Height</strong></td>
<td>16.4cm (6.5 in.)</td>
</tr>
<tr>
<td><strong>Terminal weight</strong></td>
<td>10 kg (22 lbs.)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>90-128 Vac</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>180-256 Vac</td>
</tr>
<tr>
<td><em>(switch-selectable)</em></td>
<td><strong>Printing</strong></td>
</tr>
<tr>
<td></td>
<td>45 W maximum</td>
</tr>
<tr>
<td><strong>Non-printing</strong></td>
<td>25 W maximum</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td><strong>Operating</strong></td>
</tr>
<tr>
<td></td>
<td>10° to 40°C (50 to 104°F)</td>
</tr>
<tr>
<td><strong>Nonoperating</strong></td>
<td></td>
</tr>
</tbody>
</table>
Relative Humidity

Operating 10 to 90% with a maximum wet bulb temperature of 28°C (82°F) and a minimum dew point of 2°C (36°F), noncondensing

Nonoperating 5% to 95%, noncondensing

Paper Requirement

Roll Feed

Width 7.6cm - 37.8cm (3 in. - 14 7/8 in.)

Weight

Single-part 6.8 kg (15 lb.) paper minimum

Roll diameter 11.3cm (4½ in.) maximum

Core diameter 1 in.

NOTES

1. Cut sheet or roll paper may be used
2. Multipart forms are not recommended
3. Impact paper is not recommended
4. Card stock is not recommended

Pin Feed

Width 7.6cm - 37.8cm (3 in. - 14 7/8 in.)

Weight 6.8 kg (15 lbs.) paper minimum

Single-part 0.25mm (0.01 in.) thick card stock maximum

Multipart 1 to 4 parts (see notes) 0.5mm (0.02 in.) thick maximum

NOTES

1. Multipart forms may have only one card part; the card must be the last part
2. First-surface impact paper is not recommended
3. Dot or line glue margins are acceptable (if line is on one margin only)
4. Split-forms (forms with each side containing a different number of sheets) are not recommended
Quick Reference—DECwriter IV

Ribbon
Cartridge
Dimensions
Length 10.6cm (4.2 in.)
Width 14.2cm (5.6 in.)
Height 1.4cm ± .05cm (.6 in. ± .02 in.)

Ribbon Fabric
Material Nylon, non-textured
Thickness .08mm - .12mm (.0034 in. - .0024 in.)
Width 1.3cm ± .04cm
Ribbon Life 16 hours of continuous printing
PROGRAMMING INFORMATION
The DECwriter IV responds to software which is based on ANSI (American National Standards Institute) standards.\textsuperscript{1} The DECwriter IV will simply ignore any ANSI control function that it does not recognize.

NOTE
For a complete listing of the ANSI control functions which may be used to program the LA34/38, consult the LA34/38 Users Guide.

SYNCHRONIZATION
When the DECwriter IV receives a character (other than the fill character, NUL and DEL), it stores it in its 130-character input buffer. When the printer is ready, characters are fetched from the input buffer and printed. If the printer falls behind by more than 130 characters, the input buffer overflows and data are lost. There are two ways to avoid buffer overflows.

1. Send data only as fast as it can be printed. When receiving data at 300 baud or less, the DECwriter IV can keep up with normal character sequences. Fill characters may be used to maintain throughput when horizontal tabs are used.

2. Use a terminal synchronization protocol, such as XON/XOFF. Using a synchronization protocol, the DECwriter IV can tell the data source when to pause in sending data and when to resume. Synchronization allows maximum throughput and eliminates the need for fill character calculations and message size limits.

When synchronization is used, the DECwriter IV constantly monitors the number of characters stored in its input buffer. When the number of characters exceeds a "high water mark" (100 characters), the DECwriter IV signals the data source to temporarily pause. Meanwhile the printer continues to take characters out of the input buffer. When the number of characters remaining is less than a "low water mark" (10 characters), the DECwriter IV signals transmission to resume.

The DECwriter IV also sends a pause signal when the printer is not ready due to error conditions or operator actions. Running out of paper or detecting a printhead jam can cause a pause request to be sent. The operator can induce a pause request by opening the cover or entering SET-UP mode.

\textsuperscript{1} ANSI X3.4-1977, X3.41-1974, X3.64-1979
The pause and resume signals to the data source are sent using the control character XON (octal code 021) and XOFF (octal code 023). XON/XOFF is suitable for either local or remote operation, as long as the connection is full-duplex. The XON/XOFF protocol is complicated by the fact that the synchronization characters may be interspersed between the characters typed at the DECwriter IV keyboard. The operator can tell the data source to pause by typing XOFF (CTRL/S) and to resume by typing XON (CTRL/Q). To make sure that neither the buffer controller’s nor the operator’s pause requests are lost, typed characters may be transmitted with an XOFF character immediately following.

**FILL TIME FORMULAS**

**Horizontal Movement**
This movement includes horizontal tabs and horizontal positioning escape sequences. First convert to the actual number of columns moved, then allow:

- 15 milliseconds for each of the first ten columns
- 5.5 milliseconds for each additional column

**Vertical Movement**
This movement includes line feeds, vertical tabs, form feeds, and vertical positioning escape sequences. First convert to the actual number of lines moved, then allow:

- 38 milliseconds for the first line moved up to .42cm (1/6 in.)
- 200 milliseconds for each additional inch

**Product Identification**
The LA34 terminal automatically transmits an answer to the ANSI standard request for device attributes escape sequence.

**Horizontal Pitch**
Horizontal pitch determines the width of printed characters as well as their spacing. The DECwriter IV has four different horizontal pitch selections. Any combination of pitch may be used on a single print line. Changing the horizontal pitch modifies the active column. The resulting new active column is that of the first column boundary at or to the right of the physical position of the previous active column in the old pitch. It is calculated as follows.
Newcol = \frac{1 + (Oldcol - 1) Oldpitch}{Newpitch}

where:

Newcol = The new active column

Newpitch = The new pitch in characters/inch

Oldcol = The old active column

Oldpitch = The old pitch in characters/inch

The division performed above is an integer division. Any remainder or fractional part of the quotient is discarded.

**Horizontal Margins**

Printing is permitted only within the inclusive left and right margins. A carriage return character moves the active column to the left margin. Attempting to move the active column to the left of the left margin sets the active column equal to the left margin.

Note that the maximum column is a function of horizontal pitch.

<table>
<thead>
<tr>
<th>Horizontal Pitch</th>
<th>Maximum Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>132</td>
</tr>
<tr>
<td>12</td>
<td>158</td>
</tr>
<tr>
<td>13.2</td>
<td>174</td>
</tr>
<tr>
<td>16.5</td>
<td>216</td>
</tr>
</tbody>
</table>

**Horizontal Tabs**

The DECwriter IV has 216 possible horizontal tab stops, one for each column. Tab stops are associated with column numbers, not physical positions on the paper. Thus, changing horizontal pitch will also change the physical position of tab stops. Each stop may be set or cleared independently. Setting a stop already set has no effect; the same is true for clearing a stop already cleared. Tab stops may be set or cleared without regard to margins or horizontal pitch.

**Vertical Pitch**

Vertical pitch determines the spacing between lines, not the height of printed characters. Changing vertical pitch does not affect active line number.
Active Column and Active Line
The active column is defined as the column where the next character will normally be printed. The active line is defined as the line where the next character will normally be printed. Column and line numbers begin with one, not zero. Printable characters normally increment the active column. Line feeds normally increment the active line. The active column and active line are collectively known as active position.

If the active column is not greater than the right margin, each printable character is printed at the printing rate and the active column is incremented. Exceeding the right margin generates a carriage return, line feed, and print function. This causes the character which exceeded the right margin to be printed on a new line.

Active position is only loosely linked to the physical position of the DECrwriter IV printhead and paper mechanism. In general, the active column is only recorded when a character is actually printed. Any previous history of active column values is not significant. The active line is different because it may only be advanced. Backward paper motion is not allowed. When the DECrwriter IV is idle, the active and physical positions are identical.

In the DECrwriter IV, bell characters have only an active line attribute. They are not guaranteed to be sounded at any particular column within a line.

Terminal Reset
The DECrwriter IV contains a read-only memory which contains standard SET-UP information. This memory is non-destructible; it cannot be changed or erased. This is useful if there are no special setting requirements, or if a specific starting point for SET-UP is desired. When the terminal receives the reset escape sequence, or when power to the unit is removed and restored, the DECrwriter IV will reset all volatile SET-UP parameters to the following values.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal tab stops</td>
<td>1, 9, 17, 25, 33, 41, 49, 57, 65, 73, 81, 89, 97, 105, 113, 121, 129</td>
</tr>
<tr>
<td>Left Margin</td>
<td>1</td>
</tr>
<tr>
<td>Right Margin</td>
<td>132</td>
</tr>
<tr>
<td>Horizontal pitch</td>
<td>10 cpi</td>
</tr>
<tr>
<td>Vertical pitch</td>
<td>6 lpi</td>
</tr>
</tbody>
</table>
APPENDIX B

QUICK REFERENCE FOR
THE DECwriter III (LA120)

Detailed Specifications ........................................ 266
Options .............................................................. 270
Accessories .......................................................... 271
Programming Information ....................................... 273
Summary of Modem Control Features ...................... 279
## LA120 specifications

**Printer**
- Printing technique: Impact dot matrix, smart bidirectional
- Print matrix (width by height): $7 \times 7$
- Maximum print speed: 180 cps
- Horizontal slew speed: 60 ips
- Single linefeed time: 33 msec.
- Vertical slew speed: 7.5 ips
- Paper feed: Pin-feed, tractor drive
- Paper type: Fanfold, up to six parts (see paper requirements)
- Forms length: 1 to 168 lines
- Vertical pitch (lines per inch): 2, 3, 4, 6, 8, 12

### Horizontal pitch (characters per inch)

- 180 cps: 10, 12, 13.2, 16.5
- 90 cps: 5, 6, 6.6, 8.25

### Maximum line length (varies with horizontal pitch)

- 5 cpi: 66 columns
- 6 cpi: 79 columns
- 6.6 cpi: 87 columns
- 8 cpi: 108 columns
- 10 cpi: 132 columns
- 12 cpi: 158 columns
- 13.2 cpi: 174 columns
- 16.5 cpi: 217 columns

**Margins**
- Left, right, top, bottom

**Tabs**
- Up to 217 horizontal and 168 vertical tab stops; can be set from keyboard or line
Forms storage | True nonvolatile memory (no batteries)
Positioning commands | Horizontal and vertical, absolute and relative
Character set | ASCII upper/lowercase set
National character sets
Standard .
Optional
National character sets
United States
United Kingdom
Optional
Finland
Denmark
Sweden
Germany
Norway
France
APL character set | Optional
Other printer features | Paper out and cover open interlocks, manual and automatic last character view, selectable auto new line, self-test, status message, 4-digit numeric display used as column counter and to set parameters, permanently stored factory set forms and set-up parameters for reference (10 cpi, 6 lpi, 66 lines per form, tab stops every eight columns, etc.)

Keyboard

Keyboard

Typewriter style with multi-key rollover
Selectable auto line feed | Standard
Optional numeric keypad | 18 keys including 4 function keys
Feature selection | Keyboard entry to nonvolatile memory
Other keyboard features | Local form feed key, local line feed key, auto repeat on all alphanumeric keys, and selectable keyclick
### Communication

**Data transfer**: Serial, asynchronous

**Baud rates (bits per second)**: 50, 75, 110, 134, 134.5, 150, 300, 600, 1200, 1800, 2400, 4800, 7200, 9600

**Split speeds (bits per second)**: 600 or 1200 receive, with 75 or 150 transmit; 2400 or 4800 receive, with 300 or 600 transmit

**Parity**: Odd, even, or none (8th bit mark or space transmitted, or data bits only)

**Input buffer**: 1024 characters standard, 4096 characters optional

**Interface**: Full EIA standard (includes auto answer/disconnect)

### Physical

**Dimensions**

- **Width**: 69.9cm (27.5 in.)
- **Height**: 85.1cm (33.5 in.)
- **Depth**: 61.0cm (24.0 in.)

**Weight**

- **Uncrated**: 46.4 kg (102 lbs.)
- **Shipping**: 63.7 kg (140 lbs.)

**Power**

- **Voltage**: 90-128V or 180-256V
- **Frequency**: 47-63 Hz
- **Input current**: 4.2A max. at 115V
- **Heat dissipation—printing**: 440 W max.

**Temperature**

- **Operating**: 10° to 40°C (50° to 104°F)
- **Nonoperating**: -40° to 66°C (-40° to 151°F)

**Relative Humidity**

- **Operating**: 10% to 90% with a maximum wet bulb temperature of 28°C (82°F) and a minimum dewpoint of 2°C (36°F), noncondensing
Nonoperating: 5% to 95%, noncondensing

**Paper Requirements**

**General**
Continuous, fanfold, pin-feed forms

**Width**
7.6cm - 37.8cm (3 in. - 14 7/8 in.)

**Hole spacing**
12.7mm ± 0.25mm (0.500 in. ± 0.010 in.) non-accumulative over 5cm (2 in.)

**Hole diameter**
3.8mm - 4.1mm (0.15 in. - 0.16 in.)

**Forms thickness**

**Single part**
15 lb. paper minimum, 0.25mm (0.010 in.) card stock maximum

**Multipart**
Up to six parts (see notes), 0.50mm (0.020 in.) maximum

**NOTES**

1. Multipart forms may have only one card part. The card part must be the last part.

2. Multipart carbonless forms up to six parts may be used. Ribbon must be used on the top copy. First-surface impact paper is not recommended.

3. Multipart forms with 3- or 4-prong margin crimps on both margins are recommended. Stapled forms are not recommended and may damage tractors and other areas of the machine. Dot or line glue margins are acceptable if line is on one margin only. Line glue on both margins prevents air from escaping and results in poor impressions.

4. Split forms with each side containing a different thickness or number of sheets are not recommended.
OPTIONS

LA12X-DL—Expanded Buffer
Typically the printer receives a series of characters, temporarily stores the characters in a buffer, and then prints the characters one at a time. The DECwriter III contains a standard 1000-character buffer. This option enables the standard buffer to be increased in size to 4000 characters (4K). This option is most useful under the following conditions:

1. **You are communicating over long distances (which often involves a satellite link)** — There may be a delay after the XOFF is sent by your terminal and before it is received by the host computer. The terminal must buffer all the data sent before the computer receives the XOFF. This could result in an overflow of the 1K buffer.

2. **Your host computer does not recognize the XON and XOFF signals** — The extended buffer allows you to run your DECwriter III at 1200 baud without buffer overflow.

3. **You want to get a hardcopy printout from a video terminal** — The extended buffer lets you “fast dump” from the video terminal without synchronization. The DECwriter III could receive the data at 9600 baud, store all the data in the buffer, and then print the screen image at the printing speed of the DECwriter III (180 characters per second).

The DECwriter III buffer control feature is *not* affected by this option. If XON/XOFF and the large buffer is selected, XOFF will still be generated when the number of characters buffered reaches the same preset point. The only difference is that the buffer can now store 4000 characters instead of 1000 characters.

LA12X-AL—20 mA Loop
This option kit includes the 20 mA loop interface, BC05F cable and all associated hardware.
SUPPLIES AND ACCESSORIES

LAXX-KB—Casters
This set of casters attaches to the rear of the cabinet and facilitates terminal mobility.

LAXX-NC—Paper Basket
The paper basket neatly collects and stacks printer paper as it feeds through the printer. The steel constructed unit is 30.5cm long, 40.6cm wide, and 33.0cm high (12 inches long, 16 inches wide, and 13 inches high). It holds up to one complete box of paper. It is shipped with brackets and instructions for easy attachment.

LAXX-KD—Wire Shelf
The wire paper shelf collects fanfold paper as it feeds through the printer. The shelf is 26.7cm long, 45.7cm wide, and 5.1cm high (10½ inches long, 18 inches wide, and 2 inches high). No tools or screws are required for attachment. Instructions are included.

LAXX-KC—Work Surface Shelf
The durable surface shelf attaches to either the left or right side of the terminal and provides convenient workspace to accommodate data printouts, printer paper, manuals, etc. The shelf is 61cm long and 38.7cm wide (24 inches long and 15¼ inches wide). It is shipped with the necessary bars, screws, and instructions for easy attachment.

LAXX-KA—Accessories Kit
The kit includes the following accessories:

1 LAXX-KB—Caster Set
1 LAXX-KD—Work Surface Shelf
1 LAXX-KD—Wire Shelf

The kit is shipped with the necessary brackets, screws, and instructions for easy attachment.

H981-A—Copy Holder
The copy holder improves efficiency, accuracy, and typing speed by furnishing space for viewing reference data at eye level. The copy holder clamps on a desk or table. Minimum eye movement is required as the flexible arm adjusts to the desired position. Attach the copy holder to the LAXX-KC work surface shelf for convenient data reference while using the printer.

12-12375—Dust Cover
The clear vinyl dust cover protects the terminal when not in use.
36-12153-01—Ribbon
DIGITAL-specified nylon ribbon produces excellent print quality and lengthens print head operating life. Ribbon measures 0.5 inch wide by 60 yards long. Ribbons come individually sealed, 12 per box.
PROGRAMMING INFORMATION
The DECwriter III responds to software which is based on ANSI (American National Standards Institute) standards. The DECwriter III will simply ignore any ANSI control function that it does not recognize.

NOTE
For a complete listing of the ANSI Control Functions which may be used to program the LA120, consult the LA120 Users Guide.

Synchronization Limits

<table>
<thead>
<tr>
<th>SET-UP choice</th>
<th>Low limit</th>
<th>High limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (small)</td>
<td>50 chars</td>
<td>60 chars</td>
</tr>
<tr>
<td>1 (large)</td>
<td>256 chars</td>
<td>576 chars</td>
</tr>
</tbody>
</table>

Printable Character Keys
There are 47 keys that generate printable character codes. The relationship between these keys and the SHIFT and CAPS LOCK keys is such that each of the 26 alphabetic keys transmits the lowercase code unless either or both of the SHIFT keys are down, or the CAPS LOCK key is down.

Each nonalphabetic key generates two different codes:
1. One code is generated if neither SHIFT key is down.
2. The other code is generated if either or both of the SHIFT keys are down.

Unlike the SHIFT LOCK key of a typewriter, the CAPS LOCK key does not affect the nonalphabetic keys. The codes for each code-generating key are shown below.

1 ANSI X3.4-1977, X3.41-1974, X3.64-1979
Figure B-1  Octal codes generated by LA120 keyboard  
Shifted codes are shown at the top of the keys  
Unshifted codes are shown at the bottom of the keys
Alternate Keypad Mode
When *Alternate Keypad Mode* is selected during SET-UP, each key on
the 18-key numeric keypad generates a unique escape code rather
than the code which corresponds to the key’s legend.

Alternate Keypad Mode can be selected from the keyboard or by the
software.

<table>
<thead>
<tr>
<th>Key</th>
<th>Code Transmitted Normal</th>
<th>Code Transmitted Alternate Keypad Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF1</td>
<td>ESC O P</td>
<td>ESC O P</td>
</tr>
<tr>
<td>PF2</td>
<td>ESC O Q</td>
<td>ESC O Q</td>
</tr>
<tr>
<td>PF3</td>
<td>ESC O R</td>
<td>ESC O R</td>
</tr>
<tr>
<td>PF4</td>
<td>ESC O S</td>
<td>ESC O S</td>
</tr>
<tr>
<td>ENTER</td>
<td>Same as RETURN key</td>
<td>ESC O M</td>
</tr>
<tr>
<td>, (comma)</td>
<td>, (comma)</td>
<td>ESC O I</td>
</tr>
<tr>
<td>— (dash)</td>
<td>— (dash)</td>
<td>ESC O I</td>
</tr>
<tr>
<td>. (period)</td>
<td>. (period)</td>
<td>ESC O m</td>
</tr>
<tr>
<td>0 (number)</td>
<td>0 (number)</td>
<td>ESC O p</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>ESC O q</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>ESC O r</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>ESC O s</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>ESC O t</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>ESC O u</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>ESC O v</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>ESC O w</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>ESC O x</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>ESC O y</td>
</tr>
</tbody>
</table>
Control Character Keys
There are seven keys that generate control character codes. The codes generated by these keys are independent of the SHIFT and CAPS LOCK keys.

<table>
<thead>
<tr>
<th>Key</th>
<th>Octal Code</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN</td>
<td>015 or 015 012</td>
<td>CR or NL</td>
</tr>
<tr>
<td>LINE FEED</td>
<td>012</td>
<td>LF or NL</td>
</tr>
<tr>
<td>BACK SPACE</td>
<td>010</td>
<td>BS</td>
</tr>
<tr>
<td>TAB</td>
<td>011</td>
<td>HT</td>
</tr>
<tr>
<td>SPACEBAR</td>
<td>040</td>
<td>SP</td>
</tr>
<tr>
<td>DELETE</td>
<td>177</td>
<td>DEL</td>
</tr>
<tr>
<td>ESC</td>
<td>033</td>
<td>ESC</td>
</tr>
</tbody>
</table>

In coded control half-duplex, the RETURN key transmits the turn-around character automatically after transmitting its normal code or codes.

CTRL (Control) Key
When the CTRL key is held down, certain other keys on the terminal keyboard will generate control character codes when they are pressed.

- These control character codes are totally independent of the SHIFT and CAPS LOCK keys.
- It is never necessary to use more than two keys to generate control character codes—you never have to try to hold both the CTRL key and the SHIFT key down and then press another key.
- There is only one CTRL key combination for each of the 32 character codes
Figure B-2 The control characters and octal codes generated by each key when the **CTRL** key is held down
Control Characters
The LA120 receives the following control characters and responds accordingly.

<table>
<thead>
<tr>
<th>Code</th>
<th>Mnemonic</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>NUL</td>
<td>Null</td>
</tr>
<tr>
<td>003</td>
<td>ETX</td>
<td>End of Text</td>
</tr>
<tr>
<td>004</td>
<td>EOT</td>
<td>End of Transmission</td>
</tr>
<tr>
<td>005</td>
<td>ENQ</td>
<td>Enquiry</td>
</tr>
<tr>
<td>007</td>
<td>BEL</td>
<td>Bell</td>
</tr>
<tr>
<td>010</td>
<td>BS</td>
<td>Backspace</td>
</tr>
<tr>
<td>011</td>
<td>HT</td>
<td>Horizontal Tabulation</td>
</tr>
<tr>
<td>012</td>
<td>LF</td>
<td>Line Feed</td>
</tr>
<tr>
<td>013</td>
<td>VT</td>
<td>Vertical Tabulation</td>
</tr>
<tr>
<td>014</td>
<td>FF</td>
<td>Form Feed</td>
</tr>
<tr>
<td>015</td>
<td>CR</td>
<td>Carriage Return</td>
</tr>
<tr>
<td>016</td>
<td>SO</td>
<td>Shift Out</td>
</tr>
<tr>
<td>017</td>
<td>SI</td>
<td>Shift In</td>
</tr>
<tr>
<td>020</td>
<td>DLE</td>
<td>Data Link Escape</td>
</tr>
<tr>
<td>030</td>
<td>CAN</td>
<td>Cancel</td>
</tr>
<tr>
<td>032</td>
<td>SUB</td>
<td>Substitute</td>
</tr>
<tr>
<td>033</td>
<td>ESC</td>
<td>Escape</td>
</tr>
<tr>
<td>177</td>
<td>DEL</td>
<td>Delete</td>
</tr>
</tbody>
</table>

Control characters not listed above are always ignored when received by the LA120.
<table>
<thead>
<tr>
<th>Feature</th>
<th>DECwriter III</th>
<th>DECwriter IV</th>
<th>DECwriter V</th>
<th>DECwriter V+</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDX Initial Channel</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td>HDX Secondary Channel</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td>Break Action</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td>Calling State</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td>Local Echo</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td>Auto Disconnect</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Buffer Control</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
<td>Enabled</td>
</tr>
<tr>
<td>Auto Answerback</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Modem Setup Choices</td>
<td>(FDX, no modem, XON/OFF enabled)</td>
<td>(FDX, no modem, XON/OFF enabled)</td>
<td>(FDX, no modem, XON/OFF enabled)</td>
<td>(FDX, no modem, XON/OFF enabled)</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
<td>No effect</td>
</tr>
</tbody>
</table>
**EFFECTS OF PAPER OUT**

The DECwriter III operates normally until the physical end of paper passes the print head; then printing ceases. If the data source is using XON and XOFF, no data are lost. If auto disconnect is enabled, the data terminal ready signal becomes unasserted during the paper out and recovery interval. If break is enabled, a break signal is sent when the paper out condition occurs. The possible paper out actions as a function of auto disconnect (D), break enable (U), and XON/XOFF enable (X) SET-UP commands are shown below.

<table>
<thead>
<tr>
<th>X=1</th>
<th>X=0</th>
<th>X=0</th>
</tr>
</thead>
<tbody>
<tr>
<td>U=0 or 1</td>
<td>U=1</td>
<td>U=0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D=0</th>
<th>XOFF</th>
<th>Break</th>
<th>No action</th>
</tr>
</thead>
<tbody>
<tr>
<td>D=1</td>
<td>XOFF</td>
<td>DTR low</td>
<td>DTR low</td>
</tr>
<tr>
<td></td>
<td>then DTR Low</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OPTIONS

Advanced Video Option—VT1XX-AB
The Advanced Video Option enhances the basic VT100 by adding the following features:

- Ten additional lines of 132 column display—this capability is added to the VT100 by providing additional display memory. The screen can now display a total of 24 lines in either 80- or 132-column format.

- Additional character attributes—the VT100 is now capable of highlighting any character(s) on the screen in any of the following ways:
  - Bold
  - Blink
  - Underline
  - Reverse
  - Any combination of the above

- Capability of an additional character generator ROM—this capability is added to the VT100 by providing the memory required to access a second character generator ROM.

20 mA Current Loop Option—VT1XX-AA
This plug-in adapter provides a switch-selectable active or passive 20 mA current loop interface complete with cable.
PROGRAMMING INFORMATION

The VT100 responds to software based on either the previous DIGITAL standard or ANSI standards
The VT100 has a “VT52 compatible” mode in which the VT100 responds to control sequences as a VT52. In this mode, most of the new VT100 features cannot be used, but it does permit the use of existing DIGITAL software designed around the VT52.

The American National Institute (ANSI) has standardized control functions of terminals in documents ANSI X3.4-1977, X3.41-1974, and X3.64-1979. All new software should be designed around the VT100 “ANSI mode.” Future DIGITAL video terminals will not necessarily be committed to VT52 compatibility.

NOTE
ANSI standards may be obtained by writing:
Sales Department
American National Standards Institute
1430 Broadway
New York, New York 10018

The Keyboard
The VT100 uses a keyboard with a key arrangement similar to an ordinary office typewriter. In addition to the standard typewriter keys, the VT100 keyboard has additional keys and indicators used to generate control sequences, cursor control commands, and to show the current terminal status.

LED Indicators
The keyboard has seven light emitting diodes (LEDs). 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 terminal due to a full buffer or by the host through the transmission of an XOFF to the terminal.

The four remaining LEDs are programmable and can be assigned any meaning for specific applications.
SET-UP
The SET-UP key is at the upper left corner of the main key array. Operations performed in SET-UP mode can be stored in nonvolatile memory (NVR) so that turning the terminal power off does not, by itself, alter the terminal configuration.

<table>
<thead>
<tr>
<th>SET-UP Feature or Machine State</th>
<th>Changeable from Host Computer*</th>
<th>Saved in NVR and Changeable in SET-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternate keypad mode</td>
<td>Yes (DECKPAM/DECKPNM)</td>
<td>No</td>
</tr>
<tr>
<td>ANSI/VT52</td>
<td>Yes (DECANM)</td>
<td>Yes</td>
</tr>
<tr>
<td>Auto repeat</td>
<td>Yes (DECARM)</td>
<td>Yes</td>
</tr>
<tr>
<td>AUTO XON XOFF</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Bits per character</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Characters per line</td>
<td>Yes (DECCOLM)</td>
<td>Yes</td>
</tr>
<tr>
<td>Cursor</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Cursor key mode</td>
<td>Yes (DECKKM)</td>
<td>No</td>
</tr>
<tr>
<td>Interlace</td>
<td>Yes (DECINLM)</td>
<td>Yes</td>
</tr>
<tr>
<td>New Line</td>
<td>Yes (LNM)</td>
<td>Yes</td>
</tr>
<tr>
<td>Keyclick</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Margin bell</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Origin mode</td>
<td>Yes (DECOM)</td>
<td>No</td>
</tr>
<tr>
<td>Parity</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Parity sense</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Power</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Receive speed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Screen</td>
<td>Yes (DECSCNM)</td>
<td>Yes</td>
</tr>
<tr>
<td>Scroll</td>
<td>Yes (DECSCLM)</td>
<td>Yes</td>
</tr>
<tr>
<td>Tabs</td>
<td>Yes (HTS/TBC)</td>
<td>Yes</td>
</tr>
<tr>
<td>Transmit speed</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Wraparound</td>
<td>Yes (DECAWM)</td>
<td>Yes</td>
</tr>
<tr>
<td>#£3(shifted)</td>
<td>Yes (SCS)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* The appropriate control or escape sequence mnemonic is indicated in parentheses.
Keyboard Operation
The operator uses the keyboard to transmit codes to the host. Some keys transmit one or more codes to the host immediately when typed. Other keys, such as CTRL and SHIFT, do not transmit codes when typed, but modify the codes transmitted by other keys. The code-transmitting keys cause the terminal to make a clicking sound to verify to the operator that the keystroke has been processed by the terminal. If two code-transmitting keys are pressed together, two codes will be transmitted according to the order in which the keys were typed. The terminal will not wait for the keys to be lifted, but will transmit both codes as soon as possible after the keys are first typed. If three such keys are pressed simultaneously, the codes for the first two keys are transmitted immediately; the code for the third will be transmitted when one of the first two keys is lifted.

Alphabetic Keys — The VT100 will transmit the lowercase unless either or both of the SHIFT keys are down, or unless the CAPS LOCK key is down. Pressing the CAPS LOCK key will lock only the 26 alphabetic keys in the shifted (uppercase) mode.

Nonalphabetic Keys — Each of the nonalphabetic keys can be used to generate two different codes. One code will be generated if neither SHIFT key is pressed. The other code will be generated if either or both of the SHIFT keys are down. Unlike the SHIFT LOCK key of a typewriter, the CAPS LOCK key does not affect these keys; it affects only alphabetic keys.
<table>
<thead>
<tr>
<th>Lowercase Character</th>
<th>Neither SHIFT Key Down (Octal)</th>
<th>Uppercase Character</th>
<th>Either or Both SHIFT Keys Down (Octal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>061</td>
<td>!</td>
<td>041</td>
</tr>
<tr>
<td>2</td>
<td>062</td>
<td>@</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>063</td>
<td># or £</td>
<td>043</td>
</tr>
<tr>
<td>4</td>
<td>064</td>
<td>$</td>
<td>044</td>
</tr>
<tr>
<td>5</td>
<td>065</td>
<td>%</td>
<td>045</td>
</tr>
<tr>
<td>6</td>
<td>066</td>
<td>↑</td>
<td>136</td>
</tr>
<tr>
<td>7</td>
<td>067</td>
<td>&amp;</td>
<td>046</td>
</tr>
<tr>
<td>8</td>
<td>070</td>
<td>*</td>
<td>052</td>
</tr>
<tr>
<td>9</td>
<td>071</td>
<td>(</td>
<td>050</td>
</tr>
<tr>
<td>0</td>
<td>060</td>
<td>)</td>
<td>051</td>
</tr>
<tr>
<td>—</td>
<td>055</td>
<td>—</td>
<td>137</td>
</tr>
<tr>
<td>=</td>
<td>075</td>
<td>+</td>
<td>053</td>
</tr>
<tr>
<td>[</td>
<td>133</td>
<td>{</td>
<td>173</td>
</tr>
<tr>
<td>;</td>
<td>073</td>
<td>:</td>
<td>072</td>
</tr>
<tr>
<td>’(apostrophe)</td>
<td>047</td>
<td></td>
<td>042</td>
</tr>
<tr>
<td>, (comma)</td>
<td>054</td>
<td>&lt;</td>
<td>074</td>
</tr>
<tr>
<td>. (period)</td>
<td>056</td>
<td>&gt;</td>
<td>076</td>
</tr>
<tr>
<td>/</td>
<td>057</td>
<td>?</td>
<td>077</td>
</tr>
<tr>
<td>\</td>
<td>134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>°</td>
<td>140</td>
<td>~</td>
<td>176</td>
</tr>
<tr>
<td>]</td>
<td>135</td>
<td></td>
<td>175</td>
</tr>
</tbody>
</table>
**Function Keys** — There are several keys on the keyboard which transmit control codes. Control codes do not produce displayable characters but are codes for functions. If these codes are received by the terminal, the VT100 will perform the associated function as shown below.

<table>
<thead>
<tr>
<th>Key</th>
<th>Octal Values of Code Sent or Received by VT100</th>
<th>Action The Terminal Would Take If Host Sent That Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>RETURN*</td>
<td>015</td>
<td>Carriage return function</td>
</tr>
<tr>
<td>LINE FEED</td>
<td>012</td>
<td>Line feed</td>
</tr>
<tr>
<td>BACK SPACE</td>
<td>010</td>
<td>Backspace function</td>
</tr>
<tr>
<td>TAB</td>
<td>011</td>
<td>Tab function</td>
</tr>
<tr>
<td>SPACE BAR</td>
<td>040</td>
<td>Deposit a space on the screen, erasing what was there before</td>
</tr>
<tr>
<td>ESC</td>
<td>033</td>
<td>The initial delimiter of an escape sequence—interpret the following character string from the host as a command, rather than displaying it</td>
</tr>
<tr>
<td>DELETE</td>
<td>177</td>
<td>Ignored by the VT100</td>
</tr>
</tbody>
</table>

* The RETURN key can be redefined so that it issues 015<sub>8</sub> 012<sub>8</sub> (carriage return, line feed). The New Line feature in SET-UP mode provides this capability.

**CTRL (Control)** — The CTRL key is used in conjunction with other keys on the keyboard to generate control codes. If the CTRL key is held down when any of the keys shown below are typed, the code actually transmitted is in the range 000<sub>8</sub> - 037<sub>8</sub>.
<table>
<thead>
<tr>
<th>Key Pressed with CTRL key down (shifted or unshifted)</th>
<th>Octal Code Transmitted</th>
<th>Function Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Bar</td>
<td>000</td>
<td>NUL</td>
</tr>
<tr>
<td>A</td>
<td>001</td>
<td>SOH</td>
</tr>
<tr>
<td>B</td>
<td>002</td>
<td>STX</td>
</tr>
<tr>
<td>C</td>
<td>003</td>
<td>ETX</td>
</tr>
<tr>
<td>D</td>
<td>004</td>
<td>EOT</td>
</tr>
<tr>
<td>E</td>
<td>005</td>
<td>ENQ</td>
</tr>
<tr>
<td>F</td>
<td>006</td>
<td>ACK</td>
</tr>
<tr>
<td>G</td>
<td>007</td>
<td>BELL</td>
</tr>
<tr>
<td>H</td>
<td>010</td>
<td>BS</td>
</tr>
<tr>
<td>I</td>
<td>011</td>
<td>HT</td>
</tr>
<tr>
<td>J</td>
<td>012</td>
<td>LF</td>
</tr>
<tr>
<td>K</td>
<td>013</td>
<td>VT</td>
</tr>
<tr>
<td>L</td>
<td>014</td>
<td>FF</td>
</tr>
<tr>
<td>M</td>
<td>015</td>
<td>CR</td>
</tr>
<tr>
<td>N</td>
<td>016</td>
<td>SO</td>
</tr>
<tr>
<td>O</td>
<td>017</td>
<td>SI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key Pressed with CTRL key down (shifted or unshifted)</th>
<th>Octal Code Transmitted</th>
<th>Function Mnemonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>020</td>
<td>DLE</td>
</tr>
<tr>
<td>Q</td>
<td>021</td>
<td>DC1 or XON</td>
</tr>
<tr>
<td>R</td>
<td>022</td>
<td>DC2</td>
</tr>
<tr>
<td>S</td>
<td>023</td>
<td>DC3 or XOFF</td>
</tr>
<tr>
<td>T</td>
<td>024</td>
<td>DC4</td>
</tr>
<tr>
<td>U</td>
<td>025</td>
<td>NAK</td>
</tr>
<tr>
<td>V</td>
<td>026</td>
<td>SYN</td>
</tr>
<tr>
<td>W</td>
<td>027</td>
<td>ETB</td>
</tr>
<tr>
<td>X</td>
<td>030</td>
<td>CAN</td>
</tr>
<tr>
<td>Y</td>
<td>031</td>
<td>EM</td>
</tr>
<tr>
<td>Z</td>
<td>032</td>
<td>SUB</td>
</tr>
<tr>
<td>[</td>
<td>033</td>
<td>ESC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>]</td>
<td>034</td>
<td>FS</td>
</tr>
<tr>
<td>~</td>
<td>035</td>
<td>GS</td>
</tr>
<tr>
<td>?</td>
<td>036</td>
<td>RS</td>
</tr>
<tr>
<td></td>
<td>037</td>
<td>US</td>
</tr>
</tbody>
</table>
Cursor Control — The keyboard also contains four keys labeled with arrows in each of four directions. These keys transmit control sequences. If the host echoes these control sequences back to the terminal, the cursor will move one character up, down, right, or left.

<table>
<thead>
<tr>
<th>Cursor Key (Arrow)</th>
<th>VT52* Mode</th>
<th>ANSI Mode and Cursor Key Mode Reset</th>
<th>ANSI Mode and Cursor Key Mode Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up</td>
<td>ESC A</td>
<td>ESC[A</td>
<td>ESC O A</td>
</tr>
<tr>
<td>Down</td>
<td>ESC B</td>
<td>ESC[B</td>
<td>ESC O B</td>
</tr>
<tr>
<td>Right</td>
<td>ESC C</td>
<td>ESC[C</td>
<td>ESC O C</td>
</tr>
<tr>
<td>Left</td>
<td>ESC D</td>
<td>ESC[D</td>
<td>ESC O D</td>
</tr>
</tbody>
</table>

Auxiliary Keypad — The keys on the auxiliary keypad normally transmit the codes for the numerals, decimal point, minus sign, and comma. In addition, the key labeled ENTER transmits the same code as the RETURN key. The host cannot tell if these keys were typed on the auxiliary keypad as opposed to the corresponding keys on the main keyboard. Therefore, software which requires considerable numeric data entry need not be rewritten to use the keypad.

However, if software must be able to distinguish between pressing a key on the auxiliary keypad and pressing the corresponding key on the main keyboard, the host can give the terminal a command to place it in keypad application mode. In keypad application mode, all keys on the auxiliary keypad are defined to give control sequences which may be used by the host as user-defined functions.

NOTE
None of the keys are affected by pressing the SHIFT, CAPS LOCK, or CTRL keys.
### VT52 Mode Auxiliary Keypad Codes

<table>
<thead>
<tr>
<th>Key</th>
<th>Keypad Numeric Mode</th>
<th>Keypad Application Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>ESC?p</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>ESC?q</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>ESC?r</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>ESC?s</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>ESC?t</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>ESC?u</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>ESC?v</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>ESC?w</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>ESC?x</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>ESC?y</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key</th>
<th>Keypad Numeric Mode</th>
<th>Keypad Application Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ESC?m</td>
</tr>
<tr>
<td>,(comma)</td>
<td></td>
<td>ESC!?</td>
</tr>
<tr>
<td>.(period)</td>
<td></td>
<td>ESC?n</td>
</tr>
<tr>
<td>ENTER</td>
<td>Same as RETURN</td>
<td></td>
</tr>
</tbody>
</table>

- The last character of this escape sequence is a lowercase L (154₄).
### ANSI Mode Auxiliary Keypad Codes

<table>
<thead>
<tr>
<th>Key</th>
<th>Keypad Numeric Mode</th>
<th>Keypad Application Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>ESC O p</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>ESC O q</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>ESC O r</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>ESC O s</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>ESC O t</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>ESC O u</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>ESC O v</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>ESC O w</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>ESC O x</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>ESC O y</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key</th>
<th>Keypad Numeric Mode</th>
<th>Keypad Application Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ESC O m</td>
</tr>
<tr>
<td>,(comma)</td>
<td></td>
<td>ESC O l*</td>
</tr>
<tr>
<td>.(period)</td>
<td></td>
<td>ESC O n</td>
</tr>
<tr>
<td>ENTER</td>
<td></td>
<td>Same as RETURN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key</th>
<th>Keypad Numeric Mode</th>
<th>Keypad Application Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF1</td>
<td>ESC O P</td>
<td>ESC O P</td>
</tr>
<tr>
<td>PF2</td>
<td>ESC O Q</td>
<td>ESC O Q</td>
</tr>
<tr>
<td>PF3</td>
<td>ESC O R</td>
<td>ESC O R</td>
</tr>
<tr>
<td>PF4</td>
<td>ESC O S</td>
<td>ESC O S</td>
</tr>
</tbody>
</table>

* The last character of this escape sequence is a lowercase L (154₉).

### NOTE

In ANSI mode, if the codes are echoed back to the VT100, or if the terminal is in local mode, the last character of the sequence will be displayed on the screen; e.g., PF1 will display a "P."
**Quick Reference—VT100**

**Special Graphics Characters** — If the Special Graphics set is selected, the graphics for ASCII codes 137<br>through 176 will be replaced as indicated.

<table>
<thead>
<tr>
<th>Octal Code</th>
<th>Graphics with US or UK Set</th>
<th>Graphic with “Special Graphics” Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>137</td>
<td>—</td>
<td>Blank</td>
</tr>
<tr>
<td>140</td>
<td>\</td>
<td>Diamond</td>
</tr>
<tr>
<td>141</td>
<td>a</td>
<td>Checkerboard (error indicator)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>142</td>
<td>b</td>
<td>Horizontal tab</td>
</tr>
<tr>
<td>143</td>
<td>c</td>
<td>Form Feed</td>
</tr>
<tr>
<td>144</td>
<td>d</td>
<td>Carriage return</td>
</tr>
<tr>
<td>145</td>
<td>e</td>
<td>Line feed</td>
</tr>
<tr>
<td>146</td>
<td>f</td>
<td>Degree symbol</td>
</tr>
<tr>
<td>147</td>
<td>g</td>
<td>Plus/minus</td>
</tr>
<tr>
<td>150</td>
<td>h</td>
<td>New line</td>
</tr>
<tr>
<td>151</td>
<td>i</td>
<td>Vertical tab</td>
</tr>
<tr>
<td>152</td>
<td>j</td>
<td>Lower-right corner</td>
</tr>
<tr>
<td>153</td>
<td>k</td>
<td>Upper-right corner</td>
</tr>
<tr>
<td>154</td>
<td>l</td>
<td>Upper-left corner</td>
</tr>
<tr>
<td>155</td>
<td>m</td>
<td>Lower-left corner</td>
</tr>
<tr>
<td>156</td>
<td>n</td>
<td>+ Crossing lines</td>
</tr>
<tr>
<td>157</td>
<td>o</td>
<td>Horizontal line-Scan 1</td>
</tr>
<tr>
<td>160</td>
<td>p</td>
<td>Horizontal line-Scan 3</td>
</tr>
<tr>
<td>161</td>
<td>q</td>
<td>Horizontal line-Scan 5</td>
</tr>
<tr>
<td>162</td>
<td>r</td>
<td>Horizontal line-Scan 7</td>
</tr>
<tr>
<td>163</td>
<td>s</td>
<td>Horizontal line-Scan 9</td>
</tr>
<tr>
<td>164</td>
<td>t</td>
<td>Left “T”</td>
</tr>
<tr>
<td>165</td>
<td>u</td>
<td>Right “T”</td>
</tr>
<tr>
<td>166</td>
<td>v</td>
<td>Bottom “T”</td>
</tr>
<tr>
<td>167</td>
<td>w</td>
<td>Top “T”</td>
</tr>
<tr>
<td>170</td>
<td>x</td>
<td>Vertical Bar</td>
</tr>
<tr>
<td>171</td>
<td>y</td>
<td>Less than or equal to</td>
</tr>
<tr>
<td>172</td>
<td>z</td>
<td>Greater than or equal to</td>
</tr>
<tr>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>174</td>
<td></td>
<td></td>
</tr>
<tr>
<td>175</td>
<td></td>
<td></td>
</tr>
<tr>
<td>176</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NOTE
1: Codes $152_8$-$156_8$, $161_8$, and $164_8$-$170_8$ are used to draw rectangular grids; each piece of this line drawing set is contiguous with others so that the lines formed are unbroken.

2: Codes $157_8$-$163_8$ give better vertical resolution than dashes and underlines when drawing graphs; using these segments, $120 \times 132$ resolution may be obtained in $132$-column mode with the Advanced Video Option installed.

COMMUNICATION PROTOCOLS

Full-Duplex
The terminal can operate at transmission speeds up to 19,200 baud. However, the terminal may not be able to keep up with incoming data. The terminal stores incoming characters in a 64-character buffer and processes them on a first-in/first-out basis. When the contents of the buffer reach 32 characters, the terminal will transmit $023_8$ (XOFF or DC3). On this signal, the host should suspend its transmission to the terminal. Eventually, if the host stops transmitting, the terminal will deplete the buffer. When 16 characters remain in the buffer, the terminal will transmit $021_8$ (XON or DC1) to signal the host that it may resume transmission.

If the host fails to respond to an XOFF from the terminal in a timely manner, the buffer will continue to fill. When the 64-character capacity of the buffer is exceeded, a condition occurs called “buffer overflow.” To determine if the buffer will overflow, use the following formulas:

No. of characters to overflow = $32 - [3 \times (\text{receiver speed}/\text{transmit speed})]

Time to respond to XOFF = No. of characters to overflow \times (\text{bits per character} + \text{parity bit})/\text{receiver speed}

Two of the terminal functions, Reset and Self-Test, reinitialize the terminal and erase the buffer. This means that if characters are received subsequent to the commands to perform these two functions and are placed in the buffer, the characters would be destroyed without being processed.

To compensate for this, the host may act in one of two ways:

1. Immediately after sending the commands to perform either the Reset or Self-Test functions, the host may act as if it had received
XOFF from the terminal, thus sending no more characters until it receives XON. The terminal will transmit XON only after it completes the specified operation and the XOFF/XON feature is enabled.

2. When the first method cannot be implemented, a delay of no less than 10 seconds may be used to allow the terminal time to complete the invoked function. This method, however, does not guarantee against the loss of data when an invoked function has detected an error; and while this delay is currently adequate, future options may require a change in the time delay.

The XOFF/XON synchronization scheme has an advantage over requiring the host to insert delays or filler characters in its data stream. Requiring a minimum of software support, XON/XOFF ensures that every character or command sent to the VT100 will be processed in correct order. It frees interface programs from all timing considerations and results in more reliable operation.

In addition to the buffer-filling condition, there are two other means of transmitting XOFF and XON; the NO SCROLL key, and CTRL S/CTRL Q. If the XON/XOFF feature is enabled, the VT100 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 buffer empties, the VT100 waits until the operator types the NO SCROLL key again before sending XON.

Also, entering SET-UP mode causes the VT100 to temporarily stop taking characters from the buffer. An XOFF will be sent if the buffer becomes nearly full.

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

If the XON/XOFF feature is disabled, the buffer-filling condition will not send an XOFF, the NO SCROLL key is disabled, and CTRL/S and CTRL/Q will be transmitted as typed.

The VT100 also recognizes received XOFF and XON. Receipt of XOFF will inhibit the VT100 from transmitting any codes except XOFF and XON. From three to seven keystrokes on the keyboard will be stored in a keyboard buffer (some keys transmit two or three codes, e.g., cursor controls). If the keyboard buffer overflows, keyclicks will stop and the KBD LOCKED LED will come on. Transmission resumes upon receipt of XON.
If the user transmits an XOFF to the host (by \texttt{CTRL/S} or \texttt{NO SCROLL}), the host should not echo any further type-in until the user types XON. This places the burden of not overloading the host's output buffer on the user.

Entering and exiting SET-UP clears the keyboard locked condition.

<table>
<thead>
<tr>
<th>CONTROL CHARACTERS</th>
<th>Octal Code</th>
<th>Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUL</td>
<td>000</td>
<td>Ignored on input (not stored in input buffer; see full-duplex protocol)</td>
</tr>
<tr>
<td>ENQ</td>
<td>005</td>
<td>Transmit answerback message</td>
</tr>
<tr>
<td>BEL</td>
<td>007</td>
<td>Sound bell tone from keyboard</td>
</tr>
<tr>
<td>BS</td>
<td>010</td>
<td>Move the cursor to the left one character position, unless it is at the left margin, in which case no action occurs</td>
</tr>
<tr>
<td>HT</td>
<td>011</td>
<td>Move the cursor to the next tab stop, or to the right margin if no further tab stops are present on the line</td>
</tr>
<tr>
<td>LF</td>
<td>012</td>
<td>This code causes a line feed or a new line operation (see new line mode)</td>
</tr>
<tr>
<td>VT</td>
<td>013</td>
<td>Interpreted as LF</td>
</tr>
<tr>
<td>FF</td>
<td>014</td>
<td>Interpreted as LF</td>
</tr>
<tr>
<td>CR</td>
<td>015</td>
<td>Move cursor to left margin on the current line</td>
</tr>
<tr>
<td>SO</td>
<td>016</td>
<td>Invoke G1 character set, as designated SCS control sequence</td>
</tr>
<tr>
<td>SI</td>
<td>017</td>
<td>Select G0 character set, as selected by ESC( sequence</td>
</tr>
<tr>
<td>Control Character</td>
<td>Octal Code</td>
<td>Action Taken</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------</td>
<td>--------------</td>
</tr>
<tr>
<td>XON</td>
<td>021</td>
<td>Causes terminal to resume transmission</td>
</tr>
<tr>
<td>XOFF</td>
<td>023</td>
<td>Causes terminal to stop transmitting all codes except XOFF and XON</td>
</tr>
<tr>
<td>CAN</td>
<td>030</td>
<td>If sent during a control sequence, the sequence is immediately terminated and not executed; it also causes the error character to be displayed</td>
</tr>
<tr>
<td>SUB</td>
<td>032</td>
<td>Interpreted as CAN</td>
</tr>
<tr>
<td>ESC</td>
<td>033</td>
<td>Introduces a control sequence</td>
</tr>
<tr>
<td>DEL</td>
<td>177</td>
<td>Ignored on input (not stored in input buffer)</td>
</tr>
</tbody>
</table>
COMMUNICATION CABLES
The following communication cables are available for use with the VT100. Contact your local DIGITAL sales office for ordering information.

<table>
<thead>
<tr>
<th>Cable Number</th>
<th>Length</th>
<th>Connector Types</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC22A-10</td>
<td>10 ft.</td>
<td>RS-232 (female) to RS-232 (female)</td>
<td>Null modem; direct connection between VT100 and line unit (6-conductor cable)</td>
</tr>
<tr>
<td>BC22A-25</td>
<td>25 ft.</td>
<td>RS-232 (female) to RS-232 (female)</td>
<td>Null modem; direct connection between VT100 and line unit (6-conductor cable)</td>
</tr>
<tr>
<td>BC22B-10*</td>
<td>10 ft.</td>
<td>RS-232 (female) to RS-232 (male)</td>
<td>Extension; connect VT100 to a modem (14-conductor cable)</td>
</tr>
<tr>
<td>BC22B-25*</td>
<td>25 ft.</td>
<td>RS-232 (female) to RS-232 (male)</td>
<td>Extension; connect VT100 to a modem (14-conductor cable)</td>
</tr>
<tr>
<td>BC03M-XX</td>
<td>Variable</td>
<td>RS-232 (female) to RS-232 (female)</td>
<td>Null modem; direct connection between VT100 and line unit</td>
</tr>
<tr>
<td>Cable Number</td>
<td>Length</td>
<td>Connector Types</td>
<td>Purpose</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>-------------------------</td>
<td>----------------------------------------------</td>
</tr>
<tr>
<td>BC05D-XX**</td>
<td>Variable</td>
<td>RS-232 (female) to RS-232 (male)</td>
<td>Extension; connects VT100 to a modem</td>
</tr>
<tr>
<td>BC05F-XX†</td>
<td>Variable</td>
<td>Mate-'N'-Lok</td>
<td>20 mA; direct connection between VT100 with a 20 mA option installed and a line unit</td>
</tr>
</tbody>
</table>

* This cable cannot be used with a DF01-A Acoustic Coupler. Use cable BC05D-XX in its place.

** For use with a DF01-A Acoustic Coupler. Pin 23 of this cable must be disconnected.

† A BC05F-15 cable is shipped with the VT1XX-AA option.
**FILL CHARACTER REQUIREMENTS**

Fill characters are required to keep the VT100 synchronized with the host computer when the XON/XOFF control codes are not used. The table below shows the VT100 fill character requirements for every receive speed at which the terminal is capable of operating. No entry in a column indicates that fill characters are not required in that specific case.

**Control Function**

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>Receive</th>
<th>19200</th>
<th>9600</th>
<th>4800</th>
<th>3600</th>
<th>2400</th>
<th>2000</th>
<th>1800</th>
<th>1200</th>
<th>600</th>
<th>300</th>
<th>200</th>
<th>150</th>
<th>134.5</th>
<th>110</th>
<th>75</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEL, IND, LF, RI (Smooth Scroll feature selected)</td>
<td>DECALN</td>
<td>DECCOLM</td>
<td>ED</td>
<td>NEL, IND, LF, RI (Jump scroll feature selected)</td>
<td>EL</td>
<td>DECINLM</td>
<td>All others except DECTST and RIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>384</td>
<td>243</td>
<td>243</td>
<td>90</td>
<td>60</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19200</td>
<td>192</td>
<td>122</td>
<td>122</td>
<td>45</td>
<td>30</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9600</td>
<td>96</td>
<td>61</td>
<td>61</td>
<td>23</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4800</td>
<td>72</td>
<td>46</td>
<td>46</td>
<td>17</td>
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APPENDIX D
LOCAL TERMINAL TO COMPUTER CABLEING REQUIREMENTS

This table is specifically designed to provide information regarding local-terminal-to-computer cabling requirements, and does not apply to remote communications via modems. All terminals listed must be connected via either a null modem (H312A) or a null-modem cable.

The table is set up with current terminal equipment on the extreme left and current communications controllers on the extreme right, with respective adjacent columns indicating what cables, if any, are supplied with the appropriate equipment. The middle column indicates what connector cabling is required to hook up any listed terminal with any listed communications device.

Terminals and communications equipment is also divided into two main categories, asynchronous and synchronous. All but the VT62 block mode terminal are asynchronous devices. The VT62 has the capability of either asynchronous or synchronous communication, and is separated on the table.

Example 1: If a user wanted to hook up a VT52 video display terminal to a DZ11-A communications interface, the table indicates:
- The VT52 is supplied with a BN52A-7F cable.
- The DZ11-A is not supplied with a cable.
- The connector cable required would be a BC22A-10, -25 to connect to the DZ11-A distribution panel.

Example 2: If a user wanted to hook up an LA120 smart printing terminal to a DZ11-A communications interface, the table indicates:
- The LA120 is not supplied with a cable.
- The DZ11-A is not supplied with a cable.
- The BC22A null-modem cable is required.
- The BC22B connection cable may be employed to connect to the DZ11-A distribution panel.

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<thead>
<tr>
<th>VT52</th>
<th>TERMINAL</th>
<th>CONNECTOR</th>
<th>DZ11-A</th>
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<td>CABLE</td>
<td>DISTRIBUTION</td>
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<td>PANEL</td>
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<th>LA120</th>
<th>NULL MODEM</th>
<th>EXTENSION</th>
<th>DZ11-A</th>
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<td>BC22-A</td>
<td>CABLE</td>
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<tr>
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<table>
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301
### Character Mode Terminals — EIA Interface

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<tr>
<th>Terminal Model</th>
<th>Supplied Cable If Any</th>
<th>Interconnection Devices</th>
<th>Host Equipment</th>
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<td><strong>Asynchronous Communications</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LA36</td>
<td>70-xxxxxxxx</td>
<td>All terminals listed must be connected via either a null modem, H312A, or a null modem cable, BC22A-10, -25 or BC03M-25, -A0(100°), -B5(250°), -E0(500°), -L0(1000°). The H312A does not come supplied with any cables. BC22B-10, -25 extension cables may be used if required.</td>
<td></td>
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<tr>
<td>LS120</td>
<td>70-xxxxxx</td>
<td>BC05C-25 DL11-WB, or DL11-B, etc.</td>
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<tr>
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<td>BN52A-7F</td>
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<td>DLV11</td>
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<tr>
<td>VT55</td>
<td>BN52A-7F</td>
<td>Z11-A, B, E</td>
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<td>BC05C-25</td>
<td>DH11</td>
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<td>+M792 or BC01N-25</td>
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### Block Mode Terminals — EIA Interface

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<td><strong>Asynchronous Communications</strong></td>
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</tr>
<tr>
<td>VT62-AC</td>
<td>BN61B-05</td>
<td>Null-modem device: BC03Z null-modem cable or H312 with BC05D or BC22B extension cable, or a pair of modems. BC05D-10, -25 or BC22B-10, -25 extension cable may be used if required.</td>
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<tr>
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<td>BN61B-05</td>
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<td>DZ11-A, B, E</td>
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### Synchronous Communications

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<th>Host Equipment</th>
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<td>BN61B-05</td>
<td>A modem eliminator or a pair of modems. BC05D-10, -25 extension cable may be used if required.</td>
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<td>BC05C-25 DUP11-DA</td>
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302
### PRINTABLE CHARACTERS

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APPENDIX E
7-BIT ASCII CODE

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<tr>
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<td>016</td>
<td>00011100</td>
</tr>
<tr>
<td>SI</td>
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<tr>
<td>DLE</td>
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<tr>
<td>DC1</td>
<td>021</td>
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</tr>
<tr>
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<td>037</td>
<td>00111111</td>
</tr>
<tr>
<td>DEL</td>
<td>177</td>
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ACK0, ACK1 (Affirmative Acknowledgement) The replies (DLE sequences in binary synchronous communications) indicate that the previous transmission block was accepted by the receiver and that it is ready to accept the next block of the transmission. Use of ACK0 and ACK1 alternately provides sequential checking control for a series of replies. ACK0 is also an affirmative (ready to receive) reply to a station selection (multipoint), or to an initialization sequence (line bid) in point-to-point operation.

acoustic coupler A device that converts electrical signals into audio signals, enabling data to be transmitted over the public telephone network via a conventional telephone handset.

alternate route A secondary path used to reach a destination if the primary path is unavailable.

amplitude modulation (AM) A method of transmission whereby the amplitude of the carrier wave is modified in accordance with the amplitude of the signal wave.

AND gate A circuit with multiple inputs that will function only when signals are present at all inputs.

asynchronous transmission Transmission in which time intervals between transmitted characters may be of unequal length. Transmission is controlled by start and stop elements at the beginning and end of each character. Also called start/stop transmission.

audio frequencies Frequencies that can be heard by the human ear (usually between 15 and 20,000 Hertz) when transmitted as sound waves.

Automatic Calling Unit (ACU) A dialing device supplied by the communication common carriers that permits a business machine to dial calls automatically over the communication networks.

bandwidth The range of frequencies assigned to a channel or system; the difference expressed in Hertz between the highest and lowest frequencies of a band.

baseband signaling Transmission of a signal at its original frequencies, i.e., unmodulated.

baud A unit of signaling speed equal to the number of discrete condition or signal events per second. In asynchronous transmission, the unit of signaling speed corresponding to one unit interval per second,
that is, if the duration of the unit interval is 20 milliseconds, the signaling speed is 50 baud. Baud is the same as "bits per second" only if each signal event represents exactly one bit. A baud is the reciprocal of the unit interval. See also: unit interval.

**Baudot Code** A code for the transmission of data in which five bits represent one character. It is named for Emile Baudot, a pioneer in printing telegraphy. The name is usually applied to the code used in many teleprinter systems, which was first used by Murray, a contemporary of Baudot.

**binary digit (bit)** In binary notation either of the characters 0 or 1. "Bit" is the commonly used abbreviation for binary digit.

**Binary Synchronous Communications (BSC)** A uniform discipline, using a defined set of control characters and control character sequences, for synchronized transmission of binary coded data between stations in a data communications system. Also called BISYNC.

**bit** Abbreviation for Binary Digit.

**bit transfer rate** The number of bits transferred per unit time, usually expressed in bits per second (bps).

**block** A group of bits transmitted as a unit, over which a coding procedure is usually applied for synchronization or error control purposes. See also: packet.

**block check character (BCC)** The result of a transmission verification algorithm accumulated over a transmission block, and normally appended at the end, e.g., CRC, LRC.

**broadband** See wideband.

**buffer** A storage device used to compensate for a difference in the rate of data flow transmitting data from one device to another.

**busy hour** The peak 60-minute period during a business day when the largest volume of communications traffic is handled.

**byte** A binary element string operated upon as a unit and usually shorter than a computer word, e.g., 6-bit, 8-bit, or 9-bit bytes.

**carrier** A continuous frequency capable of being modulated or impressed with a signal.

**carrier system** A means of obtaining a number of channels over a single path by modulating each channel upon a different "carrier" frequency, and demodulating at the receiving point to restore the signals to their original form.

**cathode-ray tube (CRT)** A television-like picture tube used in visual terminals.
CCITT  Comité Consultatif Internationale de Télégraphie et Téléphonie. An international consultative committee that sets international communications usage standards.

central office  The place where communications common carriers terminate customer lines and locate the equipment that interconnects those lines.

channel  That part of a communications system that connects a message source to a message sink. A path for electrical transmission between two or more points. Also called a circuit, facility, line, link, or path.

channel capacity  A term which expresses the maximum data rate that can be handled by the channel.

circuit  In communications, the complete electrical path providing one or two-way communication between two points, comprising associated go and return channels. Compare: channel.

circuit switching  A method of communications where an electrical connection between calling and called stations is established on demand for exclusive use of the circuit until the connection is released. See also: packet switching, message switching.

code  1) A set of unambiguous rules specifying the way in which data may be represented, e.g., the set of correspondences in the Standard Code for Information Interchange. 2) In data communications, a system of rules and conventions according to which the signals representing data can be formed, transmitted, received, and processed. 3) In data processing, to represent data or a computer program in a symbolic form that can be accepted by a data processor.

common carrier  In data communications, a public utility company that is recognized by an appropriate regulatory agency as having a vested interest and responsibility in furnishing communication services to the general public, e.g., Western Union, The Bell System. See also: specialized common carrier, value added service.

communication control character  A functional character intended to control or facilitate transmission over data networks. There are ten control characters specified in ASCII which form the basis for character-oriented communications control procedures. See also: control character.

communications computer  A computer that acts as the interface between another computer or terminal and a network, or a computer controlling data flow in a network. See also: front-end processor, concentrator.
computer network  An interconnection of assemblies of computer systems, terminals, and communications facilities.

concentrator  A communications device that provides communications capability between many low speed, usually asynchronous channels and one or more high speed, usually synchronous channels. Usually different speeds, codes, and protocols can be accommodated on the low speed side. The low speed channels usually operate in contention requiring buffering. The concentrator may have the capability to be polled by a computer, and may in turn poll terminals.

conditioning  The addition of equipment to leased voice-grade lines to provide specified minimum values of line characteristics required for data transmission, e.g., equalization and echo suppression.

connect time  A measure of system usage by a user, usually the time interval during which the user terminal was on-line during a session. Also, the amount of time it takes a switching system to connect the calling party to the called party.

console  1) A part of a computer used for communication between operator or maintenance engineer and the computer. 2) Part of a terminal providing user input and output capability.

contention  A contention on a communications channel is when two or more stations try to transmit at the same time.

control character  1) A character whose occurrence in a particular context initiates, modifies, or stops a control function. 2) In the ASCII code, any of the 32 characters in the first two columns of the standard code table. See also: communications control character.

control procedure  The means used to control the orderly communication of information between stations on a data line. Also called: line discipline. See also: protocol.

control station  The station on a network which supervises the network control procedures such as polling, selecting, and recovery. It is also responsible for establishing order on the line in the event of contention, or any other abnormal situation, arising between any stations on the network. Compare: tributary station.

conversational mode  A procedure for communication between a terminal and the computer in which each entry from the terminal elicits a response from the computer and vice versa.

crosstalk  The unwanted transfer of energy from one circuit, called the disturbing circuit, to another circuit, called the disturbed circuit.
cyclic redundancy check (CRC)  An error detection scheme in which the check character is generated by taking the remainder after dividing all the serialized bits in a block of data by a predetermined binary number.

data access arrangement (DAA)  Data communication equipment furnished or approved by a common carrier, permitting attachment of privately owned data terminal and data communication equipment to the common carrier network.

data collection  The act of bringing data from one or more points to a central point.

data communication  The interchange of data messages from one point to another over communications channels. See also: data transmission.

data communications equipment (DCE)  The equipment that provides the functions required to establish, maintain, and terminate a connection, the signal conversion and coding required for communication between data terminal equipment and data circuits. The data communication equipment may or may not be an integral part of a computer (e.g., a modem). See also: terminal installation.

data concentration  Collection of data at an intermediate point from several low and medium speed lines for retransmission across high speed lines.

data integrity  A performance measure based on the rate of undetected errors.

DATAPAC  Packet switching network provided by the (CCG) Computer Communications Group of the Trans-Canada Telephone System (TCTS).

Data-Phone  A trademark as well as a service mark of the AT&T Company. As a trademark, it identifies the data sets or modems manufactured and supplied by the Bell System for use in the transmission of data over the regular telephone network. As a service mark, it identifies the transmission of data over the regular telephone network.

Data-Phone 50  A public switched communications service of the Bell System featuring high-speed data communications at 50 kbps.

Data-Phone Digital Service (DDS)  A communications service of the Bell System in which data is transmitted in digital rather than analog form, thus eliminating the need for modems.

data set  1) A modem. 2) A collection of data records, with a logical relation of one to another. See also: Data-Phone, modem.
Communications Glossary

data terminal equipment (DTE)  1) The equipment comprising the data source, the data sink, or both. 2) Equipment usually comprising the following functional units: control logic, buffer store, and one or more input or output devices or computers. It may also contain error control, synchronization, and station identification capability. See also: data communication equipment, terminal installation.

DDCMP (Digital Data Communications Message Protocol)  A uniform discipline for the transmission of data between stations in a point-to-point or multipoint data communications system. The method of physical data transfer used may be parallel, serial synchronous, or serial asynchronous.

DECnet  Contraction of Digital Equipment Corporation Networks. A concept or philosophy to allow intercommunication among the systems connected together in a DECnet environment.

delay distortion  Distortion resulting from nonuniform speed of transmission of the various frequency components of a signal through a transmission medium.

delimiter  A character that separates and organizes elements of data.

demodulation  The process of retrieving an original signal from a modulated carrier wave. This technique is used in modems to make communications signals compatible with computer signals.

dial-up line  A communications circuit established by a switched circuit connection.

direct distance dialing (DDD)  A telephone exchange service that enables a user to dial telephones outside his local area directly, without operator assistance.

direct memory access (DMA)  A facility that permits I/O transfers directly into or out of memory without passing through the processor’s general registers; performed either independently of the processor or on a cycle-stealing basis.

DLE (Data Link Escape)  A control character used exclusively to provide supplementary line control signals (control character sequences or DLE sequences). These are two-character sequences where the first character is DLE. The second character varies according to the function desired and the code used.

DNA  DIGITAL Network Architecture. A hardware and software scheme for interconnecting DIGITAL’s computers in a network. It is composed of three elements: Data Access Protocol (DAP), Network Services Protocol (NSP), and DIGITAL Data Communications Message Protocol (DDCMP).
DSDA  Digital Switch Data Service (U.S.A.—Bell System).

duplex  Simultaneous two-way independent transmission in both directions. Also referred to as full duplex.

EBCDIC (Extended Binary Coded Decimal Interchange Code)  An 8-bit character code used primarily in IBM equipment. The code provides for 256 different bit patterns.

echo  A portion of the transmitted signal returned from the distant point to the source with sufficient magnitude and delay to cause interference.

echo check  A method of checking the accuracy of transmission of data in which the received data is returned to the sending end for comparison with the original data.

echo suppressor  A device used to suppress the effects of an echo.

Electronic Industries Association (EIA)  A standards organization specializing in the electrical and functional characteristics of interface equipment.

electronic switching system (ESS)  The common carrier communications switching system which uses solid state devices and other computer-type equipment and principles, in particular, such systems provided by the Bell System.

engaged signal  (UK) An audible signal indicating that the required circuit or intermediate apparatus used in setting up the connection is busy, i.e., not available.

ENQ (Enquiry)  Used as a request for response to obtain identification and/or an indication of station status. In binary synchronous (BSC) transmission, ENQ is transmitted as part of an initialization sequence (line bit) in point-to-point operation, and as the final character of a selection or polling sequence in multipoint operation.

EOT (End of Transmission)  Indicates the end of a transmission, which may include one or more messages, and resets all stations on the line to control mode (unless it erroneously occurs within a transmission block).

EPSS  Experimental Packet Switching System (UK-BPOC).

error  Any discrepancy between a computed, observed, or measured quantity and the true, specified, or theoretically correct value or condition. Systematic error: A constant error or one that varies in a systematic manner (e.g., equipment misalignment). Random error: An error that varies in a random fashion (e.g., an error resulting from radio static).
error control  An arrangement that detects the presence of errors. In some systems, refinements are added that will correct the detected errors, either by operations on the received data or by transmisssion from the source.

Erlang  The international dimensionless unit of traffic intensity. One E is the intensity in a traffic path continuously occupied, aggregate traffic of 1 call-hour per hour, 1 call-minute per minute, etc.

equalization  Compensation for the increase of attenuation with frequency. Its purpose is to produce a flat frequency response.

ETX (End of Text)  Indicates the end of message. If multiple transmission blocks are contained in a message in BSC systems, ETX terminates the last block of the message. (ETB is used to terminate preceding blocks). The block check character is sent immediately following ETX. ETX requires a reply indicating the receiving station’s status.

exchange  A defined area, served by a communications common carrier, within which the carrier furnishes service at the exchange rate and under the regulations applicable in that area as prescribed in the carrier’s filed tariffs.

facility  See channel.

facsimile (FAX)  Transmission of pictures, maps, diagrams, etc. The image is scanned at the transmitter, reconstructed at the receiving station, and duplicated on some form of paper.

FIFO  See: silo.

flip-flop  A circuit that is used to store one bit of information.

foreign exchange line  A line offered by a common carrier in which a termination in one central office is assigned a number belonging to a remote central office.

forward channel  A data transmission channel in which the direction of transmission coincides with that in which information is being transferred. Compare: reverse channel.

frame  See: block.

frequency division multiplexing (FDM)  Dividing the available transmission frequency range into narrower bands, each of which is used for a separate channel.

frequency modulation (FM)  A method of transmission whereby the frequency of the carrier wave is changed to correspond to changes in the information signal wave.
frequency shift keying (FSK)  Also called frequency shift signaling. A method of frequency modulation in which frequency is made to vary at sufficient instants by smooth as well as abrupt transitions. Typically a data “1” bit is represented as one frequency and a data “0” as another frequency.

front-end processor  A communications computer associated with a host computer. It may perform line control, message handling, code conversion, error control and applications functions such as control and operation of special-purpose terminals.

full duplex  See: duplex

fully connected network  A network in which each node is directly connected with every other node.

half duplex  A circuit designed for transmission in each direction but not in both directions simultaneously.

hardware  Physical equipment, as opposed to a computer program or method of use, e.g., mechanical, electrical, magnetic, or electronic devices.

header  The control information prefixed in a message text, e.g., source or destination code, priority, or message type. Also called: heading, leader.

Hertz  A unit of frequency equal to one cycle per second. Cycles are referred to as Hertz in honor of the experimenter Heinrich Hertz. Abbreviated Hz.

holding time  The length of time a communication channel is in use for each transmission. Includes both message time and operating time.

host computer  A computer attached to a network providing primarily services such as computation, data base access, or special programs, or programming languages.

host interface  The interface between a communications processor and a host computer.

hunt group  An arrangement of a group of telephone lines listed as a single telephone number in the directory. A person dialing that listed number is automatically connected by the telephone switching equipment to an available line in that group. Only if all lines in the group are busy does the caller get a busy signal.

information  The organizational content of a signal.

information bit  A bit which is generated by the data source and which is not used for error control by the data transmission system. Compare: overhead bit.
**information path**  The functional route by which information is transferred in a one-way direction from a single data source to a single data sink.

**information retrieval**  That branch of computer technology concerned with techniques for storing and searching large quantities of data and making selected data available. An information retrieval system may or may not be a real-time system.

**information (transfer) channel**  1) The functional connection between the source and the sink data terminal equipment. It includes the circuit and the associated data communications equipment. 2) The assembly of data communications and circuits, including a reverse channel if it exists.

**INTELSAT**  The International Telecommunications Satellite consortium, formed in 1964 with the purpose of creating a worldwide communications satellite system.

**interchange point**  A location where interface signals are transmitted from one piece of equipment to another by means of electrical interconnections. See also: interface.

**interface**  1) A shared boundary defined by common physical interconnection characteristics, signal characteristics, and meanings of interchanged signals. 2) Equipment or a device making possible interoperation between two systems, e.g., a hardware component or a common storage register. 3) A shared logical boundary between two software components.

**ITB (Intermediate Text Block)**  In binary synchronous communications, a control character used to terminate an intermediate block of characters. The block check character is sent immediately following ITB, but no line turnaround occurs. The response following ETB or ETX also applies to all of the ITB checks immediately preceding the block terminated by ETB or ETX.

**ITU**  International Telecommunications Union.

**laser**  Light Amplification by Stimulated Emission of Electronic Radiation; in communications it acts as a communication device with a coherent frequency carrier.

**LDX**  Long Distance Xerography. A name used by the Xerox Corporation to identify its high-speed facsimile system. The system uses Xerox terminal equipment and a wide-band data communication channel.

**leased line**  A line reserved for the exclusive use of a leasing customer without interchange switching arrangements. Also called: private line.
line 1) The portion of a circuit external to the apparatus consisting of the conductors connecting a telegraph or telephone set to the exchange or connecting two exchanges. 2) The group of conductors on the same overhead route in the same cable.

line switching The switching technique of temporarily connecting two lines together so that the stations exchange information directly.

link 1) Any specified relationship between two nodes in a network. 2) A communications path between two nodes. 3) A data line. See also: line, circuit, virtual circuit.

load sharing The distribution of a given load among several computers on a network.

local channel A channel connecting a communication subscriber to a central office.

local exchange An exchange in which subscribers' lines terminate. Also called: end office.

longitudinal redundancy check (LRC) An error checking technique based on an accumulated exclusive-OR of transmitted characters. An LRC character is accumulated at both the sending and receiving stations during the transmission of a block. This accumulation is called the Block Check Character (BCC), and is transmitted as the last character in the block. The transmitted BCC is compared with the accumulated BCC character at the receiving station for an equal condition. An equal comparison indicates a good transmission of the previous block.

loop discount pulsing (UK) A method of signaling which makes use of break pulses in a loop circuit.

mark Presence of a signal. In telegraphy, mark represents the closed condition or current flowing. Equivalent to a binary one condition.

maser Acronym for Microwave Amplification by the Stimulated Emission of Radiation. A device capable of amplifying or generating radio frequency radiation. Maser amplifiers are used in satellite communication ground stations to amplify the extremely weak signals received from communication satellites.

message A communication, prepared for information interchange, in a form suitable for passage through the interchange medium. It includes:

a. all portions of the communication such as machine sensible controls,

b. an indication of the start of the message and the end of the message,
c. a heading containing routing and other information, one or more texts containing the originator-to-addressee communication(s), and the end of text indicator.

message format Rules for the placement of such portions of a message as message heading, address text, and end of message.

message numbering The identification of each message within a communications system by the assignment of a sequential number.

message retrieval The capacity to retrieve a message some time after it has entered an information system.

message switching The switching technique of receiving a message, storing it until the proper outgoing circuit and station are available and then retransmitting it toward its destination.

microwave All electromagnetic waves in the radio frequency spectrum above 890 mHz.

modem (modulator-demodulator) A device that modulates signals transmitted over communications circuits. Also called data set.

modulation The process by which some characteristic of a high frequency carrier signal is varied in accordance with another, a lower frequency "information" signal. This technique is used in modems to make business machine signals compatible with communication facilities.

multiple address message A message to be delivered to more than one destination.

multiplexer A device used for multiplexing. It may or may not be a stored program computer. Also a device for connecting a number of communications lines to a computer.

multiplexing A division of a transmission facility into two or more channels. See also: frequency division multiplexing and time division multiplexing.

multipoint line A single communications line to which more than one terminal is attached. Use of this type of line normally requires some kind of polling mechanism, addressing each terminal with a unique ID. Also called multidrop.

narrowband channels Sub-voice grade channels characterized by a speed range of 100 to 300 bits per second.

negative acknowledgement (NAK) Indicates that the previous transmission block was in error and that the receiver is ready to accept a retransmission of the erroneous block. NAK is also the "not ready"
reply to a station selection (multipoint) or to an initialization sequence (line bid) in point-to-point operation.

**network**  1) A series of points interconnected by communications channels.  2) The switched telephone network is the network of telephone lines normally used for dialed telephone calls.  3) A private network is a network of communications channels confined to the use of one customer.

**noise**  Undesirable disturbances in a communications system. Noise can generate errors in transmission.

**non-switched line**  A communications link which is permanently installed between two points. Also called: leased or private line.

**non-transparent mode**  Transmission of characters in a defined character format, e.g., ASCII or EBCDIC, in which all defined control characters and control sequences are recognized and treated as such.

**NTT**  Nippa Telephone and Telegraph; government owned corporation that furnishes all domestic telecommunication services in Japan.

**null modem**  A device which interfaces between a local peripheral that normally requires a modem, and the computer near it that expects to drive a modem to interface to that device; an initiation modem in both directions.

**off-line**  Pertaining to equipment or devices not under direct control of the central processing unit. May also be used to describe terminal equipment not connected to a transmission line.

**on-line**  Pertaining to equipment or devices in direct communication with the central processing unit.

**one-way only operation**  A mode of operation of a data link in which data is transmitted in a preassigned direction over one channel. Also called: simplex operation.

**operating system**  Software that controls the execution of computer programs and that may provide scheduling, debugging, input and output control, accounting, storage assignment, data management, and related services. Sometimes called supervision, executive, monitor, or master control program, depending on the computer manufacturer.

**operating time**  The time required for dialing the call, waiting for the connection to be established, and coordinating the forthcoming transaction with the personnel or equipment at the receiving end.

**OR gate**  A circuit with multiple inputs that will function when a signal is present at any input.
output  1) Data that has been processed. 2) The state or sequence of states occurring on a specified output channel. 3) The device or collective set of devices used for taking data out of a device. 4) A channel for expressing a state of a device or logic element. 5) The process of transferring data from an internal storage to an external storage device.

overhead bit  A bit other than an information bit, e.g., check bit, framing bit.

packet  A group of bits including data and control elements which is switched and transmitted as a composite whole. The data and control elements and possibly error control information are arranged in a specified format.

packet switching  A data transmission process, utilizing addressed packets, whereby a channel is occupied only for the duration of transmission of the packet. NOTE: In certain data communication networks the data may be formatted into a packet or divided and then formatted into a number of packets (either by the data terminal equipment or by equipment within the network) for transmission and multiplexing purposes. See also: circuit switching, message switching.

parallel transmission  Method of data transfer in which all bits of a character or byte are transmitted simultaneously either over separate communication lines or on different carrier frequencies on the same communication line.

parity check  Addition of non-information bits to data, making the number of ones in each grouping of bits either always odd for odd parity or always even for even parity. This permits single error detection in each group.

phase modulation (PM)  A method of transmission whereby the angle of phase of the carrier wave is varied in accordance with the signal.

point-to-point connection  1) A network configuration in which a connection is established between two, and only two, terminal installations. The connection may include switching facilities. 2) A circuit connecting two points without the use of any intermediate terminal or computer. Compare multipoint connection.

polling  The process of inviting another station or node to transmit data. Compare: selecting.

primary station  1) The station which at any given instant has the right to select and to transmit information to a secondary station, and the responsibility to insure information transfer. There should be only one primary station on a data link at one time. 2) A station which has
control of a data link at a given instant. The assignment of primary status to a given station is temporary and is governed by standardized control procedures. Primary status is normally conferred upon a station so that it may transmit a message, but a station need not have a message to be nominated primary station.

**priority or precedence** Controlled transmission of messages in order of their designated importance, e.g., urgent or routine.

**private line or private wire** A channel or circuit furnished to a subscriber for his exclusive use.

**protocol** A formal set of conventions governing the format and relative timing of message exchange between two communicating processes. See also: control procedure.

**PSTN** Private Switched Telephone Network (UK-BPOC). (Generic term for European telephone carriers.)

**PTT (Post, Telephone and Telegraph Authority)** The governmental agency that functions as the communications common carrier in most areas of the world except North America.

**pulse code modulation (PCM)** Modulation of a pulse train in accordance with a code.

**redundancy** In a protocol, the portion of the total characters or bits that can be eliminated without any loss of information.

**regulatory agency** In data communications, an agency controlling common and specialized carrier tariffs, e.g., the Federal Communications Commission and the state public utility commissions.

**remote station** 1) (multipoint) Synonymous with tributary station. 2) (Point-to-point switched network) A station that can be called by the central station, or can call the central station if it has a message to send.

**repeater** An amplifier designed for two-way amplification in a 2-wire line, or both directions in a 4-wire line.

**reperforator** A device that automatically punches a paper tape from received signals.

**response time** The elapsed time between the generation of the last character of a message at a terminal and the receipt of the first character of the reply. It includes terminal delay, network delay, and service node delay.

**reverse channel** A channel used for transmission of supervisory or error-control signals. The direction of flow of these signals is in the direction opposite to that in which information is being transferred.
The bandwidth of this channel is usually less than that of the forward channel, i.e., the information channel.

**reverse interrupt (RVI)** In binary synchronous communications, a control character sequence (DLE sequence) sent by a receiving station instead of ACK1 or ACK0 to request premature termination of the transmission in progress.

**ring network** A computer network where each computer is connected to adjacent computers.

**SDLC (Synchronous Data Link Control)** A uniform discipline for the transfer of data between stations in a point-to-point, multipoint, or loop arrangement, using synchronous data transmission techniques.

**secondary station** A station that has been selected to receive a transmission from the primary station. The assignment of secondary status is temporary, under control of the primary station, and continues for the duration of a transmission. Compare: primary station.

**selecting** A process of inviting another station or node to receive data. Compare: polling.

**serial transmission** A method of transmission in which each bit of information is sent sequentially on a single channel rather than simultaneously as in parallel transmission.

**signal element** Each of the parts of a digital signal, distinguished from others by its duration, position, and sense, or by some of these features only. In start/stop operation, a signal element has a minimum duration of one unit interval. If several unit intervals of the same sense run together, a signal element of duration of more than one unit element may be formed. Signal elements may be start elements, information elements, or stop elements.

**signal-to-noise ratio (SNR)** Relative power of the signal to the noise in a channel, usually measured in decibels.

**silo** A first-in/first-out (FIFO) hardware buffer used with multiplexers.

**simplex mode** Operation of channel in one direction only, with no capability of reversing.

**slave** A remote system or terminal whose functions are controlled by a central "master" system. It is similar in concept to a host system in that it responds to remotely generated requests, but, unlike a host system, is usually capable of performing a limited range of operations.

**SNA** IBM's System Network Architecture — Similar to DECnet (DNA), it provides a common method of support for a wide range of communication activities sharing a single communications network.
SNA is composed of three elements: Virtual Telecommunication Access Method (VTAM), Network Control Program/Virtual Storage (NCP/VS), and Synchronous Data Link Control (SDLC).

**software** A set of computer programs, procedures, rules and associated documentation concerned with the operation of network computers, e.g., compilers, monitors, editors, utility programs. Compare: hardware.

**specialized common carrier** A company that provides private line communications services, e.g., voice, teleprinter, data, facsimile transmission. See also: common carrier, value added service.

**start element** In start/stop transmission, the first element in each character, which serves to prepare the receiving equipment for the reception and registration of the character.

**start of header (SOH)** A communication control character used at the beginning of a sequence of characters which constitute a machine-sensible address or routing information. Such a sequence is referred to as the heading.

**start of text (STX)** A communication control character that precedes a sequence of characters that is to be treated as an entity and entirely transmitted through to the ultimate destination. Such a sequence is referred to as text. STX may be used to terminate a sequence of characters (heading) started by SOH.

**start/stop transmission** Asynchronous transmission in which a group of code elements corresponding to a character signal is preceded by a start element and is followed by a stop element.

**station** That independently controllable configuration of data terminal equipment from or to which messages are transmitted on a data link. It includes those elements that serve as sources or sinks for the messages, as well as those elements that control the message flow on the link, by means of data communication control procedures. See also: terminal installation.

**STD (Subscriber Trunk Dialing)** European version of Direct Distance Dialing.

**stop element** In start/stop transmission, the last element in each character, to which is assigned a minimum duration, during which the receiving equipment is returned to its rest condition in preparation for the reception of the next character.

**stunt-box** A device to control the nonprinting functions of a teleprinter terminal. Control characters can be sent to it over the communications channel.
supervisory programs  Computer programs that have the primary function of scheduling, allocating, and controlling system resources rather than processing data to produce results.

supervisory sequence  In data communications, a sequence of communication control characters and other characters that perform a defined control function.

switched line  A communications link for which the physical path may vary with each usage, e.g., the dial-up telephone network.

synchronous idle (SYN)  Character used as a time fill in the absence of any data or control character to maintain synchronization. The sequence of two continuous SYN is used to establish synchronization (character phase) following each line turnaround.

synchronous transmission  Transmission in which the data characters and bits are transmitted at a fixed rate with the transmitter and receiver synchronized. This eliminates the need for start/stop elements, thus providing greater efficiency. Compare: asynchronous transmission.

tandem exchange  A telephone switching office that handles traffic among local exchanges.

tariff  1) A published rate for services provided by a common or specialized carrier. 2) The means by which regulatory agencies approve such services. The tariff is a part of a contract between customer and carrier.

telegraphy  A system of communication for the transmission of graphic symbols, usually letters or numerals, by use of a signal code.

Teletype®  Trademark of Teletype Corporation. Usually refers to one of their series of teleprinters.

teletypewriter exchange service (TWX)  A public teletypewriter exchange (switched) service in the United States and Canada, formerly belonging to AT&T Company, now owned by the Western Union Company. Both Baudot and ASCII-coded machines are used.

Telex Service  A Western Union worldwide teletypewriter exchange service that uses the public telegraph network. Baudot equipment is used.

Telpak  The name given to the pricing arrangement by AT&T in which many voice-grade telephone lines are leased as a group between two points.

temporary text delay (TTD)  In binary synchronous communications, a control character sequence (STX...EXQ) sent by a transmitting station either to indicate a delay in transmission or to initiate an abort of the transmission in progress.
terminal  A device or computer which may be connected to a local or remote host system, and for which the host system provides computational and data access services. Two common types of terminals are timesharing (typically interactive keyboard terminals) and remote batch.

terminal installation  1) The totality of equipment at a user's installation including data terminal equipment, data communication equipment, and necessary support facilities. See also: terminal, station.  
                           2) A set composed of data terminal, a signal converter, and possibly intermediate equipment; this set may be connected to a data processing machine or may be part of it.

terminal noise  Electromagnetic noise omitted from hot bodies; sometimes called Johnson noise.

text  1) A sequence of characters forming part of a transmission sent from the data source to the data sink, and containing the information to be conveyed. It may be preceded by a header and followed by an "End of Text" signal. 2) In ASCII as well as in general communications usage, a sequence of characters treated as an entity if preceded by a "Start of Text" and followed by an "End of Text" control character.

tie line  A private line communications channel of the type provided by communications common carriers for linking two or more points together.

time-division multiplexing  A system of multiplexing in which channels are established by connecting terminals one at a time at regular intervals by means of an automatic distribution.

timesharing  A method of operation in which a computer facility is shared by several users for different purposes; the computer makes it appear that the users are all handled simultaneously.

Touch Tone®  AT&T registered trademark for push-button dialing. The signaling form is multiple tones.

transit exchange  European version of tandem exchange.

transparent mode  Transmission of binary data with the recognition of most control characters suppressed. In binary synchronous communications, entry to and exit from the transparent mode is indicated by a sequence beginning with a special Data Link Escape (DLE) character.

tributary station  A station, other than the control station, on a centralized multipoint data communications system, which can communicate with the control station only when polled or selected by the control station.
trunk A single circuit between two points, both of which are switch- ing centers or individual distribution points.

turnaround time 1) The elapsed time between submission of a job to a computing center and the return of results. 2) In communications, the actual time required to reverse the direction of transmission from sender to receiver or vice versa when using a two-way alternate circuit. Time is required by line propagation effects, modem timing, and computer reaction.

two-way alternate operation A mode of operation of a data link in which data may be transmitted in both directions, one way at a time. Also called: half-duplex operation (U.S.).

two-way simultaneous operation A mode of operation of a data link in which data may be transmitted simultaneously in both directions over two channels. NOTE: One of the channels is equipped for transmission in one direction while the other is equipped for transmission in the opposite direction. Also called: full-duplex, duplex.

TWX See: teletypewriter exchange service.

unattended operation The automatic features of a station's operation which permit the transmission and reception of messages on an unattended basis.

unit element A signal element of one unit duration.

unit interval A unit interval is the duration of the shortest nominal signal element. It is the longest interval of time such that the nominal durations of the signal elements in a synchronous system, or the start and information elements in a start/stop system, are whole multiples of this interval. The duration of the unit interval (in seconds) is the reciprocal of the telegraph speed expressed in bits per second.

value added service A communication service utilizing communications common carrier networks for transmission, and providing added data services with separate additional equipment. Such added service features may be store-and-forward message switching, terminal interfacing, and host interfacing.

vertical redundancy check (VRC) A check or parity bit added to each character in a message such that the number of bits in each character, including the parity bit, is odd (odd parity) or even (even parity).

virtual circuit A connection between a source and a sink in a network that may be realized by different circuit configurations during transmission of a message. Also called logical circuit.
voice-grade channel  A channel used for speech transmission, usually with an audio frequency range of 300-3400 Hertz. It is also used for transmission of analog and digital data. Up to 10,000 bits per second can be transmitted on a voice-grade channel.

WACK (Wait Before Transmitting Positive Acknowledgement)  In binary synchronous communications, this DLE sequence is sent by a receiving station to indicate that it is temporarily not ready to receive.

WATS (Wide Area Telephone Service)  A service provided by telephone companies in the United States that permits a customer to make calls to or from telephones in specific zones for a flat monthly charge. The monthly charges are based on size of the zone instead of number of calls. WATS may be used on a measured-time or full-time basis.

white noise  Noise containing all frequencies equally (usually applied to noise containing all frequencies equally in a given bandwidth).

wideband  Communications channel having a bandwidth greater than a voice-grade channel characterized by data transmission speeds of 10,000-500,000 bits per second.

word  1) In telegraphy, six characters (five characters plus one space). 2) In computing, an ordered set of characters that is the normal unit in which information may be stored, transmitted, or operated upon within a computer.
answerback  The ability of a terminal to transmit a stored message that identifies it. This message may be sent from the keyboard or transmitted automatically when the terminal receives an enquiry character (ENQ).

ASCII  The American Standard Code for Information Interchange assigns a digital code to each of 96 printing characters and 32 control characters. ASCII characters are 7 bits long and may have an additional parity bit for error detection.

ASR  ASR stands for Automatic Send/Receive and refers to terminals, usually printing, that have paper tape or other local storage.

auto repeat  If a key is held down for a half-second or so, it begins to repeat automatically until it is released.

batch terminal  A terminal whose chief function is to input data to and access data from a centrally located computer in groups or "batches" of data characters.

bidirectional printing  A printing terminal technique to increase printing throughput by printing some lines from right to left rather than left to right, thus avoiding the carriage return time. If the printer is buffered, the data may be sent in the usual order even if it is to be printed bidirectionally (right to left).

block mode  A block mode terminal saves up several keystrokes before sending them in a block to the computer.

broadcast  When a message is sent to all devices connected to a network, it is said to be broadcast to them.

buffer  A place where data may be stored temporarily. Terminals may store data in a buffer if data is received faster than it can be processed.

communication link  The physical connection, typically a phone line, between a terminal and a central computer or other peripheral device.

console  A console is another name for a terminal. A "system console" or "operator's console" is a specially privileged terminal used to control the computer system.

control unit  A device, usually incorporated into a terminal, that allows data to be encoded and decoded for transmitting and receiving.
Terminals Glossary

CPU  A central processing unit that serves as a repository for incoming data from a terminal and provides updated data in return.

CRT terminal  Cathode Ray Tube terminal is another name for a video terminal.

current loop interface  Current loop interfaces are used to connect terminals directly to computers and are particularly good for long direct-wired hookups or for use where there may be a lot of electrical noise, as in factories.

cursor  On a video terminal screen, the cursor is a distinctive mark (such as a flashing square or underline) that indicates where the next character will be displayed.

data collection  A mode of data processing whereby data collected by a terminal or group of terminals is sent back to the CPU.

data distribution  A mode of data processing whereby a terminal or group of terminals serves as receptacle for data supplied by the CPU.

DDCMP  DEC's Digital Data Communications Message Protocol is a high-level protocol with sophisticated error detection and selective addressing capabilities.

direct cursor addressing  A video terminal feature that allows the computer to move the cursor anywhere on the screen to write the next group of data.

dot matrix  A technique for producing characters using dots. The matrix may be described as n by m, where n is the number of possible dot columns in a character and m is the number of rows.

echo  When a computer sends back a character just received to the terminal that sent it, the character is said to have been “echoed.”

error control  A technique whereby errors occurring in the transmission of data characters can be caught, based upon one of several calculations performed on the bit string.

escape sequence  A special sequence of ASCII characters beginning with the escape character (ESC) used to send special text formatting or editing commands to terminals.

fill character  Fill characters and nonprinting characters that are transmitted to allow the receiver enough time to process data already sent. The ASCII characters NUL and DEL are most commonly used as fill characters.

full duplex (FDX)  Full duplex describes a communication channel on which simultaneous two-way communication is available.
glass Teletype  A very basic "dumb" video terminal.

half duplex (HDX)  Half duplex describes a communication channel on which only one-way communication is permitted at a time. The line may be "turned around" to allow data to flow the other way. Some half-duplex links provide a special "reverse channel" in the direction opposite to the data flow that permits transmission of control signals only.

hard copy  Hard copy refers to paper printout, as opposed to video displays or "soft copy" that cannot be saved.

integral modem  A modem built into a terminal rather than packaged separately.

intelligent terminal  A terminal containing a processor that can be programmed by the user and typically has local mass storage.

interactive terminal  A terminal capable of eliciting immediate response to individual user requests, which may instantly update the data base of a central computer.

keypad  A keypad is a small auxiliary keyboard, often used for entering numeric data, editing, or similar special functions.

KSR  KSR stands for Keyboard Send/Receive and refers to a terminal with a keyboard and printer (or display) but no local storage medium.

local  A terminal is said to be in local mode when it is functionally disconnected from a communication link.

message switching  A mode of data processing whereby the CPU is used as a switching center where data is distributed or switched between remote terminals.

multidrop  A communication link which allows more than two terminals to be attached directly.

on-line  A terminal is on-line when it is ready to send or receive data over a communication link.

parity  A common technique for error detection in data transmission. Parity check bits are added to the data so that each group of bits adds up to an even number for even parity and an odd number for odd parity.

polling  The process whereby a reply is solicited remotely from a particular terminal or computer in a network.

port  A port is the place of hookup on the CPU where physical connection is made between a terminal and the central computer.
printing terminals Printing or hard copy terminals display data on paper by one of several printing techniques, including dot matrix, daisy wheel impact, thermal, and inkjet. Impact printers can generally make carbon copies, while non-impact technologies cannot.

protocol A set of rules governing the format and timing of messages exchanged.

receive only (RO) A receive-only terminal cannot transmit data back over the communication link, but merely prints, punches or displays what is sent to it. RO terminals often have no keyboard except for a few control keys such as paper feed.

remote batch processing A mode of batch processing whereby terminals are placed in locations remote to a CPU and have access and input to a central data base.

remote job entry Same as above.

response time The time it takes the CPU to process an instruction or user request at a terminal.

reverse video A video terminal feature that allows part or all of the data to be displayed as black on white instead of the usual white on black.

rollover A characteristic of a keyboard that can continue to send the proper codes when several keys are held down at one time. A keyboard with 2-key rollover will handle depression of two keys at a time. N-key rollover describes keyboards with no limit to the number of keys that can be depressed without interfering with code generation.

scrolling When a video terminal’s screen is filled, a new line of data may be displayed by adding it at the bottom of the screen and shifting all the previous lines upward, discarding the top line. This process is known as scrolling; when the upward movement is continuous rather than in line steps, it is called smooth scrolling.

selective addressing On a multidrop line, selective addressing allows a sender to address a message to a particular receiver (or group of receivers) by sending the intended destination before the message.

smart printing Printing terminals use smart printer techniques to increase their throughput. Smart printing eliminates unnecessary printhead motions by seeking the shortest path to the next print position. The head does not have to return to the margin with each line feed, as a typewriter does.

smart terminal A terminal that is factory pre-programmed to do certain tasks.
**soft copy**  Soft copy is the display on a video terminal.

**system device**  A term usually referring to a peripheral device such as a terminal or disk drive.

**thermal printing**  Thermal printing produces dot matrix characters on special paper that blackens when heated. Since the paper deteriorates with time, thermal printed output is not suitable for permanent records.

**timesharing terminals**  A mode of data processing that allows many terminal users to utilize a computer’s resources to perform a variety of tasks simultaneously.

**video display terminal**  A terminal device that may operate in either batch or interactive mode, and is characterized by a TV-like screen which displays the data visually as soft copy.

**video terminal**  A terminal using a television-like screen for displaying information. Video terminals’ advantages include silent operation, the ability to operate at very high data rates, and the capability to put new data anywhere on the screen or erase data already displayed.

**XON/XOFF**  XON and XOFF are the names of two special characters used in DIGITAL systems and elsewhere for controlling the flow of data across a full-duplex communications channel. If the receiver sends the transmitter an XOFF character, the transmitter is supposed to stop sending until the receiver signals it to resume by sending the transmitter an XON character.
INDEX

accessories
with DEWriter II 9
see also options

acoustic couplers 88
DF01-A 250

ADCCP (Advanced Data Communications Control Procedures) 95

address assignment, on DH11 144 to 145

Advanced Video Option 45, 54

Advanced Research Projects Agency (ARPA) 231, 232

American Standard Code for Information Interchange (ASCII code) 1, 84, 92 to 94, 303 to 306

analog data 87

ANSI New Line 19

Answerback 33 to 34, 51

APL characters 38

applications
on COMM IOP-DUP 202 to 203
on COMM IOP-DZ 133 to 134
on PDT-11/110 terminals 72
on PDT-11/130 terminals 74
on PDT-11/150 terminals 79 to 80

ARPA (Advanced Research Projects Agency) 231, 232

ASCII code (American Standard Code for Information Interchange) 1, 84, 92 to 94, 303 to 306

asynchronous null modems (H312-A) 251

asynchronous serial transmission 91 to 94
  interfaces for 101 to 103
  isochronous operation and 196 to 197
  multiline interfaces for 115 to 157

single line interfaces for 105 to 113
  synchronous/asynchronous
  multiline interfaces for 207 to 218

Auto Disconnect 28, 34

auto-echo, on DH11 140 to 141

Auto Line Feed 33

automatic calling unit interfaces (DN11) 250

Auto New Line 19, 33

Auto Repeat 33

Auto XON/XOFF 19, 34, 51

auxiliary processors (KMC11-A) 130 to 132, 199 to 204, 219 to 223

baud rate 91

BCC (Block Check Characters) 251

bells 32, 50

binary codes 84

binary data 87 to 89
  asynchronous serial transmission of 91 to 94
  synchronous serial transmission of 94 to 97

BISYNC (Binary Synchronous communication protocol) 95, 96

bit-oriented receivers, DUP11 167 to 168

bit-oriented transmitters, DUP11 166 to 167

bits 84
  start and stop 91, 92, 103, 196 to 197

Block Check Characters (BCC) 251

BREAK signals 143 to 144

buffer descriptor lists 202

buffers
  in asynchronous communications 102
INDEX

on DECwriter III 29 to 30, 32, 38
in synchronous communications 160
buses
TDM 240 to 242
see also UNIBUS
byte-oriented receivers, DUP11 166
byte-oriented transmitters, DUP11 165 to 166
cables
for CS11 switches 226
requirements for 301 to 302
CAR (Carrier Register) 121
CCITT system 89
characters
asynchronous serial transmission of 91 to 94, 102, 103
synchronous serial transmission of 94 to 97
character sets
on DECwriter III 38
on VT100 54
clear-to-send characters 97
CLR SCAN 216
color television monitors, VTV30-H graphics display controllers for 244 to 247
COMM IOP-DUP interfaces 199 to 205
COMM IOP-DZ interfaces 130 to 136
communications 83 to 98
on DECwriter III 27 to 28, 33 to 34
on DECwriter IV 18 to 20
on PDT-11 terminals 69 to 70
on VT100 terminals 45, 51 to 54
communications arithmetic option (KG11-A) 151
Control and Status Registers (CSR) 118, 119, 202, 221
control characters 95, 97, 160
COPY key 59
CRC (Cyclic Redundancy Check) 165 to 168, 181, 208, 209
KG11-A communications arithmetic option for 251
CS11-MA/MB switch options 226 to 227
CS11-MC/MD switch options 227
CS11-ME/MF switch options 229
CS11-MH/MJ switch options 228
CS11-M switch options 225 to 230
CSR (Control and Status Register) 118, 119, 202, 221
current loop interfaces (20 mA) 21, 38, 46, 54, 88 to 89, 122
cursor 50
Cyclic Redundancy Check (CRC) 165 to 168, 181, 208, 209
KG11-A communications arithmetic option for 251
data
asynchronous serial transmission of 91 to 94, 102, 103
synchronous serial transmission of 94 to 97, 159 to 160
data communications equipment 249 to 251
data phones see modems
Data Terminal Ready (DTR) registers 120 to 121
data transparency 97
DDCMP (Digital Data Communications Message Protocol) 95, 96, 181 to 186, 203 to 204
DECwriter II (LA36) 2, 5 to 9
DECwriter III (LA120) 2, 6, 27 to 41, 266 to 280
DECwriter IV (LA34/38) 2, 8, 11 to 25, 256 to 263
demodulation 88

336
DF01-A acoustic telephone couplers 250
DH11-AA interface 138
DH11-AC interface 138
DH11-AD interface 138 to 139
DH11-EA interface 139
DH11 interfaces 137 to 151
Diagnostics, on PDT-11 terminals 71
Digital Data Communications Message Protocol (DDCMP) 95, 96, 181 to 186, 203 to 204
Direct Memory Access (DMA) control 140, 172
COMM IOP-DUP interfaces for 199 to 205
DV11 interfaces for 209, 210
KMC11-A interfaces for 221
distributed processing networks, PCl11-B parallel communications links for 240
DJ11 asynchronous serial line multiplexer 249 to 250
DL11-E interface 106 to 108
DL11 interface 105 to 113
DL11-WA interface 106
DL11-WB interface 106
DM11-BB modem control multiplexer 141 to 143
DMA (Direct Memory Access) control 140, 172
COMM IOP-DUP interfaces for 199 to 205
DV11 interfaces for 209, 210
KMC11-A for 221
DMC11-AL microprocessors 185, 187 to 188
DMC11-AR/AL microprocessor modules 185, 187
DMC11-DA modules 185 to 187, 189 to 190
DMC11-FA modules 185 to 187, 189 to 190
DMC11 interfaces 179 to 192
DMC11-MA modules 185, 187 to 189
DMC11-MD modules 185, 187 to 189
DN11 automatic calling unit interfaces 250
down-line loading 183 to 184
DQ11-DA interface 172
DQ11-EA interface 172
DQ11 interfaces 171 to 178
DR11-B interface logic assembly 232 to 234
DTR (Data Terminal Ready) registers 120 to 121
DU11 communications devices 250 to 251
DUP11 interfaces 163 to 170
COMM IOP-DUP interfaces and 199 to 201, 203
DUV11 interfaces 193 to 198
DV11-AA interface 208
DV11-BA interface 208
DV11-BB interface 208
DV11-BC interface 208
DV11 interfaces 207 to 218
DZ11-A interface 124
DZ11-B interface 124
DZ11-C interface 124
DZ11-D interface 124
DZ11-E interface 124
DZ11-F interface 124
DZ11 interfaces 115 to 129
COMM IOP-DZ interfaces and 130
DZV11-B interface 152, 153
DZV11 interfaces 152 to 157
echoing on DH11 140 to 141
local 19, 32 to 33
efficiency (in communications) 83
EIA system 89

electrical interfaces
  on DZ11 121 to 122
  20 mA 21, 38, 46, 54, 88 to 89

End-of-Text control characters 160

errors
  checking for and recovery from, in synchronous serial
  transmission 97
  parity checking for 93 to 94

fields, in synchronous serial
  transmission 96

flag characters 95

FLAG sequence 166, 167

floppy disks, on PDT-11/150
  terminals 77

formatting, in synchronous serial
  transmission 96

Framing Error bits 118 to 119

full-duplex (FDX) mode 90
  on DMC11 182 to 183

general purpose interactive
  terminals 1

graph drawing terminals 59 to 62

graphics display controllers
  (VTX30-H) 244 to 248

H312-A asynchronous null
  modems 251

half-duplex (HDX) mode 90
  on DMC11 183
  on DUP11 168
  handshaking in 97

handshaking 96 to 97
  four-way 233

hardcopy terminals 2

HDLC (High Level Data Link
  Controls) 95

headers 96

HERE IS key 34

IDLE characters 173

idling, in asynchronous serial
  transmission 92

IMP (Interface Message
  Processor) 231, 232

IMP11-A interfaces 231 to 239

intelligent terminals 2 to 3
  PDT-11 family 65 to 80

interactive terminals 1

Interface Message Processor
  (IMP) 231, 232

interfaces 99
  for asynchronous
  communications 101 to 103
  asynchronous multilines 115 to
  157
  asynchronous single line 105 to
  113

CS11 switches for 225 to 230

DN11 automatic calling unit

interface 250

IMP11-A 231 to 239

synchronous/asynchronous
  multilines 207 to 218

synchronous
  communications 159 to 161
  synchronous multilines 199 to 205
  synchronous single line 163 to
  198

20 mA loop 21, 38, 46, 54, 89

interrupts
  on DH11 144
  on DL11 108 to 109
  on DMC11 187
  on DQ11 175
  on DV11 215
  on DZ11 119

isochronous operation 196 to 197

KG11-A communications arithmetic
  option 251

KMC11-A auxiliary processors 219
  to 223
  in COMM IOP-DUP
  interfaces 199 to 204
  in COMM IOP-DZ interfaces 130
  to 132

last character viewing (LCV) 11, 14,
  32
INDEX

Line Parameter Registers (LPR) 118, 119
loading
  of COMM IOP-DUP 204
  of DMC11 183 to 184
Local Echo 19, 32, 33
local operations, DZ11 interfaces for 117
Longitudinal Redundancy Checks (LRC) 208 to 209
LPR (Line Parameter Register) 118 to 119
LRC (Longitudinal Redundancy Checks) 208 to 209
LSI-11 microprocessors 65 to 67
  DUV11 interfaces for 193 to 195
  VTV30-H for connecting color television to 244 to 246
LSI-11 bus, DZV11 interface for 152 to 153
MACRO-11 222
MAINT (maintenance) bits 122
maintenance
  of CS11 switch options 229 to 230
  of DECwriter III 38
  of DECwriter IV 20
  of DMC11 186 to 187
  of DZ11 122 to 123
  of VT100 54
maintenance mode, on DZV11 154 to 155
Master Scan Enable (MSE) bits 118 to 119
media of transmission 83
message buffers 160
microprograms, for KMC11-A 220 to 223
modems (data phones) 87 to 88
  DM11-BB modem control multiplexer for 141 to 143
  DZ11 interfaces and 120 to 121
  H312-A asynchronous null 251
  20 mA loops not used with 89
  modes of transmission 89 to 90
  modulation 88
  MSE (Master Scan Enable) bits 118 to 119
  noise (in communications) 83, 97
  non-existent memory interrupts 144
  null modems 89
  H312-A asynchronous 251
  numeric keypads 16, 21, 47
options
  CS11 switches 225 to 230
  with DECwriter II 8 to 9
  with DECwriter III 38
  with DECwriter IV 20 to 21
  KG11-A communications arithmetic 251
  with VT100 54
overrun bits 119
parallel communications links (PCL11-B) 240 to 243
parallel transmission 85 to 86
parameters
  for isochronous operation 196
  for PDT-11/TIM-VT100 communications 69
PARCSR (Parameter Status Register) 165 to 168, 197
parity
  in asynchronous serial transmission 93 to 94
  on DECwriter IV 18 to 19
  on VT100 52
parity bits 92 to 94, 118
parity sense
  on DECwriter IV 18 to 19
  on VT100 52
PCL11-B parallel communication link 240 to 243
PDP-11 systems
  COMM IOP-DUP interfaces for 200 to 201
  DH11 interfaces for 137
INDEX

DL11 interfaces for 105 to 107
DMC11 interfaces for 179 to 186
DQ11 interfaces for 171
DU11 communications devices for 250 to 251
DUP11 interfaces for 163
DV11 interfaces for 207
DZ11 interfaces for 115 to 116
IMP11-A interfaces for 231 to 232
KMC11-A auxiliary processors for 219 to 221
PCL11-B parallel communications links for 240
PDT-11 terminals for 65 to 67
PDT-11/110 terminal 2 to 3, 67, 72 to 73
PDT-11/130 terminal 3, 67, 74 to 75
PDT-11/150 terminal 3, 67, 77 to 80
PDT-11 cluster option 71
PDT-11 diagnostics 71
PDT-11 Intelligence Module Set 68
PDT-11 processor 68
PDT-11 ROM layout 71 to 72
PDT-11 terminal controller 70
PDT-11 terminals 2, 65 to 80
PDT-11/TIM-host communications 69 to 70
PDT-11/TIM-VT100 communications 69
PDT-11/VT100 terminals 70
peripherals, UNIBUS control of 221 to 222
plotters, VT55 59
powerfail recovery 184
printers, VT55 59
print formats
  on DECwriter III 28, 35, 36
  on DECwriter IV 15 to 18
program interrupt priority 187
programming
  DH11 143 to 145
  DL11 108 to 109
  DMC11 184 to 185
  DQ11 174 to 175
  DUV11 197
  DV11 215 to 216
  DZ11 123 to 124
protocols
  on COM IOP-DUP 201 to 204
  on DMC11 181 to 182
  on DUP11 163, 165
  for synchronous serial transmission 95
Random Access Memory (RAM), on KMC11-A 222
rate of transmission 91
RBUF (receiver data buffer register) 107, 108, 118, 119
RCSR (receiver status register) 107, 108
RCVEN (Receiver Enable) bits 166, 168
Read-Only Memory (ROM), on PDT-11, terminals 71 to 72
Ready-for-Next-Bits (RFNB) 233
Receive Go (RxGO) bits 174
Receiver Active (RxACT) bits 168
receiver data buffer registers (RBUF; RxDBUF) 107, 108, 118, 119, 166, 168, 196, 197
Receiver Done (RxDONE) bits 166, 168, 196
Receiver Enable (RCVEN) bits 166, 168
Receiver Interrupt Enable (RIE) bits 119
receiver interrupts 144
receiver 83
  of asynchronous communications 103
  DH11 139 to 140
  DL11 107 to 108
  DQ11 174
  DUP11 166 to 168
  DUV11 196
INDEX

DV11  211 to 213
DZ11  117 to 118
DZV11 154
receiver status registers (RCSR; RxCSR)  107, 108, 165, 166, 168, 195, 197
reception
  asynchronous  103
  synchronous  161
remote load detect  183 to 184
remote operations, DZ11 interfaces for  117
request-to-transmit characters  97
reverse video  43, 50
RFNB (Ready-for-Next-Bit) bit  233
RIE (Receiver Interrupt Enable) bits  119
RING (ring register)  121
roll paper holders  20
ROM (Read-Only Memory), on PDT-11 terminals  71 to 72
RxACT (Receiver Active) bits  168
RxCSR (Receiver Status Register)  165, 166, 168, 195, 197
RxDBUF (Receiver Data Buffer Registers)  166, 168, 196, 197
RxDONE (Receiver Done) bits  166, 168, 196
RxGO (Receive Go) bits  174
SAE (Silo Alarm Enable) bits  119
scan control, on DV11  215 to 216
SCH SYNC (Search Sync)  196
scrolling, on VT100  43, 47, 53
SDLC (Synchronous Data Link Control)  95
Search Sync (SCH SYNC)  196
senders
  see transmitter
serial transmission
  see asynchronous serial transmission;
see synchronous serial transmission
SETUP key  15, 31, 47
Setup Mode
  on DECwriter III  31 to 32
  on DECwriter IV  15 to 16
  on VT100  47 to 49
Silo Alarm Enable (SAE) bits  119
silos
  on DH11  139 to 140
  on DV11  213
  on DZ11  118
silo status bits  118 to 119
simplex mode  90
software
  for COMM IOP-DUP  204
  for COMM IOP-DZ  134 to 135
  for KMC11-A  220 to 223
  for PC11-B  242
  for PDT-11/130 terminals  74
  for PDT-11/150 terminals  55
special purpose terminals  3
special systems  225 to 248
specifications
  of DECwriter III  39 to 41, 266 to 280
  of DECwriter IV  23 to 25, 256 to 263
  of DH11  145 to 150
  of DL11  109 to 113
  of DMC11  187 to 190
  of DQ11  175 to 176
  of DUP11  168 to 169
  of DUV11  197 to 198
  of DV11  216 to 217
  of DZ11  124 to 128
  of DZV11  155 to 156
  of IMP11-A  239
  of PC11-B  242 to 243
  of VT55  60 to 62
  of VT100  55 to 57, 282 to 299
  of VTV30-H  247 to 248
split screen scrolling  43
start bits  91, 92, 103, 196
INDEX

start/stop transmission
see asynchronous serial transmission

STATUS key  16, 31
stop bits  91, 92, 196 to 197
storage, floppy disks for  77
storage overflow interrupts  144
STRIP SYNC bits  166
switches, CS-11 family of  225 to 230
sync characters  95, 97, 160, 165, 166, 173, 174, 195, 209
synchronization  95
Synchronous Data Link Control (SDLC)  95
synchronous serial transmission  94 to 97
interfaces for  159 to 161
multiline interfaces for  199 to 205
single line interfaces for  163 to 198
synchronous/asynchronous multiline interfaces for  207 to 218
system addresses, on DV11  215
TCR (Transmitter Control Register)  120, 121
TDM (time division multiplexed) buses  240 to 242
Terminal Intelligence Module (TIM)  68 to 70
terminals  1 to 3
cabling requirements for  301 to 302
DECwriter II (LA36)  5 to 9
DECwriter III (LA120)  27 to 41, 266 to 280
DECwriter IV (LA34/38)  11 to 25, 256 to 263
PDT-11 family  65 to 80
VT52  249
VT55  29 to 62
VT100  43 to 57, 282 to 299
terminal support, on COMM IOP-DZ  134
text, synchronous serial transmission of  96, 97

There's-Your-Bits (TYB)  233
TIE (Transmitter Interrupt Enable) bits  119
TIM (Terminal Intelligence Module)  68 to 70
time division multiplexed (TDM) buses  240 to 242
timing, on DV11  215 to 216
transmission
asynchronous serial  91 to 104, 101 to 103
isochronous  196 to 197
modes of  89 to 90
synchronous serial  94 to 97, 159 to 160
Transmit Active (TxACT) bits  167
Transmit Go (TxGO) bits  173
Transmit Line Number (TLINE) fields  120
Transmit Ready (TRDY) bits  119, 120
Transmit Start of Message (TSOM) bits  166, 167
Transmitter Control Registers (TCR)  120, 121
transmitter data buffer registers (TxDBUF; XBUF)  108, 166, 197
Transmitter Done (TxDONE) bits  166, 167
Transmitter Interrupt Enable (TIE) bits  119
transmitter interrupts  144
transmitters (senders)  83
of asynchronous communications  102
DH11  140
DL11  108
DQ11  173
DUP11  165 to 167
DUV11  195 to 196
DV11  213 to 215
DZ11  119 to 120
DZV11  154
transmitter status registers (TxCSR; XCSR)  108, 165, 167, 168, 197

342
INDEX

transparency, data 97
TRDY (Transmit Ready) bits 119, 120
TSOM (Transmit Start of Message) bits 166, 167
20 mA current loops 88 to 89
20 mA current loop switches 226
20 mA loop interfaces
  on DECwriter IV 21
  on DECwriter III 38
  on DZ11 122
  20 mA transmissions and 88 to 89
  on VT100 46, 54
TxACT (Transmit Active) bits 167
TxCSR (Transmitter Status Registers) 167, 168, 197
TxDBUF (Transmitter Data Buffer Registers) 166, 197
TxDONE (Transmitter Done) bits 166, 167
TxGO (Transmit Go) bits 173
TYB (There's-Your-Bit) 233
UARTs (Universal Asynchronous Receiver/Transmitters)
  on DH11 139, 140, 143 to 144
  on DL11 107
  on DV11 211, 213
  on DZ11 116, 119
  on DZV11 154
unattended remote printing, on DECwriter III 34
UNIBUS
  controlling peripherals over 221 to 222
IMP11-A interface for 231
KG11-A communications arithmetic option for 251
KMC11-A auxiliary processor and 219
VAX-11/780 systems
  DMC11 interfaces for 179, 186
  DZ11 interfaces for 115, 116
vector assignment
  on DH11 144 to 145
  on DMC11 187
  on DQ11 175
  on DV11 215
  on DZ11 123 to 124
video terminals 2
  VT52 249
  VT55 59 to 62
  VT100 43 to 57, 282 to 299
VIEW key 11, 14, 32
VT52 terminal 249
VT55 graph drawing video terminal 2, 59 to 62
VT100 terminal 2, 43 to 57, 282 to 299
VTV30-H graphics display controller 244 to 248
wraparound 53
XBUF (transmitted data buffer register) 108
XCSR (transmitter status register) 108
XOFF code 19, 51
XON code 19, 51
zero data rate 143
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