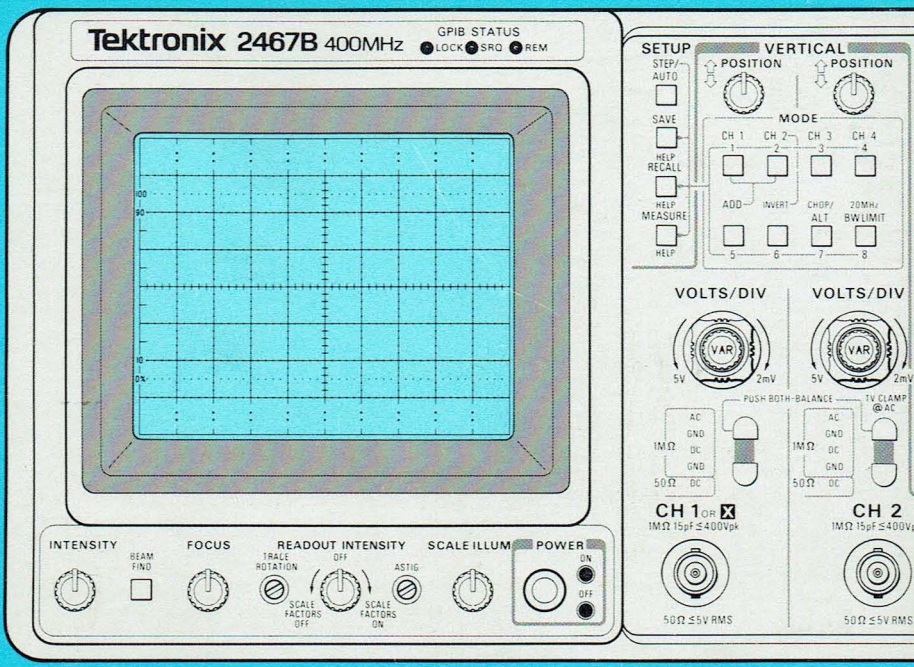
24X5B/2467B OPTION 10 INSTRUMENT INTERFACING GUIDE



Tektronix®
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TEK

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Product Group 38

24X5B/2467B OPTION 10 INSTRUMENT INTERFACING GUIDE

Please Check for CHANGE INFORMATION at the Rear of This Manual

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INSTRUMENT SERIAL NUMBERS

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

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

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Operators Safety Summary

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

Terms

In This Manual

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

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

As Marked on Equipment

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

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

Symbols

In This Manual

This symbol indicates where applicable cautionary or other information is to be found. For maximum input voltage see Table 6-1.

As Marked on Equipment

DANGER—High voltage.

Protective ground (earth) terminal.

ATTENTION—Refer to manual.

Power Source

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

Grounding the Product

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

Danger Arising From Loss of Ground

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

Use the Proper Power Cord

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

Use only a power cord that is in good condition.

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

Use the Proper Fuse

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

Do Not Operate in Explosive Atmospheres

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

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.

1

Introduction

Introduction

The Tektronix 2445B, 2455B, 2465B, and 2467B Portable Oscilloscopes have raised measurement capability and operator efficiency far above previous standards. These qualities are enhanced by a family of Options. Options are available individually or in Special Editions which combine them in synergistic packages.

Table 1-1
Functional Enhancement Options

Number	Designation	Function
10	IEEE-488 (GPIB) Interface	Adapts the oscilloscope to measurement systems. (Included in 2465B DV, 2465B DM, 2465B CT.)
06/09	Counter-Timer-Trigger (CTT)	Measures frequency, period, or total; enhances timing accuracy; delays trigger by event count; triggers on signal combinations. (Included in 2465B DV, 2465B DM, 2465B CT.)
09	Word Recognizer (WR)	Triggers sweep or counter on 17-bit word. (Included in 2465B DV, 2465B DM, 2465B CT.)
01	Digital Multimeter (DMM)	Measures V_{dc}, V_{rms}, A_{dc}, A_{rms}, resistance, continuity, temperature, dB, averages, and changes, with 4 1/2 digits (included in 2465B DV, 2465B DM).
05	TV/Video Analysis System (TV)	Triggers on selected video lines; clamps "back porch." (Included in 2465B DV.)

This Interfacing Guide shows how to use the 24X5B/2467B Oscilloscopes with Option 10 in a GPIB system. It explains the instruments' measurement capabilities, how to set them up for GPIB operation, and how to communicate with the oscilloscopes and their options with a system controller. Consult the instrument operators manual for basic measurement techniques.

If your instrument is configured with the GPIB and CTT (Options 10 and 06 or Options 10 and 09), it can measure frequency, period, time interval, rise and fall time, slew rate, duty factor, frequency ratio, and other signal parameters automatically and with generally greater accuracy and resolution than the automated Parametric Measurements available with the base instrument. The DMM adds precise measurements of low-speed signals to the possibilities for automation.

If your tests are not suited to automation, a measurement system can interact with an operator through the instrument. The controller sets the scope to display a waveform and the operator positions ΔV or Δt cursors to the points of interest. The controller then logs the measurement or compares it to limits. In other applications, the operator adjusts a circuit or device by looking at an automatically displayed waveform. Cursors can indicate test limits or adjustment targets.

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Measurement Capabilities and Characteristics

Measurement Capabilities and Characteristics

Automated Parametric Measurements

The GPIB option allows access to the automated parametric measurements available from the front panel. The A and B triggers, A and B sweeps, and the AC trigger coupling capacitor are used to make automated time and voltage measurements. All of these measurements are repetitive, requiring stable signals to function properly.

Cursors

For semiautomatic measurements, the cursors aid communication between the system and the operator. An operator can align the cursors with specific waveform features and the controller can assimilate the data. A controller can set the cursors to nominal starting positions, close to the actual measurement or to limit positions within which a waveform should fall.

The cursors give excellent accuracies. They eliminate graticule interpolation and they eliminate CRT geometry errors. Time measurements spanning 4 divisions or more are accurate within ±1.25% of reading with X10 MAG off or ±1.75% with X10 MAG on. Low-frequency voltage measurements spanning 3.2 divisions or more are accurate within ±2.25%. Always use the largest possible display of any waveform for the best accuracy.

For intervals less than 4 ns, delta-time cursors are more accurate than the 55 ps basic accuracy of counter-based, delta-delay-time measurements.

Frequency and Period

Frequency measurement using the Parametric Measurement function uses the B sweeps and triggers to measure the A trigger period and frequency. This capability extends to the trigger bandwidth.

An oscilloscope with the CTT option directly measures frequency or period of the A-trigger signal, but accurate counting requires greater signal amplitudes than stable sweep triggering requires. The highest frequency specified for counting is 150 MHz, even though sweep triggering is specified to much higher frequencies. Two factors cause these differences. First, the counter must "see" every cycle of the signal, even though the sweep will trigger on marginal or very-high-frequency signals that the shaping comparator sometimes misses. Second, the shaping circuits driving the sweep and the counter may have slightly different thresholds.

To count the frequency or period of a Channel 1 or Channel 2 signal, use DC trigger coupling and at least 1.5 divisions peak-to-peak signal amplitude, from 0.5 Hz to 50 MHz; use at least 4 divisions up to 150 MHz. Counting from Channel 3 or Channel 4 requires only half as much display amplitude.

Time Interval

Four parametric time interval measurements are available:

- Rise time and Fall time measure between the 10% and 90% points on the input signal.
- Width measures between the signal high and low times referenced to the signal 50% point.
- The general purpose Time-interval measurement allows setting the channel, slope, and level of the start and stop events.

Automatic time interval measurements depend on the relationship between a waveform and the sweep generators. This relationship is established by the horizontal display, sweep delay, and trigger controls.

Instruments equipped with the Counter/Timer/Trigger (CTT) measure actual delay time, whether the B Sweep runs immediately after delay or waits until receiving a trigger signal after delay. If the B Sweep is triggered after delay, the measurement automatically tracks varying intervals.

The counter operates with the delayed (B) sweep, in both delay-time and delta-delay-time modes. It counts time-base-clock pulses from the A-Sweep trigger event to the start of the B Sweep. In the delta-delay-time mode the B Sweep displays a pair of events that define the interval of interest and the counter determines the difference between the pair of delay times.

The time resolution you select determines how long you must wait for the instrument to complete a time interval measurement. AUTO resolution gives the fastest measurement response, as short as 0.5 second. With 10 ps, 100 ps, or 1 ns resolution, response time depends on how long it takes to accumulate 1,000,000 or 10,000 or 100 A Triggers, respectively. Higher signal frequencies give higher A-Trigger rates, but the minimum trigger period is about 2 μs plus 12 times the A SEC/DIV setting. Increasing HOLDOFF increases the minimum trigger period.

Repetitive Time Intervals

The counter measures each of the two delay-times inherent in the delta-delay-time mode; then it determines the equivalent time between the B-Trigger events by taking the difference between the pair of measured times.

Delta-delay-time mode yields the best possible accuracy for many time measurements. The difference measurement cancels delay differences between the A Trigger and the B Trigger. With delta-time, you can measure very short intervals, down to the resolution limit. However, delta-time measurements require repetitive signals.

For the best delta-delay-time accuracy, expanded displays of the beginning and ending of an interval must be visually superimposed. You can disregard superposition of the ends of the interval, with triggered delta-delay-time, if the transition times of the signals are short compared to the accuracy you need.

Non-Repetitive Time Intervals

The CTT also measures non-repetitive signals and isolated intervals, by measuring delay-time. If the A Sweep triggers on one event and the B Sweep triggers on another, the counter records the time between the events. The two events could be the rising and falling edges of a single pulse. Using the delay mode, you can measure pulse widths or propagation delays as short as 70 ns. You can measure single-shot time intervals with 10-ns resolution.

Peak Amplitude

In response to a command from a GPIB system controller, the oscilloscope can measure signal peak voltages, average volts, and peak-to-peak voltage. The A-Trigger circuit compares trigger levels to the peaks.

Peak voltage accuracy is not specified for signals with transition times less than 20 ns. Fortunately, peak voltages of similar signals can be compared more accurately than the specifications indicate they can be measured. Differences between signals with similar waveforms and repetition rates can be accurately determined, even if the signal transitions are faster than 20 ns.

If SEC/DIV is 5 ms or faster, the measurement should take no more than 2 seconds, and usually takes much less. To accommodate slower signals, the measurement can take up to 20 seconds.

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Programming Techniques

Programming Techniques

Self-Contained Programs

The oscilloscopes in this series can satisfy many repetitive test and measurement requirements, without external controllers. They can store as many as 30 setups or measurements, with seven-character names, which can be grouped into multiple sequences. The setups in any of the sequences can be recalled by operating a single button on the front panel or by operating an external switch, connected to the instrument's rear panel.

With the CTT (Option 09 or 06), these setups can measure frequency, period, time intervals, and slew rate automatically. With some operator interaction, or using the automated Parametric Measurements, you can measure rise and fall time, duty factor, peak voltage, and other signal parameters. With the GPIB (Option 10), the 30 setups can be copied from one oscilloscope to others, using only a GPIB cable, without a controller or other external device. See EXER 13 and EXER 14 in Section 4. See the instrument Operators manual for complete instructions.

Easy Programs

With minimal programming, a system controller can augment the oscilloscope with conditional sequences, limit testing, data logging, and extended operator prompting, beyond the seven-character setup names. Test program generators and executors facilitate this level of programming and relieve the test developer of writing and debugging code. The test developer sets the instrument manually and chooses a set of test parameters for each step in a test procedure. The controller "learns" the setup and the set of test parameters for future use.

Test program development and execution software from Tektronix includes EZ-TEK-2400-PC, for the IBM AT/XT/PC and equivalents, and EZ-TEK-2400 and EZ-TEST, for the Tek 4041 controller. The Tektronix GURU interface package, which adds GPIB controller capability to the IBM AT/XT/PC and equivalents, also includes a test program generator.

If you use a test program generator, you can disregard the tables of commands in this guide. Refer to "Setting GPIB System Parameters" to establish compatibility with your controller.

Full-Power Programs

If you need to automate voltage measurements and indirect time measurements, you can take advantage of the versatility of the instrument command language. Automatic measurements can include rise and fall time, duty factor, peak voltage, and other signal parameters, by programming specific instrument commands.

Even if you use the full power of the instrument command language and the controller language, most tests and measurements can be set up by operating the instrument manually, then transferring the setup information to the controller for future use and possible modification. See the "LLSET?" query and "LLSET" directive described in Table 6-5, System Commands. Sample program segments follow the command tables.

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System Configuration

System Configuration

Setting GPIB System Parameters

To use the oscilloscope with a GPIB controller, system compatibility must be established by setting a few key parameters. Use the oscilloscope front panel controls to select the primary address, message terminator, and talk/listen mode. These selections are accessible through "exerciser" routines. GPIB exercisers also can transfer the set of thirty saved setups from one instrument to one or more other instruments, without a system controller.

GP EXER 11 Program GPIB Address
GP EXER 12 Program GPIB Message Terminator and Talk/Listen
GP EXER 13 Receive-Setups Mode
GP EXER 14 Send-Setups Mode

To operate these exercisers:

1. Enter the Diagnostic Monitor mode by pressing and holding both ΔV and Δt, then pressing Trigger SLOPE while holding ΔV and Δt. The readout will display "DIAGNSTIC. PUSH A/B TRIG TO EXIT," indicating the Diagnostic Monitor mode.
2. Repeatedly press the upper or lower Trigger MODE button to sequence through the TEST and EXER routine labels and select the one you want to run.
3. Press the upper Trigger COUPLING button to execute the selected Exerciser.
4. To exit an exerciser, press the lower Trigger COUPLING button.
5. To return to normal instrument operation, press A/B/TRIG.

In the following descriptions, the lines marked with > show what is displayed in the top row of the readout.

GP EXER 11 Program GPIB Address for Talk and Listen

> GPIB ADDRESS nn

nn = a primary address within 0 to 31. Turn the Δ control to select the appropriate address. With address 31, bus data has no effect on the instrument and is unaffected by the instrument. The instrument does not have secondary addressing.

GP EXER 12 Program GPIB Message Terminator and Talk/Listen

Press the upper MODE button to select EOI or LF as message terminator.

Press the upper SOURCE button to select TALK/LISTEN or LISTEN operation.

> TERMINATOR EOI MODE TALK LISTEN

The instrument accepts only the EOI bus message as the end of a string of received bytes. The instrument asserts EOI at the end of a string of transmitted bytes. The instrument can be addressed either as a talker to send settings and readings or as a listener to receive control information.

> TERMINATOR LF MODE TALK LISTEN

The instrument accepts either the EOI bus message or an LF (line feed) character as the end of a string of received bytes. The instrument asserts CR (carriage return) then LF with EOI at the end of a string of transmitted bytes.

> TERMINATOR EOI MODE LISTEN ONLY

The instrument will not operate as a bus talker. It will receive control information. The listen-only mode allows the instrument to share a GPIB address with another instrument that talks.

> TERMINATOR LF MODE LISTEN ONLY

GP EXER 13 Receive-Setups Mode

> READY TO RECEIVE SETUPS

1. Connect the instrument to another instrument of the same model and with the same options by a GPIB cable. If the instrument is a different model in the following list: 2445B, 2455B, 2465B, 2465BCT, 2465BDM, 2465BDV, and 2467B, or one with a different set of options, most setups will be valid, but some will give unpredictable results.
2. Select GP EXER 14 in the other instrument.

> RECEIVING SETUPS

When the transfer is complete, the instrument will exit EXER 13 automatically.

GP EXER 14 Send-Setups Mode

Before executing this exerciser, make sure the instrument is connected to another by a GPIB cable and be sure the other instrument is in the "READY TO RECEIVE SETUPS" state initiated by GP EXER 13.

> SENDING SETUPS

When the transfer is complete, the instrument will exit EXER 14 automatically.

Instrument Configuration

1. Select a primary address for the oscilloscope.
2. Set the scope address through the diagnostic exerciser.

NOTE

If you are using an HP controller, the standard I/O port is 7. Add the value of the scope address to 700 and use the result as the device identifier in all calls to the scope.

3. Select the message terminator. If you are using an HP controller, the message terminator must be set to LF. For other controllers, use EOI.
4. Select TALK/LISTEN mode, not LISTEN ONLY.

IBM PC/XT/AT Configuration

For IBM computers, using the Tektronix GURU interface or the National Instruments IEEE-488 interface, do the following.

1. Determine whether you have a PC2 or PC2A interface board. PC2A has a clock. Be sure jumpers and switches are set correctly.
2. If you are using the National Instruments interface package, execute IBSTART, which augments the CONFIG.SYS file on the root drive by adding a line.

   DEVICE=GPIB.COM

   If you are using the Tektronix GURU package, be sure the GURU diskette is in the root drive or else copy the CONFIG.SYS file on the GURU diskette to the root drive, after backing up the original file.
3. Execute the IBCONF program.

   - In the GPIB0 menu, be sure the correct card is selected. DMA should be 1. Set any other configuration parameters as required.
   - Choose and enter a name for the oscilloscope. Use "o2465" if you are going to use the XTNLEV program.
   - Using the sub-menu of the device name you chose, set the primary address to the value you selected in Step 1 of Instrument Configuration.
   - Save any changes you made and exit IBCONF.
4. Make sure a copy of the file GPIB.COM exists in the directory from which your computer boots up.
5. "Boot" the system to initialize it for GPIB operation with the defined device address(es).
6. Be sure the logged drive contains a copy of the file BIB.M, part of the interface package.
7. Execute BASICA.
8. Load and execute any valid application program. Each application program must incorporate at least lines 1-6 of the file DECL.BAS, part of the interface package.

Program Considerations at Power-on

If you are using the self-programming features or a test program generator, you can disregard the information in this section. At power-on, the instrument restores the setup in effect at power-off or saved setup number 1, depending on the selection made by an extended-function exerciser, described in the Operators manual. The GPIB interface enters the Local State (LOCS).

If service requests were enabled at power-off, the GPIB interface asserts Service Request (SRQ) at power on. The normal response of a controller to SRQ is a serial poll, but the instrument will communicate normally on the GPIB whether or not the controller responds to an SRQ. If the controller performs a serial poll, the oscilloscope responds with a status byte of 65 decimal, meaning that the instrument has just powered up.

Some controllers, such as the Tektronix 4051 and 4052 without the 405XR14 GPIB ROM pack, require a program with an SRQ handler. The program should begin by enabling this handler; otherwise, a power-on SRQ will cause the program to halt and display the error message "NO SRQ ON UNIT." Examples of SRQ handler routines for both Tektronix 4041 and 405X series controllers are contained in the "SRQ and EVENT Codes" section.

5

Communication Between Oscilloscope and Controller

Communication Between Oscilloscope and Controller

GPIB controllers use high-level languages such as Pascal, C, and BASIC to define messages and transfer them to and from the oscilloscope. Statements in these languages usually contain three parts: the input/output keyword (such as "PRINT" or "read"), the GPIB logical unit designator (such as "08" or "scope"), and a character string or string variable designator (such as "CH1 COUPLING:DC") that forms a specific instrument command or response. The following statement in Tektronix 4041 BASIC sets CH 1 coupling to dc, if the instrument has been previously identified as logical unit #8. All program examples are given in Tek 4041 BASIC unless otherwise noted.

```
220  PRINT  #8:  "CH1  COUPLING:DC"
```

You may prefer to assign the oscilloscope GPIB address to a variable and use that variable in I/O statements. This can make the code more understandable and reduce effort and errors when changes are required.

```
320  Let  scope=6
 ...
730  Print  #scope:  "CH1  COUPLING:DC"
```

Output Statements

The following examples show output statements in several controller languages. Any instrument command can take the place of "string" in the examples. Each statement assumes a prior configuration and declaration of the GPIB port and the device (oscilloscope) on the bus.

Tek 4041 BASIC:

```
PRINT  #10:  "string"
```

IBM AT/XT/PC, with Tek GURU GPIB Interface and Microsoft BASIC, where WRT$ is an output string buffer:

```
IBWRT (SCOPE%,WRT$)
```

IBM AT/XT/PC, with National GPIB/Pascal Interface and Turbo Pascal, where wrt is an output string buffer and cnt is the number of bytes to be sent:

```
ibwrt (scope,wrt,cnt);
```

HP 9826A BASIC:

```
OUTPUT  710;  "string"
```

Query Commands and Responses

The oscilloscope will transmit measurement or status information after a query command has been sent to the scope. Query commands are formed by immediately following a header with a question mark. The query and input operations can be specified by separate statements. In some controllers, a prompting input statement can perform both functions. For example, the following Tek 4041 statement acquires the channel 1 settings, where set$ has previously been declared an array of 100 characters.

```
160  Input  #10  prompt  "CH1?":  set$
```

The controller addresses the oscilloscope as a listener at primary address #10 then sends "CH1?" over the bus. The controller then reassigns the instrument to be a talker and inputs the characters into the target variable (set$). The set$ variable then contains the following information, for example:

```
CH1  VOL:50.0E-3,VAR:0.0,POS:0.0,COU:FIF;
```

If a query includes an argument to specify a parameter, the response is shortened. For example, if the query "CH1? COUPLING" were sent to the oscilloscope, the response returned to the controller could be:

```
CH1  COU:DC;
```

Input Statements

The following examples show input statements in several controller languages. The instrument response occupies the S$ or rd$ buffer in the examples. Each statement assumes a prior configuration and declaration of the GPIB port and the device (oscilloscope) on the bus. Each input must be preceded by a query to identify the information desired.

Tek 4041 BASIC:

```
INPUT  #10:S$
```

IBM AT/XT/PC, with Tek GURU GPIB Interface and Microsoft BASIC, where WRT$ is an output string buffer:

```
IBRD (SCOPE%,RD$)
```

IBM AT/AT/XT/PC, with National GPIB/Pascal Interface and Turbo Pascal, where wrt is an output string buffer and cnt is the number of bytes to be sent:

```
ibrd (scope,rd,cnt);
```

HP 9826A BASIC:

```
INPUT  710;S$
```

Setup Transfers

Only rarely should an oscilloscope setup be defined entirely by the commands in the command tables. Initial setups normally should be copied from a manually operated instrument, then modified if necessary by a few commands. The instrument can transfer setups in four ways. See the operators manual and the command tables for details.

1. Thirty internally stored setups can be copied directly from one instrument to another, through a GPIB cable, without a controller.
2. The current setup can be transferred to a controller in response to an LLSET? query and returned by an LLSET command. The setup is transmitted compactly, in an eight-bit binary format.
3. The current setup can be transferred to a controller in response to a SET? query and the response returned as a command. The setup is described fully in ASCII characters, as defined in the command tables.
4. Thirty internally stored setups can be transferred to a GPIB controller, in eight-bit binary format, using the LOADSEQ? query. The setups can be sent to an oscilloscope with the LOADSEQ command.

Table 5-1
Command or Query Byte Counts

Command or Query	Maximum Byte Count with GPIB Only		Maximum Byte Count with All Options	
LONGFORM	**Off**	**On**	**Off**	**On**
LLSET	90	92	154	156
SET	588	845	842	1303
LOADSEQ	4719	4723	4719	4723

Use LLSET? and LLSET to avoid wasting time and memory space, if your controller can handle binary data.

Sending and Receiving ASCII Setups

To save a setup for future use, request a SET? string from the oscilloscope and store it in a string variable. To set the instrument up with the stored parameters, simply send the string back to the instrument.

```
400  Dim  str$  to  1400     ! Dimension   variable
410  Input   #8  prompt   "SET?":str$!    Input  front
                           ! panel  setup  into  str$
420  Dim  str$  to  len(str$)!   Re-dimension    str$  to  actual
                           ! string
 ...
450  Print  #8:str$
```

Sending and Receiving Binary Setups

To obtain a Binary front-panel setup from the oscilloscope, send LLSET? and store the response either in a string variable or in a numeric array according to the capability of your controller. If the data is stored as an ASCII character string, the controller must support 8-bit ASCII characters or the data will be invalid. The following 4041 example inputs the LLSET? response to a binary variable. To set the instrument up with the stored parameters, simply send the array back to the instrument.

```
 ...
400  Dim  bin$  to  200     ! Dimension   array  variable
410  Open  #8:"GPIB(PRI=8,EOM=<0>):"
420  Input   #8  prompt   "SET?":bin$!    Input  front
                           ! panel  setup  into  bin$
430  Dim  bin$  to  len(bin$)!   Re-dimension    bin$
                           ! to  actual  array
 ...
460  Print  #8:bin$
```

SRQ and Event Codes

The most recent RQS ON or RQS OFF command (see Table 6-5, System Commands) determines whether the instrument will generate the Service Request (SRQ) message on the GPIB when either an error or a change in status occurs. The enabling or disabling effect of the RQS command persists through power-off and power-on, so the power-on SRQ also is controlled by the RQS command. The SRQ indicator lights when the scope asserts the message on the bus.

If the controller is configured and programmed appropriately, the SRQ interrupts the normal flow of the program. To service an interrupt, the controller performs a Serial Poll. In response, the oscilloscope returns a Status Byte (STB), which reveals the type of event that occurred. It also drops SRQ. If the instrument has another event to report, it reasserts SRQ. The SRQ indicator extinguishes when all events are reported. If the controller does not respond to the SRQ message, the instrument continues to operate and communicate normally, even though the condition that initiated the SRQ may invalidate a measurement.

The operator can generate SRQ and the user-request event (403). The SWRQS ON; command enables or disables SRQ on closure of a switch connected to the rear-panel STEP/AUTO EXT SWITCH connector, if RQS is on. The event is included in the response to serial poll regardless of RQS. If a Tektronix probe with an Identify button is connected to a vertical input, pressing the button with RQS and PID on also generates the SRQ and event 403. Pressing the BEAM FIND button with RQS on, also generates the SRQ and event 403.

To obtain more information about an event, the controller can send an EVENT? query. The instrument responds with a number which indicates the specific event. The various status bytes, events codes, and errors are defined in Appendix B.

This program segment shows how to handle an SRQ, determine the instrument status, and display the Status Byte and the associated event code on the controller screen.

```
800?????                    ! Simple  SRQ  Handler
810  poll  stb,  dev        ! poll  bus,  store  status
                            ! byte  in  "stb"
820  input  #dev  prompt     "event?";event
830  print  stb;  event     ! print  stb  and  event  on  screen
```

Interface Messages

This section describes the effects of GPIB interface messages received by the oscilloscope from a controller. See ANSI/IEEE Std 488-1978 for detailed descriptions of interface messages and resultant interface states. These messages are encoded as single bits or as single bytes. They may be explicitly generated by the GPIB interface software in the controller or they can be composed in hexadecimal format according to the IEEE Standard. They can NOT be sent as character strings in the manner of instrument commands.

Local Lockout (LLO)

The Local Lockout message (LLO) may be received from the controller at any time, whether the instrument is addressed or not. Once the LLO message has been received, the My Listen Address (MLA) message locks out the front-panel controls and the Go to Local (GTL) message enables them. The LLO message disables the front-panel controls immediately if the instrument is addressed as a listener when LLO is received. If the program sends the LLO message, it should also send the GTL message to a listener-addressed device when the front panel should be active. The LOCK indicator lights when front-panel operation is suspended.

If the LOCK ON or LOCK OFF command has been received the LLO message is ignored.

If the controller sets the Remote Enable (REN) line false, the LOCK ON or LOCK OFF command is received, or if power is cycled off and on, the effect of the LLO message is cancelled and the instrument controls operate normally.

Remote Enable (REN)

When the Remote Enable (REN) line is true and the instrument receives its listen address (MLA), the oscilloscope can receive data from the bus and the oscilloscope's REM (remote) indicator lights.

If the REN line goes false, the instrument must receive MLA again before it can receive commands. If a command is in process when REN goes false, it continues to execute.

Go To Local (GTL)

If GTL is received, the instrument must receive MLA again before it can receive commands. If a command is in process when GTL is received, it continues to execute.

My Listen Address and My Talk Addresses (MLA and MTA)

These messages condition the instrument to receive commands or respond to queries and serial polls, respectively. They are received when the Attention (ATN) line is true and the data on the GPIB is hexadecimal 20 or 40 plus the address defined by GP EXER 11.

Unlisten (UNL) and Untalk (UNT)

These messages, equivalent to talk and listen address decimal 31, cancel the MLA and MTA messages, respectively.

Interface Clear (IFC)

Receiving this message is equivalent to receiving both the UNL and the UNT messages.

Device Clear (DCL)

The DCL message initializes 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. Any errors and events waiting to be reported are cleared except the power-on event. The SRQ message is cleared unless it is asserted for power-on.

Selected Device Clear (SDC)

This message performs the same function as DCL, only if the instrument has been listen addressed.

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 returns the instrument to normal operation.

Command Handler

A command handler establishes communication between the controller and oscilloscope, sends commands and queries to the oscilloscope, receives responses from the oscilloscope, and processes the responses as required. The following outline indicates a general sequence of command-handling functions.

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. Send a command to the oscilloscope.
6. Check for a response from the oscilloscope.
7. Process any response as desired.
8. Repeat steps 5 through 7 as desired.

Service-Request Handler

A service-request handler processes the interrupts generated by the SRQ message on the GPIB. For example, when cursors have been placed on points of interest on a waveform, an operator can press a switch connected to the rear panel which can cause the oscilloscope to assert SRQ. In response the controller program can verify that the switch closure caused the interrupt, then query the cursor measurement and compare the measured value to preset limits.

Events at which the oscilloscope asserts SRQ are identified in Appendix B.

Some controllers can ignore service requests and others require a programmed response to SRQ. Most controllers ignore service requests until SRQ interrupts are explicitly enabled.

An SRQ handler needs an interrupt-enabling statement (eg. ON SRQ statement-label) near the beginning of the program and a serial-poll subroutine with that label. The ON SRQ statement directs program control to the serial-poll subroutine whenever an SRQ interrupt occurs. The instrument maintains the identity of an event that generates an SRQ until a serial poll is executed by the interrupt-service subroutine.

The following general steps handle service requests from the oscilloscope:

1. Perform a serial poll to determine which device on the bus is requesting service. The serial poll clears an SRQ generated by the oscilloscope, unless more than one event has been identified.
2. Send an EVENT? query to the oscilloscope requesting service.
3. If the EVENT? query response is not zero, perform the appropriate response to the event.
4. Return to the main program.

GPIB Commands

The GPIB commands set instrument operating states, query the operating states, and query the results of measurements. These commands are specified in mnemonics that are related to function names or front-panel control names. Commands follow the conventions established in the Tektronix Codes and Formats Standard.

Command messages consist of headers, arguments, separators, and message terminators.

Headers

A command contains at least a header. A few commands are fully specified by a header. For example:

BALance

Arguments

Most commands require arguments after the headers. An argument must be separated from its header by at least one space.

DELAY 1.0E03

HMODE XY

Some arguments consist of primary and secondary arguments, or primary, secondary, and tertiary arguments. Primary, secondary, and tertiary arguments must be separated by colons.

CH1 VOLTS:5

ATRIGGER MODE:AUTOLEVEL

MSETUP START:CH1POS:10.0

Some headers allow multiple arguments, which must be separated by commas. A colon still separates primary and secondary arguments.

CH1 VOLTS:5,COUPLING:DC,POSITION:1.2

VMODE CH1:OFF,CH2:ON,ADD:ON

Command Separator

Multiple commands can be combined in one message by separating the individual commands with semicolons.

CH1 VOLTS:5,COUPLING:DC;VMODE ADD:ON

Queries

In a query, the question mark must immediately follow the header, with no space.

DVOLTS?

ATRIGGER? COUPLING

Message Terminator

Messages can be terminated with either EOI or LF, depending on the system controller. The GPIB interface can be set to accept either terminator, using EXER 12, as previously explained. With EOI selected, a data byte received with EOI asserted is recognized as the end of an input message. The instrument also asserts EOI concurrently with the last byte of an output message. With the LF setting, either an LF character or any data byte received with EOI asserted is recognized as the end of an input message. With the LF selection, the instrument transmits a Carriage Return character followed by Line Feed (LF) with EOI asserted to terminate an output message.

Abbreviations

The defined words in headers and arguments can be entered at full length or shortened to reduce typing and bus traffic. The command tables show the essential characters of headers and arguments in upper-case characters and optional characters in lower-case. The instrument accepts either upper case or lower case characters. For example, any of the following commands are acceptable.

VMO?
vmod?
vmode invert
VMODE INVE

Numeric Arguments

The following table depicts the formats for numeric arguments in the GPIB command set. Both signed and unsigned numbers are accepted but unsigned numbers are interpreted as positive.

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

Table 5-2
Numeric Argument Format for GPIB Commands

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

6

GPIB Commands

GPIB Commands

NOTE

Some commands are valid only with 2445B, 2455B, 2465B, or 2467B. These are indicated by "(B)" in the descriptions. Some commands are valid only with the 24X5A/B, 2467, or 2467B. These are indicated by "(A)" in the descriptions. The other commands are valid with the earlier 2445 and 2465.

Table 6-1
Vertical Commands

Header	Argument	Argument	Description
CH1			Selects Channel 1 vertical parameters.
	COUpling:	AC DC FIFty GND	Sets input coupling.
	POSition:	<nrx>	Sets position to <nrx> divisions from center. Range extends ±11 divisions.
	VARiable:	<nrx>	Sets Volts/Div Var to the approximate value of <nrx> in the range from 0 to 10. At <nrx> = 0, Volts/Div is calibrated.
	VOLts:	<nrx>	Sets Volts/Div deflection factor to the value of <nrx>. If <nrx> is not a valid, calibrated Volts/Div for the installed probe, the next higher calibrated Volts/Div or the highest Volts/Div is used and an error event is generated.
CH1?			Query returns CH1 VOL:<nr2 or nr3>, VAR:<nr1>, POS:<nr3>, COU:<argument>;.
	COUpling		Response: CH1 COU:<argument>;.
	POSition		Response: CH1 POS:<nr2 or nr3>;.
	VARiable		Response: CH1 VAR:<nr1 or nr2>;.
	VOLts		Response: CH1 VOL:<nr2 or nr3>;.
	PRObe		CH1? PROBE must be queried explicitly; it is not included in the CH1? query response. The response string indicates the probe attenuation coding: X1, X10, X100 or X1000.

Table 6-1 (cont)

Header	Argument	Argument	Description
CH2			Same as CH1 plus INVert: argument.
	INVert:	ON OFF	Turns Channel 2 inversion on or off. This command has the same effect as VMOde INVert:<argument>. Default is INV (ON).
CH2?	INVert		Same as CH1, except query also returns INV:<argument>, where argument is either ON or OFF.
CH3 CH3?			Same as CH1, except COUpling and VARiable arguments are invalid and POSition range is ±4 divisions.
CH4 CH4?			Same as CH3.
VMOde			Selects channels to be displayed, Chop or Alternate channel-multiplexing mode, limited or full vertical bandwidth, and Channel 2 inversion. When all channels are off, Channel 1 is displayed.
	BWLimit:	ON OFF	Sets state of bandwidth limit. Default is BWL (ON).
	CHOp:	ON OFF	Selects Chop or Alternate multiplexing. Default is Chop (ON).
	CH1:	ON OFF	Turns Channel 1 on or off. Default is CH1 (ON).
	CH2:	ON OFF	Turns Channel 2 on or off. Default is CH2 (ON).
	CH3:	ON OFF	Turns Channel 3 on or off. Default is CH3 (ON).
	CH4:	ON OFF	Turns Channel 4 on or off. Default is CH4 (ON).
	ADD:	ON OFF	Turns display of sum of Channel 1 plus Channel 2 on or off. Default is ADD (ON).
	INVert:	ON OFF	Selects normal or inverted Channel 2 display. Default is INV (ON).

Table 6-1 (cont)

Header	Argument	Argument	Description
VMOde?	CHOp CH1 CH2 CH3 CH4 ADD INVert BWLimit		Query returns current state of the vertical display: VMO CH1:<argument>, CH2:<argument>, CH3:<argument>, CH4:<argument>, ADD:<argument>, BWL:<argument>, INV:<argument>, CHO:<argument>;.

Table 6-2
Horizontal Commands

Header	Argument	Argument	Description
HORizontal			Selects Horizontal display parameters.
	ASEcdiv:	<nrx>	Selects A-Sweep speed in seconds per division. Range for the 2465B and 2467B is from 5E-9 to 1.5. Range for the 2445B and 2455B is from 10E-9 to 1.5. If the selected speed is faster than the current B Sweep, B-Sec/Div is set equal to A-Sec/Div. The effects of MAGnify: are independent of ASEcdiv:.
	BSEcdiv:	<nrx>	Selects B-Sweep speed in seconds per division. Range for the 2465B and 2467B is from 5E-9 to 0.15. Range for the 2445B and 2455B is from 10E-9 to 0.15. B-Sec/Div is updated whether B Sweep is active or not. If the selected B-Sec/Div is slower than the current A-Sec/Div, A-Sec/Div is set equal to B-Sec/Div. The effects of MAGnify: are independent of BSEcdiv:.
	MAGnify:	ON OFF	Turns X10 sweep magnification on or off. Default is MAG (ON).
	POSition:	<nrx>	Sets the starting position of the sweep in divisions from the left edge of the screen over the range ±5.46 divisions.
	TRACEsep:	<nrx>	Offsets B Sweep from A Sweep or Δ-B Sweep from the B Sweep with the reference delay by the indicated amount, in the approximate range from 0 to −4 divisions.

Table 6-2 (cont)

Header	Argument	Argument	Description
HORizontal?	ASEcdiv BSEcdiv MAGnify POSition TRACEsep		Query returns the horizontal selections: HOR ASE:<nrx>, BSE:<nr3>, MAG:<argument>, POS:<nr2>, TRACE:<nr2>;. Argument is either ON or OFF.
HMOde			Selects Horizontal display mode. Choices are mutually exclusive.
	ALTernate		Selects both A Sweep and B Sweep for display. This is equivalent to pulling the SEC/DIV knob out.
	ASWeep		Selects only the A Sweep for display.
	BSWeep		Selects only B Sweep for display. If A-Sec/Div and B-Sec/Div are equal, then a settings conflict error is generated.
	XY		Selects XY mode, where Channel 1 drives the horizontal display.
HMOde?			Query returns HMO string;, where the string represents one of the possible Horizontal display modes.

Table 6-3
Trigger Commands

Header	Argument	Argument	Description
ATRigger			Selects A-Trigger parameters.
	MODe:	AUTOBaseline AUTOLevel NORmal SGLseq	Selects Mode from the list of arguments. (AUTOBaseline is equivalent to AUTO.)
	SOUrce:	CH1 CH2 CH3 CH4 LINe VERtical	Selects Source from the argument list.
	COUpling:	AC DC HFRej LFRej NOIserej	Selects Coupling from the argument list. (Use DC for most applications.)
		FLD1 FLD2 ALTernate LINES	Only with the available TV option, selects TV trigger mode.
	LEVel:	<nrx>	Sets Trigger Level in volts with vertical channel sources or in dimensionless units with LINE source. The numeric argument is stored as a target value. Trigger level is set at the target value or at a limit value defined by the trigger source. The limits are ±18 times the Volts/Div setting for CH 1 and CH 2, ±9 times the Volts/Div setting for CH 3 and CH 4, and ±10 for LINE. A LEVel? query returns the value of the current target.

Table 6-3 (cont)

Header	Argument	Argument	Description
	INIt50		Measures signal peaks at the A-Trigger source and sets trigger level at the midpoint between peaks. (A)
	SLOpe:	MINUs PLUs	Selects Slope of the A-Trigger signal.
	BENdsa:	ON OFF	Sets the B ENDS A mode ON or OFF. Default is BENDsa (ON).
	HOLdoff:	<nrx>	Sets Holdoff to the value of <nrx> in the arbitrary range from 0 to 10, with 0 representing minimum (normal) holdoff.
ATRigger?	BENdsa COUpling HOLdoff LEVel MODe SLOpe SOUrce		Query returns ATR BEN:string, COU:string, HOL:string, LEV:<nr2>, MOD:string, SLO:string, SOU:string.
			Arguments MAX, MINI, READY, and TRIGD must be requested explicitly, e.g. ATR? MINI,MAX.
	MAXimum		Query-only returns ATR MAX:<nrx>;. The value of <nrx> represents the most positive peak voltage, measured in volts, at the A-Trigger source at the most recent operation of the INIT@50% button with the A Trigger or in response to the most recent ATRigger INIt50 command or the most recent Auto Level acquisition or the most recent ATRigger MODe AUTOLevel command. Normally, the ATRigger INIt50 command should be sent just prior to an ATRigger? MAXimum query.

Table 6-3 (cont)

Header	Argument	Argument	Description
	MINImum		Query-only returns ATR MINI:<nrx>;. The value of <nrx> represents the most negative peak voltage, measured in volts, under the same conditions as ATRigger? MAXimum.
	READY		Query-only returns ATR READY:string;. String is ON if the single-sequence READY indicator is ON. Otherwise, string is OFF.
	TRIGD		Query-only returns ATR TRIGD:string;. String is ON if TRIG'D indicator is illuminated. Otherwise, string is OFF.
BTRigger			Selects B-Trigger parameters.
	MODe:	RUN TRIGGERAble	Selects B-Trigger Mode.
		DRTRigger	Only with the available CTT, conditions the instrument to direct front-panel Slope and Level controls to the B-Trigger associated with the Δ REF delay. This command forces Delta Mode:Time on unless Delta Mode:Pertime or Delta Mode:Cpertime is on. If Delta Mode Cpertime is on, the command forces a change to Delta Mode:Pertime. (A)
		DTRIgger	Only with the available CTT, conditions the instrument to direct front-panel Slope and Level controls to the B-Trigger associated with the Δ delay. This command forces Delta Mode:Time on unless Delta Mode:Pertime or Delta Mode:Cpertime is on. If Delta Mode Cpertime is on, the command forces a change to Delta Mode:Pertime. (A)

Table 6-3 (cont)

Header	Argument	Argument	Description
		ALTSlope	Only with the available CTT, included only for compatibility with earlier instruments, and not recommended for new applications; conditions the instrument to direct front-panel Slope and Level controls to the B-Trigger associated with both Δ delays, maintaining common levels and opposite slopes. This command forces Delta Mode:Time on unless Delta Mode:Pertime or Delta Mode:Cpertime is on. If Delta Mode Cpertime is on, the command forces a change to Delta Mode:Pertime.
	SOUrce:	CH1 CH2 CH3 CH4 VERtical	Selects B-Trigger Source.
	COUpling:	AC DC HFRej LFRej NOIserej	Selects B-Trigger Coupling. (Use DC for most applications.)
	LEVel:	<nrx>	Sets Trigger Level in volts. The numeric argument is stored as a target value. Trigger level is set at the target value or at a limit value defined by the trigger source. The limits are ±18 times the Volts/Div setting for CH 1 and CH 2 and ±9 times the Volts/Div setting for CH 3 and CH 4. A level query returns the value of the current target.
	INIt50		Measures signal peaks at the B-Trigger source and sets trigger level at the midpoint between peaks. (A)

Table 6-3 (cont)

Header	Argument	Argument	Description
	SLOpe:	MINUs PLUs	Selects Slope of the B-Trigger signal.
	DLEVel:	<nrx>	Only with the available CTT, sets trigger level for the B Sweep controlled by the Δ delay setting, in the same manner as LEVel sets trigger level for all other B-Trigger functions. (A)
	DSLope:	MINUs PLUs	Only with the available CTT, selects trigger slope for the B Sweep controlled by the Δ delay setting, in the same manner as SLOpe sets slope for all other B-Trigger functions. (A)
BTRigger?			Query returns BTR MOD:string, COU:string, SLO:string, SOU:string, LEV:<nrx>;.
	COUpling LEVel MODe SLOpe SOUrce		
	DLEVel DSLOpe		BTRigger? query response only with the available CTT: BTR MOD: string, DSL:string, DLEV:<nrx>, COU: string, SLO:string, SOU:string, LEV:<nrx>;. (A)

Table 6-4
Delay and Delta Commands

Header	Argument	Argument	Description
DELAy	<nrx>		Sets sweep delay to <nrx> divisions in the range from −0.05 to 9.95. This command has the same effect as DTIME REF: <nrx>, except when cursors are active with single B sweep delay. The value of −0.05 assures that the A-Trigger event is visible on the B Sweep.
DELAy?			Query returns the current delay setting in divisions: DELA <nr2>;.
DELTa			Sets Delta-display parameters.
	MODe:	OFF	Selects or cancels a Delta mode.
		CPERTime	Activates 1/Δt cursors with A-Sweep or B-Sweep display. With ALT horizontal display, the command produces an error response. (A)
		CTIMe	Activates Δt cursors with A-Sweep or B-Sweep display. With ALT horizontal display, the command produces an error response. (A)
		PERTime	Activates 1/Δt cursors with A-Sweep display; activates 1/delta-delay-time with Alternate or B-Sweep horizontal display.
		TIMe	Activates Δt cursors with A-Sweep display; activates delta-delay-time with Alternate or B-Sweep horizontal display.

Table 6-4 (cont)

Header	Argument	Argument	Description
DELTa (cont)		VOLts	Activates ΔV cursors.
	TRACKing:	ON OFF	Selects Tracking or Independent Δ REF control mode. Default is Tracking (ON).
DELTa?	MODe TRACKing		Query returns DELT MOD:string,TRACK:string;.
DTIme	REFerence	<nrx>	Sets Δt or 1/Δt reference cursor/delay <nrx> divisions from A-Sweep start or left edge of the display, in the range from −0.05 to 9.95. If Tracking is on, the delta delay or cursor moves as required to maintain its distance from the reference, within the −0.05 to 9.95 range.
	DELTa:	<nrx>	Sets Δt or 1/Δt delta cursor/delay <nrx> divisions from the reference delay or cursor. The sum of the reference setting plus the delta setting must be within −0.05 to 9.95 divisions.
DTIme?	REFerence DELTa		Query returns the Delta Time settings in divisions: DTI REF:<nr2>, DELT:<nr2>;.
TDELta?			Query returns the delta time setting in seconds, hertz, percent, or degrees: <nrx>;. No "TDELTA" header is returned so high-level input drivers can process the response. NOTE: if the query follows a MESSAGE command, a DELTA MODE:<argument>; command must be given again to restore the delta reading. (A)

Table 6-4 (cont)

Header	Argument	Argument	Description
DVOlts	REFerence:	<nrx>	Sets the reference cursor <nrx> divisions from the center of the display, within the ±4.0 range. If Tracking is on, the delta delay or cursor moves as required to maintain its distance from the reference, within the ±4.0 range.
	DELTa:	<nrx>	Sets the delta cursor <nrx> divisions from the reference cursor. The sum of the reference setting plus the delta setting must be within ±4.0 divisions.
DVOlts?	REFerence DELTa		Query returns the delta volts settings in divisions: DVO REF:<nr2>,DELT:<nr2>;.
VDELta?			Query returns the delta volts setting in volts, or percent: <nrx>;. No "VDELTA" header is returned so high-level input drivers can process the response. NOTE: If the query follows a MESSAGE command, a DELTA MODE:VOLTS; command must be given again to restore the delta reading. (A)

Table 6-5
System Commands

Header	Argument	Argument	Description
AUTOSetup			Initiates an automatic setup of scale factors, trigger, and intensity. (A)
BALance			Initiates the vertical DC Balance procedure. The instrument initializes after BALANCE (see INIt).

Table 6-5 (cont)

Header	Argument	Argument	Description
CYCles?			Query-only returns CYC <nr1>;. The value of <nr1> is the number of times power has been cycled off and on. (A)
ERRor?			Query returns ERR <nr1>;. Response is equivalent to EVEnt? query. Command is included for compatibility with earlier instruments.
EVEnt?			Query returns EVE <nr1>;. The value of <nr1> is the most severe of the current errors. Errors are prioritized into three levels, but only the most recent error is maintained for each level. If no error is pending, 0 is returned. Event codes are listed in Tables B-1 and B-2.
HELp HELp?			QUERY ONLY. Returns a list of all command headers that are valid in the current instrument state (Normal, Diagnostic Monitor, Diagnostic Step in Progress). (B) The "?" following HELp is optional. EXAMPLE: HELP ATRIGGER, AUTOSETUP,BALANCE, BTRIGGER,CALIBRATE, CH1,CH2,CH3,CH4, DELAY,DELTA,DTIME, DVOLTS,HELP,HMODE, HORIZONTAL,INIT, INTENSITY,LLMESSAGE, LLSET,LOADSEQ,LOCK, LONGFORM,MEASURE, MESSAGE,MSETUP, NORMAL,OPC,PATH,PID, READOUT,RECALL,RQS, SAVE,SWRQS,TEST, UNLOCK,VMODE,WARNING;

Table 6-5 (cont)

Header	Argument	Argument	Description
HRSon?			Query-only returns HRS <nr1>;. The value of <nr1> is the approximate number of hours of instrument operation. (A)
ID?			Query returns ID TEK/model, V81.1, SYS:FVx, BB:FVy, [string:FV<nr1>,]GPIB:FVz;. The word model stands in place of the strings 2445B, 2455B, 2465B, or 2467B. The characters x, y, and z stand in place of the firmware version numbers of the oscilloscope, Buffer board, and GPIB option, respectively. The section in brackets is repeated for each installed option, including TV and CTT. String V81.1 indicates that the GPIB interface is compatible with the V81.1 version of the Tektronix Codes and Formats standard.
INIt			COMMAND ONLY. INIT with no argument sets the oscilloscope and all options except the GPIB to an initialized state equivalent to cycling the power off and on. The GPIB system-command states (RQS, OPC, WARning, SWRQS, PID, PATh, LOCk, and LONgform) are not initialized (RQS is not changed by power-down/power-up.) This command should be the final or only command in a message. Additional commands in the same message give unpredictable results.

Table 6-5 (cont)

Header	Argument	Argument	Description
INIt (cont)	PANel		COMMAND ONLY. Causes the oscilloscope to go to a factory preset front-panel setup. This command is useful when beginning a new test setup for initializing the oscilloscope to a known setup from which to make changes. It also causes all bus unique commands to be initialized to known states (power-up conditions): (B) PATh ON;LONg OFF; RQS ON;OPC OFF; WARN ON:SWRQS OFF; PID ON;LOCk LLO
	SRQ		COMMAND ONLY. Clears all pending SRQs and event codes. This is normally used to initialize the oscilloscope so that waiting for an OPC event can be programmed as a test for event code not equal to zero. (B)
INTEnsity	SWEep:	<nrx>	Sets trace intensity to dimensionless value of <nrx> in the 0 to 255 range. (A)
	READOut:	<nrx>	Sets readout intensity to <nrx> in the 0 to 255 range. (A)
	RESTore		In the 2467 and 2467B, restores trace and readout intensities to previously set values, in the event intensities may have been automatically reduced for CRT protection. In the 24X5B, no action is performed but the command is allowed. (A)
INTEnsity?	SWEep READOut		Query returns INTE READO: <nr2>, SWE:<nr2>;. (A)

Table 6-5 (cont)

Header	Argument	Argument	Description
LLMessage	%<**byte**><**byte**>...		Sends binary data to the top line of the CRT readout. The readout displays the block of binary data according to the codes in Tables 14 and 15. The first pair of bytes represent the number of characters. The last byte is the two's complement of the least significant byte of the sum of the character codes.
LLMessage?			Query returns the contents of the top line of the CRT readout in a binary block of data, in the form: LLM %<byte> <byte> ... <byte>;. The first two bytes following the % character are a 16-bit count of the bytes that follow. The display is encoded according to Tables 14 and 15, not ASCII. The last byte of the block is the two's complement of the least significant byte of the sum of data bytes. (See MESsage? for ASCII coding of the readout.)
LLSet	%<**byte**><**byte**>...,		Returns a previously acquired setup to the instrument. The Low Level binary Setup data can be generated only by a LLSet? query.

Table 6-5 (cont)

Header	Argument	Argument	Description
LLSet?			Query response is a block of binary data representing the instrument setup in the form: LLSET %<byte><byte>, %<byte><byte>;. The block of data comprises a sub-block for each installed option. Each sub-block begins with a % character followed by two bytes which are a 16-bit count of the bytes that follow. The last two bytes of each sub-block are the two's complement of the least significant byte of the sum of data bytes, followed by a comma, except that the final block is followed by a semicolon. *NOTE* *The LLSET? query behaves unpredictably if the controller recognizes the LF character as the end of a message.*
LOAdseq	**%<binary data>, ...**		Loads 30 setups into instrument memory which can then be recalled as desired. The binary data is defined only by the LOAdseq? query. (A)
LOAdseq?			Query returns 4719 to 4723 bytes of binary setup data which is valid to send with a LOAdseq command. (A) *NOTE* *The LOADSEQ? query behaves unpredictably if the controller recognizes the LF character as the end of a message.*

Table 6-5 (cont)

Header	Argument	Argument	Description
LOCk	ON OFF LLO		Controls the front lock state. If ON then the front panel controls are locked out. LOCK initializes to LLO at powerup and indicates that the oscilloscope will lock out the front panel whenever the universal GPIB command, LLO, is received. If OFF then the front panel controls are unlocked and may not be locked by the universal GPIB command, LLO, if received. Default argument is ON. (B)
LONgform	ON OFF		Enables queries to respond with the full length versions of commands. When LONgform is OFF, the shortest acceptable version of commands are used in query responses. Default argument is ON.
LONgform?			Query returns either LONGFORM ON; or LONG OFF;.
MESsage	"string"		Displays up to 32 mostly-ASCII-coded characters to the top row of the readout. The string must be enclosed in quotes and may exceed 32 characters because of character translations. The display is filled with blanks after the specified characters. If the string specifies more than 32 display characters, the command is ignored except for an error response. Table C-1 lists the character set and codes.

Table 6-5 (cont)

Header	Argument	Argument	Description
MESsage (cont)			*NOTE* *Before a TDELTA? or VDELTA? query following a MESSAGE command, a DELTA MODE:<argument>; command must be given to restore the delta reading.*
MESsage?			Query returns an ASCII representation of the top line of the display: MES "string";. The string may exceed 32 characters due to character translations.
OPC	ON OFF		Enables the instrument to assert SRQ as an "Operation Complete" indication after certain diagnostic and option commands. OPC initializes to OFF at power-up. Default argument is ON. Only with the available CTT, if RQS is on, OPC enables SRQ at CTT measuremenmt completion (Event 778). Reading the event code by an EVENT? query clears the event and the SRQ. The event and SRQ remain clear until the CTT measurement has been read by the appropriate query and a new measurement is complete.
OPC?			Query returns either OPC ON; or OPC OFF;.

Table 6-5 (cont)

Header	Argument	Argument	Description
PATh	ON OFF		When PATh is ON, the full path name is returned for a query response. If PATh is OFF, just the last item is sent. For example, with PATh and LONg both ON, the query INTENSITY? READOUT would return: "INTENSITY READOUT:250.0". With PATh OFF, just "250.0" would be returned. This allows just the oscilloscope setup part of the response to be read into a program without having to "strip" off unwanted parts. Defaults to ON at powerup. (B)
PID	ON OFF		Enables/disables an SRQ generated by a probe identify button being pushed. Default argument is ON. (B)
READOut	ON OFF		Turns the CRT SCALE FACTORS readout ON or OFF. Default argument is ON.
READOut?			Query returns READO string;. String is either ON or OFF, indicating the state of the Scale Factors readout.

Table 6-5 (cont)

Header	Argument	Argument	Description
RECall	<nrx>	[:SEQ]	Sets the instrument to saved setup <nrx>, in the 1 to 30 range, and initiates the Sequence mode if the argument string ":SEQ" is included or cancels the Sequence mode if the argument is not included. In Sequence mode, the front-panel STEP/AUTO button selects following setups. (A) Most parametric measurements require 5 to 10 seconds to complete. If 10 Hz or 1 Hz minimum frequency is selected, and a slow repetition rate signal applied, a measurement may need up to 1 minute to complete. While performing a parametric measurement, the instrument will not respond to GPIB commands or queries until the measurement has completed.
RECall	NEXT		In Sequence mode only, selects the next higher numbered setup saved in the instrument, or the previous setup with the BEGIN attribute if the current setup has the END attribute. RECall NEXT is invalid after RECall <nrx> without the ":SEQ" colon and argument. (A)
RQS	ON OFF		Enables the instrument to assert SRQ on detection of specific events, including error conditions. The power-on SRQ depends on the most recent RQS ON/OFF before power-off. (Note that this command is distinct from the RQS message on the GPIB, which is one bit in the serial poll response.) Default argument is ON.
RQS?			Query returns either RQS ON; or RQS OFF;.

Table 6-5 (cont)

Header	Arguments		Description
SAVe	<nrx> :STEP :BEGIN :END	:"string" :FREquency :WIDth :TIMe :RISe :FALl :VOLts	Saves the current setup or a parametric measurement as setup <nrx>, in the range from 1 through 30. The optional STEP, BEGIN, and END arguments define attributes for sequential recall operation. BEGIN and END define sequence looping boundaries. The STEP argument is assumed if neither BEGIN nor END are given. The optional "string" with up to 7 characters must be delimited by quotes. The string defines a name for the setup. If any parametric measurement is selected, the current vertical selections, and channel 1 and 2 coupling are saved. If the configurable 'TIME' parametric measurement is selected, the current configuration of this measurement is also saved (see MSETup). If no name is given in the command, the previous name of the setup <nrx> is retained, except that the name "NOT.SET" will change to "SET." (A) *NOTE* *The string can include any of the characters, A..Z, 0..9, and the following punctuation marks.* . : , ? + − / < > %

Table 6-5 (cont)

Header	Argument	Argument	Description
SAVe (cont)			*Lower case letters are converted to upper case. The space character is converted to a period, unless it is not the first character in a name and no other non-space characters follow it. The following punctuation characters are translated to lower case English characters or to Greek characters.* & to k, to m, (to n, ! to p, = to s,] to t, # to lower case mu (micro), [to upper case omega (ohms)
SETtings?			Query returns an ASCII string of commands as defined in these tables that represent the current instrument setup. The string contains all required headers and if it is returned to the instrument, it should not be preceded by SETtings or any other header. LLSet? and LLSet should be used to acquire and restore complete instrument settings to save time and memory space. *NOTE* *The SETtings? query may give inconsistent results with SEC/DIV VARiable. If the variable is manually set for an A Sweep slower than the next slower speed settable by the SEC/DIV switch, the SETtings? query will attach the variable to the B Sweep, and the A Sweep will be shown at the next slower speed selectable by the switch.*

Table 6-5 (cont)

Header	Argument	Argument	Description
SWRQS	ON OFF		Enables or disables a user-request event (403) on closure of a switch connected to the rear-panel STEP/AUTO EXT SWITCH connector. An SRQ will be generated if RQS is on (see RQS command). The event is included in the response to serial poll regardless of RQS. Default argument is ON. (A)
UNLock	POT: Switch:	<nr1> <nr1>	COMMAND ONLY. Used to unlock certain pot/switch controls. This command is useful for selective front-panel lockout. UNLock with no arguments is the same as the LOCk OFF command. (B)

Table 6-5 (cont)

Header	Argument	Argument	Description
UNLock (cont)			The UNLock POT: or UNLock SWItch: commands are only valid during the time the front panel is in local lockout state. A settings conflict SRQ is issued if these commands are received and the front panel is not in local lockout state. When the front panel is first set to the local lockout state, the entire front panel is locked out. To unlock specific pots and/or switches use the UNLock POT: and UNLock SWitch: command with the appropriate <nr1> value from the tables below:

POT TABLE

<nr1>	Pot
1	Holdoff
2	Trigger Level
3	Sec/Div Variable
4	Horizontal Position
5	Delta Control
6	Delta Reference or Delay Position
7	CH1 Variable
8	CH2 Variable
9	CH1 Position
10	CH2 Position
11	CH3 Position
12	CH4 Position
13	Trace Separation
14	Readout Intensity
15	Intensity

Table 6-5 (cont)

Header	Argument	Argument	Description
UNLock (cont)			SWITCH TABLE
			<nr1> Switch
			1 Trigger Coupling
			2 Measurement
			3 CH1 Input Coupling
			4 CH4 Volts/Div
			5 CH3 Volts/Div
			6 Init@50%
			7 CH2 Input Coupling
			8 CH1 Volts/Div
			9 CH2 Invert
			10 CH2 Volts/Div
			11 A/B Sec/Div
			12 A/INT/ALT/B Horz. Mode
			13 CH1 Vertical Mode
			14 CH2 Vertical Mode
			15 ADD Vertical Mode
			16 CH3 Vertical Mode
			17 CH4 Vertical Mode
			18 Auto/Step
			19 Save
			20 Recall
			21 CHOP/ALT Vertical Mode
			22 20 MHz BWLIMIT
			23 X10 MAG
			24 TRACK/INDEP
			25 Delta Time
			26 Delta Volts
			27 Trigger Slope
			28 Trigger Source
			29 Trigger Mode
			30 A/B Trigger Select
WARning	ON OFF		Enables SRQ assertion on detection of a potential error. Warning initializes to ON at power-up. Default argument is ON.
WARning?			Query returns either WARN ON; or WARN OFF;.

Table 6-6
Parametric Measurement Commands

Header	Argument	Argument	Description
MEAsure	FREquency WIDth VOLts RISe FALl TIMe		Makes the specified measurement or measurement group as if initiated from the front panel. (B) Most parametric measurements require 5 to 10 seconds to complete. If 10 Hz minimum frequency is selected, and a slow repetition rate signal is applied, a measurement may require up to 1.5 minutes to complete. While performing a parametric measurement, the instrument will not respond to any GPIB commands or queries until the measurement has completed.
MSETup	UNITs:	PERCent VOLts	Sets the trigger level units used by the TIMe measurement. When the units are changed, the levels are initialized to 50% or 0 volts. (B)
	AUTOSetup:	FREquency WIDth VOLts RISe FALl TIMe AUTOSetup	Associate a measurement with the AUTOSetup command, the AUTO/STEP button on the front panel, and the switch jack on the rear panel or two successive probe identify actions. (B)
	MINFreq:	HZ50 HZ10	Sets the minimum frequency recognized by the measurement functions. Recognizing lower frequencies implies considerably longer search times (up to 1.5 minutes). (B)

Table 6-6 (cont)

Header	Argument	Argument	Description
MSETup (cont)	START:	CH1Pos: <nrx> CH1Neg: <nrx> CH2Pos: <nrx> CH2Neg: <nrx>	Selects the channel, slope, and trigger level of the start event. Trigger level range depends on the units selected with the UNITs argument. (B) PERCent 10.0 to 90.0 VOLts −10.00 to +10.00
	STOP:	CH1Pos: <nrx> CH1Neg: <nrx> CH2Pos: <nrx> CH2Neg: <nrx>	Selects the channel, slope, and trigger level of the stop event. Trigger level range depends on the units selected with the UNITs argument. (B) PERCent 10.0 to 90.0 VOLts −10.00 to +10.00
MSETup?	UNITs AUTOSetup MINFreq START STOP		Query returns MSET UNIT: <str>, AUTOS:<str>, MINF:<str>, START:<str>:<nr2>, STOP:<str>:<nr2>;.

Table 6-6 (cont)

Header	Argument	Argument	Description
VALue?	FREquency:	FREQuency PERIod	Query returns Frequency and Period measurements. (B)
	WIDth:	HTIme LTIme HDCycle LDCycle	Query returns Hi time, Lo time, Hi duty cycle (%), and Lo duty cycle (%) measurements. (B)
	VOLts:	PK2pk AVGvolts MINImum MAXimum	Query returns Peak-to-peak, Average, +Peak, and −Peak measurements. (B)
	RISe		Query returns Rise time measurement. (B)
	FALl		Query returns Fall time measurement. (B)
	TIMe		Query returns Time measurements. (B)
			Queries return the parametric measurement(s), each in <nr3> format, after first making the measurement(s). If an argument from the second argument column is given, only the requested value is returned.
			1.0E+99 is returned if the instrument is unable to make a valid FREQ, WIDTH, RISE, FALL, or TIME measurement because signal amplitude is too small, signal frequency is too low, or there is improper channel selection.

Table 6-6 (cont)

Header	Argument	Argument	Description
VALue? (cont)			1.0E+98 is returned if the instrument is unable to make a valid AVG VOLTS, MINIMUM, or MAXIMUM VOLTS measurement due to AC input coupling on measured channel. 1.0E+97 is returned if the instrument is unable to make a valid PK2PK, MINIMUM, or MAXIMUM VOLTS measurement because signal peak to peak amplitude is too small, with DC input coupling on measured channel. 1.0E+96 is returned if the instrument is unable to make any valid VOLTS measurement because signal peak to peak amplitude is too small, with AC input coupling on measured channel. All second arguments are optional. (B) Most parametric measurements require 5 to 10 seconds to complete. If 10 Hz minimum frequency is selected, and a slow repetition rate signal is applied, a measurement may require up to 1.5 minutes to complete. While performing a parametric measurement, the instrument will not respond to any GPIB commands or queries until the measurement has completed.

Table 6-7
GPIB Command Set for the TV Option

Header	Argument	Argument	Description
TVClamp	ON		Selects AC and TV (back-porch) Clamp input coupling for CH 2. Default argument is ON.
	OFF		If the TV (back-porch) Clamp is active, CH 2 input coupling changes to AC and the TV (back-porch) clamp is turned off. Otherwise, the CH 2 input coupling does not change.
TVClamp?			Query returns either TVC ON or TVC OFF.
TVLine	<nrx>		Selects TV line number <nrx> for the A Trigger.
TVLine?			Query returns TVL <nr1>;. The value of <nr1> is the selected line number.
LCNTStart	PREfld		Selects line count beginning 3 lines before field-sync pulse (Format 2).
	ATFld		Selects line count beginning at field-sync pulse (Format 1).
LCNTStart?			Query returns Line 1 definition: either LCNTS PRE; or LCNTS ATF;.
LCNTReset	F1Only		Selects line count reset only on field 1 (Format 2).
	BOTh		Selects line count reset on both field 1 and field 2 (Format 1).
LCNTReset?			Query returns Line count reset status: either LCNTR F1O; or LCNTR BOT;.

NOTE

CTT measurements are requested with the CTSend? query command. DELAy? and DTIme? queries return delay and delta settings, not measurements.

Table 6-8
Counter/Timer/Trigger GPIB Commands

Header	Argument	Argument	Description
CTRdy?			Query returns 1; if a CTT measurement is available or 0; if not. If no measurement function is active, or if a measurement function is suspended because another option is using the display, an option-not-in-correct-mode error is generated.
CTSend?	IMMediate WAIt		Command requests the result of any of the following measurements: frequency, period, totalize, delay-time, delta-delay-time, or 1/delta-delay-time. The measurement is returned in format <nr3>. The "?" following CTSend has no effect and is optional. If the measurement is invalid, one of the following error codes is returned in place of the measurement: 1.0E+99 for missing B trigger. 1.0E+98 for missing A trigger. 1.0E+97 when the time interval in 1/Δt mode is less than 1% of full scale. 1.0E+96 for Totalize mode overflow. 1.0E+95 for A Trigger VERT Source selected (multiple A Trigger sources).

Table 6-8 (cont)

Header	Argument	Argument	Description
CTSend? (cont)			If no measurement function is active, or if a measurement function is suspended because another option is using the display, an option-not-in-correct-mode error is generated. A measurement is sent only once then cleared. A new measurement must be completed before another value will be sent. CTSend with no argument or the WAIt argument conditions the instrument to send no response until the measurement is complete. The IMMediate argument conditions the instrument to send a null message (talked with nothing to say) if the measurement is not complete.
		CTT Setup Commands	
COUNt	EVEnt:	ATRigger WREcognizer	Configures the Count function.
	MODe:	FREquency TOTal PERIod	If the Word Recognizer Option is not installed and If EVEnt:WRE is received, an option-not-installed error is generated.
COUNt?	EVEnt MODe		Query returns COUN MOD:string, EVE:string;, or COUN arg:string; if an argument is given in the query.
CTT	COUNt DBEvents LTRigger OFF		Selects or cancels a CTT function. Selecting any function cancels any other selected function and sets B-Trigger mode to Run Aft Dly.

Table 6-8 (cont)

Header	Argument	Argument	Description
CTT (cont)	RESET		CTT RESET resets any count or time measurement currently in progress, including delay and delta time.
CTT?			Query returns CTT string;. The "string" names the current CTT function.
DBEvents	COUNt:	<nr1>	Sets Delay-by-Events for <nr1> events in the range 1 - 4194303, inclusive. If an out of range or noninteger number is received a numeric-argument error is generated.
	EVEnt:	BTRigger WREcognizer	If the Word Recognizer Option is not installed and if EVEnt:WREcognizer or STArt:WREcognizer is received, an option-not-installed SRQ error is sent.
	STArt:	ATRigger WREcognizer	Selecting STArt:WREcognizer WREcognizer sets SWEep to ASWeep.
	SWEep:	ASWeep BSWeep	Selecting SWEep:BSWeep sets BSWeep STArt to ATRigger.
DBEvents?	COUNt EVEnt STArt SWEep		Query returns DBE SWE:string, STA:string, EVE:string, COUN:<nr1>;, or DBE arg:string; if an argument is given in the query.

Table 6-8 (cont)

Header	Argument	Argument	Description
LTRigger	ASWeep:	AANdb AORb WREcognizer	Configures the Logic Trigger function. If the Word Recognizer Option is not installed and if either the ASW:WRE or BSW:WRE command is received, then an option-not-installed error is generated.
	BSWeep:	WREcognizer	
LTRigger?			Query returns LTR ASW:string; or LTR BSW:WRE;.
RESolution	AUTO R1Ns R100ps R10Ps		Sets the resolution of delay and delta-delay measurements.
RESolution?			Query returns RES string;.

Table 6-9
Word Recognizer GPIB Commands

Header	Argument	Argument	Description
WREcognizer	CLOck:	ASYnch DNClock UPClock	Configures the Word Recognizer.
	RADix:	BINary HEX OCTal	The RADix: argument controls only the format of the Word Recognizer display and manual settings.
	WORd:	<ASCII binary data>	The format of ASCII binary data is #Y followed by 17 digits, where each digit may be either 0, 1, or X (don't care). Spaces may be used anywhere to separate groups of digits. The option will accept ASCII binary data command arguments without the #Y prefix. The following are all valid and equivalent: WOR:#Y1 00X01X10 0X0X110X, WOR:#Y100X01X100 X0X110X, WOR: 1 00X0 1X10 0X0X 110X, WOR:#Y1 0 0X0 1X1 00X 0X1 10X The digit order is qualifier bit, then a 16-bit word in most-significant to least-significant bit order. All 17 digits must be sent. If an error is detected in the ASCII binary data argument, a command-argument error is generated.

Table 6-9 (cont)

Header	Argument	Argument	Description
WREcognizer (cont)			If the Word Recognizer Option is not installed and any word recognizer command or query is received, an option-not-installed error is generated.
WREcognizer?	CLOck RADix WORd		Query returns WRE RAD:string, CLO:string,WOR:<ASCII binary data>;. For example, WRE? WOR returns WOR:#Y1 00X01X10 0X0X110X;

Table 6-10
GPIB Command Set for the DMM Option

Header	Argument	Description
DMM	OFF SUSp	Turns off the DMM. Any DMM function command turns the DMM on. The DMM SUSP; command suspends DMM operation to permit another function to occupy the readout space. The only difference between DMM SUSP and DMM OFF is that the next time a DMM function is selected, if it is the same function previously suspended, the reference value and the states of SMOOTH, AUTO, etc. are maintained.
DMM?		Query returns DMM ON;, DMM SUSP;, or DMM OFF;.
DMMSend DMMSend?		Command/query returns the displayed DMM measurement in <nr3> format, adjusted to basic units of volts, ohms, or amperes. DMMSend and DMMSend? have identical effects. No response will be given unless or until a measured value is displayed. If the value is out of measurement range, the value 1.0E+99 is returned. If continuity function is active, 24X5B instruments will return 0 for resistance less than 10 Ω, and 1.0E+99 for resistance greater than 10 Ω. 24X5 and 24X5A instruments return "< 10 OHMS" for resistance less than 10 Ω and "> 10 OHMS" for resistance greater than 10 Ω.

Table 6-10 (cont)

Header	Argument	Description
DISplay	MINImum MAXimum	Select the minimum or maximum measurements made since the function was selected or since Min/Max Reset.
	REFerence	Selects the present value of the reference.
	NORmal	Selects the most recent measurement. Default argument is NORmal.
		To receive the present minimum value over the GPIB, for example, send DIS MINI; followed by DMMSEND;.
DISplay?		Query returns DIS MINI;, DIS MAX;, DIS NOR; or DIS REF;.
MINMaxres		Resets the minimum and maximum accumulators to the next valid measurement value.
RANge	<nrx>	Selects the range of the DMM function suited to measuring the value <nrx>.
RANge?		Query returns RANGE <nr3>;. The range value will be stated in basic units of volts, amperes, or ohms.
REFset	<nrx>	Sets the reference to <nrx>. If the argument is zero, the reference turns off. Also, if the argument is a negative value and the present function doesn't allow negative values, the reference turns off. The argument is rounded up to the closest value represented by the DMM (1 part in 40,000). If the argument is too large for the function, an error is generated and the reference remains unchanged. If no argument follows REFSET, the reference value is set to the displayed value. The command is illegal with the Continuity function.
REFset?		Query returns REFSET <nr3>;. The reference value will be sent in basic units such as volts, ohms, or amps. The query is illegal in Continuity.

Table 6-10 (cont)

Header	Argument	Description
HOLd	ON OFF	Freezes the display with the present measurement. Default argument is ON.
HOLd?		Query returns HOLD ON; or HOLD OFF;.
SMOoth	ON OFF	Turns smoothing on or off. SMOOTH ON resets the number of measurements averaged to zero. Default argument is ON.
SMOoth?		Query returns SMOOTH ON; or SMOOTH OFF;.
AVGs?		Query returns AVGS <nr3>;. The value of <nr3> reflects the number of measurements averaged in the smoothed value presently displayed. If smoothing is off, the query generates an error.
DCV ACV DCA ACA HIOhms LOOHms DBV DBM DEGC DEGF CONt	<nrx> <nrx> <nrx> <nrx> <nrx> <nrx> <nrx> <nrx>	Select DMM measurement functions, with the measurement range suited to measure the value of <nrx> with the best available resolution. If the argument is omitted or zero, the DMM will autorange. If the argument is negative, the DMM will autorange after initializing the range according to <nrx>, except for the dBV and dBm functions. If <nrx> exceeds the highest range, an error is generated and the command has no other effect.

Table 6-10 (cont)

Header	Argument	Description
FUNCtion?		Query returns "function name" <nr3>;. The value of <nr3> is the highest value in the present range. The <nr3> value is omitted for fixed-range functions, e.g. DEGC. If the DMM is autoranging, the range value is preceded by a minus sign, e.g. DCV −2.E+1, except for the dBV and dBm functions.
OVEr	ON OFF	Turns the over range warning SRQ on or off. Default argument is ON.
OVEr?		Query returns OVER ON; or OVER OFF;.
TONE	<nrx>	Selects the tone to be used by the Continuity function according to <nrx> in the 1 to 4 range. The default value is 1.
TONE?		Query returns TONE <nr3>;. The value of <nr3> is the selected tone value.
HIZ	ON OFF	Selects the input impedance of the DCV function in the 200 mV and 2 V ranges. No argument or the ON argument selects an input impedance > 100 GΩ, while OFF selects 10 MΩ input resistance. During calibration "Settable Input Impedance" must have been selected or a Settings Conflict error will be generated. Default argument is ON.
HIZ?		Query returns HIZ ON; or HIZ OFF;.
BEEp	<t>:<d>[,<t>:<d>]...	Generates a series of tones <t> of durations <d>, where multiple tones are specified by separating groups of arguments by commas. The DMM must be either off or suspended or a mode error (254) is generated. The range of values for t is 0 to 13 and for d is 0 to 255. If arguments are not specified, default values of 6 for t and 3 for d are used. A value of 0 for t or d produces no sound, and each unit of d is approximately a duration of 0.1 second.

Table 6-11
Calibration and Diagnostic Commands

NOTE

Calibration and diagnostic commands should be used only for programmed maintenance procedures. They have no application for measurements.

Header	Argument	Argument	Description
CALibrate	<nrx>:	<nrx>	Initiates Diagnostic mode and the Calibration routine indicated by the arguments, if the internal CAL/NO CAL jumper is in the CAL position. The first digit of the first argument represents an option. The second digit of the first argument represents the specific routine. The second argument is a step number within the routine. Refer to the Service Manual for information about the calibration routines. The option numbers are the same as described for the ID? query.
GO			Executes the currently selected CALIBRATION or TEST routine. This command has the same effect as pressing the upper Trigger COUPLING button when in Diagnostic mode.
LOOping	ON OFF		Enables or disables looping of diagnostic tests in diagnostic mode. Default argument is ON.
LOOping?			Query returns LOO "string";. "String" is either ON or OFF.
NORmal			Exits Diagnostic mode. The command has no effect in normal mode. Commands following NORmal in the same message give unpredictable results. NORmal should be the final or only command in a message.

Table 6-11 (cont)

Header	Argument	Argument	Description
STEp			Increments the currently executing Diagnostic routine to its next step.
STEp?			Query returns STEP <nr1>;. The current step number is given by <nr1>.
STOp			TERMINATES the currently executing Diagnostic routine. Control returns to the Diagnostic monitor.
TESt	<nrx>:	<nrx>	Selects Diagnostic mode test sequences. The first argument represents an option, and the second is the routine number. See CALibrate command for option numbers.
TESt?	<nrx>:	<nrx>	Executes the selected test and returns the test's status value: TES <nr1>. Zero is returned for a passed test.

7

Measurement Techniques

Measurement Techniques

Introduction

This section gives some important considerations, measurement procedures, and brief program examples for semiautomatic and automatic measurements. Examples in the Programming Examples section are shown in BASIC dialects for the Tektronix 4041, IBM PC/XT/AT, and HP 98XX. Many measurements, such as frequency, period, and time interval and any operator-interactive measurements, require only the capabilities available with the highly efficient test-program generators described earlier.

Trigger Settings

Select DC coupling for vertical inputs and triggers, unless unusual signal characteristics require blocking dc, low-frequency, or high-frequency components. NOISE REJ trigger coupling preserves full frequency response but increases the signal amplitude requirement. Trigger level is calibrated and predictable only with DC or NOISE REJ trigger coupling and DC vertical input coupling. Also, to have a calibrated trigger level, the V/DIV VAR of the trigger source must be at the calibrated position and the source must be a single channel.

Set trigger level at the midpoint between the positive and negative peaks of the signal, for most measurements. With repetitive signals, set trigger level at the signal midpoint by pressing the INIT@50% button or sending the ATRIGGER INIT50 or BTRIGGER INIT50 command.

Use NORM trigger mode for most automatic measurements. With AUTO LVL mode, the instrument attempts to trigger on static signals, which could result in anomalous measurements. AUTO LVL also takes time to acquire the trigger level, which is an unnecessary delay when the correct trigger level is known.

Frequency and period measurements are immune to trigger level errors, so long as trigger level is near the signal midpoint and the signal amplitude is adequate.

When measuring time with the B Sweep and B Trigger, trigger-level uncertainty can interact with signal transition times to cause measurement errors. Consult the trigger level specifications and consider the signal slew rate to determine how much error to expect. The effective trigger level may change slightly with different waveforms or with different instruments using the same trigger level data. However, trigger-level for a given instrument, making a given measurement, is accurately repeatable.

Minimize trigger-timing errors by programming trigger levels to exactly fit a measurement. Use the B Sweep to expand the display and observe superposition of the transitions defining a measurement. Set the B-Trigger level to superimpose the points of interest and save the setup for future use.

Automatic delta-delay-time measurements between two channels require a single channel source for the A Trigger, VERT source for B Trigger, and ALT vertical mode. B-Trigger levels for the pair of delays should be set independently, using the TRIG Δ DLY and TRIG AFT DLY modes or using the following commands:

BTRIGGER LEVEL: <nrx>;

for the delta-delay reference trigger, and

BTRIGGER DLEVel: <nrx>;

for the delta-delay trigger.

If the transition time of the signal is a big part of the allowable error, program the instrument for an automatic measurement, then pause for operator intervention. An operator should carefully set B-Trigger LEVEL as required for exact superposition of the points of interest. If you use RUN AFT DLY B-Trigger Mode, the operator should adjust the Δ REF and Δ controls for superposition. Superposition avoids the effects of waveform changes and trigger level uncertainty.

Measuring Time Intervals on Repetitive Signals

First, manually set the instrument to measure delta-time, following this outline:

1. Select the desired measurement resolution, using the menu. AUTO gives the fastest response.
2. Trigger the A Sweep, using NORM mode, on a signal that occurs at least 70 ns before the interval of interest.
3. Set the A-Sweep SEC/DIV to display the interval of interest.
4. Use the B Sweep to expand the waveform and superimpose the points on the waveform(s) that define the beginning and end of the interval. The delay controls, Δ REFerence and Δ, determine two times at which the B Trigger is enabled. The B Triggers, with independent slopes and levels set in TRIG AFT DLY and TRIG Δ DLY modes, determine the exact point of intersection of the superimposed B-Sweep displays.
5. In some cases, signal variations could cause the wrong transition to be recognized as the beginning or the end of an interval. Set Δ REF and Δ so that the B Trigger is enabled for the events of interest over any expected variation of the signal(s) under test. One way is to set each of the controls in the middle of the range over which it triggers on the desired transition.
6. Store these control settings by using the "learn" procedure given in the "Programming Examples" section.
7. To automatically measure delta-time with similar signals, send the recorded settings back to the instrument and read the result. See the "Programming Examples" section for the GETCTTN subroutine.

Tek

```
100  Print#scope:set$       !Send  previously   stored  settings
110  Call  GETCTTN (delta)
```

IBM

```
340  CALL  IBWRT (SCOPE%,SET$)'Send      previous   setting
350  GOSUB  (Statement   Number  of  Get  CTT  routine)
```

HP

```
430  OUTPUT  D2465;Set$    !Send  previously   stored  setting
440  CALL  Get_cttn (D2465,Interval)
```

If you require the best possible delta-delay-time accuracy, and if signal transition time is a big part of the allowable measurement error, program the instrument for an automatic measurement, except for a pause for an operator to carefully set B-Trigger LEVEL for exact superposition of the points of interest. This is the only way to completely avoid the effects of waveform changes and trigger level uncertainty.

Measuring Single-Shot Time Intervals

To make single-shot measurements, you must use the delay-time mode with AUTO RESolution. Establish the conditions for automatic measurements by manually operating the instrument. The following steps will generate a program to measure delay time automatically.

1. Select AUTO measurement resolution, through the measurement configure menu.
2. Set the A Trigger to respond to the signal transition that defines the beginning of the interval of interest, using NORM mode.
3. Set SEC/DIV to display the interval of interest on the A Sweep, with delta-time off. Be sure the interval is at least 70 ns.
4. Pull the SEC/DIV knob out to display an intensified zone. Set the DLY POS control and the B-Trigger controls, with TRIG AFT DLY mode, for the end of the interval. DLY POS determines when the B Trigger is enabled. Delay should be set at zero for most measurements, such as pulse widths and propagation delays.
5. If more than one transition could be recognized as the end of the interval, set DLY POS so that the B Trigger will be enabled for the event of interest, over any expected variation of the signal(s) under test. One way is to set DLY POS in the middle of the range over which the B Trigger recognizes the desired transition.
6. Transfer the instrument settings to the system controller.

A program to automatically measure delay-time with similar signals should send the recorded settings back to the instrument and call the GETCTTN subroutine, listed in the "Programming Examples" section.

Tek

```
100  Print#scope:set$       !Send  previously   stored   settings
110  Call  GETCTTN (interval)
```

IBM

```
340  CALL  IBWRT (SCOPE%,SET$)'Send      previous   setting
350  GOSUB  {Statement   Number  of  Get  CTT  routine}
```

HP

```
430  OUTPUT  D2465;Set$    !Send  previously   stored   setting
440  CALL  Get_cttn (D2465,Interval)
```

Measuring Peak Voltages

Trigger coupling should be set at DC and vertical input coupling should be set at DC. Always display the signal with at least three divisions of amplitude. Larger amplitudes, up to twenty divisions, generally give more repeatable peak voltage measurements. However, each peak of the signal must be within ten divisions of ground. Set the A Sweep at any convenient speed faster than 10 ms/division, for any signal period less than 20 ms. For signal periods up to 200 ms, set SEC/DIV slower than 0.25 times the period. SEC/DIV settings from 50 ms to 500 ms allow measuring the peaks of signals having periods up to 200 ms.

Manually set the instrument for the measurement and store the settings in the controller with an "LLset?" query. An automatic test routine should return the settings to the scope and then call the GETPEAKS subroutine, listed in the "Programming Examples" section.

Tek

```
100  Print#scope:set$       !Send  previously   stored   settings
110  Call  GETPEAKS (high,    low)
120  pktopk=high-low
```

IBM

```
220  CALL  IBWRT (SCOPE%,SET$)'Send      previous   setting
230  GOSUB  (Statement   Number  of  Get  Peaks  routine)
240  PKTOPK=   HIPEAK-LOPEAK
```

HP

```
120  OUTPUT  D2465;Set$    !Send  previously   stored   setting
130  CALL  Get_peaks (D2465,Hipeak,Lopeak)
140  Pktopk  = Hipeak-Lopeak
```

Measuring Rise and Fall Times

A system comprising a controller and an oscilloscope with CTT and GPIB can measure transition times automatically, on repetitive signals. The system measures peak voltages and calculates the appropriate trigger levels for delay measurements. The trigger levels define points on a signal transition from which delay times are measured. Transition time is the difference between delay times with the trigger level set at 10% and 90% of the transition amplitude.

Waveform variations and trigger system distortions make transition time measurements less accurate than other time measurements. Even so, these measurements are adequate to characterize or verify many devices and systems, especially if the measurements are optimized by the techniques described here.

The best procedure for measuring rise time or fall time depends on signal characteristics. The oscilloscope requires 70 ns after the A Trigger before enabling the B Trigger, with delay set at minimum using either the DLY POS control or a DELAY −0.05 command.

- If a pulse is wider than 70 ns, the A Trigger and the B Trigger can operate on opposite slopes of the pulse.
- If the pulse is shorter than 70 ns, the B Trigger should be set for the same slope as the A Trigger. The A-Sweep rate and delay should be set so that the B Trigger operates on a later cycle of the signal.
- If the high and low states of the pulse are at least 10 microseconds long, the necessary signal delay to the B Trigger can be supplied by using HF REJ coupling. On such low-frequency signals, Using HF REJ and same-slope triggering gives faster results and better resolution than opposite-slope triggering with DC coupling.

Depending on signal characteristics, use one of the following procedures to manually set the instrument for a delay measurement. Always display the signal with at least three divisions of amplitude. Larger amplitudes, provided each peak of the signal is within ten divisions of ground, generally give more repeatable measurements. These measurements are made by the trigger and time-interval counter systems and are independent of the display.

- For pulses more than 70 ns wide:

  1. Set A Sweep to display the rising and falling edges of the signal, with the A Trigger set for the transition of interest, and delta-time off.

2. Pull the SEC/DIV knob out to display an intensified zone and set DLY POS for zero delay.

3. Select TRIG AFT DLY mode for the B Trigger. Set B-Trigger SLOPE opposite from the A Trigger. Set B-Trigger SOURCE and LEVEL to trigger the intensified zone at the pulse transition after the transition of interest.

- For pulses shorter than 70 ns:

1. Set A Sweep to display one cycle of the signal, with A Trigger set for the transition of interest, and delta-time off. SEC/DIV should be set at 10 ns/div for any signal with a period less than 100 ns.

2. Pull the SEC/DIV knob out to display an intensified zone and set DLY POS at minimum.

3. Select TRIG AFT DLY mode and DC coupling for the B Trigger. Set B-Trigger SLOPE the same as the A Trigger. Set B-Trigger SOURCE and LEVEL to trigger the intensified zone at a later pulse transition than the transition of interest.

4. While holding the A/B TRIG button depressed to access the A-Trigger controls, vary LEVEL. Verify that the B Trigger responds to the same signal cycle with any A-Trigger LEVEL setting that could be used. If the intensified zone jumps from one cycle to another, reset DLY POS to enable B Trigger at a time such that the intensified zone tracks the same transition for all usable settings of A-Trigger LEVEL. Set DLY POS in the middle of the range that produces proper operation.

- For pulses with both high and low states at least 10 microseconds long:

1. Set the oscilloscope controls to display the signal. Set the A Sweep at 1 microsecond/division. Set the A Trigger for the transition of interest. Set delta-time off.

2. Pull the SEC/DIV knob out to display an intensified zone and set DLY POS for zero delay.

3. Set the B Trigger to TRIG AFT DLY Mode, the same SLOPE and SOURCE as the A Trigger, and HF REJ Coupling. Then press INIT@50 to set the B-Trigger Level.

- For pulses of any width and period, with an auxiliary pulse occurring at least 70 ns after the transition of interest:

  1. Display the transition of interest on one vertical channel and the auxiliary pulse on another channel. Set A-Trigger SOURCE and SLOPE for the transition of interest. Set delta-time off.
  2. Pull the SEC/DIV knob out to display an intensified zone and set DLY POS for zero delay.
  3. Select TRIG AFT DLY mode and DC coupling for the B Trigger. Set B-Trigger SOURCE and LEVEL for the auxiliary pulse. If necessary, readjust DLY POS to position the intensified zone at the earliest possible transition of the auxiliary pulse and such that the intensified zone remains on the same transition for all settings of A-Trigger Level (while holding A/B TRIG for access to the A Trigger).

  Transfer the appropriate instrument settings to the system controller.

  To automatically measure transition time:

  1. Return the appropriate, recorded instrument settings and measure positive and negative peaks of the signal, using a procedure such as the following. See the "Programming Examples" section for the GETCTTN and GETPEAKS subroutines.

Tek

```
100  Print#scope:set$       !Send  previously   stored  settings
110  Call  GETPEAKS (hipeak,     lopeak)
120  pktopk=hipeak-lopeak
```

IBM

```
220  CALL  IBWRT (SCOPE%,SET$)'Send      previous   setting
230  GOSUB  {Statement   Number  of  Get  Peaks  routine}
240  PKTOPK=   HIPEAK-LOPEAK
```

HP

```
120  OUTPUT   D2465;Set$    !Send  previously   stored  setting
130  CALL  Get_peaks (D2465,Hipeak,Lopeak)
140  Pktopk   = Hipeak-Lopeak
```

2. Set the B-Trigger level to the average of the positive and negative peak values, using the BTRIGGER INIT50 command.

3. Set the A-Trigger level to the negative peak value plus 10 percent of the difference between the positive and negative peaks.

Tek

```
250 low=0.1                    !Typically   10%,  may  be
changed  260 Print#scope:"atr
level:";lopeak+low*pktopk
                               !Send  low  level  to  the  A
Trigger
```

IBM

```
1100   Low=0.1
1110   ATRLEV$="ATR    LEV:"+STR$(LOPEAK+LOW*PKTOPK)
1120   CALL  IBWRT(SCOPE%,    ATRLEV$)
```

HP

```
1100   Low=0.1
1110   OUTPUT  D2465;"atr   lev:"&  VAL$(Lopeak   + Low*Pktopk)
```

4. Read the delay time.

```
270 Call  getcttn(delay1)!Get     first  measurement
```

5. Set the A-Trigger level to the negative peak value plus 90 percent of the difference between the positive and negative peaks.

```
280 high=0.9                !Typically   90%,  may  be  changed)
290 Print#scope:"atr     level:";lopeak+high*pktopk
                            !Send  90%  level  to  A-trigger
```

6. Read the delay time.

```
300 Call  getcttn(delay2)!Get     second  measurement
```

7. Subtract the second reading from the first to obtain rise time.

```
310 Risetime=delay1 —delay2!Delay       difference
```

If the A-Trigger SLOPE is negative, the result will be negative and the measurement will be the negative of fall time.

Trigger Level Compensation

Because of signal distortions in the trigger system, a transition time measured with calculated 10% and 90% thresholds may not agree with a direct measurement of the waveform, especially with fast transitions. Any discrepancy can be treated as an error in the measured peak voltages, which correspond approximately to the 0% and 100% values of the transition region. Even with this discrepancy, transition times of similar signals with similar repetition rates can be compared to a reference with enough accuracy for most applications. For good accuracy, use the CTT and trigger system to measure transition times comparatively, and use the cursors to determine actual values.

1. Carefully measure a transition time using the delta-time cursors.
2. Measure the same transition time by the appropriate procedure, above.
3. Estimate new values for the "low" and "high" variables (initially 10% and 90%) as required to adjust the CTT and trigger measurement to agree with the cursor measurement. Adjust "high" if the transition is much slower at the high end than at the low end, such as an exponential step. Adjust "low" if the transition is much slower at the low end. If one peak has a large overshoot, adjust the variable near that peak. If both peaks are severely overshot, both "high" and "low" should be adjusted. If the transition slew rate is constant and pulse distortions are less than 5%, adjust only "high" for rise time or "low" for fall time. Repeat the measurement, estimation of new values, and the trigger-level adjustment steps until the desired accuracy is achieved.

Programming Examples

Each of the examples assumes the following declaration statement or an equivalent. For illustration, the GPIB address of the oscilloscope is assumed to be 1.

Tek

```
10 scope=1                    !Assuming   GPIB  adrs  is  1
```

IBM

```
10 SCOPE$="o2465"             !String   name  of  scope  for
                              ! GPIB  driver  must  = name  given
                              ! in  IBCONF.
20 CALL  IBFIND (SCOPE$,SCOPE%)       !Returns   with
                              ! SCOPE%  I/O  address  for  scope
                              ! seen  through  GPIB  driver.
                              ! I/O  statements   use  SCOPE%
30 IF  IBSTA%<0   THEN  {Statement   Number  of
        ! ERROR  ROUTINE}
```

HP

```
10 D2465  = 701               !I/O  pointer  = 700  plus  scope
                  !address
```

The system controller can "learn" the oscilloscope settings for a given test, using a routine similar to the following.

Tek

```
20 Dim  set$  to  180         !Array  to  store  settings
 ...
 ...
110  Print#scope:"llset?"!Ask      for  settings
120  Input#scope:set$         !Put  setup  into  set$
```

IBM

```
20  SET$=SPACE$ (180)        'String  to  store  binary  setting
30  SETQUER$="llset?         'Define  set  query  string  once.
 ...
 ...
110  CALL  IBWRT (SCOPE%,SETQUER$)'Ask       for  settings
120  CALL  IBRD (SCOPE%,SET$)'Put      setup  into  SET$
```

HP

```
20 Dim  Set$[180]             !Array  to  store  settings
 ...
 ...
110  OUTPUT  D2465;"llset?"!Ask     for  settings
110  ENTER  D2465;Set$        !Store  in  Set$
```

The "LLset?" query transfers binary control data to save time. If your controller will not support eight-bit binary data transfers, you can use an ASCII transfer. To store instrument settings as ASCII data, dimension the set$ array, above, to 1200 bytes and replace "LLset?" with "SET?".

The instruments, interacting with an operator, can measure time with cursors, delay time, or delta-delay time. With the CTT, they also can measure delay time or delta-delay time without an operator, using TRIG AFT DLY and TRIG Δ DLY B-Trigger modes.

Table 7-1
Delay Time and Delta-Delay Time

Mode	Query	Conditions and Results
Cursor Δt or 1/Δt	TDELTA?	Requires [1] A-Sweep or B-Sweep display (not ALT or INTEN) [2] cursors on with Δt or 1/Δt [3] operator to set DLY POS control. Gives time or frequency in seconds, hertz, percent, or degrees. If cursors are active, DELTA? :MODE query returns DELTA MODE:CTIME or DELTA MODE:CPERTIME. In the special case where cursors are active with B-Sweep delayed by events (with CTT) the last three characters of a MESSAGE? query are BSW.
Delta-Delay Δt or 1/Δt	TDELTA?	Requires [1] INTEN, ALT, or B-Sweep display [2] RUN AFT DLY B-Trigger mode [3] operator to set Δ REF and Δ controls. Gives time or frequency in seconds, hertz, percent, or degrees. (Invalid result is returned with TRIG AFT DLY.) If Δt or 1/Δt is active without cursors, a DELTA? MODE: query returns DELTA MODE:TIME or DELTA MODE:PERTIME.
Delay	DELAY?	Requires [1] INTEN, ALT, or B-Sweep display [2] RUN AFT DLY B-Trigger mode [3] operator to set DLY POS control. Gives delay setting in divisions which must be multiplied by A-SEC/DIV to determine delay time. (Invalid result is returned with TRIG AFT DLY.)
Delta-Delay Δt or 1/Δt or Delay, with CTT	CTSEND?	Requires [1] INTEN, ALT, or B-Sweep display [2] TRIG AFT DLY or TRIG Δ display [2] TRIG AFT DLY or TRIG Δt or 1/Δt display [2] TRIG AFT DLY or TRIG Δ or Delay, DLY B-Trigger mode [3] appropriate with CTT settings to frame desired measurement [4] selecting Δt or 1/Δt in INTEN or ALT mode or with DELTA MODE:TIME or DELTA MODE:PERTIME command. Alternative to requirement [2] is RUN AFT DLY B-Trigger mode and operator to set Δ REF and Δ controls. Gives time or frequency in seconds or hertz.

A

Appendix A

Programming Examples

Tektronix 4041 Program to Send Commands to the Oscilloscope

The program first asks for the GPIB address of the oscilloscope, then asks for a command to be entered at the keyboard. Any response from the oscilloscope is displayed on the controller. A serial poll is performed in response to service request (SRQ). The service request and the EVENT codes are then displayed.

```
100  ! Program  to send  commands  and  queries
++++       and  receive  responses
110  ! from  TEKTRONIX  2400-Series
++++       Oscilloscopes
120  !
130  Init  all
140  ! Disable  SRQ  handler  until  ready
150  Disable  srq
160  ! Get  address  of  the  oscilloscope
170  Print  "Enter  the  GPIB  address  of  the
++++     oscilloscope:    ";
180  Input  addr$
190  ! Set  up physical  and logical  unit  -
200  ! Set  up so only  EOI  can terminate  the
++++       communication.
210  !
220  Set  driver  "gpib0  (eom=<0>):"
230  Open  #1:"gpib0  (pri="&addr$&",
++++       eom=<0>):"
240  !
250  ! Enable  SRQ  handler
260  On srq  then  gosub  srqhdl
270  Enable  srq
280  !
290  Repeat:  ! Sending  command  or  query
300  Print  "* * * * *"
310  Print
320  Print  "Enter  command  or  query:  ";
330  ! Get  the  command
340  Input  a$
```

```
350  ! Send  command  or  query  to  scope
360  Print  #1:a$
370  ! Get  response  if  there  is  any
380  DIM  resp$  to  2000
390  Input  #1:resp$
400  Print
410  ! If  no  response  then  prompt  for
++++       another  command
420  If  len(resp$)=0  then  goto  repeat
430  ! If  yes  then  print  the  response
440  Print  "Response  from  the  oscilloscope
++++       is:  "
450  Print  resp$
460  Goto  repeat
470  Srqhdl:  ! routine  to  handle  the  srq
480  Poll  stb,dev
490  Print  #dev:"event?"
500  ! Get  event  number
510  Input  #dev:event
520  Print  "Instrument  #";dev;"status
++++     byte=";stb;"  ,event=";event
530  Resume
```

Tektronix 4041 Program to Calibrate Trigger Levels for Transition Time

```
 10  !A Tektronix  4041  BASIC  Program
++++        to Adjust  Trigger  Thresholds
 20  ! for Transition  Time  Measurements
 30  !            30 June  1986
 40  !
 50  !Note:  "++++"  in place  of line  number
 ++++      indicates  printed  break
 60  !in long line,  which  must  be  entered
 ++++      without  "++++"  or  break.
 70  !
 80  Compress  !4041  housekeeping
 90  Scope=1  !Use  actual  GPIB  adrs  of
 ++++      Oscilloscope
100  True=1
110  False=0
120  Integer  count
```

```
130   Count=0
140   Risetime=0
150   Print
160   Print  "Execute  this  procedure  and
++++        program  to  find  the  optimum"
170   Print  "high  and  low  thresholds  for
++++        transition  time  measurements."
180   Print
190   Print  "Repeat  the  procedure  to  find
++++        the  optimum  thresholds  for"
200   Print  "each  dissimilar  signal."
210   Print
220   Print  "1.  Connect  oscilloscope  to
++++        controller  IEEE-488  bus."
230   Print
240   Print  "2.  Carefully  measure
++++        transition  time  with  cursors."
250   Print  "    Use  10%  and  90%  or  20%
++++        and  80%  as  appropriate."
260   Print
270   Print  "3.  Manually  set  the  scope  to
++++        measure  the  transition  of"
280   Print  "    interest,  with  the  same
++++        control  settings  that  will  be"
290   Print  "    used  in  the  automatic  test.
++++        Review  ""Measuring  Rise"
300   Print  "    and  Fall  Times""  to
++++        determine  the  best  settings."
310   Print
320   Print  "4.  Enter  transition  time,
++++        measured  in  step  2,"
330   Print  "    in  exponential  form,  eg.
++++        5.43e-9."
340   Print
350   Print  "    Use  minus  time  for  fall
++++      time,  eg.  -32.7e-6."
360   Print
370   Input  prompt  "Transition  Time:
++++        ":actual
380   Wbyte  dcl  !Send  Device  CLear  message
++++        to  GPIB
390   Highok=true
```

```
400   Lowok=true
410   Low=0.1   !Typically   10%,   may   be
++++        adjusted   later.
420   High=0.9   !Typically   90%,   may   be
++++        adjusted   later.
430   Print
440   Print   "Enter   ""y<RETURN>""     for
++++      ""yes,""   or   ""n<RETURN>""
++++      for   ""no."""
450   Print
460   Input   prompt   "Are   you   using   a   low
++++    threshold   other   than   10%?":answer$
470   If   answer$<>"y"     then   goto   ask90
480   Input   prompt   "Enter   low   threshold
++++    value   as   decimal   fraction:    ":low
490   If   low<0.02    then   low=0.1
500   If   low>0.9    then   low=0.1
510 Ask90:        input   prompt   "Are   you
++++   using   a   high   threshold   other   than
++++   90%?":answer$
520   If   answer$<>"y"     then   goto   askx
530   Input   prompt   "Enter   high   threshold
++++        value   as   decimal   fraction:    ":high
540   If   high<0.1    then   high=0.9
550   If   high>0.98    then   high=0.9
560 Askx:        print   "Initial   low
++++        threshold=";low;"        Initial   high
++++    threshold=";high
570   Print   "Is   the   transition    OBVIOUSLY
++++        slower   near   the   high   than
++++    near   the   low?   ";
580   Input   answer$
590   If   answer$="y"     then   highok=false
600   If   answer$="y"     then   goto   aberr
610   Print   "Is   the   transition    OBVIOUSLY
++++        slower   near   the   low   than
++++    near   the   high?   ";
620   Input   answer$
630   If   answer$="y"     then   lowok=false
640 Aberr:      !
650   Print   "Do   both   high   and   low   levels
++++        have   less   than   5%"
```

```
660   Print  "    overshoot,   undershoot,
++++        tilt,  or  other  aberration?    ";
670   Input  answer$
680   If  answer$="y"    then  goto  measure
690   Print  "Does  high  level  have  less
++++        than  5%"
700   Print  "    overshoot,   undershoot,
++++        tilt,  or  other  aberration?    ";
710   Input  answer$
720   If  answer$<>"y"    then  highok=false
730   If  answer$="yr"    then  lowok=false
740   If  answer$="y"    then  goto  measure
750   Print  "Does  low  level  have  less
++++        than  5%"
760   Print  "    overshoot,   undershoot,
++++     tilt  or  other  aberration?    ";
770   Input  answer$
780   If  answer$<>"y"    then  lowok=false
790   !
800 Measure:      !Measurement    Routine
810   Print  "Wait  for  iterative
++++        measurements."
820   Highx=false    !Don't   change   high
++++        unless   required
830   Lowx=false    !Don't   change   low  unless
++++        required
840   If  highok=false    then  highx=true
850   If  lowok=false    then  lowx=true
860   If  highok=true    and  lowok=true    and
++++        actual>0   then  highx=true
870   If  highok=true    and  lowok=true    and
++++        actual<0   then  lowx=true
880   Call  getpeaks(hipeak,lopeak)
890   Pktopk=hipeak-lopeak      !Find
++++        peak-to-peak
900   !Send  50%  level  to  B-trigger
910   Print  #scope:"btr    level:";lopeak+
++++        (0.5*pktopk)
920   Hlprev=0.8
930   SlopeO=4   !Initial   ratio   of
++++      risetime/threshold
940   Accmcnt=0
```

```
950   Riseaccm=0
960   Hlaccm=0
970   !
980  Again:     !Iteration   Loop
990   Count=count+1
1000   Print  #scope:"atr   level:";
++++        lopeak+low*pktopk
1010   !Send  low  level  to  A-trigger
1020   Call  getcttn(delay1)     !Get  1st
++++        delay  reading
1030   Print  #scope:"atr   level:";lopeak
++++        +high*pktopk
1040   !Send  high  level  to  A-trigger
1050   Call  getcttn(delay2)     !Get  2nd
++++        delay  reading
1060   Riseprev=risetime
1070   Risetime=delay1-delay2       !Delay
++++        difference
1080   If  risetime/actual>0.99      and
++++        risetime/actual<1.01      then
++++        goto  finish
1090   If  count>19   then  goto  finish
++++        !Can't  converge  within  1%
1100   If  count>1   then  riseaccm=riseaccm
++++       +abs((risetime-     riseprev)
++++       /risetime)
1110   If  count>1   then  hlaccm=hlaccm
++++       +abs((high-    low-hlprev)
++++       /(high-low))
1120   If  hlaccm>0.02    then  slope0=
++++       riseaccm/hlaccm
1130   Slope=slope0
1140   If  highx=true    and  lowx=true    then
++++        slope=slope*2
1150   Change=(high-low)*(actual/risetime
++++        -1)  /slope
1160   If  hlprev>0.95    and  high=0.98    and
++++        low=0.02   then  goto  finish
1170   Hlprev=high-low
1180   If  highx=true    then  high=high+change
1190   If  lowx=true    then  low=low-change
1200   If  high>0.98    then  high=0.98
```

```
1210   If low<0.02 then low=0.02
1220   If (low+0.1)>high then goto finish
++++     !Invalid "actual"
1230   If high=0.98 then lowx=true
1240   If low=0.02 then highx=true
1250   Goto again
1260   !
1270 Finish:     !
1280   Print
1290   Print count;" iterations"
1300   Print "Use these new values for high
++++       and low with similar signals."
1310   Print "      New value for high =
++++     ";high
1320   Print "      New value for low =
++++       ";low
1330   Print "Measured Rise Time (Fall Time
++++       if Negative) = ";risetime
1340   If count>19 then print "Verify
++++       risetime measurement value."
1350   Print
1360   Print "Entered (target) Transition
++++       Time = ";actual
1370   Print
1380   If (high-low)<0.2 then print
++++       "*** ENTERED TRANSITION TIME
++++    OUT OF RANGE. ***"
1390   If high=0.98 and low=0.02 then print
++++       "*** ENTERED
++++    TRANSITION TIME OUT OF RANGE. ***"
1400   Stop "-- Enter ""run"" to do another
++++       threshold optimization."
1410   End
1420   Sub getpeaks(var hipeak,lopeak)
++++     local timeref,result$
1430   !Set A-trigger to INIT @ 50% for peak
++++       measurement cycle
1440   Print #scope:"atr init50"
1450   timeref=ask("time")     !Starting time
1460 Waitpks:  Input #scope prompt "atr?
++++       trigd":result$     !Triggered?
```

```
1470   If result$="ATR    TRIGD:ON;"    then goto
++++          found  !Peaks  found
1480   If timeref+20>ask("time")       then goto
++++          waitpks  !Loop  if  < 20
++++        sec  since  start
1490   !Else
1500   Print  "***  FAULTY  PEAK  VOLTAGE
++++    MEASUREMENT    ***   20  SECOND  TIMEOUT"
1510   Print  "Check  oscilloscope    settings
++++        and  signal  source."
1520   Stop  "--  Enter  ""run""  to  try  again."
1530   !
1540 Found:      !Ask  instrument   for  peaks  by
++++         A-trigger   query
1550   Input  #scope  prompt  "atr?  mini,
++++          max":result$
1560 !
1570   !Typical   result  string--   ATR  MINI:
++++          -489E-3,MAX:496E-3;
1580   !Extract   low  peak  from  result  string
1590   Lopeak=val(result$)
1600   !Extract   high  peak  from  result  string
1610   Hipeak=valc(result$,pos(result$,
++++          "MAX",1))
1620   Return
1630   End
1640 Sub  getcttn(var    cttcount)
1650   Long  cttcount   !To  accept  up  to  1e99
++++          error  code
1660   Print  #scope:"ctt    reset"   !Discard
++++          stale  measurements
1670 Waiting:     input  #scope  prompt  "ctr?"
++++         :cttcount   !Is  scope  ready?
1680   If  cttcount=0    then  goto  waiting
++++          !Hang  until  ready
1690   Input  #scope  prompt  "cts?":cttcount
++++          !Get  reading  from  scope
1700   If  cttcount<1.0E+9     then  return
++++          !>1E9  count  indicates   error
1710   !Else
```

```
1720   Print  "***  FAULTY  TIME  OR  COUNTING
++++          MEASUREMENT    ***   Error
++++       Code:  ";cttcount
1730   Print  "Check  oscilloscope    settings
++++    and  signal  source."
1740   Stop  "--  Enter  ""run""  to  try  again."
1750   End
```

IBM PC/XT/AT Program to Calibrate Trigger Levels for Transition Time

```
10  'XTNLEV.BAS--    a BASIC  program  for  the
++++          IBM  PC/XT/AT   with
20  '  Tektronix   GPIB  User's  Resource
++++          Utility   (GURU)
30  '                              or
40  '  National   Instruments    IEEE-488
++++          Instrumentation     Interface
50  'To  Adjust   Trigger   Thresholds   for
++++         Transition   Time  Measurements
60  '  with   the  Tektronix   24X5B  and  2467B
++++             Oscilloscopes    with  CTT
70  '           30  June  1986
80  'NOTE:  "++++"  in  place  of  a  line  number
++++          indicates   that
90  '         separately   printed   lines   must   be
++++          joined.    The  "++++"
100  '        symbols   must   not   be   entered.
110  'INITIALIZE
120  KEY  OFF  :  SCREEN   0  :  LOCATE   1,1,0
++++          :  CLS
130  'The   following   6  lines   load   the
++++          utilities   into   memory   that
140  'are   necessary   for   program   operation.
++++          This   should   be   done
150  'at   the   beginning   of   every   application
++++          program.
160     CLEAR    10000,59665!
170     IBINIT1        =  59665!
```

```
180     IBINIT2   = IBINIT1   + 3
190     BLOAD  "bib.m",IBINIT1
200     CALL  IBINIT1 (IBFIND,IBTRG,IBCLR,
++++        IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,
++++        IBONL,IBRSC,IIBSRE,IBRSV,IBPAD,
++++        BSAD,IBIST,IBDMA,IBEOS,IBTMO,
++++        IBEOT,IBRDF,IBWRTF)
210     CALL  IBINIT2 (IBGTS,IBCAC,IBWAIT,
++++        IBPOKE,IBWRT,IBWRTA,IBCMD,
++++        IBCMDA,IBRD,IBRDA,IBSTOP,IBRPP,
++++    IBRSP,IBDIAG,IBXTRC,IBRDI,
++++        IBWRTI,IBRDIA,IBWRTIA,IBSTA%,
++++    IBERR%,IBCNT%)
220  '
230  'Use  this  program  only  for  system
++++     setup  and  calibration.
240  '
250   SCOPE$="o2465"      'The  same  name  must
++++     be  assigned   with  IBCONF
260  '
270  TRUE  = 1 : FALSE  = 0
++++   'Initialize   logical   values
280  PRINT
290  PRINT"Execute    this  procedure   and
++++   program   to  find  the  optimum"
300  PRINT  "high  and  low  thresholds   for
++++   transition   time  measurements."
310  PRINT
320  PRINT"Repeat    the  procedure   to  find  the
++++   optimum   thresholds"
330  PRINT"for   each  dissimilar   signal."
340  PRINT
350  PRINT"1.   Connect   oscilloscope    to
++++    IEEE-488   bus  and  configure   system."
360  PRINT"     Primary   address   of  the  scope
++++   must  equal  the
370  PRINT"     address   assigned   to  o2465
++++   with  IBCONF."
380  PRINT
390  PRINT"2.   Carefully   measure   transition
++++   time  with  cursors."
```

```
400  PRINT"     Use  10%  and  90%  or  20%  and
++++  80%  as  appropriate."
410  PRINT
420  PRINT"3.   Manually   set  the  scope   to
++++  measure   the  transition   of"
430  PRINT"     interest,   with  the  same
++++  control   settings   that  will  be"
440  PRINT"     used  in  the  automatic   test.
++++  Review   ""Measuring   Rise"
450  PRINT"     and  Fall  Times""   to  determine
++++  the  best  settings."
460  PRINT
470  PRINT"4.   Enter  transition   time,
++++  measured   in  step  2,"
480  PRINT"     in  exponential   form,
++++      eg.  5.43e-9."
490  PRINT"     Use  minus  time  for  fall  time,
++++  eg.  -29.6e-6."
500  PRINT
510  CALL  IBFIND (SCOPE$,SCOPE%)
++++  'Find  scope  specifier   'scope%'
520  IF  IBSTA%  <  0  THEN  2360
++++                  'Incorrect   symbolic   name
530  IDTEST$="id?"
540  CALL  IBWRT (SCOPE%,IDTEST$)      'First  call
++++  to  test  scope  address
550  IF  IBSTA%  <  0  THEN  2360
++++                'Incorrect   address
560  CALL  IBLOC (SCOPE%)
++++                'User  sets  up  scope
570  INPUT"Transition     Time:     ",ACTUAL
580  CALL  IBCLR (SCOPE%)
++++         'Send  Device  Clear  message
++++          to  GPIB
590  PRINT
600  PRINT"The   LOW  threshold   is  typically
++++  10%  (0.1  as  a  decimal)"
610  PRINT"      If  this  is  your  low
++++  threshold,   just  press  <Enter>"
620  PRINT"        Otherwise,   type  in  a  new
++++  low  threshold   as  a"
```

```
630  INPUT"                decimal   fraction   and
++++   press   <Enter>:      ",LOW
640  IF  LOW  <  .02  OR  LOW  >  .98
++++   THEN   LOW  =  .1
650  PRINT
660  PRINT"The    HIGH  threshold    is  typically
++++   90%(0.9   as  a  decimal)"
670  PRINT"      If  this  is  your  high
++++   threshold,    just  press  <Enter>"
680  PRINT"             Otherwise,    type  in  a
++++   new  high  threshold   as  a"
690  INPUT"                 decimal   fraction
++++   and  press  <Enter>:     ",HIGH
700  IF  HIGH  <  .1  OR  HIGH  >  .98  THEN
++++   HIGH  =  .9
710  PRINT
720  PRINT"Initial     low  threshold    =  ";LOW;
730  PRINT"Initial     high  threshold    =  ";HIGH
740  PRINT
750  PRINT"Enter      'Y'   for  a  yes  answer,   or
++++   'N'  for  a  no  answer."
760  HIGHX  =  FALSE
++++   'Don't   change   unless   required
770  LOWX   =  FALSE
++++   'Don't   change   unless   required
780  PRINT"Is    the  transition    CLEARLY
++++   slower   near   the   high   than
++++     near   the   low?   ";
790  GOSUB  1620  'Get  response
800  IF  ANSWR$   =  "Y"    THEN   HIGHX   =  TRUE   :
++++            GOTO  840  'Aberrations
810  PRINT"Is    the  transition    CLEARLY
++++   slower   near   the   low   than
++++     near   the   high?   ";
820  GOSUB  1620
830  IF  ANSWR$   =  "Y"    THEN   LOWX   =  TRUE
840  'Aberrations
850  PRINT"Do    both   high   and   low   levels
++++   have   less   than   5%"
860  PRINT"      overshoot,    undershoot,
++++   tilt   or   other   aberration?      ";
```

```
++++  tilt  or  other  aberration?      ";
870  GOSUB  1620
880  IF  ANSWR$  =  "Y"          THEN
++++  GOTO  990   'Measure
890  PRINT"Does   the  high  level  have  less
++++  than  5%"
900  PRINT"     overshoot,   undershoot,   tilt
++++  or  other  aberration?      ";
910  GOSUB  1620
920  IF  ANSWR$  <>  "Y"   THEN  HIGHX  =  TRUE
930  IF  ANSWR$  =  "Y"   THEN  LOWX  =  TRUE  :
++++  GOTO  990  'Measure
940  PRINT"Does   the  low  level  have  less
++++  than  5%"
950  PRINT"     overshoot,   undershoot,   tilt
++++  or  other  aberration?      ";
960  GOSUB  1620
970  IF  ANSWR$  <>  "Y"  THEN  LOWX  =  TRUE
980  '
990  'Measurement     Routine
1000     PRINT"                    --  Wait  for
++++    iterative   measurements.     --"
1010     IF  HIGHX=FALSE    AND  LOWX=FALSE    AND
++++    ACTUAL>0   THEN  HIGHX=TRUE
1020     IF  HIGHX=FALSE    AND  LOWX=FALSE    AND
++++    ACTUAL<0   THEN  LOWX=  TRUE
1030     GOSUB  1680                    'Get  peaks
1040     PKTOPK  =  HIPEAK-LOPEAK
++++          'Find  peak  to  peak
1050     BTRLEV$="btr    lev:"+  STR$(LOPEAK
++++     +.5*PKTOPK)'Find     50%  level
1060     CALL  IBWRT(SCOPE%,BTRLEV$)
++++     'Send  50%  level  to  B  trigger
1070     IF  IBSTA%  <  0  THEN  2360
1080     HLPREV  =  .8
++++     'Initialize   loop  variables
1090     SLOPEO  =  .25
++++    'Initial   ratio  of  threshold/risetime
1100     RISEACCM   =  0
1110     HLACCM  =  0
1120     COUNT  =  0
```

```
1130    RISETIME   = 0
1140    '
1150    WHILE  COUNT  < 20       'Iteration   loop
1160      COUNT  = COUNT  + 1
1170      COLOR  1,7  : PRINT  COUNT;"    ";
1180      ATRLEV$  = "atr  lev:"  + STR$(LOPEAK
++++      + LOW*PKTOPK)
1190      CALL  IBWRT(SCOPE%,ATRLEV$)
++++          'Send  low  level  to  A-trigger
1200      IF  IBSTA%  < 0 THEN  2360
1210      GOSUB  2020     'Get  1st  delay  reading
1220      DELAY1  = VAL(RD$)
1230      ATRLEV$  = "atr  lev:"  + STR$(LOPEAK
++++      + HIGH*PKTOPK)
1240     CALL  IBWRT(SCOPE%,ATRLEV$)
++++       'Send  high  level  to  A-trigger
1250     IF  IBSTA%  < 0 THEN  2360
1260     GOSUB  2020     'Get  2nd  delay  reading
1270     DELAY2  = VAL(RD$)
1280     RISEPREV  = RISETIME
1290     RISETIME  = DELAY1  - DELAY2
++++       'Delay  difference
1300    IF  RISETIME/ACTUAL>.99     AND
++++    RISETIME/ACTUAL<1.01     THEN  1480
1310    IF  COUNT  > 1 THEN    RISEACCM  =
++++      RISEACCM  + ABS((RISETIME
++++       - RISEPREV)/RISETIME)
1320    IF  COUNT  > 1 THEN    HLACCM  = HLACCM
++++       + ABS((HIGH  - LOW  -
++++         HLPREV)/(HIGH-LOW))
1330    IF  HLACCM  > .02  THEN  SLOPE0  =
++++       HLACCM/RISEACCM
1340     SLOPE  = SLOPE0
1350    IF  HIGHX  = TRUE  AND  LOWX  = TRUE
++++   THEN  SLOPE  = SLOPE/2
1360    CHANGE= (HIGH-LOW) * (ACTUAL/RISETIME
++++      - 1)*SLOPE
1370    IF  HLPREV>.95    AND  HIGH  =.98  AND
++++      LOW  =.02  THEN  1480
1380    HLPREV  = HIGH  - LOW
1390    IF  HIGHX  = TRUE  THEN    HIGH  =
++++      HIGH  + CHANGE
```

```
1400      IF LOWX   = TRUE THEN     LOW   =
++++       LOW - CHANGE
1410      IF HIGH   > .98  THEN     HIGH  = .98
1420      IF LOW    < .02  THEN     LOW   = .02
1430      IF (LOW + .1) > HIGH THEN 1480
++++       'Finish  Invalid  "actual"
1440      IF HIGH   = .98  THEN     LOWX  = TRUE
1450      IF LOW    = .02  THEN     HIGHX = TRUE
1460   WEND                 'End iteration loop
1470   '
1480   'Finish
1490   COLOR 7,0 : PRINT : PRINT
++++    COUNT;"  ITERATIONS"
1500   PRINT"Use  these new values for high
++++    and low with similar signals."
1510   PRINT"   New value for high = ";HIGH
1520   PRINT"    New value for low  = ";LOW
1530   PRINT"Measured   Rise Time (Fall Time
++++    if Negative)=   ";RISETIME
1540   IF COUNT > 19 THEN COLOR 15,4,0:
++++    PRINT "Verify Risetime
++++     measurement   value."  : COLOR 7,0
1550   PRINT
1560   PRINT "Entered  (target)
++++    Transition  Time = ";ACTUAL
1570   PRINT
1580   IF ((HIGH-LOW   < .2)  OR (HIGH = .98
++++    AND LOW = .02)) THEN
++++     COLOR 15,4 : PRINT"  **#**  ENTERED
++++     TRANSITION  TIME OUT OF RANGE
++++     **#**"  : COLOR 7,0
1590   PRINT"--    Enter 'run' to do another
++++     threshold  optimization."
1600   GOTO 2400'End  Routine
1610   '----------------------------------
1620   'Subroutine  to Wait for, Receive
++++         and Print Response
1630   ANSWR$ = INKEY$ : IF ANSWR$ =
++++      "" THEN 1630
1640   IF ANSWR$ = "y" THEN ANSWR$ = "Y"
1650   IF ANSWR$ = "Y" THEN PRINT "YES"
++++           ELSE PRINT "NO"
```

```
1660  RETURN
1670  '----------------------------------
1680  'Subroutine    Get  peaks
1690  ATRINIT50$    = "atr  init50"
1700  ATRQUER$    = "atr?  trigd"
1710  ATRPEKS$    = "atr?  max,mini"
1720  '
1730  'Set  A-trigger    to  INIT  @ 50%  for
++++          peak  measurement    cycle
1740  CALL  IBWRT (SCOPE%,ATRINIT50$)
1750  IF  IBSTA%  < 0 THEN  2360
1760  SENTLEV=TIMER          'START  TIMER
1770  CALL  IBWRT (SCOPE%,ATRQUER$)
++++          'Ask  if  trigger  found
1780    IF  IBSTA%  < 0 THEN  2360
1790    RD$  = SPACE$ (95)
1800    CALL  IBRD (SCOPE%,RD$)
1810    IF  IBSTA%  < 0 THEN  2360
1820    IF  MID$ (RD$,INSTR (1,RD$,":")
++++    +1,2)="ON"    THEN  1890  'Found  trg
1830  IF  SENTLEV  +20>TIMER    THEN  1770
++++          'Under  20  seconds,    try  again
1840  COLOR  15,4
1850  PRINT"         **#**  FAULTY  PEAK  VOLTAGE
++++          MEASUREMENT    **#**"
1860  PRINT"     20  SECOND  TIMEOUT"
1870  PRINT"Check    settings    and
++++          'run'  to  try  again."
1880  GOTO  2400'End    Routine
1890  '     Found
1900                      ' Ask  instrument    for
++++           peaks  by  A-trigger    query
1910  CALL  IBWRT (SCOPE%,ATRPEKS$)
1920  IF  IBSTA%  < 0 THEN  2360
1930  RD$=SPACE$ (95)
1940  CALL  IBRD (SCOPE%,RD$)
1950  IF  IBSTA%  < 0 THEN  2360
1970  IF  IBSTA%  < 0 THEN  2360
1980          'Extract    high  and  low  peaks
1990  HIPEAK    = VAL (MID$ (RD$,INSTR (1,RD$,
++++          ":")+1,10))
2000  LOPEAK    = VAL (MID$ (RD$,INSTR (10,RD$,
++++          ":")+1))
```

```
2010  RETURN
2020  '-------------------------------------
2030  ' Get  Count  Subroutine        (equivalent
++++            to  GETCTTN  subroutine)
2040  CTTRSET$   = "ctt  reset"  'These  4  lines
++++            should  appear  early  in
2050  CTRQUER$   = "ctr?"  'the  main
++++       program;  they  are  shown  here
2060  CTSQUER$   = "cts?"  'to  indicate
++++       the  actual  string  values
2070  EVENT$  = "event?"
++++            'required  by  the  scope.
2080  CALL  IBWRT (SCOPE%,CTTRSET$)
++++            'Discard  stale  measurements
2090  IF  IBSTA%  < 0 THEN  2360
2100  CALL  IBWRT (SCOPE%,CTRQUER$)
++++            'Measurement  available?
2110    IF  IBSTA%  < 0 THEN  2360
2120    RD$=SPACE$ (95)
2130    CALL  IBRD (SCOPE%,RD$)
2140    IF  IBSTA%  < 0 THEN  2360
2150    CALL  IBWRT (SCOPE%,EVENT$)
++++          'Event  query
2160    IF  IBSTA%  < 0 THEN  2360
2170    EV$=SPACE$ (20)
2180    CALL  IBRD (SCOPE%,EV$)
2190    IF  IBSTA%  < 0 THEN  2360
2200    IF  VAL (MID$ (EV$,INSTR (1,EV$,"
++++          ")+1))  <> 0 THEN  2280
2210    IF  VAL (RD$)  = 0 THEN  2100
++++          'No  measurement  available
2220  CALL  IBWRT (SCOPE%,CTSQUER$)
2230  IF  IBSTA%  < 0 THEN  2360
2240  RD$=SPACE$ (95)
2250  CALL  IBRD (SCOPE%,RD$)
++++          'Get  reading  from  scope
2260  IF  IBSTA%  < 0 THEN  2360
2270  IF  VAL (RD$)  < 1E+09  THEN  RETURN
++++          '>= 1.0e+9  indicates  error
2280  COLOR  15,4  'Print  error  message
2290  PRINT"          **#**  FAULTY  TIME  OR
++++          COUNTING  MEASUREMENT  **#**"
```

```
2300  PRINT"Error    Code  ";VAL(RD$);
2310  PRINT"    Check  scope  settings  and
++++          signal  source."
2320  COLOR  7,0  : PRINT"-----
++++       Enter  'run'  to  try  again.  -----"
2330  GOTO  2400'End  Routine
2340  '--------------------------------
2350  'Incorrect  symbolic  name  or  address
2360  S$ = HEX$(IBSTA%)    : COLOR  15,4
2370  PRINT  "    IBSTA  = ";S$,"IBCNT    =
++++            ";IBCNT%,"IBERR    = ";IBERR%
2380  IF  S$="8000"   THEN  PRINT"
++++   ";SCOPE$;"   is  not  a  valid  name."
++++     ELSE  PRINT"     ";SCOPE$;"   is  not
++++             correctly   addressed."
2390  '--------------------------------
2400  'End  Routine
2410  V% = 0 : CALL  IBONL(SCOPE%,V%)
2420  COLOR  7,0  : KEY  ON  : CALL
++++          IBLOC(SCOPE%)
2430  END
```

HP 98XX Program to Calibrate Trigger Levels for Transition Time

```
10  !        A BASIC  Program  for  the
++++           Hewlett  Packard  98XX
20  !to  Adjust  Trigger  Thresholds  for
++++     Transition  Time  Measurements
30  !           with  the  Tektronix
++++        24X5B  and  2467B  Oscilloscopes.
40  !                30  June  1986
50        GOSUB  Setup
++++          !Initialize  and  setup  crt
60    !
70    !Use  this  program  only  for  system
++++        setup  and  calibration.
80    !'NOTE:  "++++"  in  place  of  a  line
++++        number  indicates  that
90    !'         separately  printed  lines
++++       must  be  joined.   The  "++++"
```

```
100  !'        symbols  must  not  be  entered.
110       PRINT  "Execute   this  procedure   and
++++           program  to  find"
120       PRINT  "optimum   high  and  low
++++           thresholds   for  transition"
130       PRINT  "        time  measurements."
140       PRINT
150       PRINT  "Repeat  the  procedure  to  find
++++           optimum  thresholds"
160       PRINT  " for  each  dissimilar  signal."
170       PRINT  "1.  Connect  oscilloscope
++++           to  controller  IEEE-488  bus."
180       PRINT  "2.  Carefully  measure
++++           transition  time  with  cursors."
190       PRINT  "    Use  10%  and  90%  or
++++           20%  and  80%  or  other"
200       PRINT  "         appropriate   levels."
210       PRINT  "3.  Manually  set  the  scope
++++           to  measure  the  transi-"
220       PRINT  "    tion  of  interest,  with
++++           the  same  control  setting"
230       PRINT  "    that  will  be  used  in
++++           the  automatic  test.  Review"
240       PRINT  "    ""Measuring   Rise  and
++++           Fall  Times""  to  determine"
250       PRINT  "     the  best  settings."
260       PRINT  "4.  Enter  the  transition
++++           time  measured  in  step  2,"
270       PRINT  "    in  exponential   form,
++++           eg.   5.43E-9   <ENTER>."
280       PRINT  "    fall  time  is  minus,
++++           eg.  -29.6E-6   <ENTER>."
290       CALL  Check_communi(D2465)
++++           !Check  bus  to  scope
300       LOCAL  D2465          !User  sets
++++           up  scope
310       PRINT  "Transition   Time:     ";
320       LINPUT  Actual$          !E  or  e
++++           accepted
330       Actual=VAL(UPC$(Actual$))
++++           !Converts   e  to  E
```

```
340     PRINT  Actual
350     PRINT
360     PRINT  "The  LOW  threshold   is
++++         typically   10%  (.1  as
++++         decimal)"
370     PRINT  "If  this  is  your  low
++++         threshold,   just  press
++++         <Enter>"
380     PRINT  "  Otherwise,   type  in  a
++++         low  threshold   as  a"
390     PRINT  "        decimal   fraction
++++         and  press  <Enter>:"
400     INPUT  Low
410     IF  Low<.2  OR  Low>.98  THEN
++++         Low=.1
420     PRINT
430     PRINT  "The  HIGH  threshold   is
++++       typically   90%(.9  as  decimal)"
440     PRINT  "If  this  is  your  high
++++       threshold,   just  press  <Enter>"
450     PRINT  "  Otherwise,   type  in  a  new
++++         high  threshold   as  a"
460     PRINT  "   decimal   fraction   and
++++         press  <Enter>:"
470     INPUT  High
480     IF  High<.1  OR  High>.98  THEN
++++         High=.9
490     PRINT
500     PRINT  "Initial  low  threshold   =
++++         ";Low
510     PRINT  "   Initial  high
++++         threshold   = ";High
520     CONTROL  1,12;0     !Turn  on  soft
++++         key  display.
530     PRINT
540     PRINT  CHR$(129);"Use    softkeys
++++         to  answer  the  following
++++       questions:";CHR$(128)
++++    !Color  change  - CHR$(128-140)
++++       are  for  color  control
550     PRINT
```

```
560      Highx=False      !Don't  change
++++       unless  required
570      Lowx=False       !Don't  change
++++       unless  required
580      PRINT  "Is  the  transition
++++       CLEARLYslower    near"
590      PRINT  "     the  high  than  near
++++       the  low?";
600                GOSUB  Rsponse
610      IF  Answr$="YES"    THEN
620           Highx=True
630           GOTO  Aberr
640      END  IF
650      PRINT  "Is  the  transition
++++           CLEARLY  slower  near"
660      PRINT  "           the  low  than
++++           near  the  high?";
670                GOSUB  Rsponse
680      IF  Answr$="YES"    THEN  Lowx=True
690  Aberr:      !
700      PRINT  "Do  both  levels  have
++++         less  than  5% overshoot,"
710      PRINT  "  undershoot,   tilt  or
++++         other  aberration?";
720                GOSUB  Rsponse
730      IF  Answr$="YES"    THEN  GOTO  Measure
740      PRINT  "Does  the  high  level  have
++++         less  than  5% overshoot,"
750      PRINT  "  undershoot,   tilt  or
++++         other  aberration?";
760                GOSUB  Rsponse
770      IF  Answr$="YES"    THEN
780           Lowx=True
790           GOTO  Measure
800      ELSE
810           Highx=True
820      END  IF
830      PRINT  "Does  the  low  level  have
++++         less  than  5% overshoot,"
840      PRINT  "  undershoot,   tilt  or
++++         other  aberration?";
850                GOSUB  Rsponse
```

```
860     IF Answr$<>"YES"    THEN  Lowx=True
870   !
880 Measure:       !
890     REMOTE  7                !Place
++++          scope  under  HP  control  and
900     LOCAL  LOCKOUT  7      !Lockout  user
++++          from  scope's  front  panel
910     FOR  I=0  TO  Num_keys     !Adjust
++++          soft  keys
920     KEY  I  LABEL  "" GOSUB  Inactive
930     NEXT  I
940     ON  KEY  7  LABEL  "ABORT"  GOTO
++++       Done   !Key  7  only  will  abort
950     PRINT  "-----    Wait  for  iterative
++++          measurements      -----"
960     IF  Highx=False    AND  Lowx=False
++++          AND  Actual>0   THEN  Highx=True
++++          Lopeak)           !Get  peaks
990     Pktopk=Hipeak-Lopeak
++++          !Find  peak  to  peak
1000    OUTPUT  D2465;"btr   lev:"
++++          &VAL$(Lopeak+.5*Pktopk)
++++     !Send  50%  level  to  b-trig
1010    Hlprev=.8
++++          !Initialize   loop  variables
1020    Slope0=.25
++++          !Ratio  threshold/risetime
1030    Riseaccm=0
1040    Hlaccm=0
1050    Count=0
1060    Risetime=0
1070    LOOP               !Iteration   loop
1080          Count=Count+1
1090          PRINT  CHR$(129);Count;"      ";
1100          OUTPUT  D2465;"atr   lev:"&VAL$
++++       (Lopeak+Low*Pktopk)
++++             !Send  low  to  a-trig
1110          CALL  Get_cttn(D2465,Delay1)
++++       !Get  1st  delay  rdg
1120          OUTPUT  D2465;"atr   lev:"&VAL$
++++       (Lopeak+High*Pktopk)
++++             !Send  high  to  a-trig
```

```
1130          CALL  Get_cttn(D2465,Delay2)
++++       !Get  2nd  delay  rdg
1140          Riseprev=Risetime
1150          Risetime=Delay1-Delay2
++++       !Delay  difference
1160    EXIT  IF  Risetime/Actual>.99     AND
++++         Risetime/Actual<1.01
++++              !Under  1% error
1170    EXIT  IF  Count>19
++++         !Can't  converge  under  1%
1180          IF  Count>1  THEN
1190                Riseaccm=Riseaccm+ABS
++++         ((Risetime-Riseprev)/Risetime)
1200                Hlaccm=Hlaccm+ABS
++++         ((High-Low-Hlprev)/(High-Low))
1210          END  IF
1220          IF  Hlaccm>.02   THEN  Slope
++++       0=Hlaccm/Riseaccm
1230          Slope=Slope0
1240          IF  Highx=True   AND  Lowx=True
++++       THEN  Slope=Slope/2
1250          Change=(High-Low)*(Actual
++++       /Risetime-1)*Slope
1260    EXIT  IF  Hlprev>.95   AND  High=.98
++++         AND  Low=.02        !At  limits
1270          Hlprev=High-Low
1280          IF  Highx=True   THEN  High=
++++          High+Change
1290          IF  Lowx=True   THEN  Low=
++++              Low-Change
1300          IF  High>.98   THEN  High=.98
1310          IF  Low<.02   THEN  Low=.02
1320    EXIT  IF  Low+.1>High
++++         !Low  too  close  to  high
1330          IF  High=.98   THEN  Lowx=True
1340          IF  Low=.02   THEN  Highx=True
1350    END  LOOP
1360  !End  of  measurement   routine
1370    PRINT  CHR$(128);Count;"
++++         ITERATIONS"
1380    PRINT  "Use  these  high  &  low
++++         values  with  similar  signals:"
```

```
1390    PRINT  "                New  value
++++         for  high  =  ";DROUND(High,4)
1400    PRINT  "                New  value  for
++++         low   =  ";DROUND(Low,4)
1410    PRINT  "Measured   Rise  Time
++++         (Fall  Time  IF  negative)   ="
1420    PRINT  TAB(30);DROUND(Risetime,4)
1430    IF  Count>19   THEN
1440    PRINT  CHR$(129);"Verify     Risetime
++++         Measurement   Value."
1450    END  IF
1460    PRINT  CHR$(128)
1470    PRINT  "Entered   (target)
++++         Transition   Time  =  ";Actual
1480    IF  ((High-Low<.2)    OR  (High=.98
++++         AND  Low=.02))   THEN
1490    PRINT
1500    PRINT  CHR$(129);"**#**
++++         ENTERED  TRANSITION   TIME  OUT
++++         OF  RANGE    **#**";CHR$(128)
1510   PRINT  CHR$(129);"Press     <RUN>  to
++++        do  another  threshold
++++        optimization.";CHR$(128)
1520    END  IF
1530    GOTO  Done
1540    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
++++      !!!!!!!!!!!!!!!!!!!!!!!!!!
1550  Setup:                        !Initialize
++++      controller   and  GPIB
1560    DIM  Clr$[2]
1570    Clr$=CHR$(255)&CHR$(75)
1580    OUTPUT  2;Clr$;      !Clear  screen
1590    PRINT  CHR$(128)     !Set  color
1600    CONTROL  1,12;1  !Turn  off  softkey
++++       display
1610    Model$=SYSTEM$("SYSTEM      ID")
++++         !Find  model  id  and  define
++++         num_keys   to
1620    IF  VAL(Model$)=9816     THEN  !Use  in
++++         softkeys   configuration    loop
1630          Num_keys=9
++++      !9816  has  only  10  softkeys
```

```
1640      ELSE
1650           Num_keys=19
++++   !Others   have  20  softkeys
1660      END  IF
1670     FOR  I=0  TO  Num_keys
++++           !Configure    softkey   menu
1680       ON  KEY  I  LABEL  "   " GOTO  Wrong
1690     NEXT  I
1700     ON  KEY  5  LABEL  "YES"  GOTO  Yes
1710     ON  KEY  6  LABEL  "NO"  GOTO  No_
1720     ON  KEY  7  LABEL  "ABORT"  GOTO  Done
1730     D2465=701   !Default   address   - use
++++           actual  scope  address
1740     True=1      !Initialize   logical
++++         values
1750     False=0
1760     RETURN
1770    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
1780   Rsponse:
++++        !Accept   and  interpret   softkey
++++        input
1790   Spin:  GOTO  Spin
1800   Yes:  Answr$="YES"
1810     PRINT  "       YES"
1820     RETURN
1830   No_:  Answr$="NO"
1840     PRINT  "       NO"
1850     RETURN
1860   Wrong:  GOTO  Rsponse
++++       !Wrong  key  during  user  input
1870   Inactive:         RETURN
++++         !Inactive   key  during
++++         program   control
1880     !-------------------------------
1890   Done:                          !End  routine
1900          PRINT  CHR$(128)
++++         !Return   color  to  normal
1910          LOCAL  7    !Return   local
++++            control
1920     END
1930    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
1940     SUB  Check_communi(D2465)
++++          !Be  sure  scope  communicates.
```

```
1950          ON  TIMEOUT   7,1  GOTO  Incorrect
1960             I=SPOLL (D2465)
1970           OFF  TIMEOUT
1980           SUBEXIT
++++        !Serial   poll  complete
1990  Incorrect:        !
2000     PRINT   CHR$ (129);"COMMUNICATION
++++          ERROR  -  Check  cable
++++               connections,";CHR$ (128)
2010     PRINT   CHR$ (129);"Message
++++         terminator    (must  be  LF)  and
++++         address.     ";CHR$ (128)
2020     INPUT   "IF  incorrectly   addressed,
++++         enter  correct  address:",D2465
2030     IF  D2465>=0   AND  D2465<=31   THEN
2040      D2465=D2465+700
2050      GOTO  1950
++++  !Try  again
2060     ELSE
2070      INPUT   "Out  of  range   (0  -  31)
++++  -  enter  correct  address:",D2465
2080      GOTO  2030
2090     END  IF
2100     SUBEND
2110   !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
2120     SUB  Get_peaks (D2465,Hipeak,
++++         Lopeak)
2130        ON  KEY  7  LABEL  "ABORT"   GOTO
++++    Stop_   !Activate   abort  softkey
2140        DIM  Atrd$[60],Max_mini$[60]
2150        OUTPUT   D2465;"atr    init50"
2160        ON  DELAY   20  GOTO  Quit
++++    !Activate    timer
2170  Again:        OUTPUT   D2465;"atr?
2180        ENTER   D2465;Atrd$
++++        trigd"!Ask    if  triggered
++++     ="OFF"   THEN  Again    !Not  found
2190        IF  Atrd$[POS (Atrd$,":")+1;3]
```

```
2200        OFF DELAY          !Found trigger
2210        OUTPUT D2465;"atr?   max,mini"
++++    !Ask for peaks via A-trigger
2220        ENTER D2465;Max_mini$
2230  !
2240        Hipeak=VAL(Max_mini$[POS
++++        (Max_mini$,"MAX:")+4,
++++          POS(Max_mini$,"MINI:")-1])
++++      !Extract high peak
2250    Lopeak=VAL(Max_mini$[POS(Max_mini$,
++++    "MINI:")+5])    !Low peak
2260        SUBEXIT
2270  Quit:              !Trigger not found
2280      PRINT CHR$(129)          !Set color
2290      PRINT " *#* FAULTY PEAK VOLTAGE
++++        MEASUREMENT    *#* "
2300        PRINT "    20 second timeout      "
2310        PRINT "Check scope settings and
++++        signal source."
2320         PRINT "    Press 'run' to try
++++        again.           "
2330  Stop_:       PRINT CHR$(128)
2340               LOCAL 7
2350               STOP
2360    SUBEND
2370    !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
2380    SUB Get_cttn(D2465,Delay)
2390          ON KEY 7 LABEL "ABORT"
++++    GOTO Stop_
2400          OUTPUT D2465;"ctt   reset"
++++      !Discard stale measurements
2410  Again:  OUTPUT D2465;"ctr?"
++++        !Measurement    available?
2420              ENTER D2465;Cttrset$
2430              IF Cttrset$=CHR$(255)
++++                  THEN Quit
```

```
++++              !Bad  scope  setting
2440           IF  VAL(Cttrset$)=0     THEN  Again
++++             !No  measurement    ready
2450             OUTPUT   D2465;"cts?"
++++         !Get  reading   from  scope
2460             ENTER  D2465;Delay
2470          IF  Delay<1.E+9    THEN  SUBEXIT
++++         !>=1.E+9   indicates   error
2480  Quit:             !Print   error  message
2490       PRINT  CHR$(128)
2500       PRINT  CHR$(129)
2510       PRINT  "  **#**  FAULTY   TIME  OR
++++    COUNTING   MEASUREMENT    **#**"
2520       PRINT  "      Check  scope  settings
++++    and  signal   source.      "
2530       PRINT  "        -----  Press  <RUN>
++++    to  try  again.  -----        "
2540  Stop_:         PRINT  CHR$(128)
2550       LOCAL  7
2560       STOP
2570  SUBEND
```

Tektronix 4041 Subroutine to Measure Frequency, Count, and Time

```
1640  Sub  getcttn(var    cttcount)
1650   Long  cttcount   !To  accept  up  to
++++         1e99  error  code
1660   Print  #scope:"ctt    reset"
++++        !Discard   stale  measurements
1670  Waiting:          input  #scope  prompt
++++    "ctr?":cttcount     !Is  scope  ready?
```

IBM PC/XT/AT Subroutine to Measure Frequency, Count, and Time

```
1680   If cttcount=0   then goto waiting
++++       !Hang until ready
1690   Input #scope prompt "cts?"
++++    :cttcount   !Get reading from scope
1700   If cttcount<1.OE+9    then return
++++       !>1E9 count indicates error
1710   !Else
1720   Print "*** FAULTY TIME OR
++++     COUNTING MEASUREMENT *** Error
++++     Code: ";cttcount
1730   Print "Check scope settings and
++++       signal source."
1740   Stop "-- Enter ""run"" to try again."
1750   End
2030 ' Get Count Subroutine (equivalent
++++   to GETCTTN subroutine)
2040 CTTRSET$ = "ctt reset" 'These 4
++++     lines should appear early in
2050 CTRQUER$ = "ctr?"
++++   'the main program; they are
++++    shown here
2060 CTSQUER$ = "cts?"          'to
++++  indicate the actual string values
2070 EVENT$ = "event?"
++++     'required by the scope.
2080 CALL IBWRT (SCOPE%,CTTRSET$)
++++     'Discard stale measurements
2090 IF IBSTA% < 0 THEN 2360
2100 CALL IBWRT (SCOPE%,CTRQUER$)
++++     'Measurement available?
2110   IF IBSTA% < 0 THEN 2360
2120   RD$=SPACE$(95)
2130   CALL IBRD (SCOPE%,RD$)
2140   IF IBSTA% < 0 THEN 2360
2150   CALL IBWRT (SCOPE%,EVENT$)
++++       'Event query
2160   IF IBSTA% < 0 THEN 2360
```

```
2170    EV$=SPACE$(20)
2180    CALL  IBRD(SCOPE%,EV$)
2190    IF  IBSTA%  <  0  THEN  2360
2200    IF  VAL(MID$(EV$,INSTR(1,EV$,"       ")
++++         +1))  <>  0  THEN  2280
2210    IF  VAL(RD$)  =  0  THEN  2100
++++         'No  measurement  available
2220  CALL  IBWRT(SCOPE%,CTSQUER$)
2230  IF  IBSTA%  <  0  THEN  2360
2240  RD$=SPACE$(95)
2250  CALL  IBRD(SCOPE%,RD$)
++++      'Get  reading  from  scope
2260  IF  IBSTA%  <  0  THEN  2360
2270  IF  VAL(RD$)  <  1E+09  THEN
++++    RETURN  '>=  1.0e+9  indicates
++++      error
2280  COLOR  15,4      'Print  error
++++      message
2290  PRINT"          **#**  FAULTY  TIME
++++      OR  COUNTING  MEASUREMENT
++++      **#**"
2300  PRINT"Error  Code  ";VAL(RD$);
2310  PRINT"  Check  scope  settings
++++      and  signal  source."
2320  COLOR  7,0  :  PRINT"-----  Enter
++++      'run'  to  try  again.  -----"
2330  GOTO  2400'End  Routine
2340  '---------------------------------
2350  'Incorrect  symbolic  name  or
++++       address
2360  S$  =  HEX$(IBSTA%)  :  COLOR  15,4
```

HP 98XX Subroutine to Measure Frequency, Count, and Time

```
2370  PRINT  "    IBSTA  = ";S$,"IBCNT    =
++++       ";IBCNT%,"IBERR     = ";IBERR%
2380  IF  S$="8000"   THEN  PRINT"
++++       ";SCOPE$;"    is  not  a  valid
++++      name.  "ELSE  PRINT"      ";SCOPE$;"
++++  is  not  correctly   addressed."
2390  '--------------------------------
2400  'End  Routine
2410  V% = 0 : CALL  IBONL (SCOPE%,V%)
2420  COLOR  7,0  : KEY  ON  :
++++       CALL  IBLOC (SCOPE%)
2430  END
2380    SUB  Get_cttn (D2465,Delay)
2390           ON  KEY  7  LABEL  "ABORT"
++++           GOTO  Stop_
2400           OUTPUT  D2465;"ctt   reset"
++++       !Discard   stale  measurements
2410  Again:   OUTPUT  D2465;"ctr?"
++++       !Measurement    available?
2420             ENTER  D2465;Cttrset$
2430           IF  Cttrset$=CHR$ (255)     THEN
++++          Quit     !Bad  scope  setting
2440           IF  VAL (Cttrset$)=0     THEN
++++          Again  !No  measurement    ready
2450           OUTPUT  D2465;"cts?"
++++       !Get  reading  from  scope
2460           ENTER  D2465;Delay
2470           IF  Delay<1.E+9    THEN  SUBEXIT
++++       !>=1.E+9   indicates   error
2480  Quit:           !Print  error  message
2490       PRINT  CHR$ (128)
2500       PRINT  CHR$ (129)
2510       PRINT  "  **#**  FAULTY  TIME  OR
++++    COUNTING   MEASUREMENT    **#**"
2520       PRINT  "      Check  scope
++++    settings  and  signal  source.   "
2530       PRINT  "        -----  Press
++++      <RUN>  to  try  again.  -----    "
2540  Stop_:        PRINT  CHR$ (128)
2550       LOCAL  7
2560       STOP
2570  SUBEND
```

Tektronix 4041 Subroutine to Measure Peak Voltages

```
1420  Sub  getpeaks(var    hipeak,lopeak)
++++        local  timeref,result$
1430   !Set  A-trigger   to  INIT  @  50%
++++         for  peak  measurement   cycle
1440   Print  #scope:"atr   init50"
1450   Timeref=ask("time")
++++         !Starting   time
1460  Waitpks:    input  #scope  prompt
++++     "atr?  trigd":result$
++++       !Triggered?
1470   If  result$="ATR    TRIGD:ON;"   then
++++         goto  found  !Peaks  found
1480   If  timeref+20>ask("time")      then
++++         goto  waitpks  !Loop  if  < 20
++++       sec  since  start
1490   !Else
1500   Print  "***  FAULTY  PEAK  VOLTAGE
++++     MEASUREMENT    ***   20  SECOND
++++     TIMEOUT"
1510   Print  "Check  scope  settings  and
++++         signal  source."
1520   Stop  "--  Enter  ""run""  to
++++        try  again."
1530   !
1540  Found:     !Ask  instrument   for
++++        peaks  by  A-trigger   query
1550   Input  #scope  prompt  "atr?
++++         mini,max":result$
1560  !
1570   !Typical   result   string--
++++       ATR  MINI:-489E-3,MAX:496E-3;
1580   !Extract   low  peak  from  result
++++          string
```

```
1590   Lopeak=val(result$)
1600   !Extract  high  peak  from  result
++++         string
1610   Hipeak=valc(result$,pos(result$,
++++       "MAX",1))
1620   Return
1630   End
```

IBM PC/XT/AT Subroutine to Measure Peak Voltages

```
1680  'Subroutine   Get  peaks
1690  ATRINIT50$   = "atr  init50"
1700  ATRQUER$   = "atr?  trigd"
1710  ATRPEKS$   = "atr?  max,mini"
1720  '
1730  'Set  A-trigger   to  INIT  @ 50%  for
++++       peak  measurement   cycle
1740  CALL  IBWRT(SCOPE%,ATRINIT50$)
1750  IF  IBSTA%  < 0  THEN  2360
1760  SENTLEV=TIMER       'START  TIMER
1770  CALL  IBWRT(SCOPE%,ATRQUER$)
++++       'Ask  if  trigger  found
1780    IF  IBSTA%  < 0  THEN  2360
1790    RD$  = SPACE$(95)
1800    CALL  IBRD(SCOPE%,RD$)
1810    IF  IBSTA%  < 0  THEN  2360
1820    IF  MID$(RD$,INSTR(1,RD$,":")
++++      +1,2)="ON"   THEN  1890
++++      'Found  trg
1830  IF  SENTLEV  +20>TIMER   THEN  1770
++++    'Under  20  seconds,   try  again
1840  COLOR  15,4
1850  PRINT"        **#**  FAULTY  PEAK
++++       VOLTAGE  MEASUREMENT   **#**"
```

```
1860  PRINT"          20  SECOND   TIMEOUT"
1870  PRINT"Check    settings   and
++++       'run'   to   try   again."
1880  GOTO  2400'End    Routine
1890  '      Found
1900                        ' Ask  instrument
++++      for  peaks   by  A-trigger    query
1910  CALL   IBWRT (SCOPE%,ATRPEKS$)
1920  IF  IBSTA%   <  0  THEN   2360
1930  RD$=SPACE$ (95)
1940  CALL   IBRD (SCOPE%,RD$)
1950  IF  IBSTA%   <  0  THEN   2360
1970  IF  IBSTA%   <  0  THEN   2360
1980      'Extract    high   and   low   peaks
1990  HIPEAK    =  VAL (MID$ (RD$,INSTR
++++        (1,RD$,":")+1,10))
2000  LOPEAK    =  VAL (MID$ (RD$,
++++      INSTR (10,RD$,     ":")+1))
2010  RETURN
2340  '---------------------------------
2350  'Incorrect    symbolic    name   or
++++         address
2360  S$  =  HEX$ (IBSTA%)     :  COLOR   15,4
2370  PRINT   "     IBSTA    =  ";S$,"IBCNT     =
++++       ";IBCNT%,"IBERR      =  ";IBERR%
2380  IF  S$="8000"    THEN   PRINT"
++++     ";SCOPE$;"    is  not  a  valid   name."
++++     ELSE   PRINT"      ";SCOPE$;"    is   not
++++  correctly    addressed."
2390  '--------------------------------
2400  'End   Routine
2410  V% = 0  :  CALL   IBONL (SCOPE%,V%)
2420  COLOR   7,0   :  KEY   ON   :  CALL
++++       IBLOC (SCOPE%)
2430  END
```

HP 98XX Subroutine to Measure Peak Voltages

```
2120     SUB  Get_peaks (D2465,Hipeak,
++++        Lopeak)
2130       ON  KEY  7  LABEL   "ABORT"    GOTO
++++         Stop_   !Activate    abort
++++            softkey
2140        DIM  Atrd$[60],Max_mini$[60]
2150        OUTPUT   D2465;"atr    init50"
2160        ON  DELAY   20  GOTO  Quit
++++    !Activate    timer
2170  Again:        OUTPUT   D2465;"atr?
++++        trigd"              !Ask  if
++++        triggered
2180        ENTER   D2465;Atrd$
2190        IF  Atrd$[POS (Atrd$,":")
++++    +1;3]="OFF"     THEN  Again
++++        !Not  found
2200        OFF  DELAY           !Found   trigger
2210        OUTPUT   D2465;"atr?    max,mini"
++++    !Ask  for  peaks  via  A-trigger
2220        ENTER   D2465;Max_mini$
2230  !
2240     Hipeak=VAL (Max_mini$[POS (Max_mini$,
++++        "MAX:")+4,POS (Max_mini$,"MINI:")
++++    -1])!Extract    high  peak
2250        Lopeak=VAL (Max_mini$[POS (Max_mini$,
++++            "MINI:")+5])     !Low  peak
2260        SUBEXIT
2270  Quit:               !Trigger   not  found
2280            PRINT   CHR$ (129)          !Set  color
2290            PRINT   "  *#*  FAULTY   PEAK
++++              VOLTAGE   MEASUREMENT    *#*  "
2300            PRINT   "    20  second   timeout      "
2310            PRINT   "Check   scope   settings   and
++++              signal   source."
```

```
2320            PRINT  "           Press  'run'  to
++++              try  again.              "
2330  Stop_:        PRINT  CHR$(128)
2340                LOCAL  7
2350                STOP
2360     SUBEND
```

NOTES

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B

Appendix B

Status and Error Reporting

The oscilloscope interrupts the bus controller by asserting the Service Request (SRQ) line on the GPIB. The SRQ indicates that a significant event has occurred, either a change in status or an error. To service a request, the controller performs a Serial Poll. In response, the instrument returns a Status Byte (STB), which indicates the type of event that occurred.

Bit 4 of the Serial-Poll Status Byte is true if a command is executing when the event occurs and false if it is not. The other bits in the Status Byte encode other information about the specific cause of the SRQ. The various status events and errors are grouped in categories defined in Table B-1. The dual entries in the Status Byte column are for the cases of no command executing and a command executing.

When more than one type of event is reportable, the status byte indicates the most serious error. A serial poll clears the most serious error indicator and the SRQ. If more events are reportable, SRQ is asserted again.

An EVENT? query can reveal more detail about an event generating an SRQ. When more than one event is reportable, the query returns the most serious error and clears the most serious error indication. When all events have been EVENT? queried, the event code is cleared and further queries will return 0.

The RQS OFF and WARNING OFF commands inhibit SRQ generation, but the controller can test for events by EVENT? query only. The program also could respond to SRQ and neglect the event query. If the program uses both SRQ and EVENT? query, a query should be given after each serial poll to keep the status byte and query response consistent with each other.

The Device Clear (DCL) message clears all event conditions except power-on. The INIt SRQ command clears all event conditions including power-on.

Table B-1
Status Event and Error Categories

Category	Serial-Poll Status Byte	Description
Command Error	97 or 113	The instrument received a command that it cannot understand.
Execution Error	98 or 114	The instrument received a command that it cannot execute. This is caused by either out-of-range arguments or settings that conflict.
Internal Error	99 or 115	The instrument detected a hardware condition or a firmware problem that prevents operation.
Routine Events	65-67, 81-83	Normal events of significance to a system (e.g., Power-on and User Request).
Execution Warning	101 or 117	The instrument is executing a command, but the result is questionable. For example, the instrument is out-of-range, but is sending a reading anyway.
Internal Warning	102 or 118	The instrument detected a problem that permits operation, but should be corrected (e.g., out of calibration).
Instrument Status	0 or 16, 193-238, and 209-254	Significant operational events, defined only for these oscilloscopes.

Table B-2
GPIB Status Codes

Serial-Poll Status Byte	EVENT? Code	Instrument Status
00, 16	0	No status to report
65, 81	401	Power on
66, 82	402	Operation complete
67, 83	403	User request
97, 113	101	Command header error
97, 113	102	Header delimiter error
97, 113	103	Command argument error
97, 113	104	Argument delimiter error
97, 113	105	Non-numeric argument, numeric expected
97, 113	106	Missing argument
97, 113	107	Invalid message-unit delimiter
97, 113	108	Checksum error
97, 113	109	Byte-count error
98, 114	201	Remote-only command in Local mode
98, 114	202	Pending settings lost on rtl
98, 114	203	I/O deadlock detected
98, 114	204	Setting conflict
98, 114	205	Argument-out-of-range
98, 114	250	Diagnostic in progress
98, 114	251	Diagnostic step in progress
98, 114	252	In normal mode

Table B-2 (cont)

Serial-Poll Status Byte	EVENT? Code	Instrument Status
98, 114	253	Option not installed
98, 114	254	Option not in correct mode
98, 114	255	GPIB command lost to local override
99, 115	302	System error
99, 115	350	Math pack error
101, 117	550	Warning of possible conflict
102, 118	650	Warning that measurement not yet available
193, 209	750	Asynchronous option error
194, 210	751	Overrange error
195, 211	752	No probe installed
196, 212	753	Fifty-ohm overload
200, 216	770	Oscilloscope test/cal/exer complete, passed
201, 217	779	Oscilloscope test complete, failed

NOTE

The following option numbers are internal codes unrelated to product designation or ordering codes.

Table B-2 (cont)

Category	Serial-Poll Status Byte	Description
231, 247	771	Option 01 measurement complete.
232, 248	772	Option 02 measurement complete.
233, 249	773	Option 03 measurement complete.
234, 250	774	Option 04 measurement complete.
235, 251	775	Option 05 measurement complete.
236, 252	776	Option 06 measurement complete.
237, 253	777	Option 07 (DMM) measurement complete.
238, 254	778	Option 08 (CTT) measurement complete.

C

Appendix C

Message Command Character Translations

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

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

Table C-1
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
20			space
21	!	p	pico
22	"		
23	#	μ	micro
24	$	m	milli
25	%	%	percent
26	&	k	kilo
27	'		
28	(	1/	one-over symbol
29	)	Δ	delta
2A	*	Δt	delta t
2B	+	+	plus symbol
2C	,	,	comma
2D	—	—	minus symbol
2E	.	.	period
2F	/	/	slash
30	0	0	0
31	1	1	1
32	2	2	2
33	3	3	3
34	4	4	4
35	5	5	5
36	6	6	6
37	7	7	7
38	8	8	8
39	9	9	9
3A	:	:	colon
3B	;		
3C	<	<	less than
3D	=	=	equal to
3E	>	>	greater than
3F	?	?	question mark

Table C-1 (cont)
MESsage Command Character Translations

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

Table C-1 (cont)
MESsage Command Character Translations

ASCII		CRT	Description
Hex	Char	Readout	
5F	_	_	underscore
60	`	°	degrees
61	a	A	A
62	b	B	B
63	c	C	C
64	d	D	D
65	e	E	E
66	f	F	F
67	g	G	G
68	h	H	H
69	i	I	I
6A	j	J	J
6B	k	K	K
6C	l	L	L
6D	m	M	M
6E	n	N	N
6F	o	O	O
70	p	P	P
71	q	Q	Q
72	r	R	R
73	s	S	S
74	t	T	T
75	u	U	U
76	v	V	V
77	w	W	W
78	x	X	X
79	y	Y	Y
7A	z	Z	Z
7B			
7C	—		
7D			
7E	~	~	ac symbol
7F			

D

Appendix D

Sweep Speed Command Considerations

Table D-1 shows the results of various sweep speed commands. Left column entries indicate what would happen if the commands were carried out. The headings for the right three columns reflect the oscilloscope's Horizontal mode just prior to receiving the command. Each block in the table shows "NV" if the new sweep speed is the value in the command or "PV" if the sweep retains the previous speed.

Table D-1
Sweep Speed Command Results

Command Implies	Horizontal Mode Before Command		
	A Only	**A ALT B**	**B Only**
A faster than B	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
A = B and faster than 0.1 s	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
A slower than B	A = NV B = NV A only	A = NV B = PV A ALT B	A = NV B = PV B only
B faster than A	A = PV B = NV B only	A = PV B = NV A ALT B	A = PV B = NV B only
B = A	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
B slower than A and			
B equal to or faster than 50 ms	A = NV B = NV A only	A = NV B = NV A INTEN	A = NV B = NV A only
B slower than 50 ms and B faster than 0.15 s	B = 50 ms A = 50 ms A only	B = NV A = 50 m A INTEN	B = 50 ms A = NV A only
B slower than 0.15 s	A = 50 ms B = 50 ms A only	A = 50 ms B = 50 ms A INTEN	A = 50 ms B = 50 ms A only

E

Appendix E

GPIB Command Reference

Table E-1
GPIB Command Summary

Header	Argument	Argument
	Vertical Commands	
CH1	COUpling:	AC DC FIFty GND
	POSition:	<nrx>
	VARiable:	<nrx>
	VOLts:	<nrx>
CH1?	COUpling POSition VARiable VOLts PRObe	
CH2	INVert:	ON OFF
CH2?	INVert	
CH3 CH3?		
CH4 CH4?		

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Vertical Commands (cont)	
VMOde	BWLimit:	ON
		OFF
	CHOp:	ON
		OFF
	CH 1:	ON
		OFF
	CH2:	ON
		OFF
	CH3:	ON
		OFF
	CH4:	ON
		OFF
	ADD:	ON
		OFF
	INVert:	ON
		OFF
VMOde?	CHOp	
	CH1	
	CH2	
	CH3	
	CH4	
	ADD	
	INVert	
	BWLimit	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Horizontal Commands	
HORizontal	ASEcdiv:	<nrx>
	BSEcdiv:	<nrx>
	MAGnify:	ON
		OFF
	POSition:	<nrx>
	TRAcesep:	<nrx>
HORizontal?	ASEcdiv	
	BSEcdiv	
	MAGnify	
	POSition	
	TRACEsep	
HMOde	ALTernate	
	ASWeep	
	BSWeep	
	XY	
HMOde?		
	Trigger Commands	
ATRigger	MODe:	AUTOBaseline
		AUTOLevel
		NORmal
		SGLseq
	SOUrce:	CH1
		CH2
		CH3
		CH4
		LINe
		VERtical

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Trigger Commands (cont)	
ATRigger (cont)	COUpling:	AC
		DC
		HFRej
		LFRej
		NOIserej
		FLD1
		FLD2
		ALTernate
		LINES
	LEVel:	<nrx>
	INIt50	
	SLOpe:	MINUs
		PLUs
	BENdsa:	ON
		OFF
	HOLdoff:	<nrx>
ATRigger?		
	BENdsa	
	COUpling	
	HOLdoff	
	LEVel	
	MODe	
	SLOpe	
	SOUrce	
	MAXimum	
	MINImum	
	READY	
	TRIGD	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Trigger Commands (cont)	
BTRigger	MODe:	RUN
		TRIGGERAble
		DRTRigger
		DTRigger
		ALTSlope
	SOUrce:	CH1
		CH2
		CH3
		CH4
		VERtical
	COUpling:	AC
		DC
		HFRej
		LFRej
		NOIserej
	LEVel:	<nrx>
	INIt50	
	SLOpe:	MINUs
		PLUs
	DLEVel:	<nrx>
	DSLOpe:	MINUs
		PLUs
BTRigger?	COUpling	
	LEVel	
	MODe	
	SLOpe	
	SOUrce	
	DLEVel	
	DSLOpe	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Delay and Delta Commands	
DELAy DELAy?	<nrx>	
DELTa	MODe:	 OFF CPERTime CTIMe PERTime TIMe VOLts
	TRACKing:	ON OFF
DELTa?	MODe TRACKing	
DTIme	REFerence DELTa:	<nrx> <nrx>
DTIme? TDELta?	REFerence DELTa	
DVOlts	REFerence: DELTa:	<nrx> <nrx>
DVOlts? VDELta?	REFerence DELTa	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	System Commands	
AUTOSetup		
CYCles?		
ERRor?		
EVEnt?		
HELp HELp?		
HRSon?		
ID?		
INIt	PANel SRQ	
INTEnsity INTEnsity?	SWEep: READOut: RESTore SWEep READOut	<nrx> <nrx>
LOCk	ON OFF LLO	
LLMessage LLMessage?	%<byte><byte>...	
LLSet LLSet?	%<byte><byte>...,	
LONgform LONgform?	ON OFF	
LOAdseq LOAdseq?	%<binary data>, ...	
MESsage MESsage?	"string"	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	System Commands (cont)	
OPC OPC?	ON OFF	
PATh	ON OFF	
PID	ON OFF	
READOut READOut?	ON OFF	
RECall	<nrx>	
RECall	NEXT	
RQS RQS?	ON OFF	
SAVe	<nrx> [:STEP / :BEGIN / :END] [:"string" / :FREquency / :WIDth / :TIMe / :RISe / :FALl / :VOLts]	
SETtings?		
SWRQS	ON OFF	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
System Commands (cont)		
UNLock	POT:<nr1> SWItch:<nr1>	**POT TABLE** 1 Holdoff 2 Trigger Level 3 Sec/Div Variable 4 Horizontal Position 5 Delta Control 6 Delta Reference or Delay Position 7 CH1 Variable 8 CH2 Variable 9 CH1 Position 10 CH2 Position 11 CH3 Position 12 CH4 Position 13 Trace Separation 14 Readout Intensity 15 Intensity **SWITCH TABLE** 1 Trigger Coupling 2 Measurement 3 CH1 Input Coupling 4 CH4 Volts/Div 5 CH3 Volts/Div 6 Init@50% 7 CH2 Input Coupling 8 CH1 Volts/Div 9 CH2 Invert 10 CH2 Volts/Div

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
System Commands (cont)		
		SWITCH TABLE (cont)
		11 A/B Sec/Div
		12 A/INT/ALT/B Horz. Mode
		13 CH1 Vertical Mode
		14 CH2 Vertical Mode
		15 ADD Vertical Mode
		16 CH3 Vertical Mode
		17 CH4 Vertical Mode
		18 Auto/Step
		19 Save
		20 Recall
		21 CHOP/ALT Vertical Mode
		22 20 MHz BWLIMIT
		23 X10 MAG
		24 TRACK/INDEP
		25 Delta Time
		26 Delta Volts
		27 Trigger Slope
		28 Trigger Source
		29 Trigger Mode
		30 A/B Trigger Select
WARning	ON OFF	
WARning?		

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Parametric Measurement Commands	
MEAsure	FREquency WIDth VOLts AVGVolts RISe FALl TIMe	
MSETup	UNITs:	PERCent VOLts
	AUTOSetup:	FREquency WIDth VOLts RISe FALl TIMe AUTOSetup
	MINFreq:	HZ50 HZ10
	START:	CH1Pos: <nrx> CH1Neg:<nrx> CH2Pos:<nrx> CH2Neg:<nrx>
	STOP:	CH1Pos:<nrx> CH1Neg: <nrx> CH2Pos: <nrx> CH2Neg: <nrx>

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
	Parametric Measurement Commands (cont)	
MSETup?	UNITs AUTOSetup MINFreq START STOP	
VALue?	FREquency:	FREquency PERIod
	WIDth:	HTIme LTIme HDCycle LDCycle
	VOLts:	PK2pk AVGvolts MINImum MAXimum
	RISe	
	FALl	
	TIMe	

Table E-1 (cont)
GPIB Command Summary

Header	Argument	Argument
Calibration and Diagnostic Commands		
CALibrate	<nrx>:	<nrx>
GO		
LOOping LOOping?	ON OFF	
NORmal		
STEp STEp?		
STOp		
TESt TESt?	<nrx>: <nrx>:	<nrx> <nrx>

F

Appendix F

LLMessage Command Character Translations

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

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

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

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

4.The two tables cross-reference each other.

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

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

Decimal	Hex	Character Description
0	00	1
1	01	large 0
2	02	large 0
3	03	
4	04	4
5	05	large 1
6	06	large 1
7	07	
8	08	7
9	09	large 2
10	0A	large 2
11	0B	
12	0C	t
13	0D	large 3
14	0E	large 3
15	0F	k
16	10	Z
17	11	large 4
18	12	large 4
19	13	Horizontal cursor 1
20	14	n (nano)
21	15	large 5
22	16	large 5
23	17	
24	18	m (micro)
25	19	large 6
26	1A	large 6
27	1B	
28	1C	/
29	1D	large 7
30	1E	large 7
31	1F	Horizontal cursor 2

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

Decimal	Hex	Character Description
32	20	Δ (delta)
33	21	large 8
34	22	large 8
35	23	
36	24	↑
37	25	large 9
38	26	large 9
39	27	
40	28	0
41	29	
42	2A	2
43	2B	↓
44	2C	3
45	2D	<
46	2E	5
47	2F	
48	30	6
49	31	>
50	32	8
51	33	
52	34	9
53	35	~ v (volts ac)
54	36	1.
55	37	large 0 dot
56	38	large 0 dot
57	39	
58	3A	4.
59	3B	large 1 dot
60	3C	large 1 dot
61	3D	
62	3E	7.
63	3F	large 2 dot
64	40	large 2 dot
65	41	

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

Decimal	Hex	Character Description
66	42	%
67	43	large 3 dot
68	44	large 3 dot
69	45	
70	46	s (seconds)
71	47	large 4 dot
72	48	large 4 dot
73	49	
74	4A	z
75	4B	large 5 dot
76	4C	large 5 dot
77	4D	
78	4E	Vertical cursor 2
79	4F	large 6 dot
80	50	large 6 dot
81	51	
82	52	_
83	53	large 7 dot
84	54	large 7 dot
85	55	
86	56	~ (approximately)
87	57	large 8 dot
88	58	large 8 dot
89	59	
90	5A	,
91	5B	large 9 dot
92	5C	large 9 dot
93	5D	
94	5E	0.
95	5F	
96	60	2.
97	61	
98	62	3.
99	63	

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

Decimal	Hex	Character Description
100	64	5.
101	65	
102	66	6.
103	67	
104	68	8.
105	69	
106	6A	9.
107	6B	
108	6C	U
109	6D	large R
110	6E	large R
111	6F	
112	70	V
113	71	large S
114	72	large S
115	73	
116	74	X
117	75	large T
118	76	large T
119	77	
120	78	MNL (manual)
121	79	
122	7A	large V
123	7B	large V
124	7C	Y
125	7D	DEG (degrees)
126	7E	HO (holdoff)
127	7F	
128	80	large X
129	81	large X
130	82	0 over 0
131	83	
132	84	0 over 1
133	85	

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

Decimal	Hex	Character Description
134	86	1 over 0
135	87	
136	88	A
137	89	
138	8A	B
139	8B	
140	8C	D
141	8D	
142	8E	H
143	8F	
144	90	M
145	91	
146	92	N
147	93	
148	94	R
149	95	
150	96	W
151	97	
152	98	I
153	99	large F
154	9A	large F
155	9B	
156	9C	J
157	9D	large Ω (omega)
158	9E	large Ω (omega)
159	9F	
160	A0	K
161	A1	large H
162	A2	large H
163	A1	
164	A4	large d
165	A5	large d
166	A6	=
167	A7	+

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

Decimal	Hex	Character Description
168	A8	L
169	A9	Ω (omega)
170	AA	⏚ (ground symbol)
171	AB	
172	AC	O
173	AD	large L
174	AE	large L
175	AF	
176	B0	P
177	B1	:
178	B2	1 over 1
179	B3	
180	B4	Q
181	B5	?
182	B6	0 over X
183	B7	
184	B8	S
185	B9	large O
186	BA	large O
187	BB	
188	BC	T
189	BD	d
190	BE	x over 0
191	BF	
192	C0	(space)
193	C1	large A
194	C2	large A
195	C3	
196	C4	C
197	C5	large B
198	C6	large B
199	C7	
200	C8	E
201	C9	large C

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

Decimal	Hex	Character Description
202	CA	large C
203	CB	
204	CC	F
205	CD	large D
206	CE	large D
207	CF	
208	D0	G
209	D1	large E
210	D2	large E
211	D3	
212	D4	
213	D5	large n (nano)
214	D6	large n (nano)
215	D7	large u (micro)
216	D8	large u (micro)
217	D9	large k
218	DA	large k
219	DB	large m (milli)
220	DC	large m (milli)
221	DD	
222	DE	large +
223	DF	large +
224	E0	low underline
225	E1	large DLY (delay)
226	E2	large DLY (delay)
227	E3	
228	E4	HLD (hold measurement)
229	E5	
230	E6	1 over x
231	E7	
232	E8	x over 1
233	E9	
234	EA	BWL (bandwidth limit)
235	EB	

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

Decimal	Hex	Character Description
236	EC	1/
237	ED	superscript dash
238	EE	p (pico)
239	EF	
240	F0	underline
241	F1	dotted underline
242	F2	large s (seconds)
243	F3	large s (seconds)
244	F4	large z
245	F5	large z
246	F6	Vertical cursor 1
247	F7	Logical AND symbol
248	F8	Δ t (delta t)
249	F9	
250	FA	Large minus symbol
251	FB	high underline
252	FC	x over x
253	FD	
254	FE	m (milli)
255	FF	

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

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

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
A	136	88	193	C1
			194	C2
B	138	8A	197	C5
			198	C6
C	196	C4	201	C9
			202	CA
D	140	8C	205	CD
			206	CE
E	200	C8	209	D1
			210	D2
F	204	CC	153	99
			154	9A
G	208	D0		
H	142	8E	161	A1
			162	A2
I	152	98		
J	156	9C		
K	160	A0		
L	168	A8	173	AD
			174	AE

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
M	144	90		
N	146	92		
O	172	AC	185	B9
			186	BA
P	176	B0		
Q	180	B4		
R	148	94	109	6D
			110	6E
S	184	B8	113	71
			114	72
T	188	BC	117	75
			118	76
U	108	6C		
V	112	70	122	7A
			123	7B
W	150	96		
X	116	74	128	80
			129	81
Y	124	7C		
Z	16	10		

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
d	189	BD	164	A4
			165	A5
k	15	0F	217	D9
			218	DA
t	12	0C		
z	74	4A	244	F4
			245	F5
space	192	C0		
%	66	42		
+	167	A7	223	DF
,	90	5A		
_	82	52	250	FA
■	212	D4		
/	28	1C		
:	177	B1		
<	45	2D		
=	166	A6		
>	49	31		
?	181	B5		
↑	36	24		
↓	43	2B		

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
0.	94	5E	55	37
			56	38
1.	54	36	59	3B
			60	3C
2.	96	60	63	3F
			64	40
3.	98	62	67	43
			68	44
4.	58	3A	71	47
			72	48
5.	100	64	75	4B
			76	4C
6.	102	66	79	4F
			80	50
7.	62	3E	83	53
			84	54
8.	104	68	87	57
			88	58
9.	106	6A	91	5B
			92	5C

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
p	(pico)	238	EE	
n (nano)	20	14	213	D5
			214	D6
μ (micro)	24	18	215	D7
			216	D8
m (milli)	254	FE	219	DB
			220	DC
s (seconds)	70	46	242	F2
			243	F3
DEG (degrees)	125	7D		
Ω (omega)	169	A9	157	9D
			158	9E
⏚ (ground symbol)	170	AA		
$\tilde{V}$ (volts ac)	53	35		
~ (approximately)	86	56		
MNL (manual)	120	78		
0 over 0	130	82		
0 over 1	132	84		
1 over 0	134	86		
1 over 1	178	B2		
0 over X	182	B6		

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

Character Description	Character Size and Code			
	Normal Size		Large Size	
	Decimal	Hex	Decimal	Hex
x over 0	190	BE		
1 over x	230	E6		
x over 1	232	E8		
x over x	252	FC		
1/	236	EC		
Underline	240	F0		
Dotted underline	241	F1		
Low underline	224	E0		
High underline	251	FB		
Superscript dash	237	ED		
Logical AND symbol	247	F7		
Hold measurement	228	E4		
HO (holdoff)	126	7E		
BWL (bandwidth limit)	234	EA		
Horizontal cursor 1	19	13		
Horizontal cursor 2	31	1F		
Vertical cursor 1	246	F6		
Vertical cursor 2	78	4E		
Δ (delta)	32	20		
Δ (delta t)	248	F8		
DLY (delay)			225	E1
			226	E2

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Appendix G

Specification

Introduction

Option 10 to the 24X5B and 2467B Oscilloscopes adds the hardware and software that allows these instruments to be remotely controlled and queried using a standard interface system. The interface implemented conforms to the specifications contained in *IEEE Standard Digital Interface for Programmable Instrumentation (ANSI/IEEE Std 488-1978)*, commonly referred to as the General Purpose Interface Bus (GPIB). It also complies with a Tektronix Standard relating to GPIB Codes, Formats, Conventions and Features.

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

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

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

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

All oscilloscope front-panel functions are controllable through the GPIB, with these exceptions: BEAM FIND, FOCUS, TRACE ROTATION, ASTIG, SCALE ILLUM, and POWER. Structure and format of the commands and queries executable by the GPIB Option are explained in Section 5. A listing of command headers and arguments, along with concise descriptions, is provided in Section 6.

The alphanumeric CRT readout is used to display measurement results, diagnostic test messages, exercise messages, and calibration messages. Any measurement result that is displayed on the CRT readout can also be transmitted over the GPIB.

Accessories and Software

Standard Accessory

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

24X5B/2467B Option 10 Instrument Interfacing Guide

Optional Accessories

The optional accessories for Option 10 are:

- 24X5B/2467B Options Service Manual
- GPIB Cables—1 m, 2 m and 4 m double shield, low EMC
- Protective Waterproof Vinyl Cover

Software

The following software is available for instruments with GPIB:

- EZ-TEK 2400 Test Program Generator
- EZ-TEK 2400 PC Test Program Generator (requires GURU hardware)
- GPIB User's Resource Utility (GURU)

The service manual and all other optional accessories and software can be ordered from Tektronix, Inc. A local Tektronix Field Office, representative, or the Tektronix Product catalog can provide ordering and product information.

Standard Functions, Formats, and Features

The total interface-function repertoire of an instrument on the GPIB, in terms of interface-function subsets, is identified in *ANSI/IEEE Std 488-1978*. The status of subsets applicable to 24X5B and 2467B Oscilloscopes with Option 10 are listed in Table G-1.

A Tektronix standard identifies the format and features of messages sent over the bus to communicate with other instruments equipped with a GPIB. Specific features implemented in the 24X5B and 2467B Oscilloscopes are listed in Table G-2, and specific formats are shown in Table G-3.

Table G-1
ANSI/IEEE Std 488-1978 (GPIB) Functions

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

NOTE

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

Table G-2
Specific Features Implemented

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

Table G-3
Specific Format Choices

Format Parameter	Description
Format Characters	Not transmitted; ignored on reception.
Message Terminator	Either the End-or-Identify (EOI) or the Line-Feed (LF) mode can be selected.
Measurement Terminator	Follows program message-unit syntax, which allows numeric characters in headers and alphabetic data arguments for reporting.
Link Data (Arguments)	Used in Listen and Talk modes.
Instrument Identification Query	Descriptors are added for other installed options.
SETtings Query	Extended, using LLSet commands, to allow block binary response.
INIt Command	Causes the oscilloscope to return to a power-on condition. All operating modes then agree with actual front-panel settings.
Return to Local (rtl) Message	Asserted when any front-panel control attempts to change a GPIB-controllable function.
Time/Date Commands	Not implemented.
Stored Setting Commands	30 stored setups.
Waveform Transmission	Not implemented.
Device Trigger (DT)	Not implemented.
Multiple Event Reporting	Not implemented.

Performance Conditions

Except as noted in Table G-4 of this manual, the electrical, environmental, and mechanical characteristics of Option 10 instruments (including the performance conditions) are identical to those specified in the respective 24X5B and 2467B Oscilloscope Operators manuals.

Table G-4
Option 10 Electrical Characteristics

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

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