
Programmer's Reference

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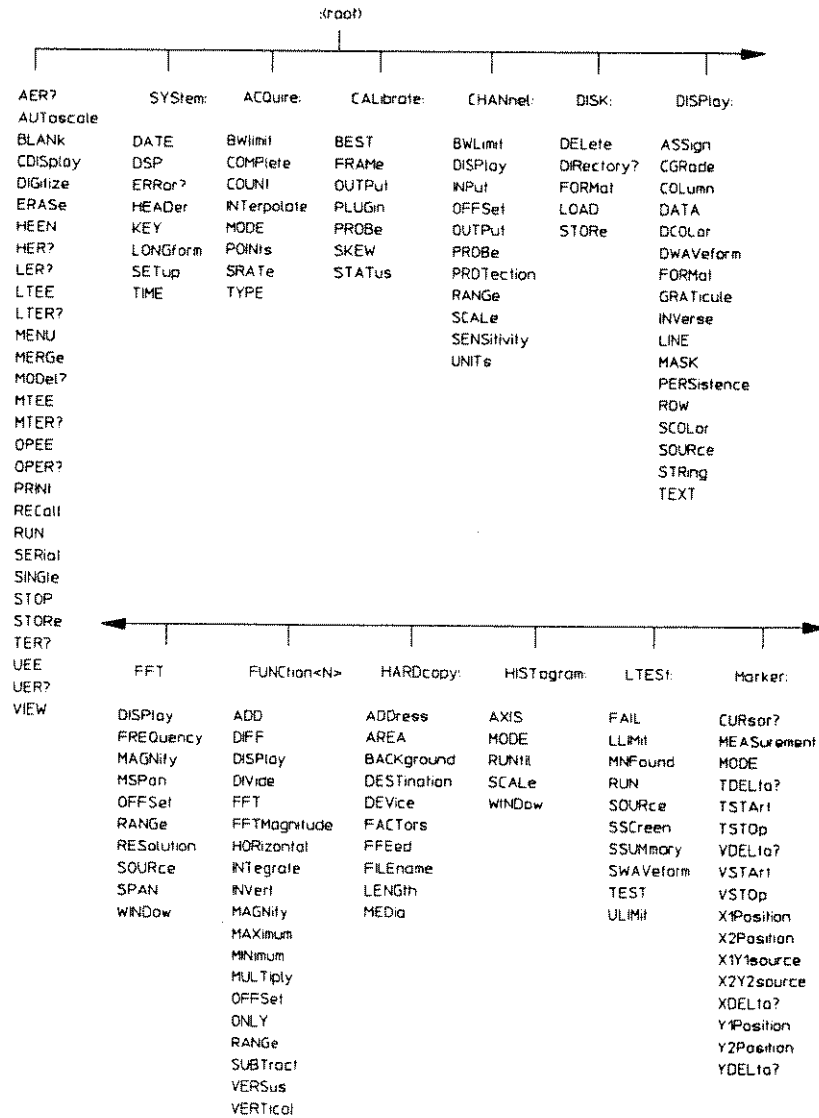
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HP 54710 and HP 54720 Oscilloscopes

The HP 54710 and HP 54720 Oscilloscope Programming Command Set

- Common Commands
- *CLS
 - *ESE
 - *ESR?
 - *IDN?
 - *LRN?
 - *DPC?
 - *OPT?
 - *RCL
 - *RST
 - *SAV
 - *SRE
 - *STB?
 - *TRG
 - *TST?
 - *WAI



54710B03

MEASure:	MTESt:	Timebase:	TRIGger:	TRIGger<N>:	PMEMory:	WMEMory<N>:	WAVEform:
DEFine	AMASK	DElay	DEvents	BWLimit	ADD	DISPlay	BANDpass?
DELTime	COUNt	POSition	DTIME	PROBE	CLEAR	SAVe	BYTeorder
DUTycycle	MASK	RANGe	EDGE		DISPlay	XOFFset	COMplete?
FALLtime	POLYgon	REFerence	GLITch		ERASe	XRANGe	COUNt?
FFT	RUMode	SCALE	HOLDoff		MERGE	YOFFset	COUPling?
FREQuency	SCALE	VIEW	HYSTEResis			YRANGe	DATA
HISTagram	SSCREEN	WINDow	LEVEL				FORMat
NWIDth	SSUMmary		MODE				POINts?
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PERiod	TEST		SLOPe				SOURce
PREShoot			SOURce				TYPE?
PWIDth			STATe				VIEW
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RISetime			STV				XINcrement?
SCRatch			SWEep				XORigin?
SENDvalid			UDTV				XRANGe?
SOURce							XREFERENCE?
STATistics							XUNIts?
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TMAX							YINcrement?
TMIN							YORigin?
TVOLt							YRANGe?
VAMPItude							YREFERENCE?
VAVerage							YUNIts?
VBASE							
VLOWer							
VMAX							
VMIIdle							
VMIN							
VPP							
VRMS							
VTIME							
VTOP							
VUPper							

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In This Book

This book is your guide to programming the HP 54710 and HP 54720 Digitizing Oscilloscopes using the HP-IB command set.

Part One, "Introduction to Programming the HP 54710/HP 54720 Oscilloscopes," gives you the conceptual information needed to start programming the oscilloscope. This part includes information about basic program communications, interface, syntax, data types, and status reporting. It also has a set of sample programs that show you some typical applications.

Part Two, "HP 54710/HP 54720 HP-IB Command Reference," describes all the commands used to program the oscilloscope. Each chapter lists the commands that belong to an individual subsystem, and explains the function of each command.

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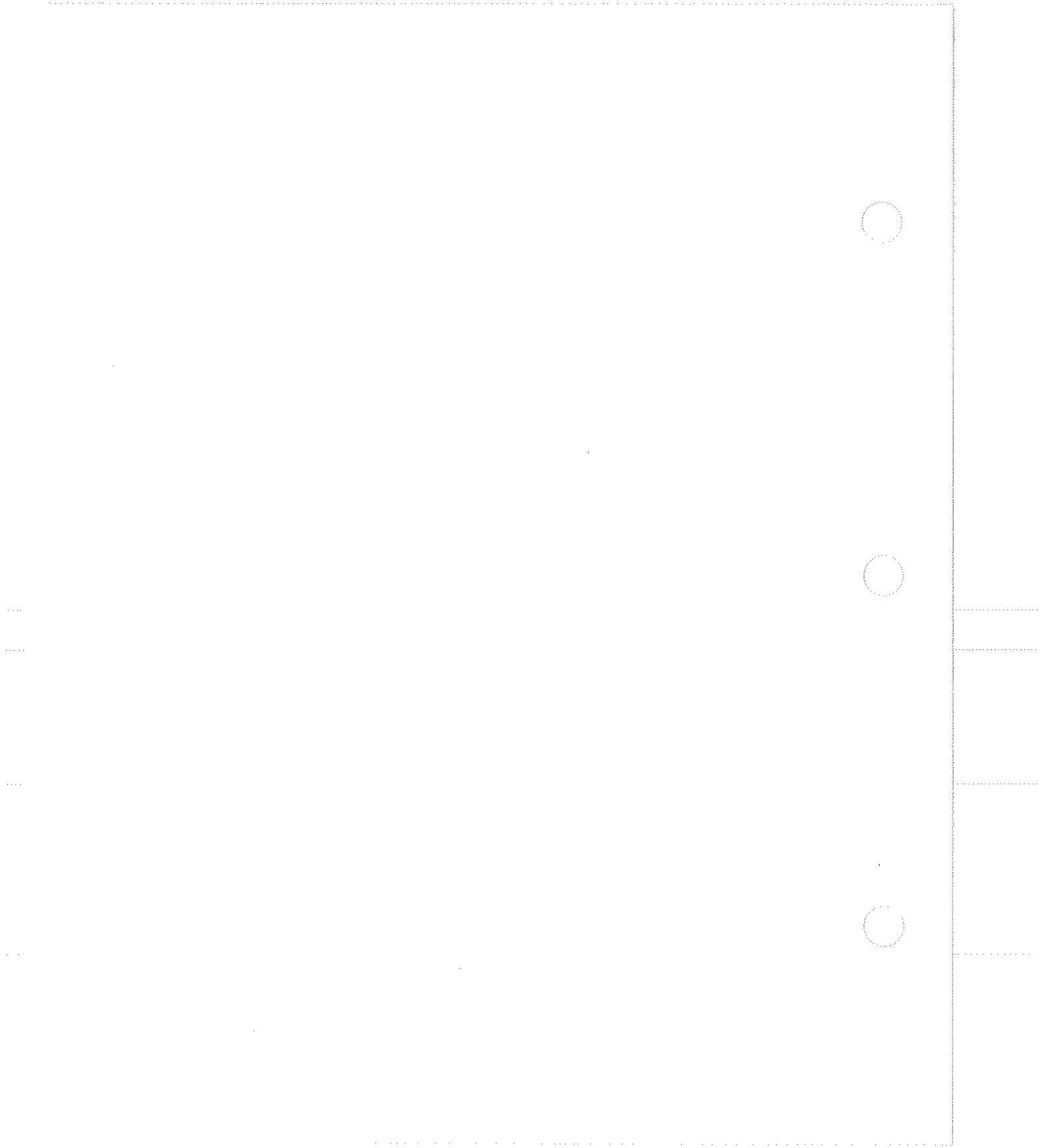
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- 2** Interface Functions
- 3** Message Communication and System Functions
- 4** Status Reporting
- 5** Programming Syntax
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- 7** Example Programs

Introduction to Programming the HP 54710/HP 54720 Oscilloscopes



**Introduction to
Programming**

Introduction to Programming

This chapter introduces the basics for remote programming of an oscilloscope. The programming instructions in this manual conform to the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The programming instructions provide the means of remote control.

There are basic operations that can be done with a controller and an oscilloscope:

- Set up the instrument.
- Make measurements.
- Get data (waveform, measurements, configuration) from oscilloscope.
- Send information (pixel image, configurations) to oscilloscope.

Other tasks are accomplished by combining these basic functions.

The programming examples for individual commands in this manual are written in HP BASIC 5.0 for an HP 9000 Series 200/300 Controller.

Talking to the Instrument

Computers acting as controllers communicate with the instrument by sending and receiving messages over a remote interface. Instructions for programming normally appear as ASCII character strings embedded inside the output statements of a "host" language available on your controller. The input statements of the host language are used to read in responses from the oscilloscope.

For example, HP 9000 Series 200/300 BASIC uses the OUTPUT statement for sending commands and queries. After a query is sent, the response is usually read in using the ENTER statement.

Messages are placed on the bus using an output command and passing the device address, program message, and terminator. Passing the device address ensures that the program message is sent to the correct interface and instrument.

The following HP BASIC OUTPUT statement sends a command that sets the bandwidth limit of channel 1 to on:

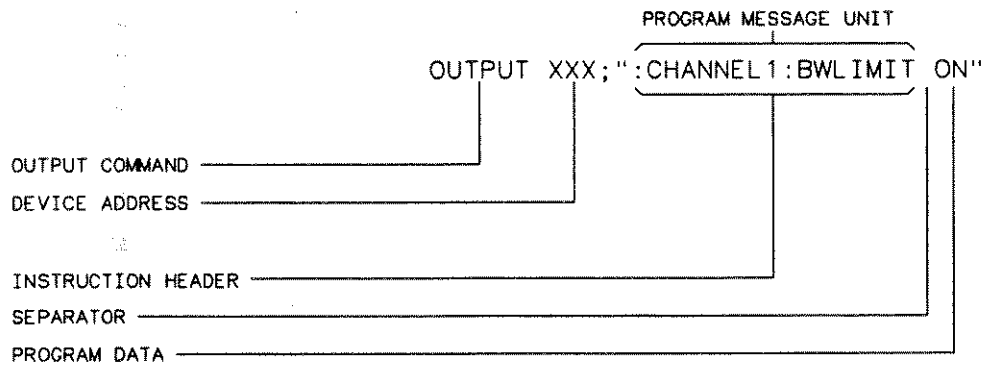
```
OUTPUT < device address > ;":CHANNEL1:BWLIMIT ON"<terminator>
```

The < device address > represents the address of the device being programmed. Each of the other parts of the above statement are explained in the following pages.

Program Syntax

To program the instrument remotely, you must have an understanding of the command format and structure expected by the instrument. The IEEE 488.2 syntax rules govern how individual elements such as headers, separators, program data, and terminators may be grouped together to form complete instructions. Syntax definitions are also given to show how query responses are formatted. Figure 1-1 shows the main syntactical parts of a typical program statement.

Figure 1-1



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Program Statement Syntax

Output Command

The output command is entirely dependent on the programming language. Throughout this manual HP 9000 Series 200/300 BASIC 5.0 is used in the examples of individual commands. If you are using other languages, you will need to find the equivalents of HP BASIC commands like `OUTPUT`, `ENTER`, and `CLEAR` in order to convert the examples. The instructions listed in this manual are always shown between quotes in the example programs.

Device Address

The location where the device address must be specified is also dependent on the programming language you are using. In some languages, this may be specified outside the output command. In HP BASIC, this is always specified after the keyword OUTPUT. The examples in this manual assume the oscilloscope is at device address 707. When writing programs, the address varies according to how the bus is configured.

Instructions

Instructions (both commands and queries) normally appear as a string embedded in a statement of your host language, such as BASIC, Pascal, or C. The only time a parameter is not meant to be expressed as a string is when the instruction's syntax definition specifies <block data>, such as learnstring. There are only a few instructions that use block data.

Instructions are composed of two main parts:

- The header, which specifies the command or query to be sent.
- The program data, which provide additional information needed to clarify the meaning of the instruction.

Instruction Header

The instruction header is one or more mnemonics separated by colons (:) that represent the operation to be performed by the instrument. The command tree in figure 5-1 illustrates how all the mnemonics can be joined together to form a complete header (see the “Programming Conventions” chapter).

The example in figure 1-1 is a command. Queries are indicated by adding a question mark (?) to the end of the header. Many instructions can be used as either commands or queries, depending on whether or not you have included the question mark. The command and query forms of an instruction usually have different program data. Many queries do not use any program data.

White Space (Separator)

White space is used to separate the instruction header from the program data. If the instruction does not require any program data parameters, you do not need to include any white space. In this manual, white space is defined as one or more spaces. ASCII defines a space to be character 32 (in decimal).

Program Data

Program data are used to clarify the meaning of the command or query. They provide necessary information, such as whether a function should be on or off, or which waveform is to be displayed. Each instruction's syntax definition shows the program data, as well as the values they accept. The section “Program Data Syntax Rules” in this chapter has all of the general rules about acceptable values.

When there is more than one data parameter, they are separated by commas (,). Spaces can be added around the commas to improve readability.

Header Types

There are three types of headers:

- Simple Command headers.
- Compound Command headers
- Common Command headers.

Simple Command Header

Simple command headers contain a single mnemonic. AUTOSCALE and DIGITIZE are examples of simple command headers typically used in this instrument. The syntax is:

<program mnemonic><terminator>

When program data must be included with the simple command header (for example, :DIGITIZE CHAN1), white space is added to separate the data from the header. The syntax is:

<program mnemonic><separator><program data><terminator>

Compound Command Header

Compound command headers are a combination of two program mnemonics. The first mnemonic selects the subsystem, and the second mnemonic selects the function within that subsystem. The mnemonics within the compound message are separated by colons. For example:

To execute a single function within a subsystem:

:<subsystem>:<function><separator><program data><terminator>

(For example :CHANNEL1:BWLIMIT ON)

Combining Commands in the Same Subsystem

To execute more than one function within the same subsystem a semi-colon (;) is used to separate the functions:

:<subsystem>:<function><separator><data>;<function><separator><data><terminator>

(For example :CHANNEL1:COUPLING DC;BWLIMIT ON)

Introduction to Programming
Duplicate Mnemonics

Common Command Header

Common command headers control IEEE 488.2 functions within the instrument (such as clear status). Their syntax is:

***<command header><terminator>**

No space or separator is allowed between the asterisk (*) and the command header. *CLS is an example of a common command header.

Duplicate Mnemonics

Identical function mnemonics can be used for more than one subsystem. For example, the function mnemonic RANGE may be used to change the vertical range or to change the horizontal range:

:CHANNEL1:RANGE .4

sets the vertical range of channel 1 to 0.4 volts full scale.

:TIMEBASE:RANGE 1

sets the horizontal time base to 1 second full scale.

CHANNEL1 and TIMEBASE are subsystem selectors and determine which range is being modified.

Query Headers

Command headers immediately followed by a question mark (?) are queries. After receiving a query, the instrument interrogates the requested function and places the answer in its output queue. The answer remains in the output queue until it is read or another command is issued. When read, the answer is transmitted across the bus to the designated listener (typically a controller). For example, the query :

TIMEBASE:RANGE?

places the current time base setting in the output queue. In HP BASIC, the controller input statement:

ENTER < device address > ;Range

passes the value across the bus to the controller and places it in the variable Range.

Query commands are used to find out how the instrument is currently configured. They are also used to get results of measurements made by the instrument. For example, the command:

:MEASURE:RISETIME?

instructs the instrument to measure the rise time of your waveform and place the result in the output queue.

The output queue must be read before the next program message is sent. For example, when you send the query :MEASURE:RISETIME? you must follow that query with an input statement. In HP BASIC, this is usually done with an ENTER statement immediately followed by a variable name. This statement reads the result of the query and places the result in a specified variable.

Sending another command or query before reading the result of a query causes the output buffer to be cleared and the current response to be lost. This also generates a query interrupted error in the error queue.

Program Header Options

Program headers can be sent using any combination of uppercase or lowercase ASCII characters. Instrument responses, however, are always returned in uppercase.

Program command and query headers may be sent in either long form (complete spelling), short form (abbreviated spelling), or any combination of long form and short form.

TIMEBASE:DELAY 1US - long form

TIM:DEL 1US - short form

Programs written in long form are easily read and are almost self-documenting. The short form syntax conserves the amount of controller memory needed for program storage and reduces the amount of I/O activity.

The rules for the short form syntax are shown in the chapter, "Programming Conventions."

Program Data Syntax Rules

Program data is used to convey a variety of types of parameter information related to the command header. At least one space must separate the command header or query header from the program data.

<program mnemonic><separator><data><terminator>

When a program mnemonic or query has multiple program data a comma separates sequential program data.

<program mnemonic><separator><data>,<data><terminator>

For example, :MEASURE:TVOLT 1.0V,2 has two program data: 1.0V and 2.

There are two main types of program data that are used in commands: character and numeric program data.

Character Program Data

Character program data is used to convey parameter information as alpha or alphanumeric strings. For example, the `:TIMEBASE:REFERENCE` command can be set to left, center, or right. The character program data in this case may be `LEFT`, `CENTER`, or `RIGHT`. `:TIMEBASE:REFERENCE RIGHT` sets the time base reference to right.

The available mnemonics for character program data are always included with the instruction's syntax definition. When sending commands, either the long form or short form (if one exists) may be used. Upper-case and lower-case letters may be mixed freely. When receiving responses, upper-case letters are used exclusively.

Numeric Program Data

Some command headers require program data to be expressed numerically. For example, `:TIMEBASE:RANGE` requires the desired full scale range to be expressed numerically.

For numeric program data, you have the option of using exponential notation or using suffix multipliers to indicate the numeric value. The following numbers are all equal:

$28 = 0.28E2 = 280E-1 = 28000m = 0.028K = 28E-3K$.

When a syntax definition specifies that a number is an integer, that means that the number should be whole. Any fractional part would be ignored, truncating the number. Numeric data parameters that accept fractional values are called real numbers. For more information see the chapter, "Interface Functions."

All numbers are expected to be strings of ASCII characters. Thus, when sending the number 9, you would send a byte representing the ASCII code for the character "9" (which is 57). A three-digit number like 102 would take up three bytes (ASCII codes 49, 48, and 50). This is taken care of automatically when you include the entire instruction in a string.

Embedded Strings

Embedded strings contain groups of alphanumeric characters which are treated as a unit of data by the oscilloscope. For example, the line of text written to the advisory line of the instrument with the :SYSTEM:DSP command:

```
:SYSTEM:DSP "This is a message."
```

Embedded strings may be delimited with either single (') or double (") quotes. These strings are case-sensitive and spaces act as legal characters just like any other character.

Program Message Terminator

The program instructions within a data message are executed after the program message terminator is received. The terminator may be either an NL (New Line) character, an EOI (End-Or-Identify) asserted in the HP-IB interface, or a combination of the two. All three ways are equivalent. Asserting the EOI sets the EOI control line low on the last byte of the data message. The NL character is an ASCII linefeed (decimal 10).

The NL (New Line) terminator has the same function as an EOS (End Of String) and EOT (End Of Text) terminator.

Selecting Multiple Subsystems

You can send multiple program commands and program queries for different subsystems on the same line by separating each command with a semicolon. The colon following the semicolon enables you to enter a new subsystem. For example:

```
<program mnemonic><data>;<program mnemonic><data><terminator>  
:CHANNEL1:RANGE 0.4;:TIMEBASE:RANGE 1
```

Multiple commands may be any combination of compound and simple commands.

Programming Getting Started

The remainder of this chapter deals mainly with how to set up the instrument, how to retrieve setup information and measurement results, how to digitize a waveform, and how to pass data to the controller. Refer to the chapter, "Measure Subsystem" for information on sending measurement data to the instrument.

The programming examples in this manual are written in HP BASIC 5.0 for an HP 9000 Series 200/300 Controller.

Initialization

To make sure the bus and all appropriate interfaces are in a known state, begin every program with an initialization statement. For example, HP BASIC provides a CLEAR command which clears the interface buffer:

CLEAR 707 ! initializes the interface of the instrument

When you are using HP-IB, CLEAR also resets the oscilloscope's parser. The parser is the program that reads in the instructions that you send.

After clearing the interface, initialize the instrument to a preset state:

OUTPUT 707;"*RST" ! initializes the instrument to a preset state.

The actual commands and syntax for initializing the instrument are discussed in the chapter, "Common Commands."

Refer to your controller manual and programming language reference manual for information on initializing the interface.

Autoscale

The AUTOSCALE feature of Hewlett-Packard digitizing oscilloscopes performs a very useful function on unknown waveforms by setting up the vertical channel, time base, and trigger level of the instrument.

The syntax for the autoscale function is:

:AUTOSCALE<terminator>

Introduction to Programming Example Program

Setting Up the Instrument

A typical oscilloscope setup would set the vertical range and offset voltage, the horizontal range, delay time, delay reference, trigger mode, trigger level, and slope.

A typical example of the commands sent to the oscilloscope are:

```
:CHANNEL1:PROBE 10; RANGE 16;OFFSET 1.00<terminator>  
:TIMEBASE:MODE NORMAL;RANGE 1E-3;DELAY 100E-6<terminator>
```

This example sets the timebase at 1 ms full-scale (100 μ s/div) with delay of 100 μ s. Vertical is set to 16 V full-scale (2 V/div) with center of screen at 1 V and probe attenuation of 10.

Example Program

This program demonstrates the basic command structure used to program the oscilloscope.

```
10 CLEAR 707      ! Initialize instrument interface  
20 OUTPUT 707;"*RST"      !Initialize instrument to preset state  
30 OUTPUT 707;":TIMEBASE:RANGE 5E-4" ! Time base to 500 us  
                                full scale  
40 OUTPUT 707;":TIMEBASE:DELAY 0"    ! Delay to zero  
50 OUTPUT 707;":TIMEBASE:REFERENCE CENTER" ! Display  
                                reference at center  
60 OUTPUT 707;":CHANNEL1:PROBE 10"    ! Probe attenuation to 10:1  
70 OUTPUT 707;":CHANNEL1:RANGE 1.6"    ! Vertical range to 1.6 V full scale  
80 OUTPUT 707;":CHANNEL1:OFFSET -.4"  ! Offset to -0.4  
90 OUTPUT 707;":CHANNEL1:INPUT DC"    ! Coupling to DC  
100 OUTPUT 707;":TRIGGER:MODE EDGE"   ! Edge triggering  
110 OUTPUT 707;":TRIGGER:LEVEL chan1,-.4" ! Trigger level to -0.4  
120 OUTPUT 707;":TRIGGER:SLOPE POSITIVE" ! Trigger on positive slope  
130 OUTPUT 707;":ACQUIRE:TYPE NORMAL" ! Normal acquisition  
140 OUTPUT 707;":DISPLAY:GRATICULE FRAME" ! Grid off  
150 END
```

Program Overview

Line 10 initializes the instrument interface to a known state.

Line 20 initializes the instrument to a preset state.

Lines 30 through 50 set the time base mode to normal with the horizontal time at 500 μ s full scale with 0 s of delay referenced at the center of the graticule.

Lines 60 through 90 set the vertical range to 1.6 volts full scale with center screen at -0.4 volts with 10:1 probe attenuation and DC coupling.

Lines 100 through 120 configures the instrument to trigger at -0.4 volts with normal triggering.

Line 130 configures the instrument for normal acquisition.

Line 140 turns the grid off.

Using the Digitize Command

The Digitize command is a macro that captures data satisfying the specifications set up by the acquire subsystem. When the digitize process is complete, the acquisition is stopped. The captured data can then be measured by the instrument or transferred to the controller for further analysis. The captured data consists of two parts: the waveform data record and the preamble.

After changing the oscilloscope configuration, the waveform buffers are cleared. Before doing a measurement, the Digitize command should be sent to ensure new data has been collected.

The DIGITIZE command can be sent without parameters for a higher throughput. Refer to the DIGITIZE command in the Root Level Commands chapter for details.

When the DIGITIZE command is sent to an instrument, the specified channel signal is digitized with the current ACQUIRE parameters. To obtain waveform data, you must specify the WAVEFORM parameters for the waveform data prior to sending the :WAVEFORM:DATA? query.

Introduction to Programming Using the Digitize Command

The number of data points comprising a waveform varies according to the number requested in the ACQUIRE subsystem. The ACQUIRE subsystem determines the number of data points, type of acquisition, and number of averages used by the DIGITIZE command. This allows you to specify exactly what the digitized information contains. The following program example shows a typical setup:

```
OUTPUT 707;":ACQUIRE:TYPE AVERAGE"<terminator>  
OUTPUT 707;":ACQUIRE:COMPLETE 100"<terminator>  
OUTPUT 707;":WAVEFORM:SOURCE CHANNEL1"<terminator>  
OUTPUT 707;":WAVEFORM:FORMAT BYTE"<terminator>  
OUTPUT 707;":ACQUIRE:COUNT 8"<terminator>  
OUTPUT 707;":ACQUIRE:POINTS 500"<terminator>  
OUTPUT 707;":DIGITIZE CHANNEL1"<terminator>  
OUTPUT 707;":WAVEFORM:DATA? "<terminator>
```

This setup places the instrument into the averaged mode with eight averages. This means that when the DIGITIZE command is received, the command will execute until the signal has been averaged at least eight times.

After receiving the :WAVEFORM:DATA? query, the instrument will start passing the waveform information when addressed to talk.

Digitized waveforms are passed from the instrument to the controller by sending a numerical representation of each digitized point. The format of the numerical representation is controlled with the :WAVEFORM:FORMAT command and may be selected as BYTE, WORD, or ASCII.

The easiest method of entering a digitized waveform depends on data structures, available formatting and I/O capabilities. You must scale the integers to determine the voltage value of each point. These integers are passed starting with the leftmost point on the instrument's display. For more information, refer to chapter 18, "Waveform Subsystem."

When using HP-IB, a digitize operation may be aborted by sending a Device Clear over the bus (CLEAR 707).

Receiving Information from the Instrument

After receiving a query (command header followed by a question mark), the instrument interrogates the requested function and places the answer in its output queue. The answer remains in the output queue until it is read or another command is issued. When read, the answer is transmitted across the interface to the designated listener (typically a controller). The input statement for receiving a response message from an instrument's output queue typically has two parameters; the device address, and a format specification for handling the response message. For example, to read the result of the query command :CHANNEL1:COUPLING? you would execute the HP BASIC statement:

```
ENTER <device address> ;Setting$
```

where <device address> represents the address of your device. This would enter the current setting for the channel one coupling in the string variable Setting\$.

All results for queries sent in a program message must be read before another program message is sent. For example, when you send the query :MEASURE:RISETIME?, you must follow that query with an input statement. In HP BASIC, this is usually done with an ENTER statement.

Sending another command before reading the result of the query causes the output buffer to be cleared and the current response to be lost. This also causes an error to be placed in the error queue.

Executing an input statement before sending a query causes the controller to wait indefinitely.

The format specification for handling response messages is dependent on both the controller and the programming language.

String Variable Example

The output of the instrument may be numeric or character data depending on what is queried. Refer to the specific commands for the formats and types of data returned from queries.

For the example programs, assume that the device being programmed is at device address 707. The actual address varies according to how you have configured the bus for your own application.

In HP BASIC 5.0, string variables are case sensitive and must be expressed exactly the same each time they are used. The following example shows the data being returned to a string variable:

```
10 DIM Rang$(30)
20 OUTPUT 707;":CHANNEL1:RANGE?"
30 ENTER 707;Rang$
40 PRINT Rang$
50 END
```

After running this program, the controller displays:

+8.00000E-01

In this example, the oscilloscope is set to 100 mV/division given this output value.

Numeric Variable Example

The following example shows the data being returned to a numeric variable:

```
10 OUTPUT 707;":CHANNEL1:RANGE?"
20 ENTER 707;Rang
30 PRINT Rang
40 END
```

After running this program, the controller displays:

.8

Definite-Length Block Response Data

Definite-length block response data allows any type of device-dependent data to be transmitted over the system interface as a series of 8-bit binary data bytes. This is particularly useful for sending large quantities of data or 8-bit extended ASCII codes. The syntax is a pound sign (#) followed by a non-zero digit representing the number of digits in the decimal integer. After the non-zero digit is the decimal integer that states the number of 8-bit data bytes being sent. This is followed by the actual data.

For example, for transmitting 4000 bytes of data, the syntax would be:

```
#44000 <4000 bytes of data> <terminator>
```

The "4" represents the number of digits that follow, and "4000" represents the number of bytes to be transmitted.

Multiple Queries

You can send multiple queries to the instrument within a single program message, but you must also read them back within a single program message. This can be accomplished by either reading them back into a string variable or into multiple numeric variables. For example, you could read the result of the query :TIMEBASE:RANGE?;DELAY? into the string variable Results\$ with the command:

```
ENTER 707;Results$
```

When you read the result of multiple queries into string variables, each response is separated by a semicolon. For example, the response of the query :TIMEBASE:RANGE?;DELAY? would be:

```
<range_value>; <delay_value>
```

Use the following program message to read the query :TIMEBASE:RANGE?;DELAY? into multiple numeric variables:

```
ENTER 707;Result1,Result2
```

Instrument Status

Status registers track the current status of the instrument. By checking the instrument status, you can find out whether an operation has been completed, whether the instrument is receiving triggers, and more. The chapter on “Status Reporting” explains how to check the status of the instrument.



Interface Functions

Interface Functions

The interface functions deal with general bus management issues, as well as messages which can be sent over the bus as bus commands. In general, these functions are defined by IEEE 488.1.

HP-IB Interface Connector

The oscilloscope is equipped with an HP-IB interface connector on the rear panel. This allows direct connection to an HP-IB compatible printer or external controller. An external HP-IB compatible device can be connected to the oscilloscope by installing an HP-IB cable between the two units. Finger tighten the captive screws on both ends of the HP-IB cable to avoid accidentally disconnecting the cable during operation.

Up to fifteen HP-IB compatible instruments (including a controller) can be interconnected in a system by stacking (piggy-backing) connectors. This allows the instruments to be connected in virtually any configuration desired, as long as there is a path from the controller to every device operating on the bus.

CAUTION

Avoid stacking more than three or four cables on any one connector. Multiple connectors produce leverage that can damage a connector mounting.

HP-IB Default Startup Conditions

The following default HP-IB conditions are established during power-up.

- HP-IB local mode is active.
- Local lockout is cleared.
- The Request Service (RQS) bit in the status byte register is set to zero.
- All event registers, the Standard Event Status Enable Register, Service Request Enable Register, and the Status Byte Register are cleared.

**Interface Functions
Interface Capabilities**

Interface Capabilities

The interface capabilities of this oscilloscope, as defined by IEEE 488.1, are listed in the following table.

Table 2-1

Interface Capabilities

Code	Interface Function	Capability
SH1	Source Handshake	Full Capability
AH1	Acceptor Handshake	Full Capability
T5	Talker	Basic Talker/Serial Poll/Talk Only Mode/ Unaddress if Listen Address (MLA)
L4	Listener	Basic Listener/ Unaddresses if Talk Address (MTA)
SR1	Service Request	Full Capability
RL1	Remote Local	Complete Capability
PP1	Parallel Poll	Remote Configuration
DC1	Device Clear	Full Capability
DT1	Device Trigger	Full Capability
C0	Controller	No Capability
E2	Driver Electronics	Tri State (1 MB/SEC MAX)

Command and Data Concepts

The HP-IB has two modes of operation: command mode and data mode. The bus is in the command mode when the Attention (ATN) control line is true. The command mode is used to send talk and listen addresses and various bus commands such as group execute trigger (GET).

The bus is in the data mode when the ATN line is false. The data mode is used to convey device-dependent messages across the bus. The device-dependent messages include all of the oscilloscope specific commands, queries, and responses found in this manual including instrument status information.

Addressing

The oscilloscope is always in the addressed (talk/listen) mode from the HP-IB menu of the front panel of the oscilloscope. The HP-IB menu is selected by pressing the Utility key on the front panel, then selecting the HP-IB softkey.

Addressed mode is used when the instrument operates in conjunction with a controller. When the instrument is in the addressed mode, the following is true:

- Each device on the HP-IB resides at a particular address, ranging from 0 to 30.
- The active controller specifies which devices talk and which listen.
- An instrument may be talk addressed, listen addressed, or unaddressed by the controller.

If the controller addresses an instrument to talk, the instrument remains configured to talk until it receives an interface clear message (IFC), another instrument's talk address (OTA), its own listen message (MLA), or a universal untalk command (UNT).

If the controller addresses an instrument to listen, the instrument remains configured to listen until it receives an interface clear message (IFC), its own talk address (MTA), or a universal unlisten command (UNL).

Interface Functions
Communicating Over the Bus

Communicating Over the Bus

Device addresses are sent by the controller in the command mode to specify who talks and who listens. Since HP-IB can address multiple devices through the same interface card, the device address passed with the program message must include not only the correct interface select code, but also the correct instrument address.

Device Address = (Interface Select Code * 100) + (Instrument Address)

The examples in this manual assume that the oscilloscope is at device address 707.

Interface Select Code

Each interface card has a unique interface select code. This code is used by the controller to direct commands and communications to the proper interface. The default is typically "7" for HP-IB controllers.

Instrument Address

Each instrument on the HP-IB must have a unique instrument address between decimal 0 and 30. This instrument address is used by the controller to direct commands and communications to the proper instrument on an interface. The default is typically "7" for this oscilloscope. This address can be changed in the HP-IB menu of the Utility menu of the oscilloscope.

Address 21 is usually reserved for the Computer interface Talk/Listen address and should not be used as an instrument address.

Remote, Local, and Local Lockout

The remote, local, and local lockout modes are used for various degrees of front-panel control while a program is running.

The instrument accepts and executes bus commands while in the local mode with all front-panel controls active.

The instrument is placed in the remote mode when the controller sets the Remote Enable (REN) bus control line true and addresses the instrument to listen. In the remote mode, all controls except the power switch and the front-panel LOCAL key are entirely locked out. Local control can only be restored by the controller or by pressing the front-panel LOCAL key.

Cycling the power also restores all front-panel controls (local mode), but this also resets certain HP-IB states.

The Local Lockout command (LLO) disables all front-panel controls including the LOCAL key. The only active control is the power switch. This prevents undesired or accidental front-panel control which could result in data or settings being changed. The instrument accepts the Local Lockout command whether the instrument is addressed in the remote or local mode. The instrument is returned to the local mode by either setting the REN line false, or by sending the go-to-local command (GTL) to the instrument.

Bus Commands

The following commands are IEEE 488.1 bus commands (ATN true). IEEE 488.2 defines many of the actions that are taken when these commands are received by the instrument.

Device Clear

The device clear (DCL) and selected device clear (SDC) commands clear the input buffer and output queue, reset the parser, and clear any pending commands. If either of these commands is sent during a digitize operation, the digitize operation is aborted.

Group Execute Trigger

The group execute trigger (GET) command arms the trigger. This is the same action produced by sending the RUN command.

Interface Clear

The interface clear (IFC) command halts all bus activity. This includes unaddressing all listeners and the talker, disabling serial poll on all devices, and returning control to the system controller.

Status Messages

When the instrument is in the remote mode, the Remote message is displayed on the oscilloscope screen.

**Message
Communication
and System
Functions**

Message Communication and System Functions

This chapter describes the operation of instruments that operate in compliance with the IEEE 488.2 (syntax) standard. It is intended to give you enough basic information about the IEEE 488.2 Standard to successfully program the instrument. You can find additional detailed information about the IEEE 488.2 Standard in ANSI/IEEE Std 488.2-1987, *“IEEE Standard Codes, Formats, Protocols, and Common Commands.”*

This instrument series is designed to be compatible with other Hewlett-Packard IEEE 488.2 compatible instruments. Instruments that are compatible with IEEE 488.2 must also be compatible with IEEE 488.1 (HP-IB bus standard); however, IEEE 488.1 compatible instruments may or may not conform to the IEEE 488.2 standard. The IEEE 488.2 standard defines the message exchange protocols by which the instrument and the controller will communicate. It also defines some common capabilities that are found in all IEEE 488.2 instruments. This chapter also contains a few items which are not specifically defined by IEEE 488.2, but which deal with message communication or system functions.

Protocols

The message exchange protocols of IEEE 488.2 define the overall scheme used by the controller and the instrument to communicate. This includes defining when it is appropriate for devices to talk or listen, and what happens when the protocol is not followed.

Functional Elements

Before proceeding with the description of the protocol, a few system components should be understood.

Input Buffer The input buffer of the instrument is the memory area where commands and queries are stored prior to being parsed and executed. It allows a controller to send a string of commands, which could take some time to execute, to the instrument, and then proceed to talk to another instrument while the first instrument is parsing and executing commands.

Output Queue The output queue of the instrument is the memory area where all output data (<response messages>) are stored until read by the controller.

Parser The instrument's parser is the component that interprets the commands sent to the instrument and decides what actions should be taken. "Parsing" refers to the action taken by the parser to achieve this goal. Parsing and executing of commands begins when either the instrument recognizes a <program message terminator> (defined later in this chapter) or the input buffer becomes full. If you wish to send a long sequence of commands to be executed and then talk to another instrument while they are executing, you should send all the commands before sending the <program message terminator>.

Protocol Overview

The instrument and controller communicate using <program message>s and <response message>s. These messages serve as the containers into which sets of program commands or instrument responses are placed. <program message>s are sent by the controller to the instrument, and <response message>s are sent from the instrument to the controller in response to a query message. A <query message> is defined as being a <program message> that contains one or more queries. The instrument will only talk when it has received a valid query message, and therefore has something to

Message Communication and System Functions Protocols

say. The controller should only attempt to read a response after sending a complete query message, but before sending another <program message>. The basic rule to remember is that the instrument will only talk when prompted to, and it then expects to talk before being told to do something else.

Protocol Operation

When the instrument is turned on, the input buffer and output queue are cleared, and the parser is reset to the root level of the command tree.

The instrument and the controller communicate by exchanging complete <program message>s and <response message>s. This means that the controller should always terminate a <program message> before attempting to read a response. The instrument will terminate <response message>s except during a hardcopy output.

If a query message is sent, the next message passing over the bus should be the <response message>. The controller should always read the complete <response message> associated with a query message before sending another <program message> to the same instrument.

The instrument allows the controller to send multiple queries in one query message. This is referred to as sending a "compound query." As noted later in this chapter, multiple queries in a query message are separated by semicolons. The responses to each of the queries in a compound query will also be separated by semicolons.

Commands are executed in the order they are received.

Protocol Exceptions

If an error occurs during the information exchange, the exchange may not be completed in a normal manner. The following are some of the protocol exceptions.

Command Error A command error is reported if the instrument detects a syntax error or an unrecognized command header.

Execution Error An execution error is reported if a parameter is found to be out of range, or if the current settings do not allow execution of a requested command or query.

Device-specific Error A device-specific error is reported if the instrument is unable to execute a command for a strictly device dependent reason.

Query Error A query error is reported if the proper protocol for reading a query is not followed. This includes the interrupted and unterminated conditions described in the following paragraphs.

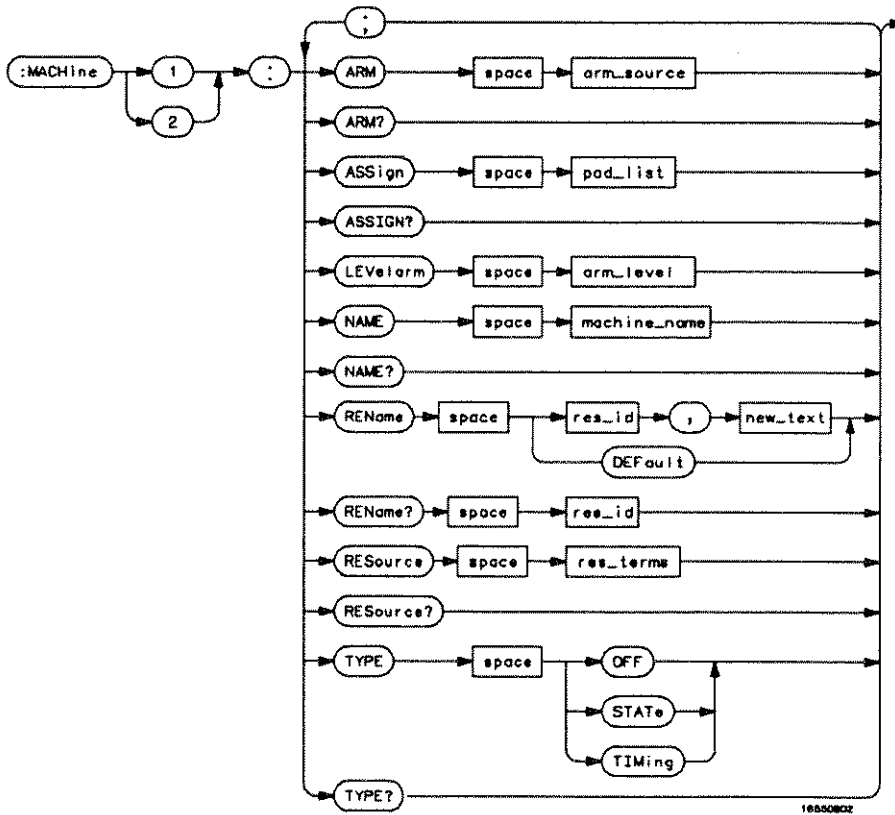
Syntax Diagrams

The example syntax diagrams in this chapter are similar to the syntax diagrams in the IEEE 488.2 specification. Commands and queries are sent to the instrument as a sequence of data bytes. The allowable byte sequence for each functional element is defined by the syntax diagram that is shown.

The allowable byte sequence can be determined by following a path in the syntax diagram. The proper path through the syntax diagram is any path that follows the direction of the arrows. If there is a path around an element, that element is optional. If there is a path from right to left around one or more elements, that element or those elements may be repeated as many times as desired.

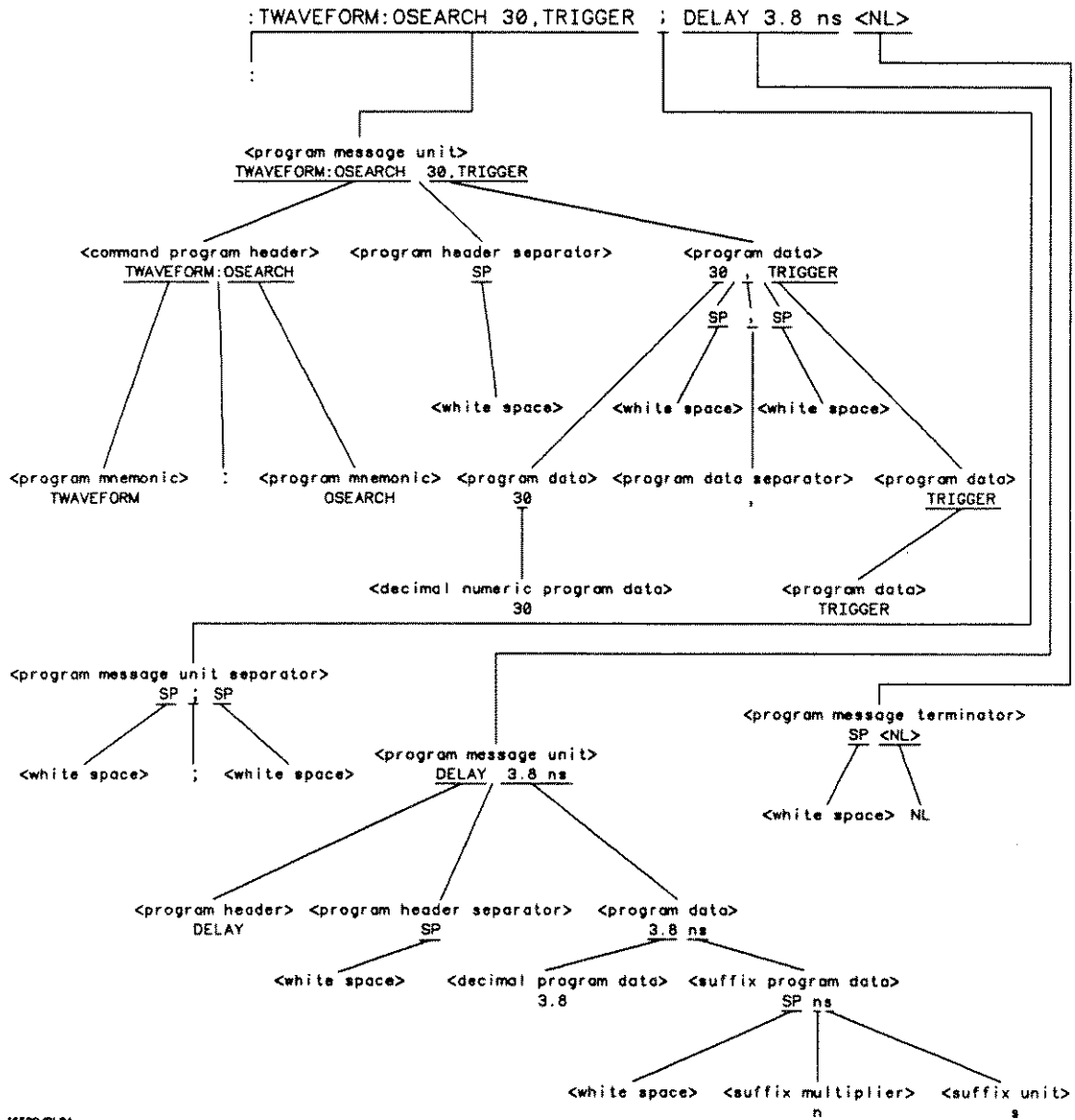
**Message Communication and System Functions
Syntax Diagrams**

Figure 3-1



Example Syntax Diagram

Figure 3-2



16500/BL31

<program message> Parse Tree

Syntax Overview

This overview is intended to give a quick glance at the syntax defined by IEEE 488.2. It will help you understand many of the things about the syntax you need to know.

IEEE 488.2 defines the blocks used to build messages that are sent to the instrument. A whole string of commands can therefore be broken up into individual components.

Figure 3-1 is an example syntax diagram and figure 3-2 shows a breakdown of an example <program message> in the parse tree. There are a few key items to notice:

- A semicolon separates commands from one another. Each <program message unit> serves as a container for one command. The <program message unit>s are separated by a semicolon.
- A <program message> is terminated by a <NL> (new line). The recognition of the <program message terminator>, or <PMT>, by the parser serves as a signal for the parser to begin execution of commands. The <PMT> also affects instrument command tree traversal.
- Multiple data parameters are separated by a comma.
- The first data parameter is separated from the header with one or more spaces.
- The header MACHINE1:ASSIGN 2,3 is an example of a compound header. It places the parser in the machine subsystem until the <NL> is encountered.
- A colon preceding the command header returns you to the top of the parser tree.

Upper/Lower Case Equivalence

Upper and lower case letters are equivalent. The mnemonic **SINGLE** has the same semantics as the mnemonic **single**.

<white space>

<white space> is defined to be one or more characters from the ASCII set of 0 - 32 decimal, excluding 10 decimal (NL). <white space> is used by several instrument listing components of the syntax. It is usually optional, and can be used to increase the readability of a program.

Suffix Multiplier The suffix multipliers that the instrument will accept are shown in table 3-1.

Table 3-1

<suffix mult>

Value	Mnemonic
1E18	EX
1E15	PE
1E12	T
1E9	G
1E6	MA
1E3	K
1E-3	M
1E-6	U
1E-9	N
1E-12	P
1E-15	F
1E-18	A

**Message Communication and System Functions
Syntax Overview**

Suffix Unit The suffix units that the instrument will accept are shown in table 3-2.

Table 3-2

<suffix unit>

Suffix	Referenced Unit
V	Volt
S	Second

Status Reporting

Status Reporting

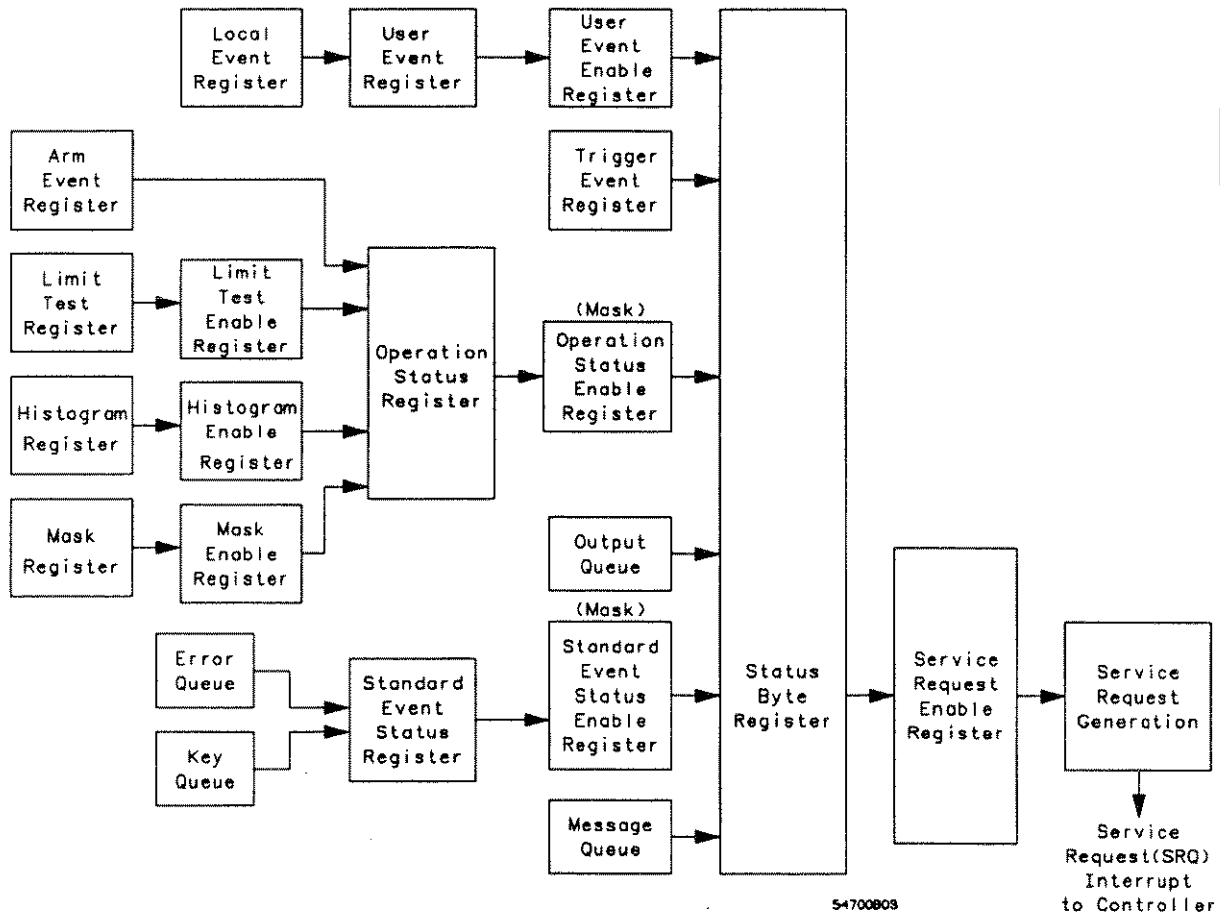
Figure 4-1 is an overview of the oscilloscope's status reporting structure. The status reporting structure allows monitoring specified events in the oscilloscope. The ability to monitor and report these events allows determination of such things as the status of an operation, the availability and reliability of the measured data, and more.

- To monitor an event, first clear the event, then enable the event. All of the events are cleared when you initialize the instrument.
- To generate a service request (SRQ) interrupt to an external controller, enable at least one bit in the Status Byte Register.

The Status Byte Register, the Standard Event Status Register group, and the Output Queue are defined as the Standard Status Data Structure Model in IEEE 488.2-1987.

IEEE 488.2 defines data structures, commands, and common bit definitions for status reporting. There are also instrument-defined structures and bits.

Figure 4-1



Status Reporting Overview Block Diagram

The status reporting structure consists of the registers in figure 4-1.

Table 4-1 is a list of the bit definitions for the bit in the status reporting data structure.

Status Reporting

Table 4-1

Status Reporting Bit Definition

Bit	Description	Definition
PON	Power On	Indicates power is turned on.
URQ	User Request	Indicates whether a front-panel key has been pressed.
CME	Command Error	Indicates whether the parser detected an error.
EXE	Execution Error	Indicates whether a parameter was out of range, or inconsistent with the current settings.
DDE	Device Dependent Error	Indicates whether the device was unable to complete an operation for device dependent reasons.
QYE	Query Error	Indicates if the protocol for queries has been violated.
RQL	Request Control	Indicates whether the device is requesting control.
OPC	Operation Complete	Indicates whether the device has completed all pending operations.
OPER	Operation Status Register	Indicates if any of the enabled conditions in the Operation Status Register have occurred.
RQS	Request Service	Indicates that the device is requesting service.
MSS	Master Summary Status	Indicates whether a device has a reason for requesting service.
ESB	Event Status Bit	Indicates if any of the enabled conditions in the Standard Event Status Register have occurred.
MAV	Message Available	Indicates if there is a response in the output queue.
MSG	Message	Indicates whether an advisory has been displayed.
USR	User Event Register	Indicates if any of the enabled conditions have occurred in the User Event Register.
TRG	Trigger	Indicates whether a trigger has been received.
LCL	Local	Indicates if a remote-to-local transition occurs.
FAIL	Fail	Indicates that the specified test has failed.
COMP	Complete	Indicates that the specified test has completed.
LTEST	Limit Test	Indicates if any of the enabled conditions have occurred in the Limit Test Register.
MTEST	Mask Test	Indicates if any of the enabled conditions have occurred in the Mask Test Register.
HIST	Histogram	Indicates if any of the enabled conditions have occurred in the Histogram Register.
WAIT TRIG	Wait for Trigger	Indicates instrument is armed and ready for trigger.

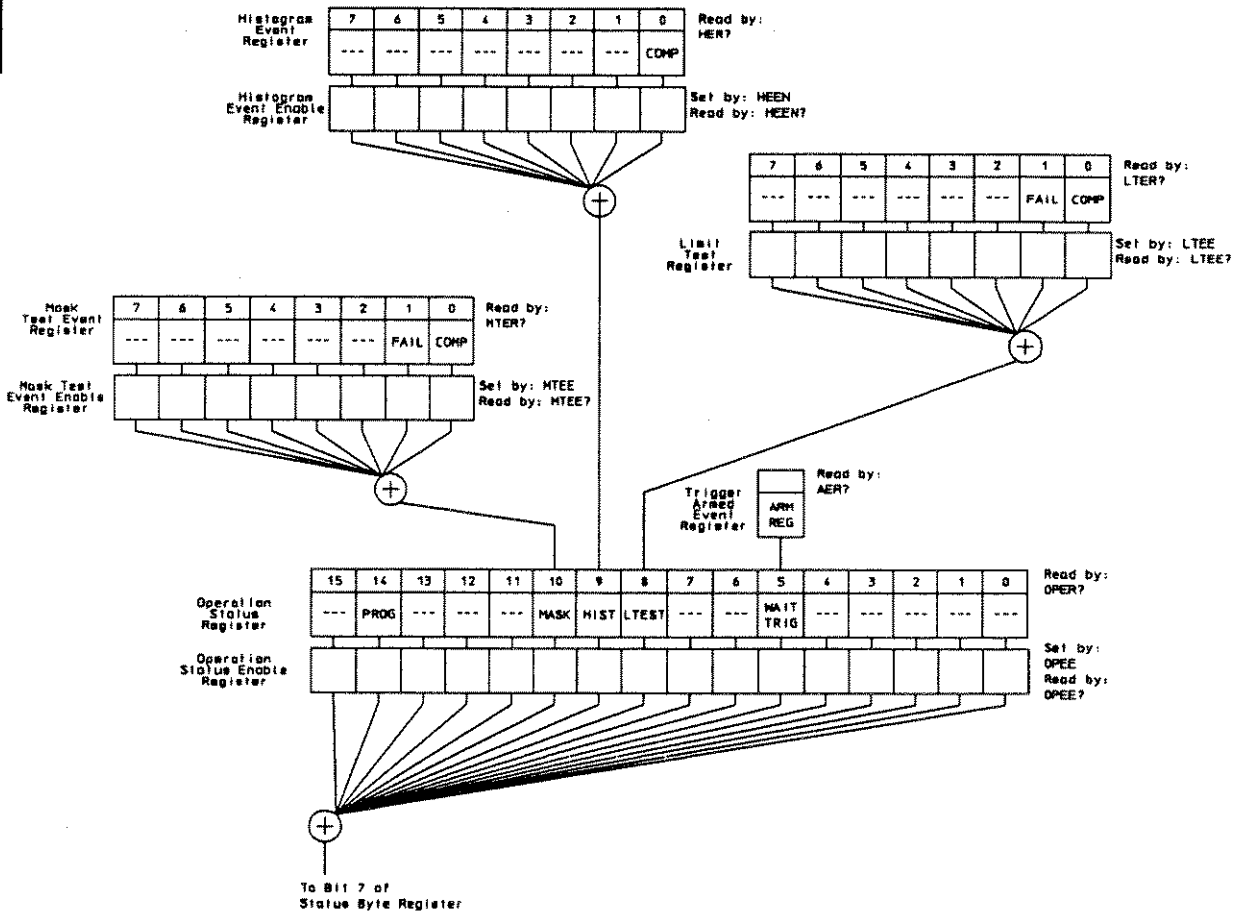
Status Reporting Data Structures

Figure 4-2 brings together the different status reporting data structures mentioned in this chapter and shows how they work together. To make it possible for any of the Standard Event Status Register bits to generate a summary bit, the bits must be enabled. These bits are enabled by using the *ESE common command to set the corresponding bit in the Standard Event Status Enable Register.

To generate a service request (SRQ) interrupt to an external controller, at least one bit in the Status Byte Register must be enabled. These bits are enabled by using the *SRE common command to set the corresponding bit in the Service Request Enable Register. These enabled bits can then set RQS and MSS (bit 6) in the Status Byte Register.

Status Reporting Status Reporting Data Structures

Figure 4-2

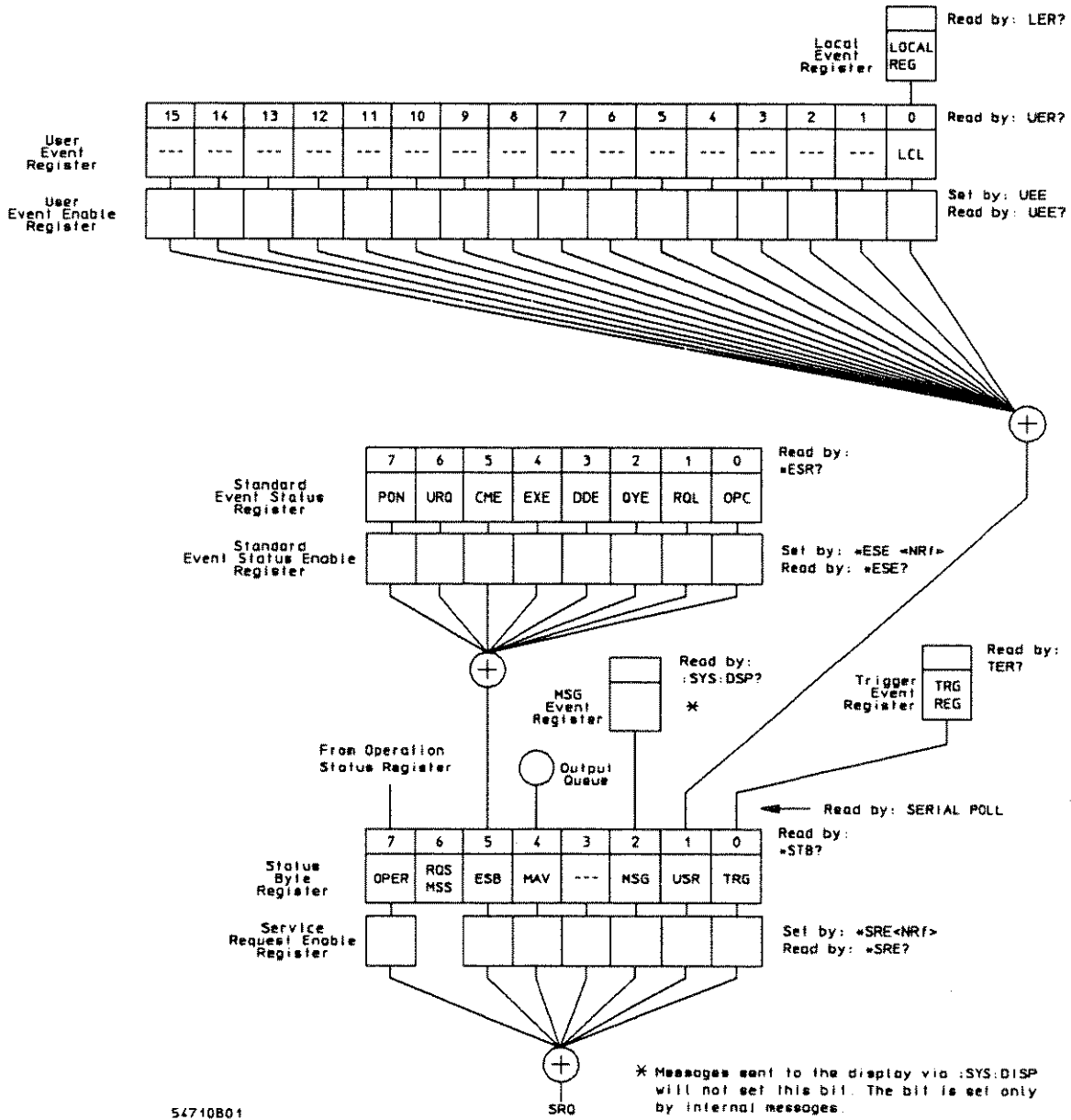


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Status Reporting Data Structures

Status Reporting Status Reporting Data Structures

Figure 4-2 (continued)



54710801

Status Reporting Data Structures (continued)

Status Byte Register

The Status Byte Register is the summary-level register in the status reporting structure. It contains summary bits that monitor activity in the other status registers and queues. The Status Byte Register is a live register. That is, its summary bits are set and cleared by the presence and absence of a summary bit from other event registers or queues.

If the Status Byte Register is to be used with the Service Request Enable Register to set bit 6 (RQS/MSS) and to generate an SRQ, at least one of the summary bits must be enabled, then set. Also, event bits in all other status registers must be specifically enabled to generate the summary bit that sets the associated summary bit in the Status Byte Register.

The Status Byte Register can be read using either the *STB? Common Command or the HP-IB serial poll command. Both commands return the decimal-weighted sum of all set bits in the register. The difference between the two methods is that the serial poll command reads bit 6 as the Request Service (RQS) bit and clears the bit which clears the SRQ interrupt. The *STB? command reads bit 6 as the Master Summary Status (MSS) and does not clear the bit or have any affect on the SRQ interrupt. The value returned is the total bit weights of all of the bits that are set at the present time.

The use of bit 6 can be confusing. This bit was defined to cover all possible computer interfaces, including a computer that could not do a serial poll. The important point to remember is that, if you are using an SRQ interrupt to an external computer, the serial poll command clears bit 6. Clearing bit 6 allows the oscilloscope to generate another SRQ interrupt when another enabled event occurs.

No other bits in the Status Byte Register are cleared by either the *STB? query or the serial poll, except the Message Available bit (bit 4). If there are no other messages in the Output Queue, bit 4 (MAV) can be cleared as a result of reading the response to the *STB? command.

If bit 4 (weight = 16) and bit 5 (weight = 32) are set, the program prints the sum of the two weights. Since these bits were not enabled to generate an SRQ, bit 6 (weight = 64) is not set.

Example 1

The following example uses the *STB? query to read the contents of the oscilloscopes Status Byte Register when none of the register's summary bits are enabled to generate an SRQ interrupt.

```
10 OUTPUT 707;":SYSTEM:HEADER OFF;*STB?"      !Turn headers off
20 ENTER 707;Result      !Place result in a numeric variable
30 PRINT Result         !Print the result
40 End
```

The next program prints 112 and clears bit 6 (RQS) of the Status Byte Register. The difference in the decimal value between this example and the previous one is the value of bit 6 (weight = 64). Bit 6 is set when the first enabled summary bit is set and is cleared when the Status Byte Register is read by the serial poll command.

Example 2

The following example uses the HP BASIC serial poll (SPOLL) command to read the contents of the oscilloscopes Status Byte Register.

```
10 Result = SPOLL(707)
20 PRINT Result
30 END
```

Serial polling is the preferred method to read the contents of the Status Byte Register because it resets bit 6 and allows the next enabled event that occurs to generate a new SRQ interrupt.

Service Request Enable Register

Setting the Service Request Enable Register bits enable corresponding bits in the Status Byte Register. These enabled bits can then set RQS and MSS (bit 6) in the Status Byte Register.

Bits are set in the Service Request Enable Register using the *SRE command and the bits that are set are read with the *SRE? query.

Refer to figure 4-2.

Example

The following example sets bit 4 (MAV) and bit 5 (ESB) in the Service Request Enable Register.

```
OUTPUT 707; **SRE 48"
```

This example uses the parameter "48" to enable the oscilloscope to generate an SRQ interrupt under the following conditions:

- When one or more bytes in the Output Queue set bit 4 (MAV).
- When an enabled event in the Standard Event Status Register generates a summary bit that sets bit 5 (ESB).

Trigger Event Register (TRG)

This register sets the TRG bit in the status byte when a trigger event occurs. The TRG event register stays set until it is cleared by reading the register or using the *CLS command. If your application needs to detect multiple triggers, the TRG event register must be cleared after each one.

If you are using the Service Request to interrupt a program or controller operation when the trigger bit is set, then you must clear the event register after each time it has been set.

Standard Event Status Register

The Standard Event Status Register (SESR) monitors the following oscilloscope status events:

- PON - Power On,
- URQ - User Request,
- CME - Command Error,
- EXE - Execution Error,
- DDE - Device Dependent Error,
- QYE - Query Error,
- RQC - Request Control, and
- OPC - Operation Complete.

When one of these events occur, the event sets the corresponding bit in the register. If the bits are enabled in the Standard Event Status Enable Register, the bits set in this register generate a summary bit to set bit 5 (ESB) in the Status Byte Register.

The contents of the Standard Event Status Register can be read and the register cleared by sending the *ESR? query. The value returned is the total bit weights of all of the bits that are set at the present time.

Example

The following example uses the *ESR query to read the contents of the Standard Event Status Register.

```
10 OUTPUT 707;":SYSTEM:HEADER OFF"      !Turn headers off
20 OUTPUT 707;"*ESR?"
30 ENTER 707;Result      !Place result in a numeric variable
40 PRINT Result          !Print the result
50 End
```

If bit 4 (weight = 16) and bit 5 (weight = 32) are set, the program prints the sum of the two weights.

Status Reporting
Standard Event Status Enable Register

Standard Event Status Enable Register

To make it possible for any of the Standard Event Status Register (SESR) bits to be able to generate a summary bit, first enable the bit. Enable the bit by using the *ESE (Event Status Enable) common command to set the corresponding bit in the Standard Event Status Enable Register.

Set bits are read with the *ESE? query.

Example

For example, suppose your application requires an interrupt whenever any type of error occurs. The error related bits in the Standard Event Status Register are bits 2 through 5. The sum of the decimal weights of these bits is 60. Therefore, you can enable any of these bits to generate the summary bit by sending:

```
OUTPUT 707; "*ESE 60"
```

Whenever an error occurs, it sets one of these bits in the Standard Event Status Register. Because the bits are all enabled, a summary bit is generated to set bit 5 (ESB) in the Status Byte Register.

If bit 5 (ESB) in the Status Byte Register is enabled (via the *SRE command), an SRQ service request interrupt is sent to the external computer.

Standard Event Status Register bits that are not enabled still respond to their corresponding conditions (that is, they are set if the corresponding event occurs). However, because they are not enabled, they do not generate a summary bit to the Status Byte Register.

User Event Register (UER)

This register hosts the LCL bit (bit 0) from the Local Event Register. The other 15 bits are reserved. You can read and clear this register using the UER? query. This register is enabled with the UEE command. For example, if you want to enable the LCL bit, you send a mask value of 1 with the UEE command; otherwise, send a mask value of 0.

Local Event Register (LCL)

This register sets the LCL bit in the User Event Register and the USR bit (bit 1) in the status byte. It indicates a remote-to-local transition has occurred. The LER? query is used to read and to clear this register.

Operation Status Register (OPR)

This register hosts the WAIT TRIG bit (bit 5), the LTEST bit (bit 8), the HIST bit (bit 9), the MASK bit (bit 10), and the PROG bit (bit 14).

The WAIT TRIG bit is set by the Trigger Armed Event Register and indicates that the trigger is armed.

The LTEST bit is set when a limit test fails or is completed and sets the corresponding FAIL or COMP bits in the Limit Test Event Register.

The HIST bit is set when the COMP bit is set in the Histogram Event Register, indicating that the **histogram** measurement has satisfied the specified completion criteria.

The MASK bit is set when the Mask Test either fails specified conditions or satisfies its completion criteria, setting the corresponding FAIL or COMP bits in the Mask Test Event Register.

The PROG bit is reserved for future use.

If any of these bits are set, the OPER bit (bit 7) of the Status Byte Register is set. The Operation Status Register is read and cleared with the OPER? query. The register output is enabled or disabled using the mask value supplied with the OPEE command.

Status Reporting
Limit Test Event Register (LTER)

Limit Test Event Register (LTER)

Bit 0 (COMP) of the Limit Test Event Register is set when the Limit Test completes. The Limit Test completion criteria are set by the LTEST:RUN command.

Bit 1 (FAIL) of the Limit Test Event Register is set when the Limit Test fails. Failure criteria for the Limit Test are defined by the LTEST:FAIL command.

The Limit Test Event Register is read and cleared with the LTER? query.

When either the COMP or FAIL bits are set, they in turn set the LTEST bit (bit 8) of the Operation Status Register. You can mask the COMP and FAIL bits, thus preventing them from setting the LTEST bit, by defining a mask using the LTEE command.

Enable	Mask Value
Block COMP and FAIL	0
Enable COMP, block FAIL	1
Enable FAIL, block COMP	2
Enable COMP and FAIL	3

Mask Test Event Register

Bit 0 (COMP) of the Mask Test Event Register is set when the Mask Test completes. The Mask Test completion criteria are set by the MTEST:RUMode command.

Bit 1 (FAIL) of the Mask Test Event Register is set when the Mask Test fails. This will occur whenever any sample is recorded within any polygon defined in the mask.

The Mask Test Event Register is read and cleared with the MTER? query.

When either the COMP or FAIL bits are set, they in turn set the MASK bit (bit 10) of the Operation Status Register. You can mask the COMP and FAIL bits, thus preventing them from setting the MASK bit, by defining a mask using the MTEE command.

Enable	Mask Value
Block COMP and FAIL	0
Enable COMP, block FAIL	1
Enable FAIL, block COMP	2
Enable COMP and FAIL	3

Histogram Event Register

Bit 0 (COMP) of the Histogram Event Register is set when the Histogram completes. The Histogram completion criteria are set by the HISTogram:RUNTil command. The Histogram Event Register is read and cleared with the HER? query.

When the COMP bit is set, it in turn sets the HIST bit (bit 9) of the Operation Status Register. Results from the Histogram Register can be masked by using the HEEN command to set the Histogram Event Enable Register to the value 0. You enable the COMP bit by setting the mask value to 1.

Arm Event Register (ARM)

This register sets bit 5 (Wait Trig bit) in the Operation Status Register and the OPER bit (bit 7) in the Status Byte Register when the instrument becomes armed.

The ARM event register stays set until it is cleared by reading the register with the AER? query or using the *CLS command. If your application needs to detect multiple triggers, the ARM event register must be cleared after each one.

If you are using the Service Request to interrupt a program or controller operation when the trigger bit is set, then you must clear the event register after each time it has been set.

Error Queue

As errors are detected, they are placed in an error queue. This queue is first in, first out. If the error queue overflows, the last error in the queue is replaced with error -350, "Queue overflow." Any time the queue overflows, the least recent errors remain in the queue, and the most recent error is discarded. The length of the oscilloscope's error queue is 30 (29 positions for the error messages, and 1 position for the "Queue overflow" message).

The error queue is read with the `SYSTEM:ERROR?` query. Executing this query reads and removes the oldest error from the head of the queue, which opens a position at the tail of the queue for a new error. When all the errors have been read from the queue, subsequent error queries return 0, "No error."

The error queue is cleared when any of the following items occur:

- When the instrument is powered up.
- When the instrument receives the `*CLS` common command.
- When the last item is read from the error queue.

For more information on reading the error queue, refer to the `SYSTEM:ERROR?` query in the System Commands chapter. For a complete list of error messages, refer to the chapter, "Error Messages."

Output Queue

The output queue stores the oscilloscope-to-controller responses that are generated by certain instrument commands and queries. The output queue generates the Message Available summary bit when the output queue contains one or more bytes. This summary bit sets the MAV bit (bit 4) in the Status Byte Register.

The output queue may be read with the HP Basic ENTER statement.

Message Queue

The message queue contains the text of the last message written to the advisory line on the screen of the oscilloscope. The length of the oscilloscope's message queue is 1. The queue is read with the SYSTEM:DSP? query. Note that messages sent with the SYSTem:DSP command do not set the MSG status bit in the Status Byte Register.

Key Queue

The key queue contains the key codes for the last 10 keys pressed on the front panel. This queue is first in, first out. If the key queue overflows, the oldest key codes are discarded as additional keys are pressed. The key queue is read with the SYSTEM:KEY? query.

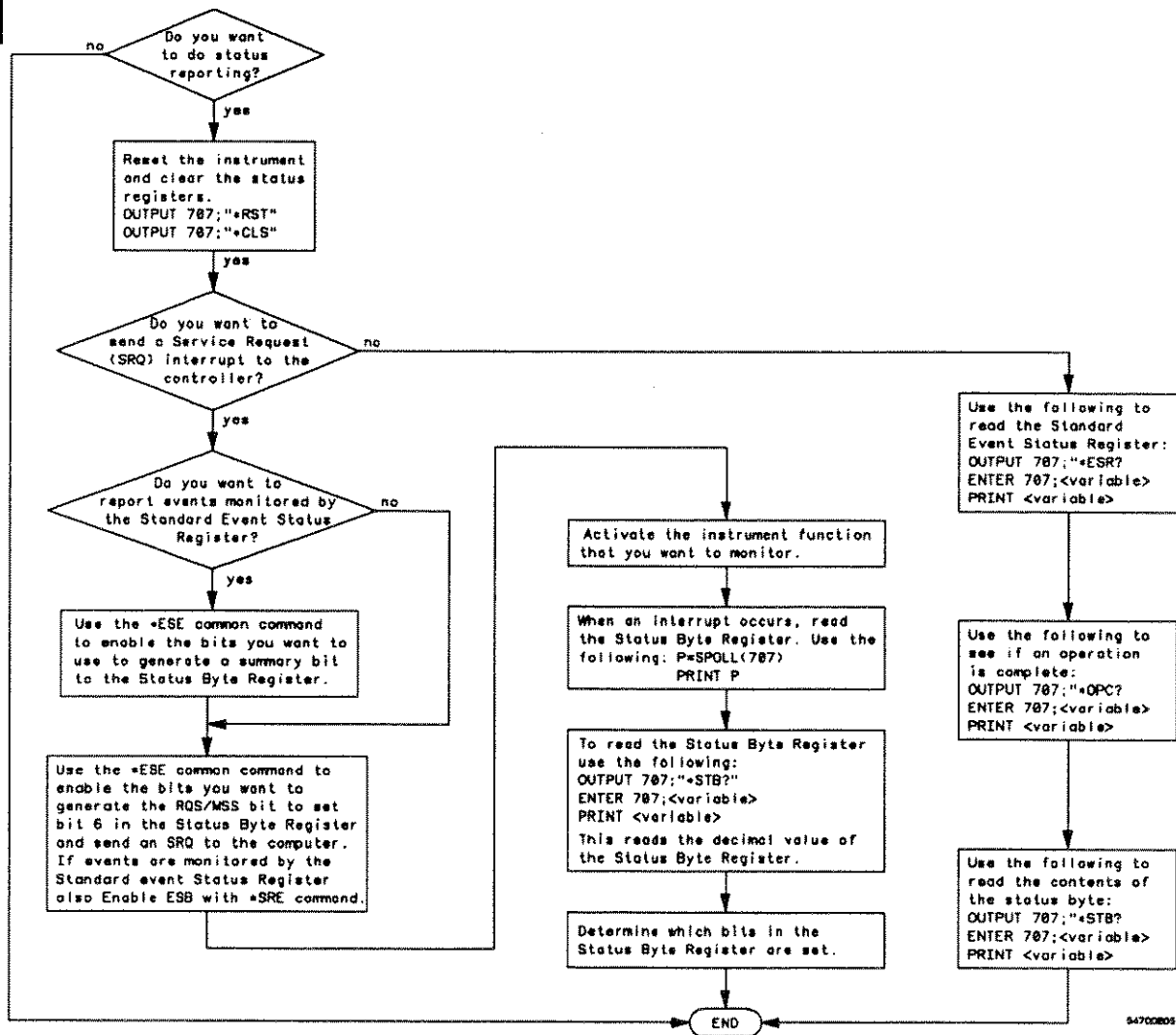
Clearing Registers and Queues

The *CLS common command clears all event registers and all queues except the output queue. If *CLS is sent immediately following a program message terminator, the output queue is also cleared.

Status Reporting Clearing Registers and Queues

Figure 4-3

Status Reporting Decision Chart



**Programming
Syntax**

Programming Syntax

Computers acting as controllers communicate with the oscilloscope by sending and receiving program messages over a remote interface. Program messages are placed on the bus using an input or output command and passing the device address, instruction, and terminator. Passing the device address ensures that the instruction is sent to the correct interface and instrument. Instructions for programming the oscilloscope normally appear as ASCII character strings embedded inside the output statement of a "host" language available on your controller. Responses from the oscilloscope are read with the input statements of the host language.

HP BASIC Output Statement

HP 9000 Series 200/300 BASIC uses the OUTPUT statement for sending commands and queries to the oscilloscope.

Figure 5-1

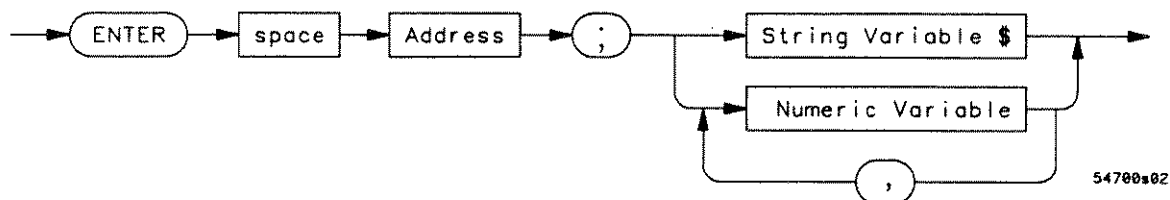


HP Basic Syntax for Sending Program Messages

HP BASIC Enter Statement

After a query is sent, the response is usually read using the HP BASIC ENTER statement. The ENTER statement passes the value across the bus to the controller and places it in the designated variable.

Figure 5-2



HP Basic Syntax for Receiving Responses

Device Address

The examples in this manual assume the oscilloscope is at device address 707. In HP BASIC, the address is specified after the keyword OUTPUT or ENTER. In actual programs, the number you use varies according to how you have configured the bus for your application.

Instructions

Instructions can be sent to the oscilloscope in either the long form (complete spelling) or the short form (abbreviated spelling). Upper-case and lower-case letters may be mixed freely. When receiving responses from the instrument, upper-case letters are used exclusively. The use of the long form or short form in a response depends on the setting you last specified with the SYSTEM:LONGFORM command.

Instructions are composed of two main parts:

- The header, which specifies the command or query to be sent.
- The program data, which provide additional information needed to clarify the meaning of the instruction.

Instruction Header

Colons

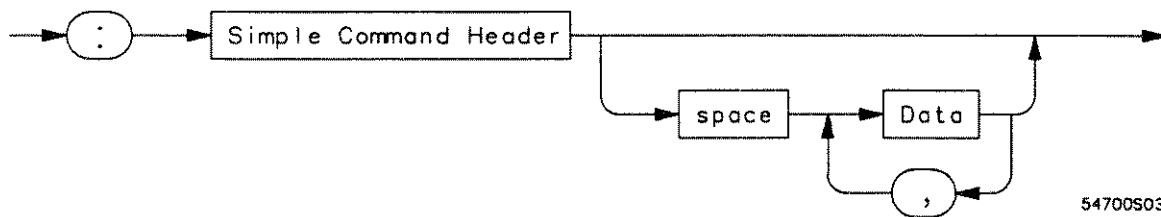
The instruction header is one or more mnemonics separated by colons (:) that represent the operation to be performed by the instrument. There are three types of headers:

- Simple Command headers.
- Compound Command headers.
- Common Command headers.

Simple Command Headers

Simple command headers contain a single mnemonic. AUTOSCALE and DIGITIZE are examples of simple command headers typically used in this oscilloscope.

Figure 5-3

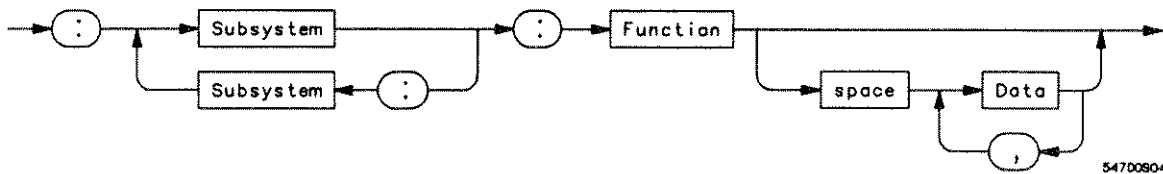


Simple Command Syntax

Compound Command Headers

Compound command headers are a combination of two or more program mnemonics. The first mnemonic selects the subsystem, and the last mnemonic selects the function within the subsystem. Additional mnemonics may appear between the subsystem mnemonic and the function mnemonic when there are additional levels within the subsystem that must be transversed. The mnemonics within the compound header are separated by colons. An example of a compound header is :SYSTEM:LONGFORM.

Figure 5-4

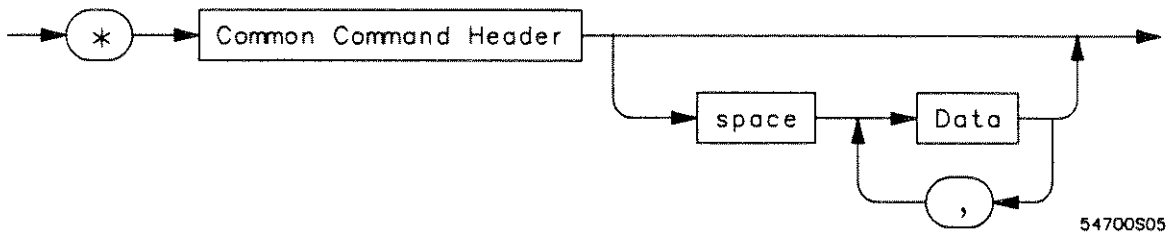


Compound Command Syntax

Common Command Headers

Common command headers control IEEE 488.2 functions within the instrument such as clearing the status (*CLS). No space or separator is allowed between the asterisk (*) and the command header.

Figure 5-5



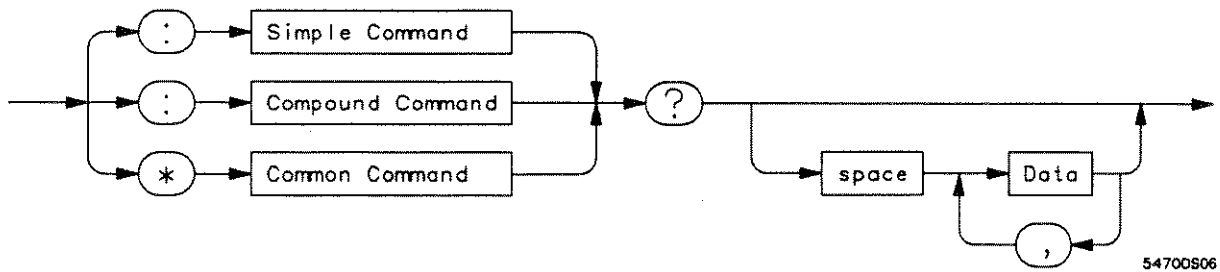
Common Command Syntax

Queries

Headers immediately followed by a question mark (?) are queries. After receiving a query, the instrument interrogates the required function and places the answer in its output queue. The answer remains in the output queue until it is read or another command is issued. When read, the answer is transmitted across the bus to the designated listener (typically a controller). For example, the query :TIMEBASE:RANGE? places the current time base setting in the output queue.

Sending another command or query before reading the result of a query causes the output queue to be cleared and the current response to be lost. This also generates an error in the error queue.

Figure 5-6



Query Syntax

Queries can be used to find out how the instrument is currently configured. They are also used to get results of measurements made by the oscilloscope, with the query actually activating the measurement.

Program Data

Program data are used to clarify the meaning of a command or query. They provide necessary information such as whether a function should be on or off, which waveform is to be displayed, and more.

Spaces and Commas

A space separates the header from the data. When there is more than one data parameter, the data parameters are separated by commas (,).

Character Program Data

Character program data is used to convey parameter information as alpha or alphanumeric strings. The available mnemonics for program data are listed with the individual commands in this manual.

Numeric Program Data

With numeric program data, you have the option of using exponential notation or using suffix multipliers to indicate a numeric value. The following numbers are all equal:

$$28 = 0.28E2 = 280E-1 = 28000m = 0.028K = 28E-3K$$

When a syntax definition specifies that a number is an integer, that means the number should be whole without any fractional part or decimal point.

Embedded Strings

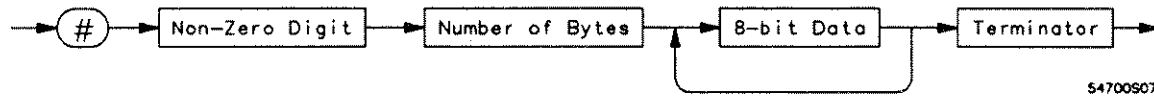
Embedded strings contain groups of alphanumeric characters that are treated as a unit of data by the oscilloscope. For example, the line of text written to the advisory line of the oscilloscope with the :SYSTEM:DSP command. Embedded strings may be delimited with either single (') or double (") quotes. These strings are case-sensitive and spaces act as legal characters just like any other character.

Programming Syntax Program Data

Block Data

Definite-length block response data (block data) allows any type of device-dependent data to be transmitted over the bus as a series of 8-bit binary data bytes. This is particularly useful for sending large quantities of data or 8-bit extended ASCII codes. The syntax is a pound sign (#) followed by a non-zero digit representing the number of digits in the decimal integer. After the non-zero digit is a decimal integer that states the number of 8-bit data bytes being sent. This is followed by the actual data.

Figure 5-7



Block Data Syntax

For example, for transmitting 500 bytes of data, the syntax would be:

#3500<500 bytes of data><terminator>

The "3" states the number of digits that follow, and the "500" states the number of bytes to be transmitted.

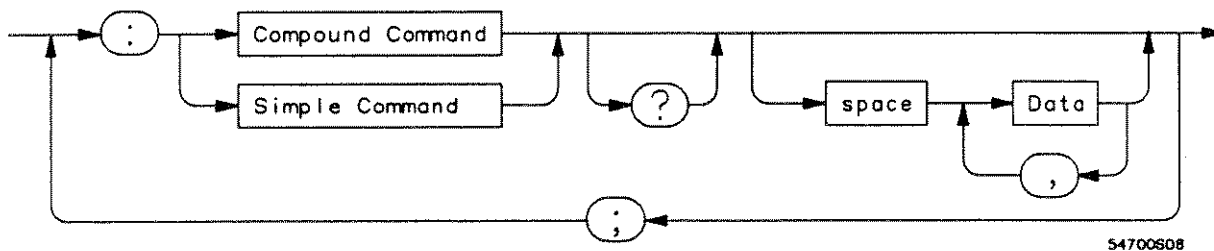
Multiple Subsystems

Semi-Colon

You can send multiple instructions (commands and queries) for different subsystems on the same line by separating each instruction with a semi-colon (;). The colon following the semi-colon enables you to enter a new subsystem (for example :CHANNEL1:RANGE 0.4;:TIMEBASE:RANGE 1).

Multiple instructions may be any combination of compound and simple commands.

Figure 5-8



54700S08

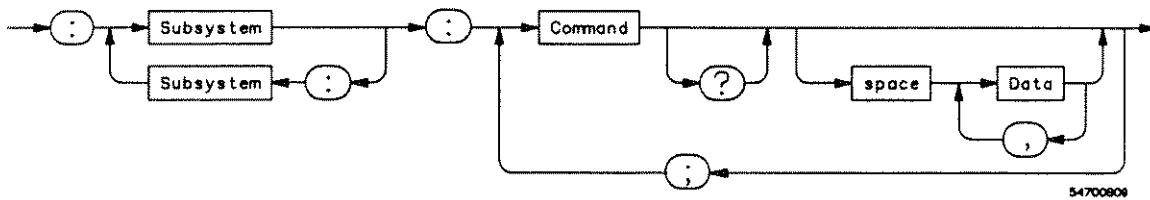
Selecting Multiple Subsystems

Multiple Functions within a Subsystem

Semi-Colon

To execute more than one function within the same subsystem, separate each function with a semi-colon (;). For example :SYSTEM:LONGFORM ON;HEADER ON turns the long form on and the headers on.

Figure 5-9



Selecting Multiple Functions within a Subsystem

Common Commands within a Subsystem

Common commands can be received and processed by the oscilloscope whether they are sent over the bus as separate program messages or within other program messages. If a subsystem has been selected and a common command is received by the oscilloscope, the instrument remains in the selected subsystem. For example, if the program message

```
" :ACQUIRE:TYPE AVERAGE;*CLS;COUNT 1024 "
```

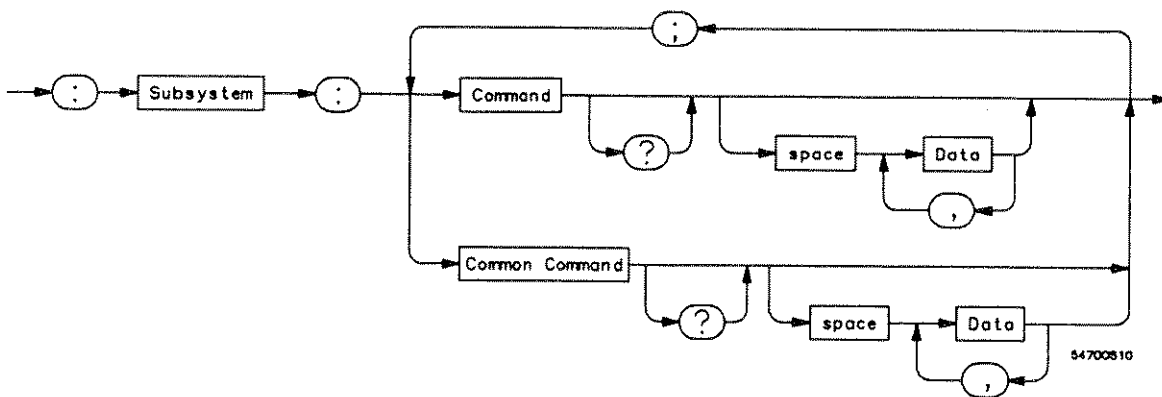
is received by the oscilloscope, the oscilloscope sets the acquire type and count, then clears the status information without leaving the selected subsystem.

If some other type of command is received within a program message, you must reenter the original subsystem after the command. For example, the program message

```
" ACQUIRE:TYPE AVERAGE; :AUTOSCALE; ACQUIRE:COUNT 1024 "
```

sets the acquire type, completes the autoscale operation, then sets the acquire count. In this example, :ACQUIRE must be sent again after the AUTOSCALE command in order to reenter the acquire subsystem and set count.

Figure 5-10

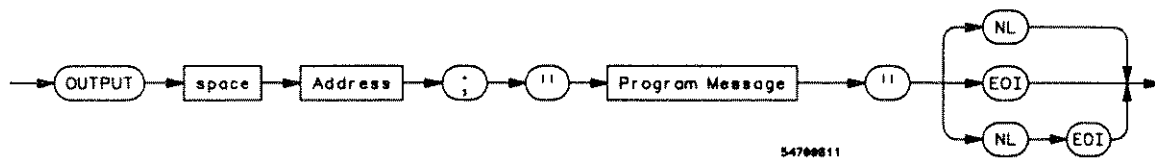


Selecting Common Commands within a Subsystem

Instruction Terminator

The instructions within the program message are executed after the instruction terminator is received. The terminator may be either a New Line (NL) character, and End-Of-Identify (EOI) asserted, or a combination of the two. All three ways are equivalent. Asserting the EOI sets the EOI control line low on the last byte of the data message. The NL character is an ASCII linefeed (decimal 10).

Figure 5-11



Instruction Terminator

**Programming Syntax
Instruction Terminator**

**Programming
Conventions**

Programming Conventions

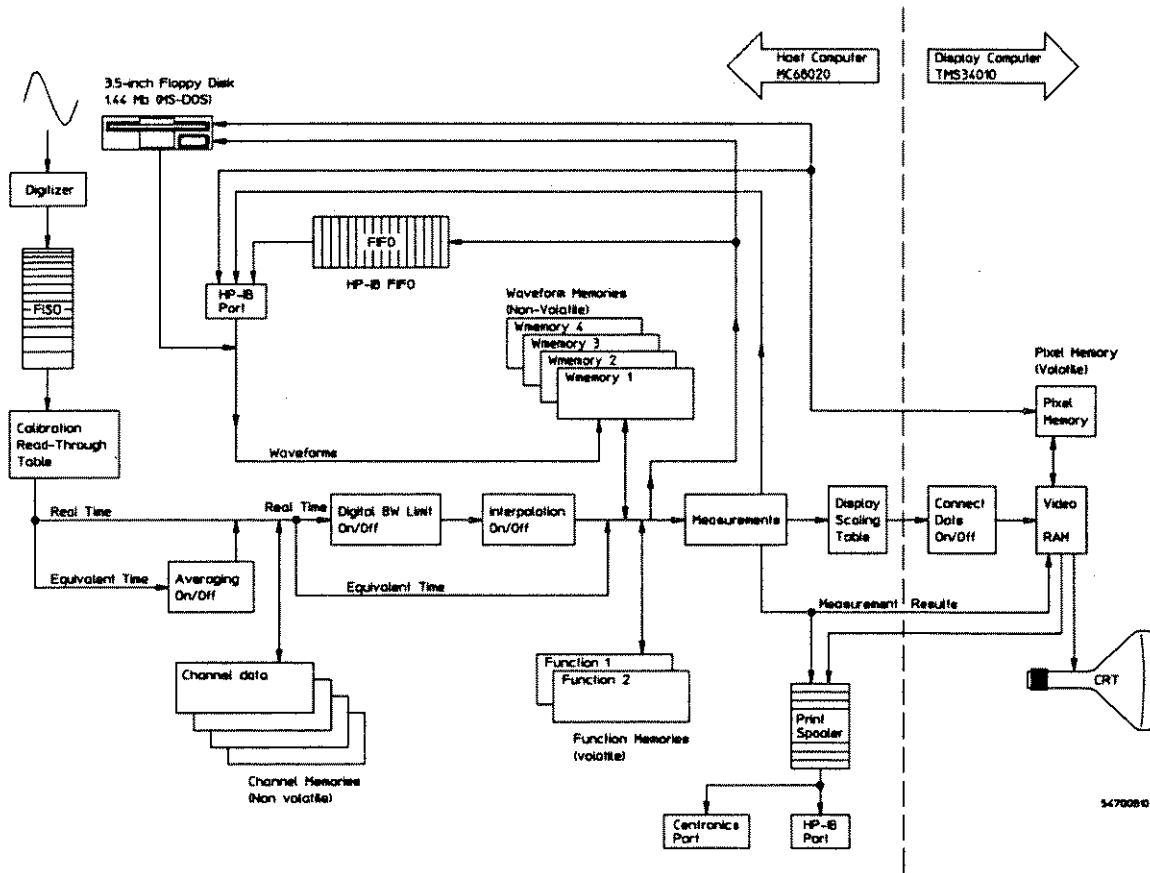
This chapter covers conventions used in programming the oscilloscope, as well as conventions used throughout this manual. A block diagram and description of data flow is included for understanding oscilloscope operations. A detailed description of the command tree and command tree traversal is also included in this chapter.

Data Flow

The data flow gives you an idea of where the measurements are made on the acquired data, and when the post-signal processing is applied to the data.

Figure 6-1 is a data flow diagram of the oscilloscope. The diagram is laid out serially for a visual perception of how the data is affected by the oscilloscope.

Figure 6-1



Oscilloscope Data Flow

Programming Conventions

Data Flow

The digitizer samples the applied signal and converts it to a digital signal. The FISO holds the data until the system bus is ready for the data. The output of the FISO is raw data, and it is used as an address to the calibration read-through table (cal table).

The cal table automatically applies the calibration factors to the raw data, so that the output of the cal table is calibrated data.

In the real-time sampling mode, the calibrated data is stored in the channel memories before any of the postprocessing is performed. Postprocessing includes turning on or off the digital bandwidth limit filter or the interpolator, calculating functions, storing data to the waveform memories, transferring data over the HP-IB bus, or transferring data to and from the disk. Notice that the measurements are performed on the real-time data after it has gone through postprocessing.

Therefore, you can make measurements on the data, and you can turn on or off digital bandwidth limit or interpolation without having to reacquire the data. This is important because the real-time sampling mode is primarily used on events that happen either once or infrequently, and reacquiring the data may not be one of your options. Also, turning on interpolation usually improves the repeatability of your measurements.

The equivalent-time sampling mode is slightly different. Notice that averaging is turned on or off before the data is stored in the channel memories. That means once the data is acquired, if you need to turn averaging on or off before making any measurements, you must reacquire the data. However, because the equivalent-time sampling mode is primarily used on repetitive signals, you should be able to reacquire the data.

Also, you may notice that postprocessing the data in the equivalent-time signal path includes calculating functions, storing data to the waveform memories, transferring data over the HP-IB bus, or transferring data to and from the disk.

After the measurements are performed, the data is sent through the display portion of the oscilloscope. Notice that connected dots is a display feature, and that it has no influence on the measurement results. The pixel memory is also part of the video RAM, which is past the point where the measurements are performed on the data. Therefore, you cannot make measurements on data in the pixel memory. But, you can make measurements on data stored to the waveform memories.

Truncation Rule

The following truncation rule is used to produce the short form (abbreviated spelling) for the mnemonics used in the programming headers and alpha arguments.

Truncation Rule

The mnemonic is the first four characters of the keyword, unless the fourth character is a vowel. Then the mnemonic is the first three characters of the keyword.

If the length of the keyword is four characters or less, this rule does not apply and the short form is the same as the long form.

The following table shows how the truncation rule is applied to various commands.

Table 6-1

Mnemonic Truncation

Long Form	Short Form	How The Rule is Applied
RANGE	RANG	Short form is the first four characters of the keyword.
PATTERN	PATT	Short form is the first four characters of the keyword.
TIME	TIME	Short form is the same as the long form.
DELAY	DEL	Fourth character is a vowel, short form is the first three characters.

The Command Tree

The command tree in figure 6-2 shows all of the commands in this oscilloscope and the relationship of the commands to each other. The IEEE 488.2 common commands are not listed as part of the command tree since they do not affect the position of the parser within the tree.

When a program message terminator (<NL>, linefeed - ASCII decimal 10) or a leading colon (:) is sent to the instrument, the parser is set to the "root" of the command tree.

Command Types

The commands in this instrument can be placed into three types: Common commands, root level commands, and subsystem commands.

- Common commands are commands defined by IEEE 488.2 and control some functions that are common to all IEEE 488.2 instruments. These commands are independent of the tree and do not affect the position of the parser within the tree. *RST is an example of a common command.
- Root level commands control many of the basic functions of the instrument. These commands reside at the root of the command tree. They are always parsable if they occur at the beginning of a program message, or are preceded by a colon. Unlike common commands, root level commands place the parser back at the root of the command tree. AUTOSCALE is an example of a root level command.
- Subsystem commands are grouped together under a common node of the command tree, such as the TIMEBASE commands. Only one subsystem may be selected at a given time. When the instrument is initially turned on, the command parser is set to the root of the command tree and no subsystem is selected.

Tree Traversal Rules

Command headers are created by traversing down the command tree. A legal command header from the command tree in figure 6-2 would be :TIMEBASE:RANGE. This is referred to as a compound header. A compound header is a header made up of two or more mnemonics separated by colons. The mnemonic created contains no spaces. The following rules apply to traversing the tree.

Tree Traversal Rules

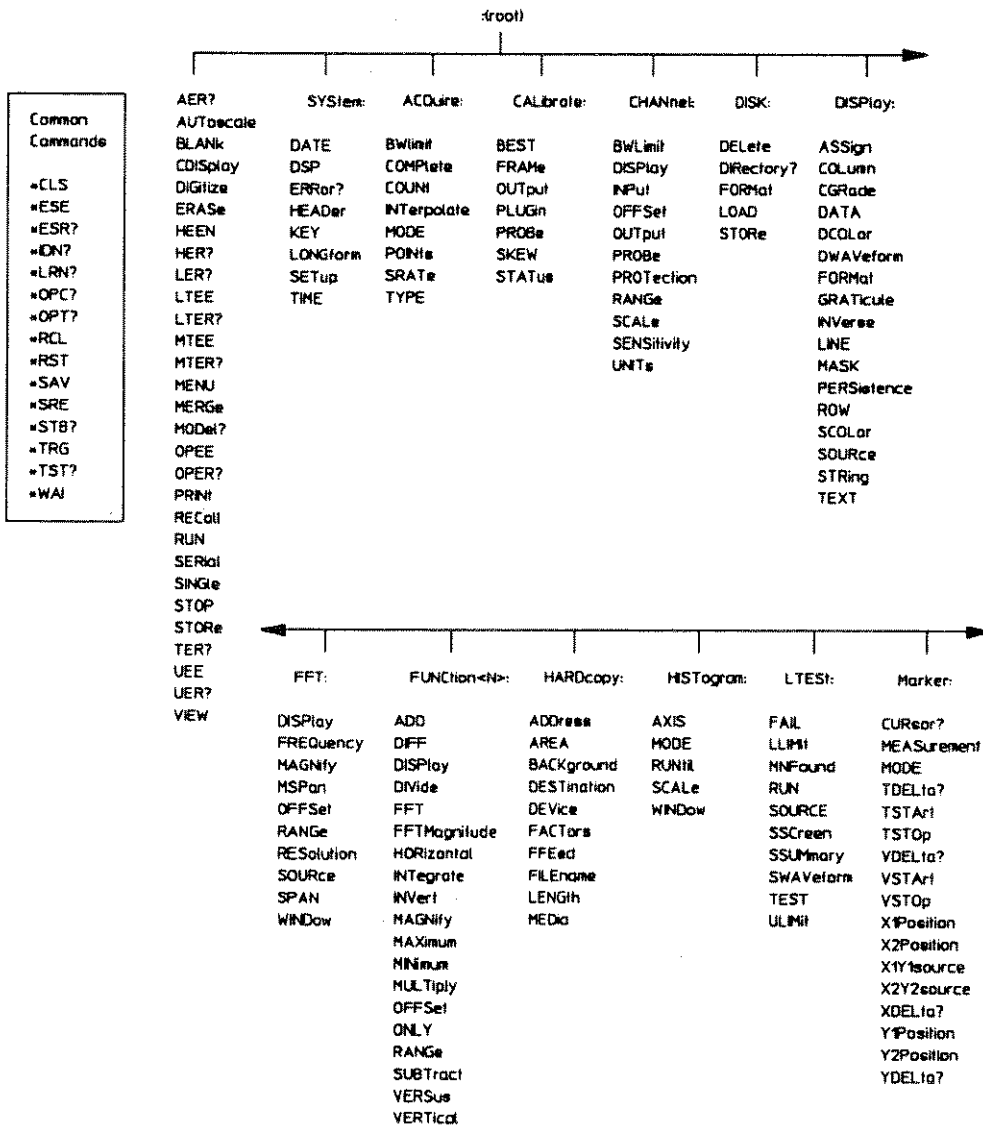
A leading colon or a program message terminator (either an <NL> or EOI true on the last byte) places the parser at the root of the command tree. A leading colon is a colon that is the first character of a program header.

Executing a subsystem command places you in that subsystem until a leading colon or a program message terminator is found.

In the command tree of figure 6-2, use the last mnemonic in the compound header as a reference point (for example, RANGE). Then find the last colon above that mnemonic (TIMEBASE:). That is the point where the parser resides. Any command below this point can be sent within the current program message without sending the mnemonics which appear above them (for example, REFERENCE).

Programming Conventions The Command Tree

Figure 6-2



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Command Tree

Figure 6-2 (continued)

MEASure:	MTEST:	Timebase:	TRIGger:	TRIGger<N>:	PMEMary:	WMEMary<N>:	WAVEform:
DEFine	AMASK	DELay	DEVenTs	BWLimit	ADD	DISPlay	BANDpass?
DELTAime	COUNt	POSition	DTIME	PROBE	CLEAR	SAVE	BYTeorder
DUTYcycle	MASK	RANGE	EDGE		DISPlay	XOFFset	COMPlete?
FALLtime	POLYgon	REFerence	GLITCh		ERASe	XRANge	COUNt?
FFT	RUMode	SCALE	HOLDoff		MERGe	YOFFset	COUPLing?
FREQuency	SCALE	VIEW	HYSTEResis			YRANge	DATA
HISTogram	SSCReen	WINDow	LEVel				FORMat
NWIDth	SSUMmary		MODE				POINts?
OVERshoot	SWAVEform		PATtern				PREAmble
PERiod	TEST		SLOPe				SOURce
PREShoot			SOURce				TYPE?
PWIDth			STATE				VIEW
RESults?			SWEEp				XDISplay?
RISetime							XINCrement?
SCRatch							XORigin?
SENDvalid							XRANge?
SOURce							XREFerence?
STATistics							XUNIts?
TEDGE							YDISplay?
THAX?							YINCrement?
TVQL1?							YORigin?
VAMPititude							YRANge?
VAVerage							YREFerence?
VBASe							YORigin?
VLOWer							YREFerence?
VMAX							YUNIts?
VMIN							
VPP							
VRMS							
VTIME							
VTOP							
VUPper							

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Command Tree (continued)

Programming Conventions The Command Tree

Tree Traversal Examples

The OUTPUT statements in the following examples are written using HP BASIC 5.0 on an HP 9000 Series 200/300 controller. The quoted string is placed on the bus, followed by a carriage return and linefeed (CRLF).

Example 1

```
OUTPUT 707;":CHANNEL1:RANGE 0.5;OFFSET 0"
```

In the previous example, the colon between CHANNEL1 and RANGE is necessary because CHANNEL1:RANGE is a compound command. The semicolon between the RANGE command and the OFFSET command is required to separate the two functions. The OFFSET command does not need CHANNEL1 preceding it since the CHANNEL1:RANGE command sets the parser to the CHANNEL1 node in the tree.

Example 2

```
OUTPUT 707;":TIMEBASE:REFERENCE CENTER;POSITION 0.00001"
```

OR

```
OUTPUT 707;":TIMEBASE:REFERENCE CENTER"  
OUTPUT 707;":TIMEBASE:POSITION 0.00001"
```

In the first line of example 2, the "subsystem selector" is implied for the POSITION command in the compound command.

A second way to send these commands is shown in the second part of the example. Since the program message terminator places the parser back at the root of the command tree, TIMEBASE must be re-selected to re-enter the TIMEBASE node before sending the POSITION command.

Example 3

OUTPUT 707;":TIMEBASE:REFERENCE CENTER;:CHANNEL1:OFFSET 0"

In example 3, the leading colon before CHANNEL1 tells the parser to go back to the root of the command tree. The parser can then recognize the CHANNEL1:OFFSET command and enter the correct node.

Infinity Representation

The representation for infinity for this oscilloscope is 9.99999E+37. This is also the value returned when a measurement cannot be made.

Sequential and Overlapped Commands

IEEE 488.2 makes a distinction between sequential and overlapped commands. Sequential commands finish their task before the execution of the next command starts. Overlapped commands run concurrently. Commands following an overlapped command may be started before the overlapped command is completed.

Response Generation

As defined by IEEE 488.2, query responses may be buffered for the following reasons:

- When the query is parsed by the instrument.
- When the controller addresses the instrument to talk so that it may read the response.

This oscilloscope buffers responses to a query when the query is parsed.

EOI

The EOI bus control line follows the IEEE 488.2 standard without exception.

Programming Conventions
E01



Example Programs

Example Programs

The programs listed in this chapter are the same as those on the disks provided with this programmer's reference. The disks are provided in both LIF and DOS formats. The disks contain some interactive files, i.e., additional files are created while running the programs. To preserve the original quality of the example programs disks, make a copy of the originals and use the copy for running the programs.

Digitize Example Program

```
10  | "DIG_7XX.ibw"
20  |
30  |      Copyright: (c) 1993, Hewlett-Packard Co. All rights reserved.
40  |      Contributor: Colorado Springs Division
41  |      Product: Example Program
42  |
43  | $Revision: 3.0
44  | $Date$ 6.9.93
45  | $Author$ Ed Mierzejewski
46  |
47  | Description: DIG_7XX.ibw autoscales to get a waveform on screen and
48  |              digitizes the waveform. Then the operator can reposition
49  |              before transferring the data to the computer. Then the
50  |              computer will draw the waveform as repositioned on the
51  |              computer screen. It also save the data to a record and
52  |              recalls that data before drawing it.
53  |
54  | Main Routine: Begin_main.
55  | Sub routines: none.
56  | Sub programs: Get_waveform, Graph, Initscope, Readme, Readme2,
57  |              Retrieve_wave, Save_waveform.
59  | Functions: none.
60  | Variable List: Preamble & Waveform, @Path, & @Scope
61  |
62  |      Preamble = Real array for the first 15 parameters of the
63  |                preamble, they are numerics and the remaining 3
64  |                parameters are alphas and are not used.
66  |      Waveform = Integer array to store the waveform data.
67  |      @Path = the path for saving/recalling data to/from media.
68  |      @Scope = The scope's complete HP-IB address.
70  |
71  | REAL Preamble(1:15)
130 | INTEGER Waveform(1:32000)
140 | Begin_main: |
185 | CALL Readme
186 | CALL Initscope(@Scope)
190 | CALL Get_waveform(@Scope,Waveform(*),Preamble(*))
220 | CALL Save_waveform(@Path,Waveform(*),Preamble(*))
240 | CALL Readme2
260 | CALL Retrieve_wave(@Path,Waveform(*),Preamble(*))
290 | CALL Graph(Waveform(*),Preamble(*))
```

Example Programs
Digitize Example Program

```
291 PRINT TABXY(15,30);"Program has Ended."  
292 LOCAL 707  
300 End_main: !  
310 END  
320 Begin_subs:!  
321 !  
330 SUB Readme  
340 ! Description: Readme prints program explanation to the computer  
341 ! screen.  
342 ! Parameters: none.  
343 !  
350 CLEAR SCREEN  
360 PRINT "DIG_7XX.lbw does the following tasks:"  
370 PRINT  
380 PRINT " a. initialize interface and scope"  
390 PRINT " b. digitize and acquire data"  
400 PRINT " c. store data to disk"  
410 PRINT " d. retrieve data from disk"  
420 PRINT " e. draw signal on computer"  
430 PRINT  
440 PRINT "Assumed system configuration is:"  
450 PRINT  
460 PRINT " HP-IB address = 7"  
470 PRINT " Scope address = 7"  
480 PRINT " signal attached to channel 1"  
490 PRINT  
500 PRINT "If the addresses are not correct, change the ASSIGN "  
510 PRINT "statements in sub program 'Initscope'."  
520 PRINT  
530 PRINT "Press Continue when ready to start"  
540 PAUSE  
550 CLEAR SCREEN  
560 SUBEND  
570 !  
580 SUB Readme2  
590 !  
600 ! Description: Readme2 is user information and status.  
610 !  
611 ! Parameters: none.  
620 !  
621 CLEAR SCREEN  
623 PRINT  
630 PRINT "The waveform data and preamble information have now been"  
640 PRINT "read from the scope and stored in the computer's disk."  
641 PRINT
```

Example Programs
Digitize Example Program

```
642 PRINT "When you press continue that information will be retrieved"
650 PRINT "from the disk, and plotted to the computer screen."
680 PRINT
690 PRINT "Press CONTINUE to continue."
700 PAUSE
710 CLEAR SCREEN
720 SUBEND
730 !
740 SUB Initscope(@Scope)
750 !
760 ! Description: Initscope assigns the path to the scope, initializes
761 ! the scope, autoscales, and sets up the acquisition
762 ! parameters.
763 ! Parameters:
764 ! Passed: @Scope = the HP-IB address of the scope.
765 ! Internal: @Isc = interface select code of the HP-IB interface.
766 ! Modified Variables: @Scope and @Isc
773 !
774 CLEAR SCREEN
780 PRINT "INITIALIZE"
781 Assign_paths: !
790 ASSIGN @Isc TO 7 ! Interface Select Code = 7
800 ASSIGN @Scope TO 707 ! scope address
801 Init_sys: !_
810 CLEAR @Isc ! clear HP-IB interface
820 OUTPUT @Scope;"*RST;*CLS" ! set scope to default config
830 OUTPUT @Scope;":AUToscale"
840 OUTPUT @Scope;":SYStem:HEAdEr OFF"
850 Acq_setup: !
890 OUTPUT @Scope;":ACQuire:COMPLete 100;POINts 500"
910 OUTPUT @Scope;":WAVeform:FORMat BYTE;SOURce CHANnel"
911 !
920 ! Normally WORD data would be recommended because it allows better
930 ! use of the full resolution of the scope, especially in ET MODE.
940 ! Byte data is shown because HPBasic doesn't recognize signed bytes
950 ! and requires a conversion. FNBcon will do the conversion.
960 !
980 CLEAR SCREEN
990 SUBEND
1000 !
1010 SUB Get_waveform(@Scope,INTEGER Waveform(*),REAL Preamble(*))
1020 !
1021 ! Description: Get_waveform digitizes the autoscaled waveform,
1022 ! gets waveform data and preamble after the operator
1023 ! adjusts the display to show the data as desired.
```

Example Programs Digitize Example Program

```
1050  !
1051  !           There are 2 forms of digitize: 1. 'with parameters'
1052  !           will digitize the specified channel/function, screen
1053  !           is blanked, then place the data in associated channel/
1054  !           function memory. 2. 'without parameters' digitizes
1055  !           all 'on' channels/functions and places data in the
1056  !           associated channel/function memory, and leaves them on
1057  !           but stopped.
1058  !
1059  !           Both digitizes are here and on adjacent lines. One of
1060  !           the lines must be commented out or only the last one
1061  !           will be used.
1062  !
1063  !
1064  ! Parameters:
1065  !   Passed:  @Scope, Waveform, Preamble
1066  !   Internal: Digits = this is the length of the data header.
1067  !             Length = the number of bytes of data from the scope.
1068  !             End$   = empties output buffer of linefeed.
1069  !             One_char$ = used to find the '#' character.
1070  !
1071  ! Modified Variables: Waveform, Preamble, Digits, Length, End$, and
1072  !                   One_char$.
1073  !
1074  !
1075  CLEAR SCREEN
1076  PRINT "Get_waveform"
1077  ! OUTPUT @Scope;" :DIGitize CHAN1"
1078  OUTPUT @Scope;" :DIGitize"
1079  User_sets_disp:  !
1150  LOCAL 707
1160  PRINT "Adjust Display as you want it. Press continue when ready."
1170  PAUSE
1171  Read_data:  !
1180  OUTPUT @Scope;" :WAVEform:DATA?"
1190  ENTER @Scope USING "#,1A,";One_char$
1200  IF One_char$="#" THEN
1220  ENTER @Scope USING "#,1D";Digits
1230  ENTER @Scope USING "#,&VAL$(Digits)&"D";Length
1231  CLEAR SCREEN
1232  PRINT
1233  PRINT "reading ";Length;" bytes from scope"
1240  !
1250  !
1260  !Redimention the array for the waveform data. After data is
1270  !read in, one extra byte read to clear the line feed (10)
1280  !attached to the end of the scope's output buffer.
1290  !
```


Example Programs
Digitize Example Program

```
1300     REDIM Waveform(1:Length)
1310     ENTER @Scope USING "#,B";Waveform(*)
1320     ENTER @Scope USING "-K,B";End$
1330     OUTPUT @Scope;" :WAVEFORM:PREAMBLE?"
1340     ENTER @Scope;Preamble(*)
1370     ELSE
1380         PRINT "BAD DATA"
1390     END IF
1400 SUBEND
1410 !
1420 SUB Save_waveform(@Path,INTEGER Waveform(*),REAL Preamble(*))
1430 !
1431 ! Description: Save_waveform sends acquired data and preamble to the
1432 !               computer's disk. It is stored in 'WAVESAMPLE'. If
1433 !               'WAVESAMPLE' already exist, it will be purged then a
1434 !               new one created.
1435 !
1436 ! Parameters:
1437 !   Passed: @Path, Waveform, Preamble
1438 !   Internal: none
1439 !
1440 ! Modified Variables: none
1441 ! Sub programs: Ertrap
1442 !
1449     ON ERROR CALL Ertrap
1450     CREATE BDAT "WAVESAMPLE",1,4080
1451     ASSIGN @Path TO "WAVESAMPLE"
1452     OUTPUT @Path;Waveform(*),Preamble(*)
1453 SUBEND
1454 !
1455 SUB Retrieve_wave(@Path,INTEGER Waveform(*),REAL Preamble(*))
1456 !
1457 ! Description: Retrieve_wave reads data and preamble stored in
1458 !               'WAVESAMPLE'.
1459 ! Parameters:
1460 !   Passed: @Path, Waveform, Preamble
1461 !   Internal: Con = indexing variable
1462 ! Functions: FNBcon = converts from signed bytes.
1463 !
1464     ASSIGN @Path TO "WAVESAMPLE"
1465     ENTER @Path;Waveform(*),Preamble(*)
1466     FOR Con=1 TO Preamble(3)
1467         Waveform(Con)=FNBcon(Waveform(Con))
1468     NEXT Con
1469 SUBEND
```

Example Programs

Digitize Example Program

```
1650 |
1660 SUB Graph(INTEGER Waveform(*),REAL Preamble(*))
1670 |
1680 | Description: Graph takes the converted data and plots it on screen.
1690 |           It uses the 'Y Display Range' to show the data as seen
1700 |           on screen vertically, and 'X Display Range' to show
1710 |           as seen horizontally (pre(14 and 12 respectively).
1720 |
1730 | Parameters: Waveform(*) = array of data values. Enters as q levels
1740 |           leaves as voltages.
1750 |           Preamble(*) = the preamble for the data.
1760 |
1770 | Internal: Vrange = preamble(14), y-axis duration of waveform displayed.
1780 |           Srange = preamble(12), x-axis duration of waveform displayed.
1790 |           Offset = preamble(15), center of screen vertically.
1800 |           vmin   = lower limit vertically.
1810 |           vmax   = upper limit vertically.
1820 |           hmin   = lower limit horizontally (preamble(13)).
1830 |           hmax   = upper limit horizontally.
1840 |           Hdata(*) = Horizontal values in proper units.
1850 |           Vdata(*) = Vertical values in proper units.
1851 |           I = indexing variable.
1860 |
1870 | Modified variables: Hdata(*), Vdata(*), and I
1880 |
1890 | Subprogram calls:V_convert and H_convert.
1900 |
1910 ALLOCATE REAL Hdata(1:Preamble(3))
1920 ALLOCATE REAL Vdata(1:Preamble(3))
1930 CALL V_convert(Waveform(*),Preamble(*),Vdata(*))
1940 CALL H_convert(Hdata(*),Preamble(*))
1950 Vrange=Preamble(14)
1960 Srange=Preamble(12)
1970 Offset=Preamble(15)
1980 Vmin=Offset-Vrange/2
1990 Vmax=Vrange/2+Offset
2000 Hmin=Preamble(13)
2010 Hmax=Hmin+Srange
2020 GCLEAR                               !initialize graphics
2030 CLEAR SCREEN
2040 GINIT
2050 GRAPHICS ON
2060 VIEWPORT 0,130,35,100
2070 WINDOW Hmin,Hmax,Vmin,Vmax
2080 FRAME
```

Example Programs
Digitize Example Program

```
2090     PEN 4
2100     MOVE Hdata(1),Vdata(1)
2110     FOR I=1 TO Preamble(3)           !plot data points
2120         DRAW Hdata(I),Vdata(I)
2130     NEXT I
2140     PRINT TABXY(0,18),"Vertical=";Vrange/8;" V/div";TAB(50),"Offset =
";Offset;"V"
2150     PRINT TABXY(0,19),"Time=";Srange/10;" s/div"
2160     DEALLOCATE Hdata(*)
2170     DEALLOCATE Vdata(*)
2180     SUBEND
2190     !
2200     DEF FNBcon(INTEGER B)
2201     !
2202     ! Description:  FNBcon takes the signed byte value from the scope and
2203     !                converts it to a positive integer of the proper value.
2204     ! Parameters:
2205     !     Passed: B
2206     !     Internal: Orparam = value to OR with the passed value, B, when the
2207     !                MSB is set.
2208     ! Modified Variables:  B
2209     !
2260     Orparam=-256
2270     IF BIT(B,7) THEN B=BINIOR(Orparam,B)
2280     RETURN B
2290     FNEEND
2300     !
2310     SUB Ertrap
2311     !
2312     ! Description:  Ertrap is called by an error interrupt.  It checks for
2313     !                error #54 which will occur when there is a duplicate
2314     !                file name.  The existing file will be purged.
2315     ! Parameters: none
2316     !
2350     IF ERRN=54 THEN PURGE "WAVESAMPLE"
2360     OFF ERROR
2370     SUBEND
2380     !
2390     SUB V_convert(INTEGER Wav(*),REAL Pre(*),Vdata(*))
2400     !
2410     ! Description:  V_convert takes the data from the scope and converts it
2420     !                into voltage values using the equation from the manual.
2430     !
2440     ! Parameters: Wav(*) = array of data values.  Enters as q levels
2450     !                leaves as voltages.
```

Example Programs
Digitize Example Program

```
2460 !           Pre(*) = the preamble for the data.
2470 !           Vdata (*) = array of vertical values, volts.
2480 !
2490 ! Internal: yref = pre(10), level associated with y origin.
2500 !           yinc = pre(8), duration between y-axis levels.
2510 !           yorg = pre(9), y-axis value at level zero.
2511 !           C = indexing variable.
2520 !
2530 ! Modified variables: Vdata(*)
2540 !
2550 Yref=Pre(10)
2560 Yinc=Pre(8)
2570 Yorg=Pre(9)
2580 FOR C=1 TO Pre(3)
2590     Vdata(C)=(Wav(C)-Yref)*Yinc+Yorg
2600 NEXT C
2610 SUBEND
2620 !
2630 SUB H_convert(Hdata(*),Pre(*))
2640 !
2650 ! Description: H_convert creates horizontal axis values using the
2660 !           equation from the manual.
2670 !
2680 ! Parameters: Hdata(*) = Horizontal values.
2690 !           Pre(*) = the preamble for the data.
2700 !
2710 ! Internal: xref = pre(7), data point associated with the x origin.
2720 !           xinc = pre(5), duration between x-axis data points.
2730 !           xorg = pre(6), x-axis value of first point in record.
2740 !
2750 ! Modified variables: Hdata(*)
2760 !
2770 Xref=Pre(7)
2780 Xinc=Pre(5)
2790 Xorg=Pre(6)
2800 FOR C=1 TO Pre(3)
2810     Hdata(C)=((C-1)-Xref)*Xinc+Xorg
2820 NEXT C
2830 SUBEND
```

Measurement Example Program

```

10 ! RE-SAVE "MEAS_7XX" !Observing True Representation of signal.Rev. 1.18
20 !
30 !*****|
40 !***** Main Program *****|
50 !*****|
60   Readme
70   Initscope(@Scope)
80   True_rep(@Scope)
90   Measure(@Scope)
100  Rt_4g(@Scope)
110  Measure(@Scope)
120  Rt_2g(@Scope)
130  Measure(@Scope)
140  PRINT " The program has completed! "
150  BEEP
160  !*****|
170  END   !*           End of Main Program           *|
180  !*****|
190  !                                           !
200  !*****|
210  !*           Begin Sub Programs           *|
220  !*****|
230  SUB Readme
240  !*****|
250  !* This sub program writes user program information to the screen. *|
260  !*****|
270  CLEAR SCREEN
280  PRINT "This example program will setup and measure the cal."
290  PRINT "signal from the 54721A with different sampling rates"
300  PRINT "and statistics. It shows the difference sampling rate"
310  PRINT "makes when measuring a fast pulse."
320  PRINT
330  PRINT "The program assumes that the system is configured such that:"
340  PRINT "  HP-IB interface is at address 7."
350  PRINT "  Scope is at address 7."
360  PRINT "  A 54721A is installed into slots 1 & 2."
370  PRINT
380  PRINT "If these addresses are incorrect, break program and set addresses"
390  PRINT "as needed in the ASSIGN statements."
400  PRINT
410  PRINT "PRESS continue to run program"

```

Example Programs Measurement Example Program

```
420     PAUSE
430     CLEAR SCREEN
440 SUBEND
450     !
460 SUB Initscope(@Scope)
470     !*****!
480     !* This sub program initializes the I/O and scope.      *!
490     !*****!
500     ASSIGN @Scope TO 707
510     CLEAR @Scope                                     !clear HP-IB interface
520     OUTPUT @Scope;"*cls"
530     OUTPUT @Scope;"*RST"                             !reset scope to default config
540     OUTPUT @Scope;":SYSTEM:HEADER OFF"!turn off header
550     CLEAR SCREEN
560 SUBEND
570 SUB True_rep(@Scope)
580     !*****!
590     !* The first step of this demonstration is to show the true *!
600     !* signal in the equivalent time mode.                  *!
610     !*****!
620     PRINT " First see the true signal in the Equivalent Time mode."
630     PRINT
640     PRINT " !*****!"
650     PRINT " Connect the HP 54721A Calibrator Output to the Input "
660     PRINT " of the 54721A. "
670     PRINT " !*****!"
680     PRINT
690     PRINT " Press continue when ready to continue. "
700     PAUSE
710     CLEAR SCREEN
720     OUTPUT @Scope;":channel1:display on"
730     !***** Turn on the calibrator signal on the 21 plug-in.
740     OUTPUT @Scope;":channel1:output on"
750     OUTPUT @Scope;":acquire:mode ETIME"
760     OUTPUT @Scope;":autoscale"
770     OUTPUT @Scope;":display:persistence infinite"
780     ! This completes the first setup. FTE26
790     OUTPUT @Scope;":menu acquire"
800     PRINT "Waiting 5 seconds for Autoscale to complete and to "
810     PRINT "acquire a waveform."
820     WAIT 5
830     CLEAR SCREEN
840     PRINT " The displayed waveform on the 54720A is the true "
850     PRINT " representation of the signal."
860     PRINT
```

Example Programs
Measurement Example Program

```

870 PRINT " The HP 54720A is in equivalent time mode:"
880 PRINT " Sampling rate is 500 MSa/S,"
890 PRINT " Analog Bandwidth is 1.1 GHz"
900 PRINT
910 PRINT " Press Continue to Continue"
920 ! Save the True Waveform to a Pixel memory for later
930 ! comparison.
940 PAUSE
950 CLEAR SCREEN
960 OUTPUT @Scope;":pmemory1:clear"
970 OUTPUT @Scope;":pmemory1:display on"
980 OUTPUT @Scope;":pmemory1:add"
990 BEEP
1000 INPUT "Do you want to leave the saved waveform on? <Y or N>",$Y
1010 IF UPC$(Y$(1,1))="Y" THEN
1020 ELSE
1030 OUTPUT @Scope;":pmemory1:display off"
1040 END IF
1050 SUBEND
1060 !
1070 SUB Rt_4g(@Scope)
1080 !*****!
1090 !* This sub program will require the 54721A calibration *!
1100 !* output in the real time mode with 4GSa/s. *!
1110 !*****!
1120 CLEAR SCREEN
1130 PRINT "Setting up for 4GSa/sec."
1140 OUTPUT @Scope;":acquire:mode rtime"
1150 OUTPUT @Scope;":acquire:srate 4E+9"
1160 OUTPUT @Scope;":acquire:interpolate on"
1170 PRINT
1180 PRINT " When ready to make some measurements press continue."
1190 PAUSE
1200 CLEAR SCREEN
1210 SUBEND
1220 !
1230 SUB Measure(@Scope)
1240 !*****!
1250 !* This sub program will make a +width and Vpp measurement. " *!
1260 !* It will also report the mean and standard deviations. " *!
1270 !*****!
1280 CLEAR SCREEN
1290 REAL R(1:14),A(1:14)
1300 DIM Ex$(1:14)[1],M$(32)
1310 !

```

Example Programs
Measurement Example Program

```
1320  ! Normally when making measurements they should be preceded
1330  ! by a DIGITIZE. But, because I have the scope setup like I
1340  ! want it from previous sub programs and I will be using the
1350  ! statistics, I will not use the DIGITIZE command.
1360  !
1370  PRINT " Making measurements on Channel 1. "
1380  PRINT "     Measuring for 5 seconds."
1390  OUTPUT @Scope;"measure:source channel1"
1400  OUTPUT @Scope;"measure:statistics on;sendvalid on"
1410  OUTPUT @Scope;"measure:pwidth;vpp"
1420  WAIT 5      ! Give the measurements a chance to build up values
1430  OUTPUT @Scope;"stop" ! Stop; match on screen values with returned.
1440  OUTPUT @Scope;"measure:results?"
1450  ENTER @Scope USING "%,K";A(*)
1460  Eng(A(*),R(*),Ex$(*)) ! Convert to Engineering Notation
1470  CLEAR SCREEN
1480  PRINT " The results of the positive pulse width measurement are;"
1490  PRINT
1500  Result_state(R(2),M$) ! Interpret the Result State value
1510  PRINT "The current value is ";R(1);Ex$(1)
1520  PRINT "The state value is ";R(2),"It means, ";M$
1530  PRINT "The minimum value is ";R(3);Ex$(3)
1540  PRINT "The maximum value is ";R(4);Ex$(4)
1550  PRINT "The average value is ";R(5);Ex$(5)
1560  PRINT "The standard deviation is ";R(6);Ex$(6)
1570  PRINT "The number of measurements is ";R(7);Ex$(7)
1580  PRINT " The results of the peak to peak measurement are;"
1590  PRINT
1600  Result_state(R(9),M$) ! Interpret the Result State Value.
1610  PRINT " The current values is ";R(8);Ex$(8)
1620  PRINT " The state value is ";R(9),"It means, ";M$
1630  PRINT " The minimum value is ";R(10);Ex$(10)
1640  PRINT " The maximum value is ";R(11);Ex$(11)
1650  PRINT " The average value is ";R(12);Ex$(12)
1660  PRINT " The standard deviation is ";R(13);Ex$(13)
1670  PRINT " The number of measurements is ";R(14);Ex$(14)
1680  PRINT
1690  PRINT " Press continue when ready to continue."
1700  PAUSE
1710  CLEAR SCREEN
1720  OUTPUT @Scope;"run"
1730  SUBEND
1740  !
1750  SUB Rt_2g(@Scope)
1760  !*****!
```


Example Programs
Measurement Example Program

```
1770      !* This sub program is just like "Rt_4g" except it samples at *!  
1780      !* 2 GSa/s.                                                    *!  
1790      !*****!  
1800      CLEAR SCREEN  
1810      PRINT "Setup Scope for 2 GSa/Sec."  
1820      OUTPUT @Scope;":acquire:rate 2E+9"  
1830      OUTPUT @Scope;":acquire:interpolate on"  
1840      PRINT  
1850      PRINT "  When ready to make the measurements press continue."  
1860      PAUSE  
1870      CLEAR SCREEN  
1880      SUBEND  
1890      !  
1900      SUB Eng(N(*),A(*),Ex$(*))  
1910      !*****!  
1920      !* This sub program converts a # to engineering notation *!  
1930      !*****!  
1940      S=SIZE(N,1)  
1950      FOR C=1 TO S  
1960          SELECT N(C)  
1970              CASE >.999  
1980                  A(C)=N(C)  
1990              CASE >9.99E-4  
2000                  A(C)=N(C)/1.E-3  
2010                  Ex$(C)="m"  
2020              CASE >9.99E-7  
2030                  A(C)=N(C)/1.E-6  
2040                  Ex$(C)="u"  
2050              CASE >9.99E-10  
2060                  A(C)=N(C)/1.E-9  
2070                  Ex$(C)="n"  
2080              CASE >9.99E-13  
2090                  A(C)=N(C)/1.E-12  
2100                  Ex$(C)="p"  
2110              CASE >9.99E-16  
2120                  A(C)=N(C)/1.E-15  
2130                  Ex$(C)="f"  
2140              CASE ELSE  
2150                  A(C)=N(C)  
2160          END SELECT  
2170      NEXT C  
2180      SUBEND  
2190      !  
2200      SUB Result_state(N,M$)  
2210      !*****!
```

Example Programs
Measurement Example Program

```
2220  !* This sub program interprets the Result State Value *!  
2230  !*****!  
2240  SELECT N  
2250  CASE 0  
2260      M$="Result Correct"  
2270  CASE 1  
2280      M$="Result Questionable"  
2290  CASE 2  
2300      M$="Result Less than or Equal to"  
2310  CASE 3  
2320      M$="Result Greater than or Equal to"  
2330  CASE 4  
2340      M$="Result Invalid"  
2350  CASE 5  
2360      M$="Edge Not Found"  
2370  CASE 6  
2380      M$="Max. q level not found"  
2390  CASE 7  
2400      M$="Min. q level not found"  
2410  CASE 8  
2420      M$="Requested Time not found"  
2430  CASE 9  
2440      M$="Voltage not found"  
2450  CASE 10  
2460      M$="Top and Base are equal"  
2470  CASE 11  
2480      M$="Measurement zone too small"  
2490  CASE 12  
2500      M$="Lower Threshold"  
2510  CASE 13  
2520      M$="Upper Threshold"  
2530  CASE 14  
2540      M$="Bad Upper/Lower combination"  
2550  CASE 15  
2560      M$="Top not on waveform"  
2570  CASE 16  
2580      M$="Base not on waveform"  
2590  CASE 17  
2600      M$="Completion Criteria not reached"  
2610  CASE 18  
2620      M$="Invalid Signal for measurement"  
2630  CASE 19  
2640      M$="Source Signal not displayed"  
2650  CASE 20  
2660      M$="Clipped High"
```

Example Programs
Measurement Example Program

```
2670 CASE 21
2680 M$="Clipped Low"
2690 CASE 22
2700 M$="Clipped High and Low"
2710 CASE 23
2720 M$="All Holes"
2730 CASE 24
2740 M$="No Data on Screen"
2750 CASE 25
2760 M$="Cursor not on screen"
2770 CASE 26
2780 M$="Measurement Aborted"
2790 CASE 27
2800 M$="Measurement timed out"
2810 CASE 28
2820 M$="No measurement to track"
2830 CASE ELSE
2840 END SELECT
2850 SUBEND
```

Example Programs
Results? Measurement Example

Results? Measurement Example

```
10 ! RE-SAVE "RESU_7XX"!Operation of SENDValid & STATISTICS on RESULTS?
20 !
30 !*****!
40 !***** Main Program, Rev. 1.18 *****!
50 !*****!
60   Readme
70   Initscope(@Scope)
80   True_rep(@Scope)
90   Measure(@Scope)
100  PRINT "End of Program -- Results are on your printer."
110  BEEP 15,2
120   !*****!
130  END   !*           End of Main Program           *!
140   !*****!
150   !
160   !*****!
170   !*           Begin Sub Programs           *!
180   !*****!
190  SUB Readme
200   !*****!
210   !*This sub program writes user program information to the screen.*!
220   !*****!
230   CLEAR SCREEN
240   PRINT "This example program will setup and measure the cal."
250   PRINT "signal from the 54721A in the ET mode.  "
260   PRINT
270   PRINT "It measures the Positive Pulse Width with Statistics."
280   PRINT "Then uses the *RESULTS?* to report over the HP1B."
290   PRINT
300   PRINT "The report from the RESULTS? varies depending on the status"
310   PRINT "of STATISTICS ON|OFF and SENDValid ON|OFF."
320   PRINT
330   PRINT "This program will print the results for each of the cases."
340   PRINT
350   PRINT "The program assumes that the system is configured such that:"
360   PRINT
370   PRINT "  HP-1B interface is at address 7."
380   PRINT "  Scope is at address 7."
390   PRINT "  A 54721A is installed into slots 1 & 2."
400   PRINT "  Printer at 701"
410   PRINT
```

Example Programs
Results? Measurement Example

```
420 PRINT "If these addresses are incorrect, break program and set addresses"
430 PRINT "as needed in the ASSIGN statements."
440 PRINT
450 PRINT "PRESS continue to run program"
460 PAUSE
470 CLEAR SCREEN
480 SUBEND
490 !
500 SUB Initscope(@Scope)
510 !*****|
520 !* This sub program initializes the I/O and scope. *|
530 !*****|
540 ASSIGN @Scope TO 707
550 CLEAR @Scope !clear HP-IB interface
560 OUTPUT @Scope;"*cls"
570 OUTPUT @Scope;"*RST" !reset scope to default config
580 OUTPUT @Scope;":SYSTEM:HEADER OFF"!turn off header
590 CLEAR SCREEN
600 SUBEND
610 !
620 SUB True_rep(@Scope)
630 !*****|
640 !* This sets up the scope to look at the calibration signal of *|
650 !* the 54721A in the ET (equivalen time mode). *|
660 !*****|
670 PRINT " Connect the HP 54721A Calibrator Output to the Input "
680 PRINT " of the 54721A. "
690 PRINT
700 PRINT " Press continue when ready to continue. "
710 PAUSE
720 CLEAR SCREEN
730 OUTPUT @Scope;":channel1:display on"
740 !***** Turn on the calibrator signal on the 21 plug-in.
750 OUTPUT @Scope;":channel1:output on"
760 OUTPUT @Scope;":acquire:mode etime"
770 OUTPUT @Scope;":autoscale"
780 OUTPUT @Scope;":display:persistence infinite"
790 WAIT 5
800 PRINT " The displayed waveform on the 54720A is the true "
810 PRINT " representation of the 54721A cal. signal."
820 PRINT
830 PRINT " The HP 54720A is in equivelent time mode:"
840 PRINT " Sampling rate is 500 MSa/S,"
850 PRINT " Analog Bandwidth is 1.1 GHz"
860 PRINT
```

Example Programs Results? Measurement Example

```
870 SUBEND
880 !
890 SUB Measure(@Scope)
900 !*****!
910 !* This sub program will make a +width measurement.      *!
920 !* It will also report the mean and standard deviations.  *!
930 !*****!
940 CLEAR SCREEN
950 PRINT " Measuring Waveform and Reporting Results. "
960 REAL R(1:12)
970 !*****!
980 ! Normally when making measurements, they should be preceded !
990 ! by a DIGITIZE. But, because I have the scope setup like I !
1000 ! want it from previous sub programs and I will be using the !
1010 ! statistics, I will not use the DIGITIZE command.      !
1020 !*****!
1030 OUTPUT @Scope;"measure:source channel"
1040 PRINTER IS 701
1050 FOR C=1 TO 4
1060     OUTPUT @Scope;"run"
1070     MAT R= (0)
1080     OUTPUT @Scope;"measure:statistics ";INT(C/3)
1090     OUTPUT @Scope;"measure:sendvalid ";C MOD 2
1100     OUTPUT @Scope;"measure:statistics?"
1110     ENTER @Scope;St$
1120     OUTPUT @Scope;"measure:sendvalid?"
1130     ENTER @Scope;Sv$
1140     OUTPUT @Scope;"measure:pwidth"
1150     OUTPUT CRT;"Measuring for 20 seconds to get good stats."
1160     WAIT 20     !* Give the measurements a chance to build up values *!
1170     OUTPUT @Scope;"stop"!* See that values match ON SCREEN & OVER HPIB *!
1180     OUTPUT @Scope;"measure:results?"
1190     ENTER @Scope USING "%,K";R(*)
1200     OUTPUT CRT;"Printing Results to your printer"
1210     PRINT
1220     PRINT "Statistics is ";St$,"SendValid is ";Sv$
1230     PRINT
1240     PRINT "First value is ";R(1)
1250     PRINT "Second value is ";R(2)
1260     PRINT "Third value is ";R(3)
1270     PRINT "Fourth value is ";R(4)
1280     PRINT "Fifth value is ";R(5)
1290     PRINT "Sixth value is ";R(6)
1300     PRINT "Seventh value is ";R(7)
1310     WAIT 5
```

Example Programs
Results? Measurement Example

1320 CLEAR SCREEN
1330 NEXT C
1340 PRINTER IS CRT
1350 SUBEND

Example Programs
Learn String Example Program

Learn String Example Program

```
10  !RE-SAVE "LSTG7XX2"  !HP Basic for HP-IB interface, rev 2.0
20  !*****
30  !*  This program reads and returns the learn string from and to a  *
40  !*  547XX Oscilloscope.                                          *
50  !*          *****                                              *
60  !*          *****                                              *
70  !*          Begin MAIN PROGRAM                                    *
80  !*****
90  COM /Io/ @Scope,Hpib
100  Readme                  !Description of the program
110  Initscope              !initialize interface and scope
120  Length=FNStsize       !find setup string size.
130  Get_learnstr(Length)  !save 3 configurations on disk
140  Recall_learnstr(Length) !select & recall 1 of 3 setups
150  PRINT
160  BEEP 15,1
170  PRINT "program done"
180  !*****
190  !*          End of Main Programs                                *
200  !*****
210  END
220  !*****
230  !*          Begin Sub Programs                                  *
240  !*****
250  SUB Initscope
260  !*****
270  !*  This sub program initializes the INTERFACE AND SCOPE  *
280  !*****
290  COM /Io/ @Scope,Hpib
300  Hpib=7
310  Scope=7
320  ASSIGN @Scope TO Hpib*100+Scope  !scope address
330  CLEAR Hpib                       !clear HPIB interface
340  OUTPUT @Scope;"*RST"             !set scope to default config
350  OUTPUT @Scope;":AUTOSCALE"      !AUTOSCALE
360  OUTPUT @Scope;":SYST:HEAD OFF"
370  OUTPUT @Scope;"*OPC?"           !wait for scope to finish auto
380  ENTER @Scope;Opc
390  SUBEND
400  !
410  SUB Readme
```


Example Programs
Learn String Example Program

```

420      !*****
430      !* This sub program displays a message about the program for the      *
440      !* user.                                                                *
450      !*****
460      CLEAR SCREEN
470      PRINT "This sample program will prompt the user to set up the"
480      PRINT "scope in three different configurations and will store"
490      PRINT "them to the computer disk. Any of the three configurations"
500      PRINT "may then be recalled from the disk and sent to the scope"
510      PRINT
520      PRINT "The program assumes that the system is configured such that:"
530      PRINT "      HP-IB interface is at address 7"
540      PRINT "      scope is at address 7"
550      PRINT "      a signal is attached to channel 1"
560      PRINT
570      PRINT "If these addresses are incorrect, break program and set addresses"
580      PRINT "as needed in the Initialize in the ASSIGN statements."
590      PRINT
600      PRINT "Press CONTINUE when ready to start. Scope will first autoscale"
610      PRINT "on signal on channel 1 and will then prompt for user to setup"
620      PRINT "scope as desired before saving configurations in computer."
630      PRINT
640      PAUSE
650      CLEAR SCREEN
660  SUBEND
670  !
680  SUB Get_learnstr(Length)
690      !*****
700      !* This sub program will get the learn string from the 547XX *
710      !* and place it in SET$. Then it will create a BDAT file      *
720      !* called "JSETUPS" which holds 3 records. If this file is   *
730      !* already created it will be PURGED!                          *
740      !*****
750      COM /Io/ @Scope,Hpib
760      ON ERROR CALL Ertrap
770      CREATE BDAT "JSETUPS",3,Length      !create 3 files for 3 different
780                                          !setups.
790      ALLOCATE Set$(Length)              !temp variable to hold string.
800      ASSIGN @Path TO "JSETUPS"         !open file
810      FOR I=1 TO 3
820          CLEAR SCREEN
830          LOCAL @Scope
840          PRINT "PLEASE HAVE SETUP #";I;" READY AND PRESS RETURN"
850          INPUT A$
860          OUTPUT @Scope;" :SYSTEM:SETUP?"      !query learnstring from scope

```

Example Programs
Learn String Example Program

```

870     ENTER @Scope USING "-K";Set$      !read learn string from scope
880     IF Set$[1;1]="#" THEN
890         OUTPUT @Path,I;Set$          !store setup string to disk
900     ELSE
910         CLEAR SCREEN
920         PRINT "Received bad data.  No setup saved."
930     END IF
940     NEXT I
950     ASSIGN @Path TO *                  !close file
960     DEALLOCATE Set$
970 SUBEND
980 !
990 SUB Ertrap
1000 !*****
1010 !* The program will branch to this Error Trap if the      *
1020 !* ON ERROR is ON and an error occurs.  It reset the      *
1030 !* ON ERROR to OFF the return to where it was called.    *
1040 !*****
1050 IF ERRN=54 THEN ! Error 54 is Duplicate File Name
1060     PURGE "JSETUPS"
1070     OFF ERROR
1080 ELSE
1090     CLEAR SCREEN
1100     PRINT ERRM$
1110     BEEP
1120     PAUSE
1130 END IF
1140 SUBEND
1150 !
1160 SUB Recall_learnstr(Length)
1170 !
1180 ! This sub program lets the user select which of the 3 setups
1190 ! that have been stored on the disk in "JSETUPS1, 2, or 3 to
1200 ! use to setup the scope.  It will loop until the user selects
1210 ! (E) to exit.
1220 !
1230 COM /Io/ @Scope,Hpib
1240 ASSIGN @Path TO "JSETUPS"            !open file
1250 ALLOCATE Set${Length}                !create temp variable.
1260 Done=0
1270 REPEAT
1280     CLEAR SCREEN
1290     PRINT "Please enter (1) to recall setup 1"
1300     PRINT "                (2) to recall setup 2"
1310     PRINT "                (3) to recall setup 3"

```

Example Programs
Learn String Example Program

```

1320 PRINT " (E) to exit"
1330 INPUT A$
1340 SELECT UPC$(A$)
1350 CASE "1","2","3"
1360 ENTER @Path,VAL(A$);Set$ !read data from disk.
1370 IF Set$[1;1]="#" THEN !Have good data.
1380 !
1390 ! Add command header to setup string and send entire string to scope.
1400 !
1410 OUTPUT @Scope USING "#,K";":SYSTEM:SETUP ";Set$
1420 ELSE
1430 CLEAR SCREEN
1440 PRINT "Received bad data, no string entered."
1450 END IF
1460 CASE "E"
1470 Done=1
1480 END SELECT
1490 UNTIL Done
1500 DEALLOCATE Set$
1510 ASSIGN @Path TO *
1520 SUBEND
1530 !
1540 DEF FNStsize
1550 !
1560 !The setup string size can vary dependant upon operating system
1570 !revision. Must read the header to determine the proper lengths.
1580 !The format of the data is #NX...X<setup data string>. Then I
1590 !add 5 for the bdat file management headers.
1600 !
1610 COM /Io/ @Scope,Hpib
1620 DIM Psign$[1]
1630 INTEGER Length,Cnt,L
1640 ON TIMEOUT Hpib,3 CALL Tout
1650 !Set the bus timeout so if there is no/bad data, can't find
1660 !the # sign, we will stop and let the operator know.
1670 OUTPUT @Scope;":SYSTEM:SETUP?"
1680 !Query scope for the setup string.
1690 Cnt=0
1700 REPEAT
1710 ENTER @Scope USING "#,A";Psign$
1720 !Enter a character at a time until find the # sign. It
1730 !indicates the beginning of the block header.
1740 Cnt=Cnt+1
1750 !FN must keep track of the number of characters before the #
1760 !sign for cases where the system headers are ON.

```

Example Programs
Learn String Example Program

```
1770 UNTIL Psign$="#"
1780 ENTER @Scope USING "#,A";Psign$
1790 !Next character tells the number of digits in the header.
1800 ENTER @Scope USING "#,&Psign$&"D";Length
1810 !Length is the number of data values to follow before the NL.
1820 ALLOCATE Temp$(Length+1)
1830 ENTER @Scope USING "#,-K";Temp$
1840 L=7+Cnt+VAL(Psign$)+Length
1850 DEALLOCATE Temp$
1860 RETURN L
1870 FNEND
1880 !
1890 SUB Tout
1900 !Branching here says that the HP-IB bus was idle for 3 seconds.
1910 !This would be caused by reaching the end of the setup data without
1920 !finding a # sign.
1930 CLEAR SCREEN
1940 PRINT "Bad Data, query aborted."
1950 BEEP
1960 PAUSE
1970 SUBEND
```

Service Request Example Program

```

10  ! RE-SAVE "SRQ_7XX"
20  ! This program sets the Event Status Enable Register and the
30  ! Service Request Enable Register so that an error will cause
40  ! a service request. It also saves a setup to a setup memory
50  ! and recalls that setup.
60  DIM Query$(15),Command$(15),Q$(9000)
70  COM /Err/ Hpib,Scope
80  COM /S/ @S
90  Hpib=7
100 CLEAR Hpib
110 Scope=7
120 Saddr=Hpib*100+Scope      !Sets the I/O address.
130 Readme
140 ASSIGN @S TO Saddr
150 ON INTR Hpib,15 CALL Ermsg !Tells computer where to go on an error
160 CLEAR Saddr
170 OUTPUT @S;"*ESE 60;*SRE 32;*CLS"
180 !   *ESE XX sets the Event Status Enable Register.
190 !       32 => CME or Command Error
200 !       16 => EXE or Execution Error
210 !       8  => DDE or Device Dependent Error
220 !       4  => QYE or Query Error
230 ! -----
240 !       60
250 !   *SRE XX sets the Service Request Enable Register.
260 !       32 => ESB or Event Status Bit
270 ENABLE INTR Hpib;2      !Allows the HPIB to interrupt the computer.
280 Saveset$="*SAV "      !This command is missing the parameter, 1.
290 Recallset$="*RCL 1"   !This recalls setup #1.
300 !
310 OUTPUT @S;Saveset$    !Send the command, causes CME until the 1 is added.
320 WAIT 1
330 LOCAL Saddr
340 Readme1
350 OUTPUT @S;Recallset$  !Recalls setup #1.
360 LOCAL Saddr
370 Readme2
380 END
390 !
400 SUB Ermsg              !Error Trap
410 COM /S/ @S

```

Example Programs
Service Request Example Program

```
420 COM /Err/ Hpib,Scope
430 DIM E$(50)
440 PRINT "An error occured.",
450 Sp=SPOLL(707)
460 IF BIT(Sp,6) THEN
470 ! Testing bit 6 will tell us if the scope is the source of the interupt.
480 OUTPUT @S;"*ESR?"!Reads then clears the Standard Event Status Register
490 ENTER @S;J
500 Srq_type(J) !Call to the SRQ interpreter subprogram.
510 Done=0
520 REPEAT
530 ! Read the Error Queue to determine the specific error. Repeat reading
540 ! until the Queue is empty. Each time the queue is read the error will
550 ! be reported or the message 'THERE ARE NO MORE ERRORS' will be returned.
560 OUTPUT @S;"*SYSTEM:ERROR? STRING"
570 ENTER @S;E$
580 IF E$[1;1]="0" THEN
590 PRINT "THERE ARE NO MORE ERRORS."
600 OUTPUT @S;"*CLS" !Clears all event registers and queues except
610 !the output queue.
620 ENABLE INTR Hpib;2
630 Done=1
640 Readme3
650 ELSE
660 PRINT E$
670 END IF
680 UNTIL Done
690 ELSE
700 CLEAR SCREEN
710 PRINT "An interupt on the HPIB has occured but it is not the "
720 PRINT "scope. Please clear the other source of interupt before"
730 PRINT "restarting this program."
740 PAUSE
750 END IF
760 SUBEND
770 !
780 SUB Readme
790 PRINT " This program sets the Event Status Enable Register and the"
800 PRINT " Service Request Enable Register so that an error will cause"
810 PRINT " a service request. "
820 PRINT
830 PRINT " The second function of this program is to save and then recall"
840 PRINT " the current scope setup to and from setup memory 1. However,"
850 PRINT " there is a bug in this program. The save command is missing a"
860 PRINT " parameter. It needs a 1 after the space or '*SAV 1'."
```

Example Programs
Service Request Example Program

```
870 PRINT
880 PRINT " After you have seen how the SRQ's work you may edit line 280"
890 PRINT " to save the setup."
900 PRINT
910 PRINT " Once you have fixed the bug the program will run and save the"
920 PRINT " current setup to setup memory 1 then pause and allow you to "
930 PRINT " change the setup. When you continue, the original setup will"
940 PRINT " be restored."
950 PRINT
960 PRINT " The expected configuration is;"
970 PRINT "     The scope is at address 7"
980 PRINT "     The HPIB is at address 7"
990 PRINT
1000 PRINT " If the configuration is different break program and set "
1010 PRINT " the addresses as required using the variables Hpib and "
1020 PRINT " Scope. Then run again."
1030 PRINT
1040 PRINT " Press Continue when ready to resumen operation."
1050 PRINT
1060 PAUSE
1070 CLEAR SCREEN
1080 SUBEND
1090 !
1100 SUB Readme1
1110 PRINT
1120 PRINT " The current setup has been saved in setup memory #1."
1130 PRINT
1140 PRINT " Change the scopes setup from the front panel. When you"
1150 PRINT " press continue the original setup will be restored."
1160 PRINT
1170 BEEP
1180 PAUSE
1190 CLEAR SCREEN
1200 SUBEND
1210 !
1220 SUB Readme2
1230 PRINT " The program has ended. Thanks for trying our Save "
1240 PRINT " and Recall setup memories."
1250 PRINT
1260 PRINT " Now would you have the opportunity to edit the program"
1270 PRINT " to generate and error and see how the interupt masking"
1280 PRINT " works."
1290 PRINT
1300 PRINT "          GOODBYE.          "
1310 SUBEND
```

Example Programs
Service Request Example Program

```
1320 !
1330 SUB Readme3
1340 PRINT
1350 PRINT " Break the program at this time and determine the cause of "
1360 PRINT " the error."
1370 PRINT
1380 PRINT " Once you have fixed the cause of the error described by"
1390 PRINT " the error code and message, rerun the program by pressing"
1400 PRINT " RUN."
1410 PAUSE
1420 CLEAR SCREEN
1430 SUBEND
1440 !
1450 SUB Srq_type(J)
1460 ! The scope has interrupted the computer and we have read the
1470 ! Standard Event Status Register. Now the value, J, that was
1480 ! read by the *ESR? will be evaluated to determine why the
1490 ! SRQ was generated.
1500 PRINT "ESR value is ";J
1510 SELECT J
1520 CASE 32
1530 PRINT "32 => CME or Command Error."
1540 CASE 16
1550 PRINT "16 => EXE or Execution Error."
1560 CASE 8
1570 PRINT "8 => DDE or Device Dependent Error."
1580 CASE 4
1590 PRINT "4 => QYE or Query Error."
1600 END SELECT
1610 SUBEND
```

Configuration Example Program

```
10  !RE-SAVE "CONFIG"   !This is an RMB and IBasic Program.
20  !
30  !It queries the scope to determine the configuration and then
40  !prints it to the crt.  It assumes that the scope is at HPIB
50  !
60  DIM Mframe$(13),Slot$(1:4)(13)
70  OUTPUT 707;"SYSTEM:HEADER ON"
80  OUTPUT 707;"SYSTEM:LONGFORM ON"
90  !
100 !***** DETERMINE THE FRAME MODEL NUMBER *****!
110 !
120 OUTPUT 707;"MODEL? FRAME"
130 ENTER 707;Mframe$
140 !
150 !***** DETERMINE THE PLUG-INS AND THEIR LOCATIONS *****!
160 !
170 FOR I=1 TO 4
180     OUTPUT 707 USING "K";"MODEL? PLUGIN";I
190     ENTER 707;Slot$(I)
200 NEXT I
210 !
220 !***** REPORT THE MAINFRAME MODEL # AND PLUG-INS *****!
230 !
240 CLEAR SCREEN
250 PRINT "The Main frame is ";Mframe$
260 PRINT
270 PRINT "The plug-in in slot 1 is ";Slot$(1)
280 PRINT "The plug-in in slot 2 is ";Slot$(2)
290 PRINT "The plug-in in slot 3 is ";Slot$(3)
300 PRINT "The plug-in in slot 4 is ";Slot$(4)
310 PRINT
320 PRINT "End of Program"
330 END
```

Example Programs
Limit Test Example Program

Limit Test Example Program

```
10  | MLIM.lbw
20  |
30  |      Copyright: (c) 1993, Hewlett-Packard Co. All rights reserved.
40  |      Contributor: Colorado Springs Division
50  |      Product: Throughput Application
60  |
70  | $Revision$      3.0
80  | $Date$          6-14-93
90  | $Author$       Ed Mierzejewski
100 |
110 | Structure Chart: None
120 |      Description: This Uses Measure Limit Testing to make 3 measurements
130 |                  on 10 successive pulses at a 10 Hz rate.
170 |
180 | Considerations: None
200 |      Main routine: Begin_main
210 |      Sub-routines: None
220 |      Functions: None
230 |      Sub-programs: Readme, Set_paths, Set_scope, Meas, Tcount
240 |
250 Variable_list:
280 Begin_main:  |
290   CALL Readme
300   CALL Set_paths(@Scope,Isc)
310   CALL Set_scope(@Scope)
320   CALL Meas(@Scope,Isc)
330 End_of_main:  |
340   END
350 |
360 Begin_subs:  |
370 |
380   SUB Readme
390 |
400 | Description: Readme writes instructions and information at the
410 |              beginning of the program for the user to ensure
420 |              proper setup prior to continuing the program.
430 |
440 | Parameters: None
450 |
460   CLEAR SCREEN
461   PRINT TABXY(5,5)
```

Example Programs
Limit Test Example Program

```
470 PRINT "MLIM.ibw uses a HP8131 in the burst mode to manually start a "  
471 PRINT "burst of 10, 2ns pulses with a 99.9 ns period, 1 V amp."  
472 PRINT  
473 PRINT " It will work with any similar signal, including the "  
474 PRINT " front panel cal."  
475 PRINT  
480 PRINT "It makes a Vpp, Risetime, and Positive pulse width measurement"  
490 PRINT "on each and reports the mean after all 10 measurement sets are"  
491 PRINT "complete."  
500 PRINT  
510 PRINT "There are NO specific plug-ins required, except a suitable 1"  
520 PRINT "must be in channel 1. (Program was developed using a '13A"  
521 PRINT "installed in slot 1 of a 54710A."  
530 PRINT  
540 PRINT "The HP-IB card is assumed to be at interface select code 7 and"  
550 PRINT "the scope is at address 7."  
560 PRINT  
570 PRINT "Ensure all of this is correct before continuing."  
571 PRINT  
580 PRINT "press continue when through reading this."  
590 PAUSE  
600 CLEAR SCREEN  
610 SUBEND  
620 !  
960 SUB Set_scope(@S)  
970 !  
980 ! Description: Set_scope has 2 parts:  
990 !           1 -- initialize the scope and i/o.  
1010 !          2 -- set for RT acquires and measurement of the pulses.  
1020 !  
1030 ! Parameters:  
1040 !       Passed: (@S) @Scope = specific scope's address,  
1050 !       Internal:  
1060 !  
1070 ! Modified Variables: None  
1080 !  
1090 Part_1: ! Initialize for RT to measure pulses.  
1100 OUTPUT @S;"*rst;*cls"  
1101 OUTPUT @S;":opec 256" ! Unmasks the Lim.Tst. Comp. bit.  
1104 OUTPUT @S;"*sre 128" ! Unmasks the oper bit, see Lttest.  
1105 OUTPUT @S;":disp:grat fram"  
1110 OUTPUT @S;":blan chan2;view chan1" ! 54710 only has 2 chan's avail.  
1112 OUTPUT @S;":acq:mode rtim;srat 2E9;poin 512"  
1113 OUTPUT @S;":chan1:bw1 off;disp on;inp dc50;offs 0;prob 1,rat;scal .5"  
1140 OUTPUT @S;":tim:pos 10E-9;scal 2.5E-9"
```

Example Programs
Limit Test Example Program

```
1150 OUTPUT @S;":trig:swe trig;sour trig1;lev trig1,.5"
1190 Part_2:                                     ! Set Measurements
1200 OUTPUT @S;":meas:send off;stat on;sour chan1"
1201 !
1202 ! Turn off sendvalid, on statistics, and sets source to channel 1
1203 !
1210 OUTPUT @S;":meas:vpp;ris;pwid"
1220 SUBEND
1230 !
1240 SUB Set_paths(@Scope,Isc)
1250 !
1260 ! Description: Set_paths simply assigns HP-IB select code to be 7 and
1261 !               the scope address to be 7.
1270 !
1280 ! Parameters:
1310 !   Passed:   @Scope = I/O path 707
1320 !             scope = the HP-IB address that the scope is selected to.
1330 !   Internal:  Isc   = the interface select code for the HP-IB card.
1350 ! Modified Variables: @Scope
1360 !
1400 CLEAR SCREEN
1420 Isc=7
1430 Scope=7
1580 ASSIGN @Scope TO Isc*100+Scope
1610 SUBEND
1620 !
1630 SUB Meas(@S,Isc)
1640 !
1641 ! Description: The scope is setup and waiting to make continuous meas's.
1642 !               1 -- Setup On interrupt so Lim. Tst. Comp. gives SRQ.
1643 !               2 -- Setup Limit test.
1644 !               3 -- Set RUN Limit Tests.
1645 !               4 -- Report results.
1646 !
1647 ! Parameters:
1648 !   Passed:  (@S) @Scope = specific scope's address,
1650 !           COM /For_cnt/ INTEGER num_acq, M
1651 !
1653 !   Internal: Results(*) = array of values returned from a RESULTS?
1654 !                   Value 4 of each set is the mean. Therefore,
1655 !                   Results(4), (13), and (22) are the ones of
1656 !                   interest.
1657 !           M = measurement sets requested.
1658 !           Num_acq = the termination variable.
1661 !
```

Example Programs
Limit Test Example Program

```

1662 ! Modified Variables: Num_acq
1663 !
1664 ! Calls sub programs: Tcount
1665 !
1871 COM /For_cnt/ INTEGER Num_acq,M,S ! need to pass num_acq on intr.
1872 REAL Results(1:27) ! 9 parameters per measurement.
1900 M=10
1901 Num_acq=0
1910 CLEAR SCREEN
1920 Part1: ! Setup interrupt
1930 ON INTR Isc,9 CALL Tcount
2000 Part2: !
2001 OUTPUT @S;":ltes:sour 1;fail nev;mnf pass;run wav,";M
2002 OUTPUT @S;":ltes:sour 2;fail nev;mnf pass;run wav,";M
2003 OUTPUT @S;":ltes:sour 3;fail nev;mnf pass;run wav,";M
2010 OUTPUT @S;":stop;cdis"
2020 OUTPUT @S;":ltes:test on"
2060 Part3: !
2068 ENABLE INTR Isc;2
2069 OUTPUT @S;":run" ! scope will wait for triggers.
2070 PRINT "If using the 8131A, Start Generator NOW."
2071 REPEAT ! wait for limit test complet.
2076 UNTIL Num_acq=M
2077 Part4: !
2080 OUTPUT @S;":meas:res?" ! read summary of measurements.
2081 ENTER @S;Results(*)
2082 CLEAR SCREEN
2083 PRINT " The results are;"
2085 PRINT "the vpp mean is ";Results(4);","
2086 PRINT "the rise time mean is ";Results(13);", and"
2087 PRINT "the +width mean is ";Results(22);"."
2088 PRINT
2089 PRINT Results(*),
2091 SUBEND
2100 !
2110 SUB Tcount
2111 !
2112 ! Description: Tcount will set Num_acq to the #stop value when the Lim.
2113 ! Test Complete interrupt occurs.
2118 ! Parameters:
2119 ! Passed:
2120 ! COM /For_cnt/ INTEGER Num_acq,M
2121 ! Num_acq = the variable used to terminate at proper number.
2122 ! M = the number of acquisitions wanted, termination value.
2124 ! Internal: None

```

Example Programs
Limit Test Example Program

```
2129 !  
2130 ! Modified Variables: num_acq  
2131 !  
2132 ! Calls sub programs: None  
2133 !  
2134   COM /For_cnt/ INTEGER Num_acq,M,S  
2135   PRINT "hello"  
2137   Num_acq=M  
2138 SUBEND
```

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