ADVANCED FUNCTION MENU (for the 2230 only)

The following functions are available as part of the ADVANCED FUNCTIONS Menu on 2230 instruments containing either the GPIB or the RS-232-C option.

REFERENCE—Allows a non-volatile SAVE REF memory to be copied, deleted, or protected.

COPY—Selects and copies one non-volatile SAVE REF memory to another SAVE REF memory. Waveforms stored in the lettered extended memory locations (REFA through REFZ) must be moved to one of the numbered SAVE REF memory locations to be displayed. Waveform data to be retrieved from or written to an extended memory location must go through a numbered SAVE REF memory.

DELETE—Selects a non-volatile SAVE REF memory and erases the stored data if not locked.

PROTECT—Selects memory space to lock or unlock. Locked memory locations cannot be overwritten or deleted. Via the Communications interface, extended memory locations may be permanently protected to prevent them from being overwritten by the UNLOCK or DELETE menu functions.

COMM—Allows the selection of parameters for optional communications options, when they are present.

DATA—Selects the data-coding format (ASCII, HEX, or BINARY), source or destination target of the data (ACQ, REF1, REF2, REF3 or REF4), and channel selection (CH1 or CH2) for data transmissions.

STOP BITS—Selects the number of stop bits for RS-232-C data transmissions. (Stop bits are selected by interface command in the 2220 and 2221.) The usual choice for stop bits is 1, but some printers/plotters require two stop bits for some baud rates.

FLOW—Sets the data flow control over the interface ON and OFF. Binary waveform information cannot be sent with FLOW ON.

NON-VOLATILE EXTENDED MEMORY (for the 2230 only)

When either Communications option is installed in the 2230 DSO, extra battery-backed memory is also installed. Waveforms stored in the extra memory may be protected from overwriting or deleting (locked) using the Advanced Functions menu. Commands that are available via the communications interface can also lock that memory space. Memory spaces may be also made "permanent" via the Communications interface. Permanent waveforms cannot be overwritten, unlocked, or deleted by the operator with the Advanced Functions menu.

The extra memory provides 26 Kbytes of non-volatile waveform storage space. The memory is divided into 1 Kbyte locations labeled REFA through REFZ, but the number of actual waveforms that may be stored depends on the acquired waveform record length (1024 bytes or 4096 bytes) and acquisition mode (normal or average). Averaged waveforms require two bytes for each point so that an averaged 1 K waveform needs 2 Kbytes of non-volatile SAVE REF storage and an averaged 4 K waveform needs 8 Kbytes. Specifications for the non-volatile Extended Memory are given in Table 7-1.

OPTION 10 GPIB OPERATORS INFORMATION

The GPIB Communications Option complies with ANSI/IEEE Standard 488-1978. All other specifications for the instrument (including the performance conditions) are identical to those specified in "Specification" in Section 1 of this manual.

Standard Functions, Formats, and Features

The interface-function capabilities of a GPIB instrument, in terms of interface-function subsets, are identified in ANSI/IEEE Std 488-1978. The status of subsets applicable to this instrument with Option 10 are listed in Table 7-2.

The GPIB interface conforms to the Tektronix standard on Codes, Formats, Conventions, and Features of messages sent over the bus to communicate with other GPIB instruments. Specific format choices implemented in this instrument are listed in Table 7-3; specific features implemented are shown in Table 7-4.

Table 7-1
Extended Memory Specification

Characteristic	Performance Requirement
NON-VOLATILE EXTENDED MEMORY	
Available Waveform Memory	26 Kbytes.
Power Down	
Battery Voltage	Memory retained for battery voltages greater than 2.3 V.
Data Retention	Memory maintained greater than six months without instrument power.
Battery Life	Power down data-retention specification shall be maintained for three years without battery change with normal oscilloscope use.
Power Down Detection	
Threshold	Fail asserted for supply drop to less than 4.75 V. Reset held until supply is greater than 5.0 V.
Reset Delay	Power down interrupt to reset delay greater than or equal to 1 ms.

Table 7-2
Function Subsets Implemented

Function Subset	Capability	States Omitted	Other Requirements	Other Subsets Required
SH1 (Source Handshake)	Complete Capability	None	None	T5
AH1 (Acceptor Handshake)	Complete Capability	None	None	None
T5 (Talker)	Basic Talker, Serial Poll, Unaddress if MLA	None	Include [MLA (ACDS)]	SH1 and L3
L3 (Listener)	Basic Listener, Listen Only, Unaddress if MTA	None	Include [MTA (ACDS)]	AH1 and T5
SR1 (Service Request)	Complete Capability	None	None	T5
RL2 (Remote/Local)	No Local Lockout	LWLS and RWLS	RTL always false	L3
PP0 (Parallel Poll)	No Capability	All	None	None
DC1 (Device Clear)	Complete Capability (Selective Device Clear)	None	None	L3
DT0 (Device Trigger)	No Capability	All	None	None
C0 (Controller)	No Capability	All	None	None
E2 (Drivers)	Three-state			

Table 7-3

Specific Format Choices

Format Parameter	Choice Made
Format Characters	Not transmitted; ignored on reception.
Message Terminator	Either EOI or LF can be selected for message termination.
Measurement Terminator	Follows program message-unit syntax.
Link Data (Arguments)	Used in Listen and Talk.
Multiple Event Reporting	Not implemented to report all events on a single query. Multiple events may be reported by using multiple queries.
Instrument Identification Query	Descriptors added for all options.
Set Query	Extended by using other commands.
Device Trigger (DT)	Not implemented.
INIT Command	Causes the instrument to return to a default set up condition.
Time/Date Commands	Not implemented.
Stored Setting Commands	Not implemented.
Waveform Transmission	Implemented.
Return to Local (rtl)	Not implemented.
IEEE 728	Compliance not intended.

Option 10 GPIB Side Panel

The Option 10 instrument is supplied with the side panels shown in Figure 7-1. The Option 10 side panel includes one AUXILIARY connector, one GPIB (IEEE 488-1978) interface port, and one PARAMETERS switch. The Controls, Connectors, and Indicators part of this manual contains information on the use of the AUXILIARY Connector. Refer to Figure 7-1 for location of the Option 10 side-panel controls and connectors.

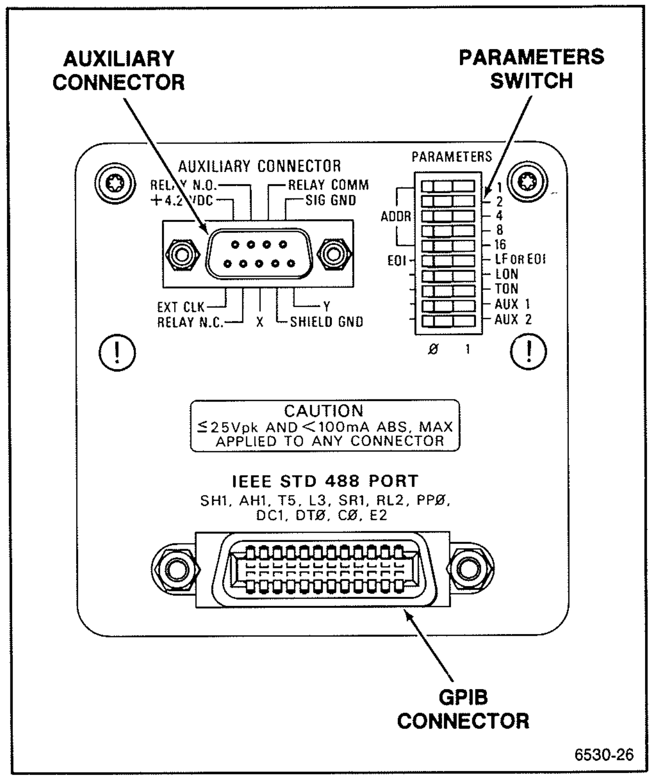


Figure 7-1. Option 10 side panel.

Table 7-4

Implementation of Specific Features

Feature	Choice Made	Comments
Secondary Addressing	Not implemented.	
Indicators	ADDR (addressed), SRQ (service request), and PLOT (acquisitions locked out) indicators are included.	
Parameter Selection	A ten-section switch sets the instrument's bus address, message terminator, listen-only or talk-only mode, and makes printer/plotter selections.	Switch settings are read only at power on.

AUXILIARY Connector—Provides connections for an X-Y Plotter and an External Clock input (see Controls, Connectors, and Indicators).

GPIB Connector—Provides the ANSI/IEEE Std 488-1978 compatible electrical and mechanical connection to the GPIB. The connector is only on instruments with Option 10. The function of each pin of the connector is shown in Table 7-5.

GPIB PARAMETERS Switch—Allows the selection of setup options for the GPIB interface. The switch is read at power-up and when interface clear messages are received. Five sections of the switch select the GPIB address, one selects the terminator, two select talk/listen modes, and two are used for printer/plotter selection. The function of each switch section is shown in Table 7-6.

Table 7-5
GPIB Connector

Pin	Line Name	Description
1	DIO1	IEEE-488 Data I/O
2	DIO2	IEEE-488 Data I/O
3	DIO3	IEEE-488 Data I/O
4	DIO4	IEEE-488 Data I/O
5	EOI	IEEE-488 END or Identify
6	DAV	IEEE-488 Handshake
7	NRFD	IEEE-488 Handshake
8	NDAC	IEEE-488 Handshake
9	IFC	IEEE-488 Input
10	SRQ	IEEE-488 Output
11	ATN	IEEE-488 Input
12	SHIELD	System Ground (Chassis)
13	DIO5	IEEE-488 Data I/O
14	DIO6	IEEE-488 Data I/O
15	DIO7	IEEE-488 Data I/O
16	DIO8	IEEE-488 Data I/O
17	REN	IEEE-488 Input
18	GND	Digital Ground (DAV)
19	GND	Digital Ground (NRFD)
20	GND	Digital Ground (NDAC)
21	GND	Digital Ground (IFC)
22	GND	Digital Ground (SRQ)
23	GND	Digital Ground (ATN)
24	GND	Digital Ground (LOGIC)

Table 7-6
GPIB PARAMETERS Switch

Switch Section	Switch Position	Function
1		Address selection
	0	0
	1	Binary weight = 1
2		Address selection
	0	0
	1	Binary weight = 2
3		Address selection
	0	0
	1	Binary weight = 4
4		Address selection
	0	0
	1	Binary weight = 8
5		Address selection
	0	0
	1	Binary weight = 16
6		Terminator selection
	0	EOI
	1	LF or EOI
7	0	No function
	1	LON (Listen only)
8	0	No function
	1	TON (Talk only)
9		Printer/plotter selection[a]
10		Printer/plotter selection[a]

[a]Switches 9 and 10 select printer/plotter devices at power-up. The devices may be changed after power-up using Option commands, or in the case of the 2230, the MENU controls. Two EPSON® formats are selectable. EPS7 uses seven print wires per head pass, and is usually slower. It is the chr$(27) "L" mode. EPS8 uses eight print wires per head pass, and is usually the faster print-head speed. It is the chr$(27) "Y" mode. In this mode, most Epson and Epson-compatible printers will not strike any print wire more often than every second pixel. EPS8 is selected when parity is disabled.

Printing/plotting devices are selected with the following switch positions:

Switch 9	Switch 10	Device Selected
0	0	HP-GL® plotter
1	0	Epson® EPS7 or EPS8
0	1	ThinkJet® printer
1	1	X-Y Plotter

HP-GL® and ThinkJet are trademarks of Hewlett-Packard Company. Epson is a trademark of Epson Corporation.

GPIB Parameter Selection

The correct selection of GPIB parameters (primary address, message terminator, and talk/listen mode) must be made before power on. That is when the GPIB PARAMETERS switch is read to determine what the address and other settings of the switch are. See Table 7-6 (shown previously) to determine the specific parameters switch settings.

PRIMARY ADDRESS—The selected GPIB address establishes the talk and listen address for the oscilloscope. It can be set to any value between 0 and 31, inclusive. Address 31 is "OFF LINE." With an address of 31, the instrument still presents an active load, but it neither responds to nor interferes with any bus traffic.

SECONDARY ADDRESS—Not implemented in the 2200 Family of digital storage oscilloscopes.

INPUT END-OF-MESSAGE TERMINATOR—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 instrument will:

- accept only EOI as the end-of-message terminator, and
- assert EOI concurrently with the last byte of a message.

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

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

TALK/LISTEN MODE—Four talk/listen modes are selectable:

- TALK ONLY mode allows the instrument to send data over the GPIB but not to listen.
- LISTEN ONLY mode permits the instrument to receive data over the GPIB but not to talk.
- TALK/LISTEN mode (both TON and LON modes unselected) allows the instrument to both send and receive data over the GPIB.
- OFF BUS mode (both TON and LON modes selected) switches the instrument off the bus (same as setting address to 31).

To select a different Talk/Listen mode, see the GPIB PARAMETERS switch settings in Table 7-7. The new settings must be made before power on to be in effect.

Option 10 Interface Status Indicators

Three indicators appear in the CRT readout to indicate the status of the GPIB communication option. The indicators are labeled SRQ (service request pending), ADDR (addressed to talk), and PLOT (output data to the plotter) on the CRT bezel. The active indication is seen as an intensified line in the CRT display just below the associated label. Refer to Figure 7-2 for the location of the communications interface status indicators.

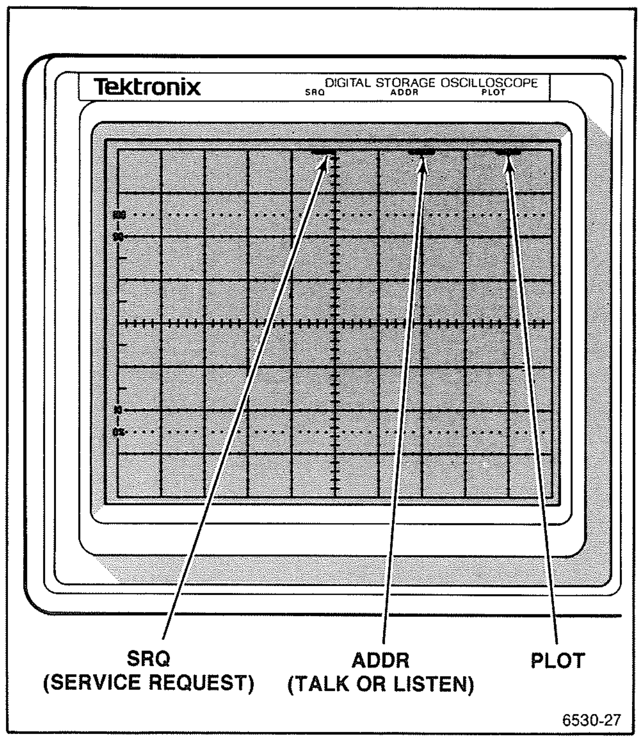


Figure 7-2. SRQ, ADDR, and PLOT indicators.

SRQ Indicator—Indicates the communications option requires service by the controller. Service requests are cleared when the instrument has been polled for its status and no further warning or error conditions are pending. The communication option asserts a power-up service request (SRQ) when turned on. Other service requests are asserted as enabled by the RQS and OPC commands.

ADDR Indicator—Indicates the instrument is addressed to talk or listen.

PLOT Indicator—Indicates the communication option is currently sending waveform data over its interface and acquisitions are inhibited.

Instrument Response To Interface Messages

OPTION 10 GPIB. The following 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)—Local Lockout is not supported by the instrument. In response to a LLO message via the GPIB interface, Option 10 generates an SRQ error.

REMOTE ENABLE (REN)—When Remote Enable is asserted and the instrument receives its listen address, the oscilloscope is placed in the Remote State (REMS). When in the Remote State, the oscilloscope's Addressed (ADDR) indicator is lit.

Unasserting REN causes a transition 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 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 the GPIB Parameter Selection information.

UNLISTEN (UNL) AND UNTALK (UNT)—When the 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 bus.

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

INTERFACE CLEAR (IFC)—When IFC is asserted, both the Talk and Listen functions are placed in an idle state and the CRT ADDR indicator is turned off. This produces the same effect as receiving both the UNL and the UNT messages.

DEVICE CLEAR (DCL)—The 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.

Reset Under Communication Option Control

Some oscilloscope modes may be set to their default or power-on states by sending the INIt command via the communication option. The major settings that are affected by INIt are:

ACQUISITION REP:AVE
ACQUISITION HSREC:SAMPLE
ACQUISITION LSREC:PEAKDET
ACQUISITION SCAN:PEAKDET
ACQUISITION ROLL:PEAKDET
ACQUISITION SMOOTH:ON
ACQUISITION WEIGHT:4 (16 in the 2220 and 2221)
ACQUISITION NUMSWEEPS:0
ACQUISITION VECTORS:ON
DATA ENCDG:BINARY
DATA SOURCE:ACQ
DATA TARGET:REF1 (REF4 in the 2220 and 2221)
PLOT GRAT:OFF
PLOT FORMAT:<power-on setting>
READOUT ON
Menu system reset.

Option 10 Status and Error Reporting

The status and error reporting system of Option 10 interrupts the GPIB bus controller by asserting an SRQ (service request). The service request indicates that an event has occurred that requires attention. When the controller polls the bus, the status-byte returned by the oscilloscope indicates the type of event that occurred. A further EVEnt? query will return an event code that gives more specific information about the cause of the service request. The SRQ status byte and the event code provide a limited amount of information about the specific cause of the service request. Command errors, execution errors, and internal errors assert an immediate SRQ (if RQS is on). To retrieve other system event and warning status bytes, OPC must also be ON, and the oscilloscope must be queried by the STAtus? command. See Tables 7-34 and 7-35 at the back of this section for status and event codes.

GPIB Programming

Programming considerations are provided in this part to assist in developing your own unique programs for interfacing to the oscilloscope via the GPIB.

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 were given previously 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—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 Table 7-14.

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 response required to handle the event.

4. Return to the main program.

OPTION 12 RS-232-C OPERATORS INFORMATION

The RS-232-C Communications interface conforms to the Tektronix standard on Codes, Formats, Conventions, and Features for messages sent over to bus for communications to other RS-232-C devices. Specific formats implemented in the 2200 DSO family for the Option 12 Communications interface are listed in Table 7-7. Specific feature implementation is shown in Table 7-8.

Option 12 Side Panel

The side panel for Option 12 instruments (Figure 7-3) includes one AUXILIARY connector, one RS-232-C interface port (providing both DTE and DCE capability), and one PARAMETERS switch. The Controls, Connectors, and Indicators part of this manual contains information on the use of the AUXILIARY Connector. Refer to Figure 7-3 for location of the Option 12 side-panel controls and connectors.

AUXILIARY Connector—Provides connections for an X-Y Plotter and an External Clock input (see Controls, Connectors, and Indicators).

RS-232-C PARAMETER Switch—Allows the selection of setup options for the RS-232-C interface. The switches are read at power-up. Four sections of the switch select the baud rate, three select parity, one selects the terminator, and two are for printer/plotter selection. The function of each switch section is shown in Table 7-11.

NOTE

Do not hook up external devices to the DTE connector and the DCE connector at the same time.

Table 7-7
Specific Format Choices for Option 12

Format Parameter	Choice Made
Format Characters	Not transmitted; ignored on reception.
Message Terminator	Either CR or CR-LF may be selected as the message terminator.
Measurement Terminator	Follows program message-unit syntax.
Link Data (Arguments)	Used in sending and receiving messages.
Multiple Event	Not implemented to report multiple events on a single reporting query. Multiple events may be reported by multiple queries.
Instrument Identification Query	Descriptors added for all options.
Set Query	Extended by using other commands as queries.
Device Trigger (DT)	Not implemented.
INIT Command	Causes the instrument to return to a default initialization state.
Time/Date Commands	Not implemented.
Stored Setting Commands	Not implemented.
Waveform Transmission	Implemented. Waveforms may be encoded in ASCII, HEX, or BINARY. The oscilloscope powers on with the encoding set to BINARY.
Remote On/Off	REMote must be set to ON to get the instrument to change a remote-controllable function. The instrument powers up with REMote OFF.
IEEE 728	Compliance not intended.

RS-232-C DTE Connector—Provides connection meeting the EIA RS-232-C standard for data terminal equipment (see Figure 7-3). Table 7-9 lists the function of each pin of the connector. This connector is provided only on Option 12 instruments.

Table 7-8
Implementation of Specific Features for Option 12

Feature	Choice Made	Comments
Secondary Addressing	Not implemented.	
Indicators		
ADDR (carrier detect)	Implemented.	ADDR indicator comes on when carrier is detected.
SRQ (service request)	Implemented.	SRQ indicator is on only when a status byte is sent.
PLOT	Implemented	PLOT indicator is on when acquistions are locked out during a waveform plot.
Parameter Selection	Implemented	A ten-section switch sets the instruments's baud rate, data parity type, message terminator, and printer/plotter selections. Switch settings are read at power on only.

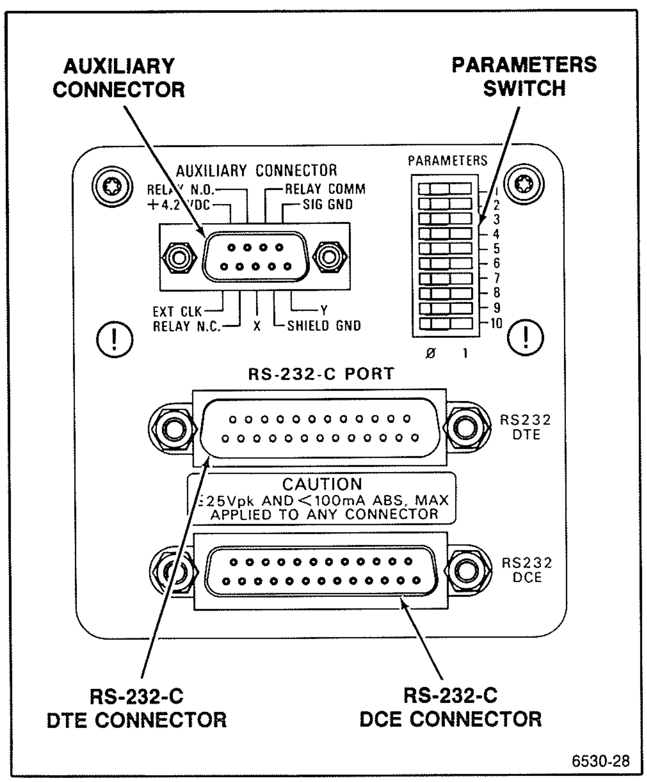


Figure 7-3. Option 12 side panel.

Table 7-9
RS-232-C DTE Connector

Pin	Signal Name		Function
	Internal	External	
1	CHAS GND	CHAS GND	Chassis ground
2[a]	ITXD	TXD	Transmitted data
3[a]	IRXD	RXD	Received data
4	IRTS	RTS	Request to send
5	ICTS	CTS	Clear to send
6	IDSR	DSR	Data set ready
7[a]	SIG GND	SIG GND	Signal ground
8	IRLSD2	RLSD	Received line signal detect
20	IDTR	DTR	Data terminal ready

[a]These lines are all that are required for communication without hard control lines.

NOTE

Do not hook up external devices to both the DTE connector and the DCE connector at the same time.

RS-232-C DCE Connector—Provides a connector that meets the EIA RS-232-2 standard for data communications equipment (see Figure 7-3). Table 7-10 lists the function of each pin of the connector. The connector is provided only on Option 12 instruments.

Option 12 Interface Status Indicators

The three indicator labels (SRQ, ADDR, and PLOT) above the CRT indicate the status of the Communications interface. Refer to Figure 7-2 (shown previously) for the location of the status indicators. Their operation is as follows:

The SRQ indicator is on only during the time an asynchronous status byte is being sent. A status byte or event code is not generated for power-on. Events must be queried to receive pending events codes. Status must also be queried to receive pending status bytes, except for command and execution error status which are returned immediately upon recognition of an error. If OPC is also on, additional system events (i.e., warnings and operation complete) will also generate an asynchronous service request. All status bytes are prevented from reporting if RQS is off, but the SRQ indicator does not indicate that a status byte is pending. In this case, the event code must be queried (EVEnt?) to find out if an event has happened.

The ADDR indicator is on when a carrier is detected. With no devices connected to either the DTE port or the DCE port, the ADDR indicator will be on. If an RS-232-C DCE device is connected to the DCE port, the carrier will also be on all the time. The indicator will be off if a DTE device is connected to the DTE port and no carrier is detected.

The PLOT indicator is on when the communication option is currently sending waveform data. Acquisitions are inhibited during this time.

Table 7-10
RS-232-C DCE Connector

Pin	Signal Name		Function
	Internal	External	
1	CHAS GND	CHAS GND	Chassis ground
2[a]	IRXD	TXD	Transmitted data
3[a]	ITXD	RXC	Received data
4	ICTS	RTS	Request to send
5	IRTS	CTS	Clear to send
6	IDTR	DSR	Data set ready
7[a]	SIG GND	SIG GND	Signal ground
8	IRLSDC1	RLSD	Received line signal detect
20	IDSR	DTR	Data terminal ready

[a]**These lines are all that are required for communication without hard control lines.**

RS-232-C Parameter Selection

Selection of RS-232-C parameters (baud rate, parity, and line terminator) must be made prior to power on using the RS-232-C PARAMETER switch and Table 7-11 through Table 7-13. Changes to the PARAMETER switch after power on will not be read until the next power on occurs. PARAMETERS switch settings and setups for some common printers and plotters are given in Appendix B. There are two other communications parameters that are set using commands via the interface itself. These are STOP bits and FLOW control. The most used setting for STOP is 1. The power-on default for FLOW is OFF.

Baud Rate. Baud rate switch settings determine the baud rate used by the instrument for both sending and receiving data. The available baud rates are listed in Table 7-12.

When OFF LINE (baud-rate switch settings 1111) is selected, the instrument still presents an active load to the other RS-232-C device, but it can't send or receive any interface traffic.

Use Table 7-11, Table 7-12, and the PARAMETERS switch to select the desired baud rate.

Parity. The selected parity settings determine the oscilloscope's response to received parity errors and the parity of data sent by the oscilloscope.

Table 7-11
RS-232-C PARAMETERS Switch

Switch Section	Switch Position	Function
1	--	Baud rate[a]
2	--	Baud rate[a]
3	--	Baud rate[a]
4	--	Baud rate[a]
5		Parity enable/disable
	0	Parity is not checked. The data word is 8 bits long.
	1	Parity is checked according to the settings of switches 6 and 7. A parity error causes a status byte to be sent if RQS is on. The data word is 7 bits long with the 8th bit being the parity bit.
6		Parity select[b]
7		Parity select[b]
8		Line terminator selection
	0	Lines are terminated with carriage return (CR).
	1	Lines are terminated with carriage return-line feed (CR-LF).
9		Printer/Plotter selection[c]
10		Printer/Plotter selection[c]

[a]See Table 7-12.

[b]See Table 7-13.

[c]Switches 9 and 10 select printer/plotter devices at power up. The devices may be changed after power-up using Option commands or, in the case of the 2230, the MENU controls. Two EPSON formats are selectable. EPS7 uses seven print wires per head pass, and is usually slower. It is the chr$(27) "L" mode. EPS8 uses eight print wires per head pass, and is usually the faster print-head speed. It is the chr$(27) "Y" mode. In this mode, most Epson and Epson-compatible printers will not strike any print wire more often than every second pixel. EPS8 is selected when parity is disabled. Printing/plotting devices are selected with the following switch positions:

Switch 9	Switch 10	Device Selected
0	0	HP-GL® plotter
1	0	Epson® (EPS7 or EPS8)
0	1	ThinkJet® printer
1	1	X-Y Plotter

HP-GL® and ThinkJet® are trademarks of Hewlett-Packard Company. Epson® is a trademark of Epson Corporation.

Table 7-12
Baud Rate

Switch Position 4 3 2 1	Baud Rate
0 0 0 0	50
0 0 0 1	75
0 0 1 0	110
0 0 1 1	134.5
0 1 0 0	150
0 1 0 1	300
0 1 1 0	600
0 1 1 1	1200
1 0 0 0	1800
1 0 0 1	2000
1 0 1 0	2400
1 0 1 1	3600
1 1 0 0	4800
1 1 0 1	7200
1 1 1 0	9600
1 1 1 1	Off Line

Section 5 of the PARAMETERS switch determines whether or not received parity errors will cause an error report (see Table 7-11). With parity enabled, seven bits represent the characters being sent. The eighth bit is the parity bit, and is interpreted as selected by the settings of switches 6 and 7. These sections of the PARAMETERS switch determine the parity used when transmitting and receiving data over the RS-232-C interface. ODD, EVEN, MARK, or SPACE parity is selectable (see Table 7-13).

By setting both the transmitting and receiving devices to use parity, some degree of checking may be done on 7-bit data. Setting parity to "even" causes the transmitter to send a parity bit that makes the number of "mark" bits in the data (plus the parity bit) come out to an even number. Upon receiving the data, the receiving device adds up the "mark" bits in the data byte. If an error is detected, a system event status byte is sent. When the event code byte is interpreted, the controller may make a hardware change or alter its routine to handle the error.

"Odd" parity works in the same way, except that the number of "mark" bits is expected to be odd. Parity may also be set to "mark" or "space" where the parity bit is always set to a mark or a space respectively.

Table 7-13
Parity Selection[a]

Switch Position 6 7	Parity Type	Comment
0 0	ODD	The parity bit of each byte is set or cleared as needed to make the number of logical ones per word byte odd.
1 0	EVEN	The parity bit of each byte is set or cleared as needed to make the number of logical ones per word byte even.
0 1	MARK	The parity bit is always set to a logical one.
1 1	SPACE	The parity bit is always cleared to a logical zero.

[a]Characters are always accepted if possible. If parity is enabled and RQS is on, a status byte is sent if the received parity doesn't match the parity selected. Parity must be disabled (PARAMETERS switch position 5 set to 0 before power on) for binary data transfers.

Message Line Terminator. PARAMETERS switch section 8 selects the line terminator. The line terminator is either CR (carriage return), with switch section 8 open, or CR-LF (carriage return and line feed), with switch section 8 closed (see Table 7-11).

NOTE

Commands to the oscilloscope are interpreted and carried out as soon as they are recognized as such; the oscilloscope does not wait for a CR or CR-LF to end the command string. If a command needs to be correctly done before the next command is sent, the controller must wait for the correct return. If an error occurs (due to command syntax or incompatible instrument settings), the error status will be immediately reported. The controller can detect the error, query the event code, and take corrective action before going on with another command that may not be handled properly. This is especially true if the previous command puts the oscilloscope in a state that prevents it from responding. For this reason, the recommended practice is to send only one command in each message line to the oscilloscope.

When CR (normal mode) is selected as the terminator, the instrument will:

- Accept only CR as the line terminator.
- Send CR as the last byte of a message.

When CR-LF is selected as the terminator, the instrument will:

- Accept either CR-LF or LF only as the line terminator.
- Send CR-LF (carriage return followed by line feed) at the end of every message.

STOP Bits

Once communication is established between the controller and the oscilloscope, commands may be sent to the oscilloscope. When dealing with the transfer of data via the RS-232-C interface, the bits used to make up a character consist of a start bit, seven or eight data bits, and, finally, one or two stop bits. Start and stop bits separate the data bytes and are called framing pulses. The start bit is always set to a "mark," and the one or two stop bits are set to a "space." One stop bit is used in most applications. Two stop bits may be needed for some printers at some baud rates. The command STOP 1 or STOP 2 sets the number of stop bits in the character frame.

NOTE

For the 2220 and 2221 instruments, selection of the stop bits is not possible from the front-panel controls. When connecting to a printer or plotter with a choice of stop bits for different baud-rate settings, select a baud rate that requires only one stop bit.

The transition from one character's stop bit(s) to the next character's start bit is used to synchronize the receiver to the transmitter. This causes the coded data bits for each character to be read at the best time relative to the start of the character's start.

Errors that occur due to mismatched baud rates, data bits, or stop bits show up as "framing errors." The start-bit and stop-bit frame surrounding the character bits have the wrong timing relationship with respect to each other. Since they are not recognized properly, the data stream cannot be interpreted by the receiving device.

FLOW Control

When transmitting data using modems to interconnect two devices via the telephone lines, the normal handshaking lines are not used. The two devices can still communicate using a data-transmission technique called "flow control." Using this method, the data sent can be separated from non-data being received (such as noise). This is done by interpreting every correctly framed data pattern as a valid character and constantly checking for two specific characters that turn the transmission on and off.

These flow-control characters are called XON (transmission on) and XOFF (transmission off). The usual assignment for these is <control-Q> for XON and <control-S> for XOFF, though the specific characters chosen are a function of the communications program used. When communicating over telepnone lines, flow control greatly increases the chance that ASCII or HEX encoded data will be correctly transferred.

The FLOW ON command allows the oscilloscope some on/off control of the data transfer. At power-on, the default data encoding is BINARY. Flow control can not be used for the transmission of binary-encoded waveform data, so the power-on setting of FLOW is set to off. Before sending binary-encoded data, FLOW OFF must be sent if flow control was previously set ON. The Advanced Functions menu of the 2230 also has a menu choice for setting flow control.

Remote-Local Operating States

The following paragraphs describe the two operating states of the instrument: Local and Remote.

REMOTE OFF (LOCAL)—With REMOTE OFF, instrument settings are controlled manually by the operator using the front-panel controls. Option interface messages such as REMOTE ON, RQS ON, and OPC ON are received and executed. Queries about instrument's states or measurement results will be answered. Device-dependent commands that require an instrument operating mode change to be made cause an execution error, and a service request will be generated if RQS is on.

REMOTE ON (REMOTE)—In this state, the oscilloscope executes all commands sent to it. Remote-controllable front-panel indicators and CRT readouts are updated as commands are carried out. There is no local lockout (LLO). Changing any option-controllable front-panel setting locally overrides the remote settings. If a waveform is being transmitted, the PLOT indicator will be lit, and new waveform data will not be acquired until the transmission is done.

Reset Under Communication Option Control

Certain default settings for acquisition and plot modes may be set up sending the INIt command. The INIt command does not invoke the power-up test. Upon completion of the INIt command, no status byte or event code is generated.

The default settings are as follows:

ACQUISITION REP:AVE
ACQUISITION HSREC:SAMPLE
ACQUISITION LSREC:PEAKDET
ACQUISITION SCAN:PEAKDET
ACQUISITION ROLL:PEAKDET
ACQUISITION SMOOTH:ON
ACQUISITION WEIGHT:4 (16 in the 2220 and 2221)
ACQUISITION NUMSWEEPS:0
ACQUISITION VECTORS:ON
DATA ENCDG:BINARY
DATA SOURCE:ACQ
DATA TARGET:REF1 (REF4 in the 2220 and 2221)
PLOT GRAT:OFF
PLOT FORMAT:<power-on setting>
READOUT ON
Menu system reset.

RS-232-C PROGRAMMING

Things to consider when writing programs for your RS-232-C controller are given here to help you when you must develop your own interfacing software. Before a program can be used to control the oscilloscope, the RS-232-C communication parameters for baud rate, line terminator, and parity must be set. Settings for these parameters are selected and set using the RS-232-C PARAMETERS switch found on the side panel of the oscilloscope.

Controller programs are usually composed of two main parts or routines. The two parts are generally called the command handler and the service-request handler.

COMMAND HANDLER—Basically, a command handler establishes communication between the controller and the oscilloscope, sends commands to the oscilloscope, receives responses from the oscilloscope, and displays the responses as required. The steps of the following procedure are the general functions that the command-handler software routine should be able to do for the most useful communications.

1. Initialize the controller in the communications mode.
2. Watch for a service request.
3. Check the event code (by sending an EVEnt? query) if a service request occurs.
4. Determine the action needed to be taken from the event code byte that is returned and take it.
5. Get a command to send to the oscilloscope.
6. Send a command to the oscilloscope.
7. Check for a response from the oscilloscope.
8. If the response is an error status, check the event code (Step 3) and take the appropriate action (Step 4).
9. Repeat Steps 5 through 8 as many times as needed.

SERVICE REQUEST HANDLER—The service-request handler routine should contain the necessary instructions to process the possible event codes generated by the 2200 Family DSO. The 2200 Family DSO requests service by sending asynchronous status bytes when certain errors occur (if RQS is ON). Other status bytes return as the result of a STAtus? query, or when OPC is on. The immediate mode service request may cause the controller to halt unless the controller's program is written to properly handle them. A user may also want the controller routine to be able to recognize and handle the other events requiring service. These events are identified in Tables 7-34 and 7-35 at the back of this section.

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

1. Watch for an asynchronous service-request status byte. This is the same concept as checking for an SRQ with the GPIB controller program.

2. Send an EVEnt? query to obtain the event-code byte that describes in more depth what caused the service request.

3. If the response to the EVEnt? query is not zero, perform the action required to handle the event.

4. Return to the main program.

Option 12 Status and Error Reporting

The status and error reporting system used by the Communication Option sends status bytes that may be viewed as a service request when monitored by the appropriate controller software. As soon as a change of status or an error occurs, the 2200 Family instrument returns a service request status byte that indicates the type of event that occurred (if RSQ is on). The status byte returned and the event code returned as the reply to an EVEnt? query provide a limited amount of information about the specific cause of the service-request status-byte. Command errors, execution errors, and internal errors generate a service-request status byte immediately (if RQS is ON). To retrieve other system-event and warning status bytes, OPC must be ON, and the oscilloscope must be queried by the STAtus? command. See Tables 7-34 and 7-35 at the back of this section for status-byte and event codes.

COMMUNICATION AND WAVEFORM TRANSFER

This subsection contains information common to both Option 10 and Option 12. The commands available, the command protocol, waveform transfer information, and the service request status bytes are included in this subsection.

READOUT/MESSAGE COMMAND CHARACTER SET

Character translations performed by the MESsage command and query, when sending data to or receiving data from the CRT readout, are indicated in Table 7-14. The standard ASCII character codes are given in Table 7-15.

NOTE

Values in Table 7-14 that have no CRT equivalent are translated into spaces when sent to the display.

MESSAGES AND COMMUNICATION PROTOCOL

The commands available to the user via either the Option 10 GPIB or the Option 12 RS-232-C communications option can set some of the instrument's digital storage operating modes, query the results of measurements made, or query the state of the oscilloscope. The commands are specified in mnemonics that are related to the functions 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.

NOTE

All measurement results returned by the options have the same accuracy as the main instrument.

Commands

Commands for this instrument, like those for other Tektronix 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 user familiar with the commands to reduce the number of key strokes needed and still have the command unambiguous. Syntax is also standardized to make the commands easier to learn.

In the Command tables found at the end of this section, headers and arguments are listed in a combination of upper-case and lower-case characters. The instrument accepts abbreviated headers and arguments that contain at least the upper-case characters shown in the tables (whether sent in upper case or lower case). The lower-case characters may be added to the abbreviated (upper case) version, but they can only be those shown in lower case. For a query, the question mark must immediately follow the header. For example, any of the following formats are acceptable to the oscilloscope:

VMO? or vmo?
VMOd? or vmod?
VMOde? or 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; for example:

INIt
OPC

ARGUMENTS—Some commands require the addition of arguments to their 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 a single word; for example:

REFTo REF4
PLOt STArt

In other cases, the argument itself requires another argument. When a second argument, or "link argument," is required, a colon must separate the two arguments. Two examples of this are:

ACQuisition REPetitive:SAMple

and

WFMpre XINcr:1.0E-3

Table 7-14

Readout/MESage Command Character Set

BITS (B4 B3 B2 B1 / B7 B6 B5)				0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
B4	B3	B2	B1	CONTROL		SYMBOLS		UPPERCASE		LOWERCASE	
0	0	0	0	0 0	10 T 16	20 SP 32	30 0 48	40 @ 64	50 P 80	60 ` 96	70 p 112
0	0	0	1	1 1	11 17	21 ! 33	31 1 49	41 A 65	51 Q 81	61 a 97	71 q 113
0	0	1	0	2 $^{B}W_{L}$ 2	12 18	22 " 34	32 2 50	42 B 66	52 R 82	62 b 98	72 r 114
0	0	1	1	3 ⊠ 3	13 19	23 # 35	33 3 51	43 C 67	53 S 83	63 c 99	73 s 115
0	1	0	0	4 Δ 4	14 20	24 $ 36	34 4 52	44 D 68	54 T 84	64 d 100	74 t 116
0	1	0	1	5 — 5	15 µ 21	25 % 37	35 5 53	45 E 69	55 U 85	65 e 101	75 u 117
0	1	1	0	6 = 6	16 Ṽ 22	26 & 38	36 6 54	46 F 70	56 V 86	66 f 102	76 v 118
0	1	1	1	7 ⏚ 7	17 ↓ 23	27 ' 39	37 7 55	47 G 71	57 W 87	67 g 103	77 w 119
1	0	0	0	8 8	18 24	28 (40	38 8 56	48 H 72	58 X 88	68 h 104	78 x 120
1	0	0	1	9 9	19 25	29) 41	39 9 57	49 I 73	59 Y 89	69 i 105	79 y 121
1	0	1	0	A 10	1A 26	2A * 42	3A : 58	4A J 74	5A Z 90	6A j 106	7A z 122
1	0	1	1	B 11	1B 27	2B + 43	3B ; 59	4B K 75	5B [91	6B k 107	7B { 123
1	1	0	0	C 12	1C 28	2C , 44	3C < 60	4C L 76	5C \ 92	6C l 108	7C ¦ 124
1	1	0	1	D 13	1D 29	2D - 45	3D = 61	4D M 77	5D] 93	6D m 109	7D } 125
1	1	1	0	E Hz 14	1E 30	2E . 46	3E > 62	4E N 78	5E ^ 94	6E n 110	7E ~ 126
1	1	1	1	F 1/Δ 15	1F 31	2F / 47	3F ? 63	4F O 79	5F — 95	6F o 111	7F 127

6530-29

Table 7-15
ASCII Code Chart

B7 B6 B5 / BITS / B4 B3 B2 B1	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
Ø Ø Ø Ø	0 **NUL** 0 0	20 **DLE** 10 16	40 0 **SP** 20 32	60 16 **0** 30 48	100 0 **@** 40 64	120 16 **P** 50 80	140 0 **`** 60 96	160 16 **p** 70 112
Ø Ø Ø 1	1 GTL **SOH** 1 1	21 LLO **DC1** 11 17	41 1 **!** 21 33	61 17 **1** 31 49	101 1 **A** 41 65	121 17 **Q** 51 81	141 1 **a** 61 97	161 17 **q** 71 113
Ø Ø 1 Ø	2 **STX** 2 2	22 **DC2** 12 18	42 2 **"** 22 34	62 18 **2** 32 50	102 2 **B** 42 66	122 18 **R** 52 82	142 2 **b** 62 98	162 18 **r** 72 114
Ø Ø 1 1	3 **ETX** 3 3	23 **DC3** 13 19	43 3 **#** 23 35	63 19 **3** 33 51	103 3 **C** 43 67	123 19 **S** 53 83	143 3 **c** 63 99	163 19 **s** 73 115
Ø 1 Ø Ø	4 SDC **EOT** 4 4	24 DCL **DC4** 14 20	44 4 **$** 24 36	64 20 **4** 34 52	104 4 **D** 44 68	124 20 **T** 54 84	144 4 **d** 64 100	164 20 **t** 74 116
Ø 1 Ø 1	5 PPC **ENQ** 5 5	25 PPU **NAK** 15 21	45 5 **%** 25 37	65 21 **5** 35 53	105 5 **E** 45 69	125 21 **U** 55 85	145 5 **e** 65 101	165 21 **u** 75 117
Ø 1 1 Ø	6 **ACK** 6 6	26 **SYN** 16 22	46 6 **&** 26 38	66 22 **6** 36 54	106 6 **F** 46 70	126 22 **V** 56 86	146 6 **f** 66 102	166 22 **v** 76 118
Ø 1 1 1	7 **BEL** 7 7	27 **ETB** 17 23	47 7 **'** 27 39	67 23 **7** 37 55	107 7 **G** 47 71	127 23 **W** 57 87	147 7 **g** 67 103	167 23 **w** 77 119
1 Ø Ø Ø	10 GET **BS** 8 8	30 SPE **CAN** 18 24	50 8 **(** 28 40	70 24 **8** 38 56	110 8 **H** 48 72	130 24 **X** 58 88	150 8 **h** 68 104	170 24 **x** 78 120
1 Ø Ø 1	11 TCT **HT** 9 9	31 SPD **EM** 19 25	51 9 **)** 29 41	71 25 **9** 39 57	111 9 **I** 49 73	131 25 **Y** 59 89	151 9 **i** 69 105	171 25 **y** 79 121
1 Ø 1 Ø	12 **LF** A 10	32 **SUB** 1A 26	52 10 ***** 2A 42	72 26 **:** 3A 58	112 10 **J** 4A 74	132 26 **Z** 5A 90	152 10 **j** 6A 106	172 26 **z** 7A 122
1 Ø 1 1	13 **VT** B 11	33 **ESC** 1B 27	53 11 **+** 2B 43	73 27 **;** 3B 59	113 11 **K** 4B 75	133 27 **[** 5B 91	153 11 **k** 6B 107	173 27 **{** 7B 123
1 1 Ø Ø	14 **FF** C 12	34 **FS** 1C 28	54 12 **,** 2C 44	74 28 **<** 3C 60	114 12 **L** 4C 76	134 28 **** 5C 92	154 12 **l** 6C 108	174 28 **|** * 7C 124
1 1 Ø 1	15 **CR** D 13	35 **GS** 1D 29	55 13 **−** 2D 45	75 29 **=** 3D 61	115 13 **M** 4D 77	135 29 **]** 5D 93	155 13 **m** 6D 109	175 29 **}** 7D 125
1 1 1 Ø	16 **SO** E 14	36 **RS** 1E 30	56 14 **.** 2E 46	76 30 **>** 3E 62	116 14 **N** 4E 78	136 30 **^** 5E 94	156 14 **n** 6E 110	176 30 **~** 7E 126
1 1 1 1	17 **SI** F 15	37 **US** 1F 31	57 15 **/** 2F 47	77 UNL **?** 3F 63	117 15 **O** 4F 79	137 UNT **_** 5F 95	157 15 **o** 6F 111	177 **DEL (RUBOUT)** 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	
							(PPE)	(PPD)

* | on some keyboards or systems

KEY

octal	25 PPU	GPIB code
	NAK	ASCII character
hex	15 21	decimal

6530-30

Where a header has multiple arguments, the arguments (or argument pairs, if the argument has its own argument) must be separated by commas. Two examples of this syntax are:

DATa ENCdg:BINary,CHAnnel:CH2

and

VMOde? CH1,CH2,ADD

NOTE

With Option 12, multiple commands (especially queries) should not be used in a single programmed message line. Commands (and arguments to commands) are interpreted and acted on by the oscilloscope as soon as a separator is recognized; the oscilloscope does not wait for the message terminator (CR or CR-LF) to signal the end of the command line. If one of the commands in a command line requires a response for any reason (i.e., command error, illegal command, or unable to do the command), the oscilloscope's service-request status-byte response will be asynchronously sent. If the service request is not handled correctly, the controller may not be able to continue with its program.

COMMAND SEPARATOR—Multiple commands may be put into one command line by separating the individual commands with a semicolon; for example:

DATa ENCdg:BINary,CHAnnel:CH2;WFMpre XINcr:1.0E-3

Multiple commands in a message are not recommended with RS-232-C controller routines for Option 12. See the previous NOTE. However, the command separator is valid, and multiple commands on the same message line may be used. A waveform preamble is one example of using multiple commands in a single message. With Option 10, GPIB controller programs often use multiple commands in a single line.

GPIB MESSAGE TERMINATOR—As previously explained, GPIB 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 messages.

RS-232-C MESSAGE TERMINATOR—RS-232-C messages from the oscilloscope may be terminated with either carriage return (CR) or the CR and line-feed (LF) characters. The RS-232-C Option can be set to send and receive either terminator as the last byte of a message. The instrument does not wait for the end-of-line terminator when it handles incoming messages. It recognizes a semicolon as the end of command terminator and immediately begins its response to the preceding command string. Because of the way the instrument handles commands, messages should be limited to one command per line. Incoming and outgoing messages are not stacked. If more than one command per line is sent, responses to the first commands in a line may be lost when the output buffer is reinitialized to output the response to the last command in a line. Even single command messages should not be terminated twice. The response to the command may be lost when the instrument sees the second terminator.

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 upper-case or lower-case ASCII characters. All data output is in upper case.

Spaces can be used as formatting characters to enhance the readability of command sequences. As a general rule, spaces can be placed either after commas and semicolons or after the space that follows a header.

NUMERIC ARGUMENTS—Table 7-16 shows the number formats for the <NR1>, <NR2>, and <NR3> arguments used in a command. Both signed and unsigned numbers are accepted, but unsigned numbers are taken as positive.

Table 7-16
Numeric Argument Format for Commands

Numeric Argument	Number Format	Examples
<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

WAVEFORM TRANSFERS

The instrument can transmit and receive waveforms. It can transfer these waveforms in binary, hexadecimal, or ASCII encoding. When sending waveforms to the instrument, the target must be one of the numbered reference memories (REF4 only for the 2220 and 2221). Waveforms transferred from the oscilloscope to the controller may be from either the current acquisition or one of the numbered reference memories (again REF4 for the 2220 and 2221). The data source (the memory location from which the waveform data comes) and the data target (the memory location where data sent to the oscilloscope ends up) are selected independently.

Waveform Preamble

The waveform preamble contains the attributes for the associated waveform data. These attributes include the number of points per waveform, scale factors, vertical offsets, horizontal increment, scaling units, and data encoding. The preamble information is sent as an ASCII-encoded string in all cases. The exact attributes sent depend on the waveform and the acquisition mode.

A typical response to the preamble query WFMpre? for a Y (time-implied) acquisition is:

```
WFM WFI:"ACQ, CH1,0.5V,DC,0.2mS,SAMPLE,
CRV# 1",NR.P:4096,PT.O:122,PT.F:Y,
XMU:0.0E0,XOF:0,XUN:S,XIN:2.0E−6,
YMU:20.0E−3,YOF:−20,YUN:V,ENC:HEX,BN.F:RP,
BYT:1,BIT:8,CRV:CHK;
```

A typical response to the preamble query for an X-Y acquisition is:

```
WFM WFI:"ACQ,XY,0.2V,DC,50.0mV,DC,
1.0µS, SAMPLE, CRV# 4",
NR.P:2048,PT.O:216,PT.F:XY,XMU:8.0E−3,
XOF:0,XUN:S,XIN:20.0E−9,YMU:2.0E−3,YOF:0,
YUN:V,ENC:BIN,BN.F:RP,BYT:1,BIT:8,CRV:CHK;
```

These replies are single line messages that end with the selected message terminator (CR or CR-LF). With the GPIB interface, EOI (end-or-identify) is also sent if that terminator mode is selected.

Transferring Waveforms

The oscilloscope can respond with the preamble only, the curve data only, or the preamble and curve data together. The queries to obtain these responses are, in order, WFMpre?, CURVe?, and WAVfrm?

For the combined response to WAVfrm?, the preamble is separated from the curve data by a semicolon (;).

The preamble information is always formatted as ASCII characters. Waveform (CURVE) data internal to the oscilloscope is stored as 8-bit, unsigned integers. Before that data is sent via the Communications option, it is changed into one of three formats: binary, hexadecimal, or ASCII. The resolution of the formatted data points may be either 8-bit or 16-bit. Waveform record length is 1024 data points for the shortest or 4096 data points for the longest. The number of bytes that are required to transfer data depends on several variables. See the NR.Pts description in the Waveform Preamble Fields command table for more information. The largest number of curve data bytes ever needed to send a waveform is 8192 bytes (for a 4K record that has two bytes per data point).

Binary Encoding

BINary data is transferred as unsigned binary integers. Each data point in the record is either 8 bits or, when averaged, 16 bits. BINary encoding format has the following waveform curve data form:

CURVE <space> % <Binary Count MSB> <Binary Count LSB> <Binary Data> <Checsum> <Terminator>

Where:

CURVE	is a literal string indicating that curve data follows.
%	is used as a header character to show the start of a binary block.
<Binary Count MSB>	is the most-significant byte of the two-byte Binary Count. Binary Count is the length of the waveform, in bytes, plus the one-byte checksum.
<Binary Count LSB>	is the least-significant byte of the Binary Count.
<Binary Data>	is made up of 256, 512, 1024, 2048, or 4096 data points. Each data point is either a 1-byte (8 bits) or 2-byte (16 bits) representation of each digitized value.
<Checksum>	is the two's-complement of the modulo 256 sum of the preceding data bytes and the binary count. The Checksum is used by the controller program to verify that all data values have been received correctly.

Table 7-17 illustrates the data transferred for a 4096-point, 8-bit, binary-encoded waveform. The waveform data-point values vary with the signal amplitude.

Table 7-18 illustrates the data transferred for a 4096-point, 16-bit (averaged), binary-encoded waveform.

Table 7-17
Typical 8-Bit Binary-Encoded Waveform Data

Byte	Contents	Decimal	GPIB EOI (1=Asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	%	37	0
8	<Bin Count MSB>	16[a]	0
9	<Bin Count LSB>	01[a]	0
10	1st Pt	d_1	0
11	2nd Pt	d_2	0
.	.	.	0
.	.	.	0
.	.	.	0
4105	4096th Pt	d_{4096}	0
4106	<Checksum>	chk	1 When TERM=EOI
4107[b]	<CR>	13	0
4108[c]	<LF>	10	1

[a](1001_{16} or 4097_{10})

[b]All RS-232-C or GPIB with TERM = LF/EOI.

[c]RS-232-C with TERM = CR-LF.

Hexadecimal Encoding

With HEXadecimal waveform data encoding, characters representing an 8-bit or 16-bit data point are sent in a fixed ASCII hexadecimal format. There are no delimiters (commas) between data points. Data format is very similar to BINary format, with the following exceptions:

1. The curve header is "CURVE #H" instead of "CURVE %".

2. Each data point is two ASCII hexadecimal characters for 8-bit transfers and four ASCII hexadecimal characters for 16-bit transfers.

3. The byte count is sent as four successive ASCII hexadecimal characters, but the value of the byte count is identical to a comparable BINary transfer.

4. The checksum is sent as two successive ASCII hexadecimal characters.

Table 7-18
Typical 16-Bit Binary-Encoded Waveform Data

Byte	Contents	Decimal	GPIB EOI (1=Asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	%	37	0
8	<Bin Count MSB>	32[a]	0
9	<Bin Count LSB>	01[a]	0
10	1st Pt MSB	d_{1H}	0
11	1st Pt LSB	d_{1L}	0
12	2nd Pt MSB	d_{2H}	0
13	2nd Pt LSB	d_{2L}	0
.	.	.	0
.	.	.	0
.	.	.	0
8200	4096th Pt MSB	d_{4096H}	0
8201	4096th Pt LSB	d_{4096L}	0
8202	<Checksum>	chk	1 When TERM=EOI
8203[b]	<CR>	13	0
8204[c]	<LF>	10	1

[a](2001_{16} or 8193_{10})

[b]All RS-232-C or GPIB with TERM = LF/EOI.

[c]RS-232-C with TERM = CR-LF.

Tables 7-19 and 7-20 illustrate 8-bit and 16-bit HEXadecimal-encoded waveform-data transfers.

ASCII Encoding

With ASCII waveform data encoding, ASCII characters representing the binary value of each waveform data point are sent in variable length format, separated by commas. In ASCII format, the curve data transfer is represented as:

CURVE<space>data,data,data,.....,data<terminator>

Table 7-19
Typical 8-Bit Hexadecimal-Encoded Waveform Data

Byte	Contents	Decimal	GPIB EOI (1=Asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	#	35	0
8	H	72	0
9	<Bin Count MS 4 bits>	49	0
10	.	48	0
11	.	48	0
12	<Bin Count LS 4 bits>	49	0
13	1st Pt MS 4 bits	d_{1H}	0
14	1st Pt LS 4 bits	d_{1L}	0
15	2nd Pt MS 4 bits	d_{2H}	0
16	2nd Pt LS 4 bits	d_{2L}	0
.	.	.	0
.	.	.	0
.	.	.	0
203	4096th Pt MS 4 bits	d_{4096H}	0
204	4096th Pt LS 4 bits	d_{4096L}	0
205	<Checksum MS 4 bits>	chk_H	0
206	<Checksum LS 4 bits>	chk_L	1 When TERM=EOI
207[a]	<CR>	13 (if term =LF/EOI)	0
208[b]	<LF>	10 (if term =CR-LF)	1

[a]All RS-232-C or GPIB with TERM = LF/EOI.

[b]RS-232-C with TERM = CR-LF.

Table 7-21 illustrates an 8-bit ASCII-encoded waveform transfer. Transmission length depends on specific waveform data values, record length, acquisition mode and smoothing, and whether the acquisition is one or two channels.

Table 7-20
Typical 16-Bit Hexadecimal-Encoded Waveform Data

Byte	Contents	Decimal	GPIB EOI (1=Asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	#	35	0
8	H	72	0
9	<Bin Count MS 4 bits>	50	0
10	.	48	0
11	.	48	0
12	<Bin Count LS 4 bits>	49	0
13	1st Pt MS 4 bits	d_{1H}	0
14	.	.	0
15	.	.	0
16	1st Pt LS 4 bits	d_{1L}	0
17	2nd Pt MS 4 bits	d_{2H}	0
18	.	.	0
19	.	.	0
20	2nd Pt LS 4 bits	d_{2L}	0
.	.	.	0
.	.	.	0
.	.	.	0
6393	4096th Pt MS 4 bits	d_{4096H}	0
6394	.	.	0
6395	.	.	0
6396	4096th Pt LS 4 bits	d_{4096L}	0
6397	<Checksum MS 4 bits>	chk_H	0
6398	<Checksum LS 4 bits>	chk_L	1 When TERM=EOI
6399[a]	<CR>	13 (If term =LF/EOI)	0
6400[b]	<LF>	10 (If term =LF/EOI)	1

[a]All RS-232-C or GPIB with TERM = LF/EOI.

[b]RS-232-C with TERM = CR-LF.

Table 7-21
Typical ASCII-Encoded Waveform Data

Byte	Contents	Decimal	GPIB EOI (1=Asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	Pt^{100}_{1}[a]	d^{100}_{1}	0
8	Pt^{10}_{1}[a]	d^{10}_{1}	0
9	Pt^{1}_{1}[a]	d^{1}_{1}	0
10	.	44[b]	0
.	.	.	0
.	.	.	0
.	.	.	0
XXX	Pt^{100}_{4096}[a]	d^{100}_{4096}	0
XXX	Pt^{10}_{4096}	d^{10}_{4096}	0
XXX	Pt^{1}_{4096}[a]	d^{1}_{4096}	0
XXX[c]	<CR>	13	0
XXX[d]	<LF>	10	1

[a]Each value sent may consist of from 1 to 3 characters. The notation Pt^{100} means "the hundreds digit", and Pt^{10} means "the tens digit", which may or may not be sent, depending on the magnitude of the value.

[b]The decimal value 44 equates to the comma sent between each successive value.

[c]All RS-232-C or GPIB with TERM = LF/EOI.

[d]RS-232-C with TERM = CR-LF.

COMMUNICATION COMMANDS

Tables 7-22 through 7-33 describe all commands available for the 2200 Family Digital Storage Oscilloscopes equipped with either Communications option. The Commands column lists the complete command with header and argument(s). Multiple link arguments are enclosed in angle brackets (<link1, link2, or link3>). Numeric value arguments are also enclosed in angle brackets (<NR1>). Default arguments are enclosed in square brackets ([default]). Default arguments may be omitted from the command if that is the mode you want. The 2200 Family DSO for which the command is valid is identified immediately above the command. ALL indicates that the command is valid for all 2200 Family DSO intruments. Commands that are valid only for specific 2200 Family instruments are so indicated.

The capital letters shown are the fewest number of characters that identify the command as unique. They are also the letters returned by the oscilloscope with LONG OFF. Those letters shown in lower case are optional in the command. With LONG ON, all the letters of query return will be returned. All responses to queries are returned in upper case. The second column of the command tables gives a complete description of the command operation.

With GPIB, one or more arguments, separated by commas, may be given in a query to request only the information wanted rather than sending separate commands for each query. An example of this type of command is as shown:

CH1? VOLts,COUpling;

With RS-232-C, program your controller routines to send only one command at a time with single arguments of the form:

header argument:link argument;

This allows the controller to handle any asynchronous service request that may be generated by a command before attempting a second command.

Command Tables

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

Table	Command Group
7-22	Vertical Commands
7-23	Horizontal Commands
7-24	Trigger Commands
7-25	Cursors Commands
7-26	Display Commands
7-27	Acquisition Commands
7-28	Save and Recall References Commands
7-29	Waveforms Commands
7-30	Waveform Preamble Fields
7-31	Miscellaneous Commands
7-32	Service Request Group Commands
7-33	RS-232-C Specific Commands

Table 7-22
Vertical Commands

Commands	Description
2221 and 2230 CH1?	Query only. Returns the present CH1 settings: CH1 VOL:<NR3>, COU:<AC, DC, or GND>. <NR3> is the VOLTS/DIV setting.
2221 and 2230 CH1? VOLts	Query only. Returns the CH1 VOLTS/DIV setting (including the probe attenuation factor). The value returned is a <NR3> number. For example, if the VOLTS/DIV setting is 50 mV, the value returned is CH1 VOL:5.0E−2. An execution warning is generated if the VOLTS/DIV CAL knob is not in the detent (calibrated) position.
2221 and 2230 CH1? COUpling	Query only. Returns the present CH1 input coupling: COU:<AC, GND, or DC>.
2221 and 2230 CH2? CH2? VOLts CH2? COUpling	Queries for CH2 the same as for CH1.
2221 and 2230 CH2? INVert	Query only. Returns CH2 INV:<ON or OFF>.
ALL VMOde?	Query only. Returns the vertical mode setting: VMO:<CH1, CH2, ADD, CHOp, ALT, or XY>.
2221 and 2230 PROBe? CH1 or CH2>	Query only. Returns the probe attenuation coding of the queried channel: CH<1 or 2> PROB:<NR1>. <NR1> may be 1000, 100, 10, 1, −1, or −2. The −1 value is for identify, and the −2 value is for unknown probe coding.

Table 7-23
Horizontal Commands

Commands	Description
2230 DELAy?	Returns the present horizontal delay settings as: DELA VAL:<NR3>,UNI:<S or DIV>.
2230 DELAy? VALue	Returns an <NR3> value that represents the present delay value in the units returned by the UNIts query as: DELA VAL:<NR3>.
2230 DELAy? UNIts	Returns a string of either S or DIV that corresponds to the DELAy? VALue units as: DELA UNI:<S or DIV>. The units are DIV when the SEC/DIV knob is set to EXT CLK.
ALL HORizontal?	Returns all present horizontal settings as appropriate for the type of instrument.
ALL HORizontal? ASEdiv	Returns an <NR3> value that represents the present A SEC/DIV setting in the form: HOR ASE:<NR3>. The value returned is zero when the SEC/DIV knob is set to EXT CLK.
2230 HORizontal? BSEdiv	Returns an <NR3> value that represents the present B SEC/DIV setting in the form: HOR BSE:<NR3>.
ALL HORizontal? EXTclk	Returns the state of the external clock as: HOR EXT:<ON or OFF>.
ALL HORizontal? HMAg	Returns the state of the X10 magnifier as: HOR HMA:<ON or OFF>.
2230 HORizontal? MODe	Returns the present horizontal mode setting as: HOR MOD:<ASW, AIN, or BSW>.

Table 7-24
Trigger Commands

Commands	Description
ALL ATRigger? [MODe]	Returns the present A trigger mode in the form: ATR MOD:<NOR, PPA, or SGL>;. PPA is returned for both Peak-to-Peak Auto and TV Field trigger modes. The reply is the same with or without the optional [MODe] argument.
ALL SGLswp ARM	Rearms a completed single sweep. An execution error is generated if the instrument is not in SGL SWP mode, and an execution warning is generated if the single sweep is already armed. With OPC ON, a service request status byte for operation complete is generated when the single sweep occurs.
ALL SGLswp?	Returns the state of the SGL SWP trigger mode as: SGL <ARM or DON>; when SGL SWP trigger mode is on. If SGL SWP trigger mode is not on, a reply of "SGL ;" is made, and an execution warning is generated.
ALL TRIggerd?	Returns the present state of the TRIG'D indicator as: TRI <ON or OFF>;.

Table 7-25
Cursor Commands

Commands	Description
2221 and 2230 CURSor CHAnnel:<CH1-CH2>	Selects the named channel as the channel from which the cursor voltage difference is returned by the DELTAV? query. No warning is generated if the cursors are directed to an undisplayed channel.
2221 and 2230 CURSor POSition:<NR1>	Selects the horizontal data point position of the active cursor. If the acquisition is a 1-Kbyte record and the position requested is past 1023 data points, the value is limited to position 1023, and no warning is sent. If the acquisition is a 4-Kbyte record and the position requested is past 4095 data points, a command error service request is generated, and the command is ignored.
2221 and 2230 CURSor SELect:<CURS1-CURS2>	Selects the named cursor to be positioned by the CURS POS command.
2221 and 2230 CURSor TARget:ACQuisition	Attaches the displayed cursors to acquisition waveform.
2230 CURSor TARget:<REF1-REF3>	Attaches the displayed cursors to the named reference waveform. If the named reference is not displayed, the command is ignored. No warning is issued for directing the cursors to an undisplayed reference.
2221 and 2230 CURSor TARget:REF4	Attaches the displayed cursors to REF4. No warning is issued for directing the cursors to REF4 if it is not displayed, but an execution error service request is generated if REF4 is empty.
2221 and 2230 CURSor?	Returns all the present cursor argument states in the form: CURS SEL:CH1, TAR:ACQ,CHA:CH1,POS:1047;. Each of the CURSor arguments may be separately queried as in: CURSOR? TAR to obtain the present status of that argument only.
2221 and 2230 DELTAV?	Returns an <NR3> value that represents the present voltage difference between the selected TARget and CHAnnel cursors and the measurement units as either V or PERcent. The form of the return is: DELTAV VAL:0.500E0,UNI:VOL;. PERcent is returned for the units when the VOLT/DIV variable knob is out of the CAL detent position.
2221 and 2230 DELTAV? VALue	Returns the cursor voltage difference only in the form: DELTAV VAL:<NR3>;. The return defaults to a displayed CHAnnel even if directed elsewhere to an undisplayed CHAnnel.
2221 and 2230 DELTAV? UNIts	Returns the voltage measurement units only in the form: DELTAV UNI:<V or PER>;. See the preceding DELTAV? query description.

Table 7-25 (cont)

Commands	Description
2221 and 2230 DELTAT?	Returns an <NR3> value that represents the present time difference between the two cursors with the measurement units in the form: DELTAT VAL:1.180E−3, UNI:SEC;. The measurement units are returned in DIVisions if the SEC/DIV setting is EXT CLK.
2221 and 2230 DELTAT? VALue	Returns the cursor time difference only in the form: DELTAT VAL:<NR3>;.Time difference is returned even when the readout is in frequency units for 1/Δt measurements.
2221 and 2230 DELTAT? UNIts	Returns the time measurement units only in the form: DELTAT UNI:<S or DIV>;. See the preceding DELTAT? query description.

Table 7-26
Display Commands

Commands	Description
2221 and 2230 MESsage <NR1>:"message"	Writes the "message" text on the named row. Values of <NR1> row numbers are from 16 (the top row) to 1 (the bottom row). The normal readout displays are turned off by the MESsage <16-1> command. Changing a front-panel control that requires a readout overrides the "message" and returns the normal readout display. The MES [0] command turns off the message display and also turns the normal readout displays back on (the zero may be omitted from the command). The message must be enclosed in quote marks. The displayed message lines start at the left edge of the graticule area. If longer than about 40 characters, the message runs off the right edge of the CRT. If the message is too long, it is truncated, and a service request is issued (if RQS is ON). Displaying many message lines can cause display flicker and may exceed the display memory area.
ALL PLOt ABOrt	Stops a plot in progress and returns to the previous mode. PLOt ABOrt is the only command or query that the oscilloscope responds to during a plot. PLOt ABOrt turns off the AUTo argument.
2221 and 2230 PLOt AUTo:<ON or OFF>	Turns the AUTo plot mode ON or OFF. If AUTo is ON, each waveform is plotted after it is acquired. The graticule will be plotted once in AUTo, if GRAt is ON.
ALL PLOt FORmat:<[XY], HPG1, EPS7, EPS8, or TJEt>	Sets the output data format for the named plotter. If one of the named plotters is not selected, the data is plotted in the default XY format. HPGl formats for HP-GP compatible plotters. EPS7 and EPS8 format for 7-bit (low-speed, double-density) and 8-bit (high-speed, double-density) EPSON® format printers respectively. TJEt formats for the Hewlett-Packard ThinkJet® printer. With Option 10, a GPIB controller may direct the plotting operation by addressing the plotter to listen and then addressing the oscilloscope to talk and giving the PLOt STArt command.
ALL PLOt GRAt:<ON or OFF>	Turns the plotted graticule either ON or OFF.
ALL PLOt SPEed:<NR1>	The <NR1> number must be an integer from 1 to 10 and changes the analog plotter pen speed. The units are roughly in divisions per second.
ALL PLOt STArt	Starts a plot using the parameters selected by PLOt FORmat, PLOt GRAt, and PLOt SPEed. While a plot is in progress, all commands and queries (except PLOt ABOrt) are ignored.

Table 7-27
Acquisition Commands

Commands	Description
ALL ACQuisition CURRent:<AVErage, [DEFault], PEAkdet, or SAMple>	Selects the named mode for the CURRent acquisition type and SEC/DIV setting. If a mode argument is not specified, the command selects the default mode for the present acquisition type and SEC/DIV setting. A service request is generated if the mode asked for is not valid with the present acquisition type or SEC/DIV setting.
2221 and 2230 ACQuisition CURRent:ACCpeak	Selects the ACCpeak mode for the current acquisition type and SEC/DIV setting.
2221 and 2230 ACQuisition HSRec:<ACCpeak or AVErage>	Selects the named mode for the SEC/DIV settings for 5 μs/div and 10 μs/div.
ALL ACQuisition HSRec:[SAMple]	Selects the SAMple mode for the acquisitions made at 5 μs/div and 10 μs/div. This is the default mode and will be selected if the mode argument is omitted.
2221 and 2230 ACQuisition LSRec:<ACCpeak or AVErage>	Selects the ACCpeak or AVErage mode for acquisitions made at 0.02 ms/div to 50 ms/div.
ALL ACQuisition LSRec:<[PEAkdet] or SAMple>	Selects the PEAkdet or SAMple mode for acquisitions made at 0.02 ms/div to 50 ms/div. PEAkdet will be selected if the argument to LSRec is omitted.
2221 and 2230 ACQuisition NUMsweeps:<NR3>	Sets the number of sweeps done before halting; 0 implies continuous mode (don't halt).
2221 and 2230 ACQuisition REPetitive:<ACCpeak or SAMple>	Selects the named mode for repetitive acquisitions at SEC/DIV settings from 0.05 μs/div to 2 μs/div.
ALL ACQuisition REPetitive:[AVErage]	Selects the AVErage mode for repetitive acquisitions for SEC/DIV settings from 0.05 μs/div to 2 μs/div. This is the default argument and will be selected if the mode argument is omitted.
ALL ACQuisition RESet	Command only. Sets sampling at all SEC/DIV settings to its default mode. Default modes are enclosed in brackets ([]) in the commands.
ALL ACQuisition ROLl:<[PEAkdet] or SAMple>	Selects the PEAKdet or SAMple mode for ROLl acquisitions from 0.1 sec/div to 5 sec/div. ROLl mode acquisitions are untriggered.
ALL ACQuisition SCAn:<[PEAkdet] or SAMple>	Selects the PEAkdet or SAMple mode for SCAn acquisitions.

Table 7-27 (cont)

Commands	Description
2221 and 2230 ACQuisition SCAn:<ACCpeak or AVErage>	Selects the ACCpeak or AVErage mode for SCAn acquisitions at 0.1 sec/div to 5 sec/div. The oscilloscope must in NORM or SGL SWP trigger mode to observe a change in the READOUT.
ALL ACQuisition SMOoth:<ON or OFF>	Applies smoothing to the acquired waveform data when ON.
2220 ACQuisition TRIGCount: <NR1>	Sets the number of data points acquired before the trigger point in the waveform record. The range of the <NR1>number is 16 to 2048 in post-trigger and 2048 to 4080 in pre- or mid-trigger. The resolution of the <NR1> value is 4.
2221 ACQuisition TRIGCount: <NR1>	Sets the number of data points acquired before the trigger point in the waveform record. The range of the <NR1> number is from 16 to 4080. The setting of the front-panel TRIG POS switch does not limit the range of the trigger point position within the waveform record. The resolution of the <NR1> value is 4.
2230 ACQuisition TRIGCount:<NR1>	Sets the number of data points acquired before the trigger point in the waveform record. The range of the <NR1> number depends on the record length and the selection of pre- or post-trigger. In pretrigger, the <NR1> range is 4 to 512 for 1 K records and 16 to 2048 for 4 K records. In post-trigger, the range is from 512 to 1020 for 1 K records and 2048 to 4080 for 4 K records. The resolution of <NR1> is ±4 counts.
ALL ACQuisition VECtors:<ON or OFF>	Turns point-to-point display vectors ON or OFF.
ALL ACQuisition WEIght:<NR1>	Sets the number of acquisitions weighted into an AVEraged waveform record. The valid values for <NR1> are: 1, 2, 4, 8, 16, 32, 64, 128, and 256. A service request is generated and the command is ignored if the argument is not one of these numbers. If the argument for WEIght is omitted, <NR1> reverts to 4.
ALL ACQuisition?	Returns the settings of the acquisition modes in the following short form with LONG set to OFF. ACQ REP:AVE,HSR:SAM,LSR:PEA,SCA:PEA,ROL:PEA, SMO:ON,WEI:4,SWP:1037,NUM:0,POI:4096, TRIGM:POST,TRIGC:2000,SAV:OFF,DIS:SCA,VEC:ON; Each of the acquisition command arguments (except RESet) may be queried separately to find out that argument's status.
ALL ACQuisition? DISplay	Returns a string of either ROLl or SCAn for the present state of the ROLL/SCAN button. The form of the return is: ACQ DIS:<ROL or SCA>;

Table 7-27 (cont)

Commands	Description
ALL ACQuisition? POInts	Returns an <NR1> value that is the number of data points in the waveform record. The form of the return is: ACQ POI:<NR1>;
ALL ACQuisition? SAVE	Returns a string of either ON or OFF for the present state of the acquisition system (ON for SAVE and OFF for CONTINUE).
ALL ACQuisition? SWPcount	Returns an <NR1> value for the number of sweeps completed in an acquisition. The form of the return is: ACQ SWP:<NR1>;
ALL ACQuisition? TRIGMode	Returns a string of either PRE or POST for the present ACQuisition Trigger setting in the following form: ACQ TRIGM:<PRE or POST>;
ALL STORe?	Returns the present state of the STORE/NON-STORE button in the form: STOR <ON or OFF>;

Table 7-28
Save and Recall Reference Commands

Commands	Description
ALL REFFrom [ACQ]	Selects the acquisition as the source for the waveform data to be saved into one of the numbered reference memories by the SAVeref command. ACQ is the default argument (indicated by the square brackets, []) and need not be present in the command to select it as the data source. For the 2220 and 2221, ACQ is the only valid source.
2230 REFFrom REF<1-4>	Selects the named reference memory as the data source for the next SAVeref command. Acquisition (ACQ) waveforms must first be stored into one of the numbered references (REF1-REF4) before they may be saved into one of the lettered references (REFA-REFZ).

Table 7-28 (cont)

Commands	Description
2230 REFFrom REF<A-Z>	Selects the named extended memory location (REFA-REFZ) as the source of waveform data for the next SAVeref command. The total extra memory is 26 Kbytes, and stored waveform records of 1 K to 8 K (averaged 4 K acquisitions) may be stored. The nonvolatile references of the 2230 may not be displayed, plotted, or transmitted directly; they must first be moved to one of the numbered references (REF1-REF4) using the REFFrom and SAVeref commands.
2230 REFDisp REF<1-3>:ON, OFF or EMPTY>	Turns the named 2230 reference display ON or OFF. EMPTY erases the named 2230 reference display and turns it off. Reference memory locations 1, 2 and 3 are 1024-point memories.
ALL REFDisp REF4: <ON, OFF or EMPTY>	REF4 is the only available reference memory for the 2220 and 2221 instruments. Reference memory 4 stores a 4 K (4096-point) reference waveform and occupies the REF1-REF3 memory locations in the 2230.
2230 REFDisp REF<A-Z>:EMPTY	The EMPTY command erases the named reference if it is not protected (see REFProt command). The lettered references may not be displayed directly; they must be moved to a numbered save reference memory (REF1-REF4).
2230 REFProt REF<A-Z>:<LOCked, PERM, or UNLocked>	These commands control the write protection of the 2230 nonvolatile reference memories (REFA-REFZ). LOCked and PERM disable further storage into the named reference or erasure of the waveform data. PERM protected waveform data cannot be overwritten using the front-panel controls. See REFStat queries to obtain write protection and bytes free status.
2230 REFOrmat CHAnnel:<[CH1] or CH2>	Selects which channel of the saved reference to REFOrmat. If there is no SAVE REF waveform for the named channel, a service request status byte is generated. If an XY waveform is selected for reformatting, either channel may be selected. CH1 is selected without the CH1 argument.
2230 REFOrmat HMAg:ON	Increases the horizontal gain of the REFORMAT TARget reference waveform set (affects vertical channels) by a factor of ten times.
2230 REFOrmat HMAg:OFF	Turns off the horizontal magnification of the REFORMAT TARget reference waveform set.

Table 7-28 (cont)

Commands	Description
2230 REFOrmat VGAin:<NR3>	Changes the vertical gain of the reference target and channel designated by REFOrmat TARget and REFOrmat CHAnnel. This command is not valid for XY waveforms. The maximum <NR3> value permitted is the equivalent of ±3 detent positions of the VOLT/DIV switch (in a 1-2-5 sequence). An execution error status byte is generated either if the asked-for setting is out of the maximum change range or if it is not a 1-2-5 sequence setting.
2230 REFOrmat VPOsition:<NR2>	Adjusts the vertical position of the reformatting target waveform. The valid range of <NR2> is ±10 divisions from the original display position (before any reformatting) with a resolution of one displayed bit.
ALL REFDisp?	Returns the status of the REF1 reference memory location as ON, OFF, or EMPTY for the 2230; returns the status of REF4 for the 2220 and 2221.
2230 REFDisp? REF<1-3>	Returns the status of the named 2230 reference memory location as ON, OFF, or EMPTY.
ALL REFDisp? REF4	Returns the status of REF4 as ON, OFF, or EMPTY. For the 2210 and 2221 instruments, the default argument of REF4 is not needed.
ALL REFFrom?	Query returns the selected source of waveform data for the SAVeref command. The reply will be ACQ for the 2220 and 2221; for the 2230 it may be from ACQ or any REFerence from (REF1-REF4) and (REFA-REFZ).
2230 REFOrmat?	Returns the status of the REFOrmat command and query arguments. A sample return is: REFO TAR:REF4, CHA:CH2,VGA:0.5E+0, VPO:+3.96, HMA:OFF, BAS:0.2E+0,MOD:CH1; Each of the command arguments may be individually queried for their status with respect to the REFOrmat TARget and CHAnnel reference waveform.
2230 REFOrmat? BASegain	Returns the vertical gain setting at which the REFOrmat TARget waveform was acquired as an <NR3> number.
2230 REFOrmat? MODe	Returns the vertical mode in which the REFOrmat TARget waveform was acquired (CH1, CH2, ADD, CHOP, ALT, or XY).
2230 REFStat? FILl	Returns a thirty-number string that indicates the fill status of each of the reference memories from REF1 to REFZ. The numbers are 0 (empty), 1, 2, 4, or 8 and indicate the stored waveform record in Kbytes.

Table 7-28 (cont)

Commands	Description
2230 REFStat? FREe	Returns the number of free Kbytes in the nonvolatile reference memory as a <NR1> number from 0 to 26.
2230 REFStat? PROTect	Returns a thirty-character string that indicates the protected status of each of the reference memories from REF1 to REFZ. The characters returned are U, L, or P and correspond to unlocked, locked, or permanent protection status.
2230 SAVeref REF<1-3>	Command only. Saves the waveform selected by the REFFrom command into the named reference. REF1, REF2, and REF3 are 1 K (1024-point) memory locations. Any 1 K portion of 4 K waveform acquisition (from ACQ or REF4) may be saved as a 1 K reference in REF1-REF3; the 1 K portion stored into REF1-REF3 is determined by the position of the active cursor. The saved reference display is also turned on.
ALL SAVeref REF4	Command only. REF4 is a 4 K (4096-point) memory location. It is the only reference memory for the 2220 and 2221 instruments, and as such the REF4 argument may be omitted from the SAV command for those instruments.
2230 SAVeref REF<A-Z>	Command only. Saves the waveform selected by the REFFrom command into the named reference (REFA-REFZ). Reference waveforms stored as 4 K records cannot be moved as 1 K records into REF1-REF3; to be either displayed or tranmitted 4 K records must be moved into REF4.
2230 SAVeref REF<1-3>	Command only. Saves the waveform selected by the REFFrom command into the named reference. REF1, REF2, and REF3 are 1 K (1024-point) memory locations. Any 1 K portion of 4 K waveform acquisition (from ACQ or REF4) may be saved as a 1 K reference in REF1-REF3; the 1 K portion stored into REF1-REF3 is determined by the position of the active cursor. The saved reference display is also turnd on.
ALL SAVeref REF4	Command only. REF4 is a 4 K (4096-point) memory location. It is the only reference memory for the 2220 and 2221 instruments, and as such the REF4 argument may be omitted from the SAV command for those instruments.
2230 SAVeref REF<A-Z>	Command only. Saves the waveform selected by the REFFrom command into the named reference (REFA-REFZ). Reference waveforms stored as 4 K records cannot be moved as 1 K records into REF1-REF3; to be either displayed or tranmitted 4 K records must be moved into REF4.

Table 7-29
Waveform Commands

Commands	Description
ALL CURVe	Use as a command to send waveform data to the oscilloscope. The DATa TARget command points to the reference memory where the data is sent. The DATa CHAnnel command points to the channel where the data is sent. (Only REF4 is available for the 2220 and 2221.) The DATa ENCdg command tells the oscilloscope the format of the data (HEX, BINary, or ASCii). Use as a query to get waveform data from the oscilloscope. The DATa SOUrce and DATa CHAnnel commands select the source of the waveform data. The data sent or received is in the form: CURVE <data>; where the <data> is encoded for HEX, BINary, or ASCii in the following form: %<byte count><binary data><checksum> for BIN, #H<byte count><hex data><checksum> for HEX, or <ascii data> for ASCii encoding. With ASCii format, each data value is separated by a comma.
ALL DATa CHAnnel:<[CH1] or CH2>	Selects the channel of a waveform set from which CURve?, WAVfrm?, or WFMpre? query will return data and the target channel for waveform data going into oscilloscope. If there is no waveform in the named channel, a service request is sent when the data is requested. At power-up, the selected channel is CH1. CH1 must be selected for an XY acquisition.
ALL DATa ENCdg:<ASCii, [BINary], or HEX>	Sets the curve data encoding and decoding format. The power-on default is BINary. Data points are represented as unsigned integers in all formats.

Table 7-29 (cont)

Commands	Description
2230 DATa SOUrce:<REF1, REF2, or REF3>	Selects the named reference memory to provide the waveform data for a WAV?, WFM?, or CURV? query.
ALL DATa SOUrce:<[ACQ] or REF4>	Selects either the present acquisition or the REF4 reference memory to provide the waveform data for a WAV?, WFM?, or CURV? query. The power-on default is ACQ, and it will be selected if the argument is omitted. A saved 4 K record is moved from the instrument by specifying REF4 as the data source.
2230 DATa TARget:<REF1, REF2, or REF3>	Selects the named reference memory to receive data sent with a CURve or WFMpre command. At power-on, REF1 is selected. There is no default selection.
ALL DATa TARget:REF4	Selects REF4 as the reference memory to receive data sent with a CURve or WFMpre command. This is the only selection for the 2220 and 2221. For the 2230, REF4 must be selected as the data target to transfer in a 4 K waveform.
ALL DATa?	Returns the selection of data source, target, channel and encoding. The short form of the return is: DAT SOU:ACQ,TAR:REF1,CHA:CH1,ENC:BIN; Each DATa argument may be individually queried to obtain that selection only.
ALL WAVfrm?	Returns the waveform data from the oscilloscope. The return is the combined waveform preamble and waveform data. The waveform assigned by the DATa SOUrce and DATa CHAnnel commands is sent in the encoding assigned by the DATa ENCdg command. The form of the return is: WFM <ascii preamble>;CURV <waveform data>;

NOTE

The information given in the Waveform Preamble Fields table is primarily to help identify the result of a WFMpre? query. As such, the arguments are not usually sent as individual commands, but are grouped together as a complete waveform preamble. If sent as a single command, an argument value is not accepted (except as noted for ENCdg) until the curve it is supposed to go with is transferred to the selected DATa TARget reference memory. If any size error in any of the waveform preamble numeric arguments is sent to the oscilloscope, it will be accepted. Then, when the curve data is sent the error will be rejected, and a waveform preamble error service request will be sent.

Table 7-30
Waveform Preamble Fields

Commands	Description
ALL WFMpre ENCdg: <ASCii, [BINary], or HEX>	Selects the waveform curve data encoding format for transferring data. WFEpre ENCdg and DATa ENCdg operate identically. Data points are represented as unsigned integers in any of the encoding formats.
ALL WFMpre?	Returns the waveform identification string as with the WFMpre? WFId query plus the value for all the waveform preamble arguments. The short form of the return is: WFM WFI:" <identification string>", NR.P:2048, PT.O:256, PT.F:ENV, XMU:1.0E+3, XOF:0, XUN:S, XIN:10.0E-6, YMU:8.0E-3, YOF:0, YUN:V, ENC:ASC, BN.F:RP, BYT:1,BIT:8, CRV:CHK; Each of the arguments may be queried separately to find out its value.
ALL WFMpre? WFId	Returns an ASCII waveform identification string giving the key features of the waveform. The information returned is: acquisition source, channel, Volts/Div, input coupling, Sec/Div, acquisition mode, and the number of the curve being sent. In XY mode, the CH2 Volts/Div and input coupling are added. The waveform ID is ignored if received as a command. The form of the return is: WFM WFI:" ACQ, CH1, 0.2mV, DC, 0.5mS, AVERAGE, CRV# 3"; or for XY: WFM WFI:" REF4, XY, 20mV, DC, 50mV, DC, 0.5mS, SAMPLE, CRV# 1"; **NOTE** *The DATa CHAnnel must be CH1 to get the XY information. All vertical information is omitted for a 2220.*

Table 7-30 (cont)

Commands	Description
ALL WFMpre NR.Pts:<NR1>	<NR1> is the number of points in the waveform. Each point can be a single Y value (with time implied), an X-Y pair, or a Max-Min pair. Although the record length is either 1024 data point or 4096 data points, the NR.Pts <NR1> value may be 256, 512, 1024, 2048, or 4096 points. The value depends on the number of channels, the acquisition mode, and whether smoothing is on or off. A table expressing the conditions and the record length to NR.Pts ratio value follows:

NR.Pts to Record Length Ratio	Number of Channels	Acquire Mode	SMOOTH
Rec/1	1	SAMple	NA
Rec/1	1	AVErage	NA
Rec/1	1	PEAkdet	ON
Rec/1	1	ACCpeak	ON
Rec/2	2	SAMple	NA
Rec/2	2	AVErage	NA
Rec/2	2	PEAkdet	ON
Rec/2	2	ACCpeak	ON
Rec/2	1	PEAkdet	OFF
Rec/2	1	ACCpeak	OFF
Rec/4	2	PEAkdet	OFF
Rec/4	2	ACCpeak	OFF

For example, if the number of channels is two and the acquisition is peak detect with smoothing off, the number of points for a waveform in a 4 Kbyte record is 4096 divided by 4 (1024 points).

Commands	Description
ALL WFMpre PT.Off:<NR1>	<NR1> is the trigger position relative to the first data point in the record. For a 1024 point record, <NR1> for PT.Off ranges from 4 to 1024 in increments of 4. The normal values for a 4096 point record range from 4 to4096. **NOTE** *<NR1> will be a negative value if the trigger occurred before the first data point in the record window. Since any 1024 point window of a 4096 point record may be transferred, the legal values of <NR1> for PT.Off are −3096 to +4096. If the PT.Off value is unknown, −10000 is the <NR1> value returned.*

Table 7-30 (cont)

Commands	Description
ALL WFMpre PT.Fmt:<Y, XY, or ENV>	Point format defines how to interpret the curve data points. Y format means that X-axis information is derived from the waveform preamble and not sent explicitly. The data values represent the vertical amplitude of the waveform at that data point position. XY format means that the data points are in X-Y pairs, with X first. ENV format means that the vertical data is sent in max-min pairs. The data is sent in the form: ....,y1max,y1min,y2max,y2min,.. However, the max-min data is displayed in the reverse order, with min data first then max data (...,y1min,y1max,y2min,y2max,...). ENV is valid for PEAkdet and ACCpeak acquisition modes with SMOoth OFF.
ALL WFMpre XUNits:<S or CLKs>	Gives the units value for the XINcr. If XUN is S the X-increment is in seconds; if in CLK, the X-increment is unknown. (CLK is returned when the SEC/DIV setting is EXT CLK.)
ALL WFMpre XINcr:<NR3>	The XINcr <NR3> value is the time between data points. If XINcr for a waveform being sent to the oscilloscope does not correspond to a legitimate SEC/DIV setting, the new curve data is not accepted, and a command argument error service request is sent (if RQS is ON). The queried XINcr value of <NR3> is set equal to 1 (0.1E+0) if it is unknown, as is the case for EXT CLK.
ALL WFMpre YUNits:<V or DIVs>	Indicates the units of YMUlt. When the CAL knob of the DATa CHAnnel is not in the detent position, the DIVs argument is returned. DIVs is always returned for the 2220 since the vertical scaling is unknown.
ALL WFMpre YMUlt:<NR3>	The YMUlt <NR3> value is the step size of the digitizer (volts between digitizer levels). I the YMUlt for a waveform being sent to the oscilloscope does not correspond to a legitimate VOLTS/DIV setting, the new curve data is not accepted, and waveform preamble error service request is sent (if RQS is ON). The queried YMUlt value of <NR3> is 40.0E-3 when the VOLTS/DIV CAL knob for the DATa SOUrce is not in the detent position.
ALL WFMpre YOFf:<NR1>	The YOFf <NR1> value is the Y coordinate of ground. If ground level is not known, the value of −10000 is returned.
ALL WFMpre XMUlt	XMUlt and XOFf are similar to YMUlt and WFMpre XOFf YOFf. They are added to the waveform preamble for XY waveforms. For all XY waveforms, the YUNits value is valid for both the X and the Y data points. The value of XUNits is referenced to the sampling rate.

Table 7-30 (cont)

Commands	Description
ALL WFMpre BN.Fmt:RP	RP is the only argument valid argument. It means that the binary format is always right-justified and consists of positive binary integers (also known as unsigned binary integers).
ALL WFMpre BYT/nr:<NR1>	The valid numbers for <NR1> are 1 and 2. Each data point value is represented by two bytes for AVErage mode, only one byte in other modes. If two bytes are sent, the most significant byte is sent first. In HEX format, each data point is represented by two ASCII encoded hex characters.
ALL WFMpre BIT/nr:<NR1>	The data points consist of either 8 or 16 bits. **NOTE** *The least significant bits of a 16-bit waveform may or may not be valid, depending on the number of acquisitions averaged.*
ALL WFMpre CRVchk:CHKsm0	The CHKsm0 argument indicates that the last byte of a binary curve is a checksum. The checksum byte is the two's complement of the modulo 265 sum of the binary count and curve data bytes. It does not include the word and symbol CURVE % that comes before the binary count.

Table 7-31
Miscellaneous Commands

Commands	Description
ALL INIt	Command only. The INIt command causes the oscilloscope revert to the power-on default states for the acquisition modes. The 2230 menu system is also initialized.
ALL LONg <[ON] or OFF>	With LONg ON, replies to queries are reported with the full command words. With LONg OFF, replies use the short form of the command words. The short form characters are those that appear in capitol letters in these command tables and are the minimum characters accepted as valid for commands. The power-on and default states of LONg are ON. The LONg? query returns its state, ON or OFF.
ALL ID?	Returns the oscilloscope identification string in the form: ID TEK/2230,V81.1,VERS:09; The instrument type and version numbers will be reported as appropriate for the instrument queried.
ALL HELp?	Returns a list of all the valid command headers available in the instrument queried. All the valid characters of the commands are returned; the short form of the commands (LONG OFF) are in capital letters.
ALL SET?	Returns an ASCII string of headers and arguments reflecting the present states of the controls and modes that may be set via the communications interface. The query-only settings are not returned. The string returned by the SET? query may be sent as a command message to the oscilloscope to recreate those settings. The state of the LONg command affects the length of the reply. **NOTE** *To comply to Codes and Formats, a header is not sent back with the settings string.*

Table 7-32
Service Request Group Commands

Commands	Description
ALL OPC <[ON] or OFF>	When ON, the oscilloscope sends a service request upon completion of certain system events (if RQS is also ON). Events that request service when completed with OPC ON include: Acquisition completed, and plot completed. When off, OPC (operation completed) events do not generate a service request. The power-on state of OPC is OFF.
ALL RQS <[ON] or OFF>	When ON, the oscilloscope sends a service request (SRQ) when it has an event to report. When OFF, event codes of different priority still accumulate and may be retrieved with an EVEnt? query, but the reply to STAtus? will be a 0. The power-on and default states of RQS are ON.
ALL EVEnt?	Returns an <NR1> value that is the code number for oldest service-request event (if multiple events are pending). If no events are pending, <NR1> is 0. Multiple events of different priority are retrieved by sending EVEnt? until 0 is returned. Querying the event clears the service request.

Table 7-33
RS-232-C Specific Commands

Commands	Description
ALL FLOw <[ON] or OFF>	Enables (ON) or disables (OFF) DC1/DC3 flow control. FLOW ON is the default and power-on state. Binary data transfers cannot be made with FLOW ON. A FLOw? query returns the present state, ON or OFF. With FLOW ON, the <control-S>, <control-Q>, and <control-D> are recognized during data transfers. Their functions are as follows: <control-S> Temporarily suspend output of characters. <control-Q> Resume character output that has been temporarily suspended. <control-D> Abort the command or query execution; erase both input and output buffers; reset the message processor.
ALL REMote <[ON] or OFF>	Enables (ON) or disables (OFF) setting of remote-controllable oscilloscope states. An execution error service request is sent if a control command is sent with REM OFF. REM? returns the present state, ON or OFF.
ALL STOP <1 or 2>	Sets the number of stop bits used in transferring character codes. The usual selection is 1 though some printers require two stop bits at certain baud rate settings. STOP is set to 1 at power on. When connecting to a printer or plotter, select a baud rate that uses only one stop bit. STOP? returns the present setting, 1 or 2.
ALL STAtus?	Returns the current status of the instrument. If no service requests are pending, the status byte returned indicates No Status to Report. If RQS is off, an EVEnt? query must be used to find out if an event occurred and, if so, which one. The EVEnt? query produces more useful information about an event than the service request status byte.

STATUS BYTES AND EVENT CODES

The various status events and errors that can occur are divided into several categories as defined in Table 7-34. Table 7-35 lists the event codes that are returned as the result of an EVEnt? query.

Option 10

If there is more than one event of different priority levels to be reported, the oscilloscope reasserts SRQ until it reports all events of different priority. It does not issue an SRQ for duplicate events pending or for more than one event of the same priority level. Each event is automati-

Table 7-34
Status Event and Error Categories

Category	Status Byte					Description
	Binary[a]	Decimal				
		RQS Off		RQS On		
		Not Busy	Busy	Not Busy	Busy	
Command Error	0R1X 0001	33	49	97	113	The instrument received a command that it cannot understand.
Execution Error	0R1X 0010	34	50	98	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	0R1X 0011	35	51	99	115	The instrument detected a hardware condition or a firmware problem that prevents operation.
Power.On	010X 0001	1	17	65	81	Instrument power was turned on.
Operation Complete	0R0X 0010	2	18	66	82	Operation complete.
Execution Warning	0R1X 0101	37	53	101	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 sending a reading anyway.
No Status	000X 0000	0	16	0	16	There is no status to report.

[a]R is set to 1 if RQS is ON; otherwise it is 0. X is the busy bit and is set if the oscilloscope is busy at the time the status byte is read. Anytime the instrument is actively processing a command or query, the bit is a 1, otherwise it is a 0.

cally cleared when its status byte is reported. The controller option can clear all events by repeatedly sending the EVEnt? query until a zero status byte is returned. The Device Clear (DCL) interface message may be used to clear all events, except the power-on event.

With RQS set OFF, all service requests (except the power-on SRQ) are prevented. With the service requests turned off, the EVEnt? query must be sent to the oscilloscope so that the controller can determine the oscilloscope and event status. The controller may address the oscilloscope and send the STAtus? or EVEnt? query at any time. It is not necessary to wait for an SRQ. The instrument will return the status byte code for STA? status bytes pending and an event code for EVE? for events waiting to be reported (or a 0 for no events to report).

Option 12

If there is more than one event of different priority levels to be reported, the oscilloscope has a status byte and event code available for each one. It does not report duplicate events or more than one event of the same priority level. Each event is automatically cleared when its status byte or event code is reported. The Device Clear (DCL) interface message may be used to clear all events, except the power-on event. Querying EVEnt? until the return is EVE 0 clears all pending status bytes and there is no power-on event.

With RQS set OFF, all service requests are prevented. With the service requests turned off, the EVEnt? query must be sent to the oscilloscope so that the controller can determine the oscilloscope and event status. The controller may send the EVEnt? query at any time, and the instrument will return the code for an event waiting to be reported (or a 0 for no events to report). The controller can clear all events by repeatedly sending the EVEnt? query until a zero status byte is returned.

Table 7-35
Event Codes

EVENT? Code	Instrument Status
000	No status to report
	Command Errors
101	Command header error.
102	Header delimiter error.
103	Command argument error.
104	Argument delimiter error.
105	Non-numeric argument, numeric expected.
105	Non-numeric argument, numeric expected.
106	Missing argument.
107	Invalid message-unit delimiter.
108	Checksum error.
109	Byte-count error.

Table 7-35 (cont)

EVENT? Code	Instrument Status
151	The argument is too large.
152	Illegal hex character.
153	Non-binary argument; binary or hex expected.
154	Invalid numeric input.
155	Unrecognized argument type.
	Execution Errors
201	Command cannot be executed when in LOCAL.
203	I/O buffers full, output dumped.
205	Argument out of range, command ignored.
206	Group execute trigger ignored.
251	Illegal command.
252	Integer overflow.
253	Input buffer overflow.
254	Invalid waveform preamble
255	Invalid instrument state.
256	GPIB (Option 10) command not allowed.
257	RS-232-C (Option 12) command not allowed.
258	Command not allowed on 2220 or 2221.
259	Command not allowed on 2230.
260	Cannot execute command with RQS OFF.
261	Reference memory busy with local (front-panel) command.
262	Reference memory non-existent or specified as different size than selected waveform.
263	Plot active; only PLOT ABORT allowed while plotting.
	Internal Errors
351	Firmware failure. Contact your nearest Tektronix Service Center for assistance.

Table 7-35 (cont)

EVENT? Code	Instrument Status
	System Events
401	Power on.
451	Parity error.
452	Framing error.
453	Carrier lost.
454	End of acquisition OPC.
455	End of plot OPC.
456	Diagnostics test complete OPC.
	Execution Warnings
551	Single sweep is already armed.
552	No ground-dot measurement available.
553	Invalid probe code or identify.
554	Query not valid for current instrument state.
555	Requested setting is out of detent (uncalibrated).
556	MESsage display buffer is full.
557	Waveform preamble is incorrect, has been corrected.
558	Waveform transfer ended abnormally.

APPENDIX A

PERFORMANCE CHECK PROCEDURE

INTRODUCTION

PURPOSE

The "Performance Check Procedure" is used to verify the instrument's Performance Requirements statements listed in Table 1-1 and to determine the need for calibration. The performance checks may also be used as an acceptance test or as a preliminary troubleshooting aid.

PERFORMANCE CHECK INTERVAL

To ensure instrument accuracy, check its performance 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.

STRUCTURE

The "Performance Check Procedure" is structured in subsections to permit checking individual sections of the instrument whenever a complete Performance Check is not required. At the beginning of each subsection there is an equipment-required list showing only the test equipment necessary for performing the steps in that subsection. In this list, the Item number that follows each piece of equipment corresponds to the Item number listed in Table A-1.

Also at the beginning of each subsection is a list of all the front-panel control settings required to prepare the instrument for performing Step 1 in that subsection. Each succeeding step within a particular subsection should then be performed, both in the sequence presented and in its entirety, to ensure that control-setting changes will be correct for ensuing steps.

TEST EQUIPMENT REQUIRED

The test equipment listed in Table A-1 is a complete list of the equipment required to accomplish the "Performance Check Procedure". Test equipment specifications described in Table A-1 are the minimum necessary to provide accurate results. Therefore, equipment used must meet or exceed the listed specifications. Detailed operating instructions for test equipment are not given in this procedure. If more operating information is required, refer to the appropriate test equipment instruction manual.

When equipment other than that recommended is used, control settings of the test setup may need to be altered. If the exact item of equipment given as an example in Table A-1 is not available, check the "Minimum Specification" column to determine if any other available test equipment might suffice to perform the check.

LIMITS AND TOLERANCES

The tolerances given in this procedure are valid for an instrument that is operating in and has been previously calibrated in an ambient temperature between +20°C and +30°C. The instrument also must have had at least a 20-minute warm-up period. Refer to Table 1-1 for tolerances applicable to an instrument that is operating outside this temperature range. All tolerances specified are for the instrument only and do not include test-equipment error.

PREPARATION FOR CHECKS

It is not necessary to remove the instrument cover to accomplish any subsection in the "Performance Check Procedure," since all checks are made using operator-accessible front- and rear-panel controls and connectors.

The most accurate display adjustments are made with a stable, well-focused, low-intensity display. Unless otherwise noted, adjust the A and B INTENSITY, STORAGE/READOUT INTENSITY, FOCUS, and TRIGGER LEVEL controls as needed to view the display.

Table A-1

Test Equipment Required

Item and Description	Minimum Specification	Purpose	Example of Suitable Test Equipment
1. Calibration Generator	Standard-amplitude signal levels: 5 mV to 50 V. Accuracy: ±0.3%. High-amplitude signal levels: 1 V to 60 V. Repetition rate: 1 kHz. Fast-rise signal level: 1 V. Repetition rate: 1 MHz. Rise time: 1 ns or less. Flatness: ±2%.	Signal source for gain and transient response.	TEKTRONIX PG 506 Calibration Generator.[a]
2. Leveled Sine-Wave Generator	Frequency: 250 kHz to above 100 MHz. Output amplitude: variable from 10 mV to 5 V p-p. Output impedance: 50 Ω. Reference frequency: 50 kHz. Amplitude accuracy: constant within 3% of reference frequency as output frequency changes.	Vertical, horizontal, and triggering checks and adjustments. Display adjustments and Z-Axis check.	TEKTRONIX SG 503 Leveled Sine-Wave Generator.[a]
3. Time-Mark Generator	Marker outputs: 10 ns to 0.5 s. Marker accuracy: ±0.1%. Trigger output: 1 ms to 0.1 μs, time-coincident with markers.	Horizontal checks and adjustments. Display adjustment.	TEKTRONIX TG 501 Time-Mark Generator.[a]
4. Low-Frequency Generator	Range: 1 kHz to 500 kHz. Output amplitude: 300 mV. Output impedance: 600 Ω. Reference frequency: constant within 0.3 dB of reference frequency as output frequency changes.	Low-frequency trigger checks.	TEKTRONIX SG 502 Oscillator.[a]
5. Pulse Generator	Repetition rate: 1 kHz. Output amplitude: 5 V.	External clock and storage checks.	TEKTRONIX PG 501 Pulse Generator.[a]
6. Digital Voltmeter (DMM)	Range: 0 to 140 V. Dc voltage accuracy: ±0.15%. 4 1/2 digit display.	Power supply checks and adjustments. Vertical adjustment.	TEKTRONIX DM 501A Digital Multimeter.[a]
7. Coaxial Cable (2 required)	Impedance: 50 Ω. Length: 42 in. Connectors: BNC.	Signal interconnection.	Tektronix Part Number 012-0057-01.
8. Dual-Input Coupler	Connectors: BNC female-to-dual-BNC male.	Signal interconnection.	Tektronix Part Number 067-0525-01.
9. T-Connector	Connectors: BNC.	Signal interconnection.	Tektronix Part Number 103-0030-00.
10. Termination	Impedance: 50 Ω. Connectors: BNC.	Signal termination.	Tektronix Part Number 011-0049-01.
11. Termination	Impedance: 600 Ω. Connectors: BNC.	Signal termination.	Tektronix Part Number 011-0092-00.
12. 10X Attenuator	Ratio: 10X. Impedance: 50 Ω. Connectors: BNC.	Vertical compensation and triggering checks.	Tektronix Part Number 011-0059-02.
13. Adapter	Connectors: BNC male-to-tip plug.	Signal interconnection.	Tektronix Part Number 175-1178-00.

[a]Requires a TM 500-Series Power Module.

INDEX TO PERFORMANCE CHECK STEPS

VERTICAL

Equipment Required (see Table A-1):

Calibration Generator (Item 1)

Leveled Sine-Wave Generator (Item 2)

50 Ω BNC Cable (Item 7)

Dual-Input Coupler (Item 8)

50 Ω BNC Termination (Item 10)

10X Attenuator (Item 12)

INITIAL CONTROL SETTINGS

Vertical (Both Channels)

POSITION	Midrange
VERTICAL MODE	CH 1
X-Y	Off (button out)
BW LIMIT	On (button in)
VOLTS/DIV	2 mV
VOLTS/DIV Variable	CAL detent
INVERT	Off (button out)
AC-GND-DC	DC

Horizontal

POSITION	Midrange
HORIZONTAL MODE	A
A SEC/DIV	20 μs
SEC/DIV Variable	CAL detent
X10 Magnifier	Off (knob in)

A Trigger

VAR HOLDOFF	NORM
Mode	P-P AUTO
SLOPE	OUT
LEVEL	Midrange
HF REJECT	OFF
A&B INT	VERT MODE
A SOURCE	INT
A EXT COUPLING	AC

Menu Funtions

Acquisition Mode	Average

Storage

STORE/NON STORE	NON STORE (button out)
SAVE/CONTINUE	CONTINUE (button out)
PRETRIG/POST TRIG	POST TRIG (button out)
ROLL/SCAN	SCAN (button out)
1K/4K	4K (button out)
POSITION CURS/ SELECT WAVEFORM	POSITION CURS (button in)
WAVEFORM REFERENCE/ MENU SELECT	WAVEFORM REFERENCE (button in)

PROCEDURE STEPS

1. Check Deflection Accuracy and Variable Range

a. Connect the standard-amplitude signal from the Calibration Generator via a 50 Ω cable to the CH 1 OR X input connector.

b. CHECK—Deflection accuracy is within the limits given in Table A-2 for each CH 1 VOLTS/DIV switch setting and corresponding standard-amplitude signal. When at the 20 mV VOLTS/DIV switch setting, rotate the CH 1 VOLTS/DIV Variable control fully counterclockwise and CHECK that the display decreases to 2 divisions or less. Then return the CH 1 VOLTS/DIV Variable control to the CAL detent and continue with the 50 mV check.

Table A-2

Deflection Accuracy Limits

VOLTS/DIV Switch Setting	Standard Amplitude Signal	Accuracy Limits (Divisions)
2 mV	10 mV	4.90 to 5.10
5 mV	20 mV	3.92 to 4.08
10 mV	50 mV	4.90 to 5.10
20 mV	0.1 V	4.90 to 5.10
50 mV	0.2 V	3.92 to 4.08
0.1 V	0.5 V	4.90 to 5.10
0.2 V	1 V	4.90 to 5.10
0.5 V	2 V	3.92 to 4.08
1 V	5 V	4.90 to 5.10
2 V	10 V	4.90 to 5.10
5 V	20 V	3.92 to 4.08

c. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector. Set the VERTICAL MODE switch to CH 2.

d. Repeat part b using the Channel 2 controls.

2. Check Store Deflection Accuracy

a. Set:

CH 2 VOLTS/DIV	2 mV
STORE/NON STORE	STORE (button in)
POSITION CURS/ SELECT WAVEFORM	POSITION CURS (button in)

b. Use the CURSORS control and SELECT C1/C2 switch to set one cursor at the bottom and the other cursor at the top of the square wave.

c. CHECK—Deflection accuracy is within the limits given in Table A-3 for each CH 2 VOLTS/DIV switch setting and corresponding standard-amplitude signal.

Table A-3

Storage Deflection Accuracy

VOLTS/ DIV Switch Setting	Standard Amplitude Signal	Divisions of Deflection	Voltage Readout Limits
2 mV	10 mV	4.90 to 5.10	9.80 to 10.20 mV
5 mV	20 mV	3.92 to 4.08	19.6 to 20.4 mV
10 mV	50 mV	4.90 to 5.10	49.0 to 51.0 mV
20 mV	0.1 V	4.90 to 5.10	98.0 to 102.0 mV
50 mV	0.2 V	3.92 to 4.08	198.0 to 204.0 mV
0.1 V	0.5 V	4.90 to 5.10	0.490 to 0.510 V
0.2 V	1 V	4.90 to 5.10	0.980 to 1.020 V
0.5 V	2 V	3.92 to 4.08	1.960 to 2.040 V
1 V	5 V	4.90 to 5.10	4.90 to 5.10 V
2 V	10 V	4.90 to 5.10	9.80 to 10.20 V
5 V	20 V	3.92 to 4.08	19.60 to 20.40 V

d. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector. set the VERTICAL MODE switch to CH 1.

e. Repeat parts b and c using the Channel 1 controls.

3. Check Save Expansion and Compression

a. Set the CH 1 VOLTS/DIV switch to 0.1 V.

b. Set the generator to produce a 0.5 div standard-amplitude signal.

c. Set the SAVE/CONTINUE switch to SAVE (button in).

d. Set the CH 1 VOLTS/DIV switch to 10 mV and reposition the display.

e. CHECK—The display is expanded to 5 divisions in amplitude.

f. Set:

CH 1 VOLTS/DIV	0.1 V
SAVE/CONTINUE	CONTINUE (button out)

g. Set the generator to produce a 5 division standard-amplitude signal.

h. Set the SAVE/CONTINUE switch to SAVE (button in).

i. Set the CH 1 VOLTS/DIV switch to 1 V.

j. CHECK—The display is compressed to 0.5 division in amplitude.

k. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

l. Set:

VERTICAL MODE	CH 2
SAVE/CONTINUE	CONTINUE (button out)

m. Repeat parts a through j.

4. Check Position Range

a. Set:

VOLTS/DIV (both)	50 mV
AC-GND-DC (both)	AC
STORE/NON STORE	NON STORE (button out)

b. Set the generator to produce a 0.5 V standard-amplitude signal.

c. Adjust the CH 2 VOLTS/DIV Variable control to produce a 4.4 division display. Set the CH 2 VOLTS/DIV switch to 10 mV.

d. CHECK—The bottom and top of the trace may be positioned above and below the center horizontal graticule line by rotating the Channel 2 POSITION control fully clockwise and counterclockwise respectively.

e. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector. Set the VERTICAL MODE switch to CH 1.

f. Repeat parts c and d using the Channel 1 controls.

g. Disconnect the test equipment from the instrument.

5. Check Acquisition Position Registration

a. Set:

VOLTS/DIV (both)	10 mV
AC-GND-DC (both)	GND
A SEC/DIV	10 μs
SAVE/CONTINUE	CONTINUE (button out)

b. Position the trace exactly on the center horizontal graticule line using the Channel 1 POSITION control and position the trace start to the left most vertical graticule line.

c. Set STORE/NON STORE switch to STORE (button in).

d. CHECK— Trace remains within 0.5 division of the center horizontal graticule line and the trace start is within 0.5 division of the left vertical graticule line.

e. Set:

VERTICAL MODE	CH 2
STORE/NON STORE	NON STORE

f. Repeat parts b through d for Channel 2 trace.

g. Position the trace 0.5 division below the top horizontal graticule line using the Channel 2 POSITION control.

h. Set SAVE/CONTINUE switch to SAVE (button in).

i. CHECK—Trace shift of 0.5 division or less.

j. Set SAVE/CONTINUE switch to CONTINUE (button out).

k. Position the trace 0.5 division above the bottom horizontal graticule line using the Channel 2 POSITION control.

l. Set SAVE/CONTINUE switch to SAVE (button in).

m. CHECK—Trace shift of 0.5 division or less.

n. Set SAVE/CONTINUE switch to CONTINUE (button out).

o. Set the VERTICAL MODE switch to CH 1.

p. Repeat steps g through l for Channel 1 trace.

6. Check Non Store Aberrations

a. Set:

BW LIMIT	Off (button out)
VOLTS/DIV (both)	2 mV
AC-GND-DC (both)	DC
A SEC/DIV	0.05 μs
STORE/NON STORE	NON STORE (button out)

b. Connect the fast-rise, positive-going square-wave output via a 50 Ω cable, a 10X attenuator, and a 50 Ω termination to the CH 1 OR X input connector.

c. Set the generator to produce a 1 MHz, 5-division display.

d. CHECK—Display aberrations are within 4% (0.2 division or less) for the following VOLTS/DIV switch settings: 5 mV through 50 mV. Adjust the generator output and attach or remove the 10X attenuator as necessary to maintain a 5-division display at each VOLTS/DIV switch setting.

e. CHECK—Display aberrations are within 6% (0.25 division or less) for the following VOLTS/DIV switch settings: 0.1 V through 0.5 V. Adjust the generator output and attach or remove the 10X attenuator as necessary to maintain a 5-division display at each VOLTS/DIV switch setting.

f. Disconnect the cable from the CH 1 OR X input connector. Reconnect the 10X attenuator (if previously removed) and reduce the generator amplitude to minimum.

g. Connect the cable to the CH 2 OR Y input connector and set the VERTICAL MODE switch to CH 2.

h. Set the generator to produce a 5-division display.

i. Repeat parts d and e using the Channel 2 controls.

7. Check Store Aberrations

a. Reconnect the 10X attenuator and 50 Ω termination (if previously removed) and reduce the generator amplitude to minimum.

b. Set the CH 2 VOLTS/DIV switch to 2 mV.

c. Set the generator to produce a 5-division display.

d. Set:

STORE/NON STORE	STORE (button in)
SAVE/CONTINUE	CONTINUE (button out)

e. Allow acquisition cycle to complete and press in the SAVE/CONTINUE button to SAVE (button in).

f. CHECK—Display aberrations are within 4% (0.2 division or less).

g. Repeat part f for each of the following VOLTS/DIV switch settings: 5 mV through 0.5 V. Adjust the generator output and attach or remove the 10X attenuator as necessary to maintain a 5-division display at each VOLTS/DIV switch setting.

h. Disconnect the cable from the CH 2 OR Y input connector. Reconnect the 10X attenuator (if previously removed) and reduce the generator amplitude to minimum.

i. Connect the cable to the CH 1 OR X input connector and set the VERTICAL MODE switch to CH 1.

j. Set the generator to produce a 5-division display.

k. Repeat parts e and f using the Channel 1 controls.

l. Disconnect the test equipment from the instrument.

8. Check Bandwidth

a. Set:

VOLTS/DIV (both)	2 mV
A SEC/DIV	0.2 ms
STORE/NON STORE	NON STORE (button out)

b. Connect the leveled sine-wave generator output via a 50 Ω cable and a 50 Ω termination to the CH 2 OR Y input connector.

c. Set the generator to produce a 50 kHz, 6-division display.

d. CHECK—Display amplitude is 4.2 divisions or greater as the generator output frequency is increased up to the value shown in Table A-4 for the corresponding VOLTS/DIV switch setting.

Table A-4

Settings for Bandwidth Checks

VOLTS/DIV Switch Setting	Generator Output Frequency
2 mV	80 MHz
5 mV to 5 V	100 MHz

e. Repeat parts c and d for all indicated CH 2 VOLTS/DIV switch settings, up to the output-voltage upper limit of the sine-wave generator being used.

f. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector.

g. Set the VERTICAL MODE switch to CH 1.

h. Repeat parts c and d for all indicated CH 1 VOLTS/DIV switch settings, up to the output-voltage upper limit of the sine-wave generator being used.

9. Check Repetitive Store Mode and Bandwidth

a. Set:

CH 1 VOLTS/DIV	10 mV
A SEC/DIV	0.2 ms

b. Set the generator to produce a 50 kHz, 6-division display.

c. Set:

A SEC/DIV	0.05 μs
X10 Magnifier	On (knob out)

d. Set the generator to produce a 100 MHz display.

e. Set:

STORE/NON STORE	STORE (button in)
SAVE/CONTINUE	CONTINUE (button out)

NOTE

Allow the points to accumulate for a few seconds before saving the display.

f. CHECK—The 100 MHz display will accumulate and store.

g. CHECK—Display amplitude is 4.2 divisions or greater.

h. Set the VERTICAL MODE switch to BOTH and ALT.

i. Repeat parts f and g.

10. Check Single Sweep Sample Acquisition

a. Set:

VERTICAL MODE	CH 1
A SEC/DIV	5 μs
X10 Magnifier	Off (knob in)
A TRIGGER Mode	NORM
A&B INT	CH 1
SAVE/CONTINUE	CONTINUE (button out)
1K/4K	1K (button in)

b. Set the generator to produce a 50 kHz, 6-division display.

c. Set:

Channel 1 AC-GND-DC	GND
A TRIGGER	SGL SWP

d. Set the generator output to 2 MHz.

e. Set the AC-GND-DC switch to DC.

f. CHECK—The minimum peak-to-peak envelope amplitude is greater than 5.6 divisions.

11. Check Bandwidth Limit Operation

a. Set:

BW LIMIT	On (button in)
CH 1 VOLTS/DIV	10 mV
AC-GND-DC	DC
A SEC/DIV	20 μs
A TRIGGER	P-P AUTO
A&B INT	VERT MODE
STORE/NON STORE	NON STORE (button out)

b. Set the generator to produce a 50 kHz, 6-division display.

c. Increase the generator output frequency until the display amplitude decreases to 4.2 divisions.

d. CHECK—Generator output frequency is between 18 and 22 MHz.

e. Disconnect the test equipment from the instrument.

12. Check Common-Mode Rejection Ratio

a. Set:

BW LIMIT	Off (button out)
CH 2 VOLTS/DIV	10 mV
INVERT	On (button in)

b. Connect the leveled sine-wave generator output via a 50 Ω cable, a 50 Ω termination, and a dual-input coupler to the CH 1 OR X and the CH 2 OR Y input connectors.

c. Set the generator to produce a 50 MHz, 6-division display.

d. Vertically center the display using the Channel 1 POSITION control. Then set the VERTICAL MODE switch to CH 2 and vertically center the display using the Channel 2 POSITION control.

e. Set the VERTICAL MODE switches to BOTH and ADD.

f. CHECK—Display amplitude is 0.6 division or less.

g. If the check in part f meets the requirement, skip to part p. If it does not, continue with part h.

h. Set the VERTICAL MODE switch to CH 1.

i. Set the generator to produce a 50 kHz, 6-division display.

j. Set the VERTICAL MODE switch to BOTH.

k. Adjust the CH 1 or CH 2 VOLTS/DIV Variable control for minimum display amplitude.

l. Set the VERTICAL MODE switch to CH 1.

m. Set the generator to produce a 50 MHz, 6-division display.

n. Set the VERTICAL MODE switch to BOTH.

o. CHECK—Display amplitude is 0.6 division or less.

p. Disconnect the test equipment from the instrument.

13. Check Non Store and Store Channel Isolation

a. Set:

VERTICAL MODE	CH 1
VOLTS/DIV (both)	0.1 V
VOLTS/DIV Variable (both)	CAL detent
INVERT	Off (button out)
Channel 1 AC-GND-DC	AC
Channel 2 AC-GND-DC	GND
A SEC/DIV	0.1 μs

b. Connect the leveled sine-wave generator output via a 50 Ω cable and a 50 Ω termination to the CH 1 OR X input connector.

c. Set the generator to produce a 50 MHz, 5-division display.

d. Set the VERTICAL MODE switch to CH 2.

e. CHECK—Display amplitude is 0.05 division or less.

f. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

g. Set:

VERTICAL MODE	CH 1
Channel 1 AC-GND-DC	GND
Channel 2 AC-GND-DC	AC

h. CHECK—Display amplitude is 0.05 division or less.

i. Set:

CH 2 VOLTS/DIV	50 mV
STORE/NON STORE	STORE (button in)
SAVE/CONTINUE	CONTINUE (button out)

j. CHECK—Display amplitude is 0.1 division or less.

k. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector.

l. Set:

VERTICAL MODE	CH 1
CH 1 VOLTS/DIV	50 mV
CH 2 VOLTS/DIV	0.1 V
Channel 1 AC-GND-DC	GND
Channel 2 AC-GND-DC	AC

m. CHECK—Display amplitude is 0.1 division or less.

n. Disconnect the test equipment from the instrument.

14. Check Store Mode Cross Talk

a. Set:

VERTICAL MODE	BOTH and CHOP
VOLTS/DIV (both)	0.1 V
A SEC/DIV	10 μs

b. Connect the Pulse Generator pulse-period output via a 50 Ω cable and a 50 Ω termination to CH 1 OR X input connector.

c. Set the generator to produce a 100 kHz, 5-division display.

d. Use the Channel 1 POSITION control to center the display.

e. Set CH 1 VOLTS/DIV switch to 50 mV for a 10-division display.

f. CHECK—Display amplitude on Channel 2 is less than 1% (0.1 division).

g. Set the A SEC/DIV switch to 10 ms.

h. CHECK—Display amplitude on Channel 2 is less than 1% (0.1 division).

i. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

j. Set:

CH 2 VOLTS/DIV	0.1 V
Channel 1 AC-GND-DC	GND
Channel 2 AC-GND-DC	AC

k. Use the Channel 2 POSITION control to center the display.

l. Set CH 2 VOLTS/DIV switch to 50 mV for a 10-division display.

m. Repeat parts f through h for Channel 1.

15. Check Store Pulse Width Amplitude

a. Set:

VERTICAL MODE	CH 2
A SEC/DIV	1 ms
STORE/NON STORE	NON STORE (button out)
ROLL/SCAN	SCAN (button out)
1K/4K	1K (button in)

b. Set the generator to produce a 1 ms period, 100 ns pulse duration, 5-division display.

c. Set the STORE/NON STORE switch to STORE (button in).

d. CHECK—The amplitude of the display is 2.5 divisions or greater.

e. Set the A SEC/DIV switch to 0.1 sec.

f. CHECK—The amplitude of the display is 2.5 divisions or greater.

g. Set ROLL/SCAN switch to ROLL (button in).

h. CHECK—The amplitude of the display is 2.5 divisions or greater.

i. Set:

VERTICAL MODE	BOTH and CHOP
A SEC/DIV	1 ms
STORE/NON STORE	NON STORE (button out)
ROLL/SCAN	SCAN (button out)

j. Set the generator to produce a 0.1 s period, 2 ms pulse duration, 5-division display.

k. Repeat parts c through h.

l. Set:

A SEC/DIV	1 ms
STORE/NON STORE	NON STORE (button out)
ROLL/SCAN	SCAN (button out)

m. Set the generator to produce a 1 ms period, 20 μs pulse duration, 5-division display.

n. Repeat parts c and d.

o. Disconnect the test equipment from the instrument.

16. Check Average Mode

a. Set the WAVEFORM REFERENCE/MENU SELECT switch to MENU SELECT (button out).

b. Use the Menu controls to select SWP LIMIT.

c. CHECK—The SWP LIMIT is adjustable from 1 to 100,000 or NO LIMIT by rotating the CURSORS control.

NOTE

Earlier instrument firmware had the SWP LIMIT adjustable from 1 to 2047.

HORIZONTAL

Equipment Required (see Table A-1):

Calibration Generator (Item 1)

Leveled Sine-Wave Generator (Item 2)

Time-Mark Generator (Item 3)

50 Ω BNC Cable (Item 7)

50 Ω BNC Termination (Item 10)

INITIAL CONTROL SETTINGS

Vertical

Channel 1 POSITION	Midrange
VERTICAL MODE	CH 1
X-Y	Off (button out)
BW LIMIT	Off (button out)
CH 1 VOLTS/DIV	0.5 V
CH 1 VOLTS/DIV Variable	CAL detent
Channel 1 AC-GND-DC	DC

Horizontal

POSITION	Midrange
HORIZONTAL MODE	A
A SEC/DIV	0.05 μs
SEC/DIV Variable	CAL detent
X10 Magnifier	Off (knob in)
B DELAY TIME POSITION	Fully counterclockwise

B TRIGGER

SLOPE	OUT
LEVEL	Fully clockwise

A TRIGGER

VAR HOLDOFF	NORM
Mode	P-P AUTO
SLOPE	OUT
LEVEL	Midrange
HF REJECT	OFF
A&B INT	VERT MODE
A SOURCE	INT
A EXT COUPLING	DC÷10

Storage

STORE/NON STORE	NON STORE (button out)
SAVE/CONTINUE	CONTINUE (button out)
PRETRIG/POST TRIG	POST TRIG (button out)
ROLL/SCAN	SCAN (button out)
1K/4K	4K (button out)
POSITION CURS/ SELECT WAVEFORM	POSITION CURS (button in)
WAVEFORM REFERENCE/ MENU SELECT	WAVEFORM REFERENCE (button in)

PROCEDURE STEPS

1. Check Timing Accuracy and Linearity

a. Connect the time-mark generator output via a 50 Ω cable and a 50 Ω termination to the CH 1 OR X input connector.

b. Select 50 ns time markers from the time-marker generator.

c. Use the Channel 1 POSITION control to center the display vertically. Adjust the A TRIGGER LEVEL control for a stable, triggered display.

d. Use the Horizontal POSITION control to align the 2nd time marker with the 2nd vertical graticule line.

e. CHECK—Timing accuracy is within 2% (0.16 division at the 10th vertical graticule line), and linearity is within 5% (0.1 division over any 2 of the center 8 divisions). For checking the timing accuracy of the A SEC/DIV switch settings from 50 ms to 0.5 s, watch the time marker tips only at the 2nd and 10th vertical graticule lines while adjusting the Horizontal POSITION control.

f. Repeat parts c through e for the remaining A SEC/DIV and time-mark generator setting combinations shown in Table A-5 under the "Normal (X1)" column.

g. Set:

A SEC/DIV	0.05 μs
X10 Magnifier	On (knob out)

h. Select 10 ns time markers from the time-mark generator.

Table A-5

Settings for Timing Accuracy Checks

SEC/DIV Switch Setting	Time-Mark Generator Setting	
	Normal (X1)	X10 Magnified
0.05 μs	50 ns	10 ns
0.1 μs	0.1 μs	10 ns
0.2 μs	0.2 μs	20 ns
0.5 μs	0.5 μs	50 ns
1 μs	1 μs	0.1 μs
2 μs	2 μs	0.2 μs
5 μs	5 μs	0.5 μs
10 μs	10 μs	1 μs
20 μs	20 μs	2 μs
50 μs	50 μs	5 μs
0.1 ms	0.1 ms	10 μs
0.2 ms	0.2 ms	20 μs
0.5 ms	0.5 ms	50 μs
1 ms	1 ms	0.1 ms
2 ms	2 ms	0.2 ms
5 ms	5 ms	0.5 ms
10 ms	10 ms	1 ms
20 ms	20 ms	2 ms
50 ms	50 ms	5 ms
A Sweep Only		
0.1 s	0.1 s	10 ms
0.2 s	0.2 s	20 ms
0.5 s	0.5 s	50 ms

i. Use the Horizontal POSITION control to align the 1st time marker that is 25 ns beyond the start of the sweep with the 2nd vertical graticule line.

j. CHECK—Timing accuracy is within 3% (0.24 division at the 10th vertical graticule line), and linearity is within 5% (0.1 division over any 2 of the center 8 divisions). Exclude any portion of the sweep past the 100th magnified division.

k. Repeat parts i and j for the remaining A SEC/DIV and time-mark generator setting combinations shown in Table A-5 under the "X10 Magnified" column.

l. Set:

HORIZONTAL MODE	B
A SEC/DIV	0.1 μs
B SEC/DIV	0.05 μs
X10 Magnifier	Off (knob in)

m. Repeat parts b through k for the B Sweep. Keep the A SEC/DIV switch one setting slower than the B SEC/DIV switch.

2. Check Store Differential and Cursor Time Difference Accuracy

a. Set:

Channel 1 AC-GND-DC	GND
HORIZONTAL MODE	A
A SEC/DIV	0.1 ms
X10 Magnifier	Off (knob in)
STORE/NON STORE	STORE (button in)
1K/4K	1K (button in)

b. Use the Channel 1 POSITION control to center the base line vertically and the Horizontal POSITION control to align the start of the trace with the 1st vertical graticule line.

c. Use the CURSORS control and SELECT C1/C2 switch to set one cursor exactly on the 2nd vertical graticule line and position the active cursor to the right using the CURSORS control until ΔT readout displays 0.800 ms.

d. CHECK—Graticule indication of cursor difference at the 10th vertical graticule line is within 0.16 division.

e. Set the Channel 1 AC-GND-DC switch to DC.

f. Select 0.1 ms time markers from the time-mark generator.

g. Align the 2nd time marker with the 2nd vertical graticule line using the Horizontal POSITION control.

h. Set the SAVE/CONTINUE switch to SAVE (button in) for a stable display.

i. Use the CURSORS control and SELECT C1/C2 switch to set the first cursor on the trailing edge of the 2nd time marker.

j. Press in the C1/C2 button to activate the second cursor.

k. Set the second cursor on the trailing edge of the 10th time marker at the same voltage level as on the 2nd time marker.

l. CHECK—The ΔT readout is between 0.798 ms and 0.802 ms.

m. Set the SAVE/CONTINUE switch to CONTINUE (button out).

n. Set the A SEC/DIV switch to 0.5 μs.

o. Select 0.5 μs time markers from the time-mark generator.

p. Align the 2nd time marker with the 2nd vertical graticule line using the Horizontal POSITION control.

NOTE

Allow the points to accumulate for a few seconds before saving the display.

q. Repeat parts h through k.

NOTE

Pulses with fast rise and fall times have only a few sample points and it may not be possible to place the cursors at exactly the same voltage levels.

r. CHECK—The ΔT readout is between 3.948 μs and 4.052 μs.

3. Check Variable Range and Sweep Separation

a. Set:

A and B SEC/DIV	0.2 ms
SEC/DIV Variable	Fully counterclockwise
STORE/NON STORE	NON STORE (button out)

b. Select 0.5 ms time markers from the time-mark generator.

c. CHECK—Time markers are 1 division or less apart.

d. Set:

Channel 1 AC-GND-DC	GND
SEC/DIV Variable	CAL detent
HORIZONTAL MODE	BOTH

e. Use the Channel 1 POSITION control to set the A Sweep at the center horizontal graticule line.

f. CHECK—The B Sweep can be positioned more than 3.5 divisions above and below the A Sweep when the A/B SWP SEP control is rotated fully clockwise and counterclockwise respectively.

4. Check Delay Time Differential Accuracy

a. Use the Horizontal POSITION control to align the start of the A Sweep with the 1st vertical graticule line.

b. Set the B DELAY TIME POSITION control fully counterclockwise.

c. CHECK—Intensified portion of the trace starts within 0.5 division of the start of the sweep.

d. Rotate the B DELAY TIME POSITION control fully clockwise.

e. CHECK—Intensified portion of the trace is past the 11th vertical graticule line.

f. Set the A and B SEC/DIV switch to 0.5 μs.

g. Repeat parts a through e.

h. Set:

Channel 1 AC-GND-DC	DC
B SEC/DIV	0.05 μs
B DELAY TIME POSITION	Fully counterclockwise

i. Select 0.5 μs time markers from the time-mark generator.

j. Rotate the B DELAY TIME POSITION control so that the top of the 2nd time marker on the B Sweep is aligned with a selected reference vertical line. Record the DLY> readout for part l.

k. Rotate the B DELAY TIME POSITION control fully clockwise until the top of the 10th time marker on the B Sweep is aligned with the same selected reference vertical line as in part j. Record the DLY> readout for part l.

l. CHECK—Delay time readout is within the limits given in Table A-6 (Delay Readout Limits column) by subtracting the delay time reading in part j from part k.

m. Repeat parts k through l for the remaining B SEC/DIV and time-mark generator settings given in Table A-6, check the 8-division delay time accuracy for each A SEC/DIV switch setting given in column 1 of the table.

Table A-6

Settings for Delay Time Differential Checks

Time-Mark Generator and A SEC/DIV Settings	B SEC/DIV Setting	Eight Division Delay	Delay Readout Limits
0.5 μs	0.05 μs	4.000 μs	3.948 to 4.052 μs
5 μs	0.5 μs	40.00 μs	39.48 to 40.52 μs
50 μs	5 μs	400.0 μs	394.8 to 405.2 μs
0.5 ms	50 μs	4.000 ms	3.948 to 4.052 ms
5 ms	0.5 ms	40.00 ms	39.48 to 40.52 ms
50 ms	5 ms	400.0 ms	394.8 to 405.2 ms
0.5 s	50 ms	4.000 s	3.948 to 4.052 s

5. Check Delay Jitter

a. Set:

A SEC/DIV	0.5 ms
B SEC/DIV	0.5 μs
HORIZONTAL MODE	B

b. Select 50 μs time markers from the time-mark generator.

c. Rotate the B DELAY TIME POSITION control counterclockwise to position a time marker within the graticule area for each major dial division and CHECK that the jitter on the leading edge of the time marker does not exceed 2 divisions. Disregard slow drift.

6. Check Position Range

a. Set:

HORIZONTAL MODE	A
A SEC/DIV	10 μs

b. Select 10 μs time markers from the time-mark generator.

c. CHECK—Start of the sweep can be positioned to the right of the center vertical graticule line by rotating the Horizontal POSITION control fully clockwise.

d. CHECK—The 11th time marker can be positioned to the left of the center vertical graticule line by rotating the Horizontal POSITION control fully counterclockwise.

e. Select 50 μs time markers from the time-mark generator.

f. Align the 3rd time marker with the center vertical graticule line using the Horizontal POSITION control.

g. Set the X10 Magnifier knob to On (knob out).

h. CHECK—Magnified time marker can be positioned to the left of the center vertical graticule line by rotating the Horizontal POSITION control fully counterclockwise.

i. CHECK—Start of the sweep can be positioned to the right of the center vertical graticule line by rotating the Horizontal POSITION control fully clockwise.

7. Check Store Expansion Range

a. Set:

A SEC/DIV	0.1 μs
X10 Magnifier	Off (knob in)

b. Select 10 ns time markers from the time-mark generator.

c. Use the Horizontal POSITION control to align the start of the A Sweep with the 1st vertical graticule line.

d. Set the STORE/NON STORE switch to STORE (button in).

e. Set the X10 Magnifier knob to On (knob out).

f. CHECK—The time markers are 1 division apart.

8. Check 4K to 1K Display Compress

a. Set:

A SEC/DIV	50 μs
X10 Magnifier	Off (knob in)
1K/4K	4K (button out)

b. Select 0.1 ms time markers from the time-mark generator and check that the time markers are 2 divisions apart.

c. Rotate the SEC/DIV Variable control out of detent.

d. CHECK—For 2 time markers per division over the center 8 divisions.

9. Check Non Store Sweep Length

a. Set:

SEC/DIV Variable	CAL detent
STORE/NON STORE	NON STORE (button out).

b. Use the Horizontal POSITION control to align the start of the A Sweep with the 1st vertical graticule line.

c. CHECK—End of the sweep is to the right of the 11th vertical graticule line.

d. Disconnect the test equipment from the instrument.

10. Check X Gain

a. Set:

X-Y	On (button in)
CH 1 VOLTS/DIV	10 mV
Horizontal POSITION	Midrange

b. Connect the standard-amplitude signal from the Calibration Generator via a 50 Ω cable to the CH 1 OR X input connector.

c. Set the generator to produce a 50 mV signal.

d. Use the Channel 2 POSITION and Horizontal POSITION controls to center the display.

e. CHECK—Display is 4.85 to 5.15 horizontal divisions.

f. Disconnect the test equipment from the instrument.

11. Check X Bandwidth

a. Set the STORE/NON STORE switch to NON STORE (button out).

b. Connect the leveled sine-wave generator output via a 50 Ω cable and a 50 Ω termination to the CH 1 OR X input connector.

c. Set the generator to produce a 5-division horizontal display at an output frequency of 50 kHz.

d. Increase the generator output frequency to 2.5 MHz.

e. CHECK—Display is at least 3.5 horizontal divisions.

f. Disconnect the test equipment from the instrument.

TRIGGER

Equipment Required (see Table A-1):

Leveled Sine-Wave Generator (Item 2)
Low Frequency Generator (Item 4)
50 Ω BNC Cable (Item 7)
Dual-Input Coupler (Item 8)
50 Ω BNC Termination (Item 10)
600 Ω BNC Termination (Item 11)

INITIAL CONTROL SETTINGS

Vertical

POSITION (both)	Midrange
VERTICAL MODE	CH 1
X-Y	Off (button out)
BW LIMIT	Off (button out)
CH 1 VOLTS/DIV	5 mV
CH 2 VOLTS/DIV	50 mV
VOLTS/DIV Variable (both)	CAL detent
INVERT	Off (button out)
AC-GND-DC (both)	DC

Horizontal

POSITION	Midrange
HORIZONTAL MODE	A
A and B SEC/DIV	0.2 μs
SEC/DIV Variable	CAL detent
X10 Magnifier	Off (knob in)
B DELAY TIME POSITION	Fully counterclockwise

B TRIGGER

SLOPE	OUT
LEVEL	Midrange

A TRIGGER

VAR HOLDOFF	NORM
Mode	P-P AUTO
SLOPE	OUT
LEVEL	Midrange
HF REJECT	OFF
A&B INT	CH 1
A SOURCE	INT
A EXT COUPLING	DC

Storage

STORE/NON STORE	NON STORE (button out)
SAVE/CONTINUE	CONTINUE (button out)
PRETRIG/POST TRIG	POST TRIG (button out)
ROLL/SCAN	SCAN (button out)
1K/4K	4K (button out)
POSITION CURS/ SELECT WAVEFORM	POSITION CURS (button in)
WAVEFORM REFERENCE/ MENU SELECT	WAVEFORM REFERENCE (button in)

PROCEDURE STEPS

1. Check Internal A and B Triggering

a. Connect the leveled sine-wave generator output via a 50 Ω cable and a 50 Ω termination to the CH 1 OR X input connector.

b. Set the generator to produce a 10 MHz, 3.5-division display.

c. Set the CH 1 VOLTS/DIV switch to 50 mV.

d. CHECK—Stable display can be obtained by adjusting the A TRIGGER LEVEL control for each switch combination given in Table A-7.

e. Set the HORIZONTAL MODE switch to B.

f. CHECK—Stable display can be obtained by adjusting the B TRIGGER LEVEL control to a position other than the B RUNS AFTER DLY position for both the OUT and IN positions of the B TRIGGER SLOPE switch.

Table A-7

Switch Combinations for A Triggering Checks

A TRIGGER Mode	A TRIGGER SLOPE
NORM	OUT
NORM	IN
P-P AUTO	IN
P-P AUTO	OUT

g. Set:

VERTICAL MODE	CH 2
HORIZONTAL MODE	A
A&B INT	CH 2

h. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

i. Repeat parts d through f.

j. Set:

HORIZONTAL MODE	A
A SEC/DIV	0.1 μs
X10 Magnifier	On (knob out)

k. Set the generator to produce a 60 MHz, 1.0-division display.

l. Repeat parts d through f.

m. Set:

VERTICAL MODE	CH 1
HORIZONTAL MODE	A
A&B INT	CH 1

n. Move the cable from the CH 2 OR Y input connector to the CH 1 OR X input connector.

o. Repeat parts d through f.

p. Set:

HORIZONTAL MODE	A
A SEC/DIV	0.05 μs

q. Set the generator to produce a 100 MHz, 1.5-division display.

r. Repeat parts d through f.

s. Set:

VERTICAL MODE	CH 2
HORIZONTAL MODE	A
A&B INT	CH 2

t. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

u. Repeat parts d through f.

v. Disconnect the test equipment from the instrument.

2. Check HF Reject A Triggering

a. Set:

VERTICAL MODE	CH 1
VOLTS/DIV (both)	50 mV
HORIZONTAL MODE	A
A SEC/DIV	5 μs
X10 Magnifier	Off (knob in)
A TRIGGER Mode	NORM
A TRIGGER LEVEL	Midrange
A&B INT	CH 1

b. Connect the low-frequency generator output via a 50 Ω cable and a 600 Ω termination to the CH 1 OR X input connector.

c. Set the low-frequency generator output to produce a 250 kHz, 1-division display.

d. Adjust the A TRIGGER LEVEL control for a stable display.

e. Set HF REJECT switch to ON.

f. CHECK—Stable display cannot be obtained by adjusting the A TRIGGER LEVEL control for each switch combination given in Table A-7.

g. Set:

VERTICAL MODE	CH 2
A&B INT	CH 2

h. Move the cable from the CH 1 OR X input connector to the CH 2 OR Y input connector.

i. Repeat part f.

j. Disconnect the test equipment from the instrument.

3. Check External Triggering

a. Set:

VERTICAL MODE	CH 1
CH 1 VOLTS/DIV	5 mV
HORIZONTAL MODE	A
A SEC/DIV	0.1 μs
HF REJECT	OFF
A&B INT	CH 1
A SOURCE	EXT

b. Connect the leveled sine-wave generator output via a 50 Ω cable, a 50 Ω termination, and a dual-input coupler to both the CH 1 OR X and EXT INPUT connectors.

c. Set the leveled sine-wave generator output voltage to 40 mV and the frequency to 10 MHz.

d. CHECK—Stable display can be obtained by adjusting the A TRIGGER LEVEL control for each switch combination given in Table A-7.

e. Set:

CH 1 VOLTS/DIV	50 mV
X10 Magnifier	On (knob out)

f. Set the generator output voltage to 120 mV and the frequency to 60 MHz.

g. Repeat part d.

h. Set the generator output voltage to 150 mV and the frequency to 100 MHz.

i. Repeat part d.

4. Check External Trigger Ranges

a. Set:

CH 1 VOLTS/DIV	0.5 V
A SEC/DIV	20 μs
X10 Magnifier	Off (knob in)
A TRIGGER SLOPE	OUT
A TRIGGER Mode	NORM

b. Set the generator to produce a 50 kHz, 6.4-division display.

c. CHECK—Display is triggered along the entire positive slope of the waveform as the A TRIGGER LEVEL control is rotated.

d. CHECK—Display is not triggered (no trace) at either extreme of rotation.

e. Set the A TRIGGER SLOPE button to IN.

f. CHECK—Display is triggered along the entire negative slope of the waveform as the A TRIGGER LEVEL control is rotated.

g. CHECK—Display is not triggered (no trace) at either extreme of rotation.

5. Check Single Sweep Operation

a. Adjust the A TRIGGER LEVEL control to obtain a stable display.

b. Set:

Channel 1 AC-GND-DC	GND
A SOURCE	INT

c. Press in the SGL SWP button. The READY LED should illuminate and remain on.

d. Set the Channel 1 AC-GND-DC switch to DC.

NOTE

The A INTENSITY control may require adjustment to observe the single-sweep trace.

e. CHECK—READY LED goes out and a single sweep occurs.

f. Press in the SGL SWP button several times.

g. CHECK—Single-sweep trace occurs, and the READY LED illuminates briefly every time the SGL SWP button is pressed in and released.

h. Disconnect the test equipment from the instrument.

6. Check Acquisition Window Trigger Point

a. Set:

A TRIGGER Mode	P-P AUTO
1K/4K	4K (button out)
PRETRIG/POST TRIG	POST TRIG (button out)
WAVEFORM REFERENCE/ MENU SELECT	MENU SELECT (button out)

b. Use the Menu controls to select A TRIG POS.

c. CHECK—The A TRIG POS default number is 512.

d. Press in momentarily the PRETRIG/POST TRIG switch to activate the trigger point display on the crt. Return the PRETRIG/POST TRIG switch to POST TRIG (button out).

e. CHECK—The trigger point (T) appears near the 2nd vertical graticule line below the Menu.

f. Set the PRETRIG/POST TRIG switch to PRETRIG (button in).

g. CHECK—The A TRIG POS default number is 3584 and the trigger point (T) appears near the 9th vertical graticule line below the Menu.

h. Set the 1K/4K switch to 1K (button in).

i. CHECK—The A TRIG POS default number is 896 and the trigger point (T) appears near the 9th vertical graticule line below the Menu.

j. Set the PRETRIG/POST TRIG switch to POST TRIG (button out).

k. CHECK—The A TRIG POS default number is 128 and the trigger point (T) appears near the 2nd vertical graticule line below the Menu.

l. CHECK—The trigger point (T) can be moved between the 1st and the center vertical graticule line as the CURSORS control is rotated.

m. Set the PRETRIG/POST TRIG switch to PRETRIG (button in).

n. CHECK—The trigger point (T) can be moved between the 10th and the center vertical graticule line as the CURSORS control is rotated.

o. Set the 1K/4K switch to 4K (button out).

p. Repeat part n for PRETRIG mode and part l for POST TRIG mode.

EXTERNAL Z-AXIS, PROBE ADJUST, EXTERNAL CLOCK, AND X-Y PLOTTER

Equipment Required (see Table A-1):

Leveled Sine-Wave Generator (Item 2)	BNC T-Connector (Item 9)
Pulse Generator (Item 5)	50 Ω BNC Termination (Item 10)
Digital Voltmeter (Item 6)	BNC Male-to-Tip Plug (Item 13)
Two 50 Ω BNC Cables (Item 7)	10X Probe (provided with instrument)

INITIAL CONTROL SETTINGS

VERTICAL

Channel 1 POSITION	Midrange
VERTICAL MODE	CH 1
X-Y	Off (button out)
BW LIMIT	Off (button out)
CH 1 VOLTS/DIV	1 V
CH 1 VOLTS/DIV Variable	CAL detent
Channel 1 AC-GND-DC	DC

Horizontal

POSITION	Midrange
HORIZONTAL MODE	A
A SEC/DIV	20 μs
SEC/DIV Variable	CAL detent
X10 Magnifier	Off (knob in)

A TRIGGER

VAR HOLDOFF	NORM
Mode	P-P AUTO
SLOPE	OUT
LEVEL	Midrange
HF REJECT	OFF
A&B INT	VERT MODE
A SOURCE	INT

Storage

STORE/NON STORE	NON STORE (button out)
SAVE/CONTINUE	CONTINUE (button out)
PRETRIG/POST TRIG	POST TRIG (button out)
ROLL/SCAN	SCAN (button out)
1K/4K	4K (button out)
POSITION CURS/ SELECT WAVEFORM	POSITION CURS (button in)
WAVEFORM REFERENCE/ MENU SELECT	WAVEFORM REFERENCE (button in)

PROCEDURE STEPS

1. Check External Z-Axis Operation

a. Connect the leveled sine-wave generator output via a 50 Ω cable and a T-connector to the CH 1 OR X input connector. Then connect a 50 Ω cable and a 50 Ω termination from the T-connector to the EXT Z-AXIS INPUT connector on the rear panel.

b. Set the generator to produce a 5 V, 50 kHz signal.

c. CHECK—For noticeable intensity modulation. The positive part of the sine wave should be of lower intensity than the negative part.

d. Disconnect the test equipment from the instrument.

2. Check Probe Adjust Operation

a. Set:

CH 1 VOLTS/DIV	10 mV
A SEC/DIV	0.5 ms

b. Connect the 10X Probe to the CH 1 OR X input connector and insert the probe tip into the PROBE ADJUST jack on the instrument front panel. If necessary, adjust the probe compensation for a flat-topped square-wave display.

c. CHECK—Display amplitude is 4.75 to 5.25 divisions.

d. Disconnect the probe from the instrument.

3. Check External Clock

a. Set:

CH 1 VOLTS/DIV	1 V
A SEC/DIV	1 ms

b. Connect the Pulse Generator high-amplitude output via a 50 Ω cable and a 50 Ω termination to CH 1 OR X input connector.

c. Set the generator to produce a 1 kHz, 5-division display.

d. Disconnect the cable from the CH 1 OR X input connector and connect it to the BNC male-to-tip plug via BNC female to BNC female connector.

e. Insert the BNC male-to-tip plug signal lead and ground lead into pin 1 and pin 9 respectively of the X-Y Plotter connector.

f. Set the A SEC/DIV switch to 0.1 sec.

g. Connect the Calibration Generator high-amplitude output via a 50 Ω cable and a 50 Ω termination to CH 1 OR X input connector.

h. Set the generator to produce a 100 Hz, 5-division display.

i. Set:

A SEC/DIV	EXT CLK
STORE/NON STORE	STORE (button in)

j. CHECK—The 100 Hz signal is displayed on the screen and updated.

k. Set the SAVE/CONTINUE switch to SAVE (button in).

l. CHECK—The display is saved.

m. Disconnect the test equipment from the instrument.

4. Check X-Y Plotter

a. Connect the digital voltmeter low lead to either chassis ground or pin 9 (signal ground) of the X-Y Plotter connector. Connect the volts lead to pin 3 (X Output) of the X-Y Plotter connector.

b. Set the digital voltmeter to the 20 V scale.

c. Set the WAVEFORM REFERENCE/MENU SELECT switch to MENU SELECT (button out).

d. Use the Menu controls to select PLOT and then ON for GRATICULE.

NOTE

The next menu selection is only valid if the instrument contains one of the communication options.

e. Use the Menu controls to select PLOT and then XY for FORMAT.

f. Use the Menu controls to select PLOT START.

g. Press in momentarily the CURSORS button to activate the X-Y Plotter.

NOTE

Voltage reading of the X Output will be negative left of the center vertical graticule line and positive to the right of the center vertical graticule line. Voltage reading of the Y output will be negative below the center horizontal graticule line and positive above the center horizontal graticule line.

h. Record the voltage reading as the instrument plots the 1st and the 10th graticule line (as the intensity spot moves along the graticule line).

i. CHECK—The voltage difference between the 1st and 10th graticule line is between 4.5 V and 5.5 V.

j. Move the volts lead of the voltmeter from pin 3 (X Output) to pin 5 (Y Output) of the X-Y Plotter connector.

k. Press in momentarily the CURSORS button to activate the X-Y Plotter.

l. Record the voltage reading as the instrument plots the top and the bottom of the graticule lines (as the intensity spot moves along the graticule line).

m. CHECK—The voltage difference between the top and bottom graticule line is between 3.6 V and 4.4 V.

n. Disconnect the test equipment from the instrument.

APPENDIX B

This appendix supplies some additional information about connecting and using the RS-232-C Communications Option. Printer/Plotter switch settings for some tested formats and plotter types are shown for both RS-232 and GPIB (Option 10). Some common questions and answers about the Communications Options are included. Most of the questions are about Option 12.

RS-232-C DEVICE INTERCONNECTION

INTRODUCTION

This information will aid you in determining the cabling needed to hook your 2200 Family oscilloscope to other RS-232-C devices. The majority of interconnection situations that you may see are covered.

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

DETERMINING DEVICE TYPE

When interconnecting your 2200 Family oscilloscope to other RS-232-C devices you must determine the device type and the connector type. From that information, the interconnection cable you need can be determined.

NOTE

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

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

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

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

Male is standard for a DTE connector.

Female is standard for a DCE connector.

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

INTERCONNECTION RULES

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

1. A standard RS-232-C cable connects a DTE device to a DCE device. Both devices must adhere to the electrical and mechanical specifications of the RS-232-C standard. The standard cable has a female connector on one end and a male connector on the other end. The Transmit and Receive conductors are not interchanged. The standard RS-232-C cable is sometimes referred to as a "straight through" cable. In Table B-1, the Cable-Type Identification table, the straight-through cable is referred to as Type A.

2. A "Null Modem" cable or device may be used to interconnect two DTE or two DCE devices. Generally the cable is custom made with RS-232-C connectors that match the devices to be interconnected. A null modem cable permits two devices of the same type (DCE to DCE and DTE to DTE) to communicate as if they were connected DTE to DCE. The Transmit and Receive lines and the associated handshake line are swapped in the null modem to satisfy the requirements for data transfer between the two devices. See Figure B-1 for the "Null Modem" cable wiring schematic.

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

The gender changer is connected between the non-conforming device and the appropriate end of a standard RS-232-C cable. Situations may occur when neither device has conforming connectors; in that case, use gender changers on both devices to permit interconnection with a standard RS-232-C cable (or use one of the specified cables from Table B-1).

4. If non-standard cabling or connectors are used, an interconnection terminal box may be needed to provide user-customized hookups.

The 2200 Family DSOs have both a DTE port and a DCE port to make it easy to connect to either a DTE or a DCE device using a standard RS-232-C cable. Both connectors conform to the electrical and mechanical specifications of the RS-232-C. Therefore, in most cases, you should not have to modify the 2200 Family DSO end of an interconnection cable to hook up other devices with the oscilloscope.

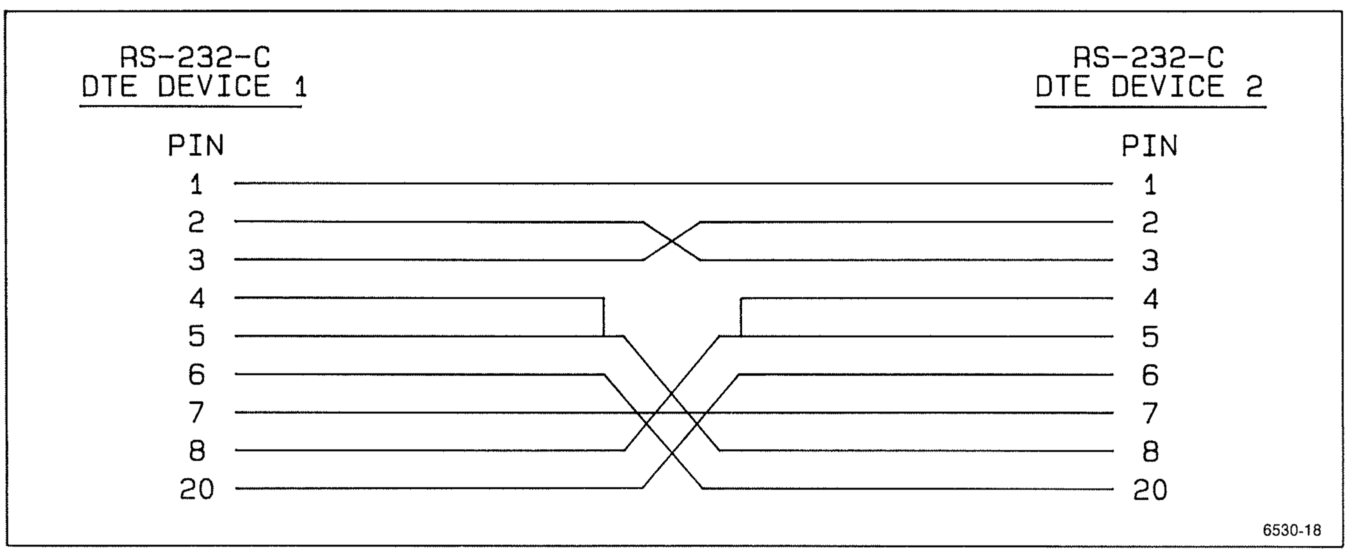


Figure B-1. Null Modem cable wiring (non-handshaking).

INTERCONNECTION CABLE-TYPE IDENTIFICATION

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

RS-232-C INTERCONNECTION CABLE-TYPE ILLUSTRATIONS

The cable-wiring illustrations of B-2 through B-7 correspond to the Cable-Type designations of Table B-1. They are divided into the straight through (Type A) interconnections and the null modem (Type B) interconnections. Both the straight through and the null modem interconnections will also require gender changers when making male-to-male or female-to-female equipment hookups. In summary, the basic cable types are:

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

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

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

Table B-1
Cable-Type Identification

Type of Interconnection	Cable-Type Designator	Application
		Straight-Through Cables
DTE/male to DCE/female DTE/female to DCE/male	A	Use a straight through cable terminated on one end with a male connector and on the other end with a female connector. This is the "standard" cable connection in our discussion.
DTE/female to DCE/female	A1	Use a male-to-male gender changer and a standard cable.
DTE/male to DCE/male	A2	Use a female-to-female gender changer and a standard cable.
		Null-Modem Cables
DTE/male to DTE/male DCE/male to DCE/male	B	Use a null modem cable terminated with female connectors. This is the "standard null modem" in our discussion.
DTE/female to DTE/male DCE/male to DCE/female	B1	Use a standard null modem with a male-to-male gender changer or use a male-to-female null modem.
DTE/female to DTE/female DCE/female to DCE/female	B2	Use two male-to-male gender changers and a standard null modem cable or use a male-to-male null modem.

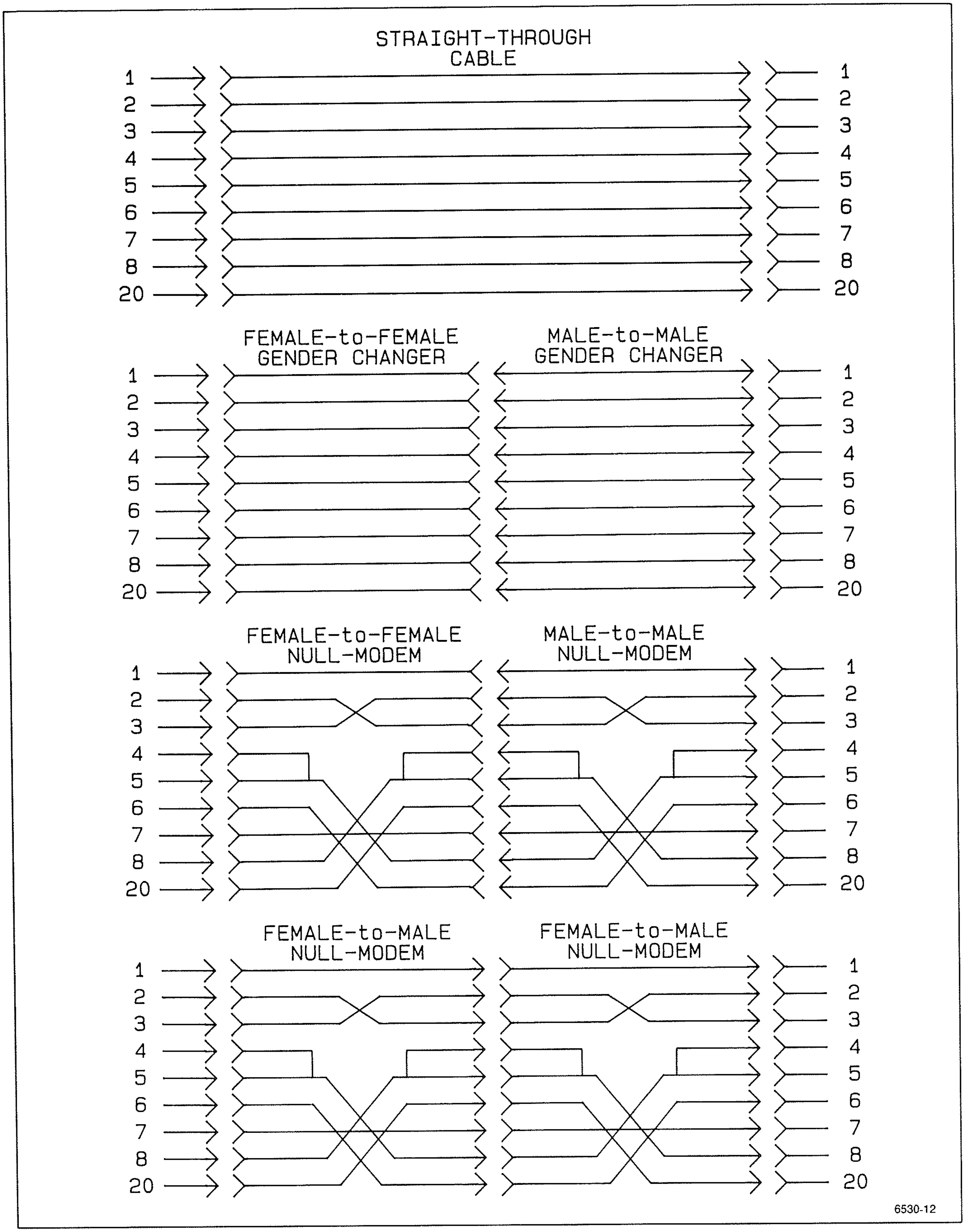


Figure B-2. Type A Connections—DTE male to DCE female.

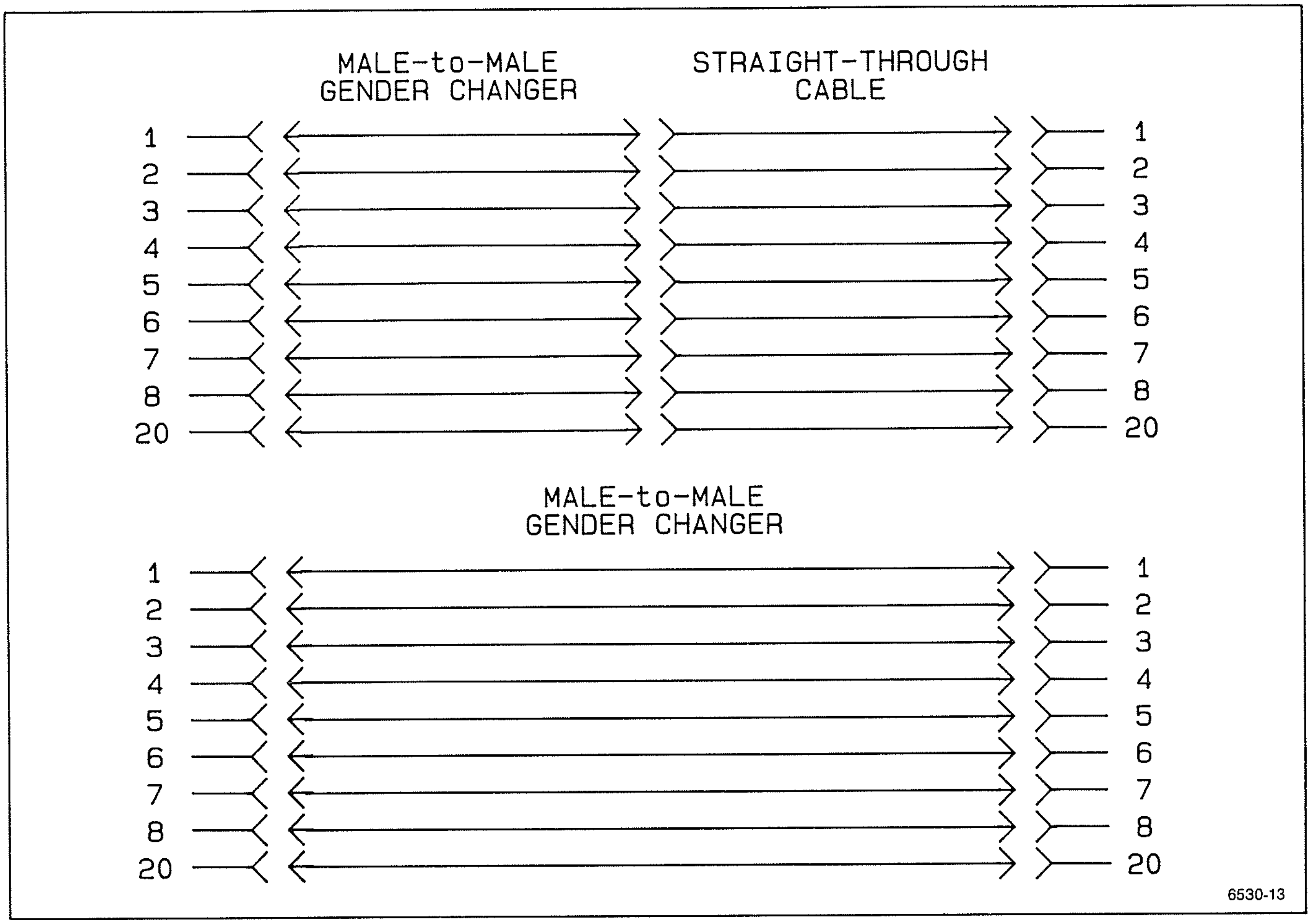


Figure B-3. Type A1 Connections—DTE female to DCE female.

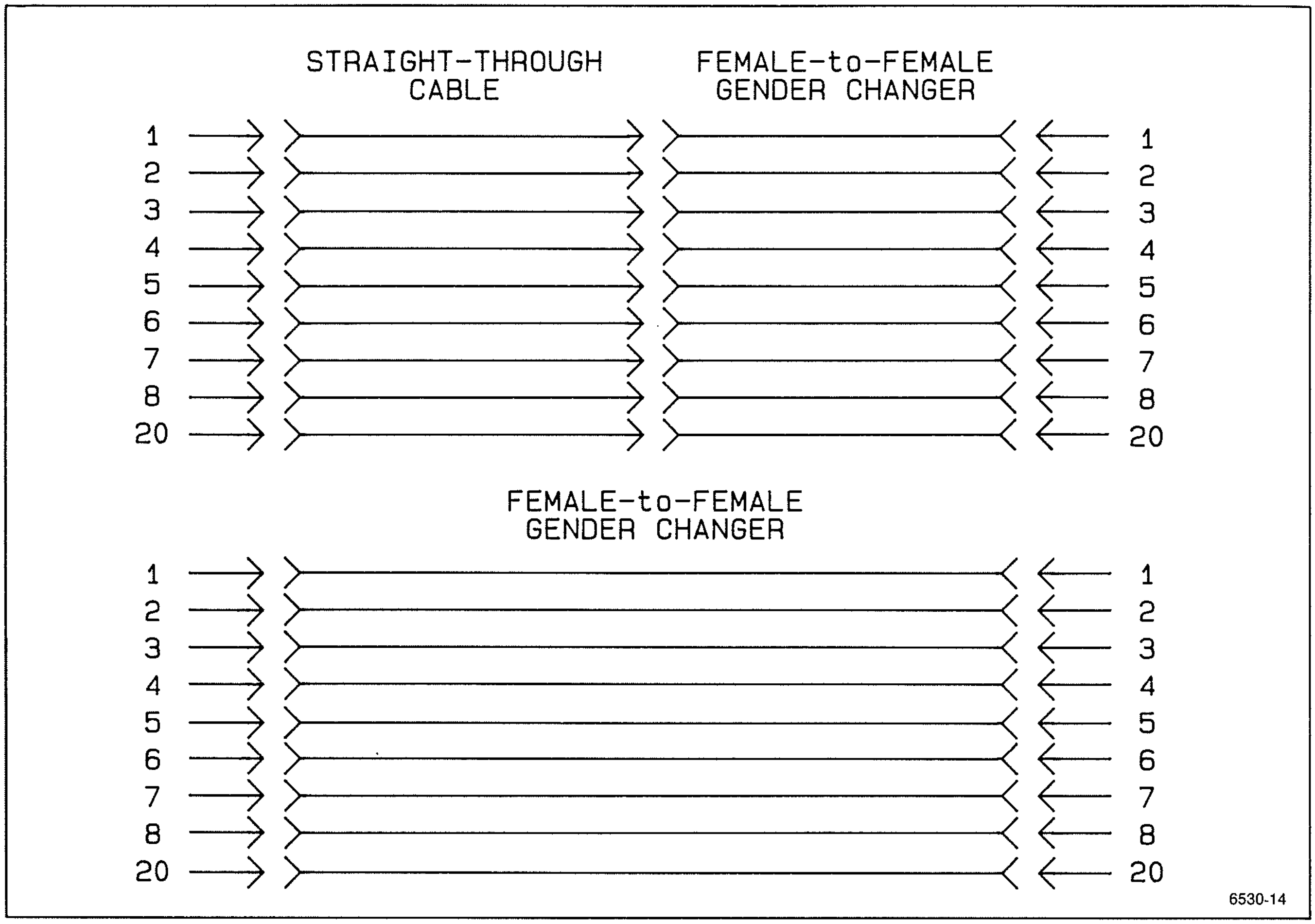


Figure B-4. Type A2 Connections—DTE male to DCE male.

INTERCONNECTION CABLE PART NUMBERS

Tektronix part numbers and stocks RS-232-C interconnection cables. Part numbers and a description are as follows:

RS-232 Interconnection cable, length 10 ft.	012-0911-00
RS-232 Null-Modem cable, length 16 ft.	012-0689-00

Type B connections require a "null-modem" cable to connect two devices of the same logical type together. Either two DTE devices or two DCE devices can be made to communicate by externally reversing the data and logic lines as shown in the figures. A gender change is needed for Type B and Type B2 connections. For Type B1 connections, a gender change is needed only to match up to the null-modem cable connectors. Gender changing can be done with the null-modem cable if it is made with the correct gender connectors for the application.

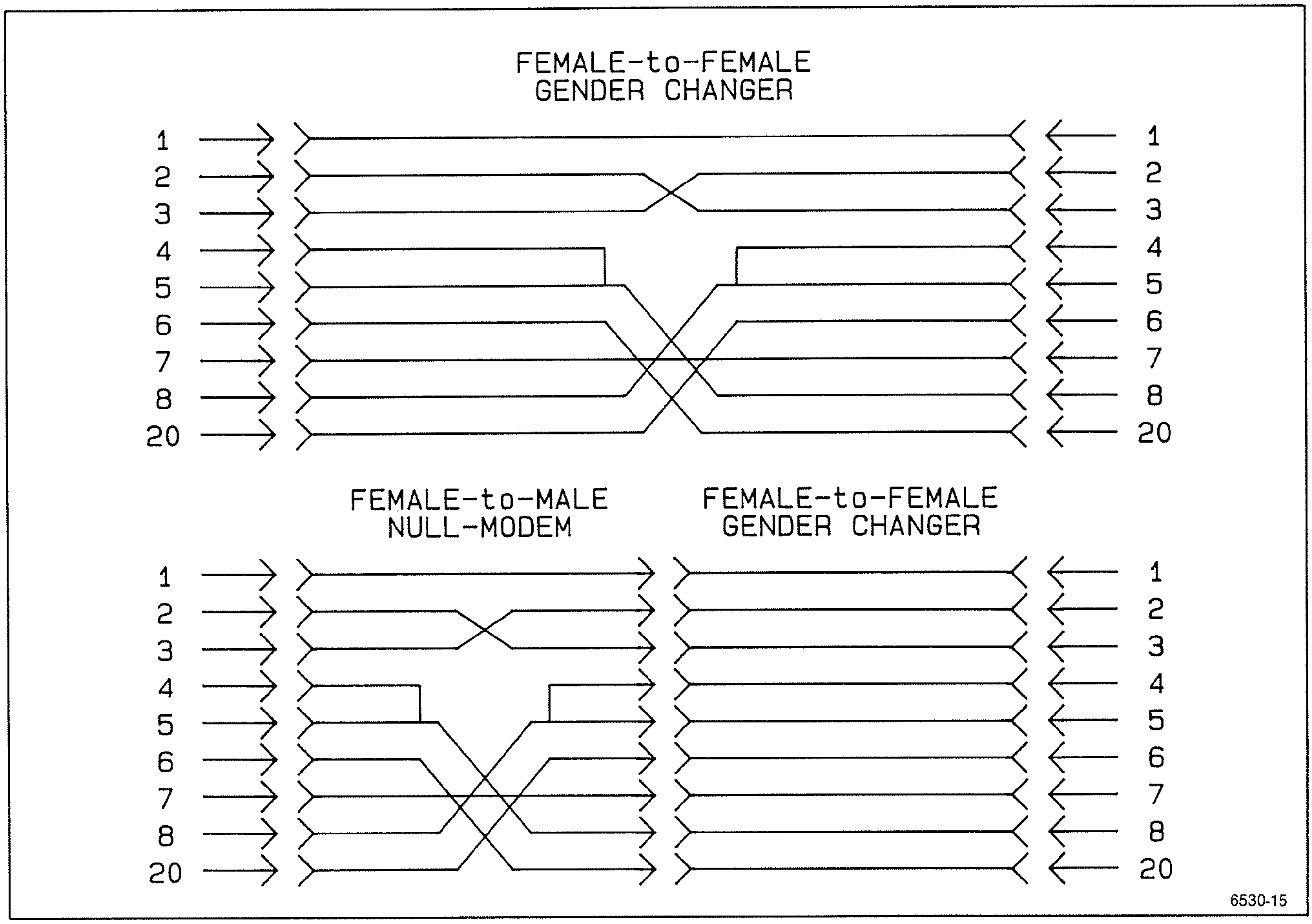


Figure B-5. Type B Connections—DTE male to DTE male and DCE male to DCE male.

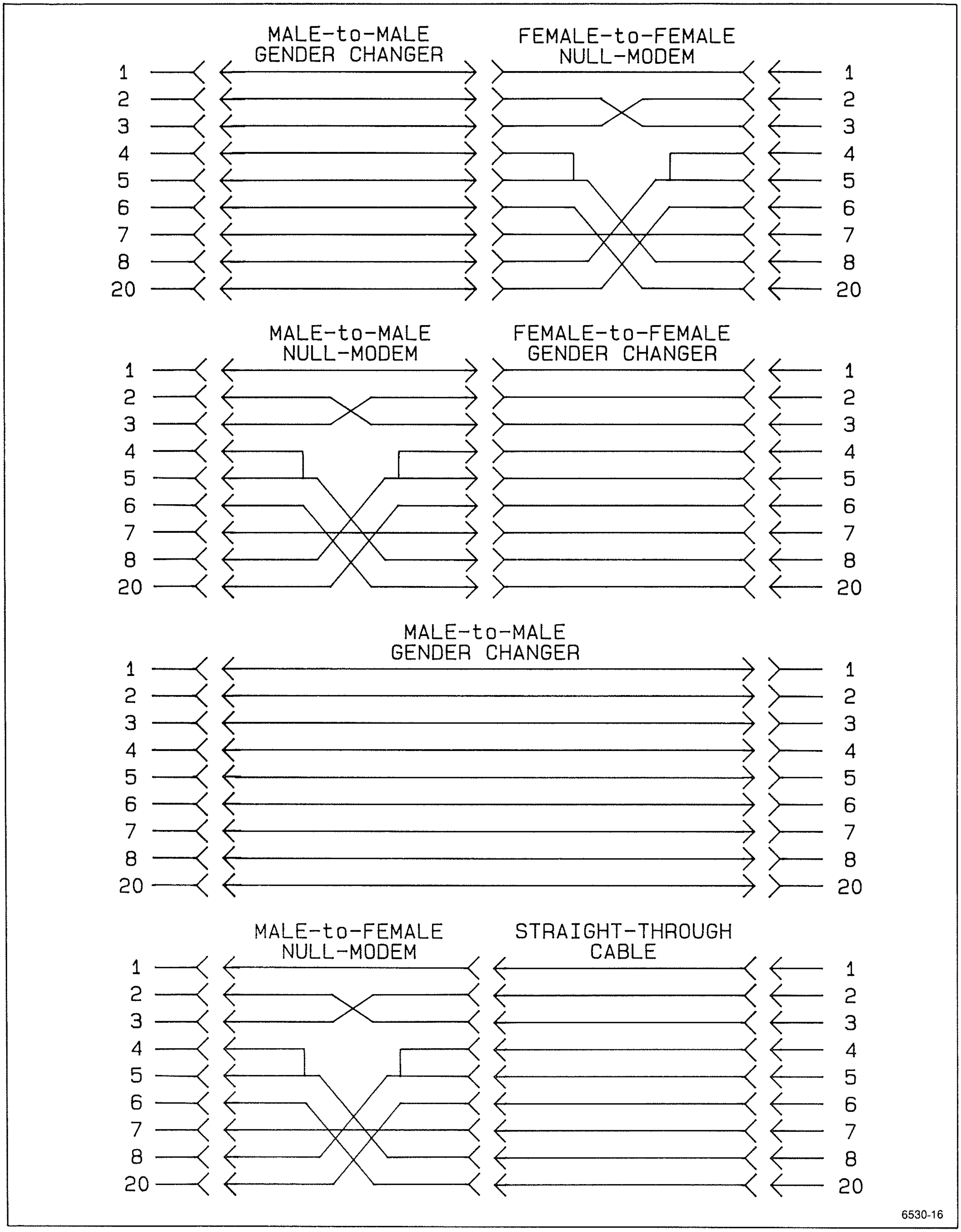


Figure B-6. Type B1 Connections—DTE female to DTE male and DCE female to DCE male.

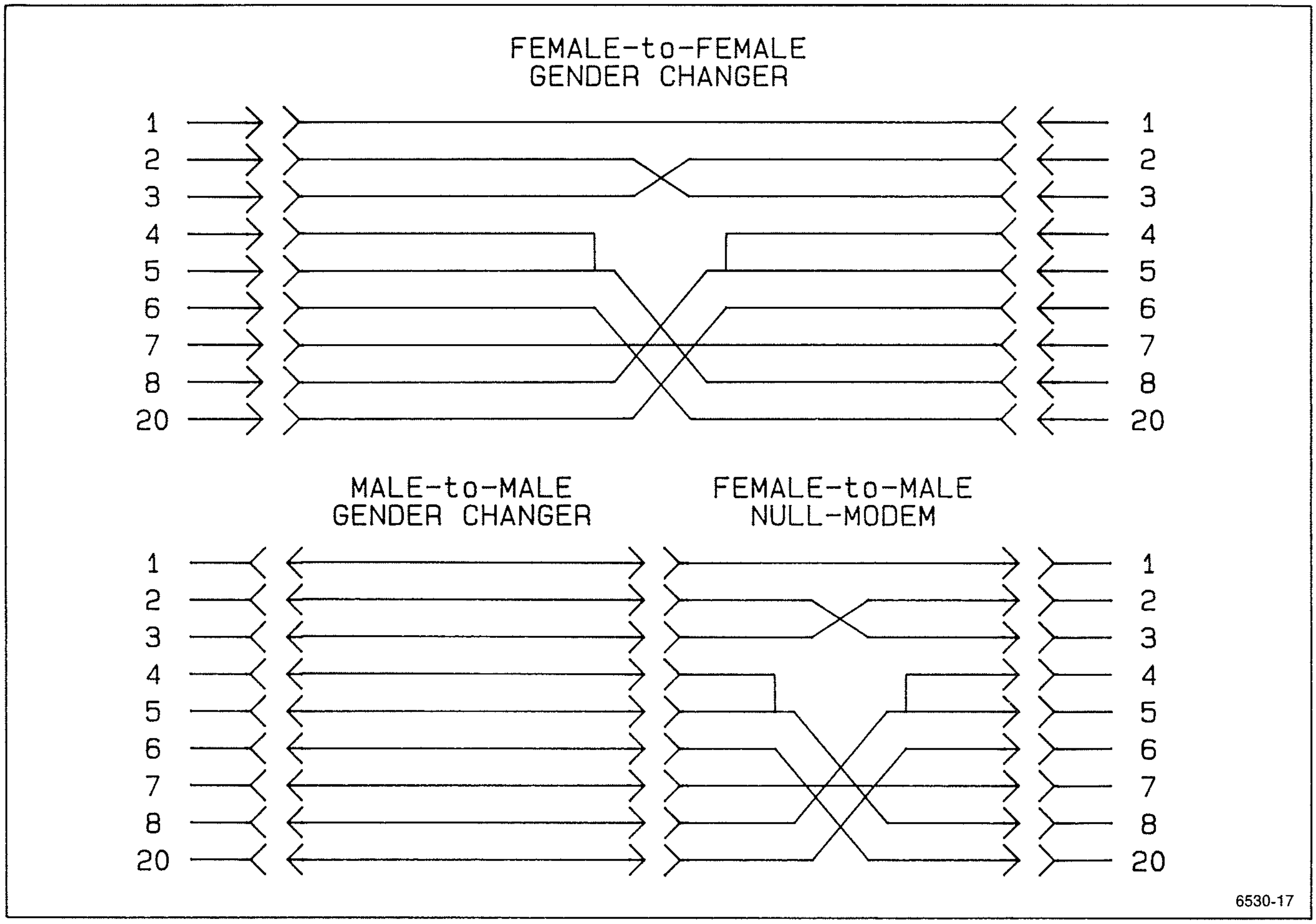


Figure B-7. Type B2 Connections—DTE female to DTE female and DCE female to DCE female.

PRINTER/PLOTTER OPERATION

PLOTTER TYPES

Both communication options allow waveform plotting through their communication port or through the X-Y plotter output. Four different digital plotter or printer formats are supported via the communications interface. They are: HP-GL®, Epson® (both low-speed, double density, and high-speed, double density), ThinkJet®, and the standard X-Y plotter.

Digital printer/plotter format can be selected two ways. The PARAMETERS switch settings (read at power on) for the compatible printer/plotter formats are illustrated in the following figures. The PARAMETERS switch supports direct oscilloscope to printer/plotter hookup. The PLOt FORmat commands (described in the Command Tables of Section 7 in this manual) may be used to select the data format when a controller is used to control the communications.

NOTE

With Option 12, a controller and an RS-232 plotter can not be connected to the oscilloscope at the same time. An X-Y plotter may be connected to the X-Y plotter output and used in conjunction with a controller. With RS-232 plotters/printers, the RS-232-C controller may still be used to set up the formats, then disconnected to permit the printer to be connected to the oscilloscope. An alternative to disconnecting the controller is to use an interconnecting switching device to switch the oscilloscope between the controller and the printer/plotter. Plotting is then controlled using the front-panel PLOT switches or menus of the oscilloscope.

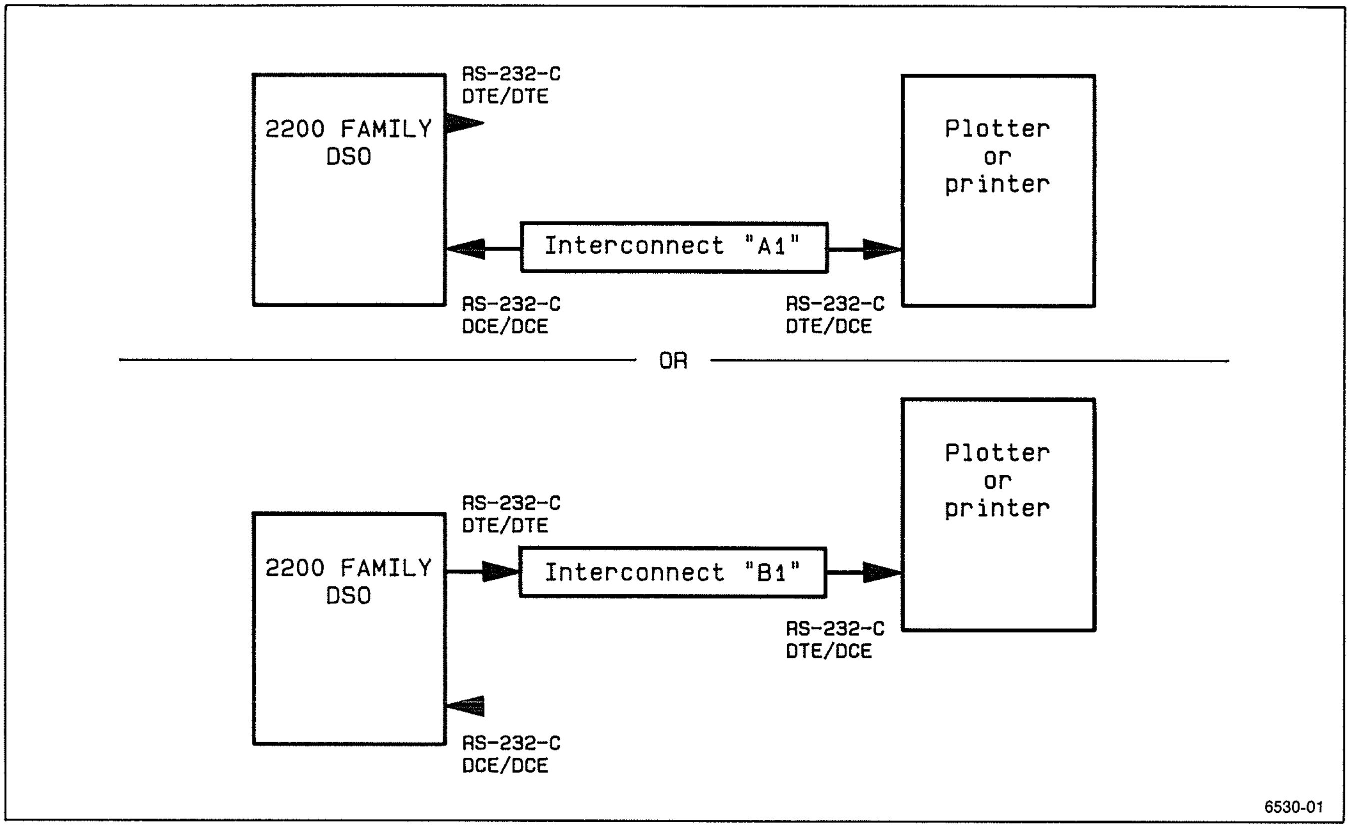
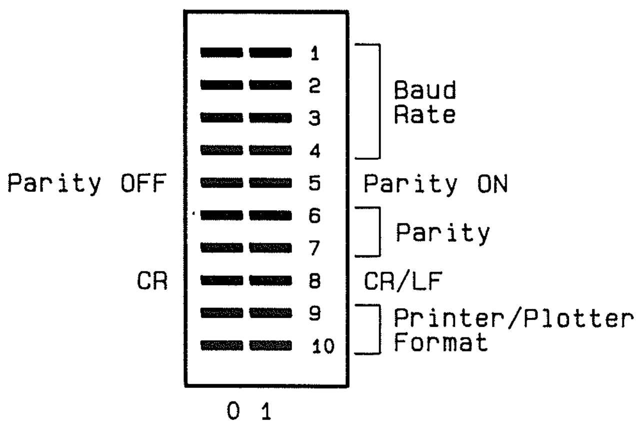


Figure B-8. Option 12 RS-232-C Printer/Plotter interconnects.



Baud Rate Settings

SWITCH S4	S3	S2	S1	BAUD
0	0	0	0	50
0	0	0	1	75
0	0	1	0	110
0	0	1	1	134.5
0	1	0	0	150
0	1	0	1	300
0	1	1	0	600
0	1	1	1	1200
1	0	0	0	1800
1	0	0	1	2000
1	0	1	0	2400
1	0	1	1	3600
1	1	0	0	4800
1	1	1	1	Off Line

Parity Settings

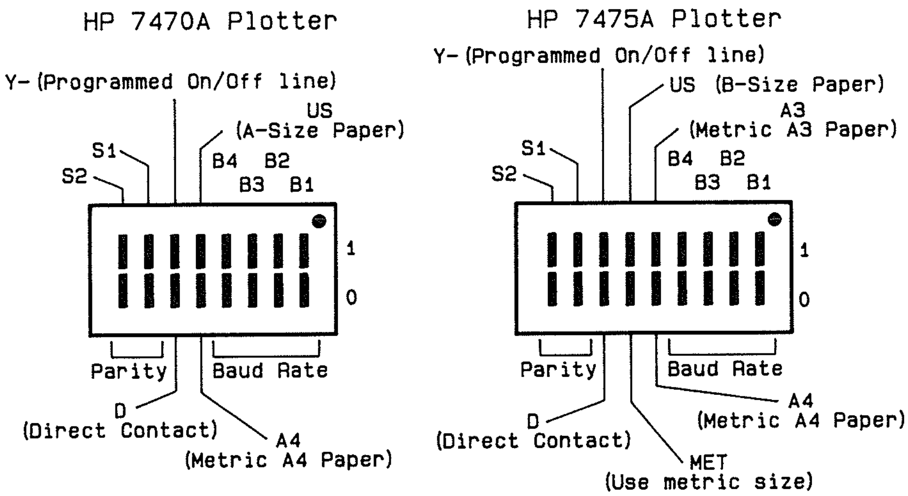
SWITCH S7	S6	PARITY
0	0	ODD
0	1	EVEN
1	0	MARK
1	1	SPACE

Printer/Plotter Format

SWITCH S10	S9	FORMAT
0	0	HP-GL
0	1	Epson 7-bit
1	0	ThinkJet
1	1	X-Y

6530-02

Figure B-9. Option 12 RS-232-C communication parameters.



Parity Settings

SWITCH S7	SWITCH S6	PARITY
0	0	NONE (8-bit)
0	1	EVEN (7-bit)
1	0	NONE (8-bit)
1	1	ODD (7-bit)

Baud Rate Settings

SWITCH S4	S3	S2	S1	BAUD
0	0	0	0	External (16x) clock
0	0	0	1	75*
0	0	1	0	110*
0	0	1	1	150
0	1	0	0	200
0	1	0	1	300
0	1	1	0	600
0	1	1	1	1200
1	0	0	0	2400
1	0	0	1	4800
1	0	1	0	9600
1	0	1	1	300*
1	1	0	0	600*
1	1	0	1	1200*
1	1	1	0	2400*
1	1	1	1	4000*

* Use two stop bits.
All others use one stop bit.

6530-03

Figure B-10. HP 7470A and HP 7475A plotter RS-232-C switch settings.

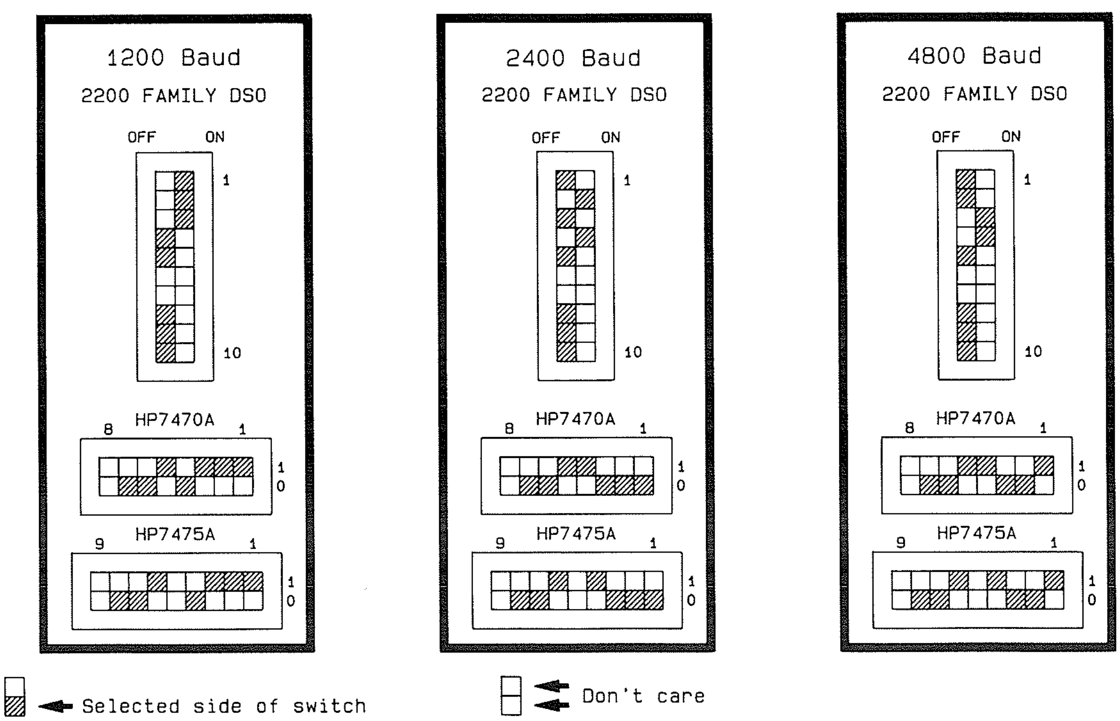
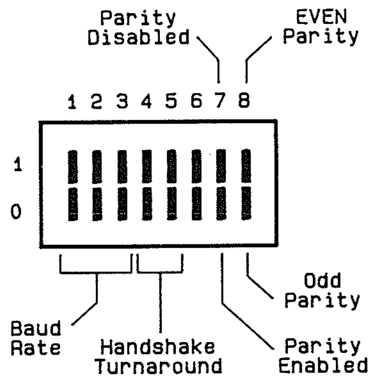
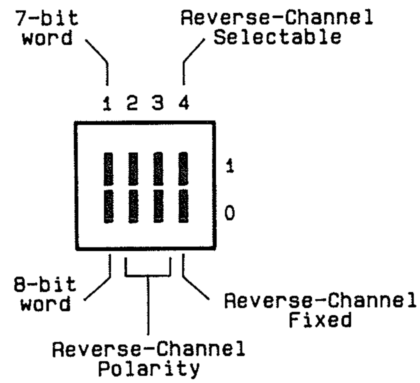


Figure B-11. Option 12 PARAMETERS switch settings for HP-GL compatible plotters.





Handshake Turnaround*

SWITCH S6	SWITCH S5	Free bytes for Turnaround
0	0	1936
0	1	560
1	0	288
1	1	152

*Printer tells sender to stop when only 16 free bytes are left in buffer until specified number of bytes are free.

Reverse-Channel Polarity

SWITCH S3	SWITCH S2	Reverse Channel (pin 11)	TxD
0	1	MARK	SPACE
1	0	SPACE	MARK

Baud Rate Settings

SWITCH S4	SWITCH S3	SWITCH S2	SWITCH S1	BAUD
1	1	1	1	Self Test
0	0	0	1	9600
0	0	1	0	4800
0	0	1	1	2400
0	1	0	0	1800
0	1	0	1	1200
0	1	1	0	600
0	1	1	1	300
1	0	0	0	200
1	0	0	1	150
1	0	1	0	135
1	0	1	1	110
1	1	0	0	75

6530-05

Figure B-12. Epson FX-Series printer RS-232-C switch settings.

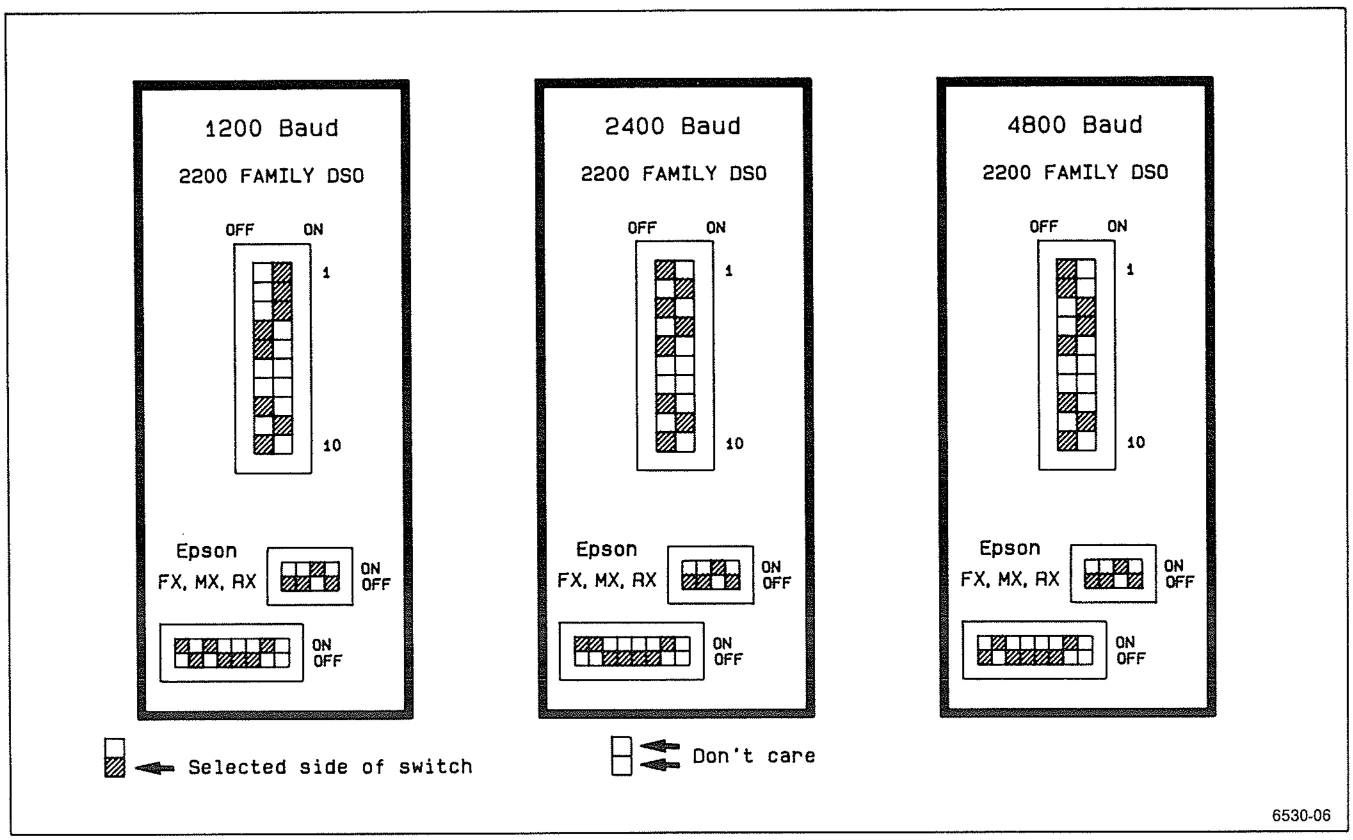
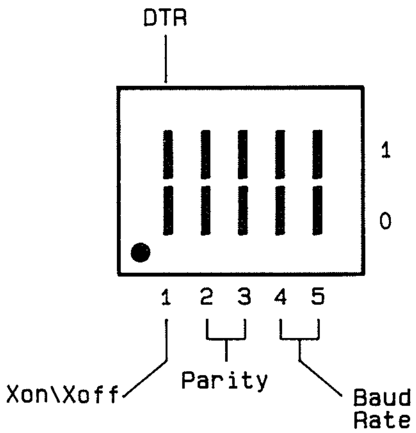


Figure B-13. Option 12 PARAMETERS switch settings for Epson printers.



Baud Rate Settings

SWITCH S4	SWITCH S5	BAUD
1	1	1200
1	0	2400
0	1	19200
0	0	9600

Parity Settings

SWITCH S2	SWITCH S3	PARITY
0	0	NONE (8-bit)
0	1	ODD (7-bit)
1	0	EVEN (8-bit)
1	1	ONES (7-bit)

6530-07

Figure B-14. HP ThinkJet RS-232-C switch settings.

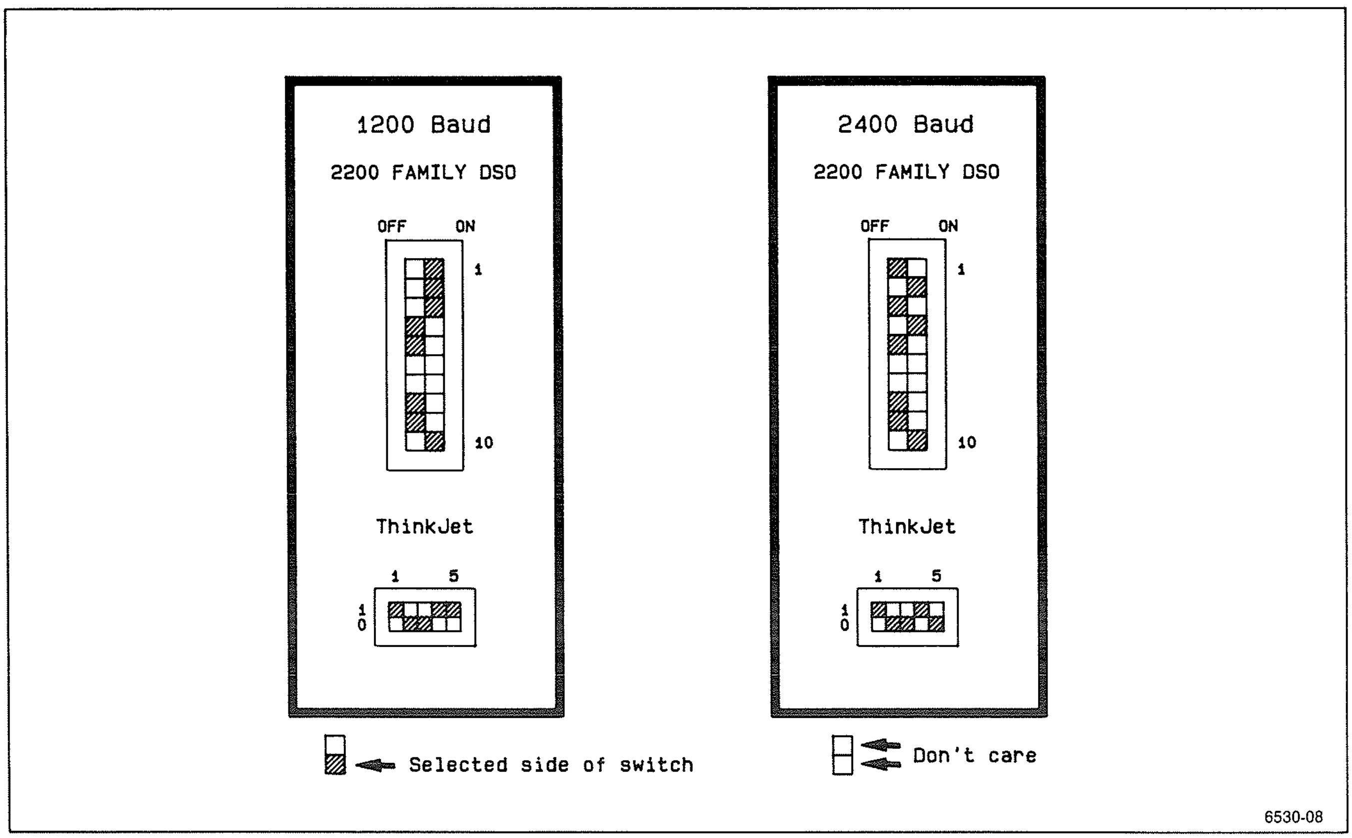


Figure B-15. Option 12 PARAMETERS switch settings for HP ThinkJet printer.

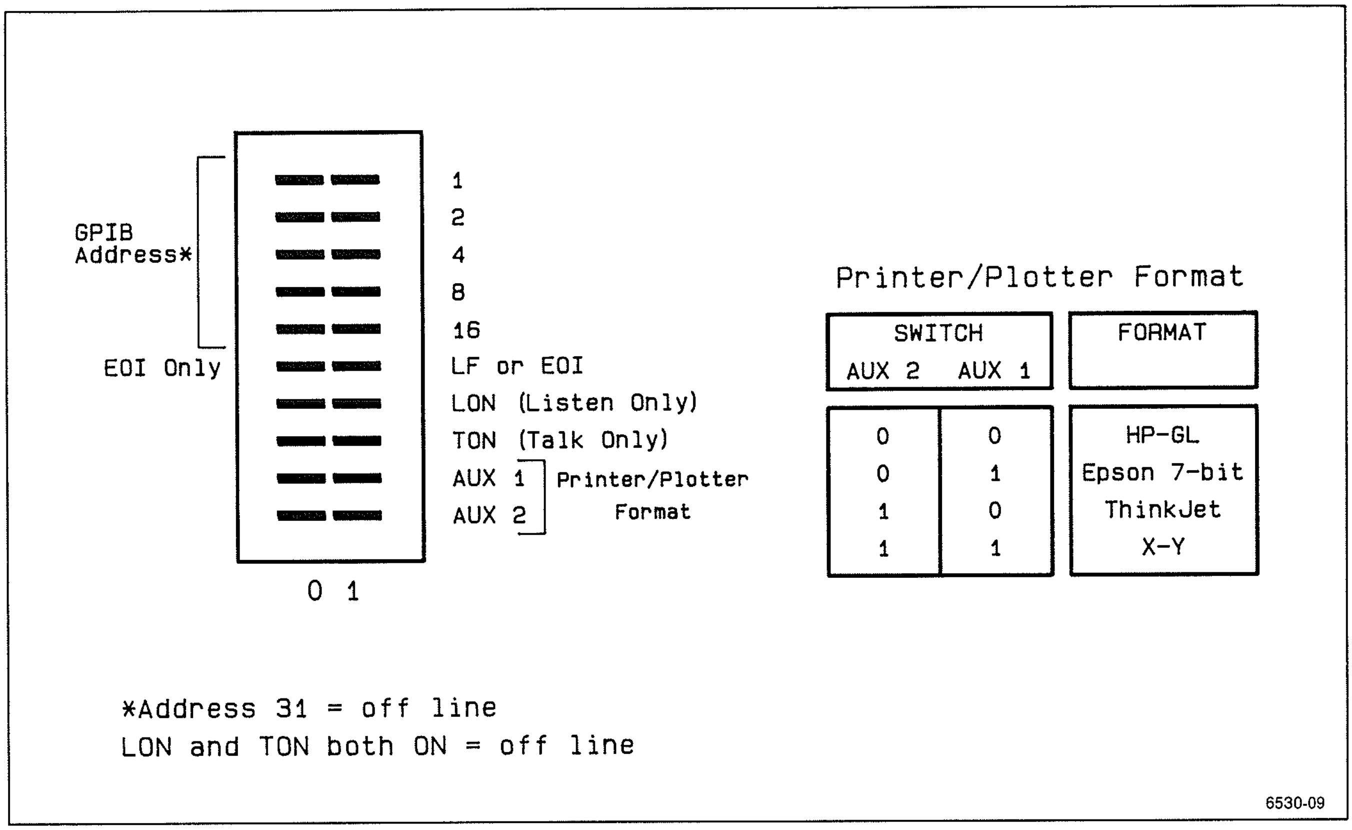


Figure B-16. Option 10 GPIB Interface PARAMETERS switch.

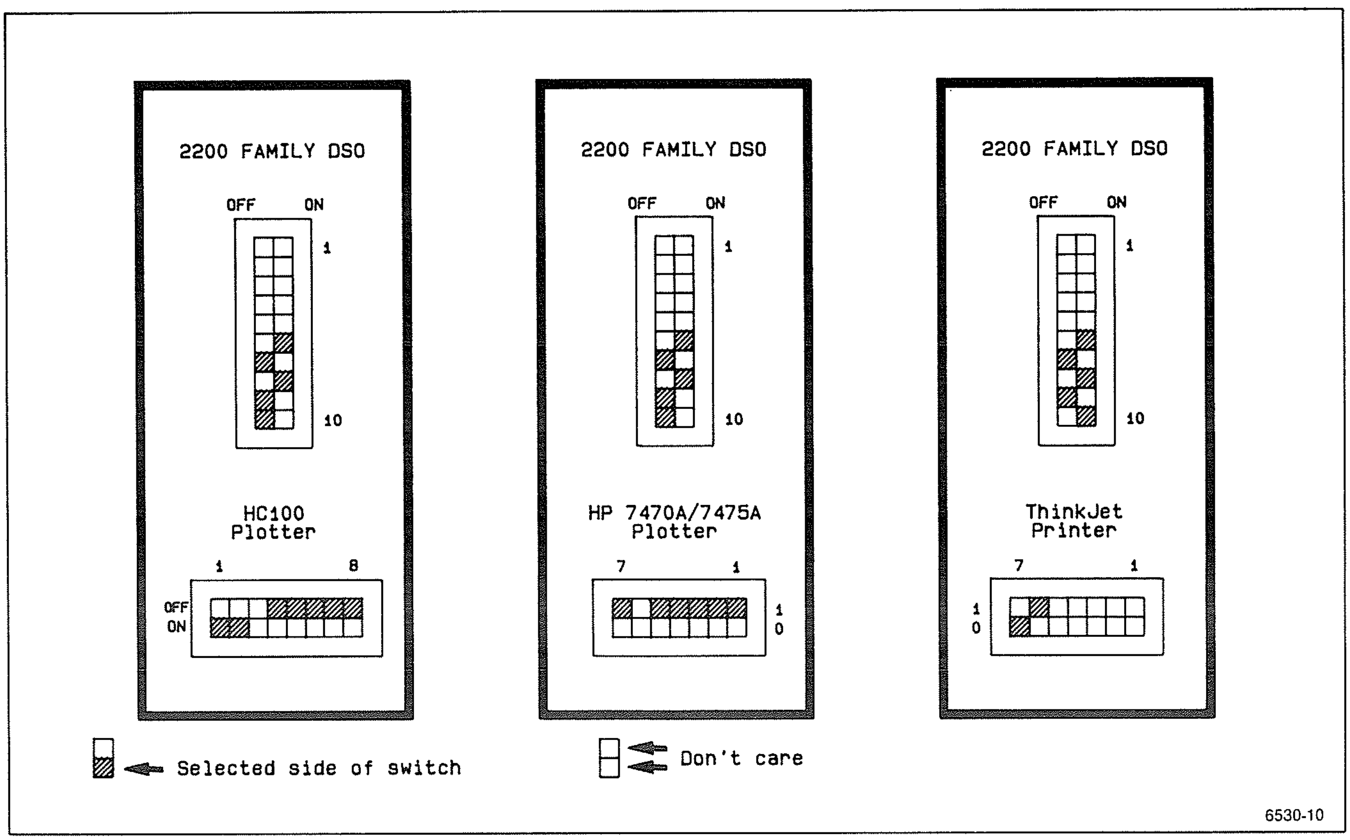


Figure B-17. Option 10 PARAMETERS switch settings for compatible GPIB printers/plotters.

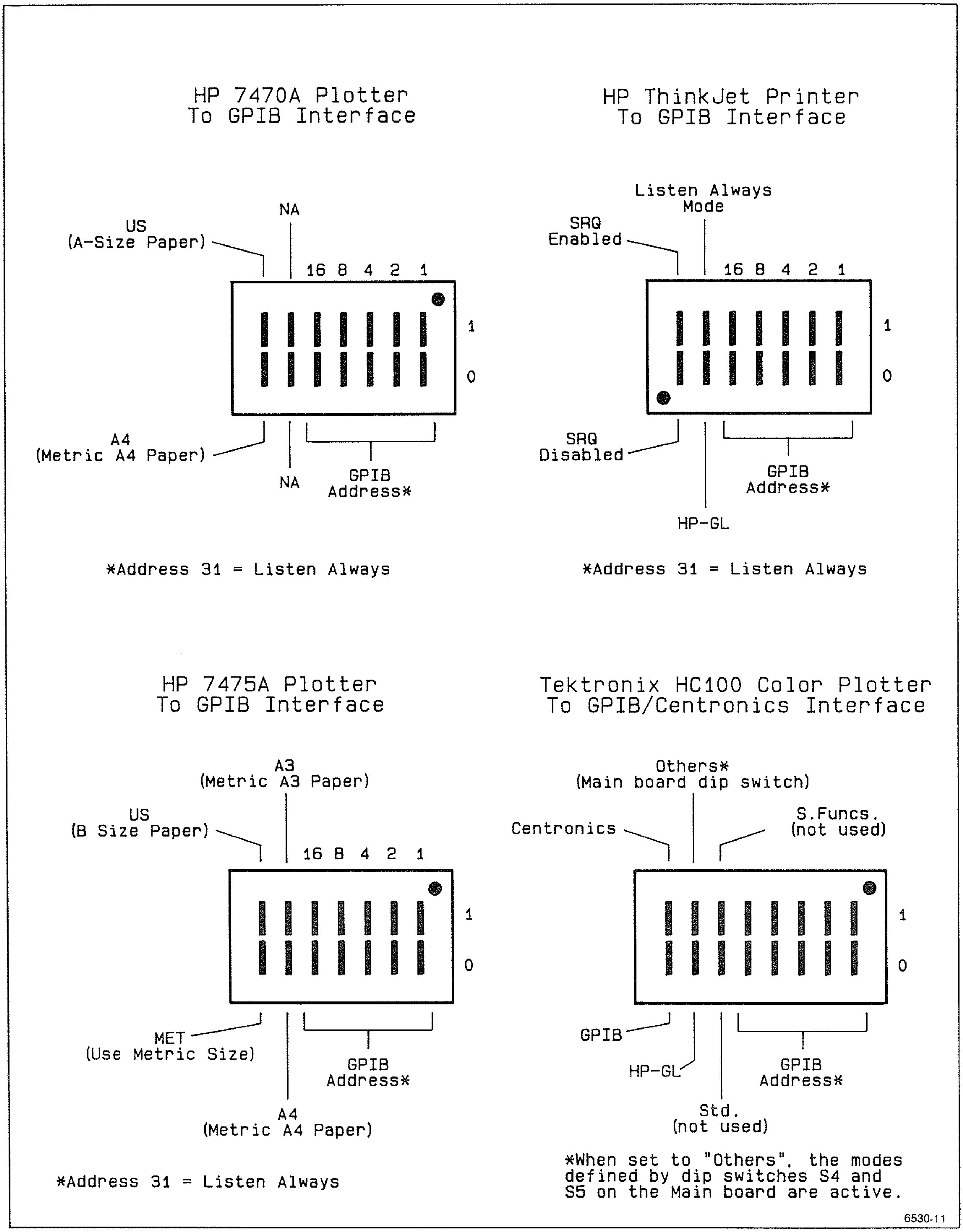


Figure B-18. Switch settings for compatible GPIB plotters.

QUESTIONS AND ANSWERS

Here are answers to some typical questions that you may have about operation of the Communications Options.

Q: What is the data transfer rate?

A: For the Option 10 GPIB interface, the data transfer rate is approximately 1 Kbyte per second. This equates to one waveform per second for 1 K records or about four seconds for 4 K waveform records.

For the Option 12 RS-232-C interface, the data transfer rate depends on the format (ASCII, HEX, or BINARY) and the baud rate. Typical times for 1200, 2400, and 4800 baud are given in Table B-2.

Table B-2
RS-232-C Transfer Rates

Baud Rate	Record Size	Format	Transfer Time (Min:Sec)
1200	4K	ASCII	2:20
		HEX	1:10
		BINARY	0:36
	1K	ASCII	0:36
		HEX	0:20
		BINARY	0:10
2400	4K	ASCII	1:15
		HEX	0:40
		BINARY	0:20
	1K	ASCII	0:19
		HEX	0:10
		BINARY	0:05
4800	4K	ASCII	2:39
		HEX	1:16
		BINARY	0:45
	1K	ASCII	0:58
		HEX	0:29
		BINARY	0:13

Q: Why does the data transfer rate slow down at 4800 baud?

A: At that baud rate, the internal data buffer of the 2200 Family oscilloscope fills before the oscilloscope's processor is ready. That interrupts the processor from its other tasks, and it must stop to issue flow control commands to halt further data input while it gets ready to accept the data from the buffer. After it handles the buffer data, it must then start the data input again. All the interrupt handling slows down the transfer rate. At 2400 baud, the oscilloscope's processor is usually ready to handle the incoming data before the buffer fills, and it is not necessary to continually interrupt the data flow.

Q: The operators manual states that multiple commands may be sent in one message line, but sometimes errors are generated when I try this with Option 12. Why is that, and what can I do about it?

A: To answer the second question first, write RS-232-C controller programs to send only one command at a time.

For the first question of why multiple commands sometimes cause errors, the answer is that only one command at a time can be reliably handled by the processor. Commands (and arguments to commands) are interpreted and handled as they are recognized; the oscilloscope processor does not wait for the message terminator to end the message. If a service request is generated by one of the commands in a command string, a correcting action may have to be taken. If the service request is not handled properly, all following commands in a string may not be valid, and the controller program may not be able to continue.

Q: Sometimes when I send commands to change the operating state of the instrument, they are not accepted. What is the problem?

A: The REM ON command must be sent as the first command before attempting to change the operating state of the oscilloscope. The power-on state of REM is OFF.

Q: When I send waveforms to the oscilloscope at 2400 baud or more, I get bad transfers when I try to use binary-encoded curve data. What is the problem?

A: Flow control must be used when sending waveform data to the oscilloscope at the higher baud rates. That is because the input data buffer is only 160 characters long and it fills up before the processor is ready to handle the input. Because of the nature of binary data, flow control can not be used to reliably send or receive binary-encoded curve data. Use either HEX or ASCII encoding instead. HEX-coded waveform data requires fewer characters to be transferred than ASCII-coded waveform data, and therefore is faster than ASCII format. Also, parity must be disabled with the PARAMETERS switch setting for binary data transfers. That setting has to be made before the instrument is turned on since power-on is the only time the switch is read.

Q: What is the size of the oscilloscope's data output buffer?

A: The output buffer is about 1,000 characters.

Q: Why do I sometimes get bad curve data when I operate the DSO in the Repetitive Store Mode?

A: This problem is caused by not allowing enough sweeps to occur to fill the entire waveform record. Repetitive Store Mode (random equivalent-time sampling) depends on the probability of filling the waveform record in a specified number of sweeps. The more sweeps that are used to sample an input signal, the more probable it is that the waveform record will be filled when the waveform is asked to be transferred. If you receive bad curve data, you must allow more sweeps to occur before requesting the waveform from the oscilloscope.

One way to do this is to set the number of sweeps (via either the oscilloscope's menu controls or a command message) to a value several times larger than the number of sweeps needed for a 50% probability of filling the record (see Controls, Connectors, and Indicators—Section 3 of the Operators manual). Also, you can set RQS and OPC on. Then, when the specified number of sweeps have been acquired, the oscilloscope will issue a single SRQ (service request). When the controller software determines that an the end-of-acquisition OPC state caused the service request, it can request the curve data.

Q: When operating in ALT or CHOP Vertical Mode, how do I designate from which channel of the acquisition or reference memory the waveform data is retrieved? How do I designate in which channel of a reference memory the waveform data is stored when sending waveforms to the oscilloscope?

A: The data channel for source and target for waveform transfers is designated using the REFERENCE WAVEFORM commands (see DATa CHAnnel). Either channel of the acquisition or Save Ref memory may be retrieved from the oscilloscope. Waveform data may be sent to either channel of a targetted Save Ref memory (see DATa TARget).

Q: What is the purpose of the external clock?

A: The external clock can be used to acquire signals that change too slowly for the normal calibrated SEC/DIV settings (for example, one sample every hour). Another use is to synchronize the 2230 so that samples are done on selected events.

Q: Can you re-arm Single Sweep via the communication option?

A: The Single Sweep function may be armed using the SGLswp ARM command. Single Sweep may also be queried to determine the state of the Single Sweep function (ARM or DONE).

Q: What is the maximum sensitivity in digital storage?

A: It is 2 mV/division, the same as in nonstore mode.

Q: Can I compress, expand, or reposition the stored waveforms?

A: The 2230 has commands for reformatting a target reference waveform; the 2220 and 2221 do not.

Q: What is the maximum expansion/compression factor for stored waveforms with the 2230?

A: Vertically, the reformat target waveforms may be expanded or compressed by a factor of ten from their acquired VOLTS/DIV setting. Horizontally, the X10 Magnification feature may be turned on for the reformat target waveforms.

Q: Can I return a reformatted waveform back to its original settings?

A: Yes. Query the BASegain to determine the acquired volts/div setting and set the VGAin to that setting. To return to the original vertical position, set VPOsition to 0; turn HMag off to regain the acquired sec/div setting.

Q: Can the baud rate, end-of-line terminator, or parity setups be changed from the RS-232-C controller?

A: No. Those communications parameters must be set up using the PARAMETERS switch on the oscilloscope's side panel before the oscilloscope is turned on.

Q: Can the GPIB address of the oscilloscope be changed from the bus or the front-panel?

A: The GPIB address and other communication parameters are settable only from the PARAMETERS switch on the oscilloscope's side panel, and the switch settings are read only at power on.

Q: Can a waveform preamble be sent to the instrument?

A: Yes, a waveform preamble can be sent to the oscilloscope. That preamble should correspond to the curve data that is sent to the target Save Ref memory.

Q: Can the waveform display be modified by changing the preamble fields?

A: Modifying the preamble information so that it does not correspond to the curve data invalidates the waveform, but it doesn't usually change the way it is displayed. If drastic changes are made to the preamble (such as data encoding or point format), the oscilloscope will probably reject the curve data as not matching the preamble.

Q: What type of averaging is used for the AVERAGE acquisition mode?

A: A normalized averaging algorithm is used.

$$A_s = A_{(s-1)} + (i_s - A_{(s-1)}) \text{ (Weight)}$$

Where:

A_s	= the average after s number of sweeps,
$A_{(s-1)}$	= the average after (s−1) sweeps,
i_s	= the sth input sample,
Weight	= the selectable weighting factor from 1/1 though 1/256 in a power of 2 sequence.

Q: Can I get readout information over the communications interface?

A: CRT display information may be queried individually or obtained as part of the waveform preamble. The volts/div, sec/div, acquisition mode, trigger information, and cursor readouts are all available in the 2221 and 2230. Vertical information (except for Vertical Mode) and cursor readouts are not available with the 2220.

Q: What is the 26-K non-volatile memory supplied with the 2230 Communications option, and what are its waveform storage capabilities?

A: Memory space for 26, 1-K waveforms, or 6, 4-K waveforms, or any combination of waveform record totaling not more than 26 K bytes is provided by the added memory. The non-volatile memory is battery-backed for long-term waveform data storage.

Q: Can acquired waveforms be stored in the added memory using the 2230 front-panel controls?

A: Yes. Waveforms may be transferred into and out of the added memory using the Reference menu selections available in the Advanced Functions Menu. Waveforms must be transferred through one of the numbered Safe Ref memory locations (REF1—REF4).

Q: How are the waveforms stored in the added memory addressed via the 2230 communications option?

A: The added memory locations are designated REFA through REFZ. These memory locations are accessed through the REF1—REF4 memory locations for both reading and writing using the REFFrom and SAVeref commands; they cannot be directly accessed.

Q: What are the differences between Peak Detect (PEAK) and Accumulated Peak Detect (ACCPEAK) acquisition modes?

A: Peak Detect and Accumulated Peak Detect are both envelope acquisition modes. Peak Detect captures the maximum and minimum points for each sample interval during each successive acquisition. Accumulated Peak Detect holds previously acquired peak values until reset so that the changes over time are detectable. Accumulated Peak Detect is valid only for triggered acquisitions and is not allowed in untriggered modes. Peak Detect is valid for both triggered and untriggered modes, since no peaks are held between acquisitions.

Q: What is the default number of acquisitions in ACCPEAK mode?

A: The number of sweeps that may be accumulated can be set for a default of continuous (ACQ NUM:0) or any number between 1 through 2047. With each new acquisition, the most-positive and most-negative values are added to the existing display. When set to a specified number, the acquisition stops when the limit is reached, and the waveform is held displayed.

Q: What is the envelope sampling rate in Peak Detect and Accumulated Peak Detect?

A: 20 megasamples per second.

Q: Can the 2230 and 2221 cursor positions be addressed over the communications interface?

A: Yes. The cursors may be targeted to the acquisition or a Save Reference waveform and positioned within the waveform record. Their voltage difference and time difference may be queried to determine the readout values.

Q: Is delay time included in the 2230 waveform preamble?

A: No. The preamble does not indicate if the curve data was taken at an A or a B SEC/DIV setting, just what the SEC/DIV setting is for that curve data.

Q: Are the displayed intensified zones seen in a 2230 acquisition stored in either SAVE mode or in SAVE REF memory?

A: Yes, they are saved in both SAVE and in SAVE REF.

Q: What waveform data is sent by a 2230 if the waveform acquired in BOTH Horizontal Mode is requested?

A: The A Sweep waveform is sent.

Q: Can a waveform be sent to a controller from the front panel of the oscilloscope?

A: No, but the waveform may be sent to plotter or printer. With Option 10, the oscilloscope must be in Talk Only mode. With either option, the PARAMETERS switch must be set to output the correct format for the printer or plotter being used. See Section 7 of the Operators Manual and the Printer/Plotter Operation text in this Appendix for information.

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MANUAL CHANGE INFORMATION

Date: 6-23-88 Change Reference: C1/0688(REV)

Product: 2230 OPERATORS Manual Part No.: 070-4998-02

DESCRIPTION Product Group 41

EFFECTIVE ALL SERIAL NUMBERS

TEXT CHANGES

Page 1-4 Table 1-1

Replace the Characteristics and Performance Requirements for the "Aberrations (NON STORE and STORE in Default Modes)".

Characteristics	Performance Requirements
Aberrations (NON STORE and STORE in Default Modes)	
2 mV/div to 50 mV/div	+4%, −4%, 4% p-p. 3% or less at 25°C with cabinet installed.
0.1 V/div to 0.5 V/div	+6%, −6%, 6% p-p. 5% or less at +25°C with cabinet installed.
1 V/div and 2 V/div	+12%, −12%, 12% p-p. 10% or less at +25°C with cabinet installed.
5 V/div	+12%, −12%, 20% p-p. +10%, −10%, 20% p-p at +25°C with cabinet installed. Measured with a five-division reference signal, from a 50 Ω source driving a 50 Ω coaxial cable terminated in 50 Ω at the input connector with the VOLTS/DIV Variable control in the CAL detent. Vertically center the top of the reference signal.

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MANUAL CHANGE INFORMATION

Date: 5-26-88 **Change Reference:** M66862

Product: 2230 OPERATORS **Manual Part No.:** 070-4998-02

DESCRIPTION Product Group 41

The Standard Test Probes for your instrument have been replaced with the P6109 Test Probes. Please note this change in the Standard Accessories List in this manual.

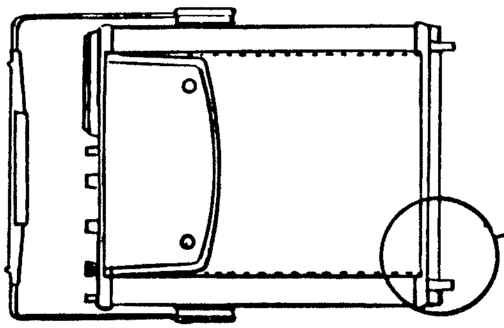


FIG - 2

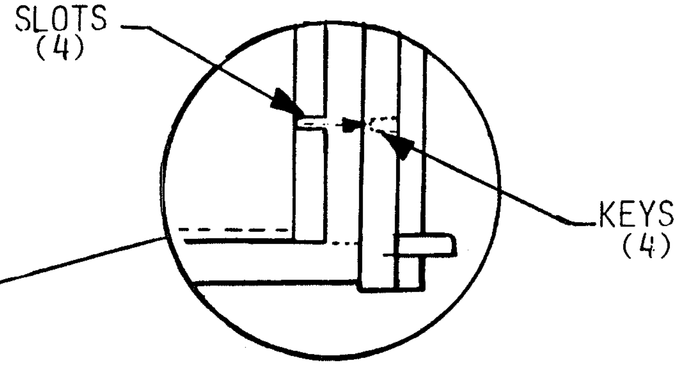


FIG - 3

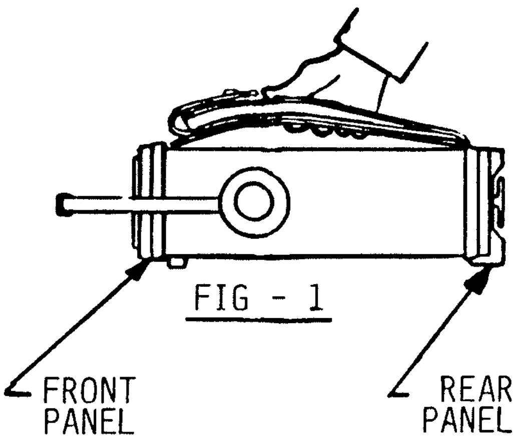
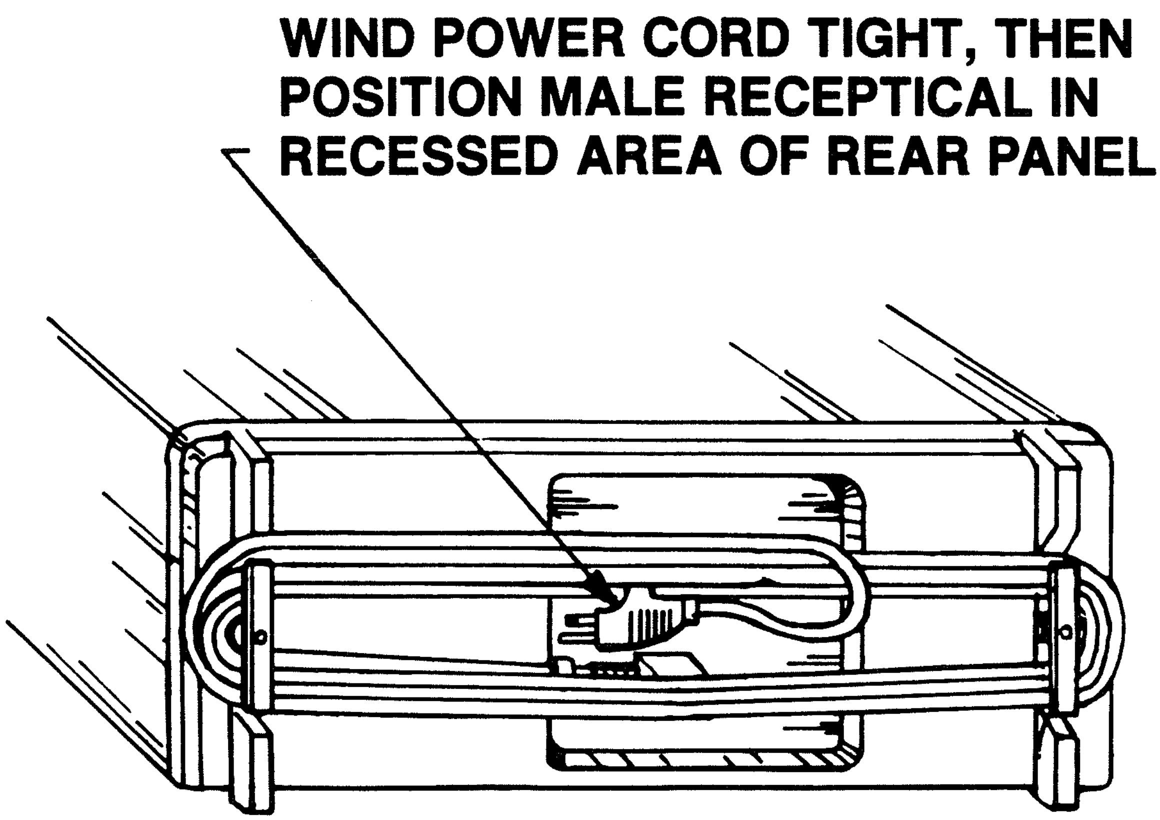


FIG - 1

POUCH MOUNTING - (2200 INST)

1. POUCH IS MOUNTED ON TOP, SECURED BY THE TWO END PANELS
2. POUCH CAN BE MOUNTED BY ARCHING THE POUCH & SLIDING THE TWO ENDS UNDER THE REAR & FRONT PANELS. (SEE FIG - 1)
3. WHEN POUCH IS SECURED PROPERLY THE (4) SLOTS IN THE METAL POUCH PLATE WILL MATE WITH THE (4) KEYS INSIDE THE FRONT & REAR PANELS (SEE FIG - 3)



2200 SERIES POWER CORD WRAP