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PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

2445/2465
OPTION 10
GPIB OPTION
SERVICE

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

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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

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LIST OF TABLES

OPERATORS SAFETY SUMMARY

The general safety summary 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 as Marked on Equipment


This symbol indicates where applicable cautionary or other information is to be found.


Protective ground (earth) terminal.


ATTENTION — Refer to manual.

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.

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 connecting 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 insulating) 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.

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 product 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. Do not operate product without the covers and panels properly installed.

SERVICING SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

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.

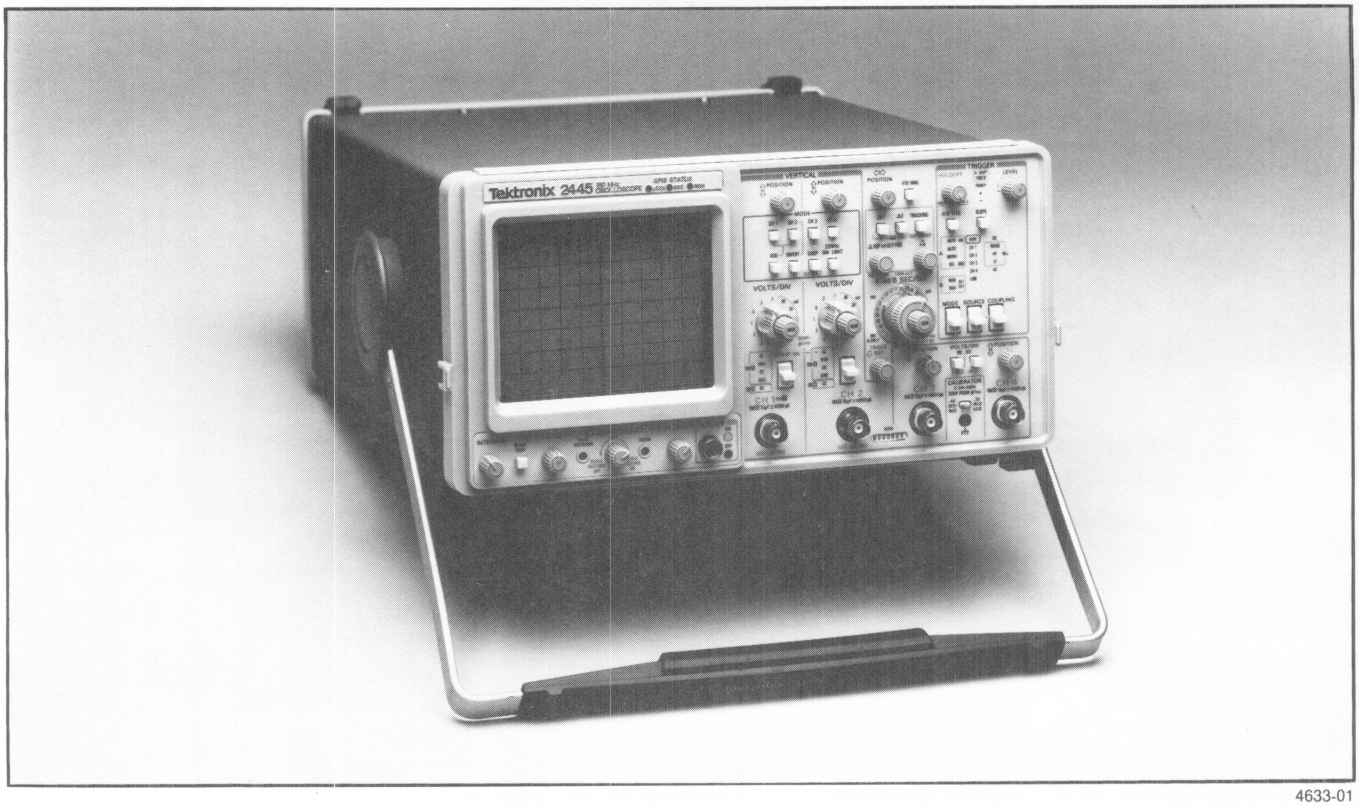
Use Care When Servicing With Power On

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.

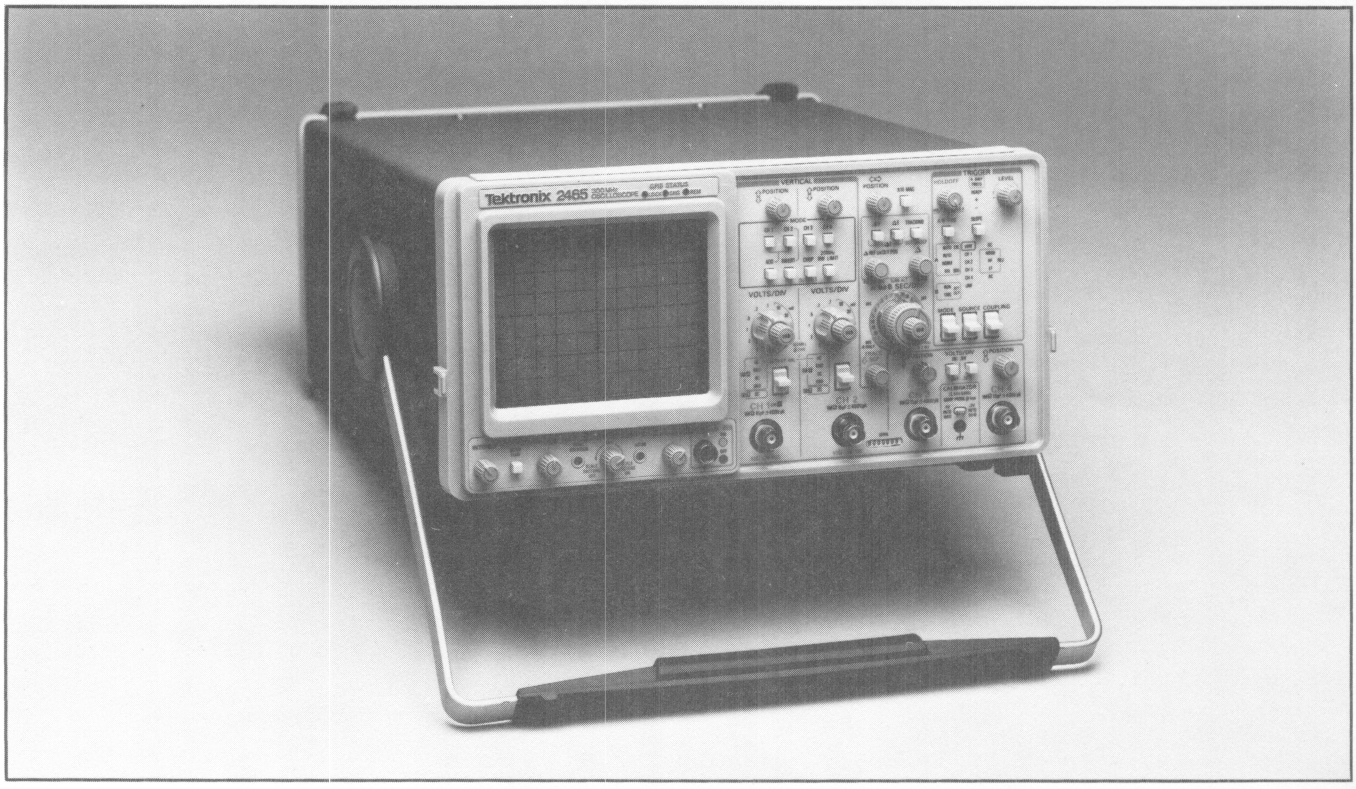
Power Source

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.



4633-01

The 2445 Option 10 (GPIB) Oscilloscope.



4633-02

The 2465 Option 10 (GPIB) Oscilloscope.

SPECIFICATION

INTRODUCTION

Option 10 to the TEKTRONIX 2445 and 2465 Oscilloscopes adds the hardware and the software that allows these instruments to be remotely controlled and queried using a standard interface system. The interface implemented conforms to the specifications contained in *IEEE Standard Digital Interface for Programmable Instrumentation (ANSI/IEEE Std 488-1978)*, commonly referred to as the General Purpose Interface Bus (GPIB). It also complies with a Tektronix Standard relating to GPIB Codes, Formats, Conventions and Features.

This manual describes GPIB operational elements only in relation to communication between the oscilloscope and the remote controller by way of the bus. For complete information regarding GPIB electrical, mechanical, and functional aspects, refer to ANSI/IEEE Std 488-1978, which is published by:

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, New York 10017

Messages originating from a remote controlling device and transmitted over the GPIB perform one of three functions:

1. Set the oscilloscope operating mode;
2. Query the state of the oscilloscope; or
3. Query the results of measurements made.

All oscilloscope front-panel functions are controllable through the GPIB interface, except the power and display controls (INTENSITY, BEAM FIND, FOCUS, READOUT INTENSITY, TRACE ROTATION, ASTIG, SCALE ILLUM, and POWER). Structure and format of the commands and queries executable by the GPIB Option are explained in "Controlling Oscilloscope Functions Over the GPIB" in Section 2 of this manual. A listing of command headers and arguments, along with concise descriptions, is also provided in that section.

The alphanumeric crt readout is used to display measurement results, diagnostic test messages, exercise messages, and calibration messages. Any measurement result that is displayed on the crt readout can also be transmitted over the GPIB. While the READOUT INTENSITY control itself is not GPIB controllable, scale-factor readouts can be turned on and off over the bus.

STANDARD ACCESSORIES

In addition to the standard accessories listed in the basic oscilloscope manuals, one copy each of the following Option 10 accessories is also provided:

Description	Part Number
2445/2465 Option 10 Operators Manual	070-4633-00
2445/2465 Option 10 Service Manual	070-4640-00

STANDARD FUNCTIONS, FORMATS, AND FEATURES

The total interface-function repertoire of an instrument on the GPIB, in terms of interface-function subsets, is identified in ANSI/IEEE Std 488-1978. The status of subsets applicable to 2445 and 2465 Oscilloscopes with Option 10 are listed in Table 1-1.

A Tektronix standard identifies the format and features of messages sent over the bus to communicate with other instruments equipped with a GPIB interface. Specific features implemented in the 2445 and 2465 Oscilloscopes are listed in Table 1-2, and specific formats are shown in Table 1-3.

Table 1-1

ANSI/IEEE Std 488-1978 (GPIB) Functions

Function	Description
SH1	Source Handshake. Complete capability.
AH1	Acceptor Handshake. Complete capability.
T6	Basic Talker. Responds to Serial Poll. Unaddress if My Listen Address (MLA) is received.
L3	Basic Listener. Listen Only. Unaddress if My Talk Address (MTA) is received.
SR1	Service Request. Complete capability.
RL1	Remote-Local. Complete capability.
DC1	Device Clear. Complete capability.
PP0	Parallel Poll. Does not respond to Parallel Poll.
DT0	Device Trigger. Does not have Device Trigger capability.
C0	Controller. Does not have Controller capabilities.

NOTE

Open collector bus drivers (E1) are used by this instrument.

Table 1-2

Specific Features Implemented

Feature	Description
Indicators	REM (remote), SRQ (service request), and LOCK (front-panel lockout) indicators are included.
Parameter Selection	Selection is via diagnostic menu and crt readout. Nonvolatile storage is in EAROM. No hard-wired switches are provided for this feature.
Secondary Addressing	Not implemented.

Table 1-3

Specific Format Choices

Format Parameter	Description
Format Characters	Not transmitted; ignored on reception.
Message Terminator	Either the End-or-Identify (EOI) or the Line-Feed (LF) mode can be selected.
Measurement Terminator	Follows program message-unit syntax, which allows numeric characters in headers and alphabetic data arguments for reporting.
Link Data (Arguments)	Used in Listen and Talk modes.
Instrument Identification Query	Descriptors are added for other installed options.
SETtings Query	Extended, using LLSet commands, to allow block binary response.
INIt Command	Causes the oscilloscope to return to a power-on condition. All operating modes then agree with actual front-panel settings.
Return to Local (rtl) Message	Asserted when any front-panel control attempts to change a GPIB-controllable function.
Time/Date Commands	Not implemented.
Stored Setting Commands	Not implemented.
Waveform Transmission	Not implemented.
Device Trigger (DT)	Not implemented.
Multiple Event Reporting	Not implemented.
IEEE 728	Compliance not intended.

PERFORMANCE CONDITIONS

Except as noted in Tables 1-4 and 1-5 of this manual, the electrical, environmental, and mechanical characteristics of Option 10 instruments (including the performance conditions) are identical to those specified in the respective 2445 and 2465 Oscilloscope Operators Manual.

Table 1-4
Option 10 Electrical Characteristics

Characteristics	Performance Requirements
Vertical Position Accuracy	Position accuracy is only valid when: 1. Positioning occurs after a BALance command is invoked at the ambient temperature in which the instrument is operating. 2. The VOLTS/DIV VAR control is in the calibrated detent.
CH 1, CH 2 (noninverted)	
+15°C to +35°C	±(0.3 div + 3% of distance from center screen in divs + .5 mV/V/DIV setting.)
CH 2 Inverted	Add 0.2 div.
−15°C to +55°C (excluding +15°C to +35°C)	Add 1.5 mV/V/DIV setting
CH 3, CH 4	
−15°C to +55°C	±(0.7 div + 3% of distance from center screen in divs.)
IEEE 488 Outputs	
Volts Out for True (I_{QT} = 48 mA)	Max 0.5 V.[a]
Volts Out for False (I_{OF} = −5.2 mA)	Min 2.5 V.[a]
Volts Out with Output Disabled	Max 3.7 V, Min 2.5 V.[a]
Output Leakage Current with Power OFF (0 V<V_{IN}<2.5 V)	Max 40 μA.[a]
IEEE 488 Inputs	
Volts In for True	Max 0.8 v, Min 0 V.[a]
Volts in for False	Max 5.5 V, Min 2.0 V.[a]
Current in for True (V_{IT} = 0.5 V)	Max −0.1 mA.[a]
Current in for False (V_{IT} = 2.7 V)	Max 20 μA.[a]

[a]**Performance Requirement not checked in manual.**

Table 1-5
Option 10 Mechanical Characteristics

Characteristics	Description
Weight With Power Cord, Cover, Pouch, Probes, Operators Manual, and Options	⩽ 12.0 kg (26.4 lb).
Domestic Shipping Weight	⩽ 17.6 kg (38.8 lb).

OPERATING INFORMATION

CONTROLS, CONNECTORS, AND INDICATORS

FRONT-PANEL CONTROLS

Controls used to set up the instrument for GPIB operation (i.e., selecting the instrument's GPIB address, end-of-message terminator, and talk/listen mode) are described in "GPIB Preparation for Use" in this section. The use of all other controls for operating the instrument remains the same as explained in the oscilloscope Operators manual.

REAR PANEL

See Figure 2-1 for the location of the following connector.

(50) **GPIB CONNECTOR**—This connector provides the IEEE Std 488-1978 compatible electrical and mechanical connection to the GPIB.

INDICATORS

See Figure 2-2 for the location of the indicators (LOCK, SRQ, and REM) added to the front panel above the crt.

(51) **LOCK (Local Lockout)**—Illuminates to indicate that the Local Lockout universal command has been sent over the GPIB. If the instrument has been addressed and the Remote Enable line asserted, the front-panel controls, except display and power, will be locked out.

(52) **SRQ (Service Request)**—Illuminates to indicate that the instrument has detected either an error or a warning condition and is requesting service by the bus controller.

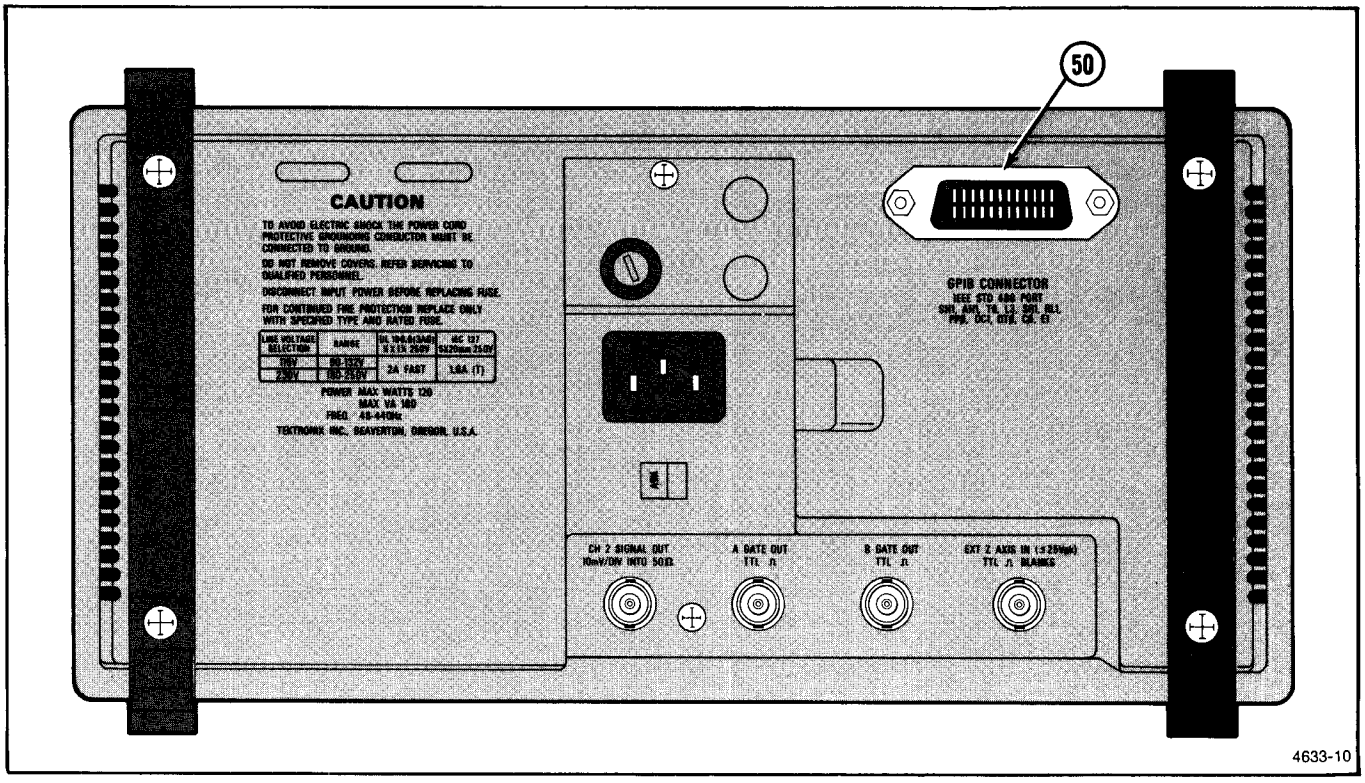


Figure 2-1. Rear Panel GPIB CONNECTOR.

(53) **REM (Remote)**—Illuminates to show that the instrument's GPIB interface is in a Remote state. The interface enters a Remote state at the request of the bus controller. It leaves the Remote state either at the controller's request or when a GPIB-controllable front-panel control is changed while the instrument is not in a Local Lockout state.

READOUT DISPLAYS

Readout displays of GPIB-controllable oscilloscope functions are identical to crt readout displays for non-GPIB-equipped instruments. Consult Sections 3 and 6 in the oscilloscope Operators manual for readout display information and typical examples. The additional displays associated with GPIB functions are illustrated in "Controlling Oscilloscope Functions Over the GPIB" in this section.

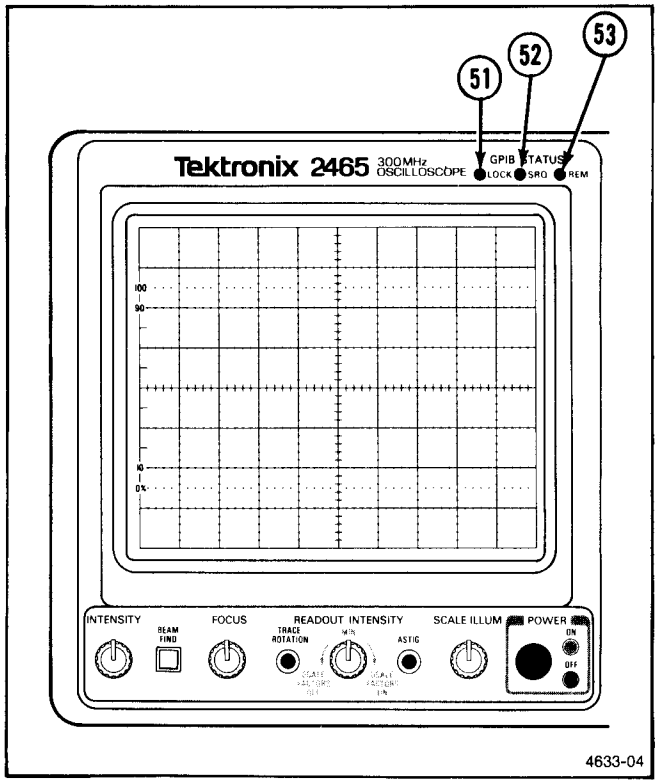


Figure 2-2. GPIB STATUS indicators.

GPIB PREPARATION FOR USE

POWER-UP SEQUENCE

Before initially turning on power to the instrument, read Section 2, "Preparation for Use", in the oscilloscope Operators manual and follow the safety and precautionary information described there.

The power-up tests, automatically performed each time the oscilloscope is turned on, examines both the oscilloscope circuitry and the Option 10 GPIB circuitry. Tests specifically applicable to Option 10 are integrated into the power-up tests for the host oscilloscope and likewise consist of two main parts: Kernel tests and a Confidence test.

Kernel Tests

The Option 10 memory (ROM) is checked by standard instrument Kernel tests. Kernel test failures will result in an attempt to flash the front-panel A SWP TRIG'D indicator.

Even with a Kernel failure, pressing in the A/B TRIG switch may still place the instrument in the normal operating mode. However, if the operating mode is successfully entered, instrument operation may be unpredictable.

NOTE

On some instruments with other options installed, the A/B TRIG button may be labeled A/B/MENU.

Confidence Test

Failure of the GPIB Confidence test during power-up is indicated in the bottom line of the crt readout. The failure display has the following format:

GP TEST 11 FAIL YY

where **YY** represents the code for the failed test segment.

A Confidence test failure may not render the GPIB interface inoperable. Pressing in the A/B TRIG button may still place the instrument into the normal operating mode; however, it may not meet all GPIB specifications.

Successful Power-Up Sequencing

When the power-up routine is successfully completed without a failure indication, five instrument events occur:

1. The oscilloscope enters the normal operating mode.
2. The GPIB interface enters the Local State (LOCS).
3. The GPIB interface asserts Service Request (SRQ).
4. The oscilloscope functions are set to the values which were established at least 15 seconds before the instrument was last turned off, with front-panel switch settings taking precedence.
5. The GPIB interface responds to a controller's serial poll with a status byte of 65 (decimal), meaning that all tests were successful and power is on.

The instrument is now ready to make measurements as required.

Unsuccessful Power-Up Sequencing

If power-up tests fail, four instrument events occur:

1. The oscilloscope does not enter the normal operating mode.
2. The GPIB interface enters the Local State (LOCS).
3. The GPIB interface asserts Service Request (SRQ).
4. The GPIB interface responds to a controller's serial poll with a status byte of 65 (decimal), meaning that power is on.

As explained in preceding paragraphs, it may be possible, after a power-up test failure, to place the instrument into the normal operating mode by pressing in the A/B TRIG switch. If it then functions adequately for your particular measurement requirement, the instrument can be used, but refer it to a qualified service technician for repair of the problem as soon as possible.

POWER-DOWN SEQUENCE

There are no special sequences associated with powering down the instrument. When the POWER switch is set to OFF, the instrument powers down and SRQ is not asserted.

CONTROLLING OSCILLOSCOPE FUNCTIONS OVER THE GPIB

INTRODUCTION

This part provides information for controlling the 2445 and 2465 Oscilloscopes via the IEE Std 488-1978 digital interface. With Option 10 installed, all basic instrument functions (as explained in the oscilloscope Operators manual) remain unchanged. Consult the oscilloscope Operators manual to acquire a thorough understanding of the operation of the basic instrument before trying to control it via the GPIB.

All measurement results returned by GPIB commands have the same accuracy as the main instrument or instrument option being accessed by the GPIB interface.

GPIB PARAMETER SELECTION

After power-up sequencing is complete and the oscilloscope is in the normal operating mode, selection of GPIB parameters (primary address, message terminator, and talk/listen mode) can be made.

Primary Address

The selected GPIB address establishes both the primary talk and listen addresses for the oscilloscope. It can be set to any value between 0 and 31, inclusive.

NOTE

Option 10 has no provisions for secondary addressing as defined by ANSI/IEEE Std 488-1978.

With an address of 31, the option still presents an active load but does not respond to nor interfere with any bus traffic. This feature is useful for changing the instrument's status without turning off the oscilloscope's power.

Perform the following procedure to either set or change the primary GPIB address:

1. Hold in both the ΔV and Δt switches while pushing the TRIGGER SLOPE switch to access diagnostic mode.
2. Repeatedly push up on the TRIGGER MODE switch until **GP EXER 11** appears in the bottom line of the crt readout.
3. Push up on the TRIGGER COUPLING switch to initiate the routine.
4. Rotate the Δ control until the desired address is displayed in the top row of the crt readout; for example:

   GPIB ADDRESS 29

   NOTE

   *Trying to select an address outside the range of 0 to 31 will cause **LIMIT** to appear on the top right side of the crt display.*

5. Push down on the TRIGGER COUPLING switch to end the routine and update the stored copy of the address to its new value.
6. Push the A/B TRIG switch (or the A/B/MENU switch, if applicable) to exit diagnostic mode.

Input End-of-Message Terminator and Talk/Listen Mode

The end-of-message terminator can be selected to be either the End-or-Identify (EOI) interface signal or the Line-Feed (LF) character.

When EOI (normal mode) is selected as the terminator, the option will:

- Accept only EOI as the end-of-message terminator.
- Assert EOI concurrently with the last byte of a message.

When LF is selected as the terminator, the option will:

- Accept either LF or EOI as the end-of-message terminator.
- Send Carriage Return (CR) followed by LF at the end of every message, with EOI asserted concurrently with the LF.

Two talk/listen modes are selectable:

- TALK LISTEN mode allows the oscilloscope to both send and receive data over the GPIB.
- LISTEN ONLY mode permits the oscilloscope to only receive data over the GPIB.

The default mode is TALK LISTEN.

To select or change the end-of-message terminator and the talk/listen modes perform the following procedure:

1. Hold in both the ΔV and Δt buttons while pushing the TRIGGER SLOPE switch to access the diagnostic mode.
2. Repeatedly push up on the TRIGGER MODE switch until **GP EXER 12** appears in the bottom line of the crt readout.
3. Push up on the TRIGGER COUPLING switch to initiate the routine.
4. Push the TRIGGER MODE switch up repeatedly until the desired terminator appears in the top line of the crt readout. Push the TRIGGER SOURCE switch up repeatedly until the desired Talk/Listen mode appears in the top line of the crt readout. Four terminator/mode combinations are available:

   TERMINATOR EOI MODE TALK LISTEN

   or

   TERMINATOR LF MODE TALK LISTEN

   or

   TERMINATOR EOI MODE LISTEN ONLY

   or

   TERMINATOR LF MODE LISTEN ONLY
5. Push down on the TRIGGER COUPLING switch to end the routine and update the stored copy of the settings.
6. Push the A/B TRIG switch (or the A/B/MENU switch, if applicable) to exit diagnostic mode.

MESSAGES AND COMMUNICATION PROTOCOL

The GPIB Option commands can set the instrument operating mode, query the results of measurements made, or query the state of the oscilloscope. These commands are specified in mnemonics that are related to the functions intended to be implemented. For example, the command INIt initializes instrument settings to states that would exist if the instrument's power was cycled. To further facilitate programming, command mnemonics are similar to front-panel control names.

Commands

Commands for the 2445 and 2465 Oscilloscopes, like those for other Tektronix GPIB-controllable instruments, follow the conventions established in a Tektronix Codes and Formats Standard. The command words were chosen to be as understandable as possible, while still allowing a familiar user to shorten them as much as necessary, as long as the result is unambiguous. Syntax is also standardized to make the commands easier to learn.

In the command lists (Tables 2-2 through 2-7), headers and arguments are listed in a combination of uppercase and lowercase characters. The instrument accepts any abbreviated header or argument containing at least the characters shown in uppercase. Any characters added to the abbreviated (uppercase) version must be those shown in lowercase. For a query, the question mark must immediately follow the header. For example, any of the following formats are acceptable:

VMO?
VMOd?
VMOde?

Headers

A command consists of at least a header. Each command has a unique header, which may be all that is needed to invoke a command; e.g.,

NORmal
GO

Arguments

Some commands require the addition of arguments to the headers to describe exactly what is to be done. If there is more to the command than just the header (including the question mark if it is a query), then the header must be followed by at least one space.

In some cases, the argument is either a single word or a numeric value; e.g.,

DELay 1.0E−03
HMOde XY

In other cases, the argument itself requires another argument. When a second argument is required, a colon must separate the two arguments; e.g.,

CH1 VOLts:10
ATRigger MODe:AUTOLevel

Where a header has multiple arguments, the arguments (or argument pairs, if the argument has its own argument) must be separated by commas; e.g.,

CH1 VOLts:10,COUpling:DC,POSition:1.2
VMOde CH1:OFF,CH2:ON,ADD:ON

Command Separator

It is possible to put multiple commands into one message by separating the individual commands with a semicolon; e.g.,

CH1 VOLTS:10,COUPLING:DC;VMODE ADD:ON

Message Terminator

As previously explained, messages may be terminated with either EOI or LF. Some controllers assert EOI concurrently with the last data byte; others use only the LF character as a terminator. The GPIB interface can be set to accept either terminator. With EOI selected, the instrument interprets a data byte received with EOI asserted as the end of the input message; it also asserts EOI concurrently with the last byte of an output message. With the LF setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message; it transmits a Carriage Return character followed by Line Feed (LF with EOI asserted) to terminate output messages.

Command Formatting

Commands sent to the oscilloscope must have the proper format (syntax) to be understood; however, this format is flexible in that many variations are acceptable. The following paragraphs describe this format and the acceptable variations.

The oscilloscope expects all commands to be encoded as either uppercase or lowercase ASCII characters. All data output is in uppercase.

Spaces, Carriage Returns, and Linefeeds are all formatting characters that can be used to enhance the readability of command sequences. As a general rule, these characters can be placed either after commas and semicolons or after the space that follows a header.

Numeric Arguments

Table 2-1 depicts the number formats for numeric arguments in the GPIB command set. As shown in the table, both signed and unsigned numbers are accepted; but unsigned numbers are interpreted to be positive.

The symbol <nrx> indicates that any of the three formats is allowed. When only one specific format is permitted, it is represented by nr1, nr2, or nr3.

Table 2-1

Numeric Argument Format for GPIB Commands

Numeric Argument Symbol		Number Format	Examples
<nrx>	<nr1>	Integers	+1, 2, −1, −10
	<nr2>	Explicit decimal point	−3.2, +5.1, 1.2
	<nr3>	Floating point in scientific notation	+1.E−2, 1.0E+2, 1.E−2, 0.02E+3

GPIB COMMAND LISTS

Tables 2-2 through 2-7 describe all GPIB commands available in 2445 and 2465 Oscilloscopes equipped with only the GPIB Option. The first column lists the name (or header) of the command. The capitalized letters must be present to identify the command, while those shown in lowercase are optional. The second column lists arguments that can be associated with the command. The third column lists arguments associated with the first argument. Finally, descriptions of each command and its arguments are contained in the last column.

One or more arguments, separated by commas, may be given in a query to request only the information wanted. For example,

CH1? COUpling,VARiable

Instrument commands are presented in tables divided into the following functional groups:

COMMAND TABLE INDEX

Other 2445 and 2465 options (if installed) use Option 10 for GPIB access. When present, these options add their own command sets to the GPIB commands listed in Tables 2-2 through 2-7. For information on the additional GPIB command sets, consult the respective option manuals.

Table 2-2
Vertical Commands

Header	Argument	Argument	Description
CH1			Selects Channel 1 vertical parameters.
	COUpling:	AC DC FIFTY GND	Sets Vertical Coupling to the selected mode.
	POSition:	<nrx>	Sets Vertical Position to the value of <nrx> in divisions. Range is ± 10 divisions, with center screen at 0.
	VARiable:	<nrx>	Sets Vertical Volts/Div Var gain control circuitry to the value of <nrx>. Values range from 0 to 10 and are not calibrated. Zero represents the calibrated position.
	VOLts:	<nrx>	Sets Vertical Volts/Div gain to the value of <nrx>. The argument must be valid for the installed probe. If the value does not correspond to a calibrated position, the next higher calibrated value will be used and an SRQ warning will be issued.
CH1?			Query returns: CH1 VOLTS:<nr3>, VAR:<nr1>, POS:<nr3>, COUPL:string
	COUpling POSition VARiable VOLts		
	PROBe		PROBe must be queried explicitly, e.g., CH1? PROBe. The string returned for PROBe corresponds to the probe attenuation coding (X1, X10, X100 or X1000).

Table 2-2 (cont)

Header	Argument	Argument	Description
CH2			Same as CH1 plus INVert: argument.
	INVert:	ON OFF	Turns Channel 2 inversion on or off. Default is ON. This command has the same effect as VMOde INVert:string.
CH2?			Same as CH1, except query also returns INV:string, where string is either ON or OFF.
	INVert		
CH3 CH3?			Same as CH1, except COUpling and VARiable arguments are invalid and POSition range is ±4 divisions.
CH4 CH4?			Same as CH1, except COUpling and VARiable arguments are invalid and POSition range is ±4 divisions.
VMOde			Selects channels to be displayed, chopped or alternated display mode, limited or not limited vertical bandwidth, and Channel 2 inversion. When all channels are deselected, Channel 1 is displayed.
	BWLimit:	ON OFF	Sets state of the bandwidth limit function. With no arguments, defaults to ON.
	CHOp:	ON OFF	Selects chopped or alternate display mode. Default is ON.
	CH1:	ON OFF	Turns Channel 1 on or off. Default is ON.
	CH2:	ON OFF	Turns Channel 2 on or off. Default is ON.
	CH3:	ON OFF	Turns Channel 3 on or off. Default is ON.
	CH4:	ON OFF	Turns Channel 4 on or off. Default is ON.
	ADD:	ON OFF	Turns Channel 1 plus Channel 2 on or off. Default is ON.
	INVert:	ON OFF	Turns Channel 2 inversion on or off. Default is ON.
VMOde?	CHOp CH1 CH2 CH3 CH4 ADD INVert BWLimit		Query returns current state of the vertical display: VMO CH1:string, CH2:string, CH3:string, CH4:string, ADD:string, BWL:string, INV:string, CHO:string.

Table 2-3
Horizontal Commands

Header	Argument	Argument	Description
HORizontal			Selects Horizontal sweep system parameters.
	ASEcdiv:	<nrx>	Selects the A sweep speed in seconds per division. Range for the 2465 is from 5E−9 to 1.5. For the 2445, range is from 10E−9 to 1.5. If the resulting speed is faster than the current B sweep, the B sweep will be set equal to the A sweep. The effects of MAGnify: are independent of ASEcdiv:. See Appendix D for additional command considerations.
	BSEcdiv:	<nrx>	Selects the B sweep speed in seconds per division. Range for the 2465 is from 5E−9 to 0.15. For the 2445, range is from 10E−9 to 0.15. The sweep speed is updated whether the B sweep is active or not. If the B sweep requested is slower than the current A sweep speed, the A sweep will be set equal to the B sweep speed. The effects of MAGnify: are independent of BSEcdiv:. See Appendix D for additional command considerations.
	MAGnify:	ON OFF	Turns the X10 horizontal magnification function on or off. Default is ON.
	POSition:	<nrx>	Selects the starting position of the sweep. Units are divisions from the left edge of the screen and cover a range of approximately ± 5.4 divisions.
	TRACEsep:	<nrx>	Offsets the B sweep from the A sweep by the indicated amount. Range is from 0 to −4, and units are approximately divisions.
HORizontal?	ASEcdiv BSEcdiv MAGnify POSition TRACEsep		Query returns the current state of the horizontal selections: HOR ASE:<nr3>, BSE:<nr3>, MAG:string, POS:<nr3>, TRACE:<nr3>;, where the string is either ON or OFF.
HMOde			Selects Horizontal display mode from the list. Choices are mutually exclusive.
	ALTernate		Selects both normal and delayed sweeps for display. This is equivalent to pulling the SEC/DIV knob out.
	ASWeep		Selects only the A sweep for display.
	BSWeep		Selects only the B sweep for display. If both the A and the B sweeps are set to the same rate, then a settings conflict SRQ error is generated.
	XY		Selects XY mode.
HMOde?			Query returns: HMO string;, where the string represents one of the possible Horizontal display modes.

Table 2-4
Trigger Commands

Header	Argument	Argument	Description
ATRigger			Selects the A Trigger parameters.
	MODe:	AUTOBaseline AUTOLevel NORmal SGLseq	Selects Trigger Mode from the list of arguments.
	SOUrce:	CH1 CH2 CH3 CH4 LINe VERtical	Selects Trigger Source from the list of arguments.
	COUpling:	AC DC HFRej LFRej NOIserej	Selects Trigger Coupling Mode from the list of arguments.
	LEVel:	<nrx>	Sets Trigger Level in units of volts; range depends on the gain setting of the current Trigger Source. Range is ± 18 divisions when the Source is either Channel 1 or Channel 2, and ± 9 divisions when the Source is either Channel 3 or Channel 4. LINe SOUrce uses a fixed range of ± 10 divisions.
	SLOpe:	MINUs PLUs	Selects Slope of the trigger signal.
	BENdsa:	ON OFF	Sets the B ENDS A TRIGGER Mode to either ON or OFF.
	HOLdoff:	<nrx>	Sets Holdoff to the value of <nrx>. Range is from 0 to 10, with 0 representing minimum holdoff. This command is not calibrated.
ATRigger?			Query response is: ATR BEN:string, COU:string, HOL:string, LEV:<nr3>, MOD:string, SLO:string, SOU:string. Arguments TRIGD, READY, MAX, and MINI must be requested explicitly, e.g. ATR? MINI,MAX.
	COUpling LEVel MODe SLOpe SOUrce BENdsa HOLdoff		
	MINImum		Query only. Returns the current minimum level of the A Trigger channel in volts: ...,MINI:<nr3>,.... Data returned by MINI is valid only in AUTO LVL and only immediately following completion of an Auto Level cycle. An Auto Level cycle can be initiated by sending ATRigger MODe:AUTOLevel.

Table 2-4 (cont)

Header	Argument	Argument	Description
	MAXimum		Query only. Returns the current maximum level of the A Trigger channel in volts: ...,MAX:<nr3>,.... Data returned by MAX is valid only in AUTO LVL and only immediately following completion of an Auto Level cycle. An Auto Level cycle can be initiated by sending ATRigger MODe:AUTOLevel.
	TRIGD		Query only. Determines whether TRIG'D indicator is illuminated. Returns: TRIGD: string, where string is either ON or OFF.
	READY		Query only. Determines whether the single-sequence READY indicator is illuminated. Returns: READY string, where string is either ON or OFF.
BTRigger			Selects the B Trigger parameters.
	MODe:	RUN TRIGGerable	Selects the B Trigger Mode.
	SOUrce:	CH1 CH2 CH3 CH4 VERtical	Selects the B Trigger Source.
	COUpling:	AC DC HFRej LFRej NOIserej	Selects the B Trigger Coupling Mode.
	LEVel:	<nrx>	Sets the Trigger Level in units of volts, with the range depending on the VOLTS/DIV switch setting of the current trigger source. Range is either ± 18 divisions when the source is either Channel 1 or Channel 2, and ± 9 divisions otherwise.
	SLOpe:	MINUs PLUs	Selects slope of the trigger signal.
BTRigger?	COUpling LEVel MODe SLOpe SOUrce		Query response is: BTR COU:string, LEV:<nr3>, MOD:string, SLO:string, SOU:string.

Table 2-5
Delay and Delta Commands

Header	Argument	Argument	Description
DELAy	<nrx>		Sets value of the sweep delay in units of divisions. This command has the same effect as DTIME REF: <nrx>. Range is from −0.05 to 9.95. The value of −0.05 is used to guarantee the ability to view A trigger events with the B Sweep.
DELAy?			Query returns the current delay setting in divisions: DELA <nr3>. This response is not included in a SET? query.
DELTa			Sets parameters relating to the Delta displays.
	MODE:	OFF PERTime TIMe VOLts	Selects a Delta mode or turns off the Delta display.
	TRACKing:	ON OFF	Turns TRACKING on or off. Default is ON.
DELTa?	MODE TRACKing		Query returns: DELT MOD:string, TRACK:string, where the first string is either OFF, PERTIME, TIME, or VOLTS, and the second is either ON or OFF.
DTIme	REFerence:	<nrx>	Sets position of the first Delta Time cursor in units of divisions. Left edge of the display corresponds to −0.05, and the maximum value is 9.95. If TRACKING is on, the second cursor will also attempt to move.
	DELTa:	<nrx>	Sets position of the second Delta Time cursor relative to the first cursor in units of divisions. Range depends on the current position of the first cursor.
DTIme?	REFerence DELTa		Query returns the current Delta Time settings: DTI REF:<nr3>, DELT:<nr3>.
DVOlts	REFerence:	<nrx>	Sets position of the first Delta Volts cursor in units of divisions. The center of the display corresponds to zero, and the range is ± 4. If TRACKING is on, the second cursor will also attempt to move.
	DELTa:	<nrx>	Sets position of the second Delta Volts cursor relative to the first cursor in units of divisions. Range depends on the current position of the first cursor.
DVOlts?	REFerence DELTa		Query returns the current Delta settings: DVO REF:<nr3>, DELT:<nr3>.

Table 2-6
System Commands

Header	Argument	Argument	Description
ERRor?			Query returns: ERR <nr1>;. Response is identical to EVEnt? query. Command is included for compatibility with earlier instruments.
EVEnt?			Query returns: EVE <nr1>; where <nr1> is the most severe of the currently existing errors. Errors are prioritized into three levels, but only the most recent error is maintained for each level. If there is no error pending, 0 is returned. A list of other codes can be found in Appendix B.
ID?			Query returns: ID TEK/24w5,V81.1,SYS:FVx, BB:FVy, [string:FV<nr1>,] GPIB: FVz; Where w is either 4 or 6; x, y, and z are the version numbers of the oscilloscope, Buffer board, and GPIB option, respectively; and the section in brackets is repeated for each installed option. String V81.1 indicates that the GPIB interface is compatible with the V81.1 version of the Tektronix Codes and Formats standard.
INIt			Causes the instrument and all options (except the GPIB message processor) to go to an initialized state equivalent to a power-up condition. All internal settings will agree with the front-panel switch settings. Since the GPIB message processor is not initialized, GPIB system-command states (OPC, RQS, WARning, and LONgform) are not initialized. Commands following INIt in the same message may not be executed. This command should be immediately followed with EOI.
LLMessage	%<byte><byte>...		This command allows the character equivalent of a binary block to be written to the top line of the crt readout. The binary block must be in the same format as data returned by the LLMessage? query. The following TEKTRONIX 4050 series controller statements will write **HELLO** in large letters on the crt readout of an oscilloscope with a GPIB address of 1. 100 DIM H(19) 110 I=33 120 READ H 130 WBYTE @I:H 140 DATA 76,76,77,32,37,0,11,162,161 150 DATA 210,209,174,173,174,173,186 160 DATA 185,230,−59 See Appendix E for a description of the character set available for use with this command.
LLMessage?			Returns the contents of the top line of the crt readout. Response is a binary block of data in the form: LLM %<byte><byte>...<byte>. The first two bytes following the % character are a 16-bit count of the bytes that follow. The last byte of the block is the two's complement of the least significant byte of the sum of data bytes.

Table 2-6 (cont)

Header	Argument	Argument	Description
LLSet	%<byte><byte>...,		Returns the oscilloscope to a previous setup. The data can only be generated by a LLSet? query.
LLSet?			Queries instrument settings. Response is a block of binary data in the form: LLSET %<byte><byte>...,% <byte><byte>...,... The number of blocks depends on the installed oscilloscope options. The first two bytes following the % character are a 16-bit count of the bytes that follow. Each % block has its own count. The last byte of the block is the two's complement of the least significant byte of the sum of data bytes.
MESsage	"string"		This command will allow strings to be written to the top line of the crt. Up to 32 symbols may be displayed at one time. The string must be enclosed in quotes. See Appendix C for a description of the character set available for use with this command.
MESsage?			Returns an ASCII representation of the top line of the display: MES "message", where the message may be more than 32 characters due to character translations (See Appendix C).
OPC	ON OFF		When enabled, the instrument will assert SRQ on completion of certain commands. Only diagnostic commands and some options assert OPC service requests. Default is ON with no argument, but initializes to OFF at power-up.
OPC?			Query returns either: OPC ON or OPC OFF.
READOut	ON OFF		Turns the crt SCALE FACTORS readout ON or OFF. Default is ON.
READOut?			Query returns state of the SCALE FACTORS readout: READO string, where string is either ON or OFF.
RQS	ON OFF		When enabled, the instrument will assert SRQ on detection of an error condition. Default is ON, with no argument, and initializes to ON at power-up.
RQS?			Query returns either: RQS ON or RQS OFF.
SETtings?			Queries instrument settings. Response is an ASCII string that can be sent to the instrument to return it to the state it was when the query was received. The ASCII string consists of a series of properly formatted commands, which should not be preceded by SETtings when sent back to the instrument. *NOTE* *The SETtings? query will have an inconsistency when using variable sweep speeds. If the variable is used to set the A Sweep slower than the next slowest sweep speed, transfers via SETtings? will result in the variable being attached to the B Sweep, and the A Sweep will be set to its next slowest sweep speed.*

Table 2-6 (cont)

Header	Argument	Argument	Description
LONgform	ON OFF		When LONgform is ON, all queries will respond with the full length versions of commands. When LONgform is OFF, the shortest acceptable version of commands are used in query responses. Default is OFF.
LONgform?			Query returns either: LONGFORM ON or LONG OFF.
WARning	ON OFF		When enabled, the instrument asserts SRQ on detection of a warning condition. Default is ON, with no argument, and initializes to ON at power-up.
WARning?			Query returns either: WARN ON or WARN OFF.

Table 2-7
Calibration and Diagnostic Commands

Header	Argument	Argument	Description
BALance			Causes the oscilloscope to initiate its Automatic Balance procedure. An automatic initialization (see INIt) will occur after BALance. Available only from normal mode, not Diagnostic.
CALibrate	<nrx>:	<nrx>	Causes oscilloscope to go to Diagnostic mode and the Calibration routine indicated by the arguments. The first argument represents the option and is the most significant digit of the displayed routine number. The second represents the routine number and is the least significant digit of the displayed routine number. The option numbers are shown in hexadecimal in the crt readout of the Diagnostic menu. Option numbers are: Standard Oscilloscope 0 Option 10 (GPIB) 1 Option 05 (TV) 6 Option 01 (DMM) 7 Option 06 (C/T/T) 8 Option 09 (Word Recognizer) 8 Buffer Board 15

Table 2-7 (cont)

Header	Argument	Argument	Description
GO			Causes the currently selected CALIBRATION, EXERCISE, or TEST routine to begin execution. This command has the same effect as pushing up on the TRIGGER COUPLING switch when in Diagnostic mode.
LOOping	ON OFF		When in Diagnostic mode, this command causes looping of diagnostics to be either enabled or disabled. Default is ON.
LOOping?			Query returns: LOO string; where string is either ON or OFF.
NORmal			Causes instrument to exit Diagnostic mode. It has no effect if already in normal mode. Commands following NORmal in the same message may not be executed. It is recommended that NORmal be immediately followed with EOI.
STEp			Causes the currently executing Diagnostic routine to proceed to its next step.
STEp?			Query returns: STEP <nr1>; where nr1 is the current step.
STOp			Causes the currently executing Diagnostic routine to stop executing and return control to the Diagnostic monitor. This command should not be used to exit EXErcise 1:1 and EXErcise 1:2.
TESt	<nrx>:	<nrx>	Controls Diagnostic mode test sequences. The first argument represents the option, and the second is the routine number. See CALibrate command for option numbers.
TESt?	<nrx>:	<nrx>	Executes the requested test and returns the test's status value: TES <nr1>. Zero is returned for a passed test.

REMOTE-LOCAL OPERATING STATES

The following paragraphs describe the four operating states of the Option 10 instrument: Local, Local With Lockout, Remote, and Remote With Lockout.

Local State (LOCS)

In LOCS, instrument parameters are both set and changed manually by operator manipulation of the front-panel controls. Only IEEE-488 interface messages can be received and executed. Device-dependent commands (without REN asserted) will cause SRQ errors since their functions are under front-panel control while in LOCS. Additional information about GPIB errors is contained in Appendix B.

Local With Lockout State (LWLS)

The oscilloscope operates the same as it does in LOCS, except that manual manipulation of front-panel controls will not cause the instrument to return to the Local State. The interface will enter the Remote With Lockout State (RWLS) if it receives its listen address (MLA).

Remote State (REMS)

In this state, the oscilloscope executes all commands addressed to it over the GPIB. Front-panel indicators and crt readouts are updated as applicable when commands are executed. Manually changing any GPIB-controllable front-panel control causes the instrument to return to the Local State.

Remote With Lockout State (RWLS)

In RWLS, oscilloscope operation is identical to REMS operation, except that manual manipulation of any front-panel control does not change the previously established value of that parameter.

INSTRUMENT RESPONSE TO INTERFACE MESSAGES

The following paragraphs explain effects on the oscilloscope of standard interface messages received from a remote controller. Message abbreviations used are from ANSI/IEEE Std 488-1978.

Local Lockout (LLO)

In response to the Local Lockout (LLO) message, the instrument assumes a lockout state in accordance with the following table:

Before LLO	After LLO
Local State (LOCS)	Local With Lockout State (LWLS)
Remote State (REMS)	Remote With Lockout State (RWLS)

Remote Enable (REN)

When the Remote Enable (REN) line is asserted and the instrument receives its listen address, the oscilloscope is placed in either the Remote State (REMS) or the Remote With Lockout State (RWLS). When in either remote state, the oscilloscope's REM indicator is illuminated.

Disasserting the REN line causes a transition from any state to LOCS; the instrument remains in LOCS as long as REN is false. The transition may occur after processing of a different message has begun. In this case, execution of the message being processed is not interrupted by the transition.

Go To Local (GTL)

Instruments that are already listen-addressed respond to the Go To Local message (GTL) by assuming a local state. Remote-to-local transitions caused by GTL do not affect the execution of any message being processed when GTL was received.

My Listen and My Talk Addresses (MLA and MTA)

The primary Talk/Listen address is established as previously explained in this section.

Unlisten (UNL) and Untalk (UNT)

When the Unlisten (UNL) message is received, the oscilloscope's listen function is placed in an idle (unaddressed) state. In the idle state, the instrument will not accept commands over the GPIB.

The talk function is placed in an idle state when the oscilloscope receives the Untalk (UNT) message. In this state, the instrument cannot transmit data via the GPIB.

Interface Clear (IFC)

When the Interface Clear (IFC) line is asserted, both the Talk and Listen functions are placed in an idle state and the front-panel REM indicator is turned off. This produces the same effect as receiving both the UNL and the UNT messages.

Device Clear (DCL)

The Device Clear (DCL) message reinitializes communication between the instrument and the controller. In response to DCL, the instrument clears any input and output messages as well as any unexecuted control settings. Also cleared are any errors and events waiting to be reported (except the power-on event). If the SRQ line is asserted for any reason (other than power-on), it becomes unasserted when the DCL message is received.

Selected Device Clear (SDC)

This message performs the same function as DCL; however, only instruments that have been listen-addressed respond to SDC.

Serial Poll Enable and Disable (SPE and SPD)

The Serial Poll Enable (SPE) message causes the instrument to transmit its serial-poll status byte when it is talk-addressed. The Serial Poll Disable (SPD) message switches the instrument back to its normal operation.

PROGRAMMING

Programming considerations and program examples are provided in this part to assist you in developing your own unique programs for controlling 2445 and 2465 Oscilloscopes over the GPIB. Program examples were designed using TEKTRONIX 4050-series and TEKTRONIX 4041 controllers with 2445 and 2465 Oscilloscopes containing Option 10. While programming was done using Tektronix controllers, other controllers capable of being programmed to perform the same functions can also be used.

Before a program can be used for controlling the oscilloscope, the GPIB parameters (primary address, message terminator, and talk/listen mode) must be set. Procedures describing how these parameters are selected and set at the oscilloscope are given in "GPIB Preparation for Use" in this section of the manual.

Programs are usually composed of two main parts (or routines), which can be generally categorized as a command handler and a service-request handler.

Command Handler

Basically, a command handler should establish communication between the controller and oscilloscope, send commands and queries to the oscilloscope, receive responses from the oscilloscope, and display responses as required. The following outline indicates the general sequence of functions that the command-handling routine should perform to accommodate communications between the controller and oscilloscope over the GPIB.

1. Initialize the controller.
2. Disable the service-request handler until the program is ready to handle them.
3. Get the GPIB address of the oscilloscope.
4. Enable the service-request handler.
5. Get the command to send to the oscilloscope.
6. Send the command to the oscilloscope.
7. Check for a response from the oscilloscope.
8. If there is a response, perform the desired function.
9. You are ready for a new command. Repeat the functions in statements 5 through 9 as many times as desired.

Service-Request Handler

The typical service-request handler routine contains the necessary instructions to permit proper processing of interrupts. For example, whenever power-on occurs, the oscilloscope asserts an SRQ interrupt. If a GPIB program is operating on the controller when a power-on SRQ is received, the program should be able to determine that the oscilloscope's power was interrupted at some time during program operation. This event could cause improper program execution, unless the program was written to adequately handle the possibility of a power-on SRQ occurring.

Other interrupts (or events) for which the oscilloscope asserts SRQ are identified in Appendix B.

While some controllers have the capability of ignoring service requests, others require that all SRQs be managed. The programmer should understand the controller being used. If service requests are to be handled in the program, the interrupts must first be enabled.

A service-request handler routine can be developed to service interrupts when they occur during program operation. It basically should consist of an interrupt-enabling statement (ON SRQ) near the beginning of the program and a serial-poll subroutine somewhere in the program. The ON SRQ statement directs program control to the serial-poll subroutine whenever an SRQ interrupt occurs. For each interrupt received by the controller, the program should perform a serial-poll subroutine.

The following general steps are required to handle service requests from the oscilloscope:

1. Perform a serial poll.
2. Send an EVENT? query to the oscilloscope requesting service.
3. If the EVENT? query response is not zero, then perform the desired response to the event.
4. Return to the main program.

Sample Program A

The program that follows is written to run on TEKTRONIX 4050-series controllers. It first asks for the GPIB address of the oscilloscope, then repeatedly asks for a command to be entered. When a command is entered at the controller, the program sends it to the oscilloscope. Any response from the oscilloscope is printed on the controller's display. If there are any service requests, a serial poll is

performed. The service request and the EVENT codes are then printed before returning to the main part of the program.

```
100 REM   Program to send commands and queries
    to and receive
110 REM   responses from TEKTRONIX 2445 and
    2465 Oscilloscopes
120 INIT
125 PAGE
130 REM   Disable SRQ Handler until ready
140 ON SRQ THEN 570
150 REM * Page when screen is full *
160 PRINT @32,26:2
170 REM
180 REM
190 PRINT "Enter address of the
    oscilloscope ";
200 REM * Get address and put in variable A *
210 INPUT A
220 REM * Enable SRQ handler *
230 ON SRQ THEN 440
235 DIM S$(2000)
240 REM
250 PRINT
260 PRINT "*******"
270 PRINT "ENTER COMMAND OR QUERY: ";
280 REM * Put command or query in string Z$ *
290 INPUT Z$
300 REM * Send string Z$ to the oscilloscope *
310 PRINT @A:Z$
320 REM * Get response (if any) and put in
    string S$ *
330 INPUT @A:S$
340 REM * Check if there is a response *
350 REM *   If not then ready to send another
    command or query *
360 REM *   If yes then print the response *
370 IF LEN(S$)=0 THEN 250
380 PRINT
390 PRINT "RESPONSE FROM THE OSCILLOSCOPE
    IS: "
400 PRINT S$
410 REM * Ready to send another command or
    query *
420 GO TO 250
430 REM *** SRQ HANDLER ***
440 POLL D,C;A
450 REM * Look for an Event and put Event in E *
460 REM *     If EVENT=0 then no error *
470 REM *     If EVENT<>0 then warn the user
and
480 REM *           print SRQ Code and
    EVENT NO.
490 REM *
500 PRINT @A: "EVENT?"
510 INPUT @A:E
520 IF E=0 THEN 570
530 PRINT " ERROR - SRQ CODE ";
540 PRINT C;
550 PRINT " - EVENT NO. ";
560 PRINT E
570 RETURN
```

Sample Program B

The program example that follows performs functions similar to Sample Program A, but is written to run on a TEKTRONIX 4041 controller.

```
100   !     Program to send commands and
    queries to and receive
110   !     responses from TEKTRONIX 2445 and
    2465 Oscilloscopes
120   !
130     Init all
140   !     Disable SRQ handler until ready
150     Disable srq
160   ! Get address of the oscilloscope
170     Print "Enter the GPIB address of the
    2445/65: ";
180     Input addr$
190   ! Set up physical and logical unit -
200   ! Set up so only EOI can terminate the
    communication.
210   !
220     Set driver "gpib0(eom=<0>):"
230     Open
    #1:"gpib0(pri="&addr$&",eom=<0>):"
240   !
250   !   Enable SRQ handler
260     On srq then gosub srqhdl
270     Enable srq
280   !
290 Repeat:   ! Sending command or query
300     Print "******"
310     Print
320     Print "Enter command or query :";
330   ! Get the command
340     Input a$
350   ! Send command or query to scope
360     Print #1:a$
370   ! Get response if there is any
380     DIM resp$ to 2000
390     Input #1:resp$
400     Print
410   ! If no response then prompt for another
    command
420     If len(resp$)=0 then goto repeat
```

```
430   ! If yes then print the response
440     Print "Response from the oscilloscope
    is:"
450     Print resp$
460     Goto repeat
470 Srqhdl:   ! routine to handle the srq
480             Poll stb,dev
490             Print #dev:"event?"
500       ! Get event number
510             Input #dev:event
520             Print "Instrument #";dev;"
    status byte = ";stb;", event = ";event
530             Resume
```

Using SETtings? and LLSet? Queries

Using the SETtings? and LLSet? queries simplifies programming. These queries return a string that, in turn, can be sent back to the oscilloscope to set its front-panel parameters to the values that existed when the query was received.

The string returned from the SETtings? query is in user-readable ASCII and allows easy verification by the programmer. When simply sent back to the instrument using no other command, this string will return the instrument parameters to the previous state.

The LLSet? query returns a binary string that is not easily read by the programmer, but is much shorter. It therefore allows faster instrument setup using the LLSet command. This binary string, returned via the LLSet? query, may only be sent back to the instrument using the LLSet command.

Sample Program C

The following program illustrates use of the LLSet command and query to transfer the front-panel control set up from one 2445/2465 Oscilloscope to another. It is written for use on TEKTRONIX 4050-series GPIB controllers.

```
4 GOTO 100
100 INIT
110 ON SRQ THEN 720
120 REM: DISABLE SRQ HANDLER UNTIL READY
130 PAGE
140 PRINT "THIS PROGRAM TRANSFERS A
    FRONT-PANEL SETUP FROM ONE"
150 PRINT " 2445/2465 TO ANOTHER 2445/2465."
160 PRINT
170 PRINT "SET THE GPIB ADDRESS OF THE
    'REFERENCE' INSTRUMENT TO 2, AND"
180 PRINT "THE ADDRESS OF THE 'INSTRUMENT TO BE
    SET UP' TO 4."
190 PRINT
200 PRINT "PRESS RETURN TO CONTINUE"
210 INPUT I$
220 X=2
230 REM: X= ADDRESS OF 'REFERENCE' INSTRUMENT
240 Y=4
250 REM: Y= ADDRESS OF 'INSTRUMENT TO BE
    SET UP'
260 ON SRQ THEN 570
270 REM: ENABLE SRQ HANDLER
280 DELETE F
290 DIM F(400)
300 REM: DIMENSION F LARGE ENOUGH TO HANDLE ANY
    POSSIBLE SETUP
310 F=0
320 PRINT @X:"LLSET?"
330 REM: TELL THE 2445/2465 TO SEND A BINARY
    PANEL SETUP
340 WBYTE @64+X:
350 REM: ASSIGN DEVICE #X ON THE BUS TO BE
    A TALKER
360 C=0
370 REM: INITIALIZE COUNTER
380 REM: T= TEMPORARY STORAGE FOR INCOMING
    BYTE
390 RBYTE T
400 REM: READ IN A BYTE
410 C=C+1
420 REM: INCREMENT COUNTER
430 F(C)=T
440 REM: STORE BYTE IN ARRAY
450 IF T<0 THEN 500
460 REM: CHECK TO SEE IF BYTE IS NEGATIVE. IF IT
    IS, THEN THE ARRAY
470 REM: TRANSFER IS COMPLETE.
480 GO TO 390
490 REM: GO GET ANOTHER BYTE UNTIL THE ARRAY
    TRANSFER IS COMPLETE
500 DIM F(C)
510 REM: RE-DIMENSION ARRAY TO THE EXACT SIZE
    OF THE DATA.
520 WBYTE @63,95,32+Y:F
530 REM: SEND SET-UP TO GPIB DEVICE #Y
540 PRINT
550 PRINT "PRESS UDK #1 TO RESTART PROGRAM"
560 END
570 REM
580 REM SRQ HANDLER ROUTINE
590 REM
600 POLL A,B;X;Y
610 REM: PERFORM SERIAL POLL
620 IF A=2 THEN 680
630 PRINT @X: "EVENT?"
```

```
640 REM: GET "EVENT" RESPONSE IF DEVICE #X
    ASSERTED SRQ
650 INPUT @X:D
660 PRINT "INSTRUMENT #";X;" STATUS BYTE =
    ";B;", EVENT = ";D
670 RETURN
680 PRINT @Y:"EVENT?"
690 REM: GET "EVENT" RESPONSE IF DEVICE #Y
    ASSERTED SRQ.
700 INPUT @Y:D
710 PRINT "INSTRUMENT #";Y;" STATUS BYTE =
    ";B;", EVENT = ";D
720 RETURN
```

Sample Program D

The following program is similar to Sample Program C, except that it is written for use on the TEKTRONIX 4041 controller. It assumes a terminal has been connected to the 4041 and is properly set up. The 4041 technical manuals should be consulted for complete information regarding 4041 operation and programming.

```
100   ! PROGRAM TO TRANSFER A FRONT-PANEL SETUP
    FROM ONE 2445/2465 TO
110   ! ANOTHER 2445/2465.
120   !
130     INIT ALL
140     DISABLE SRQ
150   !
220   !
230     PRINT
240     PRINT "SET THE GPIB ADDRESS OF THE
    'REFERENCE' INSTRUMENT TO 2, "
250     PRINT "AND THE ADDRESS OF THE
    'INSTRUMENT TO BE SET UP' TO 4."
260     PRINT
270     REF$="2"
280     SET$="4"
290   !
300   ! SET UP PHYSICAL AND LOGICAL UNITS -
310   ! SET UP TERMINATOR FOR EOI
320   !
330     SET DRIVER "GPIBO (EOM=<O> ):"
340     OPEN
    #2:"GPIBO (PRI="&REF$&",EOM=<O> ):"
350     OPEN
    #4:"GPIBO (PRI="&SET$&",EOM=<O> ):"
360   !
370     ON SRQ THEN GOSUB SRQHAND
380     ENABLE SRQ
390   !
400 TRANSFER:    ! ROUTINE TO TRANSFER SETUP
410     INPUT PROMPT "PRESS RETURN TO TRANSFER
    FRONT-PANEL SETUP ":START$
420   !
430    DIM STRING$ TO 400
440   ! DIMENSION "STRING$" LARGE ENOUGH TO
    HANDLE ANY POSSIBLE SETUP
450     PRINT #2:"LLSET?"
460     INPUT #2:STRING$
470     DIM STRING$ TO LEN (STRING$ )
480     PRINT #4:STRING$
490     PRINT "TRANSFER COMPLETE"
500     PRINT
510     INPUT PROMPT "DO YOU WISH TO CONTINUE:
    (Y OR N )":CONT$
520     IF CONT$="N" THEN STOP
530     GOTO TRANSFER
540 SRQHAND:    ! ROUTINE TO HANDLE THE SRQ
550     POLL STB,DEV
560     PRINT #DEV:"EVENT?"
570   ! GET EVENT NUMBER
580     INPUT #DEV:EVENT
590     PRINT "INSTRUMENT #";DEV;" STATUS BYTE
    = ";STB;", EVENT = ";EVENT
600     RESUME
```

Front Panel Lockout

The front panel may be locked out so that only the controller is able to change instrument settings. To lock out the front panel, first assert REN (true). The REN line must remain true as long as lockout is desired. For 4050-series controllers, the RUN statement automatically asserts REN; the END statement unasserts REN.

Next, send the LLO interface message. In the 4050-series controller this is accomplished with the WBYTE statement.

Finally, address the instrument by sending any setting command or query and use a Print @D statement; or send only the Listen address, using the WBYTE statement.

After these three steps are executed, the front panel is locked out and remains so until either REN goes false or a GTL interface message is sent. While the front panel is locked out, moving any front-panel switch will generate an SRQ. In a program, this event may be used to indicate to a controller that an operator is ready for the next setup.

Reset Under GPIB Control

The oscilloscope may be set to its power-up state by sending the INIt command via the GPIB. This command always initiates the power-up self tests. On completion of power-up tests, SRQ code 65 (operation complete) is generated, and the oscilloscope enters the normal operating state. If there is a self-test error, the option also generates SRQ code 65 and does not shift the instrument to the normal operating state (see "Power-up Sequence" in this section). Invoking the INIt command can simplify a program. When using INIt, fewer commands will usually be needed to set the instrument state, since all front-panel settings may not need to be individually specified.

THEORY OF OPERATION

INTRODUCTION

SECTION ORGANIZATION

This section contains a functional circuit description of the Option 10 (GPIB) circuitry for the 2445 and 2465 Oscilloscopes. The discussion begins with an overview of the option functions and continues with detailed explanations of each major circuit. Reference is made to supporting schematic and block diagrams which will facilitate understanding of the text. These diagrams show interconnections between parts of the circuitry, identify circuit components, list specific component values, and indicate interrelationships with the standard oscilloscope.

The block and schematic diagrams are located in the tabbed "Diagrams" section at the rear of this manual. The particular schematic diagram associated with each circuit description is identified in the text, and the diagram number is shown (enclosed within a diamond symbol) on the tab of the appropriate foldout page. For optimum understanding of the circuit being described, refer to both the applicable schematic and block diagrams.

DIGITAL LOGIC CONVENTIONS

Digital logic circuits perform many functions within the instrument. The operation of these circuits is represented by specific logic symbology and terminology. Logic-function descriptions contained in this manual use the positive-logic convention. The specific voltages which constitute a HI or a LO vary between individual devices. For specific device characteristics, refer to the manufacturer's data book.

GENERAL CIRCUIT DESCRIPTION

Before individual circuits are discussed in detail, a general block-level discussion is provided to aid in understanding overall operation of the option circuitry. A simplified block diagram of the option, showing basic interconnections, is shown in Figure 7-4. The diamond-enclosed numbers in the blocks refer to the schematic diagrams at the rear of this manual in which the corresponding circuitry is located. Throughout this discussion, standard oscilloscope refers to 2445 and 2465 Oscilloscope circuitry without option circuitry.

The activities of the option are directed by the microprocessor contained in the standard oscilloscope. The microprocessor, under the control of firmware present in the option, monitors the option's functions and sets up the operating modes according to instructions received.

While executing the control program, the microprocessor retrieves previously stored calibration constants and front-panel settings and, as necessary, places program-generated data in temporary storage for later use. The electrically alterable read-only memory (EAROM), random access memory (RAM), and ultraviolet erasable programmable read only memory (EPROM) contained in the Buffer and option circuit boards provide these storage locations.

BUFFER BOARD

The option circuit board connects to the standard oscilloscope through the Buffer circuit board. The Buffer board performs the following functions:

1. Buffers and modifies the timing of the microprocessor bus.

2. Distributes the microprocessor bus, power supplies, and analog signals from the standard oscilloscope to the options.

3. Provides additional ROM for interfacing options to the standard instrument.

4. Provides an EAROM for options use.

5. Provides a mechanical interface.

The microprocessor control bus, address bus, and data bus are buffered by Buffer board circuitry. Microprocessor bus timing for the option is modified by buffers on the Buffer board to make bus timing more compatible with the options. The EAROM bus allows the microprocessor to access the option EAROM located on the Buffer board. Address bus decoding allows individual circuits to be addressed.

These signal paths are used for communications between the option and the standard oscilloscope and involve both data and control signals. The main oscilloscope circuitry uses them to control the option. The option uses them to send information to the standard oscilloscope for display and to control the standard oscilloscope.

GPIB BOARD

The GPIB option adds a GPIB port to the instrument. The standard oscilloscope and the option are interconnected by the Buffer board. The GPIB board is divided into analog and digital sections.

Vertical position control signals and the trace separation control signal in the standard oscilloscope are digitized and regenerated in the analog section. This allows the GPIB to control the position of each trace on the crt.

The digital section contains the microprocessor interface including RAM and EPROM that permits the microprocessor to control the option. A GPIB interface IC, buffers, and connector provide the actual interface connection to the GPIB. Status indicators located on the front panel indicate the current status of the GPIB interface.

DETAILED CIRCUIT DESCRIPTION

INTRODUCTION

The following discussion provides detailed information concerning the electrical operation and circuit relationships of 2445 and 2465 GPIB circuitry. The descriptions are supported by the associated detailed block diagram (Figure 7-5) and schematic diagrams located at the rear of this manual in the tabbed foldout pages.

BUFFER BOARD DIGITAL DISTRIBUTION

The Buffer Board Digital Distribution circuitry (see Diagram 20) interconnects the standard oscilloscope and the GPIB board. Most of the microprocessor signals are buffered and have their timing modified. In addition, some of the memory used for option functions is included on the Buffer board.

Electrically Alterable ROM

Nonvolatile storage for the calibration constants and power-down settings is provided by EAROM U4207. By using different clock sources, the microprocessor is able to select either EAROM U2008 in the standard oscilloscope or Buffer board EAROM U4207. The clock source for the Buffer board EAROM comes from U2308 pin 5 (see Diagram 2 in the standard oscilloscope manual). Mode control inputs C1 and C3 are interchanged between the two EAROMs to prevent data contention. A TTL-to-MNOS level shift of the clock signal is provided by Q4201. For additional information on EAROM operation, consult the "Theory of Operation" section of the standard oscilloscope service manual.

Address Decoding

Gates U4240A and U4240C partially decode the address bus. Enable BVMA U4240C pin 8 is HI for addresses from 1000-7FFF (this and all other address references are in hexadecimal), the address space used by the options and the Buffer board.

Enable $\overline{\text{BUFEN}}$ U4250C pin 8 is LO for the address space of 1000-1FFF. Address strobe $\overline{\text{LOWAD}}$ is active LO for the address space of XFFC-XFFF (where X is a don't care). These decoded address signals are used in selecting ROM U4260 on the Buffer board and disabling data bus buffer U4255.

Buffer Board ROM

Buffer board ROM U4260 is used to interface the option to the main oscilloscope. Its output enable (at pin 20) is $\overline{\text{ROMEN}}$. The signals $\overline{\text{ROMEN}}$ and $\overline{\text{BUFEN}}$ are the same if P4256 is present. With $\overline{\text{ROMEN}}$ and $\overline{\text{BUFEN}}$ the same, the Buffer board ROM address space is 1000-1FFF. Whenever the Buffer board ROM is addressed, shift register U4275 (that controls the data bus buffer) is reset by $\overline{\text{ROMEN}}$. This prevents the Buffer board data bus buffer and the Buffer board ROM from driving the microprocessor side of the data bus at the same time.

Bus Buffers

The 10-MHz clock signal of the standard oscilloscope is buffered by U4265D. The buffered clock (B10MHZ) clocks the shift register (U4275) and is also sent to the options.

The $\overline{\text{E}}$ clock, $\overline{\text{RESET}}$, VMA, and R/$\overline{\text{W}}$ are buffered by latch U4225. The pull-up on U4225 pin 12 allows $\overline{\text{RESET}}$ and $\overline{\text{E}}$ to pass through the latch unmodified. The buffered E clock is delayed more than 30 ns by R4265, C4265, and U4265C. This delayed BE clock latches $\overline{\text{VMA}}$, R/$\overline{\text{W}}$ (U4225) and the address bus (U4235 and U4245), which provides extra hold time on these signals for the options.

Data Bus Buffer

Data bus buffer U4255 is a bidirectional bus driver that is controlled by the signals on pin 1 and pin 19. Pin 1 controls the direction of data flow through the buffer, and pin 19 turns the drivers on and off. When pin 1 is HI, the buffer is configured to drive data from the microprocessor to the options. Conversely when pin 1 is LO, the buffer is configured to drive data from an option to the microprocessor. Pin 1 is always HI, except when the microprocessor is reading data from an option.

Signals on pin 1 and pin 19 coordinate the states of U4255 so that data bus contention never occurs. Buffer U4255 drives two buses: the bus between U4255 and the Control board of the standard oscilloscope, and the bus between U4255 and the options. Both of these must be kept free of contentions (i.e., it is not allowed for more than one device to drive the bus at the same time). These two buses will be examined individually.

The bus between the Control board and U4255 is driven by the Control board during a write bus cycle, driven by the Control board during a read cycle from nonoption space (0000-0FFF and 8000-FFFF), driven by U4255 during a read cycle from option space (2000-7FFF), and driven by U4260 during a read from Buffer board ROM (1000-1FFF). The Control board changes its drivers from output to input on the rising edge of E (this is the high-true E, not the low-true $\overline{\text{E}}$ used by the option) when going from a write to a read cycle. It changes from input to output on the falling edge of R/W when going from a read to a write cycle. Data buffer U4255 drives the Control board data bus only when BVMA and BR/W are both true, i.e., a read cycle from the option is being performed. This is done by driving U4255 pin 1 from BVMA NANDed with BR/W (after passing through a delay consisting of two cycles of the 10 MHz clock). Pin 19 of U4255 is driven by $\overline{\text{E}}$ delayed for two cycles of the 10 MHz clock. This two-cycle delay ensures that U4255 will be driving the Control board data bus only in a read cycle from option address space, during a time interval starting after the rising edge of E and ending after the falling edge of E. A delay of two cycles of the 10 MHz clock is necessary to guarantee that the Control board data bus drivers have turned off before U4255 starts driving the bus. This is a period of time when the Control board never drives the data bus during a read cycle. Shift register stages in U4275 are cleared by $\overline{\text{ROMEN}}$, forcing U4255 pin 19 HI while Buffer board ROM is being read.

The bus between U4255 and the options must be driven by U4255 during a write cycle to the options (2000-7FFF) and may be driven by an option only during a read cycle from the option (2000-7FFF). Bus driver U4255 actually drives the bus to the options during all cycles except read cycles from 1000-7FFF. The bus is driven by an option only while E is true during an option read cycle. Address bus driver U4255 drives the bus during an option write cycle while U4255 pin 19 is LO, but in this case pin 19 is delayed from $\overline{\text{E}}$ only by one cycle of the 10 MHz clock. The delay is only one cycle in this case so that the data will be driven to the options as soon as it is available from the microprocessor.

GPIB CIRCUIT BOARD

The GPIB board (see Diagram 22) provides a GPIB port to the instrument and its options. It also digitizes and regenerates the four vertical channel position control signals and the trace separation control signal in the standard oscilloscope.

The board is divided into analog and digital sections, with separate grounds for each section. The analog section is comprised of the input and output multiplexers, the holding capacitors, the capacitors' voltage followers, the digital-to-analog converter (dac) buffer, and the comparator. The remaining circuits make up the digital section.

Digital Section

ADDRESS BUS AND DECODING. The microprocessor address bus is buffered by U4501 and U4505.

The address decode circuitry generates enabling signals and strobes that allow the microprocessor to control the various circuit functions and devices as in the standard oscilloscope (see "Address Decode" description in the service manual of the standard oscilloscope). The memory map for the GPIB option is shown in Table 3-1.

Table 3-1
GPIB Option Memory Map

Address	Description	Device No.
1000-1FFF	Buffer board ROM	U4260
2000-3BFF	Non-paged EPROM	U4710
3C00-3F7F	RAM	U4811
3FB0-3FB7	GPIB interface IC	U4818
3FCX	Input multiplexer latch	U4625
3FDX	Output multiplexer latch	U4626
3FEX	Status register	U4701
4000-7FFF	Paged EPROM	U4715
7FFF	Page register	U4838

Page register U4838B enables and disables access to paged EPROM U4715 and is selected by U4601. Whenever there is a write to address 7FFF, data bus line D0 is latched by the page register. If D0 is latched HI, paged EPROM U4715 will be selected for memory accesses within the paged address space. The paged EPROM's address is decoded by U4705B. Both the paged address range and the page register output signals are combined in U4705C to give PAGE (TP4748), the enable signal for the paged EPROM (U4715 pin 20).

Nonpaged EPROM U4710, RAM U4811, and I/O decoder addresses are decoded by U4605, U4606, U4738, and U4706. Address lines (BA7 to BA12) determine whether the nonpaged EPROM, RAM, or the I/O decoder is selected. A LO $\overline{\text{ROM}}$ signal (TP4841) indicates that EPROM U4710 is selected. A LO $\overline{\text{RAM}}$ signal (TP4843) indicates that RAM U4811 is selected. One-of-eight decoder U4708 decodes the I/O. Its gate inputs, pins 4 through 6, select the address range from 3F80 through 3FFF. Only four of the eight outputs are used:

Pin 9 selects status register U4701.

Pin 10 selects output multiplexer register U4626.

Pin 11 selects input multiplexer register U4625.

Pin 12 selects GPIB interface IC U4818.

A write strobe, $\overline{\text{GW}}$, is generated by U4831C. A LO $\overline{\text{GW}}$ indicates bus data should be written to the enabled device. Similarly, read strobes, $\overline{\text{GR}}$ and GR, are generated by U4706D and U4705D. They are used to identify microprocessor read cycles. All three strobes are generated from $\overline{\text{ECK}}$ and R/$\overline{\text{W}}$.

The three major address-space strobes, for the page register and the unpaged and paged ROMs, are brought together at U4738B to generate OPTS. It will be HI whenever the option is addressed.

DATA BUS BUFFERS. The data bus is buffered by bidirectional buffer U4608. This buffer is enabled by OPTS and $\overline{\text{E}}$ through U4706A and U4705A. The direction of data is controlled by the delayed R/$\overline{\text{W}}$ signal. This delayed R/$\overline{\text{W}}$ signal, which extends the time data buffer U4608 is enabled, is generated through latch U4801 pins 4, 5, 3, and 2 which are connected to form a two-bit shift register clocked by the 10 MHz clock. This delay is required whenever there is a write to either the RAM or the GPIB interface IC.

WAIT STATE GENERATOR. A wait state is required anytime the GPIB interface IC is written to. The wait state (MR LO U4730D) is started by $\overline{\text{GW}}$ and $\overline{\text{GPIB}}$ through U4831B, U4706B, and U4730D. It continues until the same signals are clocked through shift register U4801, latch U4838A, and U4730D. The shift register and latch combination provide a delay of 500-600 ns.

GPIB INTERFACE IC AND BUFFERS. The actual interface to the IEEE 488 bus is accomplished by GPIB interface IC U4818 and buffers U4805 and U4808. The GPIB interface IC is enabled by $\overline{\text{GPIB}}$, which is generated by U4708. Bus data is gated out of and into the IC by GR and $\overline{\text{GW}}$. The microprocessor enable line, $\overline{\text{ECK}}$ is used as a clock at pin 18. Address lines A0, A1, and A2 are applied to register select pins 6, 7, and 8 to select registers internal to the interface IC. Data bus lines are reversed, D0 for D7, to accommodate the GPIB interface IC's internal convention. The TRIG signal, pin 39, is sensed by STATUS register pin 4 for a diagnostic check of the GPIB interface IC. Bus buffers U4805 and U4808 provide the drive characteristics required by IEEE 488 bus standards.

GPIB BUFFER POWER SWITCH. To prevent glitches occurring at power up from disturbing the GPIB bus, a fast-rise-time power-supply switch is provided for GPIB buffers U4805 and U4808. At power up, $\overline{\text{RST}}$ clears U4801 via pin 1. With U4801 reset, both Q4745 and Q4743 are held OFF, preventing the buffers from receiving power. Both inputs to U4735D are LO after reset, keeping U4801 pin 17 LO and

the buffer power switch off. The first time that status register U4701 is enabled and read, pin 13 of both U4701 and U4735D go LO. This causes U4801 pins 16 and 17 to change states and to stay HI, applying power to the GPIB buffers.

STATUS REGISTER. This tristate buffer (U4701) is used for the following diagnostic and operational functions:

Read the state of analog comparator U4631 via pin 15.

Check GPIB interface IC U4818 via pin 5.

Check the GPIB buffer's switched 5 V supply via pin 3.

Check wait state generation via pin 7.

Check latches U4625 and U4626 and light-emitting diode (LED) driver U4730 via pins 9 and 11.

Control the GPIB buffer's switched supply via pin 13.

LIGHT-EMITTING DIODE DRIVERS AND LED BOARD. GPIB status indicator signals are latched along with multiplexer select codes in both the input multiplexer latch, U4625, and the output multiplexer latch, U4626. Open collector, inverting buffers U4730A, U4730B, and U4730C drive the remotely located LED board. Series resistors at the output of each buffer limit LED current. Two of the buffer outputs are sensed by the Status register U4701 for diagnostic purposes.

Analog Circuitry

The output of the digital-to-analog converter from the standard oscilloscope is scaled by U4641B to the ± 5 volt range needed by the Vertical Position control and Trace Separation circuitry. The buffered and scaled dac signal is used to charge holding capacitors through the output multiplexer U4621, and as a reference for comparator U4631.

Analog comparator U4631, whose output is read on pin 15 of the status register U4701, is used to compare input signals selected by input multiplexer, U4525, with the scaled-dac level. Its primary function is to digitize the Vertical positioning and Trace Separation signals input on U4525 pins 13, 14, 15, 12, and 1. Digitization is accomplished by a successive-approximation technique where the dac voltage is moved and compared with the voltage to be measured until the desired accuracy is achieved.

The comparator and input multiplexer are also used to test other circuits on the board. The ground on U4525 pin 2 is digitized to test the input multiplexer, latch, and dac. Pin 5 is used to check the switched GPIB buffer supply. Pin 4 is used in checking the analog outputs for the Vertical positioning and Trace Separation signals after first setting them to known values during the analog-to-digital and digital-to-analog conversion process.

The dac is also used to reproduce the position levels. First the dac and its buffer generate a voltage equal to the desired position. Then the output multiplexer, U4621, steers the voltage to one of the holding capacitors. The capacitors are buffered by voltage followers, U4635 and U4641. Diodes at the outputs of each voltage follower provide protection against voltage swings that would damage components in the main oscilloscope.

PERFORMANCE CHECK AND CALIBRATION PROCEDURES

INTRODUCTION

This section contains the Option 10 (GPIB) portion of the instrument's performance check and calibration procedures. The "Performance Check Procedure" is used to check the instrument's performance against the requirements listed in the "Specification" (Section 1). The "Calibration Procedure" is used to restore optimum performance or return the option to conformance with its "Performance Requirements" as listed in the "Specification" (Section 1).

Instrument performance should be checked after every 2000 hours of operation or once each year if used infrequently. A more frequent interval may be necessary if the instrument is subjected to harsh environments or severe usage. The results of these periodic checks will determine the need for recalibration.

Before performing these procedures, ensure that the LINE VOLTAGE SELECTOR switch is set for the ac power source being used (see "Preparation for Use" in Section 2 of the standard instrument's Service manual). Connect the instrument to be checked and the test equipment to an appropriate power source.

LIMITS AND TOLERANCES

The tolerances given in these procedures are valid for an instrument that is operating in and has been previously calibrated in an ambient temperature between −15°C and +55°C. The instrument also must have had at least a 20 minute warm-up period. To assure instrument performance, perform all steps in the following procedures at the same ambient temperature. When performing the GPIB Option checks and calibration, it is assumed that the standard instrument meets all of its "Performance Requirements" as stated in the "Specification" (Section 1) of the standard instrument's Service manual.

PERFORMANCE CHECK PROCEDURE

This procedure is used to verify proper operation of the option and may be used to determine the need for calibration. This check may also be used as an acceptance test and as a preliminary troubleshooting aid. Perform all steps, both in the sequence presented and in their entirety, to ensure that control settings are correct for the following step.

PREPARATION

Removing the wrap-around cabinet is not necessary to perform this procedure. All checks are made using the operator accessible front- and rear-panel controls and connectors.

Test equipment listed in Table 4-1 is required to perform this procedure. Since detailed operating instructions for the test equipment are not provided in this procedure, refer to the appropriate test-equipment instruction manual if additional information is required.

Turn the oscilloscope on by pressing in the POWER button. Check that it enters its normal operating mode and that no error message is displayed on the crt. If an error message is present, have the instrument repaired or calibrated by a qualified service technician before performing this procedure.

Set the oscilloscope's GPIB address to 1, the end-of-message terminator to EOI, and the talk/listen mode to TALK LISTEN (see "GPIB Parameter Selection" in Section 2).

Table 4-1
Test Equipment Required

Item and Description	Specification	Examples of Applicable Test Equipment
1. GPIB Controller	IEEE-488-1978 compatible.	TEKTRONIX 4050-Series Computers.
2. GPIB Cable	IEEE-488-1978 compatible.	Tektronix Part Number 012-0630-03.

GPIB OPTION CHECKS

Initial Control Settings

Control settings not listed do not affect the procedure.

Set:

VERTICAL MODE	
CH 1	On (button in)
CH 2, CH 3, CH 4, ADD, and INVERT	Off (buttons out)
CHOP/ALT	ALT (button out)
20 MHz BW LIMIT	Off (button out)
VOLTS/DIV	
CH 1 and CH 2	1 V
CH 1 and CH 2 VAR	In detent
CH 3 and CH 4	0.1 V (buttons out)
Input Coupling	
CH 1 and CH 2	1 MΩ GND
A and B SEC/DIV	1 ms (knobs locked)
A and B SEC/DIV VAR	In detent
X10 MAG	Off (button out)
Δt and ΔV	Off (press and release until associated readout is off)
TRACKING	Off (button out)
TRACE SEP	Fully CW
TRIGGER	
HOLDOFF	Fully CCW
LEVEL	Midrange
SLOPE	+ (plus)
A/B TRIG SELECT	A
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC

1. Verify GPIB STATUS Indicators

a. Set the oscilloscope's POWER button to OFF and then to ON.

b. VERIFY—All three GPIB STATUS indicators illuminate during the oscilloscope's power-up sequence.

c. VERIFY—The GPIB STATUS SRQ indicator is still illuminated when the power-up sequence is finished.

d. Turn on the controller and enter "Program A" from the "Programming" part of Section 2 of this manual.

e. Run "Program A".

f. Connect the GPIB controller to the oscilloscope's rear-panel GPIB CONNECTOR using the GPIB cable.

g. Enter **1** in response to the controller's prompt for the oscilloscope's address.

h. VERIFY—Response displayed by the controller is:

ERROR - SRQ CODE 65
- EVENT NO. 401

i. VERIFY—The GPIB STATUS SRQ indicator is no longer illuminated.

j. VERIFY—The GPIB STATUS REN indicator is now illuminated.

2. Check GPIB Vertical Position Accuracy

a. Enter the **BALance** command.

b. Enter the command **CH1 POS:3.0**.

c. CHECK—The oscilloscope trace is between 2.6 and 3.4 divisions above the center horizontal graticule line.

d. Enter the command **CH1 POS:−3.0**.

e. CHECK—The oscilloscope trace is between 2.6 and 3.4 divisions below the center horizontal graticule line.

f. Enter the command **CH1 POS:0.0**.

g. CHECK—The oscilloscope trace is within 0.3 division of the center horizontal graticule line.

h. Enter the **VMOde CH1:OFF,CH2:ON;CH2 POS:3.0** commands.

i. CHECK—The oscilloscope trace is between 2.6 and 3.4 divisions above the center horizontal graticule line.

j. Enter the command **CH2 POS:−3.0**.

k. CHECK—The oscilloscope trace is between 2.6 and 3.4 divisions below the center horizontal graticule line.

l. Enter the command **CH2 POS:0.0**.

m. CHECK—The oscilloscope trace is within 0.3 division of the center horizontal graticule line.

n. Enter the **VMOde CH2:OFF,CH3:ON;CH3 POS:3.0** commands.

o. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions above the center horizontal graticule line.

p. Enter the command **CH3 POS:−3.0**.

q. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions below the center horizontal graticule line.

r. Enter the command **CH3 POS:0.0**.

s. CHECK—The oscilloscope trace is within 0.5 division of the center horizontal graticule line.

t. Enter the **VMOde CH3:OFF,CH4:ON;CH4 POS:3.0** commands.

u. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions above the center horizontal graticule line.

v. Enter the command **CH4 POS:−3.0**.

w. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions below the center horizontal graticule line.

x. Enter the command **CH4 POS:0.0**.

y. CHECK—The oscilloscope trace is within 0.5 division of the center horizontal graticule line.

z. Enter the **VMOde CH4:OFF,CH2:ON,INVert:ON; CH2 POS:3.0** commands.

aa. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions above the center horizontal graticule line.

ab. Enter the command **CH2 POS:−3.0**.

ac. CHECK—The oscilloscope trace is between 2.4 and 3.6 divisions below the center horizontal graticule line.

ad. Enter the command **CH2? POS**.

ae. VERIFY—Response displayed by the controller is:

CH2 POS: <X>
where <X> is between 2.98 and 3.01.

af. Enter the command **CH2 POS:0.0**.

ag. CHECK—The oscilloscope trace is within 0.5 division of the center horizontal graticule line.

3. Verify GPIB Trace Separation

a. Enter the **VMOde CH2:OFF,INVert:OFF,CH1:ON; CH1 POS:3.0** commands.

b. Enter the command **HMOde ALTernate**.

c. Enter the **HORizontal ASEcdiv:1E-3,BSEcdiv:.5E-3, TRACEsep:-4.0** command.

d. VERIFY—There are two traces on the crt.

e. Disconnect the test setup.

CALIBRATION PROCEDURE

INTRODUCTION

The "Calibration Procedure" is used to restore optimum performance or return the option to conformance with its "Performance Requirements" as listed in the "Specification" (Section 1). The GPIB option should be calibrated only when the vertical section of the standard instrument is known to meet its "Performance Requirements" as stated in the "Specification" section of its manual. Performing this procedure while the temperature is drifting or before the standard instrument is calibrated may cause erroneous calibration settings.

The four Vertical POSITION controls and the TRACE SEP control are digitized by the GPIB Option. The option can accurately control them only after they are calibrated. They are automatically calibrated by GPIB calibration routine 11 of the Diagnostic Monitor.

PREPARATION

Remove the wrap-around cabinet from the instrument as described in the "Maintenance" section of the standard instrument Service manual. Then set the CAL/NO CAL jumper P501 in the standard instrument to the CAL position (between pins 1 and 2).

Turn the oscilloscope on by pressing in the POWER button. Check that it enters its normal operating mode and that no error message is displayed on the crt. If an error message is present, have the instrument repaired or calibrated by a qualified service technician before performing this procedure.

Before starting this procedure, remove any signal sources from the CH 3 and CH 4 input connectors.

CALIBRATE VERTICAL POSITIONING

a. Set the CH 1 and CH 2 VOLTS/DIV VAR controls to their calibrated detents.

b. Push the TRIGGER SLOPE switch while holding in both the ΔV and Δt switches to access the Diagnostic Menu.

NOTE

If the calibration feature is disabled (the CAL/NO CAL jumper is in the NO CAL position), CAL messages will not appear in the Diagnostic Menu of the crt readout.

c. Repeatedly push the TRIGGER MODE switch until the "BU CAL F1" message appears in the Diagnostic Menu of the crt readout.

d. Start the calibration routine by pushing up on the TRIGGER COUPLING switch.

e. Repeatedly push the TRIGGER MODE switch up until the "GP CAL 11" message appears in the Diagnostic Menu of the crt readout.

f. Start the calibration routine by pushing up on the TRIGGER COUPLING switch.

g. When the routine ends (after about one minute), exit the Diagnostic Menu by pushing the A/B TRIG switch.

h. Return the CAL/NO CAL jumper to its NO CAL position and reinstall the instrument cabinet.

MAINTENANCE

This section contains information for troubleshooting the 2445 and 2465 Option 10 (GPIB). Maintenance information contained in the standard instrument service manual "Maintenance" section also applies to the GPIB Option. To function properly, the option requires a working standard oscilloscope and Buffer board.

TROUBLESHOOTING

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 "Theory of Operation" and "Diagrams" sections of this manual and the "Troubleshooting" section of the standard instrument's service manual may be helpful while troubleshooting.

GENERAL TROUBLESHOOTING PROCEDURE

The information presented here is intended to complement the information contained in the "Troubleshooting Procedures" part of the "Diagrams" section of the manual. Become familiar with the rest of the information in this section before proceeding with instrument troubleshooting. If the instrument will run the diagnostic routines as described in the "Diagnostic Routines" part of this section, perform the routines to help localize the instrument problems.

First make sure that the standard instrument functions properly. The option assembly will have to be removed to verify this. Then make sure that the Buffer board functions properly. To do this, the board will have to be connected to the standard instrument using the extender cables and all the option boards will have to be removed. Then verify that each option works properly by checking the operation of each option one at a time. Consult each option's service manual for operating and troubleshooting information and extender cable use. After all the options are working correctly, reassemble the instrument.

DIAGNOSTIC ROUTINES

Control of the instrument diagnostic routines and their display format is the same as for the standard instrument.

Kernel Tests

The standard instrument's Kernel tests include checks to determine if the Buffer board and any options are present. A ROM checksum test is performed on the Buffer board ROM and each option ROM contained in the instrument.

A failure of a Kernel test is considered "fatal" to the operation of the microprocessor system. Kernel test failures will result in an attempt to flash the front-panel A SWP TRIG'D indicator and illuminate certain other front-panel indicators with an error code. The code points to the failure area as indicated in Table 5-1. Tables 5-2 and 5-3 are used to determine the option and device numbers used in Table 5-1. Only the GPIB Option, Buffer board, and standard instrument codes are given in Table 5-1.

Table 5-1
Kernel Test Failure Codes

Failure Codes		Failing Device
Option	Device	
0	0	Control Board RAM (U2496)
0	1	ROM at 8000 (hex) (U2178)
0	2	ROM at A000 (hex) (U2378)
0	3	ROM at C000 (hex) (U2362)
0	4	ROM at E000 (hex) (U2162)
1	1	GPIB Board ROM U4715
1	2	GPIB Board ROM U4710
1	4	GPIB Board RAM U4811
F	1	Buffer Board ROM U4260

Table 5-2
Front-Panel LED Option Codes

Option Code				Option Number (in hex)	Option Name
CH 1 LED (bit 3)	CH 2 LED (bit 2)	CH 3 LED (bit 1)	CH 4 LED (bit 0)		
OFF	OFF	OFF	OFF	0	Basic Instrument
OFF	OFF	OFF	ON	1	Option 10 (GPIB)
OFF	ON	ON	OFF	6	Option 05 (TV)
OFF	ON	ON	ON	7	Option 01 (DMM)
ON	OFF	OFF	OFF	8	Option 06 (C/T/T)
ON	OFF	OFF	OFF	8	Option 09 (WR)
ON	ON	ON	ON	F	Buffer Board

Table 5-3
Front-Panel LED Device Codes

Ready LED (bit 2)	+ LED (bit 1)	− LED (bit 0)	Device Number
OFF	OFF	OFF	0
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6
ON	ON	ON	7

Even if a failure is reported, the A/B TRIG (sometimes labeled A/B/MENU switch, dependent upon which option is installed) may be pushed (or the GPIB command NORM may be used) to try to resume normal instrument operation. However, because of the failure, operation of particular instrument functions is unpredictable.

Confidence Tests

Option 10 related Confidence tests, Exerciser routines, and their associated error codes are listed in Table 5-4. Option-related Confidence tests are performed automatically at power up if the Kernel tests are completed successfully. These tests may also be initiated by the operator from the Diagnostics Monitor using the following procedure:

1. Push the TRIGGER SLOPE switch while holding in both the ΔV and Δt switches to access the Diagnostic Menu.

2. Select the desired test number by repeatedly pushing the TRIGGER MODE switch up until the test number appears in the Diagnostic Menu of the crt readout.

3. Start the test procedure by pushing up on the TRIGGER COUPLING switch.

4. If a failure is reported in the Diagnostic Menu, refer the instrument to a qualified service technician.

5. When the procedure ends, exit the Diagnostic Menu by pushing the A/B TRIG switch.

EAROM TEST (BU TEST 01). Checks EAROM to verify its contents and the interface circuitry.

Read/Write Test—The contents of one location are read, modified, and then reread to verify functioning of the device interface.

Test checks: EAROM input and output lines, EAROM mode control, EAROM reading and writing, and EAROM clock.

Checksum Test—The contents of locations containing calibration constants and power-down settings are verified using a spiral-add checksum technique. The result is compared to the contents of location 0.

Test checks: EAROM addressing and EAROM contents.

Table 5-4
Diagnostic and Exerciser Routines

Routine Type	Test Number	Routine Name	Error Code	Error Code Meaning
Buffer Board Test	F1	EAROM Test	X8 1X	Bad read after write. Bad checksum.
GPIB Test	11	GPIB Board		
		RAM	01	Error in RAM or associated circuitry.
		GPIB Controller	02	Malfunction of U4818, decoder U7408, or buffer U4701.
		Power Latch	03	Failure in latch U4801, gate U4735D, Q4745, or buffer U4701.
		Output Latches	04	Malfunction of latch U4625, gate U4730, buffer U4701, a GPIB STATUS indicator, or latch U4626.
		Input Multiplexer	05	Malfunction of DAC amplifier U4641B, input multiplexer U4525 or comparator U4631.
		Switched Supply	06	Malfunction of switch Q4725 or Q4743.
		Output Multiplexer	07	Malfunction of the output multiplexer, associated holding capacitors, or buffers.
		Wait State Generator	08	Malfunction of U4831B, U4706B, U4801, or U4838A.
Buffer Board Exerciser	F1 F2	Option Identification Page Selection	None None	
Exerciser	02	EAROM Examine	None	
GPIB Exerciser	11	Address Selection	None	
GPIB Exerciser	12	Terminator and Talk/Listen Mode Selection	None	

An X in the Error Code column indicates a don't care condition.

GPIB BOARD (GP TEST 11). Circuitry on the GPIB board is checked for proper operation, and error conditions are reported.

Test checks: Circuitry listed in Table 5-4 under GPIB Test 11.

Exerciser Routines

Operation of Exerciser routines is the same as for the standard instrument. The Exerciser routines allow the operator to set and examine various bytes of control data used in determining option function.

OPTION IDENTIFICATION (BU EXER F1). This routine displays the option designator for all installed options across the top line of the crt readout. Option designators are listed in Table 5-5.

Table 5-5
Option Designators

Option	Option Designator
Buffer Board	BU
GPIB	GP
TV	TV
DMM	DM
Counter/Timer/Trigger	CT
Word Recognizer	CT

PAGE SELECTION (BU EXER F2). This routine continuously selects and deselects each of the option page registers.

EAROM EXAMINE (EXER 02). This is the standard instrument EAROM Examine routine. The Buffer board memory contents are displayed when Buffer board location 64 (hex) to Buffer board location C7 (hex) are accessed.

ADDRESS SELECTION (GP EXER 11). Used to select the instrument's GPIB address. Its use is explained in Section 2 of this manual.

TERMINATOR AND TALK/LISTEN MODE SELECTION (GP EXER 12). Used to select both the instrument's end-of-message terminator and the Talk/Listen mode of the instrument's GPIB interface. Use of this routine is described in Section 2 of this manual.

EXTENDER CABLE USE

Extender Cable Kit

An extender cable kit, which can be ordered from Tektronix, Inc. (Tektronix Part Number 020-1075-00), is needed when troubleshooting an instrument containing options. The kit is used when troubleshooting the standard instrument by itself or when connecting a removed option assembly to the standard instrument for troubleshooting purposes.

All the cables contained in the kit are listed in Table 5-6. In addition to the cables, the kit contains 12 zero-ohm jumpers (Tektronix Part Number 131-0993-00). The procedures that follow and the "Troubleshooting Procedures" in the "Diagrams" section of this manual reference the cables by number as shown in column one. See Figure 5-1 for a pictorial representation of each cable to aid in cable identification.

Table 5-6
Extender Cables

Cable Number	Tektronix Part Number	Option Usage
1	175-7183-00	All
2	175-7184-00	All
3	175-9178-00	All
4	175-9181-00	All
5	175-7215-00	GPIB
6	175-9179-00	GPIB
7	175-9182-00	GPIB
8	175-9175-00	TV
9	175-9180-00	TV
10	175-9183-00	TV
11	175-9174-00	TV,C/T/T
12	175-7932-00	C/T/T
13	175-9176-00	C/T/T
14	175-9177-00	C/T/T

Instrument Troubleshooting Without Options

When it is desired to troubleshoot the standard instrument with the option assembly removed, perform the following steps to complete the signal paths required for operation of the standard instrument circuitry. Note that all the steps will not necessarily be performed, depending on which options were included in the instrument.

NOTE

In the following steps, P100, P101, and P102 are all located on the Main board in the standard instrument.

1. If the instrument contained the GPIB Option, use cable 7 to connect front-panel connector P4256 and Control board connector P651.

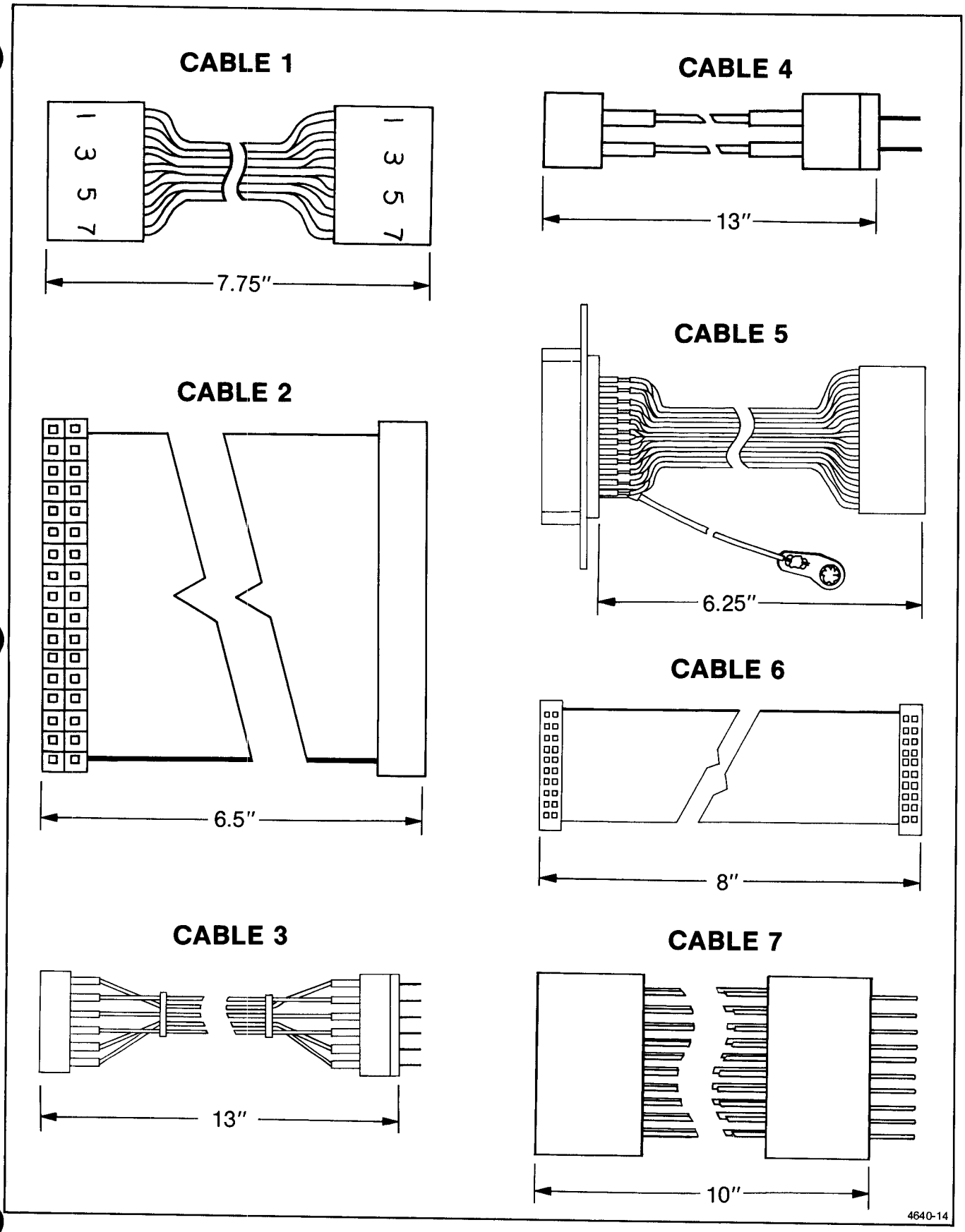


Figure 5-1. Option extender cables.

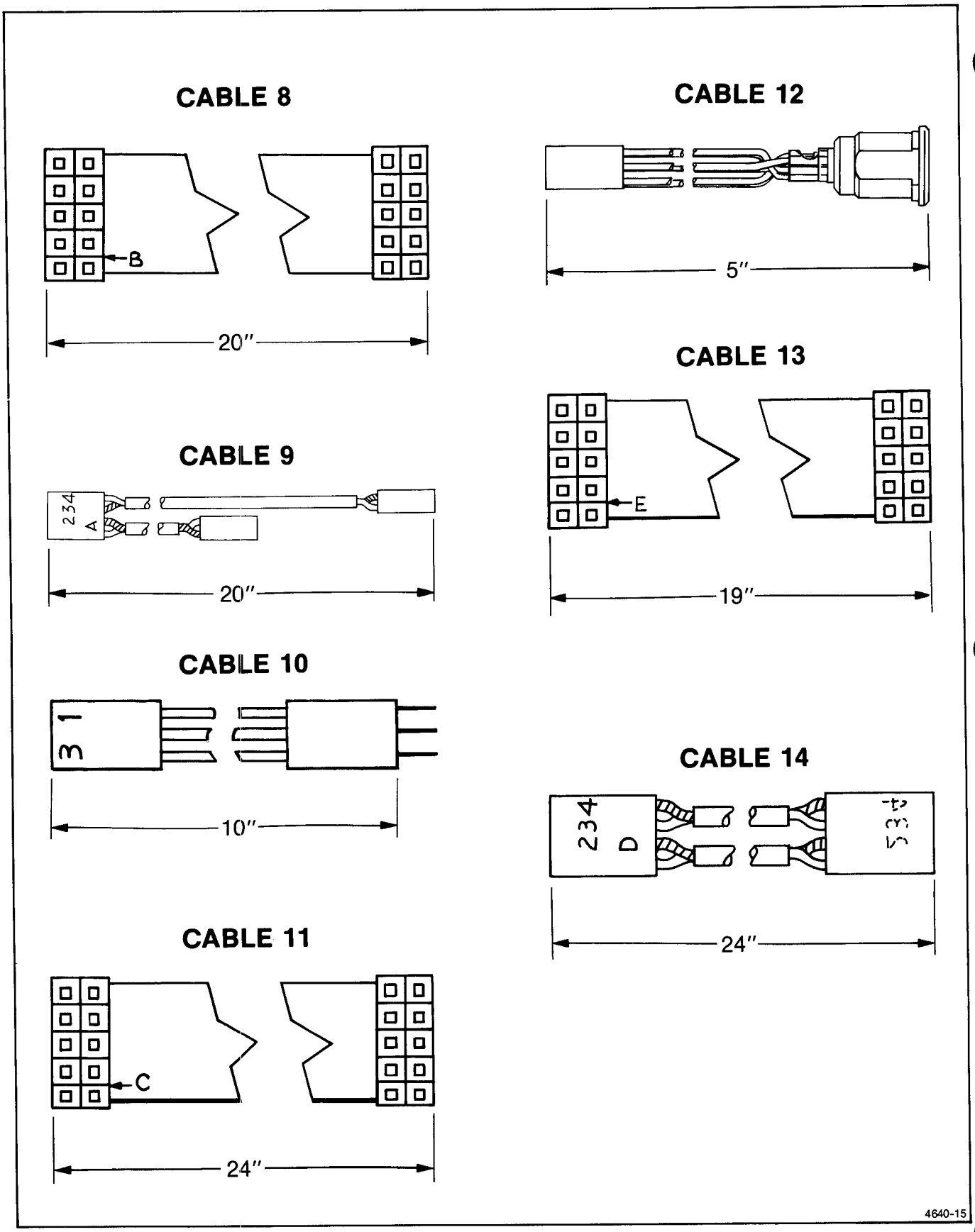


Figure 5-1 (cont). Option extender cables.

2. If the instrument contained the TV Option, connect pins 1 and 2 of P100 and pins 9 and 10 of P100 using the extender cable kit jumpers.

3. If the instrument contained the TV or C/T/T Options, connect pins 3 and 4 of P102 and pins 7 and 8 of P102 using the extender cable kit jumpers.

4. If the instrument contained the C/T/T Option, connect pins 1 and 3 of P101 and pins 6 and 8 of P101 using the extender cable kit jumpers.

Instrument Troubleshooting With Options

To operate the instrument and its options with the option assembly removed for troubleshooting, the assembly is placed upside down and to the right of the standard instrument (see Figure 5-2). The arrow represents the extender cables that are connecting the option assembly and the standard instrument.

Connecting all the extender cables is not required for each option. Column three in Table 5-6 lists which extender cables are used to connect and operate a particular option whose operation is in question. Cable number and Buffer board-standard instrument interconnection information for the GPIB Option is shown in Figure 5-3. The "Troubleshooting Procedures" in the "Diagrams" section of this manual contain information about cable usage during the troubleshooting session.

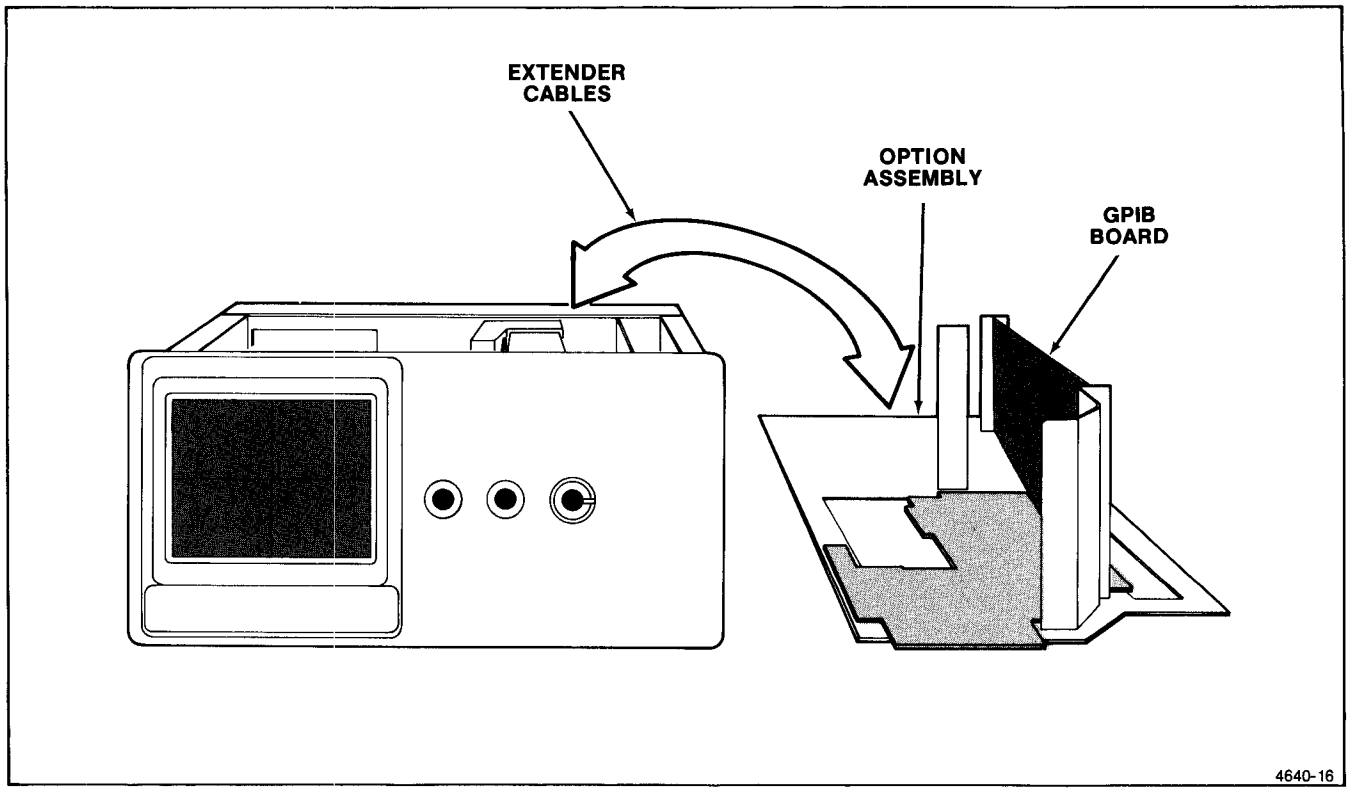


Figure 5-2. Orientation of assemblies when using extender cables.

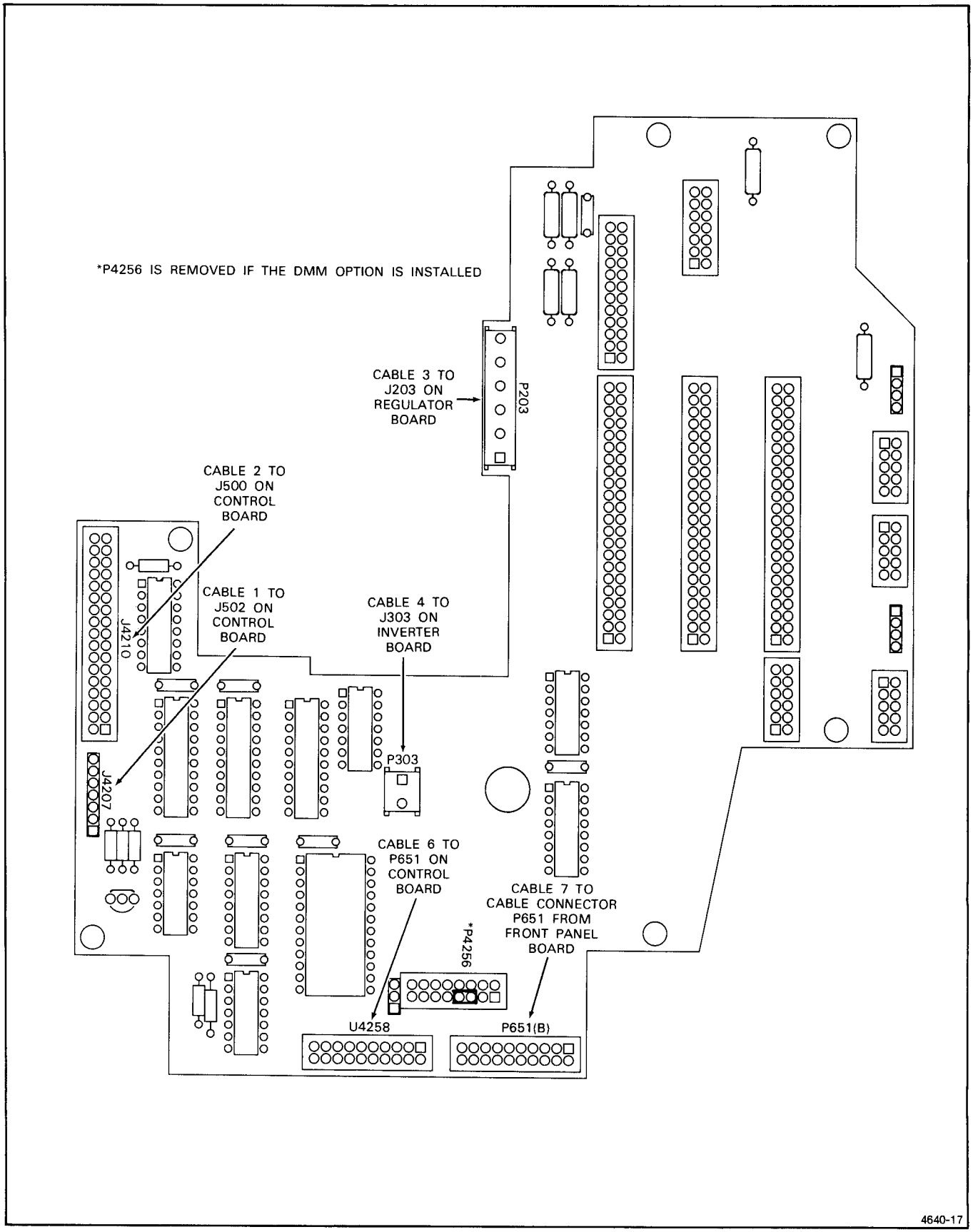


Figure 5-3. Extender cable connection points for troubleshooting.

CORRECTIVE MAINTENANCE

Corrective maintenance for this option is the same as for the standard instrument unless stated otherwise in this section.

REMOVAL AND REPLACEMENT INSTRUCTIONS

The GPIB Option board and the Buffer board may be removed for repair or replacement using the following procedures. Before beginning any procedure, read the information at the beginning of "Removal and Replacement Instructions" in the "Maintenance" section in the standard instrument service manual. If additional options are installed in the instrument, consult their service manuals for removal and replacement information that may impact the following procedures.

GPIB Board Removal

Removal of the GPIB board for repair or replacement is accomplished by performing the following procedure:

1. If the GPIB cable from the controller is connected to the instrument, disconnect it from the oscilloscope rear panel.

2. Perform the "Cabinet Removal" procedure as outlined in the "Removal and Replacement Instructions" in the standard instrument service manual.

3. Perform the first six steps of the "Top-Cover Plate Removal" procedure as outlined in the "Removal and Replacement Instructions" in the standard instrument service manual.

4. Remove the two top securing screws located at the right-center portion of the top-cover plate.

5. Lift the top-cover plate above the instrument approximately 2 inches.

6. Disconnect the GPIB connector cable (P4800) from the GPIB board.

7. Disconnect two cables at the right-front edge of the Buffer board (P4207 and P4210).

8. Lift and then rotate the option assembly about the instrument front panel until the assembly is almost upside down.

9. Disconnect the LED connector (P4540) from the GPIB board. Note the cable routing for reinstallation reference.

10. Disconnect two cables at the front edge of the Buffer board (P4258 and P651).

11. Remove the GPIB board from the option assembly by lifting it straight out from the Buffer board. Note the option assembly slot that the GPIB board is removed from for reinstallation reference.

To reinstall the GPIB board and option assembly into the standard instrument, perform the reverse of the preceding steps. When securing the option assembly back into the main instrument, be sure that the connector cables are indexed correctly. Also check that the cables are not crimped and that P203 and P303 are seated correctly in their connectors. The two circuit board retainers located along the right edge of the top-cover plate should securely engage the Readout board.

Buffer Board Removal

To remove the Buffer board for repair or replacement:

1. Perform the preceding "GPIB Board Removal" procedure.

2. Remove the five securing screws that attach the Buffer board to the Vertical Board support.

3. Remove the Buffer board from the top-plate cover and option assembly.

To reinstall the Buffer board and option assembly into the standard instrument, perform the reverse of the preceding steps.

GPIB LED Board Removal

To remove the LED board for repair or replacement:

1. Perform the first nine steps of the preceding "GPIB Board Removal" procedure.

2. Remove the two screws securing the LED Mounting plate.

3. Remove the LED Mounting plate and the LED board while being careful not to damage the clear LED light lens.

To reinstall the LED board into the standard instrument, perform the reverse of the preceding steps.

REPLACEABLE ELECTRICAL 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.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

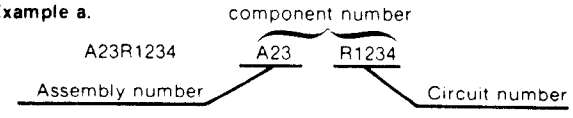
ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

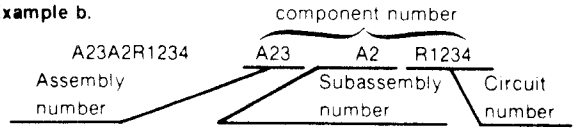
A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:

Example a.



Read: Resistor 1234 of Assembly 23

Example b.



Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

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.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00779	AMP, INC.	P.O. BOX 3608	HARRISBURG, PA 17105
01121	ALLEN-BRADLEY COMPANY	1201 2ND STREET SOUTH	MILWAUKEE, WI 53204
01295	TEXAS INSTRUMENTS, INC. SEMICONDUCTOR GROUP	P.O. BOX 5012	DALLAS, TX 75222
04222	AVX CERAMICS, DIVISION OF AVX CORP.	P O BOX 867	MYRTLE BEACH, SC 29577
04713	MOTOROLA, INC., SEMICONDUCTOR PROD. DIV.	5005 E MCDOWELL RD,PO BOX 20923	PHOENIX, AZ 85036
07263	FAIRCHILD SEMICONDUCTOR, A DIV. OF FAIRCHILD CAMERA AND INSTRUMENT CORP.	464 ELLIS STREET	MOUNTAIN VIEW, CA 94042
08261	SPECTRA-STRIP CORP.	7100 LAMPSON AVE.	GARDEN GROVE, CA 92642
12969	UNITRODE CORPORATION	580 PLEASANT STREET	WATERTOWN, MA 02172
22526	BERG ELECTRONICS, INC.	YOUK EXPRESSWAY	NEW CUMBERLAND, PA 17070
27014	NATIONAL SEMICONDUCTOR CORP.	2900 SEMICONDUCTOR DR.	SANTA CLARA, CA 95051
27264	MOLEX, INC.	2222 WELLINGTON COURT	LISLE, IL 60532
34335	ADVANCED MICRO DEVICES	901 THOMPSON PL.	SUNNYVALE, CA 94086
50522	MONSANTO CO., ELECTRONIC SPECIAL PRODUCTS	3400 HILLVIEW AVENUE	PALO ALTO, CA 94304
51642	CENTRE ENGINEERING INC.	2820 E COLLEGE AVENUE	STATE COLLEGE, PA 16801
51984	NEC AMERICA INC. RADIO AND TRANSMISSION DIV.	2990 TELESTAR CT. SUITE 212	FALLS CHURCH, VA 22042
54473	MATSUSHITA ELECTRIC, CORP. OF AMERICA	1 PANASONIC WAY	SECAUCUS, NJ 07094
55112	PLESSEY CAPACITORS, DIV. OF PLESSEY INC.	5334 STERLING CENTER DR.	WEST LAKE VILLAGE, CA 91361
56289	SPRAGUE ELECTRIC CO.	87 MARSHALL ST.	NORTH ADAMS, MA 01247
57668	R-OHM CORP.	16931 MILLIKEN AVE.	IRVINE, CA 92713
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
91637	DALE ELECTRONICS, INC.	P. O. BOX 609	COLUMBUS, NE 68601
T1015	MUSASHI WORKS OF HITACHI LTD	1450 JOSUIHON-CHO	KODAIRA-SHI TOKYO, JAPAN

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
				ASSEMBLIES		
A20	670-7830-00	B020000	B021699	CKT BOARD ASSY:BUFFER	80009	670-7830-00
A20	----- -----			(2445 ONLY)		
A20	670-7830-00	B020000	B021999	CKT BOARD ASSY:BUFFER	80009	670-7830-00
A20	----- -----			(2465 ONLY)		
A20	670-7830-01			CKT BOARD ASSY:BUFFER	80009	670-7830-01
A20	----- -----			(2445/2465 OPT 01,06,09 ONLY)		
A20	670-7830-02	B021700		CKT BOARD ASSY:BUFFER	80009	670-7830-02
A20	----- -----			(2445 ONLY)		
A20	670-7830-02	B022000		CKT BOARD ASSY:BUFFER	80009	670-7830-02
A20	----- -----			(2465 ONLY)		
A20	670-7830-03			CKT BOARD ASSY:BUFFER	80009	670-7830-03
A20	----- -----			(2445/2465 OPT 05 ONLY)		
A20	670-7830-04			CKT BOARD ASSY:BUFFER	80009	670-7830-04
A20	----- -----			(2445/2465 OPT 01 & 05,OR OPT 05,06 & 09)		
A20	670-7830-05	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-05
A20	----- -----			(2445 ONLY,OPT 01,W/ANY COMBO OF		
A20	----- -----			OPTS 06,09,10)		
A20	670-7830-05	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-05
A20	----- -----			(2465 ONLY,OPT 01,W/ANY COMBO OF		
A20	----- -----			OPTS 06,09,10)		
A20	670-7830-06	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-06
A20	----- -----			(2445 ONLY,OPT 10 ONLY)		
A20	670-7830-06	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-06
A20	----- -----			(2465 ONLY,OPT 10 ONLY)		
A20	670-7830-07	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-07
A20	----- -----			(2445 ONLY,OPT 05,OR OPT 05/OPT 10 COMBO)		
A20	670-7830-07	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-07
A20	----- -----			(2465 ONLY,OPT 05,OR OPT 05/OPT 10 COMBO)		
A20	670-7830-08	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-08
A20	----- -----			(2445 ONLY,OPT 01 & 05,W/ANY COMBO OF		
A20	----- -----			OPT 06,09 & 10)		
A20	670-7830-08	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-08
A20	----- -----			(2465 ONLY,OPT 01 & 05,W/ANY COMBO OF		
A20	----- -----			OPT 06,09 & 10)		
A22	670-8159-00			CKT BOARD ASSY:LED	80009	670-8159-00
A23	670-7558-00	B020000	B021519	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-00
A23	----- -----			(2445 ONLY)		
A23	670-7558-02	B021520	B024399	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-02
A23	----- -----			(2445 ONLY)		
A23	670-7558-04	B024400	B025499	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-04
A23	----- -----			(2445 ONLY)		
A23	670-7558-05	B025500		CKT BOARD ASSY:GPIB OPTION	80009	670-7558-05
A23	----- -----			(2445 ONLY)		
A23	670-7558-00	B020000	B022699	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-00
A23	----- -----			(2465 ONLY)		
A23	670-7558-02	B022700	B026299	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-02
A23	----- -----			(2465 ONLY)		
A23	670-7558-04	B026300	B027849	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-04
A23	----- -----			(2465 ONLY)		
A23	670-7558-05	B027850		CKT BOARD ASSY:GPIB OPTION	80009	670-7558-05
A23	----- -----			(2465 ONLY)		

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A20	670-7830-00	B020000	B021699	CKT BOARD ASSY:BUFFER	80009	670-7830-00
A20	----- -----			(2445 ONLY)		
A20	670-7830-00	B020000	B021999	CKT BOARD ASSY:BUFFER	80009	670-7830-00
A20	----- -----			(2465 ONLY)		
A20	670-7830-01			CKT BOARD ASSY:BUFFER	80009	670-7830-01
A20	----- -----			(2445/2465 OPT 01,06,09 ONLY)		
A20	670-7830-02	B021700		CKT BOARD ASSY:BUFFER	80009	670-7830-02
A20	----- -----			(2445 ONLY)		
A20	670-7830-02	B022000		CKT BOARD ASSY:BUFFER	80009	670-7830-02
A20	----- -----			(2465 ONLY)		
A20	670-7830-03			CKT BOARD ASSY:BUFFER	80009	670-7830-03
A20	----- -----			(2445/2465 OPT 05 ONLY)		
A20	670-7830-04			CKT BOARD ASSY:BUFFER	80009	670-7830-04
A20	----- -----			(2445/2465 OPT 01 & 05,OR OPT 05,06 & 09)		
A20	670-7830-05	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-05
A20	----- -----			(2445 ONLY,OPT 01,W/ANY COMBO OF		
A20	----- -----			OPTS 06,09,10)		
A20	670-7830-05	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-05
A20	----- -----			(2465 ONLY,OPT 01,W/ANY COMBO OF		
A20	----- -----			OPTS 06,09,10)		
A20	670-7830-06	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-06
A20	----- -----			(2445 ONLY,OPT 10 ONLY)		
A20	670-7830-06	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-06
A20	----- -----			(2465 ONLY,OPT 10 ONLY)		
A20	670-7830-07	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-07
A20	----- -----			(2445 ONLY,OPT 05,OR OPT 05/OPT 10 COMBO)		
A20	670-7830-07	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-07
A20	----- -----			(2465 ONLY,OPT 05,OR OPT 05/OPT 10 COMBO)		
A20	670-7830-08	B025500		CKT BOARD ASSY:BUFFER	80009	670-7830-08
A20	----- -----			(2445 ONLY,OPT 01 & 05,W/ANY COMBO OF		
A20	----- -----			OPT 06,09 & 10)		
A20	670-7830-08	B028060		CKT BOARD ASSY:BUFFER	80009	670-7830-08
A20	----- -----			(2465 ONLY,OPT 01 & 05,W/ANY COMBO OF		
A20	----- -----			OPT 06,09 & 10)		
A20C4215	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4224	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4240	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4241	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4255	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4260	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4265	281-0764-00			CAP.,FXD,CER DI:82PF,5%,100V	56289	492CCOG820J100B
A20C4270	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20C4280	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A20J651	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J651	----- -----			(QUANTITY OF 20)		
A20J4203	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4203	----- -----			(QUANTITY OF 3)		
A20J4207	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4207	----- -----			(QUANTITY OF 7)		
A20J4210	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4210	----- -----			(QUANTITY OF 34)		
A20J4220	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4220	----- -----			(QUANTITY OF 14)		

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A20J4221	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4221	----- -----			(QUANTITY OF 24)		
A20J4228	131-2919-00			CONN,RCPT,ELEC:HEADER,1 X 4,0.1 SPACING	00779	87232-4
A20J4230	131-2920-00			CONN,RCPT,ELEC:HEADER,2 X 5,0.1 SPACING	00779	86479-3
A20J4232	131-2920-00			CONN,RCPT,ELEC:HEADER,2 X 5,0.1 SPACING	00779	86479-3
A20J4234	131-2919-00			CONN,RCPT,ELEC:HEADER,1 X 4,0.1 SPACING	00779	87232-4
A20J4236	131-2920-00			CONN,RCPT,ELEC:HEADER,2 X 5,0.1 SPACING	00779	86479-3
A20J4238	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4238	----- -----			(QUANTITY OF 12)		
A20J4240	131-1742-00	B020000	B021699	TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4240	----- -----			(QUANTITY OF 40) (2445 ONLY) (LOCATION A)		
A20J4240	131-0589-00	B021700		TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4240	----- -----			(QUANTITY OF 40) (2445 ONLY) (LOCATION A)		
A20J4240	131-1742-00	B020000	B021999	TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4240	----- -----			(QUANTITY OF 40) (2465 ONLY) (LOCATION A)		
A20J4240	131-0589-00	B022000		TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4240	----- -----			(QUANTITY OF 40) (2465 ONLY) (LOCATION A)		
A20J4240	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4240	----- -----			(QUANTITY OF 4)(2445/2465 LOCATION B)		
A20J4242	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4242	----- -----			(QUANTITY OF 44)		
A20J4243	131-0589-00			TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4243	----- -----			(QUANTITY OF 44)		
A20J4256	131-1742-00			TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4256	----- -----			(QUANTITY OF 2)		
A20J4256	131-0608-00	B020000	B021699	TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4256	----- -----			(QUANTITY OF 14) (2445 ONLY)		
A20J4256	131-1742-00	B020000	B021699	TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4256	----- -----			(QUANTITY OF 2) (2445 ONLY)		
A20J4256	131-0589-00	B021700		TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4256	----- -----			(QUANTITY OF 2) (2445 ONLY)		
A20J4256	131-0608-00	B020000	B021999	TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4256	----- -----			(QUANTITY OF 2) (2465 ONLY)		
A20J4256	131-1742-00	B020000	B021999	TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4256	----- -----			(QUANTITY OF 2) (2465 ONLY)		
A20J4256	131-0589-00	B022000		TERMINAL,PIN:0.46 L X 0.025 SQ	22526	48283-029
A20J4256	----- -----			(QUANTITY OF 2) (2465 ONLY)		
A20J4258	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4258	----- -----			(QUANTITY OF 20)		
A20J4330	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A20J4330	----- -----			(QUANTITY OF 14)		
A20J4330	131-1742-00			TERMINAL,PIN:0.662 L X 0.025 SQ PH BRS	22526	48283-086
A20J4330	----- -----			(QUANTITY OF 2)		
A20P203	131-2924-00			CONN,RCPT,ELEC:HEADER,1 X 6,0.2 SPACING	27264	10-51-1061
A20P303	131-2923-00			CONN,RCPT,ELEC:HEADER,1 X 2,0.2 SPACING	27264	10-51-1021
A20Q4201	151-0190-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7969
A20R4200	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A20R4201	321-0085-00			RES.,FXD,FILM:75 OHM,1%,0.125W	91637	MFF1816G75R00F
A20R4202	321-0122-00	B020000	B025499	RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A20R4202	----- -----			(2445 ONLY)		
A20R4202	321-0132-00	B025500		RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
A20R4202	----- -----			(2445 ONLY)		
A20R4202	321-0122-00	B020000	B028059	RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A20R4202	----- -----			(2465 ONLY)		

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A20R4202	321-0132-00	B028060		RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
A20R4202	----- -----			(2465 ONLY)		
A20R4203	321-0105-00	B020000	B025499	RES.,FXD,FILM:121 OHM,1%,0.125W	01121	ORD BY DESCR
A20R4203	----- -----			(2445 ONLY)		
A20R4203	321-0101-00	B025500		RES.,FXD,FILM:110 OHM,1%,0.125W	91637	MFF1816G110R0F
A20R4203	----- -----			(2445 ONLY)		
A20R4203	321-0105-00	B020000	B028059	RES.,FXD,FILM:121 OHM,1%,0.125W	01121	ORD BY DESCR
A20R4203	----- -----			(2465 ONLY)		
A20R4203	321-0101-00	B028060		RES.,FXD,FILM:110 OHM,1%,0.125W	91637	MFF1816G110R0F
A20R4203	----- -----			(2465 ONLY)		
A20R4204	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A20R4205	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A20R4206	315-0512-00			RES.,FXD,CMPSN:5.1K OHM,5%,0.25W	57668	NTR25J-E05K1
A20R4207	321-0105-00	B020000	B025499	RES.,FXD,FILM:121 OHM,1%,0.125W	01121	ORD BY DESCR
A20R4207	----- -----			(2445 ONLY)		
A20R4207	321-0101-00	B025500		RES.,FXD,FILM:110 OHM,1%,0.125W	91637	MFF1816G110R0F
A20R4207	----- -----			(2445 ONLY)		
A20R4207	321-0105-00	B020000	B208059	RES.,FXD,FILM:121 OHM,1%,0.125W	01121	ORD BY DESCR
A20R4207	----- -----			(2465 ONLY)		
A20R4207	321-0101-00	B028060		RES.,FXD,FILM:110 OHM,1%,0.125W	91637	MFF1816G110R0F
A20R4207	----- -----			(2465 ONLY)		
A20R4208	321-0122-00	B020000	B205499	RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A20R4208	----- -----			(2445 ONLY)		
A20R4208	321-0132-00	B025500		RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
A20R4208	----- -----			(2445 ONLY)		
A20R4208	321-0122-00	B020000	B028059	RES.,FXD,FILM:182 OHM,1%,0.125W	91637	MFF1816G182R0F
A20R4208	----- -----			(2465 ONLY)		
A20R4208	321-0132-00	B028060		RES.,FXD,FILM:232 OHM,1%,0.125W	91637	MFF1816G232R0F
A20R4208	----- -----			(2465 ONLY)		
A20R4210	315-0471-00	B020000	B021699	RES.,FXD,CMPSN:470 OHM,5%,0.25W	57668	NTR25J-E470E
A20R4210	----- -----			(2445 ONLY)		
A20R4210	315-0471-00	B020000	B021999	RES.,FXD,CMPSN:470 OHM,5%,0.25W	57668	NTR25J-E470E
A20R4210	----- -----			(2465 ONLY)		
A20R4224	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A20R4265	315-0681-00			RES.,FXD,CMPSN:680 OHM,5%,0.25W	57668	NTR25J-E680E
A20U4207	156-1566-00			MICROCIRCUIT,DI:EPROM,100 X 14	80009	156-1566-00
A20U4225	156-1318-00			MICROCIRCUIT,DI:4-BIT BISTABLE LATCH SCR	01295	SN74LS375
A20U4235	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A20U4240	156-0718-03			MICROCIRCUIT,DI:TRIPLE 3-INP NOR GATE	01295	SN74LS27
A20U4245	156-1065-01			MICROCIRCUIT,DI:OCTAL D TYPE TRANS LATCHES	34335	AM74LS373
A20U4250	156-0386-02			MICROCIRCUIT,DI:TRIPLE 3-INP NAND GATE	27014	DM74LS10N
A20U4255	156-1111-02			MICROCIRCUIT,DI:OCTAL BUS TRANSCEIVERS	01295	SN74LS245 N3ORJ4
A20U4260	160-1833-05			MICROCIRCUIT,DI:4096 X 8 EPROM,PRGM	80009	160-1833-05
A20U4265	156-0383-02			MICROCIRCUIT,DI:QUAD 2-INP NOR GATE	01295	SN74LS02
A20U4275	156-0392-03			MICROCIRCUIT,DI:QUAD LATCH W/CLEAR	01295	SN74S175NP3
A20U4280	156-0866-02			MICROCIRCUIT,DI:13 INP NAND GATES,SCRN	80009	156-0866-02

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A22	670-8159-00			CKT BOARD ASSY:LED	80009	670-8159-00
A22DS4540	150-1064-00			LT EMITTING DIO:YELLOW,585NM,40 MA MAX	50522	MV5374C
A22DS4542	150-1064-00			LT EMITTING DIO:YELLOW,585NM,40 MA MAX	50522	MV5374C
A22DS4545	150-1064-00			LT EMITTING DIO:YELLOW,585NM,40 MA MAX	50522	MV5374C
A23	670-7558-00	B020000	B021519	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-00
A23	----- -----			(2445 ONLY)		
A23	670-7558-02	B021520	B024399	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-02
A23	----- -----			(2445 ONLY)		
A23	670-7558-04	B024400	B025499	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-04
A23	----- -----			(2445 ONLY)		
A23	670-7558-05	B025500		CKT BOARD ASSY:GPIB OPTION	80009	670-7558-05
A23	----- -----			(2445 ONLY)		
A23	670-7558-00	B020000	B022699	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-00
A23	----- -----			(2465 ONLY)		
A23	670-7558-02	B022700	B026299	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-02
A23	----- -----			(2465 ONLY)		
A23	670-7558-04	B026300	B027849	CKT BOARD ASSY:GPIB OPTION	80009	670-7558-04
A23	----- -----			(2465 ONLY)		
A23	670-7558-05	B027850		CKT BOARD ASSY:GPIB OPTION	80009	670-7558-05
A23	----- -----			(2465 ONLY)		
A23C4521	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4530	281-0861-00			CAP.,FXD,CER DI:270 PF,5%,50V	51642	G1710-050-NP0-27
A23C4621	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4625	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4626	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4631	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4635	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4636	285-1187-00			CAP.,FXD,MTLZD:0.47UF,10%,100V	55112	160.47 K 100F
A23C4637	285-1187-00			CAP.,FXD,MTLZD:0.47UF,10%,100V	55112	160.47 K 100F
A23C4638	285-1187-00			CAP.,FXD,MTLZD:0.47UF,10%,100V	55112	160.47 K 100F
A23C4640	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4644	285-1187-00			CAP.,FXD,MTLZD:0.47UF,10%,100V	55112	160.47 K 100F
A23C4645	285-1187-00			CAP.,FXD,MTLZD:0.47UF,10%,100V	55112	160.47 K 100F
A23C4705	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4706	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4708	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4730	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4735	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4738	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4745	283-0203-00			CAP.,FXD,CER DI:0.47UF,20%,50V	04222	5R305SE474MAA
A23C4747	290-0847-00			CAP.,FXD,ELCTLT:47UF,+50-10%,10 V	54473	ECE-B1AV470S
A23C4801	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4805	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4808	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4831	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23C4838	283-0421-00			CAP.,FXD,CER DI:0.1UF,+80-20%,50V	04222	DG015E104Z
A23CR4525	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4526	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4527	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4530	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4531	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A23CR4532	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4533	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4534	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4540	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23CR4541	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V,DO-35	12969	NDP0263 (1N4152)
A23J4540	131-1614-00			CONN,RCPT,ELEC:CKT BD,1 X 36,0.1 SPACING	08261	800-380-000
A23J4800	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23J4800	----- -----			(QUANTITY OF 24)		
A23P4238	131-2888-00			CONN,RCPT,ELEC:CKT BD,HORIZ,2X6,0.100 SPC	00779	86063-2
A23P4243	131-2887-00			CONN,RCPT,ELEC:CKT BD,HORIZ,2 X 22,0.100SP	00779	1-86063-8
A23Q4743	151-0622-00			TRANSISTOR:SILICON,PNP	27014	92PU51A
A23Q4745	151-0736-00			TRANSISTOR:SILICON,NPN	04713	SPS8317
A23R4501	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4502	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4503	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4510	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4511	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	57668	NTR25J-E02K7
A23R4512	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4513	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A23R4515	315-0101-00			RES.,FXD,CMPSN:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A23R4516	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	57668	NTR25J-E02K7
A23R4520	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	57668	NTR25J-E02K7
A23R4521	321-0344-00			RES.,FXD,FILM:37.4K OHM,1%,0.125W	91637	MFF1816G37401F
A23R4523	321-0300-00			RES.,FXD,FILM:13K OHM,1%,0.125W	91637	MFF1816G13001F
A23R4525	321-0300-00			RES.,FXD,FILM:13K OHM,1%,0.125W	91637	MFF1816G13001F
A23R4526	321-0300-00			RES.,FXD,FILM:13K OHM,1%,0.125W	91637	MFF1816G13001F
A23R4531	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4532	315-0272-00			RES.,FXD,CMPSN:2.7K OHM,5%,0.25W	57668	NTR25J-E02K7
A23R4533	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4534	315-0130-00			RES.,FXD,CMPSN:13 OHM,5%,0.25W	01121	CB1305
A23R4535	315-0104-00			RES.,FXD,CMPSN:100K OHM,5%,0.25W	57668	NTR25J-E100K
A23R4543	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	57668	NTR25J-E200E
A23R4544	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	57668	NTR25J-E200E
A23R4545	315-0201-00			RES.,FXD,CMPSN:200 OHM,5%,0.25W	57668	NTR25J-E200E
A23R4546	315-0620-00			RES.,FXD,CMPSN:62 OHM,5%,0.25W	01121	CB6205
A23R4547	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A23R4548	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A23R4549	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A23R4550	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A23R4615	307-0445-00			RES NTWK,FXD,FI:4.7K OHM,20%,(9) RES	91637	MSP10A01-472M
A23R4630	307-0730-00			RES NTWK,FXD,FI:7,47K OHM,2%,0.18W	01121	208A473
A23R4731	315-0102-00			RES.,FXD,CMPSN:1K OHM,5%,0.25W	57668	NTR25JE01K0
A23R4732	315-0103-00			RES.,FXD,CMPSN:10K OHM,5%,0.25W	57668	NTR25J-E10K0
A23R4734	315-0131-00			RES.,FXD,CMPSN:130 OHM,5%,0.25W	01121	CB1315
A23R4735	315-0271-00			RES.,FXD,CMPSN:270 OHM,5%,0.25W	01121	CB2715
A23R4740	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	57668	NTR25J-E01K5
A23R4743	315-0152-00			RES.,FXD,CMPSN:1.5K OHM,5%,0.25W	57668	NTR25J-E01K5
A23TP4523	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4524	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4748	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4749	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4809	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4841	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4843	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036

Component No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Name & Description	Mfr Code	Mfr Part Number
A23TP4845	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4848	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23TP4849	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 PH BRZ GOLD	22526	48283-036
A23U4501	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A23U4505	156-0956-02			MICROCIRCUIT,DI:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A23U4525	156-0513-03			MICROCIRCUIT,LI:CMOS,8 CHAN ANALOG MU		
A23U4601	156-0866-02			MICROCIRCUIT,DI:13 INP NAND GATES,SCRN	80009	156-0866-02
A23U4605	156-0866-02			MICROCIRCUIT,DI:13 INP NAND GATES,SCRN	80009	156-0866-02
A23U4606	156-0385-02			MICROCIRCUIT,DI:HEX INVERTER	01295	SN74LS04
A23U4608	156-1111-02			MICROCIRCUIT,DI:OCTAL BUS TRANSCEIVERS	01295	SN74LS245 N3ORJ4
A23U4621	156-0513-03			MICROCIRCUIT,LI:CMOS,8 CHAN ANALOG MU		
A23U4625	156-1221-00			MICROCIRCUIT,DI:HEX D-TYPE FF,SCRN	01295	SN74LS378NP3
A23U4626	156-1221-00			MICROCIRCUIT,DI:HEX D-TYPE FF,SCRN	01295	SN74LS378NP3
A23U4631	156-1126-00			MICROCIRCUIT,LI:VOLTAGE COMPARATOR	51984	UPC311C
A23U4635	156-1200-00			MICROCIRCUIT,LI:OPERATIONAL AMPL	01295	TL074CN
A23U4641	156-1191-00			MICROCIRCUIT,LI:BI-FET OPNL AMPL	01295	TL072ACP
A23U4701	156-1277-00			MICROCIRCUIT,DI:3 STATE OCTAL BFR	27014	DM81LS95
A23U4705	156-0480-02			MICROCIRCUIT,DI:QUAD 2 INP & GATE	01295	SN74LS08NP3
A23U4706	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A23U4708	156-0469-02			MICROCIRCUIT,DI:3/8 LINE DCDR	01295	SN74LS138NP3
A23U4710	160-1681-08	B020000	B021519	MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-08
A23U4710	----- -----			(2445 ONLY)		
A23U4710	160-1681-13	B021520	B024399	MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-13
A23U4710	----- -----			(2445 ONLY)		
A23U4710	160-1681-14	B024400		MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-14
A23U4710	----- -----			(2445 ONLY)		
A23U4710	160-1681-08	B020000	B022699	MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-08
A23U4710	----- -----			(2465 ONLY)		
A23U4710	160-1681-13	B022700	B026299	MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-13
A23U4710	----- -----			(2465 ONLY)		
A23U4710	160-1814-14	B026300		MICROCIRCUIT,DI:8192 X 8 EPROM,PRGM	80009	160-1681-14
A23U4710	----- -----			(2465 ONLY)		
A23U4715	160-1692-08	B020000	B021519	MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-08
A23U4715	----- -----			(2445 ONLY)		
A23U4715	160-1692-13	B021520	B024399	MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-13
A23U4715	----- -----			(2445 ONLY)		
A23U4715	160-1692-14	B024400		MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-14
A23U4715	----- -----			(2445 ONLY)		
A23U4715	160-1692-08	B020000	B022699	MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-08
A23U4715	----- -----			(2465 ONLY)		
A23U4715	160-1692-13	B022700	B026299	MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-13
A23U4715	----- -----			(2465 ONLY)		
A23U4715	160-1692-14	B026300		MICROCIRCUIT,DI:16K X 8 EPROM,PRGM	80009	160-1692-14
A23U4715	----- -----			(2465 ONLY)		
A23U4730	156-0467-02			MICROCIRCUIT,DI:QUAD 2-INP NAND BFR,SCRN	01295	SN74LS38
A23U4735	156-0382-02			MICROCIRCUIT,DI:QUAD 2-INP NAND GATE	01295	SN74LS00
A23U4738	156-0386-02			MICROCIRCUIT,DI:TRIPLE 3-INP NAND GATE	27014	DM74LS10N
A23U4801	156-0865-02			MICROCIRCUIT,DI:OCTAL D-TYPE FF W/CLEAR	01295	SN74LS273NP3
A23U4805	156-1415-00			MICROCIRCUIT,DI:OCTAL GPIB XCVR MTG BUS	01295	SN75161A
A23U4808	156-1414-00			MICROCIRCUIT,DI:OCTAL GPIB XCVR DATA BUS	01295	SN75160
A23U4811	156-1594-00			MICROCIRCUIT,DI:2048 X 8 SRAM	T1015	HM6116P-3(DP-24)
A23U4818	119-1703-00			MICROCKT,ASSY:10 BIT VIDEO SPEED D/A CONV	80009	119-1703-00
A23U4831	156-0479-02			MICROCIRCUIT,DI:QUAD 2-INP OR GATE	01295	SN74LS32NP3
A23U4838	156-0388-03			MICROCIRCUIT,DI:DUAL D FLIP-FLOP	07263	74LS74A

REPLACEABLE MECHANICAL 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.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

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
- - - * - - -
  Detail Part of Assembly and/or Component
  Attaching parts for Detail Part
  - - - * - - -
    Parts of Detail Part
    Attaching parts for Parts of Detail Part
    - - - * - - -
```

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.

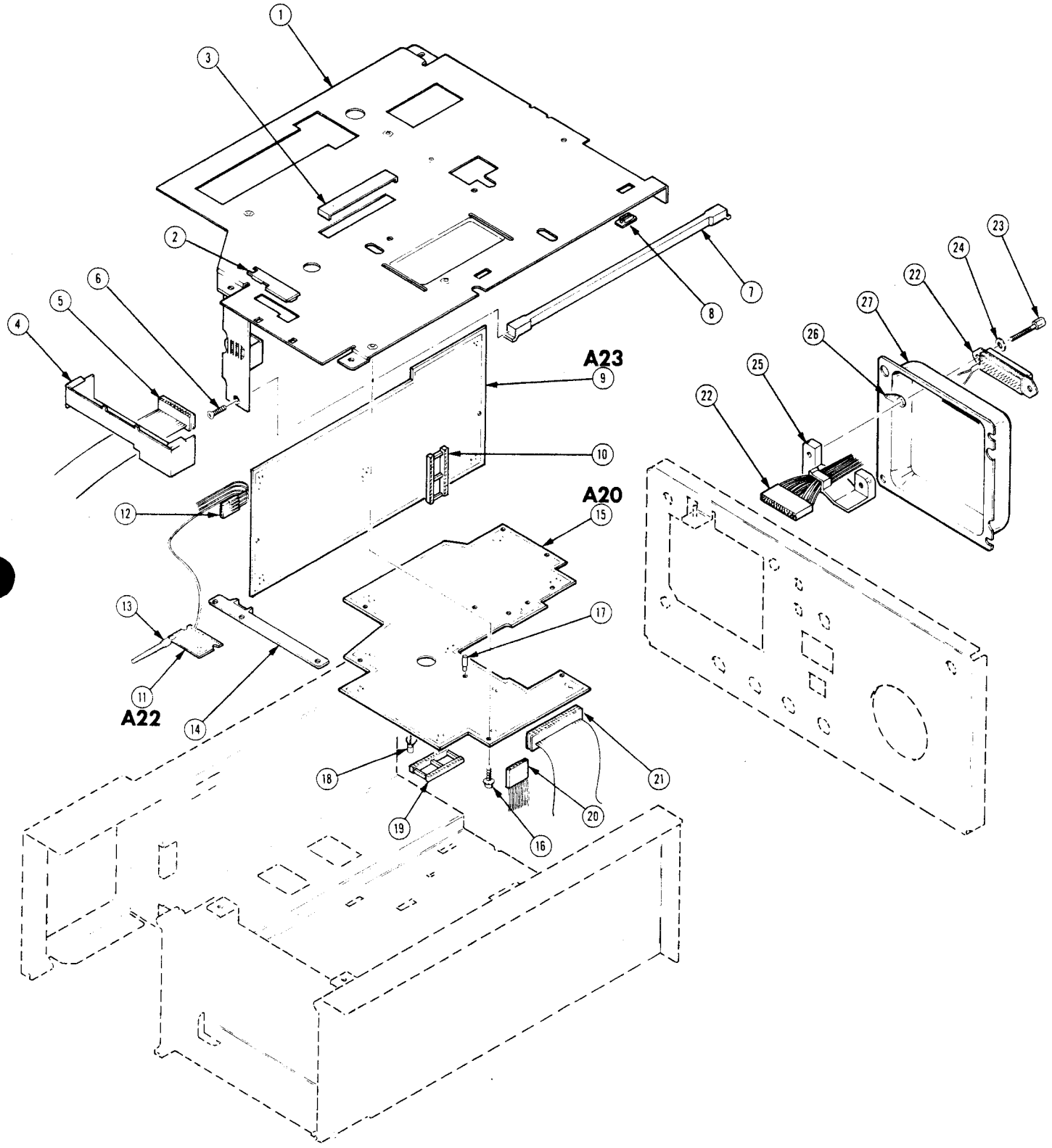
Attaching parts must be purchased separately, unless otherwise specified.

CROSS INDEX—MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip
00779	AMP, INC.	P.O. BOX 3608	HARRISBURG, PA 17105
01536	CAMCAR DIV OF TEXTRON INC. SEMS PRODUCTS UNIT	1818 CHRISTINA ST.	ROCKFORD, IL 61108
06383	PANDUIT CORPORATION	17301 RIDGELAND	TINLEY PARK, IL 60477
09922	BURNDY CORPORATION	RICHARDS AVENUE	NORWALK, CT 06852
22670	G.M. NAMEPLATE, INC.	2040 15TH AVENUE WEST	SEATTLE, WA 98119
80009	TEKTRONIX, INC.	P O BOX 500	BEAVERTON, OR 97077
83385	CENTRAL SCREW CO.	2530 CRESCENT DR.	BROADVIEW, IL 60153
83486	ELCO INDUSTRIES, INC.	1103 SAMUELSON ROAD	ROCKFORD, IL 61101
86928	SEASTROM MFG. COMPANY, INC.	701 SONORA AVENUE	GLENDALE, CA 91201
T1319	MORELLIS Q & D PLASTICS	1812 16TH AVE	FOREST GROVE OR 97116

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
1-	----- -----			1		GPIB OPTION 10,2445/2465		
-1	407-1473-00			1		.BRACKET,SUPPORT:CKT BD,ALUMINUM	80009	407-1473-00
-2	200-2277-00			1		.COVER,ELEC CONN:POLYCARBONATE	80009	200-2277-00
-3	200-2871-00			1		.COVER,ELEC CONN:PLASTIC	T1319	ORD BY DESCR
-4	337-3141-00			1		.SHIELD,ELEC:BULKHEAD	80009	337-3141-00
-5	175-7180-00			1		.CA ASSY,SPEC,ELEC:20,28 AWG,12.25L,RIBBON	80009	175-7180-00
-6	211-0722-00			2		.SCREW,MACHINE:6-32 X 0.25 L,PNH,TORX		
	211-0718-00			2		.SCREW,MACHINE:6-32 X 0.312,FLH,DEG TORX	83486	ORD BY DESCR
-7	129-1032-00	B020000	B021649	1		.SPACER,POST:6.75L W/6-32 INT THD		
	----- -----			-		.(2445 ONLY)		
	361-1286-00	B021650		1		.SPACER,BRACKET:7.5L,POLYCARBONATE,BLACK		
	----- -----			-		.(2445 ONLY)		
	129-1032-00	B020000	B022909	1		.SPACER,POST:6.75L W/6-32 INT THD		
	----- -----			-		.(2465 ONLY)		
	361-1286-00	B022910		1		.SPACER,BRACKET:7.5L,POLYCARBONATE,BLACK		
	----- -----			-		.(2465 ONLY)		
-8	343-1012-00			2		.RETAINER,CKT BD:	80009	343-1012-00
-9	----- -----			1		.CKT BOARD ASSY:GPIB OPTION(SEE A23 REPL)		
-10	136-0755-00			2		..SKT,PL-IN ELEK:MICROCIRCUIT,28 DIP	09922	DILB28P-108
-11	----- -----			1		.CKT BOARD ASSY:LED(SEE A22 REPL)		
-12	175-7185-00			1		..CA ASSY,SPEC,ELEC:4,26 AWG,12.5L,RIBBON	80009	175-7185-00
-13	378-0896-00	B020000	B025499	3		.LENS,LIGHT:CLEAR LED		
	378-0896-01	B025500		3		.LENS,LIGHT:CLEAR LED	80009	378-0896-01
	----- -----			-		.(2445 ONLY)		
	378-0896-00	B020000	B027849	3		.LENS,LIGHT:CLEAR LED		
	----- -----			-		.(2465 ONLY)		
	378-0896-01	B027850		3		.LENS,LIGHT:CLEAR LED	80009	378-0896-01
	----- -----			-		.(2465 ONLY)		
-14	386-0867-00			1		.PLATE,MOUNTING:LED	80009	386-0867-00
-15	----- -----			1		.CKT BOARD ASSY:BUFFER(SEE A20 REPL)		
						.**********(ATTACHING PARTS)**********		
-16	211-0711-00			5		.SCR,ASSEM WSHR:6-32 X 0.25 L,PNH,TORX	01536	ORD BY DESCR
						.**********(END ATTACHING PARTS)*********		
	----- -----			-		.CKT BOARD ASSY INCLUDES:		
-17	361-1252-00	B020000	B021174	5		..SPACER,CKT BD:0.1 ID X 0.188 OD X 0.185		
	----- -----			-		..(2445 ONLY)		
	361-1252-01	B021175		5		..SPACER,CKT BD:0.1ID X 0.188 X 0.185,PLAS	T1319	ORD BY DESCR
	----- -----			-		..(2445 ONLY)		
	361-1252-00	B020000	B022174	5		..SPACER,CKT BD:0.1 ID X 0.188 OD X 0.185		
	----- -----			-		..(2465 ONLY)		
	361-1252-01	B022175		5		..SPACER,CKT BD:0.1ID X 0.188 X 0.185,PLAS	T1319	ORD BY DESCR
	----- -----			-		..(2465 ONLY)		
-18	131-0993-00			1		..BUS,CONDUCTOR:2 WIRE BLACK	00779	850100-01
-19	136-0751-00			1		..SKT,PL-IN ELEK:MICROCKT,24 PIN	09922	DILB24P108
-20	175-7183-00			1		.CA ASSY,SP,ELEC:7,22 AWG,7.75 L,RIBBON	80009	175-7183-00
-21	175-7184-00			1		.CA ASSY,SP,ELEC:34,28 AWG,6.5 L,RIBBON	80009	175-7184-00
	346-0120-00			1		.STRAP,TIEDOWN:5.5 L MIN,PLASTIC	06383	SST 1.5M
-22	175-7215-00			1		.CA ASSY,SPEC,ELEC:24 CONDUCTOR,FLEX	80009	175-7215-00
						.**********(ATTACHING PARTS)**********		
-23	129-1003-00			2		.SPACER,POST:0.705 L,6-32 EXT THD ONE		
-24	210-0069-00			2		.WASHER,LOCK:0.168 ID X 0.293 " OD,SPLIT	83385	ORD BY DESCR
						.**********(END ATTACHING PARTS)*********		
-25	337-0118-00			1		.SHIELD,ELEC:GPIB	80009	337-0118-00
-26	210-0201-00			1		.TERMINAL,LUG:0.12 ID,LOCKING,BRZ TIN PL	86928	ORD BY DESCR
-27	200-2686-01			1		.COVER,READ:CRT ALUM	80009	200-2686-01
						.**********(ATTACHING PARTS)**********		
	211-0711-00			4		.SCR,ASSEM WSHR:6-32 X 0.25 L,PNH,TORX	01536	ORD BY DESCR
						.**********(END ATTACHING PARTS)*********		
	334-4758-00			1		.MARKER,IDENT:MKD GPIB	22670	ORD BY DESCR
	----- -----			-		.(POSITIONED ON REAR COVER OF HOST		
	----- -----			-		.INSTRUMENT UNDER GPIB CONNECTOR)		
	334-5180-00			1		.MARKER,IDENT:MKD GPIB OPTION(2465 ONLY)		
	334-5187-00			1		.MARKER,IDENT:MKD GPIB OPTION(2445 ONLY)		
	----- -----			-		.(POSTIIONED ABOVE CRT OPENING ON TRIM RIN		
	----- -----			-		.OF HOST INSTRUMENT)		

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Dscont	Qty	1 2 3 4 5	Name & Description	Mfr Code	Mfr Part Number
2-						STANDARD ACCESSORIES		
	070-4633-00			1		MANUAL,TECH:OPERATORS,2445/2465 OPT 10 GPI	80009	070-4633-00
	070-4640-00			1		MANUAL,TECH:SERVICE,2445/2465 OPT 10 GPIB	80009	070-4640-00
	070-5150-00	B022742		1		MANUAL,INSTR:2445/2465 OPT 10 INSTR INTF	80009	070-5150-00
	----- -----			-		(2445 ONLY)		
	070-5150-00	B024364		1		MANUAL,INSTR:2445/2465 OPT 10 INSTR INTF	80009	070-5150-00
	----- -----			-		(2465 ONLY)		
	070-5364-00	B024900		1		CARD,INFO:REF,GPIB OPTION	80009	070-5364-00
	----- -----			-		(2445 ONLY)		
	070-5364-00	B026720		1		CARD,INFO:REF,GPIB OPTION	80009	070-5364-00
	----- -----			-		(2465 ONLY)		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DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it is in the low state.

Abbreviations are based on ANSI Y1.1-1972.

Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

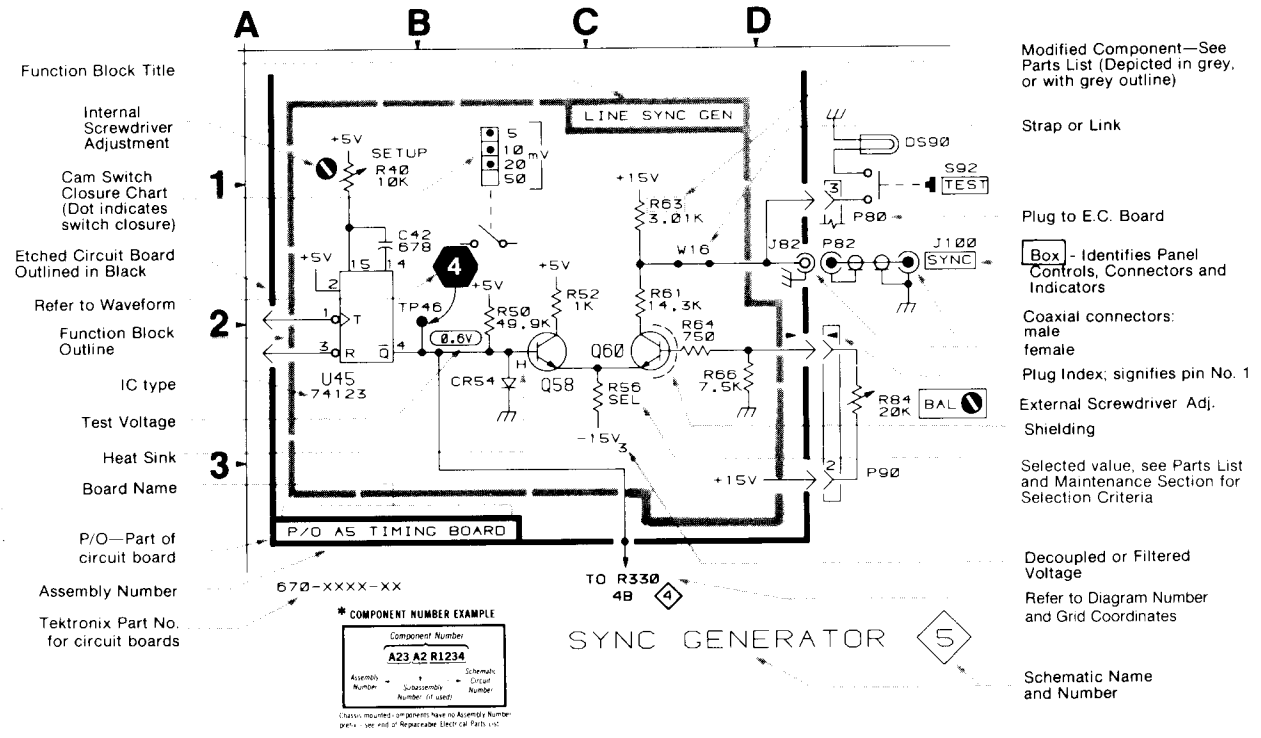
Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).
Resistors = Ohms (Ω).

The information and special symbols below may appear in this manual.

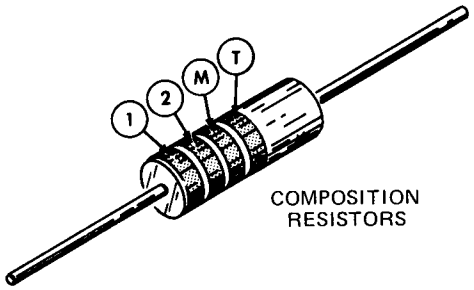
Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

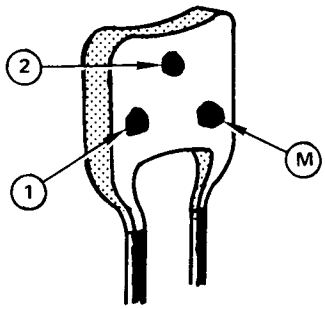
The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.



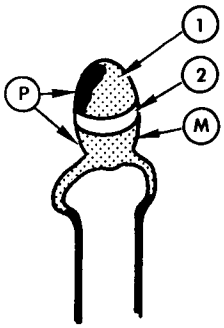
COLOR CODE



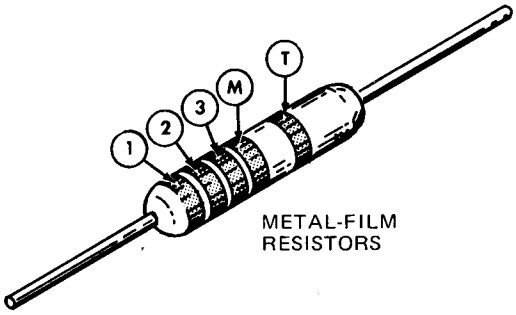
COMPOSITION RESISTORS



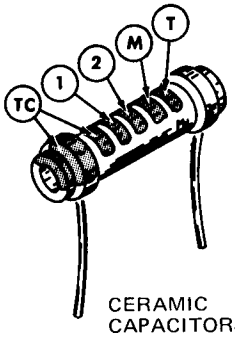
SMALL DISC CAPACITORS



DIPPED TANTALUM ELECTROLYTICS



METAL-FILM RESISTORS



CERAMIC CAPACITORS

(1)(2) and (3) – 1st, 2nd, and 3rd significant figures

(M) –multiplier (T) –tolerance

(TC) –temperature coefficient

(P) –polarity and voltage rating

(T) and/or (TC) color code may not be present on some capacitors

COLOR	SIGNIFICANT FIGURES	RESISTORS		CAPACITORS			DIPPED TANTALUM VOLTAGE RATING
		MULTIPLIER	TOLERANCE	MULTIPLIER	TOLERANCE		
					over 10 pF	under 10 pF	
BLACK	0	1	---	1	±20%	±2 pF	4 VDC
BROWN	1	10	±1%	10	±1%	±0.1 pF	6 VDC
RED	2	10^2 or 100	±2%	10^2 or 100	±2%	---	10 VDC
ORANGE	3	10^3 or 1 K	±3%	10^3 or 1000	±3%	---	15 VDC
YELLOW	4	10^4 or 10 K	±4%	10^4 or 10,000	+100% –9%	---	20 VDC
GREEN	5	10^5 or 100 K	±½%	10^5 or 100,000	±5%	±0.5 pF	25 VDC
BLUE	6	10^6 or 1 M	±¼%	10^6 or 1,000,000	---	---	35 VDC
VIOLET	7	---	±1/10%	---	---	---	50 VDC
GRAY	8	---	---	10^{-2} or 0.01	+80% –20%	±0.25 pF	---
WHITE	9	---	---	10^{-1} or 0.1	±10%	±1 pF	---
GOLD	–	10^{-1} or 0.1	±5%	---	---	---	---
SILVER	–	10^{-2} or 0.01	±10%	---	---	---	---
NONE	–	---	±20%	---	±10%	±1 pF	---

(1861-20A)4206-31

Figure 7-1. Color code for resistors and capacitors.

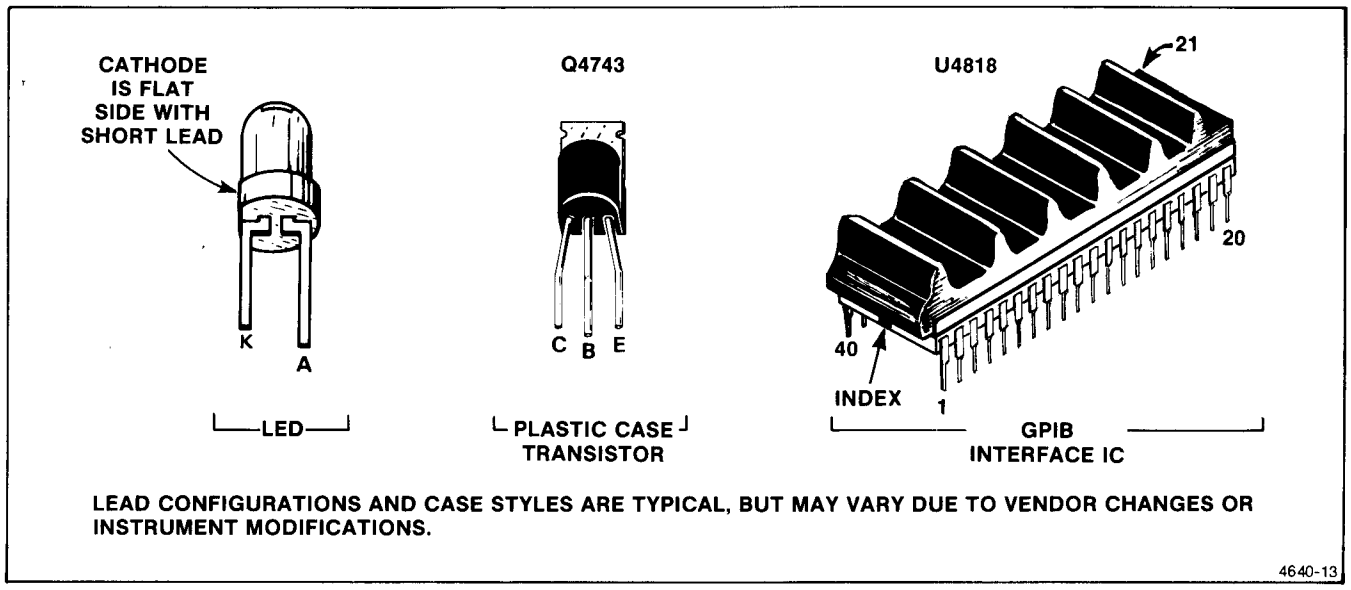


Figure 7-2. Semiconductor lead configurations.

To identify any component mounted on a circuit board and to locate that component in the appropriate schematic diagram

1. Locate the Circuit Board Illustration

a. In the instrument identify the Assembly Number of the circuit board in question. The Assembly Number is usually printed on the upper left corner of the circuit board on the component side.

b. In the manual locate and pull out tabbed page whose title corresponds with the Assembly Number of the circuit board. Circuit board assembly numbers and board nomenclature are printed on the back side of the tabs (facing the rear of the manual).

2. Determine the Circuit Number

a. Compare the circuit board with its illustration and locate the desired component by area and shape on the illustration.

b. Scan the table adjacent to the Circuit Board Illustration and find the Circuit Number of the desired component.

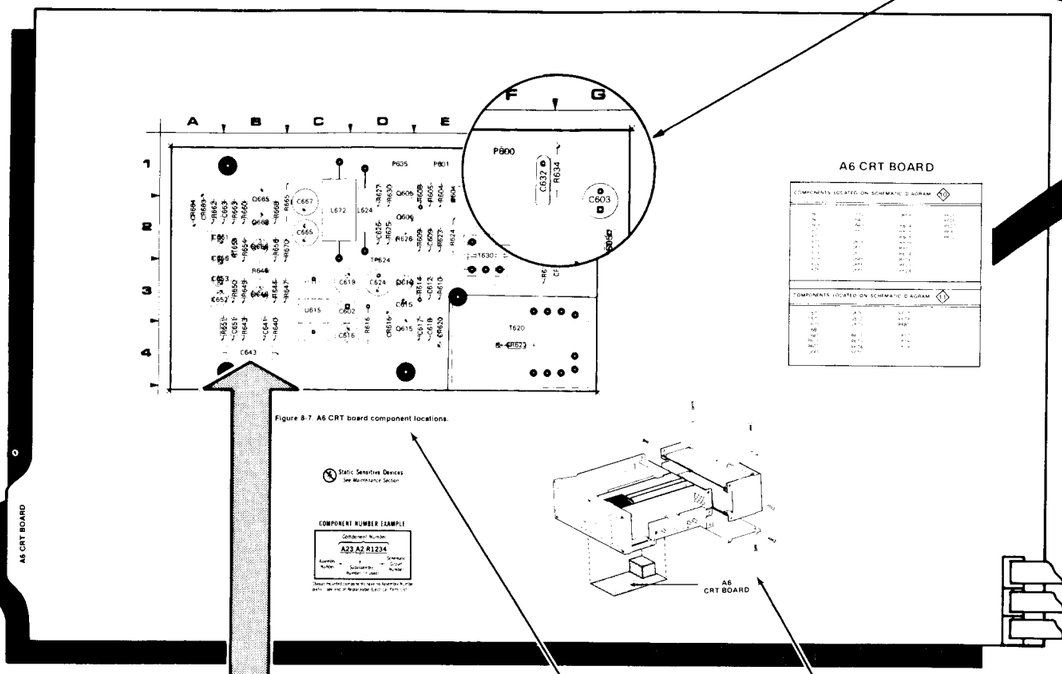
c. Determine the Schematic Diagram Number in which the component is located.

3. Locate the Compon

a. Locate and pull correspond with determined in th and numbers ar (facing the front

b. Scan the Comp schematic diagra desired compone

A6 CRT BOARD



A6 CRT BOARD

COMPONENTS LOCATED ON SCHEMATIC DIAGRAM 10			
C602	C632	Q668	R625
C603	C641		R626
C609	C643	R604	R627
C611	C651	R605	R630
C615		R608	R632
C616	Q606	R609	
C617	Q610	R610	
C618	Q615	R614	
C619	Q645	R616	
C624	Q656	R623	
C626	Q665	R624	

COMPONENTS LOCATED ON SCHEMATIC DIAGRAM 11			
C670	Q670	R677	
C671	Q672	R679	
C673	Q673	R680	
C680			
C681	R671	U617	
P603	R673	U618	
P607	R674	U619	
Q669	R675		

COMPONENT LOCATION TABLE

CRT CIRCUIT DIAGRAM 10

CRT CIRCUIT DIAGRAM 10

MANUAL BINDER

A6 ASSEMBLY

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C602	2C	3C	Q656	2F	2B
C603	1C	1G	Q665	1G	1B
C609	4E	2E	Q668	2G	2B
C612	7C	3E			
C615	7C	3D	R604	4C	1E
C616	2C	3C	R605	5D	1E
C617	7D	3D	R608	4E	1D
C618	7E	3E	R609	4E	2D
C619	6E	3C	R610	7B	3E
C624	4F	3D	R614	7C	3D
C626	7G	2D	R616	1C	3D
C632	8G	1E	R623	4D	2E
C643	3D	4B	R625	7F	2D
C651	3E	3B	R626	7F	2D
			R627	7G	1D
			R630	4F	1D
Q606	4E	2D			
Q610	7C	3D	TP624	3B	2D
Q615	7D	3D			
Q645	3E	3B	U615	1D	3C

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
L635	5I	CHASSIS	V635	6J	CHASSIS

MANUAL BINDER

PULL OUT PAGE TABS FOR CIRCUIT BOARD ILLUSTRATION

ASSEMBLY NUMBER AND CIRCUIT BOARD NAME

ILLUSTRATION FOR INSTRUMENT CIRCUIT BOARD LOCATION

4. Determine the Circuit Board Illustration and Component Location

a. From the schematic diagram, determine the Assembly Number of the circuit board on which the component is mounted. This information is boxed and located in a corner of the heavy line that distinguishes the board outline.

b. Scan the Component Location Table for the Assembly Number just determined and find the Circuit Number of the desired component.

c. Under the BOARD LOCATION column, read the grid coordinates for the desired component.

5. Locate the Component on the Circuit Board

a. In the manual, locate and pull out the tabbed page whose title and Assembly Number correspond with the desired circuit board. This information is on the back side of the tabs.

b. Using the Circuit Number and grid coordinates, locate the component on the Circuit Board Illustration.

c. In the circuit board location illustration, determine the location of the circuit board in the instrument.

d. Find the circuit board in the instrument and compare it with its illustration in the manual to locate the desired component on the board.

Figure 7-3. Locating components on schematic diagram and circuit board illustrations.

ine the Circuit Number

npare the circuit board with its illustration and locate desired component by area and shape on the illustra-.

an the table adjacent to the Circuit Board Illustration and d the Circuit Number of the desired component.

ermine the Schematic Diagram Number in which the nponent is located.

3. Locate the Component on the Schematic Diagram

a. Locate and pull out tabbed page whose number and title correspond with the Schematic Diagram Number just determined in the table. Schematic diagram nomenclature and numbers are printed on the front side of the tabs (facing the front of the manual).

b. Scan the Component Location Table adjacent to the schematic diagram and find the Circuit Number of the desired component.

c. Under the SCHEM LOCATION column, read the grid coordinates for the desired component.

d. Using the Circuit Number and grid coordinates, locate the component on the schematic diagram.

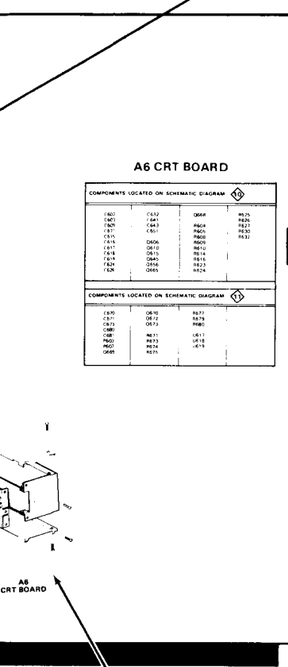


ILLUSTRATION FOR INSTRUMENT CIRCUIT BOARD LOCATION

MANUAL BINDER

A6 CRT BOARD

COMPONENTS LOCATED ON SCHEMATIC DIAGRAM 10

C602	C632	Q668	R625
C603	C641		R626
C609	C643	R604	R627
C671	C651	R605	R630
C615		R608	R632
C616	Q606	R609	
C617	Q610	R610	
C618	Q615	R614	
C619	Q645	R616	
C624	Q656	R623	
C626	Q665	R624	

COMPONENTS LOCATED ON SCHEMATIC DIAGRAM 11

C670	Q670	R677	
C671	Q672	R679	
C673	Q673	R680	
C680			
C681	R671	U617	
P603	R673	U618	
P607	R674	U619	
Q669	R675		

CRT CIRCUIT DIAGRAM 10

A6 ASSEMBLY

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C602	2C	3C	Q656	2F	2B
C603	1C	1G	Q665	1G	1B
C609	4E	2[illegible]	Q668	2G	2B
C612	7C	3E			
C615	7C	3D	R604	4C	1E
C616	2C	3C	R605	5D	1E
C617	7D	3D	R608	4E	1D
C618	7E	3E	R609	4E	2D
C619	6E	3C	R610	7B	3E
C624	4F	3D	R614	7C	3D
C626	7G	2D	R616	1C	3D
C632	8G	1F	R623	4D	2E
C643	3D	4B	R625	7F	2D
C651	3E	3B	R626	7F	2D
		3B	R627	7G	1D
			R630	4F	1D
Q606	4E	2D	TP624	3B	2D
Q610	7C	3D			
Q615	7D	3D	U615	1D	3C
Q645	3E	3B			

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
L635	51	CHASSIS	V635	6J	CHASSIS

tration and Component

determine the Assembly n which the component is oxed and located in a corner ishes the board outline.

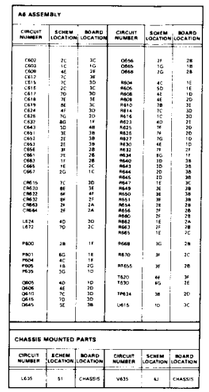
n Table for the Assembly nd the Circuit Number of the

N column, read the grid mponent.

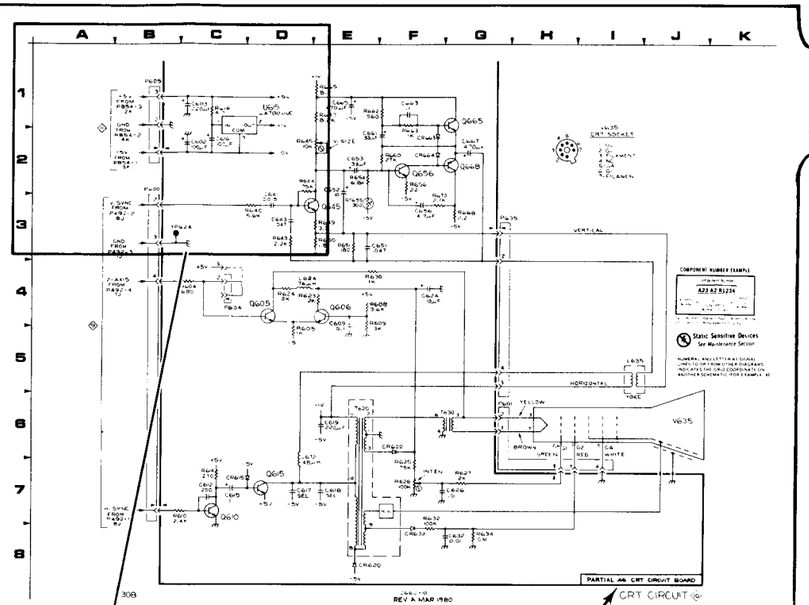
schematic diagram and circuit board illustrations.

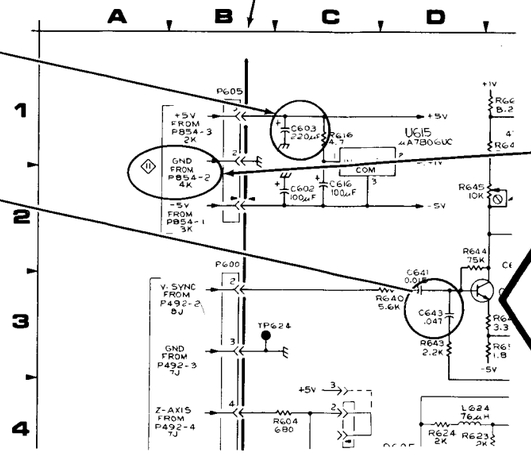
COMPONENT LOCATION TABLE

CRT CIRCUIT DIAGRAM 10



PULL OUT PAGE TABS FOR SCHEMATIC DIAGRAMS





PARTIAL A6 CRT CIRCUIT BOARD

CRT CIRCUIT 10

Numeral and letter at signal lines to or from other diagrams indicates the grid coordinates on another schematic (for example: 4E)

To identify any component in a schematic diagram and to locate that component on its respective circuit board.

SCHEMATIC DIAGRAM NAME AND NUMBER

(3516-81)4206-33

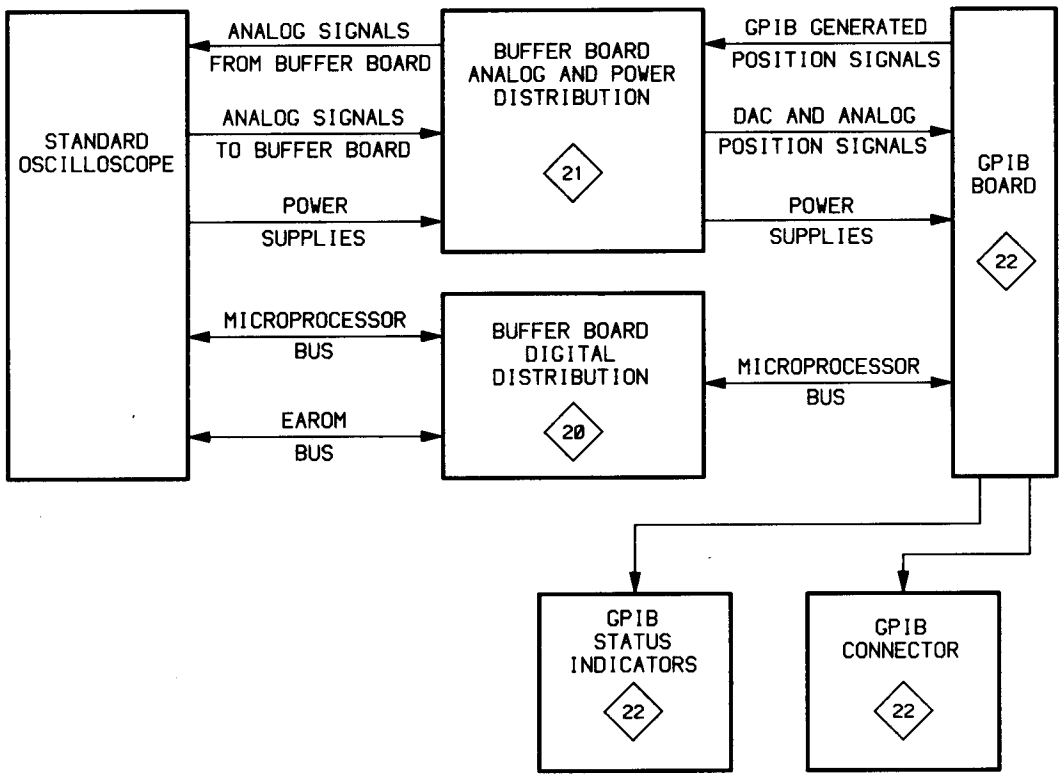


Figure 7-4. Simplified block diagram.

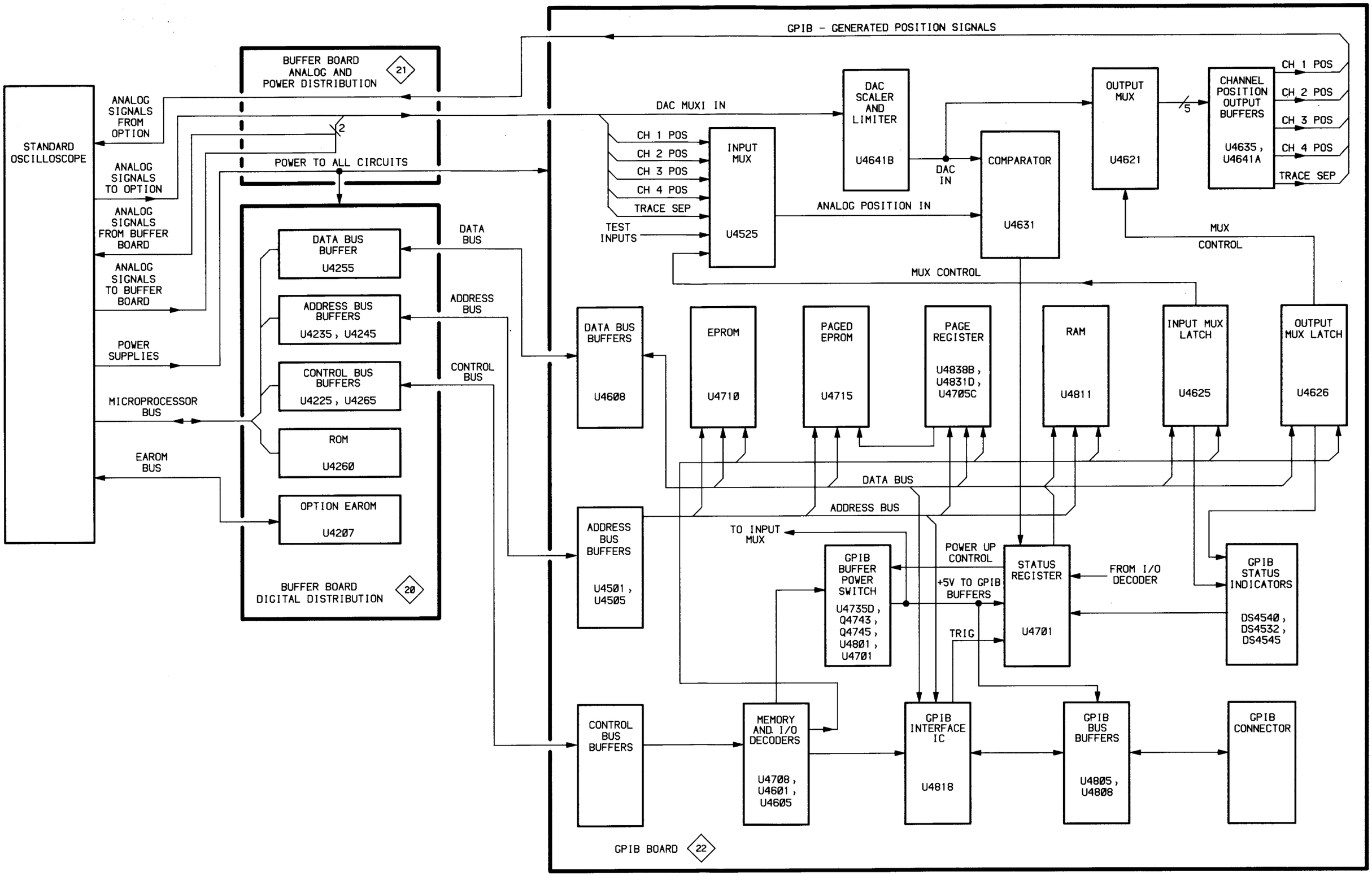
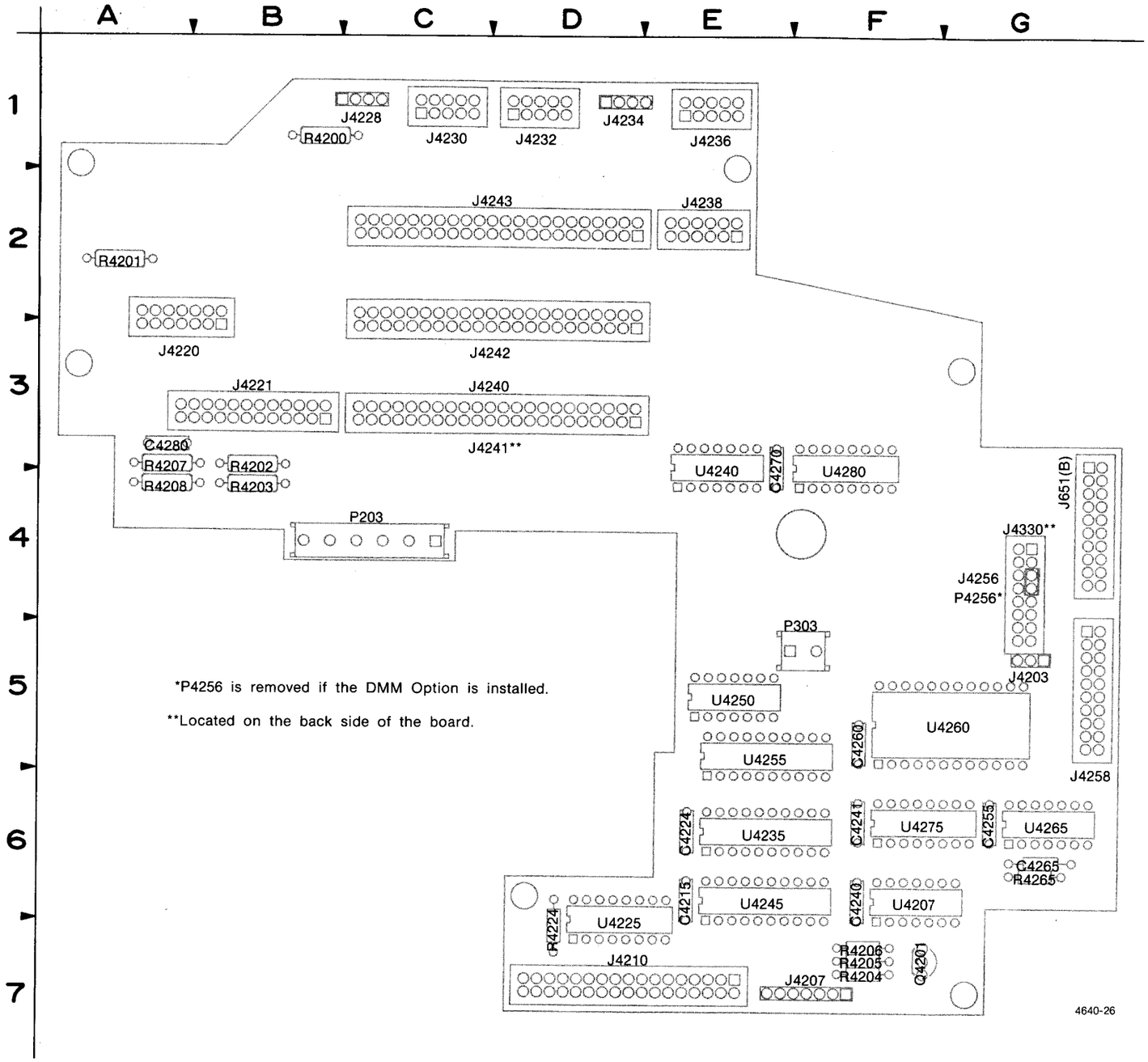


Figure 7-5. Detailed block diagram.

4640-12

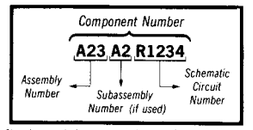


*P4256 is removed if the DMM Option is installed.

**Located on the back side of the board.

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

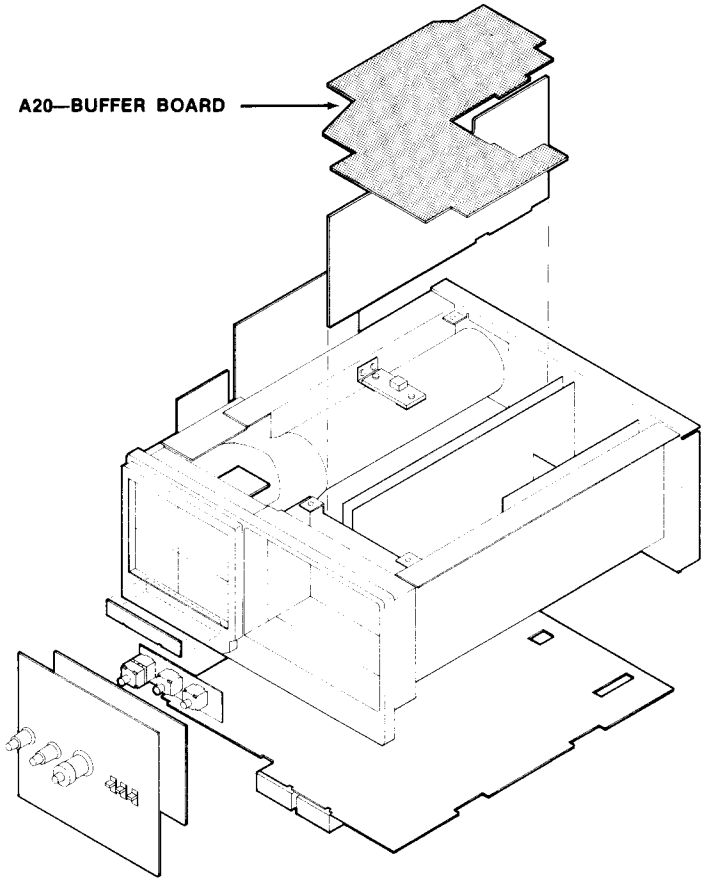


Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Figure 7-6. A20—Buffer board.

A20—BUFFER BOARD

CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER
C4215	21	J4240	20	R4203	21	U4250	20
C4224	21	J4240	21	R4204	20	U4250	20
C4240	21	J4241	20	R4205	20	U4250	20
C4241	21	J4241	21	R4206	20	U4250	21
C4255	21	J4242	20	R4207	21	U4255	20
C4260	21	J4242	21	R4208	21	U4255	21
C4265	20	J4243	20	R4224	20	U4260	20
C4270	21	J4243	21	R4265	20	U4260	21
C4280	21	J4256	20	U4207	20	U4265	20
J4203	21	J4258	21	U4207	20	U4265	20
J4207	20	J4330	20	U4225	20	U4265	20
J4210	20	J4330	21	U4225	21	U4265	20
J4220	21	J651(B)	21	U4235	20	U4265	21
J4221	21	P203	21	U4235	21	U4275	20
J4228	21	P303	21	U4240	20	U4275	21
J4230	21	P4256	20	U4240	20	U4280	20
J4232	21	Q4201	20	U4240	20	U4280	21
J4234	21	R4200	21	U4240	21		
J4236	21	R4201	21	U4245	20		
J4238	21	R4202	21	U4245	21		



BUFFER BOARD DIGITAL DISTRIBUTION 

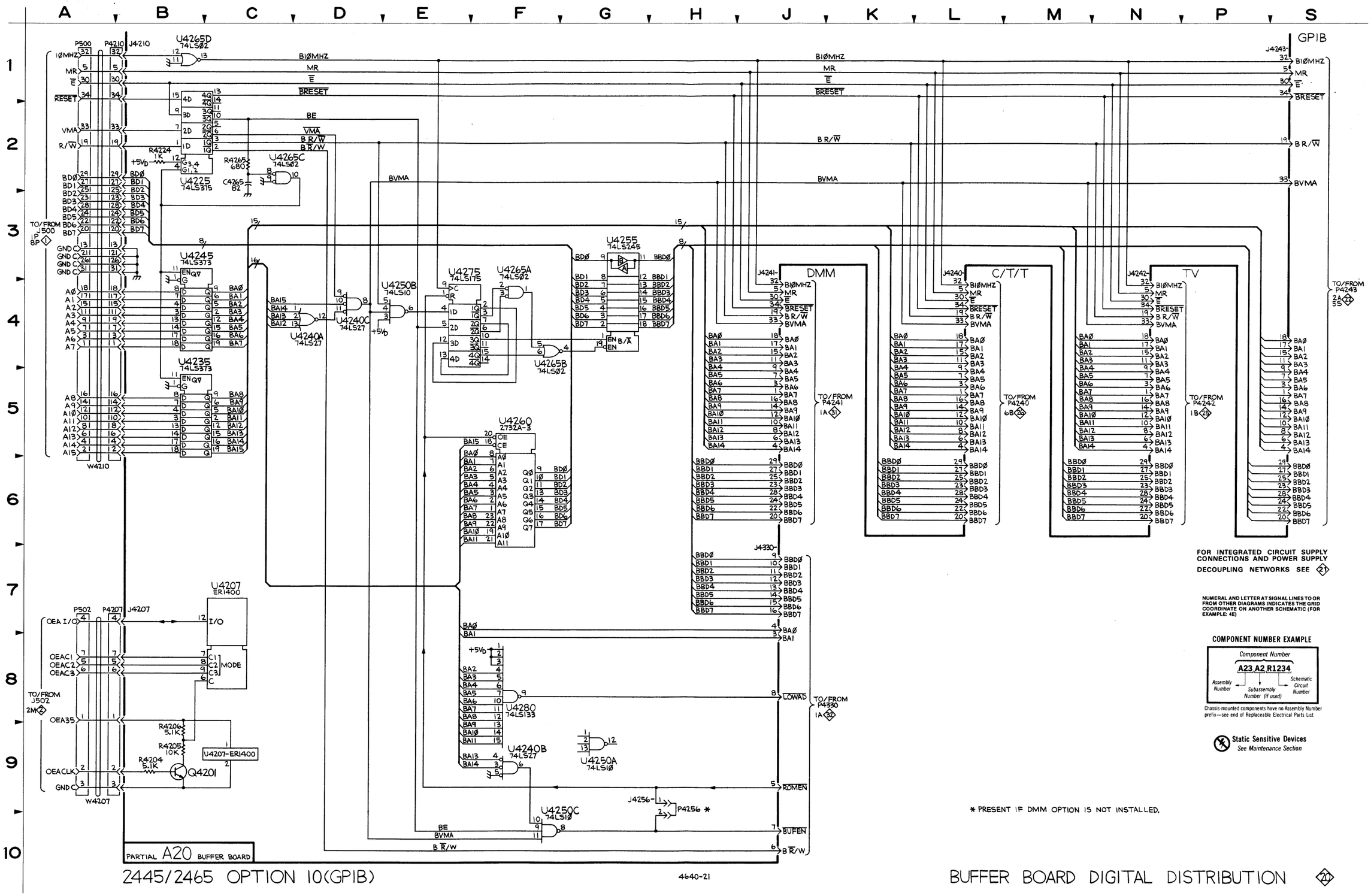
ASSEMBLY A20

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4265	2C	6G	P4256	10H	4G	U4207	7C	6F	U4250C	10F	5E
						U4207	9C	6F	U4255	3G	5E
J4207	7B	7F	Q4201	9B	7F	U4225	2B	7D	U4260	5F	5G
J4210	1B	7D				U4235	4B	6E	U4265A	3F	6G
J4240	3L	3D	R4204	9B	7F	U4240A	4D	3E	U4265B	4F	6G
J4241	3J	3D	R4205	9B	7F	U4240B	9F	3E	U4265C	2C	6G
J4242	3N	3D	R4206	9B	7F	U4240C	4D	3E	U4265D	1B	6G
J4243	1S	2D	R4224	2B	7D	U4245	3B	6E	U4275	3E	6F
J4256	9G	4G	R4265	2C	6G	U4250A	9G	5E	U4280	8F	3F
J4330	7J	4G				U4250B	4E	5E			

Partial A20 also shown on diagram 21.

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
P500	1A	CHASSIS	P4207	7A	CHASSIS	W4207	9A	CHASSIS			
P502	7A	CHASSIS	P4210	1A	CHASSIS	W4210	6A	CHASSIS			



FOR INTEGRATED CIRCUIT SUPPLY CONNECTIONS AND POWER SUPPLY DECOUPLING NETWORKS SEE 21

NUMERAL AND LETTER AT SIGNAL LINES TO OR FROM OTHER DIAGRAMS INDICATES THE GRID COORDINATE ON ANOTHER SCHEMATIC (FOR EXAMPLE: 4E)

COMPONENT NUMBER EXAMPLE

Component Number: A23 A2 R1234
(Assembly Number · Subassembly Number (if used) · Schematic Circuit Number)

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

* PRESENT IF DMM OPTION IS NOT INSTALLED.

2445/2465 OPTION 10(GPIB)

4640-21

BUFFER BOARD DIGITAL DISTRIBUTION 20

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM NUMBER	SCHEM LOCATION	CIRCUIT NUMBER	SCHEM NUMBER	SCHEM LOCATION
P100	21	3A	P4236	21	6B
P101	21	6A	P4258	21	1P
P102	21	4A	P4800	22	6S
P103	21	3A	P651(B)	21	1S
P104	21	5A			
P109	21	3A	W4203	21	9S
P500	20	1A	W4207	20	9A
P502	20	7A	W4210	20	6A
P602	21	8S	W4228	21	3B
P4203	21	8P	W4230	21	4B
P4207	20	7A	W4232	21	5B
P4210	20	1A	W4234	21	6B
P4228	21	3B	W4236	21	7B
P4230	21	3B	W4258	21	3S
P4232	21	4B			
P4234	21	5B			

BUFFER BOARD ANALOG AND POWER DISTRIBUTIONS

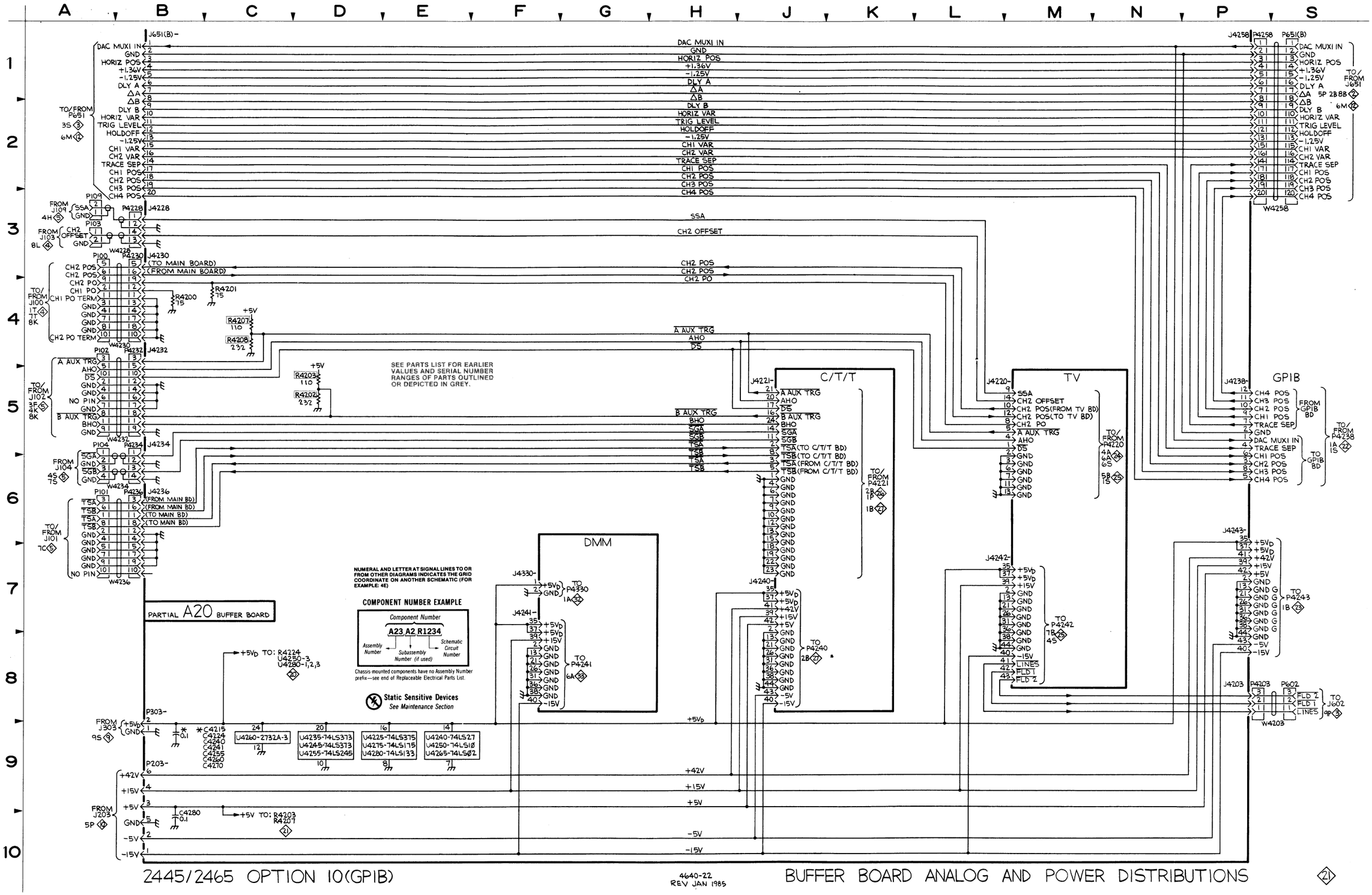
ASSEMBLY A20

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4215	9C	6E	J4228	3B	1C	J651(B)	1B	4G	U4225	9D	7D
C4224	9C	6E	J4230	3B	1C				U4235	9D	6E
C4240	9C	6F	J4232	4B	1D	P203	9B	4C	U4240	9E	3E
C4241	9C	6F	J4234	5B	1D	P303	8B	5F	U4245	9D	6E
C4255	9C	6G	J4236	6B	1E				U4250	9E	5E
C4260	9C	5F	J4238	5P	2E	R4200	4B	1B	U4255	9D	5E
C4270	9C	3E	J4240	7J	3D	R4201	4C	2A	U4260	9C	5G
C4280	10B	3A	J4241	7F	3D	R4202	5D	3B	U4265	9E	6G
			J4242	7L	3D	R4203	5D	4B	U4275	9D	6F
J4203	8P	5G	J4243	6P	2D	R4207	4C	3A	U4280	9D	3F
J4220	5L	3A	J4258	1P	5G	R4208	4C	4A			
J4221	5J	3B	J4330	7F	4G						

Partial A20 also shown on diagram 20.

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
P100	3A	CHASSIS	P602	8S	CHASSIS	P4236	6B	CHASSIS	W4230	4B	CHASSIS
P101	6A	CHASSIS	P4203	8P	CHASSIS	P4258	1P	CHASSIS	W4232	5B	CHASSIS
P102	4A	CHASSIS	P4228	3B	CHASSIS	P651(B)	1S	CHASSIS	W4234	6B	CHASSIS
P103	3A	CHASSIS	P4230	3B	CHASSIS				W4236	7B	CHASSIS
P104	5A	CHASSIS	P4232	4B	CHASSIS	W4203	9S	CHASSIS	W4258	3S	CHASSIS
P109	3A	CHASSIS	P4234	5B	CHASSIS	W4228	3B	CHASSIS			



2445/2465 OPTION 10(GPIB)

4640-22
REV JAN 1985

BUFFER BOARD ANALOG AND POWER DISTRIBUTIONS

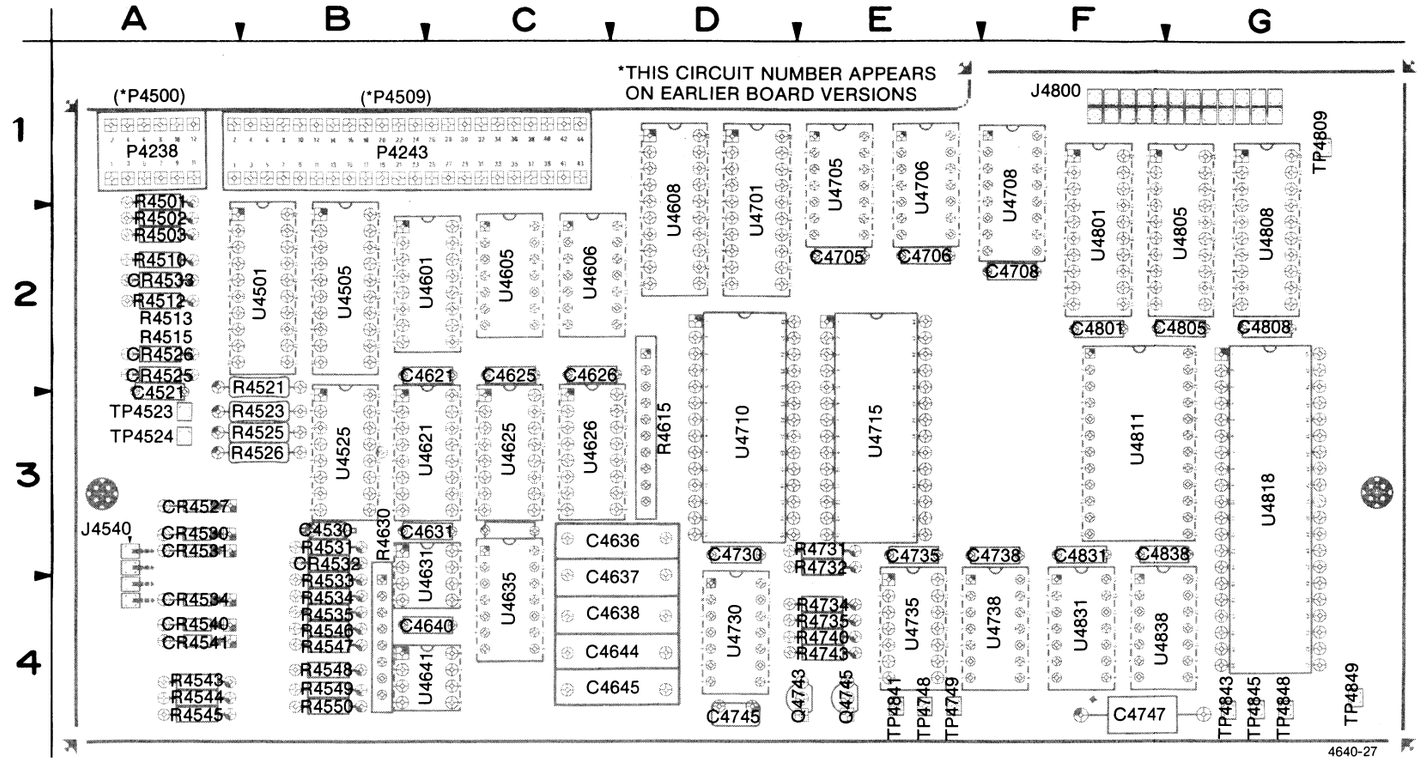


Figure 7-7. A23—GPIB board.

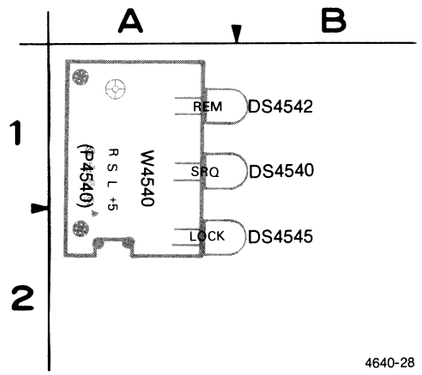
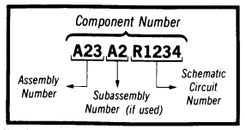


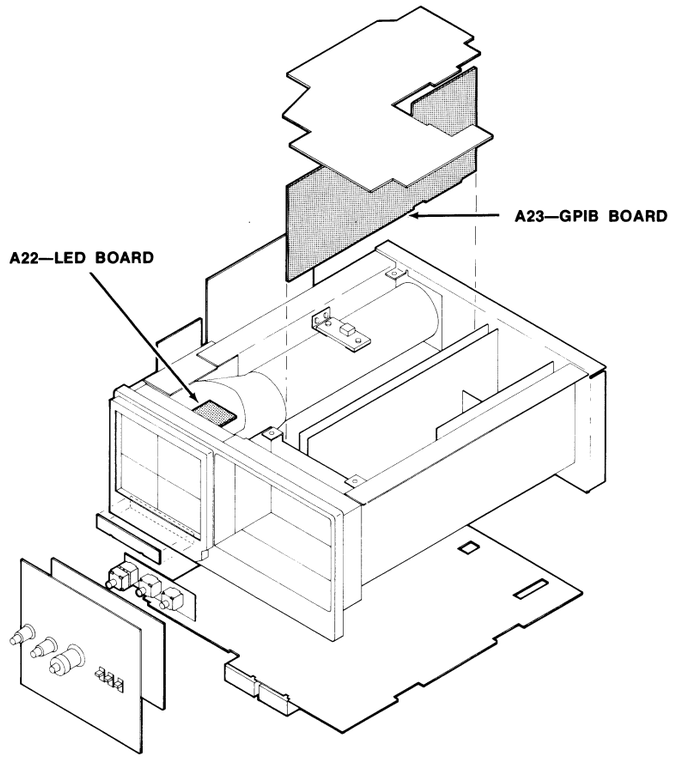
Figure 7-8. A22—LED board.

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.



A23—GPIB BOARD

CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER
C4521	23	P4500*	22	U4525	22	U4706	22
C4530	22	P4500*	22	U4525	23	U4706	22
C4621	23	P4509*	22	U4601	22	U4706	23
C4625	23	P4509*	22	U4601	23	U4708	22
C4626	23	P4509*	23	U4605	22	U4708	23
C4631	23	Q4743	22	U4605	22	U4710	22
C4636	22	Q4745	22	U4605	22	U4710	23
C4637	22	R4501	22	U4605	23	U4715	22
C4638	22	R4502	22	U4606	22	U4715	23
C4640	23	R4503	22	U4606	22	U4730	22
C4644	22	R4510	22	U4606	22	U4730	22
C4645	22	R4512	22	U4606	22	U4730	22
C4705	23	R4513	22	U4606	22	U4730	22
C4706	23	R4515	22	U4606	22	U4730	23
C4708	23	R4521	22	U4606	23	U4735	22
C4730	23	R4523	22	U4608	22	U4735	22
C4735	23	R4525	22	U4608	23	U4735	22
C4738	23	R4526	22	U4621	22	U4735	22
C4745	23	R4531	22	U4621	23	U4735	23
C4747	23	R4533	22	U4625	22	U4738	22
C4801	23	R4534	22	U4625	23	U4738	22
C4805	22	R4535	22	U4626	22	U4738	22
C4808	23	R4543	22	U4626	23	U4738	23
C4831	23	R4544	22	U4631	22	U4801	22
C4838	23	R4545	22	U4631	23	U4801	23
CR4525	22	R4546	22	U4635	22	U4805	22
CR4526	22	R4547	22	U4635	22	U4805	22
CR4527	22	R4548	22	U4635	22	U4808	22
CR4530	22	R4549	22	U4635	22	U4808	22
CR4531	22	R4550	22	U4635	23	U4811	22
CR4532	22	R4615	22	U4641	22	U4811	23
CR4533	22	R4630	22	U4641	22	U4818	22
CR4534	22	R4731	22	U4641	23	U4818	23
CR4540	22	R4732	22	U4701	22	U4831	22
CR4541	22	R4734	22	U4701	23	U4831	22
J4540	22	R4735	22	U4705	22	U4831	22
J4800	22	R4740	22	U4705	22	U4831	22
P4238	22	R4743	22	U4705	22	U4831	23
P4238	22	U4501	22	U4705	22	U4838	22
P4243	22	U4501	23	U4705	23	U4838	22
P4243	22	U4505	22	U4706	22	U4838	23
P4243	23	U4505	23	U4706	22		

***This circuit number appears on earlier board versions.**

A22—LED BOARD

CIRCUIT NUMBER	SCHEM NUMBER	CIRCUIT NUMBER	SCHEM NUMBER
DS4540	22	P4540	22
DS4542	22	W4540	22
DS4545	22		

GPIB BOARD 22

ASSEMBLY A22

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
DS04540	3N	1B	DS4545	4P	2B	P4540	3M	1A	W4540	4M	1A
DS4542	4N	1B									

ASSEMBLY A23

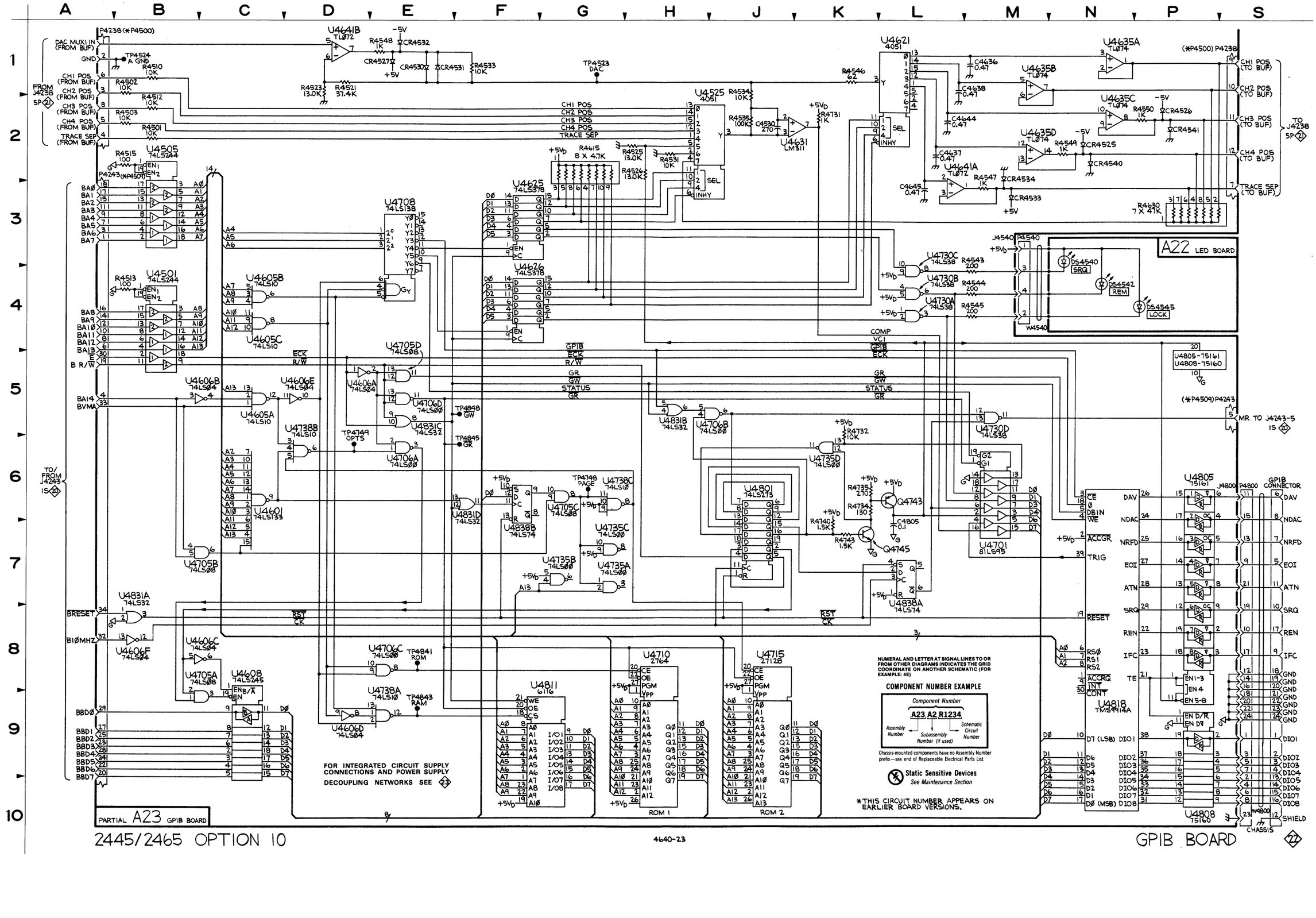
CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4530	2J	3B	Q4745	7L	4E	R4743	7K	4E	U4706B	5J	1E
C4636	1M	3D							U4706C	8E	1E
C4637	2L	4D	R4501	2B	1A	U4501	4B	2B	U4706D	5E	1E
C4638	1M	4D	R4502	1B	2A	U4505	2B	2B	U4708	3E	1F
C4644	2M	4D	R4503	2B	2A	U4525	1J	3B	U4710	8H	3D
C4645	3L	4D	R4510	1B	2A	U4601	6C	2C	U4715	8J	3E
C4805	7L	2G	R4512	2B	2A	U4605A	5C	2C	U4730A	4L	4D
			R4513	4B	2A	U4605B	4C	2C	U4730B	4L	4D
CR4525	2N	2A	R4515	2B	2A	U4605C	4C	2C	U4730C	3L	4D
CR4526	2P	2A	R4521	1D	2B	U4606A	5D	2C	U4730D	5M	4D
CR4527	1E	3A	R4523	1D	3B	U4606B	5C	2C	U4735A	7G	4E
CR4530	1E	3A	R4525	2H	3B	U4606C	8C	2C	U4735B	7G	4E
CR4531	1E	3A	R4526	2H	3B	U4606D	9D	2C	U4735C	7G	4E
CR4532	1E	3B	R4531	2H	3B	U4606E	5D	2C	U4735D	6K	4E
CR4533	3M	2A	R4533	1F	4B	U4606F	8B	2C	U4738A	9E	4F
CR4534	2M	4A	R4534	1J	4B	U4608	8C	2D	U4738B	5D	4F
CR4540	2N	4A	R4535	2J	4B	U4621	1L	3C	U4738C	6G	4F
CR4541	2P	4A	R4543	3M	4A	U4625	3F	3C	U4801	6J	2F
			R4544	4M	4A	U4626	4F	3C	U4805	5P	2G
J4540	3M	3A	R4545	4M	4A	U4631	2K	4C	U4805	6P	2G
J4800	6S	1F	R4546	1K	4B	U4635A	1N	4C	U4808	10P	2G
			R4547	2M	4B	U4635B	1M	4C	U4808	5P	2G
P4238	1A	1A	R4548	1E	4B	U4635C	2N	4C	U4811	8G	3F
P4238	1S	1A	R4549	2N	4B	U4635D	2M	4C	U4818	9N	3G
P4243	2A	1B	R4550	2P	4B	U4641A	2L	4C	U4831A	7B	4F
P4243	5S	1B	R4615	2G	3D	U4641B	1D	4C	U4831B	5H	4F
P4500*	1B	1A	R4630	3P	3B	U4701	7M	2D	U4831C	5E	4F
P4500*	1P	1A	R4731	2K	3E	U4705A	8C	1E	U4831D	6F	4F
P4509*	2B	1B	R4732	5K	3E	U4705B	7C	1E	U4838A	7L	4F
P4509*	5P	1B	R4734	6K	4E	U4705C	6G	1E	U4838B	7F	4F
			R4735	6K	4E	U4705D	4E	1E			
Q4743	6L	4E	R4740	7K	4E	U4706A	6E	1E			

Partial A23 also shown on diagram 23.

CHASSIS MOUNTED PARTS

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
P4800	6S	CHASSIS	W4800	10S	CHASSIS						

***This circuit number appears on earlier board versions.**



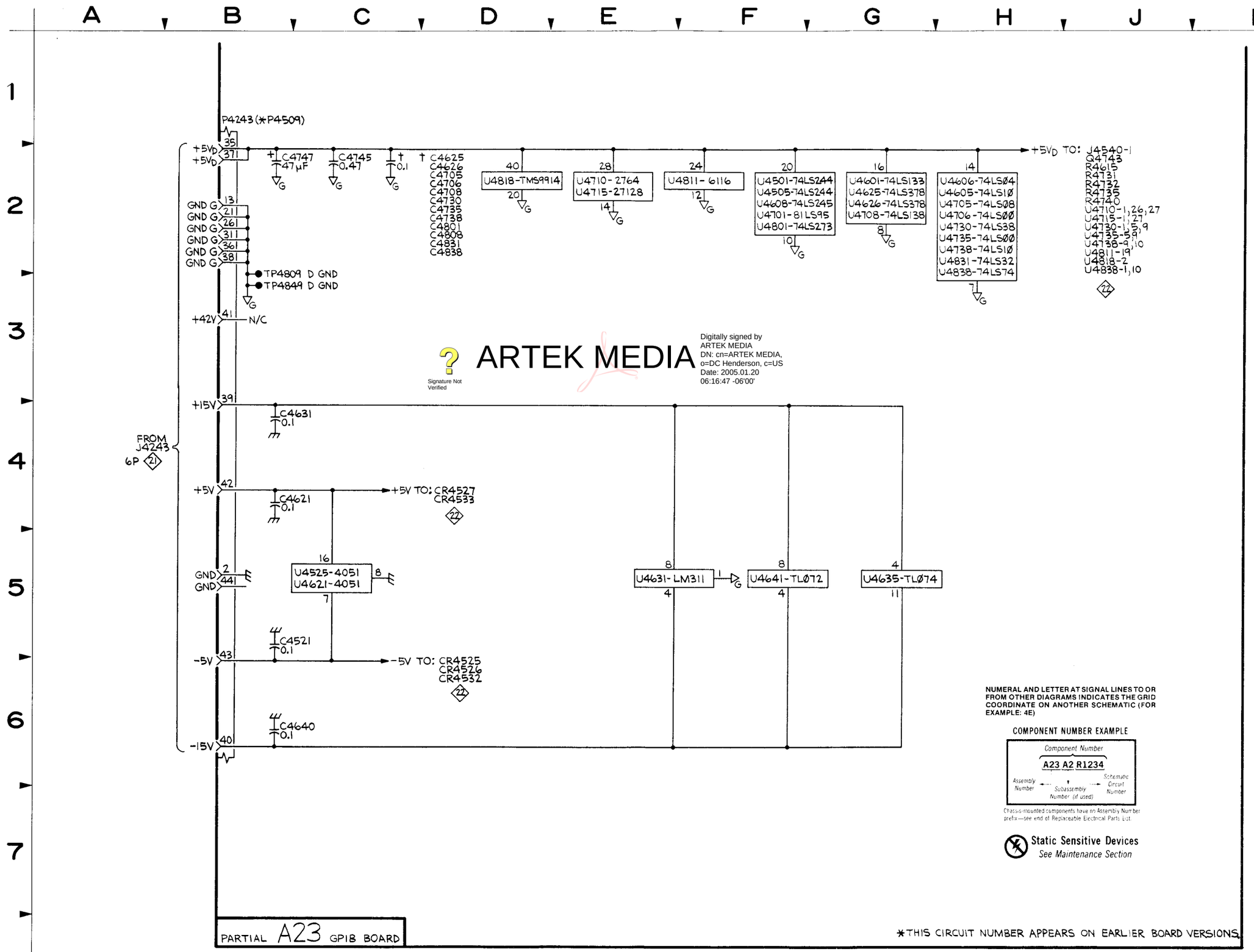
GPIB BOARD POWER DISTRIBUTION 23

ASSEMBLY A23

CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEM LOCATION	BOARD LOCATION
C4521	5B	3A	C4747	2B	4F	U4605	2H	2C	U4710	2E	3D
C4621	4B	2C	C4801	2D	2F	U4606	2H	2C	U4715	2E	3E
C4625	2D	2C	C4808	2D	2G	U4608	2F	2D	U4730	2H	4D
C4626	2D	2C	C4831	2D	3F	U4621	5C	3C	U4735	2H	4E
C4631	4B	3C	C4838	2D	3F	U4625	2G	3C	U4738	2H	4F
C4640	6B	4C				U4626	2G	3C	U4801	2F	2F
C4705	2D	2E	P4243	1B	1B	U4631	5E	4C	U4811	2F	3F
C4706	2D	2E	P4509*	1B	1B	U4635	5G	4C	U4818	2D	3G
C4708	2D	2F				U4641	5F	4C	U4831	2H	4F
C4730	2D	3D	U4501	2F	2B	U4701	2F	2D	U4838	2H	4F
C4735	2D	3E	U4505	2F	2B	U4705	2H	1E			
C4738	2D	3F	U4525	5C	3B	U4706	2H	1E			
C4745	2C	4D	U4601	2G	2C	U4708	2G	1F			

Partial A23 also shown on diagram 22.

***This circuit number appears on earlier board versions.**



2445/2465 OPTION 10

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GPIB BOARD POWER DISTRIBUTION

J/P100 A1 TO A20

Pin	Line Name	Schem
1	CH1 PO TERM	4,21
2	CH1 PO	4,21
3	GND	4,21
4	GND	4,21
5	CH2 POS	4,21
6	CH2 POS	4,21
7	GND	4,21
8	GND	4,21
9	CH2 PO	4,21
10	CH2 PO TERM	4,21

J/P101 A1 TO A20

Pin	Line Name	Schem
1	$\overline{\text{TSA}}$	5,21
2	GND	5,21
3	$\overline{\text{TSA}}$	5,21
4	GND	5,21
5	GND	5,21
6	$\overline{\text{TSB}}$	5,21
7	GND	5,21
8	$\overline{\text{TSB}}$	5,21
9	GND	5,21
10	NO PIN	5,21

J/P102 A1 TO A20

Pin	Line Name	Schem
1	BHO	5,21
2	GND	5,21
3	$\overline{\text{A AUX TRG}}$	5,21
4	GND	5,21
5	AHO	5,21
6	NO PIN	5,21
7	GND	5,21
8	$\overline{\text{B AUX TRG}}$	5,21
9	GND	5,21
10	$\overline{\text{DS}}$	5,21

J/P500 A5 TO A20

Pin	Line Name	Schem
1	A7	1,20
2	A15	1,20
3	A6	1,20
4	A14	1,20
5	MR	1,20
6	A13	1,20
7	A5	1,20
8	A12	1,20
9	A4	1,20
10	A11	1,20
11	A3	1,20
12	A10	1,20
13	GND C	1,20
14	A9	1,20
15	A2	1,20
16	A8	1,20
17	A1	1,20
18	A0	1,20
19	R/$\overline{\text{W}}$	1,20
20	BD7	1,20
21	GND C	1,20
22	BD6	1,20
23	BD3	1,20
24	BD5	1,20
25	BD2	1,20
26	GND C	1,20
27	BD1	1,20
28	BD4	1,20
29	BD0	1,20
30	$\overline{\text{E}}$	1,20
31	GND C	1,20
32	10MHz	1,20
33	VMA	1,20
34	$\overline{\text{RESET}}$	1,20

J/P502 A5 TO A20

Pin	Line Name	Schem
1	OEA35	2,20
2	OEACLK	2,20
3	GND C	2,20
4	OEAI/O	2,20
5	OEAC2	2,20
6	OEAC3	2,20
7	OEAC1	2,20

J651(B)/P651/W651 A6 TO A20

Pin	Line Name	Schem
1	DAC MUX1 IN	3,21
2	GND	12,21
3	HORIZ POS	3,21
4	+1.36V	3,21
5	-1.25V	3,21
6	DLY A	3,21
7	ΔA	3,21
8	ΔB	3,21
9	DLY B	3,21
10	HORIZ VAR	3,21
11	TRIG LEVEL	3,21
12	HOLDOFF	3,21
13	-1.25V	3,21
14	TRACE SEP	3,21
15	CH1 VAR	3,21
16	CH2 VAR	3,21
17	CH1 POS	3,21
18	CH2 POS	3,21
19	CH3 POS	3,21
20	CH4 POS	3,21

J651/P651(B) A20 TO A5

Pin	Line Name	Schem
1	DAC MUX1 IN	2,21
2	GND	12,21
3	HORIZ POS	2,21
4	+1.36V	2,21
5	-1.25V	2,21
6	DLY A	2,21
7	ΔA	2,21
8	ΔB	2,21
9	DLY B	2,21
10	HORIZ VAR	2,21
11	TRIG LEVEL	2,21
12	HOLDOFF	2,21
13	-1.25V	2,21
14	TRACE SEP	2,21
15	CH1 VAR	2,21
16	CH2 VAR	2,21
17	CH1 POS	2,21
18	CH2 POS	2,21
19	CH3 POS	2,21
20	CH4 POS	2,21

J/P/W4207 A5 TO A20

Pin	Line Name	Schem
1	OEA35	20
2	OEACLK	20
3	GND C	20
4	OEAI/O	20
5	OEAC2	20
6	OEAC3	20
7	OEAC1	20

J/P4220 A20 TO A25

Pin	Line Name	Schem
1	$\overline{DS}$	21,25
2	GND	21,25
3	GND	21,25
4	AHO	21,25
5	$\overline{A\ AUX\ TRG}$	21,25
6	GND	21,25
7	GND	21,25
8	CH2 PO	21,24
9	SSA	21,24
10	CH2 POS	21,25
11	GND	21,25
12	CH2 POS	21,25
13	GND	21,25
14	CH2 OFFSET	21,24

J/P/W4230 A1 TO A20

Pin	Line Name	Schem
1	CH1 PO TERM	21
2	CH1 PO	21
3	GND	21
4	GND	21
5	CH2 POS	21
6	CH2 POS	21
7	GND	21
8	GND	21
9	CH2 PO TERM	21
10	CH2 PO TERM	21

J/P/W4236 A1 TO A20

Pin	Line Name	Schem
1	$\overline{TSA}$	21
2	GND	21
3	$\overline{TSA}$	21
4	GND	21
5	GND	21
6	$\overline{TSB}$	21
7	GND	21
8	$\overline{TSB}$	21
9	GND	21
10	NO PIN	21

J/P4240 A20 TO A27

Pin	Line Name	Schem
1	BA7	20,26
2	GND	21,27
3	BA6	20,26
4	BA14	20,26
5	MR	20,26
6	BA13	20,26
7	BA5	20,26
8	BA12	20,26
9	BA4	20,26
10	BA11	20,26
11	BA3	20,26
12	BA10	20,26
13	GND	21,27
14	BA9	20,26
15	BA2	20,26
16	BA8	20,26
17	BA1	20,26
18	BA0	20,26
19	BR/$\overline{W}$	20,26
20	BBD7	20,26
21	GND	21,27
22	BBD6	20,26
23	BBD3	20,26
24	BBD5	20,26
25	BBD2	20,26
26	GND	21,27
27	BBD1	20,26
28	BBD4	20,26
29	BBD0	20,26
30	$\overline{E}$	20,26
31	GND	21,27
32	B10MHz	20,26
33	BVMA	20,26
34	$\overline{BRESET}$	20,26
35	+5V$_D$	21,27
36	GND	21,27
37	+5V$_D$	21,27
38	GND	21,27
39	+15V	21,27
40	−15V	21,27
41	+42V	21,27
42	+5V	21,27
43	−5V	21,27
44	GND	21,27

J/P/W4241 A20 TO A29

Pin	Line Name	Schem
1	BA7	20,31
2	GND	21,33
3	BA6	20,31
4	BA14	20,31
5	MR	20,31
6	BA13	20,31
7	BA5	20,31
8	BA12	20,31
9	BA4	20,31
10	BA11	20,31
11	BA3	20,31
12	BA10	20,31
13	GND	21,33
14	BA9	20,31
15	BA2	20,31
16	BA8	20,31
17	BA1	20,31
18	BA0	20,31
19	BR/$\overline{W}$	20,31
20	BBD7	20,31
21	GND	21,33
22	BBD6	20,31
23	BBD3	20,31
24	BBD5	20,31
25	BBD2	20,31
26	GND	21,33
27	BBD1	20,31
28	BBD4	20,31
29	BBD0	20,31
30	$\overline{E}$	20,31
31	GND	21,33
32	B10MHz	20,31
33	BVMA	20,31
34	$\overline{BRESET}$	20,31
35	+5V$_D$	21,33
36	GND	21,33
37	+5V$_D$	21,33
38	GND	21,33
39	+15V	21,33
40	−15V	21,33

J/P/W4210 A5 TO A20

Pin	Line Name	Schem
1	A7	20
2	A15	20
3	A6	20
4	A14	20
5	MR	20
6	A13	20
7	A5	20
8	A12	20
9	A4	20
10	A11	20
11	A3	20
12	A10	20
13	GND C	20
14	A9	20
15	A2	20
16	A8	20
17	A1	20
18	A0	20
19	R/$\overline{W}$	20
20	BD7	20
21	GND C	20
22	BD6	20
23	BD3	20
24	BD5	20
25	BD2	20
26	GND C	20
27	BD1	20
28	BD4	20
29	BD0	20
30	$\overline{E}$	20
31	GND C	20
32	10MHz	20
33	VMA	20
34	$\overline{RESET}$	20

J/P4221 A20 TO A27

Pin	Line Name	Schem
1	GND	21,27
2	$\overline{TSA}$	21,26
3	$\overline{TSA}$	21,26
4	GND	21,27
5	$\overline{TSB}$	21,26
6	GND	21,27
7	GND	21,27
8	$\overline{TSB}$	21,26
9	GND	21,27
10	GND	21,27
11	$\overline{SGB}$	21,26
12	GND	21,27
13	GND	21,27
14	$\overline{SGA}$	21,26
15	GND	21,27
16	$\overline{B\ AUX\ TRG}$	21,26
17	$\overline{DS}$	21,26
18	GND	21,27
19	GND	21,27
20	AHO	21,26
21	$\overline{A\ AUX\ TRG}$	21,26
22	GND	21,27
23	GND	21,27
24	BHO	21,26

J/P/W4232 A20 TO A1

Pin	Line Name	Schem
1	BHO	21
2	GND	21
3	$\overline{A\ AUX\ TRG}$	21
4	GND	21
5	AHO	21
6	GND	21
7	GND	21
8	$\overline{B\ AUX\ TRG}$	21
9	GND	21
10	$\overline{DS}$	21

J/P4238 A20 TO A23

Pin	Line Name	Schem
1	DAC MUX1 IN	21,22
2	GND	21,22
3	CH2 POS	21,22
4	TRACE SEP	21,22
5	CH4 POS	21,22
6	CH1 POS	21,22
7	TRACE SEP	21,22
8	CH3 POS	21,22
9	CH1 POS	21,22
10	CH2 POS	21,22
11	CH3 POS	21,22
12	CH4 POS	21,22

J/P4242		A20 TO A25
Pin	Line Name	Schem
1	BA7	20,25
2	GND	21,25
3	BA6	20,25
4	BA14	20,25
5	MR	20,25
6	BA13	20,25
7	BA5	20,25
8	BA12	20,25
9	BA4	20,25
10	BA11	20,25
11	BA3	20,25
12	BA10	20,25
13	GND	21,25
14	BA9	20,25
15	BA2	20,25
16	BA8	20,25
17	BA1	20,25
18	BA0	20,25
19	BR/$\overline{W}$	20,25
20	BBD7	20,25
21	GND	21,25
22	BBD6	20,25
23	BBD3	20,25
24	BBD5	20,25
25	BBD2	20,25
26	GND	21,25
27	BBD1	20,25
28	BBD4	20,25
29	BBD0	20,25
30	$\overline{E}$	20,25
31	GND	21,25
32	B10MHz	20,25
33	BVMA	20,25
34	$\overline{BRESET}$	20,25
35	+5V$_D$	21,25
36	GND	21,25
37	+5V$_D$	21,25
38	GND	21,25
39	+15V	21,25
40	-15V	21,25
41	$\overline{FLD1}$	21,25
42	$\overline{LINES}$	21,25
43	$\overline{FLD2}$	21,25
44	GND	21,25

J/P4243		A20 TO A23
Pin	Line Name	Schem
1	BA7	20,22
2	GND	21,23
3	BA6	20,22
4	BA14	20,22
5	MR	20,22
6	BA13	20,22
7	BA5	20,22
8	BA12	20,22
9	BA4	20,22
10	BA11	20,22
11	BA3	20,22
12	BA10	20,22
13	GND G	21,23
14	BA9	20,22
15	BA2	20,22
16	BA8	20,22
17	BA1	20,22
18	BA0	20,22
19	BR/$\overline{W}$	20,22
20	BBD7	20,22
21	GND G	21,23
22	BBD6	20,22
23	BBD3	20,22
24	BBD5	20,22
25	BBD2	20,22
26	GND G	21,23
27	BBD1	20,22
28	BBD4	20,22
29	BBD0	20,22
30	$\overline{E}$	20,22
31	GND G	21,23
32	B10MHz	20,22
33	BVMA	20,22
34	$\overline{BRESET}$	20,22
35	+5V$_D$	21,23
36	GND G	21,23
37	+5V$_D$	21,23
38	GND G	21,23
39	+15V	21,23
40	-15V	21,23
41	+42V	21,23
42	+5V	21,23
43	-5V	21,23
44	GND	21,23

J/P/W4258		A20 TO A5
Pin	Line Name	Schem
1	DAC MUX1 IN	21
2	GND	21
3	HORIZ POS	21
4	+1.36V	21
5	-1.25V	21
6	DLY A	21
7	△A	21
8	△B	21
9	DLY B	21
10	HORIZ VAR	21
11	TRIG LEVEL	21
12	HOLDOFF	21
13	-1.25V	21
14	TRACE SEP	21
15	CH1 VAR	21
16	CH2 VAR	21
17	CH1 POS	21
18	CH2 POS	21
19	CH3 POS	21
20	CH4 POS	21

J/P4330		A20 TO A30
Pin	Line Name	Schem
1	+5V$_D$	21,32
2	GND	21,32
3	BA1	20,32
4	BA0	20,32
5	$\overline{ROMEN}$	20,32
6	$\overline{BR}$/W	20,32
7	$\overline{BUFEN}$	20,32
8	$\overline{LOWAD}$	20,32
9	BBD0	20,32
10	BBD1	20,32
11	BBD2	20,32
12	BBD3	20,32
13	BBD4	20,32
14	BBD5	20,32
15	BBD6	20,32
16	BBD7	20,32

J/P4800 A23 TO GPIB CONNECTOR

Pin	Line Name	Schem
1	DIO1	22
2	DIO5	22
3	DIO2	22
4	DIO6	22
5	DIO3	22
6	DIO7	22
7	DIO4	22
8	DIO8	22
9	EOI	22
10	REN	22
11	DAV	22
12	GND G	22
13	NRFD	22
14	GND G	22
15	NDAC	22
16	GND G	22
17	IFC	22
18	GND G	22
19	SRQ	22
20	GND G	22
21	ATN	22
22	GND G	22
23	GND	22
24	GND G	22

J/P5290 A20 TO A29

Pin	Line Name	Schem
1	BA7	31
2	GND	33
3	BA6	31
4	BA14	31
5	MR	31
6	BA13	31
7	BA5	31
8	BA12	31
9	BA4	31
10	BA11	31
11	BA3	31
12	BA10	31
13	GND	33
14	BA9	31
15	BA2	31
16	BA8	31
17	BA1	31
18	BA0	31
19	BR/$\overline{W}$	31
20	BBD7	31
21	GND	33
22	BBD6	31
23	BBD3	31
24	BBD5	31
25	BBD2	31
26	GND	33
27	BBD1	31
28	BBD4	31
29	BBD0	31
30	$\overline{E}$	31
31	GND	33
32	B10MHz	31
33	BVMA	31
34	$\overline{BRESET}$	31
35	$+5V_D$	33
36	GND	33
37	$+5V_D$	33
38	GND	33
39	+15V	33
40	-15V	33

J/P/W5990 A27 TO WORD RECOGNIZER CONNECTOR

Pin	Line Name	Schem
1	$\overline{WORD}$	26,28
2	WDATA	26,28
3	WCLOCK	26,28
4	GND	26,28
5	+5Vw	26,28
6	DATA RETURN	26,28

J/P/W6370 WORD RECOGNIZER CONNECTOR TO A32

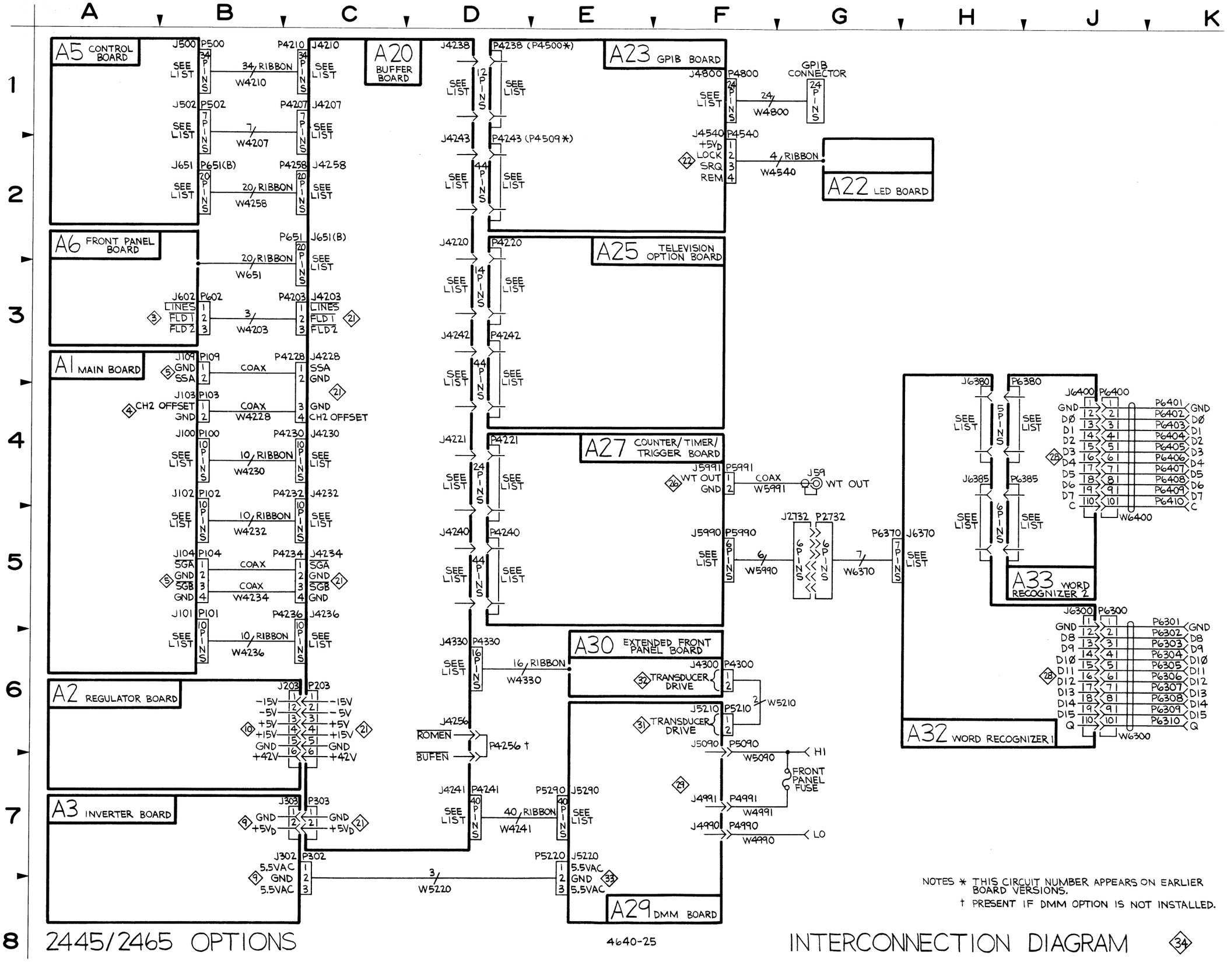
Pin	Line Name	Schem
1	$\overline{WORD}$	28
2	WDATA	28
3	WCLOCK	28
4	GND	28
5	+5Vw	28
6	DATA RETURN	28
7	GND	28

J/P6380 A32 TO A33

Pin	Line Name	Schem
1	+5Vw	28
2	WCLOCK	28
3	SYNCH	28
4	GATED CLOCK	28
5	GND	28

J/P6385 A32 TO A33

Pin	Line Name	Schem
1	GND	28
2	$\overline{LOW\ BYTE\ EQUAL}$	28
3	SERIAL DATA	28
4	GATED Q	28
5	Q DONT CARE	28
6	DATA RETURN	28



2445/2465 OPTIONS

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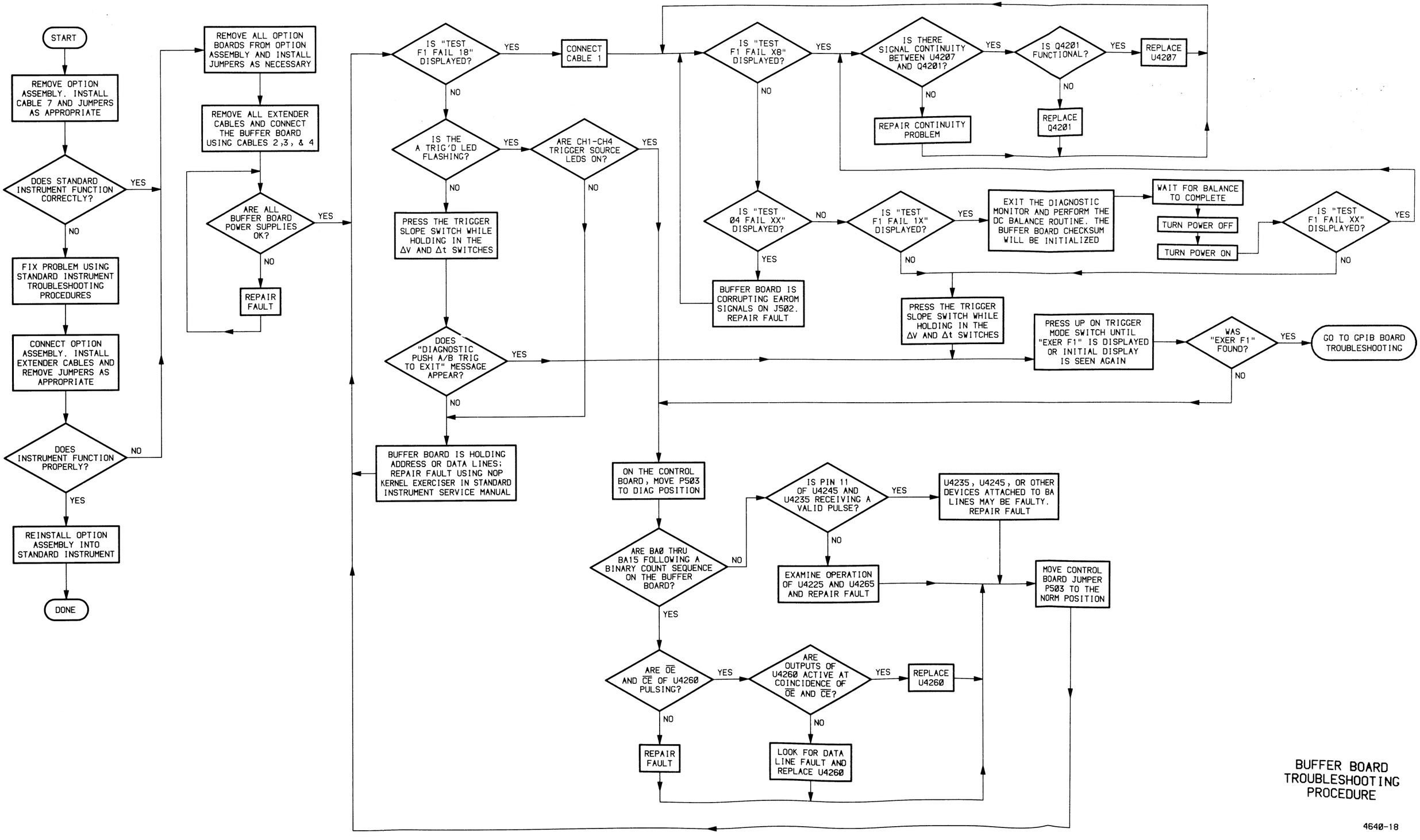
INTERCONNECTION DIAGRAM 34



BUFFER BOARD TROUBLESHOOTING PROCEDURE

GPIB BOARD TROUBLESHOOTING

INSTALL GPIB BOARD IN OPTION ASSEMBLY

REMOVE CABLE 7 FROM THE CONTROL BOARD. CONNECT IT AND CABLE 6 TO THE BUFFER BOARD

TURN POWER ON

IS THE A TRIG'D LED FLASHING? — YES

NO

IS "DIAGNOSTIC PUSH A/B TRIG TO EXIT" MESSAGE DISPLAYED? — YES → PERFORM ERROR MESSAGE DIAGNOSTIC PROCEDURE

NO

DO TRIGGER MODE LEDS RESPOND TO MOVING TRIG MODE SWITCH UP AND DOWN? — YES

NO

ARE ALL GPIB BOARD POWER SUPPLIES OK? — NO → REPAIR POWER SUPPLY AND/OR IT'S DISTRIBUTION

YES

IS MR LINE HI? — NO → REPAIR FAULT

YES

IS $\overline{E}$ LINE A 1.25MHz SQUARE WAVE? — YES → FIND AND REPAIR FAULT BY CHECKING OPERATION OF U4811, U4710, AND U4715

NO

PRESS THE TRIGGER SLOPE SWITCH WHILE HOLDING IN THE ΔV AND Δt SWITCHES

CAN "EXER F1" BE FOUND? — NO → ARE ALL POWER SUPLIES OK? — YES → MOVE CONTROL BOARD JUMPER P503 TO THE DIAG POSITION → DO BA0-BA15 FOLLOW A BINARY COUNT SEQUENCE? — YES → DO BBD0-BBD7 MOVE BETWEEN VALID LOGIC LEVELS? — YES → IS B10 MHz SIGNAL OK? — YES → ARE $\overline{E}$, BR/$\overline{W}$, AND BVMA SIGNALS ACTIVE? — YES → IS $\overline{\text{BRESET}}$ SIGNAL HI? — YES → MICROP… SIGNA… CORRU… THE…

ARE ALL POWER SUPLIES OK? — NO

YES

START EXER F1

IS CORRECT OPTION CONFIGURATION DISPLAYED? — YES → PUSH A/B TRIG TO EXIT THE DIAGNOSTIC MONITOR

NO

PRESS THE TRIGGER SLOPE SWITCH WHILE HOLDING IN THE ΔV AND Δt SWITCHES

FIND AND START BU EXER F2

PUSH A/B TRIG TO EXIT THE DIAGNOSTIC MONITOR

DO ALL FRONT-PANEL POT CONTROLS FUNCTION PROPERLY? — NO → IS DAC MUX IN SIGNAL ACTIVE? — YES → ARE -1.25V AND +1.36V REFERENCE SIGNALS OK? — YES → ALL FRONT-PANEL POT SIGNAL RANGES AT BUFFER BOARD INPUT OK? — YES → ALL FRONT-PANEL POT SIGNAL RANGES AT BUFFER BOARD OUTPUT OK? — YES → VERTICAL POSITION AND TRACE SEP SIGNALS AT U4525 OK? — YES → MOVE … POSIT… POTENTI… FULLY…

IS DAC MUX IN SIGNAL ACTIVE? — NO

ARE -1.25V AND +1.36V REFERENCE SIGNALS OK? — NO

ALL FRONT-PANEL POT SIGNAL RANGES AT BUFFER BOARD INPUT OK? — NO

ALL FRONT-PANEL POT SIGNAL RANGES AT BUFFER BOARD OUTPUT OK? — NO

VERTICAL POSITION AND TRACE SEP SIGNALS AT U4525 OK? — NO

REPAIR FAULT

MOVE TRA… POTENTI… FULLY…

DOES INPUT OF … VARY FRO… TO -5…

REPAIR FA… CHECKING … ASSOCI… CIRCUITR… INTERCONN…

YES

SET UP USEABLE GPIB ADDRESS, END OF MESSAGE TERMINATOR, AND TALK/LISTEN MODE

DOES INSTRUMENT TALK AND LISTEN? — NO → CONTINUITY OF GPIG SIGNALS FROM REAR PANEL CONNECTOR TO GPIB BOARD OK? — YES → DO BUFFERS U4805 AND U4808 FUNCTION PROPERLY? — NO → REPAIR FAULT

YES → REINSTALL OPTION ASSEMBLY → DONE

NO → REPAIR FAULT

YES → REPLACE U4818

IS PAGE SIGNAL ON GPIB BOARD ACTIVE? — NO → IS D0 ON GPIB BOARD ACTIVE? — YES → IS OUTPUT OF U4601 ACTIVE? — NO → MOVE CONTROL BOARD JUMPER P503 TO THE DIAG POSITION → DO A0-A15 SIGNALS MOVE IN A BINARY COUNT PATTERN? — YES → REPAIR FAULT BY CHECKING U4601, U4831D, AND U4738B → MOVE CONTROL BOARD JUMPER P503 TO THE NORM POSITION

IS D0 ON GPIB BOARD ACTIVE? — NO → REPAIR FAULT

IS OUTPUT OF U4601 ACTIVE? — YES → REPAIR FAULT BY CHECKING OPERATION OF U4831D, U4838B, AND U4705C

DO A0-A15 SIGNALS MOVE IN A BINARY COUNT PATTERN? — NO → REPAIR FAULT

YES

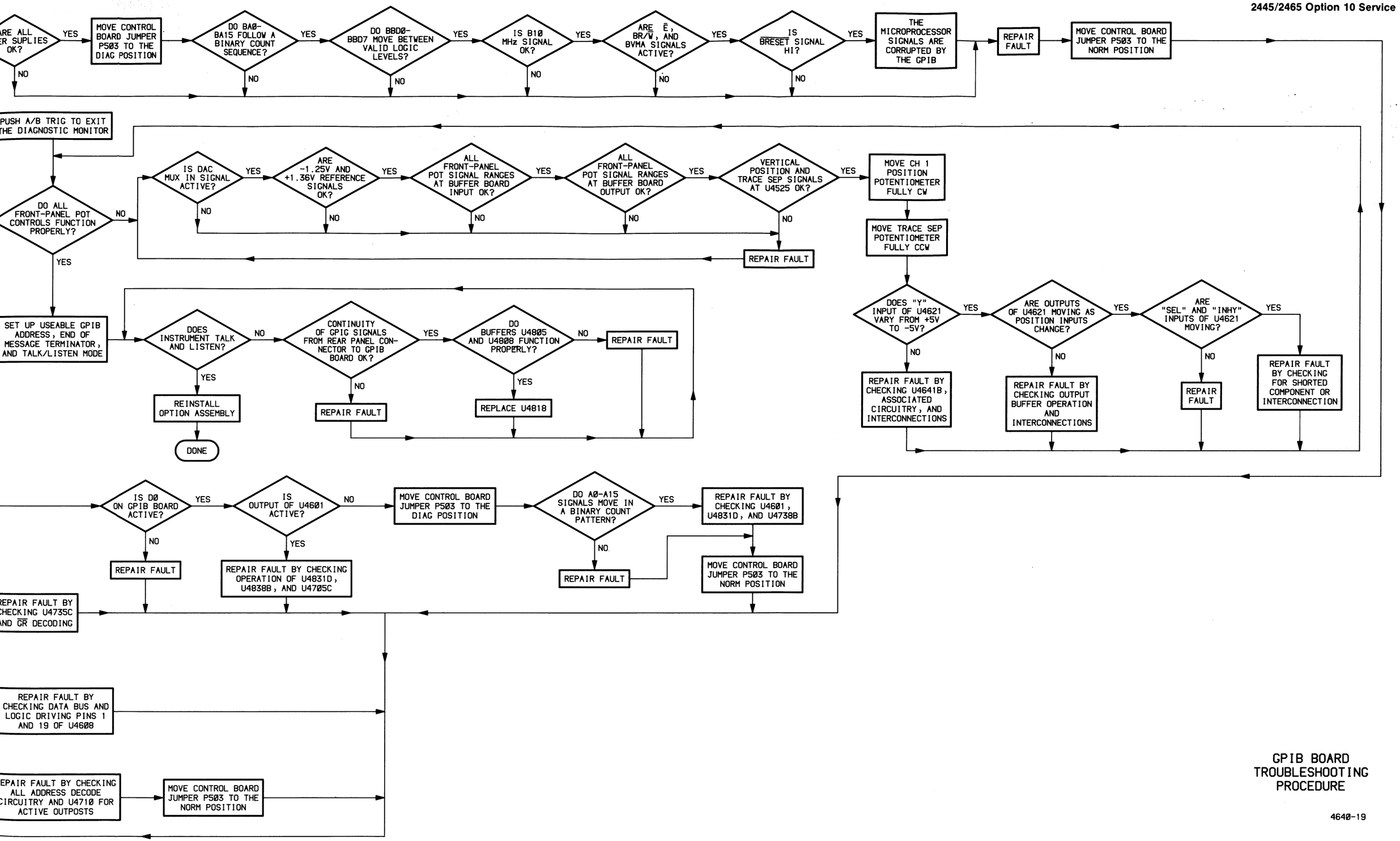
ARE $\overline{CE}$ AND $\overline{OE}$ OF U4715 ACTIVE? — NO → REPAIR FAULT BY CHECKING U4735C AND $\overline{GR}$ DECODING

YES

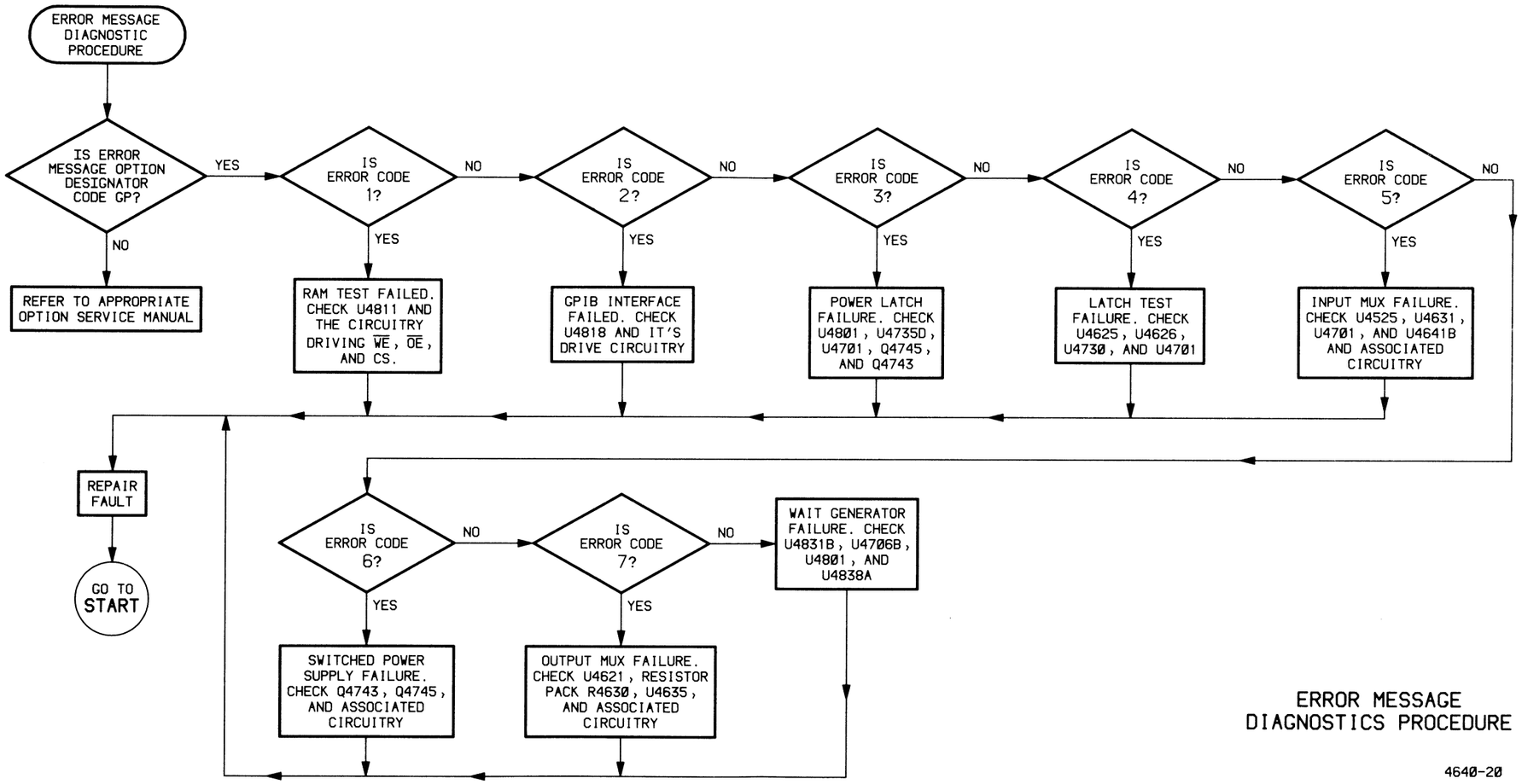
ARE OUTPUTS OF U4715 AND U4608 VALID AT COINCIDENCE OF $\overline{OE}$ AND $\overline{CE}$? — NO → REPAIR FAULT BY CHECKING DATA BUS AND LOGIC DRIVING PINS 1 AND 19 OF U4608

YES

MOVE CONTROL BOARD JUMPER P503 TO THE DIAG POSITION → REPAIR FAULT BY CHECKING ALL ADDRESS DECODE CIRCUITRY AND U4710 FOR ACTIVE OUTPOSTS → MOVE CONTROL BOARD JUMPER P503 TO THE NORM POSITION



GPIB BOARD TROUBLESHOOTING PROCEDURE



ERROR MESSAGE DIAGNOSTICS PROCEDURE

4640-20

APPENDIX A

GPIB COMMAND REFERENCE

Table A-1
GPIB Command Summary

Header	Argument	Argument
Vertical Commands		
CH1	COUpling:	AC
		DC
		FIFTY
		GND
	POSition:	<nrx>
	VARiable:	<nrx>
	VOLts:	<nrx>
	PROBe	
CH1?		
CH2	INVert:	ON
		OFF
CH2?		
CH3		
CH3?		
CH4		
CH4?		
VMOde	BWLimit:	ON
		OFF
	CHOp:	ON
		OFF
	CH1:	ON
		OFF
	CH2:	ON
		OFF
	CH3:	ON
		OFF
	CH4:	ON
		OFF
	ADD:	ON
		OFF
	INVert:	ON
		OFF
VMOde?		

Table A-1 (cont)
GPIB Command Summary

Header	Argument	Argument
Horizontal Commands		
HORizontal	ASEcdiv:	<nrx>
	BSEcdiv:	<nrx>
	MAGnify:	ON
		OFF
	POSition:	<nrx>
	TRACEsep:	<nrx>
HORizontal?		
HMOde	ALTernate	
	ASWeep	
	BSWeep	
	XY	
HMOde?		
Trigger Commands		
ATRigger	MODe:	AUTOBaseline
		AUTOLevel
		NORmal
		SGLseq
	SOUrce:	CH1
		CH2
		CH3
		CH4
		LINe
		VERtical
	COUpling:	AC
		DC
		HFRej
		LFRej
		NOIserej
	LEVel:	<nrx>
	SLOpe:	MINUs
		PLUS
	BENdsa:	ON
		OFF
	HOLdoff:	<nrx>
ATRigger?		
	MINImum	
	MAXimum	
	TRIGD?	
	REAdy?	

Table A-1 (cont)
GPIB Command Summary

Header	Argument	Argument
BTRigger	MODe:	RUN TRIGGerable
	SOUrce:	CH1 CH2 CH3 CH4 VERtical
	COUpling:	AC DC HFRej LFRej NOIserej
	LEVel:	<nrx>
	SLOpe:	MINUs PLUS
BTRigger?		
Delay and Delta Commands		
DELAy DELAy?	<nrx>	
DELTa	MODE:	OFF PERTime TIMe VOLts
	TRACKing:	ON OFF
DELTa?	MODE TRACKing	
DTIme	REFerence: DELTa:	<nrx> <nrx>
DTIme?	REFerence DELTa	
DVOlts	REFerence: DELTa:	<nrx> <nrx>
DVOlts?	REFerence DELTa	
System Commands		
ERRor?		
EVEnt?		
ID?		
INIt		

Table A-1 (cont)
GPIB Command Summary

Header	Argument	Argument
LLMessage LLMessage?	%<byte><byte>...	
LLSet LLSet?	%<byte><byte>...,%<byte><byte>...	
MESsage MESsage?	"string"	
OPC OPC?	ON OFF	
REAdout REAdout?	ON OFF	
RQS RQS?	ON OFF	
SETtings?		
LONgform LONgform?	ON OFF	
WARning WARning?	ON OFF	
Calibration and Diagnostic Commands		
BALance		
CALibrate	<nrx>:	<nrx>
GO		
LOOping LOOping?	ON OFF	
NORmal		
STEp STEp?		
STOp		
TESt TESt?	<nrx>: <nrx>:	<nrx> <nrx>

APPENDIX B

STATUS AND ERROR REPORTING

The status and error reporting system used by the GPIB Option interrupts the bus controller by asserting the Service Request (SRQ) line on the GPIB. This SRQ provides the means of indicating that an event (either a change in status or an error) has occurred. To service a request, the controller performs a Serial Poll; in response, the instrument returns a Status Byte (STB), which indicates the type of event that occurred. Bit 4 of the Serial-Poll Status Byte is used to indicate that the command processor is active. This bit will be set when the command processor is executing a command, and reset when it is not. The Status Byte, therefore, provides a limited amount of information about the specific cause of the SRQ. The various status events and errors that can occur are divided into several categories as defined in Table B-1.

Each serial poll can in turn cause a second SRQ assertion, if more than one error exists. The most serious error at the time of the serial poll is the reported error. An EVEnt? query returns a number which can be used as an index to the specific type of error that occurred. Table B-2 lists the Serial-Poll Status Bytes and the associated EVEnt? codes generated by the GPIB Option.

If there is more than one event to be reported, the instrument reasserts SRQ until it reports all events. Each event is automatically cleared when it is reported via serial poll. The Device Clear (DCL) interface message may be used to clear all events, except the power-on event.

Table B-1
Status Event and Error Categories

Category	Serial-Poll Status Byte	Description
Command Error	97 or 113	The instrument received a command that it cannot understand.
Execution Error	98 or 114	The instrument received a command that it cannot execute. This is caused by either out-of-range arguments or settings that conflict.
Internal Error	99 or 115	The instrument detected a hardware condition or a firmware problem that prevents operation.
System Events	65-67 and 81-83	Events common to instruments in a system (e.g., Power-on and User Request).
Execution Error Warning	101 or 117	The instrument received a command and is executing it, but a potential problem may exist. For example, the instrument is out of range, but is sending a reading anyway.
Internal Warning	102 or 118	The instrument detected a problem. It remains operational, but the problem should be corrected (e.g., out of calibration).
Device Status	0 or 16, 193-238, and 209-254	Device-dependent events.

With both the RQS OFF and the WARning OFF commands invoked, all service requests (except the power-on SRQ) are inhibited. In this mode, the EVEnt? query allows the controller to determine event status without first performing a serial poll. The controller may then send the EVEnt? query at any time, and the instrument returns the code for an event waiting to be reported. The controller can clear all events by repeatedly sending the EVEnt? query until a zero Status Byte is returned. An alternative method for clearing all events (except power-on) is the use of the Device Clear (DCL) interface message.

Table B-2
GPIB Status Codes

Serial-Poll Status Byte	EVENT? Code	Instrument Status
00, 16	000	No status to report
65, 81	401	Power on
66, 82	402	Operation complete
67, 83	403	User request
97, 113	101	Command header error
97, 113	102	Header delimiter error
97, 113	103	Command argument error
97, 113	104	Argument delimiter error
97, 113	105	Non-numeric argument, numeric expected
97, 113	106	Missing argument
97, 113	107	Invalid message-unit delimiter
97, 113	108	Checksum error
97, 113	109	Byte-count error
98, 114	201	Remote-only command in Local mode
98, 114	202	Pending settings lost on rtl
98, 114	203	I/O deadlock detected
98, 114	204	Setting conflict
98, 114	205	Argument out of range
98, 114	250	Diagnostic in progress
98, 114	251	Diagnostic step in progress
98, 114	252	In normal mode
98, 114	253	Option not installed
98, 114	254	Option not in correct mode
98, 114	255	GPIB command lost to local override
99, 115	302	System error
99, 115	350	Math pack error

Table B-2 (cont)
GPIB Status Codes

Serial-Poll Status Byte	EVENT? Code	Instrument Status
101, 117	550	Warning of possible conflict
102, 118	650	Warning that measurement not yet available
193, 209	750	Asynchronous option error
194, 210	751	Overrange error
195, 211	752	No probe installed
196, 212	753	Fifty-ohm overload
200, 216	770	Oscilloscope test/cal/exer complete, passed
201, 217	779	Oscilloscope test complete, failed
231, 247	771	Option 1 measurement complete
232, 248	772	Option 2 measurement complete
233, 249	773	Option 3 measurement complete
234, 250	774	Option 4 measurement complete
235, 251	775	Option 5 measurement complete
236, 252	776	Option 6 measurement complete
237, 253	777	Option 7 measurement complete
238, 254	778	Option 8 measurement complete

APPENDIX C

MESSAGE COMMAND CHARACTER TRANSLATIONS

Character translations performed by the MESsage command and query, when sending data to or receiving data from the crt readout, are indicated in Table C-1. The following notes apply:

1. ASCII values that are not specified in Table C-1 (i.e., those less than 20 Hex) are ignored when sent to the readout.
2. Values in Table C-1 that have no crt equivalent are translated into spaces when sent to the display.
3. Lowercase characters are translated into uppercase equivalents.
4. Character pairs (i.e., digits followed by periods) sent to the readout are translated into single characters with embedded decimal points. The embedded decimal points are displayed as carets. Single characters with embedded decimal points read from the display are received as character pairs.

Table C-1
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
20			space
21	!	p	pico
22	"		
23	#	μ	micro
24	$	m	milli
25	%	%	percent
26	&	k	kilo
27	'		
28	(	1/	one-over symbol
29	)	Δ	delta
2A	*	Δt	delta t
2B	+	+	plus symbol
2C	,	,	comma
2D	–	–	minus symbol
2E	.	.	period
2F	/	/	slash

Table C-1 (cont)
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
30	0	0	0
31	1	1	1
32	2	2	2
33	3	3	3
34	4	4	4
35	5	5	5
36	6	6	6
37	7	7	7
38	8	8	8
39	9	9	9
3A	:	:	colon
3B	;		
3C	<	<	less than
3D	=	=	equal to
3E	>	>	greater than
3F	?	?	question mark

Table C-1 (cont)
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
40	@	°	degrees
41	A	A	A
42	B	B	B
43	C	C	C
44	D	D	D
45	E	E	E
46	F	F	F
47	G	G	G
48	H	H	H
49	I	I	I
4A	J	J	J
4B	K	K	K
4C	L	L	L
4D	M	M	M
4E	N	N	N
4F	O	O	O
50	P	P	P
51	Q	Q	Q
52	R	R	R
53	S	S	S
54	T	T	T
55	U	U	U
56	V	V	V
57	W	W	W
58	X	X	X
59	Y	Y	Y
5A	Z	Z	Z
5B	[	Ω	omega
5C	\	⏚	ground symbol
5D	]	~V	volts ac
5E	↑	↑	up arrow
5F	_	_	underscore

Table C-1 (cont)
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
60	`	°	degrees
61	a	A	A
62	b	B	B
63	c	C	C
64	d	D	D
65	e	E	E
66	f	F	F
67	g	G	G
68	h	H	H
69	i	I	I
6A	j	J	J
6B	k	K	K
6C	l	L	L
6D	m	M	M
6E	n	N	N
6F	o	O	O
70	p	P	P
71	q	Q	Q
72	r	R	R
73	s	S	S
74	t	T	T
75	u	U	U
76	v	V	V
77	w	W	W
78	x	X	X
79	y	Y	Y
7A	z	Z	Z
7B	{		
7C	|		
7D	}		
7E	~	~	ac symbol
7F			

APPENDIX D

SWEEP SPEED COMMAND CONSIDERATIONS

Table D-1 provides information on the results of various sweep speed commands received over the GPIB. The left column indicates the desired effect of the GPIB command that was sent. The headings for the right three columns reflect the oscilloscope's Horizontal mode just prior to receipt of the command. Each block in the table shows the resulting sweep speed values and the Horizontal mode after the command is received.

Table D-1
Horizontal Command Results

Command Attempts to Make	Horizontal Mode Before Command		
	A Only	A ALT B	B Only
A faster than B	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
A = B and faster than 0.1 s	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
A slower than B	A = NV B = NV A only	A = NV B = PV A ALT B	A = NV B = PV B only
B faster than A	A = PV B = NV B only	A = PV B = NV A ALT B	A = PV B = NV B only
B = A	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
B slower than A and			
B equal to or faster than 50 ms	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
B slower than 50 ms and B faster than 0.15 s	B = 50 ms A = 50 ms A only	B = NV A = 50 m A INTEN	B = 50 ms A = NV A only
B slower than 0.15 s	A = 50 ms B = 50 ms A only	A = 50 ms B = 50 ms A INTEN	A = 50 ms B = 50 ms A only
B = 1 s/div (2445 only)	B = 500 ms A = 500 ms A only	B = 500 ms A = 500 ms A INTEN	B = 500 ms A = 500 ms A only

NV = New value of sweep speed sent over the GPIB.
PV = Previous value of sweep speed.

APPENDIX E

LLMESSAGE COMMAND CHARACTER TRANSLATIONS

Character translations performed by the LLMessage command and query, when sending data to or receiving data from the crt readout, are indicated in Tables E-1 and E-2. The following notes apply:

1. Most large size characters are formed with a left half and a right half.

2. Code for the right half of large size characters is given first, followed by the code for the left half of the character.

3. Not all codes are assigned. Use of the unlabeled (not assigned) codes will result in a nonsensical display.

4. The two tables cross-reference each other.

5. Character pairs (i.e., digits followed by periods) sent to the readout are translated into single characters with embedded decimal points. For normal-size characters, the decimal points are displayed as carets. For large characters, the decimal points are displayed as periods. Single characters with embedded decimal points read from the display are received as character pairs.

Table E-1
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
0	00	1
1	01	large 0
2	02	large 0
3	03	
4	04	4
5	05	large 1
6	06	large 1
7	07	
8	08	7
9	09	large 2
10	0A	large 2
11	0B	
12	0C	t
13	0D	large 3
14	0E	large 3
15	0F	k
16	10	Z
17	11	large 4
18	12	large 4
19	13	Horizontal cursor 1
20	14	n (nano)
21	15	large 5

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
22	16	large 5
23	17	
24	18	m (micro)
25	19	large 6
26	1A	large 6
27	1B	
28	1C	/
29	1D	large 7
30	1E	large 7
31	1F	Horizontal cursor 2
32	20	Δ (delta)
33	21	large 8
34	22	large 8
35	23	
36	24	↑
37	25	large 9
38	26	large 9
39	27	
40	28	0
41	29	
42	2A	2
43	2B	↓

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
44	2C	3
45	2D	<
46	2E	5
47	2F	
48	30	6
49	31	>
50	32	8
51	33	
52	34	9
53	35	$\tilde{V}$ (volts ac)
54	36	1.
55	37	large 0 dot
56	38	large 0 dot
57	39	
58	3A	4.
59	3B	large 1 dot
60	3C	large 1 dot
61	3D	
62	3E	7.
63	3F	large 2 dot
64	40	large 2 dot
65	41	
66	42	%
67	43	large 3 dot
68	44	large 3 dot
69	45	
70	46	s (seconds)
71	47	large 4 dot
72	48	large 4 dot
73	49	
74	4A	z
75	4B	large 5 dot
76	4C	large 5 dot
77	4D	
78	4E	Vertical cursor 2
79	4F	large 6 dot
80	50	large 6 dot
81	51	
82	52	–
83	53	large 7 dot
84	54	large 7 dot
85	55	
86	56	~ (approximately)
87	57	large 8 dot
88	58	large 8 dot
89	59	
90	5A	,
91	5B	large 9 dot
92	5C	large 9 dot

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
93	5D	
94	5E	0.
95	5F	
96	60	2.
97	61	
98	62	3.
99	63	
100	64	5.
101	65	
102	66	6.
103	67	
104	68	8.
105	69	
106	6A	9.
107	6B	
108	6C	U
109	6D	large R
110	6E	large R
111	6F	
112	70	V
113	71	large S
114	72	large S
115	73	
116	74	X
117	75	large T
118	76	large T
119	77	
120	78	MNL (manual)
121	79	
122	7A	large V
123	7B	large V
124	7C	Y
125	7D	DEG (degrees)
126	7E	HO (holdoff)
127	7F	
128	80	large X
129	81	large X
130	82	0 over 0
131	83	
132	84	0 over 1
133	85	
134	86	1 over 0
135	87	
136	88	A
137	89	
138	8A	B
139	8B	
140	8C	D
141	8D	

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
142	8E	H
143	8F	
144	90	M
145	91	
146	92	N
147	93	
148	94	R
149	95	
150	96	W
151	97	
152	98	I
153	99	large F
154	9A	large F
155	9B	
156	9C	J
157	9D	large Ω (omega)
158	9E	large Ω (omega)
159	9F	
160	A0	K
161	A1	large H
162	A2	large H
163	A1	
164	A4	large d
165	A5	large d
166	A6	=
167	A7	+
168	A8	L
169	A9	Ω (omega)
170	AA	⏚ (ground symbol)
171	AB	
172	AC	O
173	AD	large L
174	AE	large L
175	AF	
176	B0	P
177	B1	:
178	B2	1 over 1
179	B3	
180	B4	Q
181	B5	?
182	B6	0 over x
183	B7	
184	B8	S
185	B9	large O
186	BA	large O
187	BB	
188	BC	T
189	BD	d
190	BE	x over 0

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
191	BF	
192	C0	(space)
193	C1	large A
194	C2	large A
195	C3	
196	C4	C
197	C5	large B
198	C6	large B
199	C7	
200	C8	E
201	C9	large C
202	CA	large C
203	CB	
204	CC	F
205	CD	large D
206	CE	large D
207	CF	
208	D0	G
209	D1	large E
210	D2	large E
211	D3	
212	D4	.
213	D5	large n (nano)
214	D6	large n (nano)
215	D7	large u (micro)
216	D8	large u (micro)
217	D9	large k
218	DA	large k
219	DB	large m (milli)
220	DC	large m (milli)
221	DD	
222	DE	large +
223	DF	large +
224	E0	low underline
225	E1	large DLY (delay)
226	E2	large DLY (delay)
227	E3	
228	E4	HLD (hold measurement)
229	E5	
230	E6	1 over x
231	E7	
232	E8	x over 1
233	E9	
234	EA	BWL (bandwidth limit)
235	EB	
236	EC	1/
237	ED	superscript dash
238	EE	p (pico)
239	EF	

Table E-1 (cont)
LLMessage? Query Character Set (Code-Sequenced)

Decimal	Hex	Character Description
240	F0	underline
241	F1	dotted underline
242	F2	large s (seconds)
243	F3	large s (seconds)
244	F4	large z
245	F5	large z
246	F6	Vertical cursor 1
247	F7	Logical AND symbol
248	F8	Δt (delta t)
249	F9	
250	FA	Large minus symbol
251	FB	high underline
252	FC	x over x
253	FD	
254	FE	m (milli)
255	FF	

Table E-2
LLMessage Command Character Set
(Character-Sequenced)

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
0	40	28	1	01
			2	02
1	0	00	5	05
			6	06
2	42	2A	9	09
			10	0A
3	44	2C	13	0D
			14	0E
4	4	04	17	11
			18	12
5	46	2E	21	15
			22	16
6	48	30	25	19
			26	1A
7	8	08	29	1D
			30	1E
8	50	32	33	21
			34	22
9	52	34	37	25
			38	26

Table E-2 (cont)
LLMessage Command Character Set
(Character-Sequenced)

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
A	136	88	193	C1
			194	C2
B	138	8A	197	C5
			198	C6
C	196	C4	201	C9
			202	CA
D	140	8C	205	CD
			206	CE
E	200	C8	209	D1
			210	D2
F	204	CC	153	99
			154	9A
G	208	D0		
H	142	8E	161	A1
			162	A2
I	152	98		
J	156	9C		
K	160	A0		
L	168	A8	173	AD
			174	AE
M	144	90		
N	146	92		
O	172	AC	185	B9
			186	BA
P	176	B0		
Q	180	B4		
R	148	94	109	6D
			110	6E
S	184	B8	113	71
	114	72		
T	188	BC	117	75
			118	76
U	108	6C		
V	112	70	122	7A
			123	7B
W	150	96		
X	116	74	128	80
			129	81
Y	124	7C		
Z	16	10		

Table E-2 (cont)
LLMessage Command Character Set
(Character-Sequenced)

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
d	189	BD	164	A4
			165	A5
k	15	0F	217	D9
			218	DA
t	12	0C		
z	74	4A	244	F4
			245	F5
space	192	C0		
%	66	42		
+	167	A7	223	DF
,	90	5A		
–	82	52	250	FA
.	212	D4		
/	28	1C		
:	177	B1		
<	45	2D		
=	166	A6		
>	49	31		
?	181	B5		
↑	36	24		
↓	43	2B		
0.	94	5E	55	37
			56	38
1.	54	36	59	3B
			60	3C
2.	96	60	63	3F
			64	40
3.	98	62	67	43
			68	44
4.	58	3A	71	47
			72	48
5.	100	64	75	4B
			76	4C
6.	102	66	79	4F
			80	50
7.	62	3E	83	53
			84	54
8.	104	68	87	57
			88	58
9.	106	6A	91	5B
			92	5C

Table E-2 (cont)
LLMessage Command Character Set
(Character-Sequenced)

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
p (pico)	238	EE		
n (nano)	20	14	213	D5
			214	D6
μ (micro)	24	18	215	D7
			216	D8
m (milli)	254	FE	219	DB
			220	DC
s (seconds)	70	46	242	F2
			243	F3
DEG (degrees)	125	7D		
Ω (omega)	169	A9	157	9D
			158	9E
⏚ (ground symbol)	170	AA		
Ṽ (volts ac)	53	35		
~ (approximately)	86	56		
MNL (manual)	120	78		
0 over 0	130	82		
0 over 1	132	84		
1 over 0	134	86		
1 over 1	178	B2		
0 over x	182	B6		
x over 0	190	BE		
1 over x	230	E6		
x over 1	232	E8		
x over x	252	FC		
1/	236	EC		
Underline	240	F0		
Dotted underline	241	F1		
Low underline	224	E0		
High underline	251	FB		
Superscript dash	237	ED		
Logical AND symbol	247	F7		
Hold measurement	228	E4		
HO (holdoff)	126	7E		
BWL (bandwidth limit)	234	EA		
Horizontal cursor 1	19	13		
Horizontal cursor 2	31	1F		
Vertical cursor 1	246	F6		
Vertical cursor 2	78	4E		
Δ(delta)	32	20		
Δt (delta t)	248	F8		
DLY (delay)			225	E1
			226	E2

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MANUAL CHANGE INFORMATION

Date: 2-25-85 **Change Reference:** M56786

Product: 2445/2465 OPTION 10 SERVICE **Manual Part No.:** 070-4640-00

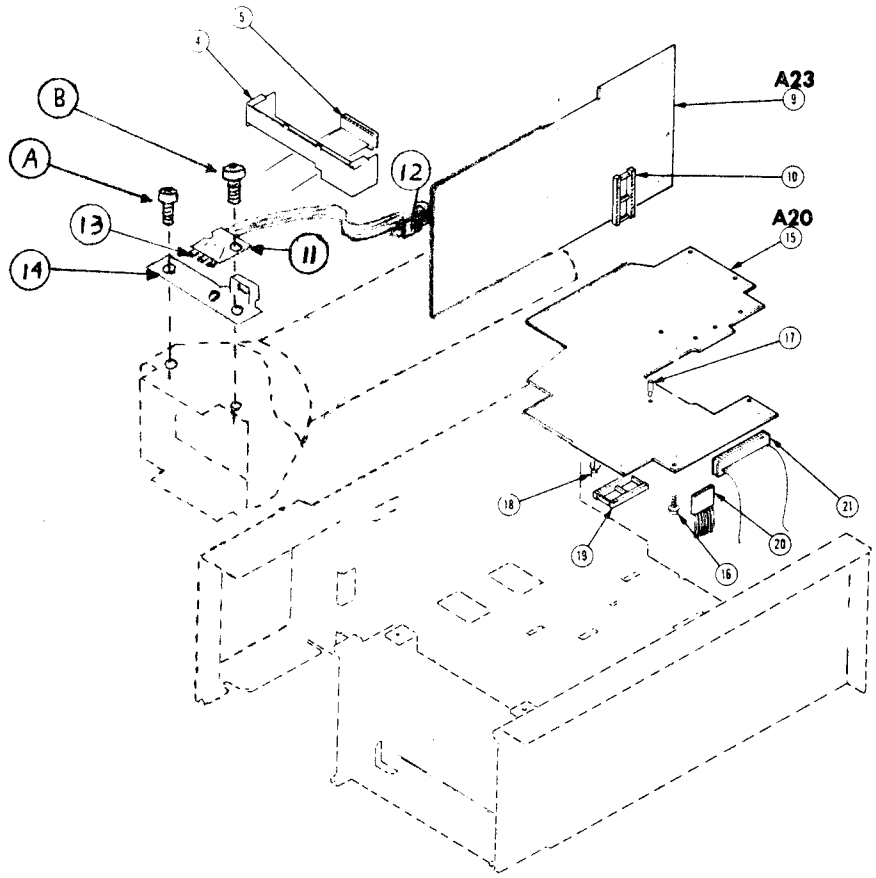
DESCRIPTION PG 38

EFFECTIVE SERIAL NUMBERS: B026800 (2445)
B030188 (2465)

REPLACEABLE MECHANICAL PARTS LIST CHANGES

Add the following screws to the parts list. Refer to the partial exploded view for placement.

A	211-0337-00	1	SCR,ASSEM WSHR: 4-40 X .250L,PNH
B	211-0304-00	1	SCR,ASSEM WSHR: 4-40 X .312L,PNH



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MANUAL CHANGE INFORMATION

Date: 3-17-85 Change Reference: M55293

Product: 2445/2465 OPTION 10 SERVICE Manual Part No.: 070-4640-00

DESCRIPTION PG 38

SEE BELOW FOR EFFECTIVE SERIAL NUMBERS

PLACEABLE ELCTRICAL PARTS LIST CHANGES

CHANGE TO:

A23	670-7558-04 ---- ----	B024400	CKT BOARD ASSY: GPIB OPTION (2445)
A23	670-7558-04 ---- ----	B026300	CKT BOARD ASSY: GPIB OPTION (2465)
A23	670-7558-05 ---- ----	B025500	CKT BOARD ASSY: GPIB OPTION (2445)
A23	670-7558-05 ---- ----	B027850	CKT BOARD ASSY: GPIB OPTION (2465)
A23U4710	160-1681-14 ---- ----	B024400	MICROCKT,DGTL: 8192 X 8 EPROM,PRGM (2445)
A23U4710	160-1681-14 ---- ----	B026300	MICROCKT,DGTL: 8192 X 8 EPROM,PRGM (2465)
A23U4715	160-1692-14 ---- ----	B024400	MICROCKT,DGTL: 16K X 8 EPROM,PRGM (2445)
A23U4715	160-1692-14 ---- ----	B026300	MICROCKT,DGTL: 16K X 8 EPROM,PRGM (2465)

Tektronix
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MANUAL CHANGE INFORMATION

Date: 3-18-85 **Change Reference:** M56265

Product: 2445/2465 OPTION 10 SERVICE **Manual Part No.:** 070-4640-00

DESCRIPTION PG 38

EFFECTIVE SERIAL NUMBERS: B025993 (2445)
B028865 (2465)

REPLACEABLE ELECTRICAL PARTS LIST CHANGES

CHANGE TO:

A23	670-7558-06	CKT BOARD ASSY: GPIB

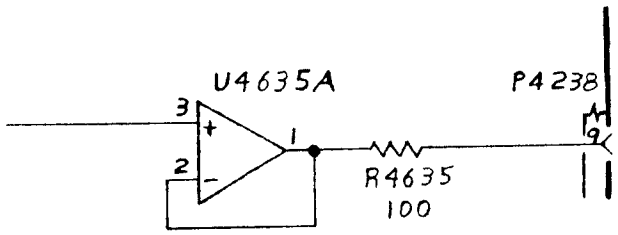
ADD:

A23R4635	315-0101-00	RES,FXD,CMPSN: 100 OHM,5%,0.25W

DIAGRAM CHANGES

DIAGRAM  **GPIB BOARD**

Add R4635 (100 Ω) in series from the connection of pin 1 & 2 of U4635A and Pin 9 of P4238 at location 1P.



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