TEK PROGRAMMERS MANUAL

Part No.: 070-7555-00
Product Group 2E

492PGM
SPECTRUM ANALYZER

Please Check for CHANGE INFORMATION at the Rear of This Manual

First Printing JUNE 1989
Revised SEPTEMBER 1991

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Safety Summary

(Refer all servicing to qualified servicing personnel)

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

Conformance to Industry Standards

This instrument complies with the following Industry Safety Standards and Regulatory Requirements.

Safety

CSA: Electrical Bulletin

ANSI C39.5 — Safety Requirements for Electrical and Electronic Measuring and Controlling Instrumentation.

IEC 348 (2nd edition) — Safety Requirements for Electronic Measuring Apparatus.

Regulatory Requirements

VDE 0871 Class B — Regulations for RFI Suppression of High Frequency Apparatus and Installations.

Terms

In This Manual

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

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

As Marked on Equipment

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

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

Symbols

In This Manual

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

As Marked on Equipment

DANGER — High voltage.

Protective ground (earth) terminal.

ATTENTION — refer to manual.

Refer to manual

Power

Power Source

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

Grounding the Product

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

Danger From Loss of Ground

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

Use the Proper Power Cord

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

Use only a power cord that is in good condition.

CSA certification applies to the spectrum analyzer with CSA-certified power cords only (the power cord shipped with your instrument and Tektronix Option A4). International power cords (Tektronix Options A1, A2, A3, and A5) are approved only for the country of use, and are not included in the CSA certification.

Refer cord and connector changes to qualified service personnel.

For detailed information on power cords and connectors, see the Maintenance section in the Service Manual, Volume 1.

Use the Proper Fuse

To avoid fire hazard or equipment damage, use only the fuse of correct type, voltage rating, and current rating for your product (as specified in the Replaceable Electrical Parts list in Volume 2 of the Service Manual). Refer fuse replacement to qualified service personnel.

Operational Precautions

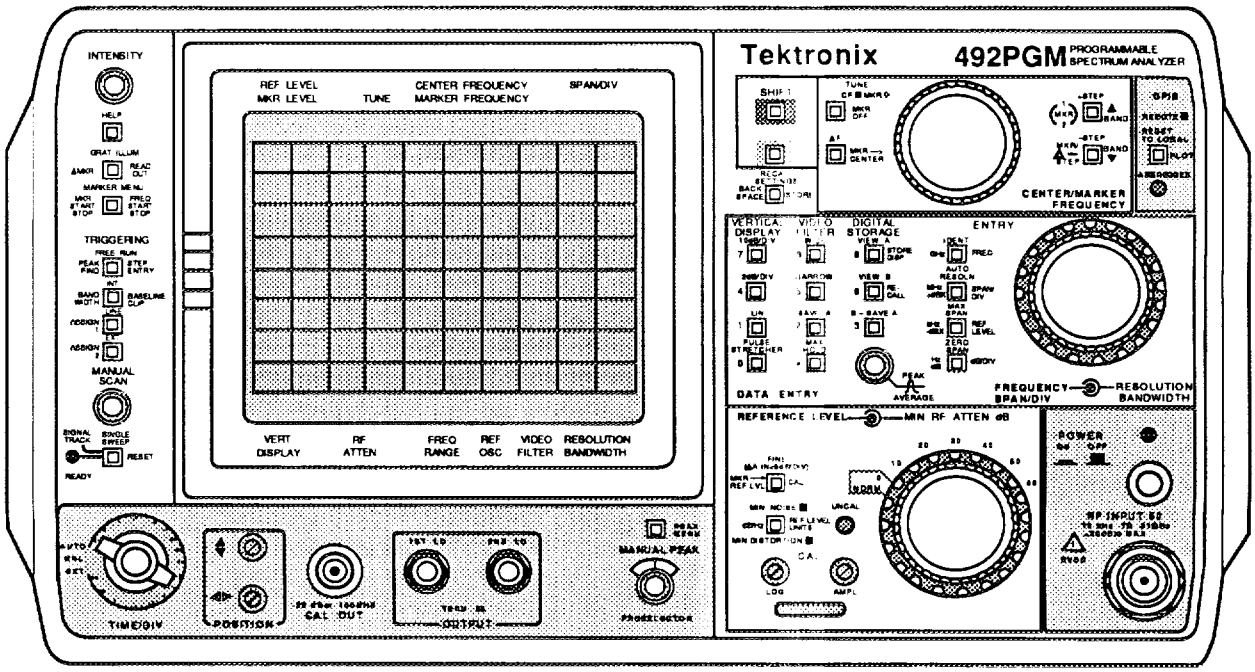
Do Not Operate In Explosive Atmospheres

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

Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels unless you are qualified to do so. Do not operate the product without the covers and panels properly installed.

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on. REFER ALL SERVICING TO QUALIFIED SERVICE PERSONNEL.



TEKTRONIX 492PGM Programmable Spectrum Analyzer

Introduction To GPIB Operation

The TEKTRONIX 492PGM Programmable Spectrum Analyzer allows remote control of instrument functions. In addition spectrum data can be acquired, processed, and analyzed. The front panel controls can be remotely controlled (except those intended for local use only, such as INTENSITY).

The IEEE STD 488 General Purpose Interface Bus (GPIB) port in the spectrum analyzer rear panel allows it to be used with a wide variety of systems and controllers; the instrument follows the Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features. This standard promotes ease of operation and makes this spectrum analyzer compatible with other Tektronix instruments and, as much as possible, with GPIB instruments from other manufacturers.

GPIB Push button and Indicator (see Figure 1-1)

RESET TO LOCAL/REMOTE

The REMOTE indicator is lit when the spectrum analyzer is under control of the GPIB controller. While under remote control, most other front-panel controls and push buttons are not active; indicators will still reflect the current state of all front-panel functions except TIME/DIV, MIN RF ATTEN dB, and PEAK/AVERAGE.

The REMOTE indicator is not lit when the instrument is under local, operator control. While under local control, the instrument does not execute GPIB messages that would conflict with front-panel controls, and it does not accept the CURVE input command.

When the instrument is under remote control and RESET TO LOCAL is pressed, local control is restored to the operator unless the controller prevents this with the local lockout message. Programmable functions do not change when switching from remote to local control except as necessary to match the settings of front-panel controls for TIME/DIV, MIN RF ATTEN dB, and PEAK/AVERAGE.

The spectrum analyzer flashes the instrument name, firmware version number, and GPIB address on the CRT when RESET TO LOCAL is pressed.

<Blue-SHIFT> PLOT

Press this push button when the spectrum analyzer is in the talk-only mode for the instrument to send the appropriate commands over the GPIB to a plotter, which must be in the listen-only mode, connected to the bus (see the TALK ONLY, LISTEN ONLY switch descriptions later in this section). The spectrum analyzer display (waveform, marker(s), graticule, and CRT readout) can be recreated on a TEKTRONIX 4662 Option 01 or 4662 Option 31 Interactive Digital Plotter (or a 4663 in the 4662 emulation mode); or a Hewlett-Packard HP7470A or HP7475A, HP7580B, HP7585B, or HP7586B; or a Gould 6310 or 6320 plotter. Select plotter type with <blue-SHIFT> SAVE A, described in Section 4 of this manual. A bus controller is not required.

<Green-SHIFT> SRQ

This SRQ (service request) push button sequence gets the controller's attention so it will listen/respond to the spectrum analyzer. For example, if the controller put instructions on the screen, in the TEXT LONG mode, to set up test equipment, etc., the last line of the instructions might say "PRESS <green-SHIFT> SRQ WHEN READY". This would instruct the controller to go on to the next step. An SRQ will only be issued if RQS is on.

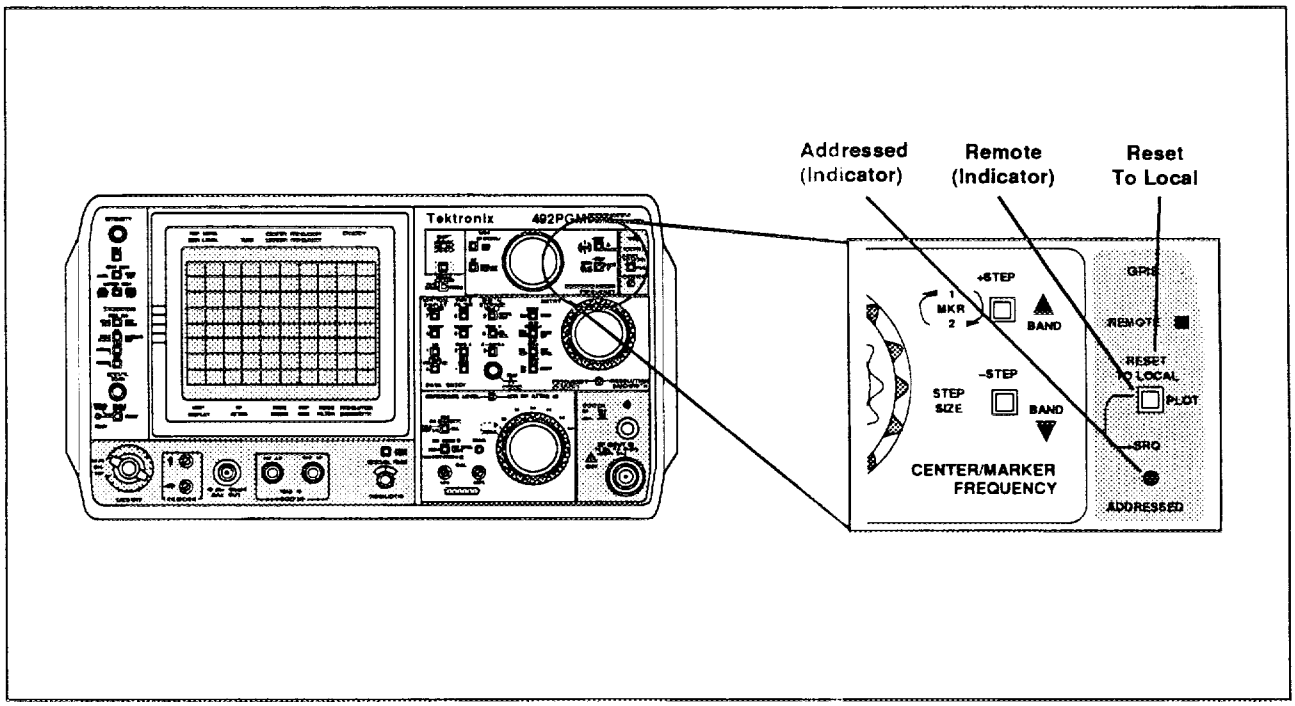


Figure 1-1. GPIB push button and indicators.

ADDRESSED

This indicator is lit when the spectrum analyzer is addressed to listen or talk.

GPIB Function Readout

A single character appears in the lower CRT readout when the spectrum analyzer is talking (T), or listening (L) (see Figure 1-2). Two characters will appear in this location if the instrument is talking or listening and also requesting service (S), or if the instrument is in both the talk-only and listen-only modes.

Setting the GPIB ADDRESS Switches

The rear-panel GPIB ADDRESS switches shown in Figure 1-3 set the value of the GPIB address (refer to Table 1-1). The instrument's primary address (0 through 31) is the 1-2 value of the lower five bits, which are labeled 4 through 8 in Figure 1-3. These switches are read each time power is turned on to the instrument and again each time the RESET TO LOCAL or <blue-SHIFT> PLOT push button is pressed.

The address transmitted by the controller is seven bits wide. The first five bits are the primary address and the last two bits determine whether it is a listen address (32 + primary address) or talk address (64 + primary address). For example; 0100010 is primary address 2 and is a listener, and 1000010 is primary address 2 and is a talker. Secondary addresses (when both bits 6 and 7 are set) are not used by the spectrum analyzer, so are ignored.

Set the switches as desired; however, addresses 30 and 0 are usually reserved for controller addresses. Selecting a primary address of 31 logically removes the spectrum analyzer from the bus; it does not respond to any GPIB address, but remains both unlistened and untalked. Remember, if you change these switches when the instrument is running, you must press RESET TO LOCAL or <blue-SHIFT> PLOT to cause the primary address to be updated.

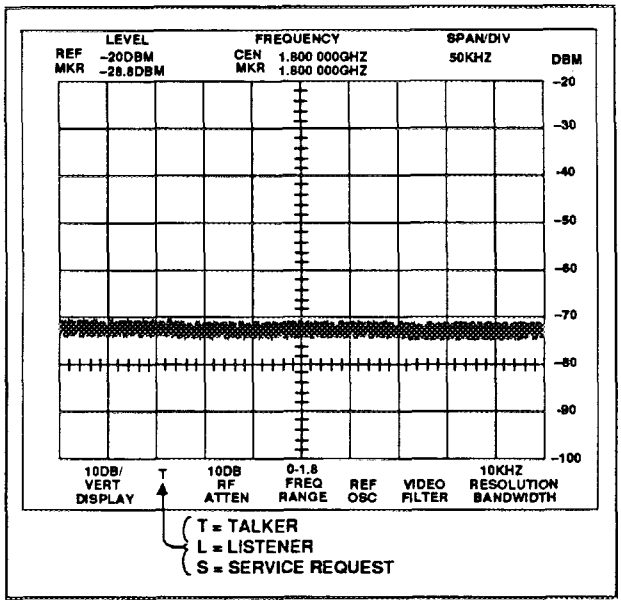


Figure 1-2. Status of active GPIB functions.

Setting the LF or EOI Switch

Switch 3 of the rear-panel GPIB ADDRESS switch bank (see Figure 1-3) selects the terminator for messages on the bus. If LF or EOI is selected (switch up, 1), the spectrum analyzer interprets either the data byte LF or the end message (EOI asserted concurrently with a data byte) as the end of a message. If EOI is selected (switch down, 0), the spectrum analyzer interprets the end message (EOI asserted as well as a data byte) as the end of a message.

Switch 3 also selects the output terminator. Set to LF OR EOI, the instrument adds CR and LF (with EOI asserted as well as LF) after the last byte of the message. Set to EOI, the instrument asserts EOI concurrently with the last byte of the message.

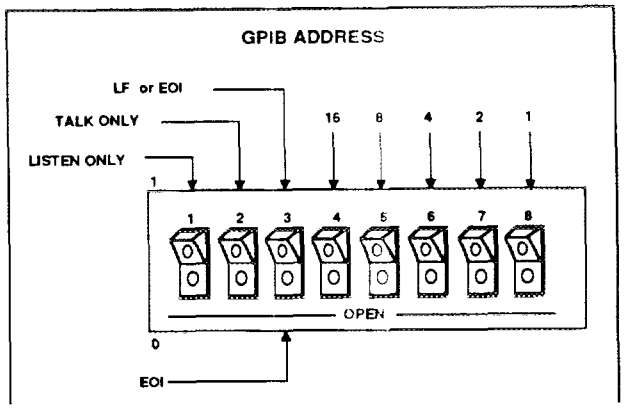
Figure 1-4 shows the effect of this switch for both input and output.

Select EOI (switch down) for Tektronix controllers. The other position of this switch is provided to accommodate most other controllers. A change in this switch takes immediate effect.

Setting the TALK ONLY and LISTEN ONLY Switches

The spectrum analyzer switches for talk-only and listen-only operation are part of the GPIB ADDRESS switch bank shown in Figure 1-3. These switches are on in the up (1) position and off in the down (0) position. If instrument power is on, press RESET TO LOCAL or <blue- SHIFT> PLOT for a change in these switches to take effect.

Both the TALK ONLY and LISTEN ONLY switches must be off when the spectrum analyzer is used with any controller. As contrast, both switches must be on to allow spectrum analyzer output to be exchanged with a storage device without the need of a controller. The TALK ONLY switch must be on to allow spectrum analyzer output to be sent to a plotter. With the LISTEN ONLY switch on, information sent to a storage device can be fed back to the spectrum analyzer.



Introduction to GPIB Operation — 492PGM Programmers

Source Handshake (SH1)

The spectrum analyzer has complete capability to transfer messages to other devices on the bus. Although tri-state drivers are used on the data lines, T1 (DAV delay for data setting) is greater than 2 µs.

Acceptor Handshake (AH1)

The spectrum analyzer has complete capability to receive messages on the bus.

Talker (T5)

The spectrum analyzer has the complete talker function including serial poll; it unaddresses as a talker when addressed as a listener. The instrument operates in a simple system in a talk-only mode if the TALK ONLY switch is set to 1, up.

Listener (L3)

The spectrum analyzer has the complete listener function; unaddresses as a listener when addressed as a talker. The instrument operates in a simple system in a listen-only mode if the LISTEN ONLY switch is set to 1, up.

Service Request (SR1)

The spectrum analyzer has the complete service request function; asserts SRQ (service request) for the conditions indicated under STATUS BYTE in Section 9 in this manual and reports the corresponding status when polled

Remote/Local (RL1)

The spectrum analyzer has the complete remote/local function. The front-panel RESET TO LOCAL push button returns the instrument from remote to local control unless the LLO (local lockout) message was previously received. The GTL (go to local) message also returns the instrument from remote to local control. Refer to the discussion under STATUS BYTE in Section 9 of this manual for the effect of busy status on remote/local transitions.

The current value of most programmable functions is maintained when switching from local to remote control. Only the value of TIME/DIV, MIN RF ATTEN dB, and PEAK/AVERAGE may change to match the front-panel control settings when switching from remote to local control, so they won't conflict with local control.

The spectrum analyzer must be under remote control to begin executing device-dependent messages that change the state of local controls or to load data into digital storage. Once

Device Clear (DC1)

The spectrum analyzer responds to the DCL (device clear) and SDC (selected device clear) interface messages by resetting its input and output buffers to restart bus communications. When these messages are executed, they clear outstanding SRQ conditions and set the ERR query response to zero. Power-up status, if selected internally, is an exception; see STATUS BYTE in Section 9 of this manual for more on power-up status and for the affect of busy status on the execution of DCL and SDC.

Device Trigger (DT1)

The spectrum analyzer DT (device trigger) function allows the GET (group execute trigger) message to cause the instrument to stop the current sweep and reset for the new sweep. The new sweep begins when the triggering conditions are met. The DT command must be on and the instrument must be in the Remote mode for GET to have any effect.

Controller (C0)

The spectrum analyzer does not act as a controller.

Connecting to a System

The spectrum analyzer can be connected directly to a GPIB system with the cable available as an optional accessory (contact your local Tektronix Field Office or representative for ordering information). The IEEE STD 488 PORT is shown in Figure 1-5. Printed under the IEEE STD 488 PORT are the Interface Function abbreviations and the codes indicating their use in the instrument (refer to IEEE 488 Functions earlier in this section for an explanation of each function). The E2 following the functions indicates that three-state drivers are used, rather than open-collector drivers, because of the high-speed operation of the instrument.

The GPIB is a flexible system that works either in a star or linear pattern shown in Figure 1-6. Up to 15 devices can be connected at one time. To maintain bus electrical characteristics, no more than one 2-meter cable should be connected for each device (one for the controller, one for the spectrum analyzer, and so on), and at least two-thirds of the devices connected must be on. (Appendix A details the IEEE STD 488 GPIB System Concepts.)

An internal switch change causes the spectrum analyzer to assert SRQ when power is first applied. This requires immediate action by some controllers, so is not recommended for these controllers. Because changing the switch requires that the cover be removed, refer this task to qualified service personnel.

The instrument start-up procedure is provided in the Operators Manual. Refer to this book for instructions on how to begin operating the instrument. Refer to your local Tektronix Field Office or representative for manual ordering information.

The initial power-on setting of all programmable functions is restored by the INIT command. Refer to Section 8 of this manual for more on this command and a list of the initial power-on settings.

The spectrum analyzer automatically picks resolution bandwidth and time/division to fit the new span/division, unless Auto Resolution and Time Auto are cancelled. For most purposes, leave the TIME/DIV control set to AUTO so that Time Auto is in effect in either local or remote control, and leave Auto Resolution selected.

3. Press the <SHIFT> REF LEVEL 2 0 –dBm push buttons to set the signal to the reference level.

The spectrum analyzer automatically selects the appropriate input attenuation and IF gain for a reference level at the power level of the CAL OUT signal's fundamental frequency. The spectrum analyzer takes into account the MIN RF ATTEN dB and MIN NOISE settings when positioning the attenuation and gain.

The spectrum analyzer powers up with the automatic modes active and in MAX SPAN to display a complete frequency band. You can restore this condition at any time with the <blue-SHIFT> RESET push button sequence.

Controller Operation

Steps 2, 3 and 4 in the last example are adapted here for a controller. The 492PGM commands are inserted in the following GPIB output PRINT statement.

```
250     CMD$ = "FREQ 100 MHZ"
260     CALL IBWRT (PORT1%, CMD$)
270     CMD$ = "SPAN 1 MHZ"
280     CALL IBWRT (PORT1%, CMD$)
290     CMD$ = "REFLVL -20 DBM"
300     CALL IBWRT (PORT1%, CMD$)
```

or

```
250     CMD$ = "FREQ 100 MHZ;SPAN 2 MHZ;REFLVL -20 DBM"
260     CALL IBWRT (PORT1%, CMD$)
```

As this last statement shows, all three commands can be strung together, delimited by semicolons.

When the 492PGM runs this statement, it tunes center frequency, changes to the narrower span, and changes the reference level to display the signal peak at the top of the screen if the instrument settings are at the factory default values. Resolution bandwidth, time, input attenuation, and IF gain are changed automatically, as necessary. The signal peak should occur vertically at the reference level and horizontally at the graticule center. If not, refer to the Initial Turn On procedure in the Operators Manual.

The following amended program example illustrates adding an SRQ handler to your program. This sequence can be added to any program example shown in this manual.

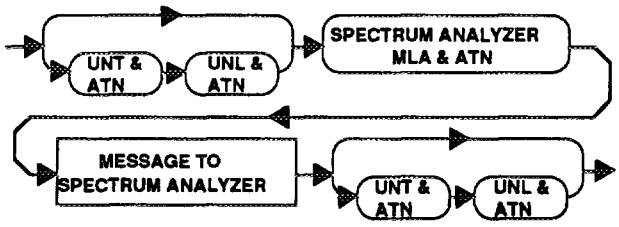
```
240 REM set up srq action
250     ON PEN GOSUB 1000                    (on srq gosub 1000)
260     PEN ON                               (enable srq interrupt)
270 REM Send GPIB commands
280     CMD$ = "FREQ 100 MHZ;SPAN 1 MHZ;REFLVL -20 DBM"
290     CALL IBWRT (PORT1%, CMD$)
300     END

1000 REM 492PGM SRQ/Error Handler
1010    PEN OFF                              (disable interrupts)
1020    CALL IBRSP (PORT1%, SBYTE%)          (read status byte)
1030    WHILE SBYTE%<>)                      (loop until all events read)
1040       CMD$ = "event?"                   (send event query)
1050       CALL IBWRT (PORT1%, CMD$)
1060       RSP$ = SPACE$(80)
1070       CALL IBRD (PORT1%, RSP$)          (read query resp)
1080       PRINT "Status Byte-"SBYTE%" "RSP$ (print status + event)
1090       SBYTE% = 0
1100       CALL IBRSP (PORT1%, SBYTE%)       (read status byte)
1110    WEND
1120    PEN ON                               (reenable interrupts)
1130    RETURN
1140    END
```

Line 250 causes execution to jump to the subroutine at line 1000 any time an SRQ occurs, and line 260 enables the SRQ interrupt. The rest of the main program is the same as the previous example.

Lines 1000 to 1140 are an error handling subroutine that disables the SRQ interrupt, does a serial poll and an event query, and prints the resulting status byte and event code. The process is repeated until all errors are reported. The National GPIB interface uses the "PEN" event for the SRQ interrupt, so that "PEN ON" and "PEN OFF" enable and disable the interrupt.

Whatever controller is used or statement is sent, the actions shown in the following syntax diagram must be taken to get a message to the 492PGM.



The unlisten (UNL) and untalk (UNT) messages are optional in the previous syntax diagram. However, one or both are sent by most controllers when they begin transmitting and end transmitting in order to guarantee a clear communications channel. The controller sends the GPIB address you entered as part of the controller's GPIB I/O statement. The controller either converts it to the 492PGM listen address or expects to receive the listen address with the offset included (i.e., 33). The controller then sends the device-dependent message you inserted into the statement, and may finish by sending UNL and UNT. If the controller does not activate remote enable (REN) automatically for GPIB I/O, you can set it with an earlier control statement.

The format of the response allows it to be used to restore the instrument settings with no operator manipulation required. First, set up for the measurement (and try it) from the spectrum analyzer front panel. Store the message as it is transmitted by the spectrum analyzer using the SET query. Your controller must be ready for a long character string. Allow at least 750 characters for the SET query response, although the exact size depends on the current settings. Then, perform any desired instrument operations. Finally, restore the spectrum analyzer to the original settings by transmitting the stored SET query response back to the instrument (the following program steps you through the operation).

```
300 Rem This program stores/recalls spectrum analyzer front-panel settings
305 FID$ = "SETS"                    (name settings file)
310 INPUT "Press <Return> key to store settings",K$
320 CMD$ = "SET?"
325 CALL IBWRT (PORT1%,CMD$)         (send message to 492PGM instrument)
330 CALL IBRDF (PORT1%,FID$)         (read response into file)
335 PRINT "Settings stored..."
340 INPUT "Press <Return> to recall settings to front panel",K$
360 IBWRTF (PORT1%,FID$)             (send file to 492PGM instrument)
365 Print "Settings recalled..."
370 End
```

Line 305 — Dimensions the string variable

Lines 310 through 335 — Inputs a SET? response from the spectrum analyzer.

Lines 340 through 365 — Returns a SET? response to the spectrum analyzer.

Resetting the Spectrum Analyzer and Interface Messages

The INIT command resets the instrument's programmable controls to their initial turn-on condition (see Section 9 in this manual for more on this command). INIT is sent in the same manner as other commands.

Interface message DCL (device clear) clears the instrument I/O buffers and can be used to restart bus communications with the spectrum analyzer. DCL does not interrupt message execution. If the spectrum analyzer is waiting for its talk address so it can execute an output query, output is stopped and the buffers are cleared by DCL (decimal code 20) or any device-dependent input. The decimal codes for other universal commands are 17 for LLO (local lockout), 21 for PPU (parallel poll unconfigure), 63 for UNL (unlisten), and 95 for UNT (untalk).

Addressed commands such as GTL (go to local) can also be sent to the spectrum analyzer. Use the IBTRG call to send GET, IBLOC to send GTL, IBCLR to send SDC, and IBPPC to send PPC. GET causes the spectrum analyzer to stop the current sweep and immediately start another sweep, synchronizing data acquisition with the interface message.

When the IFC (interface clear) line is asserted by the controller, the spectrum analyzer talker and listener functions are initialized (same effect as UNT and UNL).

Use the IBCMD statement to send the universal commands. For example, use the following statement to send a device clear message on the bus.

```
100 CMD$ = CHR$(20)
110 CALL IBCMD(BOARD%,CMD$)
```

For addressed commands, include the primary address of the programmable spectrum analyzer being talked to. For example, the following statement sends a go to local command to the spectrum analyzer.

```
100 CALL IBLOC(PORT1%)
```

Acquiring a Waveform

The waveform in digital storage can be requested as either ASCII-coded decimal numbers or a block of binary data. ASCII is discussed here. When the 492PGM powers up with the default settings, it is ready to transmit waveforms in ASCII.

The following program fragment will read the FULL waveform into the file CURVE, using ASCII encoding. The use of the FULL identifier automatically selects WFMODE WORD and accesses a 1001-point waveform to be returned, vertically scaled from 0 to 1000. A waveform identifier of A, B, or FULL can be selected (these select 500- and 1000-point waveforms scales according to 492PGM conventions [0 to 255]). See CURVE and WFMPRE in Section 4 for further details.

```
250     FID$ = "CURVE"                  (name output file)
260     CMD$ = "WFMPRE WFID:FULL,ENCDG:ASC;CURVE?:
270     CALL IBWRT (PORT1%, CMD$)       (send message to 492PGM instrument)
280     CALL IBRDF (PORT1%, FID$)       (read response into file)
```

The above program fragment can be modified to return the waveform in binary format, as shown below.

```
250     FID$ = "CURVE"                  (name output file)
260     CMD$ = "WFMPRE WFID:FULL,ENCDG:BIN:CURVE?"
270     CALL IBWRT (PORT1%, CMD$)       (send message to 492PGM instrument)
280     CALL IBRDF (PORT1%, FID$)       (read response into file)
```

See Section 10 in this manual for help in plotting the waveform.

Signal Analysis

The 492PGM has advanced internal waveform-processing capabilities to find and measure signals. Here is a simple application. (The following program catalogs the first 10 harmonics of the REF SIGNAL OUT signal.)

```
210 REM     Set up 492PGM instrument for harmonic search
220 REM
230    CMD$ = "SPAN 2 MHZ;REFLVL -20 DBM; VIDFLT NARROW; SIGSWP"
240    CALL IBWRT (PORT1%, CMD$)
250 REM
260 REM SET UP FREQUENCY STEP
270 REM
280    CMD$ = "FREQ 0MHZ;STEP 100MHZ)
290    CALL IBWRT (PORT1%, CMD$)
300 REM
310 REM Step frequency through first 10 harmonics of 100 MHz
320 REM
330    FOR 1%=1 TO 10
340         CMD$ = "PSTEP;SWEEP"            (step frequency, sweep analyzer)
350         CALL IBWRT (PORT1%, CMD$)
360         CMD$ = "FIBIG;MFREQ?;MAMPL?"    (find and query peak)
370         CALL IBWRT (PORT1%, CMD$)
380         RSP$ = SPACE$(80)               (clear response string)
390         CALL IBRD (PORT1%, RSP$)        (read query response)
400         PRINT RSP$                      (print results)
410    NEXT
```

Lines 230 and 240 set up the basic instrument settings for examining the harmonics of the REF SIGNAL output and selects single sweep mode.

Lines 280 and 290 set up a frequency step size of 100 MHz and sets the frequency to 0 so that the first step in the loop will set the 492PGM instrument to 100 MHz.

Line 340 steps the center frequency and performs a sweep; the SWEEP command triggers a single sweep and waits for the end of sweep before allowing subsequent commands to be executed.

Line 360 does a peak search and queries the resulting marker frequency and amplitude. Lines 380 through 390 clear the response string, read the response, and print the result.

Device-Dependent Messages

Structure and Execution

The goal of the programmable spectrum analyzer device-dependent message structure is to enhance compatibility with a variety of GPIB systems, yet be simple and obvious to use.

This goal is achieved within the framework of the Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features. This standard is intended to make messages on the bus clear and uncomplicated, while allowing the instrument to handle messages in a friendly manner (i.e., to accept variations in the message). Compatibility with existing devices is maintained as much as possible, while use of codes and data formats is encouraged to make maximum use of bus capabilities.

To make spectrum analyzer messages easy to understand and write, ordinary engineering terms are used. Message codes (mnemonics) are chosen to be short, yet remind you of their function. For example, to set the instrument center frequency to 500.000 MHz, the message FREQ 500.000 MHZ could be sent over the bus after the instrument has been addressed as a listener. Variations on this message are allowed to make it shorter or send the frequency in scientific notation, but this example shows the conversational format of spectrum analyzer messages that makes them readable; therefore, human-oriented.

The spectrum analyzer device-dependent messages in this manual are downward compatible with the Tektronix 490P-Series and 2750P-Series programmable spectrum analyzers, except as noted later in this section under Spectrum Analyzer Compatibility.

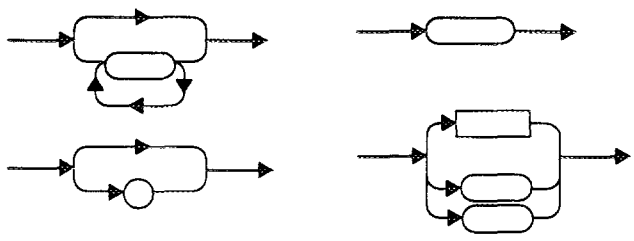
Syntax Diagrams

Spectrum analyzer messages are presented in this manual in syntax diagrams that show the sequence of elements transferred over the bus. Each element is enclosed in a circle, oval, or box.

Circles or ovals contain the mnemonics for literal elements; i.e., a character or string of characters that must be sent exactly as shown. Because most mnemonics may be shortened, the required characters in command and query literal elements (i.e., the first three characters of the element) are shown larger than optional characters. Although mnemonics are shown all upper case, the spectrum analyzer accepts either upper-case or lower-case ASCII characters. Query response characters are shown exactly as they will be returned.

Boxes are used for defined elements and contain a name that stands for the element defined elsewhere. NUM is such an name and is defined under Numbers later in this section.

Elements of the syntax diagram are connected by arrows that show the possible paths through the diagram (i.e., the sequence in which elements must be transferred). Parallel paths mean that one, and only one, of the paths must be followed; while a path around an element or group of elements indicates an optional skip. Arrows indicate the direction that must be followed (usually the flow is to the right; but, if an element may be repeated, an arrow returns from the right to the left of the element). Some examples of such sequences follow.

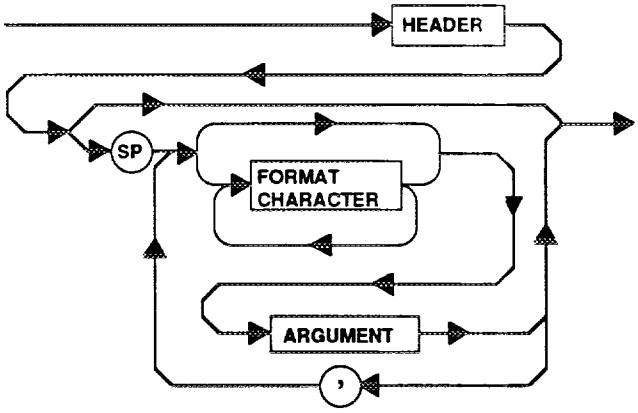


Spectrum Analyzer Input Messages

Input Message Format

A remote control message to the spectrum analyzer comprises one or more message units of two types. The message units either consist of commands that the spectrum analyzer inputs as control or measurement data, or they consist of queries that request the spectrum analyzer to output data.

One or more message units can be transmitted as a message to the spectrum analyzer. Message units contain ASCII characters (binary may also be used for data). The spectrum analyzer accepts either upper-case or lower-case characters for the mnemonics shown in the syntax diagrams.



Message Unit Delimiter (;)

Message units are separated by a semicolon (;). A semicolon is optional following the last message unit.

Message Terminator (TERM)

The end-of-message terminator may be either the END message (EOI asserted concurrently with the last data byte), or the ASCII code for line feed (LF) sent as the last data byte.

The active terminator is selected by the rear panel GPIB ADDRESS switch 3.

Format Characters

Format characters may be inserted at many points to make the message more intelligible, but are required only if they are included as a literal element (i.e., in circles or ovals) with no bypass. Allowable format characters are SP (space), CR (carriage return), and LF (line feed unless the end of message terminator is set for LF), as well as all other ASCII control characters and comma (,). At some points in a message, the spectrum analyzer may accept other non-alphanumeric characters, such as quotation marks (").

Input Buffering and Execution

The spectrum analyzer buffers each message it receives with a capacity that exceeds that required for the SET? response. The spectrum analyzer waits until the end of the message to decode and execute it. A command error in any part of a message prevents its execution. When the instrument is under local control, commands that would conflict with local control are ignored (see Remote/Local under IEEE 488 Functions in Section 1 of this manual).

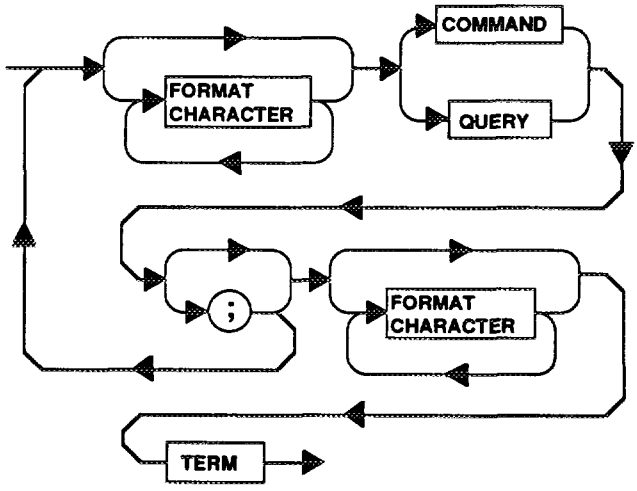
If the message contains multiple message units, none are acted on until the instrument sees the end-of-message terminator. When the spectrum analyzer sees the terminator, it executes the commands in the message in the order they were received. The instrument remains busy until it is done executing the commands in the buffer, unless the process is stopped by the DCL (Device Clear) or SDC (Selected Device Clear) interface messages. While busy, further input is not accepted (see STATUS BYTE in Section 9 in this manual for more on busy status). Output, if requested, is begun only after the entire input message is executed.

Because display (measurement) data input and output and waveform processing share the same buffer, conflicts can arise. This is discussed in the Interaction part of the CURVE command in Section 7, under Display Data Point Commands Interaction in Section 8, and is further expanded on under Multiple Use of Display Buffer For Waveform Processing and I/O in Section 9, all in this manual.

Command Format

A command message unit either sets an operating mode or parameter, or it transfers data to the instrument. The command format to set a mode or parameter includes the following possible paths.

Because the general command format for display data transfers is complicated, it is omitted; see the data I/O commands in Section 7 of this manual for the specific command syntax.



Header

Header elements are mnemonics that represent a function; for example, FREQ for center frequency and CURVE for the display trace.

Header Delimiter (SP)

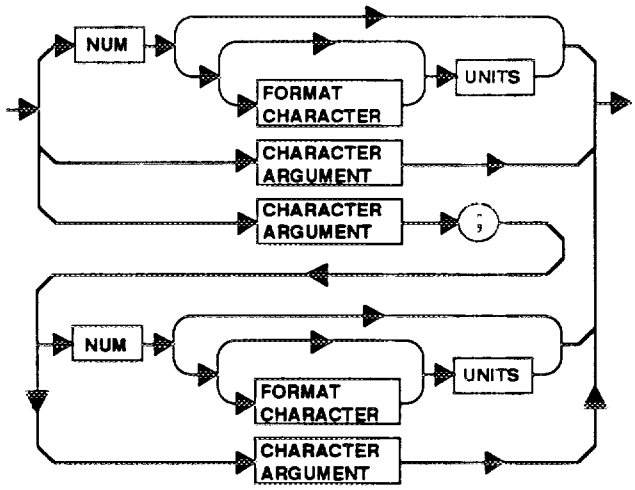
A space (SP) must separate the header from any argument(s).

Argument Delimiter (,)

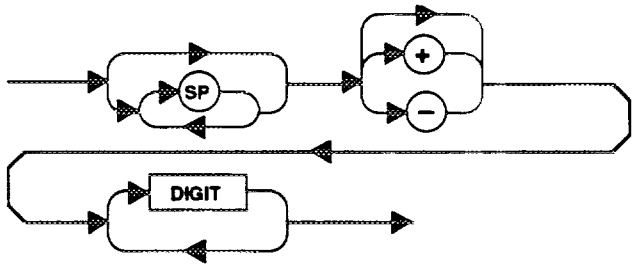
A comma (,) must separate individual arguments, and a colon (:) must separate link arguments.

Argument Format

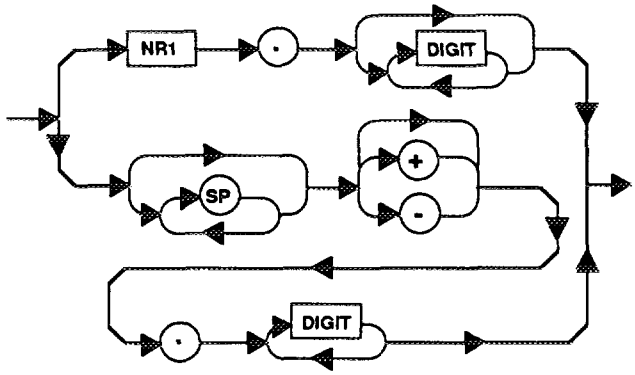
The following diagram illustrates that arguments following the header may be a number, a group of characters, or either a number or a group of characters linked to another argument.



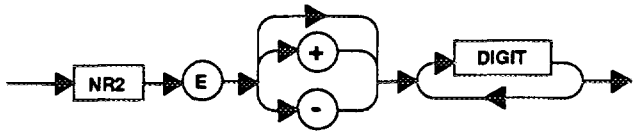
The defined element NUM is a decimal number in any of three formats; NR1, NR2, or NR3. NR1 is an integer (no decimal point).



NR2 is a floating point number (decimal point required).



NR3 is a floating point number in scientific notation.



NUM arguments may serve two functions. The first is to select the value of a continuous function (for example, the center frequency with FREQ). In this case, if NUM exceeds the range of the function, the spectrum analyzer does not execute the command, but issues an error message (see POINT in Section 4 in this manual for an exception). Numbers within the range are rounded.

The second function of a NUM argument is to substitute for character arguments in ON/OFF or mode selection. In this case, if NUM exceeds the selection range, it is rounded to the nearest end of the range. No error message is issued. Numbers within the range are rounded.

Units

The spectrum analyzer accepts arguments in engineering notation; that is, engineering units may be appended to a number argument. The instrument treats the combined number and units as scientific notation where the first letter of the units element represents a power of 10. K=1E+3, G=1E+9, and M=1E–3 or M=1E+6 (the value of M depends on the function, where MSEC stands for 1E–3 (milliseconds) in the TIME (time/div) command, and MHZ stands for 1E+6 (megahertz) in the SPAN (span/div) command). Only the first letter of the units element is of importance; the rest of the units element (i.e., SEC or HZ) does not contribute to the value of the command argument and can be omitted. This does not apply to the dBm and dBmV units in use with the RLUNITS, REFLVL, and MAXPWR commands, where all letters must be used to avoid an error. Although more than one format character may precede the units, only a space (SP) is shown in the command syntax diagrams in this manual.

In most cases (other than RLUNITS, REFLVL, and MAXPWR), if no units element (terminator) is sent with the number, one of the following will be implied as the default condition depending on usage; Volts, dB, seconds, or Hz.

Character Argument

Arguments may be either words or mnemonics. ON and OFF, for instance, are arguments for the commands that correspond to spectrum analyzer front-panel push buttons like VIEW B.

Link Argument

The bottom path in the argument diagram combines both character and number arguments in a link argument. The link is the colon (:), which delimits the first and second

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IDENT Command

The span must be ≤50 kHz/div.

Readout Maximum

Readout strings can contain up to 40 characters.

Service Requests

RQS is the master mask for service requests, and both RQS and EOS must be on to cause end-of-sweep service requests.

Affect of Busy on Device-Dependent Messages

Interface messages are processed despite busy status. If RTL interrupts a message, the programmable spectrum analyzer executes the remainder of the message before restoring local control. The response of the spectrum analyzer to interface messages depends on the manner in which they are handled. Some interface messages are handled by the GPIB interface, while others require action by the microcomputer. The latter generally involve the GPIB address, and are implemented in firmware rather than on the interface. The speed with which these commands can be handshaked depends on how fast the spectrum analyzer can service the resulting interrupt.

GET (Group Execute Trigger)

GET requires firmware action, so handshake occurs only when the interrupt can be handled. The effect of GET is masked by DT (Device Trigger).

Reference Level

The minimum reference level is -117 dBm. The delta-amplitude range is 57.75 dB and slides depending on the reference level when the delta-amplitude mode is entered.

RDOUT Command

The remote-to-local transition will always return RDOUT to NORMAL (i.e., any messages sent to the CRT with RDOUT commands will be replaced by the regular CRT readout).

Instrument Control

Commands and queries for instrument control are grouped in this section according to the following functions (the marker-related commands and queries are in the Marker System section.)

Frequency
Frequency Span and Resolution
Vertical Display and Reference Level
Sweep Control
Digital Storage
Display Control
General Purpose
Marker System Control
Marker Positioning
Marker Finding

The mnemonics (codes) in Table 4-1 correspond to the instrument names for the front-panel pushbuttons and controls and related functions.

Table 4-1

FRONT-PANEL COMMANDS AND QUERIES

Name	Mnemonic
Frequency	
FREQ ENTRY	FREQ
CENTER/MARKER FREQUENCY	TUNE
TUNE CF	TMODE
1ST LO [a]	FIRST
2ND LO [a]	SECOND
Tracking Generator Mode [a]	TGMODE
Sideband Analyzer Mode [a]	SAMODE
Disable Tuning Corrections [a]	DISCOR
▲Band and ▼Band	FRQRNG
STEP ENTRY	STEP
–STEP	MSTEP
+STEP	PSTEP
FREQ START STOP	STSTOP
Δ F	DELFR
Degauss [a]	DEGAUS
IMPEDANCE [b]	IMPED
Frequency Span and Resolution	
FREQUENCY SPAN/DIV and SPAN/DIV ENTRY	SPAN
ZERO SPAN	ZEROSP
MAX SPAN	MXSPN
RESOLUTION BANDWIDTH	RESBW
AUTO RESOLN	ARES
IDENT	IDENT

Table 4—1 (continued)

Name	Mnemonic
Vertical Display and Reference Level	
10dB/DIV, 2dB/DIV, LIN, and dB/DIV ENTRY	VRTDSP
REFERENCE LEVEL and REF LEVEL ENTRY	REFLVL
REF LEVEL UNITS and ROFSET	RLUNIT
CAL	CAL
Enable Calibration Factors [a]	ENCAL
FINE	FINE
MIN NOISE/MIN DISTORTION	RLMODE
Reduced Gain Mode [a]	RGMODE
MANUAL PEAK, AUTO PEAK	PEAK
MIN RF ATTEN dB	MINATT, MAXPWR, and RFATT?
PULSE STRETCHER	PLSTR
WIDE VIDEO FILTER and NARROW VIDEO FILTER	VIDFLT
Reference Level Offset [a]	ROFSET
Sweep Control	
FREE RUN, INT, LINE, and EXT	TRIG
SINGLE SWEEP	SIGSWP
TIME/DIV	TIME

[a]These commands are related to front-panel control functions; they are not actually labeled on the front panel.
[b]Available only on instruments with Option 07 installed.

Table 4-1 (continued)

Name	Mnemonic
Digital Storage	
VIEW A	AVIEW
VIEW B	BVIEW
SAVE A	SAVEA
B-SAVE A	BMINA
STORE DISP	DSTORE
RECALL	DRECAL
MAX HOLD	MXHLD
PEAK/AVERAGE	CRSOR
Display Control	
READOUT	REDOUT
GRAT ILLUM	GRAT
BASELINE CLIP	CLIP
General Purpose	
HELP?	HELP?
STORE	STORE
RECALL SETTINGS	RECALL
Register Data *	RDATA
PLOT?	PLOT?
Plotter Type Selection *	PTYPE
Plot (B-A) Reference *	POFSET
End of Sweep Corrections *	ECR
Register Valid *	RVALID
SRQ	SSR
Marker System Control	
ΔMKR and MARKER	MARKER
Marker on Trace *	MTRACE
ASSIGN 1	M1ASGN
ASSIGN 2	M2ASGN
dB/Hz	NSELVL
SIGNAL TRACK	SGTRAK

Table 4-1 (continued)

Name	Mnemonic
Marker Positioning	
Display Pointer to Marker *	DPMK
Marker Amplitude*	MAMPL?
MKR→CENTER	MCEN
1←MKR→2	MEXCHG
FREQ ENTRY *	MFREQ
CENTER/MARKER FREQUENCY	MKTIME
Marker to Display Pointer *	MKDP
Marker Location *	MLOCAT?
MKR→REF LVL	MTOP
Tune Marker *	MTUNE
Marker Finding	
Next Higher Amplitude *	HRAMPL
Next Lower Amplitude *	LRAMPL
Marker Bandwidth Number*	BWNUM
BANDWIDTH	BWMODE
Marker Peak Find *	MFBIG
Marker Left Next *	MLFTNX
PEAK FIND	PKFIND
Marker to Maximum and Center *	PKCEN
Move Marker to Maximum*	MMAX
Move Marker to Minimum *	MMIN
Marker Right Next *	MRGTNX
Marker Threshold *	THRHLD
Move Marker Left x dB *	MVLFDB
Move Marker Right x dB *	MVRTDB
Signal Type *	STYPE
Signal Find Error *	SGERR
Miscellaneous	
Zoom *	ZOOM
Zero Time *	ZETIME

*These commands are related to front-panel control functions; they are not actually labeled on the front panel.

The following controls and adjustments are operated only from the instrument front panel (no remote control).

INTENSITY
MANUAL SCAN
POSITION ◀▶▲▼
POWER
AMPL and LOG CAL
PEAK/AVERAGE cursor (other than fully counterclockwise or clockwise positions)

NUM Argument Values

Unless otherwise stated, the values for the NUM argument are

- 1 = ON
- ≥+0.5 are rounded to 1
- 0 = OFF
- <+0.5 are rounded to 0

Table 4-2
RANGES FOR THE TUNE, FIRST, SECOND, FRQRNG, STEP, SPAN, and MTUNE COMMANDS

Band	Freq Range (GHz)	1st IF (MHz)	1st LO Range (MHz)	N	2nd LO Range (MHz)	Tune Range (GHz)	Maximum Span/div
1	0–1.8	2072	2072–3872	1–	2181–2183	1.8	170 MHz
2	1.7–5.5	829	2529–6329	1–	718.83–719.17	3.8	370 MHz
3	3.0–7.1	829	2171–6271	1+	718.83–719.17	3.8	400 MHz
4	5.4–18	829	2076–6276	3–	718.83–719.17	12.6	1.2 GHz
5	15–21	2072	4309–6309	3+	2181–2183	6.0	590 MHZ

Frequency

The commands in this group set and change the instrument center frequency (FREQ, TUNE, and STSTOP), set the tuning mode (TMODE), set the 1ST LO (FIRST) and the 2ND LO (SECOND) frequencies, enable the tracking generator (TGMODE), and sideband analyzer (SAMODE) modes, disable tuning corrections (DISCOR), select the frequency range (FRQRNG), turn the counter mode on and off (COUNT), select counter resolution (CRES), transfer signal count to center frequency (CNTCF), set frequency step size (STEP), decrease or increase center frequency (MSTEP, PSTEP), set start-stop frequencies (STSTOP), and start the delta-frequency function (DELFR), apply degaussing current to restore preselector alignment (DEGAUS), and select the EXT MIXER input (EXMXR). Instruments with Option 07 installed change between the 50Ω and 75Ω inputs (IMPED).

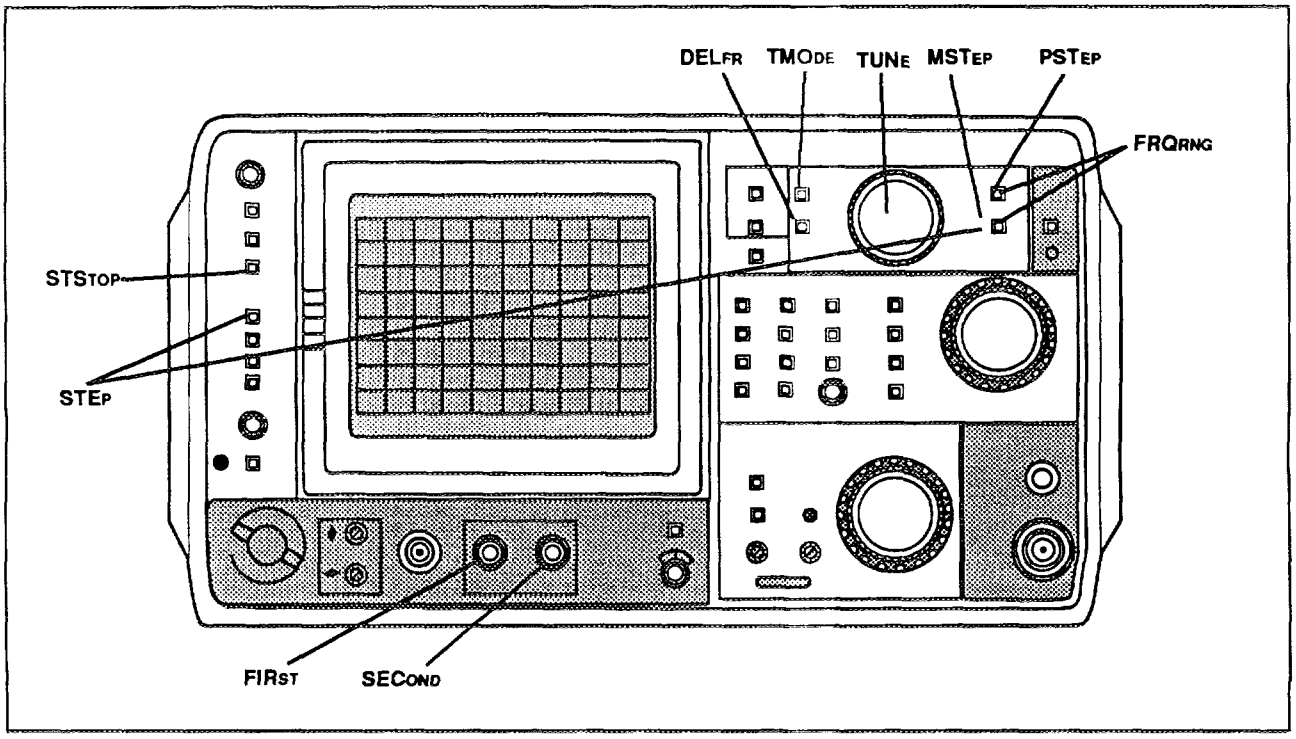
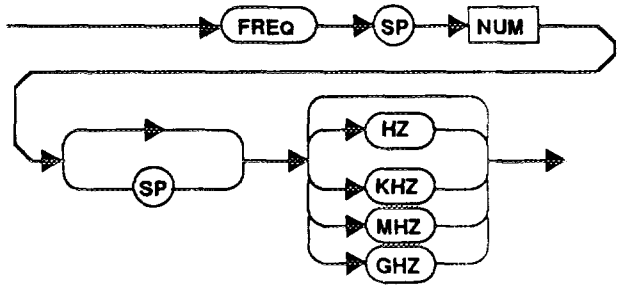


Figure 4-1. Front-panel Frequency commands.

FREQ (center frequency) command



Num — The instrument centers its span about the value in the command argument. The range of values and resolution of the instrument response are the same as for front panel operation.

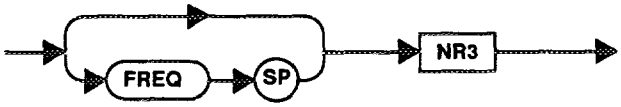
Examples — FREQ 200MHZ
FREQ 100000
FRE 200 MHZ

Range — 0 Hz to 21 GHz.

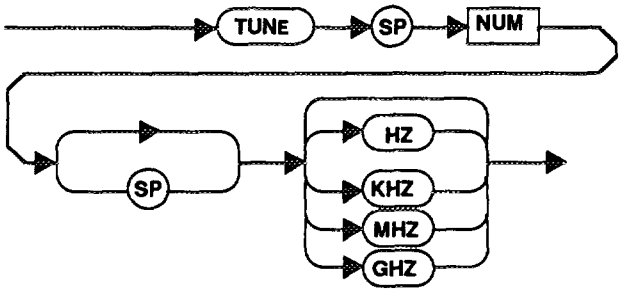
Power-up value — 0 MHz.

FREQ (center frequency) query

Response to FREQ query



TUNE (incremental frequency change) command



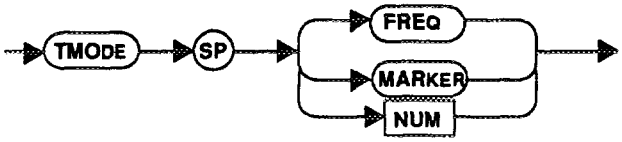
NUM — The instrument changes its center frequency by using the value of the command argument as an offset to its previous center frequency.

Examples — TUN 10 MHZ
TUNE 1.0E6
TUNE 100 KHZ

Range — The frequency resulting from using the TUNE command must be within the frequency range in use. The maximum value for each frequency range (that is, the value needed to tune from one end of the range to the other) is given in Table 4-2.

There is no TUNE query.

TMODE (set tune mode) command



MARKER — The PSTEP and MSTEP commands will change the marker frequency.

FREQ — The PSTEP and MSTEP commands will change the center frequency.

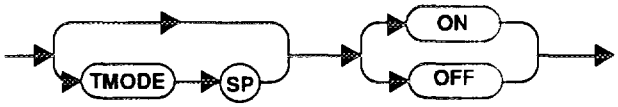
NUM — 0 = FREQ
1 = MARKER

Power-up value — FREQ.

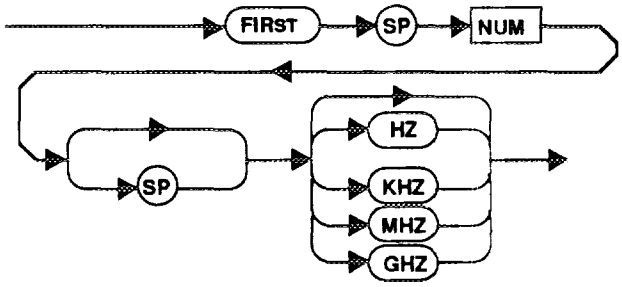
Interaction — If MARKER is OFF, TMODE MARKER sets MARKER to SINGLE. TMODE sets the tuning mode that the front-panel CENTER/MARKER FREQUENCY knob will have when the analyzer is returned to local control.

TMODE (tune mode) query

Response to TMODE query



FIRST (1ST LO frequency) command



NUM — The instrument 1ST LO is set to the requested frequency. The resulting center frequency will be displayed.

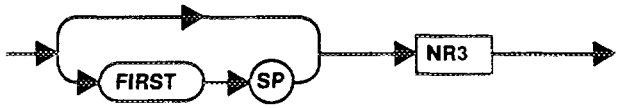
Examples—FIR 2.8 GHZ FIRST 2.8 GHZ

Range — Refer to Table 4-2.

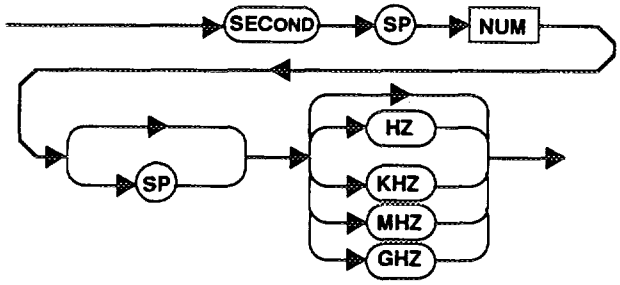
Power-up value — 2072 MHz.

FIRST (1ST LO frequency) query

Response to FIRST query



SECOND (2ND LO frequency) command



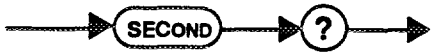
NUM — The instrument 2ND LO is set to the requested frequency. The resulting center frequency will be displayed.

Example—SECOND 2182 MHZ

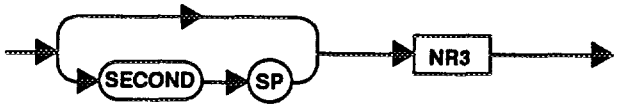
Range—Bands 1 and 5 is 2181–2183 MHz
Bands 2–4 is 718–720 MHz

Power-up value — 2182 MHz.

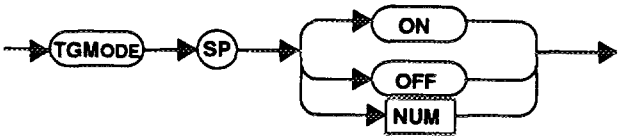
SECOND (2nd LO frequency) query



Response to SECOND query



TGMODE (tracking generator mode) command



The TGMODE command allows higher frequency accuracy when using a tracking generator. When TGMODE is ON the frequency correction factors for all resolution bandwidth filters wider than 10 kHz are disabled. These wide filters may be centered too far from 10 MHz for the difference to be corrected with the Tracking Adjust control on the tracking generator.

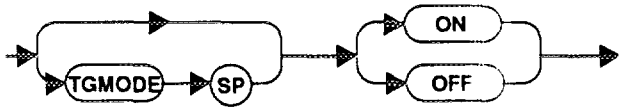
ON — The tracking generator mode is turned on.

OFF — The tracking generator mode is turned off.

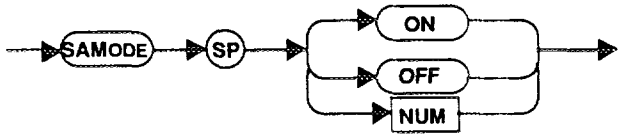
Power-up Value — OFF.

TGMODE (tracking generator mode) query

Response to TGMODE query



SAMODE (sideband analyzer mode) command



SAMODE is active in Band 1 only. When the SAMODE command is ON, the spectrum analyzer phase locks in 50 kHz/div instead of the normal 200 kHz/div. This extends the usefulness of the 1405 Sideband Analyzer, which uses only the first local oscillator of the spectrum analyzer.

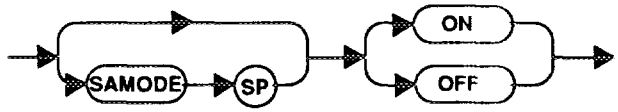
ON — The sideband analyzer mode is turned on.

OFF — The sideband analyzer mode is turned off.

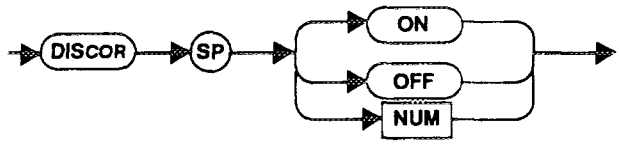
Power-up Value — OFF.

SAMODE (sideband analyzer mode) query

Response to SAMODE query



DISCOR (disable tuning corrections) command



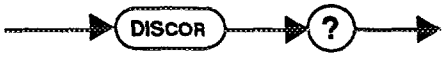
This command is included to allow disabling of the frequency control loop in the instrument for speed or diagnostics purposes. It will also allow a fallback to low accuracy center frequency operation if the frequency control loop fails.

ON — Center frequency corrections are disabled.

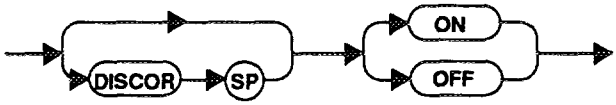
OFF — Center frequency corrections are enabled.

Power-up value — OFF.

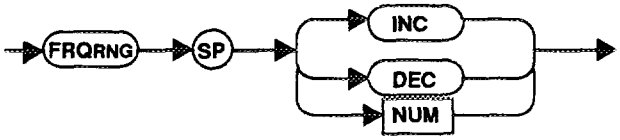
DISCOR (disable tuning corrections) query



Response to DISCOR query



FRQRNG (frequency range) command



NUM — The instrument accepts number arguments in the range of 1 through 5 and changes the frequency range accordingly. Non-integer values are rounded. If the number is too large or too small, the programmable spectrum analyzer maintains its current frequency range and reports execution error message 29.

INC — The instrument changes to the next higher frequency range, if possible.

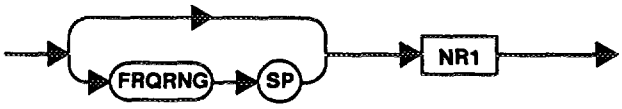
DEC — The instrument changes to the next lower frequency range, if possible.

Power-up value — Frequency Range 1.

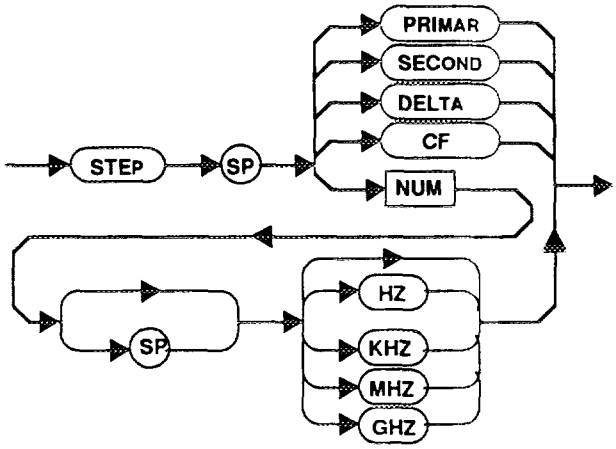
Interaction — The instrument automatically selects the frequency closest to that already in use that encompasses the frequency setting that responds to the FREQ command. In option 07 instruments when using 75 Ω input, if the requested frequency range is outside the allowable limits (if you send anything except FRQRNG 1), execution error message 102 is issued.

FRQRNG (frequency range) query

Response to FRQRNG query



STEP (step size) command



The STEP command sets the frequency step size used by the MSTEP and PSTEP commands.

PRIMAR — Sets the step size to the primary marker frequency.

SECOND — Sets the step size of the secondary marker frequency.

DELTA — Sets the step size to the absolute value of the difference in frequency between the primary and secondary markers.

CF — Sets the step size to the absolute value of the center frequency.

NUM — Sets the step size to the frequency input.

Examples — STE DEL
STE PRIMAR
STEP SEC
STE 20 KHZ
STEP 100 MHZ

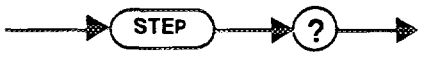
Range — Set STEP anywhere within the band range.

Power-up value — See Interaction that follows.

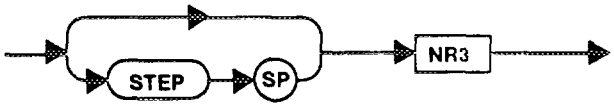
Interaction — STEP DELTA causes marker execution error message 123 to be issued if MARKER IS not set to DELTA. If STEP has not been set, MSTEP and PSTEP will set it according to the following conditions:

- In Tune CF mode — STEP is set to the absolute value of the center frequency.
- In Tune Marker mode with delta markers on — STEP is set to the absolute value of the delta marker frequency.
- In Tune Marker mode with delta markers off — STEP is set to the absolute value of the primary marker frequency.

STEP (step size) query



Response to STEP query



MSTEP (minus step) command

This command decreases the center frequency, if you are in the tune frequency mode, by the value set in the STEP command, if possible. If you are in the tune marker mode, the primary marker frequency is decreased. If the step marker is on a saved trace and you go outside the displayed trace, execution error message 120 will be issued.

If STEP has not been set, MSTEP will set it according to the following conditions:

- In Tune CF mode — STEP is set to the absolute value of the center frequency.
- In Tune Marker mode with delta markers on — STEP is set to the absolute value of the delta marker frequency.
- In Tune Marker mode with delta markers off — STEP is set to the absolute value of the primary marker frequency.

There is no MSTEP query.

PSTEP (plus step) command

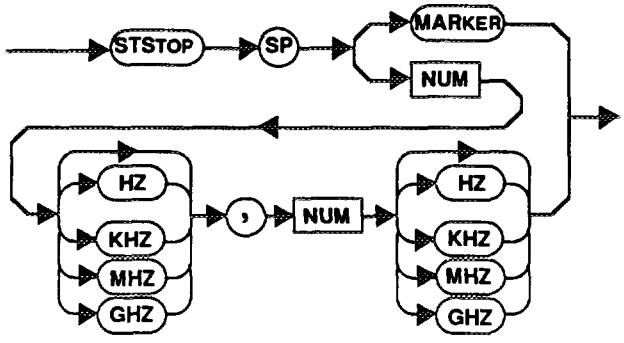
The PSTEP command increases the center frequency, if you are in the tune frequency mode, by the value set in the STEP command, if possible. If you are in the tune marker mode, the primary marker frequency is increased. If the step marker is on a saved trace and you go outside the displayed trace, execution error message 120 will be issued.

If STEP has not been set, PSTEP will set it according to the following conditions:

- In Tune CF mode — STEP is set to the absolute value of the center frequency.
- In Tune Marker mode with delta markers on — STEP is set to the absolute value of the delta marker frequency.
- In Tune Marker mode with delta markers off — STEP is set to the absolute value of the primary marker frequency.

There is no PSTEP query.

STSTOP (start-stop sweep) command



MARKER — The frequency and span are set so that the instrument sweeps over the frequency range delimited by the markers. The lowest frequency marker sets the start frequency, and the highest frequency marker sets the stop frequency.

NUM, NUM — The starting frequency of the display is set to the first NUM and the ending frequency is set to the second NUM. Execution error message 28 is issued if the second NUM is less than the first NUM.

Examples—STS MARKER
STSTOP 10MHZ,130MHZ
STS 100000HZ,66MHZ

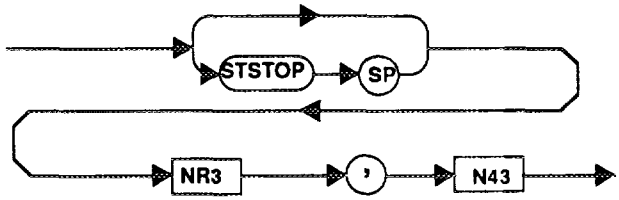
Range— Both start and stop frequencies are limited to the current band.

Power-up value — Start frequency, 0 Hz; stop frequency, 1.8 GHz.

Interaction — Marker execution error message 123 is issued if the STSTOP MARKER command is given when MARKER is not set to DELTA.

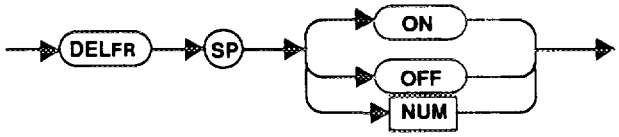
STSTOP (start-stop sweep) query

Response to STSTOP query



The response is the present start and stop frequency (in that order), whether the values were entered as start-stop frequencies or result from the combination of a center frequency and span.

DELFR (delta-frequency) command

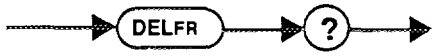


ON — The delta-frequency function is turned on. As the frequency is changed, the crt center frequency readout indicates relative frequency rather than absolute frequency. Only the readout operates differently; FREQ and FREQ? response still refer to absolute frequency. The resolution of the readout will be the lesser of the current readout resolution and the readout resolution when DELFR was turned on.

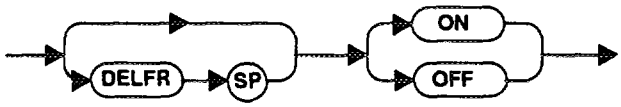
OFF — The delta-frequency function is turned off.

Power-up value — OFF.

DELFR (delta-frequency) query



Response to DELFR query

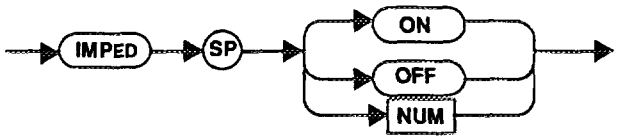


DEGAUS (degauss tuning coils) command

A current is momentarily turned off to remove residual magnetism in the 1st LO and preselector.

There is no DEGAUS query.

IMPED (Impedance) command (Option 07 only)

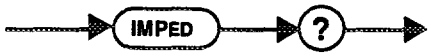


ON — The 75 Ω input is used. If Option 07 is not installed, command error message 8 will be issued.

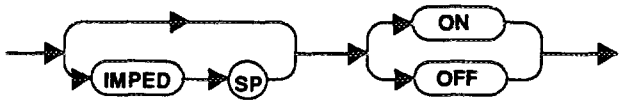
OFF — The 50 Ω input is used.

Power-up value — OFF.

IMPED (Impedance) query (Option 07 only)



Response to IMPED query (Option 07 only)



Frequency Span and Resolution

The commands in this group control the frequency span (SPAN), the zero span mode (ZEROSP), the max span mode (MXSPN) and the resolution (RESBW and ARES) of the display. Also, true signals can be distinguished from spurious frequency conversion products (IDENT).

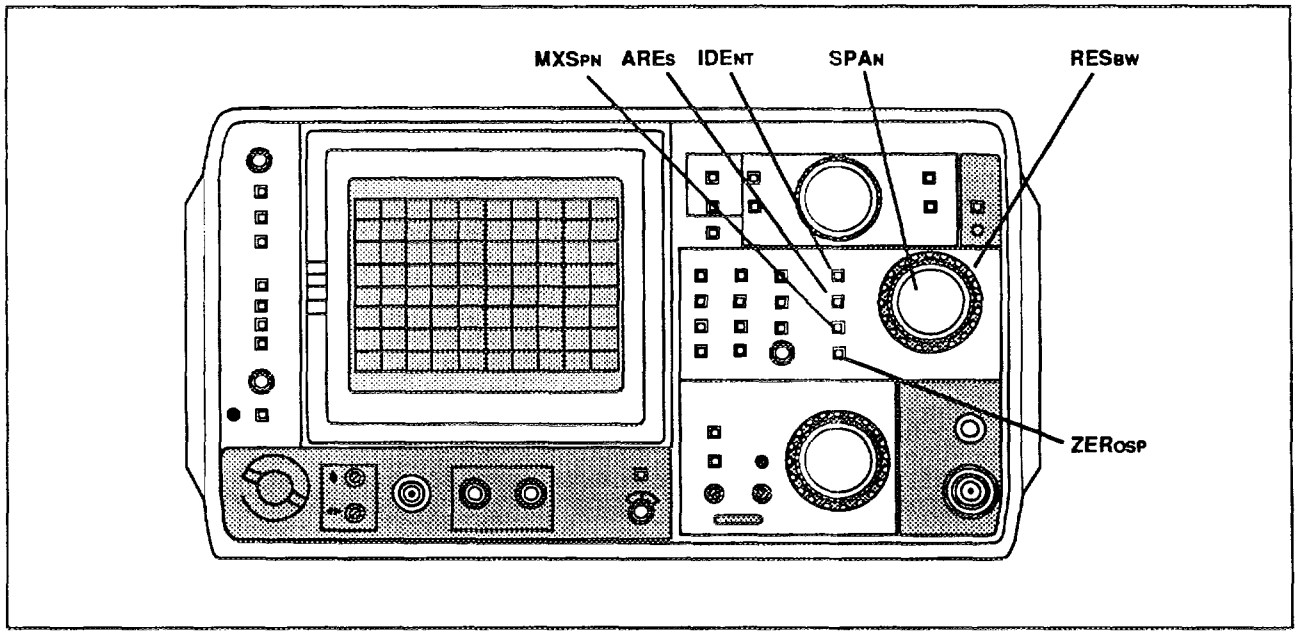
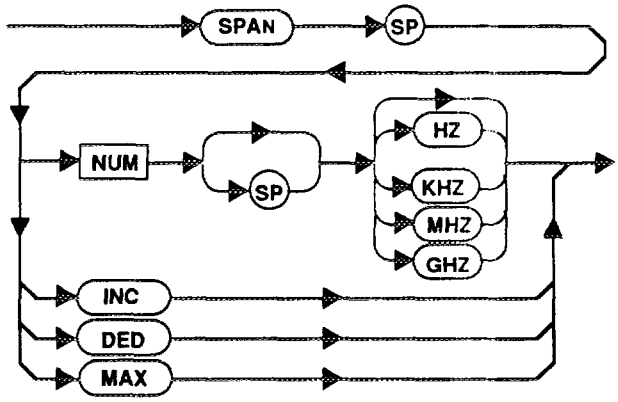


Figure 4-2. Front-panel Frequency Span and Resolution commands.

SPAN (frequency span/division) command



NUM — The span/division is selected. The value of the argument is rounded to two significant digits. Zero converts the instrument to the time domain; in zero-span mode, the instrument displays signals within its bandpass (RESBW) about its center frequency (FREQ). If the number is too large, execution warning message 50 is issued, and the instrument defaults to MAX. If the number is too small, execution warning message 111 is issued, and the spectrum analyzer defaults to the minimum span.

INC — The next larger span/division is selected in the front-panel 1-2-5 sequence, if possible.

DEC — The next smaller span/division is selected in the front-panel 1-2-5 sequence, if possible.

MAX — The entire frequency range in use is swept.

Examples —SPA 200
SPAN 50KHZ
SPA 100 MHZ
SPAN DEC

Power-up value — Maximum.

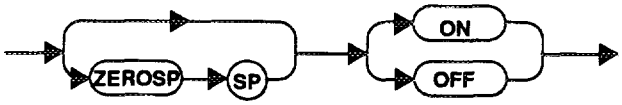
Interaction — Changing the SPAN setting turns ZEROSP OFFand MXSPN OFF.

Table 4-3
FREQUENCY SPAN/DIV RANGES

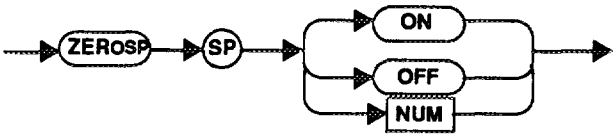
Band	Narrowest Span Available	Widest Span Available
1 (50 kHz-1.8 GHz)	200 Hz	170 MHz
2 (1.7-5.5 GHz)	200 Hz	370 MHz
3 (3.0-7.1 GHz)	200 Hz	400 MHz
4 (5.4-18.0 GHz	200 Hz	1.2 GHz
5 (15-21 GHz)	200 Hz	590 Mhz

SPAN (frequency span/division) query

Response to SPAN query



ZEROSP (zero-span mode) command



ON — The instrument is converted to a time domain mode with the frequency sweep defeated. Crt readout shifts to the TIME/DIV mode on the horizontal axis instead of FREQ SPAN/DIV. The previous FREQ SPAN/DIV is saved, and it is restored when ZEROSP is turned OFF.

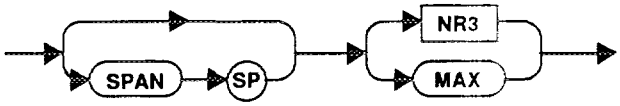
OFF — ZEROSP is cancelled, leaving the FREQ SPAN/DIV at the value previously selected.

Power-up value — Off.

Interaction — Changing the SPAN setting turns ZEROSP OFF. PKCEN, MCEN, and CNTCF are not available in ZEROSP.

ZEROSP (zero span mode) query

Response to ZEROSP query

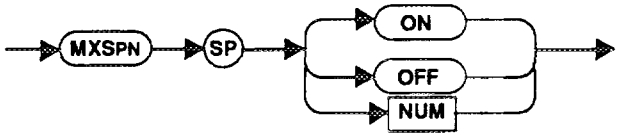


The response is the current zero span condition.

NOTE

It may be preferable to use ZEROSP rather than SPAN 0. When ZEROSP is ON, the front-panel ZERO SPAN indicator is lit so you have a positive indication that the zero span mode is set, in addition to the crt readout. When ZEROSP is turned off, the previous SPAN/DIV setting is restored.

MXSPN (max-span mode) command



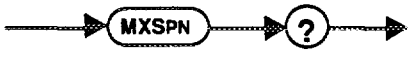
ON — The instrument sweeps the entire frequency range in use. FREQ no longer corresponds to center frequency; it now corresponds to the frequency at the tunable dot above the display or the marker on the display. The previous FREQ SPAN/DIV is saved, and it is restored when MXSPN is OFF.

OFF — MXSPN is cancelled, leaving the FREQ SPAN/DIV at the value previously selected.

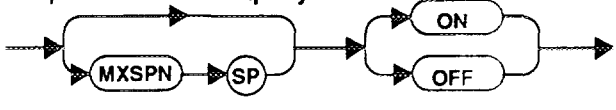
Power-up value — Off.

Interaction — Changing SPAN setting turns MXSPN OFF. PKCEN, MCEN, and CNTCF are not available in MXSPN.

MXSPN (max-span mode) query



Response to MXSPN query

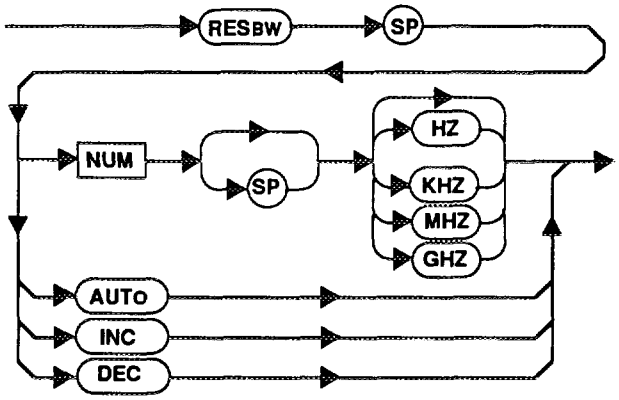


The response is the current MXSPN condition.

NOTE

It may be preferable to use MXSPN rather than SPAN MAX. When MXSPN is ON, the front-panel MAX SPAN indicator is lit so you have a positive indication that the maximum span mode is set, in addition to the crt readout. When MXSPN is turned off, the previous FREQUENCY SPAN/DIV setting is restored.

RESBW (resolution bandwidth) command



NUM — The nearest available resolution bandwidth is selected; numbers between bandwidths that can be selected from the front panel are rounded. Positive numbers above or below the range of bandwidth steps are rounded to the nearest step; refer to Table 4-3 (execution error message 32 is issued if the argument is beyond the normal range).

Table 4-4
RESOLUTION BANDWIDTH SELECTION

Value [a]	Selects
317 Hz–3.16 kHz	1 kHz
3.17 kHz–31.6 kHz	10 kHz
31.7 kHz–316 kHz	100 kHz (Non Option 07)
31.7 kHz–316 kHz	300 kHz (Option 07 Only)
317 kHz–1.72 MHz	1 MHz
1.73 MHz–5.49 MHz	3 MHz

AUTO — Auto resolution is selected (equivalent to ARES ON).

INC — The next larger step is selected (if possible).

DEC — The next smaller step is selected (if possible).

Examples — RESBW 1KHZ
RES 1.5 MHZ
RESBW INC

[a]Values outside the ranges listed cause execution error message 32 to be issued.

Range — See Table 4-2.

Power-up value — 3 MHz.

Instrument Control — 492PGM Programmers

Vertical Display and Reference Level

The commands in this group control the vertical scale factor (VRTDSP) and reference level (REFLVL and FINE) of the display, and select the reference level units (RLUNIT) and the reference level offset (ROFSET). The gain distribution (combination of RF attenuation and IF gain) is automatically set according to the reference level mode (RLMODE); this takes into account the least amount of RF attenuation (MINATT) allowed or maximum power (MAXPWR) expected, and the current RF attenuation is requested (RFATT?). The reduced gain mode (RGMODE enables 10dB of IF gain and RF attenuation reduction when in 10 dB/division.The largest signal in a window around the display data point can be peaked (PEAK). The pulse stretcher (PLSTR) stretches narrow or pulsed signals for acquisition and display. If a video filter (VIDFLT) is switched in, noise in the display is reduced. Calibration of the IF filters for frequency and amplitude is possible from the front panel (CAL and ENCAL).

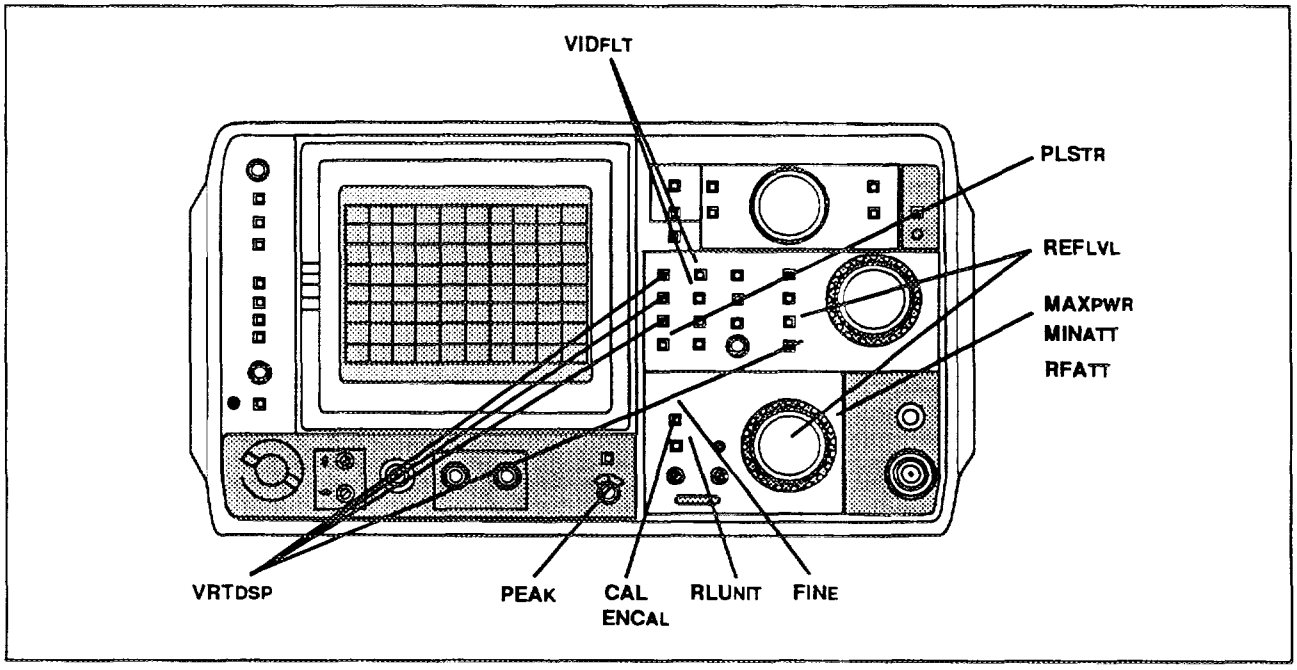
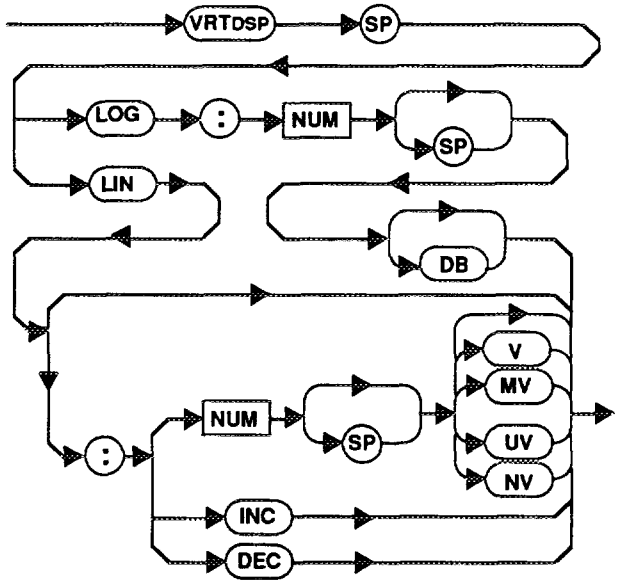


Figure 4-3. Front-panel Vertical Display and Reference Level commands.

VRTDSP (vertical display) command



LOG — The display is scaled to the dB/division specified by integers in the range 1 to 15; non-integers are rounded. VRTDSP LOG values outside this range cause execution error message 36 to be issued.

LIN — The display is scaled in volts/division. NUM is adjusted to the volts equivalent of the nearest 1 dB/div. If NUM is omitted, the display is scaled to leave the reference level at its current value; V/D = 1/8*(volts equivalent of REFLVL). INC or DEC changes the scale factor to the next step in the 1-2-5 volts/division sequence, if possible, when FINE is OFF. When FINE is ON, the next step is determined by the 1 dB change in REFLVL that INC or DEC causes; the new scale factor is 1/8*(volts equivalent of REFLVL). Out-of-range values cause the instrument to report execution error message 35.

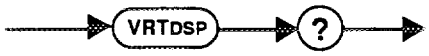
Examples — VRT LOG:3
VRTDSP LOG:2DB
VRT LOG:1 DB
VRTDSP LIN
VRT LIN:2
VRTDSP LIN:1.5MV
VRT LIN:75 NV
VRTDSP LIN:INC

Range — Log is 1–15 dBV
Lin is 39.6 nV/div to 2.8 V/div, if the reference level offset is zero

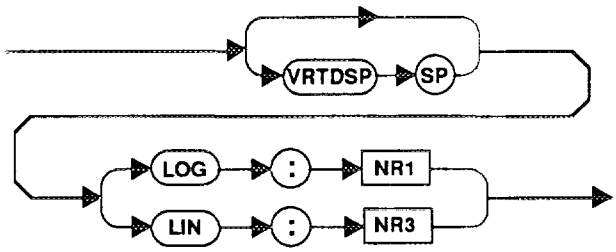
Power-up value — LOG:10 dB/division.

Interaction — The selection of 1, 2, 3, or 4 dB/div with FINE ON causes the spectrum analyzer to enter a delta amplitude mode. See FINE for a discussion of this mode.

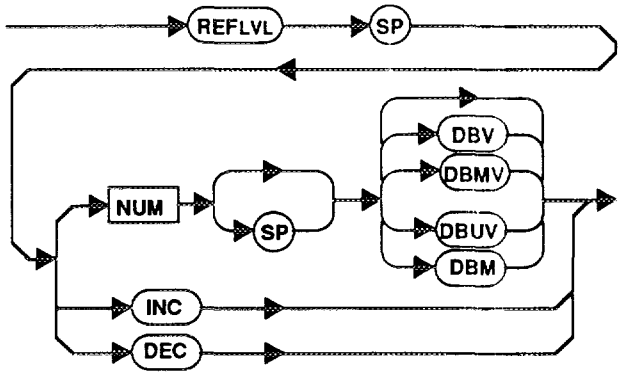
VRTDSP (vertical display) query



Response to VRTDSP query



REFLVL (reference level) command



NOTE

To ensure the correct response, all of the letters in each of the unit mnemonics for the REFLVL command must be entered; not just the first three letters as required for other mnemonics.

NUM — The instrument sets the reference level to the nearest dBm step for a log vertical display (except in the Delta Amplitude mode), and to the nearest dBm step for a linear vertical display. The Delta Amplitude mode allows 0.25 dB resolution; the argument to the REFLVL command is always the absolute reference level, not an offset to the present reference level, though the crt readout shows relative amplitude in the Delta Amplitude mode only. If the number selected is out of range, execution error message 34 is issued. If no units are specified, the instrument assumes the current reference level units.

INC or DEC — The reference level is stepped up or down once. The step value is determined by the value of the VRTDSP scale factor and FINE selection (refer to Table 44).

Table 4-5

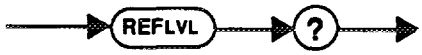
REFERENCE LEVEL STEPS

VERTDSP Scale Factor	FINE ON	FINE OFF
15 dB	1 dB	15 dB
14 dB	1 dB	14 dB
13 dB	1 dB	13 dB
12 dB	1 dB	12 dB
11 dB	1 dB	11 dB
10 dB	1 dB	10 dB
9 dB	1 dB	9 dB
8 dB	1 dB	8 dB
7 dB	1 dB	7 dB
6 dB	1 dB	6 dB
5 dB	1 dB	5 dB
4 dB	Delta-Amplitude mode (0.25 dB)	4 dB
3 dB	Delta-Amplitude mode (0.25 dB)	3 dB
2 dB	Delta-Amplitude mode (0.25 dB)	1 dB
1 dB	Delta-Amplitude mode (0.25 dB)	1 dB
LIN	1 dB	Either 6 dB or 8 dB (varies to match 1-2-5 volts/div sequence)

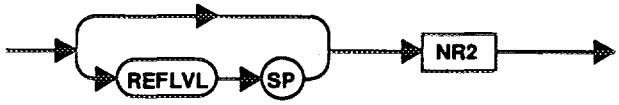
Examples — REF -20 DBV
REFLVL -10 DBMV
REF -30DBUV
REFLVL -25 DBM
REF INC

Power-up value — 0 dBm.

REFLVL (reference level) query

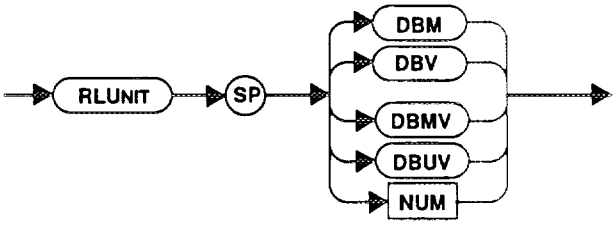


Response to REFLVL query



Only the number value will be returned; the units will not be indicated (the number will be returned in the current reference level units). The value returned is the absolute reference level, whether or not in the Delta Amplitude mode.

RLUNIT (reference level units) command



NOTE

To ensure the correct response, all of the letters in each of the unit mnemonics for the RLUNIT command must be entered; not just the first three letters as required for most other mnemonics.

DBM — The reference level (REFLVL) units are set to dBm.

DBV — The reference level (REFLVL) units are set to dBV

DBMV — The reference level (REFLVL) units are set to dBmV.

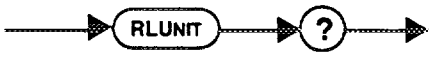
DBUV — The reference level (REFLVL) units are set to dBμV.

NUM—0 = dBm
1 = dBV
2 = dBmV
3 = dBuV

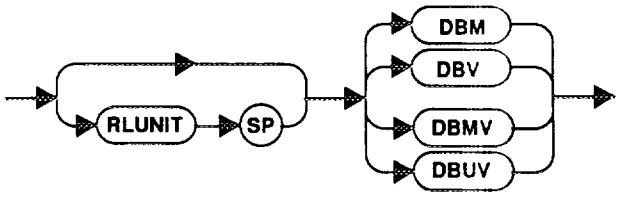
Power-up value — dBm.

Interaction — In instruments with Option 07 installed, dBmV is automatically selected when the 75 Ω input is chosen, and dBm is automatically selected when the 50 Ω input is chosen. The units designator can be overridden once the input selection has been made.

RLUNIT (reference level units) query



Response to RLUNIT query



ROFSET (reference level offset) command

NUM — This sets the offset that will be applied to the reference and marker levels.

Examples — ROF 26
ROFSET 30 DB
ROF 7.5DB

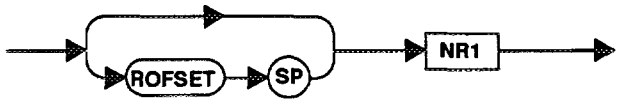
Range — -30.0 dB to +30.0 dB.

Power-up value — 0 dB.

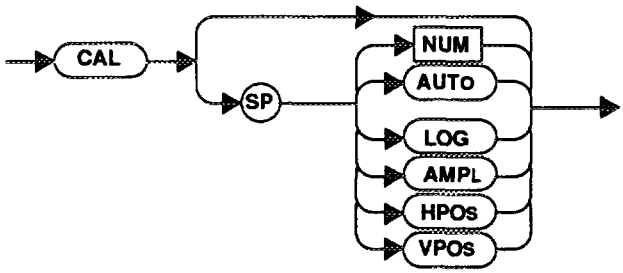
Interaction — The offset value will affect the responses to the queries of REFLVL, MAMPL, MLOCAT, MAXPWR, and THRHLD. ROFSET must be included in the values sent with the REFLVL, THRHLD, and MAXPWR commands.

ROFSET (reference level offset) query

Response to ROFSET query



CAL command



NOTE

The instrument assumes a 100 MHz calibrator is connected during CAL AUTO, CAL AMPL, and CAL LOG operation.

NUM — 0 = AUTO
1 = LOG
2 = AMPL
3 = HPOS
4 = VPOS

CAL (without arguments) or **CAL AUTO** — The resolution bandwidth filter frequencies are calibrated with respect to 10 MHz and levels relative to the 3 MHz filter level (within a range of +2, -4 dB) and bandwidths used in dB/Hz normalization are measured. During operation, the word MEASURING appears on the screen. All calibration results are stored in battery-powered memory.

CAL LOG — The instrument is set up so you can set the front-panel CAL LOG adjustment. CAL LOG has an indefinite execution time and will operate until either a device clear (DCL) is received from the GPIB port or the spectrum analyzer is returned to local control from the instrument front panel. An instruction message appears on the screen.

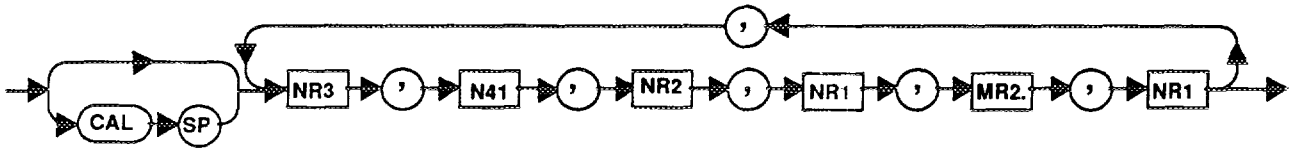
CAL AMPL — The instrument is set up so you can set the front-panel CAL AMPL adjustment. CAL AMPL has an indefinite execution time and will operate until either a device clear (DCL) is received from the GPIB port or the spectrum analyzer is returned to local control from the instrument front panel. An instruction message appears on the screen.

CAL HPOS — The instrument is set up so you can set the front-panel horizontal POSITION control. CAL HPOS has an indefinite execution time and will operate until either a device clear (DCL) is received from the GPIB port or the spectrum analyzer is returned to local control from the instrument front panel. An instruction message appears on the screen.

CAL VPOS — The instrument is set up so you can set the front-panel vertical POSITION control. CAL VPOS has an indefinite execution time and will operate until either a device clear (DCL) is received from the GPIB port or the spectrum analyzer is returned to local control from the instrument front panel. An instruction message appears on the screen.

CAL query

Response to CAL query



In the CAL? response, the same data is given in succession for the 3 MHz, 1 MHz, 100 kHz (300 kHz for Option 07 instruments), 10 kHz, and 1 kHz filters (in that order). The data given for each filter is the following.

- frequency error
- frequency calibration code
- level error
- level calibration code
- noise bandwidth factor
- bandwidth calibration code

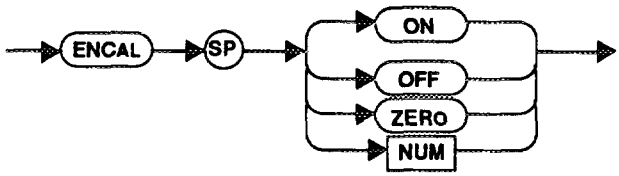
The frequency error is the difference between the measured filter frequency and 10 MHz, expressed in Hz. The level error is the difference between the measured filter level and the measured level of the 3 MHz filter, expressed in dB. The noise bandwidth is expressed as the dB correction used to normalize the filter's output to 1 Hz. Use Table 4-5 to decode the calibration code numbers.

Table 4-6

CALIBRATION CODES

Code Number	Description
0	A calibration value for this item has not been found (i.e., this filter has never been calibrated before).
1	A calibration value for this item has been found, but the most recent calibration attempt failed (the last previously-good value is used).
2	The value recorded for this item is the limit value (i.e., the best it could do). The actual required correction would exceed the limit (+2, -4 dB), so this item is not calibrated. (This applies to amplitude calibration only.)
3	A calibration value for this item has been found, but the most recent calibration attempt failed (the last previously-good value is used). The value recorded for this item is the limit value (i.e., the best it could do). The actual required correction would exceed the limit (+2, -4 dB), so this item is not calibrated. (This applies to amplitude calibration only.)
4	The last calibration attempt for this item succeeded.
5	This filter is the reference for level calibration. (This applies to amplitude calibration only.)

ENCAL (enable calibration factors) command



OFF — The filter's amplitude and frequency are not corrected, and the nominal noise bandwidth is used.

ON — The calibration factors are used internally to correct frequency and level errors and noise bandwidth in the filters.

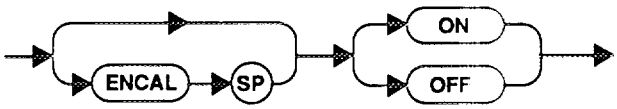
ZERO — Set calibration factors to 0; this does not affect OFF/ON status.

NUM—0 = OFF
1 = ON
2 = ZERO

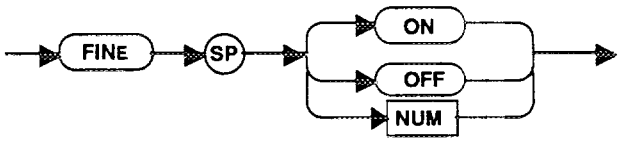
Power-up Value — ON.

ENCAL (enable calibration factors) query

Response to ENCAL query



FINE (fine reference level steps) command



ON — Small steps are selected for the INC or DEC arguments in the reference level command (see REFLVL for details). With vertical scale factors of 1, 2, 3, and 4 dB/div, FINE ON selects the delta-amplitude mode.

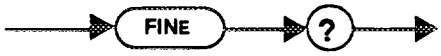
Delta-Amplitude Mode — The Delta-Amplitude mode is active when both FINE *reference* level steps and a scale factor of 4 dB/div or less are selected. In this mode, the CRT VERT DISPLAY readout initializes to 0.00 dB. Changes in reference level are displayed as the difference between the initial level and the new level, not the absolute reference level. This readout is available with UPRDO?. REFLVL? returns the absolute reference level. The initial gain distribution (RF attenuation and IF gain) is not disturbed; changes in reference level are created by an offset in the display. This allows signals to be compared with inherently higher relative accuracy over a range of at least 0 dB to –36 dB from the initial level, without an overload to the spectrum analyzer inputs.

OFF — Normal steps are restored for reference level changes, which cancels the Delta Amplitude mode (if active).

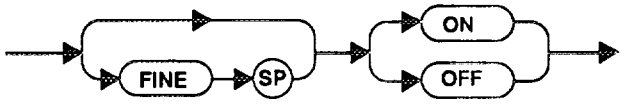
Power-up value — OFF.

Interaction — This command, along with VRTDSP, controls the spectrum analyzer response to REFLVL INC or DEC.

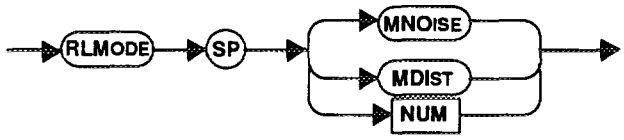
FINE (fine reference level steps) query



Response to FINE query



RLMODE (reference level mode) command



MNOISE — The instrument is requested to assign gain distribution with minimum RF attenuation for a given reference level. Generally, this yields 10 dB less RF attenuation than the MDIST argument and results in less displayed noise (but may increase distortion).

MDIST — Generally, this yields 10 dB more RF attenuation than the MNOISE argument and results in lower signal levels in the analyzer, hence less distortion.

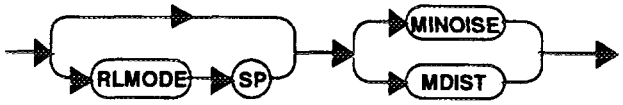
NUM—0 = MNOISE
1 = MDIST

Power-up value — MNOISE

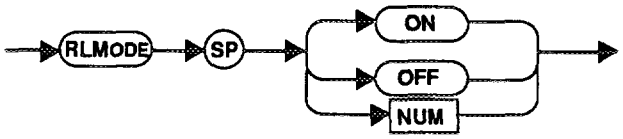
Interaction — This command affects the gain distribution obtained with the REFLVL command (see also MINATT and MAXPWR).

RLMODE (reference level mode) query

Response to RLMODE query



RGMODE (reduced gain mode) command



This command enables or disables 10 dB of IF gain and RF attenuation reduction when in 10 dB/division.

ON — The reduced gain mode is turned on.

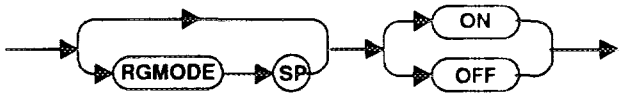
OFF — The reduced gain mode is turned off.

Interaction — When IDENT and RGMODE are ON, the identify trace moves up instead of down. RGMODE affects the maximum reference level you can get with the REFLVL command. When not in 10 dB/div vertical display, RGMODE does not affect the gain distribution.

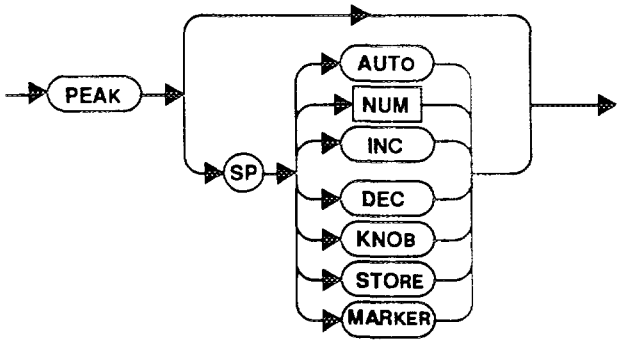
Power-up value — OFF.

RGMODE (reduced gain mode) query

Response to RGMODE query



PEAK (peaking) command



AUTO — During several sweeps, the spectrum analyzer automatically tunes the PEAK control to peak the largest signal in a window around the display data point (refer to the Waveform Processing section later in this manual for information on the display data point). When peaking the preselector, peaking occurs ±1 division or 0 MHz (whichever is less) on either side of the center or marker. The peak code consists of numbers at 500 MHz intervals when using the preselector, and one number per band when using external mixers. These numbers are stored in memory. If a signal is not found within the window, the previously acquired peaking code stored in memory is used. End-of sweep interrupts are not issued and the TRIGGERING, TIME/DIVISION, MAX HOLD, and REFLVL values may be changed by the spectrum analyzer while PEAK is active. The previous values are restored when PEAK AUTO is through. Although this command uses digital storage, it does not overwrite the A portion if SAVEA is ON.

The PEAK command without an argument is the same as PEAK AUTO.

NUM — The number is stored in memory. Non-integers or numbers outside the range are rounded to the nearest integer in the range; no warning is issued. This affects the current peaking number only.

Range — 0 to 1023.

INC or DEC — The value of PEAK is changed ±1 from its current value, which is stored in memory, and the new value is stored in memory.

KNOB — The front-panel MANUAL PEAK control is active. You can manually peak the spectrum analyzer's response from the front panel. All other arguments switch to internal peaking and cancel KNOB.

STORE — The value stored in memory is used for the present bands.

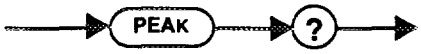
MARKER — PEAK MARKER acts the same as PEAK AUTO; except, PEAK MARKER will peak ±1 division from the marker and it will turn the marker on if off.

Examples — PEAK
PEA AUTO
PEAK 512
PEA STO

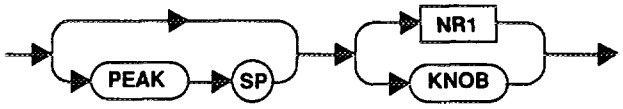
Power-up value — KNOB (MANUAL PEAK control on).

Interaction — Under the conditions where AUTO may not be used, peaking is not used, and the stored number or knob position has no effect.

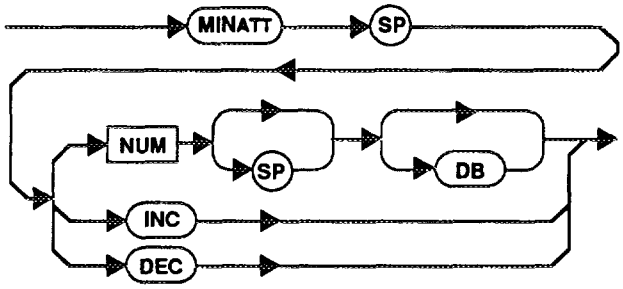
PEAK (peaking) query



Response to PEAK query



MINATT (minimum RF attenuation) command



NUM — The gain distribution set by the instrument is limited; RF attenuation may not be reduced below the attenuator step in the number argument. If NUM is not an even decade from 0 to 60, the next higher step (0, 10, 20, ... 60) is selected. If the number selected is out of range, execution error message 33 is issued.

INC or DEC — The minimum RF attenuation is changed to the next higher or lower step, if any.

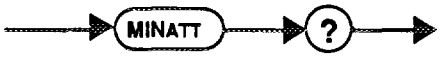
Examples — MINATT 20
MIN 42 DB
MINATT INC

Range — 0 to 60.

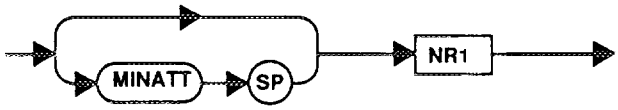
Power-up value — MIN RF ATTEN dB control setting.

Interaction — The range of RF attenuation is limited in response to the REFLVL command, which limits the range of the REFLVL command. The previous limit set by either MINATT or MAXPWR is cancelled.

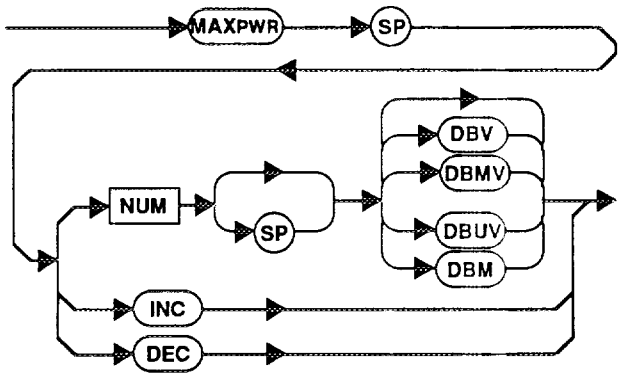
MINATT (minimum RF attenuation) query



Response to MINATT query



MAXPWR (maximum input power) command



NUM — This is an input to an instrument that protects the RF INPUT from overload at the expected maximum power level. The instrument selects a minimum RF attenuation so that the NUM signal level is reduced to no more than -18 dBm at the 1st Mixer. (This is the instrument's 1 dB compression point.) The maximum non-destructive power level that can be connected to the RF INPUT is +30 dBm. If no units are specified, the instrument assumes the current reference level units. If the number selected is out of range, execution error message 33 is issued.

NOTE

To ensure the correct response, all of the letters in each of the units mnemonics for the MAXPWR command must be entered; not just the first three letters as required for other mnemonics.

INC or DEC — The minimum RF attenuation is changed to the next higher or lower step, if any.

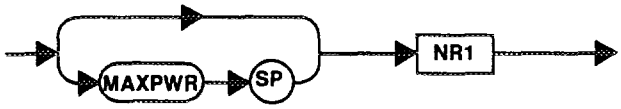
Examples — MAXPWR +20DBMV
MAX 18 DBUV
MAXPWR DEC

Power-up value — -18 to +42; dependent on MINATT value (-18 + MINATT value).

Interaction — The range of RF attenuation is limited in response to the MAXPWR command, which limits the range of the REFLVL command. MAXPWR cancels the previous limit set by either MINATT or MAXPWR.

MAXPWR (maximum input power) query

Response to MAXPWR query

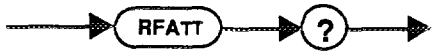


Only the number value will be returned; the units will not be indicated (the units will be the current reference level units).

RFATT (RF attenuation) command

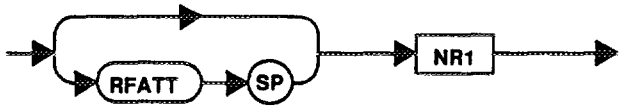
There is no RFATT command.

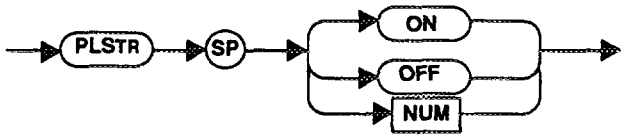
RFATT (RF attenuation) query



Requests the current value of RF attenuation.

Response to RFATT query





ON — The fall time of detected signals is increased so very narrow pulses in a line spectrum display can be seen. The effect is apparent for signals analyzed at resolution bandwidths that are narrow compared to the span. It may be necessary to turn on the pulse stretcher for digital storage of such signals, especially if the cursor is set high enough to average them.

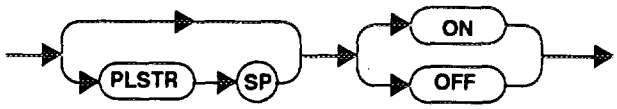
Pulse stretcher may be required to view and store fast pulsed signals. For short pulses, the signal may exist for less time than is required for a point to be digitized, causing either no value or too low a value to be stored.

OFF — The pulse stretcher is turned off.

Power-up value — OFF.

PLSTR (pulse stretcher) query

Response to PLSTR query



VIDFLT (video filter) command

OFF — Both the wide and the narrow video filters are turned off.

WIDE — A filter is turned on in the video amplifier (after the detector) to average noise in the display. The wide filter reduces video bandwidth to about 1/30 of the selected resolution bandwidth.

NARROW — The narrow video filter reduces video bandwidth to about 1/300 of the selected resolution bandwidth.

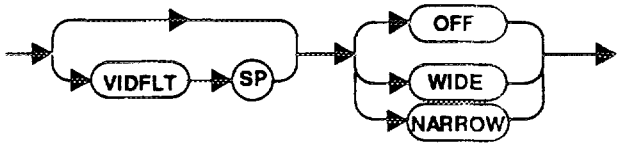
NUM — 0 = OFF
1 = WIDE
2 = NARROW

Power-up value — OFF.

Interaction — It may be necessary to reduce sweep speed (TIME) to maintain a calibrated display unless TIME is in AUTO, because the instrument's overall bandwidth is reduced by video filtering.

VIDFLT (video filter) query

Response to VIDFLT query



Sweep Control

Three commands control the instrument sweep, which is used both to sweep the frequency span and the CRT display. These commands control the sweep triggering and mode (TRIG and SIGSWP) and sweep rate (TIME). Selection of TIME AUTO directs the instrument to automatically match the sweep to related instrument parameters. Other options include manual or external analog control of the sweep.

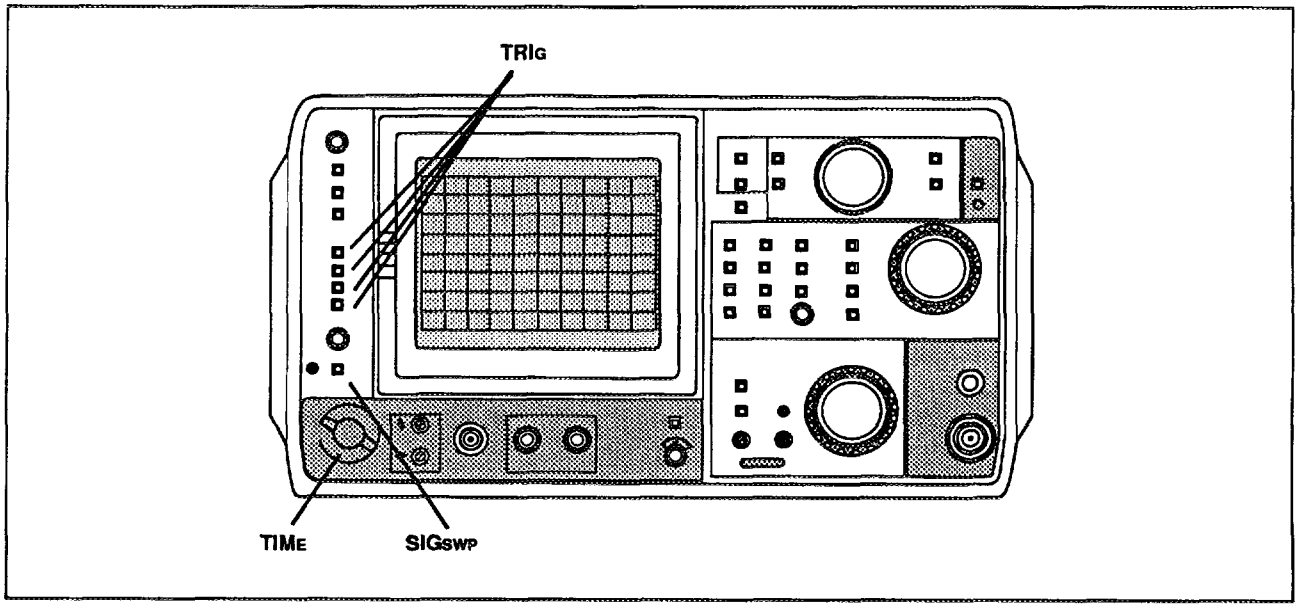
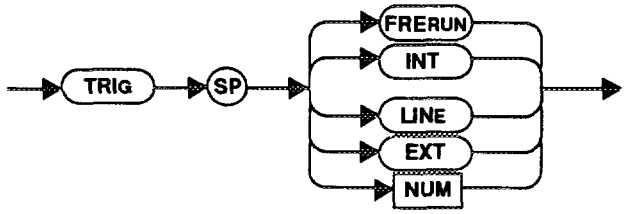


Figure 4-4. Front-panel Sweep Control commands.

TRIG (triggering) command



FRERUN — The instrument sweep is allowed to run repetitively. A trigger is not required (and is ignored), so the instrument generates a sweep immediately after the hold-off period that follows the previous sweep. This is a simple and common setup used to acquire a spectrum for manual operation.

INT — The spectrum analyzer generates a sweep only when it is triggered by an input signal. A signal amplitude of at least 2 divisions is required and must occur after the hold-off period that follows the previous sweep. This sweep mode is often used to examine time-domain signals in the zero-span mode (ZEROSP).

LINE — The power line input is selected as the trigger signal (useful in both the frequency domain and time domain modes for signals with components related to the power line frequency).

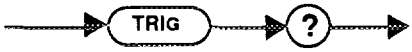
EXT — The sweep is triggered by a signal with an amplitude of at least +1.0 V peak connected to HORIZ|TRIG (EXT IN) on the rear panel.

NUM — 0 = FRERUN
1 = INT
2 = LINE
3 = EXT

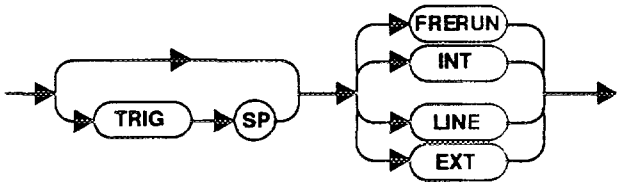
Power-up value — FRERUN.

Interaction — The signal frequency required for internal trigger is related to the center frequency. In the frequency domain mode, the required frequency corresponds to 1/2 division to the left of the left graticule edge; in the time domain mode, the required frequency is the center frequency. In the frequency domain mode, the required frequency must be within the selected frequency range.

TRIG (triggering) query



Response to TRIG query



SIGSWP (single-sweep) command

On the first SIGSWP command, the instrument enters the single-sweep mode, which stops the current sweep. Once in the single-sweep mode, this command arms the sweep and lights the front-panel READY light, which remains lit for the duration of the sweep. The spectrum analyzer makes a single sweep of the selected spectrum when the conditions determined by the TRIG command are met. Refer to Programming Techniques in the Helps and Hints section later in this manual.

NOTE

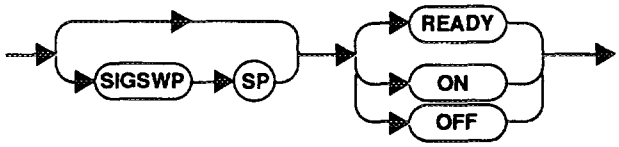
The Single Sweep mode should be used under most programming conditions (see Programming Techniques in the Helps and Hints section later in this manual).

Power-up value — OFF.

Interaction — Any TRIG command cancels the single sweep mode.

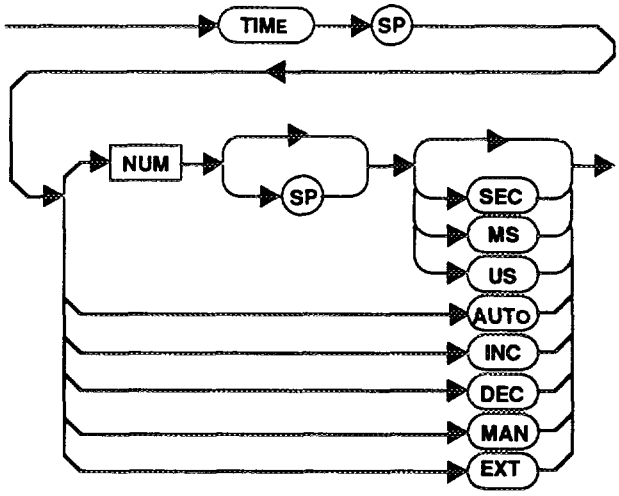
SIGSWP (single-sweep) query

Response to SIGSWP query



The response to the SET query is omitted if single-sweep is not active (see SET? under Instrument Parameters in the System Commands and Queries section of this manual).

TIME (time/div) command



NUM — 1-2-5 sequence in the range 20.0E -6 to 10. Numbers not in this sequence are rounded to the nearest step. If the number selected is out of range, execution error message 37 is issued.

AUTO — The instrument is requested to select the fastest sweep allowed for calibrated response.

INC or DEC — The sweep rate is changed ±1 in the sequence, if possible.

MAN — The sweep is coupled to the MANUAL SCAN control so you can manually scan the spectrum. As the control is turned, the horizontal position of the CRT beam and the instrument front-end tuning are varied.

EXT — The sweep is coupled to HORIZ|TRIG (EXT IN) on the rear panel. The horizontal position of the CRT beam and the instrument front-end tuning are varied by an external signal. A signal in the range 0 to +10 V scans the spectrum.

Examples — TIME 1
TIM 10 MS
TIME MAN

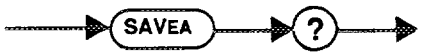
Power-up value — TIME/DIV control setting.

Interaction — Too fast a sweep speed for a given resolution bandwidth will uncalibrate the display. For digital storage to properly acquire spectrum data, 10 ms/div is the maximum usable sweep rate.

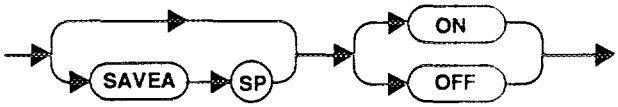
Power-up value — OFF.

Interaction — BMINA ON turns SAVEA ON. SAVEA OFF turns BMINA OFF.

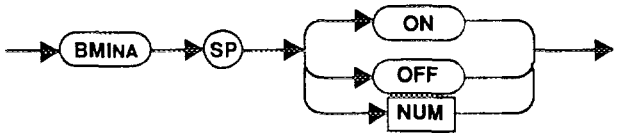
SAVEA (save A waveform) query



Response to SAVEA query



BMINA (B-A waveform display) command



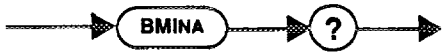
ON — The instrument turns on SAVEA if it is off and then turns on a display of the difference between the A waveform and the B waveform, which is continuously updated. The difference trace baseline is normally set at graticule center, but may be varied with an internal switch (refer any changes to qualified service personnel).

OFF — The difference display is turned off.

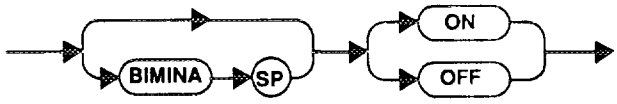
Power-up value — OFF.

Interaction — BMINA ON turns SAVEA ON SAVEA OFF turns BMINA OFF.

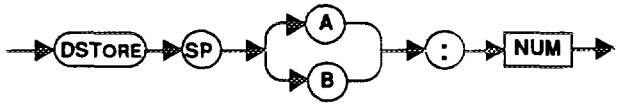
BMINA (B-A waveform display) query



Response to BMINA query



DSTORE (store display) command



A — The A waveform is stored in the memory location indicated by NUM. If the number requested is out of the range limit, execution error message 47 is issued.

B — The B waveform is stored in the memory location indicated by NUM. If the number requested is out of the range limit, execution error message 47 is issued.

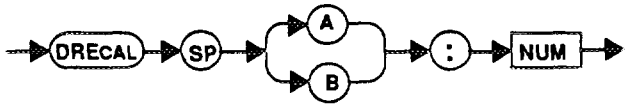
The readout and markers associated with the display are stored with the display.

Examples — DSTORE A:4
DST B:2

Range — 0 to 8.

There is no DSTORE query.

DRECAL (recall display) command



A — A waveform is recalled from the memory specified by NUM (0–8) and put in the A waveform display. If AVIEW is ON and BVIEW and BMINA are OFF, the readout associated with a recalled A waveform is displayed.

B — A waveform is recalled from the memory specified by NUM (0–8) and put in the B waveform display. If BVIEW or BMINA is ON, the readout associated with a recalled B waveform is displayed if in single sweep.

NOTE

The contents of B will be overwritten on the next sweep unless SINGLE SWEEP is ON.

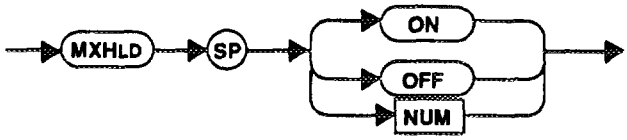
Examples — DRECAL A:4
DRE B:2

Range — 0 to 8.

Interaction — DRECAL turns SAVEA ON. The B waveform display will be overwritten if the instrument is not in the single-sweep mode. If you try to recall a waveform from an empty memory location, execution error message 62 will be issued.

There is no DRECAL query.

MXHLD (max hold) command

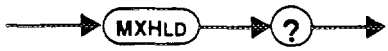


ON — Digital storage holds the maximum value obtained for each point in both the A and B waveforms; a point is updated only if the new value is greater than the current value. The A waveform is not affected if SAVEA is on.

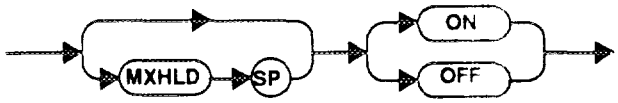
OFF — The B waveform is continuously updated; the A waveform is updated only if SAVEA is OFF.

Power-up value — OFF.

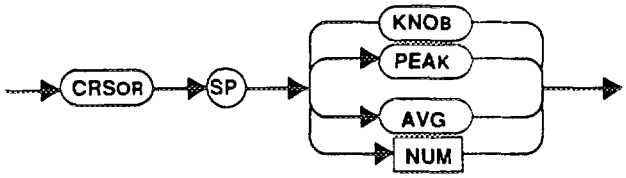
MXHLD (max hold) query



Response to MXHLD query



CRSOR (peak/average cursor) command



KNOB — The PEAK/AVERAGE control is under local control, so you can set the cursor level, which is shown by a line across the CRT. Above the line, peak values are stored as each point is updated; below the line, averaged values are stored.

PEAK — The line position on the CRT is not affected. The peak value digitized at each point is used to update digital storage, regardless of the cursor position last set by KNOB. This is the same as setting the cursor to its lowest (minimum) position.

AVG — The line position on the CRT is not affected. Average values are used to update the waveforms, regardless of the cursor position last set by KNOB. PEAK AVG is the same as if the cursor is set to its highest (maximum) position.

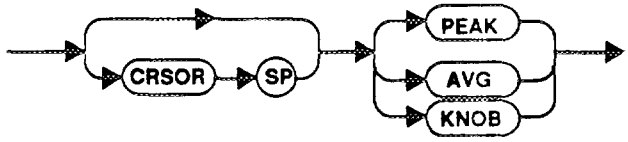
NUM—0 = KNOB
1 = PEAK
2 = AVG

Interaction — Averaging can reduce the value in digital storage for signals with very narrow response or pulsed signals.

Power-up value — KNOB.

CRSOR (peak/average cursor) query

Response to CRSOR query



Display Control

These commands control the instrument CRT display functions to display the readout (REDOUT), light the graticule (GRAT), and eliminate the baseline trace (CLIP).

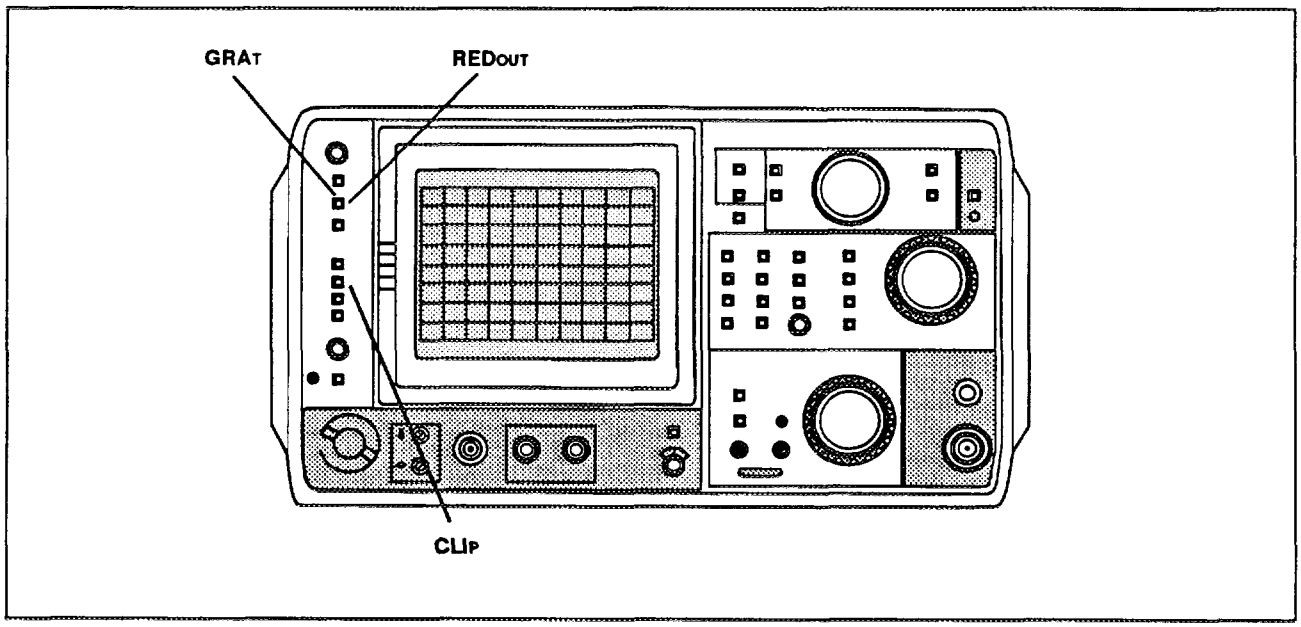
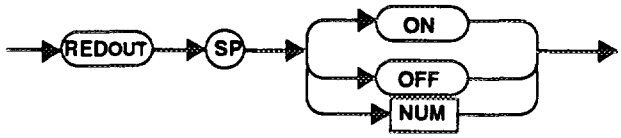


Figure 4-6. Front-panel Display Control commands.

REDOUT (readout) command



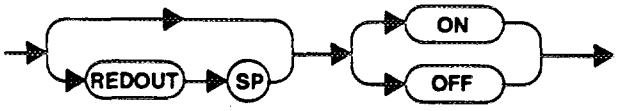
ON — The instrument settings are displayed.

OFF — The instrument settings are not displayed; the readout is blanked.

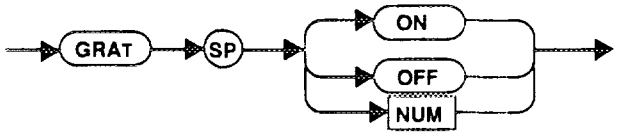
Power-up value — ON.

REDOUT (readout) query

Response to REDOUT query



GRAT (graticule) command



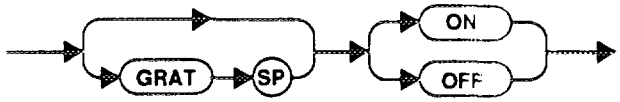
ON — The CRT graticule is lighted.

OFF — The CRT graticule is dark; not lighted.

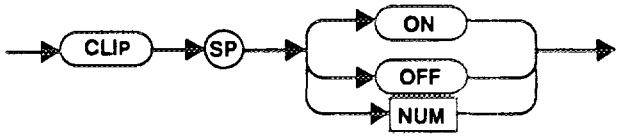
Power-up value — OFF.

GRAT (graticule) query

Response to GRAT query



CLIP (blank baseline) command



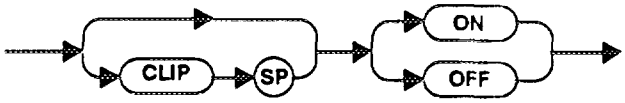
ON — Approximately one graticule division of the screen trace is turned off at the baseline of the CRT. This allows the readout at the bottom of the screen to be clearly seen when viewing or plotting the display, and it eliminates the bright baseline when photographing the display.

OFF — The full trace is displayed on the CRT.

Power-up value — OFF.

CLIP (blank baseline) query

Response to CLIP query



General Purpose

The general purpose commands and queries request front-panel help messages or GPIB command headers (HELP?), store settings in memory (STORE), recall settings from memory (RECALL), transfer data to and from storage memory (RDATA), plot CRT information (PLOT) on a choice of plotters (PTYPE), change B-A reference for the plotter (POFSET), cause oscillator corrections at the end of every sweep (ECR), send a service request (SSR), and register valid (RVALID?).

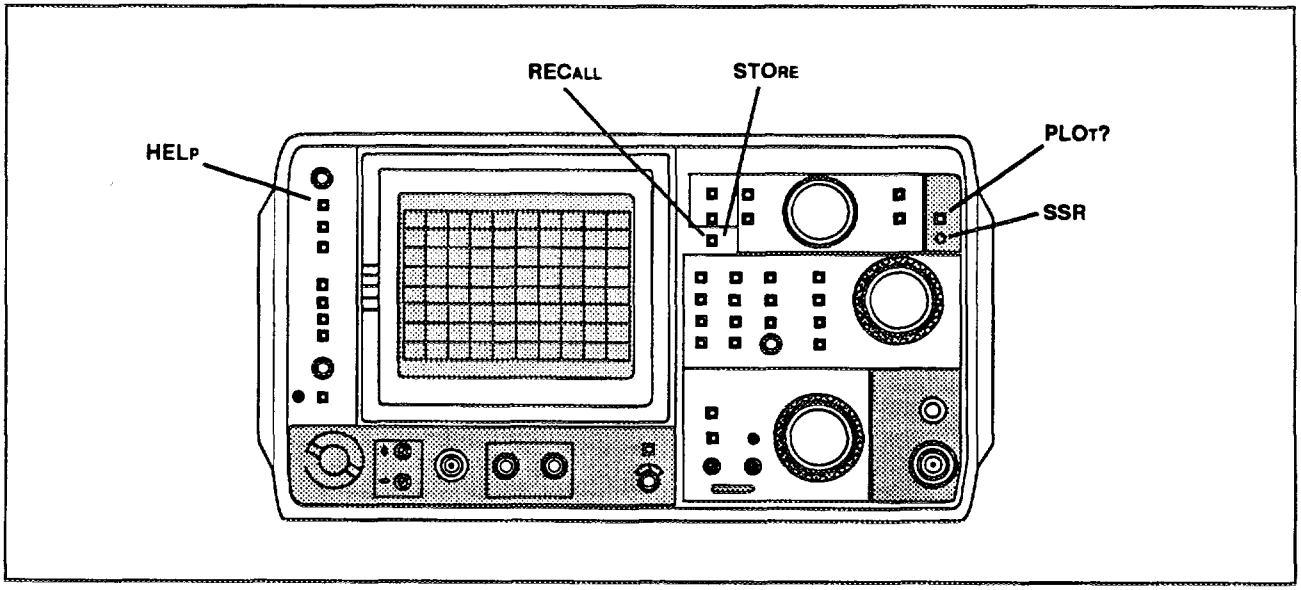
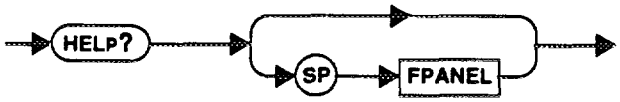


Figure 4-7. Front-panel General Purpose commands.

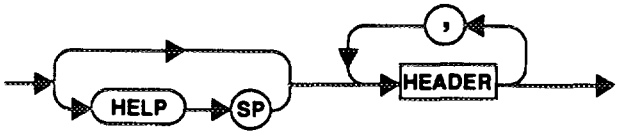
HELP command

There is no HELP command.

HELP (help) query

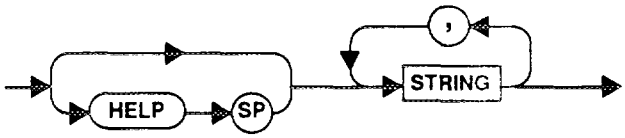


Response to HELP query (with no argument)



The response is a list of all command headers in the GPIB language.

Response to HELP query (with FPANEL)



Each string represents one CRT readout line of a help message. All help messages (black-, blue-, and green-labeled functions and all marker menu functions) are sent by this command. This response is not available when Option 45 is installed.

STORE settings) command

NUM — The instrument control settings are stored into the selected memory location.

Range — 0 to 9.

Power-up value — The instrument STOREs its current settings in memory 0 automatically when the power is turned off, overwriting any previously-stored settings.

There is no STORE query.

RECALL (recall settings) command

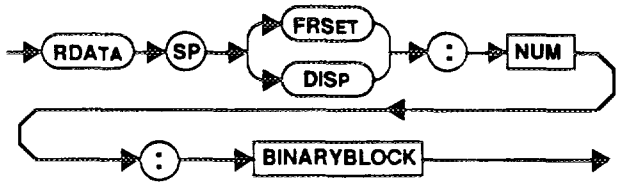
NUM — The instrument control settings are recalled from the selected memory location.

Range — 0 to 9.

Power-up value — The instrument STOREs its current settings in memory 0 automatically when the power is turned off, overwriting any previously-stored settings.

Interaction — If you try to recall settings from an empty memory location, execution error message 62 is issued.

There is no RECALL query.



This command transfers, directly to a numbered storage register, either a front-panel setting or a waveform and associated data. The data is transferred in a coded binary format. It is intended that this information be obtained from a previous RDATA query.

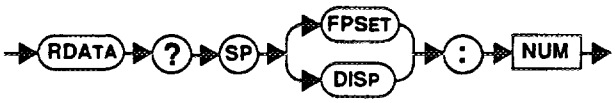
FPSET — The front-panel settings contained in the binary block are transferred to the indicated register.

DISP — The waveform and the associated readout and scaling data contained in the binary block are transferred to the associated register.

NUM — The number of the storage register to which data will be transferred. If the number is outside of the range of 0–9 when FPSET is used or the range 0–8 when DISP is used, execution error message 47 will be issued.

The binary data sent is internally checksummed. (This checksum is different than the checksum added in the binary block format.) If the internal checksum does not match the data, execution error 190 will be issued.

RDATA (register data) query



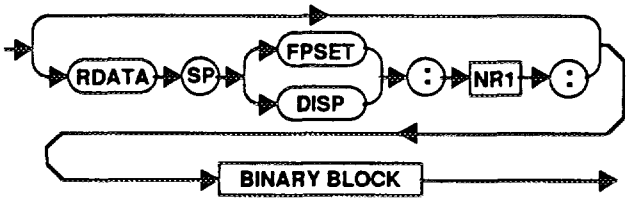
The RDATA query transfers, directly from a numbered storage register, either a front-panel setting or a waveform and associated data. The data is transferred in a coded binary format. It is intended that this information be used only as data for a subsequent RDATA command.

FPSET — The front-panel settings contained in the indicated register are transferred.

DISP — The waveform and the associated readout and scaling data contained in the associated register are transferred.

NUM — The number of the storage register to which data will be transferred. The number must be in the range of 0–9 when FPSET is used or the range 0–8 when DISP is used.

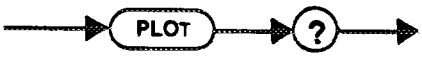
Response to RDATA query



The length of the binary data, exclusive of the byte count and checksum (see Binary Block in Section 2 of this manual) is 130 bytes when a setting is being returned and 646 bytes when a display is being returned.

If the register number sent with the query is out of range, a register number of -1 will be returned. If the requested register did not contain valid data, a register number of -2 will be returned. In either of these cases, all binary data bytes will be 0.

PLOT query



The PLOT query sends information to plot the display on a TEKTRONIX 4662 Opt 01, 4662 Opt 31 or 4663 (emulating a 4662) Interactive Digital Plotter, a Hewlett-Packard HP7470A, HP7475A, HP7580B, HP7585B, or HP7586B plotter, or a Gould 6310 or 6320 plotter.

• If REDOUT is ON, corresponding settings will be plotted.

• If GRAT is ON, the scale down the right-hand side of the screen will be plotted, as well as the graticule information. If REDOUT is also ON, the bezel information will also be plotted (this assumes that the normal instrument readout is being displayed and not text sent with the RDOUT command).

• Markers and digital storage must be on for the marker(s) to be plotted.

• The position of the marker(s) will be plotted out as an X.

• VIEWA must be ON to plot the A waveform, VIEWB must be ON to plot the B waveform, and BMINA must be ON to plot the difference between the A and B waveform.

• The readout settings currently displayed on the instrument are the only readout settings plotted.

• The plot can be in more than one color when using the Tektronix 4662 Opt 31 (or the 4663 emulating the 4662), the HP7470A, HP7475A, HP7580B, HP7585B, or HP7586B, or the Gould 6310 or 6320. The graticule, marker(s), and bezel information will plot in one color, and the waveform in another color.

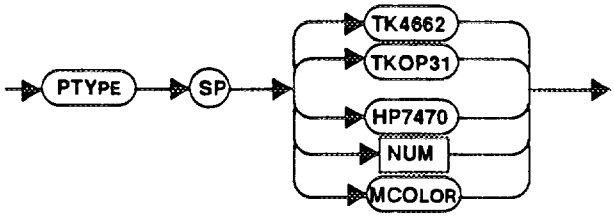
The response to PLOT? depends on the plotter in use (refer to the select plotter command (PTYPE) for a description of the plotter selections).

NOTE

Since the GPIB languages of the Tektronix 4662 Opt 01, 4662 Opt 31 and 4663 Interactive Digital Plotters, the Hewlett-Packard, or the Gould plotters do not conform to the Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features, this response does not follow the standard.

There is no PLOT command.

PTYPE (plotter type) command



TK4662 — Selects the Tektronix 4662 Opt 01 (or the 4663 in a one-pen configuration) as the plotter driven by the data generated by PLOT?.

TKOP31 — Selects the Tektronix 4662 Opt 31 (or the 4663 in a two-pen configuration) as the plotter driven by the data generated by PLOT?.

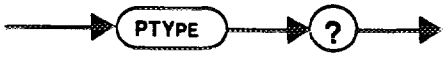
HP7470 — Selects the Hewlett-Packard HP7470A as the plotter driven by the data generated by PLOT?.

MCOLOR — Selects the Hewlett-Packard HP7475A, 7580B, 7585B, or 7586B, or the Gould 6310 or 6320 as the plotter driven by the data generated by PLOT?.

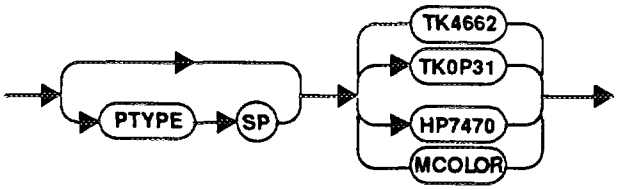
NUM—0 = TK4662
1 = TKOP31
2 = HP7470
3 = MCOLOR

Power-up value — The last value stored in memory.

PTYPE (plotter type) query



Response to PTYPE query



POFSET (set K) command

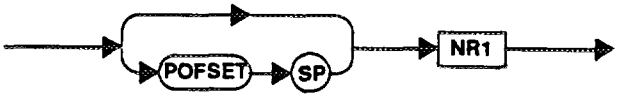
NUM — Sets the reference position for plotting B-A waveforms. Although the range is 0 to 255 the range visible on the screen is 25 at the bottom to 225 at the top. The nearest limit is used if the selected number is out of range (no error is reported).

Range — 0 to 255.

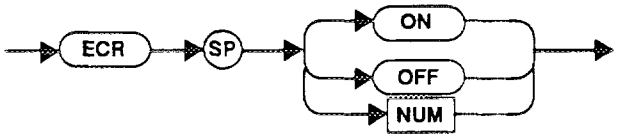
Power-up value — The last value stored in memory.

POFSET (set K) query

Response to POFSET query



ECR (end of sweep corrections) command



This command causes oscillator corrections to occur either at the end of every sweep or as needed, based on the drift rate of the oscillators.

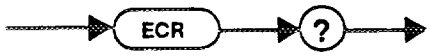
ON — Oscillator corrections occur at the end of every sweep.

OFF — The time between oscillator corrections is determined by the drift rate of the oscillators.

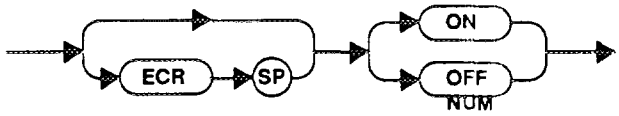
Interaction — When ECR is ON, corrections will generally occur more frequently than when ECR is OFF. The extra time spent correcting the oscillators may lengthen the response time to other commands and queries.

Power-up value — OFF.

ECR query



Response to ECR query

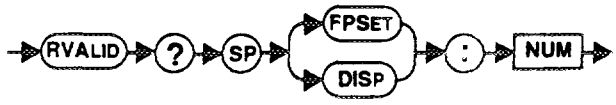


SSR (send service request) command

The SSR command asserts SRQ. The status byte will report this as an internal error warning, and system event number 140 will be returned.

Interaction — The service request will be asserted only if RQS is ON.

RVALID (register valid) query

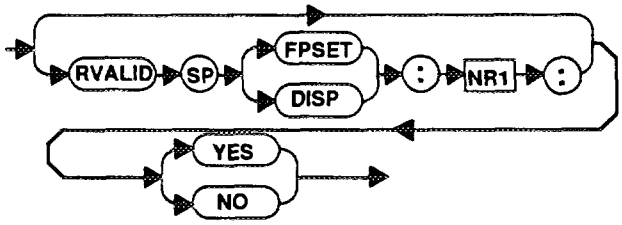


YES is returned if the indicated register contains a valid front-panel setting or display, and NO is returned if it does not.

Examples — RVALID? FPSET:2
RVA? FPS:7
RVA? DISP:7

Range — 0–9 if FPSET is used, and 0–8 if DISP is used.

Response to RVALID query



Interaction — If HDR is OFF, the register type, register number, and separators are eliminated along with the header. If the register number is out of range, the value -1 is substituted for the register number in the response (assuming HDR is ON) and NO is returned.

There is no RVALID command.

Marker System

The digital storage functions (described in Section 4 of this manual) must be on for the marker(s) to be viewable. The Primary marker (single-marker mode) displays marker frequency and amplitude. A Secondary marker is added to the Primary marker in the delta-marker mode, and the difference in frequency and amplitude between the two markers is displayed. In the delta-marker mode, the Primary marker is the brighter of the two. The GPIB marker commands in this section are divided into four categories; system control, marker positioning, marker finding, and miscellaneous.

NUM Argument Values

Unless otherwise stated, the values for the NUM argument are

- 1 = ON
- ≥+0.5 are rounded to 1
- 0 = OFF
- <+0.5 are rounded to 0

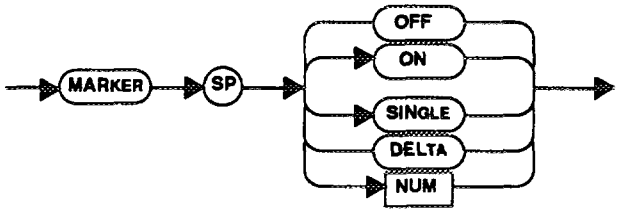
WAVEFORM FINDING

The spectrum analyzer has two sets of waveform-finding commands; five commands are described in this section and two are described in Section 8 of this manual. The MRGTNX and MLFTNX marker positioning commands move the Primary marker, and RGTNXT and LFTNXT waveform processing commands move the invisible display data point. The Primary marker is specified and reported in frequency and amplitude, and the display data point is specified and reported in screen units. The two locations (marker and data point) and the two sets of commands are independent unless the Primary marker and the display data point are coupled with the MCPOIN command. The DPMK command moves the display data point to the Primary marker location without coupling the two, and MKDP moves the Primary marker to the horizontal location of the display data point, also without coupling the locations.

SYSTEM CONTROL

The system control commands turn on the marker mode (MARKER); set the Primary or Secondary marker on a trace (MTRACE); assign a marker function to the front-panel ASSIGN 1 or ASSIGN 2 push button (M1ASGN or M2ASGN); normalize the Primary marker amplitude readout to the resolution bandwidth (NSELVL); and keep the Primary marker signal at center screen (SGTRAK).

MARKER (marker mode) command



OFF — The marker is turned off.

ON or SINGLE — The single-marker is turned on.

DELTA — The delta-marker is turned on.

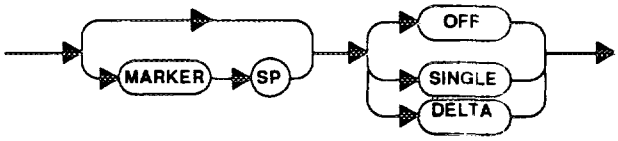
NUM — 0 = OFF
1 = ON or SINGLE
2 = DELTA

Power-up value — OFF

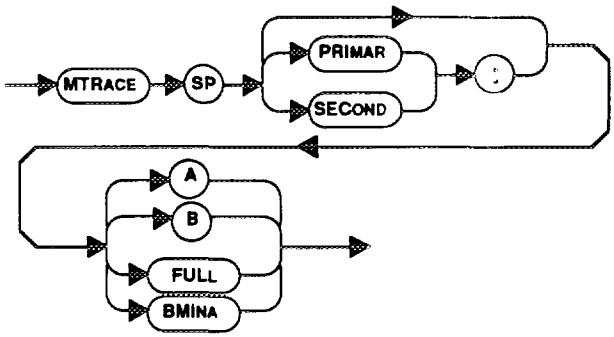
Interaction — MARKER SINGLE or ON or MARKER DELTA sets TMODE to MARKER. MARKER OFF sets TMODE to FREQ. MARKER SINGLE, or MARKER DELTA are selected by most other marker commands.

MARKER (marker mode) query

Response to MARKER query



MTRACE (marker trace position) command



MTRACE allows either the Primary or Secondary marker to be placed on a trace location other than default.

MTRACE or MTRACE PRIMAR — The Primary marker is set.

MTRACE SECOND — The Secondary marker is set.

Use A, B, FULL, or BMINA to place the selected marker on the designated trace.

Examples — MTRACE B
MTR PRI:A
MTRACE SECOND:BMINA

Power-up value — If the marker system is not turned on with the MTRACE command, the marker location will be assigned according to the settings of the digital storage commands as shown in Table 5-1.

Interaction —

• MTRACE SECOND sets MARKER to DELTA. If MARKER is OFF, MTRACE or MTRACE PRIMAR sets MARKER to SINGLE.

•Arguments A, B, and BMINA set SAVEA ON.

•BMINA sets BMINA ON.

•Argument FULL sets SAVEA OFF. SAVEA OFF moves any marker(s) on A or B to FULL; SAVEA ON moves any marker(s) on FULL to A or B, according to Table 5-1.

•If BWMODE is ON, one MTRACE command will move both markers to the same trace. If the marker is moved off the active trace, it will go back to the active trace if the instrument is in MAX SPAN when it is returned to local control.

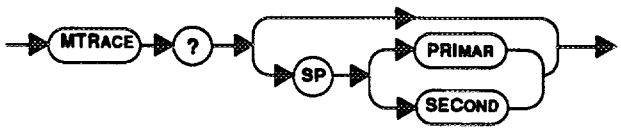
•If either marker is placed on a zero-span trace, the other marker will move there also.

Table 5-1

MARKER TRACE ORGANIZATION

VIEW A	VIEW B	SAVE A	B-SAVE A	PRIM. MARK. ON	SECOND. MARK. ON
Off	Off	Off	Off	FULL [a]	FULL [a]
Off	Off	On	Off	A [a]	A [a]
Off	Off	On	On	B-SAVEA	B-SAVEA
Off	On	Off	Off	Full	Full
Off	On	On	Off	B	B
Off	On	On	On	B	B
On	Off	Off	Off	Full	Full
On	Off	On	Off	A	A
On	Off	On	On	B-SAVE A	B-SAVE A
On	On	Off	Off	Full	Full
On	On	On	Off	B	A
On	On	On	On	B	A

MTRACE (marker trace position) query



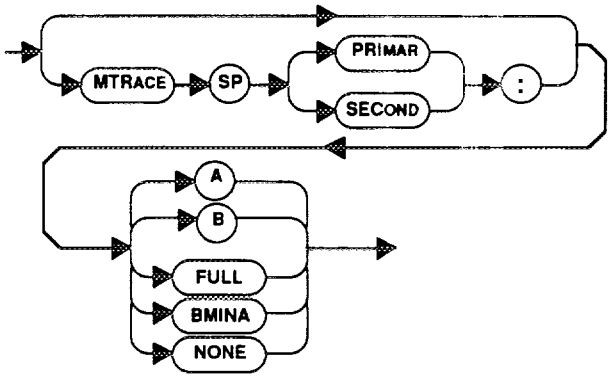
MTRACE? or MTRACE? PRIMAR — The trace containing the Primary marker is returned.

MTRACE? SECOND — The trace containing the Secondary marker is returned.

[a]Not applicable. Since no digital storage traces are being viewed, there is no visible marker. The listed trace is that for which marker MTRACE (marker trace position) query readouts are given.

Examples — MTRACE?
MTR? SEC

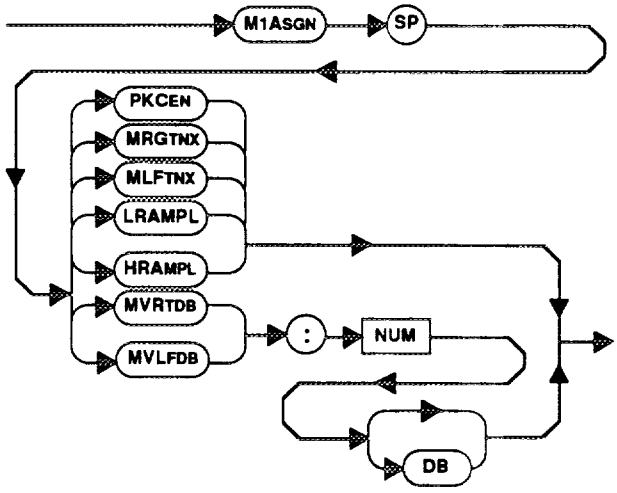
Response to MTRACE query



FULL is returned when SAVEA is OFF; A, B, or BMINA (B-Saved A) is returned when SAVEA is ON. NONE is returned when MARKER is OFF or when MTRACE? SECOND is requested while MARKER is set to SINGLE.

Interaction — If HDR is OFF, PRIMAR or SECOND and the following delimiter are eliminated along with the MTRACE header.

M1ASGN (assign marker push button 1) command



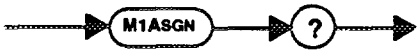
The M1ASGN command assigns the marker function that will be called up with the front-panel ASSIGN 1 push button. For the description of each argument, see the description of the command whose mnemonic is the same as the argument.

Examples — M1ASGN MRGTNX
M1A MVR: 100
M1ASGN MVLFDB : 80DB

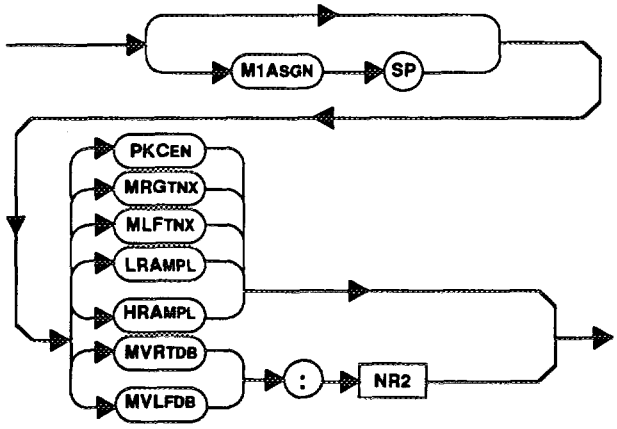
Power-up value — The assignment is stored in memory. The power-up value is the marker function that was assigned when the power to the instrument was last turned off. If no assignment has ever been made, MRGTNX is assigned.

Interaction — The M1ASGN command affects only the command that will be executed when the front-panel ASSIGN 1 push button is pressed while the instrument is under local control.

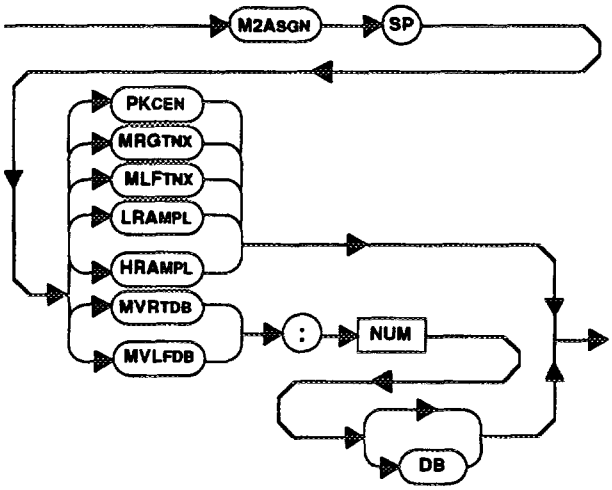
M1ASGN (assign marker push button 1) query



Response to M1ASGN query



M2ASGN (assign marker push button 2) command



The M2ASGN command assigns the marker function that will be called up with the front-panel ASSIGN 2 push button. For the description of each argument, see the description of the command whose mnemonic is the same as the argument.

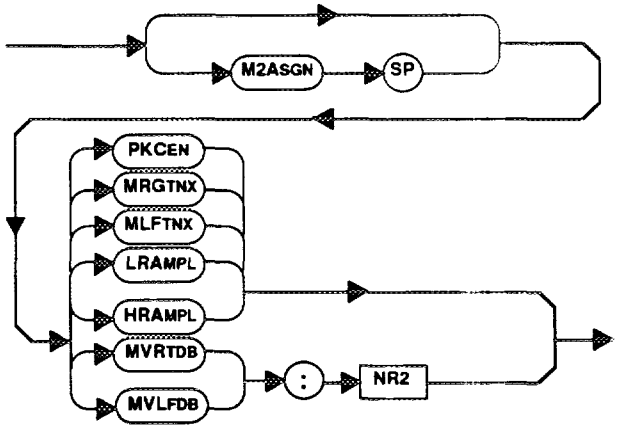
Examples —M2ASGN MRGTNX
M2A MVR: 100
M2ASGN MVLFDB: 80DB

Power-up value — The assignment is stored in memory. The power-up value is the marker function that was assigned when the power to the instrument was last turned off. If no assignment has ever been made, MLFTNX is assigned.

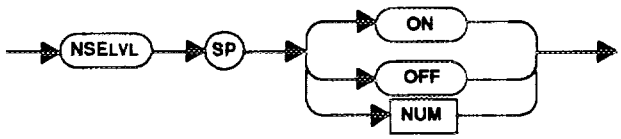
Interaction — The M2ASGN command affects only the command that will be executed when the front-panel ASSIGN 2 push button is pressed while the instrument is under local control.

M2ASGN (assign marker push button 2) query

Response to M2ASGN query



NSELVL (noise level normalization) command



The Primary marker amplitude readout normalizes to the resolution bandwidth, and changes the units of the marker amplitude readout from units to units/Hz.

This command assumes the Primary marker is on noise, not on a signal. If the marker is on a signal, the marker amplitude readout is incorrect.

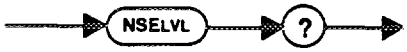
ON —The normalization is turned on.

OFF — The normalization is turned off.

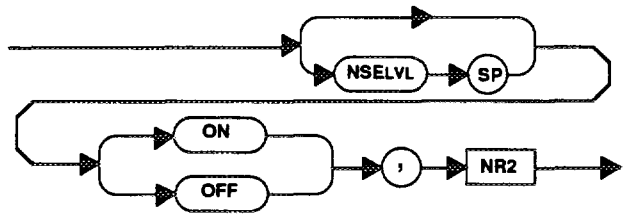
Power-up value — OFF.

Interaction — The marker amplitude readout is in reference level units/Hz. If MARKER is OFF, NSELVL sets MARKER to SINGLE.

NSELVL (noise level normalization) query



Response to NSELVL query



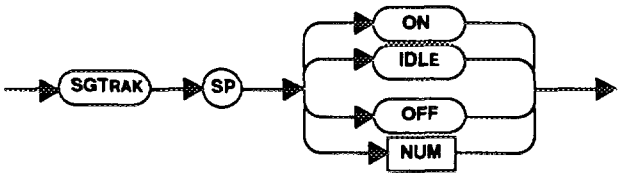
The noise level at the position of the Primary marker is returned, regardless of whether NSELVL is ON or OFF. The number is not returned with the NSELVL portion of the SET? response.

NOTE

If the Primary marker is out of the range of digital storage, one of the following will be returned.

-200.0 if under-range
+200.0 if over-range
+999.9 if markers are off

SGTRAK (signal track) command



SGTRAK attempts to keep the signal at center screen as long as the signal does not drift off screen between sweeps. Marker execution error message 120 is issued if the marker is on an inactive trace. If there is no signal at the marker location or the signal disappears, SGTRAK goes to IDLE. The signal track function takes effect at the end of the sweep after the SGTRAK command is given. SGTRAK is on during IDLE, but it is not tracking because there is no signal at the marker location.

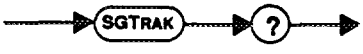
ON or IDLE — The signal track is turned on.

OFF — The signal track is turned off.

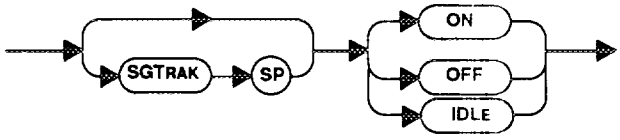
Power-up value — OFF.

Interaction — If MARKER is OFF, SGTRAK sets MARKER to SINGLE. Neither IDENT nor BWMODE are available while SGTRAK is ON; execution error message 101 will be issued if either is used. The definition of the criteria for a signal is set by the THRHLD command.

SGTRAK (signal track) query



Response to SGTRAK query



Marker Positioning

The marker positioning commands and queries move the display pointer to the Primary marker position (DPMK); return the amplitude of the Primary or Secondary marker or their difference (MAMPL?); tune the Primary marker frequency to center screen (MCEN); track the Primary marker with the display pointer (MCPOIN); exchange the Primary and Secondary marker positions (MEXCHG); set the Primary marker frequency (MFREQ); move the Primary marker to the display pointer horizontal location (MKDP); return the frequency and amplitude of the Primary or Secondary marker or their difference (MLOCAT?); move the marker to the reference level (MTOP); and tune the Primary marker (MTUNE).

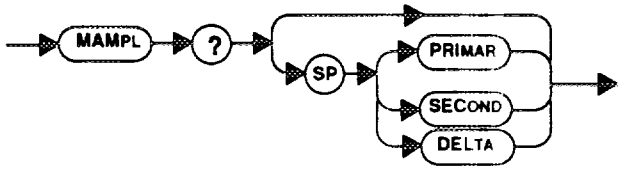
DPMK (display pointer to marker) command

The DPMK command moves the display pointer to the Primary marker position.

Interaction — DPMK cancels the WFID portion of any previous WFMPRE command or the CRVID portion of any previous CURVE command, and selects the FULL waveform for data transfers and waveform processing. If MARKER is OFF, DPMK sets MARKER to SINGLE .

There is no DPMK query.

MAMPL (marker amplitude) query



MAMPL? or MAMPL? PRIMAR — The amplitude of the Primary marker is returned.

MAMPL? SECOND — The amplitude of the Secondary marker is returned.

MAMPL? DELTA — The amplitude of the Primary marker with respect to the Secondary marker is returned.

NOTE

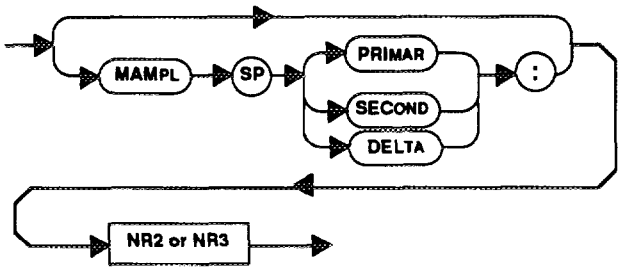
If the marker whose amplitude is being requested (or, in the case of MAMPL? DELTA, the amplitude of either marker) is out of the range of digital storage, one of the following will be returned.

- -200.0 if under-range
- +200.0 if over-range
- +999.9 if markers are off

Examples — MAMPL?
MAM? SEC

Interaction — The amplitude is returned in the current reference level units if in a log display mode, or in volts if in a linear display mode. If the frequency of the Secondary marker is off-screen, MLOCAT? SECOND and MLOCAT? DELTA use the last known Secondary marker amplitude.

Response to MAMPL query



NR2 is returned in the Log Mode, and NR3 is returned in the Lin Mode.

MAMPL is not included in the response to SET?

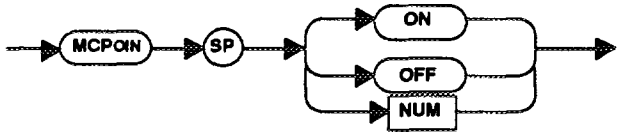
Interaction — If HDR is OFF, PRIMAR, SECOND, or DELTA and the delimiter : are eliminated along with the MAMPL header. There is no MAMPL command.

MCEN (marker to center) command

The Primary marker frequency is tuned to the center of the screen. Marker execution error message 121 is issued if the marker is not on an active trace.

Interaction — If MARKER is OFF, MCEN sets MARKER to SINGLE. In this case, since the Primary marker appears at the center of the screen, the center frequency does not change. When counting at the marker, it is the counted frequency that is tuned to center. MCEN is not available in ZEROSP or MXSPN. There is no MCEN query.

MCPOIN (marker coupled to the display pointer) command



ON — The display pointer tracks the Primary marker.

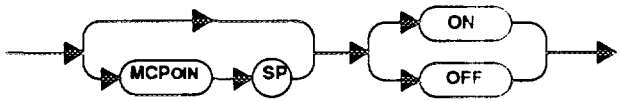
OFF — The display pointer does not track the Primary marker.

Power-up value — OFF.

Interaction — The WFID portion of any previous WFMPRE command or the CRVID portion of any previous CURVE command is cancelled, and the FULL waveform for data transfers and waveform processing is selected. A WFID or CRVID other than FULL, sets MCPOIN to OFF. If MARKER is OFF, MCPOIN sets MARKER to SINGLE.

MCPOIN (marker coupled to the display pointer) query

Response to MCPOIN query



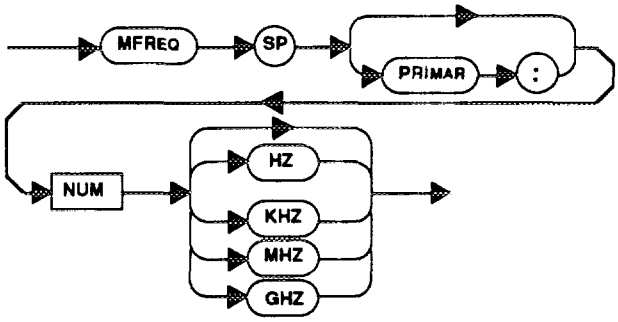
MEXCHG (marker exchange) command

The Primary marker moves to the former location of the Secondary marker, and the Secondary marker moves to the former location of the Primary marker. If the Secondary marker is off the screen before the marker exchange, the instrument center frequency will be set to the old Secondary marker frequency, and the old Primary marker (i.e., the new Secondary marker) will be off the screen.

Interaction — MEXCHG sets MARKER to DELTA.

There is no MEXCHG query.

MFREQ (marker frequency) command



The MFREQ command sets the frequency of the Primary marker to the value given by NUM.

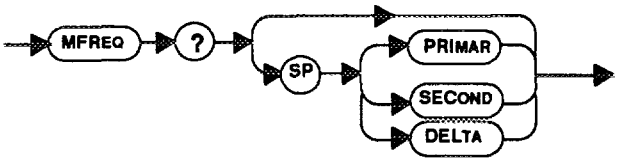
Examples — MFREQ 100000
MFR 1.8 GHZ
MFREQ PRIMAR:200 KHZ
MFR PRI:200MHZ

Range — Active trace is 0 Hz to 21 GHz. Inactive trace is limited to the edge of the screen

Power-up value — Markers are off when power is first turned on to the instrument. When markers are turned on, MFREQ is set to the center frequency of the marker trace, unless the marker is on a recalled trace that had a stored marker frequency.

Interaction — If MARKER is OFF, MFREQ sets MARKER to SINGLE. MFREQ causes marker execution error message 120 to be issued if the Primary marker is on an inactive trace and the frequency is not on the screen. MFREQ moves the Primary marker to center screen and changes center frequency if the Primary marker is on an active trace and the frequency is not on the screen.

MFREQ (marker frequency) query



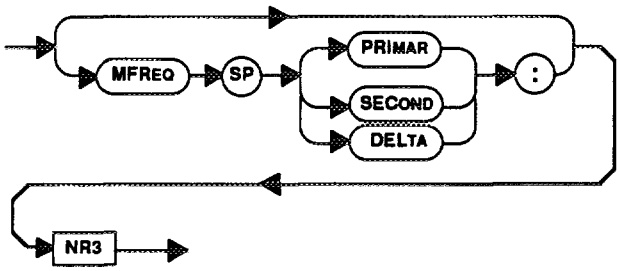
MFREQ? or MFREQ? PRIMAR — The frequency is returned for the Primary marker.

MFREQ? SECOND — The frequency is returned for the Secondary marker.

MFREQ? DELTA — The frequency is returned for the Primary marker with respect to the Secondary marker.

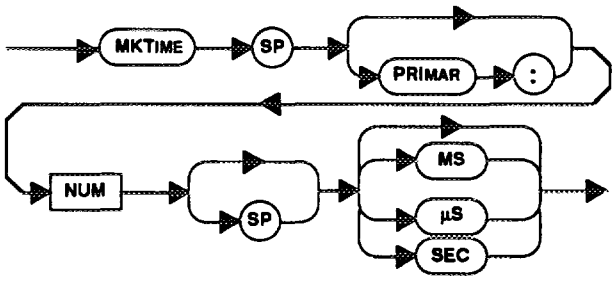
Interaction — Any MFREQ? query returns 9.999999E+99 if the requested marker or delta is not on.

Response to MFREQ query



Interaction — If HDR is OFF, PRIMAR, SECOND, or DELTA and the following delimiter : are eliminated along with the MFREQ header.

MKTIME (marker time) command



The MKTIME command sets the time of the Primary marker with respect to the trigger point (1/2 division to the left of the screen) to the value given in NUM.

Examples — MKTIME 1MS
MKT .1 S

Power-up value — Markers are off when power is first turned on to the instrument. When markers are turned on in zero span, or the instrument is set to zero span with the markers on and ZETIME is set to ON, the markers are placed at center screen and the time value is set accordingly.

Marker System — 492PGM Programmers

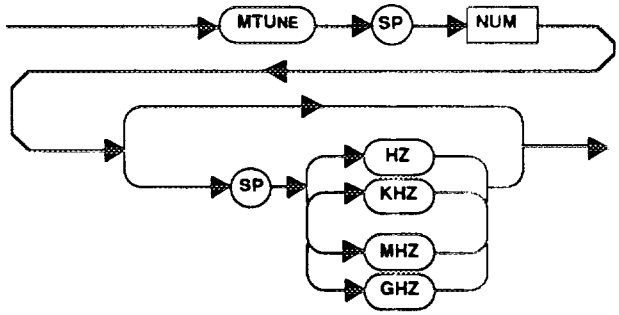
MTOP (marker to reference level) command

The MTOP command changes REFLVL to move the marker to the reference level (or as close as possible, given the specified vertical display and reference level accuracies).

Interaction — Marker execution error message 121 is issued if the Primary marker is on an inactive trace. If MARKER is OFF, MTOP sets MARKER to SINGLE. MTOP is not available in BWMODE.

There is no MTOP query.

MTUNE (tune marker) command



The Primary marker frequency is changed by the value of the number argument. Marker execution error message 120 is issued if the marker is not on an active trace and the resulting marker frequency would not be on the screen.

MTUNE moves the Primary marker to center screen and changes center frequency if the Primary marker is on an active trace and the frequency is not on the screen.

Examples — MTUNE 100
MTU 200 MHZ

Range — The same as TUNE; refer to Table 4-2.

Interaction — If MARKER is OFF, MTUNE sets MARKER to SINGLE.

There is no MTUNE query.

Marker Finding

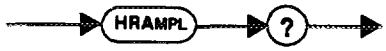
The marker finding commands move the Primary marker to the next higher or lower amplitude signal (HRAMPL or LRAMPL); set the bandwidth number (BWNUM); place delta markers at a given amplitude (BWMODE); move the Primary marker to the largest on-screen signal peak (MFBIG); move the Primary marker to the next signal peak to the left or the right (MLFTNX or MRGTNX); set the Primary marker to the largest or smallest vertical value in digital storage (MMAX or MMIN); set the Primary marker to the largest vertical value in digital storage that is above threshold (PKFIND); set the Primary marker to the largest vertical value in digital storage that is above threshold and tune the marker frequency to center screen (PKCEN); set the threshold for the Primary marker signal find commands MLFTNX, MRGTNX, MFBIG, HRAMPL, LRAMPL, SGTRAK, BWMODE, and PKFIND (THRHLD); move the Primary marker to the left, and down or up, or to the right, and down or up, from the present position (MVLFDB or MVRTDB); set the signal type (STYPE); and assert SRQ when the signal identification routine cannot find the requested signal (SGERR).

HRAMPL (Next higher amplitude) command

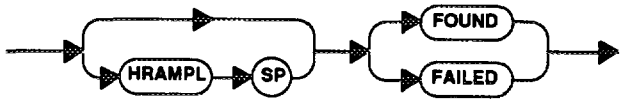
The HRAMPL command moves the Primary marker to the next higher amplitude signal on the display. If the marker is on the highest signal on the display or if no signal is found, the marker does not move.

Interaction — If SGERR is ON, marker execution warning message 130 is issued if a signal is not found. If MARKER is OFF, HRAMPL sets MARKER to SINGLE. The criteria for a signal are set by the THRHLD and STYPE commands.

HRAMPL (next higher amplitude) query



Response to HRAMPL query



FOUND is returned if the last HRAMPL command found a signal. FAILED is returned if the last HRAMPL command did not find a signal. If the HRAMPL query is given before any HRAMPL command, FAILED is returned.

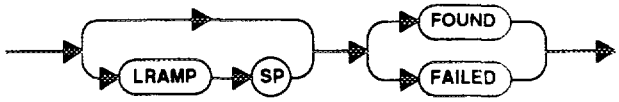
LRAMPL (next lower amplitude) command

The LRAMPL command moves the Primary marker to the next lower amplitude signal on the display. If the marker is on the lowest signal on the display or a signal cannot be found, the marker does not move.

Interaction — If SGERR is ON, marker execution warning message 130 is issued if a signal is not found. If MARKER is OFF, LRAMPL sets MARKER to SINGLE. The criteria for a signal are set by the THRHLD and STYPE commands.

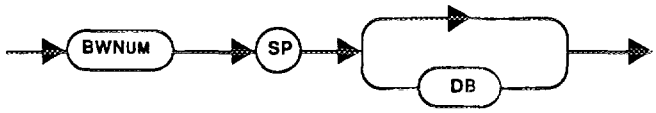
LRAMPL (next lower amplitude) query

Response to LRAMPL query



FOUND is returned if the last LRAMPL command found a signal. FAILED is returned if the last LRAMPL command did not find a signal. If the LRAMPL query is given before any LRAMPL command, FAILED is returned.

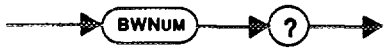
BWNUM (marker bandwidth number) command



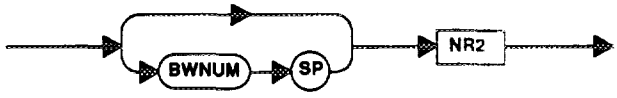
BWNUM sets the level below the signal peak used in the bandwidth mode (BWMODE) at which the bandwidth is found. This number is stored in battery-powered memory.

Power-up value — The value set is stored in memory. If a number has never been set or if the memory fails, the value will be 6 dB.

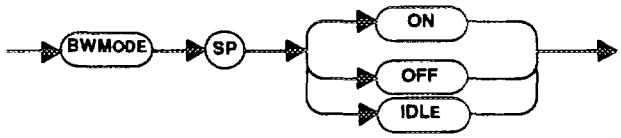
BWNUM (marker bandwidth number) query



Response to BWNUM query



BWMODE (marker bandwidth mode) command



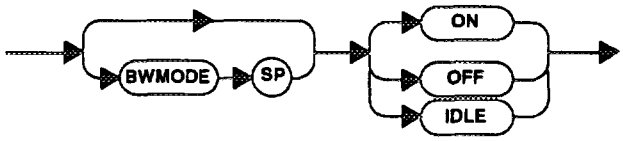
The BWMODE command moves the delta markers down from the peak of the signal that the Primary marker is on by the value set in BWNUM. (This value could also have been set from the front panel. If no value has ever been set, the value used will be 6 dB.) BWMODE moves in 1/10 dB steps. The Primary marker is placed on the right (higher frequency) side of the signal and the Secondary marker is placed on the left (lower frequency) side of the signal. If the Primary marker is not on a signal or if a point NUM dB (set by the BWNUM command) down cannot be found on each side of the signal, the Secondary marker moves to the location of the Primary marker, and BWMODE goes to IDLE. When BWMODE goes to IDLE, marker execution warning message 130 is issued if SGERR is on.

Power-up value — OFF.

Interaction — BWMODE sets MARKER to DELTA. The markers are reset after the marker position or BWNUM is changed (or at every sweep if on an active trace). The definition of the criteria for a signal is set by the THRHLD command, The Lin Mode, Multiband Sweep Mode, and Zero Span Mode are not available in BWMODE.

BWMODE (marker bandwidth mode) query

Response to BWMODE query

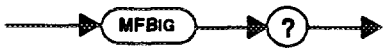


MFBIG (marker peak find) command

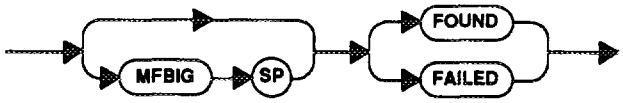
The MFBIG command moves the Primary marker to the peak of the largest on-screen signal. If no signal peak is found, the marker does not move.

Interaction — If MARKER is OFF, MFBIG sets MARKER to SINGLE. If SGERR is ON, marker execution warning message 130 is issued if a signal is not found. The definition of the criteria for a signal is set by the THRHLD and STYPE commands.

MFBIG (marker peak find) query



Response to MFBIG query



FOUND is returned if the last MFBIG command found a signal. FAILED is returned if the last MFBIG command did not find a signal. If the MFBIG query is given before any MFBIG command, FAILED is returned.

MLFTNX (marker left next) command

The MLFTNX command moves the Primary marker to the peak of the next signal to the left of the present marker position. If no signal peak is found, the marker does not move.

Interaction — If MARKER is OFF, MLFTNX sets MARKER to SINGLE. If SGERR is ON, marker execution warning message 130 is issued if a signal is not found. The definition of the criteria for a signal is set by the THRHLD and STYPE commands.

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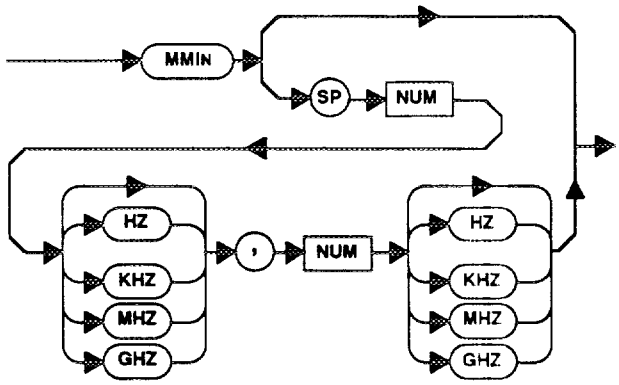
NUM, NUM — The optional arguments are two frequency values. If these are present, the search is limited to the intersection of the given frequency range and the range displayed on the screen. If the given range is totally outside the range displayed on the screen, execution error message 28 is issued.

Examples — MMAX
MMAX 15.0MHZ,19.0MHZ
MMA 15.0MHZ,19.0MHZ

Interaction — If MARKER is OFF, MMAX sets MARKER to SINGLE. There is no MMAX query.

MMIN (move marker to minimum) command



The MMIN command sets the Primary marker to the smallest vertical value in digital storage. If the smallest value is located at more than one point, the first (left-most) point is used.

NUM, NUM — The optional arguments are two frequency values. If these are present, the search is limited to the intersection of the given frequency range and the range displayed on the screen. If the given range is totally outside the range displayed on the screen, execution error message 28 is issued.

Examples — MMIN
MMIN 15.0MHZ,19.0MHZ
MMI 15.0MHZ,19.0MHZ

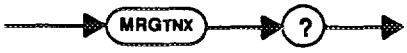
Interaction — If MARKER is OFF, MMIN sets MARKER to SINGLE. There is no MMIN query.

MRGTNX (marker right next) command

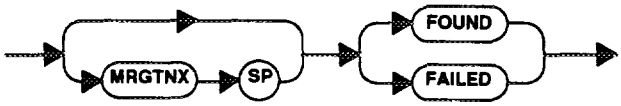
The MRGTNX command moves the Primary marker to the peak of the next signal to the right of the present marker position. If no signal peak is found, the marker does not move.

Interaction — If MARKER is OFF, MRGTNX sets MARKER to SINGLE. If SGERR is ON, marker execution warning message 130 is issued if a signal is not found. The criteria for a signal are set by the THRHLD and STYPE commands.

MRGTNX (marker right next) query

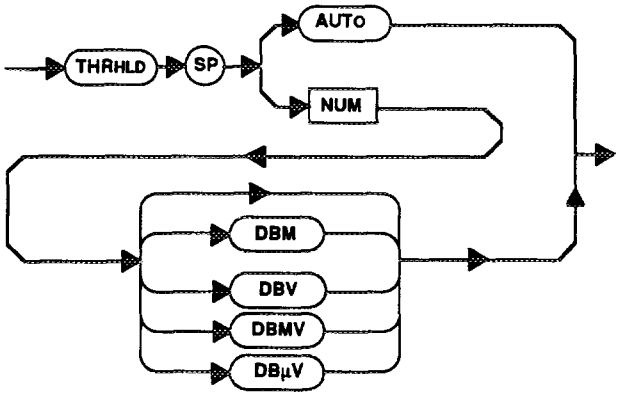


Response to MRGTNX query



FOUND is returned if the last MRGTNX command found a signal. FAILED is returned if the last MRGTNX command did not find a signal. If the MRGTNX query is given before any MRGTNX command, FAILED is returned.

THRHLD (marker threshold) command



NOTE

To ensure the correct response, all of the letters in each of the unit mnemonics for the THRHLD command must be entered; not just the first three letters as required for other mnemonics.

The THRHLD command sets the threshold for the marker signal find commands MLFTNX, MRGTNX, MFBIG, HRAMPL, LRAMPL, SGTRAK, PKFIND, PKCEN, and BWMODE. THRHLD moves in 1 dB steps.

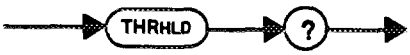
AUTO — The threshold is set to approximate the sensitivity specification plus RF attenuation plus the video filter offset. The video filter offset is 10 dB if there is no filter, 4 dB if WIDE is ON, and 2 dB if NARROW is ON.

NUM — The threshold is set to level input. If no units are specified, the spectrum analyzer assumes the current reference level units.

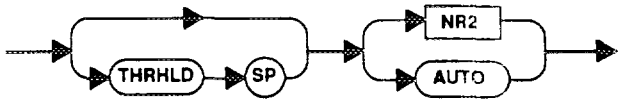
Examples — THRHLD AUTO
THRHLD -40DBMV

Power-up value — AUTO

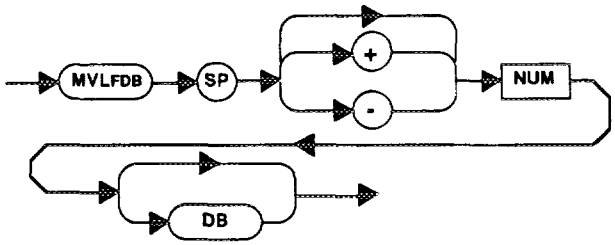
THRHLD (marker threshold) query



Response to THRHLD query



MVLFDB (move marker left x dB) command

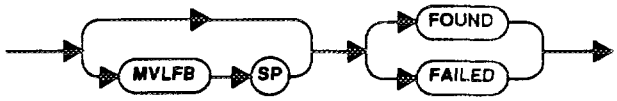


The MVLFDB command moves the Primary marker to the left and NUM DB down (negative NUM) or up (positive NUM or NUM without a sign) from the current position. If the requested amplitude cannot be found, the marker does not move.

Interaction — If MARKER is OFF, MVLFDB sets MARKER to SINGLE. If SGERR is ON, marker execution warning message 130 is issued if the requested amplitude is not found.

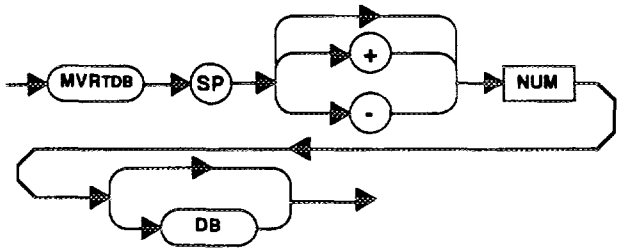
MVLFDB (move marker left x dB) query

Response to MVLFDB query



FOUND is returned if the last MVLFDB command moved the marker to the requested position. FAILED is returned if the last MVLFDB command could not move the marker to the requested position. If the MVLFDB query is given before any MVLFDB command, FAILED is returned.

MVRTDB (move marker right x dB) command

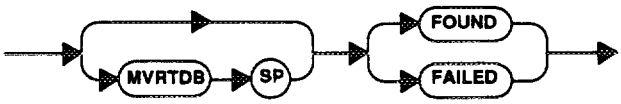


The MVRTDB command moves the Primary marker to the right and NUM DB down (negative NUM) or up (positive NUM or NUM without a sign) from the current position. If the requested amplitude cannot be found, the marker does not move.

Interaction — MARKER is OFF, MVRTDB sets MARKER to SINGLE. If SGERR is ON, marker execution warning message 130 is issued if the requested amplitude is not found.

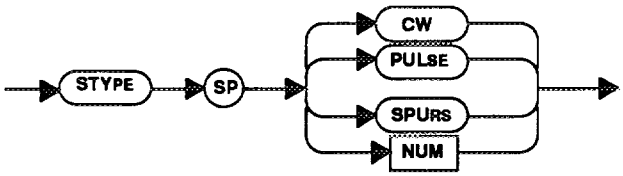
MVRTDB (move marker right x dB) query

Response to MVRTDB query



FOUND is returned if the last MVRTDB command moved the marker to the requested position. FAILED is returned if the last MVRTDB command could not move the marker to the requested position. If the MVRTDB query is given before any MVRTDB command, FAILED is returned.

STYPE (signal type) command



CW — Continuous wave signals are identified.

PULSE — Pulsed signal groups are identified.

SPURS — All signals above the threshold are identified.

NUM — 0 = CW
1 = PULSE
2 = SPURS

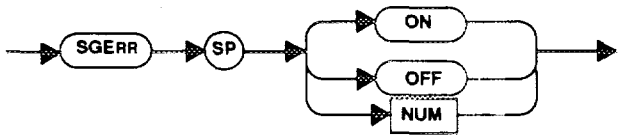
Figure 5-2 is a signal enlarged to show how the spectrum analyzer locates the signal peak with one of the signal processing commands. The signal processing commands are MLFTNX, MRGTNX, MFBIG, HRAMPL, and LRAMPL. The spectrum analyzer looks at both the individual left-most and right-most peaks of a signal. From this reading, the spectrum analyzer calculates the exact center of the signal. If this location is one of the maximum digital storage points, the marker is positioned here. If, as in Figure 5-2, the calculated center of the signal is not equal to the maximum digital storage point, the marker is positioned on the closest point to the center. At the end of this Marker Functions portion are five illustrations showing the use of this signal finding command.

To the finding routine, a "candidate" signal consists of a peak above threshold and two points (one on each side of the peak) that are 3 dB below the peak. The location of the candidate signal is the highest amplitude point on the signal. Whether or not the candidate is recognized as a signal depends upon the processing mode chosen.

When SPURS is chosen, all candidates are taken to be signals.

When CW is chosen, a signal (to be a signal) must be at least half as wide as would be predicted from the resolution filter in use. (Note that this is not the same algorithm as the one used by the data-point-related commands. In particular, the data-point algorithm looks for a particular width, while the marker-related algorithm looks only for a minimum width. Note also that if the span is wide in comparison with the resolution bandwidth, there may be no difference between SPURS and CW.)

SGERR (signal find error) command



ON — The spectrum analyzer asserts SRQ, if RQS is ON, when any of the following conditions exist.

•The internal signal identification routine cannot find the signal requested by the MFBIG, MRGTNX, MLFTNX, HRAMPL, or LRAMPL commands.

•The internal signal identification routine cannot find the amplitude requested by the PKFIND, PKCEN, MVRTDB, or MVLFDB commands.

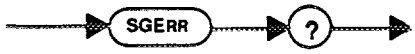
•The requested bandwidth cannot be found by the BWMODE command.

OFF — The spectrum analyzer does not assert SRQ when any of the above commands fail.

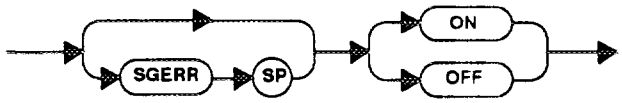
Power-up value — OFF.

Interaction — RQS must be on for marker execution warning message 130 to be issued.

SGERR (signal find error) query

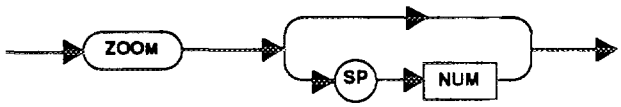


Response to SGERR query



Miscellaneous

ZOOM command

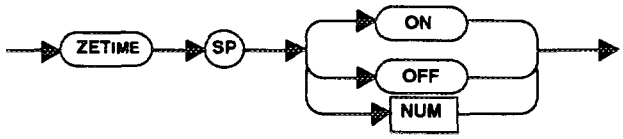


The ZOOM command moves the Primary marker frequency to the center frequency and sets the SPAN (frequency span/division) to the next smaller span/division, if possible, in the front-panel 1-2-5 sequence. If the optional number argument is given, the span/division is reduced NUM times. Numbers less than 1 are rounded to 1. Execution warning message 111 is issued if the spectrum analyzer defaults to the lowest span/division because the span could not be reduced the requested number of times.

Interaction — Marker execution error message 121 is issued if the Primary marker is not on an active trace. If MARKER is OFF, ZOOM sets MARKER to SINGLE. In this case, since the marker initially appears at the center screen, the effect is to decrement the span only.

There is no ZOOM query.

ZETIME (zero span) command



ON — In zero span, the marker readout is amplitude and time.

OFF — In zero span, the marker readout is amplitude and frequency.

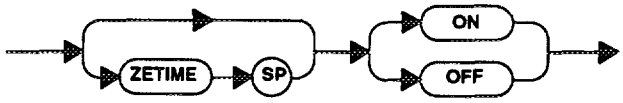
Power-up value — OFF.

Interaction — The ZETIME command has no effect when the instrument is in a non-zero span. If the markers are on different traces, the Secondary marker will move to the Primary marker trace under either of the following conditions. Under the same conditions, if the Secondary marker is off-screen, it will move on-screen.

- If the ZETIME ON command is given with the Primary marker on a zero-span trace
- If the Primary marker is moved to a zero-span trace while ZETIME is ON

ZETIME (zero span) query

Response to ZETIME query



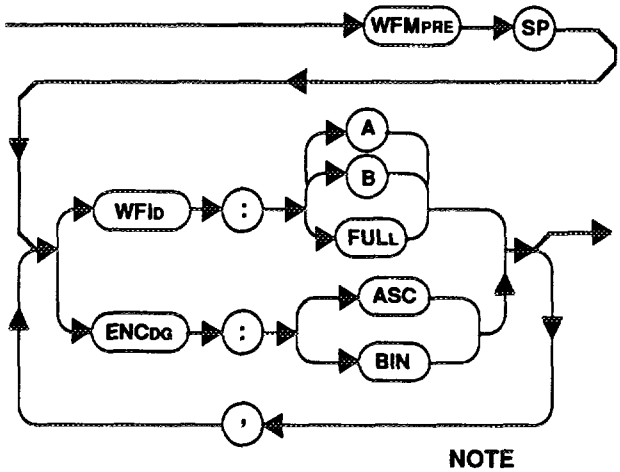
Display Data and CRT Readout I/O

The spectrum analyzer follows the Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features for waveform transfer. The commands and queries in this section transfer display and readout data to or from the spectrum analyzer and are divided into two categories; waveform transfers, and CRT readout transfers.

Waveform Transfers

The waveform transfers begin with a waveform preamble (WFMPRE) that identifies and scales the data and continues with data (CURVE) that represents the waveform. A query (WAVFRM?) displays the responses to the WFMPRE and CURVE queries. The display preamble (DPRE?) contains the numeric data necessary to reproduce the display. The display units necessary to make a hard copy of the display (DCOPY?) can be transmitted to another unit. A readout command (RDOUT) displays messages on the CRT in either a 2-line or a 16-line mode (TEXT). Three CRT readout queries return the upper row of characters (UPRDO), the middle row (MDRDO), or the lower row (LORDO).

WFMPRE (waveform preamble) command



NOTE

The WFMPRE command has no effect on the Marker Finding commands in Section 5 of this manual.

The WFID path of the waveform preamble command allows the choice of either the A or B waveform or both (FULL). Following the ENCDG path, the waveform preamble command allows selection of either ASCII-coded decimal or binary waveform data.

The contents of digital storage determine if a half-resolution or full-resolution waveform is obtained, or two different waveforms. This is because of the way digital storage is handled in the spectrum analyzer.

The B waveform is updated with each sweep; the A waveform is updated only if SAVEA is OFF. The values stored for each waveform are alternate points on the current display (i.e., B, A, B, A, B, A, ... beginning at the left edge of the screen and moving to the right).

With SAVEA OFF, each waveform is a half-resolution replica of data from the last sweep (A data points offset by 1 from corresponding B data points). Full-resolution (FULL) transfers merge the two waveforms for 1000 data points (100 points/div), and half-resolution transfers (A or B) separate the waveforms for 500 data points (50 points/div). If the waveforms are separated and SAVEA is OFF, signals resolved to a single point (with very narrow resolution bandwidths compared to span) appear in either A memory or B memory, but not both.

With SAVEA ON, only the B waveform is filled with data from the current sweep, so transfers can involve two unrelated waveforms.

WFID — Either the A or B waveform or both A and B (FULL) waveforms are selected for data transfers and waveform processing.

ENCDG — Either ASCII-coded decimal numbers or binary numbers are selected for data transfer. The two arguments may be selected independently or strung together in the same command.

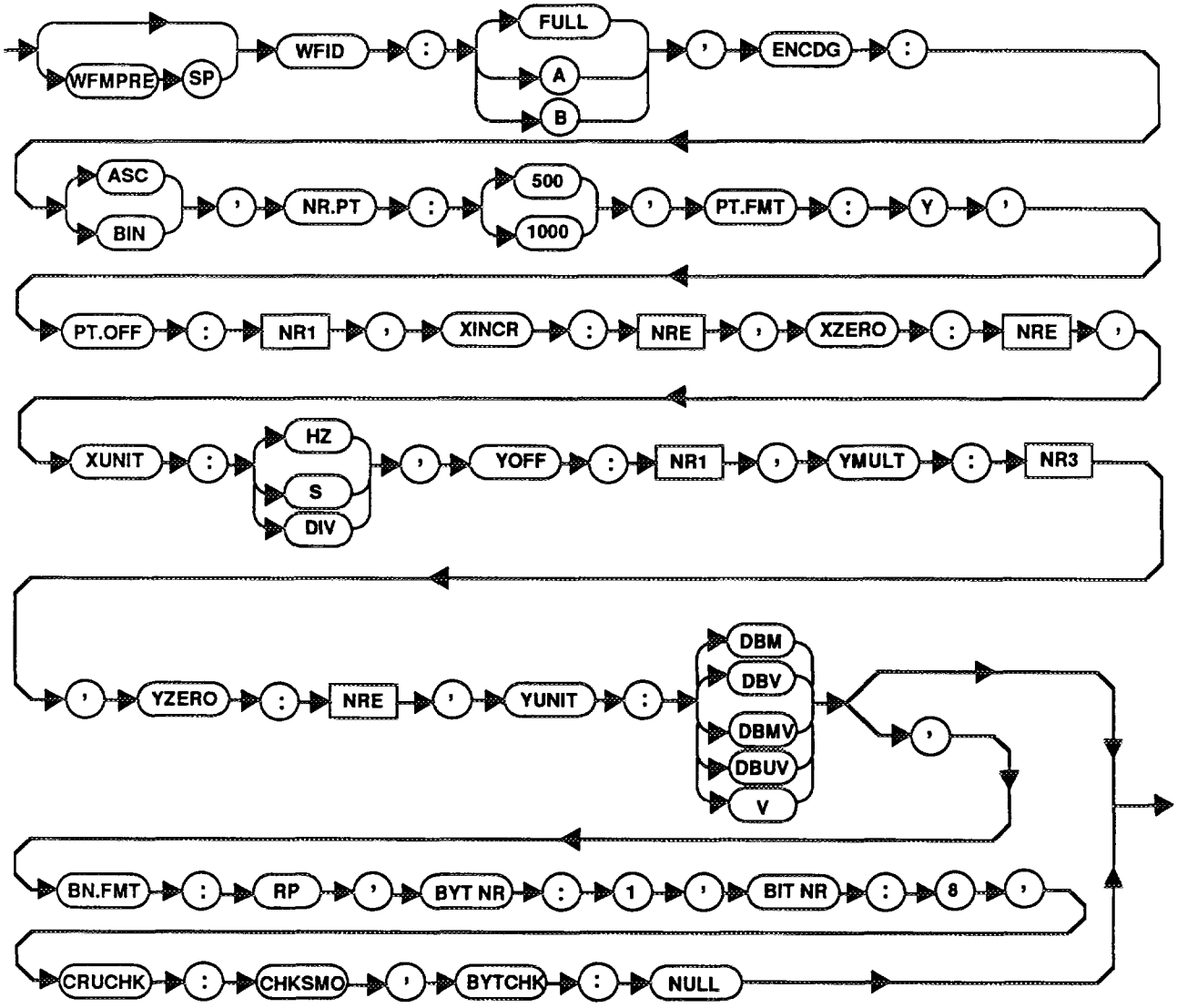
Examples — WFMPRE WFID:FULL
WFMPRE ENCDG:ASC
WFM WFID:A,ENC:BIN

Power-up value — Full (1000 point), ASCII-coded digits.

Interaction — The WFID portion of any previous WFMPRE command or the CRVID portion of any previous CURVE command is cancelled. A WFID or CRVID other than FULL sets MCPOIN to OFF. MCPOIN sets WFID to FULL.

WFMPRE (waveform preamble) query

Response to WFMPRE query



Items that follow the waveform identification and coding specify other data packet parameters that refer to number of points, scaling, and error checking.

NR.PT — Specifies either 500 or 1000 points in the curve to follow.

PT.FMT:Y — Indicates all curve data is Y (display vertical) values. The data is ordered; each point's X (display horizontal) value is determined by its point number and parameters in the waveform preamble.

PT.OFF — Relates the first point to the X origin by the point offset.

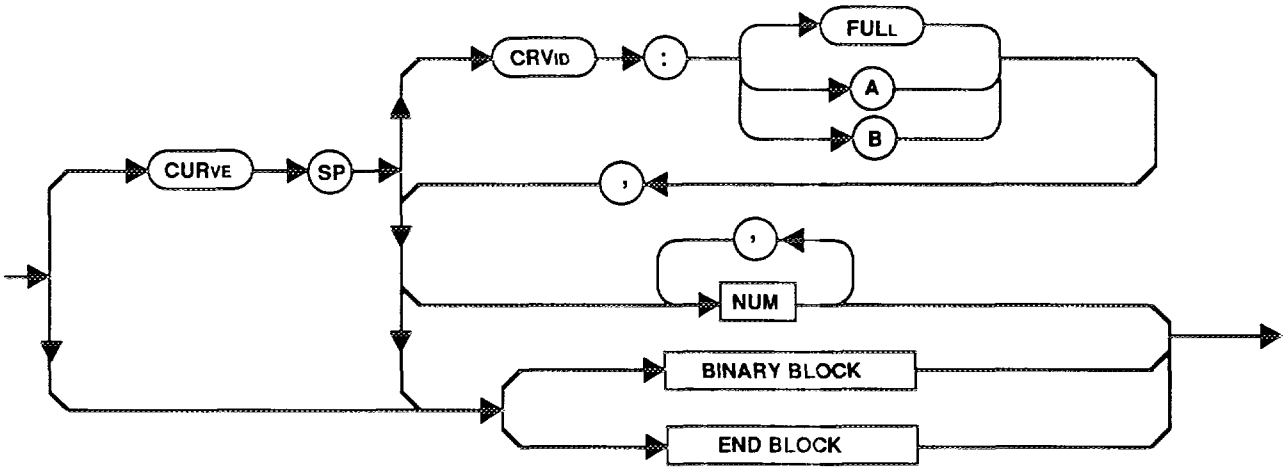
XINCR — Is the difference between adjacent data points.

XZERO — Points to the X origin. XUNIT

VUNIT Identifies the horizontal display units (e.g., seconds, divisions)

Display Data and Crt Readout I/O — 492PGM Programmers

CURVE (display curve) command



NOTE

The instrument should be in the Single Sweep mode and not be sweeping during the CURVE command or query. If it is sweeping during the CURVE query, it could give erroneous information, unless transferring a SAVEA display.

CRVID — The destination (A, B, or FULL) is selected for the waveform being sent. If this argument is omitted, the last CRVID in a CURVE command or WFID in a WFMPRE command takes precedence. A or B indicates a 500-point transfer; FULL indicates 1000 points.

NUM — This is a sequence of ASCII-coded digits, delimited by commas between successive numbers.

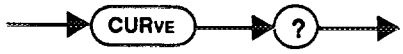
BINARY BLOCK — Binary block is a sequence of binary numbers that is preceded by the ASCII code for percent (%) and a two-byte binary integer representing the number of binary numbers plus one (the extra byte is the checksum) and followed by the checksum. The checksum is the 2's-complement of the modulo-256 sum of all preceding bytes except the first (%). Thus, the modulo-256 sum of all bytes except the first (%) should equal zero to provide an error-check of the binary block transfer.

END BLOCK — End block is a sequence of binary numbers that is preceded by the ASCII code for at (@); EOI must be asserted concurrently with the last data byte. The end block can only be the last data type in the message.

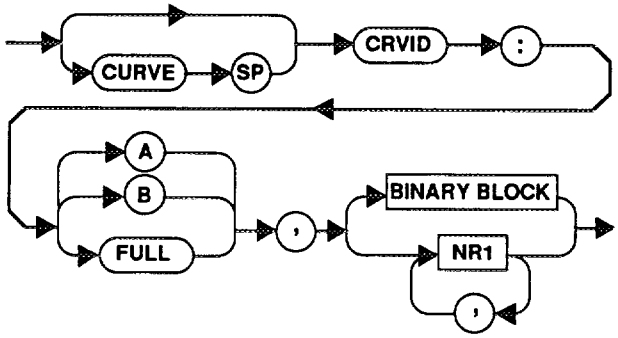
Examples — CURVE CRVID:FULL,100,100,101,99,
<996 more numbers>
CURVE <500 or 1000 numbers>
CUR <BINARY BLOCK>

Interaction — A waveform sent in a CURVE command is overwritten in the display I/O buffer if preceded by a CURVE query in the same message. This causes the queried display data to be put back into digital storage.

CURVE (display curve) query



Response to CURVE query



Waveform data is related to the display by Figure 7-1.

WAVFRM (waveform) query

The WAVFRM query response is the same as the response to WFMPRE?;CURVE?. The most recent WFID and CRVID arguments select whether A, B, or both memories are selected for data transfers and waveform processing in ASCII or binary numbers (refer to both the WFMPRE and CURVE queries).

There is no WAVFRM command.

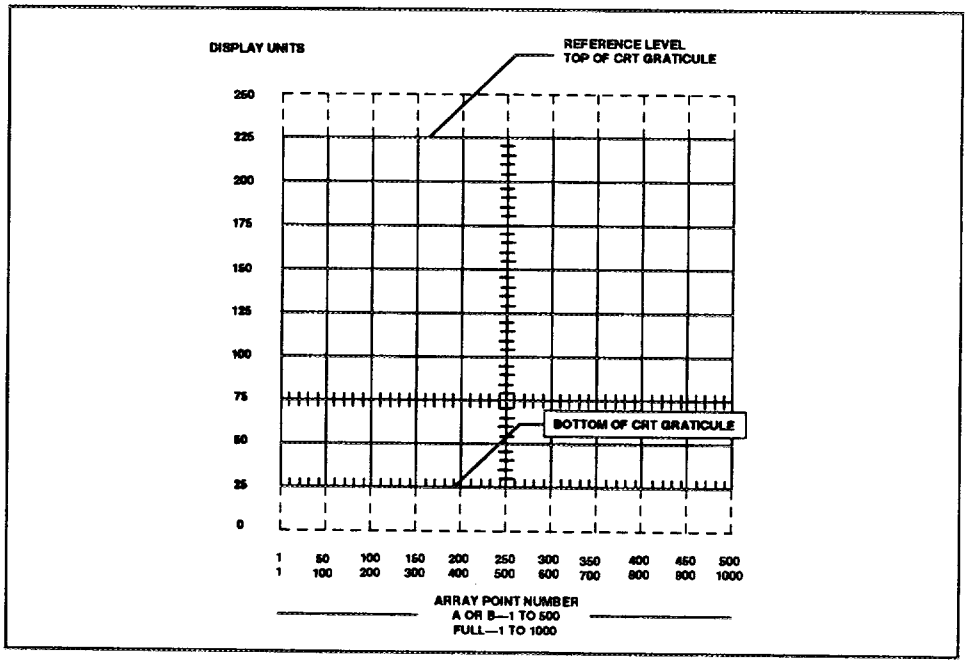
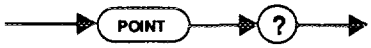


Figure 6-1. Waveform data related to the display.

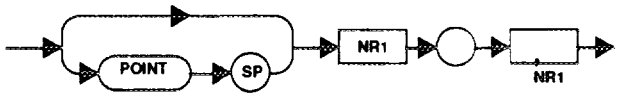
Power-up value — 500,225.

Interaction — The SET? response sent back to the instrument sets both the X and Y values of the display data point, which may not correspond to any point in digital storage. See Display Data Point Commands Interaction.

POINT (display data point) query

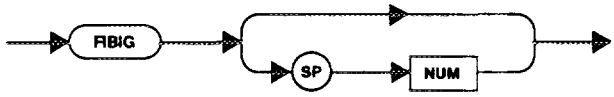


Response to POINT query



The first number is the X value of the display data point; the second number is the Y value of the display data point. Note that the query response may not match any point in digital storage if the Y value was set by a POINT command or if digital storage was updated after the display data point was acquired.

FIBIG (find big) command



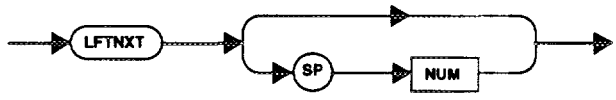
This command seeks to acquire the largest signal peak with a point of greater value than NUM. If a signal peak greater than NUM is not found, the display data point is set to 500,0. If NUM is omitted from the command, a default value of 0 is used.

A pattern recognition routine is used to recognize signals.

Interaction — See Display Data Point Commands Interaction.

There is no FIBIG query.

LFTNXT (left next) command



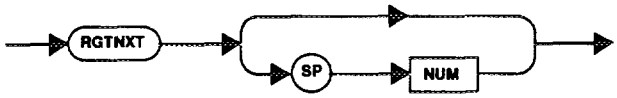
This command searches to the left of the current point to acquire the peak of a signal whose value is greater than NUM. If a signal peak greater than NUM is not found, the display data point is set to 0,0. If NUM is omitted from the command, a default value of 0 is used.

A pattern recognition routine is used to recognize signals.

Interaction — See Display Data Point Commands Interaction.

There is no LFTNXT query.

RGTNXT (right next) command



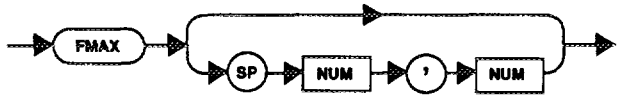
This command searches to the right of the current point to acquire the peak of a signal whose value is greater than NUM. If a signal peak greater than NUM is not found, the display data point is set to 1001,0. If NUM is omitted from the command, a default value of 0 is used.

A pattern recognition routine is used to recognize signals.

Interaction — See Display Data Point Commands Interaction.

There is no RGTNXT query.

FMAX (find maximum value) command

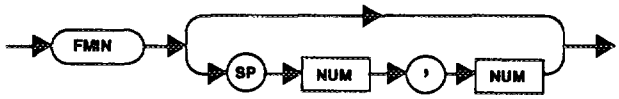


This routine sets the display data point to the point in digital storage with the largest Y value. If the largest Y value is located at more than one point, the first (left-most) point is acquired. The optional arguments are two display X values. The FMAX command will limit its search over this X range; otherwise, the full X range (1 to 1000) will be searched.

Interaction — See Display Data Point Commands Interaction.

There is no FMAX query.

FMIN (find minimum value) command



This routine sets the display data point to the point in digital storage with the smallest Y value. If the smallest Y value is located at more than one point, the first (left-most) point is acquired. The optional arguments are two display X values. The FMIN command will limit its search over this X range; otherwise, the full X range (1 to 1000) will be searched.

Interaction — See Display Data Point Commands Interaction.

There is no FMIN query.

Data Point Commands Interaction

1. The waveform processing commands in this section operate only on the waveform specified by the last WFMPRE or CURVE command; either A or B or full (both A and B). The waveform involved is first copied into a buffer. If the waveform is only half-resolution (either A or B), it is duplicated in the buffer to make a full 1000-point waveform before processing. Thus, whether the command operates on A or B or both, the range of X values for the display data point is always 1 to 1000.

2. The waveform processing commands in this section that update the display data point use the same buffer memory as display data I/O; therefore, commands for these two functions can interact if executed as part of the same message. This command interaction can cause invalid data output with either CURVE? or CURVE.

When two particular conditions exist together, it can cause CURVE? data output commands to be invalid;

(1) if CURVE? is followed by a command to update the display data point, and

(2) if digital storage is updated during the execution of the message (either by repetitive sweeps or by the SIGSWP command).

When both of these conditions exist, the curve data output that follows completion of the entire message will not be the data that was loaded in the buffer at the time CURVE? was executed. Instead, the curve data that is output will be the data that was loaded by the later command to update the display data point, because this later data overwrites the data already loaded in the buffer at the time CURVE? was executed. The curve data is output as expected if CURVE? follows the command to update the display data point instead of preceding it, because no conflict occurs in the way the commands use the buffer.

3. VRTDSP LIN interacts with FIBIG, RGTNXT, and LFTNXT because they transform linear data into logarithmic data before execution. This interaction is not apparent unless the transformed data is output over the GPIB or loaded into digital storage because of either of the conditions noted in part 2.

For further information, refer to Multiple Use of Display Buffer for Waveform Processing and I/O in Section 9 of this manual.

CENSIG (center signal) command

This command TUNES the frequency to center the signal represented by the display data point (or as close as possible, given the specified span accuracies).

This command does not get a new display data point or digital storage waveform. Therefore, if a new waveform is acquired after CENSIG is run, the display data point may no longer match the signal of interest.

TOPSIG (move to top of graticule) command

This command changes REFLVL to move the signal represented by the display data point to the reference level (or as close as possible, given the specified vertical display and reference level accuracies).

This command does not acquire a new display data point or digital storage waveform. Therefore, if a new waveform is acquired after TOPSIG is run, the display data point may no longer match the signal of interest.

There is no TOPSIG query.

System Commands and Queries

Spectrum analyzer device-dependent message units are provided to set and return parameters of use to the controller in a GPIB system. These commands and queries are described in this section in three groups related to instrument parameters, message execution, and status and error reporting.

NUM Argument

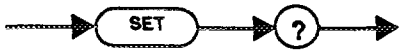
Unless otherwise stated, the values for the NUM argument are

1 = ON
≥+0.5 are rounded to 1
0 = OFF
<+0.5 are rounded to 0

Instrument Parameters

The commands and queries in this group return instrument settings (SET?), return the instrument identification parameters (ID?), initialize settings (INIT), and control return of the query response header (HDR).

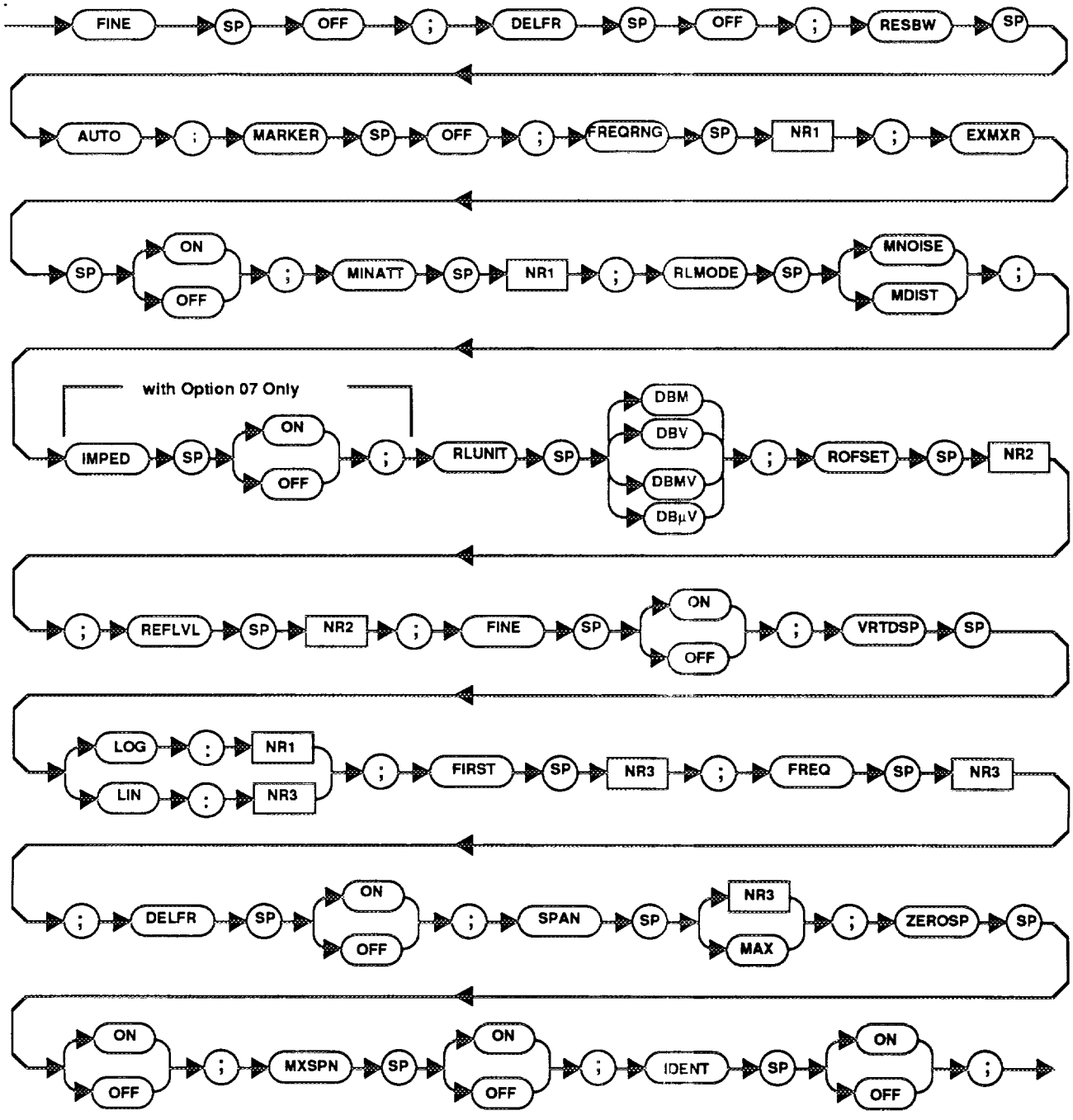
SET (Instrument settings) query



The instrument returns a string of commands that can be "learned" for later transfer to the spectrum analyzer when the same setup is desired. The response includes only those functions necessary for such a setup. To assure no interaction that might alter the setup, some commands are turned off before the setup begins. For identification purposes, the command headers are always returned in the response to SET query even if HDR is turned off.

There is no SET command.

Response to SET query



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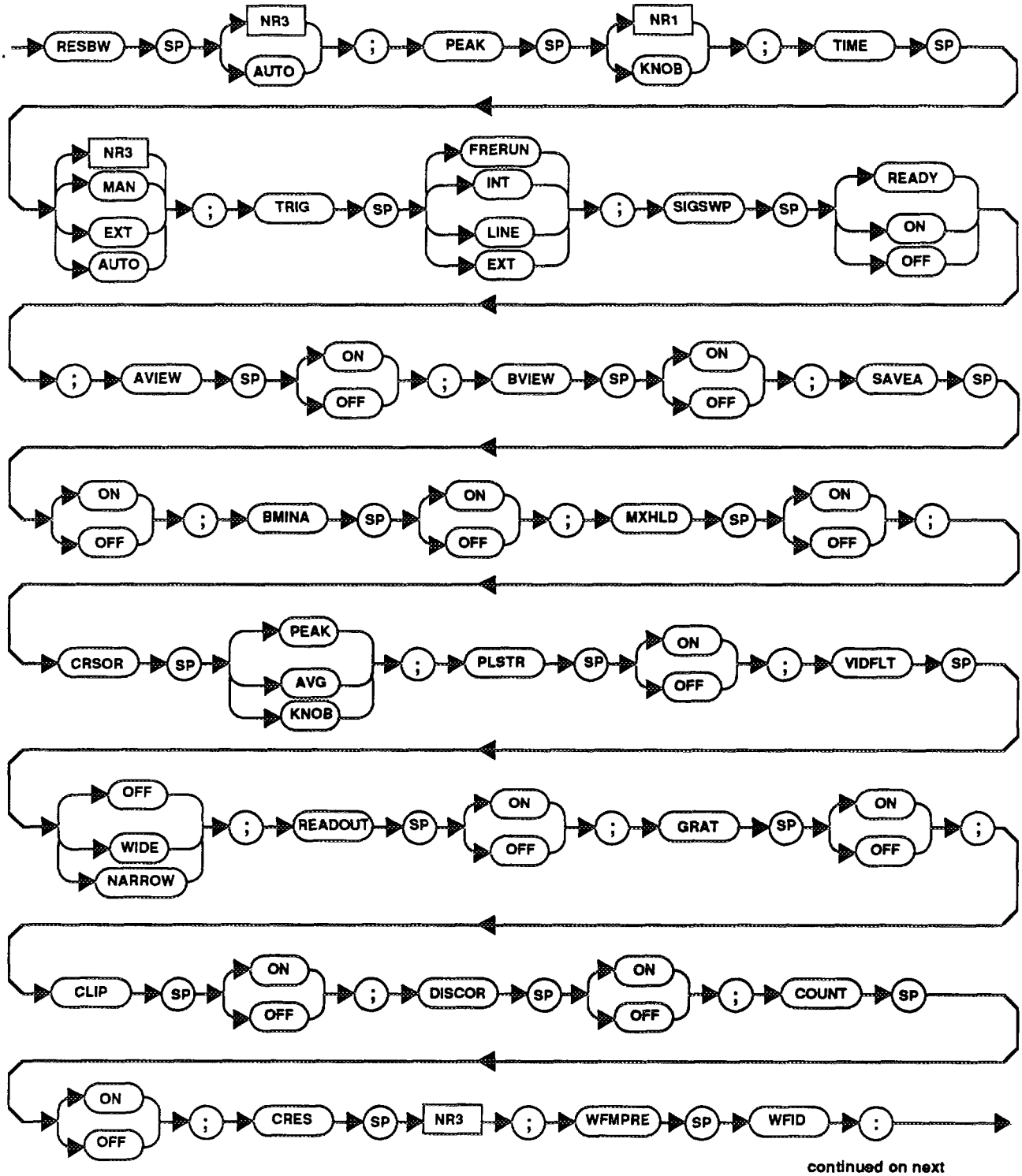
Response to SET query (continued)



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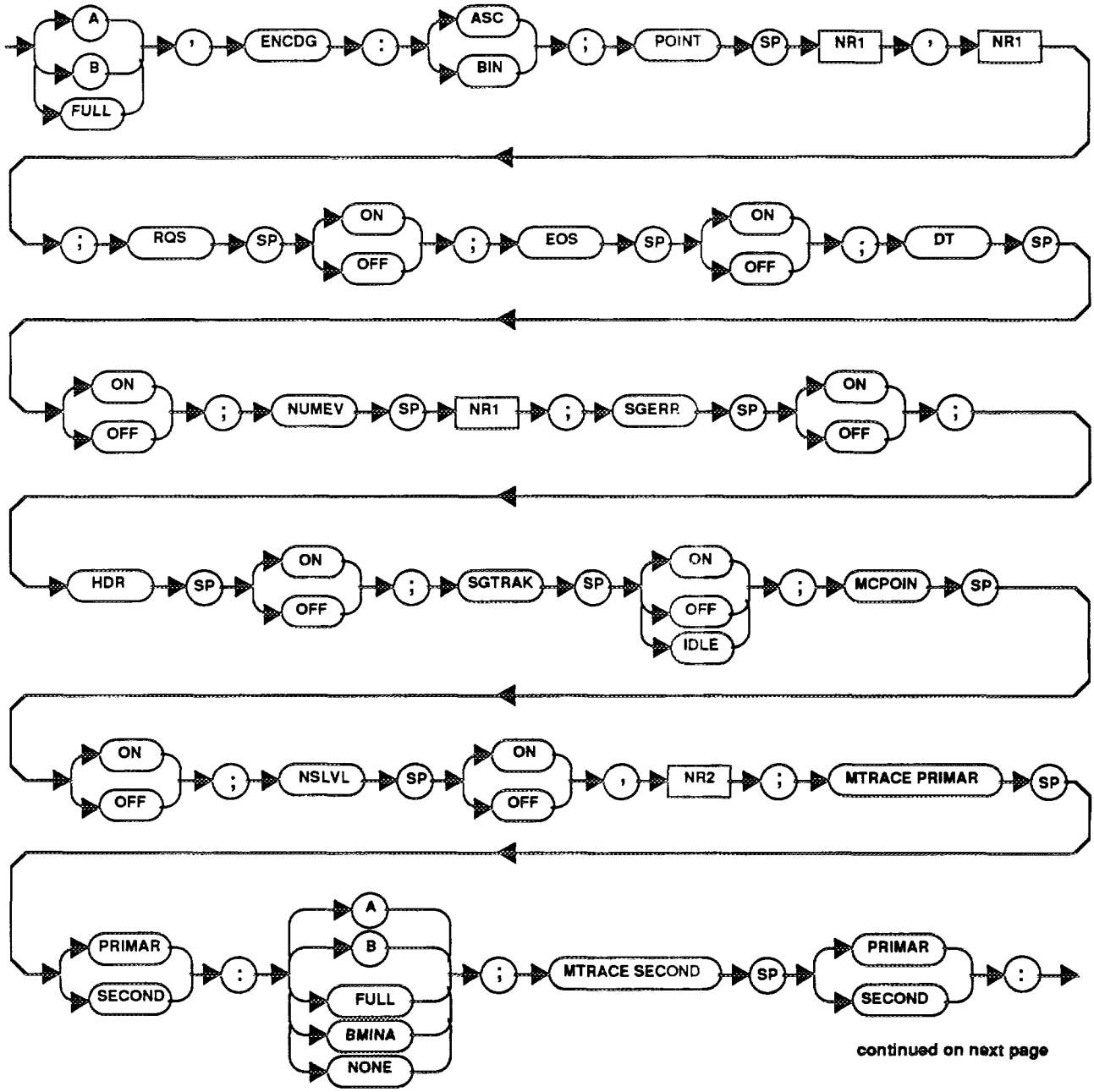
Response to SET query (continued)



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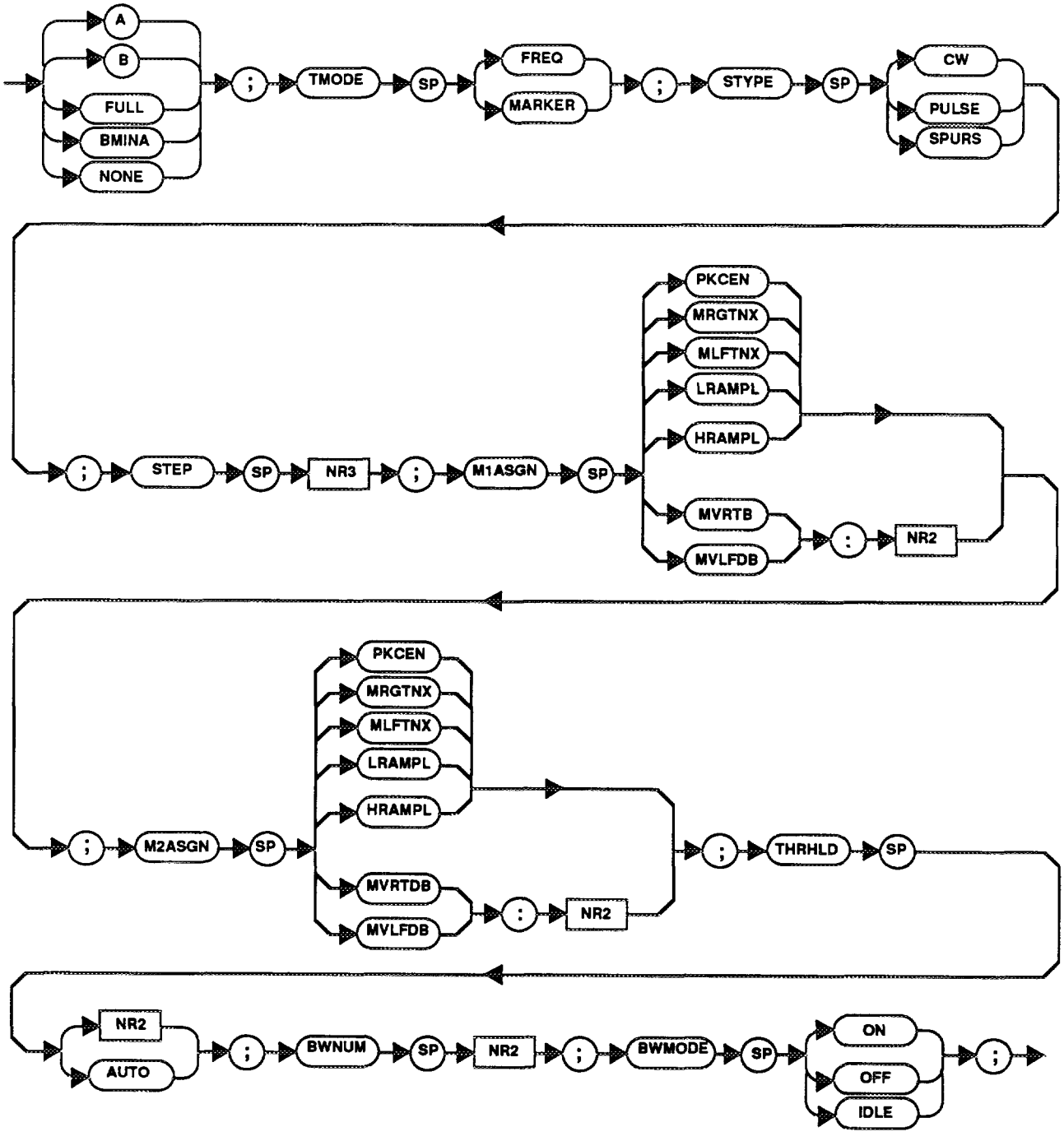
Response to SET query (continued)



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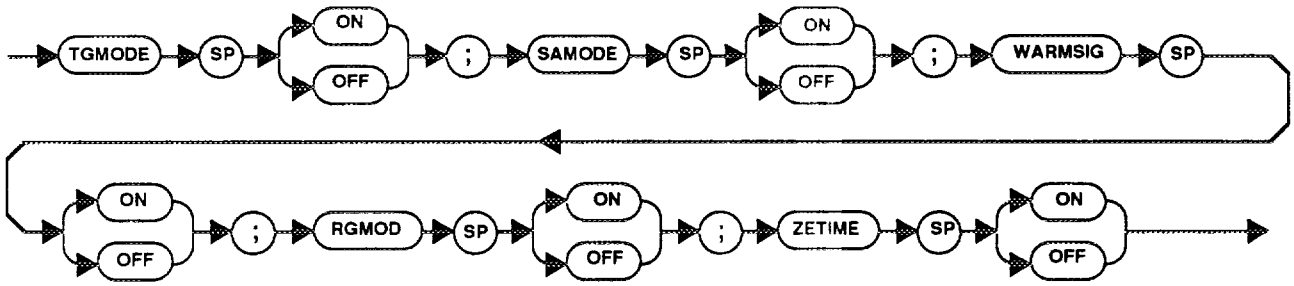
Response to SET query (continued)



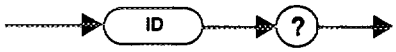
INIT (initialize settings) command

INIT resets the instrument the same as if the power was turned off, then turned back on. The instrument functions are reset as shown in Table 8-1.

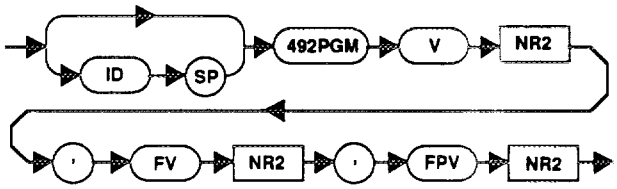
Interaction — IEEE 488 interface functions are not affected and the instrument remains under remote control. RQS is set to OFF if either the LISTEN ONLY or TALK ONLY switch is set.

There is no INIT query.

ID (identify) query



Response to ID query



492PGM — The instrument type number.

V<NR2> — Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features version number.

FV<NR2> — Instrument firmware version number.

FPV<NR2> — Front-panel processor firmware version number.

There is no ID command.

Table 8-1

INSTRUMENT FUNCTIONS

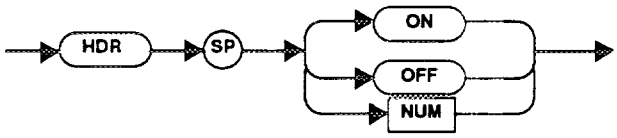
Mnemonic		INIT Value
FREQ		0
FIRST		2.972 E+9
SECOND		2.182 E+9
DISCOR		OFF
FRQRNG		1
DELFR		OFF
SPAN		MAX
ZEROSP		OFF
ARES		ON
MXSPN		OFF
PHSLK		OFF
VIDFLT		OFF
VRTDSP		LOG:10
DB REFLVL		0 dBm
FINE		OFF
RLMODE		MNOISE
MINATT		Knob position
PLSTR		OFF
TRIG		FRERUN
SIGSWP		OFF
TIME		Knob position
AVIEW		ON
BVIEW		ON
SAVEA		OFF
BMINA		OFF
MXHLD		OFF
CRSOR		KNOB
REDOUT		ON
GRAT		OFF
PT.OFF		500
YOFF		225
CLIP	OFF	
TEXT		SHORT
EOS		OFF
RQS	ON	
WARMSG		ON
NUMEV		0
IMPED		OFF (50 Ω) — Option 07 Only
RLUNIT		dBm

Table 8-1 (Continued)

INSTRUMENT FUNCTIONS

Mnemonic	INIT Value
STSTOP	0–1.8 GHz
HDR	ON
SGERR	OFF
SGTRAK	OFF
MCPOIN	OFF
NSELVL	OFF
TMODE	FREQ
STYPE	CW
MTRACE PRIMAR	NONE
MTRACE SECOND	NONE
THRHLD	AUTO
BWMODE	OFF
TGMODE	OFF
SAMODE	OFF
ECR	OFF
ZETIME	OFF
RGMODE	OFF
ROFSET	0

HDR (header) command



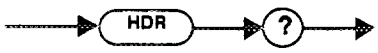
ON — The header for query responses is turned on.

OFF — The header for query responses is turned off.

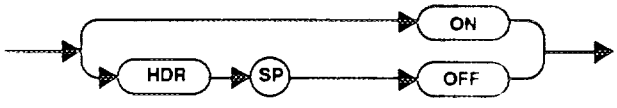
Power-up value — On.

Interaction — The HDR command has no affect on the SET? response, since the headers are necessary to interpret the response.

HDR (header) query



Response to HDR query



Message Execution

The two following commands (WAIT and REPEAT) affect how the spectrum analyzer executes message units imbedded within other messages.

WAIT (wait for end of sweep) command

The spectrum analyzer delays action on commands in its input buffer that follow the WAIT command status byte to busy and does not input device-dependent messages. The wait condition is ended in either of two ways.

1. WAIT ends if an end-of-sweep is present. If this occurs, the controller is allowed to request updated spectrum data and be guaranteed that the data has been updated. The request message would be similar to

SIGSWP;SIGSWP;WAIT;WFMPRE?;CURVE?

The first SIGSWP command sets the spectrum analyzer to the single-sweep mode if it was previously in a repetitive sweep mode. The next SIGSWP arms the sweep, and WAIT delays further action until the sweep completes. The message ends by the request of a waveform preamble and data.

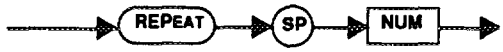
If the sweep is in the single-sweep mode and is not armed (the READY light is off) when the WAIT command comes up, the spectrum analyzer continues to execute the message in the buffer and does not wait.

2. WAIT is ended if DCL or SDC (while listener-addressed) is received. This empties the input and output buffer so any commands that follow WAIT are discarded. (See STATUS BYTE later in this section.)

Interaction — WAIT delays completion of any portion of a message that follows until one of the ending conditions just outlined occurs.

There is no WAIT query.

REPEAT (repeat execution) command



NUM — This determines the number of times, in addition to the first time, the spectrum analyzer is to repeat the commands or queries that come before REPEAT. Range — 0 to 16,777,215 (2{24} -1). Since REPEAT may itself be one of the commands that comes before a REPEAT, the nested (first) REPEAT will only be performed on the first pass through the commands that come before the second REPEAT.

For example,

RGTNXT;FREQ?;REPEAT 10;FREQ 1.4 GHZ;REPEAT 1

This causes the spectrum analyzer to output 12 frequency values, because it only performs the frequency query once on its second pass through the entire message.

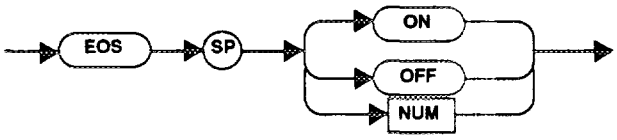
Interaction — A REPEAT loop can only be stopped by DCL. Pressing RESET TO LOCAL does not stop the loop; it only causes execution error messages to be reported if the loop contains front-panel commands. If RESET TO LOCAL is pressed while a message that includes REPEAT is being acted on, the message will only be repeated 256 times. (Since most commands are ignored after the RESET TO LOCAL button is pressed, the REPEAT loop completes quickly).

There is no REPEAT query.

Status and Error Reporting

Two commands (EOS and RQS) control spectrum analyzer service requests. STATUS BYTE reports instrument status in a format that includes both IEEE 488 and the Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features. GET is enabled to trigger a new sweep (DT), two queries (ERR?, ERCNT?) return the error codes, a query (EVENT?) returns detailed information about events reported in the last serial poll status byte, two queries and one command (ALLEV?, NUMEV, EVQTY?) specify the identity and quantity of events reported.

EOS (end-of-sweep) command



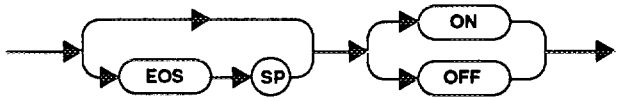
ON — The spectrum analyzer asserts SRQ (if RQS is ON) when a sweep completes.

OFF — The spectrum analyzer does not assert SRQ for the EOS condition.

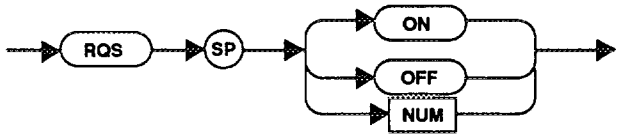
Power-up value — Off.

EOS (end-of-sweep) query

Response to EOS query



RQS (request service) command



ON — SRQ is asserted when abnormal status conditions occur.

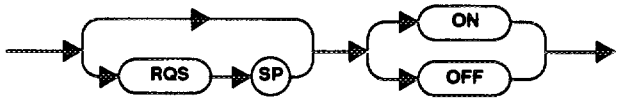
OFF — SRQ is not asserted (is masked) when abnormal status occurs.

Power-up value — On.

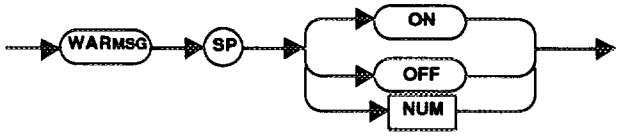
Interaction — RQS is always OFF in the talk-only and listen-only modes.

RQS (request service) query

Response to RQS query



WARMSG (warning message) command



ON — All warning messages will be issued (see Table 8-2).

OFF — No warning messages will be issued (see Table 8-2).

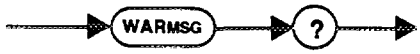
Table 8-2

WARNING MESSAGES

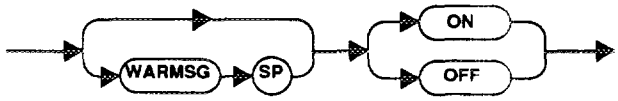
Number	Description
	Execution Warnings
49	FREQ change caused EXMXR change
50	SPAN defaulted to MAX
52	UNCAL light turned on
53	Multiple use of display buffer
54	UNCAL light turned off
110	STEP size out of range — set to maximum
111	SPAN defaulted to minimum span
	Marker Execution Warning
130	MLFTNX, MRGTNX, MFBIG, HRAMPL, LRAMPL, PKFIND, MVRDTDB, or MVLFDB commands could not find signal

Power-up value — On.

WARMSG (warning message) query

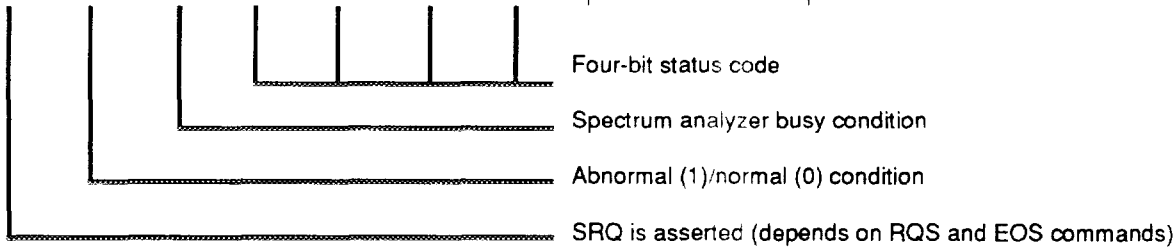


Response to WARMSG query



STATUS BYTE

8	7	6	5	4	3	2	1	Decimal	Condition
0	1	0	X	0	0	0	1	65,81	Power on
0	X	0	X	0	0	1	0	2,18,66,82	End of Sweep
0	X	1	X	0	0	0	1	0,16	Ordinary operation
0	X	1	X	0	0	0	1	33,49,97,113	Command Error
0	X	1	X	0	0	1	0	34,50,98,114	Execution error
0	X	1	X	0	0	1	1	35,51,99,115	Internal error
0	X	1	X	0	1	0	1	37,53,101,117	Execution error warning
0	X	1	X	0	1	1	0	38,54,102,118	Internal error waning



Status Byte (response to serial poll)

When the controller addresses the spectrum analyzer as a talker and sends the SPE (Serial Poll Enable) command, the spectrum analyzer responds by sending its status byte over the bus. The value of the messages returned by the spectrum analyzer is 1=on, 0=off, and X=don't care.

Power-on status — This is set when the instrument is turned on only if an internal switch is set; otherwise, SRQ is not asserted at power-up and power-on status does not exist. If selected by the switch, this status cannot be masked by the RQS command. The instrument is shipped with this switch off. Refer switch selection to qualified service personnel.

End-of-sweep status — This is set when the spectrum analyzer completes a sweep of the selected spectrum; it indicates that digital storage has been updated.

Ordinary operation status — This exists whenever there is no other status condition (nothing out of the ordinary) to report.

Command error — This occurs when a message cannot be analyzed or recognized.

Execution error — This results when a message is analyzed and is recognized, but cannot be executed; such as FREQ 999GHZ.

Internal error — This indicates that the spectrum analyzer has discovered a malfunction that could cause the instrument to operate incorrectly.

Execution warning — This results from a command that the spectrum analyzer has performed, but has a potential for error. An example is RESBW 10 KHZ in the maximum span mode. The spectrum analyzer sets the warning status because the UNCAL indicator is lit.

Internal warning — This reports that a non-fatal operating condition has been detected.

Busy — This is reported whenever the spectrum analyzer acts on a message in its input buffer. This includes the WAIT command; while waiting, the spectrum analyzer reports busy status.

Effect of Busy on Device-Dependent Messages

The spectrum analyzer will not accept further device dependent messages while the busy condition exists; if made a listener, it asserts NRFD. Commands that require interaction with the hardware can keep the spectrum analyzer busy for a second or more (significant to some bus controllers); for instance, commands such as DEGAUS and INIT in the Count mode. The waveform processing commands can also require significant processor time. Of course, long messages such as the SET? response take a while to execute (see Execution Times, Table 9-1 in Section 9 of this manual). Although output operations such as the CURVE? response may take a long time to complete, the spectrum analyzer is busy only for the time it takes to load the output buffer.

Effect of Busy on Interface Messages

Interface messages and the rtl message from the RESET TO LOCAL button are processed despite busy status. If RESET TO LOCAL interrupts a message, the spectrum analyzer tries to finish the rest of the message after local control is restored. At that time, commands that try to change a front-panel setting will result in error SRQs, because they conflict with local control.

The response of the spectrum analyzer to interface messages depends on how they are handled. Some interface messages are handled by the GPIB interface, while others require action by the spectrum analyzer. The latter generally involve the spectrum analyzer GPIB address and are part of the firmware rather than on the interface. The speed with which these commands can be handshaked depends on how fast the interrupt can be serviced; which, in most cases, should be within a few hundred µs.

The following apply to interface messages received by the spectrum analyzer.

1. Universal commands LLO, SPE, and SPD are handshaked and acted on by the interface, so they are unaffected by spectrum analyzer activity. The serial poll proceeds without delay if the talk address follows, since this function is handled by the interface.

2. UNL and UNT are handshaked by the interface, which immediately resets the talk or listen function, if active. Addresses that do not match those set by the rear-panel switches are handshaked and discarded by the interface. When the current talk or listen address (MTA or MLA) is decoded by the interface, it holds up the handshake until the spectrum analyzer can get involved. The instrument will get involved as soon as it can service the interrupt. The front-panel ADDRESSED light and the crt readout will be modified as soon as the programs are completed that update the addressed status.

Because the spectrum analyzer gets involved when a current address is received, addressed commands are affected by the speed at which the service interrupts can be handled. Serial poll is similarly affected if MTA preceded SPE.

3. GTL is handshaked immediately by the interface. If the spectrum analyzer is already listen-addressed, the spectrum analyzer returns to local control (executes GTL) after executing any message in its buffer (except WAIT or message units following WAIT). REN unasserted is handled in the same manner as the GTL command.

4. DCL requires spectrum analyzer action that will hold up the handshake if the spectrum analyzer is busy. If the spectrum analyzer is listen-addressed, SDC is treated in the same manner. These two device-clear messages are executed as soon as they are received.

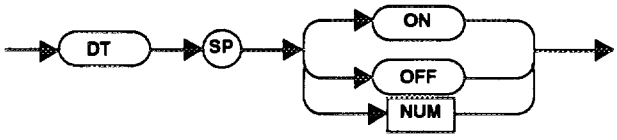
5. GET also requires spectrum analyzer action, so its handshake occurs only when the interrupt can be handled. GET is executed immediately, stopping the current sweep and rearming the sweep. If the spectrum analyzer is busy when GET is received, it will wait until the instrument is no longer busy to execute GET.

6. Parallel polls are handled by the spectrum analyzer, so PPC, PPE, PPD, and PPU must wait for the spectrum analyzer to service the interrupts before they can be executed. This assumes that the spectrum analyzer was addressed for the parallel poll sequence.

Busy and end-of-sweep are independent. Busy exists only while the spectrum analyzer is acting on a command, and end-of-sweep indicates that sweep and data-updating are complete. If a single-sweep command is sent, the spectrum analyzer remains busy only until it can start the sweep, while end-of-sweep does not occur until the operation is complete.

When polled, the spectrum analyzer reports a status code related to its SRQ, if any. Bit 5 always indicates the current condition. A serial poll clears the status byte that is reported. Since status is stacked, a new SRQ may be sent immediately.

DT (define triggered events) command



ON — GET is enabled to trigger a new sweep.

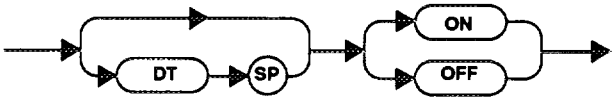
OFF — The response to GET is disabled.

Power-up value — ON.

Interaction — If DT is OFF and GET is received, execution error message 45 will be issued.

DT (define triggered events) query

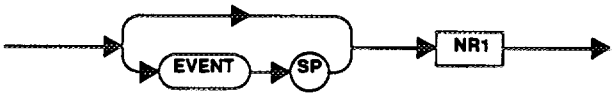
Response to DT query



EVENT (event information) query

The EVENT query returns more detailed information about the event reported in the last serial poll status byte. It also allows a controller to get information about events when the device's ability to assert RQS has been turned off (RQS OFF).

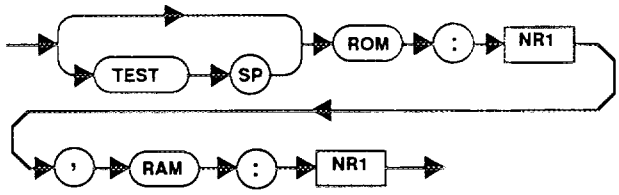
Response to EVENT query



NR1 is an event code defined later in this section in Table 8-4. The EVENT is cleared when the event code is reported.

There is no EVENT command.

Response to TEST query



The TEST query response consists of two decimal numbers that indicate if a ROM or RAM IC was found to be defective. These numbers must be translated to their binary equivalents to determine the ROM and RAM locations (If all ROM and RAM are good, the TEST query response will be ROM:0,RAM:0.) After the binary numbers are determined, put them into the conversion chart in Figure 8-1 to identify the IC number. Then, use Table 8-3 to find the correct circuit number and circuit board The following example shows how to use the conversion chart and Table 8-3. If any ROM or RAM ICs are indicated to be bad, refer this information to qualified service personnel

Example — Print #A: "TEST?"
Input #A: R$
Print R$

If the TEST query response is

TEST ROM:4112,RAM:18 then,

ROM

1. The binary equivalent of the ROM number 4112 is 00100000001000.

2. Insert this binary number in part A of Figure 8-1 (right-justified). Blocks 6 and 2 will be 0|1. This indicates that both ROM 6 and ROM 2 are bad; all other ROMs are good.

3. Table 8-3 shows that ROM 6 is U1025 and that ROM #2 is U1010; both located on the GPIB board.

RAM

1. The binary equivalent of the RAM number 10 is 1010.

2. Insert this binary number in part B of Figure 8-1 (right-justified). Blocks 4 and 2 each contain a 1, which indicates that both RAMs 4 and 2 are bad; all other RAMs are good.

3. Table 8-3 shows that RAM 4 is U1020 and RAM 2 is U3020; both located on the Memory board.

There is no TEST command.

Table 8-3

TEST CONVERSION

Device	Chart Location	Circuit Board	Circuit Number
ROM	0	A54 Memory	U3060
	1	A54 Memory	U3060
	2	A56 GPIB	U1010
	3	A56 GPIB	U1010
	4	A56 GPIB	U1020
	5	A56 GPIB	U1020
	6	A56 GPIB	U1025
	7	A56 GPIB	U1025
	8	A56 GPIB	U1035
	9	A56 GPIB	U1035
	10	A56 GPIB	U3015
	11	A56 GPIB	U3015
	12	A56 GPIB	U3020
	13	A56 GPIB	U3020
	14	A56 GPIB	U3030
	15	A56 GPIB	U3030
	16	A54 Memory	U3050
	17	A54 Memory	U3050
RAM	1	A54 Memory	U1010
	2	A54 Memory	U3020
	3	A54 Memory	U1030
	4	A54 Memory	U1020

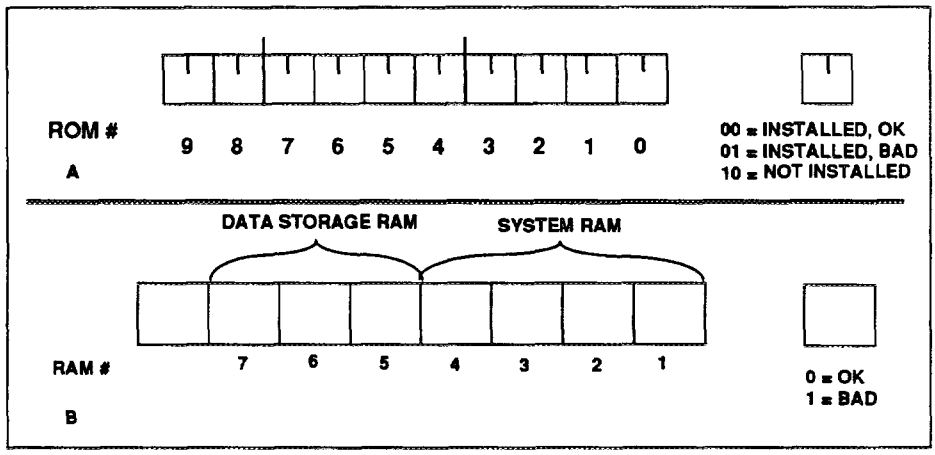


Figure 8-1. TEST Conversion Chart.

Error Codes

The Tektronix Interface Standard for GPIB Codes, Formats, Conventions, and Features specifies device-dependent Error codes by category. Table 8-4 identifies each general category and lists the codes within that category. Following the listing are the specific error messages returned by the spectrum analyzer. Error codes are returned in numerical order as they appear in Table 8-4. When the current code(s) is read, the error response is cleared.

Table 8-4
ERROR AND EVENT CODES

ERROR Code	EVENT Code	Meaning
0	0	No error
		Command Errors
	101	Command header error
	103	Command argument error
	106	Missing argument
	108	Checksum error
	109	Byte count error
	150	Input buffer overflow
1	103	Illegal numeric format
4	109	END received in block binary
5	108	Block binary checksum error
6	103	Illegal placement of question mark
7	101	Query not recognized
8	101	Header not recognized
9	106	End of message unit not expected; arguments missing
10	103	Character argument not allowed
11	103	Numeric argument not allowed
12	103	String argument not allowed
13	103	Binary argument not allowed
14	103	Link not allowed for this argument
20	103	Special argument type not recognized
21	103	Special argument not allowed
22	103	Character argument not recognized
24	150	Input buffer overflow
		Execution Errors
	201	Command not executable in Local mode
	204	Settings conflict
	205	Argument out of range
	206	Group Execute Trigger ignored (not executed)
	250	Output buffer overflow; remaining output lost
26	250	Output buffer overflow; remaining output lost
27	201	Attempt to execute command in Local mode
28	205	Frequency out of range (FREQ, TUNE, FIRST, SECOND, MMAX, MMIN, MTUNE, MFREQ, STSTOP, STEP)
29	205	FRQRNG out of range
30	205	CRES out of range
31	205	SPAN out of range
32	205	RESBW out of range
33	205	MAXPWR or MINATT out of range
34	205	Level out of range (REFLVL, THRHLD, BWNUM, MVRTDB, MVLFDB)
35	205	VRTDSP LIN out of range
36	205	VRTDSP LOG out of range
37	205	TIME out of range
39	204	IDENTify not allowed in this span/div
40	204	Signal finds not allowed in zero span
41	204	Invalid DATA or ADDR argument contents
42	204	DATA direction not compatible with ADDR direction
45	206	GET (Group Execute Trigger) ignored (not executed)
46	205	NUMEV out of range
47	205	STORE, RECALL, DSTORE, DRECAL, or RDATA out of range
48	204	PHSLK cannot be turned OFF/ON directly with PHSLK command

Table 8-4 (Continued)

ERROR Code	EVENT Code	Meaning
		Execution Errors (Continued)
100	204	Function not available when SGTRAK is on
102	205	Frequency range limited in 75 Ω input — Option 07 only
103	205	Frequency out of range after step
104	204	Bandwidth mode is not available when in linear
105	205	Illegal sweep range
106	205	Argument out of range
109	205	ROFSET out of range
		Execution Warnings
	550	FREQ change caused EXMXR change
	551	SPAN defaulted to MAX
	553	UNCAL light turned on
	554	UNCAL light turned off
	555	Multiple use of display buffer
	560	STEP defaulted to maximum
	561	SPAN defaulted to minimum span
49	550	FREQ change caused EXMXR change
50	551	SPAN defaulted to MAX
52	553	UNCAL light turned on
53	555	Multiple use of display buffer
54	554	UNCAL light turned off
110	560	STEP size out of range—set to maximum
111	561	SPAN defaulted to minimum span
		Internal Errors
	302	System error
	350	Tuning DAC carry operation failed
	351	Failed to lock 1st LO
	352	Lost 1st LO lock
	353	Recentering failure on unlocking of 1st LO
	354	Calibration failure
	355	Battery-operated RAM checksum error
	382	1st LO tuning system failed
	383	1st LO tuning system recovered from a failure
	386	2nd LO tuning system failed
	387	2nd LO tuning system recovered from a failure
	388	Phase lock system failed
	389	Phase lock system recovered from a failure
	394	IF count failed
	395	IF count recovered from a failure
	396	Power supply out of regulation
	397	Power supply regained regulation
	398	Frequency reference unlocked
	399	Frequency reference relocked
57	350	Tuning DAC carry operation failed
58	351	Failed to lock 1st LO
59	352	Lost 1st LO lock
60	353	Recentering failure on unlocking of 1st LO
61	354	Calibration failure
62	355	Battery-operated RAM checksum error
72	382	1st LO tuning system failed
74	386	2nd LO tuning system failed
75	388	Phase lock system failed
78	394	IF count failed

Data Acquisition

When the spectrum analyzer is executing commands under program control, there are two programs running, not just one. One program is running in the controller and a second in the spectrum analyzer. The key to success is synchronizing the execution of the two programs.

In addition, the two programs must be synchronized with the data acquisition event; in this case, the sweep.

Synchronizing Controller and Spectrum Analyzer

Programs must run in the controller at the same time that the spectrum analyzer acts on messages that come over the GPIB. This is all done within the spectrum analyzer by the way it buffers and executes messages.

When the spectrum analyzer receives a message, it waits until the end of the message to begin acting on it. While busy acting on the message, the spectrum analyzer does not accept any other device-dependent messages. When it is finished with the message, the spectrum analyzer is ready to handshake another message, which it then acts on, and so forth. You can depend on the spectrum analyzer to assert the NRFD handshake line on the GPIB while it is busy; this prevents a controller GPIB output statement that would send further instructions to the spectrum analyzer.

For example, enter

```
100 FOR I=1 TO 10
105 CMD$="FREQ "+STR$(I)+"GHZ"
110 CALL IBWRT (PORT1%, CMD$)
120 NEXT I
```

Watch the spectrum analyzer FREQUENCY readout change while this loop is executing. You can see that the controller executes the loop more slowly than it would if line 110 only printed what is in quotes on the controller CRT. What is making the controller step through the loop at a more deliberate pace? It must wait at line 110 for the spectrum analyzer to execute the previous FREQ command.

A controller GPIB input statement can also be used to synchronize the controller and the spectrum analyzer. The controller could make a table of frequency ranges for the frequencies covered by the previous loop, filling the table only after the FREQ command is executed.

```
100 DIM F(10,2)
110 FOR I=1 TO 10
115 CMD$="FREQ "+STR$(I)+"GHZ;FRQRNG?"
120 CALL IBWRT (PORT1%,CMD$)
125 RSP$=SPACE$(80)
130 CALL IBRD (PORT1%,RSP$)
135 F(I,1)=VAL(RSP$)
140 F(I,2)=I*1E+9
150 NEXT I
```

Line 130 — Addresses the spectrum analyzer to talk; however, the spectrum analyzer does not begin talking until it finishes executing the message in line 120. This assures that the spectrum analyzer updates the FRQRNG query response before handshaking out the response in line 130.

Synchronizing with the Sweep

Spectrum data can be acquired synchronously with the sweep that updates digital storage if a WAIT command is inserted in the message to the spectrum analyzer. Generally, WAIT is placed immediately after a SIGSWP command that arms a sweep so that data is acquired from a full sweep. WAIT delays the execution of commands or queries that follow in the same message until the full sweep is completed. This means you can direct the spectrum analyzer to acquire, process, and output data, all in the same message. If the commands or queries you add to process or output data follow WAIT, the results will be based on data acquired by the SIGSWP command.

For example, enter

```
100 DIM P(5,2)
105 CMD$="SIGSWP"
110 CALL IBWRT (PORT1%,CMD$)
120 FOR I=1 TO 5
125 CMD$="FREQ "+STR$(I)+"GHZ;SIGSWP;WAIT;FMAX;POINT?"
130 CALL IBWRT (PORT1%,CMD$)
135 RSP$=SPACE$(80)
140 CALL IBRD (PORT1%,RSP$)
142 P(I,1)=VAL(RSP$)
144 P(I,2)=VAL(MID$(RSP$,1+INSTR(RSP$,",")))
150 NEXT I
```

Lines 105, 110 — Set the spectrum analyzer to the single sweep mode (if the spectrum analyzer is not already in the single-sweep mode). Succeeding SIGSWP commands arm the sweep.

Lines 125, 130 — Illustrate how to use WAIT. WAIT follows SIGSWP and precedes the command and query that ready the spectrum analyzer to output the updated data. The spectrum analyzer does not handshake out the data in line 140 until it finishes executing the message in line 130.

Figure 9-1 further illustrates the two-program concept (one in the controller and one in the spectrum analyzer) and how they are synchronized with the sweep for data acquisition. This figure charts the execution of the two programs; arrows between the programs relate how one waits for the other. The WAIT command is executed in the loop that tests for the end of sweep; this synchronizes data acquisition with the sweep.

Using the End-of-Sweep SRQ

Although the previous method for synchronizing controller/spectrum analyzer operation with the sweep is recommended, there is another method. This alternative may be necessary to some operating systems or application program that allow a short response time when the spectrum analyzer is made a talker or that must take care of other tasks while the spectrum analyzer is acquiring data.

In such cases, the spectrum analyzer can be set up to generate an SRQ at the end of each sweep by sending EOS ON to itself. An SRQ and event message 402 will be generated at the end of each sweep. See Section 2 or your controller manual for details on how to set up an SRQ handler.

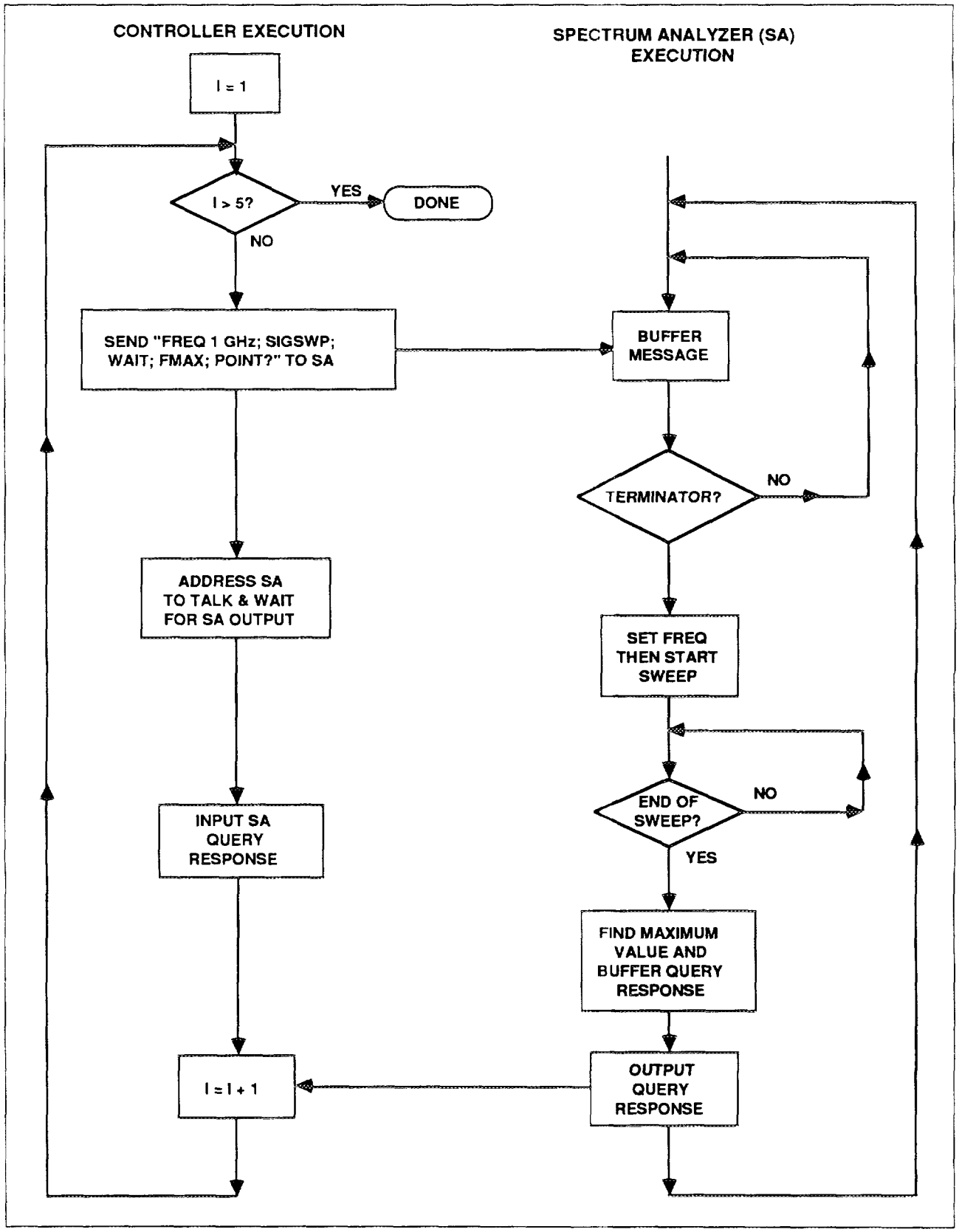


Figure 9-1. Synchronizing controller and spectrum analyzer for data acquisition.

INPUT: An SRQ Alternative

An INPUT or READ statement in the right place is an alternative to waiting for an end-of-sweep SRQ. This tactic takes advantage of a spectrum analyzer output feature; if the spectrum analyzer has no output when it receives its talk address, it outputs a byte with all bits set to one (as soon as it is not busy).

```
100 DIM P(5,2)
105 CMD$="SIGSWP"
110 CALL IBWRT(PORT1%, CMD$)
120 FOR I=1 TO 5
125 CMD$="FREQ "+STR$(I)+"GHZ;SIGSWP;WAIT"
130 CALL IBWRT(PORT1%,CMD$)
135 RSP$=SPACE$(80)
140 CALL IBRD(PORT1%,RSP$)
145 CMD$="FMAX;POI?"
150 CALL IBWRT(PORT1%,CMD$)
155 RSP$=SPACE$(80)
160 CALL IBRD(PORT1%,RSP$)
162 P(I,1)=VAL(RSP$)
164 P(I,2)=VAL(MID$(RSP$,1+INSTR(RSP$,",")))
170 NEXT I
180 END
```

Here the WAIT is put back into the spectrum analyzer message and the IBRD statement in line 140 stalls the controller while the spectrum analyzer makes a sweep.

Binary Waveform Transfer

Selecting binary, rather than ASCII coded decimal, speeds up waveform transfers. Neither the controller nor the spectrum analyzer has to perform a conversion between binary and ASCII. The difference is evident in the times for both kinds of transfer, listed in this section under Execution Times, Table 9-1. The following examples illustrates this.

Getting Spectrum Analyzer Binary Curve Output

The spectrum analyzer encloses binary waveform data values in the binary block format. For details, see the syntax diagrams in Sections 4 and 7.

For a controller routine that handles block binary, enter the following.

```
500 REM GET SPECTRUM ANALYZER CURVE OUTPUT
510 DIM W%(1000),RDD%(1000)                          (declare integer array)
515 CMD$="WFMPRE ENC:BIN"
520 CALL IBWRT(PORT1%,CMD$)
525 CMD$="CURVE?"
530 CALL IBWRT(PORT1%,CMD$)
540 EOSV%=ASC("%")+&H400                             (set EOI to % [begin
                                                      binary data])
550 CALL IBEOS(PORT1%,EOSV%)
560 RSP$=SPACE$(255)
570 CALL IBRD(PORT1%,RSP$)
580 CALL IBFIND (DEVICE$,PORT1%)                     (reset EOS)
600 RSP$=SPACE$(2)
610 CALL IBRD(PORT1%,RSP$)                           (read, byte count)
620 COUNT%=ASC(RSP$)*256+ASC(RIGHT$(RSP$,1))-1       (convert to integer)
630 CNT%=COUNT%+5
640 CALL IBRDI(PORT1%,RDD%(1),CNT%)                  (read waveform)
650 LGTH%=0:MODE%=8
660 CALL DEBLK(RDD%(1),W%(1),COUNT%,MODE%,LGTH%)     (convert array from
                                                      binary block to integer)
```

Line 510 — Declare an integer array large enough for a full 1000 points.

Lines 515, 520 — Request the spectrum analyzer to format data in a binary format.

Lines 525, 530 — Send the CURVE? query command, which gets the waveform data.

Lines 540, 570 — Read header up through % sign, then ignore it.

Lines 700, 620 — Read the byte count and convert it to integer format.

Lines 630, 640 — Read the actual binary waveform data into array RDD%.

Lines 650, 660 — Convert the binary waveform data in array RDD% into integer waveform data, and write the result into array W%.

NOTE

For more information on the DEBLK and ENBLK commands, refer to the applicable documentation from National Instruments or Tektronix.

Sending a Binary CURVE to the Spectrum Analyzer

The following routine employs end block format to transfer a waveform to the spectrum analyzer. Array W is transferred; if not already created by the preceding routine, W should be dimensioned to 1000 and filled with data in the range 0 to 255.

```
600 REM TRANSMIT AS BINARY CURVE TO THE SPECTRUM ANALYZER
605 V%=0
610 CALL IBEOT(PORT1%,V%)                                  (disable END)
615 CMD$=CHR$(64)
620 CALL IBWRT(PORT1%,CMD$)                                (send @ character)
625 CNT%=1000:MODE%=8:LGTH%=1000
630 CALL ENBLK(W%(1),RDD%(1),LGTH%,MODE%,(CNT%)            (convert array from
                                                           integer to binary block)
640 V%=1
645 CALL IBEOT(PORT1%,V%)                                  (enable END)
650 CALL IBWRTI(PORT1%,RDD%(1),(CNT%)                      (send binary data)
```

Lines 615, 620 — Send the block specifier @.

Lines 625, 630 — Convert the integer waveform data in array W% into binary data and write the result into array RDD%.

Lines 645, 650 — Write the binary data to the screen of the spectrum analyzer.

NOTE

The CURVE header has been omitted in this example, but would be accepted if sent.

Getting and Sending Binary Data with RDATA? and RDATA

The following routine illustrates the transfer of settings directly to and from the battery-backed-up memory. (A similar program may be used with displays.) The routine reads the settings from memory 1 and sends them to memory 2.

THIS PROGRAM WILL OVERWRITE ANY SETTINGS STORED IN MEMORY LOCATIONS 1 OR 2.

```
110 DIM W%(130),RDD%(130)
115 CMD$="STORE 1"
120 CALL IBWRT(PORT1%,CMD$)
125 CMD$="RDATA? FPSET:1"
130 CALL IBWRT(PORT1%,CMD$)
135 EOSV%=ASC("%")+&H400                          (set EOS to %[begin
                                                   binary data])
140 CALL IBEOS(PORT1%,EOSV%)
145 RSP$=SPACE$(255)
150 CALL IBRD(PORT1%,RSP$)
160 CALL IBFIND(DEVICE$,PORT1%)                   (reset EOS)
175 RSP$=SPACE$(2)
180 CALL IBRD(PORT1%,RSP$)
190 COUNT%=ASC(RSP$)*256+ASC(RIGHT$(RSP$,1))-1
200 CNT%=COUNT%+5
210 CALL IBRDI(PORT1%,RDD%(1),CNT%)
215 LGTH%=0:MODE%=8
220 CALL DEBLK(RDD%(1),W%(1),COUNT%,MODE%,LGTH%)  (unpack data)
225 V%=0
230 CALL IBEOT(PORT1%,V%)                         (disable END)
235 CMD$="RDATA FPSET:2:%"
240 CALL IBWRT(PORT1%,CMD$)
245 V%=1
250 CALL IBEOT(PORT1%,V%)
260 CALL ENBLK(W%(1),RDD%(1),LGTH%,MODE%,COUNT%)
270 CALL IBWRTI(PORT1%,RDD%(1),CNT%)
```

Line 110 — Dimensions an integer array to hold the settings data. This must be an integer array.

Lines 115, 120 — Places present instrument settings in memory 1 to insure there is something to transfer.

Lines 235, 240 — Sends the command header to the instrument. The preceding IBEOT stops the controller from asserting EOI, so the header and the data that follows will be received by the spectrum analyzer as a single message.

Line 270 — Sends the settings data to the instrument. The percent sign (%) and byte count preceding the data and the checksum following the data are sent by the controller.

Scaling, Saving, and Graphics Waveform Data

Helps and Hints — 492PGM Programmers

Multiple Use of Display Buffer

An error message alerts you to possibly invalid data caused by multiple use of the display buffer; that is, using the buffer for more than one purpose during execution of a message. Also, you are informed in this manual of possible interaction involving waveform processing and waveform data I/O executed in the same spectrum analyzer message. (This occurs in Section 7 under the Interaction part of the CURVE command and under Display Data Point Commands Interaction in Section 7).

There is no conflict in many cases because the spectrum analyzer buffers the message you send and then executes it in the order you sent it.

For example, you can use the spectrum analyzer as a waveform processor for spectrum data you previously acquired in array A by entering the following program.

```
100 REM BUFFER DEMO
105 CMD$="SIGSWP"
110 CALL IBWRT(PORT1%,CMD$)
115 V%=0
120 CALL IBEOT(PORT1%,V%)
125 CMD$="CURVE"
130 CALL IBWRT(PORT1%,CMD$)
140 FOR I=1 TO 1000
145 CMD$=" "+STR$(W%(I))
150 CALL IBWRT(PORT1%,CMD$)
160 NEXT I
165 V%=1
170 CALL IBEOT (PORT1%,V%)
175 CMD$=";FIBIG;POINT?"
180 CALL IBWRT(PORT1%,CMD$)
185 RSP$=SPACE$(80)
190 CALL IBRD(PORT1%,RSP$)
200 B1=VAL(RSP$)
210 B2=VAL(MID$(RSP$,1+INSTR(RSP$,",")))
```

In this case, the spectrum analyzer does what you ask; it loads a waveform into digital storage and returns the point at the peak of the largest signal. SIGSWP is included to keep the spectrum analyzer active trace from overwriting the stored trace written by the CURVE command.

Interaction is possible in other cases, however, because there is only one display data buffer used for both display input and output and as workspace for waveform processing. For instance, conflicts can arise if the CURVE command or the CURVE query are used in the same command line with another CURVE command or CURVE query.

Whether interaction results in invalid data depends on the relative position of these message units in the message. This follows from how these message units use the buffer.

Buffer Data Flow

Data flow through the buffer is diagrammed in Figure 9-2. This figure identifies the kinds of data operations as data paths or destinations branching from the right of the buffer. The partitions in digital storage memory are shown as data sources or destinations branching from the left of the buffer.

The WFMPRE and CURVE commands contain arguments that set switches to control data flow through the buffer. Either the CRVID argument or the WFID argument sets the switch to

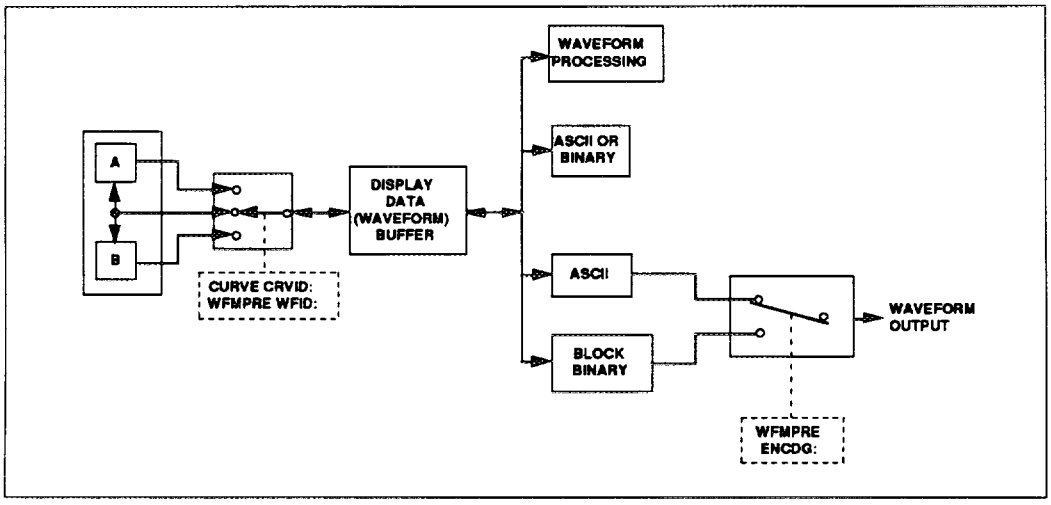


Figure 9-2. How multiple use of the display data buffers is controlled.

Order-Dependent Conflicts

Conflicts in the use of the buffer occur depending on the order in which waveform processing and I/O occurs. The CURVE command transfers the data to digital storage while executing, and the display data point commands act on the data while executing. The CURVE query, by contrast, does not transfer the data until after the entire message is executed (and the spectrum analyzer receives its talk address). Thus, if these message units are mixed in a message, the contents of the buffer may be changed between when it is loaded and when it is acted on or transferred.

```
100 REM WAVEFORM PROCESSING AND I/O
110 DIM A%(1000),B%(1000)
115 CMD$="CURVE?"
120 CALL IBWRT(PORT1%,CMD$)
125 EOSV%=ASC(",")+&H400                    (set EOS to comma)
130 CALL IBEOS(PORT1%,EOSV%)
135 RSP$=SPACE$(255)
140 CALL IBRD(PORT1%,RSP$)                  (read header and CRVID)
150 FOR I=1 TO 999
155 RSP$=SPACE$(8)
160 CALL IBRD(PORT1%,RSP$)                  (read one point)
170 W%(I)=VAL(RSP$)
180 NEXT I
190 CALL IBFIND(DEVICE$,PORT1%)             (next EOS)
205 RSP$=SPACE$(8)
210 CALL IBRD(PORT1%,RSP$)                  (read last point)
220 W%(1000)=VAL(RSP$)
225 V%=0
230 CALL IBEOT(PORT1%,V%)                   (disable END)
235 CMD$="CURVE "
240 CALL IBWRT(PORT1%,CMD$)                 (start transfer to 492PGM)
250 FOR I=1 TO 999
255 CMD$=STR$(W%(I))+" "
260 CALL IBWRT(PORT1%,CMD$)                 (send one point)
270 NEXT I
275 V%=1
280 CALL IBEOT(PORT1%,V%)                   (enable END)
285 CMD$=STR$(W%(1000))
290 CALL IBWRT(PORT1%,CMD$)                 (send last point)
```

Helps and Hints — 492PGM Programmers

•To allow data collection in the B display of digital storage while AVIEW is ON, the storage must be set with AVIEW ON and BVIEW and BMINA OFF. These settings are changed automatically when the Multiband Sweep mode is entered and cannot be changed while in the mode. The existing settings are restored when multiband sweep is exited. If there is a waveform in SAVEA, it will be automatically overwritten. SAVEA and MXHLD operate normally. Since only the A waveform is displayed, SAVEA ON stops display updating.

•Displays may only be stored and recalled into the A register. If the B display is requested with the DRECAL or DSTORE command, execution error message 140 will be issued and no display will be recalled.

•If the multiband mode is exited using either the MXSPN or ZEROSP commands, the span saved will be the multiband span. The span will return to this value, or default to maximum, when either the Max or Zero Span Mode is cancelled (refer to the information under Changing the span in Exiting Multiband Sweep for additional information). The instrument will not return to the multiband mode.

•The multiband frequency range displayed can only be changed by entering new start and stop frequencies with the STSTOP command. Changing the span with the SPAN command or directly entering a center frequency with the FREQ command exits the Multiband Sweep mode. Markers may be tuned over the displayed range only.

•The marker system treats the multiband display as if it were a saved or stored display; the tuning limits were mentioned previously. The MCEN and PKCEN commands cannot be used.

•With the ARES ON command, the resolution bandwidth used is the widest value required by the bands being swept. If any of the bands is uncalibrated, the UNCAL light will come on.

•With the TIME AUTO command, the sweep speed may vary as each band is swept. Any time/division value refers to a division of the sweep that gathered the data, not to a division of the compressed display.

•If the sweep is not in TRIG FRERUN, the triggering conditions selected will be used for only the first (lowest-frequency) sweep of the sweep needed to do one complete multiband sweep. After this sweep is triggered, the remaining sweeps will be done in the Free Run mode. Similarly, once a single sweep is started with the SIGSWP command, the number of sweeps needed to form a complete display will occur. If a multiband sweep is interrupted by the SIGSWP command or GET command, the next sweep will be the lowest-frequency sweep.

•TIME MAN or EXT cannot be used when sweeping a multiband range.

•The COUNT command cannot be used in the Multiband Sweep mode.

•Auto peaking will be done as usual in a 2-division window centered on the center or marker frequency. If this range covers more than one band, peaking will be done in all bands covered. If there is at least one signal within a band, or portion of a band, the peak value of the frequency window that contains the largest signal will be updated.

Exiting Multiband Sweep — Multiband sweep may be exited in several ways.

•Using the FREQ command to enter a frequency

•Recalling a setting with RECAL with a sweep that falls within one band

•Entering a sweep that falls within one band, using the STSTOP command

•Entering FRQRNG

•Changing the span with the SPAN, ZEROSP, or MXSPN commands

With MARKER ON, the center frequency is set to the Primary marker frequency. With MARKER OFF, the center frequency remains at the center frequency of the multiband sweep. The span is set to the span of the multiband sweep, or is defaulted to MXSPN if the multiband sweep value is larger than the maximum span of the band containing the center frequency. The command change that caused the exit from multiband sweep will then change either the center frequency or span, or both.

Comparing the Status Byte and the ERR? Response

The spectrum analyzer status byte and ERR? response described in Section 9 play complementary roles in GPIB system programming. The status byte is the spectrum analyzer response to a serial poll. The ERR? response is the spectrum analyzer answer to a device-dependent query message. The status byte provides information about instrument conditions by category; normal/abnormal, busy, command error, execution error, etc. The ERR? response details the cause of abnormal status; that is, what kind of error or warning prompted the spectrum analyzer to assert SRQ and report abnormal status.

Status bytes are not stacked. The code for the condition that caused the SRQ is not updated, although bit 5 reflects the present instrument state (1 for busy, 0 for not busy). Error codes, however, are accumulated until read and are reported in numerical order. While you can recover only one status byte, you may recover more than one code in the ERR? query response, indicating more than one abnormal condition occurred.

The status byte is cleared by a serial poll of that instrument. Error codes are cleared by reading them with the ERR? query. Reading the status byte does not clear the error codes, and vice versa. DCL and SDC (if addressed) clear both the status byte and error codes.

Execution and Transfer Times

The spectrum analyzer firmware typically takes 10 to 25 ms to execute commands received over the bus (refer to Table 9-1). This is the time the spectrum analyzer is busy following receipt of the end-of-message terminator (EOI or LF, depending on the switch). Execution time for some commands stretches beyond 25 ms, however, because of interaction between the firmware and hardware or a wait to allow hardware response. If the spectrum analyzer is busy, any command will have to wait until the hardware is not busy (e.g., if a signal count is being done, any command other than COUNT will have to wait).

Because of the way the spectrum analyzer handles output, it is free after it loads an output buffer. The additional time for the transfer (for CURVE, CURVE?, and SET?) is related to the listener for cases where the spectrum analyzer is faster.

Table 9-1

EXECUTION AND TRANSFER TIMES

Command	Time
FREQ, MFREQ	
0–1.8 GHz @	
10 MHz/div	800 ms
100 MHz step @	
10 MHz/div	150 ms
0–1.8 GHz @	
1 MHz/div	1.4 s
100 MHz step @	
1 MHz/div	350 ms
TUNE, MTUNE	
100 kHz step @	
100 kHz/div	80 ms
100 Hz step @	
100 kHz/div	60 ms
100 kHz step @	
100 Hz/div	1.4 s
100 Hz step @	
100 Hz/div	1.4 s
COUNT	
1 Hz resolution	2.6 s
1 kHz resolution	1.25 s
CNTCF	
1 Hz resolution	2.8 s
1 kHz resolution	1.75 s
EXMXR and FRQRNG if transfer switch or pre-selector/LPF switch is changed	Add 150 ms per switch
SPAN to phase lock span boundary (10 kHz/div to 1 MHz/div)	220 ms
IDENT ON	
@ 50 kHz	32.5 ms
@ 5 kHz	40.5 ms
@ 500 Hz	156 ms
REFLVL, RLMODE, MINATT, MAXPWR if RF attenuator is switched	Add 100 ms

Table 9-1 (Continued)

Command	Time
CURVE	100 ms
CURVE Display Data Input	
Binary (from number array)	1.1 s
ASCII (as a string)	8.1 s
ASCII (as numbers)	20.0 s
CURVE?	60 ms
CURVE Display Data Output	
Binary (input as strings)	3.4 s
ASCII (input as a 10-19 string)	3.0 s
ASCII (input as number)	14.3 s
POINT (X argument only)	56 ms
FIBIG	760 ms
LFTNXT, RGTNXT	100 ms * (signal separation in div)
FMAX, FMIN	480 ms
SET? (command execution time)	0.5 s to 3 s
SET? response Display Data Output	624 ms
INIT	0.5 s to 3 s
CAL AUTO	35 s
PEAK AUTO	10,6 s @ 10 ms/div
DSTORE (display)	190 ms
DRECAL (display)	380 ms
STORE (settings)	80 ms
RECALL (settings)	500 ms
MFBIG	560 ms
MLFTNXT, MRGTNXT	400 ms * (signal separation in div)
TEST?	7.3 s
HRAMPL, LRAMPL	560 ms

IEEE STD 488 (GPIB) System Concepts

The General Purpose Interface Bus (GPIB) is a digital control bus that allows efficient communications between self contained instruments or devices interconnected in an instrumentation system. The GPIB is an interface system independent of the stimulus or measurement functions incorporated in any instrument.

Instruments or devices designed to operate on the digital control bus must be developed according to the specifications contained in IEEE Std 4881978, "IEEE Standard Digital Interface for Programmable Instrumentation." At Tektronix, the IEEE 488 digital interface is commonly known as the General Purpose Interface Bus (GPIB). This section discusses the basic concepts of the GPIB. (For complete specifications, refer to the IEEE Std 488-1978 standard, published by the Institute of Electrical and Electronics Engineers, Inc.).

The GPIB has four elements; mechanical, electrical, functional, and operational. Of these four, only the last is device-dependent. Operational elements state the way in which each instrument reacts to a signal on the bus.

Mechanical Elements

The IEEE Std 488 defines the GPIB connector and cable assembly as the mechanical elements of the instrumentation system. Standardizing the connector and cable assembly ensures that GPIB-compatible instruments can be physically linked together with complete pin compatibility. The connector has 24 pins; sixteen active signal lines, seven interlaced grounds, and 1 shield connection. Standard connector pin arrangement and nomenclature for the digital control signals are illustrated in Figure A-1.

The cable that attaches to the GPIB connector must be no longer than 20 meters maximum with no more than fifteen peripheral devices (including a GPIB controller) connected at one time. The interconnecting cable assembly, which is offered as an optional accessory to the spectrum analyzer, is provided with both a plug and receptacle connector type at each end of the cable to allow either a star or linear bus structure. Contact your local Tektronix Field Office or representative for cable ordering information. Connectors may be rigidly stacked, using standard counter-bored captive screws.

Electrical Elements

The voltage and current values required at the connector nodes on the bus are based on TTL technology. The power source is not to exceed +5.25 V referenced to logic ground. The standard defines the logic levels as follows.

1. Logical 1 is a true state, low voltage level ($\leq$+0.8 V), signal line is asserted.

2. Logical 0 is a false state, high voltage level ($\geq$+2.0 V), signal line is not asserted.

Messages can be sent over the GPIB as either active-true or passive-true signals. Passive-true signals occur at a high voltage level and must be carried on a signal line using open-collector devices. Active-true signals occur at a low voltage level.

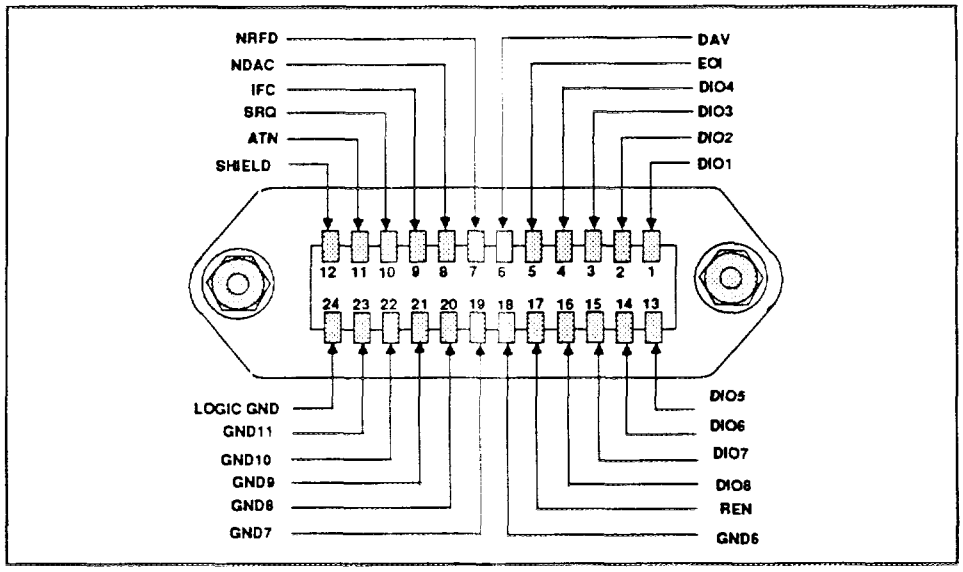


Figure A-1. IEEE Std 488 (GPIB) connector.

Functional Elements

The functional elements of the GPIB cover three areas.

1. The ten major interface functions of the GPIB, are listed in Table A-1. Each interface function is a system element that provides the basic operational facility through which an instrument can receive, process, and send messages over the GPIB.

2. The second functional element is the specific protocol by which the interface functions send and receive their limited set of messages

3. The logical and timing relationships between allowable states for all interface functions is the third area covered.

Table A-1

MAJOR GPIB INTERFACE FUNCTIONS

Interface Function	Symbol
Source Handshake	SH
Acceptor Handshake	AH
Talker or Extended Talker	T or TE
Listener or Extended Listener	L or LE
Service Request	SR
Remote-Local	RL
Parallel Poll	PP
Device Clear	DC
Device Trigger	DT
Controller	C

NOTE

The IEEE Std 488 standard defines the ten interface functions, the specific protocol, and timing relationships by the use of state diagrams. Not every instrument on the bus will have all ten interface functions incorporated, because only those functions important to a particular instrument's purpose need be implemented.

A Typical GPIB System

A typical GPIB instrumentation system is illustrated in Figure A-2, and it includes the nomenclature for the sixteen active signal lines. Only four instruments are shown connected directly to the control bus, but the GPIB can support up to fifteen instruments connected directly to the bus. However, more than fifteen devices can be interfaced to a single bus if they do not connect directly to the bus, but are interfaced through a primary device. Such a scheme can be used for programmable plug-ins housed in a mainframe where the mainframe is addressed with a primary address code and the plug-ins are addressed with a secondary address code.

To maintain the electrical characteristics of the bus, a device load should be connected for each two meters of cable length. Although instruments are usually spaced no more than two meters apart, they can be separated farther apart if the required number of device loads are lumped at any given point. For proper operation, at least two-thirds of the instruments connected directly to the bus must be in the power-on state.

Talkers, Listeners, and Controllers

A talker is an instrument that can send messages and data over the bus; a listener is an instrument that can accept messages and data from the bus. An instrument can be a talker only, listener only, or be both a talker and a listener. Unless a device is in the talk-only or listen-only mode, it can only communicate with other devices on the bus when it is enabled to do so by the controller in charge of the instrumentation system.

A controller is an instrument that determines, by software routines, which instrument will talk and which instruments will listen during any given time interval. The controller has the ability to assign itself as a talker or a listener whenever the program routine requires it. In addition to designating the current talker and listeners for a particular communication sequence, the controller is assigned the task of sending special codes and commands (called interface control messages) to any or all instruments on the bus. A complete operating system may contain more than one controller. The IEEE standard has provisions for a system controller that operates with another controller in charge of the bus. The controller that is in charge of the bus can take control only when it is directed to do so by the system controller. The system controller itself may be, but is not necessarily, the controller in charge of the bus.

Interface Control Messages

The two types of interface control messages are multi-line messages sent over the data bus and uni-line messages.

A message that shares a group of signal lines with other messages, in some mutually exclusive set, is called a multi-line message (only one multi-line message (message byte) can be sent at one time).

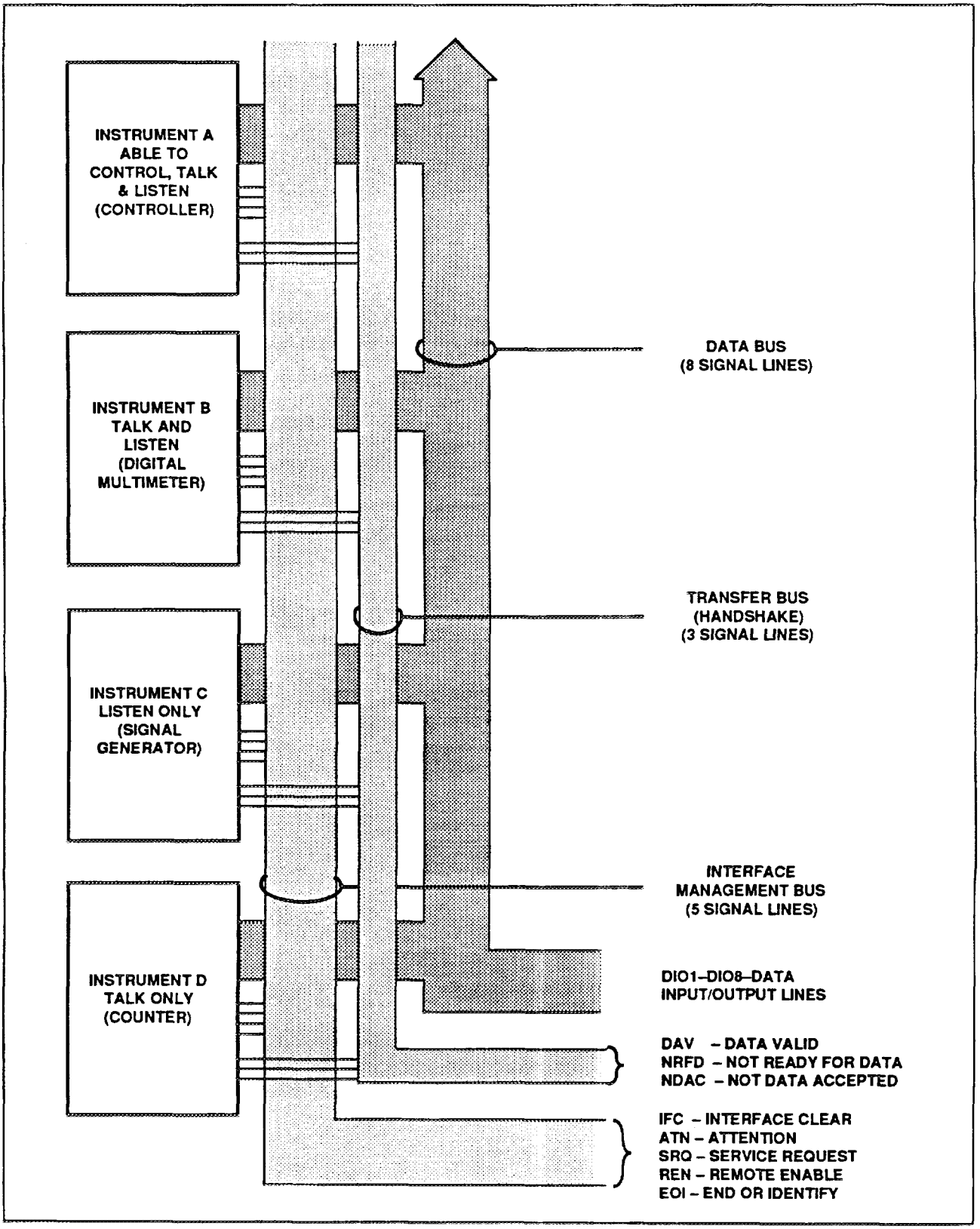


Figure A-2. A typical GPIB system.

A message sent over a single line is called a uni-line message (two or more of these messages can be sent concurrently.)

Only multi-line messages are discussed here; uni-line messages are discussed later under GPIB Signal Line Definitions.

The interface control messages (refer to Figure A-3) are sent and received over the data bus only with the ATN (attention) line asserted (true). Interface message coding can be related to the ISO (International Standards Organization) 7-bit code by relating data bus lines DIO1 through DIO7 to bits B1 through B7, respectively, in the Bits column in Figure A-3.

Interface control messages (refer to Table A-2) include the primary talk and listen addresses for instruments on the bus, addressed commands (only instruments previously addressed to listen will respond to these commands), universal commands (all instruments, whether they have been addressed or not, will respond to these commands), and secondary addresses for devices interfaced through a primary instrument. Parallel Poll Enable (PPE) messages are derived from the characters in the first column under Lower Case letters in Figure A-3 (decimal coded characters 96 through). The standard recommends the use of decimal code 112 (lower case letter p) for the Parallel Poll Disable (PPD) command. All parallel poll configured instruments respond with status information at the same time when the EOI line is asserted with ATN true.

Table A-2

INTERFACE MESSAGES (REFERRED TO IN THIS APPENDIX) AND FUNCTIONS

Mnemonic	Message	Interface Function
	Remote Messages Received	
ATN	Attention	AH,C,L, LE,PP, SH,T,TE
DAC	Data Accepted	SH
DAV	Data Valid	AH
DCL*	Device Clear	DC
GET*	Group Execute Trigger	DT
GTL*	Go To Local	RL
IFC	Interface Clear	C,L,LE, T,TE
LLO*	Local Lockout	RL
MSA*	My Secondary Address	LE,TE
MTA*	My Talk Address	T,TE
PPC*	Parallel Poll Configure	PP
PPD*	Parallel Poll Disable	PP
PPE*	Parallel Poll Enable	PP
PPU*	Parallel Poll Unconfigure	PP
REN	Remote Enable	RL
RFD	Ready For Data	SH
SDC*	Selected Device Clear	DC
SPD*	Serial Poll Disable	T,TE
SPE*	Serial Poll Enable	T,TE
SRQ	Service Request	(via C)
TCT*	Take Control	C
UNL*	Unlisten	L,LE

Table A-2 (Continued)

INTERFACE MESSAGES (REFERRED TO IN THIS APPENDIX) AND FUNCTIONS

Mnemonic	Message	Interface Function
	Remote Messages Sent	
ATN	Attention	C
DAC	Data Accepted	AH
DAV	Data Valid	SH
DCL*	Device Clear	(via C)
GET*	Group Execute Trigger	(via C)
GTL*	Go To Local	(via C)
IFC	Interface Clear	C
LLO*	Local Lockout	(via C)
MSA*	My Secondary Address	(via C)
MTA*	My Talk Address	(via C)
PPC*	Parallel Poll Configure	(via C)
PPD*	Parallel Poll Disable	(via C)
PPE*	Parallel Poll Enable	(via C)
PPU*	Parallel Poll Unconfigure	(via C)
REN	Remote Enable	C
RFD	Ready For Data	AH
SDC*	Selected Device Clear	(via C)
SPD*	Serial Poll Disable	(via C)
SPE*	Serial Poll Enable	(via C)
SRQ	Service Request	SR
TCT*	Take Control	(via C)
UNL*	Unlisten	(via C)
UNT*	Untalk	(via C)

* Multi-line messages.

Device-Dependent Messages

The IEEE standard does not specify the coding of device dependent messages (messages that control the internal operating functions of a device). After addressing a talker and the required number of listeners via interface control messages, the controller unasserts the ATN line (false) on the bus. When ATN becomes false (high), any commonly understood 8-bit binary code may be used to represent a device-dependent message.

However, the standard recommends that the alphanumeric codes associated with the numbers, symbols, and upper case characters (decimal 32 to decimal 94) in the ASCII Code Chart (Figure A-3) be used to compose device-dependent messages. One example of a device-dependent message could be the following ASCII character string:

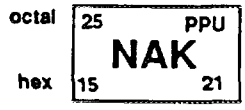
MODE V;VOLTS 2.5E-3;FREQ 1.0E3

The ASCII character string, sent with the ATN line unasserted, tells the instrument to set its front panel controls to the voltage mode and output a 2.5 mV signal at a frequency of 1000 Hz.

When 8-bit binary codes other than the ISO 7-bit are used for device-dependent messages, the most significant bit should be on data line DI08 (for bit-8).

BITS B7 B6 B5 / B4 B3 B2 B1	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
0000	0 NUL 0	20 DLE 16	40 SP 0 20 32	60 0 16 30 48	100 @ 0 40 64	120 P 16 50 80	140 ` 0 60 96	160 p 16 70 112
0001	1 GTL SOH 1 1	21 LLO DC1 17 11 17	41 ! 1 21 33	61 1 17 31 49	101 51 A 1 41 65	121 Q 17 51 81	141 a 1 61 97	161 q 17 71 113
0010	2 STX 2 2	22 DC2 18 12 18	42 " 2 22 34	62 2 18 32 50	102 B 2 42 66	212 R 18 52 82	142 b 2 62 98	162 r 18 72 114
0011	3 EXT 3 3	23 DC3 19 13 19	43 # 3 23 35	63 3 19 33 51	103 C 3 43 67	123 S 19 53 83	143 c 3 63 99	163 s 19 73 115
0100	4 SDC EOT 4 4	24 DCL DC4 20 14 20	44 $ 4 24 36	64 4 20 34 52	104 D 4 44 68	124 T 20 54 84	144 d 4 64 100	164 t 20 74 116
0101	5 PPC ENQ 5 5	25 PPU NAK 21 15 21	45 % 5 25 37	65 5 21 35 53	105 E 5 45 69	125 U 21 55 85	145 e 5 65 101	165 u 21 75 117
0110	6 ACK 6 6	26 SYN 22 16 22	46 & 6 26 38	66 6 22 36 54	106 F 6 46 70	126 V 22 56 86	146 f 6 66 102	166 v 22 76 118
0111	7 BEL 7 7	27 ETB 23 17 23	47 ' 7 27 39	67 7 23 37 55	107 G 7 47 71	127 W 23 57 87	147 g 7 67 103	167 w 23 77 119
1000	10 GET BS 8 8	30 SPE CAN 24 18 24	50 (8 28 40	70 8 24 38 56	110 H 8 48 72	130 X 24 58 88	150 h 8 68 104	170 x 24 78 120
1001	11 TCT HT 9 9	31 SPD EM 25 19 25	51) 9 29 41	71 9 25 39 57	111 I 9 49 73	131 Y 25 59 89	151 i 9 69 105	171 y 25 79 121
1010	12 LF A 10	32 SUB 26 1A 26	52 * 10 2A 42	72 : 26 3A 58	112 J 10 4A 74	132 Z 26 5A 90	152 j 10 6A 106	172 z 26 7A 122
1011	13 VT B 11	33 ESC 27 1B 27	53 + 11 2B 43	73 ; 27 3B 59	113 K 11 4B 75	133 [27 5B 91	153 k 11 6B 107	173 { 27 7B 123
1100	14 FF C 12	34 FS 28 1C 28	54 , 12 2C 44	74 < 28 3C 60	114 L 12 4C 76	134 \ 28 5C 92	154 l 12 6C 108	174 | 28 7C 124
1101	15 CR D 13	35 GS 29 1D 29	55 — 13 2D 45	75 = 29 3D 61	115 M 13 4D 77	135] 29 5M 93	155 m 13 6D 109	175 } 29 7D 125
1110	16 SO E 14	36 RS 30 1E 30	56 . 14 2E 46	76 > 30 3E 62	116 N 14 4E 78	136 ^ 30 5R 94	156 n 14 6E 110	176 ~ 30 7E 126
1111	17 SI F 15	37 US 31 1F 31	57 / 15 2F 47	77 ? UNL 3F 63	117 O 15 4F 79	137 _ UNT 5F 95	157 o 15 6F 111	177 DEL (RUBOUT) 7F 127
	ADDRESSED COMMAND	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS	

KEY



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

Figure A-3. ASCII & GPIB Code Chart.

To summarize the difference between interface control messages and device-dependent messages on the data bus, remember that any message sent or received when the ATN line is asserted (low) is an interface control message. Any message (data bytes) sent or received when the ATN line is unasserted (high) is a device dependent message.

GPIB Signal Line Definitions

Figure A-2 shows how the sixteen active signal lines on the GPIB are functionally divided into three component buses: an eight-line data bus, a three-line data byte transfer control (handshake) bus, and a five-line general interface management bus.

The data bus contains eight bidirectional signal lines, DI01 through DI08. Information, in the form of data bytes, is transferred over this bus. A handshake timing sequence between the enabled talker and the enabled listeners on the three-line data transfer control bus transfers one data byte (eight bits) at a time. These data bytes are sent and received in a byte-serial, bit-parallel fashion.

Since the handshake sequence is an asynchronous operation (no clock signal on the bus), the data transfer rate is only as fast as the slowest instrument involved in a data byte transfer. A talker cannot place data bytes on the bus faster than the slowest listener can accept them.

Figure A-4 illustrates the flow of data bytes on the bus when a typical controller sends ASCII data to an assigned listener. The first data byte (decimal 44) enables an instrument at address 12 as a primary listener. The second data byte (decimal 108) is optional; for example, enabling a plug-in device at secondary address 12 as the final destination of the data to follow. The data is the two ASCII characters A and B (decimal 65 and decimal 66). Note that the ATN line is asserted for the first two data bytes and unasserted for the device-dependent character to indicate the last data byte in the message.

The controller activates the ATN line again and sends the universal unlisten (UNL) and untalk (UNT) commands to clear the bus. Six handshake cycles on the data transfer control bus are required to send the six data bytes.

Transfer Bus (Handshake)

Each time a data byte is transferred over the data bus, an enabled talker and all enabled listeners execute a handshake sequence via signal lines DAV, NRFD, and NDAC (see Figure A-5 — the ATN line is shown to illustrate the controller's role in the process).

DAV (Data Valid). The DAV signal line is asserted by the talker after the talker places a data byte on the data bus. When asserted (low), DAV tells each assigned listener that a new data byte is on the bus. The talker is inhibited from asserting DAV as long as any listener holds the NRFD signal line asserted.

NRFD (Not Ready For Data). An asserted NRFD signal line indicates one or more of the assigned listeners are not ready to receive the next data byte from the talker. When all of the assigned listeners for a particular data byte transfer have released NRFD, the NRFD line becomes unasserted (high). When NRFD goes high, the RFD message (Ready For Data) tells the talker it may place the next data byte on the data bus.

NDAC (Not Data Accepted). Each assigned listener holds the NDAC signal line asserted until the listener accepts the data byte currently on the bus. When all assigned listeners have accepted the current data byte, the NDAC signal line becomes unasserted (high), telling the talker to remove the data byte from the bus. The DAC message (Data Accepted) tells the talker that all assigned listeners have accepted the current data byte.

NOTE

One handshake cycle transfers one data byte; then, the listeners reset the NRFD line high and the NDAC line low before the talker asserts DAV for the next data byte transfer. Both NRFD and NDAC high at the same time is an invalid state on the bus.

Management Bus

The management bus is a group of five signal lines that are used to control the operation of the IEEE Std 488 (GPIB) Digital Interface.

IFC (Interface Clear). The system controller is the only instrument on the bus allowed to assert IFC. IFC is asserted for greater-than 100 μs to place all instruments in a predetermined state. While IFC is being sent, only the DCL (Device Clear), LLO (Local Lockout), PPU (Parallel Poll Unconfigure), and REN (Remote Enable) interface messages (universal commands) will be recognized.

ATN (Attention). The controller in charge is the only instrument on the bus allowed to assert ATN. ATN is asserted when an instrument connected to the bus is being enabled as a talker or listener, or when sending other interface control messages. As long as the ATN line is asserted (low), only instrument address codes and interface control messages are sent over the bus. When the ATN line is unasserted, only those instruments enabled as a talker and listener can send and receive data over the bus.

SRQ (Service Request). Any instrument connected to the bus can request the controller's attention by asserting the SRQ line. The controller responds by asserting ATN and executing a serial poll routine to determine which instrument is requesting service. The instrument requesting service responds with a device-dependent status byte with bit seven asserted. When the instrument requesting service is found, program control is transferred to a service routine for that instrument. When the service routine is completed, program control returns to the main program. (The controller does not have to see the SRQ line asserted to perform a polling routine; it may do so whenever a program requires it).

REN (Remote Enable). The system controller asserts the REN signal line whenever the interface system operates under remote program control. Used with other interface control messages, such as LLO (Local Lockout) or GTL (Go To Local), the REN signal causes an instrument on the bus to select between two alternate sources of programming data. A remote-local interface function indicates to an instrument that the instrument will use either information input from the interface (remote) or to information input by the operator via the front panel controls (local).

EOI (End Or Identify). A talker can use the EOI signal line to indicate the end of a data transfer sequence. The talker asserts EOI as the last byte of data is transmitted. In this case, the EOI line is essentially a ninth data bit and must observe the same settling time as the data on the data bus. When an instrument controller is listening, it assumes that a data byte sent with EOI asserted is the last data byte in the complete message. When the instrument controller is talking, it may assert the EOI signal line as the last data byte is transferred. The EOI line is also asserted with the ATN line true if the controller conducts a parallel polling sequence on the bus. The EOI line is not used for a serial polling sequence.

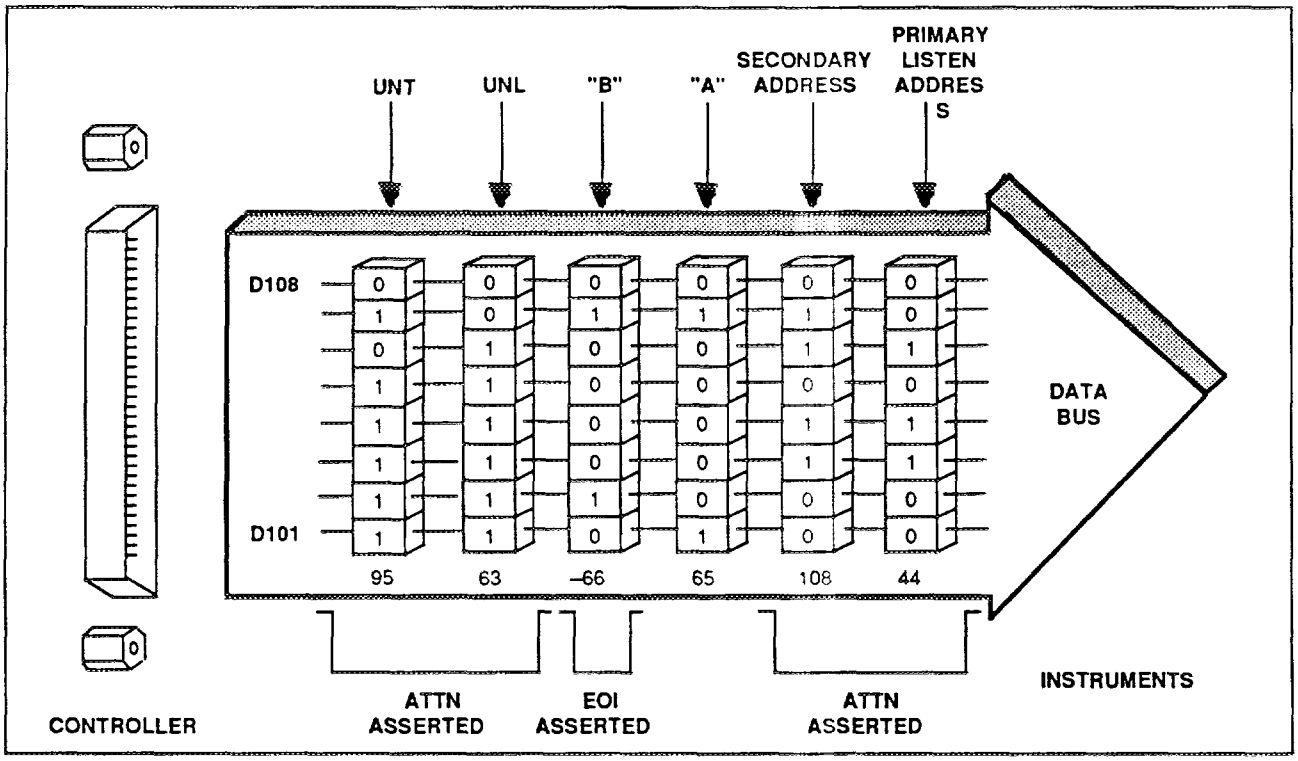


Figure A-4. An example of data byte traffic on the GPIB

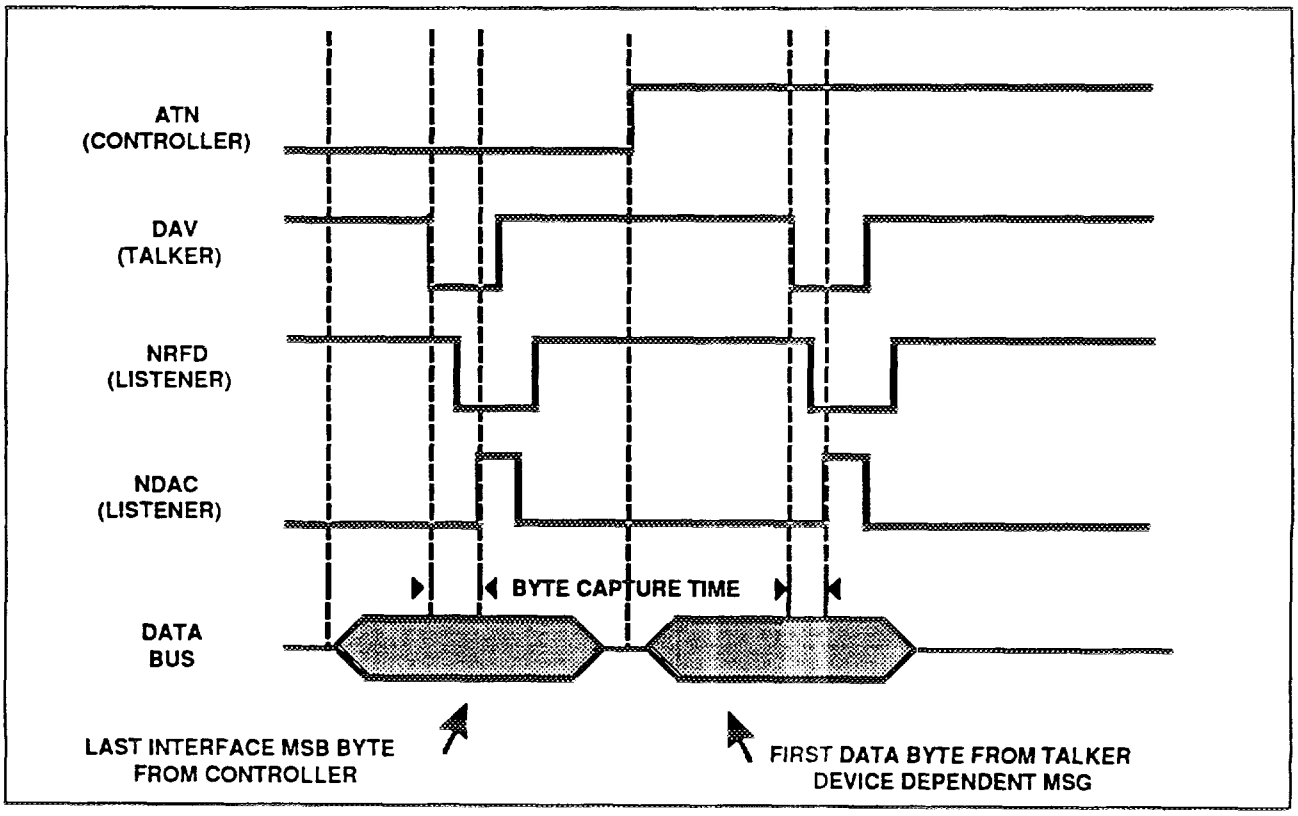


Figure A-5. A typical handshake timing sequence (idealized). Byte capture time is dependent on the slowest instrument involved in the handshake. RFD means Ready for DATA; DAC means Data Accepted.

Interface Functions and Messages

The ten major interface functions listed in Table A-1 provide a variety of capabilities and options for an instrumentation system. These functions may be implemented in, or for, any particular instrument with instrument hardware or with a programming routine (software).

Only those functions necessary for an instrument's purpose need be implemented by the instrument's designer; it is not likely that one single instrument will have all ten interface functions. For example, an instrument generally doesn't need to implement the Parallel Poll (PP) function if the instrument can respond to a serial polling sequence from the controller in charge of the GPIB system.

The following discusses the interface functions and their relationship to the interface control messages shown in Figure A-3. All the interface control messages discussed are sent and received over the GPIB with the ATN line asserted (low).

RL (Remote-Local Function)

The RL function provides an instrument with the capability to select between two sources of input information. This function indicates to the instrument that its internal device dependent functions are to respond to information input from the front panel (Local) or to corresponding programming information from the GPIB (Remote). Only the system controller is permitted to assert the REN (Remote Enable) line, whether or not it is the controller in charge at the time.

When the system controller asserts the REN line, an instrument on the GPIB goes to a remote mode when it is addressed as a listener with its listen address, not before. An instrument remains in a remote mode until the REN line is released (high), or an optional front-panel switch on the instrument is activated to request the local mode, or a GTL (Go To Local) command is received while the instrument is enabled as a listener.

However, the controller can disable the instrument's front-panel "return to local" switch(es) by sending a LLO (Local Lockout) command. The LLO command must be preceded or followed by a listen address (MLA) to cause the instrument to go to a remote mode with front-panel lockout. The UNL (Unlisten) command does not return an instrument to the local mode.

When the REN line goes false, it must be recognized by all instruments on the bus and they must go to the local mode within 100 µs. If data bytes are still being placed on the bus when REN goes false, the system program should assure that the data bytes are sent and received with the knowledge that the system is in a local mode, not remote.

T/TE and L/LE (Talker and Listener Functions)

NOTE

Although discussed under one heading, the T/TE and L/LE functions are independent of each other.

The T (Talker) and TE (Talker Extended) functions provide an instrument and its secondary devices, if any, with the capability to send device-dependent data over the GPIB (or, in case of a controller, the capability to send device dependent program data) over the GPIB. The Talker (T) function is a normal function for a talker and uses only a one-byte primary address code called MTA (My Talk Address). The Talker Extended (TE) function requires a two byte address code; an MTA code followed by the second byte called MSA (My Secondary Address).

NOTES

•*To assure correct and expected results during signal processing, use* the Single Sweep triggering mode while programming. The signal processing commands are HRAMPL, LRAMPL, MFBIG, MLFTNX, PRKIND, MMAX, MMIN, MRGTNX, MVLFDB MVRTDB, CURVE, WAVFRM, DPRE, DCOPY, DFIBIG, LFTNXT, RGTNXT, FMAX, and FMIN.

•Only the first three letters of a mnemonic are required (e.g., ARE for AREs); except all of the letters of the units arguments for REFLVL and MAXPWR must be entered.

•Form a query by adding a question mark to the header of the Display Data I/O, Marker System, or Front-Panel header (AREs?) unless no query is indicated. POInt? is the only Waveform Processing query.

•The header will be returned with responses with HDR ON, or the header will not be returned with HDR OFF.

•NUM is a decimal number; integer, floating point or scientific notation.

•NUM may be submitted for ON or OFF; 1=ON, 0=OFF.

•NUM may be followed by units in engineering notation for frequency, time, and amplitude, 100 MHz, 10 µs, –60 dBm.

•Queries are acted upon as soon as they are received.