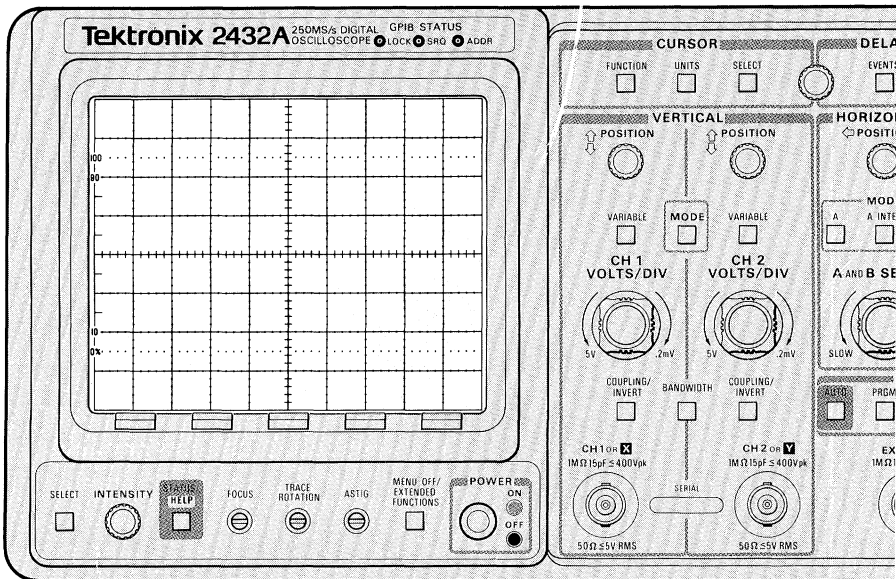


2432A PROGRAMMERS REFERENCE GUIDE



2432A PROGRAMMERS REFERENCE GUIDE

*Please Check for
CHANGE INFORMATION
at the Rear of This Manual*

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Tektronix[®]
COMMITTED TO EXCELLENCE

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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 accessible as one reads the markings, or a hazard to property, including the equipment itself.

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

Symbols

In This Manual



This symbol indicates where applicable cautionary or other information is to be found. For maximum input voltage see Table 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 2432A Digital Oscilloscope is a portable, dual-channel instrument with a maximum digitizing rate of 500 megasamples per second. The programmable features of the 2432A let you perform a wide variety of automatic tests and measurements. All of the testing capabilities of the 2432A can be controlled remotely via the GPIB.

How to Use This Guide

This guide is designed to help test-system programmers interface the Tektronix 2432A Digital Oscilloscope with GPIB systems. It also is the reference for interfacing the 2432A, via the GPIB, for non-controller directed operation (i. e., for outputting waveforms to printers without controller supervision). For a more general overview of 2432A operation, please refer to the 2432A Operators manual. Here are a few of the major topics this manual discusses:

Establishing GPIB Communication—This section (Section 2) shows how to set up the 2432A for GPIB operation and how to communicate with a controller.

How to Write Programs for the 2432A—Section 3 explains basic command syntax, types of commands, and various programming features of the 2432A.

Debugging Your Programs—Section 4 gives hints for fixing your 2432A programs if they have bugs and explains how to use the 2432A to help debug other portions of your GPIB program.

Command Tables—Appendix A gives syntax definitions and brief explanations of all GPIB commands for the 2432A.

Waveform Transfers—Appendix B explains how to transfer waveform data to or from the 2432A's internal storage areas and what that data actually means.

GPIB Introduction—Appendix C list the event codes you can get from the 2432A. Event codes are numbers that correspond to status, error, and system messages. The 2432A outputs the code (number) and you look up the message in this appendix.

GPIB Introduction—Appendix D gives a brief overview of basic GPIB theory.

Other Appendices—These provide various information useful in 2432A programming such as SRQ's, power-up states, etc.

Tips for New Users

If you have never worked with GPIB devices, we recommend that you start by reading the GPIB Concepts (Appendix D). Then come back and read the main sections of this manual. Give special attention to the sections on how to write programs for the 2432A and debugging the programs you've written. Also, use the HELP feature of the 2432A to learn about any areas that you might have questions about. (To activate HELP, push the STATUS/HELP button below the CRT and then push the menu button labeled HELP.)

2

Establishing GPIB Communication

Establishing GPIB Communication

The GPIB is the communications link between the 2432A and your controller. The first thing to do is make sure a functional GPIB cable is connected from the 2432A to the controller. Then set the 2432A GPIB parameters so they configure the 2432A for your GPIB system.

The GPIB parameters include the mode, terminator, and address. All are accessed from the front panel of the 2432A. This section discusses how to set up these various GPIB parameters.

Setting the GPIB Mode

The 2432A can be set up to be a talker, a listener, or both. It can also be taken "off bus." In addition, the 2432A can output waveform data to printers and plotters. Any of these different functions are selected by changing the GPIB Mode of the 2432A.

In general, you will set the Mode to be talker/listener. This setting allows the 2432A to accept commands from a controller over the GPIB and to send answers (in response to queries) back to the controller. The 2432A's GPIB Mode cannot be changed by remote programming.

To make the mode selection, you first need to get to the MODE menu. This is done by pressing the OUTPUT front-panel button, then pressing the SETUP menu button, followed by the MODE menu button. Once the MODE menu comes up there are several possible selections. These selections are Talk-Only, Listen-Only, Talk-Listen, Devices, and Off-Bus. We now look at each of these options.

Talk-Only

Pushing the T/ONLY selection puts the 2432A into the Talk-Only GPIB mode. In this mode, the 2432A assumes that it is always addressed to talk and will neither respond to commands nor assert the SRQ line. This mode is useful for configuring simple systems with one Talk-Only device (the 2432A) connected to one or more Listen-Only devices (such as a printer, another oscilloscope, or another 2432A).

When you press the T/ONLY selection, the front-panel ADDR indicator should light and the T/ONLY submenu should appear on the screen. The T/ONLY sub-menu lets you select what data the 2432A will send when it talks. All three talk-only options (CURVE, WAVFRM, and SEND PRGM) require at least one listener on the bus. If there is no listener present on the bus at the time the instrument is ready to transmit, the 2432A will display an error message on its CRT and refuse to transmit. The three (mutually exclusive) options available in this menu are:

CURVE. With this selection, the 2432A will send only the curve portion of waveform data (as it would in response to a CURVE? query). After making this selection, you may start transmission by pressing the OUTPUT front-panel button, followed by pressing the TRANSMIT menu button. The 2432A will then send the CURVE portion of all displayed waveforms to all listeners on the bus.

WAVFRM. With this selection, the 2432A will send both the preamble and the curve data (as it would in response to a WAVFRM? query). After making this selection, you may start transmission by pressing the OUTPUT front-panel button, followed by pressing the TRANSMIT menu button. The 2432A will then transmit both the PREAMBLE and CURVE portions of all displayed waveforms to all listeners on the bus.

SEND PRGM. With this selection, the 2432A will transmit an AutoStep Sequencer program. The 2432A will send whichever Sequencer program is currently selected (underlined) in the RECALL menu for the Sequencer (press the PRGM front-panel button followed by the RECALL menu button). To transmit the Sequencer program, simply press the SEND PRGM button (from the T/ONLY submenu), followed by pressing the OUTPUT front-panel button, followed by pressing the SENDPRGM menu button.

Listen-Only

Pushing the L/ONLY menu selection button places the 2432A into the Listen-Only mode. The front-panel ADDR indicator should light. When in Listen-Only mode, the 2432A acts only as a listener (LADS). It can only accept commands over the GPIB; it cannot send any messages or assert SRQ.

While in this mode, the controller may send setup data (previously queried from the 2432A or constructed independently) to the 2432A to implement a "canned" test setup. This mode can also be used in transfers of waveform data between two 2432A's where a controller is not involved. In this application, the 2432A that is in listen only mode will be the one to which data is sent.

Talk-Listen

Pushing the T/L menu selection button places the 2432A into the Talk-Listen mode. In this mode, the 2432A acts as both a Talker and a Listener. This is the “normal” GPIB mode and the mode most people will use for day-to-day testing activities. In this mode, the 2432A can accept data and commands and reply to queries.

Devices

Pushing the DEVICES button brings up a menu which allows you to tell the 2432A what type of hard copy device (if any) you are using. The 2432A can format waveform information for several types of output devices. The devices supported are: some devices that accept HPGL (Hewlett-Packard Graphics Language), such as the HP7470A Plotter, HP7475A Plotter, HC100 (TEK) Plotter, and the HP Thinkjet[®] printer (model HP-2225A). (HP, HPGL, and Thinkjet are registered trademarks of Hewlett-Packard). You press the menu button HPGL PLOTTER when selecting one of the plotters; press THINKJET PRINTER for selecting the HP Thinkjet[®] printer.

To make a printout, first connect the device to the 2432A and make sure the device is in Listen Always mode. Make sure all other GPIB instruments are disconnected since we will be operating without a controller. To start the printout, just press the 2432A OUTPUT front-panel button, followed by the PRINT (menu button is labeled PLOT if HPGL PLOTTER is chosen in DEVICE menu) menu button.

While the 2432A is printing, the PRINT button becomes an ABORT button. Press this button at any time to terminate the printout. To disable the printing mode of the 2432A, you must return to the MODE menu and select another mode besides DEVICES. “Making Printer or Plotter Copies” in this manual talks about setting up for different plotters and printers.

Off Bus

Pushing the OFF BUS selection makes the 2432A bus-transparent. When the 2432A is OFF BUS, the TRANSMIT selection disappears from the OUTPUT menu. You may alter certain GPIB parameters (TERM, ADDR, and ENCDG), but these selections will not take effect until a GPIB Mode other than OFF BUS is selected.

Setting the GPIB Message Terminator

To get to the GPIB Terminator menu, press the front-panel OUTPUT button, followed by pressing the SETUP menu button, followed by the TERM menu button. Within the GPIB Terminator menu, the options are either EOI or LF/EOI.

Selecting EOI in the TERM menu causes the End or Identify (EOI) line to be asserted simultaneously with the last byte of the message. LF/EOI causes Carriage-Return (CR) and Line-Feed (LF) characters to be added to the end of each message with EOI asserted simultaneously with LF.

Which Terminator Should You Choose?

The 2432A always recognizes EOI as a message terminator, no matter what byte it is asserted with. You may also program the 2432A to recognize a line feed as a terminator. Recognizing the line feed is useful when using a controller which sends a line-feed character as the last byte of a message instead of asserting EOI with the last byte of a message.

When the 2432A is set up to recognize the line-feed character as the terminator, it will assume that an incoming message is terminated if it detects either EOI or a line-feed character. On output, the 2432A will send a carriage return, followed by a line feed with EOI asserted, as the last bytes of each message. The 2432A always asserts EOI along with the last byte of a message, no matter what terminator has been selected.

A potential problem exists if you select the line-feed terminator for use with either BINARY waveform transfers or LLSET. An ambiguity occurs because the line-feed character is a valid number in binary waveform and LLSET strings. If the controller receives the line feed character as such a number, it will prematurely assume an end of message. When using a controller that does not recognize EOI only as the message terminator, it is best to use ASCII format for waveform transfers and the SET? query. (FORMAT should be off—see below.)

A similar problem occurs when transferring Auto Step sequences. (See "Sending and Receiving Sequences.") For transfers from one 2432A to another 2432A or to a printer, line feed characters are output for each line transferred. For printers, the line feeds format the output so the printer output is readable. For transfers to a scope, however, the receiving scope terminates prematurely on the first line feed it receives if its terminator character is set to LF/EOI. You should set TERM to EOI (only) to receive the entire sequence.

For controller-directed transfers, binary transfers of sequences can have the same ambiguity described for binary waveform transfers. Set controllers or 2432A's receiving binary sequences to recognize only EOI as the terminator character. Do the same for ASCII transfers of sequences, if FORMAT is turned on. (See PRGM? query and FORMAT command in Appendix A.)

Setting the GPIB Primary Address

To get to the GPIB Address menu, press the front-panel OUTPUT button, followed by the SETUP menu button, followed by the ADDR menu button. This menu allows you to increment or decrement to any GPIB address. Pushing the ↑ increments the talk and listen address by one. Pushing the ↓ decrements the address. The selected GPIB address establishes both primary talk and listen addresses for the 2432A. It can be set to any value from 0 to 30, inclusive.

Sample Controller Program

This short program allows you to send commands or queries to the 2432A and prints responses from the 2432A. Though the program is written in 4041 BASIC, it illustrates basic principles that should carry over to other languages.

```
10 scope=1
20 !=====
30 ! first enter the 2432A's address and then open the
40 ! hardware port to talk to the GPIB; finally enable
50 ! the srq interrupt and point to the handler routine
60 !=====
70 print " Enter 2432A address:" ;
80 input addr
90 if addr>30 then goto 70
100 if addr<0 then goto 70
110 open #scope:" gpib0(pri=" &str$(addr)&" ,eom=<0>):"
120 dim answr$ to 7000
130 dim comm$ to 200
140 enable srq
150 on srq then gosub 350
160 !=====
170 ! Now get the command or query to send. A query
180 ! has a " ?" right after the header. If it is a
190 ! query then talk the 2432A and print the response.
200 !=====
210 wait .25
220 print " Command? " ;
230 input comm$
240 print #scope:comm$
250 query = pos(comm$," ?" ,1)
260 if not(query) then goto 210
270 input #scope:answr$
280 print " 2432A response is: " &answr$
290 goto 210
300 !=====
310 ! This is the code that is executed when an srq
320 ! happens. We poll the bus and print the status
330 ! byte and the corresponding event query response.
340 !=====
350 poll stb,dev
360 print #scope:" path off;event?"
370 input #scope:event
380 print " srq received: status = " ;stb," event = " ;event
390 print #scope:" path on"
400 resume
410 end
```

Debugging the Interface when It Doesn't Work

This subsection helps you debug the interface when you can't talk to the 2432A with your controller. First, make sure the GPIB cable is securely connected to both the 2432A and the controller. If there is any doubt about the cable, get another one to make sure it is not causing the problem.

Next, go look at the GPIB status menu. To get there simply press the OUTPUT button on the front panel and then the STATUS (left most) menu button. This brings up a screen full of information showing how the GPIB portion of the 2432A is set up. Now make sure the mode is set to T/L (both talk and listen) and the terminator and address are set up correctly. Look at the subsection on Establishing Communication if you need to change any of these GPIB parameters.

Also, make sure that the Debug mode is not "paused." When Debug is paused, the 2432A will not listen to any bytes from the bus, so this could be the problem.

A message is printed near the top of the status screen when debug is paused. If you don't see a message, debug mode is not the problem. If debug is paused, turn it off by pressing the OUTPUT front-panel button, then the DEBUG menu button to display the DEBUG menu. Then turn debug off by pressing the DEBUG ON/OFF menu button.

GPIB Status Menu

Now a word about the GPIB status menu. This menu is very useful to refer to when you have questions about how the GPIB is set up. The underlined listings are GPIB-related 2432A functions and the adjacent listing gives the status for the function.

Most of the listings are self-explanatory (all are covered in this guide), but there are a few functions on this menu screen that need explanation. This menu is the only place where you can find out what the Fast Transmit status is. This is because as soon as the Fast Transmit mode is turned on, the 2432A will only talk waveform data and will not respond to queries.

The BINWFM to SCOPE section (on the lower left of the menu screen) indicates how the 2432A will interpret binary data sent to it. The DATA ENCDG status (just above BINWFM) shows the format of binary data the 2432A will send out. For more information see Appendix B on waveforms.

The events column (on the right of the menu screen) shows the first 7 (of 10) events contained in the 2432A's event buffer. The topmost event number will be returned in response to the next EVENT? query. If the letters SRQ appear to the right of an event number, then that event number had an SRQ associated with it. The SRQ in the listing indicates that the instrument was serial polled to handle the service request, but the corresponding event code was not requested. If an EVENT? query is sent to the 2432A, the event code pointed to will be returned.

What Do the GPIB Status LED's Mean?

The 3 lights over the 2432A CRT give an indication of GPIB activity. Look at these LED'S if a steady-state problem arises (such as dead front-panel controls). An explanation of the LED's meaning follows.

LOCK. If this LED is lit, the the 2432A will not respond to any front-panel controls. The 2432A locks out its front panel while doing a self-calibration, an Auto Setup, and during certain portions of AutoStep sequences. The LOCK LED will light during any of these operations.

The controller can lock the front panel in one of two ways. First, it can send the 'LOCK ON' command to the 2432A. Or it can send the 'LOCK LLO' command to the 2432A, and follow that command with the GPIB universal command LLO. The LLO universal command is an IEEE-488 command while 'LOCK ON' is a 2432A-specific command. The LOCK command is explained further in Appendix A.

SRQ. This LED is lit while the 2432A is asserting the SRQ GPIB hardware line to request service. When the controller performs a serial poll, this LED will go out.

ADDR. This LED is lit when the 2432A is addressed to talk or listen, or, more specifically, when it is in either the TADS or LADS state.

3

How To Write Programs

How to Write Programs for the 2432A

This section describes how to send commands to and get responses from the 2432A. A few guidelines can help make your programming task easier:

1. *If possible, use full command and argument names. This makes them more readable in program listings and makes upgrading easier (new releases of firmware may have slightly different abbreviations, usually longer since there are more commands).*
2. Try to write instrument-specific software in a modular fashion. Use subroutines, if possible. This technique makes it easier to modify your program when something beyond your control changes.

Sending a Command to the 2432A

To change the 2432A operating state, you must send it a command. For example, to change the Volt/Division setting for Channel 1 to 5 volts, send the command, CH1 VOLTS:5.

A message is composed of one or more commands separated by semicolons and ending with the message terminator. Except where noted, carriage returns, spaces, and tabs are ignored by the 2432A when receiving a message. In this section, you will learn what a command is made up of and how to compose and terminate messages.

Building Commands

A command consists of a header and arguments. A command can be compared to a tree, with the header being the tree's trunk and the arguments its branches. When you build a command, you climb the tree; that is, you pick the tree you want to climb, start at the trunk, select a branch and climb on to it. When you reach the end of some branch and can't climb any further, the command is finished.

There are many different "trees" you can climb to tell the 2432A what to do. Here are four examples of 2432A commands for you to refer to as we discuss headers and arguments.

1. READOUT ON
2. HORIZONTAL MODE:ASWEEP
3. CH1 VOLTS:5,POSITION:-1
4. CURSOR TPOS:ONE:3.12E+2

HEADERS. All commands have, at the least, a header. In the examples above, READOUT, HORIZONTAL, CH1, and CURSOR are all headers. The header can be thought of as specifying some general thing you want the 2432A to do or change. For instance, in Example 2 above, the header HORIZONTAL tells the 2432A that you want to do something related to the scope's horizontal setup (change its horizontal mode).

ARGUMENTS. Most commands require that information be added to the header to completely describe what the 2432A is to do, and they therefore require you to add one or more arguments. Referring to Example 2 again, just sending the header HORIZONTAL does not tell the 2432A whether to change the horizontal position, mode, etc. Therefore, the argument MODE is added to the header HORIZONTAL to specify that the horizontal mode is to be changed. To add an argument to a header, just separate the header from the argument by one or more spaces. Some headers are specific enough to define the entire command by themselves; these headers have no arguments. MANTRIG, which forces a triggered acquisition sequence, is an example of this type of header.

Sometimes, a single argument to the header is still not enough to completely define what the 2432A is to do. So we "climb further out on the tree" and add another level of arguments, called link arguments, and separate them from the first argument with a colon. (The link argument ASWEEP specifies that the horizontal mode is to be set to A in Example 2.) We can keep adding link arguments to the command until the action is completely defined.

Example 1 is a command requiring no link arguments; the display of the readout can only be set (by the arguments) on or off. Example 2 requires only one level of link argument, ASWEEP, to further specify the argument MODE. Example 3 has two arguments with a link argument for each (both link arguments are of the first level). Link argument 5 further specifies VOLTS and -1 further specifies POSITION. Example 4 has two levels of link arguments to the argument TPOS; the first-level link argument is ONE and the second-level is $3.12E+2$. TPOS specifies a Time cursor is to be POSITIONed, ONE selects which of two possible time cursors is to be positioned, and $3.12E+2$ specifies where the number ONE time cursor is to be positioned.

Example 3 is also an example of how multiple arguments can be included with the same header by separating each argument with a comma (.). The VOLTS and POSITION arguments, along with their associated link arguments, are attached to the same header by being separated with commas.

Numeric arguments use the ANSI X3.42 standard format. This format states that there are three types of numbers; integers, reals, and reals with exponents (these are called NR1, NR2, and NR3 respectively). Each type of number is composed of ASCII digits with the most significant digit sent first. Any of these three number types is acceptable whenever a numeric argument is required. Here are some examples of each of the three number types:

NR1	375,	0,	-23
NR2	+12.589,	1.37592,	-00037.5
NR3	-1.51E+03,	+51.2E-07,	+00.0E+00

Composing Messages

Complete messages are constructed by stringing one or more individual commands together. Multiple commands within a message are separated by a semicolon. For example, we can combine the first two examples above into one long message by inserting a semicolon between them like this: RUN SAVE;CH1 VOLTS:5,POSITION:-1. Extra spaces may be included to increase readability:

```
RUN SAVE; CH1 VOLTS: 5, POSITION: -1
```

Terminating Messages

Both talking and listening devices must agree on how to end a message. Obvious difficulties can arise when talker and listener don't agree. For example, if the listener thinks the message has ended too soon, it garbles part of the message. On the other hand, if the listener doesn't think the message has ended when it actually has, it "hangs" the bus waiting for a message that will never come.

There are two common methods for ending a message. Some controllers assert EOI concurrently with the last data byte; others use only the line-feed character as a terminator. You need to determine which type of controller you are using and make sure that the 2432A's terminator is set appropriately.

If you select EOI as terminator, the 2432A will interpret any data byte received with EOI asserted as the end of the input message. The 2432A will assert EOI simultaneously with the last data byte of an output message.

If you select the LF character as terminator, the 2432A will interpret the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message. The 2432A will transmit a carriage return followed by a line-feed (LF) with EOI asserted to terminate output messages. (See "Which Terminator Should You Choose?" in Section 2 for further information.)

Asking the 2432A a Question

There are many times when a controller needs to obtain information about the operating state of the 2432A. To do this, the controller sends a query or question to the 2432A. Queries consist of a header followed by a question mark. For example, to find out whether the 2432A is currently acquiring or in save mode, simply send the query 'RUN?' to the 2432A. If the response message is 'RUN ACQUIRE', then the 2432A is acquiring. If the response is 'RUN SAVE', then the 2432A is in save mode.

You may query the 2432A for any headers listed in Appendix A, except those specified as "COMMAND ONLY".

The query header may be followed by an argument to further specify the type of response desired. For example, the query 'CH1?' causes a response containing all of the information about that channel, whereas the query 'CH1? POSITION' returns only the position information. In general, any query can be further specified using arguments, up to one level above the "bottom" of the command tree (where the bottom of the tree is the argument in the rightmost column of Appendix A tables).

Using PATH Mode

When you issue a query, you know what type of result should be returned. For example, on a 'CH1? POSITION' query, you expect a number that represents the CH1 vertical position. With PATH set to ON, a typical answer to this query would be 'CH1 POSITION:2'. The CH1 POSITION: portion of this response is called the "path". To arrive at the number you're after (the 2), you must strip off the "path" portion. You can eliminate this extra processing by setting PATH to OFF before sending the query to the 2432A. When PATH is OFF, the 2432A will not send the "path" portion of the response. So with PATH set to OFF, the answer to the query 'CH1? POSITION' would be 2. This value can be read directly into a numeric variable used by your program.

If you are querying the 2432A to obtain a setup which you wish to send back to the 2432A (to recreate that setup), be sure to set PATH to ON. Without the "path" portion, the 2432A will be unable to interpret the command. In the above example, returning the string 'CH1 POSITION:2' to the 2432A would set the CH1 position to 2 divisions above center screen. Returning only the string '2' would result in confusion.

Using LONG Mode

Headers and arguments can be used at full length, or they can be abbreviated to reduce typing and bus traffic. The command tables in Appendix A show all essential characters in bold uppercase with the optional characters in lowercase. If LONG is ON, the 2432A will send the full representation for each header and argument contained in a query response. If LONG is OFF, only the essential characters (the abbreviations) are returned, resulting in a shorter response string. LONG does not affect commands being sent to the 2432A. The addition of new features to the 2432A may result in a longer abbreviation for some headers or arguments in future firmware releases. Therefore we recommend that you set LONG to ON if you wish to run your programs with future versions of 2432A firmware.

How to Use Service Requests (SRQs)

The 2432A can issue a Service Request (SRQ) to interrupt the controller and let it know that something "interesting" has happened. To issue an SRQ the 2432A simply asserts the SRQ bus management line on the GPIB (see Appendix D for more information on the GPIB). The SRQ indicator LED, above the display screen, will be on while the 2432A is asserting SRQ.

When a controller detects an SRQ, it performs a serial poll of each instrument currently connected to the GPIB. When an instrument is serial polled, it returns a status byte to the controller. If bit 7 (of 8) of the status byte is set, then this is the instrument that asserted the SRQ.

Whenever the 2432A sends a status byte, it will indicate, in a general way, the reason for the SRQ. For example, a status byte with a value of 97 indicates that the 2432A encountered a command error while interpreting the last command string sent by the controller. An 'EVENT?' query sent to the 2432A at this time will return a number that contains more information about what happened. In the example above, the event code might be a 156, indicating that one of the symbols (headers and/or arguments) making up the command was mis-typed and the 2432A could not make sense of it.

When the 2432A has an event to report, it first looks to see if it is already trying to assert SRQ for a previous event. If it is, then the new event is saved in a backup position. This way, when the controller eventually gets around to reading the first status byte, the backup byte will become active and try to assert SRQ.

The 2432A only saves 2 events which are capable of asserting SRQ at any one time. When these 2 "slots" are full, subsequent events (up to 8) are placed into an event buffer. If the event buffer becomes full, the oldest stored event is dropped and the current one is entered.

The event number returned by an EVENT? query is determined by first returning the events associated with the two SRQ "slots", and, if those are unfilled, the contents of the event buffer are returned starting with the newest entry. If you send an EVENT? query and the number returned is 459, the 2432A is currently asserting SRQ on the bus and will insist that the controller poll the 2432A for its status byte before returning an event code. This is done to make sure that event codes and status bytes correspond. Because of hardware constraints, once the 2432A asserts SRQ it cannot change the status byte that will be returned by the next serial poll. If the next meaningful event code were to be returned instead of the 459 event, subsequent EVENT? queries would not correspond with the correct status bytes.

The tables in Appendix C show the different status bytes and event codes that can be returned by the 2432A.

Programming With SRQs

The first thing you need to start programming with SRQs is an SRQ handling routine. This routine will be called when your controller detects an SRQ on the GPIB. This subroutine polls the instrument asserting the SRQ (optionally extracting the event code from the instrument) and takes appropriate action. A simple SRQ handling routine is included within the sample program in the "Establishing GPIB Communications" section of this manual.

Next you need to determine what kind of information you will need for your application. The 2432A allows the programmer to select the types of occurrences that will assert an SRQ. For example, sending the command 'CER ON' to the 2432A will result in command errors asserting SRQ. If you wish to keep the 2432A from asserting any SRQs, send the command 'RQS OFF'. For a complete list of commands of this type, refer to the "Service Request Commands" section of Appendix A.

One common use for SRQs is to have the 2432A assert SRQ when it has finished a task. For example, you might have the 2432A assert SRQ when it completes a single-sequence operation. For a complete list of 'tasks' that the 2432A can report with an SRQ, see the "Operation Complete Event Codes" in Appendix C. Let's walk through some of the steps a controller program would take in order to wait until the 2432A has finished an acquisition.

1. Turn this type of SRQ on by sending the 'OPC ON' command to the 2432A.
2. Clear out all previous events and SRQs by sending the command 'INIT SRQ'.
3. Set the 2432A control states appropriately to make the desired measurement.
4. Make sure the trigger mode is "single sequence" by sending the command 'ATRIGGER MODE:SGLSEQ'.
5. Tell the 2432A to start acquiring by sending the command 'RUN ACQUIRE'.

At this point the controller will wait for the SRQ from the 2432A. To end this wait, the SRQ interrupt handler routine you have written for your controller needs to report the receipt of the SRQ back to the main program. When this happens the program can continue.

In summary, the programmer needs to do several things to handle SRQs efficiently:

1. Set up the 2432A SRQ mask correctly. Make sure that the type of SRQ you are expecting is enabled.
2. Use a controller that can recognize or sense when SRQ is asserted and then perform a serial poll.
3. Have an SRQ handler routine that gathers the status byte and event code and communicates this information to the main body of the controlling program.

Programming Without SRQs

There are some situations in which SRQ's will not be used. For example, the programmer may not wish to use SRQs, or the controller may be unable to detect SRQs or to perform a serial poll. In such cases, some other approach is needed to find out the status of the 2432A. (Actually, programming without SRQs is simpler to understand and to implement, but it does not allow the controller to perform other tasks while the 2432A is completing its task.) Before you begin programming without SRQs, you must first send the 'RQS OFF' command to make sure the 2432A will not generate any SRQs.

When SRQs are not used, the status of the 2432A is determined by sending the EVENT? query. First clear out all the current events and SRQs which might be present by sending an 'INIT SRQ' command to the 2432A. Then have the controller set the 2432A to the desired operational state and wait for the 2432A to finish. During this waiting period, the controller repeatedly sends an EVENT? query to the 2432A until an event code associated with the current task is returned. (See the "Operation Complete Events" section in Appendix C for a list of event codes.) As long as the 2432A has nothing to report, it will return EVENT 0 in response to the EVENT? query. An EVENT query must be used because the 2432A will not update the status byte if RQS is OFF. The 2432A does not know when a status byte is read by a controller unless SRQ is asserted with the status byte. The 2432A never changes the current status byte because it does not know when the controller is ready for a new status byte. This situation is similar to the one discussed earlier when event number 459 is returned.

Here is an example scenario summarizing what we've just described. Let's say that the controller has set the 2432A into single-sequence mode. The controller must wait until the sequence is complete. During this wait the controller sends EVENT? queries to the 2432A until the response changes from EVENT 0 to EVENT 461.

There are other ways to determine that the 2432A has done what you requested without using SRQs or events. For example, one solution to the single sequence "problem" is to inquire about the RUN state by sending a 'RUN?' query to the scope. While the 2432A is acquiring, the response will be RUN ACQUIRE. When the single sequence operation is complete, the 2432A enters Save mode and the response will change to RUN SAVE.

Making Measurements with the 2432A

The 2432A waveform parameter extraction (WPE) feature provides a convenient method for making measurements on waveforms. When combined with Auto Setup, WPE provides a method to set up for and characterize unknown signals. Commands are provided to control how the 2432A extracts, calculates, and displays the waveform parameters, and for setting up the “window” and determining the base and top levels.

To familiarize yourself with the operation of the WPE features, see the “Controls, Connectors, and Indicators” section of the Operators Manual which gives a description of front-panel operation. Appendix C of the Operators Manual describes how measurements are actually calculated.

The 2432A also provides waveform data commands that allow you to make custom measurements when the measurement you need is not already available as one of the built-in WPE measurements. Commands are available to specify the waveform of interest, the part of the waveform you wish to look at, the minimum and maximum values, the average value, and the crossing points. You can combine these various commands and queries to make many specialized measurements.

Using the WPE Feature

Three types of GPIB commands are provided for WPE operations. The first type of commands control *how* the 2432A calculates the waveform parameters. The second type of commands control *what* parameters are calculated and returned via GPIB. The third type provides GPIB control of the screen *display* of extracted waveform parameters. For a list of measurements, see the “Measurement Commands” in Appendix A.

In addition to the commands, a significant number of error and warning messages are available to tell whether the measurement is valid and whether the confidence level of the particular measurement is high or low. Refer to “How to Use Service Requests” and to Appendix C for more information on error reporting.

DEFINING THE MEASUREMENT WINDOW. The "window" defines what portion of the waveform is used when extracting and calculating parameters. If the window function is turned off or the time cursors are not displayed, then any parameter selected will be extracted from the entire targeted waveform. Only that part of the waveform between the two time cursors will be used for making measurements when both the window function and time cursors are on. For example, to create a window on CH1 between points 200 and 500 send the following commands to the 2432A:

```
'MEASUREMENT WINDOW:ON'  
'CURSOR FUNCTION:TIME,TARGET:CH1,UNITS:BASE'  
'CURSOR TPOS:ONE:200,TPOS:TWO:500'
```

DETERMINING BASE AND TOP LEVELS. Time-related parameters are calculated from the point where the targeted waveform crosses certain user-definable levels or thresholds. If any of the thresholds are defined as a percentage, then the base (0 percent) and top (100 percent) levels must first be determined. This determination is performed according to the user-selected Measurement Method.

The Min-Max method (the factory and init-panel defaults) sets the base level to the minimum waveform value found in the active record. The top level is set to the maximum value found in the waveform.

The Cursor method uses the values of the VOLTS cursors as the base and top values. The lower cursor becomes the base and the upper cursor the top. Although volts and time cursors may not be simultaneously selected, the Cursor method may still be used in conjunction with the Window feature. First, set the base and top levels for the Cursor method using the volts cursors. Next, switch to the time cursors with Window on and set the time cursors to the desired sub-section of the waveform.

The Histogram method builds a histogram of each point in the targeted waveform and sets the base level to the most common lower level and the top level to the most common upper level. For a description of how histograms are created, see the Appendix C in the Operators Manual.

DETERMINING TIME REFERENCE CROSSING LEVELS. The time reference locations are found by searching for waveform crossings at the Proximal (near the base level), Mesial (near the middle), and Distal (near the top level) voltage levels. The Proximal, Mesial, and Distal levels (initially set to 10, 50, and 90 percent, respectively) can be adjusted. Each level can be individually set to a percentage of the difference between the Base and Top levels, or each can be set to an absolute voltage level. For example, to set the Mesial level to 45% up from the base level, send the following command to the 2432A:

```
'MEASUREMENT MESIAL:UNITS:PERCENT,MESIAL:PLEVEL:45'
```

WHAT IS SENT TO THE CONTROLLER. Once the calculation has been set up, the desired parameter may be extracted using the 'VALUE?' query. The target of the parameter extraction is set using the 'DATA SOURCE' command. See the list of "Automatic Feature Commands" in Appendix A for the various parameters which may be extracted using the 'VALUE?' query. For example, to make a frequency measurement on CH1, send the following command and query to the 2432A:

```
'DATA SOURCE:CH1;VALUE? FREQUENCY'
```

MEASUREMENT DISPLAY. Up to four parameters may be selected for display on-screen. Visual voltage threshold crossing indicators ("Marks") are available for time measurements. For example, to cause a frequency measurement of CH1 to appear on screen and have "Marks" placed on the crossing points of CH1, send the following commands to the 2432A:

```
'MEASUREMENT DISPLAY:ON'  
'MEASUREMENT MARK:ON'  
'MEASUREMENT ONE:TYPE:FREQUENCY,ONE:SOURCE:CH1'
```

ERROR AND WARNING CONDITIONS. For WPE, the 2432A defines an error condition as one that prevents it from getting the information it needs to calculate a requested parameter value. It defines a warning condition as one that makes accuracy of the value calculated for the parameter questionable. In both cases, the commands you sent to set the 2432A up for the measurement were not adequate.

Let's take errors first. Assume that you have input an approximately 10-kHz waveform into CH 1 of the oscilloscope, and you want to measure its frequency. You send the command 'ASECDIV 500E-9', which sets the oscilloscope to a 500-ns/div acquisition rate. Then, you send the command 'DATASOURCE:CH1:VALUE?PERIOD' to return the period for the waveform. An error condition is created, since a 10- μ s acquisition record (500 ns/div \times 20 div) is not long enough to let the 2432A acquire the entire period of a 10-kHz waveform (100 μ s).

The 2432A *will not* return the expected value for the parameter; instead, the value returned is always "99e99." An error message is available, in this case "NOT ENOUGH EDGES TO WORK WITH" (three edges are needed to define a waveform's period). To get the error message, you query events with the command 'EVENTS?'. The 2432A returns the Execution Error Events Code and you look up the message corresponding to the code in Appendix C of this guide.

Now let's consider warnings. Assume you put an approximately 10-V pk-pk square wave into CH 1, and you want to measure its pk-pk voltage. You send the command 'CH1 VOLT:5E-1' which sets CH1 to 0.5 V/D. Then, you send 'DATA SOURCE:CH1:VALUE?PK2PK' to return the amplitude in V pk-pk for the waveform. A warning condition is created, since the vertical window for acquisitions is 10.24 divisions. At 0.5 V/D, a 10-V pk-pk waveform requires 20 divisions for a vertical window.

NOTE

The actual vertical window size is 10.24 divisions for acquisition rates of 100 μ s/Div and slower. At acquisition rates of 50 μ s/Div and faster, the window decreases to a minimum of 9.68 divisions at some acquisition rate settings. See "The Vertical Window for Making Measurements" later in this section.

The 2432A *will* return the value for the parameter (which differentiates a warning from an error condition). A warning message is available, in this case "WAVEFORM HAS POINTS OFF THE TOP AND BOTTOM" (indicates the waveform was larger than the vertical window). To find out if the parameter value returned is valid or if, instead, a warning condition exists, you can use 'EVENT?' after each 'VALUE' to get the warning message. (This method works whether or not you are programming with SRQ's.) The event query causes the 2432A to return the Execution Warning Events Code and you look up the message, corresponding to the code, in Appendix C of this guide.

If you're programming with SRQ's (See "How to Use Service Requests," earlier in this section), you can get the error messages without testing for "99e99," or without doing an event query after each value query to get warning messages. You enable the ERW mask (default is ON) to get error message SRQ's; you enable EXW (default is ON) to get warning message SRQ's. Then you use EVENT? as before to get the error code, and you look it up in Appendix C of this guide.

NOTE

As you've seen from this subsection on error and warning conditions, there are considerations for setting up the 2432A for performing WPE's. We suggest that you consult Section 3, Section 5, and Appendix C in the 2432A Operators Manual for more information.

EXAMPLE MEASUREMENT PROGRAM. The following 4041 Basic program will automatically set the 2432A to acquire and display an unknown signal, optimize it for a rise time measurement, and return the rise time value. A wait loop is provided to continue querying the rise time while the waveform fills, as indicated by a return value of 99e99 and an event code of 269. With a fast rising edge, the 2432A will be set into its repetitive sampling mode and will take about three seconds to fill at 2 ns/div.

If event codes other than 269 are returned, the event (an error or a warning) is printed out and the program stops. The 2432A is assumed to be at address 1 for this example.

```
100 Scope=1
110 Dim resp$ to 30
120 Dim event$ to 9
130 Open #scope:" gpib0(pri=1,eom=<0>):"
135 Print #scope:" rqs off;init srq"
140 Print #scope:" autoseup mode:rise"
150 Print #scope:" autoseup resolution:hi"
160 Print #scope:" autoseup execute"
170 Print #scope:" measurement method:histogram"
180 Print #scope:" data source:ch1"
190 Print #scope:" value? rise"
200 Input #scope:resp$
210 If pos(resp$, "99e99",1) = 0 then goto 260
220 Input #scope prompt " event?" :event$
230 If event$<>" event 269" then goto 280
240 Print " waiting for fill"
250 goto 190
260 print resp$
270 goto 290
280 print event$
290 end
```

Making Custom Measurements

Waveform data commands and queries can be used to extract both voltage and timing information from a particular area of a waveform. Such extractions are useful when the automatic measurements described above do not return a useful answer because the algorithm used is not specific enough. Using waveform data commands and queries allows you to extract pertinent data about the waveform quickly and use that information in the controller. An example program which uses these commands and queries to count the number of pulses between the time cursors is found in Appendix J.

SELECTING THE WAVEFORM. The waveform data commands and queries operate on only one waveform at a time. This waveform is selected with the DATA SOURCE command. For example, to extract data from the CH1 waveform, send the 'DATA SOURCE:CH1' command to the 2432A.

The segment of the targeted waveform that is analyzed when making measurements is designated by the START and STOP commands. (The results obtained are similar those obtained by using the "window" feature of WPE.) For example, to look at the part of the waveform between points 200 and 500, send the command 'START 200;STOP 500'. To include the whole waveform, send 'START 1;STOP 1024'.

MAKING VOLTAGE MEASUREMENTS. To obtain the minimum voltage (for the segment of the waveform specified by START and STOP), send the command VMINIMUM? to the 2432A. To obtain the maximum or average voltage, send VMAXIMUM? or VAVG?, respectively. Or, to obtain the same parameters in terms of "digitizing levels", use the commands MINIMUM?, MAXIMUM?, or AVG?.

MAKING TIMING MEASUREMENTS. Timing measurements involve measuring the time between various points on the waveform. These "points" are selected by determining where the waveform crosses some arbitrary voltage level. This voltage level is user selected with the LEVEL command. To find out where a crossing occurs within the present window, send the PCROSS (for a positive-going crossing) or the NCROSS command (for a negative-going crossing).

Now, as an example, let's walk through a pulse-width measurement using this technique. The pulse width is the time between the crossing of the 50% point on the rising edge and the crossing of the 50% point on the falling edge. Here are the basic steps to determine pulse width:

1. Use VMAXIMUM? and VMINIMUM? to determine the full amplitude of the signal.
2. Set LEVEL to the 50% voltage of the pulse.
3. Use PCROSS? to find the first waveform point whose value is at or above the 50% level (positive-going).
4. Use NCROSS to find the first waveform point whose value is at or below the 50% level (negative-going).
5. Calculate the pulse-width time based upon the number of points between PCROSS and NCROSS and the present time per division setting. (There are 50 points per division.)

The HYSTERESIS command provides an added feature for use with the PCROSS and NCROSS commands. The Hysteresis command specifies the number of digitizing levels below LEVEL (for PCROSS) or above LEVEL (for NCROSS) the waveform must go across before a valid crossing is recognized. You may set the hysteresis level with the command 'HYSTERESIS #', where "#" is the hysteresis value. Hysteresis acts like a "noise filter" which insures that small variations in the waveform pattern will not be mistaken as actual crossing points.

Here is an example of how HYSTERESIS affects PCROSS. Let's say that your signal ranges from 100 digitizing levels to -20 digitizing levels. If you set the crossing level to 50 and set hysteresis to 5, the 2432A will start searching for a location that is at 45 digitizing levels or below (that's 5 below the crossing level). After finding this location, the 2432A will proceed to the first location that is at 50 digitizing levels or above. This location will be returned as the PCROSS value.

Using the same example, but changing the crossing level to -15 and the hysteresis to 10, the 2432A would never find a crossing since it would first search for a location that was at -25 digitizing levels. Since the signal only ranges from 100 to -20, such a point does not exist. In this case, the 2432A will return a value of 0 in response to PCROSS?.

The DIRECTION command allows you to choose which direction the search for the crossings will follow. To search from "left" to "right" in the data, use PLUS. To search backward in time, select MINUS.

The Vertical Window for Making Measurements

Although the 2432A's screen displays 8 vertical divisions, WPE and custom measurements can be made on waveforms fitting within at the least a 9.68-division vertical window at every acquisition rate setting and up to a 10.24-division vertical window at some acquisition rate settings. (The maximum vertical window available for any acquisition rate (Sec/Div setting) is specified in "Dynamic Range" of Section 6 of the Operators manual. For convenience, Table 3-1 in this section gives the window size in vertical divisions and range in both Signed and Positive-Integer Representation.) For maximum resolution of amplitude measurements (or time-related measurements using time-reference points tied to amplitude), choose a Volts/Div setting that sizes the waveform to occupy as much of that vertical window as possible.

Table 3-1
Vertical Window Size

Acquisition Rate (Sec/Div)	Range		Size Divisions
	Signed Integer	Positive Integer	
5 sec to 100 μ s	-128 to +127	0 to 255	10.24
50 μ s to 500 ns	-124 to +123	+4 to 251	9.92
200 ns to 2 ns	-121 to +120	+15 to 240	9.68

At acquisition rates of 100 μ s/Div and slower, the vertical window is 10.24 divisions. However, at settings of 50 μ s/Div and higher, the vertical window decreases. (Again, see Table 3-1 for exact size.) An example will illustrate why it is important to keep in mind the variability of vertical window size: a 10 V signal displayed at a Volts/Div setting of 1 V and an acquisition rate of less than 50 μ s/Div would fit within the 10.24-division vertical window available at that acquisition rate setting. However, if the acquisition rate is increased to 100 ns/Div, the vertical window decreases to about 9.68 divisions; therefore, a setting of 1 Volt/Div would cause the signal to be clipped. The Volts/Div setting for this acquisition rate should be 2V.

To avoid clipping waveforms, either determine the vertical window for the acquisition rate used and select the Volts/Div setting accordingly, or, if high-resolution measurement isn't needed, select Volts/Div setting based on the the "worst case" vertical window. The 9.68-division window just used is the smallest window available for any acquisition rate settings; therefore, selecting the Volts/Div setting to keep the waveform within this 9.68-division window ensures the waveform won't clip for all acquisition rate settings.

RESOLUTION. Although the window size varies with different acquisition rates, the per division vertical resolution for each Volts/Div setting is constant at 1/25 of 1 division, since there are always 25 values or digitizing levels (DL's) per division. Therefore, given that the waveform to be measured is sized to fit within the vertical window, you can determine the resolution you will obtain for a given measurement. Let's use the previously-discussed 10 volt waveform as an example: for the 10.24-division window, at the 1 V/DIV setting, the resolution is 1/25 of 1V and 1/25 of 2V for the 9.68-division window (2 V/DIV setting). This gives 40 mv or 0.4% resolution for the 10.24-division window versus 80 mv or 0.8% resolution for the 9.68-division window. In general, vertical resolution for a measurement is expressed as follows:

$$R(\text{volts}) = 1/25 \times \text{V/DIV setting},$$

$$R(\%) = 100/(25 \times V_{\text{sig}}),$$

where

$$R = \text{resolution} \quad V_{\text{sig}} = \text{signal amplitude in divisions}$$

Also, see the **YMUIt** Argument to the **WFMpre** query under "Waveform Commands" in Appendix A of this Guide.

Regardless of the window size, if increased resolution is needed, AVG mode can be used when measuring repetitive signals. By averaging a waveform over a user-specified number of averages, the obtainable resolution is improved by 1 divided by the user-specified number of averages. In other words, for 2 averages specified, the resolution is 2 times better or 1/50 of a division; for 4, 1/100 of a division, etc. (Accuracy of the measurement is not improved, only the resolution.)

How to Use the 2432A AutoStep Sequencer

The 2432A AutoStep Sequencer (hereafter referred to as “sequencer”) can save and recall multiple front-panel setups along with associated instrument actions. Each setup and associated set of user-specified actions is called a “step”. One or more steps can be put together to form a sequence. Sequences may be run by the 2432A, sent back to the controller, or sent to another 2432A. Any valid front-panel setup can be saved in a step. The setup may be prepared using the instrument front panel or loaded via the GPIB. A setup may include the selection of parameter measurements and Save-On-Delta.

Individual front panels can be saved using the same procedure as outlined for entire sequences. The only difference is that a sequence used for storing just one front panel has only one step.

Constructing a Sequence

Sequences are built out of “steps”. Each step consists of one front-panel setup with some associated “actions” which will be performed when the step is recalled. Saving a sequence involves setting up the 2432A as desired for the first step, specifying what actions are to take place on this step, and then issuing the GPIB command to save the sequence. Subsequent steps are added to the sequence in the same manner. Let’s walk through these steps one at a time.

SETTING UP THE FRONT PANEL. You may set up the front panel using GPIB commands just as you would in a normal controller program. The 2432A should be set to the desired operating mode including all measurements, Auto Setup modes, and output device specifications. This operating mode makes up the front panel.

Lines 5 and 6 of the screen are also considered part of the front panel which is saved into the sequencer. You may use these lines to display special messages during this step. For example, you could tell the user what type of test is running, or what stage a test is at. Use the MESSAGE command during the set up procedure to specify what message will appear on the screen with each step.

WHAT ARE ACTIONS? Each step has a set of actions that will be done when that step in the sequence is run. Some of these actions occur before the front panel is loaded, while others are run after. For example, Self-Test and Self-Cal are actions which, if selected, will be done before the front panel is loaded to make sure the 2432A is functioning optimally. The actions Auto Setup, Measurements, Print/Plot, Bell, SRQ, and Pause are executed after the front panel is loaded.

Each action has been assigned a number. After selecting the desired actions, add up their assigned numbers and send the sum to the 2432A with the command 'SETUP ACTIONS:sum'. If no actions are desired, then send 'SETUP ACTIONS:0'. For example, if the Bell and Pause action are needed, the command to send is 'SETUP ACTION:160' (32 + 128 = 160).

Here are definitions of the various actions:

- | | |
|-----------------|--|
| Repeat (1) | After the last step of a sequence, control is transferred to the most recent (highest numbered) step which has repeat enabled. This forms an infinitely repeating loop. |
| Self-Cal (2) | Self calibration is performed on the 2432A prior to loading the programmed front-panel settings. If self calibration fails, the sequence is aborted and the extended diagnostics menu is displayed. |
| Self-Test (4) | Self diagnostics are performed on the 2432A prior to loading the programmed front-panel settings. If self-diagnostics fail, the sequence is aborted and the extended diagnostics menu is displayed. |
| Auto Setup (8) | <p>An Auto Setup will be performed immediately after setting up the saved front panel. The type of Auto Setup will depend upon the mode selected in the saved front panel.</p> <p>Auto Setup makes many changes to the 2432A front-panel setup loaded before the Auto Setup is performed. See Table B-16 in Appendix B of the 2432A Operators manual to see which controls are affected and how they are affected.</p> |
| Print/Plot (16) | Turning on the Print/Plot Action causes data to be sent to the currently selected external printing or plotting device. The data printed (waveforms, measurements etc.) depends upon the selections made in the saved front panel. If there is no device on line, this action is ignored. |
| Bell (32) | When Bell is on for a step, the internal 2432A bell will ring at the end of the step. A step is considered complete after front-panel setups have been changed, an acquisition has been made, measurements done, and data output to any selected devices. |

- SRQ (64) If OPC is ON, an SRQ is generated at the end of each step with this action set. If this step is the last step in a sequence, the event code will indicate sequence complete; otherwise, it will show the end of a step. See "Operation Complete Events" in Appendix C for event code numbers.
- Pause (128) After the completion of all other actions, the 2432A will pause and wait for a step command before going to the next step. The step command may come from the GPIB ('STEP'), the front-panel PRGM button, or the rear-panel SEQUENCE IN connector. Pause does not occur on the last step in a sequence unless a repeat loop has been programmed.
- Protect (256) If protect is set on for the first step of a sequence, the sequence is protected from accidental deletion. Setting protect on for other steps has no effect. To delete a protected sequence, the first step must be edited to turn protect off for that step, or you can override the protection by sending a 'SETUPFORCE:ON' GPIB command.

The 2432A automatically controls the order of each selected action within any sequence step. For instance, Self-Cal and Self-Test actions are always completed before loading the instrument setup. The Auto Setup action is always completed before any data is acquired. An acquisition cycle, including averaging and repet mode filling, is completed before any measurements are made or before the Print/Plot, Bell, SRQ, or Pause Actions are done. This means that any measurement or waveform observed at the end of a step occurred as a result of that step.

SAVING THE SEQUENCE. After the actions have been set and the 2432A is in the desired operating mode, you may save the sequence step by sending the 'SETUP SAVE:"seq name"' command. This command will save the current front panel in a sequence named "seq name". For example, to save the current front panel in a sequence named "TEST1", you would send the command 'SETUP SAVE:TEST1' to the 2432A. The name can be up to 6 characters in length and consist of any uppercase alpha-numeric character including blanks. Leading blanks are significant and are stored as part of the name, while trailing blanks are ignored.

If the sequence name currently exists, the 2432A appends the current front panel onto the existing sequence as a new step. Long sequences are built one step at a time. If the name does not exist, a new sequence is created with the current front panel as the first step.

Five special names: "ONE", "TWO", "THREE", "FOUR", "FIVE" are reserved for saving only single-step sequences with no actions. By reserving these names, compatibility is maintained with previous 2432A instruments. Saving a step while specifying a reserved name replaces the previous step stored under the reserve name rather than appending the new step to the old (remember, reserved names are for one front-panel setups only). These names may be used without quotes just as on previous 2432A instruments. For example, 'SETUP SAVE:"ONE"' is equivalent to 'SETUP SAVE:ONE'.

The selection menu limits the number of sequences to 40 because only 40 names can be displayed on screen at once. The size of the Sequencer memory limits the total number of steps which make up those sequences. Each front-panel setup is "compressed" before becoming a new step in a sequence. Different front-panel setups have different sizes ranging from 12 to 200 bytes in length, so as many as 800 and as few as 100 steps can be stored. To find out how many bytes of memory are available to the sequencer, send a 'SETUP? MEMORY' query. To obtain a list of the names of all currently saved sequences, use the 'SETUP? NAMES' query.

Recalling a Sequence

Once you have a sequence safely stored away in the 2432A, the next thing to do is run that sequence. To run a sequence send the command 'SETUP RECALL:"seq name"', where "seq name" is the name of the existing sequence you want to recall. When you issue a recall command, the 2432A will find the desired sequence, load the first step, and begin executing the actions associated with the first step. See "What Are Actions" for more information on what each action does. If the 2432A cannot find the named sequence that you are recalling, it will issue an SRQ, and ignore the command.

Removing Unwanted Sequences

There are two ways to delete unprotected sequences. An individual sequence can be deleted by sending the 'SETUP DELETE:"seq name"' command to the 2432A. This will remove the sequence called "seq name". All sequences currently saved in the 2432A may be deleted by sending the 'SETUP CLEAR' command. Remember, deleted sequences are gone forever.

To delete "protected" sequences (protected sequences have the protect action set on for their first step), you must override the protection before using either of the 'SETUP DELETE' or 'SETUP CLEAR' commands just discussed. You override the protection by sending the 'SETUP FORCE:ON' command to the 2432A. As long as this override is in effect, any sequence can be removed by the 'SETUP DELETE' or 'SETUP CLEAR' commands. This override remains in effect until turned off by sending the 'SETUP FORCE:OFF' command. The override only effects sequence deletions from the GPIB. The front-panel user is still unable to delete a protected sequence.

Using the Sequencer

The sequencer in the 2432A can be used to store many front-panel states for recall under controller command. The sequencer can also do many tests by itself without the controller once the sequencer has been programmed. In both cases, the overall test time is reduced because the time it takes to set up the 2432A becomes much less significant.

CONTROLLING THE SEQUENCER. Several methods of maintaining synchronization between the 2432A's sequencer and the controller are provided. In addition to letting the controller command the sequencer, these methods let the controller know what state the sequencer is at any given time so that the total test can be managed.

At the conclusion of each sequencer step which has an SRQ action set, an SRQ is generated to let the controller know what stage the test is at. For instance, the "step complete SRQ" would be helpful when using the Pause action on a step to allow a technician to change an external test condition before allowing the test to continue. When finished, the technician would indicate this to the controller, which would continue the sequence.

At the end of each step, the sequencer automatically goes on to the next step in the sequence unless the Pause action is set. If paused, the sequencer will wait until it receives a command from the front panel, the GPIB, or the rear-panel BNCs to continue. From the GPIB, the controller would send the 'STEP' command to get the sequencer to continue. To stop a currently executing sequence, the controller may send a 'HALT' command. This will stop any acquisition in progress and terminate the sequence at the end of the current step. For more information on the rear-panel BNCs or the front-panel controls, see the operators manual.

HOW CAN THE SEQUENCER HELP? With the sequencer, the 2432A can provide semi-automatic, stand-alone testing. For many test applications, test setups can be entered from a controller (or from the front panel) as a sequence and the controller removed from the test system. The 2432A can then be used as a stand-alone "portable tester" for field or in-house work. Testing speed is increased, since you no longer need to change 2432A settings—you just select the next step!

In applications for which you still need the controller, the sequencer still enhances the 2432A's usefulness in test-systems. By programming the sequencer with your test-setup sequence, you enter the front-panel setups (and associated actions) once, as a sequence, and then run the sequence as often as desired. For repetitive testing tasks, running a test sequence (as opposed to sending a series of test setups again and again) increases test-system throughput by reducing bus traffic between the controller and the 2432A. Once you create and send a test sequence to the 2432A sequencer, you change to a new test setup by merely proceeding to the next sequence step (just sending the SAVE RECALL command to the 2432A is enough to invoke a completely new setup).

The sequencer also helps in controller-related applications by managing each acquisition cycle. The sequencer monitors the acquisition cycle and proceeds to the next "action" only when the oscilloscope is ready. Bus traffic is further reduced, since the controller is relieved of continuously monitoring the 2432A for these "actions"* (intraprocess updates).

Sending and Receiving Sequences

The 2432A can send stored sequences to a controller, to a printer, or to another 2432A. The controller can request the 2432A to send (in either ASCII or binary) any sequence that is currently stored. One sequence at a time can be sent to a printer or another 2432A, but the sequence must be sent in ASCII. This feature is useful for making hard copies of a sequence or updating another 2432A in your test system with the latest sequences. There are two basic modes for transferring sequences, binary and ASCII.

BINARY TRANSFERS. Binary transfers are done using the LLPRGM command. This command transfers sequences in a compact, low level form. This method is preferred for high speed transfer in a production environment.

To read a sequence from the 2432A, send the 'LLPRGM? "seq name"' query to the 2432A. This query will return a binary block of data that makes up the sequence named in the "seq name" part of the query. If the sequence name is not specified, a block containing all the sequences currently stored in the 2432A will be returned.

To send a sequence or sequences to the 2432A, send the data block (as is) returned by the LLPRGM query back to the 2432A. When sequences are entered, their names are checked against existing sequences in the instrument. Sequences with the same name will not be replaced unless the sequence is first deleted from the 2432A memory.

The binary format used by the 2432A in compressing its sequences depends on the firmware version of the instrument from which the sequence originally came. This format can change. If it does, binary format sequences from older firmware versions will not work with instruments with newer firmware versions. We recommended that you save and archive an ASCII version of the sequence so that a new binary format block can be created in the future.

ASCII TRANSFERS. ASCII transfers are done using the PRGM command. ASCII transfers of sequences are essentially the high-level commands necessary to set up the sequence steps. Because of this, ASCII transfers will be readable by, and are upwardly compatible with, future instruments in the 2430 and 2440 series. ASCII transfers are preferred for purposes of documenting or archiving sequences.

To read a sequence using an ASCII transfer, send the 'PRGM? "seq name"' query to the 2432A. The 2432A will return an ASCII block of information detailing the sequence whose name is "seq name". If no name is specified, all sequences will be returned. For each step in the named sequence, approximately 2500 bytes of information are returned. (This is about the same length response as is returned by a 'SET?' query.) To send this sequence back to the 2432A, just return the data block.

To improve readability of ASCII sequence blocks, a formatting command has been provided. If formatting is turned on, the sequence output will contain carriage returns, line feeds, and extra spacing to make it more readable. To request a formatted version of the ASCII sequence output, send the 'FORMAT ON' command to the 2432A. To discontinue formatting, send the 'FORMAT OFF' command.

NOTE

Controllers which terminate input on line feeds will be unable to read formatted output.

SENDING SEQUENCES TO A PRINTER OR ANOTHER 2432A. This operation is very similar to that used to make copies of 2432A acquired waveforms without using a controller (see "Making Copies Without A Controller"). Both operations use the "talk-only" mode of the 2432A to allow output without the controller. Here, however, instead of getting hardcopy of waveforms, a formatted ASCII sequence is sent. The device to which this information is sent may be either a printer or another 2432A.

To configure the 2432A to send sequences, first push the OUTPUT front-panel button, followed by the SETUP menu button. Then push the MODE menu button, followed by the T/ONLY menu button, and finally make your selection by pushing the SEND PRGM menu button.

If you are sending sequences to another 2432A, first set the "To" 2432A to use only EOI as the terminator. Push the OUTPUT front-panel button, followed by the SETUP menu button. Then push TERM in the setup menu. Finally, push the menu button labeled EOI to make the terminator selection. Next, configure the "To" 2432A to listen always mode. Use the same method used for configuring the "FROM" 2432A to T/ONLY, except select L/ONLY instead of T/ONLY after pushing MODE.

If you are sending sequences to a printer, first configure the printer to listen always mode (see "Making Printer or Plotter Copies" for help).

After setting up the receiving 2432A or printer, select the sequence you want to send. You select it for transfer the same way as you select for recall. First, push the PRGM front-panel button. Then, push the RECALL menu button and use the up- and down-arrow keys to underline the chosen sequence.

Now make sure there is a GPIB cable between the "from" 2432A and the "to" device (printer or 2432A). To begin the transfer, push the OUTPUT front-panel button and then the SENDPRGM menu button.

Making Printer or Plotter Copies

The 2432A can print hard copies of its waveforms on a Hewlett-Packard Thinkjet[®] printer and some HPGL plotters such as the Tektronix HC100 and the Hewlett-Packard HP7470A and HP7475A Plotters. (HPGL is an abbreviation for Hewlett-Packard Graphics Language. Most Hewlett-Packard plotters, and many plotters made by other vendors, accept HPGL.) Printing may be initiated from the front panel or by sending a PRINT command over the GPIB. When instructed to print, the 2432A will format its screen and then send the formatted data to the selected device. A Thinkjet[®] printout takes about 75 seconds, while a plotter can take from 1 to 5 minutes (depending on what is being plotted and which type of plotter is being used).

When the 2432A acquires waveforms, 20 divisions (1024 data points) are acquired. The 2432A prints only the 10 divisions (512 data points) seen on screen (but see "Special HC100 Mode," later in this section).

In this section, we discuss how to make a hard copy (with or without a controller) and introduce a special mode for use with the HC100 plotter.

Making Copies Without a Controller

There are several steps in making a print or plot without a controller. You will need to know how to set up the hard copy device, how to configure the 2432A to make the copy, how to connect the two together, and how to start the copy process.

SETTING UP THE PRINTER/PLOTTER. Here, the idea is to make the hard copy device a "listener". This task is normally the controller's responsibility, but, since we are operating without a controller, it must be done by the user. Different devices may have different methods for setting the listen always mode. We'll use the Thinkjet® and HC100 as examples.

Many devices, including the Thinkjet® and HC100, have a DIP (dual in-line package) switch which sets their operating mode. Five of the switches are used to set the device address, the rest are used to specify device functions. Many devices, such as the Thinkjet®, use one of the non-address switches to activate the listen-always mode. Other devices go into listen-always mode if all five of their address switches are set to "1". This would result in a GPIB address of 31. But since the GPIB does not define address 31, many devices use this setting to specify the listen-always mode. The HC100 operates this way. Here is how the DIP switch settings should look for the Thinkjet® and HC100 for listen-always mode:

	8	7	6	5	4	3	2	1	

Thinkjet®	x	x	x	x	x	1	x		x = don't care
									0 = Off
HC100	1	1	1	1	1	0	0		1 = On

NOTE

In making these changes, note that many devices "read" their address DIP switches only at power-up. To make sure a device is actually in the state you've set, you should turn the device off, change the DIP switches to the new mode, and then turn the device back on.

CONFIGURING THE 2432A. There are two steps involved in setting the 2432A to print or plot. Step one is selecting which hard copy device you are using. Step two is selecting what you wish to copy. To make either selection, first push the OUTPUT front panel button and then push the SETUP menu button. Next, push the MODE menu button, followed by the DEVICES menu button. Pushing the DEVICES menu button should turn on the ADDR indicator LED. This lit ADDR indicator shows that the 2432A is in "talk-only" mode, ready to talk to the selected hard copy device.

To select the type of device, push the menu button labeled HPGL PLOTTER or the button labeled THINKJET PRINTER.

To select what gets printed, push the SETUP menu button and "compose" the copy. For further information on these selections, read the help text on this subject. (To get help, push the STATUS/HELP front-panel button, then push the OUTPUT front-panel button.)

CONNECTING THE 2432A AND THE PRINTER. The 2432A and the printer/plotter should be the only instruments connected to the GPIB when a controller is not being used. Connect a GPIB cable from the 2432A to the hard copy device and you are ready to print.

STARTING THE COPY. To initiate a copy, push the OUTPUT front-panel button, and then push the right-most menu button. This button will be labeled PRINT, if you selected the Thinkjet® printer, or PLOT, if you selected the HPGL plotter mode. If an error message appears on screen at this point, you've either configured the printer/plotter incorrectly or the cable has fallen off. Check for these two potential problems.

After you have pushed the PRINT or PLOT button, the button label will change to ABORT. Push this button if you want to stop the print or plot after it has already started.

Making Copies With a Controller

A controller can also initiate a print or plot. Using a controller, you may print the Help text, GPIB and status screens, and the measurement Snapshot display. We will now walk through the same setup steps as we went through to make a print/plot without a controller.

SETTING THE PRINTER/PLOTTER. Since a controller is present on the bus, we must assign an address to the printer or plotter. The controller can then make the printer or plotter a "listener" so that it can receive and print the hard copy from the 2432A. The address is assigned in the same way as above (for printing with no controller) except that the DIP switch settings are different. Here are example switch settings to assign the device an address of 5. You may use whatever address is appropriate for your system.

	8 7 6 5 4 3 2 1	

Thinkjet®	1 0 1 0 0 0 x	x = don't care
		0 = Off
HC100	1 0 1 0 0 0 0 0	1 = On

CONFIGURING THE 2432A. If you are already using a controller to talk to the 2432A, the GPIB setup of the 2432A will not change for printing/plotting. If you need to start from scratch, see the section on changing GPIB Mode in "Establishing GPIB Communication" on how to set the 2432A to the correct address and to Talk/Listen mode.

The only other configuration information which must be selected is which printer or plotter format the 2432A should send. The format is selected by sending 'DEVICE TYPE:HPGL' or 'DEVICE TYPE:THINKJET' to the 2432A. The DEVICE command also allows you to compose the print in much the same way as the DEVICES menu button (see "Making Copies Without a Controller").

CONNECTING THE 2432A AND THE PRINTER. Make sure there is a GPIB path between the 2432A and the printer/plotter. (If both instruments can communicate with the controller, this path exists.)

STARTING THE COPY. There are three things the controller must do to start a hard copy output from the 2432A. First, the 'PRINT' command must be sent to the 2432A (to let it know what to send out the next time it is made a talker). Second, the printer/plotter must be "listen addressed." Third, the 2432A must be "talk addressed." As the 2432A sends data, the printer/plotter should receive that data and begin printing/plotting.

Here is a sample program written in 4041 Basic which initiates a hard copy to a Thinkjet® printer. Statements 130 and 140 actually initiate the print by sending the 'PRINT' command, turning the Thinkjet® printer into a listener and the 2432A into a talker. Line 120 tells the 2432A to send data for the graticule and waveform, but not to send data for plot text or settings.

```
10 scope=1
20 print " Enter 2432A address:" ;
30 input addr
40 if addr>30 then goto 30
50 if addr<0 then goto 30
60 open #scope:" gpib0(pri=" &str$(addr)& ,eom= <0>):"
70 print " Enter printer address:" ;
80 input prntaddr
90 if prntaddr>30 then goto 80
100 if prntaddr<0 then goto 80
110 print #scope:" device type:thinkjet"
120 print #scope:" device settings:off,grat:on,text:off,wavfrm:on"
130 print #scope:" print"
140 wbyte atn(unt,unl,prntaddr+32,addr+64)
150 end
```

KNOWING WHEN A COPY IS FINISHED. There are three methods for determining whether the print or plot has completed. First, the 2432A can be programmed to signal the controller by issuing an Operation Complete SRQ, with an associated event code of 463, at the conclusion of the hard copy. (Operation Complete, or OPC, SRQ's are enabled with the command 'OPC ON'.) Second, the controller can do a serial poll of the 2432A and check the BUSY bit in the status byte, since the 2432A sets this bit while it is doing the hard copy and clears it when it is done. (See "Using SRQs and Events" for more information on the status byte and Operation Complete SRQs.) The third method is to time the hard copy and insert a wait of that length in your program. This method can be dangerous since the hard copy time can vary depending on the amount of data sent.

Once the print or plot has started, the controller can abort it by sending a Device Clear (DCL) to the 2432A.

Save-On-Delta Hard Copies

When used without a controller, the 2432A can be set up in a “babysitting” mode. In this mode, the Save-On-Delta is used in tandem with Envelope mode to create a “limits” envelope for monitoring an event. (See “Storage Applications,” “Save-On-Delta” mode, for information on creating an envelope from the GPIB. These titles are found in Section 3 of the *2432A Operators Manual*.)

When events occur that move outside this “limit” window, the 2432A goes to save mode and sends a hard copy of the event to the printer. The out-of-limit event is hard copied, time-stamped, and printed. The 2432A then rearms the Save-On-Delta for further monitoring of events.

The Save-On-Delta feature highlights the out-of-limit event by centering it on the screen. Since Print outputs the 10 divisions on screen, you always get a hard copy with the event centered for easy identification.

Special HC100 Mode

In addition to understanding HPGL, the HC100 plotter can plot Positive Integer Entire Binary Format waveforms directly (see Appendix B for more information on waveform format). In this case, the formatting is done by the plotter, not by the 2432A.

NOTE

The Positive Integer format mode for the HC100 cannot be used with Save-On-Delta waveforms (either with or without controller direction). Use the HPGL mode for the HC100 plotter when using Save-On-Delta.

The special HC100 mode has two advantages. First, you get a hard copy of all 1024 points (20 divisions) of a waveform instead of just the 512 points (10 divisions) contained on the screen that the other modes print. Second, it can be faster because the plotter does its own formatting. The plotter doing the formatting reduces bus traffic considerably since fewer bytes are sent over the bus and the HC100’s input buffer can hold most of the bytes. The 2432A is freed for other tasks.

To illustrate the time savings possible by use of the special HC100 mode, consider that it takes over 2 minutes to plot one waveform using the HC100 in HPGL mode. During this time, the 2432A is dedicated only to this task. On the other hand, the plot time for one waveform using the Positive Integer waveform format is about 2.5 minutes, but the 2432A only sends data to the HC100 for about 35 seconds. Therefore, the 2432A is free for other tasks after only 35 seconds, instead of 2 minutes.

To use this special HC100 plotter mode, make sure the plotter is working correctly by following the above procedures for an HPGL plotter. Set up the configuration (controller or no controller) as you wish. Then turn the power off and change the DIP switch settings as shown below before turning the power back on:

8 7 6 5 4 3 2 1	where:	0 = Off
-----		1 = On
a a a a a 1 1 0		a = leave alone

To make a special mode HC100 plot without a controller, just follow these steps.

1. Set up the 2432A to send the Waveform Preamble with a waveform by pushing the OUTPUT front panel button, then the SETUP menu button. Push the MODE menu button, followed by the T/ONLY menu button. Finally, select the preamble mode by pushing the W/WFMPRE menu button.
2. Select Positive Integer data format by pushing the OUTPUT front panel button and then the SETUP menu button. Push the ENCDG menu button and make the format selection by pushing the RP menu button listed under the WHOLE WFMS header (the second from the left).
3. Start the plot by pushing the OUTPUT front panel button followed by the TRANSMIT menu button.

If you are using a controller, you must modify the sample program above by replacing lines 110 through 130 (delete line 120) with the following statements:

```
110 print #scope:* data encdg:rbinary*  
130 print #scope:* wavfrm?*
```

This will cause the 2432A to send both the preamble and curve data in the correct format and start the plot.

How to Save Instrument Settings

This section explains various methods for saving and restoring 2432A operational settings, or obtaining default settings. First we'll look at the two user-selectable front-panel setups the 2432A can automatically restore at power-up. Second, the two methods for saving and restoring settings when using a controller are discussed. Finally, for use without a controller, we look at how the 2432A's internal AutoStep Sequencer can be used to save and restore front-panel setups.

Power-up Default Setups

You may select one of two setups as power-up default. The options are either the LAST power-down front panel, or the factory INIT front panel. To select either of these, simply push the EXTENDED FUNCTIONS front-panel button, the SYSTEM menu button, the PANEL menu button, and finally the LAST:INIT menu button.

Using a Controller

Using a controller to store front-panel settings involves commanding the 2432A to send a data string representing its front-panel setup, and then storing that string in controller memory. The 2432A can send this string in two different formats. One format is ASCII, which looks like a series of regular 2432A commands. The other format is a low level binary representation which is not human readable. This binary format is much shorter than the ASCII string.

Because future versions of firmware for the 2432A may contain different "feature sets", the abbreviations for some symbols (and the binary version of the front-panel state) may vary between versions. For this reason, we recommend that you store an ASCII format "archive" of each front-panel state sent to the 2432A during the course of your controller program. To do this, simply send 'LONG ON;SET?' to the 2432A, then query the 2432A and save its response.

ASCII FRONT PANEL SETUP. The SET? query is used to obtain the ASCII form of the 2432A's front-panel state. The string returned by the 2432A will be about 2300 bytes in length if LONG is ON, or about 1750 bytes if LONG is OFF. Use this query when you want a human-readable copy of the current settings. ASCII format also allows you to alter small portions of the command string before sending it back to the 2432A. The SET? query is the most time-consuming method for saving a front-panel state, but it is also the safest in terms of compatibility with newer instruments.

You should use SET? when:

1. Archiving front-panel settings (set LONG to ON).
2. Loading, editing, and then restoring settings.
3. Loading settings from one 2432A and restoring them to another 2432A with different options or firmware versions.
4. Loading and restoring settings when time is not critical.
5. Loading and restoring settings using a controller that only understands the <LF> character as the end of message indicator.

BINARY FRONT PANEL SETUP. You use the 'LLSET?' query to extract a binary version of the 2432A's front panel. LLSET stands for Low-Level-SET. The response to an LLSET? query is a binary block with the same structure as the "Entire Binary Waveform Format" detailed in Appendix B. This block is about 275 bytes long and is a packed representation of the current front-panel state of the 2432A. Because this block is directly translated into a 2432A hardware configuration, any error in the order or values of the data can have expensive consequences. To insure that front panel data is in the correct format, the 2432A attaches an internal checksum byte to the block which is checked when the block is returned to the 2432A. If there is a difference, an SRQ is returned and the block is discarded. The complete block must be used just as it was originally sent by the 2432A.

When speed is important or when memory space on your controller is at a premium, use the LLSET? response instead of the SET? response. The 2432A sends and interprets the LLSET? response much faster than the SET? response. This is the main advantage; however, there are two potential problems to watch out for. First, since the line-feed (LF) character can be a valid byte in an LLSET? response, controllers which interpret the LF as end of message should not use LLSET?. In this case use the SET? query instead. Secondly, the LLSET? response string may change with different firmware versions of the 2432A. If you decide to use this method, keep a backup copy of the front panel in the SET? query format.

Using the Sequencer

The last method of saving and recalling front-panel setups of the 2432A uses the built-in sequencer. This is the fastest way to recall front-panel setups. This method is particularly attractive if you have time to load setups at the start of a test, but want them to run quickly once the test is underway. (The initial loading phase of the test may be unnecessary since the sequencer stores front-panel setups in non-volatile memory, so they are not lost when power is turned off.)

The first step in using the sequencer is to create a sequence which contains the front-panel state you wish to save. You may do this from the front panel (use the HELP mode for assistance) or from the controller. From the controller, set up the 2432A with the settings you wish to save and then issue the command 'SETUP SAVE:"name"' to the 2432A. The 2432A will store the present front panel setup into a sequence called "name".

Now, retrieve the sequence you've just created and store it in the controller so it may be loaded when the test first begins. To do this issue a 'PRGM?"seq name"' query and store the ASCII string which comes back.

To reload the "name"ed sequence into the 2432A's sequencer memory, simply send the ASCII string (as is) back to the 2432A. It takes around 8 seconds to reload the sequence into the 2432A sequencer. Once the sequence is in the 2432A's sequencer memory, it takes less than 1 second to be recalled. This is done using the 'SETUP RECALL:"seq name"' command. For more information, see the section "Using the Sequencer" as well as the "Sequencer Commands" section of Appendix A.

Using Group Execute Trigger

When the 2432A receives a Group Execute Trigger (GET) it executes a task that has been predefined using the DT command. The advantage of using GET over just sending the same defined set of commands to the 2432A is that GET speeds the execution time of the selected task. This is because the 2432A does not have to read and interpret the command before performing it. It already knows what to do. See Appendix D for an explanation of GET.

To use the GET function, first determine what you want the 2432A to do upon receipt of the GET, then issue the appropriate DT command. For example, let's say you want the 2432A to set up for a Save-On-Delta operation and then start acquiring. First, send the command 'DT SODRUN' to the 2432A. Then, when you want the scope to enter the Save-On-Delta mode and begin acquiring, issue the GET command. Refer to the manuals for your controller to learn how to make your controller to send a GET. See "Miscellaneous Commands" in Appendix A for more information on the DT command.

4

Debugging Your Programs

Debugging Your Programs

The 2432A has a DEBUG mode to help users make their GPIB programs run. You can use this feature to display all messages sent over the GPIB or only messages sent to the 2432A.

Displayed messages are scrolled horizontally across the 2432A display. You may control the scrolling speed. You may also “freeze” the screen at any time to analyze a message.

Note that Appendix G contains the answers to many common programming questions. The problem you are trying to solve may be discussed there.

Familiarization

To become familiar with the various Debug modes, we encourage you to write a very short program (for your controller) which sends just one or two commands to the 2432A over and over again. This short program will give you something with which to experiment.

After writing the program, push the OUTPUT front-panel button, followed by the DEBUG menu button. You will then see the DEBUG menu displayed on the bottom 3 lines of the screen. Push the menu button labeled DEBUG ON:OFF so that ON is underlined. DEBUG mode is now active.

Interacting with the Display

To monitor messages sent to the 2432A, push the menu button labeled BUS:SCOPE until SCOPE is underlined. Now, any mistake in an input message will cause an error message to be printed on screen with an arrow showing where the error is located.

When an error occurs, the 2432A will automatically “pause” the message to allow you to see it. To start the message scrolling again, press the PAUSE menu button. You may stop the scrolling at any time by pressing the PAUSE menu button; it acts as a toggle switch. The word “paused” appears on screen and the PAUSE button label is underlined when the display is paused.

You can observe both incoming and outgoing messages. The type of message is selected by pushing the menu button labeled IN:OUT (this button toggles between the IN and OUT settings). While IN is underlined, only messages being sent to the 2432A are displayed. While OUT is underlined, both incoming AND outgoing messages will be displayed. Outgoing messages (responses from queries) appear underlined as they scroll across the screen.

The characters appearing on screen are the 2432A’s version of the ASCII character set. To translate between the two character sets, use the conversion charts in Appendix F. For example, an incoming carriage return is shown as a lower-case “n”. Any lower-case letters in incoming messages will be changed into upper-case. Whenever the message terminator is found (whether line-feed or EOI), it will be changed into a “box” character before it is displayed.

Character Update Rate

You can select the rate at which characters appear on screen by pushing the menu button labeled SLOW. While SLOW is underlined, the update rate is reduced to allow you to read the text. Push the PAUSE button to “freeze” the message on screen. You may then take as long as you need to analyze the message.

One word of caution when using either the SLOW or the PAUSE modes: most controllers have a message timeout in their GPIB driver. If this timeout period is exceeded, the controller will think something is wrong with the 2432A and abort the message prematurely. To prevent this problem, increase your controller timeout value or remove it altogether whenever using the Debug Mode.

Using the 2432A as a Bus Monitor

You can use the 2432A to monitor all GPIB traffic by pushing the menu button labeled BUS:SCOPE so that BUS is underlined. The 2432A must be in Listen Only mode before BUS can be selected. If you get an error message while attempting to make the BUS selection, go to the section on setting up the 2432A and change the mode to Listen Only.

In BUS monitor mode, the 2432A accepts and displays characters *without* interpreting them. You could use this feature to help debug any controller program which sends out GPIB messages. (Even a program that controls devices other than the 2432A!)

To use the 2432A as a bus monitor, connect it to the GPIB cable. All messages sent over the bus will be displayed on the screen. The SLOW and PAUSE selections will work in BUS monitor mode also, but the same caution about the controller timeout discussed above applies. The IN/OUT selection has no effect while monitoring bus traffic.

A

GPIB Commands

GPIB Commands

NOTE

Throughout this appendix, headers and arguments are listed in a combination of bold uppercase and nonbold lowercase letters. The instrument accepts any abbreviated header or argument containing at least all the characters shown in bold uppercase. Any characters added to the abbreviated (uppercase) version must be those shown in lowercase. For a query, the question mark (?) must immediately follow the header. Link arguments shown in brackets ([]) are defaults (don't send the brackets as part of the argument). In any command that has a default, omitting the link argument sets the default. For example, 'RUN ACQUIRE' and 'RUN' are equivalent.

Vertical Commands

Header	Argument	Argument	Description
CH1(or CH2)	VOLts	<NR3>	<p>Sets the "screen" Volts/Div in a 1-2-5 sequence to the value of the argument. The screen Volts/Div takes attached probes into account. For example, sending a 50 Volts/Div setting in over the bus while a 100X probe is attached will result in setting the actual hardware gain to 0.5 V/div. <NR3> will be rounded and limited to a legal hardware setting. If EXW is ON and rounding or limiting occurs, a warning SRQ will be issued.</p> <p>Live expansion of non-Average waveforms is not allowed. A command to change to 1 mV, 500 μV and 200 μV will be rejected unless acquiring in Average mode. Also, if expanding in Save Mode with Volts/Div setting less than 2 mV, it will be reset to 2 mV when Acquire Mode is selected. Each of these events causes a warning SRQ to be issued if EXW is ON.</p>

EXAMPLES

Query

CH1? VOLTS

CH1? FIFTY

Response

CH1 VOLTS:1

CH1 FIFTY:OFF

Vertical Commands (cont)

Header	Argument	Argument	Description
CH1(or CH2) (cont)	VARIABLE	<NR3>	<NR3> will range from 0 to 100 with a resolution of 0.125. Zero is fully calibrated and 100 is fully uncalibrated. <NR3> will be limited to legal values, and if EXW is ON , a warning SRQ will be issued. This is not a calibrated feature and is meant to be used as a reference only.
	POSITION	<NR3>	<NR3> ranges from -10 to +10 with a resolution of 0.01 and will set the position of ground (in divisions) with "0" being center screen. If <NR3> is limited to the valid range, and EXW is ON , a warning SRQ will be issued.
	COUpling	AC DC GND	
	FIFTy	[ON] OFF	An SRQ will be issued whenever a 50 Ω overload is detected if INR is ON . If EXR is ON , an error SRQ will be issued if an attempt is made to set FIFTy to ON with an overload still present. If COUpling is AC and FIFTy is turned ON , COUpling will be set to DC . Similarly, if FIFTy is ON and COUpling is then set to AC , FIFTy will be turned OFF .
	INVert	[ON] OFF	

EXAMPLES

Query

CH1?

CH2? POSITION

Response

CH1 VOLTS:1,VARIABLE:0,POSITION:7.60E-1,
COUPLING:DC,FIFTY:OFF,INVERT:OFF

CH2 POSITION:1.51

Vertical Commands (cont)

Header	Argument	Argument	Description
PROBe?	CH1 CH2 EXT1 EXT2		QUERY ONLY. Will return the probe value attached to the indicated input BNC connector. The values can be: 1, 10, 100, or 1000.
BWLimit	TWEnty FIFty FULI		
VMODE	CH1 CH2 ADD MULT DISPlay	[ON] OFF [ON] OFF [ON] OFF [ON] OFF XY YT	VMODE turns the display for the chosen waveform ON or OFF . Even though the display is off, the scope still acquires waveforms. A VMODE change only affects the display of waveforms. ADD and MULT are mutually exclusive. The selection of one causes the other to be turned off.

EXAMPLES

Query	Response
PROBE?	PROBE CH1:10,CH2:1,EXT1:1,EXT2:1
PROBE? CH1	PROBE CH1:1
BWLIMIT?	BWLIMIT FULL
VMODE?	VMODE CH1:ON,CH2:OFF,ADD:OFF,MULT:OFF, DISPLAY:YT

Trigger Commands

Header	Argument	Argument	Description
ATRigger	MODE	AUTOLevel	Sending an AUTOLevel command while AUTOLevel is selected forces a recalculation of the trigger level. See INITAt50 command also.
		AUTO	AUTO switches to Roll at Sec/Div settings of 100 ms and slower. There is no AVG Acquire Mode during Roll.
		NORmal	
		SGLseq	A single sequence is started by issuing the RUN ACQuire command. An SRQ will be issued when the transition to Save Mode is made if OPC is ON . This is the way to do a hold next.
	SOURce	CH1 CH2 LINE VERTical EXT1 EXT2	For any SOURce selection, if LOGsrc is WORD , then LOGsrc is OFF , and a warning SRQ is issued if EXW is ON .
	LOGsrc	WORD A.B OFF	If WORD is selected and the word probe is not present, a warning SRQ will be issued if EXW is ON , and LOGsrc will change to OFF . Likewise, if WORD is currently active and the probe is disconnected, the an SRQ will be issued and the source will change to VERTical . A.B is the logical AND of A and B triggers.

EXAMPLES

Query

ATRIGGER?

ATRIGGER? MODE

Response

ATRIGGER MODE:AUTO,SOURCE:CH1,
LOGSRC:OFF,COUPLING:DC,LEVEL:-9.88E-1,
SLOPE:PLUS,POSITION:16,HOLDOFF:0,ABSELECT:A
ATRIGGER MODE:SGLSEQ

Trigger Commands (cont)

Header	Argument	Argument	Description
ATrigger (cont)	COUpling	AC DC LFRej HFRej NOIserej TV	Choosing the TV selection turns on the Video Option using the coupling choices in the SETTV command. An SRQ is issued if the Video Option is not present and EXR is ON . TV coupling and A.B or WORD logical sources are incompatible. Selecting TV coupling forces LOGsrc to OFF ; selecting any LOGsrc argument forces COUpling to DC . If either is done, a warning SRQ will be issued if EXW is ON .
	LEVel	<NR3>	Level is set in volts with no range limitations, but the actual effective level (which is based on the current trigger source) is limited to ± 18 divisions in CH1 and CH2 and ± 9 divisions otherwise. This allows the user to set the absolute trigger level of interest and let the instrument determine what its hardware can supply at any given Volts/Div setting. The Line Source level is considered to be 20 Volts/Div.
	SLOpe	PLUs MINUs	
	POSition	<NR1>	Sets number of data points which will be acquired prior to the trigger with $(1023 - [\text{NR1} \times 32])$ points acquired after the trigger. <NR1> can range from 1 to 30, with 1 meaning 32 pretrigger and 992 post-trigger points and 30 meaning 960 pretrigger and 64 post-trigger points. If necessary, <NR1> will be limited to the nearest legal setting and, if EXW is ON , a warning SRQ will be issued.

EXAMPLES

Query	Response
ATRIGGER? COUPLING	ATRIGGER COUPLING:AC

Trigger Commands (cont)

Header	Argument	Argument	Description
ATrigger (cont)	HOLdoff	<NR3>	<p><NR3> is settable with a resolution of 1/16 in the range 0 to 100, with 0 being the minimum holdoff (one screen) and 100 representing the maximum. Numbers outside these limits will be set equal to the value of the closest boundary and, if EXW is ON, an SRQ will be issued. Holdoff will always change to the minimum value on an A Sec/Div change.</p>
	ABSElect	A B	<p>Selects which trigger level the front-panel Trigger Level pot controls. It also controls which trigger status is displayed on screen and on the front-panel Trigger Status indicators.</p>
	MINimum		<p>QUERY ONLY. Returns the current minimum level of the A Trigger channel in volts. Data is only valid immediately following completion of an auto-level cycle. An auto-level cycle is forced by sending in the INITAt50 command.</p>
	MAXimum		<p>QUERY ONLY. Returns the current maximum level of the A Trigger channel in volts. Data is only valid immediately following completion of an auto-level cycle (See MINimum).</p>
	STATe		<p>QUERY ONLY. Shows the most "advanced" state the trigger system has reached since the last CLRstate command. These are the responses (in order of least to most advanced state): ARMED, READY, ATRIG, RTRIG, SAVE.</p>
	CLRstate		<p>COMMAND ONLY. Resets the trigger-state variable to ARMED.</p>

Trigger Commands (cont)

Header	Argument	Argument	Description
INITAt50			COMMAND ONLY. Will perform an autolevel cycle which will set the selected (A or B) trigger level halfway between the maximum of the signal and the minimum.
BTRigger	MODE	RUNSoft TRigaft	Selects whether B sweep free runs (RUNSoft) or must be triggered to run (TRigaft).
	EXTCLk	[ON] OFF	When ON , the B trigger source becomes the time base for the scope. The rate is one sample/cycle.
	SOURce	CH1 CH2 WORD VERTical EXT1 EXT2	See ATRigger SOURCE comments.
	COUpling	AC DC LFRej HFRej NOIserej	See ATRigger COUpling comments.
	LEVel	<NR3>	See ATRigger LEVel comments.
	SLOpe	PLUs MINUs	See ATRigger SLOpe comments.
	POSition	<NR1>	See ATRigger POSition comments.

EXAMPLES

Query

ATRIGGER? MINIMUM
ATRIGGER? STATE
BTRIGGER?

Response

ATRIGGER MINIMUM:-9.01E+1
ATRIGGER STATE:RTRIG
BTRIGGER MODE:TRIGAFT,EXTCLK:OFF,
SOURCE:CH1,COUPLING:DC,LEVEL:-9.53E-2,
SLOPE:PLUS,POSITION:16

Trigger Commands (cont)

Header	Argument	Argument	Description
SETTV	ICoupling	FLD1 FLD2 ALT TVLine	Shows the type of display when the video signal applied is an interlaced signal. If any SETTV selections are made and the Video option is not present, an SRQ will be issued, if EXR is ON , and the command ignored.
	NICoupling	FLD1 TVLine	Shows the type of display when the video signal applied is a noninterlaced signal.
	INTERlaced		QUERY ONLY. Returns ON if the Video Option detects that the applied video signal is interlaced and OFF if it detects that the signal is noninterlaced.
	TVClamp	[ON] OFF	"Locks" trigger level of composite video back porch at 0 volts.
	TVLine	<NR1>	<NR1> gives the line number to be triggered on in the selected field maximum number of lines for the field (in ALT , the field will be FLD2). If outside this range, a warning SRQ will be issued (if EXW is ON) when TV Trigger is selected.
	LCNTRreset	F1Only BOTH	Reset the line count only on field 1. Reset the line count on both field 1 and field 2.
	LCNTStart	PREfid	Line count begins three lines before the field-sync pulse. This is the SYSTEM-M selection that will be made in the Extended Functions menu from the front panel.
		ATFid	Line count begins at the sync pulse (non-SYSTEM M).
SYNc	PLUs MINUs	Show direction of the sync pulse relative to the baseline.	

Trigger Commands (cont)

Header	Argument	Argument	Description
SETWord	RADix	OCT HEX	Shows which numbering scheme will be used in the display.
	CLOck	ASync FALl RISe	ASync allows the probe to "freerun" at approximately 10KHz. FALl or RISe selects the appropriate edge for synchronous operation.
	WORD	<ascii binary data>	<ascii binary data> will be a Y or #Y followed by 17 characters, each one representing a bit in the trigger word plus the qualifier bit (the MS bit). The characters can be 0, 1, X, or x. Spaces will be ignored, but any other characters will cause an error to be generated. If an error occurs, the command will be ignored, and an SRQ will be sent if EXR is ON .
PROBe			QUERY ONLY. Returns ON if the word probe is attached or OFF if the probe is not connected.
MANtrig			COMMAND ONLY. This command forces a trigger. The trigger will only be effective if the scope is in the READY trigger state where all pretrigger data has determined by sending the scope an ATRIGGER? STATE query.
EXTGain	EXT1	DIV1 DIV5	
	EXT2	DIV1 DIV5	

EXAMPLES

Query

SETTV? TVLINE,SYNC
SETWORD?

Response

SETTV TVLINE:1,SYNC:MINUS
SETWORD RADIX:HEX,CLOCK:ASync,
WORD:#Y1111000000111001

Horizontal Commands

Header	Argument	Argument	Description
<p>HORizontal</p>	<p>MODE</p>	<p>ASweep AINtb BSweep</p>	<p>If in Roll mode (Auto trigger at slow Sec/Div settings), selecting AINtb or BSweep causes A Trig Mode to become Normal. If EXW is ON, a warning SRQ will be issued.</p>
	<p>POSition</p>	<p><NR3></p>	<p>Position will move point <NR3> of the waveform(s) to the center of the display. The range for <NR3> will be from 0 to 1023 with a resolution of up to 0.01. The resolution for unexpanded "live" waveforms is 1; the 0.01 resolution is to accommodate expanded saved displays. If the display is expanded 2X, points are "named" 0.0, 0.5, 1.0,....1022.5 (all expressed in scientific notation, of course) and the resolution is 0.5. If the display is expanded 10X, points are "named" 0.0, 0.1,... 1022.9,1023.0, and so on up to 0.01 resolution at 100X expansion. If <NR3> requires rounding, such as when the resolution specified is greater than available for the display, or limiting, such as when <NR3> value is outside the 0-1023 range, a warning SRQ will be issued if EXW is ON.</p>
	<p>ASEcdiv</p>	<p><NR3></p>	<p><NR3> can range from 2E-9 to 5 in the standard 1-2-5 sequence. If <NR3> does not match a valid Sec/Div setting, it will be set to the closest valid setting. If rounding or limiting is required, and EXW is ON, an SRQ will be issued. If the A sweep is set faster than the B sweep, B sweep is set ("locked") to match A sweep and an SRQ is sent if EXW is ON. Changing the A sweep setting causes the B sweep setting to change match until the sweeps are unlocked (see BSEcdiv).</p>

Horizontal Commands (cont)

Header	Argument	Argument	Description
HOR izontal (cont)	BSE cdiv	<NR3>	<NR3> range is the same as for ASE cdiv. The B Sec/Div setting can be set whether 'BSweep' mode is being used or not. B sweep can be set to any available Sec/Div setting faster than the A Sec/Div setting (this is how you "unlock" the A and B sweeps). As long as changes to the A and B Sec/div settings keep A slower than B, the sweeps are independently settable or "unlocked". If A sweep is set faster the B sweep, or B set slower than A, the sweeps again lock and, in both cases, SRQ's are issued if EXW is ON . Subsequent changes to the A Sec/Div sets both sweeps to the same Sec/Div setting until the sweeps are unlocked as just described.

EXAMPLES

Query

HORIZONTAL? POSITION

Response

HORIZONTAL POSITION:5.1200E+2

Horizontal Commands (cont)

Header	Argument	Argument	Description
HORizontal (cont)	EXTExp	<NR1>	<NR1> can be any of the following: 1, 2, 5, 10, 20, 50, or 100 and shows the expansion factor to be applied to an externally clocked A waveform in Save Mode. The expansion factor is reset to 1 if not in Save Mode or not working with externally clocked waveforms. Any <NR1> entered will be rounded and limited to one of the legal values and, if EXW is ON , an SRQ will be issued.
DLYTime	DELTA	[ON] OFF	If DELTA is ON , the delay time is the difference between DLY1 and DLY2 . If it is off the the delay time is DLY1 .
	DLY1 DLY2	<NR3> <NR3>	DLY1 is set to <NR3> seconds with the range and effective resolution depending on the Sec/Div setting. Both delays can be set at any time. With DELTA OFF , only DLY1 will be used. DLY2 sets the second delay relative to the first (it is the difference between the two). If the time base is being externally clocked, 1 Sec/Sample will be used to set the delay time. Delay time essentially becomes delay-by-events in external clock mode.
DLYEvts	MODE	[ON] OFF	
	VALue	<NR1>	<NR1> ranges from 1 to 65536 and shows the number of events by which the A record trigger will be delayed. It will be limited to match a legitimate value. If limiting occurs and EXW is ON , a warning SRQ will be issued.

EXAMPLES

Query

HORIZONTAL?

DLYTIME?

DLYEVTS?

Response

HORIZONTAL MODE:ASWEEP,POSITION:5.12000E+2,
ASECDIV:1E-5,BSECDIV:1E-5,EXTEXP:1

DLYTIME DELTA:OFF,DLY1:1.8400E-5,DLY2:0

DLYEVTS MODE:OFF,VALUE:124

Acquisition Commands

Header	Argument	Argument	Description
RUN	[AC quire] SA ve		The AC quire argument will cause the scope to start an acquisition. SA ve will cause an immediate transition to Save Mode.
AC quire	MO De	NOR mal EN V AV G	Selects one of the three acquisition modes listed. If set to AVG with delay time and DELTA set to ON , only Delay 1 will be displayed, and a warning SRQ will be issued if EXW is ON .
	REP et	[ON] OFF	When ON , enables equivalent time sampling at sweep speeds of 100 ns and faster. When OFF at these same speeds, points between samples will be interpolated. REP et mode has no effect at sweep speeds of 200 ns and slower.
	ER Ase		COMMAND ONLY. Causes the acquisition sequence currently running to restart similarly to a single-sequence reset.
	NUM Env	<NR1> CON t	<NR1> is the number of envelope sweeps done before resetting. It is settable to one of the following: 1, 2, 4, 8, 16, 32, 64, 128, or 256. If it does not match, the value will be rounded to coincide with one of the above and an SRQ will be issued if EXW is ON . The number of envelopes is ignored in Roll Mode.

EXAMPLES

Query	Response
RUN?	RUN ACQUIRE
ACQUIRE?	ACQUIRE MODE:NORMAL,REPET:ON,NUMENV:1, NUMAVG:2,SAVDEL:OFF
ACQUIRE? MODE	ACQUIRE MODE:AVG

Acquisition Commands (cont)

Header	Argument	Argument	Description
ACQure (cont)	NUMAVg	<NR1>	<NR1> is the number of acquisitions averaged using the Stable Average mode, before switching to the Exponential Average mode (see Section 5, "Storage System," "AVG (Average)" in the <i>2432A Operators Manual</i> , for more information). It is settable to any of these: 2, 4, 8, 16, 32, 64, 128, or 256 (handled similarly to NUMEnv).
	SAVDel	[ON] OFF	Turns Save-On-Delta mode ON or OFF . If ON and the scope detects a difference, it will go to Save Mode and issue an SRQ if OPC is ON . A controller can look for the OPC SRQ or see if BUSy? is OFF or see if the Atrigger State (ATrigger? STATe) is SAVe to know when SAVDel has terminated.
	NUMACq		QUERY ONLY. The returned number will indicate the number of acquisitions that took place before Save was activated. Turning SAVDel to ON will reset the NUMACq number. An intermediate number will be returned if Save has not been entered yet.
SMOoth	ON OFF		Turns smoothing ON or OFF . If ON a 5 point auto regressive moving average is performed on any displayed waveforms except references. Waveforms sent using a CURVe? are affected by smoothing.

EXAMPLES

Query

SMOOTH?
ACQUIRE? MODE,REPET
ACQUIRE? SAVDEL

Response

SMOOTH OFF
ACQUIRE MODE:ENV,REPET:OFF
ACQUIRE SAVDEL:OFF

Saveref Commands

Header	Argument	Argument	Description
SAVERef	[STACK] REF1 REF2 REF3 REF4		COMMAND ONLY. If STACK is selected, an automatic reference transfer is done (See Operators Manual for order). For the others, the waveform indicated by the REFFrom pointer is put into the reference memory indicated by the argument. If the waveform pointed to by REFFrom is invalid, an error SRQ will be issued if EXR is ON .
REFFrom	REF1 REF2 REF3 REF4 CH1Del CH2Del ADDDel MULTDel CH1 CH2 ADD MULt		Selects the waveform source for transfer to a reference waveform using the SAVERef command.

EXAMPLES

Query

REFFROM?
REFDISP?
REFDISP? REF2
REFPOS?

Response

REFFROM CH1
REFDISP REF1:EMPTY,REF2:OFF,REF3:ON,
REF4:OFF
REFDISP REF2:OFF
REFPOS MODE:INDEPENDENT,REF1:5.12000E+2,
REF2:4.60000E+2,REF3:5.59000E+2,
REF4:4.57000E+2

Saveref Commands (cont)

Header	Argument	Argument	Description
REFDisp	REF1	[ON] OFF	If ON , the selected reference is displayed. Because only 6 waveforms can be displayed at one time, turning on a reference does not guarantee that it will be displayed. If the reference is empty, an error results, and an SRQ is issued if EXR is ON .
		EMPTy	
	REF2	[ON] OFF EMPTy	
	REF3	[ON] OFF EMPTy	
	REF4	[ON] OFF EMPTy	
REFPos	REF1 REF2 REF3 REF4	<NR3> <NR1> <NR1> <NR1>	<NR3> ranges between 0 and 1023 with a resolution of 1 and labels the point on the reference that will be at center screen if MODE is INdependent . If VMOde is XY then REF1 and REF2 horizontal positions are "locked" (not independently selectable).
	MODE	INdependent LOCK	INdependent allows each reference to be horizontally positioned separately. LOCK slaves the reference position to the live horizontal position. This mode is particularly useful when using Save-On-Delta mode for bringing the event of difference to center screen automatically.

Display Commands

Header	Argument	Argument	Description
INTENSITY	DISPlay REAdout GRAt INTENS	<NR3> <NR3> <NR3> <NR3>	<NR3> for all the Intensity controls will be a number from 0 to 100 with a resolution of 0.25; 0 being off and 100 being the brightest. <NR3> will be limited and, if EXW is ON , a warning SRQ will be issued. INTENS sets the intensity of the intensified zone in A intensified Horizontal Mode.
	VECTors	[ON] OFF	Determines whether the display is drawn using vectors (ON) or dots (OFF).
REAdout	[ON] OFF		Turns all readout display ON or OFF .
MENUoff			COMMAND ONLY. Clears any menus occupying the three bottom display lines that label the menu buttons. Any full-screen menus/displays, such as the SNAPSHOT display, Sequencer sub-menus, status (instrument, OUTPUT, or TRIG) are also cleared. Useful for creating custom menus: MENUoff , followed by a USER ON command, must be used to clear the menu and enable SRQ's to be issued when menu buttons are pressed. The programmer then sends his own custom menu to the 2432A. (See MESSAGE command for creating the menu.)

EXAMPLES

Query

Response

INTENSITY?

INTENSITY DISPLAY:3.200E+1,READOUT:4.200E+1, GRAT:1.800E+1,INTENS:6.825E+1,VECTORS:ON

MESSAGE?

MESSAGE 1:* READOUT\ \$\ \$DISP \$\ \$
INTENS\ \$\ \$ gr a t \$\ \$ \$ o n IOFF* ,
2:* INTENSITY* ,3:* \ \$* ,4:* * ,5:* * ,6:* * ,7:* * ,8:* * ,
9:* * ,10:* * ,11:* * 12:* * ,13:* * ,
14:* RF3 1.00 V 10\ < 7 * ,15:* * ,
16:* CH1 1V A 10\ < 7 -1.23 V*

Display Commands (cont)

Header	Argument	Argument	Description
MESS age	<NR1>	"string"	<p><NR1> is settable in the range 1 to 16 and will designate which row in the readout the "string" will go (line 1 is at the bottom of the screen). <NR1> values will be limited and, if EXW is ON, an SRQ will be issued. The string will be left justified in the display and will be blank filled or truncated to 40 characters long.</p> <p>COMMAND ONLY. Clears out all 16 lines of readout from the instrument display.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>The top two, and bottom three, lines of readout are used extensively by the scope. Even though the front panel is locked out, remote changes may still cause updates to rewrite any of the top two or bottom three lines (see MENUoff command). In addition, any of the following can cause an overwrite to occur:</i></p> <ol style="list-style-type: none"> 1. 50 Ω overload. 2. word probe is disconnected while word-trigger source is selected. 3. when cursors are on, line 14 is constantly overwritten.

EXAMPLES

Query

MESSAGE? 3,4,14

MESSAGE? 5

Response

MESSAGE 14:* RF3 1.00 V 10\ < 7* ,
4:* * ,3:* *

MESSAGE 5:* \ t h i s IS UNDERLINED*

Cursor Commands

NOTE

V.T cursors will return meaningful values only when the time cursors (set with TPOs) are on screen. The voltage values at a particular time cursor location are extracted from the display so the useful range is limited to the 512 points currently being displayed.

Header	Argument	Argument	Argument	Description
CURSOR	FUNCTION	VOLts		V.T and SLOpe will place cursors only on the waveform selected using the TARget arguments. There are no ABSOLute cursors in SLOpe. If SLOpe is requested with ABSOLute cursors on, MODE will be changed to DELTa, and a warning SRQ will be issued if EXW is ON.
		V.T		
	SLOpe			
	TIME			
		ONE/Time		
		OFF		
	TARget	CH1		This command selects which waveform the user would like the cursors to appear on. The target waveform needs to be displayed; if not, an error SRQ will issued if EXR is ON, and the current target will not change.
		CH2		
		ADD		
		MULt		
		REF1		
		REF2		
		REF3		
		REF4		
		CH1Del		
		CH2Del		
		ADDDel		
		MULTDel		
		UNIts	TIME	
	PERCent			
	DEGrees			
		SLOpe	BASe	BASe units are volts/second.
			PERCent	
			DB	
		VOLts	BASe	BASe units are volts.
			PERCent	
			DB	

Cursor Commands (cont)

Header	Argument	Argument	Argument	Description
CURSOR (cont)	YPOs	ONE TWO	<NR3> <NR3>	<NR3> sets the horizontal volts cursor position in divisions. The range for <NR3> is ± 4.1 with a resolution of 0.01 divisions. <NR3> values will be limited, and if EXW is ON , a warning SRQ will be sent.
	TPOs	ONE TWO	<NR3> <NR3>	<NR3> sets the vertical time cursor position to the waveform point location selected. The range for <NR3> is 0 to 1023 with a resolution of 0.01 (see HORizontal POSition). <NR3> values will be limited, and if EXW is ON a warning SRQ will be sent.
	MODE	DELTA ABSOLute		In DELTA , both cursors are active and values displayed are the voltage or time differences between the two cursors. In ABSOLute , only the active cursor is displayed with the readout values referenced to the trigger point for time values and ground for voltage values.
	DISPlay	VALue UNIts		QUERY ONLY. VALue will return the <NR3> number from the cursor readout field of the display. UNIts will return the symbolic "units" string associated with the VALue . If the cursor function is off, the units returned will be OFF .
	SElect	ONE TWO		Command selects which cursor is the active one.

EXAMPLES

Query	Response
CURSOR? TARGET,TPOS	CURSOR TARGET:CH1,TPOS:ONE:3.12000E+2, TPOS:TWO:7.12000E+2

Automatic Feature Commands

Header	Argument	Argument	Argument	Description
AUTOSetup	MODE	VIEW PERIod RISe FALI PULse		In AUTOSetup the scope automatically sets itself up to get a good "picture" of an incoming waveform. The MODE parameter tells the scope what type of a display or measurement the user desires. For example, RISe focuses on the rising slope of the waveform while PERIod focuses on the full cycle.
	EXEcute			COMMAND ONLY. Causes one Auto Setup cycle to take place. The scope will not act on any new commands until this cycle is complete.
	RESolution	HI LO		When RESolution is set to HI , the Auto Setup cycle will "spread" the waveform out over the entire 20 division acquisition window so that a measurement can be made with as much resolution as possible. When RESolution is set to LO , the Auto Setup cycle will optimize the horizontal resolution to fit the waveform on the screen. RESolution is ignored in VIEW mode.

EXAMPLES

Query

AUTOSETUP?
 AUTOSETUP? MODE

Response

AUTOSETUP MODE:VIEW,RESOLUTION:LO
 AUTOSETUP MODE:RISE

Automatic Feature Commands (cont)

Header	Argument	Argument	Argument	Description
VALue?	<types>			<p>QUERY ONLY. Returns the specified parameter or <type> on the selected waveform. The source containing the waveform to be measured is selected with the DATA SOURCE or DATA DSOURCE commands, with DATA DSOURCE used only when VALue? uses the DELAY argument (see below). A new parameter calculation is done each time the VALue? query is received.</p> <p>DATA SOURCE is used to select the source for all measurements except for DELAY. Since DELAY requires two targets, DATA DSOURCE is used to select the second source, or the "Delay To" target, while DATA SOURCE selects the first source, or the "Delay From" target. The DATA SOURCE and DATA DSOURCE commands are in "Waveform Commands" in this appendix.</p> <p><types> available are:</p> <p>DISTal, PROXimal, MESIal, MINimum, MAXimum, MID, TOP, BASE, MEAN, PK2pk, OVERshoot, UNDERshoot, WIDTH, PERIOD, FREQUENCY, DUTY, RISE, FALL, RMS, AREA, DELAY, and DMESial.</p> <p>If no type is specified, all types are returned.</p> <p>If the scope returns a value of 99E99, then an error has occurred. Check the event code to determine which one (see EVENT?).</p>
UNIts?	<types>			<p>QUERY ONLY. The same as VALue? except the units associated with any measurement type are returned.</p>

Automatic Feature Commands (cont)

Header	Argument	Argument	Argument	Description
MEASurement	DISPlay	[ON] OFF		Controls the display of measurements on the scope display screen.
	MARK	[ON] OFF		Turns the display of threshold crossing marks on or off. All time related measurements (i.e. DUTy , RISe , FALl , etc) are taken from between these marks.
	WINdow	[ON] OFF		Turns windowing on or off. Windowing limits measurement calculations to within the time cursor area if Time Cursors are on.
	METHod	CURSor HISTogram MINMax		Selects the method for determining Top and Base. CURSor uses the current Volts cursor values. HISTogram will set Top and Base to values calculated based on a histogram. MINMax will set Top and Base to the maximum and minimum respectively.

EXAMPLES

Query

MEASUREMENT? WINDOW
 MEASUREMENT? METHOD
 MEASUREMENT? DISPLAY

Response

MEASUREMENT WINDOW:OFF
 MEASUREMENT METHOD:HISTOGRAM
 MEASUREMENT DISPLAY:OFF

Automatic Feature Commands (cont)

Header	Argument	Argument	Argument	Description
MEASurement (cont)	ONE	TYPE SOUrce DSOUrce	<types> <data src> <data src>	Specifies <type> and "source" of the value to be shown in measurement display line number one. Four measurements (from the <types> list) may be displayed on the screen constantly. Use commands ONE , TWO , THRee , and FOUR , to tell the scope what type of measurement (if any) to display on each of these four lines. <data src> are the same arguments as those for the DATA SOURCE command.
	TWO	TYPE	<types>	Specifies <type> and "source" of the value to be shown in measurement display line number two.
	THRee	TYPE SOUrce DSOUrce	<types> <data src> <data src>	Specifies <type> and "source" of the value to be shown in measurement display line number three.
	FOUR	TYPE SOUrce DSOUrce	<types> <data src> <data src>	Specifies <type> and "source" of the value to be shown in measurement display line number four.

EXAMPLES

Query

Response

MEASUREMENT? ONE

MEASUREMENT ONE:TYPE:OFF,
ONE:SOURCE:CH1,ONE:DSOURCE:CH1

MEASUREMENT? ONE:TYPE

MEASUREMENT ONE:TYPE:OFF

MEASUREMENT? ONE,TWO

MEASUREMENT ONE:TYPE:OFF,
ONE:SOURCE:CH1,ONE:DSOURCE:CH1,
TWO:TYPE:ON,TWO:SOURCE:CH1,
TWO:DSOURCE:CH2

Automatic Feature Commands (cont)

Header	Argument	Argument	Argument	Description	
MEASUREMENT (cont)	DISTal	UNIts	PERCent	Changes the distal value used in calculating measurement results. PLEvel is the value used when UNIts is set to PERCent while VLEvel is used when UNIts is VOLts . The distal value is most "distant" from the base. A typical value is 90%.	
		PLEvel	<NR3>		
		VLEvel	<NR3>		
	MESial	UNIts	PERCent		Changes the mesial value used in calculating measurement results. The mesial value is in the "middle". A typical mesial value is 50%.
		PLEvel	<NR3>		
		VLEvel	<NR3>		
	PROXimal	UNIts	PERCent	Changes the proximal value used in calculating measurement results. The proximal value is in closest "proximity" to the base. A typical proximal value is 10%.	
		PLEvel	<NR3>		
		VLEvel	<NR3>		
	DMESial	UNIts	PERCent		Changes the mesial value used in calculating where on the delay waveform to measure to.
		PLEvel	<NR3>		
		VLEvel	<NR3>		

EXAMPLES

Query

MEASUREMENT? MESIAL

MEASUREMENT? DISTAL

Response

MEASUREMENT? MESIAL:UNITS:PERCENT,
MESIAL:PLEVEL:5.00E+1,MESIAL:VLEVEL:1.300

MEASUREMENT? DISTAL:UNITS:PERCENT,
DISTAL:PLEVEL:9.00E+1,DISTAL:VLEVEL:2.400

Sequencer Commands

Header	Argument	Argument	Description
SETUp	SAVe	ONE TWO THRee FOUr FIVE "ascii string"	<p>COMMAND ONLY. The SETUp SAVe command is used to store a front-panel setting into ONE through FIVE or create a sequence of multiple front panels to be stored into "ascii string". The original SAVe command creates the sequence with subsequent SAVe commands appending new steps to the sequence. This is the normal procedure for creating a sequence:</p> <ol style="list-style-type: none"> 1. Send a SETUp ACTION: <NR1 > command. If the "Action" will not change, this step may be omitted. 2. Use normal programming commands or front-panel controls to set the scope up as desired for this particular step. 3. Send a SETUp SAVe: "ascii string" command. This will create the first step in the sequence. 4. Repeat steps 2 and 3 to add more steps to the sequence. Include the ACTION command (step 1) again if you wish to give unique "Actions" to any particular step.

Sequencer Commands (cont)

Header	Argument	Argument	Description
SETUp (cont)	RECall	ONE TWO THRee FOU FIVe "ascii string"	COMMAND ONLY. Use the SETUp RECall command to recall a sequence (named ONE to FIVe, or "ascii string"). Recalling a sequence will automatically load and run that sequence.
	ACTion	<NR1>	<p>The SETUp ACTion command saves a bit-encoded number which tells the scope what "Actions" to associate with a sequence or with any particular step within that sequence.</p> <p>The current Action number is associated with the next step or sequence. Only change the Action number when new Actions are needed.</p> <p>The <NR1> number sent with the ACTion command may be calculated as shown in this example: For the Actions Selfcal, SRQ, Pause, and Bell the ACTion number would be $2 + 64 + 128 + 32 = 226$. At pwr-up, the Action = 0.</p> <p>1 = Repeat current sequence from this step to the end. 2 = Selfcal before loading step. 4 = Selftest before loading step. 8 = Do an Auto Setup. 16 = Print/Plot at end of step. 32 = Bell at end of step. 64 = SRQ at end of step. 128 = Pause at end of step. 256 = Will protect this sequence if included on the first step.</p>

Sequencer Commands (cont)

Header	Argument	Argument	Description
SETUp (cont)	FORCe	[ON] OFF	The SETUp FORCe command overrides the Protect "Action" (See ACTION command). This allows any protected step to be altered from the GPIB. The front-panel Protect is still effective.
	DELEte	"ascii string"	COMMAND ONLY. Removes the named sequence from Sequencer memory. An error SRQ is returned if the named sequence is not present and EXR is ON .
	MEMory		QUERY ONLY. This query returns the number of bytes left in the Sequencer memory. BUSy is returned if the sequencer is being used by the front panel.
	NAMes		QUERY ONLY. This query returns the names of all sequences present in the Sequencer. BUSy is returned if the sequencer is being used by the front panel. NOne is returned if there are no stored sequences. The format is: SETUP NAMES:"name1", NAMES:"name2"
	CLEar		COMMAND ONLY. This command deletes sequences from the sequencer. If FORCe is ON then all sequences will be deleted. If FORCe is OFF then only sequences without a "Protect" Action are deleted.

EXAMPLES

Query	Response
SETUP?	SETUP ACTION:0,FORCE:OFF
SETUP? MEMORY	SETUP MEMORY:12062
SETUP? NAMES	SETUP NAMES:* TEST1* ,NAMES:* TEST2*

Sequencer Commands (cont)

Header	Argument	Description
LLPrGm	"ascii string"	<p>When used as a query, the sequence named "ascii string" will be returned in a low level binary block form. When that binary block is returned to the scope, it will reconstruct the named sequence. If the incoming sequence has the same name as one currently in memory, the incoming sequence is ignored. If no "ascii string" name is sent, all sequences will be returned. If the named sequence is not present, an error SRQ will be returned if EXR is ON.</p> <p>Any 2432A or controller receiving binary block transfers should be set up to not recognize the line feed as the terminator character. See Section 2 for information on the terminator character.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>The LLPRGM binary block form will speed up sequence transfers in a production environment but not recommended for upward compatibility with future firmware releases. The binary images of the scope setup may change with future releases.</i></p>
PRGm?	"ascii string"	<p>QUERY ONLY. Will return a list of high level commands to reconstruct the named sequence. If "ascii string" is not included, all sequences present will be sent. If FORMat is ON, formatting characters will be inserted into the text to make a very readable listing of the sequence (see FORMat command). The complete path (see PATH) will always be printed but the longform state (see LONG) will be observed.</p> <p>If FORMAT is on, any 2432A or controller receiving ascii transfers should be set up to not recognize the line feed as the terminator character. See Section 2 for information on the terminator character.</p>
FORMat	[ON] OFF	<p>If FORMat is ON, formatting characters including (CR,LF, and spaces) will be inserted into the text returned for a PRGm? query. The power-up default is OFF.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>FORMat should be set to OFF if the controller in use terminates on linefeeds.</i></p>

Output Commands

Header	Argument	Argument	Description
DEVIce	TYPE	THinkjet HPGI	Shows which device the scope will format its output for when a PRInt command is received.
	SETTIngs	[ON] OFF	Determines whether instrument settings are printed or not.
	GRAt	[ON] OFF	Determines whether the graticule is printed or not.
	TEXT	[ON] OFF	Determines whether text is printed or not. Text consists of lines 4 through 14 and, if a MENUoff command has been sent, lines 1 through 3.
	WAVfrm	[ON] OFF	Determines whether waveforms are printed or not.
	PAGesize	US A4	Determines whether the pagesize is US (8.5 x 11) or the European A4 size.
PRInt			COMMAND ONLY. Causes the scope to output a string, formatted for a device whose type is set using the DEVIce command. A Device Clear will abort the print or plot. If the busy bit in the status byte is set or an OPC SRQ has not been issued by the scope then printing or plotting is ongoing. The sequence for using the PRInt command is: first send the PRInt command to scope, then listen address the printer or plotter, and finally talk address the scope.

EXAMPLES

Query

Response

DEVIce?

DEVIce TYPE:THINKJET,SETTINGS:ON,GRAT:ON,TEXT:ON,WAVFRM:ON,PAGESIZE:US

DEVIce? TYPE

DEVIce TYPE:HPGL

Miscellaneous Commands

Header	Argument	Description
ID?		<p>QUERY ONLY. Returns the message "ID TEK/2432A, V81.1, <string>". Option(s) present will extend the ID string to show the configuration. Example: "...,<string>,TVTRIG"</p> <p>The <string> will be composed of the firmware release date, the firmware version, and the waveform processor firmware version. Example of <string>: "10-NOV-87 V1.00/1.0"</p>
DEB <u>u</u> g	<p>[ON] OFF</p>	<p>Command controls the debug option. See the description of Debug Mode for further information.</p>
HEL <u>p</u> ?		<p>QUERY ONLY. Will return a list of all valid command headers available to the user.</p>
INIT	<p>PAN<u>e</u>l</p> <p>GPI<u>b</u></p> <p>SR<u>Q</u></p> <p>[BOTH]</p>	<p>COMMAND ONLY. Will cause the scope to go to a factory preset front-panel setup. This command can help in creating new test setups; the scope is initialized to a known setup and the desired changes made to this setup.</p> <p>COMMAND ONLY. Causes all bus unique commands to be initialized to known states as follows: PATH ON; DEB<u>u</u>g OFF; LONG ON; OPC ON; CER ON; EXW ON; EXR ON; PID OFF; LOCK LLO; INR ON; DEVDep ON; USEr OFF; DATa ENCdg:RIBinary; DATa TARget:REF1, DATa SOURce:CH1; FASTxmit OFF; FASTxmit 1; FASTxmit ENCdg:RIBinary; START 256; STOP 512; LEV<u>e</u>l 0; HYSteresis 5; DIR<u>e</u>ction PL<u>S</u>; SET<u>U</u>p FOR<u>C</u>e:OFF SET<u>U</u>p ATTRIB<u>T</u>U<u>T</u>E:0; DT OFF; It also clears the event buffer.</p> <p>COMMAND ONLY. Clears all pending SRQs and event codes. This is normally used to initialize the scope so waiting for an OPC event code is a compare if event is not zero.</p> <p>Does both the PAN<u>e</u>l and GPI<u>b</u> initializations.</p>

EXAMPLES

Query

Response

ID?

ID TEK/2432A,V81.1,* 20-JAN-87 V1.20/1.2*

Miscellaneous Commands (cont)

Header	Argument	Description
LONG	[ON] OFF	Command determines whether a response to a query is given with unabbreviated symbols (ON) or not.
SET?		Returns an ascii string that reflects the current instrument state and can be returned to the scope to recreate that state. The LONG command will increase the size of the SET? response.
LLSet	<binary block>	<binary block> will consist of a low-level "readout" of the instrument state which will be shorter in length than a human readable version. The LLSet command is much faster than the SET? query.
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? DISPLAY would return: "INTENSITY DISPLAY:10.5;". With PATH OFF , just "10.5;" would be returned, allowing the programmer to read just the scope setup part of the response into his program without having to strip off unwanted parts.

EXAMPLES

Query

HELP?

Response

HELP AUTOSETUP,CH1,CH2,VMODE,ATRIGGER, ACQUIRE,DLYTIME,CURSOR,RUN,BTRIGGER, HORIZONTAL,SETWORD,EXTGAIN,REFFROM, REFDISP,BWLIMIT,DLYEVTS,INTENSITY, MEASUREMENT,DEVICE,READOUT,REFPOS, SMOOTH,CER,DATA,DEBUG,DEVDEP,DIRECTION, DT,EXR,EXW,FORMAT,HYSTERESIS,INR,LEVEL, LOCK,LONG,OPC,PATH,PID,RQS,SETUP,START, STOP,USER,SETTV,BELL,BUSY,CURVE, EXECUTE,FASTXMIT,HALT,INIT,INITAT50, LLPRGM,LLSET,LOOP,MANTRIG,MENUOFF

Miscellaneous Commands (cont)

Header	Argument	Description
BELI		COMMAND ONLY. Rings the bell.
REM	"ascii string"	COMMAND ONLY. Does nothing but throw away the "ascii string". Useful introducing comments into user programs.
Time?		QUERY ONLY. Returns the internal clock time in an ascii string. The number returned is the same number shown on screen when the save button is pushed. The format is "hh:mm" where hh is hours and mm is minutes. This clock cannot be reset by a user and any elapsed time numbers must be calculated from a starting time.
DT	OFF	The DT command tells the scope what to do with any Group Execute Trigger bus command it receives over the GPIB. The DT OFF command causes the scope to ignore any Group Execute Trigger command sent to it. DT OFF is the power-up state.
	RUN	Does the same as a RUN ACQUIRE command when a Group Execute Trigger is received.
	SODRUN	Executes the following command set when a Group Execute Trigger is received: " ACQUIRE SAVDel:ON;RUN ACQUIRE ".
	STEp	When a Group Execute Trigger command is received, the Sequencer will go on to the next step if it is currently pausing.
	"ascii string"	When a Group Execute Trigger command is received, the scope will load the named sequence into its Sequencer memory and start the execution of the sequence.

EXAMPLES

Query	Response
TIME?	TIME * 19:54*
DT?	DT SODRUN

Waveform Commands

Default values for the waveform preamble will not be sent or received, but they are needed when using the preamble information to associate waveform scaling with the waveform data in the message. The defaults are:

XZERO=0 YZERO=0 BIT/NR=8 BYT/NR=1 CRVCHK=CHKSM0

Waveforms acquired in Roll Mode do not have a trigger point. The current trigger position will be returned in a **WFMpre PT.Off** query.

Header	Argument	Argument	Description
WAVfrm?			<p>QUERY ONLY. A WAVfrm? query will cause both WFMpre? and CURVe? queries to be generated for the waveform specified by the DATA SOURCE pointer.</p>
CURVe	<wfm data>		<p>The CURVe command or query is used to send or receive just waveform data. The DATA SOURCE pointer shows which data to send when queried, the DATA TARGET pointer shows where to put data on a command, and the DATA ENCDg pointer shows which format to send it in. <wfm data>, as defined by Codes and Formats, can be either ascii or binary format. For more information see Appendix B.</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>The curve data sent is that which would go into a reference memory if the Saveref button was pressed. If SMOoth is ON, the data returned will be "smoothed".</i></p>
DATA	ENCDg	AScii RPBinary RIBinary	<p>Rpbinary is positive integer. Ribinary is two's complement.</p>

Waveform Commands (cont)

Header	Argument	Argument	Description
fDATa (cont)		RIPartial RPPartial	Ripartial is partial format for Ribinary. Rppartial is partial format for Rpbinary. <p style="text-align: center;"><i>NOTE</i></p> <p><i>For information on how to use the different data encoding formats and the ranges the data can assume for each format, see the discussions on Waveform data formats and scaling data points in Appendix B.</i></p>
	TARget	REF1 REF2 REF3 REF4	Targets which reference memory will receive the next waveform sent to the scope.
	SOUrce DSOUrce	<types> <types>	DATa SOUrce specifies the source (CH 1, CH 2, etc.) of the waveform that a CURVe?, WFMpre?, or WAVfrm? or VALue? query will return information on. For VALue? queries, it specifies the source that parameter will be extracted from. (See VALue under "Automatic Feature Commands" in this appendix.) If the source specified is an empty reference memory, an error will be returned when the information is requested if EXR is ON. DATa DSOURCE is only used when a VALue? query is used to extract the DELAY parameter. Then, it specifies the source (CH 1, CH 2, etc.) containing the "DELAY To" target (see VALue command). If secondary source is an empty reference memory, an error will be returned when the information is requested if EXR is ON. <types> available are: CH1, CH2, ADD, MULT, REF1, REF2, REF3, REF4, CH1Del, CH2Del, ADDDel, and MULTDel.

EXAMPLES

Query

DATA? ENCDG

Response

DATA ENCDG:RPPARTIAL

Waveform Commands (cont)

Header	Argument	Argument	Description
WFMpre	WFId	"ascii string"	The WFId field in the WFMpre is left undefined by Codes and Formats so individual instruments can communicate information not included elsewhere in the preamble. In the scope, this section will include labeling information to help the user remember key features about the waveform and will include vertical mode, coupling, Volts/Div, Sec/Div, and what the particular acquisition mode was. The scaling information is the same as the preamble but is given in scope "units." See examples at the end for the form of this argument. This argument will be ignored if sent as a command.
	NR.Pt	1024	During waveform input, the scope will always expect waveforms with 1024 points. (All received waveforms are placed in reference memory.) Waveforms received with less than 1024 points will have the remaining missing points filled with the last data point sent. All waveforms output by the scope will contain 1024 points. This argument will be ignored if sent as a command.
	PT.Fmt	Y	Point format defines how to interpret the curve data. Y format means that x information is implicit and the data points sent are the y values. Each point will be sequential in time (older to younger).
		ENV	Format used for envelope waveforms. The data is sent in the form: y1max,y1min,y2max.... Data sent to the scope with this format will be treated as an envelope waveform.

Waveform Commands (cont)

Header	Argument	Argument	Description
WFMpre (cont)	XUNit	SEC	If the argument is SEC , the XINcr CLKs value has units of seconds. If it is CLKs , the scaling is for EXTCLK .
	XINcr	<NR3>	<NR3> will give the time interval between points (sampling rate). It is calculated by assuming 50 pts/div and dividing that into the sweep rate. It will range from 1.0E-1 (5 Sec/Div) to 4.0E-11 (2 ns/div). <NR3> will be rounded and limited to match a legitimate Sec/Div setting, in which case a warning SRQ will be issued if EXW is ON . For a query response with an unknown Sec/Div (as for External Clock), <NR3> will be set to 1.
	PT.Off	<NR1>	Shows the location of Rtrig within the waveform. <NR1> can vary between 0 and 1023 in increments of 32. A number that does not fit the increments or limits will be rounded and limited to match. If rounding or limiting occurs, a warning SRQ will be issued if EXW is ON . 0 means the trigger point is off the record to the left, and 1023 indicates that it is off the record to the right.
	YUNit	V VV DIV	Gives magnitude in volts when associated with YMULT .

EXAMPLES

Query

WFMpre?

WFMpre? YOFF

Response

WFMpre WfID:* CH1 DC 1V 100ms ENV* ,
 NR.PT:1024,PT.OFF:512,PT.FMT:ENV,
 XUNIT:SEC,XINCR:2.000E-3,YMULT:4.000E-2,
 YOFF:1.425E+1,YUNIT:V,BN.FMT:RI,
 ENCDG:BINARY

WFMpre YOFF:5.450E+1

Waveform Commands (cont)

Header	Argument	Argument	Description
WFMPRE (cont)	YMULT	<NR3>	This value gives the vertical "step" size of the digitizer (volts between points); computed from the Volts/Div setting by assuming 25 points per division vertically.
	ENCDG	ASCII BINARY	Shows the encoding type that will be used on the next CURVE query. BINARY includes any of these modes: rbinary, rbinary, rpartial or rpartial.
	YOFF	<NR3>	YOFF locates the ground in digitizing levels relative to data 00. If the YOFF is positive, then ground is above center screen <NR3> can range from -2500 to 2500 with a resolution of 0.25. Incoming values will be limited to this range, and, should limiting occur, a warning SRQ will be issued if EXW is ON.

EXAMPLES

Query

WFMPRE? YMULT
WFMPRE? ENCDG

Response

WFMPRE YMULT:4.000E-2
WFMPRE ENCDG:ASCII

Waveform Commands (cont)

Header	Argument	Argument	Description
	BN.Fmt	RI RP	<p>BN.Fmt tells the scope how to handle binary curve data coming in. RI says treat it as a two's complement representation with the MSB being interpreted as a sign bit. Digitized values being output will range from 80 (-128) to 0 to 7F (+127). RP indicates positive integers (0 to 255). (These ranges are maximum and assume a vertical window for measurements of 10.24 divisions; some acquisition rates have a smaller vertical window, reducing the range of data available. See "Vertical Window" in index.)</p> <p style="text-align: center;"><i>NOTE</i></p> <p><i>The scope powers-up expecting RI binary data. If RP is to be sent, first send a BN.Fmt command with RP as the argument to change the scope.</i></p>
FASTxmit	<NR1> DELTA	CH1 CH2 BOTH	<p>COMMAND ONLY. Controls the fast transmit mode of the scope. This mode allows the fastest waveform transfer rate for the scope but is not as user friendly as other types of transfers. Please read Appendix I before using this mode. <NR1> selects the number of waveforms to return. The DELTA and NORmal selections determine what waveform to send and the ENCdg selects how to send it. There is a speed penalty for using RPBinary or RPPartial because the native format is RIBinary and the conversion takes time.</p>
	NORmal	CH1 CH2 BOTH	
	OFF		
	ENCdg	RIBinary RPBinary RIPartial RPPartial	

Waveform Data Commands

These commands are used as either measurement queries that fetch waveform data (**MAX**imum, **VMIN**imum, etc.) or to set up or to query the setup of certain elements that determine how or where on the waveform the measurements are taken (**STAR**t, **LEV**el, etc.). The **DATa SOUR**ce variable shows which waveform will be looked at for all waveform data queries.

When calculations are performed on waveforms, points at the positive or negative extremes of the vertical measurement window are considered "out of bounds." In other words, if the vertical window is 256 digitizing levels (10.24 divisions), any points at the -128 and the +127 levels are ambiguous, since they could represent points that are outside the vertical window or "clipped." These points are ignored when responses to measurement queries are calculated and returned; limit values are only returned for measurement queries in order to indicate an out-of- bounds waveform (see **MAX**imum?) or for setup-type queries (see **LEV**el?). Since the size of the vertical window varies with acquisition rate (SEC/DIV setting), the actual digitizing level considered out of bounds also varies. *Table 3-1 in Section 3 gives the window limits (range) in digitizing levels and divisions. Also, see "Vertical Window" in the Index of this guide for more information.*

Header	Argument	Description
STAR t	<NR1>	<NR1> varies between 1 and 1024 and sets the start of the interval for the actual measurement queries. STAR t must be less than STOP ; if not, they will be swapped before they are used. A warning SRQ will be issued if <NR1> is outside the allowable range and EXW is ON .
STOP	<NR1>	<NR1> sets the end of the interval for the waveform measurement queries (see STAR t).
LEV el	<NR1>	<NR1> varies between the negative and positive level limits (inclusive) of the vertical window for the acquisition rate in effect. It sets the vertical level for PCROSS and NCROSS .

EXAMPLES

Query	Response
START?	START 1
STOP?	STOP 1024
LEVEL?	LEVEL 23

Waveform Data Commands (cont)

Header	Argument	Description
MAXimum?		QUERY ONLY. Returns an <NR1> number between the negative and positive level limits (inclusive) of the vertical window for the acquisition rate currently in effect. This number represents the maximum value of the acquired waveform between START and STOP . If all waveform points are at the positive limit level, or if they are all at the negative limit level, that limit level is returned to indicate the direction of the "out of bounds" waveform.
VMAXimum?		QUERY ONLY. Similar to MAXimum? except VMAXimum returns an <NR3> number that represents the maximum voltage of the acquired waveform between START and STOP . Returns 99e99 if all points are "out of bounds" for the acquisition rate in effect or the units are shown as "DIV"
MINimum?		QUERY ONLY. Returns an <NR1> number between the negative and positive level limits (inclusive) of the vertical window for the acquisition rate currently in effect. This number represents the minimum value of the acquired waveform between START and STOP . If all waveform points are at the positive limit level, or if they are all at the negative limit level, that limit level is returned to indicate the direction of the "out of bounds" waveform.
VMInimum?		QUERY ONLY. Similar to MINimum? except VMInimum returns an <NR2> number that represents the minimum voltage of the acquired waveform between START and STOP . Returns 99e99 if all points are "out of bounds" for the acquisition rate in effect or the units are shown as "DIV."
AVG?		QUERY ONLY. Returns an <NR3> number between the negative and positive level limits (inclusive) of the vertical window for the acquisition rate currently in effect. This number represents the average of the points between START and STOP .

EXAMPLES

Query

MAXIMUM?
 VMAXIMUM?
 VMAXIMUM?
 VMINIMUM?
 AVG?

Response

MAXIMUM 65
 VMAXIMUM 4.200E-1
 VMAXIMUM 99e99
 VMINIMUM -2.180
 AVG 3.55370E+1

Waveform Data Commands (cont)

Header	Argument	Description
AVG? (cont)		When waveform points within the requested interval are at or beyond the vertical window boundaries, -128 is returned to indicate the direction of the "out of bounds" waveform.
VAvg?		QUERY ONLY. Similar to AVG? except VAvg? returns a value in the same units shown by the volts cursor display. 99e99 is returned if all points are "out of bounds" or the units are shown as "DIV."
PCross?		QUERY ONLY. Returns an <NR1> number, from 0 to 1024, that represents the first waveform point in the interval of START to STOP whose value is at or above LEVEL when the previous point (left to right) was below LEVEL . If there is no positive crossing point, a value of 0 is returned. Also, see the HYSTERESIS waveform data command.
NCross?		QUERY ONLY. Returns an <NR1> number, from 0 to 1024, that represents the first waveform point in the interval of START to STOP whose value is at or below LEVEL when the previous point (left to right) was above LEVEL . If there is no negative crossing point, a value of 0 is returned.
SNAP		COMMAND ONLY. Sets the START and STOP numbers to correspond to the position numbers for the left and right time cursor respectively. The numbers range from 0-1024. Useful for doing partial waveform transfers (see Appendix B).
PANS		COMMAND ONLY. Positions the time cursors to correspond to the current position numbers for START and STOP . You can then verify on screen whether or not the portion of the waveform you wish to transfer is bracketed by the START and STOP values when doing partial waveform transfers (see Appendix B).

EXAMPLES

Query	Response
VAVG?	VAVG -7.56965E-1
HYSTERESIS?	HYSTERESIS 5
DIRECTION?	DIRECTION PLUS
PCROSS?	PCROSS 0
PCROSS?	PCROSS 302
NCROSS?	NCROSS 360

Waveform Data Commands (cont)

Header	Argument	Description
HYS teresis	<NR1>	<NR1> may range from 0 to number of digitizing levels in the vertical window for the acquisition rate in effect. It specifies the number of digitizing levels (increments) that a curve must go below (or above for NCR oss) the value specified by LEV el before the search is started for the level crossing. <NR1> is set to 5 at power-up. (See "Making Custom Measurements" in Section 3 for more information.)
DIR ection	PLU s MINU s	Shows which direction to proceed with the search for a PCR oss or NCR oss. PLU s will go from STAR t to STO p and MINU s will go from STO p to STAR t. The definitions for positive and negative crossings are unaffected by the direction of the direction of the search.

Service Request Commands

Header	Argument	Description
RQS	[ON] OFF	RQS causes the scope to assert SRQ when it has an event to report. If this feature is turned off, events are still accumulated and can be retrieved with an EVEnt ? query.
OPC	[ON] OFF	Enables SRQ upon the completion of a command. The scope has several commands that use the operation complete feature, including: Single Seq, Save-On-Delta, plot complete, and self-test complete.
CER	[ON] OFF	If ON , this mask will allow the scope to assert an SRQ whenever a command error is detected. Some examples of command errors are syntax errors or invalid characters in the input.
EXR	[ON] OFF	If ON , this mask will allow the scope to assert an SRQ whenever an execution error is detected. Illegal characters sent to set up the word trigger are one example of an execution error.

EXAMPLES

Query	Response
RQS?	RQS ON
USER?	USER OFF
CER?	CER OFF

Service Request Commands (cont)

Header	Argument	Description
EXW	[ON] OFF	If ON , this mask allows scope to assert an SRQ when warning condition is detected. Some examples of warning conditions: parameter rounding or limiting and trying to set B Sec/Div slower than A Sec/Div.
INR	[ON] OFF	If ON , this mask allows scope to assert an SRQ when internal error is detected. Example of an internal error is a self-test failure.
USER	[ON] OFF	Enables/disables an SRQ generated by a menu switch being pushed. Each switch will have a unique event code associated with it, allowing a controller to create special menus and react to user feedback. A MENU off command, to tell the scope that possible custom text has been written, should be sent before bezel button push event codes will be reported.
DEVDep	[ON] OFF	Enables/disables device dependent SRQ such as that generated when a Transmit or Abort button is pushed.
PID	[ON] OFF	Enables/disables an SRQ generated by a probe identify button being pushed.
EVENT?		QUERY ONLY. Returns most recent event held by scope or 0 if none exists. See the Event Code Tables for an interpretation of event numbers.
BUSY?		QUERY ONLY. Returns "ON" if the busy bit in the status byte is set; "OFF" if not. The busy bit will be set when scope is doing something whose completion might cause an OPC SRQ to be issued.
LOCK	ON OFF LLO	Controls front-panel lock state. If ON , front-panel controls are locked out. LLO is the pwr-up default; indicates scope will lock out front panel whenever the universal GPIB command, LLO, is received. OFF unlocks front panel (certain commands will cause scope to lock its panel anyway: Self Cal, Auto Setup, Print/Plot commands, etc.

EXAMPLES

Query	Response
EXW?	EXW ON
INR?	INR OFF
LOCK?	LOCK LLO
LOCK?	LOCK ON
BUSY?	BUSY OFF
EVENT?	EVENT 0
EVENT?	EVENT 467
PID?	PID OFF

Calibration and Diagnostic Commands

Header	Argument	Description
TESTType	SELFCal SELFDiag EXTCAI EXTDiag	Indicates which type of test will run upon receipt of an EXEecute command.
TESTNum	<NR1>	<NR1> indicates the test number within the TESTType (extended calibration or extended diagnostics) that is to be run. If SELFCal or SELFDiag is the TESTType, the TESTNum will be reset to 0000 when an EXEecute command is received.
EXEecute		COMMAND ONLY. Causes the test selected by TESTNum to execute. Any tests in the test hierarchy below the selected number will all be run. An SRQ will be sent upon successful completion of the test sequence if OPC is ON. If a test was unsuccessful, an SRQ will be issued if INR is ON and the ERRor? query may then be used to return the test status. After executing any test, send a MENUoff command to reset the hardware to its original state before sending any "normal" scope commands to the scope.
ERRor?		QUERY ONLY. ERRor? returns a string of error numbers (up to nine) resulting from the last EXEecute command (or 0 if no errors exist). Only those error numbers associated with the same level in the test hierarchy as that of TESTNum are returned. The exact test that failed in a hierarchy is found by moving TESTNum to a lower level, rerunning the test, and reissuing the ERRor? query until the failure is isolated to a test at the lowest level.
STEP		COMMAND ONLY. Causes the current test to advance to the next step and begin execution of the new step. An SRQ will be sent to indicate completion of the step if OPC is ON. STEP will also cause a "paused" sequence to continue to the next step.
LOOP	CONT FAIL PASS ONE	COMMAND ONLY. Causes the next test executed to run in a loop either until a HALt is received or until the argument condition is met.
HALt		COMMAND ONLY. Stops any test being executed; specifically used to stop a looping test. Will also stop any sequence that is currently running.

B

Discussion on Waveforms

Discussion on Waveforms

A waveform transfer is a transmission of a block of waveform data between the 2432A and the controller or between one 2432A and another scope. This data block contains data points which trace the waveform shape. You can tell the 2432A to upload waveforms to the controller (for analysis, printout, etc.), or to download waveforms from the controller (for re-display, comparisons, or Save-On-Delta operations).

We cover several considerations involved in waveform transfers. First, in "Doing a Waveform Transfer" the DIRECTION (2432A-to-controller, controller-to-2432A, and 2432A-to-2432A) is discussed. Second, "Waveform Data Formats" discusses the five types of ENCODING that can be used for waveform data and how data points are REPRESENTED in those formats. Third, "Scaling the Data Points" details how the data words corresponding to data point values are SCALED into voltages.

Doing a Waveform Transfer

In this subsection, we describe transferring waveform data back and forth between a controller and a 2432A. Sending a waveform from one 2432A to another without using a controller is also discussed. During these discussions, we treat the waveforms as strings to be sent back and forth (later subsections describe what the strings mean and how to interpret them).

From the 2432A to a Controller

First, you need to tell the 2432A which waveform you wish to transfer. Use the 'DATA SOURCE' command to specify the source. (See "Waveform Commands" in Appendix A for a description of this command.) As an example, let's say you want the waveform in CH1. First, you send 'DATA SOURCE:CH1' to the 2432A to set the source pointer to CH1. Next, you need to transfer the data. Send a 'CURVe?' query to the 2432A to effect the transfer, and then read the results. You can read more about the 'DATA SOURCE' command and 'CURVe?' query by looking them up in Appendix A.

The following short, sample program, written in 4041 BASIC, performs the waveform transfer just described. In other words, it uploads a CH1 waveform from the 2432A to the controller (the 2432A's address should be set to 1). After the program has run, the controller has the CH1 waveform stored in the string array named "wave\$".

```
10 scope = 1
20 open #scope:"gpib0(pri=1,eom=<0>):"
30 dim wave$ to 6000
40 print #scope:"data source:ch1"
50 print #scope:"curve?"
60 input #scope:wave$
70 stop
80 end
```

From the Controller to the 2432A

Here, the source of the waveform is the controller and we wish to download the waveform it has stored to the 2432A. For this transfer, you need to tell the 2432A where you want the waveform stored. There are four options, REF1 through REF 4, which are the 2432A's four reference memories. Only REF memories can accept incoming waveforms.

Use the DATA TARGET command to select the memory the waveform is to be sent to (this command is explained in "Waveform Commands" of Appendix A). As an example, let's say you wish to store the waveform in the 2432A's reference memory 1. First you send 'DATA TARGET:REF1' to select the target memory, then you transmit the waveform to the 2432A. You can read more about the DATA TARGET command by looking it up "Waveform Commands" in Appendix A; the actual transmission of the waveform is illustrated in the sample program that follows.

Here is a short sample program that does what we just discussed; i. e., it takes the waveform stored in string array "wave\$" and sends it to the 2432A. The program is written in 4041 BASIC. The string array it sends could be generated by another part of the controller program, in which case this sample program is a segment of that program. Alternately, this program could be joined to the previously-shown sample program (the one that illustrated 2432A-to-controller uploads) to return the waveform that the previous sample program retrieved from the 2432A.

```
10 scope = 1
20 open #scope:"gpib0(pri=1,eom=<0>):"
30 print #scope:" data target:ref1"
40 print #scope:wave$
50 stop
60 end
```

There are a few things to consider when sending waveforms to the 2432A. First, if you want to see the waveform on screen, you must display the target reference memory on screen (see the REFDISP command under "SAVEREF Commands" in Appendix A). Keep in mind that waveform transfers to the 2432A are slower if the target reference is displayed. Second, if you are sending waveforms in binary format you must tell the 2432A what kind of binary data it is. (Read "Waveform Data Formats" in this appendix if you don't know what type of binary data you are using.) To prepare the 2432A to handle Signed Integer data, send 'WFMPRE BN.FMT:RI' to the oscilloscope. For Positive Integer data send 'WFMPRE BN.FMT:RP'. (At power-up the 2432A expects to receive binary data in Signed Integer (RI) binary format. See the "Waveform Commands", in Appendix A, for more information on the WFMPRE command.)

From 2432A to 2432A

You can transfer waveforms from one 2432A to another 2432A over the GPIB without a controller. Waveforms can also be sent from the 2432A to other oscilloscopes that understand the waveform encoding formats the 2432A uses. The Tektronix 2430, 2430A, 2432, 2440, and 7D20 can receive 2432A waveforms.

The following steps generally describe how to do a scope-to-scope transfers. To determine specifically how to set up the 2432A's bus and waveform format modes (Step a), read through "Setting the GPIB Mode" at the beginning of Section 2 of this Guide.

To perform a scope-to-scope transfer, do the following steps:

- a. Set the "From" scope's bus mode to talk only (T/ONLY) and waveform format mode to Send Waveform Curve and Waveform Preamble (W/WFMPRE).
- b. Set the "To" scope to listen only.
- c. Display on screen the signal source containing the waveform you want to send. Do *not* display any other signal sources (a signal source is CH1, CH2, ADD, MULT, and REF1-REF4) on screen.
- d. If you want watch the transfer, you must put the target REF memory for the "To" scope on screen. Push the front-panel button OUTPUT, then the menu button STATUS. Note the REF memory listed for TARGET. Push the front-panel button DISPLAY REF and set the noted REF on.
- e. Push TRANSMIT in the OUTPUT menu to send the waveform to the the target memory (and the screen if the REF was displayed from Step d).

WAVEFORM FORMAT. The procedure just detailed covers how you should send waveforms between two scopes. By setting the waveform format to send both the curve and the waveform preamble (Step a), the "To" 2432A determines the waveform encoding (ASCII, RPBINARY, or RIBINARY) the "From" scope is using and uses the same coding. If the preamble isn't sent, the "To" scope isn't set to match the "From" scope's encoding, nor is the Volt/Div and Sec/Div readouts for the target REF updated to match those for the waveform being sent. The result is misleading readouts, plus possible offset waveforms because of different encoding, for the "To" scope. Remember to make sure that you set the waveform format to W/WFMPRE and such problems are avoided.

WAVEFORM SOURCE. You may have noticed that the procedure does not have you select a source for the "From" scope. The 2432A sends all the waveforms displayed on screen (*for transfers without a controller only*) to the target REF memory of the "To" scope. It ignores the setting for SOURCE that appears in the GPIB Status menu. For this reason, you should only display the waveform you want to send on the "From" scope's screen and no others (Step c) since the last waveform sent will be the only one stored in the target REF memory.

WAVEFORM TARGET. The target for the "To" scope was not specified in our procedure either. The target for the 2432A can only be changed by a controller, so you must use the REF memory listed for TARGET in the GPIB Status menu. Use the method outlined in Step d to determine the target (and display it, if desired).

There is another consideration related to the target not being settable for transfers without controllers. If you display more than one waveform on screen (FROM scope) and push TRANSMIT, the waveforms are sent consecutively, each one overwriting the other, and only the last one sent is saved in the target REF memory.

The way to transfer several waveforms is to display each signal source containing a waveform on the screen of the "From", but only one source at a time. Send the displayed waveform, but when the transfer is complete, move the transferred waveform out of the "To" scope's target REF memory into an alternate REF memory. Repeat this process of displaying, sending, and moving the waveforms until each waveform you want to send is stored in a different REF memory. Using this method, you can send up to four transferred waveforms in REF1-REF4 of the "To" scope. See "SAVE" in Section 5 of the Operators Manual for information on moving waveforms between Ref memories.

Waveform Data Formats

Waveform data may be encoded in several different formats. These Waveform Formats define how a waveform is to be represented in a data block. Waveform Formats available on the 2432A include ASCII and four different BINARY formats including RIBINARY, RPBINARY, RIPARTIAL, or RPPARTIAL.

ASCII format uses Signed Integer data-point representation. The 2432A sends whole waveforms only for ASCII format, although the controller can send partial waveforms to the 2432A. RIBINARY sends a whole waveform (1024 data points) in Signed Integer data-point representation; RPBINARY sends a whole waveform in Positive Integer data-point representation. RIPARTIAL sends partial waveforms in Signed Integer data-point representation; RPPARTIAL sends partial waveforms in Positive Integer data-point representation.

You select any one of these waveform encoding formats over the GPIB by using the DATA ENCDG command. For example, to set the 2432A to RPBINARY format, simply send the command 'DATA ENCDG:RPBINARY'.

Data Point Representation

Before we look at the ASCII and binary formats just introduced, we need to understand the different methods for representing the waveform data points or samples. Knowledge of these methods is needed because the different waveform encoding formats use different data representation methods.

The 2432A has an A-D converter that always resolves waveforms to 1/25 of 1 vertical division. This means waveforms are displayed on the instrument screen with a vertical resolution of 25 values (also called digitizing levels) per division. The total number of values available for making waveform measurements is the vertical window size and is different for different ranges of acquisition rate settings. It is always greater than the 8 division available on screen, and varies from a minimum of 242 values (9.68 divisions) to a maximum of 256 values (10.24 divisions). (See "Vertical Window for Making Measurements" in Section 3 of this guide for a discussion of vertical windows.

Each value within the vertical window can be expressed in two different ways: Positive Integer and Signed Integer.

SIGNED INTEGER REPRESENTATION. In this format, the data value at center screen is zero. Any values below center screen are negative and any above it are positive. The range of the values will depend on the size of the vertical window and, therefore, the acquisition rate. As an example, a 10.24 division window will range from -128 to 0 to 127, with -128 being one division below the bottom of the 2432A screen, 0 being at center screen, and 127 being one division above the top of the screen.

POSITIVE INTEGER REPRESENTATION. In positive integer format, the center screen value is considered to be at the 128 data value. As before, the range varies with the vertical window; using the 10.24 division window again as an example, 0 starts one division below the bottom of the 2432A screen, 128 is at center screen, and 255 is one division above the top of the screen. See Table 3-1 in Section 3 for ranges.

ASCII Format Encoding

In ASCII format, each waveform point is composed of up to four ASCII characters that describe a Signed Integer data point value. There is one ASCII character for each digit in the Signed Integer data point value, plus an extra one for the minus sign if the data value is negative (positive Signed Integers do not have a plus (“+”) sign prefixed).

Let’s look at an example. Assume a waveform data point is one division below center screen. Its Signed Integer representation is -25 (remember, 25 digitizing levels per division). In ASCII, that point would be expressed as an ASCII minus sign (“-”), followed by the ASCII number 2, followed by the ASCII number 5 (“-25”). A waveform point one division above center screen would be a positive 25 (remember, center value is zero) Signed Integer and its ASCII representation would be the ASCII number 2, followed by the ASCII number 5 (notice that no ASCII plus sign is prefixed).

The entire waveform transfer is made of binary equivalents of the ASCII characters that comprise the data points and the commas separating those data points (data points are always separated by commas). Each ASCII character requires one byte to represent it. Therefore, since each digit in a signed integer data value requires one ASCII character, and each ASCII character requires one byte, data point binary representation can require up to 4 bytes (three digits, plus a minus sign).

ASCII format is selected by sending a 'DATA ENCDG:ASCII' command to the 2432A.

Let’s look at another example. Consider a DC level consisting of all 1024 data points setting 5 divisions below center screen. All the data point values for the DC level equal -125 . The total number of characters is 5 (for the word “curve” in header) + 1024×4 (three digits plus the minus sign) + 1023 commas, or approximately 5100 bytes.

ASCII WAVEFORM TRANSFER EXAMPLE. Table B-1 shows how traffic over the GPIB might look during an ASCII waveform transfer. In this example, the first data point value is 35 (bytes 7 and 8) and the second is 54 (bytes 10 and 11). Each value is separated by a comma. These two points are followed by an additional 1021 points. These points are not shown but are located between the two consecutive commas following byte 11. The last point is 41 and it's followed by the selected message terminator.

Since the 1021 data values between the commas could be any allowed value (this is a hypothetical waveform), the number of bytes needed to express them is not known. Therefore, the byte numbers are given as "XXXX" (unknown). Also, the "CURVE" part of the header will be absent if PATH is OFF (see PATH command in Appendix A).

**Table B-1
ASCII Waveform Transfer**

Byte	ASCII	Decimal	EOI (1=asserted)
1	C	67	0
2	U	85	0
3	R	82	0
4	V	86	0
5	E	69	0
6	<SP>	32	0
7	3	51	0
8	5	53	0
9	,	44	0
10	5	53	0
11	4	52	0
12	,	44	0
XXXX	,	44	0
XXXX	4	52	0
XXXX	1	49	1 (Only if term=EOI)
XXXX	<CR>	13	0 (If term=LF/EOI)
XXXX	<LF>	10	1 (If term=LF/EOI)

Binary Formats

There are four binary formats for sending waveforms. RIBINARY and RPBINARY are used to send an entire 1024 point waveform. RIBINARY uses the previously described Signed Integer method for representing the data points; RPBINARY uses Positive Integer representation. RIPARTIAL and RPPARTIAL are used to send partial waveforms with RIPARTIAL using Signed Integer representation and RPPARTIAL using Positive Integer representation. In all 2432A Binary Formats, each waveform point is represented by one 8-bit data byte.

Here, since we have already explained the difference between Signed Integer (RI) and Positive Integer (RP) representation, let's discuss entire and partial waveform transfers.

ENTIRE WAVEFORM BINARY FORMATS. RIBINARY and RPBINARY data encoding send the entire 1024 point waveform. The format for the curve data is as follows:

`%xxd...dc`

Where:

- `%` is the starting character for this block.
- `xx` is the byte count. It gives the the total number of all data bytes plus the checksum byte. The byte count is a 2-byte field. Waveforms sent from the 2432A always have the first byte set to 04 hexadecimal and the second byte set to 01 hexadecimal. The whole field is a 16-bit binary number (0401h, 1025 decimal) which indicates that there will be 1024 waveform points followed by the one byte of the checksum.
- `d...d` are 8-bit waveform data bytes. Waveforms sent from the 2432A contain 1024 data bytes.
- `c` is the 8-bit checksum. To get the checksum, both bytes of the byte count, plus all the data bytes, are summed. Then the two's complement is take of the least significant 8 bits of the sum to yield the checksum. Here is a sample algorithm for calculating the checksum.

```
checksum = ls_byte_count
checksum = checksum + ms_byte_count
for i = 1 to end_of_wfm
begin
    checksum = (checksum + wfm_data(i) ) mod 256
    i = i+1
end
checksum = 256 - checksum
```

EXAMPLE OF ENTIRE WAVEFORM BINARY FORMAT. This example uses the same hypothetical waveform used in the ASCII format example above. The checksum bytes are unknown so they are XX'ed out. The byte count for this format will always be 1025 (401h). The "CURVE" part of the header will not be present if PATH is OFF.

**Table B-2
Binary Waveform Transfer**

Byte	ASCII	Decimal	Hex	EOI (1=asserted)
1	C	67	43	0
2	U	85	55	0
3	R	82	52	0
4	V	86	56	0
5	E	69	45	0
6	<SP>	32	20	0
7	%	37	25	0
8	<Bin Count MSB>	4	04	0
9	<Bin Count LSB>	1	01	0
10	5	53	35	0
11	T	84	54	0
...				
... more waveform data				
...				
1033	A	65	41	0
1034	<Checksum>	XX	XX	1 (Only if term=EOI)
1035	<CR>	13	0D	0 (If term=LF/EOI)
1036	<LF>	10	0A	1 (If term=LF/EOI)

PARTIAL WAVEFORM BINARY FORMATS. RIPARTIAL and RPPARTIAL waveform formats send only part of a waveform. These two encoding modes can be used by the controller to receive partial waveforms from, or send partial waveforms to, a 2432A. Partial waveforms cannot be sent in non-controller directed transfers (i.e. 2432A-to-2432A transfers).

The portion of the acquisition sent is determined by the data point numbers for the 'START' and 'STOP' commands. For example, if 'START' is set to 256 and 'STOP' is set to 512 (power-up values), a Partial Binary Format waveform would include the 257 (512-256+1) points starting at point 256 and ending with point 512. The points in a waveform are labeled from 1 to 1024, starting with the earliest point (point 1). See "Waveform Data Commands" in Appendix A for more information on the 'START' and 'STOP' commands.

You may return a partial waveform in Binary Format to the 2432A. Partial waveform transfers only update part of the reference waveform currently in the 2432A. To force which bracket of data points out of the 1024 available are sent, you can use the 'START' and 'STOP' commands to set the beginning and ending data points for the data string (beginning/ending correspond to earliest/latest).

NOTE

You can't specify 'START' and 'STOP' for partial transfer if you use ASCII waveform encoding. ASCII transfers will transfer the partial waveform and then complete the 1024 point waveform record by replicating the last data point sent until the record is full.

Let's look at an example of a partial waveform and introduce an alternate method for setting the start and stop points for the transfer. Assume a waveform is on the 2432A screen in CH1. Turn the time cursors ON and move the time cursors so that they bracket the area you would like to send. Then send the 'SNAP' command to the 2432A. The 'START' data point number is now equal to that for the point the left cursor is positioned to; the 'STOP' data point number is now equal to that for the one positioned at the right cursor.

Once the 'START' and 'STOP' values are set (here, using 'SNAP' you could have — used the 'START' and 'STOP' commands), you can request a partial waveform from CH1. You should use 'DAT ENC' to set 'RPPartial' or waveform to the controller. When you send this CH1 partial waveform back, the segment of the waveform stored in the target REF memory that corresponds to the 'START' and 'STOP' values will be replaced by the partial waveform. When the target REF is displayed, the segment between 'START' and 'STOP' will look just like the corresponding segment of CH1.

The format for the partial curve data is:

#cx...xd...d

Where:

- # is the starting character for this block.
- c is the number of bytes in the byte-count number. This is an ASCII digit from 1 to 9.
- x...x is the byte count. These are ASCII digits from 0 to 9 with the number of digits specified in the c field. This byte count tells how many bytes are in the d...d field.

Using the example above, the '#cx...x' part of the partial format would look like: #3260.

- d...d is the waveform data field. This field has several sub-fields which look like: 'C:ssy...y'.

Where:

- C is one byte used to indicate the type of binary encoding used. This value is 02h for Positive Integer and 01h for Signed Integer.
- ss is two bytes that indicate where in the 1024 acquisition to start putting the data bytes. In the above example where 'START = 256', this field would be 0100h.
- y...y is the actual waveform data bytes.

EXAMPLE OF A PARTIAL WAVEFORM IN BINARY FORMAT. This example shows what a hypothetical partial waveform would look like. It is set up with 'START = 256' and 'STOP = 512'. The CURVE part of the header will not be present if PATH is OFF.

**Table B-3
Partial Binary Waveform Transfer**

Byte	ASCII	Decimal	Hex	EOI (1=asserted)
1	C	67	43	0
2	U	85	55	0
3	R	82	52	0
4	V	86	56	0
5	E	69	45	0
6	<SP>	32	20	0
7	#	35	23	0
8	3	51	33	0
9	2	50	32	0
10	6	54	36	0
11	0	48	30	0
12	STX	2	02	0
13	SOH	1	01	0
14	NUL	0	00	0
15	5	53	35	0
16	T	84	54	0
...				
... more waveform data				
...				
271	A	65	41	1 (Only if term=EOI)
272	<CR>	13	0D	0 (If term=LF/EOI)
273	<LF>	10	0A	1 (If term=LF/EOI)

Scaling the Data Points

So far, we have treated waveforms as data strings transferred between controllers and 2432A's. All the data values have been 8-bit numbers that correspond to digital levels (abbreviated DL's) in the 2432A's digitizing system. Now we will discuss how these digital levels/data values are converted into voltages.

The waveform preamble contains various information fields. These fields are descriptive information about the waveform the preamble is associated with. This information details characteristics about the how the waveform was acquired, such as where the trigger is located in the record, what the waveform encoding is, what the voltage increment is between consecutive digitizing levels, where ground (0 volts) level is relative to the zero data value level, etc. It is this information that lets the 2432A accurately display waveforms sent to it and allows controller programs to process waveform data it uploads. We use part of this information to scale 2432A waveforms.

The Waveform Preamble and the data values (curve) can be fetched from the 2432A using the 'WAVE?' query (recall that 'CURVE?' only returns the data values). Also, the 'WFMPRE?' query can be used to retrieve all, or just certain, fields of the waveform preamble only, and all or part of the preamble can be shipped to the 2432A to scale (and otherwise set up the scope) to display the waveform. The information and data returned by 'WAVE?' and 'WFMPRE?' queries applies to the currently selected DATA SOURCE; information sent to a 2432A applies to the currently selected DATA TARGET.

For more information about the waveform preamble and the information found in its fields, read the descriptions for the arguments belonging to the 'WFMPRE' query under "Waveform Commands" of Appendix A. Also, see 'WAVfrm?' and 'CURVe?' under the same subheading.

Sample Conversion to Volts

One of the most frequent uses for Waveform Preamble information is to convert the waveform data point values from either Signed Integer or Positive Integer values into voltage values. To correctly convert the waveform, you need to know the voltage between each digitizing level in the vertical window (vertical scaling), where ground is positioned to in the window, and whether the waveform encoding uses Signed Integer or Positive Integer representation.

We get the vertical scale from the YMULT field of the preamble. As mentioned, it is the voltage between two consecutive 2432A digitizing levels. At, say 2 Volts/Div, YMULT would equal 2 Volts/Div divided by 25 DL's/Div or .04 Volts/DL.

The YOFF field in the preamble tells how far ground (for the waveform) is positionally offset from center screen. If, say, ground level was offset 1 division below center screen, YOFF would equal -25 , since there are 25 DL's per division. YOFF is always relative to center screen, regardless of Signed or Positive Representation for the waveform data values.

The range of YOFF is from -2500 to $+2500$ DL's with a resolution of 0.25 of a DL. This large range is needed because the 2432A can vertically position waveforms from 10 divisions above, to 10 divisions below, center screen, yielding ± 250 DL's of positioning (± 10 division \times 25 DL's/Div). Also, the 2432A can vertically expand averaged waveforms up to 10 times, providing ± 250 DL's \times 10 or ± 2500 DL's of positioning range. The 2432A positions waveforms vertically with a resolution of 10 bits, instead of the 8-bit resolution for data values. The extra 2 bits provides 4 times the resolution that the digitizer does.

NOTE

Don't think that you can position a waveform outside the vertical window and read a valid data point value for the out-of-window data points. Data points positioned outside the vertical window will be clamped to the minimum (below the window) or maximum (above the window) data value available, based on the encoding method used, Signed Integer or Binary, and the vertical window available at the acquisition rate in effect. (See Table 3-1 for the limit values for both encoding methods.)

The BN.FMT field tells whether Signed Integer or Positive Integer representation is used for the data values. The field will be RI for those waveform encoding formats using Signed Integer (ASCII, RIBINARY, and RPARTIAL) and RP for those using Positive Integer (RPBINARY and RPPARTIAL).

A simple calculation is used to first remove the position offset (YOFF) from the data point value and then apply the vertical scaling multiplier (YMULT). Since Signed Integer representation considers the zero data value (ground) to be at center screen, the YOFF value (remember YOFF is the positional offset of waveform ground from center screen) is subtracted directly from the data point value to remove the offset. Here is the formula to convert a single data point value to a voltage for waveforms using Signed Integer data representation:

$$\text{Voltage} = (\text{point value} - \text{YOFF}) \times \text{YMULT}$$

Waveforms using Positive Integer representation consider center screen to be the data value 128. In other words, this method of data representation considers the center screen data value to be 128 digitizing levels above its zero digitization level at the bottom of the window. Therefore, we calculate the voltage by first subtracting 128 from the data point value (effectively, converting the Positive Integer to a Signed Integer), then subtracting YOFF. The result is multiplied by YMULT. Here is the formula for Positive Integer representation (it's the same calculation as for Signed Integer, except for subtracting 128):

$$\text{Voltage} = (\text{point value} - 128 - \text{YOFF}) \times \text{YMULT}$$

Let's use these formulas on a hypothetical waveform point 1 division below center screen, and scale it using this sample Waveform Preamble:

```
WFMPRE WFID: "CH1 DC 1V 10US NORMAL", NR.PTS:1024,  
PT.OFF:512, PT.FMT:Y, XUNIT:SEC, XINCR:2.000E-7,  
YMULT:4.000E-2, YOFF:2.800E+1, YUNIT:V, BN.FMT:RI,  
ENCDG:BINARY
```

The BN.FMT field tells us we are dealing with Signed Integer data (RI); so the waveform point value is -25 (25 waveform points per division). The YOFF field shows the position offset to be 28 DL's below center screen. The YMULT field shows us that the voltage multiplier is $4.00E-2$ volts per DL (1 Volt/Div divided by 25 Div/DL, in this case). Inserting the correct values into the first formula gives us:

$$\text{Voltage} = (-25 - 28) \times 4.000E-2 = -2.12 \text{ Volts}$$

This result corresponds with a waveform point that would be displayed 1 division below center screen (-25 DL's at 25 DL's/Div = -1 division) with no position offset, BUT with the ground reference being positionally offset slightly more than one division above center screen (28 points at 25 DL's/Div = 1.12 divisions). The actual position of the point would be 0.12 divisions above center screen.

Waveform Acquisition and Conversion Programming Example

Here is a sample program, written in 4041 BASIC, that acquires a waveform and converts the values to voltages. The program reads RIBINARY data (Signed Integer representation). The two program segments below the main program can be substituted in to the program. The first segment modifies the main program to read and do voltage conversions on RPBINARY-encoded waveforms (Positive Integer); the second on ASCII-encoded waveforms (Signed Integer).

```
10 scope = 1
20 open #scope:"gpib(pri=1,eom=<0>):"
30 integer i
40 integer wfm(1024)
50 dim voltage(1024)
60 !=====
70 ! Set up the 2432A for a waveform transfer.
80 ! Turn path off so all we get are the waveform
85 ! points. The data will be encoded in the RIBINARY
90 ! format. Then send a curve query to the 2432A.
100 !=====
110 print #scope:"path off;data encdg:ribinary,source:ch1"
120 print #scope:"curve?"
130 !=====
140 ! Now get the data values with the 'input'
145 ! statement. The 'using "8%"' part can interpret
150 ! the Entire Binary Waveform Format automatically.
160 ! Every controller will have a different way of
170 ! doing this. The idea is to get the waveform points
180 ! into a numerical array.
190 !=====
200 input using "8%" #scope:wfm
210 !=====
```

```

220 ! Now input the YOFF and YMULT scaling values.
230 ! Since path is still off, we can input these
240 ! values directly, without having to parse out
245 ! the "header".
250 !=====
260 print #scope:"wfmpre? yoff"
270 input #scope:yoff
280 print #scope:"wfmpre? ymult"
290 input #scope:ymult
300 !=====
310 ! Now convert the data points to voltage values
320 ! using the formula we were given.
330 !=====
340 for i = 1 to 1024
350 voltage(i) = (wfm(i) - yoff) × ymult
360 next i

```

The following code segment (lines 200-205) replaces line 200 in our sample program and modifies the program to read Positive Integer data. You must also change "ribinary" to "rpbinary" on line 110 and replace the equation on line 350 with the one for Positive Integers, i.e., $\text{voltage}(i) = (\text{wfm}(i) - 127 - \text{yoff}) \times \text{ymult}$.

When the sample program is modified as just described, it uses a dim statement (line 200) to create a numeric string array (created by 'using "8%"', in the Sign Integer version) and reads the waveform data into the string (called "wfm\$"). The 8-bit bytes corresponding to sample points 1-1024 (1 byte per sample point) are sequentially stripped from the record using the "seg" function. (The "seg" function extracts the substring whose location starts at the first number given (i+1) and is of a length given by the second number (1). This action causes the "temp\$" variable to become equal to the third byte for data point i=1, equal to the fourth for data point i=2, etc. (Remember, the first two bytes of RIBINARY waveforms are the byte count, not data points.) As each byte is stripped, it is converted to its ASCII decimal equivalent (decimal conversion was done by the "using %8" construct in the original program) using the "asc" function (for example, "asc(01100010)" would yield 98 decimal).

```

200 dim wfm$ to 1100
201 input #scope:wfm$
202 for i = 1 to 1024
203 temp$ = seg$(wfm$,i+3,1)
204 wfm(i) = asc(temp$)
205 next i

```

This next code segment modifies the sample program to handle ASCII-encoded waveform data instead of RIBINARY when it replaces line 200 in the ORIGINAL program. You also must replace "ribinary" with "ASCII" on line 100.

As was true for the code segment that converted RPBINARY, this code segment also treats the waveform as string and stores it in wfm\$. This time, however, since we are dealing with ASCII, the ASCII binary equivalent of a data point value can require from 1 to 4 bytes, depending on the sign and magnitude of the data value (see ASCII Format Encoding, this subsection). To strip a complete data point from the string each time through the loop, the "valc" function is used.

The "valc" function begins at the byte location in the string specified by startloc (initialized to byte 1 in line 202) and looks for a byte that belongs to a number, skipping over non-number bytes until it finds it. Once "valc" finds the first byte for a number, it reads it (into "temp\$", in this case) and continues to find and read in successive bytes until it encounters one that does not belong to a number. Since ASCII-encoded waveforms are separated by commas, "valc" stops reading in when it finds the comma. The result is a complete decimal version of one data point stored in "temp\$" (valc converts the ASCII number to its decimal equivalent).

After each ASCII data point value is stripped and converted, "startloc" is made equal to the value returned by the "ask("chpos")" function. This function returns the byte location of the character last found by the "valc" function. With startloc set to this byte location, "valc" will begin reading where it last left off, skip over the comma, and read the next data point value into temp\$. Since bytes representing commas separate those representing data point values, it would be fairly easy to implement both the "valc" and "ask("chpos")" functions in other controller languages.

```
200 dim wfm$ to 6000
201 input #scope:wfm$
202 startloc = 1
203 for i = 1 to 1024
205 wfm(i) = valc(wfm$,startloc)
206 startloc = ask("chpos")
207 next i
```

C

Event Tables

Event Tables

2432A Status Bytes

Title	Binary ^a	Decimal				Priority	
		RQS Off		RQS On		RQS Off	RQS On
		Idle	Busy	Idle	Busy		
No Status To Report	000X 0000	0	16	0	16	2	1
Power On	010X 0001	1	17	65	81	2	9
Operation Complete	0R0X 0010	2	18	66	82	2	3
User Request	0R0X 0011	3	19	67	83	2	8
Command Error	0R1X 0001	33	49	97	113	2	7
Execution Error	0R1X 0010	34	50	98	114	2	6
Internal Error	0R1X 0011	35	51	99	115	2	5
Execution Warning	0R1X 0101	37	53	101	117	2	4
Transmit Request	1R0X 0011	131	147	195	211	2	8
Transmit Aborted	1R0X 0100	132	148	196	212	2	8
Menuoff Pushed	1R0X 0101	133	149	197	213	2	8
Fatal Error	1R1X 0011	---	---	227	243	--	10

Device Dependent Bit

RQS Bit

Error Bit

Busy Bit

^a "R" is set to 1 if the GPIB and RQS are on; otherwise, it is 0.

"X" is the Busy Bit and will be set if the 2432A is busy at the time the status byte is read. Anytime the 2432A is doing something for which the OPC SRQ can be sent (calibration or self test, single sequence, Save-On-Delta, or plotting) the bit will be sent true (1); otherwise, it will be a 0.

Command Error Events**NOTE**

Command Errors are issued when a GPIB "grammatical" error has been made. Check the spelling and structure of the input strings. Set CER to ON to receive SRQ's when any of these events occurs. If CER is OFF, the 2432A will not assert SRQ.

Code	Description
108	Checksum error in CURVE transfers.
109	Count = 0 or EOI set on byte count.
151	Symbol or number too long.
152	Invalid character or control character input.
153	EOI set on back slash.
154	Invalid number input.
155	EOI set on string character before ending quote.
156	Symbol not found.
157	Command or query argument is illegal in this syntax.
158	Character should be a colon.
159	Valid symbol, but not a legal header.
160	Character should be a comma, a semicolon, or EOI.
161	Too many query arguments.
162	Command only. May not be sent as a query.
163	Query only. May not be sent as a command.
164	EOI asserted before waveform was completed.
165	Incorrect word string input.
166	Number expected on incoming ascii waveform.
167	Comma expected on incoming ascii waveform.
168	Incoming ascii waveform has more than 1024 data points.
169	Illegal LLSET string.

Execution Error Events

NOTE

Execution errors are issued when a particular scope setting doesn't allow the current command to be executed the way the user would like. Set EXR to ON to receive SRQ's when any of these events occurs. If EXR is OFF, the 2432A will not assert SRQ.

Code	Description
203	I/O buffers full, output dumped.
250	Selected recall memory is unset.
251	Measurement requested on an empty reference memory.
252	Waveform requested via GPIB is not valid or available.
253	Too many numbers were sent in (stack overflow).
254	No Video Option installed when SETTV commands issued.
255	Target selected for cursors is not displayed.
256	Clear overload condition before changing to 50 Ω coupling.
257	Waveform selected for reference source is not valid.
259	No ADD or MULT on previously SAVED waveforms; ENVELOPE waveform invalid.
260	No cal commands allowed while front panel is doing cal.
261	No sequence by that name to delete.
262	Can't save sequence—out of memory.
263	Can't send a partial waveform to an empty ref.
264	Not enough edges to extract the parameter.
265	Asked for rise time but no rising edge.
266	Asked for fall time but no falling edge.
267	Delay Measurement targets must have matching Sec/Div settings.
268	One or more of the following conditions are not satisfied: BASE \neq PROXIMAL \neq MESIAL \neq DISTAL \neq TOP, BASE \neq MESIAL2 \neq TOP, PROXIMAL $>$ MIN and DISTAL $<$ MAX, MIN $<$ MESIAL2 $<$ MAX
269	Repet waveform not filled when measurement requested.
270	No measurements during live Roll—enter Save mode first.
271	Measurement requested on a Delta Delay target but B Horizontal and Delta Delay modes are not on.
272	RMS measurement invalid due to 2432A internal overflow.
275	Sequencer currently active—new sequence commands not accepted.

Internal Errors

NOTE

Internal Errors are issued when something has happened to the hardware of the 2432A that the controller might like to know about. Set INR to ON to receive SRQ's when any of these events occurs. If INR is OFF, the 2432A will not assert SRQ.

Code	Description
330	Cal execute command returns with FAIL.
331	A 50-Ω overload occurred. Input coupling switched to DC.

System Messages

NOTE

System Messages are issued to inform the controller of bus system management events. There is no way to mask these events except by setting RQS to OFF. The event 459 indicates that the 2432A is currently asserting SRQ on the bus and the controller must read the status byte out before reading the event code.

Code	Description
401	2432A was just powered on.
459	There is an SRQ pending.

User Request Events

NOTE

User Request events are issued when any of the bezel buttons on the 2432A front panel are pushed. The MENUOFF command needs to be issued before these events will be reported. This command allows the user to monitor front panel responses (as well as to clear the menu for writing custom text to the screen when desired). Set USER to ON to receive SRQ's when any of these events occurs. If USER is OFF, the 2432A will not assert SRQ.

Code	Description
450	Menu key #1 was pushed (leftmost) .
451	Menu key #2 was pushed.
452	Menu key #3 was pushed.
453	Menu key #4 was pushed.
454	Menu key #5 was pushed (rightmost).

Probe Identify Events

NOTE

Probe Identify events are reported by the 2432A when the probe identify feature found on certain probes is actuated. (You can replicate this action by grounding the outer code ring to the inner shell on the front panel input BNC.) Set PID to ON to receive SRQ's when any of these events occurs. If PID is OFF, the 2432A will not assert SRQ.

Code	Description
455	CH1 probe identify was used.
456	CH2 probe identify was used.
457	EXT1 probe identify was used.
458	EXT2 probe identify was used.

Operation Complete Events*NOTE*

Operation Complete events are issued when the controller needs to know when the 2432A has completed a task. Set OPC to ON to receive SRQ's when any of these events occurs. If OPC is OFF, the 2432A will not assert SRQ.

Code	Description
461	Single Sequence has completed.
462	Save-On-Delta has detected a difference and gone to Save.
463	A print or plot is complete.
464	Current cal command started with an EXECUTE is done.
465	Step command is done.
466	Complete sequence is done.
467	Autoset search is complete.

Execution Warning*NOTE*

Execution Warnings are issued when the command received has been done, but the result might not be what the user expected to see. Set EXW to ON to receive SRQ's when any of these events occurs. If EXW is OFF, the 2432A will not assert SRQ.

Code	Description
539	100 MHz bandwidth limit not available in 2432A. Bandwidth limit set to 50 MHz.
540	RMS measurements need at least 1 period.
541	Amplitude too small to do an accurate timing measurement.
542	Measurement crossing points on Envelope may be misplaced. Turn on Marks to see where measurement was taken.
543	Too few points acquired to guarantee Histogram accuracy for this measurement.
544	Waveform has points off the top of vertical window.
545	Waveform has points off the bottom of vertical window.
546	Waveform has points off the top and bottom of vertical window.
547	Rising/Falling edge has too few points for optimal accuracy.
548	Min/Max method should not be used for Overshoot/Undershoot measurements.
549	Not enough samples taken to do accurate Time, Freq, Period, Pulse Width, or Delay measurement. Set Sec/Div faster if possible.
550	Only Delay 1 will be displayed if in Average.

Execution Warning (cont)

Code	Description
551	Word Recognizer Probe is disconnected.
552	A and B Sec/Div are locked together.
553	More than 1024 binary points were sent; excess discarded.
554	No absolute cursors in slope.
555	A trigger coupling and logsrc changed.
556	A trigger source change forced logsrc to off.
557	No Average in Roll. Acquire mode or A Trigger mode changed.
558	No live vertical expansion unless averaging. Gain changed.
560	Volts/Div value requested was rounded or limited.
561	Variable Volts/Div value requested was limited.
562	Vertical Position value requested was limited.
563	A or B trigger level was limited.
564	Trigger Holdoff value requested was limited.
565	Horizontal Position value requested was limited.
566	A or B Sec/Div setting requested was rounded.
567	Delay by Events events number was limited.
568	Delay by Time Delay value was limited.
569	Number of Envelopes requested was rounded.
570	Number of Averages requested was rounded.
572	Cursor reference value requested was rounded.
573	Horizontal position value (XPOS) for cursors was limited.
574	Vertical position value (YPOS) for cursors was limited.
575	Intensity value requested was limited.
576	Line number of screen text message was limited.
578	The XINCR value was rounded or limited.
579	The PTOFF value was rounded or limited.
580	The YMULT value was rounded or limited.
581	Video Option line number requested was limited.
582	Trigger position number requested was limited.
583	An ascii data point was rounded to fit into 127 to -128.
584	Waveform data level value requested was limited.
585	Start or Stop number was changed.
586	The YOFF value was limited.
587	Extexp value requested was limited.
588	Hysteresis number requested was rounded.
589	Attribute number requested was rounded.

Device Dependent Message

NOTE

Device Dependent messages are issued when the front panel user of the 2432A has done something that the controller might want to know about. Set DEVDEP to ON to receive SRQ's when any of these events occurs. If DEVDEP is OFF, the 2432A will not assert SRQ.

Code	Description
650	Waveform was requested from front panel.
651	Waveform transmission was aborted from front panel.
652	MENUOFF command was executed or front panel button pushed.

Fatal Error

NOTE

A Fatal Error is issued when something completely unexpected happens inside the 2432A. This normally is caused by a hardware failure. There is no way to prevent this error from being reported except by turning RQS to OFF.

Code	Description
750	Fatal error.

D

GPIB Concepts

GPIB Concepts

The IEEE 488 standard defines three aspects of an instrument's interface:

- Mechanical** The connector and the cable.
- Electrical** The electrical levels for logic signals and how the signals are sent and received.
- Functional** The tasks that an instrument's interface can perform, such as sending data, receiving data, triggering the instrument, etc.

Using this interface standard, instruments can be designed to have a basic level of compatibility with other instruments that meet the standard.

Mechanical

IEEE 488 specifies a standard connector and cable for linking instruments to ensure that GPIB instruments are pin-compatible. The GPIB connector (Figure D-1) has 24 pins, with 16 assigned to specific signals and 8 to shields and grounds.

Allowable Configurations

Instruments can be connected to the GPIB in linear or star configurations, or in a combination of both. A linear hookup is one where the GPIB cable is strung from one instrument to the next. A star setup is where one end of all the GPIB cables in the system are attached to one instrument.

Restrictions

Instruments connected to a single bus cannot be separated by more than two meters for each instrument on the bus. In addition, the total cable length of the bus cannot exceed 20 meters.

To maintain proper electrical characteristics on the bus, a device load must be connected for every two meters of cable length, and at least two-thirds of the instruments connected to the bus must be powered on. (For more information, see IEEE Standard 488-1978). Although instruments are usually spaced no more than two meters apart, they can be separated further if the required number of device loads are grouped at any point on the bus.

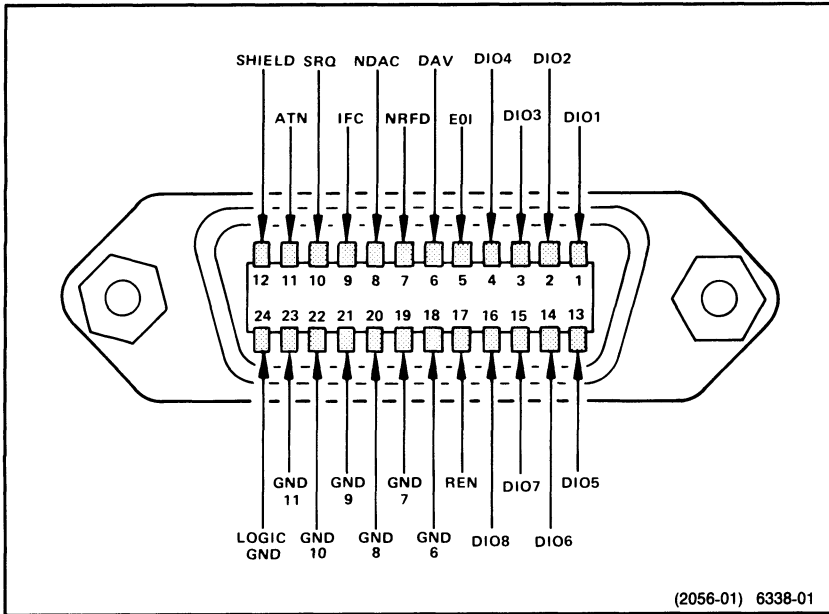


Figure D-1. GPIB connector.

Electrical Elements

The IEEE 488-1978 standard defines the voltages and current values required at connector nodes. All specifications are based on the use of TTL technology. A "0" logic state corresponds to voltages ≥ 2.0 volts and ≤ 5.2 volts (HI state). A "1" logic state corresponds to voltages ≥ 0 volts and ≤ 0.8 volts (LO state).

Messages can be sent either as active-true/passive-false or active-false/passive-true. Active levels must override passive levels wherever any conflict arises (i.e., you can't have active-true and active-false for the same message on the same line). Passive signal levels, whether true or false, correspond to the HI state, and must be carried on a signal line that uses open collector devices.

Functional Elements

Interface functions facilitate sending, processing, and receiving messages for those instruments in which those functions are implemented. The following paragraphs describes the ten different interface functions defined by the IEEE 488. Those not implemented in the 2432A are indicated. The abbreviations for these functions, which are in parenthesis, are taken from the IEEE 488 standard and are commonly used when describing the functions.

Acceptor Handshake (AH)

The AH function works with the SH function to guarantee the listening instrument properly receives data sent by the talking instrument. The AH function delays initiation or termination of a data transfer until the instrument is ready to receive the next data byte.

Source Handshake (SH)

The SH function works with the AH function to guarantee the listening instrument properly receives data sent by the talking instrument. The SH function controls the initiation and termination of the transfer of data bytes.

Listener (L) and Listener Extended (LE)

The L and LE functions allow an instrument to receive device-dependent data over the interface. This capability exists only when the instrument is addressed to listen. The L function uses a 1-byte address; the LE function uses a 2-byte address. In all other aspects, the capabilities of both functions are the same. The 2432A implements only the 1-byte address.

Talker (T) and Talker Extended (TE)

The T and TE functions allow an instrument to send device-dependent data over the interface. This capability exists only when the instrument is addressed to talk. The T function uses a 1-byte address; the TE function uses a 2-byte address. In all other respects, the capabilities of both functions are the same. The 2432A implements only the 1-byte address.

Device Clear (DC)

The DC function allows an instrument to be cleared or initialized, either individually or as part of a group of instruments.

Device Trigger (DT)

The DT function allows an instrument to have its basic operation started, either individually or as part of a group of instruments.

Remote/Local (RL)

The RL function allows the system controller to select between either the front-panel switches (*local*) of an instrument or its GPIB interface (*remote*) as information source. Invoking the function tells the instrument the instrument which source the controller wants used.

Service Request (SR)

The SR function allows an instrument to request service from the controller in charge of the interface.

Parallel Poll (PP)

The PP function allows an instrument to send a status message to the controller without being addressed to talk.

Controller (C)

The C function allows an instrument to send device addresses, universal commands, and addressed commands to other instruments over the interface. It also provides the capability to determine which instruments require service. (In other words, for an instrument in which the function is implemented, the controller presently controlling the system can invoke the C function to relinquish control to that instrument). The C function is NOT implemented in the 2432A.

Instrument Addresses

Every instrument on the bus has one or more addresses. The types of addresses an instrument can have are: primary addresses, listen addresses, talk addresses, and secondary addresses.

Primary Address

Every instrument connected to the bus has a unique primary address. You can set the primary address of most instruments. No two instruments on the GPIB can have the same primary address. Valid primary addresses range from 0 to 30.

Listen Address

Every instrument that can receive device-dependent messages over the bus has a unique listen address. An instrument's listen address is determined by adding 32 to its primary address; therefore, an instrument with primary address 19 has a listen address of $19 + 32 = 51$.

When the ATN line is asserted and an instrument senses its listen address on the bus, that instrument prepares to receive data sent over the bus. Then when ATN is unasserted, the instrument receives data. Any number of instruments on the bus may be addressed to listen at the same time.

Talk Address

Every instrument that can send data over the bus has a unique talk address. An instrument's talk address is determined by adding 64 to its primary address. Thus, an instrument with primary address 19 has a talk address of $19 + 64 = 83$.

When an instrument senses its talk address on the bus and ATN is asserted, the instrument prepares to send data over the bus. Then when ATN is unasserted, the instrument sends data. Only one instrument on the bus may be addressed to talk at a time. When an instrument addressed to talk senses another instrument's talk address on the data lines at the time ATN is asserted, the first instrument automatically untalks itself.

Secondary Address

Some instruments support a special addressing scheme called secondary addressing. Secondary addresses range from 96 to 126. Not all IEEE 488 compatible instruments support secondary addressing. The 2432A does not implement secondary addressing.

GPIB Buses

The 16 GPIB signal lines can be divided into three buses (Figure D-2): the data bus, the management bus, and the handshake bus. The data bus is composed of eight signal lines that carry data to be transferred on the GPIB. The management bus is composed of five signal lines that control data transfers. The handshake bus is composed of three signal lines that synchronize data transfers between instruments.

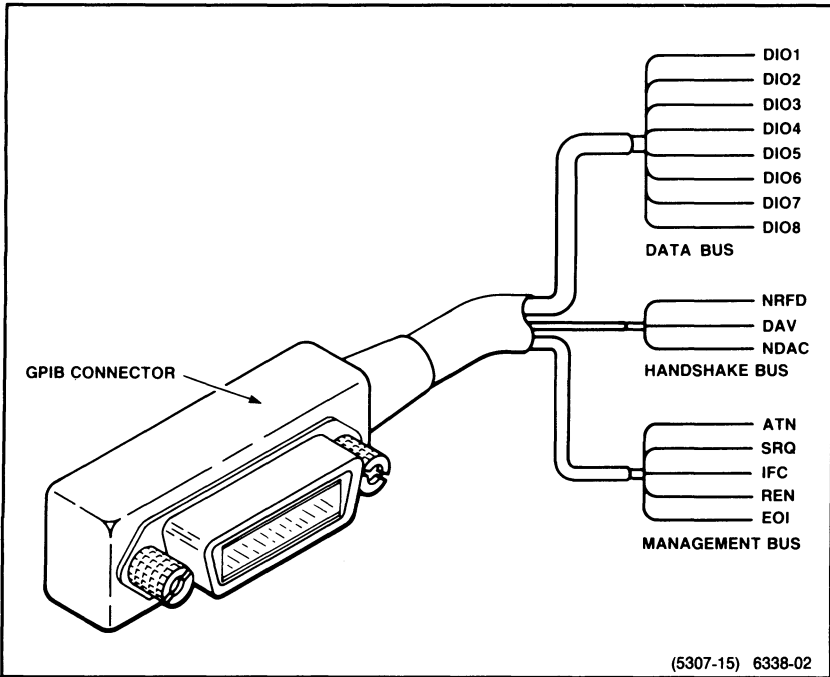


Figure D-2. GPIB Buses.

Data Bus

The data bus contains eight bidirectional signal lines, named DIO1 through DIO8. One byte of information is transferred over the bus at a time. DIO1 carries the least significant bit of the byte and DIO8 carries the most significant bit. Each byte of information transferred on the data bus represents either a command, a device address, or a device-dependent message. Data bytes can be formatted in ASCII or in a device-dependent binary code.

Management Bus

The management bus is a group of five signal lines (ATN, EOI, IFC, REN, and SRQ) used in managing data transfers on the data bus. The definitions for these lines are listed in the following paragraphs.

ATTENTION (ATN). The ATN management line is activated by the controller to send universal commands and addressed commands, and to designate instruments as talkers and listeners for an upcoming data transfer. When ATN is asserted, messages sent on the data bus are interpreted as commands or addresses. When ATN is unasserted, messages sent on the data bus are interpreted as device-dependent messages. Only instruments that have been addressed by the controller to talk or listen can take part in a device-dependent data transfer.

END OR IDENTIFY (EOI). The EOI signal line can be used by any talker to indicate the end of a data transfer sequence. Talkers that use EOI activate the EOI line simultaneously with the last byte of information as it is transferred.

INTERFACE CLEAR (IFC). When the IFC line is asserted by the controller, three things happen. First, all talk-addressed and listen-addressed instruments on the bus are unaddressed. Second, the controller issuing the IFC assumes controller-in-charge status. Last, all instruments are taken out of serial poll mode (same as sending SPD, described in "Addressed Commands" later in this subsection). Only the system controller can activate the IFC line.

REMOTE ENABLE (REN). The REN signal line is activated by the system controller to give all instruments on the bus the capability of being placed under remote (program) control. When the REN signal line is activated, instruments that receive their listen addresses on the data bus accept and execute commands from the controller-in-charge. When REN is deactivated, all instruments on the bus revert to front-panel control.

SERVICE REQUEST (SRQ). The SRQ line can be activated by any instrument on the bus to request service from the controller. The controller responds (if programmed to do so) by serial polling all instruments on the bus in order to find the instrument requesting service. The SRQ line is deactivated when the instrument requesting service is polled. The 2432A asserts SRQ whenever there is a change in its status to report to the controller. SRQ's are only asserted if the corresponding SRQ mask is enabled.

Handshake Bus

Three lines (NRFD, DAV, and NDAC) comprise the handshake bus. These three lines control the sequence of operations each time a byte is transferred on the data bus. This sequence is not under user control, but information about the three transfer lines is presented here for completeness.

NOT READY FOR DATA (NRFD). An active NRFD line indicates that one or more of the listeners is not ready to receive the next data byte. When the NRFD line goes inactive (indicating all listeners are ready to receive data), the talker places the next data byte on the data bus and activates the DAV signal line. The 2432A uses the NRFD line to hold off new data when its input buffer is full. As characters are removed from the buffer, the 2432A will again be ready to accept new data.

DATA VALID (DAV). The DAV line is activated by the talker shortly after it places a valid data byte on the data bus. This tells each listener to capture the data byte currently on the bus.

NOT DATA ACCEPTED (NDAC). The NDAC line is held active by each listener until the listener captures the data byte on the data bus. When all listeners have captured the data byte, NDAC goes inactive. This tells the talker to take the byte off the data bus.

GPIB Communication Protocol

Each instrument on the bus at any given time may be either a controller, a talker, or a listener, as long as these functions are implemented in the instrument. Some instruments have two or even three of these capabilities. For example, some instruments are talk-only, others are listen-only, others can talk and listen, others can talk, listen, and control.

Controllers

Controllers are instruments that assign talk and listen status to other instruments on the bus. Since only one instrument can talk at a time, and since it is seldom desirable for every instrument to listen, a controller is needed to designate which instrument is to talk and which instruments are to listen during any data transfer. There are two kinds of controllers on the GPIB: the system controller and the controller-in-charge.

A GPIB network can have at most one instrument acting as the system controller and one instrument acting as the controller-in-charge. The system controller and the controller-in-charge may be, and often are, the same instrument.

A GPIB configuration may include any number of instruments capable of acting as the system controller or controller-in-charge, subject only to the limitations on the total number of instruments allowed on the bus.

Once a GPIB network has been set up, system control cannot be passed from instrument to instrument, but controller-in-charge status can. Once an instrument is the system controller, no other instrument on the bus can assume that role unless you reconfigure the GPIB network.

Only the system controller can affect the status of the Interface Clear (IFC) and Remote Enable (REN) management lines. Asserting the IFC line makes the system controller the controller-in-charge and untalks, unlistens, and disables serial polling for all instruments.

Asserting REN enables the remote operation of instruments by the controller. Asserting REN does not automatically put all instruments on the bus into the remote state, but simply allows the controller to put them into this state. The LLO Universal Command must be issued to get the 2432A to go to the remote with local lockout state and lock the front panel.

Any instrument acting as controller-in-charge may pass control to any other instrument on the bus capable of assuming control.

Talkers

A talker is an instrument that has sensed its talk address on the data lines with ATN asserted. When a talker is addressed to talk, it sends data via the data lines when ATN is unasserted.

Only one instrument on the bus may be addressed to talk at a time. When an instrument addressed to talk recognizes another instrument's talk address on the data lines with ATN asserted, the first instrument automatically untalks itself. (When an instrument is untalked, it does not place data on the data lines when ATN is unasserted.)

An instrument may also untalk itself when it recognizes its listen address on the data lines with ATN asserted. In this case, the instrument becomes a listener when ATN is unasserted.

Listeners

A listener is an instrument that has sensed its listen address being sent on the data lines with ATN asserted. After an instrument is addressed to listen, it accepts information on the data lines when ATN is unasserted.

Any number of instruments on the bus may be addressed to listen at the same time. When an instrument previously addressed to listen senses its talk address being sent on the data lines with ATN asserted, the instrument may unlisten itself and become a talker when ATN is unasserted.

Universal Commands

Universal commands are commands that are obeyed by all instruments on the bus that have the appropriate subsets of the IEEE 488 interface functions implemented. The controller sends universal commands by placing certain values on the data lines with ATN asserted. The universal commands include: Device Clear (DCL), Local Lockout (LLO), Serial Poll Disable (SPD), and Serial Poll Enable (SPE).

Also included in this description on universal commands are Unlisten (UNL), and Untalk (UNT). Although not commands in the strict sense, the values of UNL and UNT act like universal commands when sent on the data lines with ATN asserted.

Device Clear (DCL)

The DCL command clears (initializes) all instruments on the bus that have a DC1 or DC2 subset of the DC interface function. The DCL message reinitializes communication between the 2432A and the controller. To send the DCL command, the controller places the value 20 on the data lines with ATN asserted.

The 2432A responds to DCL by clearing any input and output messages as well as any unexecuted control settings. Any errors and events waiting to be reported, except power-on, are also cleared. If the SRQ line is asserted for any reason other than power-on, it becomes unasserted when DCL is received. Fastxmit mode cannot be aborted with DCL.

Local Lockout (LLO)

The LLO command locks out the front panels of all instruments on the bus that have an RL1 subset of the RL interface function. (Devices with RL0 or RL2 subsets of the RL interface function ignore LLO.) After receiving the LLO command and its listen address, an instrument ignores any subsequent inputs from front panel control switches with corresponding remote controls, and only obeys commands coming over the GPIB interface. To send the LLO command, the controller places the value 17 on the data lines with ATN asserted.

To lock out the 2432A front panel, LLO must be sent with REN asserted. To keep the 2432A front panel locked out, REN must remain asserted. To unlock the 2432A front panel, unassert REN.

Serial Poll Disable (SPD)

The SPD command returns all instruments on the bus from the serial poll enabled state. To send the SPD command, the controller places the value 25 on the data lines with ATN asserted.

Serial Poll Enable (SPE)

The SPE command puts all instruments that are on the bus with an SR1 subset of the SR interface function into the serial poll enabled state. In this state, each instrument sends the controller its status byte, instead of the its normal output, after the instrument receives its talk address on the data lines with ATN asserted. To send the SPE command, the controller places the value 24 on the data lines with ATN asserted.

Unlisten (UNL)

The UNL command takes all listen-addressed instruments on the bus out of the listen-addressed state. To send the UNL command, the controller places the value 63 on the data lines with ATN asserted.

Untalk (UNT)

The UNT command takes any talk-addressed instrument on the bus out of the talk-addressed state. To send the UNT command, the controller places the value 95 on the data lines with ATN asserted.

Addressed Commands

Addressed commands are commands that are sent to specific instruments on the bus. The controller sends addressed commands by placing certain values on the data lines with ATN asserted. Addressed commands include Group Execute Trigger (GET), Go to Local (GTL), Parallel Poll Configure (PPC), Selected Device Clear (SDC), and Take Control (TCT). All of the addressed commands, except TCT, require that the instrument receiving the command be listen-addressed. The TCT command requires that the instrument be talk-addressed.

Group Execute Trigger (GET)

The GET command causes all listen-addressed instruments incorporating a DT1 subset of the DT interface function to begin operation (for example, for measurement instruments to make their measurements, output devices to output their signals, and so on). To send the GET command, the controller places the value 8 on the data lines with ATN asserted. The 2432A implements GET. See the DT command in appendix A for more information on what the 2432A does upon a receipt of GET.

Go To Local (GTL)

The GTL command causes all listen-addressed instruments to obey incoming commands from their front-panel control switches. These instruments may store, but not respond to, commands coming through the GPIB interface until the instrument is once again listen-addressed. To send the GTL command, the controller places the value 1 on the data lines with ATN asserted.

To use GTL with the 2432A, the 2432A must first be returned to the local state by unasserting the REN line. Sending the GTL command, without unasserting REN, will not unlock the 2432A front panel.

Selected Device Clear (SDC)

The SDC command clears or initializes all listen-addressed instruments. To send the SDC command, the controller sends a value of 4 on the data lines with ATN asserted.

Take Control (TCT)

The TCT command passes controller-in-charge status to a talk-addressed instrument. To send the TCT command, the controller places the value 9 on the data lines with ATN asserted. The 2432A cannot become a controller; therefore, it does not understand TCT.

Serial Polling

Serial polling is a means of serially reading the individual status messages of all instruments configured and enabled to respond to a serial poll.

Status Bytes

Each instrument on the GPIB that incorporates the SR1 subset of the SR interface function has an eight-bit status byte. The status byte's contents describe (by means of a device-dependent code) the instrument's status. The 2432A incorporates the SR1 subset of the SR interface function.

Requesting Service

The coding of an instrument's status byte is almost entirely up to the instrument's designer. There is, however, one restriction. Bit 7 (the second-most significant bit) is reserved to indicate whether or not an instrument is requesting service from the controller-in-charge.

Bit 7 of the status byte is known as the RQS or requesting service bit. A value of 1 indicates that an instrument is requesting service from the controller-in-charge. A value of 0 indicates that the instrument is not requesting service. To request service, an instrument must set the RQS bit of the status byte to 1 and then assert SRQ.

Conducting Serial Polls

The controller can be programmed to respond to instruments asserting SRQ's by doing a serial poll. If so programmed, it generates an interrupt and serially polls each instrument on the bus to determine which instrument is requesting service. The controller can be programmed to conduct a serial poll any time; it does not have to receive a request for service from an instrument on the bus.

The controller conducts the poll by sending the SPE (serial poll enable) command, followed by a sequence of listen addresses. As each listen address is received, the instrument that is listen-addressed sends its status byte to the controller. The controller can then check the status byte to see if the RQS bit is set. Receiving the status byte from the instrument requesting service clears the RQS bit of that instrument (sets the bit back to 0).

When the instrument asserting SRQ is discovered, the controller usually terminates the serial poll (by sending the SPD command), and transfers control to a user-defined SRQ handler routine for the instrument requesting service. Reading the instrument's status byte clears the instrument's RQS bit. However, the factors that caused the instrument to request service in the first place must be handled, or the instrument may simply request service again and again.

E

INIT Settings and Power Up States

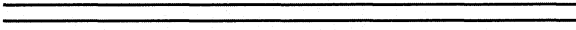
Init Settings and Power Up States

The INIT command of the 2432A is used to return the oscilloscope to a known operating state. Initializing the 2432A provides a basic setup from which to begin programming the 2432A. See the INIT command description in “Miscellaneous Commands” of Appendix A for more information.

The INIT command has several arguments which determine what type of initialization is performed. The PANEL argument causes a normal initialization of the 2432A. For a full definition of the normal reset status, refer to the Operators Manual. The GPIB argument causes an initialization of command parameters unique to the GPIB. For a list of these GPIB parameters and their reset status, refer to the “INIT Command” in Appendix A.

When the 2432A first powers up, several instrument states are initialized. These are listed below in the form of commands that a controller would use to select the same settings.

```
DEBUG OFF; USER OFF; PID OFF; OPC ON; CER ON;  
EXW ON; EXR ON; INR ON; DEVDEP ON; LOCK LLO;  
LONG ON; PATH ON; FASTXMIT OFF,1,ENCDG:RIBINARY;  
WFMPRE BN.FMT:RI; SETUP FORCE:ON,ACTION:0;  
DT OFF; START 256; STOP 512; HYSTERESIS 5;  
DIRECTION PLUS; FORMAT OFF; LEVEL 0
```



F

ASCII and Character Charts



ASCII and 2432A Character Charts

This section contains two charts. The first chart shows the character set the 2432A displays. The second chart shows ASCII symbols and their GPIB equivalents.

For the 2432A character chart, each larger character that's shown in the center of each box is a character that can be displayed on the 2432A CRT. The smaller characters and numbers in the corners are the octal value (in the top left), the hex value (in the bottom left), the decimal value (in the bottom right), and the GPIB equivalent code (in the top right). The ASCII code chart is the same as the 2432A character chart, except the large center characters are ASCII characters rather than 2432A characters.

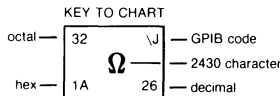
The GPIB-equivalent code designates what character string is sent by the 2432A (or should be sent by the controller) to designate the 2432A display character. Notice that many of the 2432A characters in the 2432A character chart have no equivalent ASCII characters in the ASCII chart. Any character which does not have a corresponding standard ASCII character cannot be displayed on conventional terminals. These "non-conventional" 2432A characters are, however, given a GPIB-equivalent code so they can be sent to and read from the 2432A. Any character in the 2432A chart that *does* have a corresponding ASCII character in the ASCII chart does not have a GPIB-equivalent code given, but it can be obtained from the ASCII chart.

Let's look at an example of using sending a message consisting of all ASCII characters and one that contains 2432A-unique characters. Assume you want to send the string "HELLO" to line 10 on the 2432A. Send the command 'MESSAGE 10:"HELLO"', using the ASCII characters. Now assume you want to send the same message only have "HELLO" underlined (these underlined characters have no ASCII equivalents). Send the command 'MESSAGE 10:"\h\ e\ l\ l\ o"' to the 2432A. Note the \h, \e, etc. are GPIB equivalents of 2432A-unique characters. Remember to use the GPIB-equivalent code if it appears in the 2432A characters chart.

ASCII and 2432A Character Charts

BITS		SPECIAL		NUMBERS SYMBOLS				UPPER CASE				UNDERLINED					
B7	B6 B5	SPECIAL		NUMBERS SYMBOLS				UPPER CASE				UNDERLINED					
B4	B3 B2 B1	SPECIAL		NUMBERS SYMBOLS				UPPER CASE				UNDERLINED					
0	0000	0	10	20	0	40	60	100	120	140	160	0	20	40	60		
0	0000	0	10	10	16	20	32	30	48	40	64	50	80	60	96	70	112
1	0001	1	11	21	1	41	2	61	1	101	A	121	Q	141	A	161	Q
1	0011	1	11	17	21	33	31	49	41	65	51	81	61	97	71	113	
2	0010	2	12	22	2	42	"	62	2	102	B	122	R	142	B	162	R
2	0010	2	12	18	22	34	32	50	42	66	52	82	62	98	72	114	
3	0011	3	13	23	3	43	d	63	3	103	C	123	S	143	C	163	S
3	0011	3	13	19	23	35	33	51	43	67	53	83	63	99	73	115	
4	0100	4	14	24	4	44	(blank)	64	4	104	D	124	T	144	D	164	T
4	0100	4	14	20	24	36	34	52	44	68	54	84	64	100	74	116	
5	0101	5	15	25	5	45	%	65	5	105	E	125	U	145	E	165	U
5	0101	5	15	21	25	37	35	53	45	69	55	85	65	101	75	117	
6	0110	6	16	26	6	46	z	66	6	106	F	126	V	146	F	166	V
6	0110	6	16	22	26	38	36	54	46	70	56	86	66	102	76	118	
7	0111	7	17	27	7	47	'	67	7	107	G	127	W	147	G	167	W
7	0111	7	17	23	27	39	37	55	47	71	57	87	67	103	77	119	
10	1000	8	18	30	8	50	Δ	70	8	110	H	130	X	150	H	170	X
8	1000	8	18	24	28	40	38	56	48	72	58	88	68	104	78	120	
11	1001	9	19	31	9	51	÷	71	9	111	I	131	Y	151	I	171	Y
9	1001	9	19	25	29	41	39	57	49	73	59	89	69	105	79	121	
12	1010	A	1A	32	A	52	*	72	:	112	J	132	Z	152	J	172	Z
A	1010	A	1A	26	2A	42	3A	58	4A	74	5A	90	6A	106	7A	122	
13	1011	B	1B	33	B	53	+	73	;	113	K	133	┘	153	K	173	┘
B	1011	B	1B	27	2B	43	3B	59	4B	75	5B	91	6B	107	7B	123	
14	1100	C	1C	34	C	54	,	74	<	114	L	134	\	154	L	174	
C	1100	C	1C	28	2C	44	3C	60	4C	76	5C	92	6C	108	7C	124	
15	1101	D	1D	35	D	55	-	75	=	115	M	135	┘	155	M	175	┘
D	1101	D	1D	29	2D	45	3D	61	4D	77	5D	93	6D	109	7D	125	
16	1110	E	1E	36	E	56	.	76	>	116	N	136	↑	156	N	176	~
E	1110	E	1E	30	2E	46	3E	62	4E	78	5E	94	6E	110	7E	126	
17	1111	F	1F	37	F	57	/	77	?	117	O	137	↓	157	O	177	␣
F	1111	F	1F	31	2F	47	3F	63	4F	79	5F	95	6F	111	7F	127	

* \DEL = \RUBOUT



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ASCII & GPIB CODE CHART

B7 B6 B5 BITS		0 0 1		1 0 1		1 0 0		1 1 0		1 1 1	
B4 B3 B2 B1		CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE			
0	0	NUL	DLE	SP	0	@	P	'	,	160	p
1	0	SOH	DC1	!	1	A	Q	a	70	112	q
2	0	STX	DC2	"	2	B	R	b	82	98	r
3	0	ETX	DC3	#	3	C	S	c	94	110	s
4	0	EOT	DC4	\$	4	D	T	d	106	122	t
5	0	ENQ	NAK	%	5	E	U	e	118	134	u
6	0	ACK	SYN	&	6	F	V	f	130	146	v
7	0	BEL	ETB	'	7	G	W	g	158	174	w
8	0	BS	CAN	(8	H	X	h	160	176	x
9	0	HT	EM)	9	I	Y	i	172	188	y
10	0	LF	SUB	*	:	J	Z	j	184	200	z
11	0	VT	ESC	+	;	K	[k	196	212	{
12	0	FF	FS	,	<	L	\	l	208	224	
13	0	CR	GS	-	=	M]	m	210	226	}
14	0	SO	RS	.	>	N	^	n	222	238	~
15	0	SI	US	/	?	O	_	o	234	250	DEL (RUBOUT)
		ADRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS			

KEY

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

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REF: ANSI STD X3. 4-1977
IEEE STD 488-1978
ISO STD 646-1973

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G

Answers to Common Questions

Answers to Common Questions

Who Can I Call for Help?

Ask your local Tektronix Application Engineer or Sales Engineer for help. If you don't know who they are, you can call this toll free number for the location and phone number of the nearest field office. The number is (800) 547-1512, or, if you are calling from Oregon, the number is (800) 452-1877.

How Do I Unlock the Front Panel?

If the response to a 'LOCK?' query is 'LLO', you need to strobe the remote enable line (REN) from HI to LO. Alternately, you can send the command LOCK OFF to the 2432A. Powering the 2432A off, then back on, also unlocks the front panel. Be aware that the 2432A can lock its front panel while doing some special operations. See the subsection on "What Do The GPIB Status LED's Mean".

What Does a 255 (FFh) in My Data Stream Mean?

It means the 2432A was talked with nothing to say. The most common cause is sending a query that is mis-typed and then asking for a response from the 2432A. Because the 2432A didn't understand the query, it can't send an answer. But instead of hanging the bus, it sends the FFh. See Appendix H for more information.

How Do I Get Just the Answer From a 2432A Query?

Issue the command 'PATH OFF' to the 2432A. With PATH set to ON, the response to the 'CH1? POSITION' query might be 'CH1 POSITION:1'. With PATH set to OFF the response would be '1'. See "Asking the 2432A a Question" for more information.

How Do I Clear All SRQ's and Event Codes?

By sending the command 'INIT SRQ' to the 2432A. This is usually done before waiting for the 2432A to complete a task. See "How to Use Service Requests" for more information. From the front panel, changing the GPIB address of the 2432A also clears all SRQ's and event codes.

Can I Run Self-Cal From a Controller?

Yes. Send the following command 'TESTTYPE SELFCAL;EXECUTE' to the 2432A. See the "Calibration and Diagnostics Commands" table in Appendix A for more information.

How Can I Get the Most Recent GPIB-Related Status?

Use the GPIB status screen. Display it by pushing the OUTPUT front-panel button followed by the STATUS menu button.

How Do I Get All the Measurements at Once?

Send the 'VALUE?' query to the 2432A. If no arguments follow the header, all measurement results will be returned. The VALUE? query, with no argument, is the GPIB's equivalent of the Snapshot. (If you just wanted the risetime, send the 'VALUE? RISE' query to the 2432A.) Note that if path mode is off and you request all the measurements, the 2432A returns the all the results but not the measurement types. Make sure path mode is on ('PATH ON'), so you get the measurement types also.

How Do I Clear the Screen?

To clear all 16 lines of text send the 'MESSAGE CLRSTATE' command to the 2432A. Use the 'MENUOFF' command to clear just the bottom 3 lines of readout.

How Do I Clear One Line of Text?

Send the command 'MESSAGE line#:" "' to the 2432A. The 'line#' field in this command indicates the number for the line you want to clear. Remember, the lines are numbered from 1 to 16 with line number 1 at the BOTTOM of the display.

How Do I Write Text to the Screen?

Send the command 'MESSAGE line#:" message"' to the 2432A. The line number of the line you want to clear is 'line#' and 'message' is the actual text you want to appear on the screen.

How Do I Write My Own Menus and Handle Them?

First send the 'MENUOFF;USER ON' command to the 2432A. This lets the scope know that there are custom text lines on the display and enables the issuing of User Request SRQ's when a menu button is pushed. Then write your text to the screen using the MESSAGE command. Whenever you push a menu button, the 2432A will send an SRQ. The corresponding event code will indicate which menu button was pushed. See "How to Use Service Requests" for more information. There is also a sample program in Appendix J that uses some menu text.

Why Do I Keep Getting Event 459, SRQ Pending?

You have SRQ's turned on (RQS ON), but are not handling them by serially polling the instrument. See "How to Use Service Requests" for more information.

How Do I Send a Sequence From One 2432A to Another?

Set the "From" oscilloscope to Talk Only mode with the SEND PRGM selection. Then set the "To" oscilloscope to Listen Only mode. Select the sequence to send by underlining it in the RECALL menu, found by pushing the PRGM button. Then push the OUTPUT front-panel button, followed by the SENDPRGM menu button to send the sequence. See "Establishing Communications" for more information on how to set up these modes.

How Do I Print Out a Status, Help, or Snapshot Screen?

You need to initiate the print or plot using a controller. See "Making Printer and Plotter Copies" for more information.

Why Does the Acquisition Restart When I Send Certain Commands?

Acquisitions restart because the 2432A needs to clean up when certain modes change. The interactions between various modes are numerous, and often the only solution is to restart the acquisition between each mode change. Any commands changing the Volts/Div, Sec/Div, and/or trigger system settings restart the acquisition. The 'MENUOFF' command also causes a restart because that command is used to exit from calibration and diagnostics operations and all of the hardware registers in the 2432A are reset to a "normal" state before leaving.

Why Doesn't the Waveform I Sent to the 2432A Look Like the One I Took Out?

You probably took the waveform out with different waveform encoding than the 2432A was expecting when you sent it back. This mismatch can happen when the format for encoding binary data is changed in the 2432A between transfers. See the subsections of Appendix B that deal with waveform data transfers and encoding for more information.

Why are the Abbreviations of Symbols on the 2432A Not the Same as Other Tektronix Oscilloscopes?

The sets of commands each instrument executes can differ from other instruments. The abbreviations for a command set are chosen to keep each command unique within its own command set, and the number of letters needed to keep a command unique varies with the command set. For instance in the 2432A, 'DLYEvts' and 'DLYTime' require the first four letters (DLYE and DLYT, respectively) be used as the abbreviations to differentiate between the two command headers. If an instrument had only one type of delay, "DLY" or even "DL" might be long enough to make the command header unique from others in its command set. The point is that differing command sets may have different abbreviations. To alleviate some of this problem, use full command and argument names instead of abbreviations.

Why Would I Use the INIT Command?

When setting up a test sequence, it is often much faster to set the 2432A to a known state and then change a few parameters than it is to find out what state the instrument is in and then change to a new one. The INIT command is used to set the 2432A to the known state. See the Operators Manual for a description of that state.

Do Sequences Go Away When I Turn Power Off?

No. They are stored in non-volatile memory.

Can I Access a Step in the Middle of a Sequence?

No. You must execute all steps preceding the step you want. You can only access by sequence name, not step number.

Why Do I Only Get Part of the Response to a SET? Query?

The 2432A always sends the entire response back to your controller. Since the SET? query response is very long (approximately 2500 bytes), your controller's message timeout value may be set too short. Short timeout values can also cause a problem when using DEBUG mode in either SLOW or PAUSE. The controller timeouts and stops listening, but all you see is an incomplete string.

How Can I Tell When a Command Has Been Executed?

You can insert a dummy query at the end of the command. Since the 2432A processes the message in the order it's received, it responds to the dummy query immediately after it has completed the command. After sending the command, put some type of "input" statement in your program so it waits for the 2432A to respond to the query. When you get that response, you know the command is done. (This method is suggested by the IEEE in the new release of GPIB standards.)

Let's consider an example of this method. If you send the command string 'CH1 VOLTS:5;CURSOR TPOS:ONE:50;EVENT?' to the 2432A, you know that the 2432A has executed the commands when the response to the 'EVENT?' query is returned. You also know the command string executed correctly if the event number returned is 0.

H

**Instrument
Specific Information**

2432A Specific Information

Talked With Nothing to Say

The 2432A always says something when it is made a talker. If it has nothing to say, it sends a byte of all "1's" (ASCII RUBOUT) with the EOI signal. This byte tells the listening device that no data is coming and prevents tying up the GPIB while one device waits for the 2432A to talk.

This ASCII rubout character is also sent if the 2432A is sent an incorrect query (mistyped, etc.) and then talk addressed to read the response. Since the 2432A didn't understand the query, it cannot respond with data when talked.

You may also receive the ASCII rubout character if the 2432A has been sent a query that returns a string of variable length. Very long strings (such as those that might be returned for SET? and CURVE? queries) may not be handled well by your controller. If the controller handles long strings by breaking them down into a series of smaller substrings as they come in, it still might have to finish filling some of these substrings even after the 2432A has sent all of the data in the original string. In this case, the 2432A will send the ASCII rubout character for the remaining strings.

Accepting Numbers

The 2432A always sends numbers in the number format specified in the command tables for that particular command. However, it will accept any number format the controller sends. If the 2432A receives a number whose precision is greater than the instrument can handle internally, the number will be rounded to enhance accuracy.

Accepting Characters

The 2432A accepts both uppercase and lower case alpha characters. If you type commands in lowercase letters, the 2432A converts them to uppercase before evaluating them ("a" becomes "A", "b" becomes "B", etc.). If you use DEBUG mode to see the characters being sent to the 2432A, the uppercase letters are shown since the 2432A converts any lowercase letters to uppercase as they come in.

The only exception to the lowercase-to-uppercase conversion rule is when you use the 'MESSAGE' command to create your own on-screen messages or menus. An uppercase or lowercase letter that is immediately preceded by a backslash is a GPIB-code equivalent of a 2432A-unique character (see Appendix F), and the 2432A converts it to the appropriate 2432A character ("\" becomes "A", "J" becomes "Ω", etc.). Only the converted character (the 2432A character) will be displayed in the menu that's created using 'MESSAGE'; DEBUG mode will show both the converted character and the preceding backslash.

Symbols (command and argument names) can be abbreviated to the least number of characters that guarantee a unique symbol. The minimum string that needs to be sent is shown in bold uppercase letters in the command tables of Appendix A.

Instruments with a different set of symbols than the 2432A have their own minimum string abbreviations needed to make each of these commands unique. Some of their abbreviations may conflict with 2432A abbreviations. Also, 2432A's with different versions (releases) of firmware can have the different abbreviations for the same symbol (a new release may introduce a new command that requires lengthening an existing command's abbreviation to prevent symbol conflict). To avoid both compatibility problems, use full symbols when programming the 2432A.

The time saved using the minimum abbreviation instead of a complete symbol is minor. The time it takes to send the extra characters the abbreviation saves is short relative to that taken to interpret and execute the command.

Power-Up Sequence of the 2432A

When the 2432A first powers up, it performs the following internal checks before it can be used:

BASIC HARDWARE CHECKS. The ROM'S are checksummed and the computed checksums are compared with the checksum stored in each ROM. A series of test patterns are written into RAM to check for stuck bits. Non-volatile memory is checksummed and the results compared against the stored checksum. This last check is the one that determines if oscilloscope calibration has been compromised or if the oscilloscope has "forgotten" a waveform. If all of these checks show no problems, then the RUNNING SELF TEST message appears on the display and the 2432A goes on to the next step.

ACQUISITION HARDWARE CHECKS. At this stage the CCD'S, the preamplifiers, and the triggers are tested. The tests are the same ones done for the 7000, 8000, and 9000 series of tests found in the self diagnostics section of the operators manual. If any problems are encountered, the extended diagnostic menu will be displayed and the next step (the SRQ) will not be done.

POWER-UP SRQ. The last thing done before turning control over to the user is to send a service request (SRQ). This SRQ indicates to the controller that the 2432A has just powered up. This SRQ is sent only if RQS is ON. See "Service Request" in Appendix A for more information.



How to Use Fast Transmit Mode

How to Use Fast Transmit Mode

The Fast Transmit (FASTXMIT) mode is used when it is needed to upload waveforms from the 2432A as fast as the scope can output them. This mode lets you acquire and upload a series of successive acquisitions of a waveform, without sending a CURVE? or WAV? query for each waveform. The 2432A will acquire a waveform, transfer it, and rearm itself for acquiring the next waveform. It does this “acquire-transfer-rearm” sequence at a very high rate (about 20 to 50 times/second; see “Fast Transmit Transfer Rates” in this Appendix), which results in a greatly reduced transfer time for the series of waveforms.

Increasing the transfer rate using FASTXMIT results in less “dead time” between acquisitions. The user-specified number of acquisitions is output without the need for a corresponding number of consecutive “listen 2432A-send command-talk 2432A-input waveform” exchanges between 2432A and controller. Instead, the 2432A outputs the specified number of acquisitions as a single string when it is talked by the controller. The result is that the time between waveforms is limited only by the 2432A transfer rate (including the time it takes to make the acquisition) plus the speed at which the controller can handle the data. If the triggers occur at a rate less than the waveform transfer rate (such as can be true for video waveforms), Fast Transmit can provide an acquisition for every trigger.

How to Set Up Fast Transmit

To set the 2432A up for Fast Transmit mode, you need to determine which channel(s) contain the waveforms you want to upload and the number of waveforms you want to upload. You also must determine which data encoding format (RIBINARY, RIPARTIAL, RPBINARY, RPPARTIAL) you want the data in when sent. You send this information to the 2432A using the FASTXMIT[™] command.

In our example that follows later in this Appendix, we send the command “FASTXMIT 30, NORMAL:CH1,ENCDG:RIBINARY” to the 2432A. This command tells the 2432A that it’s to send 30 acquisitions of the CH1 waveform to the controller. The “ENCDG: BINARY” argument says to encode the waveform data using RIBINARY format. The “NORMAL” argument indicates that the 2432A is to send non-delta delayed waveforms.

The argument "CH1" can be changed to "CH2" if that is the desired waveform source, or "BOTH," if waveforms from both CH1 and CH2 are desired. If both CH1 and CH2 waveforms are requested, the number specified refers to the number per channel. In other words, "FASTXMIT 30* NORMAL:BOTH*" would transfer 60 waveforms, starting with CH1 and alternating between CH1 and CH2.

If "NORMAL" is replaced with "DELTA," the 2432A sends delta delay waveform(s) for the specified signal source(s). Regardless of what waveform is displayed on the screen, the 2432A acquires both a B Delayed and Delta Delay waveform if the Horizontal mode is set to B. If the scope is set to B mode, using NORMAL with FASTXMIT uploads the B Delayed waveform; using DELTA uploads the Delta Delayed waveform. Requesting DELTA waveforms when the Horizontal mode is NOT set to B mode "hangs up" the controller program (see "Potential Traps" in this Appendix).

After sending the command string as explained, you must tell the 2432A to begin sending Fast Transmit waveforms. Address the 2432A to talk; the transition from untalked to addressed-to-talk starts the transfer. The Fast Transmit sequence will only begin when the controller issues the talk address for the 2432A and the user has requested some Fast Transmit waveforms. On most controllers, some sort of high level INPUT command causes this talking and untalking of devices automatically.

After reading your waveforms into the controller, make sure to turn Fast Transmit mode off by issuing the command "FASTXMIT OFF" and then waiting for about 50 milliseconds to make sure the command was executed before issuing any more queries.

Here is a sample 4041 Basic program that will read 30 complete CH1 waveforms in Signed Integer format from a 2432A. If the 2432A is in ACQUIRE mode when this program is run, then each waveform will be newly acquired before being sent. If the 2432A is in SAVE mode when this program is run, each successive waveform transferred will be a copy of that sent immediately before it. No newly-acquired waveforms are sent because none are acquired in SAVE mode.

In this example, the Direct Memory Access (Option 01) feature of the 4041 Controller is being used to increase the speed. The WAIT statement is necessary to allow the 2432A to interpret the command turning Fast Transmit off before continuing on with the program. See "Potential Traps" for what might happen if this wait time is omitted.

The 2432A's address must be set to 1.

```
10 Scope=1
20 Open #scope:" gpib1(pri=1,eom=<0>,tra=DMA,tim=2):"
30 Dim wave$ to 32000
40 Print #scope:" FASTXMIT 30,NORMAL:CH1,ENCDG:RIBINARY"
50 Input #scope:wave$
60 Print #scope:" FASTXMIT OFF"
70 Wait .05
80 End
```

Potential Traps

The Fast Transmit mode of the 2432A is optimized for transfer speed. To maximize speed, Device Clear and Interface Clear messages are ignored during a Fast Transmit. *The only way to abort a transmission and regain control over the 2432A during a fast transmit is to turn the scope off and then turn it back on.*

Now, let's look at the two most common problems which occur when using Fast Transmit: either the controller program hangs or the 2432A hangs.

Controller Program Hangs

The controller program will hang if the 2432A does not transmit a waveform within the timeout period specified in the controller. Here are a few reasons why the 2432A might "time out":

1. Fast Transmit mode will not work if the display is being updated in ROLL mode. There is never a true waveform "acquisition".
2. You have requested DELTA waveforms, but the Delta Time mode of the 2432A is OFF and the 2432A is in ACQUIRE mode. In this case, the requested waveforms will not be acquired so the data won't be sent.
3. You have asked for "X" number of waveforms from the 2432A, but the 2432A has been triggered less than "X" times.
4. You have not set triggering coupling, mode, or source so the specified number of waveform acquisitions can be triggered.
5. You have not dimensioned your data array(s) large enough to hold the requested number of waveforms. The array must hold the number of waveforms \times the bytes/waveform. See "Binary Formats" in Appendix B for information on determining byte length for waveforms.

2432A Hangs

This condition is most often indicated by a completely blank 2432A screen. The problem is that the 2432A has been talked, but the controller has not listened to the complete Fast Transmit waveform. The 2432A is now waiting trying to send the rest of the waveform. Here are some cases where this might happen:

1. You didn't turn the Fast Transmit mode to OFF when it was no longer needed.
2. You omitted the 50 ms delay from the controller program after sending the 'FASTXMIT OFF' command to the 2432A. This delay is necessary to allow the 2432A to interpret the command. It is needed when sending any command to the 2432A while Fast Transmit is active, including those that change any Fast Transmit parameters (i.e., 'FASTXMIT NORMAL:CH2') or any oscilloscope setup (i.e. 'CH1 VOLTS:2').

In either of these two cases, when the controller sends a normal query to the 2432A and talks it to get the response, the 2432A will try to send another waveform because the Fast Transmit mode is still active. Since the controller's INPUT statement isn't expecting such a large response, it stops listening before the 2432A is done talking.

3. You asked for "X" number of waveforms from the 2432A but read less than "X" waveforms in.

Fast Transmit Transfer Rates

Now we look at some some transfer rate numbers for Fast Transmit. There are two sets of numbers given for the rate of waveform transfer. The first set was obtained from a 4041 Controller using the sample program shown above. The second set was obtained from a very fast controller so that the only significant speed limiting factor was the 2432A.

These timing measurements were made by attaching a frequency counter to the RTRIG BNC output on the rear panel. This measures the time between record triggers, including both the time to acquire the waveform and the time it takes to send that waveform to the controller. All the waveform displays are turned off to speed up the transfer rate.

You will note that there are different waveform transfer rates given for acquisitions at 100 μ s from those at 50 μ s to 100 ns. Because waveforms acquired at sweep speeds faster 100 μ s require special processing time, Fast Transmit for waveforms acquired at 50 μ s to 100 ns have a slower transfer rate (waveforms/second) than those acquired at 100 μ s. Also, although the rates are not listed, waveforms acquired at rates slower than 100 μ s have slower transfer rates as the time to acquire the waveform increases. For example, at 100 μ s, the 2 ms required to acquire a waveform is only adding about 10% to the total transfer time; at 1 ms, the 20 ms per waveform acquisition approximately doubles the transfer time; at 10 ms, the 0.2 seconds per waveform acquisition takes up 90% of the transfer time.

By using the Partial Waveform Binary Format to extract just a piece of the waveform, you can speed up the transfer rate considerably. The 'ENCDG' portion of the 'FASTXMIT' command is used to select the type of format that Fast Transmit will use. See Appendix B for more information on waveform formats.

Transfer Rates Using the sample program:

		full waveforms/sec
100 μ s/div	normal	43
	envelope	35
	average	21
50 μ s/div to 500 ns/div	normal	37
	envelope	31
	average	20

Transfer Rates Using a very fast controller:

		full waveforms/sec
100 μ s/div	normal	47
	envelope	38
	average	22
50 μ s/div to 500 ns/div	normal	39
	envelope	33
	average	20

Some Points to Remember

1. Sending waveforms is an Acquire-Send sequence. The 2432A acquires a new waveform and then sends it.
2. In SAVE mode, sending multiple waveforms just sends multiple copies of the same waveform; no acquisition takes place.
3. Turning the display off increases the transfer rate.
4. The *only way* to abort a transmission and regain control of the 2432A is to turn the power off and then back on.
5. Fast Transmit does not work in ROLL mode.
6. When using Fast Transmit and AVERAGE mode, every intermediate average is sent. To obtain a waveform that has been averaged 8 times, you need to throw the first 7 away and use the 8th waveform sent.

J

Example Programs

Example Programs

This appendix contains sample programs to use as guidelines in programming the 2432A.

Talker-Listener Program for HP Basic

This HP Basic program allows you to send commands or queries to the 2432A and prints responses from the 2432A.

```
10 !=====
20 ! first enter the 2432A's address and then open the
30 ! hardware port to talk to the GPIB. Finally enable
40 ! the srq interrupt and point to the handler routine.
50 !=====
60 print " Enter 2432A address:"
70 input addr
80 if addr>30 then goto 60
90 if addr<0 then goto 60
100 assign @scope to 700+addr
110 dim answr$ [7000]
120 dim comm$ [200]
130 on intr 7 gosub 320
140 enable intr 7;2
150 !=====
160 ! Now get the command or query to send. A query
170 ! has a "*" right after the header. If it is a
180 ! query, then talk the 2432A and print the response.
190 !=====
200 wait .25
205 comm$=""
210 input " Command? ",comm$
215 if len(comm$)=0 then goto 210
220 output @scope;comm$,end
230 if pos(comm$,"*")=0 then goto 200
240 enter @scope;answr$
250 print " 2432A response is: " &answr$
260 goto 200
270 !=====
280 ! This is the code that is executed when an srq
290 ! happens. We poll the bus and print the status
300 ! byte and the corresponding event query response.
310 !=====
320 stb = spoll(700+addr)
330 output @scope;" path off;event?" ,end
340 enter @scope;event
350 print " srq received: status = " ;stb," event = " ;event
360 output @scope;" path on" ,end
370 enable intr 7;2
380 return
390 end
```

Talker-Listener Program for IBM Basic

This program uses the National GPIB card and the drivers supplied with that card. Lines 1 through 99 of the program need to be supplied with the DECL.BAS file.

```
100 ' =====
110 ' First find the 2432A. If no 2432A on bus, then
120 ' stop. Start by clearing the screen.
130 ' =====
140 dev$=" DEV1"
150 call ibfind(dev$,dev%)
160 cls
170 if dev%<0 then print " 2432A not found" : end
180 gosub 480
190 print " Enter your command or query (use E to exit):" ;
200 line input msg$
210 ' =====
220 ' Keep inputing commands until an e or E. These are
230 ' printed to the 2432A and the response read back. If
240 ' the response is empty it is not printed.
250 ' =====
260 while msg$<>" e" and msg$<>" E"
270 b$=space$(240)
280 call ibwrt(dev%,msg$)
290 call ibrd(dev%,b$)
300 b=ibcnt%
310 while ibcnt%=240
320 print b$;
330 call ibrd(dev%,b$)
340 b=b+ibcnt%
350 wend
360 b$=mid$(b$,1,ibcnt%)
370 print b$;
380 print
390 print " ";b;" bytes were read" ;
400 print
410 gosub 480
414 print " Command? " ;
416 line input msg$
420 wend
430 end
```

```

440 '=====
450 ' This part reads the status byte and prints both it
460 ' and the event code.
470 '=====
480 sta%=1
490 while sta%<>0
500 print " status byte :";
510 call ibrsp(dev%,sta%)
520 print sta%;
530 msg$=" event?"
540 c$=space$(75)
550 call ibwrt(dev%,msg$)
560 call ibrd(dev%,c$)
570 print " , ";mid$(c$,1,ibcnt%)
580 print
590 wend
600 return

```

Pulse Counting Program

This program is written in 4041 basic and will count the number of pulses between time cursors. It demonstrates the use of the waveform data commands and queries as well as how custom text is written to the screen of the 2432A.

```

10 !=====
20 ! setup the logical unit and enable srq's
30 !=====
40 Scope=1
50 Open #scope:" gpib0(pri=1,eom=<0>):"
60 On srq then call srqhand
70 Enable srq
80 !=====
90 ! unmask the user request srq for monitoring the
100 ! menu keys and then print a prompt message on
110 ! the 2432A screen.
120 !=====
130 Print #scope:" message clrstate;menuoff;rqs on;user on"
140 Print #scope:" message 10:" move the time cursors to bracket***
150 Print #scope:" message 9:" the part of the waveform you want***
160 Print #scope:" message 8:" to count the pulses in***
170 Print #scope:" message 6:" press any menu button when ready***
180 Print #scope:" cursor function:time"
190 !=====
200 ! Wait here until the user presses a menu key.
210 ! Menukey will be reset in the srq routine.
220 !=====
230 Menukey=0
240 If menukey=0 then goto 240

```

Example Programs

```
250 !=====
260 ! The area of interest is now bracketed by the time
270 ! cursors. Set START and STOP to these values with
280 ! the SNAP command.
290 !=====
300 Print #scope:* snap*
310 !=====
320 ! A pulse will be defined as having a positive edge
330 ! that has at least 50 percent amplitude. Now find
340 ! the amplitude of the signal and the 50 percent point
350 !=====
360 Print #scope:* data source:ch1;path off;maximum?*
370 Input #scope:maxval
380 Print #scope:* minimum?*
390 Input #scope:minval
400 Midval=minval+(maxval-minval)/2
400 !=====
410 ! Set the crossing level to the calculated 50 percent
420 ! point. Set the hysteresis up to filter noisy signals
430 ! and set the search direction from left to right.
440 !=====
450 Print #scope:* level * ;midval
460 Print #scope:* hysteresis 20; direction plus*
470 !=====
480 ! Now count the actual pulses. This consists of
490 ! looking for positive crossings of the 50 percent
500 ! level. If one is found the window is adjusted
510 ! and the count is incremented.
520 !=====
530 Pulses=0
540 Print #scope:* pcross?*
550 Input #scope:location
560 If location=0 then goto 600
570 Pulses=pulses+1
580 Print #scope:* start * ;location+1
590 Goto 540
600 Print * number of pulses found = * ;pulses
690 Stop
700 End
710 Sub srqhand
720 !=====
730 ! This routine handles an SRQ interrupt. If the
740 ! event code is 450-454, then a menu button was pushed
750 ! and menykey is set to 1.
760 !=====
770 Poll stb,saddr
780 Print #scope:* event?*
790 Input #scope:event
800 If (event>449)and(event<455) then menykey=1
810 Resume
820 End
```

Extended Accuracy Timing Measurement Program

This program (written in 4041 Basic) makes extended accuracy timing measurements. It uses the time cursors and the pcross function for the time readout and horizontal expansion for increased accuracy in locating the measurement points. The basic algorithm sets the time cursors at the 50 percent points of the waveform. It then expands the waveform 100 times and repositions the time cursors more accurately.

```

10 !=====
20 ! First set the output channel and initialize some
30 ! variables. Set up the Sec/Div, START, and
40 ! STOP, and then start the scope acquiring.
50 ! Wait for a period of time for an acquisition to occur.
60 ! You might also use single sequence to take just one
70 ! record. Path is turned off so we can just deal with
80 ! numbers on query responses. All the time measurements
90 ! will be done from level 0 or center screen.
100 !=====
110 delete var all
120 Open #1:* gpib(pri=0):*
130 Dim units$ to 200
140 Dim instr$ to 200
150 Dim outstr$ to 200
160 Integer pcr,pcr2
170 Print #1:* horizontal asecdiv:100e-6;run acquire*
180 For i=1 to 250
190 Next i
200 Print #1:* run save;start 1;stop 1024;level 0;path off*
210 !=====
220 ! Now get the first pcross value. This will be the
230 ! edge we start measuring from. If your edge is
240 ! different substitute a different search algorithm
250 ! here. The start value is moved to be one point before
260 ! the crossing of interest. Then we go looking for the
270 ! next crossing point, so we can set stop there.
280 !=====
290 Input #1 prompt * pcross?* :instr$
300 Pcr=val(instr$)-1
310 Outstr$=" start * &str$(val(instr$))&* ;pcross?"
320 Input #1 prompt outstr$:instr$
330 Pcr2=val(instr$)-1
340 !=====
350 ! Now set the time cursors to the points that we have
360 ! just found. These will be used to give us the actual
370 ! time values we want. Then expand the horizontal by
380 ! 100x. The cursors will stay at the points that we
390 ! placed them even after the expansion.
400 !=====
410 Print #1:* cursor function:time,units:time:base*

```

Example Programs

```
420 Print #1:" cursor tpos:one:" &str$(pcr)
430 Print #1:" cursor tpos:two:" &str$(pcr2)
440 Input #1 prompt " horizontal? asecdiv" :instr$
450 Horex=val(instr$)/100
460 Print #1:" horizontal asecdiv:" &str$(horex)
470 !=====
480 ! Now that we've expanded everything, we need to go in
490 ! and find the new pcross value. Next, we move the time
500 ! cursor to that point and look for the
510 ! ending point and set the other time cursor to there.
520 ! The difference between the time cursors is the answer.
530 ! A slight problem comes in here in that horizontal
540 ! position is altered slightly in doing the expansions
550 ! so that points line up correctly. This needs to be
560 ! compensated for and that is what the subroutine is
570 ! doing.
580 !=====
590 Print #1:" cursor select:one"
600 Gosub fdghpos
610 Print #1:" cursor tpos:one:" &str$(cursor)
620 Print #1:" cursor select:two"
630 Gosub fdghpos
640 Print #1:" cursor tpos:two:" &str$(cursor)
650 wait 0.5
660 Input #1 prompt " cursor? display:unit" :units$
670 Input #1 prompt " cursor? display:value" :instr$
680 Print " The time difference is " &instr$&units$
690 Stop
700 !=====
710 ! This subroutine finds the first pcross and then
720 ! fiddles with horizontal position before setting
730 ! the cursor value to a "corrected" value which
740 ! is returned in the variable cursor.
750 !=====
760 fdghpos: !
770 Input #1 prompt " start 1;pcross?" :instr$
780 Pcrex=val(instr$)-1
790 Input #1 prompt " horizontal? position" :instr$
800 Horpos=val(instr$)
810 Exhorpos=horpos*100
820 If exhorpos<256 then goto left256
830 If exhorpos<102044 then goto middle else goto rt256
840 Left256: refpos=exhorpos
850 goto calnum
860 Middle: pospick=(exhorpos-256)/100
870 refpos=256+(pospick-int(pospick))*100
880 goto calnum
890 rt256: refpos=1023-(1023-horpos)*100
900 calnum: !
910 cursor=horpos+(pcrex-refpos)/100
920 return
930 End
```

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