2402
TEKMATE
HARDWARE
USER'S MANUAL

Please Check for
CHANGE INFORMATION
at the Rear of This Manual

Tektronix®

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Product Group 37

Instrument Serial Numbers

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen,The Netherlands

German Postal Information

Certificate of the Manufacturer/Importer

We hereby certify that the 2402 TEKMATE and all factory-installed options

complies with the RF Interference Suppression requirements of Amtsbl.-Vfg 1046/1984.

The German Postal Service was notified that the equipment is being marketed.

The German Postal Service has the right to re-test the series and to verify that it complies.

TEKTRONIX

Bescheinigung des Herstellers/Importeurs

Hiermit wird bescheinigt, daß der/die/das 2402 TEKMATE and all factory-installed options

in Übereinstimmung mit den Bestimmungen der Amtsblatt-Verfügung 1046/1984 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhalten der Bestimmungen eingeräumt.

TEKTRONIX

NOTICE to the user/operator:

The German Postal Service requires that Systems assembled by the operator/user of this instrument must also comply with Postal Requlation, Vfg. 1046/1984, Par. 2, Sect. 1.

HINWEIS für den Benutzer/Betreiber:

Die vom Betreiber zusammengestelite Anlage, innerhalb derer dies Gerät eingesetzt wird, muß ebenfalls den Voraussetzungen nach Par. 2, Ziff. 1 der Vfg. 1046/1984 genugen.

NOTICE to the user/operator:

The German Postal Service requires that this equipment, when used in a test setup, may only be operated if the requirements of Postal Regulation, Vfg. 1046/1984, Par. 2, Sect. 1.7.1 are complied with.

HINWEIS für den Benutzer/Betreiber:

Deies Gerät darf in Meßaufbauten nur betrieben werden, wenn die Voraussetzungen des Par. 2, Ziff. 1. &.1 der Vfg. 1046/1984 eingehalten werden.

SOFTWARE PROBLEM REPORT

Name _____
Street _____
City _____ State _____ Zip _____
Phone _____

Instructions

Use this form to report software bugs, documentation errors, or suggested enhancements. Attach Listings, graphs or any other information that might assist in evaluating this report.

Support Line: 1-503-627-2400 or
1-800-835-9433 ext. 170

Mail this form to:

Tektronix,Inc.
D/S 47-837
P.O. Box 500
Beaverton, Or 97077-0001

Category

_____ Performance _____ Documentation _____ Suggestion _____ Other

(Is performance reproducable?) _____ yes _____ no

Software Description (INCLUDE MODEL NUMBERS)

Tektronix Product _____ Rev _____
Serial Number _____
Operating System _____ Rev _____ Supplier _____
Other Software _____ Rev _____ Supplier _____

Hardware Description

Manufacturer _____ CPU _____ Memory _____ KB
(286,386)

Display Device _____ (CGA,EGA,ETC)
Acquisition Units _____
(DIGITIZING INSTRUMENT)
Interface cards _____ (GPIB-PC2,PCA,ETC)
Peripherals _____ (SPECIFY INTERFACE)

Problem Description

Describe the problem. (Also describe how to reproduce it,and your diagnosis and suggested corrections.) Attach listings or hard copies if available. Include a copy of your CONFIG.SYS and AUTOEXEC.BAT file if appropriate.

For Tektronix Use Only

Comments:

DAte: _____

Report# _____

Action Taken:

Signed:

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WARNING

The information in Sections 6 through Appendix F is for qualified service personnel only. Refer to "Service Safety Summary" found immediately prededing Section 6.

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Operators Safety Summary

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply and do not appear in this summary.

Terms

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the markings, or a hazard to property, including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols

In This Manual

This symbol indicates where applicable cautionary or other information is to be found. For maximum input voltage see Table 4–1.

As Marked on Equipment

DANGER – High voltage.

Protective ground (earth) terminal.

ATTENTION – Refer to manual.

Power Source

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before making any connections to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulated) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

For detailed information on power cords and connectors, see Table 2-1.

Use the Proper Fuse

To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your product.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this instrument in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Donot operate the instrument without the covers and panels properlyinstalled.

General Information

General Information

Introduction

This section briefly describes your TEKTRONIX 2402 TEKMATE and tells how to prepare for and proceed with the initial start-up. It also includes safety information, as well as necessary information to prevent damage to the instrument. PLEASE READ.

NOTE

See Section 5, "Options," for a description of TEKMATE options. Information about programming the TEKMATE and operating it by means of the GPIB is contained in the optional software documentation supplied with the TEKMATE.

Product Overview

The Tektronix 2402 TEKMATE is a portable, compact, low power, PC- and GPIB-488-compatible system. The TEKMATE is ideally suited for applications where IBM PC software and bus compatibility are required and where low power consumption, small size, and high reliability are critical. The instrument can add data acquisition and control to your system, and can be mounted onto your Tektronix portable oscilloscope.

The 2402 has the following features:

- NEC V40 microprocessor system

  8088 extended capability

  7.16 MHz CPU clock

  3 DMA channels - IBM PC compatible

  Counter/timers and interrupt controllers - IBM PC compatible

- 768K dynamic RAM with parity (64K dedicated to video display)

- IBM PC compatible floppy disk drive controller

  Two 3.5 inch microfloppy disk drives

  720K-byte formatted capacity per drive

- Video controller

  Standard IBM PC monochrome display (MDA 80 characters by 25 rows)

  Hercules monochrome graphics (720 by 348 pixels)

  Standard IBM PC color graphics (CGA 620 by 200 pixels)

  Double Scan (400 line) CGA

- External I/O ports

  2 Serial RS-232C (the COM 1, and COM 4 ports)

  Centronics® parallel printer port

  IEEE 488 GPIB

  Keyboard

  Video monitor

  Hardware reset button

  Audio speaker

  Power-on LED indicator

- PC expansion bus

  Supports two full PC expansion cards or two half-cards and 1 full card

- Versatile power supply

  90-250 VAC, 48-440 Hertz one range input

  50 total load Watts available (approximately 35 load Watts available to PC expansion connectors)

  2 A, 250 V fuse is internal and located on the power supply circuit board under the power supply shield

- Real time and date clock

  Battery backed up

Standard Accessories

The TEKMATE is shipped with the following standard accessories:

1 *2402 TEKMATE Hardware Users Manual*
1 MS-DOS 3.3 Disk
1 *Running MS-DOS* Manual
1 U.S. Power Cord
1 Diagnostic Disk and Loopback Connectors

Optional Accessories

The following optional accessories are available for the 2402:

- 2400 DSO Mounting Kit
- 2445/2465 Mounting Kit (provides mechanical compatibility only)
- 2467 Mounting Kit (provides mechanical compatibility only)
- 2200 DSO Mounting Kit (provides mechanical compatibility only)
- *2402 Field Installation Guide*
- 1 Meter GPIB Cable
- Color Monitor with Cable
- Color Monitor Cable
- IBM Compatible Keyboards (U.S. and International)
- Rain Jacket
- Carrying Case

For part numbers and further information about both standard and optional accessories, refer to the Accessories information at the rear of this manual. Your Tektronix representative or local Tektronix Field Office can also provide accessories information and ordering assistance. See Section 5 for instrument Options.

Instrument Options

Section 5 describes instrument options available at the time this manual was printed. Options available include:

A1–A5	International Power Cords
01	24XX DSO compatibility
1R	Rackmounting kit
41	DSO-Utility Program Development Package

Preparation for Use

Safety

Before connecting the instrument to a power source, read entirely both this section and the Safety Summary at the front of this manual. Be sure you have the training required to safely connect the instruments you will be using. Refer to the Safety Summary for power source, grounding, and other safety considerations pertaining to the use of the instrument.

CAUTION

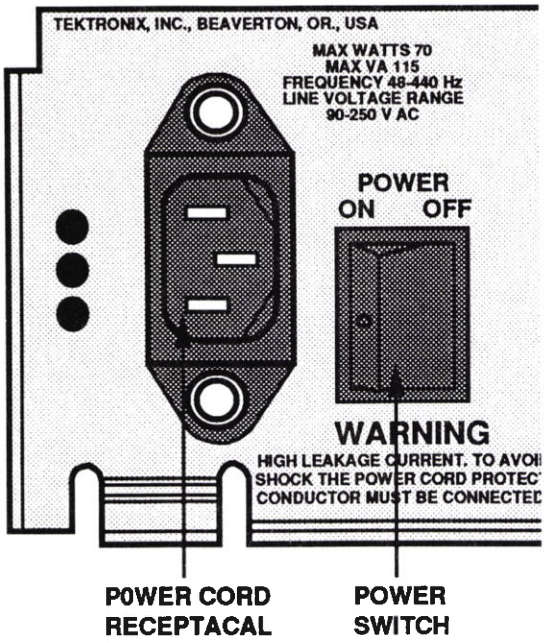
This instrument may be damaged if operated with the wrong applied AC input-source voltage or if the wrong line fuse is installed.

Line Voltage

The instrument operates from an ac-power source of 90 V to 250 V AC with any frequency from 48 Hz to 440 Hz. The detachable power cord (see Figure 1-1) may have to be replaced to match the particular power source.

Line Fuse

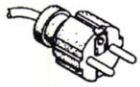
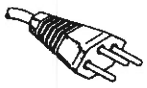
For instructions on replacing the line fuse, please refer to the "Removal and Replacement Instructions" in this manual.



6977-30

Figure 1–1. Detachable power cord.

Table 1-1
Power Cord and Voltage Data

Plug Configuration	Option	Power Cord/ Plug Type	Line Voltage	Reference Standards [2]
	U.S. Std.	U.S. 120V	115V	ANSI C73.11 NEMA 5-15-P IEC 83 UL 198.6
	A1	EURO 220V	230V	CEE(7), II, IV, VII IEC 83 IEC 127
	A2	UK[1] 240V	230V	BS1363 IEC 83 IEC 127
	A3	Australian 240V	230V	AS C112 IEC 127
	A4	North American 240V	230V	ANSI C73.20 NEMA 6-15-P IEC 83 UL 198.6
	A5	Switzerland 220V	230V	SEV IEC 127

[1] A 6A, type C fuse is also installed inside the plug of the Option A2 power cord.

[2] Reference Standards Abbreviations:

ANSI – American National Standards Institute
AS – Standards Association of Australia
BS – British Standards Institution
CEE – International Commission on Rules for the Approval of Electrical Equipment
IEC – International Electrotechnical Commission
NEMA – National Electrical Manufacturer's Association
SEV – Schweizervischer Elektrotechnischer Verein
UL – Underwriters Laboratories Inc.

Power Cord

This instrument has a detachable, three-wire power cord with a three-contact plug for connection to both the power source and protective ground. The protective-ground contact on the plug connects through the power cord to the external metal parts of the instrument. For electrical-shock protection, insert this plug into a power-source outlet that has a properly grounded protective-ground contact.

Instruments are shipped with the required power cord as ordered by the customer. Available power cord information is presented in Table 1-1, and part numbers are listed in "Options" (Section 5). Contact your Tektronix representative or local Tektronix Field Office for additional power cord information.

Instrument Cooling

To prevent instrument damage from internally generated heat, adequate air flow must be maintained. Before turning on the power, verify that the spaces around the air-intake holes on the side of the cabinet and the fan-exhaust holes on the other side of the instrument are free of any obstruction to air flow.

Start-Up

To operate the TEKMATE, install a disk containing the disk operating system in the A: (upper) drive and turn the instrument on (the ON/OFF power switch is located on the instrument's rear panel, see Figure 1-1).

The instrument automatically performs a set of power-up tests each time it is turned on. These tests warn the user of any available indication that the instrument may not be fully functional. The tests run for several seconds after power is applied. If no faults are encountered, the instrument operates normally.

If a failure of any power-up test occurs, the instrument may still be usable for some applications. Even if it functions for your particular requirement, it should be repaired by a qualified service technician at the earliest convenience.

Information on diagnostic tests and troubleshooting may be found in the "Maintenance" section of this manual. Consult your service department, your local Tektronix Service Center, or nearest Tektronix representative if additional assistance is needed.

After running the power-up diagnostic tests, the TEKMATE should automatically boot the disk, and run the application program. See specific application program documentation for further details.

Shut-Down

To shut down the TEKMATE, terminate all application programs that are running. Turn off the power switch located on the back panel. If the TEKMATE will be transported, it is advisable to remove the floppy diskettes from the floppy drives.

Repackaging for Shipment

If this instrument is to be shipped by commercial transportation, it should be packaged in the original manner. For this reason, you should retain the carton and packaging material in which your controller was shipped to you.

If the original packaging is unfit for use or is not available, repackage the instrument as follows:

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions and having a carton test strength of at least 275 pounds.
2. If the instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following: owner of the instrument (with address), the name of a person at your firm who can be contacted, complete instrument type and serial number, and a description of the service required.
3. Wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and prevent entry of packing materials into the instrument.
4. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing three inches on each side.
5. Seal the carton with shipping tape or with an industrial stapler.
6. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

Operation

Operation

Introduction

This section contains basic operating information. Examples in this manual use the MS-DOS operating system. If your operating system is not MS-DOS, consult the documentation for your operating system to see how to perform similar functions.

Also, the 2402 TEKMATE is shipped with a Disk Operating System (DOS) that uses a keyboard and monitor as the standard input and output devices. Some optional applications software uses an instrument's buttons and display as the standard input and output devices. If the instrument buttons and display are used for input and output, the TEKMATE may not require the optional keyboard and monitor. Descriptions later in this section (following "Operation with Keyboard and Monitor") assume a keyboard and monitor are being used. If your applications software uses your instrument's buttons and display to interface with the TEKMATE's DOS, consult your applications software documentation to see how the operations described (or similar operations) are performed.

Installation

Mounting the TEKMATE on an Instrument

The TEKTRONIX 2402 TEKMATE may be mounted on selected Tektronix instruments using the appropriate Field Installation kit. To mount the 2402, follow the instructions in the Field Installation Guide supplied with your Field Installation kit.

Operating Considerations

Floppy Disk Drives

Micro floppy diskettes (disks) give the 2402 TEKMATE mass storage capability. This enables you to store programs and data for future use. (Data stored in the TEKMATE's memory is lost when the TEKMATE is turned off). Disk space is reusable. Therefore, when you no longer need the data, you can erase it and use the space for new information. Also, disks are transportable from your TEKMATE to other compatible controllers or personal computers for use or further analysis of data.

Inserting and Removing Disks

Insert a disk into the disk load slot with the label up and toward you. The disk should slide in smoothly and click down into the drive when fully in place. An improperly installed disk will not function and may physically damage the drive.

To remove a disk from the drive, press the disk eject button located on the lower right corner of the drive.

Write Protection

To avoid accidentally writing on a disk and changing important stored information, slide the small tab on the bottom left front corner of the disk toward the front edge of the disk so you can see through the hole. This will prevent writing on the disk.

Disk and Drive Care

Store disks in a clean, dry area. To prevent mechanical damage or loss of data, never expose disks to heat, direct sun, or magnetic fields. Do not touch the magnetic medium that is located under the sliding metal cover on the disk. Do not install a damaged disk in the disk drive, as it may damage the drive.

New disks must be formatted (See the FORMAT command in your *Running MS-DOS* manual) before they can be used by the TEKMATE.

Operation with Keyboard and Monitor

The TEKMATE is shipped with a Disk Operating System (DOS) that uses a keyboard and monitor as the standard input and output devices. Some optional applications software uses an instrument's buttons and display as the standard input and output devices. If the instrument buttons and display are used for input and output, the TEKMATE may not require the optional keyboard and monitor. Descriptions in this manual assume a keyboard and monitor are being used. If your applications software uses an instrument's buttons and display to interface with the TEKMATE's DOS, consult your applications software documentation to see how the following (or similar) operations are performed.

Start-up and Shutdown Procedures

Start-up

The TEKMATE's On/Off power switch is located on the rear panel. To operate the TEKMATE, install a disk containing the disk operating system in the A: (upper) drive and turn the TEKMATE on.

The instrument will automatically perform a set of power-up diagnostic tests. These tests warn of any available indication that the instrument may not be fully functional. The tests run for several seconds after power is applied. If no faults are encountered, the instrument operates normally.

After running the power-up diagnostic tests, the TEKMATE will boot the disk and run the application program. See the specific application program documentation for further details.

Shut-Down

To shut down the TEKMATE, terminate all application programs that are running. Turn off the power switch on the back panel. If the TEKMATE will be transported, it is advisable to remove the floppy diskettes from the disk drives.

System Reset

A reset button on the rear panel allows you to restart the system without cycling the power. Pressing the reset button terminates operating application programs, initiates a restart of the power-up diagnostics, and then accesses disk drive A to load and execute the software operating system.

If you are using the optional keyboard and MS-DOS, you can also perform a system reset by pressing and holding the ***Ctrl-Alt-Del*** keys.

Disk Operating System

A Disk Operating System (DOS) is a program that lets you do certain tasks, such as format disks, read and write files, copy information from one disk to another, enter time and date, and load and execute other programs.

Files, Programs, File Names, and Directories

DOS typically includes files, programs, and file names. A file may contain either data or a program. Some programs may consist of several different files.

Using MS-DOS as an example, each file identifier has three parts: an optional drive name, a file name, and an optional extension.

Drive Name. The drive name is a letter from A through Z (DOS defaultis A through E) and must be followed by a colon. The use of these letters is limited by the configuration of your system. If your TEKMATE has two floppy disk drives and you try to use any drive names other than A or B, an error message is displayed.

File Name. The file name is from one to eight characters in length. These characters can be any letter from A to Z, any number from 0 to 9, or any of these nonliteral characters: $ # & @ ! % ( ) _ - { } ' ~. Blanks are not allowed. Samples of valid and invalid file names are shown in Table 2-1.

Extension. The extension contains from one to three characters. The allowed characters are the same as those allowed for a file name. A period must be used to separate the extension from the file name. Valid file extensions are shown in Table 2-1. Some extensions like .SYS are reserved for certain file types. Consult your DOS documentation for additional information.

Table 2-1
Sample File Names

Valid File Names	Invalid File Names
COMMAND.COM	PRE,WE.BAS (comma)
WALL.S1	WS.ADS.LET (first period)
A:DOCUMENT	A LETTER (no colon)

Directories. Directories allow you to organize files into related groupings. Directory names have the same format as file names. A directory entry can be a file, another directory, or a volume label. When DOS starts, the root directory is the current directory. To make a new directory, use the MKDIR (MD) command. To remove a directory, use the RMDIR (RD) command. Using the CHDIR (CD) command, you can make a different directory the current directory. For more information on the use of directories, consult your DOS documentation.

DOS Prompts

The prompt is a signal that your TEKMATE is ready to accept a command. The prompt can take various forms (DOS commands can change the prompt and even cause the name of the current directory to be included as part of the prompt). It is normally displayed as the letter representing the drive being used, followed by a symbol such as a "greater than" sign (>) and a blinking underline:

```
A>_
```

In this example, drive A is the default drive—the drive currently being used by the operating system and the normal default drive on power-up. The blinking underline is called the cursor; it lets you know where the next character will be displayed.

If you selected drive B as the default drive, the MS-DOS prompt may appear as:

```
B>_
```

You can change the default drive by typing the new drive name, a colon, and pressing the RETURN key. For example, if drive A is currently the default drive and you want to change the default drive to drive B, type ***B:*** and press the RETURN key.

If drive B is the current default drive and you want to change the default drive to drive A, type ***A:*** and press the RETURN key.

Notice that the current default drive (in the form of the prompt) is displayed after each DOS command.

Error Messages

Your operating system will display an error message when something is wrong. The message itself often tells what is wrong so you can correct the problem. An example is:

Invalid drive specification

This message tells you that your command specified a drive that is not connected to your system. Re-enter the command, specifying the correct drive.

Loading DOS

Your TEKMATE has been set at the factory to automatically load (autoboot) DOS. The following steps show how to create backups, or working copies, of the distribution disk:

NOTE

The descriptions that follow assume you are using the optional keyboard and monitor. If your applications software uses your instrument's buttons and display to interface with the TEKMATE's DOS, consult your applications software documentation to see how the following operations (or similar operations) are performed.

1. Make sure the DOS Distribution Disk is in drive A.
2. Turn on the TEKMATE.

After displaying system and power-up test messages the disk access light comes on, indicating that the disk is being read by the TEKMATE. You may hear a buzz from your drive, which is the normal sound of the disk drive motors.

Depending upon your disk operating system, you may see a number of messages, including a prompt for entering the date and time. Your DOS documentation explains these messages and prompts. The default date and time messages for MS-DOS are presented here as an example.

As MS-DOS is read into the TEKMATE, your display may show a message similar to the following:

Current date is xx-xx-xxx

Enter new date (mm-dd-yy):

The 2402 TEKMATE uses a real-time clock, so the date and time shown should be the actual date and time. If the date is not correct, the format for entering a new date is M/D/Y or M-D-Y, where M is the month (1 to 12), D is the day (1 to 31), and Y is the year (80 to 99). Four digits may be used for the year. Any other response will cause the TEKMATE to display:

Invalid date Enter new date (mm-dd-yy):

3. Enter the *current date* and press the ***RETURN*** key. The TEKMATE then displays:

   Current time is 0:03:20.20 Enter new time:

Use the format H:M:S.C to enter the time, where H is hours (0 to 23), M is minutes (0 to 59), S is seconds (0 to 59), and C is tenths of a second (0 to 9). Minutes, seconds, and tenths of a second are optional and may be omitted. The separators, colon and period must be used exactly as shown, or the following error message is displayed:

Invalid time Enter new time:

4. Enter the *current time* and press the ***RETURN*** key. The TEKMATE then displays:

   MS-DOS Version x.xx

   Copyright (C) Microsoft Corp. 1981-1986

   A>

This sample display shows that the arrow has been replaced by A>, which is the default prompt used by MS-DOS. This display also tells which drive, called the default drive, is currently being used by the system. Earlier you were told how to change the default drive being used. Now you need to create a copy, or backup, of the DOS and store the original distribution disk in a safe place.

Backups

You should make backups regularly to minimize the amount of work necessary to bring your TEKMATE records up to date if information is lost through mishandling of a disk or by some other cause.

Backups provide a method of rotating your disks so that one is not wearing out from constant use. The backup procedure also gives you a way of recovering from a disk failure with a minimum lose of data.

The following discussion gives a step-by-step method for making backups using MS-DOS. This procedure involves formatting a new disk and then copying every track from the original (source) disk to the new (destination) disk. This procedure can be used to duplicate and produce identical disks; however, you cannot use it to produce nonidentical disks. (Copying individual files can be done using the DOS ***COPY*** command.)

1. Make sure the system is on and the MS-DOS prompt, **A>**, is displayed.
2. With an MS-DOS disk in drive A, type:

   Diskcopy A: B:

3. Press the ***RETURN*** key. When you pressed the RETURN key, you told the TEKMATE to execute the command. The TEKMATE will display something similar to:

   Insert SOURCE diskette in drive A:

   Insert TARGET diskette in drive B:

   Press any key when ready...

4. Remove the MS-DOS disk from drive A.
5. Insert the SOURCE diskette (disk to be copied) into drive A.
6. Insert the TARGET diskette (the disk to which data is to be copied) into drive B.
7. Press the ***RETURN*** key.

   When the diskcopy program is complete, the TEKMATE will ask:

   Copy another diskette (Y/N)?

8. Press the ***N*** key to end the diskcopy program.

If the disk you placed in drive B contains flaws on its surface or in its magnetic coating, an imperfect copy was made and the following error message will be displayed:

Read error on destination drive

Disk verify failure

Do not use a disk that generates read errors or verify failures.

DOS Commands

A DOS command is an instruction to the operating system that is typed on the keyboard. Some of the DOS commands are **internal**—an integral part of the operating system. Other commands are **external**—actually separate programs on the DOS disk that must be loaded into the TEKMATE before their functions can be performed.

Internal commands are always present, after booting DOS. Some of the MS-DOS internal commands and their functions are:

COPY	Copy information (one or more files) from one disk to another disk or onto the same disk.
DATE	Display the current system date and prompt for a new date entry.
DEL	Delete a file from the disk (same as ERASE).
DIR	List the files in a directory.
ERASE	Delete a file from the disk (same as DEL).
REN	Rename a file (same as RENAME).
RENAME	Rename a file (same as REN).
TIME	Display the current system time and prompt for a new time entry.
TYPE	Display the contents of a text file.

External commands can be used only if the command file exists on the disk in the drive. The file name will appear on the directory listing of a disk. If the file is not present on the disk in your search path, the command will not work. Some of the more frequently used external commands from MS-DOS and their functions are:

CHKDSK	Check the disk directory, report free space, and repair the directory if necessary.
DISKCOMP	Compare the contents of two disks to see if they are identical.
DISKCOPY	Duplicate the contents of one disk onto another disk.
EDLIN	Create, edit (change), display, or delete ASCII files.
COMP	Compare the contents of two files to see if they are identical.
FORMAT	Format a disk.
SYS	Transfer the operating system.

Programming

This part of the manual briefly describes some of the programming that can be performed using DOS. For complete details see your DOS documentation.

For information about programming using other application software, see your software documentation.

Appendices B, C, and D contain information that can be used to change the TEKMATE's hardware from its standard factory configuration. Changing the factory configuration may make it necessary to modify application programs that you wish to run on the TEKMATE.

Configuration File (CONFIG.SYS)

The configuration file contains commands which set up defaults for your system that may be different from the standard DOS defaults. At power-up or when the TEKMATE is reset, DOS searches for the file named CONFIG.SYS in the root directory of the default drive. If the file is found, the commands found within the file override the DOS defaults.

When the CONFIG.SYS file is created or modified, the new defaults do not become effective until the next power-up or reset.

Commands that can be included in the configuration file include:

BREAK	Determines when breaks are looked for.
BUFFERS	Sets starting number of disk buffers.
COUNTRY	Sets country defaults (date, time, collating sequence, etc).
FCBS	Sets maximum number of open file control blocks.
FILES	Sets maximum number of open files.
LASTDRIVE	Sets maximum number of accessible drives.
DEVICE	Selects device driver file.
SHELL	Specifies a command processor.
STACKS	Overrides default stack resources.

An example CONFIG.SYS file is shown below.

```
buffers = 20
files = 20
SHELL = A:\COMMAND.COM A:\ /P /E:1024
DEVICE = A:\NANSI > SYS
DEVICE = A:\BIN\GPIB.COM
```

Batch Files

Batch files are files with a *.BAT* extension to the file name. Batch files contain DOS commands and/or programs that DOS executes in sequence when you execute the batch file.

Auto-execute Programs (AUTOEXEC.BAT)

Auto-execute programs are batch files with AUTOEXEC.BAT as their file name. Each time you boot DOS, the DOS command processor executes the AUTOEXEC.BAT file, if any, that it finds in the root directory.

Auto-execute programs can be used to execute DOS commands or programs every time you boot DOS. As an example, an AUTOEXEC.BAT file can be created to set the date and time using the real time clock.

An example AUTOEXEC.BAT file is shown below.

```
ECHO OFF
CLS
PATH A:\;A:\DOS;A:\BIN;A:\LIB;A:\ETC
SET TERM = NANSI
PROMPT $e[1;33;44m$s$e[37;41m$p$e[1;33;44m
A:\BIN\PCCLOCK
A:\BIN\FAST.BAT
```

Controls, Connectors, and Indicators

Controls, Connectors, and Indicators

Power

Refer to Figure 3–1 for the location of items 1 and 2.

(1) On/Off Switch

Turns the 2402 TEKMATE's power on and off. The On/Off power switch is located on the rear panel. To operate the TEKMATE, install a disk containing the disk operating system in the A: (upper) drive and turn the TEKMATE on by pressing the left side (from the rear of the TEKMATE) of the On/Off switch. The disk should automatically boot and run any automatically executing application program. See specific application program documentation for further details.

(2) Detachable Power Cord Receptacle

Connects the ac power source to the instrument.

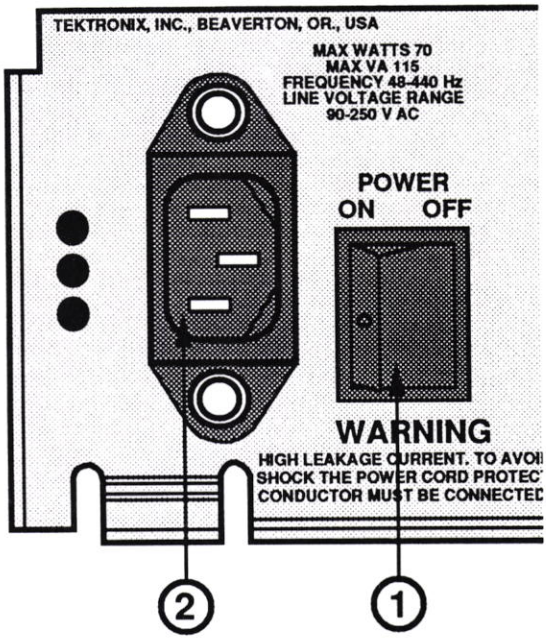


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Figure 3–1. Power control and connector.

Front Panel

Refer to Figure 3-2 for the location of items 3 and 4.

(3) Power On Indicator

Indicator is lit when the TEKMATE's power is on.

(4) Disk Drives

Disk drives are located on the right side of the front of the instrument. Each drive is a 3.5-inch micro floppy drive giving 720K bytes of formatted mass storage. They enable storage of programs and data for future use. (Data stored in the TEKMATE's RAM is lost when the TEKMATE is turned off). Disk space is reusable. When the data is no longer needed, it can be erased and the space used for new information. Disks are transportable from the TEKMATE to other compatible devices.

Disks are inserted into the disk load slot with the label up and toward you. The disk should slide in smoothly and click down into the drive when fully in place. An improperly installed disk will not function and may physically damage the drive.

To remove a disk from the drive, press the disk eject button located on the lower right corner of the drive.

To avoid accidentally writing on a disk and changing important information, slide the small tab on the bottom left front corner of the disk toward the front edge of the disk so you can see through the hole. This will prevent writing on the disk.

Disks should be stored in a clean, dry area. To prevent mechanical damage or loss of data, never expose disks to heat, direct sun, or magnetic fields. Do not touch the magnetic medium. Do not install a damaged disk in the disk drive, as it may damage the drive.

New disks must be formatted before they can be used by the TEKMATE. (See the FORMAT command in your DOS documentation.)

When the TEKMATE reads data from or writes data to a disk drive, the disk access LED is lit. The disk access LED is located on the lower left front corner of each disk drive.

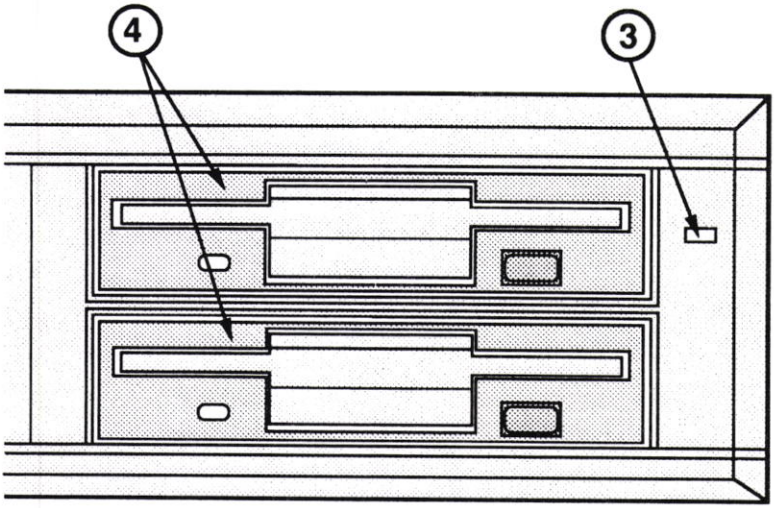

Figure 3–2. Front panel controls and indicators.

Rear Panel

Refer to Figure 3–3 for the location of items 5 through 11.

(5) System Reset

A reset button on the rear panel allows restarting the TEKMATE via a hardware reset without cycling the power. Pressing the reset button boots the system and starts any automatically executing application programs on drive A.

RS–232–C Interfaces

(6) PC Serial Port COM 1

Output connector COM 1 is a PC–compatible serial port.

Three RS–232–C output signals and five RS–232–C input signals allow a broad range of serial devices to be connected. This port can be used to connect a printer, modem, terminal, or other serial device.

The main interface consideration is that the device be RS–232–C compatible. Printers and modems generally require handshaking in one or both directions. Consult the serial device's installation manual for information regarding possible handshake and other interface considerations.

Table 3–1 gives the signal definitions for each pin of serial port connector COM 1. COM 1 is an RS–232–C DTE (data terminal equipment) device.

Table 3-1
PC Serial Port Connections COM 1

Name	Function	In/Out	Pin
DCD	Carrier Detect	in	1
RXD	Receive Data	in	2
TXD	Data Output	out	3
DTR	Terminal Ready	out	4
GND	Signal Ground	--	5
DSR	Data Set Ready	in	6
RTS	Request To Send	out	7
CTS	Clear to Send	in	8
RI	Ring Indicator	in	9

PC Serial Port Device Assignment

The PC-compatible serial port labeled COM 1 is supported by the ROM-BIOS as either the MS-DOS "COM 1" or "COM 2" serial device, depending on the setting of configuration jumpers on the CPU board. As shipped, the system is configured for "COM 1" (IRQ4 and 3F8-3FFh). If you need to alter this, refer to Appendix B.

(7) Serial Port COM 4

COM 4 is a limited RS-232-C serial port. It can be used if the program that uses it is customized for the special needs of COM 4 or if the COM 4 driver is loaded. It is best suited for attaching a terminal. Only some unmodified programs will be able to use the COM 4 port. Communications programs are not likely to work. Some programs may be able to send output to a printer attached to the port. Some mice can be attached to COM 4. It provides only one active handshaking signal (in both directions). It is not PC-compatible. Furthermore, it can be interrupt driven only if the keyboard interrupt is not needed. The rear-panel connector labeled COM 4 is supported in the ROM-BIOS as a "COM 4" device.

Since the COM 4 port has only two active handshaking signals, the handshaking requirements of the external device must be considered. Many printers can be employed, if a suitable shielded cable is used. Consult the serial device's installation manual for information regarding possible handshake and other interface considerations.

The Handshake Out signal source is hardware selectable. The factory selection uses the handshake signal internal to the microprocessor as the signal source. As utilized by the ROM-BIOS, this handshake signal automatically goes true when the receive buffer is ready to receive data, and false when the receive buffer is full. It is possible to select the printer port (not)INIT signal as the Handshake Out source. This provides a signal source which is completely under software control, but is only useful if the printer port will not be used, or if the applications running on the TEKMATE will not use the (not)INIT signal when using the printer port. To change the Handshake Output signal source, see Appendix B.

Table 3-2 gives the connector pinout and signal definitions for each pin of the connector COM 4. One output signal (pin 4) provides a means of sending an EIA TRUE to the attached device, if needed. COM 4 is an RS-232-C DTE (data terminal equipment) device.

Table 3-2
V40 Serial Port Connections (COM 4)

Name	Function	In/out	pin
RXD	Receive Data	in	2
TXD	Transmit Data	out	3
DTR	EIA TRUE	out	4
GND	Signal Ground	---	5
RTS	Handshake Out	out	7
CTS	Handshake In	in	8

(8) KEYBOARD

An IBM PC (or XT) compatible keyboard can be connected to a male 5-pin DIN plug on the rear panel. Table 3-3 gives the KEYBOARD connector pinout and signal definitions.

NOTE

Most 101 key "AT" keyboards are not compatible with PC (or XT) keyboard ports, and cannot be used with this interface unless the "AT" keyboard contains an alternate interface option for PC and XT keyboard ports.

Table 3-3
KEYBOARD Connector

Signal Name	DIN Pin
Keyboard Clock	1
Keyboard Data	2
$\overline{\text{RESET}}$	3
Ground	4
+5V power	5
No Connection	6

(9) Parallel PRINTER Port

The parallel PRINTER port connector is a standard DB-25 PC printer connector. Table 3-4 gives the printer connector's pinout and signal definitions.

A jumper option allows the printer port to be selected as either the MS-DOS "LPT1" or "LPT2" device. As shipped from the factory, the printer port is configured for "LPT1" (IRQ7, 378-37Fh, (not)INIT driven by the printer controller). To change the port configuration, see Appendix B.

Table 3-4
Parallel PRINTER Connector

Name	Function	In/out	DB-25
$\overline{\text{DS}}$	Sample input	out	1
D0	Data 0	out	2
D1	Data 1	out	3
D2	Data 2	out	4
D3	Data 3	out	5
D4	Data 4	out	6
D5	Data 5	out	7
D6	Data 6	out	8
D7	Data 7	out	9
$\overline{\text{ACK}}$	Char accepted	in	10
BUSY	Cannot receive	in	11
PAPER OUT	Out of paper	in	12
SELECT	Select	in	13
AUTOFD	Automatic feed	out	14
$\overline{\text{ERR}}$	Printer error	in	15
$\overline{\text{INIT}}$	Initialize	out	16
SELECT	Select printer	out	17
GND	Signal ground	---	18-25

(10) External Video MONITOR

A monochrome or RGB color video monitor (optional) can be connected, via a standard PC compatible cable, to the female DB-9 MONITOR connector on the rear panel of the TEKMATE. Table 3-5 gives the connector pinout and signal definitions.

Table 3-5
Video MONITOR Connector

Signal Name	DB-9 Pin
Ground	1
Ground	2
Red	3
Green	4
Blue	5
Intensity	6
Green (Video)	7
Horizontal Sync	8
Vertical Sync	9

(11) MONITOR Switch

The internal video controller supports four video protocols:

- Double scan (400 line) color graphics (2XCGA)
- Standard IBM PC color graphics (IBM 5153, CGA: 320 by 200 pixels 4 color, or 640 by 200 pixels 1 color)
- Hercules monochrome graphics (720 by 348 pixels)
- Standard IBM PC monochrome display (IBM 5101 or MDA: 80 characters by 25 rows)

Three of the four video protocols are selectable by way of the MONITORswitch:

2XCGA Selects double scan (400 line) color graphics

CGA Selects standard IBM PC color graphics (IBM 5153, CGA: 320 by 200 pixels 4 color, or 640 by 200 pixels 1 color)

MONO Selects Hercules monochrome graphics (720 by 348 pixels)

The fourth video protocol (Standard IBM PC monochrome display–IBM 5101 or MDA, 80 characters by 25 rows) can be reached by setting the MONITOR Switch to MONO and removing the A14 jumper from the video board.

The monochrome and standard color graphics modes require a standard PC-compatible monochrome or CGA monitor (optional). The double-scan high resolution color graphics mode requires a monitor that can support 400 horizontal lines and scan at 25 kHz horizontally, and 57 Hz vertically. The monitors all require TTL inputs.

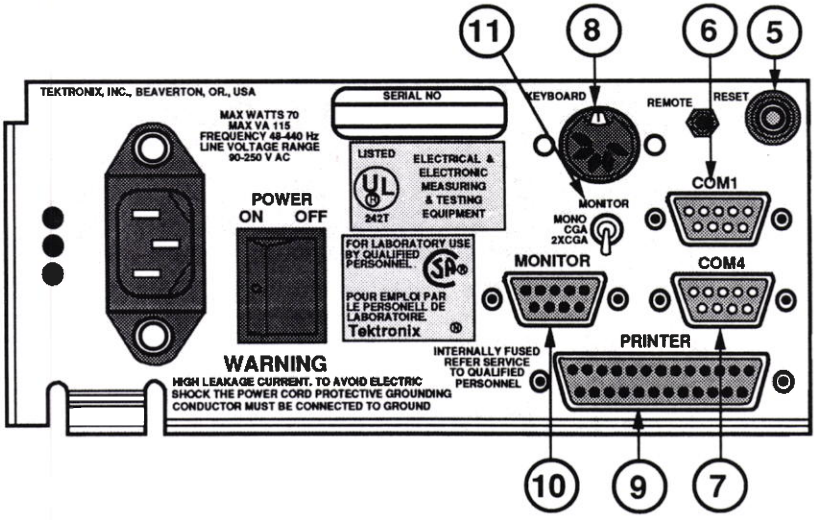

Figure 3–3. Rear panel controls and connectors.

Expansion

Refer to Figures 3-4 and 3-5 for the location of items 12 and 13.

(12) PC Expansion Bus

The TEKMATE contains an internal PC expansion bus. The bus is a standard PC expansion bus. Either two full-sized cards or two half-cards and one full-sized PC expansion card are supported.

NOTE

Addition of expansion boards must not cause the TEKMATE input Power Consumption rating to be exceeded.

To add expansion boards, remove the TEKMATE's cover and remove the expansion-board support bracket. Install the expansion board in the bus connector, and align the plastic board-support clips in the board-support bracket so they will support the board and not interfere with the board's components. Reinstall the board-support bracket and the TEKMATE cover.

The PC bus signals are buffered on the CPU board and provide peripheral boards with approximately 4 mA source and sink currents at TTL-compatible signal levels. Tables 3-6A and 3-6B indicate the pinout and signal functions of the signals on the PC expansion bus connectors. Further information about these signals is available in numerous publications, including the IBM technical reference manuals for the PC and XT computers.

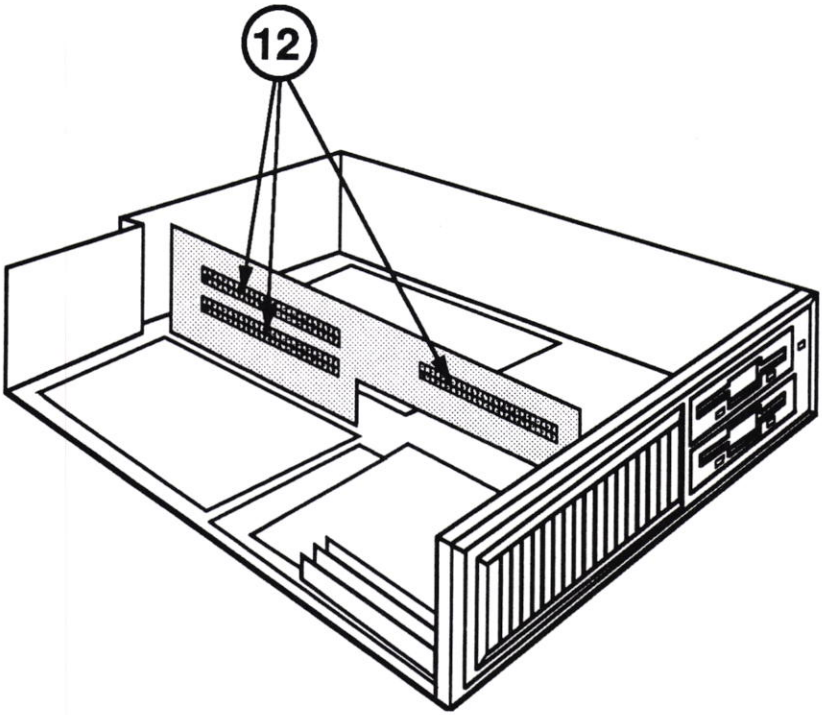

Figure 3–4. Expansion slots.

Table 3–6A
PC Expansion Bus Connector, A1–A32 (J9A)

Pin	Name	Function	In/Out
A1	$\overline{\text{I/OChCk}}$	Mem. parity err	in
A2	D7	Data bit 7	i/o
A3	D6	Data bit 6	i/o
A4	D5	Data bit 5	i/o
A5	D4	Data bit 4	i/o
A6	D3	Data bit 3	i/o
A7	D2	Data bit 2	i/o
A8	D1	Data bit 1	i/o
A9	D0	Data bit 0	i/o
A10	I/OChRdy	CPU Ready Ctrl	in
A11	AEN	Address Enable	out
A12	A19	Address bit 19	out
A13	A18	Address bit 18	out
A14	A17	Address bit 17	out
A15	A16	Address bit 16	out
A16	A15	Address bit 15	out
A17	A14	Address bit 14	out
A18	A13	Address bit 13	out
A19	A12	Address bit 12	out
A20	A11	Address bit 11	out
A21	A10	Address bit 10	out
A22	A9	Address bit 9	out
A23	A8	Address bit 8	out
A24	A7	Address bit 7	out
A25	A6	Address bit 6	out
A26	A5	Address bit 5	out
A27	A4	Address bit 4	out
A28	A3	Address bit 3	out
A29	A2	Address bit 2	out
A30	A1	Address bit 1	out
A31	A0	Address bit 0	out

Table 3-6B
PC Expansion Bus Connector, B1-B32 (J9B)

Pin	Name	Function	In/Out
B1	GND	Ground	---
B2	RST DRV	System reset	out
B3	+5V	+5 volts	---
B4	IRQ2	Int. request 2	in
B5	-5V	(no connection)	
B6	DRQ2	DMA request 2	in
B7	-12V	-12 volts	---
B8	N/C	(no connection)	
B9	+12V	+12 volts	---
B10	GND	Ground	---
B11	(not)MEMW	Memory Write	out
B12	(not)MEMR	Memory Read	out
B13	(not)IOW	I/O Write	out
B14	(not)IOR	I/O Read	out
B15	(not)DACK3	DMA Ack 3	in
B16	DRQ3	DMA Request 3	out
B17	(not)DACK1	DMA Ack 1	out
B18	DRQ1	DMA Request 1	in
B19	(not)DACK0	Memory Refresh	out
B20	CpuClk	7.16 MHz clock	out
B21	IRQ7	Int Request 7	in
B22	IRQ6	Int Request 6	in
B23	IRQ5	Int Request 5	in
B24	IRQ4	Int Request 4	in
B25	IRQ3	Int Request 3	in
B26	(not)DACK2	DMA Ack 2	out
B27	T/C	DMA Term Count	out
B28	ALE	Addr Latch	out
B29	+5V	+5 volts	---
B30	OSC	14.31818 MHz	out
B31	GND	Ground	out

(13) GPIB Connector

A General Purpose Interface Bus is implemented using a dedicated PC expansion half-card slot. A 24-pin GPIB connector is available on the rear panel of the TEKMATE, below the expansion slots. Table 3-7 gives the pinout name and function of each GPIB signal.

Refer to Appendix D for more information about using the GPIB.

Table 3-7

General Purpose Interface Bus Connector

Pin	Name	Function	In/Out
1	DIO1	Data bit 1	i/o
2	DIO2	Data bit 2	i/o
3	DIO3	Data bit 3	i/o
4	DIO4	Data bit 4	i/o
5	EOI	End or Identify	i/o
6	DAV	Data AVailable	i/o
7	NRFD	Not Ready For Data	i/o
8	NDAC	Not Data Accepted	i/o
9	IFC	InterFace Clear	out
10	SRQ	Service Request	in
11	ATN	ATtentioN	out
12	SHIELD	System Ground (Chassis)	---
13	DIO5	Data bit 5	i/o
14	DIO6	Data bit 6	i/o
15	DIO7	Data bit 7	i/o
16	DIO8	Data bit 8	i/o
17	REN	Remote ENable	out
18	GND	DAV Ground	---
19	GND	NRFD Ground	---
20	GND	NDAC Ground	---
21	GND	IFC Ground	---
22	GND	SRQ Ground	---
23	GND	ATN Ground	---
24	GND	LOGIC Ground	---

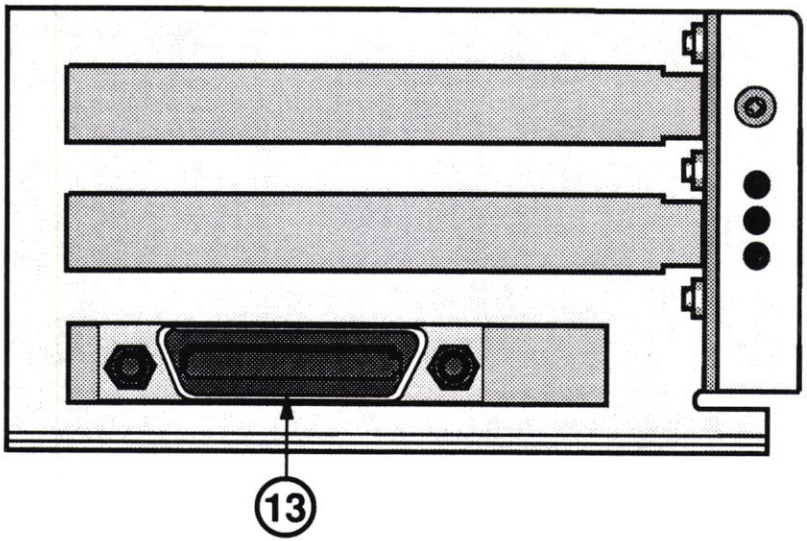

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Figure 3–5. GPIB connector.

Performance Characteristics

Performance Characteristics

Introduction

The TEKTRONIX 2402 TEKMATE is a portable, compact, low power, IBM PC and GPIB-488 compatible system. It includes a CMOS NEC V40-enhanced 8088-compatible microprocessor using MS-DOS version 3.3, 768K RAM, EPROM, DMA, interrupt controller, counter timer, 3.5 inch micro floppy disk drives, and I/O ports. Controllers are included for two RS-232-C serial ports, a parallel printer port, a keyboard port, a video monitor, a PC Expansion Bus, and a speaker.

The video controller's possible operating modes are: standard IBM PC monochrome (MDA), standard IBM PC color graphics (CGA), Hercules monochrome graphics, and double scan (400 line) color graphics.

Performance Conditions

The following electrical characteristics (Table 4-1) are valid for the instrument when it has been adjusted at an ambient temperature between 20°C and 30°C, and is operating at an ambient temperature between +5°C and +50°C (unless otherwise noted).

Mechanical characteristics are listed in Table 4-2.

Environmental characteristics are given in Table 4-3.

Any conditions that are unique to a particular characteristic are expressly stated as part of that characteristic.

Table 4-1
2402 Electrical Characteristics

Characteristics	Performance Requirements
CPU	
Processor	V40 (Intel 8088, 8086, 80186, and 80188 instruction set compatible).
Clock Rate	7.16 MHz.
DMA	3 PC-compatible channels.
Interrupts	7 PC-compatible channels.
Counter/Timers	3 PC-compatible controllers.
System DRAM	768K bytes, parity checked.
Available Byte Wide Memory Sockets	3 sockets are available: 2, 8K-128K PROM/EPROM/RAM/NVRAM Sockets. 1, 32K PROM/EPROM socket is used by the ROM-BIOS).
Hardware Reset	Momentary push-button switch.
INPUT/OUTPUT	
Mass Storage	2, 3.5 inch (720K byte) floppy disks.
Serial Ports	2 RS-232-C: 1, PC-compatible COM port with full handshaking 1, OEM serial port with two active handshake lines.
Baud rates	Up to 19.2K bits/second (software controlled).

Table 4-1 (cont)
2402 Electrical Characteristics

Characteristics	Performance Requirements
Parallel Port	1 PC/Centronics compatible.
Clock/Calendar	Programmable, with battery backup. Clock and Calendar may not operate properly at extreme temperature ranges. If temperature is returned to normal range and the time and date are reset, the clock and calendar should resume normal operation.
Keyboard Input	IBM PC/XT compatible.
Speaker	PC compatible 1.5 inch cone type.
GPIB Controller	IEEE-488-1978 compatible, supports DMA and multiple controllers.
Expansion Bus	PC compatible, expansion bus header.
Video Controller	4 modes available: 1. Standard PC monochrome (MDA) 80 characters by 25 rows. 2. Hercules monochrome graphics 720 by 348 pixels. 3. Standard PC color (CGA) 640 by 200 pixels. 4. Double scan color graphics (400 line).

Table 4–1 (cont)
2402 Electrical Characteristics

Characteristics	Performance Requirements		
POWER SUPPLY			
	Power supply specifications are typical values.		
Output Voltage	+5.1 V	+12 V	−12 V
Output Currents			
Minimum	0 A	0 A	0 A
Maximum	7.0 A	2.5 A	0.7 A
Peak[1]	7.0 A	5.0 A	1.0 A
Ripple peak-to-peak[2]	50 mV	120 mV	120 mV
Total Regulation[3]	±2.5%	±5%	±5%
Power Available at Expansion Bus	Approximately 35 W.		

1 Peak outputs lasting less than one minute with duty factor less than 5%. During peak loading, output may go outside of total regulation limits.

2 50 MHz bandwidth, peak-to-peak, measured differentially.

3 Total Regulation is defined as the static output regulation at 25°C, including initial tolerance, line voltage within stated limits, load currents within stated limits, and output voltages adjusted to their factory setting. Also, for stated regulation:

$$\frac{I1}{I2} \leq 5.0$$

where I1 is the output currrent of the +5.1 V supply and I2 is the output current of the +12 V supply.

Table 4–1 (cont)
2402 Electrical Characteristics

Characteristics	Performance Requirements
Input Voltage All Rated Load Conditions	90 to 250 VAC.
Input Frequency Range	48 Hz to 440 Hz.
Input Surge Current High Line, Cold Start	20 A maximum.
Power Consumption	70 watts. User must not let the input demand, due to expansion card loading, exceed this amount.
Fuse Rating	2A, 250 V 5x20 mm.
Output Voltage Adjustability +5 V Output	±3%.
Overshoot/Undershoot Turn-on	None.
Transient Response +5 V Output, 2.5 A to 5 A Load Change	500 mV peak transient settling to within 0.5% in 500 µs.
+12 V Output, 1 A to 2 A Load Change	300 mV peak transient settling to within 0.5% in 500 µs.
Temperature Coefficient All Outputs	±0.03% per °C maximum.
Overvoltage Protection Threshold +5 V Output	6.25 V ±0.75 V.
Total Output Power 50°C Ambient Continuous Peak	 0 W to 50 W. 60 W maximum.
Hold-up Time 50 W Output Power 85 VAC Input 110 VAC Input 170 VAC Input 220 VAC Input	 8 ms. 16 ms. 60 ms. 100 ms.

Table 4–1 (cont)
2402 Electrical Characteristics

Characteristics	Performance Requirements
	SOFTWARE
Operating System	MS-DOS 3.3.
Language Support	Microsoft C; QuickC and QuickBasic are supported.
	COMPATIBILITY
Operating System	Compatible with MS-DOS and PC-DOS 3.2 or higher. Also compatible with 8088, 8086, 80188, and 80186 instruction sets.
Display	Emulation of IBM MDA and CGA, Hercules monochrome graphics, and double scan color graphics (400 line).
Software Support	Microsoft QuickBasic, C, QuickC, ASYST, SPD, EZ-TEK, EZ-TEST, and other MS-DOS compatible packages. ***NOTE*** *Some packages may require optional keyboard and monitor.*
	CONTROLS/CONNECTORS/INDICATORS
Keyboard Connector socket.	DIN (5 pin) IBM-PC Keyboard Compatible
Monochrome/RGB	DB9 connector.
Parallel Port	DB25 connector.
Serial Ports	DB9 connectors.
PC Expansion Slots	2 full length slots, one of which can accommodate two half cards end to end, provided one half card can be isolated from external connectors. 1 additional half length slot is dedicated to a GPIB interface card.
GPIB	24 pin, IEEE 488 compatible.
Power On Indicator	Green LED on the Front Panel.
Hardware Reset	Momentary push-button switch.

Table 4–2
2402 Mechanical Characteristics

Characteristics	Description
	Mechanical specifications are typical values, not checked in the manual.
Weight	10 lb.
Domestic Shipping Weight	14.6 kg (32.1 lb).
Height	3.1 inches.
Width	12.0 inches.
Depth	15.0 inches.
Cooling	Forced-air circulation.
Finish	Tek Blue painted aluminum cabinet.
Construction	Aluminum-alloy chassis (sheet metal). Molded-plastic front panel. Glass-laminate circuit boards.

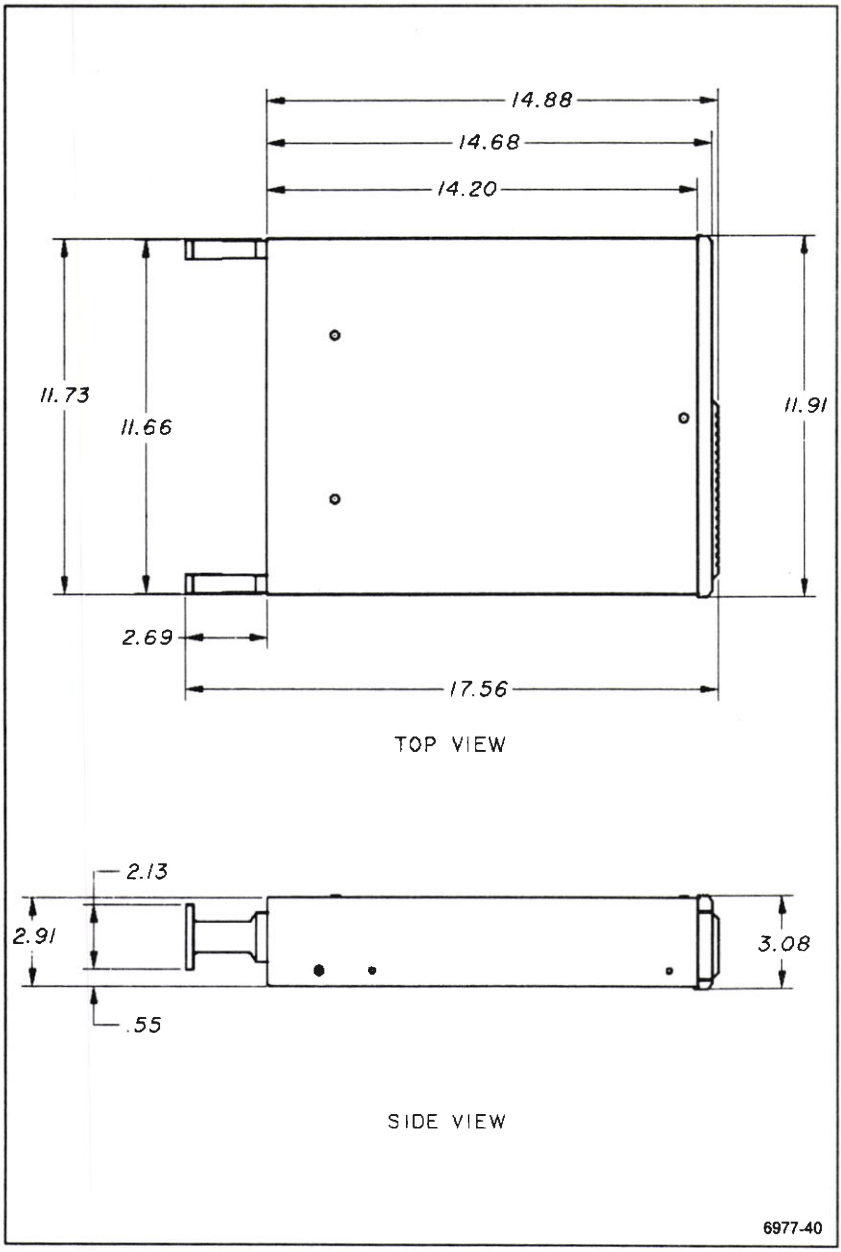


Figure 4–1. TEKMATE dimensional drawing.

Table 4–3
Environmental Characteristics

Characteristics	Description
	Environmental requirements qualify the electrical and mechanical specifications. Requirements are tested in accordance with the procedures of MIL-T-28800D except as noted for the specific characteristic. Operating and non-operating characteristics are specified for two conditions: Condition 1. Floppy disk drives non-operating and vacant of media. Condition 2. Floppy disk drives performing R/W operations. For condition 2, the media itself imposes atmospheric constraints and the electromechanical sensitivity of the disk drives imposes dynamic constraints.
Temperature and Humidity	MIL-T-28800D: low temperature as paragraph 4.5.5.1.3 except that Step 4 shall precede Step 2 to avoid moisture condensation on the instrument surfaces, and high temperature as paragraph 4.5.5.1.4 except that Step 4 shall be less than 15% RH (see Figure 4–2). Humidity, paragraph 4.5.5.1.2.2, class 5 procedure (see Figure 4–2)..
Operating:	Operational performance checks at 25°C and 50°C.
	Humidity **Temperature**
(condition 1)	10% −22°C to +60°C. 80% −22°C to +40°C.
(condition 2)	20% +4°C to +50°C. 80% +4°C to +30°C. For a rack mounted instrument, ambient temperature should be measured at the instrument's air inlet. Fan exhaust temperature should not exceed +50°C.
Nonoperating: (Storage, condition 1)	**Humidity** **Temperature** 5% −40°C to +65°C. 95% −40°C to +42°C.

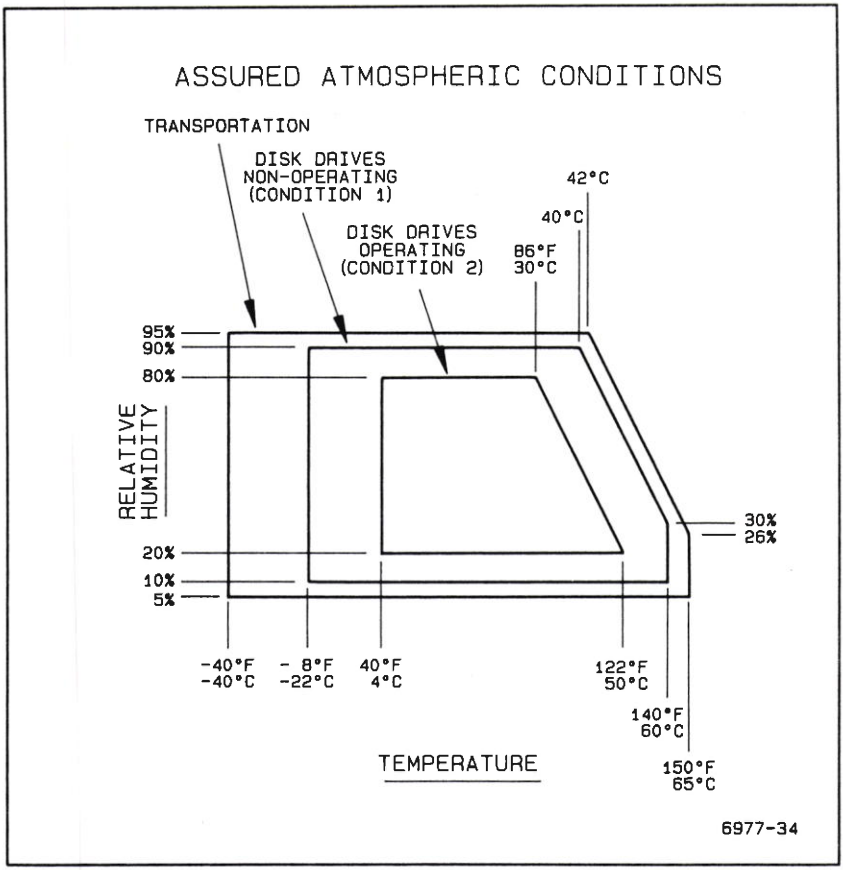


Figure 4–2. Assured Atmospheric Conditions.

Table 4–3 (cont)
2402 Environmental Characteristics

Characteristics	Description
Altitude (Operating) (conditions 1 & 2)	To 15,000 feet. Maximum operating temperature decreases 1°C for each 1000 feet above 5000 feet.
(Nonoperating) Storage, condition 1	To 50,000 feet.
Vibration (operating) condition 1	15 minutes along each of three axes at a total displacement of 0.015 inch p-p (2.3 g at 55 Hz), with frequency varied from 10 Hz to 55 Hz in one minute sweeps. Hold 10 minutes at each major resonance or, if none exists, hold 10 minutes at 55 Hz (75 minutes total test time)
Shock (operating and nonoperating) condition 1	30 g, half sine, 11 ms duration, three shocks in each of three mutually perpendicular axes, for a total of 18 shocks.
Bench Handling (cabinet on or cabinet off)	(MIL-T-28800D, para. 4.5.5.4.3).
Topple (operating with cabinet installed) condition 1	Set on rear feet and allow to topple over onto each of four adjacent faces (Tektronix Standard 062-2858-00).

Table 4–3 (cont)
2402 Environmental Characteristics

Characteristics	Description
Packaged Transportation Drop	Meets the limits of the National Safe Transit Association; test procedure 1A–B–2; 10 drops of 36 inches (Tektronix Standard 062–2858–00).
Packaged Transportation (Vibration)	Meets the limits of the National Safe Transit Association; test procedure 1A–B–1; excursion of 1 inch p–p at 4.63 Hz (1.1 g) for 30 minutes (Tektronix Standard 062–2858–00).
EMI (Electro–magnetic Interference)	Meets MIL–T–28800C; MIL–STD–461B, part 4 (CE–03 and CS–02), part 5 (CS–06 and RS–02), and part 7 (CS–01, RE–02, and RS–03)––limited to 1 GHz; VDE 0871, Category B; Part 15 of FCC Rules and Regulations, Subpart J, Class A; and Tektronix Standard 062–2866–00.
Electrostatic Discharge Susceptibility	Meets Tektronix Standard 062–2862–00. The instrument will not change control states with discharges of less than 10 kV.
X–Ray Radiation	Meets requirements of Tektronix Standard 062–1860–00.

Options

Options

Options Descriptions

This section contains a general description of the options available for the 2402 TEKMATE when this manual was published. Additional information about instrument options, option availability, and accessories can be obtained from the current Tektronix Products Catalog or by contacting your local Tektronix Field Office or representative.

Options A1–A5—International Power Cords

Instruments are shipped with the detachable power cord configuration ordered by the customer. Descriptive information about the international power cord options is provided in Section 1, "Preparation for Use." The following list identifies the Tektronix part numbers for the available power cords and associated fuses.

Universal Euro

Power cord (2.5 m) OPTION A1
Fuse (2 A, 250 V, 5 x 20 mm)

UK

Power cord (2.5 m) OPTION A2
Fuse (2 A, 250 V, 5 x 20 mm)

Australia

Power Cord (2.5 m) OPTION A3
Fuse (2 A, 250 V, 5 x 20 mm)

North America

Power Cord (2.5 m) OPTION A4
Fuse (2 A, 250 V, 5 x 20 mm)

Switzerland

Power Cord (2.5 m) OPTION A5
Fuse (2 A, 250 V, 5 x 20 mm)

Option 01

Option 01 provides the 2402 with 24XX DSO compatibility. Provided with the option is a 2400 DSO mounting kit, DSO-Utility Applications software, DSO-Utility Software User's Manual, a 0.5 meter GPIB cable, and a 2402 Option 01 Diagnostic disk.

Option 1R

Option 1R permits the 2402 to be easily installed into a 19-inch-wide electronic-equipment rack.

An on-off switch, reset button, and a keyboard connector are provided in the front panel of the rackmounted instrument.

Complete rackmounting instructions are provided in a separate document shipped with the option.

Option 41

Option 41 is the DSO-Utility Program Development Package. This package includes the source, executables, and documentation for the DSO-Utility Applications software and the QuickBasic®, and QuickC® GPIB libraries. QuickBasic® and QuickC® are also included. The option also includes the Programmer's Reference Guide for the DSO-Utility Program Development System.

Option 01 Diagnostics

The 2402 TEKMATE Option 01 Diagnostics Software is intended to verify functional performance, identify functional performance deficiencies, and isolate defective TEKMATE modules. Except for using the oscilloscope crt and bezel buttons for input and output, the Option 01 Diagnostics are the same as the standard diagnostics.

The modules that can be tested by the software are:

- Floppy Drive A:
- Floppy Drive B:
- Serial Port COM 1
- Serial Port COM 4
- Switches
- Parallel Printer Port
- Speaker
- SmartWatch
- RAM

Installing MS-DOS

The Option 01 Diagnostic disk does not contain MS-DOS. If Tektronix is licensed to distribute MS-DOS in your country (the disk is shipped with your *Running MS-DOS* book), proceed to "Installing Tektronix Supplied MS-DOS". If Tektronix in not licensed to distribute MS-DOS in your country you must purchase your own MS-DOS version 3.2 or later. Then, proceed to "Installing Customer Supplied MS-DOS".

Installing Tektronix Supplied MS-DOS

To install MS-DOS fron the Tektronix supplied MS-DOS disk onto the Option 01 Diagnostic disk:

1. Make sure the 2402 Tekmate POWER switch is in the OFF position.
2. Insert the MS-DOS distribution disk into drive A:.
3. Write enable the Option 01 Diagnostics disk by sliding the small write protect tab to the Write Enable position (the tab should cover the hole and lock into place). Then, insert the diagnostic disk into drive B:.

4. Place the 2402 Tekmate POWER switch in the ON position. After power-up, the MS-DOS files will be copied onto the diagnostic disk. This takes about 30 seconds. During the copy the drive access LEDs will turn on and off twice. When the file copy is complete the drive access LEDs will both be off.

5. Remove both disks from drive A: and Drive B:. Installation of MS-DOS is now complete.

Installing Customer Supplied MS-DOS

To install MS-DOS from the customer supplied MS-DOS disk onto the Option 01 Diagnostic disk:

1. Place the 2402 Tekmate POWER switch in the OFF position.

2. Connect an IBM PC (or XT) compatible keyboard to the 2402 Tekmate rear panel KEYBOARD connector.

3. Connect a compatible video monitor to the 2402 Tekmate rear panel MONITOR connector. Then, set the 2402 Tekmate rear-panel MONITOR switch to the position required for your monitor (see the "MONITOR Switch" part of *Controls, Connectors, and Indicators* for details).

4. Write enable the Option 01 Diagnostics disk by sliding the small write protect tab to the Write Enable position (the tab should cover the hole and lock into place). Then, insert the diagnostic disk into drive B:.

5. Insert the MS-DOS disk into drive A:.

6. Place the 2402 Tekmate POWER switch in the ON position.

7. After the power-up prompt is displayed, type:

   B:TEKPREP

8. Press the ENTER key. The MS-DOS files will be copied onto the diagnostic disk. This takes about 30 seconds. During the copy the drive access LEDs will turn on and off twice. When the file copy is complete the drive access LEDs will both be off.

5. Remove both disks from drive A: and Drive B:. Installation of MS-DOS is now complete.

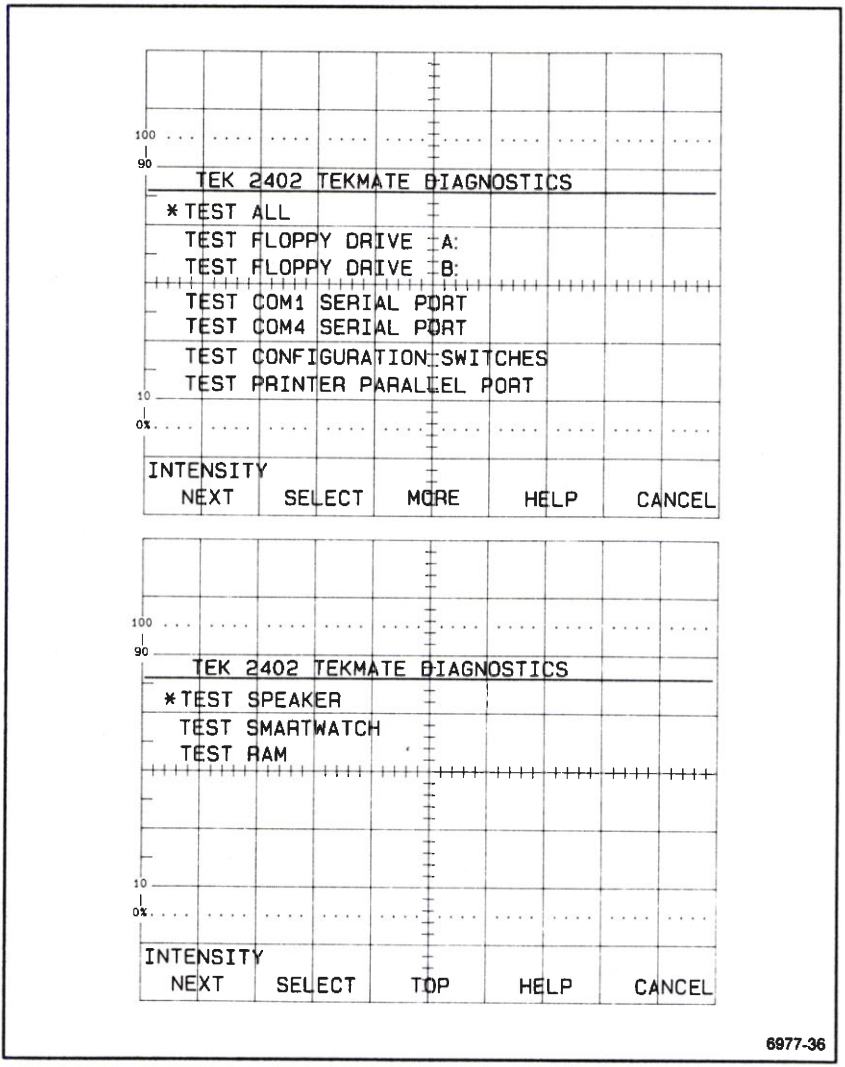


Figure 5–1. Diagnostic Menu.

Executing the Diagnostics

Before executing the diagnostics, set the oscilloscope to TALK/LISTEN (T/L) mode using the oscilloscope OUTPUT button. Connect the TEKMATE and the oscilloscope via a GPIB cable. Install Loop Back Connectors for the two Serial Ports and the Parallel Port tests. Insert the Diagnostic Disk into drive A:. Turn on the oscilloscope power, and the TEKMATE's power. If after about a minute there isn't a MENU on screen, check the GPIB cable. Select and execute the tests using the diagnostic menu. After the diagnostics boot, the diagnostic program copies itself to a RAM Drive. After the program has been copied, you are asked to remove the diagnostic disk and install blank disks:

NOTE

Both blank disks must be writable (write protect window closed).

Remove the diagnostic disk from drive A:. Insert blank writable disks into both drive A: and drive B:. Then, type **Y** and **RETURN**.

Diagnostic Menu

After the diagnostics boot and blank disks have been installed in both drives, a menu of available tests is displayed. The menu, (see Figure 5–1) along with the oscilloscope bezel buttons, is used to select and execute the diagnostics.

NEXT The NEXT bezel button moves the asterisk (*) pointer down the list of tests.

SELECT Press the SELECT button to select and execute the test pointed to by the asterisk.

MORE Pressing MORE displays additional Menu or Help screens. When the menu is displayed and MORE ispressed, the MORE bezel button is relabled TOP.

HELP Pressing HELP displays Help information for the selected test. When a Help screen is displayed, the bezel buttons are relabeled:

MORE **CANCEL**

CANCEL Pressing CANCEL while a Help screen is displayed returns you to the main menu. Pressing CANCEL while the Menu is displayed terminates the diagnostics program and returns control to DOS.

TOP Pressing TOP returns you to the top of the main menu.

Test All

Test All executes all tests in the order they are listed in the menu.This test takes about 12 minutes to complete.

Test Floppy Drive A:

The floppy drive A: test takes about 6 minutes to complete. It consists of:

- Formatting the 80 tracks, 2 sides, 512 sectors, and f9 type diskette in drive A:.
- Writing a test pattern (6D, B6, DB, 6D, B6, DB, ...) onto the diskette in drive A:.
- Reading the disk to see if the test pattern is still the same. If the test data is still intact, PASS is displayed; if the data is not the same, FAIL is displayed.

Test Floppy Drive B:

The floppy drive B: test takes about 4 minutes to complete. It consists of:

- Formatting the 80 tracks, 2 sides, 512 sectors, and f9 type diskette in drive B:.
- Writing a test pattern (6D, B6, DB, 6D, B6, DB, ...) onto the diskette in drive B:.
- Reading the disk to see if the test pattern is still the same. If the test data is still intact, PASS is displayed; if the data is not the same, FAIL is displayed.

Test Serial Port COM1

NOTE

This test requires a DB9 Loop Back Connector wired as in Table 5-1.

This test only takes a few seconds. The serial port COM1 test consists of:

- A Reset Modem test
- A DTR/DSR bit test
- A RTS/CTS bit test
- A TXD/RXD text test

The TXD/RXD Text test part of this test sends and receives all 256 ASCII characters.

Table 5-1
Serial Port Loop Back Connector

Pin#	Signal Name	Connect to Pin
1	Data Carrier Detect (DCD)	
2	Receive Data (RXD)	3
3	Transmit Data (TXD)	2
4	Data Terminal Ready (DTR)	6
5	Signal Ground (GND)	
6	Data Set Ready (DSR)	4
7	Request To Send (RTS)	8
8	Clear To Send (CTS)	7
9	Ring Indicator (RI)	

Test Serial Port COM4

Serial Port COM4 is not a full RS232-C port. It does not provide the DCD, DSR, and RI lines. So only the TXD and RXD lines can be tested. This test only takes a few seconds to complete.

The Loop Back connector is the same as the COM1 port Loop Back connector. The connection between pins 4 and 6 is redundant, but allows the connector to be used for either COM1 or COM4.

Test Configuration Switches

The Configuration Switches test senses the jumpers that determine the Video display mode, the Floppy Drive quantity, and whether or not there is a Math chip. The settings are compared with the expected default settings shown in Table 5-2. If the settings agree with the expected defaults, PASS is displayed. If the settings do not agree with the expected defaults, FAIL is displayed. This test only takes a few seconds to complete.

Table 5-2
Switch Test Jumper Defaults

PC Switch	TEKMATE Jumper	Jumper Position	Expected TEKMATE Setup
SW8	W32	ON	2 Drives
SW7	W33	OFF	
SW6	W19	OFF	640 X 200 Color
SW5	W31	ON (Pins 2 and 3)	
SW2	W30	ON	No Math Chip

Test Parallel Port Printer

The parallel port printer test requires a DB25 Loop Back Connector (see Table 5-3). This test only takes a few seconds to complete. The test consists of:

- Testing Data Lines:
  - Data 0-7 (pins 2-9)
- Testing Internal Control Lines:
  - Data Strobe (pin 1)
  - Autofeed (pin 14)
  - Initialize Printer (pin 16)
  - Select Printer (pin 17)
  - IRQ7
- Testing External Control Lines:
  - Printer Error (pin 15)
  - Ready to Receive Data (pin 13)
  - Out of Paper (pin 12)
  - Character Accept/ACK (pin 10)
  - $\overline{\text{BUSY}}$ (pin 11)

Table 5–3
Parallel Port Loop Back Connector

Pin#	Signal Name	Connect to Pin
1	Data Strobe (–DS)	
2	Data 0	15
3	Data 1	13
4	Data 2	12
5	Data 3	10
6	Data 4	11
7	Data 5	
8	Data 6	
9	Data 7	
10	Character Accepted (–ACK)	5
11	BUSY	6
12	Out of Paper	4
13	Ready to Receive Data	3
14	Autofeed	
15	Printer Error (–ERROR)	2
16	Initialize Printer (–INIT)	
17	Select Printer (SELECT)	
18–25	Signal Ground	

Test Speaker

The Speaker test produces tones on the TEKMATE's speaker. Port 42H controls the frequency of each tone, and port 61H controls the duration of each tone. After the tones are produced, the message "Did it Sound?" is displayed on the screen. This test takes about 5 seconds to complete.

If no tones are produced while running this test, the speaker is malfunctioning. If no tones are produced, check the speaker wiring.

Test SmartWatch

The SmartWatch test checks the SmartWatch by querying the clock for the current time. The time received from the clock is displayed on screen. If the time is correct according to its last setting, then the SmartWatch is OK. This test takes a few seconds to complete.

Test RAM

The RAM test checks the TEKMATE RAM by writing a pattern to each RAM location, and then reading each location to verify the data. Checks are made for parity errors following each read or write operation. If all locations are OK, PASS is displayed. If the data read from any location is incorrect, FAIL is displayed. This test takes about 2 minutes to complete.

Test Failure

Table 7-7 includes a list of each test and the assemblies to check or replace if a failure is displayed.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

SERVICING SAFETY SUMMARY

For Qualified Service Personnel Only

NOTE

Refer also to the preceding Operators Safety Summary.

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections or components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate from a power source that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Performance Check and Adjustment Procedures

Performance Check and Adjustment Procedures

Performance Check and Functional Verification

This procedure is used to verify proper operation of the instrument. This procedure verifies instrument function and may be used as an acceptance test and as a preliminary troubleshooting aid.

Removing the cabinet is not necessary to perform this procedure. All checks are made, by the TEKMATE's ROM-BIOS, using the optional monitor. The checks are performed when the instrument is powered up or reset. Even though the checks are performed at each power-up or reset, the results are only visible on the optional monitor. If more detailed and exhaustive checks are desired, the diagnostics should be used. Standard 2402 Diagnostics employ the optional keyboard and monitor (see Section 7, *Maintenance*). Diagnostics supplied with some TEKMATE options may use the "display and keyboard" of the instrument that is connected to the TEKMATE (see Section 5, *Options*).

Within the procedure, steps to verify proper operation of an instrument control or function begin with the word "VERIFY." These functions ARE NOT specifications and should not be interpreted as such.

Preparation

The optional monitor is required to perform this procedure.

Before performing this procedure, ensure that the TEKMATE is connected to an appropriate ac power source (see "Preparation for Use" in Section 1). Connect the TEKMATE to be checked and the monitor to an appropriate power source. Connect one end of the monitor cable to the TEKMATE MONITOR connector. Connect the other end of the monitor cable to the monitor's signal input connector. Turn on the monitor. Turn on the TEKMATE.

NOTE

Even though the BIOS checks will say the keyboard passed, the optional keyboard is not checked.

VERIFY—that the following messages are displayed on the monitor:

CPU passed.

Monitor passed.

Keyboard passed.

704K RAM.

If an error message is present, have the instrument repaired by a qualified service technician.

Adjustment Procedure

This instrument does not need adjustment. The power supply adjustment is for factory use. If the supplies need adjustment, there has been a power supply failure, and the power supply should be replaced (see Section 7, *Maintenance*).

Maintenance

Maintenance

This section contains information for conducting preventive maintenance, troubleshooting, and corrective maintenance on the instrument.

Static-Sensitive Components

The following precautions are applicable when performing any maintenance involving internal access to the instrument.

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. Table 7-1 lists the relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

When performing maintenance, observe the following precautions to avoid component damage:

1. Minimize handling of static-sensitive components.
2. Transport and store static-sensitive components or assemblies in their original containers or on a metal rail. Label any package that contains static-sensitive components or assemblies.
3. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these components. Servicing static-sensitive components or assemblies should be performed only at a static-free work station by qualified service personnel.
4. Nothing capable of generating or holding a static charge should be allowed on the workstation surface.
5. Keep the component leads shorted together whenever possible.

6. Pick up components by their bodies, never by their leads.

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work-surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only approved antistatic, vacuum-type desoldering tools for component removal.

Table 7-1
Relative Susceptibility to Statics-Discharge Damage

Semiconductor Classes	Relative Susceptibility Levels[1]
MOS or CMOS circuits or discretes, or linear microcircuits with MOS inputs (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFET	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[1]Voltage equivalent for levels (voltage discharged from a 100 pF capacitor through a resistance of 100 ohms):

1 = 100 to 500 V
2 = 200 to 500 V
3 = 250 V
4 = 500 V
5 = 400 to 600 V
6 = 600 to 800 V
7 = 400 to 1000 V (est)
8 = 900 V
9 = 1200 V

Preventive Maintenance

Introduction

Preventive maintenance consists of cleaning, visual inspection, and checking instrument performance. When accomplished regularly, it may prevent instrument malfunction and enhance instrument reliability. The severity of the environment in which the instrument is used determines the required frequency of maintenance. An appropriate time to accomplish preventive maintenance is just before checking instrument performance.

General Care

The cabinet minimizes accumulation of dust inside the instrument and should normally be in place when operating the instrument.

Inspection and Cleaning

The instrument should be visually inspected and cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket, preventing efficient heat dissipation. It also provides an electrical conduction path that could result in instrument failure, especially under high-humidity conditions.

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Use a nonresidue-type cleaner, preferably isopropyl alcohol or a solution of 1% mild detergent with 99% water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Exterior

INSPECTION. Inspect the external portions of the instrument for damage, wear, and missing parts; use Table 7–2 as a guide. Instruments that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Deficiencies found that could cause personal injury or could lead to further damage to the instrument should be repaired immediately.

CAUTION

To prevent getting moisture inside the instrument during external cleaning, use only enough liquid to dampen the cloth or applicator.

CLEANING. Loose dust on the outside of the instrument can be removed with a soft cloth or small soft-bristle brush. The brush is particularly useful for dislodging dirt on and around the controls and connectors. Dirt that remains can be removed with a soft cloth dampened in a mild detergent and water solution. Do not use abrasive cleaners.

Table 7–2
External Inspection Check List

Item	Inspect For	Repair Action
Cabinet, Front Panel, and Cover	Cracks, scratches, deformations, damaged hardware or gaskets.	Touch up paint scratches and replace defective components.
Front-panel Controls	Missing, damaged or loose knobs, buttons, and controls.	Repair or replace missing or defective items.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.	Replace defective parts. Clear or wash out dirt.
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors.	Replace damaged or missing items, frayed cables, and defective parts.

Interior

To gain access to internal portions of the instrument for inspection and cleaning, refer to the "Removal and Replacement Instructions" in the "Corrective Maintenance" part of this section.

INSPECTION. Inspect the internal portions of the instrument for damage and wear, using Table 7-3 as a guide. Deficiencies found should be repaired immediately. The corrective procedure for most defects is replacement of the defective circuit board or assembly. Care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

If any electrical component is replaced, conduct a Performance Check for the affected circuit (see Section 6). If the power supply is replaced, conduct a complete Performance Check (see Section 6).

CAUTION

To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the instrument.

CLEANING. To clean the interior, blow off dust with dry low-pressure air (approximately 9 psi). Remove any remaining dust with a soft brush or a cloth dampened with a solution of mild detergent and water. A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.

If these methods do not remove all the dust or dirt, the instrument may be spray washed using a solution of 5% mild detergent and 95% water as follows:

1. Gain access to the parts to be cleaned by removing easily accessible shields and panels.
2. Spray wash dirty parts with the detergent-and-water solution; then use clean water to thoroughly rinse them.
3. Dry all parts with low-pressure air.

NOTE

Most of the switches used in the instrument are sealed and the contacts are inaccessible. If cleaning is deemed necessary, use only isopropyl alcohol.

4. Clean switches with isopropyl alcohol and wait 60 seconds for the majority of the alcohol to evaporate. Then complete drying with low-pressure air.

5. Dry all components and assemblies in an oven or drying compartment using low-temperature (125°F to 150°F) circulating air.

Table 7-3
Internal Inspection Check List

Item	Inspect For	Repair Action
Circuit Boards	Loose, broken, or corroded solder connections. Burned circuitboards. Burned, broken or cracked circuit-run plating.	Clean solder corrosion with an eraser and flush with isopropyl alcohol. Replace the assembly containing the defective component.
Resistors	Burned, cracked, broken, blistered.	Replace the assembly containing the defective component.
Solder Connections	Cold solder or rosin joints.	Replace the assembly containing the defective component.
Capacitors	Damaged or leaking cases. Corroded solder on leads or terminals.	Replace the assembly containing the defective component.
Semiconductors	Loosely inserted in sockets. Distorted pins.	Firmly seat loose semiconductors. Remove devices having distorted pins. Carefully straighten (as required to fit the socket), using longnose pliers, and reinsert firmly. Ensure that straightening action does not crack pins, causing them to break off.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace defective wires or cables.
Chassis	Dents, deformations, and damaged hardware.	Straighten, repair, or replace defective hardware.

Lubrication

There is no lubrication required for this instrument.

Semiconductor Checks

Periodic checks of the transistors and other semiconductors in this instrument are not recommended. The best check of semiconductor performance is actual operation in the instrument.

Periodic Readjustment

To ensure proper operation, check the performance of this instrument every 2000 hours of operation, or if used infrequently, once each year. This instrument does not need readjustment.

Complete Performance Check and Adjustment instructions are given in Section 6. The Performance Check Procedure can also be helpful in localizing certain troubles in the instrument.

Troubleshooting

Introduction

Preventive maintenance performed on a regular basis should reveal most potential problems before an instrument malfunctions. However, should troubleshooting be required, the following information is provided to facilitate location of a fault. In addition, the material presented in the "Diagrams" section of this manual may be helpful while troubleshooting. Troubleshooting this instrument should be approached from the systems level, running diagnostics and swapping assemblies, as opposed to performing point-to-point testing and probing of the boards.

In general, servicing the instrument involves:

- Verifying system configuration.
- Running diagnostics.
- Verifying the power supply.
- Replacing faulty assemblies.
- Re-running diagnostics to ensure proper operation.

After identifying a faulty assembly, replace it with a spare and return the faulty assembly to the factory for repair.

Troubleshooting Aids

Diagnostic Firmware

The operating firmware in this instrument contains power-up tests that aid in locating malfunctions. When instrument power is applied, power-up tests are performed to verify proper operation of the instrument. If a failure is detected, this information is displayed on the optional monitor, if used. The failure information directs the operator to the failing block of circuitry. If the failure is such that the processor can still execute diagnostic routines, the user can execute diagnostic software to execute specific tests to further check the instrument. The standard diagnostic software routines are explained later in this section.

Circuit Board Illustrations

Circuit board illustrations showing the physical location of each component are provided. The illustrations are found in the "Diagrams" section.

Circuit Board Locations

The placement in the instrument of each circuit board is shown in a board locator illustration. These illustrations are located in the "Diagrams" section.

Circuit Board Interconnection Diagram

A circuit board interconnection diagram listing the interconnecting pins and signals carried is provided in the "Diagrams" section.

Multipin Connectors

Multipin connector orientation is indexed by a triangle on the cable connector, or a colored wire, and a 1 or triangle on the circuit board. Slot numbers may be molded into the connector. When a connection is made to circuit board pins or header, ensure that the index on the connector is aligned with the index on the circuit board (see Figure 7-1).

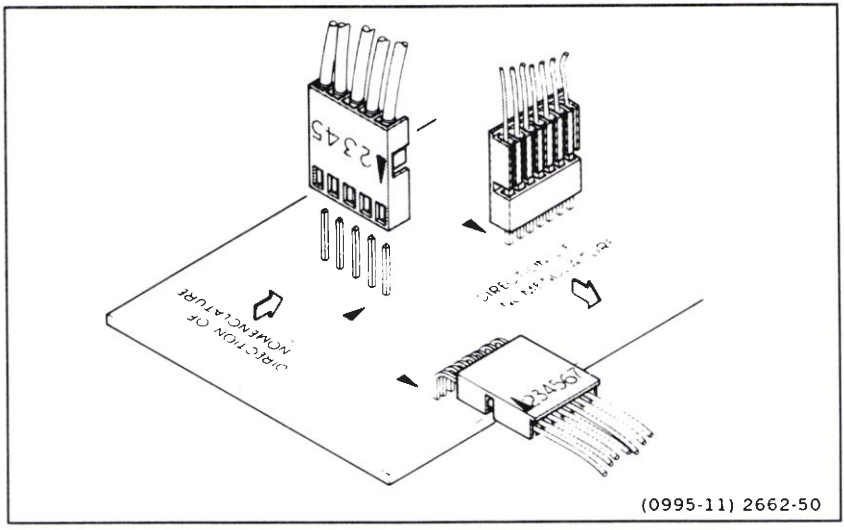


Figure 7–1. Multipin connector orientation.

Troubleshooting Techniques

The following procedure is arranged in an order that enables checking simple trouble possibilities before requiring more extensive troubleshooting. The first two steps use diagnostic aids in the instrument's operating firmware and diagnostic software. The next four procedures are check steps that ensure proper control settings, connections, operation, and jumpers. If the trouble is not located by these checks, the remaining steps will aid in locating the defective assembly. When the defective assembly is located, replace it using the appropriate replacement procedure given under "Corrective Maintenance" in this section.

Before using any test equipment to make measurements on static-sensitive, current-sensitive, or voltage-sensitive components or assemblies, ensure that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

1. Power-up Tests

The instrument performs automatic verification of the instrument's circuitry when power is first applied or when the system is reset (RESET button pushed). The BIOS diagnostics verify proper operation of the Microprocessor, the firmware ROM, and the RAM. (The optional Keyboard is not checked by the BIOS diagnostics.)

If a BIOS test fails, the area of failure is identified by a message on the monitor (if the instrument is using the optional monitor and is able to produce a display).

2. Diagnostic Software

Each of the diagnostic software tests may be individually selected.The desired test is selected from a menu of the available routines. Use of the diagnostics is explained in the "Diagnostic Routines" discussion later in this section.

3. Check Associated Equipment

Before proceeding, ensure that any equipment used with the instrument is operating correctly. Verify that loop back connectors (required by the diagnostic software) are properly connected and that any interconnecting cables are not defective. Check that the ac-power-source voltage to all equipment is correct.

4. Verify Jumpers

Verify that all TEKMATE jumpers are in their default factory positions. Default jumper positions are shown in Appendix A.

5. Visual Check

Perform a visual inspection. This check may reveal broken connections or wires, damaged components, semiconductors not firmly mounted, damaged circuit boards, or other clues to the cause of an instrument malfunction.

6. Isolate Trouble to a Circuit

To isolate problems to a particular area, use any symptoms noticed to help locate the trouble.

When trouble symptoms appear in more than one circuit, check the power supplies. Check first for the correct output voltage of each individual supply and interface power cable. These voltages are measured between the power supply outputs and ground. If the power-supply voltages and ripple are within the ranges listed in the *Performance Characteristics* section of this manual, the supply can be assumed to be working correctly. If they are outside the range, the supply may be operating incorrectly.

The Power Supply levels are interdependent. If one of the supplies appears defective, replace the power supply.

A defective component elsewhere in the instrument can create the appearance of a power-supply problem and may also affect the operation of other circuits.

7. Check Circuit Board Interconnections

After the trouble has been isolated to a particular circuit, again check for loose or broken connections, improperly seated semiconductors, and heat-damaged components.

8. Replace the Assembly

If any defective assemblies are located, follow the replacement procedures given under "Corrective Maintenance" in this section. After any electrical assembly has been replaced, the performance of the instrument should be checked. Refer to Section 6 of this manual, *Performance Check and Adjustment Procedures.*

9. Check the Software

The diagnostic program is designed to detect and isolate possible hardware problems. If the diagnostics indicate that the hardware is OK, but the application is not operating properly, consult your software documentation to see if:

- The operating system needs to be replaced.
- One or more required files is missing or not in the root directory.
- The CONFIG.SYS file is missing or incorrect. For example, the required device drivers may not be present.
- The AUTOEXEC.BAT file is missing or incorrect. The proper paths may not be set, preventing access to drivers and/or programs.
- The application software is not properly installed.

TEKMATE Diagnostic Routines

The TEKMATE Diagnostics Software is intended to verify functional performance, identify functional performance deficiencies, and isolate defective TEKMATE modules.

The modules that can be tested by the software are:

- Floppy Drive A:
- Floppy Drive B:
- Serial Port COM 1
- Serial Port COM 4
- Configuration Switches
- Parallel Printer Port
- Speaker
- SmartWatch
- GPIB
- RAM

Executing the Diagnostics

Before executing the diagnostics:

- Insert the Diagnostics diskette into drive A:
- Using a GPIB cable, connect a GPIB instrument (the GPIB instrument must conform with Tektronix Codes and Formats) to the 2402. Set the instrument to T/L (Talk/ Listen) mode (on a 2400 series digital oscilloscope, use the OUTPUT button). This connection is only needed to do the GPIB test.
- Install 9 pin Loop Back Connectors on the COM 1 and COM 4 connectors. They are required to test the COM 1 and COM 4 serial ports.
- Install the 25 pin Loop Back Connector on the PRINTER port connector. This connector is required to test the parallel PRINTER port.
- Attach a monitor and keyboard to the 2402 MONITOR and KEYBOARD connectors.
- Turn on the oscilloscope power (if the oscilloscope is used), and the TEKMATE's power.

Diagnostic Menu

After the diagnostics boot, the diagnostic program copies itself to a RAM Drive. After the program has been copied, you are asked to remove the diagnostics disk and install blank disks:

- Remove the diagnostics disk from drive A:.

NOTE

Both diskettes in drive A: and B: must be writable (write protect window closed).

- Insert blank, writable disks into both drive A: and drive B:.
- Type "Y" and "Return".

If you inserted blank, writable disks in both drives, a menu of available tests is displayed on the monitor. The menu (see Figure 7-2) allows the user to select and execute the diagnostics.

If you inserted blank, writable disks in both drives, a menu of available tests is displayed on the monitor. The menu (see Figure 7-2) allows the user to select and execute the diagnostics.

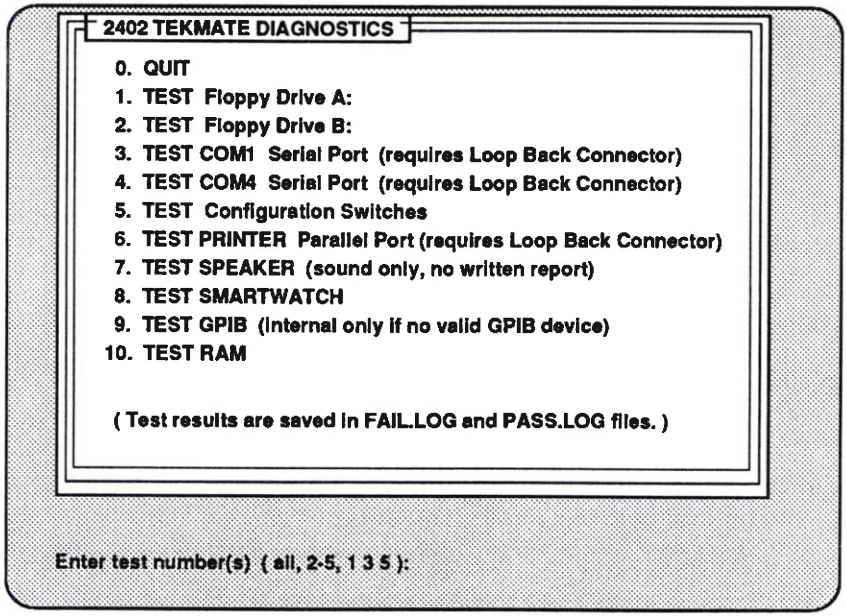


Figure 7-2. Diagnostic Menu.

Either a single test, a group of tests, or all tests can be selected for execution. The selection for group tests can be a range of tests (i.e., 2–5 , meaning all test numbers between 2 and 5 will be executed) or random test selection (i.e., 1 3 6, meaning that they don't have to be consecutive numbers.)

The number of times (loops) a test or group of tests is executed is selectable. To run (execute) a selected test or group of tests forever or continuously, enter 0. Forever/continuously is a maximum of 3500 loops (~ 1000 hours). Space to record the test results on the disk will probably run out before the maximum number of loops is reached.

Test results will be displayed on screen after each test. Each test report will include the loop number, the test name, date, time, and the PASS/FAIL status. Test results are also accumulated and recorded on both the A: and B: diskettes in PASS.LOG and FAIL.LOG files. The PASS.LOG file only keeps a record of the last loop of the test that is PASSED. The FAIL.LOG file records all tests that FAIL until the diskette is filled up.

NOTE

PASS.LOG and FAIL.LOG files are deleted every time the diagnostics program is run.

Test All

Test All executes all tests in the order they are listed in the menu. This test takes about 12 minutes to complete.

Test Floppy Drive A:

The floppy drive A: test takes about 6 minutes to complete. This test consists of:

- Formatting the 80 tracks, 2 sides, and 512 sectors of the f9 type diskette in drive A:.
- Writing a test pattern (6D, B6, DB, 6D, B6, DB, ...) onto the diskette in drive A:.
- Reading the disk to see if the test pattern is still the same. If the test data is still intact, PASS is displayed; If the data is not the same, FAIL is displayed.

Test Floppy Drive B:

The floppy drive B: test takes about 4 minutes to complete. It consists of:

- Formatting the 80 tracks, 2 sides, and 512 sectors of the f9 type diskette in drive B:.
- Writing a test pattern (6D, B6, DB, 6D, B6, DB, ...) onto the diskette in drive B:.
- Reading the disk to see if the test pattern is still the same. If the test data is still intact, PASS is displayed; if the data is not the same, FAIL is displayed.

Test Serial Port COM1

NOTE

This test requires a DB9 Loop Back Connector wired as in Table 7-4.

This test only takes a few seconds. The serial port COM1 test consists of:

- A Reset Modem test
- A DTR/DSR bit test
- A RTS/CTS bit test
- A TXD/RXD text test

The TXD/RXD Text test part of this test sends and receives all 256 ASCII characters.

Table 7-4
Serial Port Loop Back Connector

Pin#	Signal Name	Connect to Pin
1	Data Carrier Detect (DCD)	
2	Receive Data (RXD)	3
3	Transmit Data (TXD)	2
4	Data Terminal Ready (DTR)	6
5	Signal Ground (GND)	
6	Data Set Ready (DSR)	4
7	Request To Send (RTS)	8
8	Clear To Send (CTS)	7
9	Ring Indicator (RI)	

Test Serial Port COM4

Serial Port COM4 is not a full RS232-C port. It does not provide the DCD, DSR, and RI lines. Only the TXD and RXD lines can be tested. This test takes only a few seconds to complete.

The Loop Back connector is the same as the COM1 port Loop Back connector. The connection between pins 4 and 6 is redundant, but allows the connector to be used for either COM1 or COM4.

Test Configuration Switches

The Configuration Switches test senses the jumpers that determine the Video display mode, the Floppy Drive quantity, and whether or not there is a Math chip. The settings are compared with the expected default settings shown in Table 7-5. If the settings agree with the expected defaults, PASS is displayed. If the settings do not agree with the expected defaults, FAIL is displayed. This test takes only a few seconds to complete.

Table 7-5
Switch Test Jumper Defaults

PC Switch	TEKMATE Jumper	Jumper Position	Expected TEKMATE Setup
SW8 SW7	W32 W33	ON OFF	2 Drives
SW6 SW5	W19 W31	OF ON	640 X 200 Color
SW2	W30	ON	No Math Chip

Test Parallel Port Printer

The parallel port printer test requires a DB25 Loop Back Connector (see Table 7-6). This test takes only a few seconds to complete. The test consists of:

- Testing Data Lines:

Data 0-7	(pins 2-9)

- Testing Internal Control Lines:

Data Strobe	(pin 1)
Autofeed	(pin 14)
Initialize Printer	(pin 16)
Select Printer	(pin 17)
IRQ7	

- Testing External Control Lines:

Printer Error	(pin 15)
Ready to Receive Data	(pin 13)
Out of Paper	(pin 12)
Character Accept/ACK	(pin 10)
Busy(not)	(pin 11)

Table 7-6
Parallel Port Loop Back Connector

Pin#	Signal Name	Connect to Pin
1	Data Strobe (-DS)	
2	Data 0	15
3	Data 1	13
4	Data 2	12
5	Data 3	10
6	Data 4	11
7	Data 5	
8	Data 6	
9	Data 7	
10	Character Accepted (-ACK)	5
11	BUSY	6
12	Out of Paper	4
13	Ready to Receive Data	3
14	Autofeed	
15	Printer Error (-ERROR)	2
16	Initialize Printer (-INIT)	
17	Select Printer (SELECT)	
18-25	Signal Ground	

Test Speaker

The Speaker test produces tones on the TEKMATE's speaker. Port 42H controls the frequency of each tone, and port 61H controls the duration of each tone. After the tones are produced, the message "Did it Sound?" is displayed on the screen. This test takes about 5 seconds to complete.

If no tones are produced while running this test, the speaker is malfunctioning.

Test GPIB

The diagnostics program sends out an "ID?" query to try to talk to any Tektronix instrument connected to the 2402 by way of the GPIB. The Tektronix instrument should be set to T/L (Talk/Listen) mode and conform to Tektronix' Codes and Formats Standard. The GPIB test program searches for the instrument's address and attempts to "handshake." If the instrument responds to the query and the first four characters of the returned string are "TEK/", communication is established and the test is PASSED. If an appropriate string is not returned, a tone sounds and the GPIB test will report a FAIL status. If no valid GPIBdevice is connected to the TEKMATE or the device is not in T/L mode, only the TEKMATE GPIB board is tested.

Test RAM

The RAM test checks the TEKMATE RAM by writing a pattern to each RAM location, and then reading each location to verify the data. Checks are made for parity errors following each read or write operation. If all locations are OK, PASS is displayed. If the data read from any location is incorrect, FAIL is displayed. This test takes about 2 minutes to complete.

Test Failure

Table 7-7 displays a list of each test and the assemblies to check or replace if a failure occurs.

Table 7-7
Diagnostic Failure Checks

Failure	Check
	NOTE All cable connections should be carefully checked because it is easy to improperly attach cables.
Floppy Drive A:	Check/Replace diskette in drive A:. Check/Replace floppy drive cable (P160) of drive A: . Check power supply for drive A: . J111 Pin 1 +5V 2 GND 3 GND 4 NC Check/Replace disk drive A:. If the B: drive is known to be good, swap drive A: with drive B: (remove disk drive assembly, remove connectors P160 and P170 from the drives, place P160 on the B: drive connector). If the Drive A: Test will then pass, replace the "normal" Drive A:. Jumper: W05 should be ON pins 2 and 3 W07 should be ON pins 2 and 3 W32 should be ON W33 should be OFF W39 should be OFF W40 should be OFF Check/Replace CPU board (U6 WD37C65PLCC).

Table 7-7 (cont)
Diagnostic Failure Checks

Failure	Check
Floppy Drive B:	Check/Replace diskette in drive B: Check/Replace floppy drive cable (P170) of drive B: Check power supply for drive B: J12 Pin 1 +5V 2 GND 3 GND 4 NC Check/Replace disk drive B:. If the A: drive is known to be good, swap drive A: and B: (remove disk drive assembly, remove connectors P160 and P170 from the drives, place P160 on the B: drive connector). If the Drive A: Test then fails (it may prevent the system from booting and prevent the diagnostics from running), replace "normal" drive B:. Jumper: W05 should be ON pins 2 and 3 W07 should be ON pins 2 and 3 W32 should be ON W33 should be OFF W39 should be OFF W40 should be OFF Check/Replace CPU board (U6 WD37C65PLCC).
Serial Port COM1	Check to make sure the Loop Back Connector is properly plugged in. Check the Loop Back Connector wiring. ***NOTE*** Cable connections should be carefully checked because it is easy to improperly attach cables. Check/Replace COM1 cable inside the cabinet (P1011). Check/Replace CPU board (U1 8250PLCC).

Table 7–7 (cont)
Diagnostic Failure Checks

Failure	Check
Serial Port COM4	Check to make sure the Loop Back Connector is properly plugged in. Check Loop Back Connector wiring. ***NOTE*** Cable connections should be carefully checked because it is easy to improperly attach cables. Check/Replace COM4 cable inside cabinet (P1011). Check/Replace CPU board (U1 8250PLCC).
Configuration Switches	Jumper: W19 should be OFF W30 should be ON W31 should be ON W32 should be ON W33 should be OFF Check/Replace CPU board.
Printer Port	***NOTE*** The printer test program is designed to run with a Loop Back Connector. Do not run it with a real printer connected. Check to make sure the Loop Back Connector is properly plugged in. Check Loop Back Connector wiring. ***NOTE*** Cable connections should be carefully checked because it is easy to improperly attach cables. Check PRINTER cable (P1040 inside cabinet). Check/Replace CPU board (U19).

Table 7–7 (cont)
Diagnostic Failure Checks

Failure	Check
Speaker	Try another beep.exe program (if available) to see if it can make a sound through the speaker. (If the optional keyboard is connected to the instrument, push the RESET button on the rear panel. Push and hold the "S" key. After about 30 seconds, beeps should be heard from speaker.) Check the speaker's physical condition. Check the speaker connections for shorts. Check cable connector P1091 (inside the cabinet). Check/Replace CPU board (U19).
SmartWatch	Set the SMARTWATCH's internal date and time. To set the time, first set the system date and time using a DOS disk and the standard DOS commands "DATE" and "TIME." Then use the PCCLOCK.COM utility to set the SMARTCLOCK module's internal date and time to match your system's current date and time. To set the time enter: **A > PCCLOCK /S < RETURN >** The PCCLOCK.COM utility provides 4 simple commands: **A > PCCLOCK < RETURN >** Sets system date and time from the SMARTCLOCK module. **A > PCCLOCK /S < RETURN >** Sets SMARTCLOCK date and time from the current system date and time values. **A > PCCLOCK /R < RETURN >** Reads (displays on screen) the current values of date and time from the SMARTCLOCK module. **A > PCCLOCK /T < RETURN >** Tests the SMARTCLOCK module by continuously reading and displaying the time. **A > PCCLOCK ? < RETURN >** Displays help information.

Table 7–7 (cont)
Diagnostic Failure Checks

Failure	Check
SmartWatch (cont)	If you are using a keyboard and monitor, insert a DOS diskette in drive A: and diagnostics diskette in drive B: then type PCCLOCK. If PCCLOCK does not display the time on the monitor then you may have a hardware problem. Open the cabinet and check the SmartWatch IC (U26) for bent pins. Check/Replace the CPU board (SmartWatch IC U26).
RAM	Rerun the RAM test. Record the BANK number where the test hangs up. If the RAM test stops at a bank number between 0 to 3, then replace the SIMM1 DRAM. If the RAM test stops at a bank number between 4 to 7, then replace the SIMM2 DRAM. If the RAM test stops at a bank number between 8 to 10, then replace the SIMM3 DRAM. Replace the SIMM strips one at a time to determine which one is causing the problem. Verify that the CPU board memory size jumpers are set for 704K bytes of memory: **Jumper** **704K Setting** W44 On W43 On W42 Off Check/Replace the CPU board.

Corrective Maintenance

Introduction

Corrective maintenance consists of component replacement and instrument repair. This part of the manual describes special techniques and procedures required to replace components in this instrument. If it is necessary to ship your instrument to a Tektronix Service Center for repair or service, refer to the "Repackaging for Shipment" instructions in Section 1.

Maintenance Precautions

To reduce the possibility of personal injury or instrument damage, observe the following precautions.

1. Disconnect the instrument from the ac power source before removing or installing components.
2. Verify that the line-rectifier filter capacitors are discharged prior to performing any servicing.
3. Use care not to interconnect instrument grounds which may be at different potentials (cross grounding).

Obtaining Replacement Parts

Replaceable electrical assemblies and mechanical parts can be obtained through your local Tektronix Field Office or representative.

NOTE

Physical size and shape of a component may affect instrument performance. Always use direct-replacement components, unless it is known that a substitute will not degrade instrument performance.

Ordering Parts

When ordering replacement parts from Tektronix, Inc., be sure to include all of the following information:

1. Instrument type (include modification or option numbers).
2. Instrument serial number.
3. A description of the part (if electrical, include its full circuit component number).
4. Tektronix part number.

Maintenance Aids

The maintenance aids listed in Table 7-8 include items required for performing most of the maintenance procedures in this instrument. Equivalent products may be substituted for the examples given, provided their characteristics are similar.

Table 7-8
Maintenance Aids

Description	Specification	Usage	Example
1. Torx screwdrivers	Torx tips #T7, #T9, #T10, #T15, #T20.	Assembly and disassembly.	Tektronix Part Numbers: 003-1293-00 003-0965-00 003-0814-00 003-0966-00 003-0866-00
2. Nutdrivers	1/4 inch, 7/32 inch, 5/16 inch,	Assembly and disassembly	Xcelite #7, #8, #10.

Interconnections

Interconnections in this instrument are made with pins soldered onto the circuit boards. Several types of mating connectors are used for the interconnecting pins. The following information provides the replacement procedures for the various types of connectors.

End-Lead Pin Connectors

Pin connectors used to connect the wires to the interconnect pins are factory assembled. They consist of machine-inserted pin connectors mounted in plastic holders. If the connectors are faulty, the entire wire assembly should be replaced.

Multipin Connectors

When pin connectors are grouped together and mounted in a plastic holder, they are removed, reinstalled, or replaced as a unit. If any individual wire or connector in the assembly is faulty, the entire cable assembly should be replaced. Multipin connector orientation is indexed by a triangle on the cable connector and a 1 or triangle on the circuit board. Slot numbers may be molded into the connector. Be sure these index marks are aligned with each other when the multipin connector is reinstalled.

Transistors and Integrated Circuits

Transistors and integrated circuits should not be replaced unless they are actually defective. If removed from their sockets during routine maintenance, return them to their original board locations. Unnecessary replacement or transposing of semiconductor devices may affect the adjustment of the instrument. When a semiconductor is replaced, check the performance of the circuit that may be affected.

To remove socketed dual-in-line packaged (DIP) integrated circuits, pull slowly and evenly on both ends of the device. Avoid disengaging one end of the integrated circuit from the socket before the other, since this may damage the pins.

Soldering Techniques

Soldering is not required to replace any replaceable assembly in this instrument.

CAUTION

To avoid damage to instrument assemblies and surface-mounted components, soldering should not be attempted in this instrument.

Removal and Replacement Instructions

WARNING

To avoid electric shock, disconnect the instrument from the ac power source before removing or replacing any component or assembly.

The exploded view drawing in the "Replaceable Parts" list at the rear of this manual may be helpful during the removal and reinstallation of individual components or subassemblies. Circuit board and component locations are illustrated in the "Diagrams" section of this manual.

Cabinet Removal

Removal of the instrument cabinet is accomplished by the following steps:

1. Unplug the power cord from the ac power source.
2. Unplug the power cord from the rear-panel connector.
3. Remove all other cables that may be connected to the instrument.
4. Remove the screw from the back-right and back-left side of the cabinet.

WARNING

Dangerous potentials exist at several points throughout this instrument. If it is operated with the cabinet removed, do not touch exposed connections or components. Some transistors may have elevated case voltages. Disconnect the ac power source from the instrument and verify that the line-rectifier filter capacitors have discharged before cleaning the instrument or replacing parts.

5. Remove the cabinet by lifting the back of the cabinet about one inch and sliding the cabinet forward and off the instrument.

To reinstall the cabinet, perform the reverse of the preceding instructions.

Power Supply Removal

To remove the Power Supply from the instrument, perform the following steps:

1. Remove the instrument Cabinet as described in that procedure.
2. Set the instrument, bottom down, on a flat surface.
3. Remove the two screws from the top of the Power Supply Shield.
4. Remove the two screws from the right side of the instrument that secure the Power Supply Shield.
5. Lift the Power Supply Shield up and away from the instrument.
6. Unplug the five power connectors (P3001, W102, W103, P114, and E1).
7. Remove the three screws holding the Power Supply board to the chassis floor.
8. Gently push the board securing clamp toward the side of the instrument until the edge of the Power Supply board is released.
8. Lift the Power Supply assembly from the instrument.

To reinstall the Power Supply, perform the reverse of the preceding instructions. Be certain to reposition the wires and cables to their original positions.

Fuse Replacement

Replacement of the instrument fuse is accomplished by the following steps:

1. Remove the instrument cabinet as described in that procedure.
2. Remove the Power Supply shield as described in "PowerSupply Removal" procedure.
3. Remove the fuse by pulling straight up on fuse F1.

Install the proper fuse using the reverse of the preceding instructions.

Fan Removal

To remove the Fan from the instrument:

1. Remove the instrument cabinet as described in that procedure.
2. Remove the Power Supply shield as described in "Power Supply Removal" procedure.
3. Unplug fan connector P114.
4. Remove the four screws, lock washers, and nuts securing the fan to the right side of the chassis. Remove the Fan.

To reinstall the Fan, perform the reverse of the preceding instructions.

GPIB Board Removal

Removal of the GPIB Board is accomplished by the following steps:

1. Remove the instrument cabinet as described in that procedure.
2. Set the instrument, bottom down, on a flat surface.
3. Remove the three screws securing the board support bracket to the left side of the chassis.
4. Remove the screw securing the board support bracket to the rear of the chassis. Remove the bracket.
5. Remove the screw securing the GPIB board expansion slot bracket to the rear of the chassis.
6. Gently push the board securing clamp toward the front of the instrument until the edge of the GPIB board is released.
6. Remove the GPIB board by pulling it straight out from its Interface board connector.

To reinstall the GPIB board, perform the reverse of the preceding instructions.

Interface Board Removal

Removal of the Interface Board from the instrument is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.
2. Remove the Power Supply Shield as described in the Power Supply removal procedure.
3. Remove the GPIB board as described in that procedure.
4. Remove any expansion boards that may be connected to the Interface board.
5. Disconnect power connectors W102 and W103 from the Power Supply.
6. Disconnect power connectors W100 and W101 from the Floppy Disk drives.
7. Disconnect the expansion bus connector (W105) from J2 of the Video board.
8. Remove the six screws securing the Interface board to the Main Support bracket.
9. Remove the board by carefully feeding the power cables through the holes in the Main Support bracket.

To reinstall the Interface board, perform the reverse of the preceding instructions.

Video Board Removal

Removal of the Video Board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.
2. Remove connector P1001 from the Video board.
3. Remove Monitor switch connector P1003 from the Video board.
4. Remove the two nylon screws securing the Video board to the CPU board.
5. Remove the Video board by grasping the board near both ends of J2 and pulling the board straight up.

To reinstall the Video board, perform the reverse of the preceding steps.

CPU Board Removal

Removal of the CPU board is accomplished by the following steps:

1. Remove the instrument Cabinet as described in that procedure.
2. Remove the three screws securing the board support bracket to the left side of the chassis.
3. Remove the screw securing the board support bracket to the rear of the chassis. Remove the bracket.
4. Remove the Video board as described in that procedure.
5. Remove Floppy Disk Interface connector P150, Serial Port connector P1011, Utility Cable assembly P1091, and Printer Port connector P1041.
6. Remove the four screws securing the CPU board to the chassis. Remove the board.

To reinstall the CPU board, perform the reverse of the preceding steps.

Disk Drive Removal

A Disk Drive is removed by the following procedure:

1. Remove the instrument Cabinet as described in that procedure.
2. Remove the screw from the top of each disk drive support bracket.
3. Remove the two nuts from the bottom of each disk drive support bracket.
4. Slide the disk drive assembly forward about an inch by lifting the assembly above the mounting screws.
4. Remove the disk drive Power Cable (W100 or W101) and the disk drive Interface Cable (P160 or P170).
5. Remove the two screws securing the Disk Drive to the right disk drive support bracket.
6. Remove the two screws securing the Disk Drive to the left disk drive support bracket.
7. Remove the drive by sliding it forward out of the instrument.

To reinstall a Disk Drive, perform the reverse of the preceding steps.

Replaceable Electrical and Mechanical Parts

REPLACEABLE PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

```
1 2 3 4 5                    Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
          **** END ATTACHING PARTS ****
  Detail Part of Assembly and/or Component
  Attaching parts for Detail Part
          **** END ATTACHING PARTS ****
    Parts of Detail Part
    Attaching parts for Parts of Detail Part
          **** END ATTACHING PARTS ****
```

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

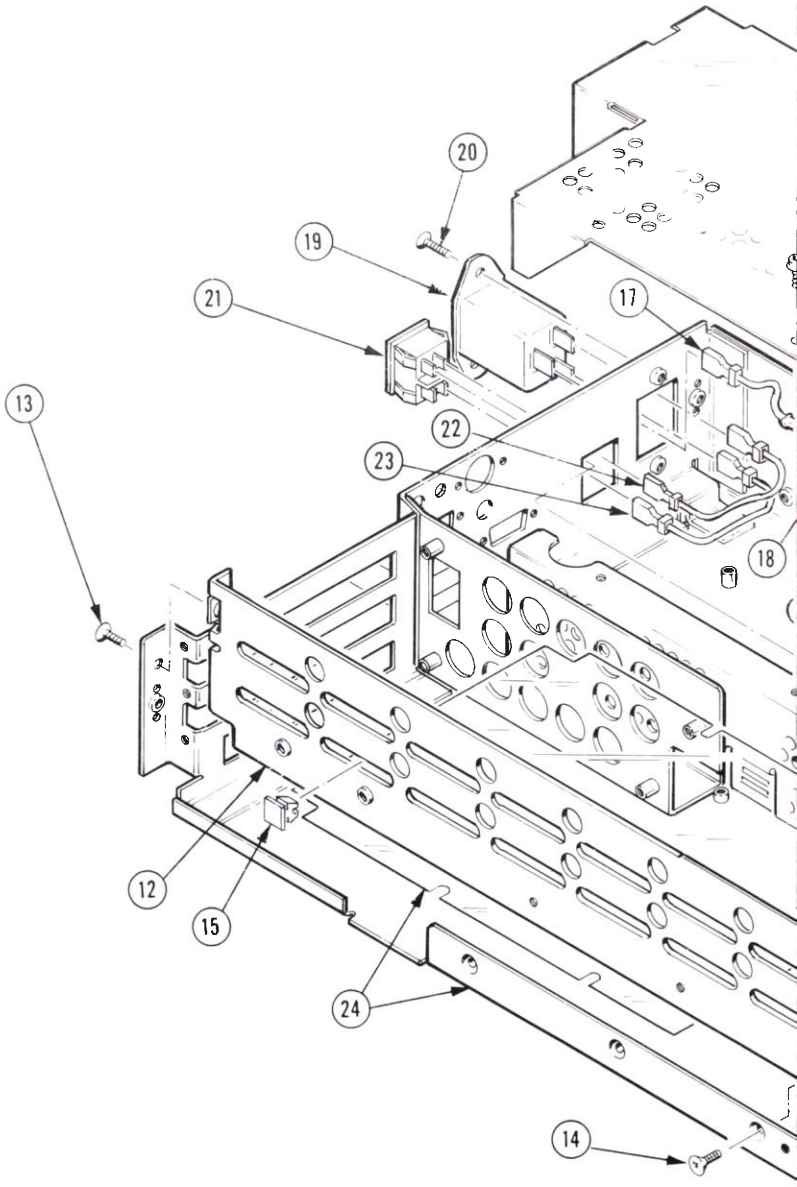
CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00779	AMP INC	2800 FULLING MILL PO BOX 3608	HARRISBURG PA 17105
01536	TEXTRON INC CAMCAR DIV SEMS PRODUCTS UNIT	1818 CHRISTINA ST	ROCKFORD IL 61108
16428	COOPER BELDEN ELECTRONIC WIRE AND CA SUB OF COOPER INDUSTRIES INC	NW N ST	RICHMOND IN 47374
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS DIV MILITARY PRODUCTS GROUP	515 FISHING CREEK RD	NEW CUMBERLAND PA 17070-3007
26365	GRIES DYNACAST CO DIV OF COATS AND CLARK INC	125 BEECHWOOD AVE	NEW ROCHELLE NY 10802
52263	MULTI-TECH INDUSTRIES INC	ROUTE 79	MARLBORO NJ 07746-3825
58361	QUALITY TECHNOLOGIES CORP	3400 HILLVIEW AVE	PALO ALTO CA 94304-1319
70903	COOPER BELDEN ELECTRONICS WIRE AND C SUB OF COOPER INDUSTRIES INC	2000 S BATAVIA AVE	GENEVA IL 60134-3325
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF DIV	ST CHARLES ROAD	ELGIN IL 60120
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97077-0001
83385	MICRODOT MFG INC GREER-CENTRAL DIV	3221 W BIG BEAVER RD	TROY MI 48098
S3109	FELLER	ASA ADOLF AG STOTZWEID CH8810	HORGEN SWITZERLAND
TK0588	UNIVERSAL PRECISION PRODUCTS	1775 NW 216TH	HILLSBORO OR 97123
TK0858	STAUFFER SUPPLY CO (DIST)	810 SE SHERMAN	PORTLAND OR 97214
TK0935	MARQUARDT SWITCHES INC	67 ALBANY ST PO BOX 465	CAZENOVIA NY 13035-1219
TK1285	GEROME MFG CO INC	PO BOX 737	NEWBURG OR 97132

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
TK1373	PATELEC-CEM (ITALY)	10156 TORINO	VAICENTALLO 62/45S ITALY
TK1543	CAMCAR/TEXTRON	600 18TH AVE	ROCKFORD IL 61108-5181
TK1650	AMP INC	19200 STEVENS CREEK BLVD SUITE 100	CUPERTINO CA 95014
TK1955	COMPUTER PRODUCTS BOSCHERT INCORPORATED	1331 CALIFORNIA CIRCLE	MILPITAS CA 95035
TK2133	SCHAFFNER	325 LEHIGH AVE	UNION NJ 07083
TK2165	TRIQUEST CORP	3000 LEWIS AND CLARK HWY	VANCOUVER WA 98661-2999
TK2237	WEST COAST TELECOM INC SUB OF KAO CORP OF AMERICA	10300 SW NIMBUS AVE	PORTLAND OR 97223
TK2279	ACER INC	602 MIN SHENG EAST RD	TAIPER TAWAN ROC

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-1	334-7239-00			1	MARKER,IDENT:MARKED FR PANEL CONTROLLER	80009	334-7239-00
-2	101-0126-00			1	TRIM,DECORATIVE:RING,FRONT PANEL	80009	101-0126-00
					ATTACHING PARTS		
-3	211-0711-00			5	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-4	437-0384-00			1	CABINET,INSTR:COVER,BLUE,ALUMINUM	80009	437-0384-00
					ATTACHING PARTS		
-5	211-0725-00			2	SCREW,MACHINE:6-32 X 0.375,FLH	01536	ORDER BY DESCR
-6	211-0725-00			4	SCREW,MACHINE:6-32 X 0.375,FLH	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-7	436-0213-00			1	TRAY,MOUNTING:ALUMINUM,BLUE	TK1285	ORDER BY DESCR
					(OPTION 01)		
					ATTACHING PARTS		
-8	212-0112-00			3	SCREW,MACHINE:8-32 X 0.188,TRH,SST	01536	ORDER BY DESCR
					(OPTION 01)		
					END ATTACHING PARTS		
-9	348-1064-00			2	FOOT,TRAY SPRT:POLYCARBONATE,BLACK	TK2165	ORDER BY DESCR
					(OPTION 01)		
					ATTACHING PARTS		
-10	211-0732-00			2	SCR,ASSEM WSHR:6-32 X 0.75,PNH,STL,T15	TK1543	ORDER BY DESCR
					(OPTION 01)		
					END ATTACHING PARTS		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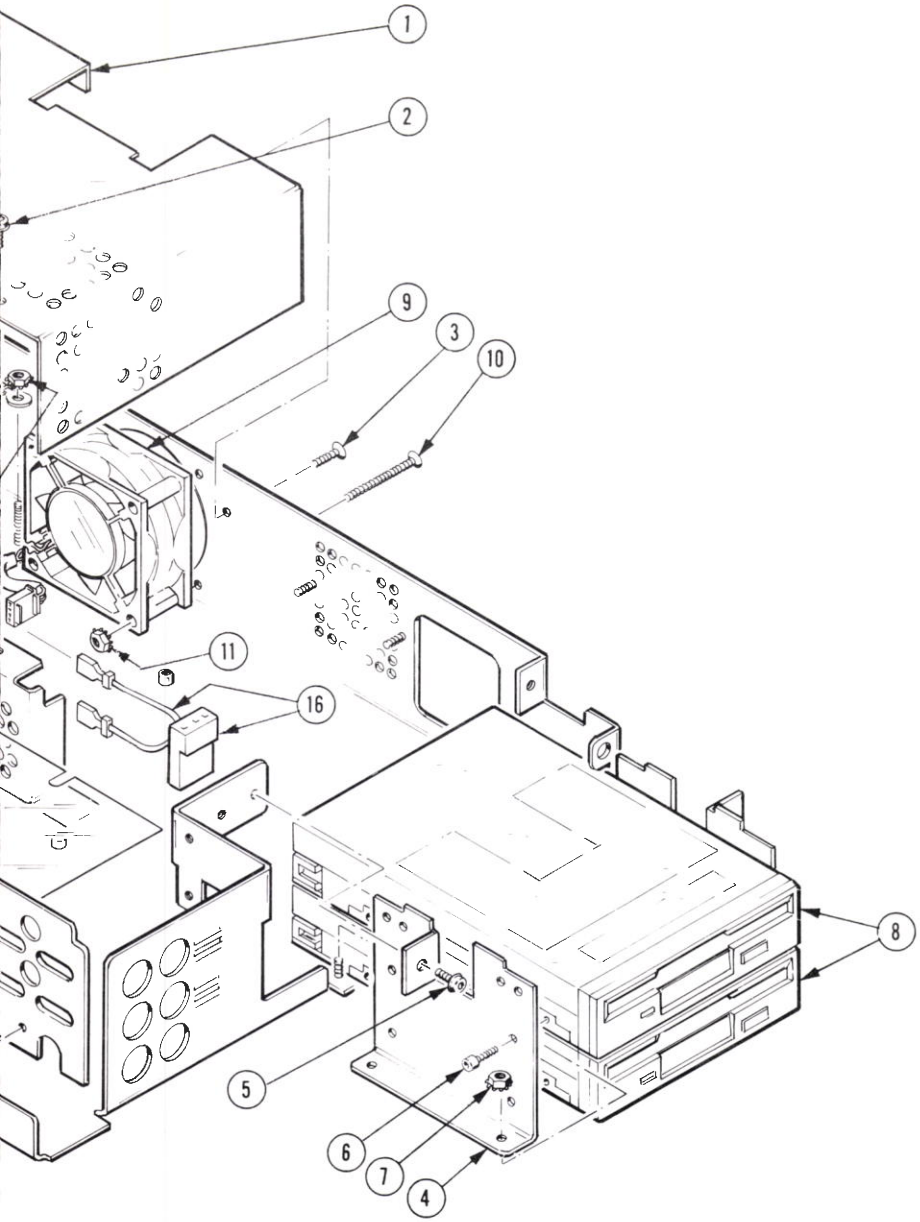


FIG.2 CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
2-	334-7282-00			1	MARKER,IDENT:MARKED CAUTION	80009	334-7282-00
-1	337-3495-00			1	SHIELD,ELEC:POWER SUPPLY,ALUMINUM	80009	337-3495-00
					ATTACHING PARTS		
-2	211-0711-00			2	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
-3	211-0725-00			2	SCREW,MACHINE:6-32 X 0.375,FLH	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-4	407-3809-00			2	BRACKET,MTG:DISK DRIVE,ALUMINUM	TK1285	ORDER BY DESCR
					ATTACHING PARTS		
-5	211-0711-00			2	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
-6	211-0461-00			8	SCREW,MACHINE:M3 X 0.5 X 6MM,PNH,STL	TK0858	211-0461-00
-7	210-0457-00			4	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	78189	511-061800-00
					END ATTACHING PARTS		
-8	118-7867-00			2	FLOPPY DISK DR:3.5 MICRO,1 IN HIGH	80009	118-7867-00
-9	119-3182-00			1	FAN:12VDC	80009	119-3182-00
					ATTACHING PARTS		
-10	211-0713-00			4	SCREW,MACHINE:6-32 X 1.25,FLH,100 DEG,STL	83385	ORDER BY DESCR
-11	210-0457-00			4	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	78189	511-061800-00
					END ATTACHING PARTS		
-12	407-3721-00			1	BRACKET,SUPPORT:ALUMINUM	80009	407-3721-00
					ATTACHING PARTS		
-13	211-0725-00			1	SCREW,MACHINE:6-32 X 0.375,FLH	01536	ORDER BY DESCR
-14	211-0725-00			3	SCREW,MACHINE:6-32 X 0.375,FLH	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-15	344-0427-00			6	CLIP,EXPANSION:CIRCUIT BOARD	80009	344-0427-00
-16	196-3206-00			1	LEAD,ELECTRICAL:18 AWG,4.0 L,5-N & 6-N	80009	196-3206-00
-17	196-3204-00			2	LEAD,ELECTRICAL:18 AWG,6.0 L,5-N	80009	196-3204-00
					ATTACHING PARTS		
-18	210-0457-00			2	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	78189	511-061800-00
					END ATTACHING PARTS		
-19	119-3183-00			1	FILTER,LINE:POWER FN 323-3/05	TK2133	FN323-3/05
					ATTACHING PARTS		

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
2-20	211-0380-00			2	SCREW,MACHINE:4-40 X 0.375,FLH,CD PL,T-9	80009	211-0380-00
					END ATTACHING PARTS		
-21	260-1961-00			1	SWITCH,ROCKER:DPST,6(4)A,250V	TK0935	1802.1121
-22	196-3205-00			1	LEAD,ELECTRICAL:18 AWG,4.5 L,6-N	80009	196-3205-00
-23	196-3207-00			1	WIRE,ELECTRICAL:18 AWG,5.0 L,1-N	80009	196-3207-00
-24	441-1862-00			1	CHAS,BASE PL:ALUMINUM	80009	441-1862-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
3-1	118-7744-00			1	CIRCUIT BD ASSY:POWER SUPPLY	TK1955	NFS50-7608
					ATTACHING PARTS		
-2	211-0711-00			2	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
-3	211-0732-00			1	SCR,ASSEM WSHR:6-32 X 0.75,PNH,STL,T15	TK1543	ORDER BY DESCR
					(OPTION 01)		
					END ATTACHING PARTS		
	159-0191-00			1	FUSE,CARTRIDGE:5 X 20MM,2.0A,250V,5MS	80009	159-0191-00
-4	361-1526-00			1	SPACER,SLEEVE:0.312 X 0.14 X 0.32,ZYTEL	80009	361-1526-00
-5	361-1527-00			1	SPACER,SLEEVE:0.312 X 0.215 X 0.25,ZYTEL	80009	361-1527-00
-6	174-1229-00			1	CA ASSY,SP,ELEC:6 WIRE UTILITY CA	80009	174-1229-00
					ATTACHING PARTS		
-7	210-0586-00			2	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
-8	211-0372-00			2	SCREW,MACHINE:4-40 X 0.312,PNH,STL	TK1543	B80-00020-003
-9	210-0586-00			2	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
-10	200-3171-00			1	COVER,NUT:W/DRESS NUT,PLASTIC	80009	200-3171-00
-11	352-0700-00			1	HOLDER,LED:PLASTIC,2 PIECE	58361	CMP52
					END ATTACHING PARTS		
-12	174-1225-00			1	CA ASSY,SP,ELEC:34,28 AWG,15.0 L,RIBBON	80009	174-1225-00
-13	174-1222-00			1	CA ASSY,SP,ELEC:10,28 AWG,19.0 L,FLAT CABLE	80009	174-1222-00
					ATTACHING PARTS		
-14	131-0890-01			2	LOCK,CONNECTOR:4-40 X 0.312 L,HEX HD,STL	00779	205818-2
					END ATTACHING PARTS		
-15	174-1463-00			1	CA ASSY,SP,ELEC:5,26 AWG,16.0 L	80009	174-1463-00
-16	174-1223-00			1	CA ASSY,SP,ELEC:16,28 AWG,12.0 L,RIBBON	80009	174-1223-00
					ATTACHING PARTS		
-17	131-0890-01			4	LOCK,CONNECTOR:4-40 X 0.312 L,HEX HD,STL	00779	205818-2
					END ATTACHING PARTS		
-18	174-1224-00			1	CA ASSY,SP,ELEC:26,28 AWG,12.0 L,RIBBON	80009	174-1224-00
					ATTACHING PARTS		
-19	131-0890-01			2	LOCK,CONNECTOR:4-40 X 0.312 L,HEX HD,STL	00779	205818-2
					END ATTACHING PARTS		

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
3-20	671-0604-00			1	CIRCUIT BD ASSY:INTERFACE	80009	671-0604-00
					ATTACHING PARTS		
-21	211-0711-00			6	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-22	407-3720-00			2	BRACKET,COVER:STEEL,NICKEL PLATED	80009	407-3720-00
					ATTACHING PARTS		
-23	211-0711-00			2	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-24	118-5054-01			1	CIRCUIT BD ASSY:GPIB INTERFACE FOR IBM	80009	118-5054-01
					ATTACHINGT PARTS		
-25	211-0711-00			1	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-26	344-0133-00			2	CLIP,SPR TNSN:CKT BOARD MT,WHITE	80009	344-0133-00
					ATTACHING PARTS		
-27	210-0586-00			1	NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL	78189	211-041800-00
					END ATTACHING PARTS		
-28	118-7745-01			1	CIRCUIT BD ASSY:VIDEO DISPLAY	80009	118-7745-01
					ATTACHING PARTS		
-29	211-0040-00			2	SCREW,MACHINE:4-40 X 0.25,BDGH,NYL	26365	ORDER BY DESCR
-30	385-0149-00			2	SPACER,POST:0.625 L W/4-40 THD EA END,NYL	TK0588	ORDER BY DESCR
-31	211-0040-00			2	SCREW,MACHINE:4-40 X 0.25,BDGH,NYL	26365	ORDER BY DESCR
					END ATTACHING PARTS		
-32	118-7746-01			1	CIRCUIT BD ASSY:LITTLE BOARD PC	80009	118-7746-01
					ATTACHING PARTS		
-33	211-0711-00			4	SCR,ASSEM WSHR:6-32 X 0.25,PNH,STL,TORX,T15	01536	ORDER BY DESCR
					END ATTACHING PARTS		
-34	131-4603-00			4	CONN,RCPT,ELEC:2 PIN,JUMPER	TK1650	531220-1
-35	156-3650-00			3	MICROCKT,DGTL:MOS,262144 X 9 DRAM MODULE	80009	156-3650-00
-36	119-3312-00			1	MODULE:REAL TIME CLOCK MICROCKT,	80009	119-3312-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
4-							
					STANDARD ACCESSORIES		
	070-6977-00			1	MANUAL,TECH:USERS,2402	80009	070-6977-00
	070-7013-00			1	MANUAL,TECH:USERS GUIDE	80009	070-7013-00
	161-0066-00			1	CABLE ASSY,PWR,:3,18AWG,115V,98.0 L	16428	CH8481, FH8481
	161-0066-09			1	CABLE ASSY,PWR,:3,0.75MM SQ,220V,99.0 L	S3109	86511000
	161-0066-10			1	CABLE ASSY,PWR,:3,0.75MM SQ,240V,96.0 L	TK1373	24230
	161-0066-11			1	CABLE ASSY,PWR,:3,0.75MM,240V,96.0 L	S3109	ORDER BY DESCR
	161-0066-12			1	CABLE ASSY,PWR,:3,18 AWG,250V,99.0 L	70903	CH-77893
	161-0154-00			1	CABLE ASSY,PWR,:3,0.75MM SQ,240V,6A,2.5M L	S3109	86515000
	174-1503-00			2	CA ASSY,SP,ELEC:9,26 AWG,LOOP BACK	80009	174-1503-00
	174-1504-00			1	CA ASSY,SP,ELEC:25,26 AWG,LOOP BACK	80009	174-1504-00
					OPTIONAL ACCESSORIES		
	012-0991-01			1	CABLE,GPIB:LOW EMI,1 METER	00779	553577-2
	016-0971-00			1	RACK MOUNT KIT:	80009	016-0971-00
	016-0978-00			1	HARDWARE KIT:MOUNTING KIT,2402	80009	016-0978-00
	016-0990-00			1	MOUNTING KIT:2402,2445B/2465B	80009	016-0990-00
	016-0991-00			1	MOUNTING KIT:2402,2467	80009	016-0991-00
	016-1013-00			1	CARRIER,PORT:STEP-SLIDE,41.5 H,175 LBS	80009	016-1013-00
	020-1747-00			1	COMPONENT KIT:US QUICKSTART (OPTION 2F)	80009	020-1747-00
	020-1748-00			1	COMPONENT KIT:EUROPEAN QUICKSTART (OPTION 3F)	80009	020-1748-00
	118-7073-00			1	KEYBOARD:INTRFACE W/IBM PC & IBM PC/AT	52263	91.10107.001
	118-7450-00			1	MANUAL,TECH:USERS GUIDE	80009	118-7450-00
	118-7642-00			1	MANUAL,TECH:USERS GUIDE	52263	49.05223.203
	118-7798-00			1	CABLE ASSEMBLY:EGA SIGNAL	52263	55.1100T.001
	200-3685-00			1	COVER,PROT:RAIN JKT,VINYL,TEK BLUE	80009	200-3685-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
4-	202-0302-00			1	CASE,CARRYING:23.75 X 15.75 X 7,TEK BLUE	80009	202-0302-00
	118-7444-05	B010100	B010450	1	MONITOR:RGB,MULTISYNC/C	80009	118-7444-05
	334-0095-00	B010100	B010450	1	EMBLEM:SMOKE TAN W/STUD	80009	334-0095-00
	334-7410-00	B010100	B010450	1	MARKER,IDENT:MARKED COLOR MONITOR	80009	334-7410-00
	118-7444-04	B010451		1	MONITOR:RGB,MULTISYNC/C	TK2279	ORDER BY DESCR
	334-7409-00	B010451		1	MARKER,IDENT:MARKED MONITOR,PEP	80009	334-7409-00
	118-7601-00			1	KEYBOARD:DENMARK	52263	91.10207.23D
	118-7794-00			1	.KEY CAP KIT:DANISH	52263	29.1024S.01D
	118-7602-00			1	KEYBOARD:FRENCH	52263	91.10207.23F
	118-7789-00			1	.KEY CAP KIT:FRENCH	52263	29.1024S.01F
	118-7603-00			1	KEYBOARD:GERMAN	52263	91.10207.23G
	118-7790-00			1	.KEY CAP KIT:GERMAN	52263	29.1024S.01G
	118-7604-00			1	KEYBOARD:ITALY	52263	91.10207.23I
	118-7791-00			1	.KEY CAP KIT:ITALIAN	52263	29.1024S.01I
	118-7605-00			1	KEYBOARD:NORWAY	52263	91.10207.23N
	118-7795-00			1	.KEY CAP KIT:NORWEIGIAN	52263	29.10245.01N
	118-7606-00			1	KEYBOARD:SPAIN	52263	91.10207.23S
	118-7792-00			1	.KEY CAP KIT:SPANISH	52263	29.1024S.01S
	118-7607-00			1	KEYBOARD:SWEDEN/FINLAND	52263	91.102078.23W
	118-7796-00			1	.KEY CAP KIT:SWEDISH	52263	29.10245.01W
	118-7608-00			1	KEYBOARD:SWISS	52263	91.10207.230
	118-7797-00			1	.KEY CAP KIT:SWITZERLAND	52263	29.10245.010
	118-7609-00			1	KEYBOARD:UNITED KINGDOM	52263	91.10207.003
	118-7793-00			1	.KEY CAP KIT:UNITED KINGDOM	52263	29.1024S.01U

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345	Name & Description	Mfr. Code	Mfr. Part No.
5-								
						OPTION 01 STANDARD ACCESSORIES		
	003-1428-00			1		TIP,SCREWDRIVER:TORX,T-10	80009	003-1428-00
	003-1429-00			1		TIP,SCREWDRIVER:TORX,T-15	80009	003-1429-00
	003-1430-00			1		TIP,SCREWDRIVER:TORX,T-20	80009	003-1430-00
	012-1282-00			1		CABLE,INTCON:GPIB,LOW EMI,1/2 METER	22526	81190-005
	016-0978-00			1		HARDWARE KIT:MOUNTING KIT,2402	80009	016-0978-00
	070-6980-00			1		MANUAL,TECH:FIELD INSTL GUIDE,2402	80009	070-6980-00
	070-7015-00			1		MANUAL,TECH:USERS,2402 OPT 01/41	80009	070-7015-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345	Name & Description	Mfr. Code	Mfr. Part No.
6-						OPTION 41		
	062-9976-00			1		SOFTWARE PKG:LAP LINK 5.25 MEDIA,RS232	TK2237	ORDER BY DESCR
	070-7014-00			1		MANUAL,TECH:PRGM REF GUIDE,2402 OPT 41	80009	070-7014-00
	070-7351-00			1		MANUAL,TECH:REFERENCE GUIDE,2402	80009	070-7351-00
	070-7358-00			1		MANUAL,TECH:USERS GUIDE	80009	070-7358-00

Diagrams

Diagrams

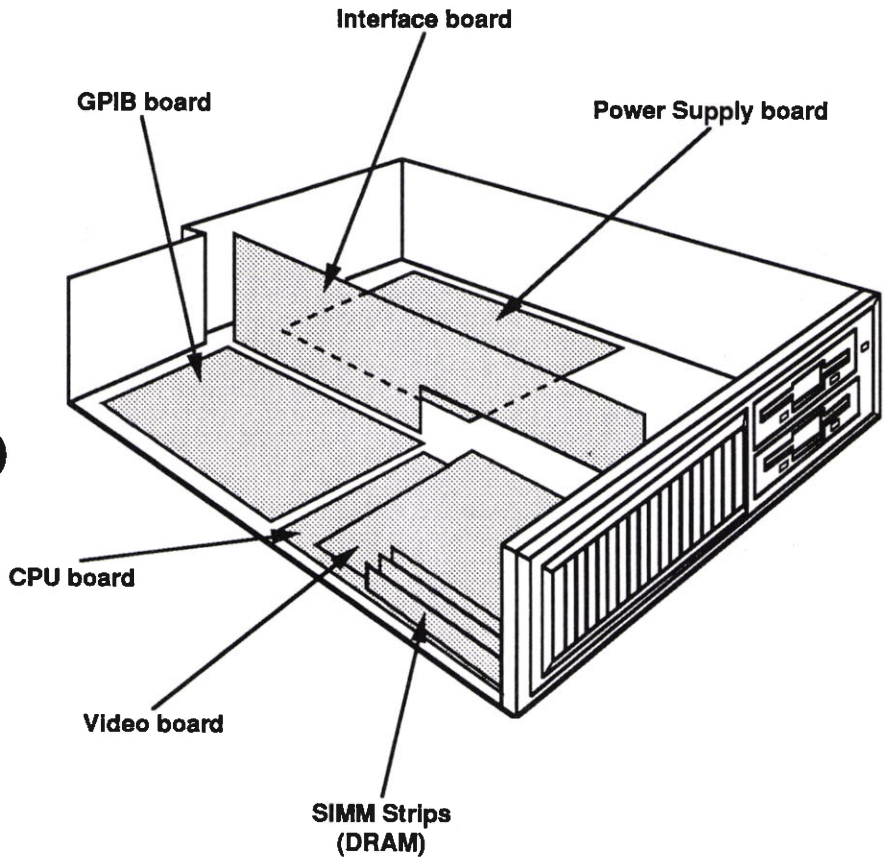


Figure 9–1. 2402 board locator.

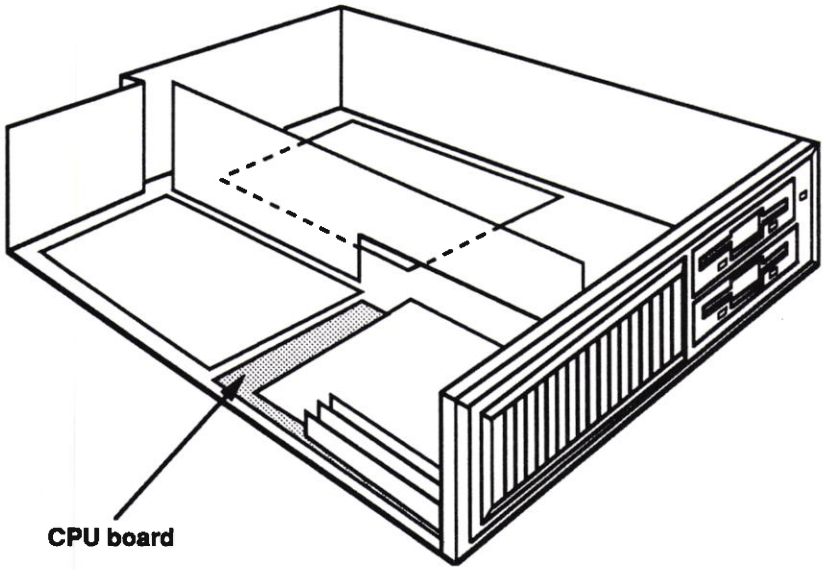


Figure 9–2. CPU board locator.

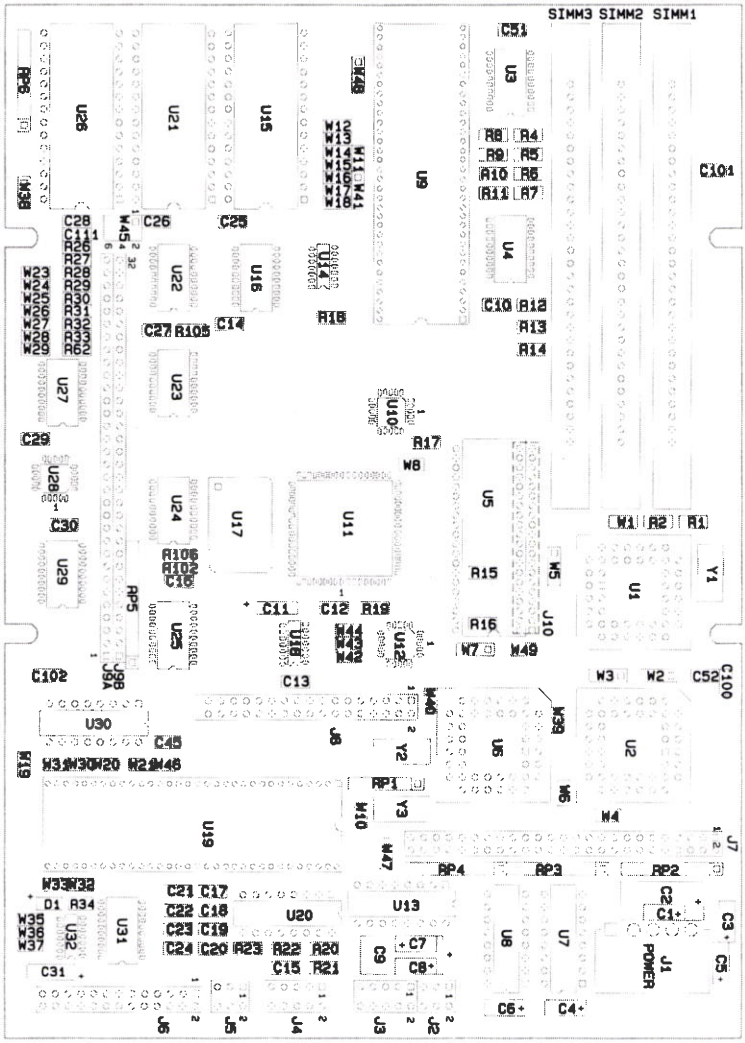


Figure 9–3. CPU board.

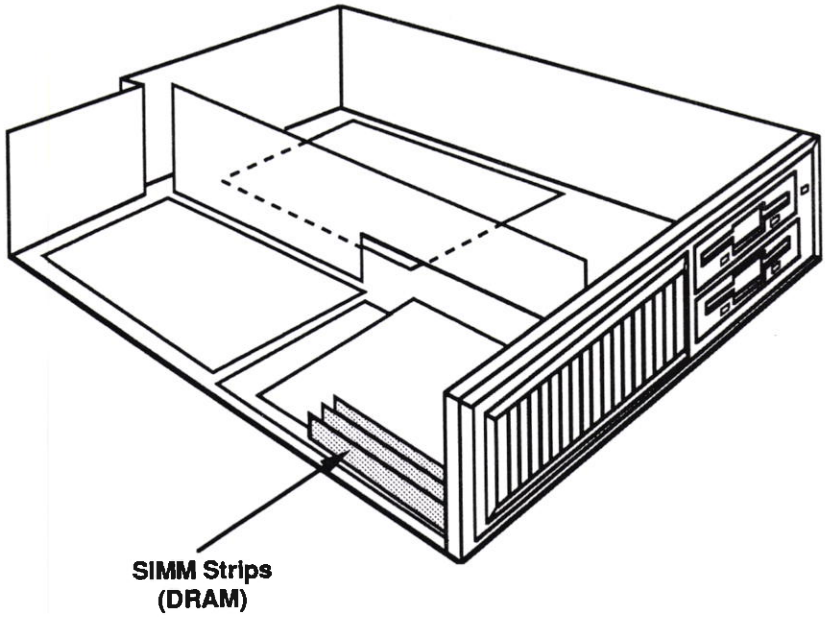
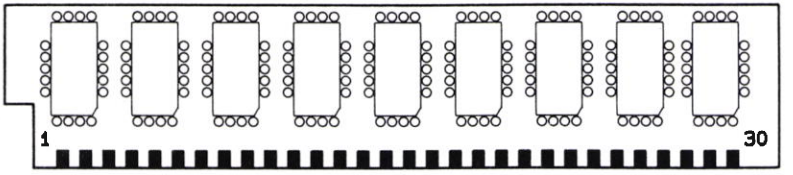
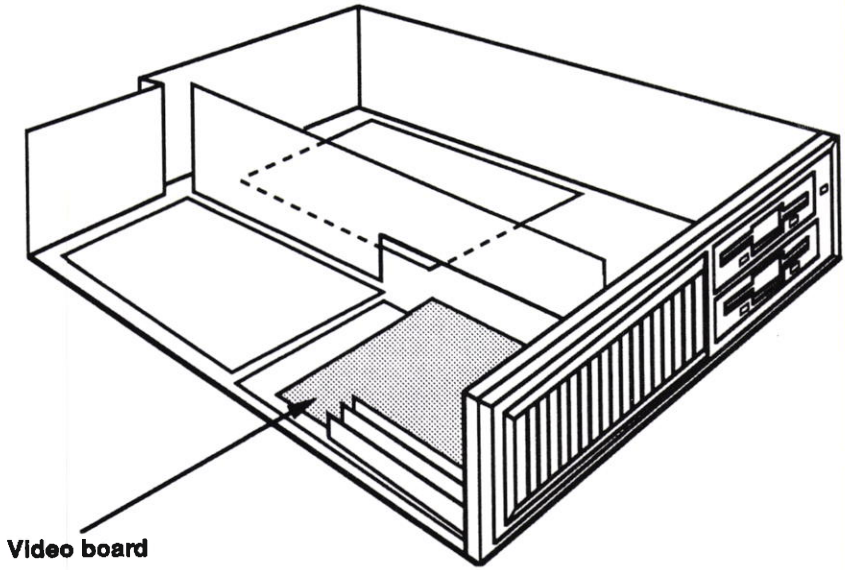


Figure 9–4. SIMM strip (DRAM) board locator.



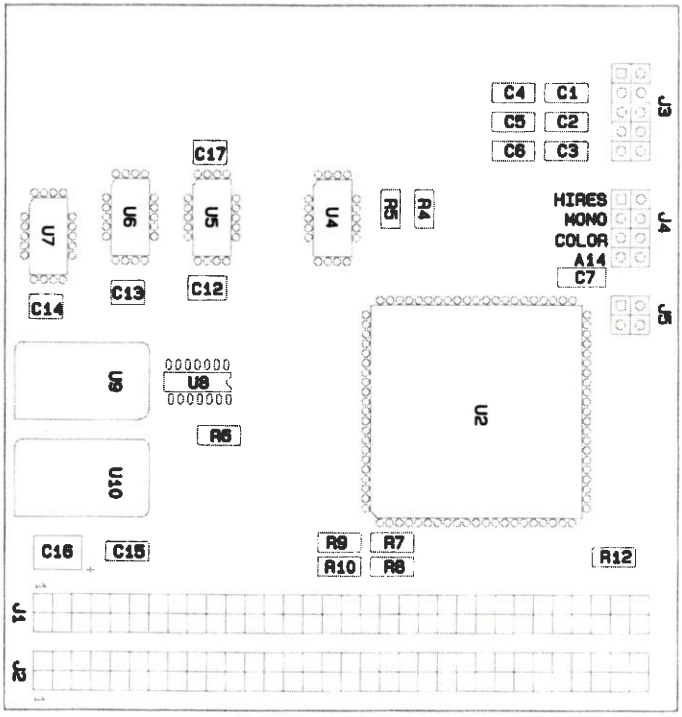
6977-08

Figure 9–5. SIMM strips (DRAM).



6977-11

Figure 9–6. Video board locator.



6977-10

Figure 9–7. Video board.

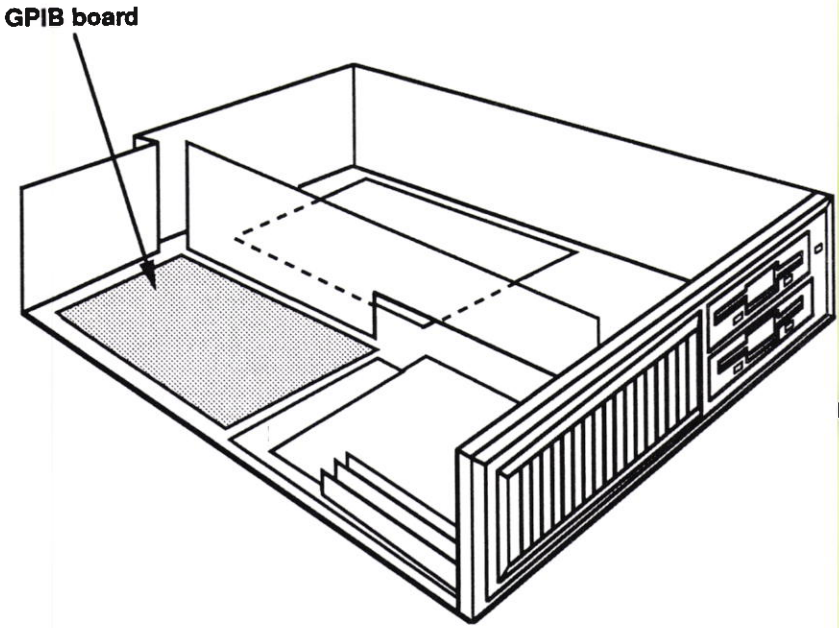
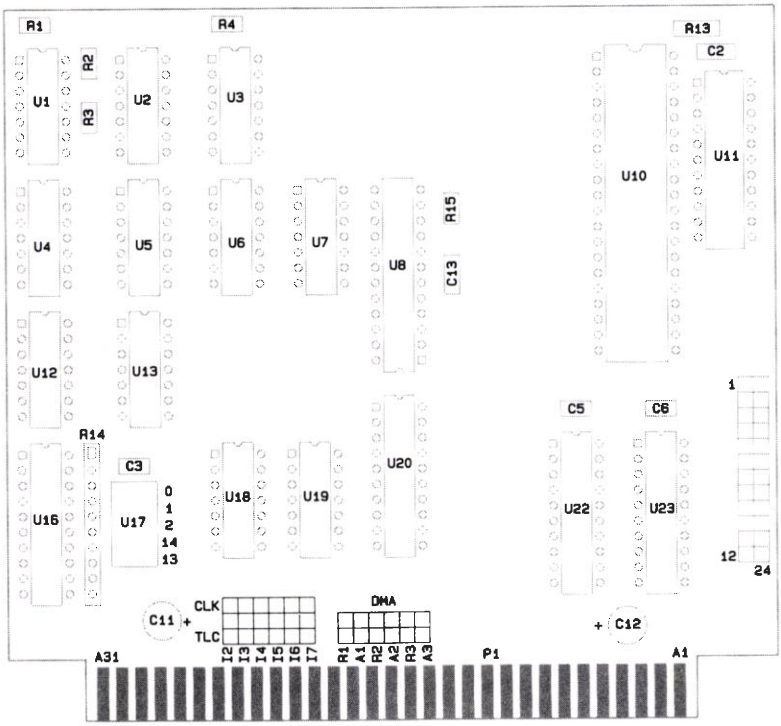


Figure 9–8. GPIB board locator.



6977-12

Figure 9–9. GPIB board.

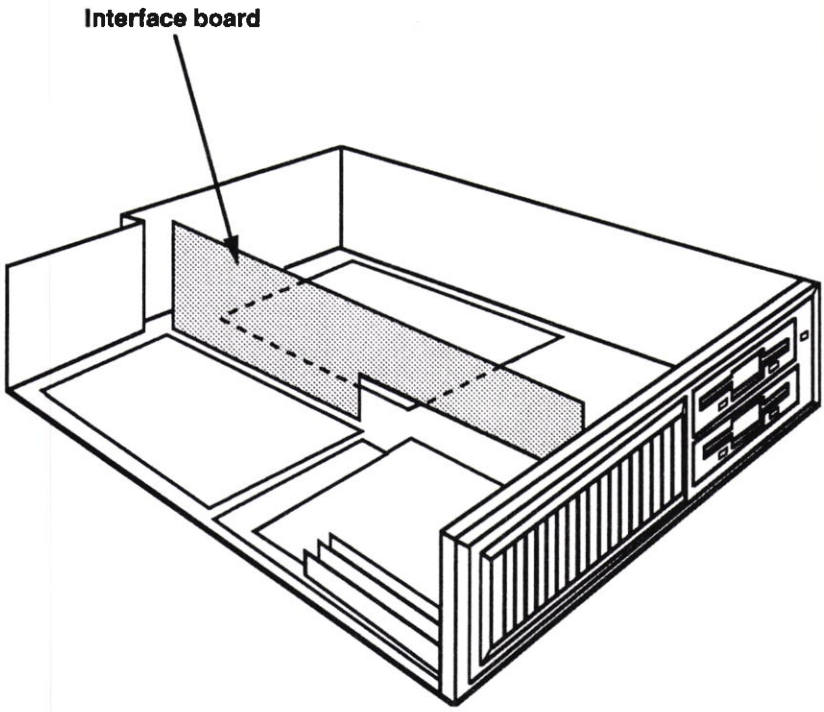
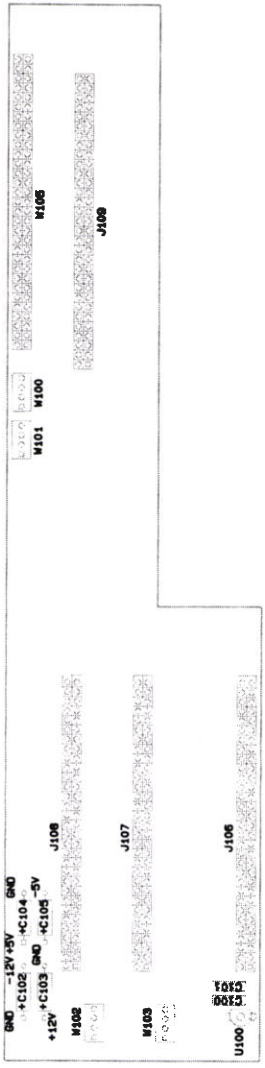


Figure 9–10. Interface board locator.



6977-14

Figure 9–11. Interface board.

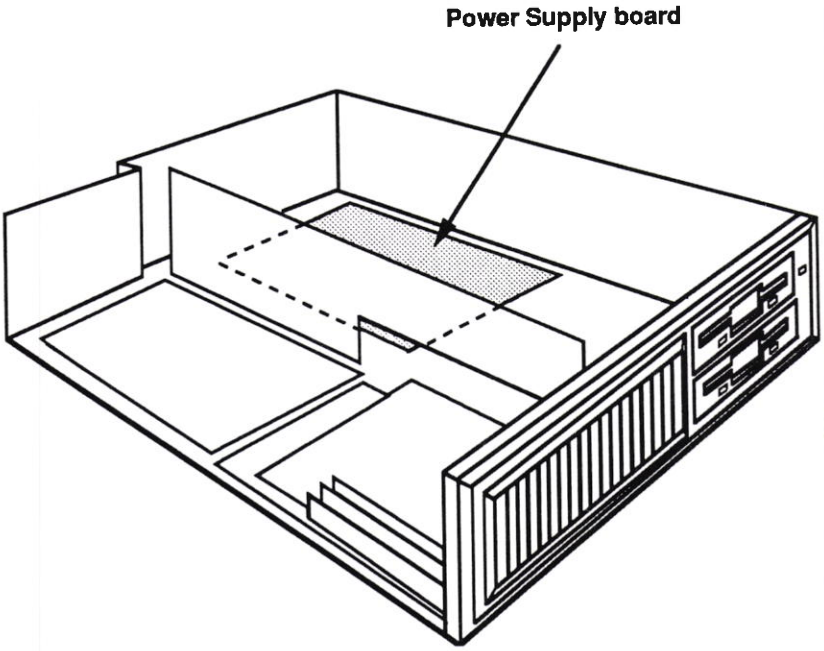


Figure 9–12. Power Supply board locator.

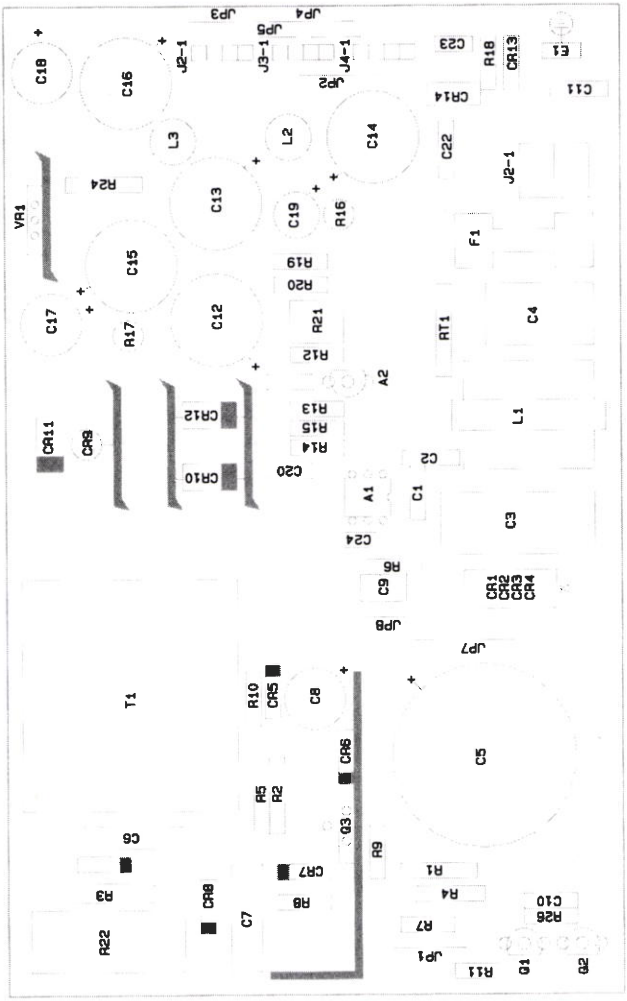


Figure 9–13. Power Supply board.

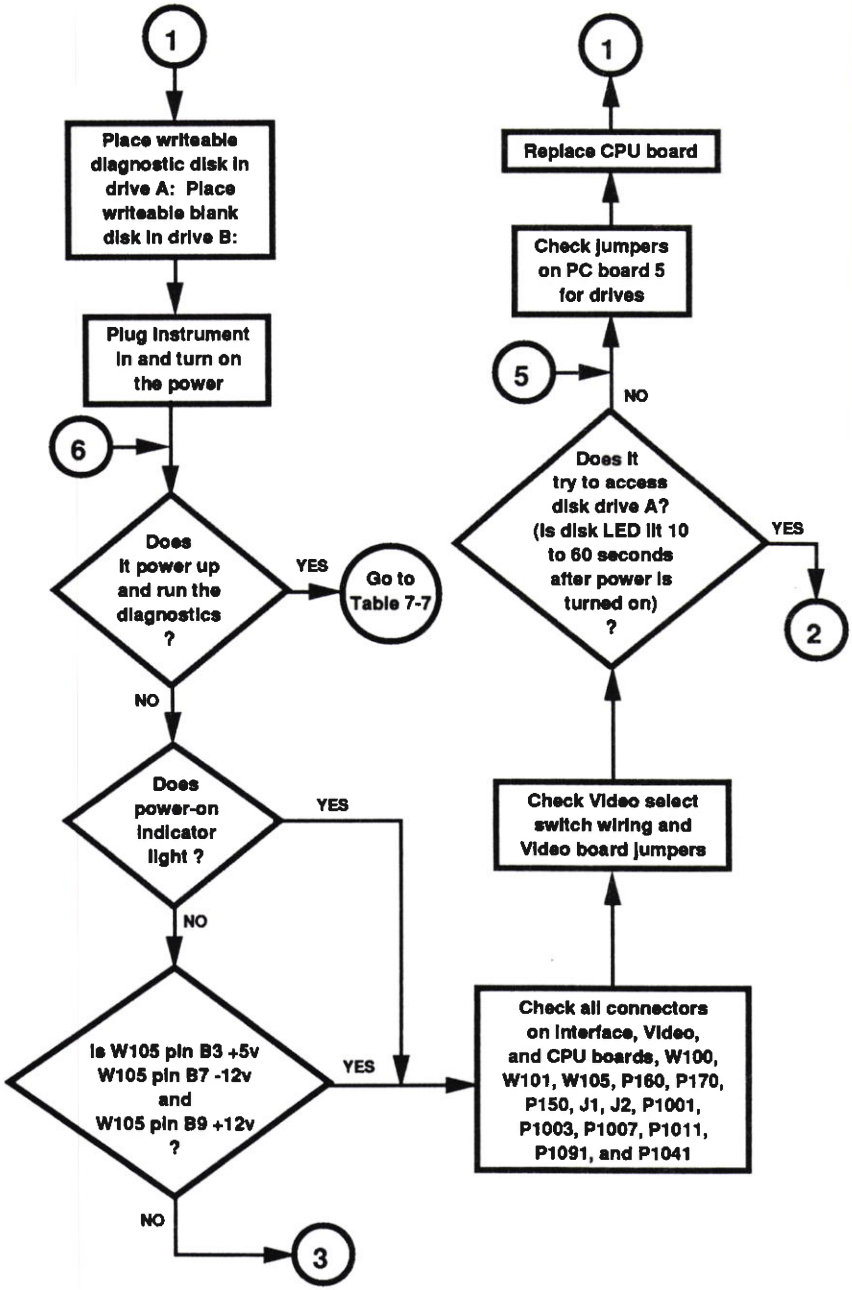


Figure 9–14. Troubleshooting tree.

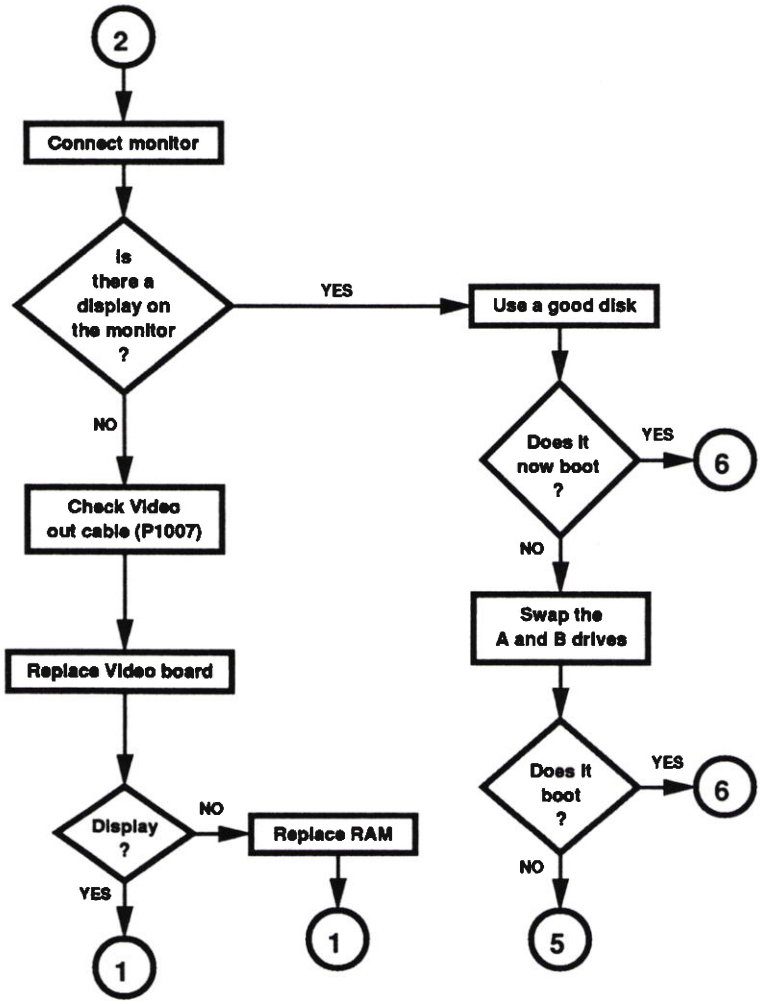


Figure 9–14. Troubleshooting tree (cont).

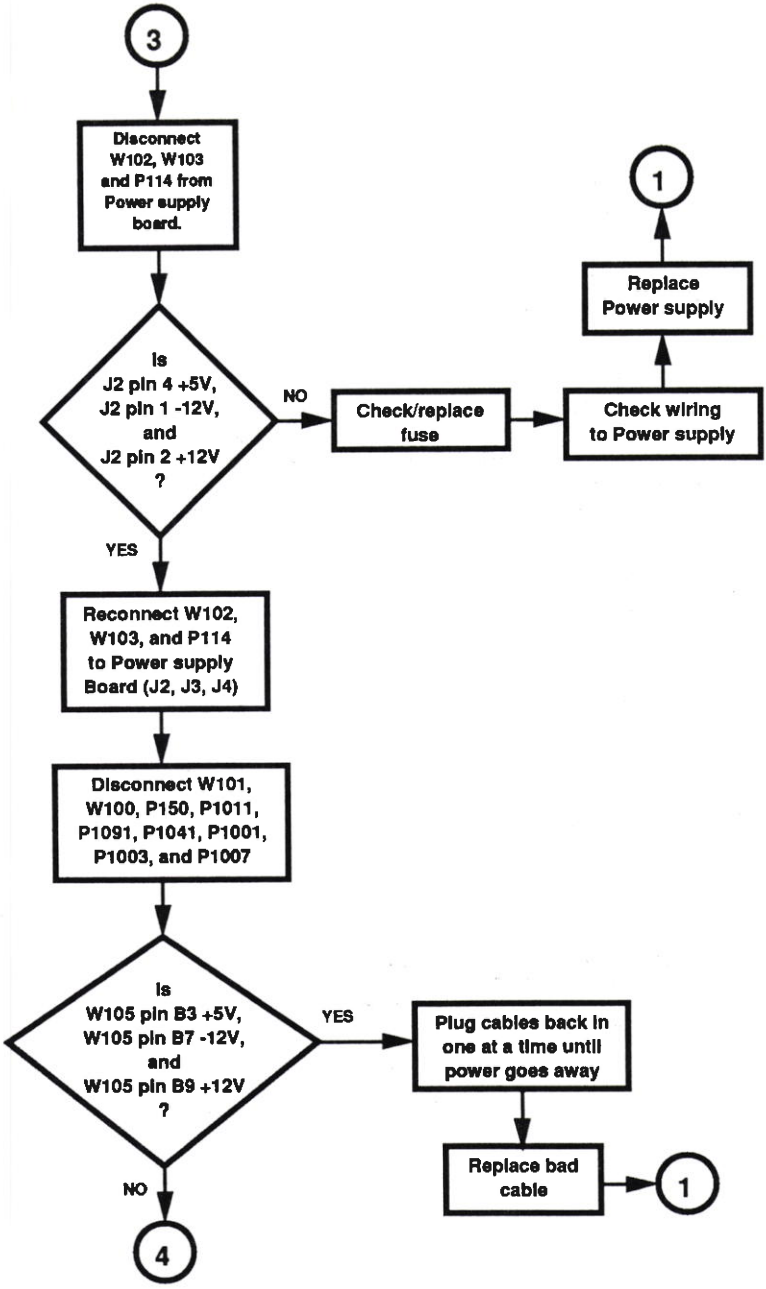


Figure 9–14. Troubleshooting tree (cont).

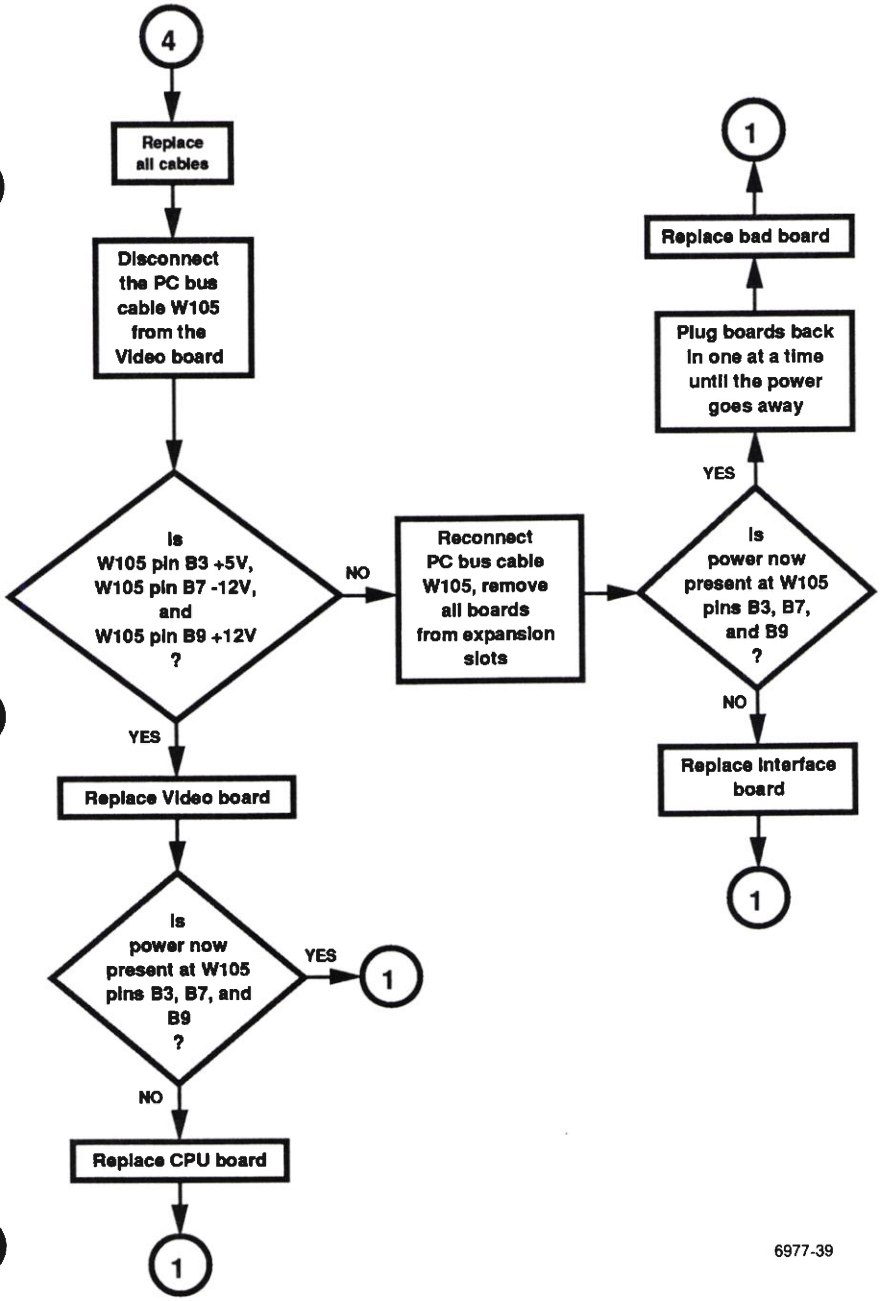
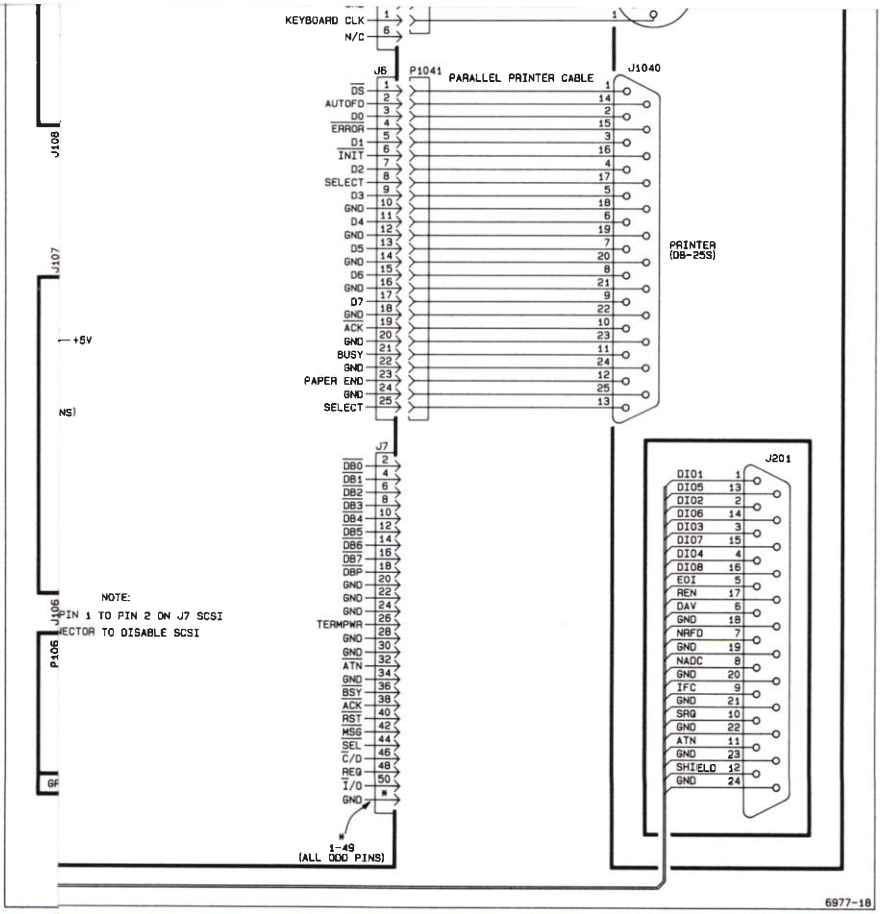


Figure 9–14. Troubleshooting tree (cont).


KEYBOARD CLK
N/C
J6
P1041
PARALLEL PRINTER CABLE
J1040
DS
AUTOFD
D0
ERROR
D1
INIT
D2
SELECT
D3
GND
D4
GND
D5
GND
D6
GND
D7
GND
ACK
GND
BUSY
GND
PAPER END
GND
SELECT
PRINTER
(DB-25S)
J7
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
DBP
GND
GND
GND
TERMPWR
GND
GND
ATN
GND
BSY
ACK
RST
MSG
SEL
C/D
REQ
I/O
GND
1-49
(ALL ODD PINS)
J201
DIO1
DIO5
DIO2
DIO6
DIO3
DIO7
DIO4
DIO8
EOI
REN
DAV
GND
NRFD
GND
NADC
GND
IFC
GND
SRQ
GND
ATN
GND
SHIELD
GND
J108
J107
+5V
NS)
J106
P106
NOTE:
PIN 1 TO PIN 2 ON J7 SCSI
ECTOR TO DISABLE SCSI
6977-18

Appendixes

Appendix A

Appendix A

This Appendix contains information about returning the 2402 TEKMATE jumpers and switches to their factory positions. Information useful in programming the hardware including the GPIB, and selecting nonstandard positions for the hardware jumpers, can be found in later Appendixes. Most users should not need this information because the applications software is designed to use the standard factory settings.

Default Settings

To return the TEKMATE to the default factory settings, place the jumpers and switches into the default positions shown below.

CPU Board Jumper Locations

NOTE

Pin 1 for all CPU board jumpers is either toward the front or left side of the instrument, depending on which axis the jumper group occupies.

Table A–1 lists each CPU board jumper and its factory default position. See Figure A–1 for the location of CPU board jumpers.

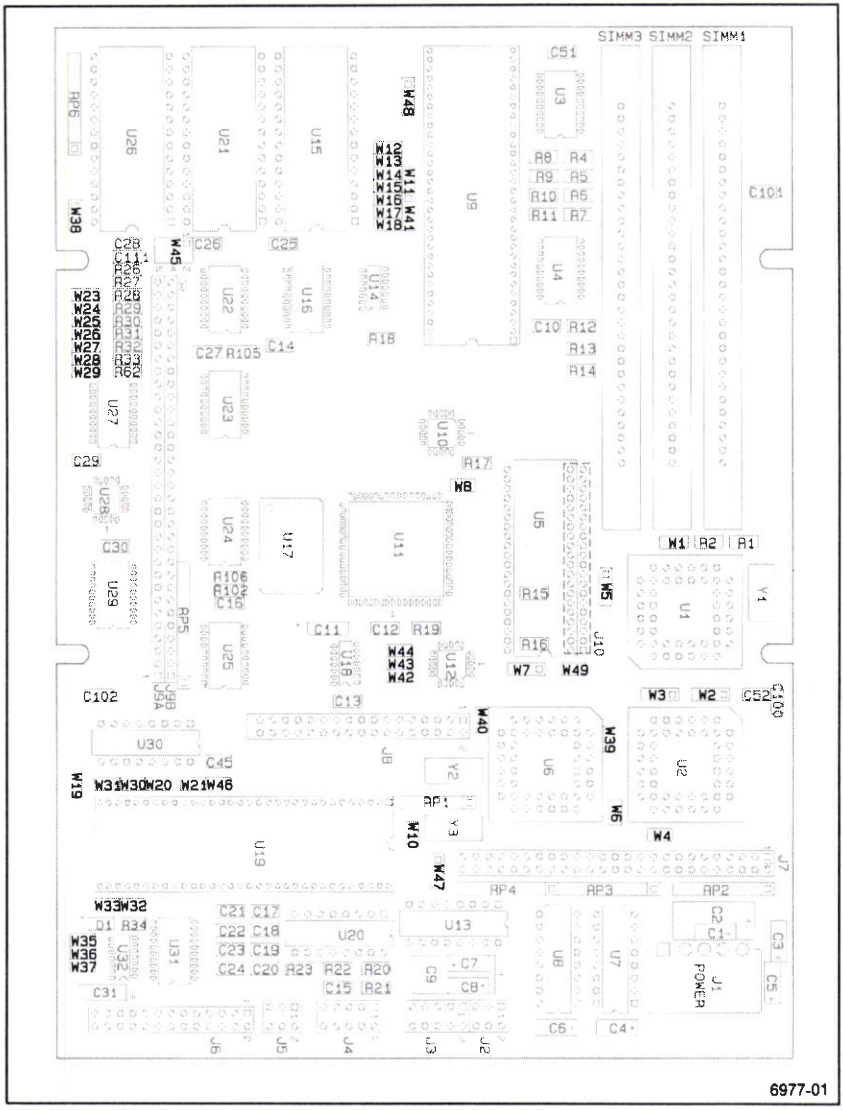


Figure A–1. CPU board default jumper locations.

Table A-1
CPU Board Default Jumper Locations

Jumper	Default	Function
W1	OFF	SCSI PCTC
W2	ON Pins 1 and 2	SCSI DRQ
W3	Off	SCSI DACK
W4	Off	SCSI termination Power opt
W5	On Pins 2 and 3	Floppy DACK
W6	Off	SCSI interrupt opt
W7	On Pins 2 and 3	Floppy DRG
W8	Off	U15 address range
W10	No pins	Floppy interrupt option
W11	Off	Printer Device Selection
W12	On	U15 pin 23 option
W13	Off	U15 pin 23 option
W14	On	U15 pin 26 option
W15	Off	U15 pin 27 option
W16	On	U15 pin 27 option
W17	On	PC serial port interrupt option
W18	Off	PC serial port interrupt option
W19	Off	PC switch 6 display mode
W20	Off	PC serial port address
W21	No pins	Parity
W22	Reserved	
W23	Off	SCSI ID
W24	Off	SCSI ID
W25	Off	SCSI ID
W26	On	Drive A type
W27	On	Drive B type
W28	Off	Drive A type
W29	Off	Drive B type
W30	On	PC switch 2 math coprocessor
W31	On	PC switch 5 video display mode
W32	On	PC switch 8 floppy quantity
W33	Off	PC switch 7 floppy quantity
W35	Off	U26 address range
W36	On	U26 address range
W37	On	U26 address range
W38	On Pins 1 and 2	U26 address range
W39	No pins	Floppy write precomp
W40	No pins	Floppy drive type
W41	On Pins 1 and 2	U15 pin 1 option
W42	Off	DRAM memory size
W43	On	DRAM memory size
W44	On	DRAM memory size
W45	On Pins 1 and 3	U26 pin 1 option
W46	No pins	Printer interrupt enable
W47	On Pins 1 and 2	V40 serial port handshake
W48	On Pins 1 and 2	Wait state generator
W49	Reserved (no pins)	

Video Board Jumper Locations

Table A-2 lists each Video board jumper and its factory default position. Figure A-2 on the following page shows the location of the Video Board jumpers.

Three of the four primary video modes are selectable by way of the rearpanel MONITOR switch when the Video board is jumpered as shown in TableA-2.The fourth video protocol (Standard IBM PC monochrome display-IBM 5101or MDA, 80 characters by 25 rows) can be reached by setting the MONITORSwitch to MONO and removing the A14 jumper from the video board.

Table A-2
Video Board Default Jumper Locations

Jumper[1]	Default
HIRES	Pins 1 and 2 of P1003
MONO	Pins 3 and 4 of P1003
COLOR	Off
A14	On

[1] **Jumper W31 and W19 (on CPU board) must be set to match the video mode selected by the Video board jumpers.**

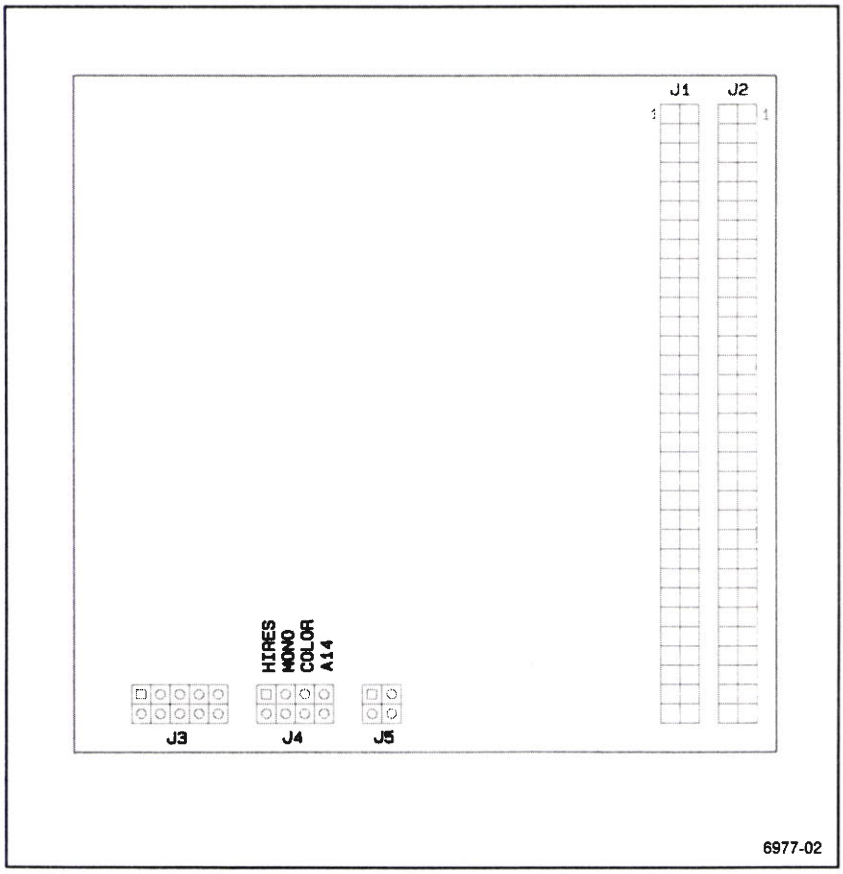


Figure A–2. Video Board jumper locations.

GPIB Board Switch and Jumper Locations

Table A-3 lists the Video board factory defaults.Figure A-2 shows the GPIB board factory default switch and jumper settings. Figure A-3 shows the location of the jumpers on the GPIB board.

Table A-3

GPIB Board Default Settings

Board Card	Factory Default
Base I/O Address (hex)	02E1
DMA Channel	1
Interrupt Line for GPIB TLC (talker/listener/controller)	I7
Interrupt Line for Clock	not used

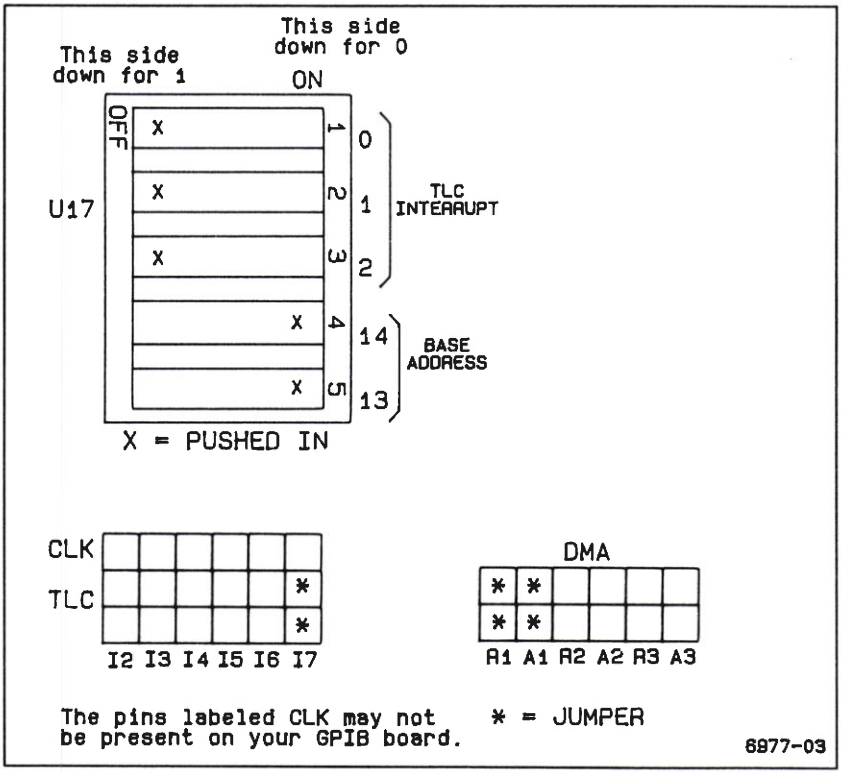


Figure A-3. GPIB board I/O base address and jumper settings.

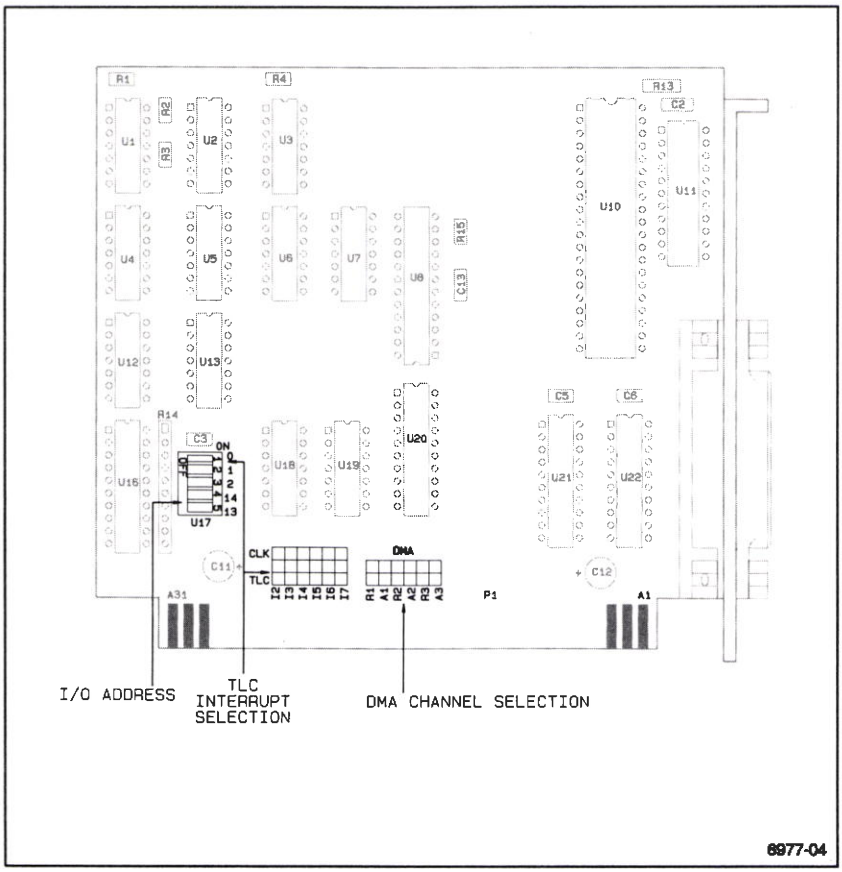


Figure A–4. GPIB board jumper locations.

Appendix B

Appendix B

Custom Programming of the CPU

This Appendix contains information useful in programming the CPU board hardware directly, and selecting nonstandard positions for the hardware jumpers. Actually, there should be little need for custom programming because the operating system, or the application software program itself, handles the hardware for you. In addition, the TEKMATE's ROM-BIOS provides a high degree of compatibility with the IBM PC ROM-BIOS.

The following references are highly recommended, and in some cases contain information that is essential for directly programming the CPU's controllers.

Technical data on the V40 CPU:

μPD70208/70216 User's Manual
NEC Electronics Inc.

Technical data on the WD37C65 Floppy Controller:

WD37C65 Technical Specification
Western Digital Corporation

Technical data on the 53C80 SCSI Controller:

53C80 SCSI Interface Chip Design Manual
NCR Microelectronics Division

Technical data on the 8250 Serial Controller:

8250 Technical Specification:
National Semiconductor Corporation

Technical data on the RS-232-C buffers:

MAX232 Data Sheet:
Maxim Integrated Products, Inc.

In addition, the following general references are recommended:

The Peter Norton Programmer's Guide to the IBM PC
Microsoft Press

Interfacing to the IBM Personal Computer
Lewis C. Eggebrecht
Howard W. Sams & Co., Inc.

System Memory Map

The V40's memory address space is specified by 20 address bits, so it can address 1 megabyte of memory. The board's 1 megabyte of memory space is decoded as indicated in Table B-1.

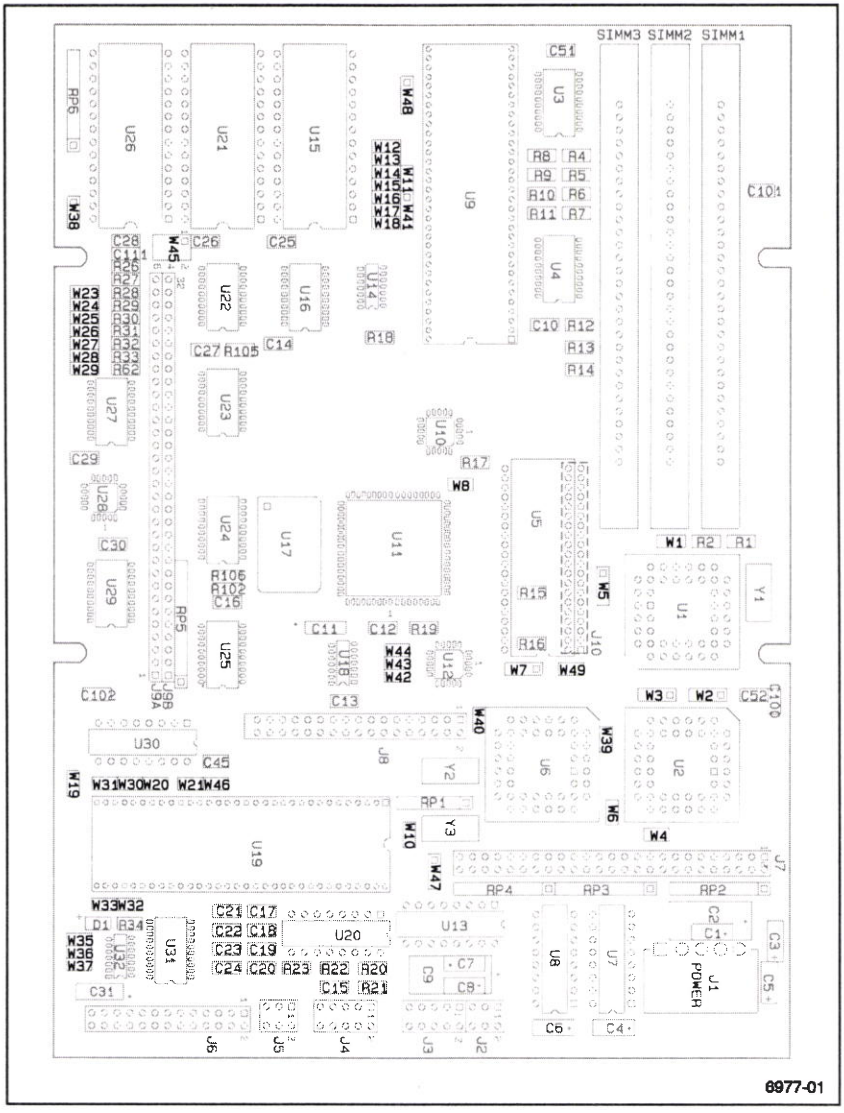


Figure B–1. CPU board jumper locations.

Table B-1
CPU Board Memory Map

Memory Adrs	Function
F8000 - FFFFFh	BIOS PROM Socket at U21 (Required). Occupied by a PC compatible ROM-BIOS with SCSI/BIOS extensions. Contains a startup vector at address FFFF0h.
F0000 - F7FFFh	Read/write byte-wide memory socket at U15.
E0000 - EFFFFh	Read/write byte-wide memory socket at U26. Jumpers allow the origin of the device to be at E0000h, E8000h, EC000h, or EE000h.
C0000 - DFFFFh	Not used in the 2402 TEKMATE.
A0000 - BFFFFh	Reserved for video RAM, as follows: CGA Video: B8000 - BFFFFh Monochrome: B0000 - B7FFFh EGA Video: A0000 - AFFFFh Jumpers allow the use of SIMM3 DRAM memory within this restricted video area.
80000 - 9FFFFh	General purpose memory. Can be accessed via DRAM socket SIMM3, or via the board's PC Expansion Bus (determined by jumpers).
40000 - 7FFFFh	General purpose memory. Can be accessed via DRAM socket SIMM2, or via the board's PC Expansion Bus (determined by jumpers).
00000 - 3FFFFh	General purpose memory. Can be accessed via DRAM socket SIMM1, or via the board's PC Expansion Bus (determined by jumpers).

I/O Address Map

NOTE

When adding expansion boards to the PC Expansion Bus, be sure to check for I/O address conflicts.

The V40's I/O address space is specified by sixteen address bits. However, as in the standard PC architecture, the TEKMATE decodes only the lower 10 of these address bits. Expansion boards designed for use on the PC Expansion Bus must therefore reside within this I/O address space.

Table B-2 provides a detailed listing of the I/O port assignments for the TEKMATE. In many cases, the ROM-BIOS functions provide all of the "hooks" needed to access devices connected to the board's I/O ports. If you must program the board's peripheral interfaces directly, refer to the individual technical data sheets for the components used. These are available from the device manufacturers.

Table B-2
I/O Port Assignment Map

I/O Address	Function
FFF0 - FFFFh	V40 internal control registers
0400 - FFEFh	Not available.
03F8 - 03FFh	PC Serial Port "primary" option
03F0 - 03F7h	Floppy disk controller ports (WD37C65) 3F2 - FDC Digital output register (LDOR) 3F4 - FDC Main status register 3F5 - FDC Data register 3F7 - FDC Control register (LDCR)
03BC - 03BFh	Parallel printer "secondary" option
0378 - 037Fh	Parallel printer "primary" option
0338h	Jumper input port. SCSI ID, floppy type, and V40 serial port handshake input.
0330 - 0337h	SCSI controller (53C80) ports (not used)
02F8 - 02FFh	PC Serial Port "secondary" option
00F0 - 00F3h	V40 Serial Port
00A0 - 00AFh	NMI Enable register
0080 - 0083h	DMA page registers (emulated) 80 - reserved 81 - PC DMA Channel 2 82 - PC DMA Channel 3 83 - PC DMA Channel 1
0060 - 0063h	Speaker control ports 61 - Bit 0 = CTC2 output gate 61 - Bit 1 = Speaker enable signal
0040 - 004Fh	Counter/Timer Controller ports 42 - Frequency count/status register 43 - Timer mode register
0020 - 002Fh	Interrupt controller ports
0010 - 001Fh	V40 DMA controller registers (actual)
0000 - 000Fh	8237A DMA controller registers (emulated)

V40 Internal Registers

The V40 CPU has the following internal controllers:

REFU Refresh Control Unit

WCU Wait State Control Unit

CTC Counter/Timer Controller

SCU Serial Control Unit

ICU Interrupt Control Unit

DMAU DMA Control Unit

The V40 accesses its internal peripherals using normal I/O addressing. The addresses assigned to these internal peripherals are not available for general use. Note, though, that these addresses are situated at the very top of the 16-bit I/O address space. Since the PC architecture only uses the lowest 1024 I/O addresses, there is no conflict.

Table B-3 contains a list of the internal V40 peripheral addresses and a brief description of their function. These are for reference only. To program any of these registers, you must refer to the V40 User's Manual for the detailed bit definitions.

Table B–3

V40 Internal Peripheral Control Registers

I/O ADR	Name	Description
FFFFh		Reserved.
FFFEh	OPCN	On-chip Peripheral Connection register. Selects between DMA3 and V40 serial.
FFFDh	OPSEL	On-chip Peripheral Selection. Enables SCU, CTC, ICU, and DMAU
FFFCh	OPHA	On-chip Peripheral High Address. Sets the upper byte of the I/O address assigned to the SCU, CTC, ICU, DMAU.
FFFBh	DULA	DMAU Low Address. Sets the lower byte of the I/O address assigned to the DMAU.
FFFAh	IULA	ICU Low Address. Sets the lower byte of the I/O address assigned to the ICU.
FFF9h	TULA	CTC Low Address. Sets the lower byte of the I/O address assigned to the CTC.
FFF8h	SULA	SCU Low Address. Sets the lower byte of the I/O address assigned to the SCU.
FFF7h		Reserved.
FFF6h	WCY2	Wait Cycles 2. Sets the number of wait cycles for DMA and refresh cycles.
FFF5h	WCY1	Wait Cycles 1. Sets the number of wait states for each of three memory regions and for I/O cycles.
FFF4h	WMB	Wait Memory Boundary. Defines the boundary addresses of the three memory wait state regions.
FFF3h		Reserved.
FFF2h	RFC	Refresh Control. Enables/Disables refresh by the RFU and sets the refresh interval.
FFF1h		Reserved.
FFF0h	TCKS	Timer Clock Selection. Selects the clock source (internal or external) for the CTC and the divisor by which the frequency of the internal clock is divided.

V40 Initialization

Table B-4 describes the state of the internal peripheral control ports after they have been initialized by the TEKMATE's ROM-BIOS. The description field shows the resulting state of the internal peripherals.

The wait state values used in the ROM-BIOS are intended to allow the system to boot and begin operation from the widest possible range of on-board and bus devices. Any of these values can be changed by writing a short program that outputs different values to the indicated I/O addresses following system boot. This can be done as part of the DOS AUTOEXEC.BAT function.

Automatic I/O Wait State Jumpering

A timing limitation in the original V40 microprocessor relative to the design of the CPU board required the insertion of wait states on all I/O cycles. The V40's now used no longer require this restriction. Jumper W48 allows the option of eliminating these extra wait states.

Short W48 pins 1 and 2 to disable automatic I/O wait states. If automatic wait states are disabled the actual number of I/O wait states is determined by the V40's internal wait state generator (use SETWAIT.COM). Short W48 pins 2 and 3 to enable automatic I/O wait states.

Table B–4
ROM–BIOS Default V40 Initialization

Register	I/O Adrs	Contents	Description
OPCN	FFFEh	00000011	Pin function options: IRQ1, IRQ2, RXD, TXD, SRDY
OPSEL	FFFDh	00001111	Enable all peripherals
OPHA	FFFCh	00000000	Set High Address = 00h
DULA	FFFBh	00010000	DMAU Low Address = 10h
IULA	FFFAh	00100000	ICU Low Address = 20h
TULA	FFF9h	01000000	CTC Low Address = 40h
SULA	FFF8h	11110000	SCU Low Address = F0h
WCY2	FFF6h	00001110	Wait States: DMAU = 3 RFU = 2
WCY1	FFF5h	01010000	Wait States: I/O = 3 Upper Memory = 0 Middle Memory = 2 Lower Memory = 1
WMB	FFF4h	01010000	Wait Memory Boundaries: Low = 256k High = 32K
RFC	FFF2h	10000110	Refresh Control: Refresh enabled 8 * 12 / 7.16 MHz = 13.4 microsec
TCKS	FFF0h	00011100	Timer Clock Control: TCT #0 = TCLK TCT #1 = TCLK TCT #2 = TCLK

PC Serial Port Jumpers

Three jumpers (W17, W18, and W20) can be used to modify the I/O port address (3F8-3FFh or 2F8-2FFh) and interrupt usage (IRQ3 or IRQ4) of the PC Serial Port (COM 1). Normally, the DOS "COM1" device has address 3F8-3FFh and interrupt IRQ4; however, the ROM-BIOS scans both choices and will install the first one it finds as COM1 regardless of which option has been configured. Jumper W20 selects the port's I/O port address, while interrupt channel selection is made using either W17 or W18. Refer to Table B-5 when making serial channel selection.

Table B-5

PC Serial Port (COM 1) Configuration

I/O Addressing	Interrupt	W17	W18	W20
3F8h thru 3FFh	IRQ4	on	off	off
2F8h thru 2FFh	IRQ3	off	on	on
	Default:	on	off	off

V40 Serial Port (COM 4) Jumpering

The only jumper option pertaining to the board's V40 Serial Port selects the source of the Handshake Out signal (RTS). W47, a 3 pin jumper group, allows the Handshake Out signal to be driven by either the V40's serial controller handshake output logic, or by the printer interface's (not)INIT signal.

As shipped from the factory, this signal is connected to the handshake signal (SRDY; V40 pin 36) generated by the serial controller within the V40 microprocessor. As utilized by the ROM-BIOS, the V40's handshake signal automatically goes true when the receive buffer is ready to receive data, and false when the receive buffer is full.

Alternatively, the Handshake Out signal source can be jumpered to the printer port (not)INIT signal. This provides a signal source which is completely under software control, but is only useful if the printer port will not be used, or if the applications running on the board will not use the (not)INIT signal when using the printer port.

To select the V40's handshake output logic, insert a shorting block (jumper) between W47 pins 1 and 2; to use the printer (not)INIT signal, short pins 2 and 3. The default is the V40's handshake output signal (W47 pins 1 and 2).

PRINTER Port Jumpering

Three jumper options (W11, W46, and W47) pertain to the functions associated with the TEKMATE's parallel printer port. The various options are shown in Table B-6.

Table B-6
Parallel Printer Configuration

Jumper	Signal	Function
W11	To ASIC1	Selects I/O address. off: 378-37Fh on: 3BC-3BFh Default: off (378-37Fh)
W46	INT7	Connects the on-board printer port to INT 7 Default: shorted (trace)
W47-1 W47-2 W47-3	V40 SRDY Handshake Out (not)INIT	V40 Serial Port handshake option. Default: pins 1 and 2 shorted (jumper)

Jumper option W11 allows a choice of two I/O port addresses for the printer port: 378-37Fh, or 3BC-3BFh. Normally, the DOS "LPT1" device has address 378-37Fh; however, the ROM-BIOS scans both choices and will install the first one it finds as "LPT1" regardless of which option has been configured. The PRINTER port should normally be configured for 378-37Fh (W11 unshorted), unless another parallel port interface is present on the PC bus.

A second jumper option, W46, has been provided to allow the use of the printer port interrupt (INT 7) as an extra interrupt on the PC Expansion Bus if you do not require interrupt-based operation of the parallel printer port. The print functions in the ROM-BIOS do not use the interrupt. However, some PC applications (e.g. spoolers) might require printer interrupts, so it is recommended that you leave this interrupt connected unless you are certain it is not needed. To free INT 7 for use on the PC Expansion Bus, cut the trace shorting W46 (on the non-component side of the board). INT 7 is then available on the PC Expansion Bus, at J9 pin B21.

The third jumper option, W47, allows the use of the printer port (not)INIT signal as a Handshake Out signal for the V40 serial port. If that option is employed, the printer port must either not be used for anything else, or must be used in a manner that does not result in erroneous handshake signal usage. As indicated in the table, shorting pin 1 to pin 2 is the normal configuration, which results in the Handshake Out signal being generated by the V40's internal serial controller handshake logic.

SCSI ID Jumpering

Normally, three jumper pin pairs (W23–W25) are used to provide a three bit SCSI Initiator ID. The Initiator ID is used by the board's ROM-BIOS and other support software. The jumper assignments are shown in Table B–7. These jumper pins can be used for other purposes if the SCSI interface is not required.

Table B–7
SCSI Initiator ID Jumpering

SCSI Bus ID	W25	W24	W23
0	on	on	on
1	on	on	off
2	on	off	on
3	on	off	off
4	off	on	on
5	off	on	off
6	off	off	on
7	off	off	off
Default: 7	off	off	off

Other SCSI Jumper Options

The SCSI interface can be configured to use either DMA channel 1 or 3 for data transfer control. DMA Channel 3 corresponds to a standard PC's fixed disk adapter, and is used as the default by the CPU board's SCSI/BIOS. You can alter these assignments relative to the defaults, but this will sacrifice SCSI/BIOS and SCSI utilities compatibility. These SCSI interface configuration options are shown in Table B–8.

No termination power protection diode is provided on the CPU board. W4 must NOT be installed if any other bus device supplies termination power, or board damage may result!

Table B–8
SCSI Interface Option Jumpers

Jumper	Signal	Function
W1	PCTC	Connects DMA END (TC) signal to 53C80's –EOP input. Default: unshorted.
W2–1 W2–2 W2–3	DRQ3 DRQ from 53C80 DRQ1	DMA request channel option. Default: 1 and 2 shorted (DRQ3), via trace. (W2–1 is at top.)
W3–1 W3–2 W3–3	DACK3 DACK to 53C80 DACK1	DMA acknowledge channel option. Default: 1 and 2 shorted (DACK3), via trace. (W3–1 is at top.)
W4	Term Power	Provides +5 volts termination power to pin 26 of the SCSI Bus. Default: unshorted.
W6	53C80 IRQ	Connects 53C80's interrupt output to PC bus IRQ5. Default: unshorted

Floppy Disk Interface

The TEKMATE's floppy disk controller subsystem and ROM-BIOS support one or two floppy disk drives in any of the standard PC-DOS and MS-DOS formats shown in Table B-9.

Table B-9
Supported Floppy Formats

Capacity	Tracks	Drive Size	Data Rate	DOS Version
360K	40	5-1/4"	250 KHz	2.1+
1.2M	80	5-1/4"	500 KHz	3.0+
720K	80	3-1/2"	250 KHz	3.2+
1.4M	80	3-1/2"	500 KHz	3.3+

As you can see from Table B-9, nearly any type of soft-sectored, single or double-sided, 40 or 80 track, mini or micro floppy disk drive is usable.

Here are some considerations regarding the selection, configuration, and connection of floppy drives to the TEKMATE.

- The drives used must be compatible with the TEKMATE's floppy disk interface, as described below. In general, any PC compatible drive will do.
- High quality, DC servo direct drive motor floppy disk drives are recommended.
- Any combination of supported drives can be used. See Table B-9.
- The CPU board must be jumpered for the number and type of floppy drives to be used.
- The drives must be jumpered to the second drive select. Use a floppy cable with a segment of wires "twisted".
- Resistive terminations should be installed only on the drive connected to the last interface cable connector (farthest from the CPU).
- When using drives with a Head Load option, jumper the drive for "head load with motor on" rather than "head load with drive select."

Note that the TEKMATE's ROM-BIOS does not provide dual-capacity use of a 1.2 megabyte drive: i.e., 360K floppies can not be read or written in this type of drive. Therefore, don't try to boot (or read or write) one type of floppy format in another type of drive!

Table B-10 shows the pinout and signal definitions of the floppy disk interface connector (J8). The connector is identical in pinout with the floppy connector of a standard PC. Note that in a PC, both drives are normally jumpered the same as the "second" drive. The drives are differentiated by swapping a group of seven wires (conductors 10-16) in the cable between the board and the "first" physical drive (drive A).

Table B-10
Floppy Disk Interface Connector (J8)

Pin	Signal Name	Function	In/out
2	(not)RPM/(not)RWC	Speed/Precomp (option)	out
4	---	(Not used)	--
6	---	(Not used)	--
8	(not)IDX	Index Pulse	in
10	(not)MO1	Motor On 1	out
12	(not)DS2	Drive Select 2	out
14	(not)DS1	Drive Select 1	out
16	(not)MO2	Motor On 2	out
18	(not)DIRC	Direction Select	out
20	(not)STEP	Step	out
22	(not)WD	Write Data	out
24	(not)WE	Write Enable	out
26	(not)TRK0	Track 0	in
28	(not)WP	Write Protect	in
30	(not)RDD	Read Data	in
32	(not)HS	Head Select	out
34	pullup	330 ohms to +5V	--
1-33	(all odd pins)	Signal grounds	--

Floppy Interface Jumpering

Nine jumper options allow customization of the operation of the floppy disk controller subsystem. The main concerns are:

- Jumpers W32 and W33 must be set to indicate the quantity of drives connected, as indicated in Table B-11. Only the choices of 1 or 2 drives are allowed, so jumper W32 must be on.
- Be sure to also set the four drive type jumpers (W26-W29) to specify the type of floppy disk drives to be used, as indicated in Table B-12 and Table B-13. Table B-12 applies to Drive A, and Table B-13 applies to Drive B. Any combination of two drives is allowed.
- If nothing is connected to the SCSI connector (J7), insert a shorting jumper on J7 pins 1 and 2 to disable attempts to boot the system from SCSI. This speeds up booting from a floppy.

Table B-11
Floppy Drive Quantity

W33	W32	Drives
on	on	1
off	on	2
on	off	3 (*)
off	off	4 (*)

Default: 2 drives
(*) Not supported.

Table B-12
Drive A Type Selection

Capacity	Tracks	Drive Size	Data Rate	DOS Version	W26	W28
360K	40	5-1/4"	250 KHz	2.1+	off	off
1.2M	80	5-1/4"	500 KHz	3.0+	off	on
720K	80	3-1/2	250 KHz	3.2+	on	off
1.4M	80	3-1/2	500 KHz	3.3+	on	on
Default: 720K, 3-1/2" drive					on	off

Table B-13
Drive B Type Selection

Capacity	Tracks	Drive Size	Data Rate	DOS Version	W27	W29
360K	40	5-1/4"	250 KHz	2.1+	off	off
1.2M	80	5-1/4"	500 KHz	3.0+	off	on
720K	80	3-1/2	250 KHz	3.2+	on	off
1.4M	80	3-1/2	500 KHz	3.3+	on	on
Default: 720K, 3-1/2" drive					on	off

Two additional options, shown in Table B-14, allow altering the DMA channel and interrupt channel assignment. Changing these from the defaults is not recommended because it would sacrifice compatibility with the ROM-BIOS.

Table B-14
Floppy Interface Options

Jumper	Signal	Function
W5-1 W5-2 W5-3	DACK1 DACK to FDC DACK2	DMA acknowledge channel option. Default: pins 2 and 3 shorted (DACK2).
W7-1 W7-2 W7-3	DRQ1 DRQ from FDC DRQ2	DMA request channel option. Default: pins 2 and 3 shorted (DRQ2).
W10	IRQ6	When shorted, connects CPU board's floppy controller to interrupt request IRQ6. Must be shorted if the board is equipped with a floppy disk controller. Default: shorted.
W26- W29		Select floppy drive type for drives A and B, as shown in Tables B-12 and B-13. Default: W26 and W27 shorted, W28 and W29 unshorted.
W32 W33	PC Switch 8 PC Switch 7	Drive quantity, as shown in Table B-11. Default: W32 on, W33 off.
W39	PCVAL	Write precompensation value. Unshorted selects 125 ns. Shorted selects 187 ns. Default: unshorted
W40	DRV	Drive type. Unshorted selects single speed drives. Shorted selects dual speed drives. Default: unshorted

Using the PC Expansion Bus

The PC Bus signals are buffered on the CPU board and provide approximately 4 mA source and sink currents for peripheral cards, with TTL compatible signal levels.

- Some PC expansion cards have asynchronous TTL inputs that are especially vulnerable to cable noise and crosstalk. In particular, the PC bus active high RESET line is one to watch out for. If this signal is found to be susceptible, a 200 pF to 500 pF capacitor connected between the RESET signal and ground can be used to prevent false expansion card resets.

- Tables 3-9A and 3-9B indicate the pinout and signal functions of the signals on the board's PC Expansion Bus connector. Further information about these signals is available in numerous publications, including the IBM technical reference manuals for the PC and XT computers, and from the reference documents listed in the beginning of this Appendix.

Math Coprocessor (J10)

Connections for a 40-pin DIP socket and a 40-pin connector are provided for possible addition of a floating point coprocessor.

CAUTION

Do not connect an 8087 directly to the 40-pin connections on the CPU Board math option socket (U5) or header (J10), as damage to both the board and the IC may result.

Jumper option W30 corresponds to switch 2 of a standard PC motherboard, and indicates whether an 8087 math coprocessor is present in the system. This jumper should be left shorted, unless an 8087 is added by means of a custom adapter assembly.

DRAM Memory

Jumper pairs W42–W44 must be set to correctly indicate the amount of onboard SIMM DRAM memory which is to be utilized. When shipped by the factory, the TEKMATE is jumpered for the amount of memory installed, so no additional jumpering is normally required.

Note that configurations which utilize onboard memory above 640K are only usable under special circumstances. For this reason, the factory setting for boards with 768K DRAM is "704K," rather than a larger amount. The following restrictions govern the use of memory above 640K:

- Do not jumper for more than 640K if an EGA video controller is in use.
- Do not jumper for more than 704K if an MDA, Hercules, or CGA (or the AMPRO 4-mode) video controller is in use.

Generally speaking, the 768K memory configuration is only usable when the DOS display device is re-routed to a serial port.

NOTE

The 768K option requires that the video mode jumpers be set to the "reserved" option; i.e. jumpers W19 and W31 must be on.

Table B–15 lists the jumper information for the eight possible onboard DRAM memory configurations.

Table B–15
Onboard DRAM Memory Size Jumpering

AMOUNT	SIMM1	SIMM2	SIMM3	W42	W43	W44
0K	no	no	no	off	off	off
64K	yes	no	no	on	off	off
128K	yes	no	no	off	on	off
256K	yes	no	no	on	on	off
512K	yes	yes	no	off	off	on
640K	yes	yes	yes	on	off	on
704K	yes	yes	yes	off	on	on
768K(*)	yes	yes	yes	on	on	on
Default: 704K						

***768K option requires the "reserved" video mode, i.e., jumpers W19 and W31 must be on.**

Byte-Wide Memory

The TEKMATE has two onboard byte-wide memory device sockets which can be used for simple program storage. The specific jumpering requirements for each type of device are given later in this Appendix.

The board's two spare byte-wide memory sockets (U15 and U26) are used with either EPROM's or nonvolatile RAM (NOVRAM) devices. The following devices are supported:

Normal EPROM's:	U15 - 2764 or 27256 (8K or 32K bytes) U26 - 2764/27128/27256/27512 (8K to 64K bytes)
Page mode EPROM's:	U15 or U26 - Intel 27011 (128K bytes per socket)
Static RAM's:	U15 or U26 - 6264 or 62256 (8K or 32K bytes per socket)

Memory Socket Jumper Configuration

If the U15 or U26 memory sockets are used, they must be configured by means of jumpers for device type, size, and the starting memory address desired. The supported memory devices and corresponding jumper settings are shown in Tables B-16 and Table B-17. The starting address for U15 is F0000h, regardless of device type or size.

The "PPROM" 128K byte device (27011) is a paged EPROM which internally contains eight 16K EPROM pages, selected by a specific write to the device. These 16K pages reside in a 32K byte address window, and are "mirrored" in the upper half of that address space (i.e. E4000-E7FFFh).

The "CPU Jumper Index" provides a more technical description of the jumper functions associated with each socket, to assist in configuring the socket for other devices not mentioned in the tables.

Table B-16
U26 Device Jumpering

TYPE	SIZE	DEVICE	ADDRESS	W35	W36	W37	W38	W45
PROM	8K	2764	E0000h	off	off	on	off	off
PROM	8K	2764	E8000h	on	on	off	off	1/3
PROM	8K	2764	EE000h	off	on	off	off	1/3
PROM	16K	27128	EC000h	on	off	off	1/2	1/3
PROM*	32K	27256	E0000h	off	on	on	1/2	1/3
PROM	32K	27256	E8000h	on	off	on	1/2	1/3
PROM	64K	27512	E0000h	on	on	on	1/2	3/5
PPROM	128K	27011	E0000h	off	on	on	2/3	2/4
RAM	8K	6264	EE000h	off	on	off	2/3	off
RAM	32K	62256	E0000h	off	on	on	2/3	4/6
RAM	32K	62256	E8000h	on	off	on	2/3	4/6

*Factory default jumpering selects this device.

Table B-17
U15 Device Jumpering (F0000h)

TYPE	SIZE	DEVICE	W12	W13	W14	W15	W16	W41	W8
PROM	8K	2764	on	off	off	off	off	2/3	on
PROM	32K	27256	on	off	on	on	off	2/3	off
PPROM	128K	27011	on	off	on	off	on	2/3	off
RAM	8K	6264	on	off	off	off	on	off	on
RAM*	32K	62256	on	off	on	off	on	1/2	off

*Factory default jumpering selects this device.

Real Time Clock Module

A battery backed real time clock module is plugged into U26, a 28-pin memory option socket (U15 or U21 could be used).

If a memory device is also required in the socket used for the clock, it can be plugged directly into the 28-pin socket on the clock module. When this is done, the memory device is accessed as though the clock is not present.

Software is provided to initialize the clock for the correct date and time, as well as to automatically set the DOS system clock from the hardware real time clock on system power-up.

Video Display Mode Jumpering

No matter what type of video display controller is used, two jumper options (W19 and W31) on the CPU board must be properly configured according to the desired video mode. This is shown in Table B-18.

NOTE

The factory default is W19 Off and P1007 on W31 pin 1. Jumper W31 is therefore controled by the MONITOR switch. Jumper W31 is On when the MONITOR switch is in CGA or 2XCGA. Jumper W31 is Off when the MONITOR switch is in MONO.

Table B-18
Video Display Mode

VIDEO MODE	W31	W19
reserved	on	on
640 X 200 color	on	off
320 X 200 color	off	on
Monochrome (80 X 25)	off	off

Jumpers W19 and W31 correspond to switches 5 and 6 of a standard PC motherboard, and are used to specify the power-up default of the video display controller. The "reserved" video mode must be set when a memory configuration of 768K is to be used, as described elsewhere in this appendix.

Be sure to also jumper the video module for the desired video mode, as indicated in Appendix C.

Jumper Input Port

This port reads eight signals. Seven of the port's eight bits reflect the state of seven jumper pairs (W23-W29); the eighth bit reflects the state of the input handshake signal of the V40 Serial Port's RS-232-C connector.

The status of the Jumper Input Port is sensed by reading I/O port 338h. The low order seven bits of the port reflect the jumpering of the seven pairs of pins at the locations labeled W23-W29 on the board. The input data for these bits will be 0 (low) when the corresponding jumper is in, and 1 (high) when the jumper is out. Bit 7 is the RS-232-C input handshake for the V40 Serial Port.

Table B-19 shows the functions of the bits of the Jumper Input Port. If it is not needed for its intended uses by the board's ROM-BIOS, the Jumper Input Port can also be used for general purpose data input.

Table B-19
Jumper Input Port

Signal	Bit	Function
HSI	7	Handshake input signal for the V40 Serial Port. Must be polled by software if active input handshaking is required. Can be used for CTS, DCD, or other desired purpose.
W26 W27 W28 W29	3 4 5 6	These four bits reflect the states of the corresponding jumper positions. A jumper "on" results in the data bit being a "0," while "off" results in a "1." These bits are normally used by the ROM-BIOS to determine the type of floppy drives.
W23 W24 W25	0 1 2	These three bits reflect the states of the corresponding jumper positions. A jumper "on" results in the data bit being a "0," while "off" results in a "1." These bits are normally used by the ROM-BIOS to determine the board's SCSI Initiator ID.

CPU Jumper Index

Table B-20 lists the signal function of each pin of the jumper options on the CPU board. This information is provided to clarify the use of each jumper, and to help the user generate custom board configurations. Refer to other portions of this Appendix for information on using the board's jumpers to select various system options.

Table B-20
CPU Jumpers

JUMPER	SUBSYSTEM	FUNCTION	SIGNALS
W1	SCSI	PCTC signal	Pin1: EOP to SCSI controller Pin2: From V40 terminal count output
W2	SCSI	DRQ selection	Pin 1: DRQ3 on PC bus Pin 2: DRQ from SCSI controller Pin 3: DRQ1 on PC bus
W3	SCSI	DACK selection	Pin 1: DACK3 on PC bus Pin 2: DACK to SCSI controller Pin 3: DACK1 on PC bus
W4	SCSI	Termination power option	Pin 1: TRMPWR on SCSI bus Pin 2: +5V on board
W5	Floppy	DACK selection	Pin 1: DACK1 on PC bus Pin 2: DACK to floppy controller Pin 3: DACK2 on PC bus
W6	SCSI	Interrupt option	Pin 1: INT from SCSI controller Pin 2: IRQ5 on PC bus
W7	Floppy	DRQ selection	Pin 1: DRQ1 on PC bus Pin 2: DRQ from floppy controller Pin 3: DRQ2 on PC bus
W8	U15 memory socket	Device address range Shorted = 8K Open = 32K	Pin 1: Ground Pin 2: To memory control logic
W9	Not implemented		
W10	Floppy	Interrupt option	Pin 1: INT from floppy controller Pin 2: IRQ6 on PC bus

Table B–20 (cont)
CPU Jumpers

JUMPER	SUBSYSTEM	FUNCTION	SIGNALS
W11	Printer port	Device selection (LPT1/SPT2)	Pin 1: To AXIC1 Pin 2: Ground
W12	U15 memory socket	Pin 23 option	Pin 1: Address bit 11 (SA11) Pin 2: U15 pin 23
W13	U15 memory socket	Pin 23 option	Pin 1: Memory write Pin 2: U15 pin 23
W14	U15 memory socket	Pin 26 option	Pin 1: Address bit (SA13) Pin 2: U15 pin 26 (with pullup)
W15	U15 memory socket	Pin 27 option	Pin 1: Address bit 14 (SA14) Pin 2: U15 pin 27 (with pullup)
W16	U15 memory socket	Pin 27 option	Pin 1: Memory write (-MWR) Pin 2: U15 pin 27 (with pullup)
W17	PC serial port	Interrupt option	Pin 1: IRQ4 on PC bus Pin 2: INT from serial controller
W18	PC serial port	Interrupt option	Pin 1: IRQ3 on PC bus Pin 2: INT from serial controller
W19	PC Config-uration Switch	"Switch 6", display mode	Pin 1: To ASIC 2 Pin 2: Ground
W20	PC Serial Port	Device address	Pin 1: Ground Pin 2: To I/O control logic
W21	Parity logic	Defeats parity	Pin 1: Parity in Pin 2: Parity out
W22	(reserved)		
W23	Configuration	Defined by BIOS	Pin 1: ID bit 0 Pin 2: Ground
W24	Configuration	Defined by BIOS	Pin 1: Jumper port bit 1 Pin 2: Ground
W25	Configuration	Defined by BIOS	Pin 1: Jumper port bit 2 Pin 2: Ground

Table B–20 (cont)
CPU Jumpers

JUMPER	SUBSYSTEM	FUNCTION	SIGNALS
W26	Configuration	Defined by BIOS	Pin 1: Jumper port bit 3 Pin 2: Ground
W27	Configuration	Defined by BIOS	Pin 1: Jumper port bit 4 Pin 2: Ground
W28	Configuration	Defined by BIOS	Pin 1: Jumper port bit 5 Pin 2: Ground
W29	Configuration	Defined by BIOS	Pin 1: Jumper port bit6 Pin 2: Ground
W30	PC configur-ation switches	Switch 2 – Math option	Pin 1: To ASIC2 Pin 2: Ground
W31	PC configur-ation switches	Switch 5 – Display mode	Pin 1: To ASIC2 Pin 2: Ground
W32	PC configur-ation switches	Switch 8 – Floppy drive quantity	Pin 1: Ground Pin 2: To ASIC2
W33	PC configur-ation switches	Switch 7 – Floppy drive quantity	Pin 1: To ASIC2 Pin 2: Ground
W34	(reserved)		
W35	U26 memory socket	Address range	Pin 1: Ground Pin 2: Memory control logic
W36	U26 memory socket	Address range	Pin 1: Ground Pin 2: Memory control logic
W37	U26 memory socket	Address range	Pin 1: Ground Pin 2: Memory control logic
W38	U26 memory socket	Address range	Pin 1: Address bit 14 (SA14) Pin 2: Pin 27 option (via pullup) Pin 3: Memory write (–MR)
W39	Floppy	Write precomp value	Pin 1: PCVAL to floppy controller (via pullup) Pin 2: Ground
W40	Floppy	Drive type	Pin 1: Ground Pin 2: DRV to floppy controller (via pullup)

Table B–20 (cont)
CPU Jumpers

JUMPER	SUBSYSTEM	FUNCTION	SIGNALS
W41	U15 memory socket	Pin 1 option	Pin 1: Address bit 14 (SA14) Pin 2: U15 pin 1 Pin 3: +5V
W42	DRAM memory	Memory size selection	Pin 1: Memory control logic Pin 2: Ground
W43	DRAM memory	Memory size selection	Pin 1: Memory control logic Pin 2: Ground
	DRAM memory	Memory size selection	Pin 1: Memory control logic Pin 2: Ground
	U26 memory socket	Pin 1 options	Pin 1: +5V Pin 2: System reset (-RESET) Pin 3: U26 pin 1 Pin 4: U26 pin 1 Pin 5: Address bit A15 Pin 6: Address bit A14
W46 B21)	Printer port	Interrupt enable	Pin 1: ASIC 2 Pin 2: PC Bus IRQ 7 (J9 pin
W47	V40 serial port	Handshake out source	Pin 1: V40 SRDY signal (pin 36) Pin 2: Handshake out (J2 pin 2)
W48	Wait state generator	Enable/disable automatic I/O wait states	Pin 1: Enable wait state Pin 2: Pin 3: Disable wait state
W49	(reserved)		Pin 1: Pin 2:

Appendix C

Appendix C

This Appendix contains information useful in programming the Video board hardware, and selecting nonstandard positions for the hardware jumpers. Most users should not need this information because the applications software is designed to use the standard factory settings.

Video Controller

The video controller supports four video protocols:

- Standard IBM PC monochrome display (IBM 5101 or MDA: 80 characters by 25 rows)
- Hercules monochrome graphics (720 by 348 pixels)
- Standard IBM PC color graphics (IBM 5153, CGA: 640 by 200 pixels 1 color, or 320 by 200 pixels, 4 color if jumper W19 isinstalled on the CPU board)
- Double scan (400 line) color graphics (2XCGA)

The monochrome and standard color graphics modes require a standard PC-compatible monochrome or CGA monitor (optional). The double-scan high resolution color graphics mode requires a monitor that can support 400 horizontal lines and scan at 25 kHz horizontally, and 57 Hz vertically. The monitors all require TTL inputs.

NOTE

The default TEKMATE startup mode is determided by the rear-panel MONITOR switch.

The startup mode is determined by the configuration of four jumpers on the edge of the CGA board and jumpers W19 and W31 on the CPU board.

NOTE

As shipped, the TEKMATE video mode is controlled by the rear-panel MONITOR switch (see Section 3).

Video Board Jumpers

At power-on reset, the video board reads a set of jumpers (on the edge of the video board) to determine its start-up mode (see Figure C-1). The jumpers select either CGA, Monochrome (MDA), Monochrome Graphics, or Double-Scan CGA modes. (Monochrome mode is selected for both MDA and Hercules modes.)

NOTE

The default TEKMATE startup mode is determided by the rear-panel MONITOR switch.

The four jumper pin pairs are labeled on the board as: "HIRES", "MONO", "COLOR", and "A14". To select a particular startup mode, these four jumper pin pairs must have shorting blocks either on or off, as indicated in Table C-1.

NOTE

The configuration jumpers, W19 and W31, on the CPU board must also be set to match the start-up mode of the Video board (see "Video Mode Jumpering" that follows).

Table C-1
Start-up Mode Configuration (J4)

Jumper Label Mode	HIRES	MONO	COLOR	A14
Monochrome	out	in	out	out
Mono Graphics	out	in	out	in
CGA	out	out	in	out
Double-scan CGA	in	out	in	out

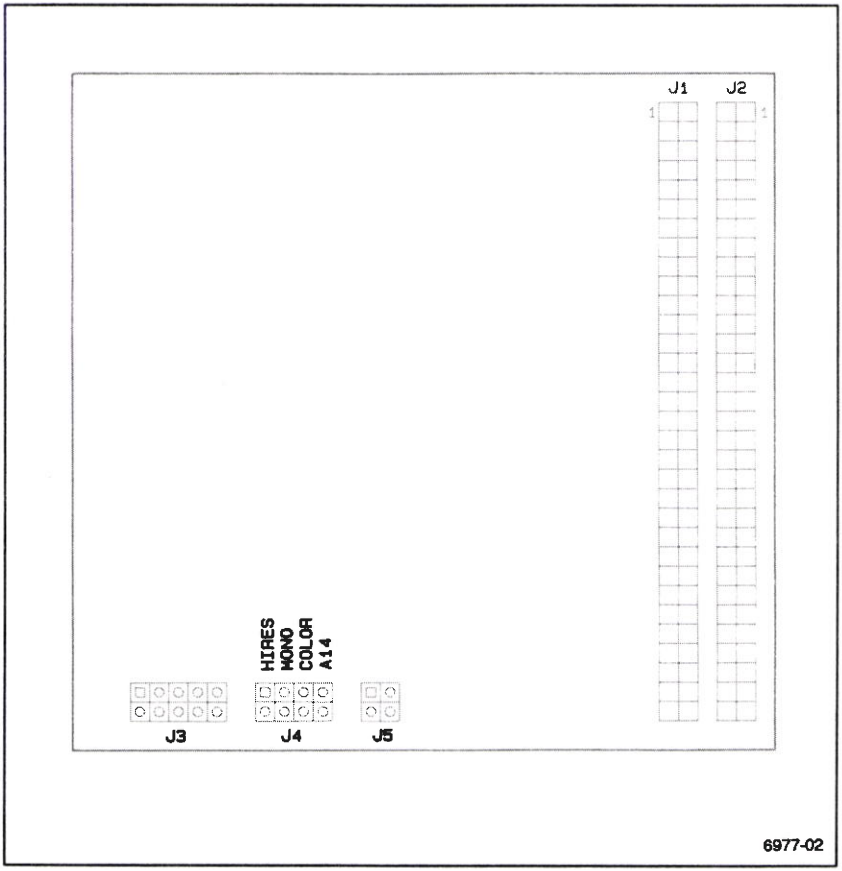


Figure C–1. Video Board jumper locations.

Video Mode Jumpering (CPU/Video Board)

No matter what type of video display controller is used, two jumper options (W19 and W31) on the CPU board must be properly configured according to the desired video mode. This is shown in Table C-2.

Table C-2
Video Display Mode Jumpering

MONITOR Switch	Video Mode	CPU Board		Video Board			
		W31	W19	HIRES	MONO	COLOR	A14
	Reserved	On	On				
CGA	640 X 200 Color Graphics	On	Off	Off	Off	On	On*
	320 X 200 Color Graphics	Off	On	Off	Off	On	Off
2XCGA	640 X 400 Color Graphics	On	Off	On	Off	On	On*
	320 X 400 Color Graphics	Off	On	On	Off	On	Off
	Monochrome (MDA, 80 X 25)	Off	Off	Off	On	Off	Off
MONO	Monochrome Graphics (80 X 25 text, 720 X 348 graphics)	Off	Off	Off	On	Off	On

*For 100% PC compatibility this jumper must be removed for this mode.

W19 and W31 correspond to switches 5 and 6 of a standard PC system board, and are used to specify the power-up default of the video display controller. The "reserved" video mode must be set when a memory configuration of 768K is to be used, as described elsewhere in this chapter. As shipped from the factory, W19 is off and W31 is on (640 X 200 color).

Video Board Architecture

The Video board is based upon the NCR 7280 single chip Color Graphics and Monochrome Adapter (CGMA) chip. The CGMA chip includes a Motorola MC6845-compatible CRT controller, dual-port DRAM control logic, 6K X 8 character generator and character generation logic, and a PC bus interface.

Its buffer memory control logic allows system access at any time without producing flicker or other distortions on the screen. Its high-resolution color display mode provides the same high definition character font as the monochrome display while retaining all the color options of the CGA mode.

Display Buffer

The display buffer consists of two 32K X 8 memory banks. The memory appears at either B0000H or B8000H in the PC address space, depending on the video mode selected. The memory organization looks exactly like its PC compatible counterparts.

The memory is organized into odd and even banks to provide "flickerless" updates by the TEKMATE. The display refresh logic reads buffer data 16 bits at a time, leaving the buffer idle for half the time. This provides an opportunity for the CPU to write bytes to the display buffer during the idle periods. Automatic synchronization logic is provided so that the programmer can read and write to the display buffer at any time without concern for video "flicker".

Only half of the 128K bytes of memory on the board is actually used. The remaining memory is inaccessible.

To match the PC standard method of addressing video memory, jumper A14 should be left off (setting address A14 to 0) for all modes except monochrome graphics (a.k.a. "Hercules"). For mono graphics, install a jumper on A14.

Video Modes

The video controller primarily supports four video modes, compatible with popular PC software and standard displays: CGA, MDA, Monochrome Graphics (Hercules) and Hi-Res (High resolution color graphics).

The following material describes the board's four video modes. For each mode, the following information is provided:

1. A list of the various display configurations (or sub-modes).
2. A description of attribute byte usage.
3. A description of display buffer usage and memory map.
4. A description of the video output signals.

CGA Mode

CGA Display Configurations

The board's CGA mode is compatible with the standard IBM PC CGA controller. It supports:

- 40 X 25 color text, 8 pages
- 80 X 25 color text, 4 pages
- 320 X 200 graphics
- 640 X 200 graphics

In text modes, characters are formed in 8 X 8 cells, containing 7 X 5 characters with one-line descenders. Each character cell can have 1 of 16 foreground colors and 1 of 16 background colors. If a master blink-mode bit is set in the Mode Selection Register, one of the background color bits is used to indicate foreground (character) blink, reducing the number of background color choices to 8.

CGA Alphanumeric Mode Attributes

The alphanumeric mode attributes are controlled as indicated in Table C-3. Note that bit 7 is either an intensity term ("I") for background colors or blink ("b") control for foreground characters, depending upon the setting of a bit in the Mode Selection Register.

Table C-3
Alphanumeric Mode Attributes

	Background	Foreground
Bit 7	6 5 4	3 2 1 0
I/b	R G B	I R G B

Key: I = Intensity bit
b = Blink bit
R = Red
G = Green
B = Blue

CGA Graphics Mode Attributes

Colors on the display are made up of combinations of I, R, G, and B signals, as shown in Table C-4.

Table C-4
Color Attributes

I	R	G	B	Color
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown/yellow
0	1	1	1	Light gray
1	0	0	0	Dark gray
1	0	0	1	Light blue
1	0	1	0	Light green
1	0	1	1	Light cyan
1	1	0	0	Light red
1	1	0	1	Light magenta
1	1	1	0	Light yellow
1	1	1	1	White

In 640 X 200 graphics mode, each byte contains information for 8 pixels. The background color is always black, and the foreground color is set to 1 of 8 possible colors via bit settings in an internal register, the Color Select Register.

In 320 X 200 graphics mode, each byte contains information for 4 pixels, 2 bits per pixel. One of 16 possible background colors is selected via four bits of the Color Select Register. The foreground color depends on two factors: a bit in the Color Select Register selects one of two pallets, and the two bits in the display buffer selects which of the four colors in the selected pallet to display. (Actually, one of the colors is the background color, so only three are visible.) This is shown in Table C-5.

Table C-5
Color Select Register Bits

Color code	Pallet 0	Pallet 1
0 0	Background Color	Background Color
0 1	Green	Cyan
1 0	Red	Magenta
1 1	Yellow	White

CGA Buffer Usage

In CGA mode, the display buffer is mapped to the PC address space at B8000H, as indicated in Tables C-6 and C-7.

Table C-6
CGA Memory Map

B8000	(Even scan lines)	B9F3F
BA000	(Odd scan lines)	BBF3F

Table C–7
CGA Screen Map

B8000	Scan line	1B809F
BA000	Scan line 2	BA09F
B80A0	Scan line 3	B813F
BA0A0	Scan line 4 etc.	BA13F

In text modes, characters are stored in a linear array with 2 bytes per character. The characters are at even addresses and the attributes are in the following odd addresses. The character set has 256 character codes. Each page requires 4000 bytes (80 X 25 X 2 bytes per character). Eight pages of text are supported.

In graphics modes, the display buffer is organized differently. Even scan lines (0, 2, 4, ... 198) use the first half of the memory and odd scan lines (1, 3, 5, ...199) use the second half of memory. For example, address B8000H is in the top left corner of the display while address BA000H displays at the top left on the next line down.

Note that a jumper is provided to connect address A14 when using the board in monochrome graphics mode. Although you can leave the jumper connected when in CGA mode, if you want complete PC compatibility, you should remove it. Removing the jumper grounds A14 into the video control logic and causes memory accesses at BC000H and up to wrap around to B8000H and up.

CGA Output signals

Table C–8 lists the video output signals in the CGA mode:

Table C–8
CGA Video Output Signals

Dot clock rate	14.31818 MHz
Video data	+R, +G, +B, +I (standard RGB)
Horizontal sync	Positive pulses at 15.75 kHz (NTSC), 64 dot clocks in duration
Horizontal blank	110 dot clocks in duration
Vertical sync	Positive pulses at 60 Hz (NTSC), 3 horizontal lines long
Monitor	Standard PC compatible RGB monitor, TTL compatible inputs

IBM Monochrome Mode (MDA)

MDA Display Configuration

The video controller's MDA mode is compatible with the standard IBM PC monochrome display adapter. It supports:

- 80 X 25 text, 4 pages

Characters are formed in 9 X 14 cells, containing 7 X 9 characters with two-line descenders.

MDA Attributes

For every character there is a corresponding attribute byte. The attribute byte determines normal video, reverse video, highlight, underline, and blink. The monochrome mode attribute bytes are shown in Table C-9.

Table C-9
Monochrome Mode Attributes

Function	Attribute Byte Bits							
	7	6	5	4	3	2	1	0
No Display	x	0	0	0	x	0	0	0
Blink	1	x	x	x	x	x	x	x
Intensity	x	x	x	x	1	x	x	x
Reverse Video	x	1	1	1	x	0	0	0
Underline	x	x	x	x	x	0	0	1
Normal Video	(all other combinations)							

MDA Buffer Usage

In monochrome mode, the display buffer is mapped to the PC address space as a linear array with 2 bytes per character, starting at B0000H. Character codes are at even addresses and the attributes for each character position are in the following odd-numbered address. The display memory wraps around after address B4000H so that a memory access to B4000H retrieves the character stored in B0000H (and so on). This follows the PC standard.

MDA Output Signals

Table C–10 lists the output signals for MDA mode.

Table C–10
MDA Video Output Signals

Dot clock rate	16.257 MHz
Video data	R, G set at TTL high, +G, +I both carry the video signal. (This allows use of the same cable for both color and mono outputs.)
Horizontal Sync	Positive pulses at 18.4 kHz, 64 dot clocks in duration.
Horizontal blank	110 dot clocks in duration.
Vertical Sync	Negative pulses at 50 Hz (PC compatible, requires long persistence phosphor screen (P39). 3 horizontal lines in duration.
Monitor	Standard PC compatible monochrome monitor.

Monochrome Graphics Mode (Hercules)

Monochrome Graphics Display Configuration

The board's monochrome graphics display mode is compatible with the Hercules monochrome graphics controller. It supports:

- 80 X 25 text, 4 pages
- 720 X 348 monochrome graphics, 2 pages

Each byte contains 8 pixels, which can be on or off. There are 90 bytes per line for 720 pixel horizontal resolution, 348 lines per page. Two pages are provided, selectable by a bit in the Mode Selection Register.

Monochrome Graphics Attributes

There is no attribute definition for monochrome graphics. All visual features are programmed explicitly.

Monochrome Graphics Buffer Usage

In monochrome graphics mode, the display buffer is mapped to the TEKMATE's address space at B0000H to BFFFFH. Page 0 starts at B0000H and page 1 starts at B8000H.

NOTE

Jumper A14 must be installed when operating in monochrome graphics mode.

The display buffer is not arranged as a simple linear array. Instead, scan lines are interleaved, and each page is divided into four segments as shown in Table C-11.

Table C-11
Mono Graphics Memory Array

Scan Line	Segment Offset
0, 4, 8	x000
1, 5, 9	x200
2, 6, 10	x400
3, 7, 11	x600

To calculate the position (offset from the page segment) of any pixel, P(x, y), use the following formula:

Offset = (2000H * (y MOD 4)) + (90 * INT(y/4)) + (INT(x/8))

Monochrome Graphics Output Signals

Same as monochrome (see above).

Double Scan CGA Mode

Double Scan CGA Display Configuration

The video controller's double scan CGA mode is software compatible with the standard IBM PC CGA controller, but provides double the vertical resolution. It supports:

- 40 X 25 text, 8 pages
- 80 X 25 text, 4 pages
- 320 X 400 graphics
- 640 X 400 graphics

Characters are formed in 8 X 16 cells, containing 7 X 9 characters with two-line descenders. This is the same font as the one used in the monochrome text mode.

Graphics modes are the same as CGA modes, except identical graphics information is output in pairs of lines. This provides a very high-definition color display.

Hi-Res mode does not support border colors; the border is always black.

Double Scan CGA Attributes

Attributes in this mode are the same as in CGA mode (described above).

Double Scan CGA Buffer Usage

Buffer usage in double-scan CGA mode is the same as that in CGA mode (described above).

Double Scan CGA Output Signals

Table C-12 lists the video output signals for double scan CGA mode.

Table C-12
Double Scan CGA Video Output Signals

Dot clock rate	20 MHz.
Video data	Same as CGA mode.
Horizontal Sync	Positive pulses at 25 kHz, 64 dot clocks in duration.
Horizontal blank	110 dot clocks in duration.
Vertical Sync	Positive pulses at 57 Hz, 3 horizontal lines duration.
Monitor specs	Monitor must be capable of 25 kHz horizontal scan rate and 57 Hz vertical rate. Multi-sync-type monitors work well. Must be capable of supporting 400 horizontal lines.

Compatibility

The TEKMATE's video controller is software compatible with standard PC video controllers:

- When in CGA and Hi-Res modes, it is programmable as a CGA adapter.
- When in monochrome text modes, it is programmable as an MDA adapter.
- When it is in monochrome graphics mode, it is programmable as a Hercules monochrome graphics adapter.

Since the VLSI chip is compatible with the popular MC6845 video controller, other modes are possible. The MC6845 allows the creative programmer to vary many of the standard video parameters.

Programmable Registers

Extended Control Register

The Extended Control Register is an 8-bit read/write register residing at I/O address 35AH. The bit pattern in this register determines the display mode and is used by the software to detect the current mode.

The bits in the Extended Control Register, shown in Table C-13, are read/write unless otherwise specified.

Table C-13

Extended Control Register Bit Description

Bit	Description
0	Text size 0 = 8 x 8 (CGA) 1 = 8 x 16 (Monochrome and Hi-Res)
1	Line doubler 0 = Single line (CGA) 1 = Double line (Monochrome and Hi-Res)
2	Mapper 0 = No map 1 = Mapper enabled (Required for Hi-Res to emulate CGA. Translates parameters sent to the MC6845-style CRT controller so that normal parameters for CGA are changed to parameters for Hi-Res operation.)
3	Monochrome 0 = Color 1 = Monochrome Used to set operational differences between color and monochrome. If software is used to set this bit, Bit 0 and Bit 1 must also be set by software. Bit 3 controls the following: A. Changes PC I/O interface from 3Dx to 3Bx. B. Changes buffer address from B8000H to B0000H. C. Changes Light Pen address from 3DC to 3B9. D. Changes the basic timing from 8 clocks per character to 9 clocks per character (text). E. Enables reverse video and underline attributes for text mode and inverts the Vertical Sync signal. F. Automatically sets the 40/80 bit in register 3B8 to 80 for text operations. G. Changes memory mapping in graphics operations. H. Disables the Red and Blue video outputs (holds them low) and outputs no video on the Green channel. Automatically sets bit 4 at 3B8 for 640 graphics.
4	Video System Disable 0 = Enabled 1 = Disabled This bit sets the video output signals to a high-impedance state and prevents the board from responding to I/O or memory reads or writes .
5	Reserved. Always 0 when read.
6	Read only. Shows mode jumper setting.
7	Read only. Shows mode jumper setting.

MC6845 Compatible Register Set

In addition to the Extended Control Register, the video controller has a set of MC6845-compatible registers to control video parameters. Tables C-14 and C-15 show the registers that are used to control the operation of the 6845 portion. Only the register names are given. The exact bit patterns and detailed explanations of the register functions are not given. For complete programming details, refer to a Motorola MC6845 CRT controller data sheet.

Table C-14
Monochrome Mode I/O Addresses

Register Name	I/O Adrs	Read/Write
Index Register	3B4	Write
Data Register	3B5	Read/Write
Display Mode Control	3B8	Write
Set Light Pen	3B9	Write
Display Status	3BA	Read
Reset Light Pen	3BB	Write

Table C-15
Color Mode I/O Addresses

Register Name	I/O Adrs	Read/Write
Mode Selection Register	3D8	Write only
Color Select Register	3D9	Write only
Status Register	3DA	Read only
Clear Light Pen	3DB	Write only
Set Light Pen	3DC	Write only
Memory Mode Register	3BF	Write only

MC6845 Register Initialization

Table C-16 shows the normal register programming bytes sent to the CRT controller for the various modes. The Hi-Res section is for reference only and indicates the codes substituted for the color codes by the mapper circuit.

All values are in hexadecimal.

Table C-16
Internal Register Initial Values

Register	MONO		CGA			HI-RES COLOR		
	Text	Graph	Text		Graph	Text		Graph
			40	80		40	80	
R0	61	35	38	71	38	31	63	31
R1	50	2D	28	50	28	28	50	28
R2	52	2E	2D	5A	2D	28	50	28
R3	0F	07	0A	0A	0A	04	0	04
R4	19	5B	1F	1F	7F	1A	1A	6B
R5	06	02	06	06	06	06	06	06
R6	19	57	19	19	64	19	19	64
R7	19	57	1C	1C	70	1A	1A	67
R8	02	0	0	02	02	02	02	02
R9	0D	3	07	07	01	0F	0F	03
R10	0B	00	06	06	06	0C*	0C*	0C*
R11	0C	00	07	07	07	0F*	0F*	0F*

* R10 = Old value X 2
R11 = Old value X 2 + 1

Appendix D

Appendix D

GPIB

The 2402 TEKMATE contains a GPIB (IEEE-488) interface. This hardware allows the TEKMATE to be used as a GPIB controller. This Appendix contains information useful in programming the GPIB hardware, and selecting nonstandard positions for the hardware switches and jumpers. Most users should not need this information because the applications software is designed to use the standard factory settings.

GPIB Subsets

The GPIB interface has been designed to the IEEE 488-1975/78 Standard with the 488A-1980 supplement. Implemented subsets are as shown in Table D-1.

Data rates for programmed I/O are up to 20K bytes per second. The DMA data rate is typically 300K bytes per second.

The maximum number of devices that can be connected to the bus is 14. Maximum cable length is 20 meters (15 meters cable length is recommended at one load per meter) or 2 meters times the number of devices, whichever is less.

Table D–1
GPIB Subsets

IEEE Code	Description
C1–5	Complete controller capability: System controller Send REN Send interface messages Send IFC and take control Receive control Pass control Take control synchronously or asynchronously Respond to service request Parallel poll
T5	Complete Talker capability: Basic Talker Serial poll Talk only mode Unaddressed on MLA Send END or EOS Dual Primary Addressing
TE5	Complete extended talker capability: Basic extended talker Serial poll Talk only mode Send END or EOS Unaddressed on MSA and TPAS
L3	Complete Listener capability: Basic Extended talker Serial poll Talk only mode Unaddressed on MTA Detect END or EOS Dual primary addressing
LE3	Complete extended listener capability: Basic Listener Listen only mode Detect END or EOS Unaddressed on MSA and LPAS
AH1 DC1 DT1 PP1, PP2 RL1 SH1 SR1 E1, 2	Complete Accepter Handshake capability. Complete Device Clear capability. Complete Device Trigger capability. Complete Parallel Poll capability. Complete Remote/Local capability. Complete Source Handshake capability. Complete Service Request capability. Three-state bus drivers (E2) with automatic switch to open collector (E1) during parallel polls.

GPIB Functional Description

Figure D–1 shows a block diagram of the GPIB interface card. The interface consists of these major sections:

- Address Decoding
- Buffering and Data Routing
- Interrupt Arbitration
- DMA Arbitration
- Configuration Switches and Jumpers
- GPIB–Adapter–TLC (talker/listener/controller)
- Clock (not used)

The GPIB software must manipulate the GPIB interface card by reading and writing to the I/O port addresses corresponding to the GPIB ADAPTER registers.

ADDRESS DECODING—monitors the address lines to recognize when the GPIB I/O address is present on the I/O channel and enables read and write access to the GPIB ADAPTER.

BUFFERING AND DATA ROUTING—handles data transfer between the I/O channel and the GPIB ADAPTER through a bidirectional internal data bus.

INTERRUPT ARBITRATION—recognizes when interrupts have been enabled or disabled and passes or inhibits them accordingly.

DMA ARBITRATION—recognizes when DMA operations are enabled or disabled, and when the last transfer has taken place. It also routes the DMA request and acknowledge signals to the selected DMA channels.

CONFIGURATION SWITCHES AND JUMPERS—determine the I/O port address, the DMA channel pair used, and the interrupt request line used.

μPD7210 GPIB ADAPTER—implements virtually all of the IEEE-488 interface functions to interact with other devices on the GPIB. Within the GPIB ADAPTER are 21 program registers that are used to configure, control, and monitor the interface functions and to pass commands and data to and from the GPIB. Special-purpose, multi-function transceivers (not shown in the diagram) interface the GPIB ADAPTER to the GPIB.

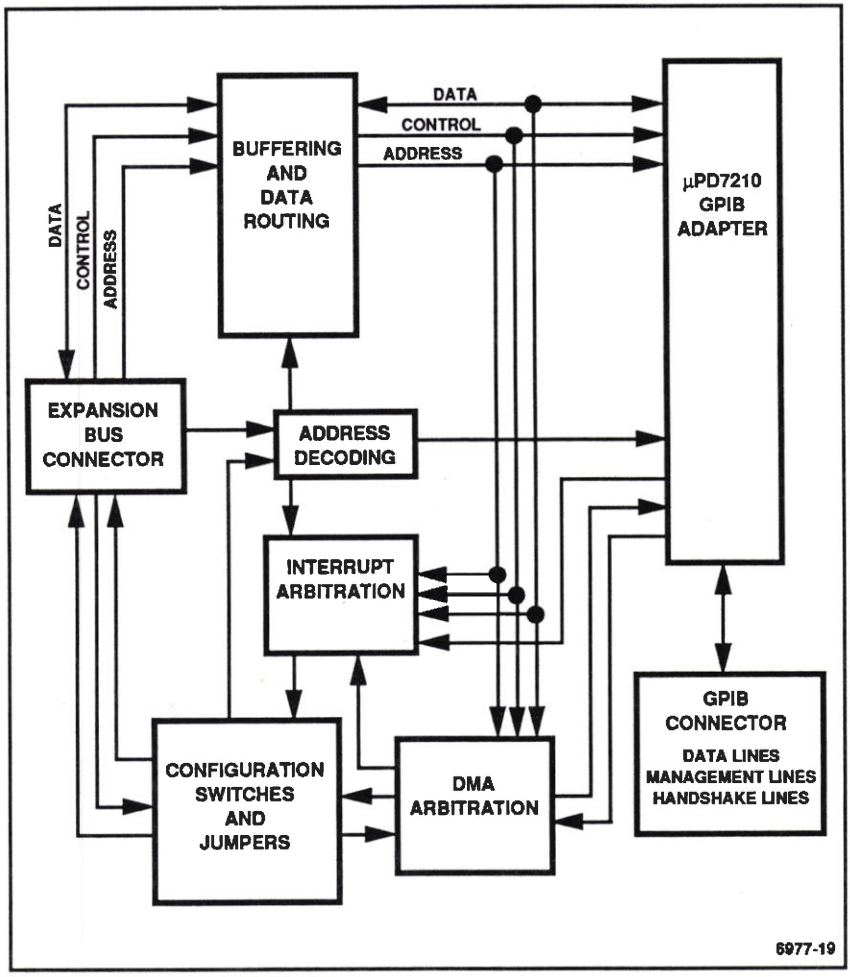


Figure D-1. GPIB block diagram.

GPIB Board Jumper Modifications

This part describes the modification of the GPIB hardware in your TEKMATE, using the board jumpers and switches.

GPIB Configuration

The DMA channel used by the GPIB interface can be either channel 1, 2, 3, or none. The interrupt used can be either interrupt 2, 3, 4, 5, 6, 7, or none. Defaults selected at the factory are DMA channel 1 and interrupt none.

Preparation

Before modifying the GPIB configuration, consider the following:

1. The number of DMA channels on the TEKMATE is limited. Seldom, if ever, can two or more devices share channels. Be sure that no other device is already using the channel you select. This also applies to IRQ levels.

2. The GPIB uses an I/O addressing scheme with which you may not be familiar. Traditionally, the lower address bits access hardware registers on the board and the higher address bits select a block of consecutive addresses. The GPIB board, on the other hand, uses the scheme shown in Table D-2:

Table D-2

Address Lines

A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
C	B	B	R	R	R	1	1	1	1	0	0	0	0	0	1

where B is a user selectable base address bit; R is a register address bit decoded by the hardware; C is a chip select bit also decoded by the hardware; and address bits A9 through A0 are fixed.

Thus, the base addresses (R-C-0) for the GPIB interface registers are hex 02E1, 22E1, 42E1, or 62E1, but the registers are not at consecutive address locations. A complete address map for each base address is shown in Figure D-4.

3. Even though your GPIB interface does not have the clock, the clock address space cannot be used by another device.

4. The hex address block 02F0-02F7h is reserved for a special interrupt handling feature of the GPIB interface.

Switch and jumper settings

The jumpers and switches on the board should be in the default positions described in Table D–3 and shown in Figure D–2. If the settings do not correspond, set them to the default positions listed. Figure D–3 shows the location of the switches and jumpers on the GPIB board.

If your TEKMATE contains cards such as networking cards and others that may use DMA and IRQ channels, you must consult the manuals for these cards. Identify channel numbers conflicting with the GPIB channels and either change the other cards' channel(s) or the GPIB channel(s) to resolve conflicts.

Table D–3
GPIB Interface Default Settings

Interface Card	Factory Default	New Value	Optional
Base I/O Address (hex)	02E1		22E1, 42E1, 62E1
DMA Channel	1		2, 3, None (not used)
Interrupt Line for GPIB TLC (talker/listener/controller)	I7		I2, I3, I4, I5, I6, None (not used)
Interrupt Line for Clock	not used		I2, I3, I4, I5, I6, I7

NOTE

If your system configuration requires settings other than the default settings, read all of this appendix before installing the changes.

If your system requires settings other than the default settings, record your settings in the "new value" column of Table D–3 for later use.

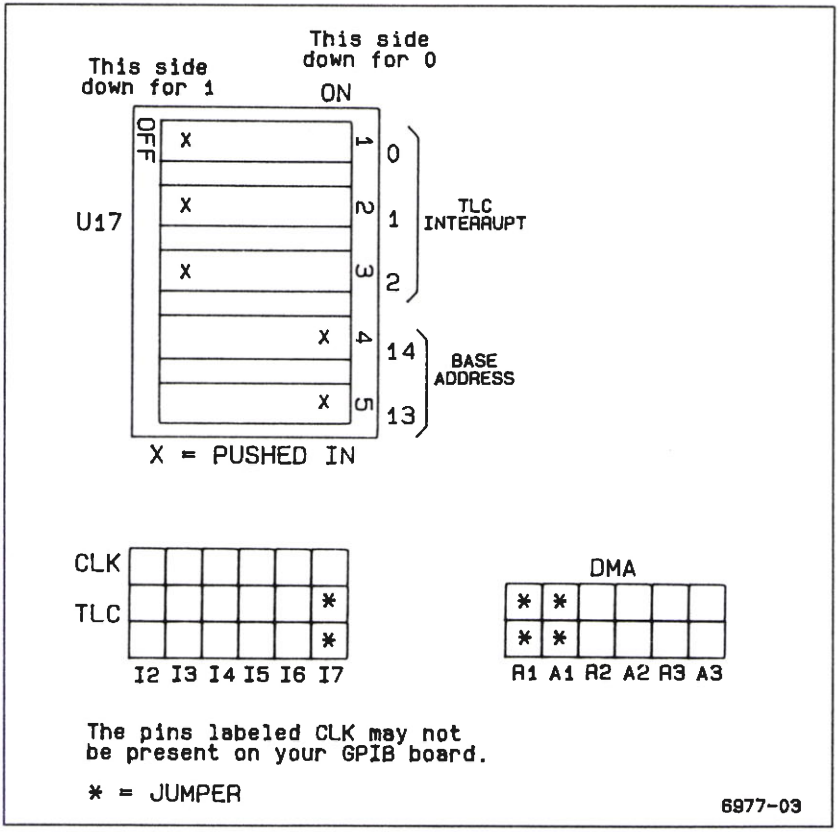


Figure D–2. GPIB board default I/O base address and jumper settings.

Changing the Base I/O Address

The GPIB interface card is programmed by the TEKMATE by reading/writing non-consecutive addresses on the I/O channel. Eight of these locations are used to program the GPIB TLC integrated circuit (IC) and others are used for the clock. Two switches on the 5-position switch module at U17 establish the base addresses and the following addresses. Figure D-4 shows the address map for each base address.

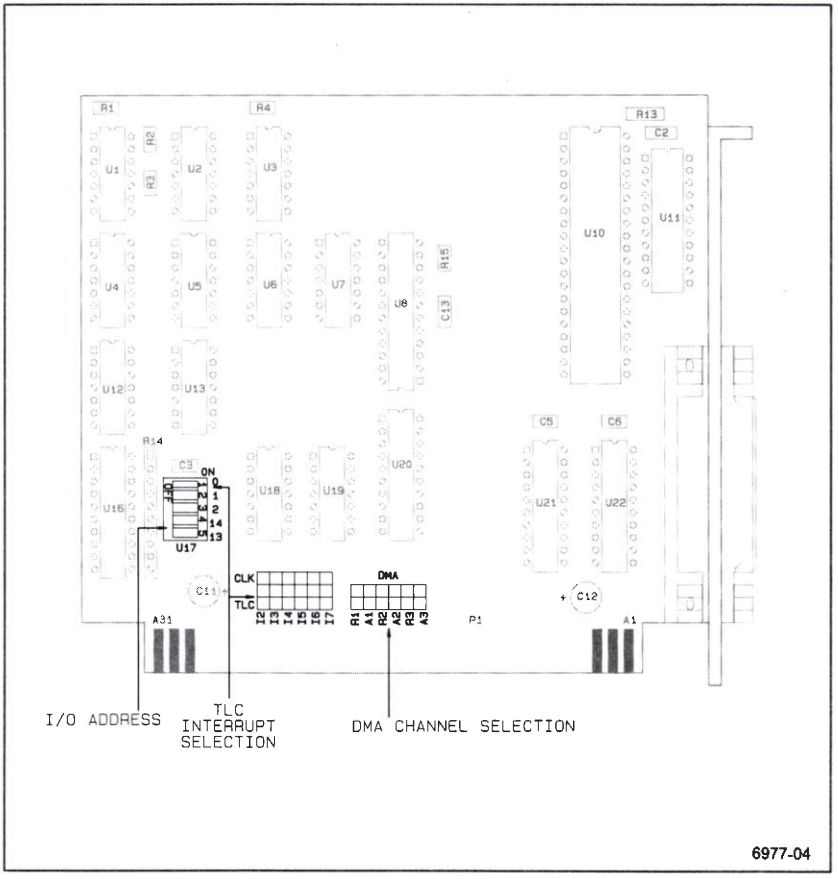


Figure D-3. GPIB jumper locator diagram.

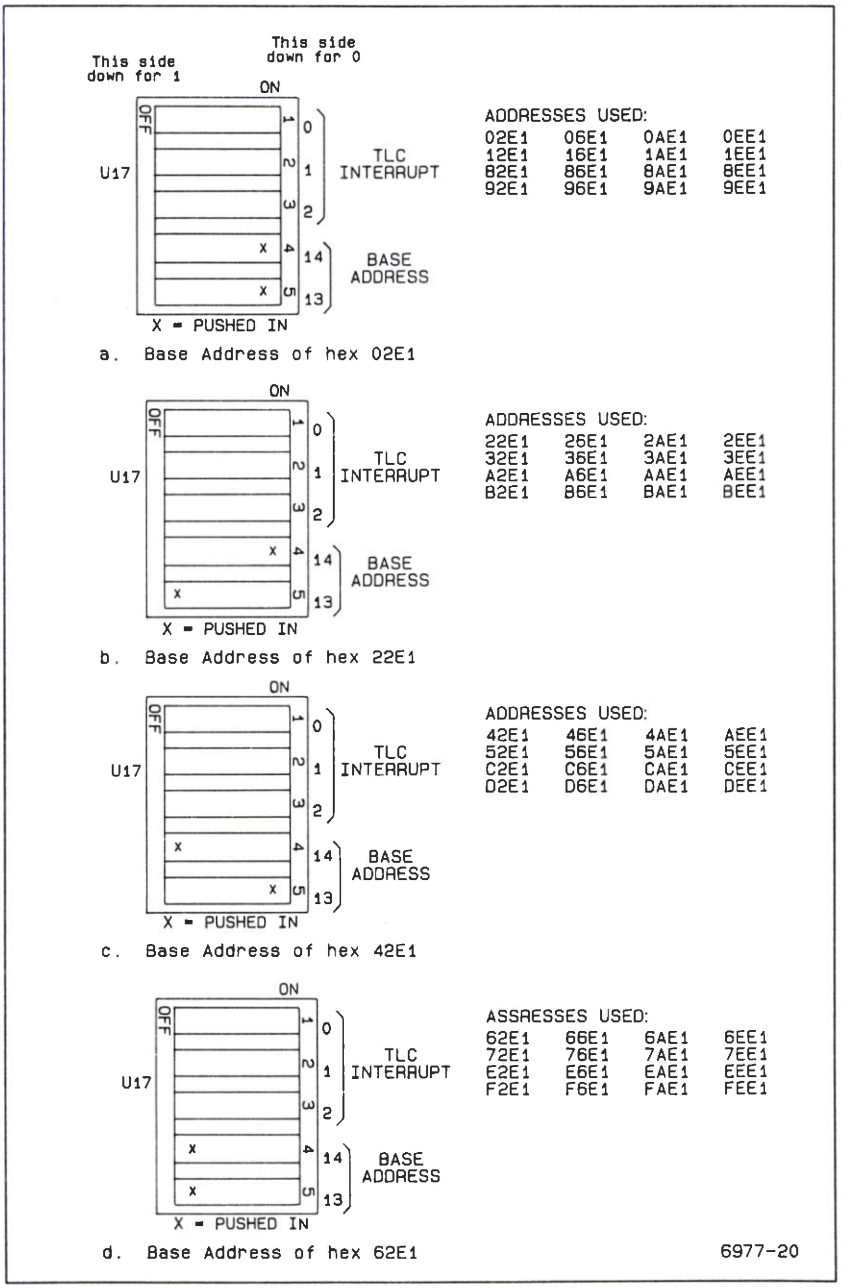


Figure D–4. Base I/O address options.

Changing the DMA Channel

Six sets of dual square pins at the bottom center of the GPIB board are used to select the DMA channel used by the TLC to access TEKMATE memory directly. Figure D–5 shows the four allowable jumper configurations.

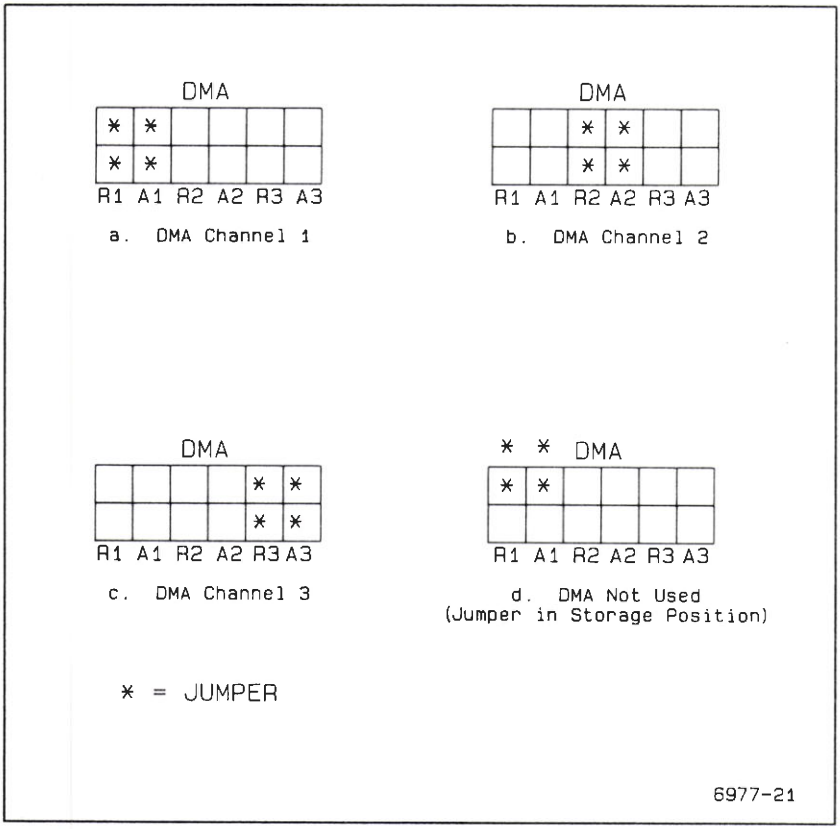


Figure D–5. DMA channel options.

Changing the TLC Interrupt

A set of jumpers and a set of switches must both be changed whenever the interrupt for the TLC is altered. Figures D–6a and D–6b show all seven of the allowable configurations.

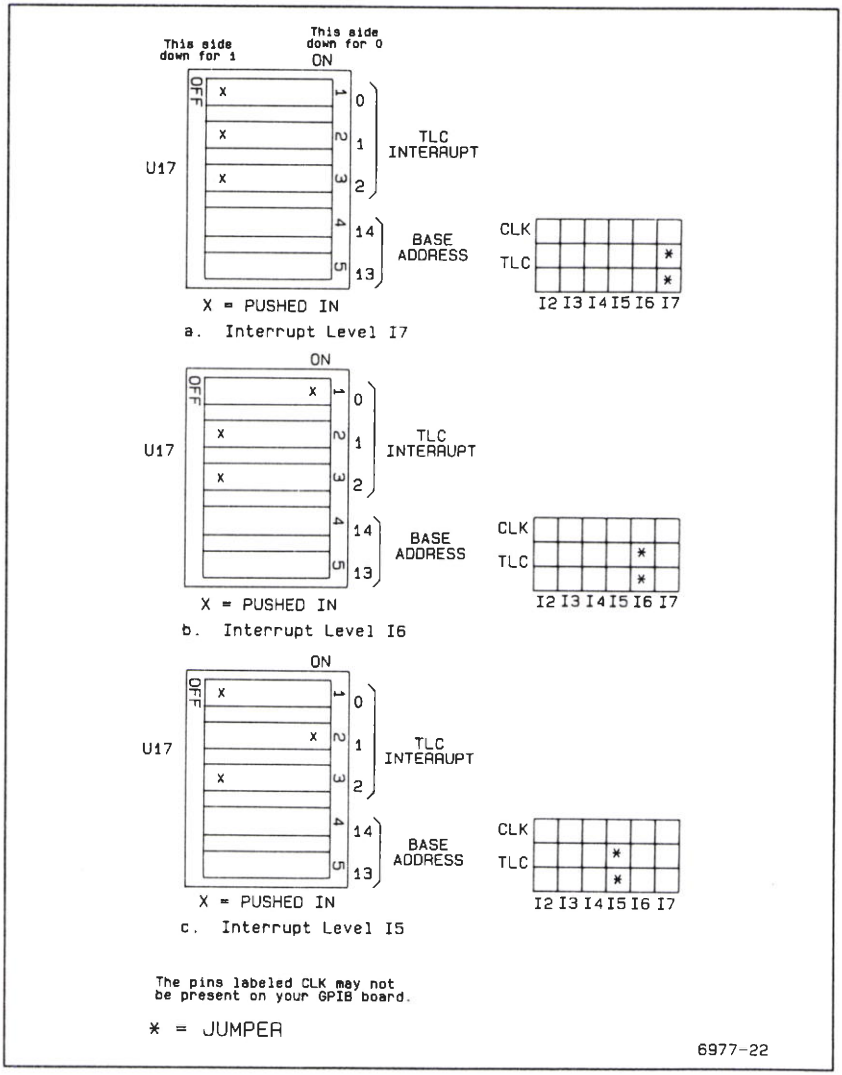


Figure D–6a. TLC interrupt options.

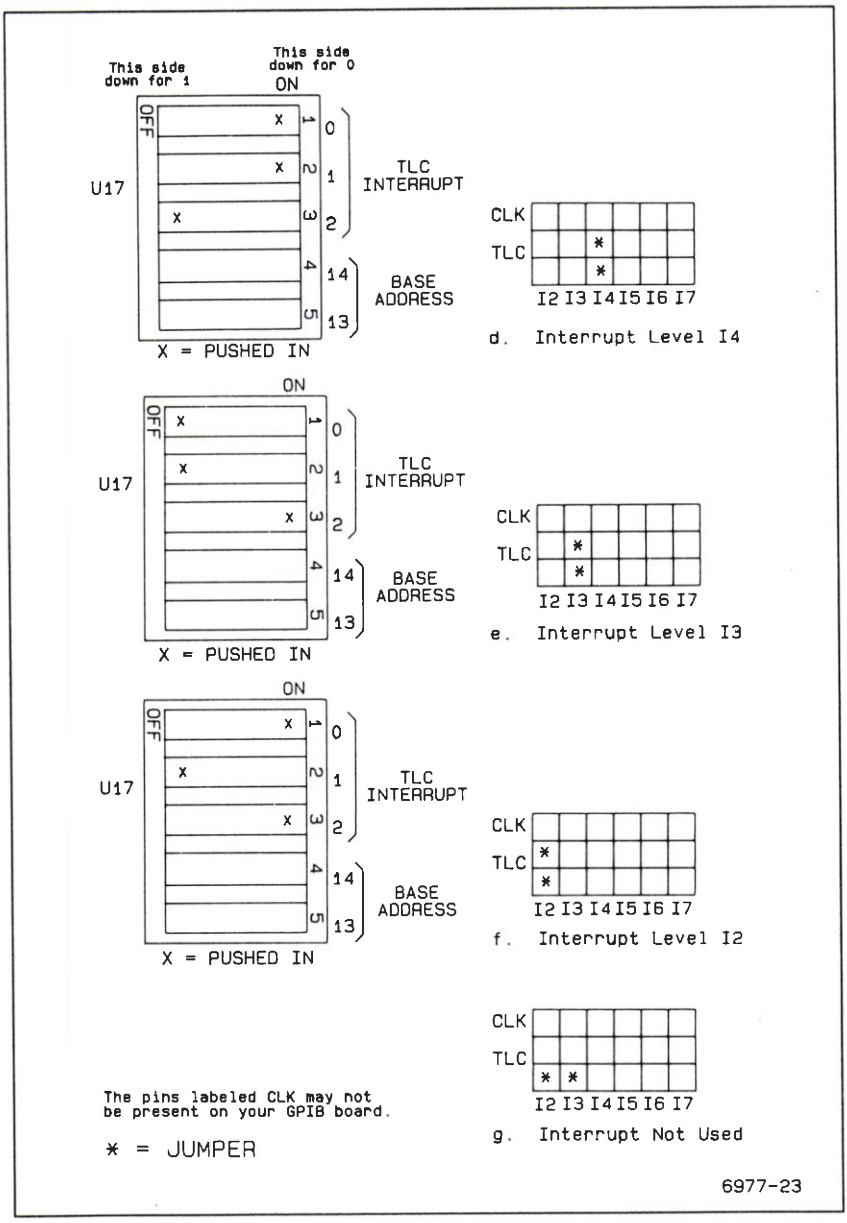


Figure D–6b. TLC interrupt options.

Appendix E

Appendix E

ROM Based Operation of the 2402

Introduction

The features of the 2402 TEKMATE make it suited for use in harsh operating environments. In such applications the use of magnetic media such as floppy disk drives to hold the operating system and application programs is often unacceptable. Instead, it may be necessary in these cases to substitute semiconductor memory (EPROM and/or nonvolatile RAM) for the disk drives normally required to boot and run the system.

If your application does not require the services of DOS, and if the use of floppy disk drives for data storage or loading is also not required, you can use the CPU board's two spare byte-wide memory sockets to load your application program directly. This is done by a "BIOS Extension," which automatically executes upon system power-up or reset.

The remainder of this Appendix provides the information a programmer needs to produce a BIOS Extension capable of automatic power-up execution without the use of DOS.

How a BIOS Extension Works

As mentioned above, the ROM-BIOS contains a mechanism for loading programs directly from EPROM prior to booting DOS. These programs are called "BIOS Extensions," and can be contained in one or both of the CPU board's two spare byte-wide memory sockets (U15 and U26).

Following system power-up or reset, the ROM-BIOS initializes the TEKMATE's hardware and performs power-up diagnostics. Following the power-up diagnostics, the ROM-BIOS scans upper memory to find any BIOS Extensions that may exist. This is the point at which the BIOS Extension can gain control.

Because a BIOS Extension executes before DOS is loaded, it cannot use DOS services, nor can it depend on any device driver specified in a CONFIG.SYS file or resident programs that might be loaded by an AUTOEXEC.BAT. All ROM-BIOS services, however, are available. These should be adequate for most applications.

Structure

The BIOS Extension has a well-defined structure. It begins with a three-byte header which consists of a two-byte ID pattern (55h, AAh) followed by a SIZE byte. The SIZE byte indicates the number of 512 byte blocks to be included in the checksum calculation.

When the ROM-BIOS locates a properly formatted BIOS Extension, it makes a FAR CALL to the fourth byte in the BIOS Extension (address 0003 in the EPROM). This is the entry point of the EPROM. The remainder of the BIOS Extension contains the program itself. (One additional constraint is that the checksum of the blocks referenced by the SIZE byte must be zero, as described below.)

Location

When the ROM-BIOS scans system memory for BIOS Extensions, it begins at address C8000h and checks for the 55AAh header on every 2K boundary up to address F4000h. If a BIOS Extension header is not found within that region of memory, the ROM-BIOS proceeds with the normal system boot sequence. Consequently, if a properly formatted BIOS Extension is present on a 2K boundary between C8000h and F4000h in memory, it can take control of the system before any attempt to boot DOS is made.

Checksum

Prior to transferring control to a BIOS Extension, the ROM-BIOS performs a checksum calculation on the number of blocks of the BIOS Extension indicated by the SIZE byte, and verifies that the result is zero. The checksum process consists of a simple additive sum (modulo 100 hex), beginning with the "55AA" ID bytes and including all other locations in memory defined by the SIZE byte. If the result is non-zero, a checksum error message is displayed, the BIOS Extension is ignored, and the boot sequence continues. Consequently, when creating a BIOS Extension, you must calculate the checksum of the memory image and then alter a byte value in the program to cause the checksum calculation to become zero.

RAM Usage

The ROM-BIOS itself uses RAM from 00000 to 00500h. Your BIOS Extension can use any RAM above this, up to the limit of the available memory in the system. It is recommended that you begin your program's data areas at 00600h, to allow for future BIOS RAM area expansion. The ROM-BIOS provides a routine for determining the amount of RAM available in the system. Executing an INT 12H will return the available memory size, in Kbytes, in register AX.

The following example shows how to set up an assembly language program as a BIOS Extension.

```
;======================================
;  This initialization code is for a "tiny model," with code, data
;  and stack in the same segment.
;======================================

BIOS_END   equu      00600h               ; end of RAM used by BIOS

DGROUP     GROUP PROG
PROG       SEGMENT BYTE PUBLIC 'PROG'
           ASSUME    CS:PROG,   DS:PROG
page
;======================================
;  Initialize the run time code
;
;  Places stack in RAM, all else is in ROM

Init       PROC    FAR
           db      055h,    0aah           ; ID pattern
Blocks     db      1                       ; # of 512 blocks code & data;
;
; Entry point:
;
Entry:
           int     012h                    ;  get number of Kbytes in AX
           mov     cl,  6                  ;  divide by 64
           shl     ax,  cl                 ;     to get paragraph address
           sub     ax, 01000h              ;  64 Kbytes for stack
           mov     bx,  ss                 ;  get callers FAR  return]
           mov     cx,  sp                 ;     address
           mov     ss,  ax                 ;  now setup
           mov     sp, 0ffffh              ;     the real stack
           push    cx                      ;  save the callers return
           push    bx                      ;     address on my stack
;
;          call    MainCode                ;  execute your program
```

```
;
;If your program exits (via a FAR return), control is given back
;   to the BIOS.
;
                pop     bx                      ;   get the BIOS
                pop     cx                      ;       stack back
                mov     ss, bx                  ;   restore
                mov     sp, cx                  ;       them
                ret                             ;   & ret to BIOS & boot
Init            ENDP
;
;MainCode is a simple sample program.  It signs on and returns.
;
MainCode        PROC    NEAR
                lea     si, Message             ;   point to the message
MainCodeLoop:
                cld                             ;   insure forward direction
                lodsb                           ;       get the next chacter
                or      al, al                  ;       is it the end?
                jz      MainCodeExit            ;           YES, exit
                mov     ah, 14                  ;           NO, get TTY output parm
                mov     bl, 7                   ;               screen attribute
                int     010h                    ;               output the character
                jmp     SHORT MainCodeLoop      ;           & loop for more
MainCodeExit:
                ret                             ;   return to BIOS

Message         db      'Main Code', 13, 10, 0  ;   signon message

MainCode        ENDP

PROG            ENDS
                END
```

Appendix F

Appendix F

Using the RS-232-C

The RS-232-C interface has long been used as a communications interface for terminals, modems, and printers. However, with the recent development of measurement instruments which use the RS-232-C interface, it has also found use as an instrumentation interface. This appendix provides information to help you better understand and use this interface (COM 1 and COM 4) in your TEKMATE applications.

What is the RS-232-C?

The acronym RS-232-C is used to describe communication interfaces on many types of equipment. But if you examine these interfaces closely, you will notice that they vary in their implementation (sometimes quite widely).

The RS-232-C standard was established by the Electronic Industries Association (EIA) to provide a common basis of communication between instruments. However, the RS-232-C standard is a "recommended standard" which, unlike some other standards, may not be rigidly followed in all aspects of a particular implementation. Various instruments use subsets and variations of the standard because of differing interpretations, cost considerations or available technology. This can lead to some confusion when supposedly compatible instruments won't talk to each other. It also demands that the user have an understanding of the interface in order to successfully implement a system based upon the RS-232-C.

Basically, adherence to the RS-232-C standard ensures three things:

1. That control and signal levels will be compatible.

2. That interface connectors of the same type may be plugged together (mated) with identical pin wiring and corresponding connections.

3. That control information supplied by one device will be understood by the other device.

The Connector

The RS-232-C standard defines the pin assignments for use with a 25-pin connector. Though the specific type of connector is not defined, industry has settled on a 25-pin D-shell connector as shown in Figure F-1.

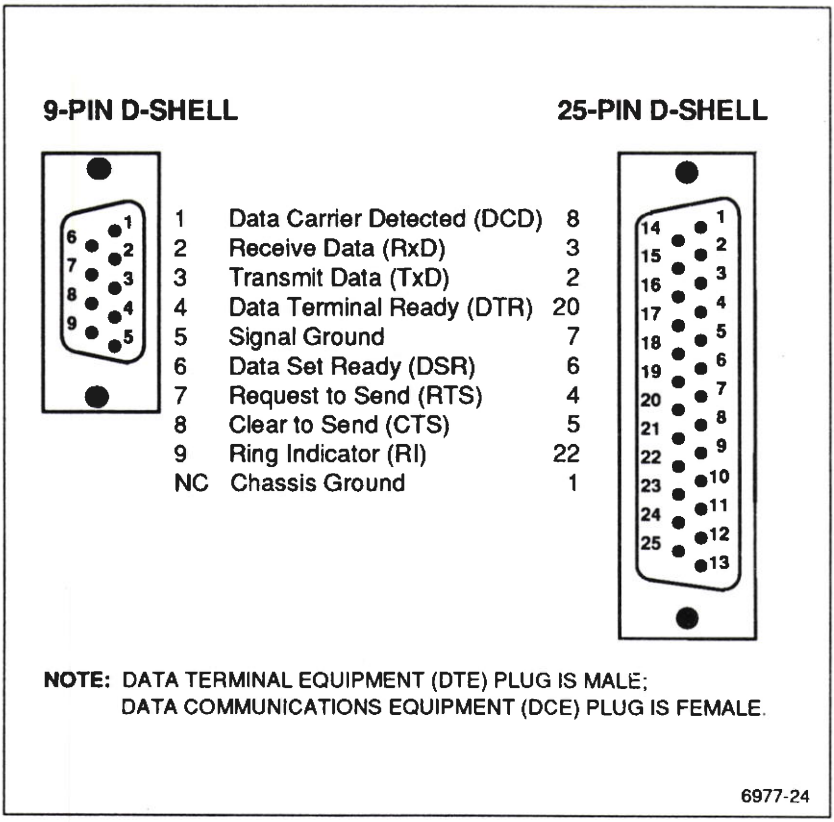


Figure F-1. Detail of the RS-232-C connector with commonly used lines identified. Left, 9-pin D-shell; Right, 25-pin D-shell connector.

Some recent implementations (including the TEKMATE) of the RS-232-C interface use a 9-pin D-shell connector which is rapidly becoming a defacto standard. Reasons for this vary, but one prime motivator is that only a few of the 25 pins are actually used in most implementations, and the 9-pin connector is adequate. In addition, space is often a consideration in most equipment designs, and the 9-pin connector requires less mounting space. Since the 9-pin connector is found on many RS-232-C instruments, Figure F-1 also identifies the pins and functions in a 9-pin connector.

Table F-1 lists the commonly used RS-232-C signals and describes their function. This should simplify the basic problem of connecting two instruments together but, unfortunately, it's not that simple.

If you are trying to interface equipment that use differing physical connectors, your first task is to get the connectors mated with the signals properly routed. The information in Figure F-1 and Table F-1 should help in the construction of an adaptor cable. These cables are also available from electronic supply houses or computer supply stores for the most common combinations. In addition, adaptor cables are often available from the manufacturer of equipment that uses a non-standard connector.

Table F–1
Commonly Used RS–232–C Signals

Signal Name	Mnemonic	Pin Number for 9–Pin Connector	Pin Number for 25–Pin Connector	Use
Data Carrier Detected	DCD	1	8	Activated by the DCE to tell the DTE that the modem has made contact with the modem on the far end and can sense the carrier.
Received Data	RxD	2	3	Incoming data path from the DTE point of view.
Transmitted Data	TxD	3	2	Outgoing data path from the DTE point of view.
Data Terminal Ready	DTR	4	20	Activated by the DTE to tell the DCE that the DTE is operational.
Signal Ground	None	5	7	Return path for all other signals on the bus.
Data Set Ready	DSR	6	6	Activated by the DCE to tell the DTE that the DCE is operational.
Request To Send	RTS	7	4	Activated by the DTE to tell the DCE that it is ready to receive data.
Clear To Send	CTS	8	5	Activated by the DCE to tell the DTE that it is ready to receive data.
Ring Indicator	RI	9	22	Indicates that the modem detects a ring signal on the phone line.
Protective Ground	None	NC	1	Connection to the metal chassis.

NOTE: DTE = Data Terminal Equipment; DCE = Data Communication Equipment.

Matching the Signals

In its most basic form, the RS-232-C interface consists of three wires – two wires used for signals, and a ground wire. Since the RS-232-C interface is intended to pass data between two pieces of equipment, the designers of the interface chose to give each piece of equipment a data output line and a data input line.

By connecting the output line of the first instrument to the input line of the second, the first can talk to the second. Or, to say it differently, the second can listen to the first. By connecting the output of the second to the input of the first, we also have a path for communication in the other direction.

In addition, four other lines are used to control the flow of data. These are called "handshake" lines and, like the data lines, are used in complementary pairs.

There are two types of RS-232-C equipment: Data Terminal Equipment (DTE), such as computers, terminals, and the TEKMATE; and Data Communication Equipment (DCE), such as modems. Both types of devices have the same basic functionality (i.e., talking, listening, and handshaking). The difference is how the logical functions are matched up to the signal names. For example, the line called TxD is the Transmitted Data from the DTE device, which goes into the DCE device's (logical) receive data input (shown in Figure F-3 and discussed in detail later). Though still called TxD at the DCE end, the logical function for the DCE device is that of receiving data. To say it another way, signal lines are named with respect to the DTE function, and DCE functions complement the signal name. (Some people prefer to deviate from the standard and relabel the DCE device connector pins according to their DCE functions. See Table F-2.)

Table F-2
DTE/DCE Device Signal Functions

25-Pin DTE	25-Pin DCE	Logical Function	9-Pin DTE	9-Pin DCE
8	8	DCD	1	1
2	3	RxD	2	3
3	2	TxD	3	2
6	20	DTR	4	6
7	7	GND (signal)	5	5
20	6	DSR	6	4
5	4	RTS	7	8
4	5	CTS	8	7
22	22	RI	9	9
1	1	Protective Ground		

Since a typical use of the RS-232-C interface is an instrument at a remote site (DTE) talking to an instrument controller (DTE) over phone lines by means of modems (DCE) (i.e., two DTE devices talking to each other by means of two DCE devices), the following handshaking discussion revolves around what the two DTE devices see during the session. While we need to remember that the DCE devices (modems) are in the system, they can be thought of as simply knowing how to properly handshake with DTE devices and how to put the DTE data onto the phone lines and get it back off in a format that the DTE devices understand.

This modem-to-modem connection can be simulated on the test bench using what is called a "null-modem cable." This is where we will start our handshaking discussion. Figure F-2 illustrates the signal-line swapping that occurs inside the null-modem cable to allow the two DTE devices to be directly connected. The end result is similar to having the DTE devices connected by means of modems with the handshaking lines thrown in (compare with the lines/connections shown in Figure F-3).

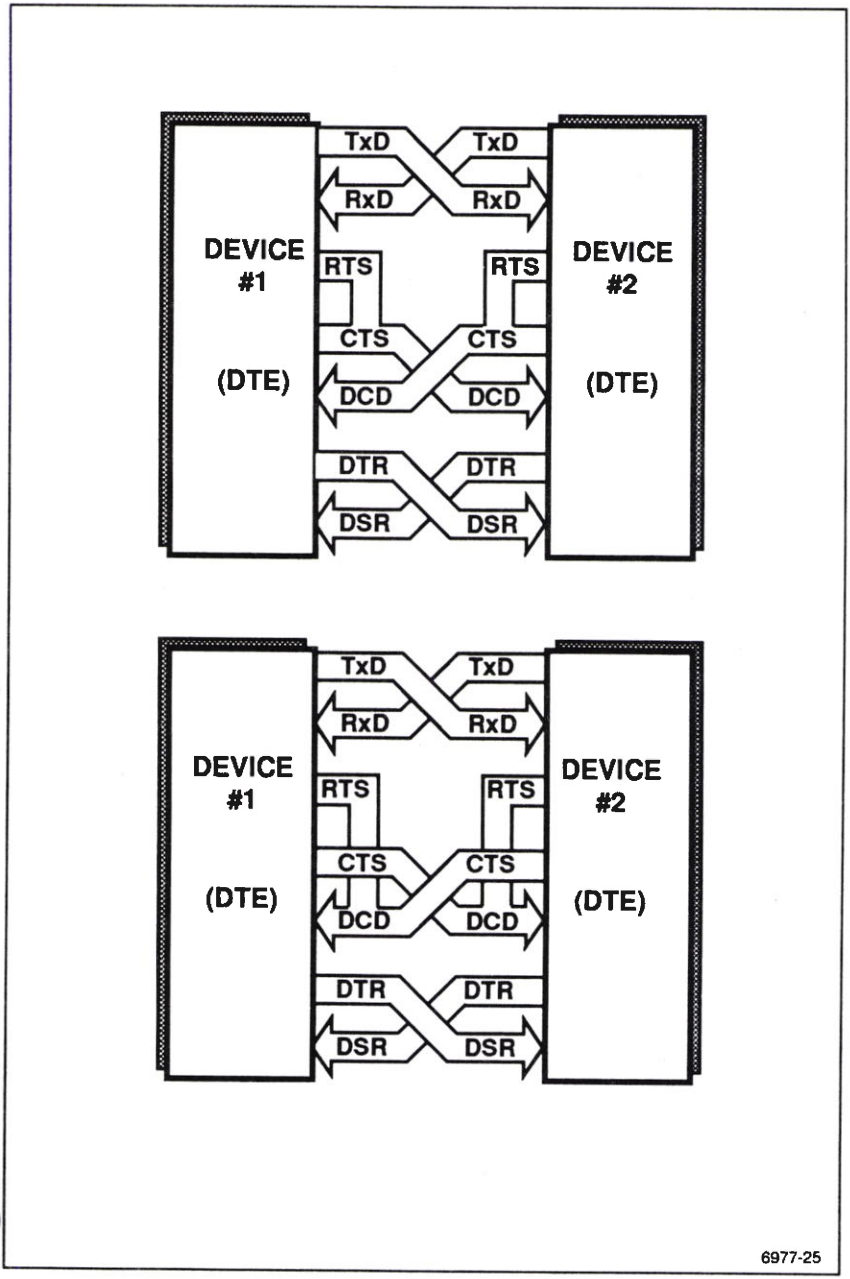


Figure F-2. Signal lines and line-swapping in a null-modem cable.

For the rest of this section, we will be speaking in terms of the DTE function/signal-name assignments. The discussion that immediately follows describes the full handshaking that occurs when two DTE devices are connected together using a null-modem cable as shown in Figure F-2.

Full Handshaking

The DTR (DATA Terminal Ready) line is an output that, when asserted (i.e., pulled above +3 V), says the device is powered up and physically able to communicate. The DSR (Data Set Ready) line is the input for the DTR from the opposite device and controls when the sending device is allowed to transmit data.

Here is what happens. Device #1 asserts DTR, telling Device #2 that it's ready to talk to it. (The DTR from Device #1 goes to the DSR of Device #2.) Device #2 also asserts its DTR, telling Device #1 that it's ready to communicate (Device #2's DTR goes to Device #1's DSR input). The order isn't important, just the fact that they both get ready to communicate.

Since either instrument may have temporary periods of time when it can't receive more data, some way of telling the other instrument to stop sending must be provided. This is accomplished with a second pair of handshake lines called "Request To Send" (RTS) and "Clear To Send" (CTS).

It should be noted that most current implementations of RS-232-C use RTS to mean "I can listen," instead of "I have something to send" as originally described in the EIA RS-232-C guidelines. The rest of this discussion uses the "I can listen" convention.

When either receiving device is able to listen, it asserts its RTS output. This output goes to the other device's CTS input and, when the other device sees CTS asserted, it knows that it can now send data.

When either device decides that it can't accept any more data right now (for example, maybe it's a personal computer and needs to write some of the data it's been receiving out to disk), it unasserts its RTS, saying "I'm not ready anymore." The other device sees this on its CTS input line and stops sending data. It will not send any more data until it sees its companion's RTS reasserted. When the other device catches up, it reasserts RTS, saying "I'm ready again," and data will again be sent. This scheme prevents the loss of data between devices when one of them has to take some time out to do other things.

Another signal line is used to inform the connected devices of the status of the communications channels. This is most useful when using modem interconnections, where it tells the receiver that the data it's seeing is coming from a properly modulated carrier tone. This line, DCD, (sometimes called, RLSD (Receive Line Signal Detected), is an output from the modem to the connected DTE device that is asserted when the modem detects a modem carrier (from the other modem) on the phone line. Essentially, this line says "I hear the other modem—the connection is OK."

The same logical function is assumed in our test-bench setup. Figure F-2 shows that any time one DTE device is ready to listen (RTS asserted), the DCD line for the opposite device will be asserted.

The handshake (from the DTE perspective) can be summarized as follows.

Assert DTR —"I'm ready to communicate."

See DSR — "I see you're ready too."

See DCD—"The communication channel is OK."

When all of the above criteria are met, the actual handshake proceeds with RTS and CTS as follows.

Assert RTS—"I can listen now. You can send data until I tell you to stop."

See CTS—"I see you're ready to listen. I'll send data whenever I have it, as long as you remain ready to listen."

The protocol described above is typical of many RS-232-C implementations. Note that DTR and DSR are only used as hardware status lines, indicating only whether or not the equipment is powered up and physically capable of communicating. These lines may also be used as handshaking lines, but in most cases are not. Most implementations use only RTS and CTS for handshaking.

Flow Control

Many deviations from the full implementation have occurred. Most of these deviations fall into two categories—handshake protocols and hardware minimization. While absolute adherence to the RS-232-C standard may be a goal well worth pursuing, the best solution to a specific problem rarely turns out to be fully standard. It usually has strings attached like "cheaper," "faster," or "almost like, but...."

Handshake-protocol deviations occur when a system has to do its task "faster," or in an "almost like, but..." fashion. By changing the way standard RS-232-C interface parts toggle their handshake lines, some specific applications can make data transfer speed improvements, or may be able to detect specific events in very specific situations. As long as both devices understand what the other is doing (the same firmware/software program at both ends), all will go well. But trying to connect one of these devices with a standard device will most often cause problems.

Hardware-minimization deviations usually occur for one reason only—cost savings. It is obviously cheaper to string 3-wire cables than 5- or 7-wire cables. In applications where cost considerations outweigh data-rate considerations, an obvious way to attack the problem is to eliminate one or both of the handshake-line pairs (and their associated support circuitry).

In fact, this is conceptually what's done with modems. The handshake lines go as far as the modems, but can't propagate over the phone lines. The only line that really relates to anything happening at the other end of the connection is DCD, which simply says that the receiver hears a proper carrier.

Using a data-transmission technique called "flow control," instruments with non-standard interfaces (i.e., those without the hardware handshake lines) can be made to talk to each other. Flow control emulates the function of the hardware handshake lines by placing special messages on the data channels to turn data transmission from the opposite device on and off. What's required is a program on each end that knows how to ignore the handshake lines and watch for these special ON/OFF commands instead.

The RS-232-C interface is based upon chopping up a data stream into small chunks that represent the individual bits in each character or number. These chunks of data are inserted (or "framed") between a start-bit and a stop-bit, and are then transmitted down the line to be decoded at the other end.

When you remove the handshake lines (or choose to ignore them), the interface hardware has no way of discriminating between valid data and invalid data except to watch for the presence of these framing pulses.

The flow control protocol can be used at each end of the interface to work around this handshaking (or lack of handshaking) problem by allowing the receiving device to tell the sender when it (the receiver) can or cannot accept more data. As the sender transmits its data, it is also watching its receive channel (RxD), interpreting every framed time-slice of information as a valid character, and checking for two specific characters to turn transmission of data on or off. These characters are called XON (transmission on) and XOFF (transmission off) and are usually assigned to be the <CTRL-Q> and <CTRL-S> characters respectively, though the specific characters chosen are a function of the program used.

What we have now is a situation where either instrument may send data to the other until it is told to stop (receives the XOFF character). It keeps watching the RxD line, interpreting every time-slice (as defined by the framing pulses) as a character, checking to see if it is the defined XON character. When it sees the XON character, it knows that the other device is now ready for more data, so it starts sending again. This stop-start process continues throughout the duration of the transmission.

One other special character is commonly used to signal the end of transmission. This is the EOT (end of text) character and is usually defined to be <CTRL-D> or <CTRL-Z>, though once again, definition is entirely dependent upon the software/firmware/application programs being used. Most programs interpret the EOT character to mean "this is the end of this message or transmission."

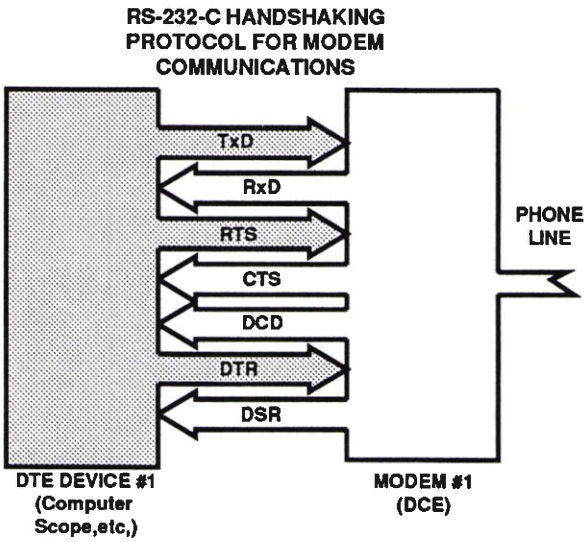
It should be noted here that flow control cannot be reliably used when doing binary data transfers, because the values of the XON and XOFF characters also correspond to valid data values. Hex or ASCII encoding should be used with flow control. Even this encoding/protocol mix is not foolproof since noise on phone lines (line hits) can simulate the required framing pulses, as well as (more rarely) the flow-control characters themselves. This is why you can get bursts of bad characters (especially with flow-control off) when using modems on noisy telephone lines. Using flow-control greatly increases the probability that data will be transmitted and received properly. Any time hardware handshaking is not used to orchestrate the orderly flow of data, the flow control protocol (with Hex or ASCII encoding) should be used when the hardware devices support it.

Communication Via Modems

Figure F-3 illustrates a typical data transmission sequence for two DTE devices communicating over phone lines using modems (DCE Devices). Note that the handshake signal-name/function correspondence changes between DTE and DCE devices.

Note also that the hardware handshake lines (and therefore their associated functions) do not propagate across the phone lines, so flow control must be used to ensure proper receipt of data.

The handshake sequence described illustrates how Device #2 can control the flow of data from Device #1. You need to remember that a data channel also exists in the opposite direction (from Device #2 to Device #1), so similar handshaking will be occurring in the opposite direction simultaneously.



RECEIVE DIALOG AS DTE DEVICE #1 SEES IT

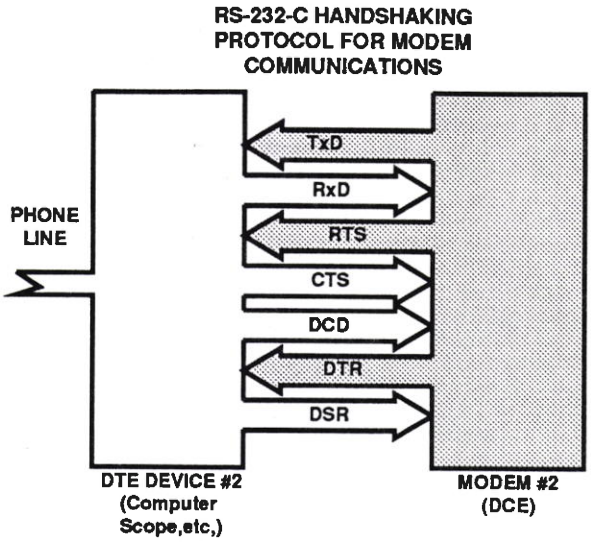
1. **DTR** - Assert DTR. Device #1 is powered up and ready.
   DSR - Modem #1 powered up (ready).
2. **DCD** - "Carrier detected" (recieve channel OK).
3. **RTS** - Assert RTS. "I can listen. Modem get ready to receive."
4. **CTS** - Delay slightly from RTS, then assert. "Modem is ready now."

6. **RxD** - Modem demodulates phone data and sends to computer on RxD.
7. **TxD** - Send XOFF character. "I can't accept any more data."
8. **RTS** - Unassert RTS. "Modem, don't decode more until RTS is re-asserted."
9. **RTS** - Asser RTS. "Modem, get ready to listen again."
10. **CTS** - Delay slighty from RTS, then assert. "Modem is again ready."
11. **TxD** - Send XON. "I can accept more data now."

13. Loop back to 5 until connection terminated.

6977-26

Figure F–3a. Typical transmission sequence for two DTE devices connected via modems.



RECEIVE DIALOG AS DTE DEVICE #2 SEES IT

1. **DTR** - Assert DTR. Device #2 is powered up and ready
   DSR - Modem #2 powered up (ready).
2. **DCD** - "Carrier detected" (recieve channel OK).

5. **TxD** - Transmit data to modem when ready. Modem modulates data onto phone line.

7. **RxD** - Receive XOFF character. "I will stop sending until I see XON."

12. **RxD** - XOFF character received. "I can again send data whenever I have it."
13. Loop back to 5 until connection terminated.

6977-27

Figure F-3b. Typical transmission sequence for two DTE devices connected via modems.

InterfaceParameters

Now we know, in general conceptual terms, how data moves between instruments on the RS-232-C interface, as well as over phone lines using modems. But there are still a lot of "nitpicky" details to be attended to in order to ensure that proper communications can take place. RS-232-C devices know how to talk binary, but the "dialect" may vary. These details may be thought of as getting the devices to talk the same dialect.

The data transmitted on an RS-232-C interface has very specific timing relationships that must be maintained. The most basic of these is what is called baud rate, and is the rate at which the individual bits of the data stream are put onto the data lines. For the receiving device to be able to correctly interpret what is being sent, it must be set to receive the data stream at the same rate as the data is being sent. In other words, the baud rates of both devices must match.

Other dialect "quirks" have to do with how many of the bits in the data stream are used to represent a data unit or character and how those bits are interpreted.

Notice that the polarity of the data channels (TxD/RxD) is reversed from that of the handshaking logic. For example, on a data channel, asserted means more negative than -3 volts while, for handshaking lines, asserted means more positive than +3 volts (as described earlier). You probably will only need to know this if you have to do low-level troubleshooting of your system, and it is only mentioned here for the sake of completeness.

Depending on the type of data to be transmitted, the data stream may assume a variety of formats, each meant to optimize transfer of a certain type of data. The most common implementations of the RS-232-C standard use 10 or 11 bits per character, broken down as follows:

Start bit—1 bit always set to "space" (unasserted). This is the first "framing" pulse.

Data Bits—7 or 8 bits, depending upon the range of values or type of data to be represented, least-significant bit first.

Seven bits provide encoding of the entire ASCII character set or for numbers ranging between 0 and 127 inclusive. Flow-control characters (<CTRL-S>, <CTRL-Q>, <CTRL-D>) are used primarily for ASCII transfers and can be properly encoded with just seven bits.

Eight bits provide encoding for numbers between 0 and 255 inclusive (binary data), as well as the ASCII character set (eighth bit set to zero). Eight-bit data is used primarily for binary transfers.

Parity bit—Used for character-validity checks on 7-bit data. Not used for 8-bit data.

By setting both the transmitting and receiving devices to use parity, some degree of checking may be done on 7-bit data. Setting parity to "even" causes the transmitter to send a parity bit that makes the number of mark bits in the data (data bits plus the parity bit) come out to be even. Upon receiving the data, the receiving device adds up the mark bits (data bits plus the parity bit) and verifies that there were indeed an even number of mark bits received. If not, an error flag may be asserted to cause the hardware/software to modify its operation to handle the error.

"Odd" parity works in the same way, except that the number of mark bits is expected to be odd. Parity may also be set to mark or space, which causes the parity bit to always be sent (and checked) to be asserted or unasserted respectively.

Stop bit(s)—1 or 2 bits always set to "mark" (asserted). The last stop bit is the second framing pulse.

1 bit is used almost exclusively; 2 bits is a carry-over from the days of mechanical teletypes (2 stop-bits allowed enough time for the carriage to return to the left margin).

The transition from one character's stop bit(s) to the next character's start bit is used to synchronize the receiver to the transmitter. This ensures that the data bits for each character are read at the optimum times relative to the transition (start of character).

Errors occurring due to mis-matched baud rates, data bits, or stop-bits often show up as framing errors; i.e., the frame surrounding the data (start-bit and stop-bit) have the wrong timing relationship with respect to each other. Since they cannot be recognized properly, the data cannot be properly extracted from the bit stream.

RS-232-C Device Interconnection

Introduction

This information will aid you in determining the cabling needed to connect your 2402 TEKMATE to other RS-232-C devices.

The RS-232-C standard defines the interconnection between two types of devices. They are Data Terminal Equipment (DTE) and Data Communications Equipment (DCE). A DTE device that conforms to the standard has a male RS-232-C connector. Examples are terminals, computers, and printers. Generally, the DTE device is the source of the data, but this is not always the case. A DCE device that conforms to the standard has a female RS-232-C connector. An example of a DCE device is a modem.

Determining Device Type

When interconnecting your TEKMATE to other RS-232-C devices you must determine the device type and the connector type. From that information, the interconnection cable you need can be determined.

NOTE

You cannot reliably determine if a device is DTE or DCE by simply looking at the RS-232-C connector. You must verify the device type from its operator or service manual.

1. To which "logical" type of device are you connecting?

From the equipment manual, find out if the device is DTE or DCE.

2. Which "physical" type of connector does the device have?

Male is standard for a DTE connector.

Female is standard for a DCE connector.

If you have a DTE device with a male connector and a DCE device with a female connector, you may use a standard RS-232-C "straight through" interconnection cable, see Figure F-4. If the connections are not standard, read the Interconnection Rules. Then read the Interconnection Cable-type Identification information to find the interconnection cable type you will need for your application.

Interconnection Rules

There are several simple rules that satisfy most RS-232-C interconnection requirements.

1. A standard RS-232-C cable connects a DTE device to a DCE device. Both devices must adhere to the electrical and mechanical specifications of the RS-232-C standard. The standard cable has a female connector on one end and a male connector on the other end. The Transmit and Receive conductors are not interchanged. The standard RS-232-C cable is sometimes referred to as a "straight through" cable. See Figure F-4 for a "straight through" cable wiring schematic.

2. A "Null Modem cable or device may be used to interconnect two DTE or two DCE devices. Generally the cable is custom made with RS-232-C connectors that match the devices to be interconnected. A null modem cable permits two devices of the same type (DCE to DCE and DTE to DTE) to communicate as if they were connected DTE to DCE. The Transmit and Receive lines and the associated handshake lines are swapped in the null modem to satisfy the requirements for data transfer between the two devices. See Figure F-5 for the "Null Modem" cable wiring schematic.

3. A "Gender Changer" has straight-through connections that may be used to convert a non-standard port connector (a DTE device with a female connector or a DCE device with a male connector) for connection with a standard RS-232-C cable. Gender changers come as male-to-male and female-to-female. The male-to-male changer is the most used.

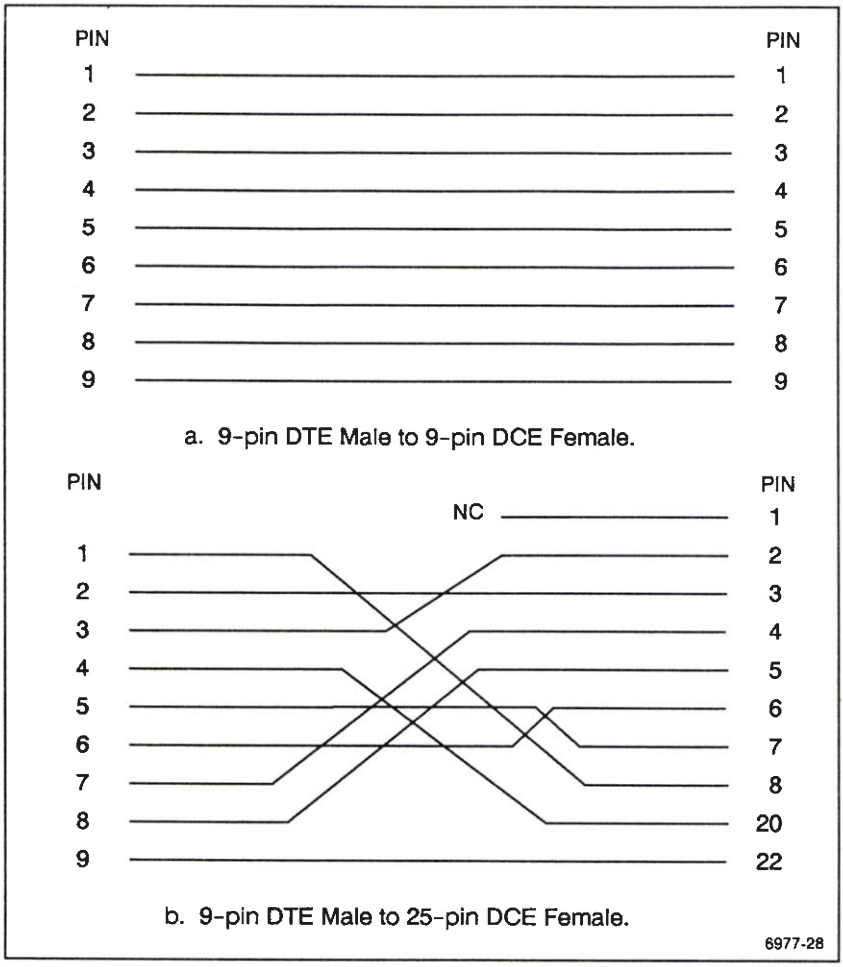


Figure F–4. Straight Through cable wiring.

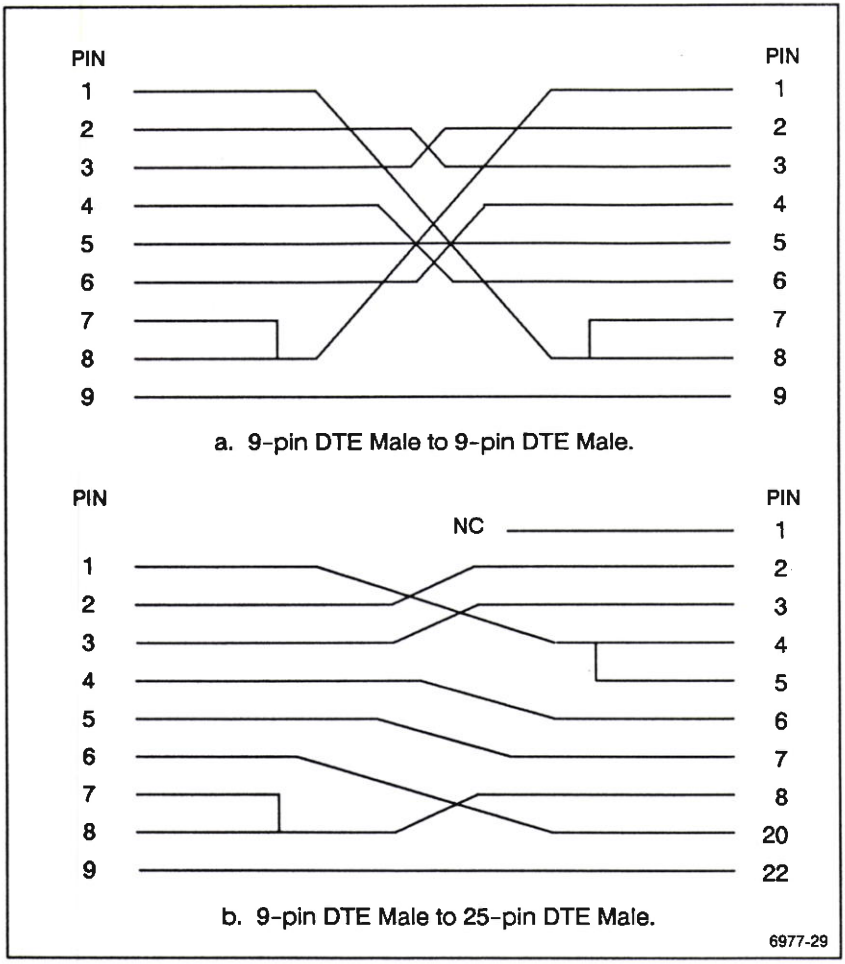


Figure F-5. Null Modem cable wiring (with handshaking).

Interconnection Cable-Type Identification

The cable-type designations found in Table F-3 correspond to the interconnection illustrations. The most used interconnections seen with different RS-232-C devices are covered. In the table, the information in column 1 (Type of Interconnection) is interpreted as follows: DTE/male to DCE/female means a DTE type device with a male RS-232-C connector connected to a DCE type device that has a female RS-232-C connector (a standard RS-232-C male-to-female interconnection).

Both the straight through and the null modem interconnections will also require gender changers when making male-to-male or female-to-female equipment connections. In summary, the basic cable types are:

1. Standard or "straight through" cables with a male connector on one end and a female connector on the other.

2. Null modem cables that may be customized to make the necessary connector matings. These come as male-to-female, female-to-female, and male-to-male.

3. Gender changers are straight-through cables with either male connectors or female connectors on both ends.

Table F-3
Cable-Type Identification

Cable Type	Type of Interconnection	Application
Straight Through	DTE/male to DCE/female DTE/female to DCE/male	Use a straight through cable terminated on one end with a male connector and on the other end with a female connector. This is the "standard" cable connection in our discussion.
	DTE/female to DCE/female	Use a male-to-male gender changer and a standard cable.
	DTE/male to DCE/male	Use a female-to-female gender changer and a standard cable.
Null Modem	DTE/male to DTE/male DCE/male to DCE/male	Use a null modem cable terminated with female connectors. This is the "standard null modem" in our discussion.
	DTE/female to DTE/male DCE/male to DCE/female	Use a standard null modem with a male-to-male gender changer or use a male-to-female null modem.
	DTE/female to DTE/female DCE/female to DCE/female	Use two male-to-male gender changers and a standard null modem cable or use a male-to-male null modem.

Index

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- ☐ Instrumentation
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- ☐ Education
- ☐ Other
- ☐ Production Test
- ☐ Quality Control
- ☐ Applied/Basic Research
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- ☐ Field Service
- ☐ Product Design
- ☐ Product Development
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