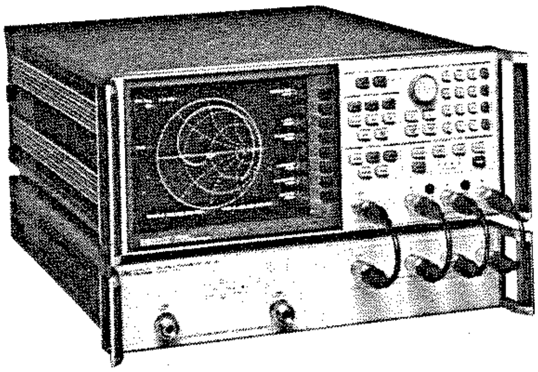
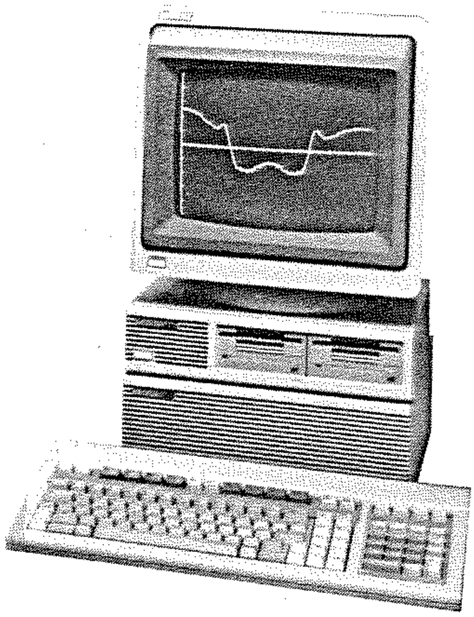
HP-IB Programming Note

Introductory Programming Guide
For the HP 8753B network analyzer
with the HP 9000 series 200/300 desktop computer (BASIC)





Introduction

This programming note is an introduction to remote operation of the HP 8753B network analyzer using an HP 9000 series 200 or 300 computer. It is a tutorial introduction, using BASIC programming examples to demonstrate the remote operation of the HP 8753B. The examples are on the Example Programs disc (part number 08753-10010), included with the HP 8753B operating manual. This document is closely associated with the HP 8753B HP-IB *Quick Reference Guide* (part number 08753-90118.) The *Quick Reference Guide* provides complete programming information in a very concise format. Included in the *Quick Reference Guide* are both functional and alphabetical lists of HP-IB commands. The HP 8753B *Quick Operating Guide* also lists HP-IB commands, along with its softkey menu explanations.

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The Hewlett-Packard computers specifically addressed are the HP 9000 series 200 and 300 computers, operating with BASIC 2.0 with AP2—1, or BASIC 3.0 or higher. This includes the 216 (9816), 217 (9817), 220 (9920), 226 (9826), 236 (9836), 310 and 320 computers.

The reader should become familiar with the operation of the HP 8753B before controlling it over HP-IB. Also, this document is not intended to teach BASIC programming or to discuss HP-IB theory except at an introductory level: see below for documents better suited to these tasks.

For more information

For more information concerning the operation of the HP 8753B, refer to the following:

User's Guide	08753-90007
Quick Operating Guide	08753-90116
Operating and Programming Reference	08753-90119

For more information concerning BASIC, see the manual set for the BASIC revision being used. For example:

BASIC 5.0 Programming Techniques	98613-90012
BASIC 5.0 Language Reference	98613-90052

For more information concerning HP-IB, see:

BASIC 5.0 Interfacing Techniques	98613-90022
Tutorial Description of the Hewlett-Packard Interface Bus	5952-0156
Condensed Description of the Hewlett-Packard Interface Bus	59401-90030

Required equipment

To run the examples of this *Introductory Programming Guide*, the following equipment is required:

1. HP 8753B network analyzer.
2. HP 9000 series 200 or 300 computer with enough memory to hold BASIC, needed binaries, and at least 64 kBytes of program space. In addition, 512 kBytes are needed for BASIC 3.0 or higher operating systems, with the binaries suggested in step 2 in the section *Powering up the system*. A disc drive (e.g. HP 9122) is required to load BASIC if no internal disc drive is available.
3. HP BASIC 2.0 with AP2—1, or BASIC 3.0 or higher operating system.
4. HP 10833A/B/C/D HP-IB cables to interconnect the computer, the HP 8753B, and any peripherals.

Optional equipment

1. HP 85032B 50 ohm type-N calibration kit.
2. HP 11852D test port return cables.
3. A test device such as a filter to use in the example measurement programs.
4. HP 7440A ColorPro plotter, an HP 2225A Thinkjet printer, or an HP 9122 or HP 9153 CS80 disc drive. See the General Information section of the manual for a more complete list of compatible peripherals.

Powering up the system

1. **Set up the HP 8753B as shown in Figure 1.**
   Connect the HP 8753B to the computer with an HP-IB cable. The HP 8753B has only one HP-IB interface, but it occupies two addresses: one for the instrument, one for the display. The display address is the instrument address with the least significant bit complemented. The default addresses are 16 for the instrument, 17 for the display. Devices on the HP-IB cannot occupy the same address as the HP 8753B.
2. **Turn on the computer and load the BASIC operating system.**
   For BASIC 2.0, load AP2—1 if available. If BASIC 3.0 or higher is used, load the following BASIC binary extensions: HPIB, GRAPH, IO, KBD, and ERR. Depending on the disc drive, a binary such as CS80 may be also be required.
3. **Turn the HP 8753B on.**
   To verify the HP 8753B's address, press **[LOCAL]** *[SET ADDRESSES]* and *[ADDRESS: 8753]*. If the address has been changed from 16, the default value, return it to 16 while performing the examples in this document by pressing **[1] [6] [x1]** and then presetting the instrument. Make sure the instrument is in either *[USE PASS CONTROL]* or *[TALKER/LISTENER]* mode, as indicated under the **[LOCAL]** key. These are the only modes in which the HP 8753B will accept commands over HP-IB.
4. **On the computer type the following:**
   `OUTPUT 716;"PRES;"` **[EXECUTE]** (or **[RETURN]**)
   This will preset the HP 8753B. If Preset does not occur, there is a problem. First check all HP-IB addresses and connections: most HP-IB problems are caused by an incorrect address and bad or loose HP-IB cables.

NOTE: Only the 9826 and 9836 computers have an actual **[EXECUTE]** key. An HP 216 has an **[EXEC]** key with the same function. All the other computers use the **[RETURN]** key as both execute and enter. Throughout this document, the notation **[EXECUTE]** is used.

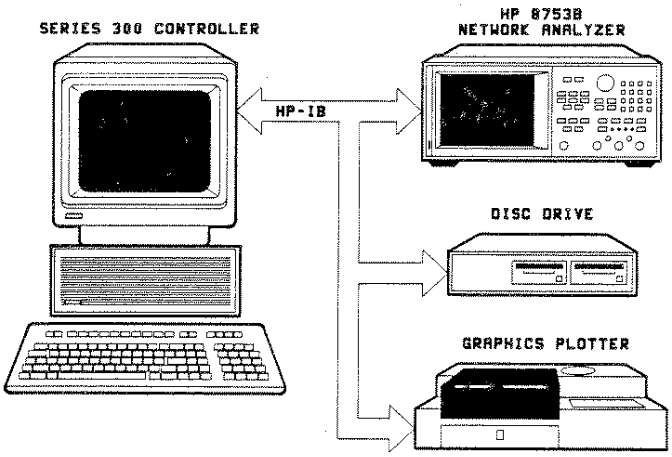

Figure 1. HP-IB connections in a typical setup.

Basic Instrument Control

A computer controls the HP 8753B by sending it commands over HP-IB. The commands sent are specific to the HP 8753B. Each command is executed automatically upon receipt, taking precedence over manual control of the HP 8753B. A command applies only to the active channel except where functions are coupled between channels, just as with front panel operation. Most commands are equivalent to front panel functions. For example, type:

```
OUTPUT 716;"STAR 10 MHZ;"
```

and press **[EXECUTE]**.

The HP 8753B now has a start frequency of 10 MHz. The construction of the command is:

```
OUTPUT 716;"STAR 10 MHZ;"
```

OUTPUT 716;	"STAR 10 MHZ;"
The BASIC data output statement. The data is directed to interface 7 (HP-IB), and on out to the device at address 16 (the HP 8753B).	The HP 8753B mnemonic for setting the start frequency. The mnemonic, less the quotation marks, is sent literally by the **OUTPUT** statement, followed by a carriage return, line feed.

The `STAR 10 MHZ;` command performs the same function as pressing **[START]** and keying in **10 [M/u]**. `STAR` is the root mnemonic for the start key, `10` is the data, and `MHZ` are the units. The HP 8753B's root mnemonics are derived from the equivalent key label where possible, otherwise from the common name for the function. The *Quick Reference Guide* lists all the root mnemonics, and all the different units accepted.

The semicolon following `MHZ` terminates the command inside the HP 8753B. It removes start frequency from the active entry area, and prepares the HP 8753B for the next command. If there is a syntax error in a command, the HP 8753B will ignore the command and look for the next terminator. When it finds the next terminator, it starts processing incoming commands normally. Characters between the syntax error and the next terminator are lost. A line feed also acts as terminator. The BASIC `OUTPUT` statement transmits a carriage return, line feed following the data. This can be suppressed by putting a semicolon at the end of the statement.

The `OUTPUT 716;` statement will transmit all items listed, as long as they are separated by commas or semicolons. It will transmit literal information enclosed in quotes, numeric variables, string variables, and arrays. A carriage return, line feed is transmitted after each item. This can be suppressed by separating items with semicolons rather than commas.

Note that the front panel remote (R) and listen (L) HP-IB status indicators are on: the HP 8753B automatically goes into remote mode when sent a command with the `OUTPUT` statement. In remote mode, the HP 8753B ignores all front panel keys except the local key. Pressing the **[LOCAL]** key returns the HP 8753B to manual operation, unless the universal HP-IB command `LOCAL LOCKOUT 7` has been issued. The only way to get out of local lockout is to either issue the `LOCAL 7` command, or to cycle power on the HP 8753B.

Setting a parameter is just one form of command the HP 8753B will accept. It will also accept simple commands that require no operand at all. For example, execute:

```
OUTPUT 716;"AUTO;"
```

In response, the HP 8753B autoscales the active channel. Autoscale only applies to the active channel, unlike start frequency, which applies to both channels as long as the channels are stimulus coupled.

The HP 8753B will also accept commands that turn various functions on and off. Execute:

```
OUTPUT 716;"DUACON;"
```

This causes the HP 8753B to display both channels. To go back to single channel display mode, execute:

```
OUTPUT 716;"DUACOFF;"
```

The construction of the command starts with the root mnemonic `DUAC` (dual channel display,) and `ON` or `OFF` is appended to the root to form the entire command.

The HP 8753B does not distinguish between upper and lower case letters. For example, execute:

```
OUTPUT 716;"auto;"
```

The HP 8753B also has a debug mode to aid in troubleshooting systems. When debug mode is on, the HP 8753B scrolls incoming HP-IB commands across the display. To turn the mode on manually, press **[LOCAL]** *[HP-IB DIAG ON]*. To turn it on over HP-IB, execute:

```
OUTPUT 716;"DEBUON;"
```

Command interrogate

Suppose the operator has changed the power level from the front panel. The computer can find out the new power level using the HP 8753B's command interrogate function. If a question mark is appended to the root of a command, the HP 8753B will output the value of that function. For instance, `POWE 7 DB;` sets the output power to 7 dB, and `POWE?;` outputs the current RF output power at the test port. For example, type **SCRATCH** and press **[EXECUTE]** to clear old programs. Type **EDIT** and press **[EXECUTE]** to get into the edit mode. Then type in:

```
10  OUTPUT 716;"POWE?;"
20  ENTER 716;Reply
30  DISP Reply
40  END
```

Run the program. The computer will display the source power level in dBm. The preset source power level is 0 dBm. Change the power level by pressing **[LOCAL]** **[MENU]** *[POWER]* and then entering **[1]** **[5]** **[x1]**. Now run the program again.

When the HP 8753B receives `POWE?`, it prepares to transmit the current RF source power level. The BASIC statement `ENTER 716` allows the HP 8753B to transmit information to the computer by addressing it to talk. This turns the HP 8753B front panel talk light (T) on. The computer places the data transmitted by the HP 8753B into the variables listed in the enter statement. In this case, the HP 8753B transmits the output power, which gets placed in the variable `Reply`.

The `ENTER` statement takes the stream of binary data output by the HP 8753B and reformats it back into numbers and ASCII strings. With the formatting in its default state, the enter statement will format the data into real variables, integers, or ASCII strings, depending on the variable being filled. The variable list must match the data the HP 8753B has to transmit: if there are too few variables, data is lost, and if there are too many variables for the data available, a BASIC error is generated.

The formatting done by the enter statement can be changed. As discussed in *Data transfer from analyzer to computer*, the formatting can be turned off to allow binary transfers of data. Also, the `ENTER USING` statement can be used to selectively control the formatting.

On/off commands can be also be interrogated. The reply is a one if the function is on, a zero if it is off. Similarly, if a command controls a function that is underlined on the HP 8753B display when active, interrogating that command yields a one if the command is underlined, a zero if it is not. For example, there are nine options on the format menu: only one is underlined at a time. The underlined option will return a one when interrogated.

For instance, rewrite line 10 as:

```
10    OUTPUT 716;"DUAC?;"
```

Run the program once, note the result, the press **[LOCAL]** **[DISPLAY]** *[DUAL CHAN]* to toggle the display mode, and run the program again.

Another example is to rewrite line 10 as:

```
10    OUTPUT 716;"PHAS?;"
```

In this case, the program will display a one if phase is currently being displayed. Since the command only applies to the active channel, the response to the `PHAS?` inquiry depends on which channel is active.

Held commands

When the HP 8753B is executing a command that cannot be interrupted, it will hold off processing new HP-IB commands. It will fill the 16 character input buffer, and then halt HP-IB until the held command has completed execution. This action will be transparent to a program unless HP-IB timeouts have been set with the `ON TIMEOUT` statement.

While a held command is executing, the HP 8753B will still service the HP-IB interface commands, such as `SPOLL(716)`, `CLEAR 716`, and `ABORT 7`. Executing `CLEAR 716` or `CLEAR 7` will abort a command hold off, leaving the held command to complete execution as if it had been begun from the front panel. These commands also clear the input buffer, destroying any commands received after the held command. If the HP 8753B has halted the bus because its input buffer was full, `ABORT 7` will release the bus.

Operation complete

Occasionally, there is a need to find out when certain operations have completed inside the HP 8753B. For instance, a program should not have the operator connect the next calibration standard while the HP 8753B is still measuring the current one.

To provide such information, the HP 8753B has an Operation Complete reporting mechanism that will indicate when certain key commands have completed operation. The mechanism is activated by sending either `OPC` or `OPC?` immediately before an OPC'able command. When the command completes execution, bit 0 of the event status register will be set. If OPC was interrogated with `OPC?`, the HP 8753B will also output a 1 when the command completes execution.

As an example, type **SCRATCH** and press **[EXECUTE]**. Type **EDIT** and press **[EXECUTE]**, and type in the following program:

```
10  OUTPUT 716;"SWET 3 S;OPC?;SING;" ........ Set the sweep time to 3 seconds, and OPC a single sweep.
20  DISP "SWEEPING"
30  ENTER 716;Reply ......................... The program will halt at this point until the HP 8753B completes the sweep and issues a one.
40  DISP "DONE"
50  END
```

Running this program causes the computer to display the sweeping message for about 3 seconds, as the instrument executes the sweep. The computer will display DONE just as the instrument goes into hold. When the DONE message appears, the program could then continue on, being assured that there is a valid data trace in the instrument. Without single sweep, we would have had to wait at least two sweep times to ensure good data.

Preparing for HP-IB control

At the beginning of a program, the HP 8753B has to be taken from an unknown state and brought under computer control. One way to do this is with an abort/clear sequence. ABORT 7 is used to halt bus activity and return control to the computer. CLEAR 716 will then prepare the HP 8753B to receive commands by clearing syntax errors, the input command buffer, and any messages waiting to be output.

The abort/clear sequence makes the HP 8753B ready to receive HP-IB commands. The next step is to put the HP 8753B into a known state. The most convenient way to do this is to send PRES, which returns the instrument to the preset state. If preset cannot be used and the status reporting mechanism is going to be used, CLES can be sent to clear all of the status reporting registers and their enables.

Type **SCRATCH** and press **[EXECUTE]**. Type **EDIT** and press **[EXECUTE]**, and type in the following program:

```
10  ABORT 7 ........................ This halts all bus action and gives active control to the computer.
20  CLEAR 716 ...................... This clears all HP-IB errors, resets the HP-IB interface, clears syntax errors. It does not affect the status reporting system.
30  OUTPUT 716;"PRES;" ............. Preset the instrument. This clears the status reporting system, as well as resetting all of the front panel settings, except the HP-IB mode and the HP-IB addresses.
40  END
```

Running this program brings the HP 8753B to a known state, ready to respond to HP-IB control.

The HP 8753B will not respond to HP-IB commands unless the remote line is asserted. When the remote line is asserted and the HP 8753B is addressed to listen, it automatically goes into remote mode. Remote mode means that all the front panel keys are disabled except **[LOCAL]** and the line power switch. ABORT 7 asserts the remote line, which remains asserted until a LOCAL 7 statement is executed. Another way to assert the remote line is to execute:

```
REMOTE 716
```

This statement asserts remote and addresses the HP 8753B to listen so that it goes into remote mode. Press any front panel key except local. None will respond until after you press **[LOCAL]**.

The local key can also be disabled with the sequence:

```
REMOTE 716
LOCAL LOCKOUT 7
```

Now no front panel keys will respond at all. The HP 8753B can be returned to local mode temporarily with:

```
LOCAL 716
```

But as soon as the HP 8753B is next addressed to listen, it goes back into local lockout. The only way to clear local lockout, aside from cycling power, is to execute:

```
LOCAL 7
```

Which un-asserts the remote line on the interface. This puts the instrument into local mode and clears local lockout. Be sure to put the instrument back into remote mode.

Measurement Programming

The previous section of this document outlined how to get commands into the HP 8753B. The next step is to organize the commands into a measurement sequence. A typical measurement sequence consists of the following steps:

1. Set up the instrument.
2. Calibrate.
3. Connect the device.
4. Take data.
5. Post process data.
6. Transfer data.

Set up the instrument:

Define the measurement by setting all of the basic measurement parameters. These include all the stimulus parameters: sweep type, span, sweep time, number of points, and RF power level. They also include the parameter to be measured, and both IF averaging and IF bandwidth. These parameters define the way data is gathered and processed within the instrument, and to change one requires that a new sweep be taken.

There are other parameters that can be set within the instrument that do not affect data gathering directly, such as smoothing, trace scaling or trace math. These functions are classed as post processing functions: they can be changed with the instrument in hold mode, and the data will correctly reflect the current state.

The save/recall registers and the learn string are two rapid ways of setting up an entire instrument state. The learn string is a summary of the instrument state compacted into a string that can be read into the computer and retransmitted to the HP 8753B. See Example 6A, *Using the learn string*, for a discussion of how to do this.

Calibrate:

Measurement calibration is normally performed once the instrument state has been defined. Measurement calibration is not required to make a measurement, but it does improve the accuracy of the data.

There are several ways to calibrate the instrument. The simplest is to stop the program and have the operator perform the calibration from the front panel. Alternatively, the computer can be used to guide the operator through the calibration, as discussed in Example 2A and 2B, S_{11} *1-port calibration* and *Full 2-port calibration*. The last option is to transfer calibration data from a previous calibration back into the instrument, as discussed in Example 6C, *Reading calibration data*.

Connect device:

Have the operator connect and adjust the device. The computer can be used to speed the adjustment process by setting up such functions as limit testing, bandwidth searches, and trace statistics. All adjustments take place at this stage so that there is no danger of taking data from the device while it is being adjusted.

Take data:

With the device connected and adjusted, measure its frequency response, and hold the data within the instrument so that there is a valid trace to analyze.

The single sweep command `SING` is designed to ensure a valid sweep. All stimulus changes are completed before the sweep is started, and the HP-IB hold state is not released until the formatted trace is displayed. When the sweep is complete, the instrument is put into hold, freezing the data inside the instrument. Because single sweep is OPC'able, it is easy to determine when the sweep has been completed.

The number of groups command `NUMGn` is designed to work the same as single sweep, except that it triggers n sweeps. This is useful, for example, in making a measurement with an averaging factor n. (n can be 1 to 999). Both single sweep and number of groups restart averaging.

Post process:

With valid data to operate on, the post-processing functions can be used. Referring ahead to Figure 2, any function that affects the data after the error correction stage can be used. The most useful functions are trace statistics, marker searches, electrical delay offset, time domain, and gating. If a 2-port calibration is active, then any of the four S-parameters can be viewed without taking a new sweep.

Transfer data:

Lastly, read the results out of the instrument. All the data output commands are designed to ensure that the data transmitted reflects the current state of the instrument:

- `OUTPDATA`, `OUTPRAWn`, and `OUTPFORM` will not transmit data until all formatting functions have completed.
- `OUTPLIML`, `OUTPLIMM`, and `OUTPLIMF` will not transmit data until limit test has occurred, if on.
- `OUTPMARK` will activate a marker if one is not already selected, and it will make sure that any current marker searches have completed before transmitting data.
- `OUTPMSTA` makes sure that statistics have been calculated for the current trace before transmitting data. If statistics is not on, it will turn statistics on to update the current values, and then turn it off.
- `OUTPMWID` makes sure that a bandwidth search has been executed for the current trace before transmitting data. If bandwidth search is not on, it will turn the search on to update the current values, and then turn it off.

Data transfer is discussed further in Examples 3A through 3C, *Data transfer using ASCII transfer format*, etc.

Example 1: Setting up a basic measurement

In general, the procedure for setting up measurements on the HP 8753B via HP-IB follows the same sequence as if the setup was performed manually. There is no required order, as long as the desired frequency range, number of points and power level is set prior to performing the calibration.

This example illustrates how a basic measurement can be set up on the HP 8753B. The sequence will be to first select the desired S-parameter, the measurement format, and then the frequency range. Performing calibrations is described later.

By interrogating the analyzer to determine the actual values of the start and stop frequencies, the computer can keep track of the actual frequencies.

This example program is stored on the Example Programs disc as **IPG1.**

```
10  ABORT 7
20  CLEAR 716 ........................................ Prepare for HP-IB control.
30  OUTPUT 716;"PRES;" ............................... Preset the HP 8753B.
40  OUTPUT 716;"CHAN1; S11; LOGM;" ................... Make channel 1 the active channel, and
                                                       measure S11, displaying its magnitude in dB.
50  OUTPUT 716;"CHAN2; S11; PHAS;" ................... Make channel 2 the active channel, and
                                                       measure the phase of S11 on it.
60  OUTPUT 716;"DUACON;" ............................. Tell the analyzer to display both channels
                                                       simultaneously.
70  INPUT "ENTER START FREQUENCY (MHz):",F_start ..... Input a start frequency.
80  INPUT "ENTER STOP FREQUENCY (MHz):",F_stop ....... Input a stop frequency.
90  OUTPUT 716;"STAR";F_start;"MHZ;" ................. Set the start frequency to F_start.
100 OUTPUT 716;"STOP";F_stop;"MHZ;" .................. Set the stop frequency to F_stop.
110 DISP F_start, F_Stop ............................. Show the current start and stop frequencies.
120 END
```

Running the program

The program will set up a measurement of S_{11}, log magnitude on channel 1, and S_{11}, phase on channel 2, and turn on the dual channel display mode. When prompted for start and stop frequencies, enter any value in MHz from 0.3 (300 kHz) to 3 GHz. These will be entered into the HP 8753B, and the frequencies are then displayed.

Performing a measurement calibration

This section will demonstrate how to coordinate a measurement calibration over HP-IB. The HP-IB command sequence follows the key sequence required to calibrate from the front panel: there is a command for every step.

The general key sequence is to select the calibration, measure the calibration standards, and then declare the calibration done. The actual sequence depends on the calibration kit and changes slightly for 2-port calibrations, which are divided into three calibration sub-sequences.

Calibration kits

The calibration kit tells the HP 8753B what standards to expect at each step of the calibration. The set of standards associated with a given calibration is termed a class. For example, measuring the short during an S_{11} 1-port calibration is one calibration step. All of the shorts that can be used for this calibration step make up the class, which is called class $S_{11}B$. For the 7 mm and the 3.5 mm cal kits, class $S_{11}B$ has only one standard in it. For type-N cal kits, class $S_{11}B$ has two standards in it: male and female shorts.

When doing an S_{11} 1-port calibration in 7 or 3.5 mm, selecting *[SHORT]* automatically measures the short because there is only one standard in the class. When doing the same calibration in type-N, selecting *[SHORTS]* brings up a second menu, allowing the user to select which standard in the class is to be measured. The sex listed refers to the test port: if the test port is female, then the user selects the female short option.

Doing an S_{11} 1-port calibration over HP-IB is very similar. In 7 or 3.5 mm, sending `CLASS11B` will automatically measure the short. In type-N, sending `CLASS11B` brings up the menu with the male and female short options. To select a standard, use `STANA` or `STANB`. The `STAN` command is appended with the letters A through G, corresponding to the standards listed under softkeys 1 through 7, softkey 1 being the topmost softkey.

The `STAN` command is OPC'able. A command that calls a class is only OPC'able if that class has only one standard in it.

If there is more than one standard in a class, the command that calls the class only brings up another menu, and there is no need to OPC it.

Hence, both the manual and HP-IB calibration sequences depend heavily on which calibration kit is active.

Full 2-port calibrations

Each full 2-port measurement calibration is divided into three sub-sequences: transmission, reflection, and isolation. Each subsequence is treated like a calibration in its own right: each must be opened, have all the standards measured, and then be declared done.

The opening and closing statements for the transmission sub-sequence are `TRAN` and `TRAD`. The opening and closing statements for the reflection sub-sequence are `REFL` and `REFD`. The opening and closing statements for isolation are `ISOL` and `ISOD`.

Example 2A: S_{11} 1-port calibration

To demonstrate coordinating a calibration over HP-IB, the following program does an S_{11} 1-port calibration, using the HP 85032B 50 ohm type-N calibration kit. This program simplifies the calibration for the operator by giving explicit directions on the HP 8753B display, and allowing the user to continue the program from the HP 8753B front panel.

This example program is stored on the Example Programs disc as **IPG2A**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare for HP-IB control.
`30 OUTPUT 716;"CALKN50;MENUOFF;CLES;ESE64;"`	This is the minimum instrument set up: the 50 ohm type-N cal kit is selected, the softkey menu is turned off, and the status reporting system is set up so that bit 6, User Request, of the event status register, is summarized by bit 5 of the status byte. This allows us to detect a key press with a serial poll. Refer to Appendix A.
`40 OUTPUT 716;"CALIS111;"`	Open the calibration by calling the S_{11} 1-port calibration.
`50 CALL Waitforkey("CONNECT LOAD AT PORT 1")`	Now ask for the load, and wait for the operator. The Waitforkey subroutine will not return until the operator presses a key on the front panel of the HP 8753B.
`60 OUTPUT 716;"OPC?;CLASS11C;"`	There is only one choice in this class, so the CLASS command is OPC'able. Using the OPC? command causes the program to wait until the standard has been measured before continuing. This is very important, because the prompt to connect the next standard should only appear after the first standard is measured.
`70 ENTER 716;Reply`	Wait until the HP 8753B is done with the standard.
`80 CALL Waitforkey("CONNECT OPEN AT PORT 1")`	Ask for an open, and wait for the operator to connect it.
`90 OUTPUT 716;"CLASS11AOPC?;STAN;"`	Measure the open. There is more than one standard in this loads class, so we must identify the specific standard within that class. The female open is the second softkey selection from the top in the menu, so select a lowband load as the standard using the command `STANB`.
`100 ENTER 716;Reply`	Wait for the standard to be measured.
`110 CALL Waitforkey("CONNECT SHORT LOAD AT PORT 1")`	Have the operator connect the short and wait for his reply.

```
120 OUTPUT 716;"CLASS11B:OPC?;STANB;"
```

There is more than one standard in the short class, too. The specific standard is the female short, or STAN B. Measure the short.

```
130 ENTER 716;Reply
```

Wait for the standard to be measured.

```
140 OUTPUT 717;"PG;"
```

The PG command sent to the display clears the user graphics, removing the last prompt.

```
150 DISP "COMPUTING CALIBRATION COEFFICIENTS"
160 OUTPUT 716;"DONE;OPC?;SAV1;"
```

Affirm the completion of the calibration, and save the calibration.

```
170 ENTER 716;Reply
```

Wait until the HP 8753B is done calculating the calibration coefficients before allowing the program to go on.

```
180 DISP "S11 1-
    PORT CAL COMPLETED. CONNECT TEST DEVICE."
190 OUTPUT 716;"MENUON;"
```

The calibration is completed, so turn the soft key menu back on.

```
200 END
210 SUB Waitforkey(Lab$)
```

This subroutine displays the passed message on the HP 8753B, and waits for the operator to press a key. It assumes that bit 6, User Request, of the event status register has been enabled.

```
220 DISP Lab$
```

First, display a message on the computer in case the operator has returned to the computer keyboard.

```
230 OUTPUT 717;"PG;PU;PA390,3600;PD;LB";Lab$;", PRESS
    ANY KEY WHEN READY;"
```

This statement writes on the HP 8753B's display. PG (page) clears old user graphics. PU (pen up) prevents anything from being drawn. PA390,3600; moves the logical pen to just above the message area on the display. PD (pen down) enables drawing. LB (label) writes the message on the display. The label command is terminated with an ETX symbol, which is **[CTRL] [C]** (pressed simultaneously) on the keyboard.

```
240 CLEAR 716
```

Clear the message line on the HP 8753B.

```
250 OUTPUT 716;"ESR?;"
```

Clear the latched User Request bit so that old key presses will not trigger a measurement.

```
260 ENTER 716;Estat
270 Stat=SPOLL(716)
```

Now wait for a key press to be reported.

```
280 IF NOT BIT(Stat,5) THEN GOTO 340
290 SUBEND
```

Running the program

The program assumes that the port being calibrated is a 50 ohm, type-N female test port. The prompts appear just above the message line on the HP 8753B display. Pressing any key on the front panel of the HP 8753B continues the program and measures the standard. The program will display a message when the measurement calibration is complete.

Before running the program, set up the desired instrument state. This program does not modify the instrument state in any way. Run the program, and connect the standards as prompted. When the standard is connected, press any key on the HP 8753B's front panel to measure it.

Example 2B: Full 2-port measurement calibration

The following example shows how to perform a full 2-port measurement calibration using the HP 85032B calibration kit. The main difference between this example and Example 2A is that in this case, the calibration process allows removal of both the forward and reverse error terms, so that all four S-parameters of the device under test can be measured. Port 1 is a female test port and Port 2 is a male test port.

This example program is stored on the Example Programs disc as **IPG2B**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare for HP-IB control.
`30 OUTPUT 716;"CALKN50;MENUOFF;CLES;ESE64;"`	This is the minimum instrument set up: the 50 ohm type-N kit is selected, the softkey menu is turned off, and the status reporting system is set up so that bit 6, User Request, of the event status register, is summarized by bit 5 of the status byte. This allows us to detect a key press with a serial poll. Refer to Appendix A.
`40 OUTPUT 716;"CALIFUL2;"`	Open the calibration by calling for a full 2-port calibration.
`50 OUTPUT 716;"REFL;"`	Open the reflection calibration subsequence.
`60 CALL Waitforkey("CONNECT OPEN AT PORT 1")`	Now ask for the open, and wait for the operator. The Waitforkey subroutine will not return until the operator presses a key on the front panel of the HP 8753B.
`70 OUTPUT 716;"CLASS11A;OPC?;STANB;"`	There is more than one standard in the open class, so we must identify the specific standard within that class. The female open selection is the second softkey from the top in the menu, so we select a broadband load as the standard using the command `STANB`.
`80 ENTER 716;Reply`	Wait until the HP 8753B is done with the standard.
`90 CALL Waitforkey("CONNECT SHORT AT PORT 1")`	Ask for a short, and wait for the operator to connect it.
`100 OUTPUT 716;"CLASS11B;OPC?;STANB;"`	Measure the short.
`110 ENTER 716;Reply`	Wait for the standard to be measured.
`120 CALL Waitforkey("CONNECT BROADBAND LOAD AT PORT 1")`	Have the operator connect the broadband load, and wait for his reply.
`130 OUTPUT 716;"OPC?;CLASS11C;"`	There is only one choice in this class, so the `CLASS` command is OPC'able. Using the `OPC?` command causes the program to wait until the standard has been measured before continuing. This is very important, because the prompt to connect the next standard should only appear after the first standard is measured.
`140 ENTER 716;Reply`	Wait for the standard to be measured.
`150 CALL Waitforkey("CONNECT OPEN AT PORT 2")`	Ask for the male open for port 2, and wait for the operator.
`160 OUTPUT 716;"CLASS22A;OPC?;STANA;"`	Measure the open.
`170 ENTER 716;Reply`	Wait until the HP 8753B is done with the standard.
`180 CALL Waitforkey("CONNECT SHORT AT PORT 2")`	Ask for a male short, and wait for the operator to connect it.
`190 OUTPUT 716;"CLASS22B;OPC?;STANA;"`	Measure the short.
`200 ENTER 716;Reply`	Wait for the standard to be measured.
`210 CALL Waitforkey("CONNECT LOAD AT PORT 2")`	Have the operator connect the load, and wait for his reply.

`220 OUTPUT 716;"OPC?;CLASS22C;"`	Measure the load.
`230 ENTER 716;Reply`	Wait for the standard to be measured.
`240 OUTPUT 716;"REFD;"`	Close the reflection calibration subsequence.
`250 DISP "COMPUTING REFLECTION CALIBRATION COEFFICIENTS"`	
`260 OUTPUT 716;"TRAN;"`	Open the transmission calibration subsequence.
`270 CALL Waitforkey("CONNECT THRU [PORT 1 TO PORT 2]")`	
`280 DISP "MEASURING FORWARD TRANSMISSION")`	
`290 OUTPUT 716;"OPC?;FWDT;"`	Measure forward transmission.
`300 ENTER 716;Reply`	
`310 OUTPUT 716;"OPC?;FWDM;"`	Measure forward load match.
`320 ENTER 716;Reply`	
`330 DISP "MEASURING REVERSE TRANSMISSION")`	
`340 OUTPUT 716;"OPC?;REVT;"`	Measure reverse transmission.
`350 ENTER 716;Reply`	
`360 OUTPUT 716;"OPC?;REVM;"`	Measure reverse load match.
`370 ENTER 716;Reply`	
`380 OUTPUT 716;"TRAD;"`	Close the transmission calibration subsequence.
`390 INPUT "SKIP ISOLATION CAL? Y OR N.", An$`	Ask operator if the isolation cal should be skipped.
`400 "IF An$="Y" THEN`	If the answer is yes, skip the isolation cal and branch to the computation of the calibration coefficients.
`410 OUTPUT 716;"OMII;"`	
`420 GOTO 520`	
`430 END IF`	
`440 CALL Waitforkey("ISOLATE TEST PORTS")`	Ask operator to isolate the test ports.
`450 OUTPUT 716;"ISOL;AVERFACT10;AVEROON;"`	Open the isolation calibration subsequence. Turn on averaging with an averaging factor of 10 for the isolation cal.
`460 DISP "MEASURING REVERSE ISOLATION"`	
`470 OUTPUT 716;"OPC?;REVI;"`	Measure reverse isolation.
`480 ENTER 716;Reply`	
`490 DISP "MEASURING FORWARD ISOLATION"`	
`500 OUTPUT 716;"OPC?;FWDI;"`	Measure forward isolation.
`510 ENTER 716;Reply`	
`520 OUTPUT 716;"ISOD;AVEROOFF;"`	Close the isolation calibration subsequence and turn off averaging.
`530 OUTPUT 717;"PG;"`	The PG command sent to the display clears the user graphics, removing the last prompt.
`540 DISP "COMPUTING CALIBRATION COEFFICIENTS"`	
`550 OUTPUT 716;"OPC?;SAV2;"`	
`560 ENTER 716;Reply`	Wait until the HP 8753B is done calculating the calibration coefficients before allowing the program to go on.
`570 DISP "DONE FULL 2-PORT CAL. CONNECT TEST DEVICE."`	
`580 OUTPUT 716;"MENUON;"`	The calibration is completed, so turn the soft key menu back on.
`590 END`	
`600 SUB Waitforkey(Lab$)`	This subroutine displays the passed message on the HP 8753B, and waits for the operator to press a key. It assumes that bit 6, User Request, of the event status register has been enabled.
`610 DISP Lab$`	First, display a message on the computer in case the operator has returned to the computer keyboard.

`620 OUTPUT 717;"PG;PU;PA390,3600;PD;LB";Lab$;", PRESS ANY KEY*;"`	This statement writes on the HP 8753B's display. `PG` (page) clears old user graphics. `PU` (pen up) prevents anything from being drawn. `PA390,3600;` moves the logical pen to just above the message area on the display. `PD` (pen down) enables drawing. `LB` (label) writes the message on the display. The label command is terminated with an ETX symbol, which is **[CTRL] [C]** (pressed simultaneously) on the keyboard.
`630 CLEAR 716`	Clear the message line on the HP 8753B.
`640 OUTPUT 716;"ESR?;"`	Clear the latched User Request bit so that old key presses will not trigger a measurement.
`650 ENTER 716;Estat`	Now wait for a key press to be reported.
`660 Stat=SPOLL(716)`	
`670 IF NOT BIT(Stat,5) THEN GOTO 660`	
`680 OUTPUT 717;"PG;"`	Clear the prompt from the display.
`690 SUBEND`	

Running the program

The program assumes that the test ports being calibrated are type-N, port 1 being a female test port and port 2 being a male test port. The HP 85032B 50 ohm type-N calibration kit is to be used. The prompts appear just above the message line on the HP 8753B display. Pressing any key on the front panel of the HP 8753B continues the program and measures the standard. The operator has the option of omitting the isolation cal. If the isolation cal is performed, averaging is automatically employed to ensure a good calibration. The program will display a message when the measurement calibration is complete.

Before running the program, set up the desired instrument state. This program does not modify the instrument state in any way. Run the program, and connect the standards as prompted. When the standard is connected, press any key on the HP 8753B's front panel to measure it.

Data transfer from analyzer to computer

Using markers to obtain trace data at specific points

Trace information can be read out of the HP 8753B in several ways. Data can be read off the trace selectively using the markers, or the entire trace can be read out. If only specific information such as a single point off the trace or the result of a marker search is needed, the marker output command can be used to read the information. If all the trace data is needed, see Examples 3A thru 3C.

To get data off the trace using the marker, the marker first has to be put at the frequency desired. This is done with the marker commands. For example, execute:

```
OUTPUT 716;"MARK1  1.56 GHZ;"
```

This places marker one at 1.56 GHz. If the markers are in continuous mode, the marker value will be linearly interpolated from the two nearest points if 1.5600 GHz was not sampled. This interpolation can be prevented by putting the markers into discrete mode. The key sequence for this is **[LOCAL] [MKR]** *[MARKER MODE MENU] [MARKERS:DISCRETE]*. To do it over HP-IB, execute:

```
OUTPUT 716;"MARKDISC;"
```

After executing this, note that the marker is may no longer be precisely on 1.56 GHz. (This depends on the start and stop frequencies).

Another way of using the markers is to let the HP 8753B pick the stimulus value on the basis of one of the marker searches: max, min, target value, or bandwidths search. For example, execute:

```
OUTPUT 716;"SEAMAX;"
```

This executes a one-time trace search for the trace maximum, and puts the marker at that maximum. In order to continually update the search, turn tracking on. The key sequence is **[MKR FCTN]** *[MKR SEARCH] [TRACKING] [SEARCH: MAX]*. To do it over HP-IB, execute:

```
OUTPUT 716;"TRACKON;SEAMAX;"
```

The trace maximum search will stay on this time, until search is turned off, tracking is turned off, or all markers are turned off. For example, execute:

```
OUTPUT 716;"MARKOFF;"
```

Marker data is read out with the command `OUTPMARK`. This command causes the HP 8753B to transmit three numbers: marker value 1, marker value 2, and marker stimulus value. In this case we get the log magnitude at marker 1, zero, and the marker frequency. See Table 1 for all the different possibilities for values one and two. The third value is frequency in this case, but it could have been time as in time domain (option 010 only) or CW time.

Table 1. Units as a Function of Display Format.

DISPLAY FORMAT	MARKER MODE	OUTPMARK value 1, value 2	OUTPFORM value 1, value 2	MARKET READOUT** value, aux value
LOG MAG		dB,*	dB,*	dB,*
PHASE		degrees,*	degrees,	degrees,*
DELAY		seconds,*	seconds,*	seconds,*
SMITH CHART	LIN MKR	lin mag, degrees	real, imag	lin mag, degrees
	LOG MKR	dB, degrees	''	dB, degrees
	Re/Im	real, imag	''	real, imag
	R + jX	real, imag ohms	''	real, imag ohms
	G + jB	real, imag Siemens	''	real, imag Siemens
POLAR	LIN MKR	lin mag, degrees	real, imag	lin mag, degrees
	LOG MKR	dB, degrees	''	dB, degrees
	Re/Im	real, imag	''	real, imag
LIN MAG		lin mag,*	lin mag,*	lin mag,*
REAL		real,*	real,*	real,*
SWR		SWR,*	SWR,*	SWR,*

* Value not significant in this format, but is included in data transfers.

** The marker readout values are the marker values displayed in the upper left hand corner of the display. They also correspond to the value and aux value associated with the fixed marker.

Type **SCRATCH** and press [EXECUTE]. Type **EDIT** and press **[EXECUTE]**, and then type in the following program:

Program	Description
`10 OUTPUT 716;"SEAMIN;OUTPMARK;"`	Have the HP 8753B search out the trace minimum, and then output the marker values at that point.
`20 ENTER 716;Val1,Val2,Stim`	Read marker value 1, marker value 2, and the stimulus value.
`30 DISP Val1,Val2,Stim`	Display the values.
`40 END`	

Run the program. The values displayed by the computer should agree with the marker values displayed on the HP 8753B, except that the second value displayed by the computer will be meaningless in phase and log mag formats. To see the possibilities for different values, run the program three times: once in log magnitude format, once in phase format, and once in Smith chart format. To change display format, press **[LOCAL] [FORMAT]** and then select the desired format.

Trace transfer

Getting trace data out of the HP 8753B with a 200/300 series computer can be broken down into three steps:

1. Setting up the receive array.
2. Telling the HP 8753B to transmit the data.
3. Accepting the transferred data.

Data inside the HP 8753B is always stored in pairs, to accommodate real/imaginary pairs, for each data point. Hence, the receiving array has to be two elements wide, and as deep as the number of points. This memory space for this array must be declared before any data is to be transfered from the HP 8753B to the computer.

The HP 8753B can transmit data over HP-IB in four different formats. The type of format affects what kind of data array is declared (real or integer), since the format determines what type of data is transferred. Examples for data transfers using different formats are given below. The first, Example 3A, illustrates the basic transfer using form 4, an ASCII transfer. For more information on the various data formats, see the section entitled *Data Formats.* For information on the various types of data that can be obtained (raw data, corrected data and so on), see the section entitled *Data Levels.*

Note that Example 9, *Reading disc files into a computer,* allows the operator to access disc files from a computer.

Example 3A: Data transfer using form 4 (ASCII transfer)

As detailed in the *Quick Reference Guide,* when form 4 is used, each number is sent as a 24 character string, each character being a digit, sign, or decimal point. Since there are two numbers per point, a 201 point transfer in form 4 takes 9,648 bytes. An example simple data transfer using form 4, an ASCII data transfer is shown in this program.

This example program is stored on the Example Programs disc as **IPG3A**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare for HP-IB control.
`30 OUTPUT 716;"PRES;"`	Preset the analyzer.
`40 DIM Dat(1:11,1:2)`	This line sets up an array to receive the data. The `ENTER 716;Dat(*)` statement in line 60 fills the array `Dat` automatically, changing the second subscript fastest. Since the HP 8753B transmits the data as ordered pairs, we make the second dimension two so that the pairs will be properly grouped. The number of points will be set to 11, so we know to make the first dimension 11.
`50 OUTPUT 716;"POIN 11;SING;FORM4;OUTPFORM;"`	Set the number of points, tell the HP 8753B to use ASCII transfer format, and request the formatted trace data. Frequency information is not included in the transfer.
`60 ENTER 716;Dat(*)`	The computer takes the data from the instrument and puts it in the receiving array. By specifying `Dat(*)`, we have told the enter statement to fill every location in the array.
`70 DISP DAT(1,1),DAT(1,2)`	This line checks the first data point received. The data is in the current HP 8753B display format: see Table 1 for the contents of the array as a function of display format.
`80 END`	

Running the program

The first number of the result is a trace value in dB, and the second is zero. Put a marker at 300 kHz, which was the first point transmitted, to see that the values displayed by the computer agree with the HP 8753B. Keep in mind that no matter how many digits are displayed, the HP 8753B is specified to measure magnitude to a resolution of .001 dB, phase to a resolution of .01 degrees, and group delay to a resolution of .01 psec.

Changing the display format will change the data sent with the `OUTPFORM` transfer. See Table 1 for a list of what data is provided with what formats. The data from `OUTPFORM` reflects all the post processing such as time domain, gating, electrical delay, trace math, and smoothing. Note that if time domain (option 010 only) is on, operation is limited to 201 points in the lowpass mode.

Relating the data from a linear frequency sweep to frequency can be done by interrogating the start frequency, the frequency span, and the number of points. Given that information, the frequency of point N in a linear frequency sweep is just:

$$F = Start\_frequency + (N-1) \times Span/(Points-1)$$

Alternatively, it is possible to read the frequencies directly out of the instrument with the `OUTPLIML` command. `OUTPLIML` reports the limit test results by transmitting the stimulus point tested, a number indicating the limit test results, and then the upper and lower limits at that stimulus point, if available. The number indicating the limit results is a −1 for no test, 0 for fail, and 1 for pass. If there are no limits available, the HP 8753B transmits zeros.

For this example, we throw away the limit test information and keep the stimulus information. Edit line 40 to read:

```
40  DIMDat(1:11,1:2),Stim(1:11)
```

And type in:

```
70  OUTPUT716;"OUTPLIML;" ........  Request the limit test results.
80  FORI=1TO11 ........  Loop 11 times to read in all 11 data points.
90  ENTER716;Stim(I),Reslt,Upr,Lwr ........  Read the stimulus values in, throw the rest away.
                                              Because we are not loading the data into a single
                                              array, it is necessary to loop and read every point.
100 PRINTStim(I),Dat(I,1),Dat(I,2) ........  Print the data value and stimulus value.
110 NEXTI
120 DISPReslt,Upr,Lwr ........  Show what the last limit test result was, just to
                                 see what came out.
130 END
```

Running this program will print out all the trace data and the stimulus values. Put the instrument into a log frequency sweep by pressing **[LOCAL] [MENU]** *[SWEEP TYPE MENU] [LOG FREQ]*, and run the program again. If you define a list frequency table with 11 points, this program will still show the sampled frequencies. If you define a limit test table, `Reslt` will hold the limit test results.

Data levels

Different levels of data can be read out of the instrument. Referring to the data processing chain in Figure 2, there is available:

- Raw data. The basic measurement data, reflecting the stimulus parameters, IF averaging, and IF bandwidth. If a full 2-port measurement calibration is on, there are actually four raw arrays kept: one for each raw S-parameter. The data is read out with the commands `OUTPRAW1`, `OUTPRAW2`, `OUTPRAW3`, `OUTPRAW4`. Normally, only raw 1 is available, and it holds the current parameter. If a 2-port calibration is on, the four arrays refer to S_{11}, S_{21}, S_{12}, and S_{22} respectively. This data is in real/imaginary pairs.
- Error Corrected data. This is the raw data with error correction applied. The array is for the currently measured parameter, and is in real/imaginary pairs. The error corrected data is read out with `OUTPDATA`. `OUTPMEMO` reads the trace memory if available, which is also error corrected data. Note that neither raw nor error corrected data reflect such post-processing functions as electrical delay offset, trace math, or time domain gating.
- Formatted data. This is the array of data actually being displayed. It reflects all post-processing functions such as electrical delay or time domain, and the units of the array read out depends on the current display format. See Table 1 for the various units as a function of display format.
- Calibration coefficients. The results of a calibration are arrays of calibration coefficients which are used in the error correction routines. Each array corresponds to a specific error term in the error model. The *Quick Reference Guide* details which error coefficients are used for specific calibration types, and which arrays those coefficients are to be found in. Not all calibration types use all 12 arrays. The data is stored as real/imaginary pairs.

Formatted data is the most generally useful data, being the same information an operator sees on the display. However if the post processing is unneeded or unwanted, as may be the case with smoothing, error corrected data is more desirable. Error corrected data also gives you the opportunity to put the data into the instrument and apply post-processing at a later time.

As an example of error corrected data, change line 50 to:

```
50  OUTPUT716;"POIN11;SING;FORM4;
    OUTPDATA;"
```

Running the program now displays real and imaginary trace data, regardless of what display format is currently being used. Select the real display format to verify that the data is indeed the real portion.

Data formats

As stated earlier, the HP 8753B can transmit data over HP-IB in four different formats. Until now, we have been using form 4, an ASCII data transfer. Another option is to use form 3, which is the IEEE 64 bit floating point format. In this mode, each number takes only 8 bytes instead of 24. This means that a 201 point transfer takes only 3,216 bytes. This mode is particularly attractive since data is stored internally in the 200/300 series computer with the IEEE 64 bit floating point format, removing the need for any reformatting by the computer.

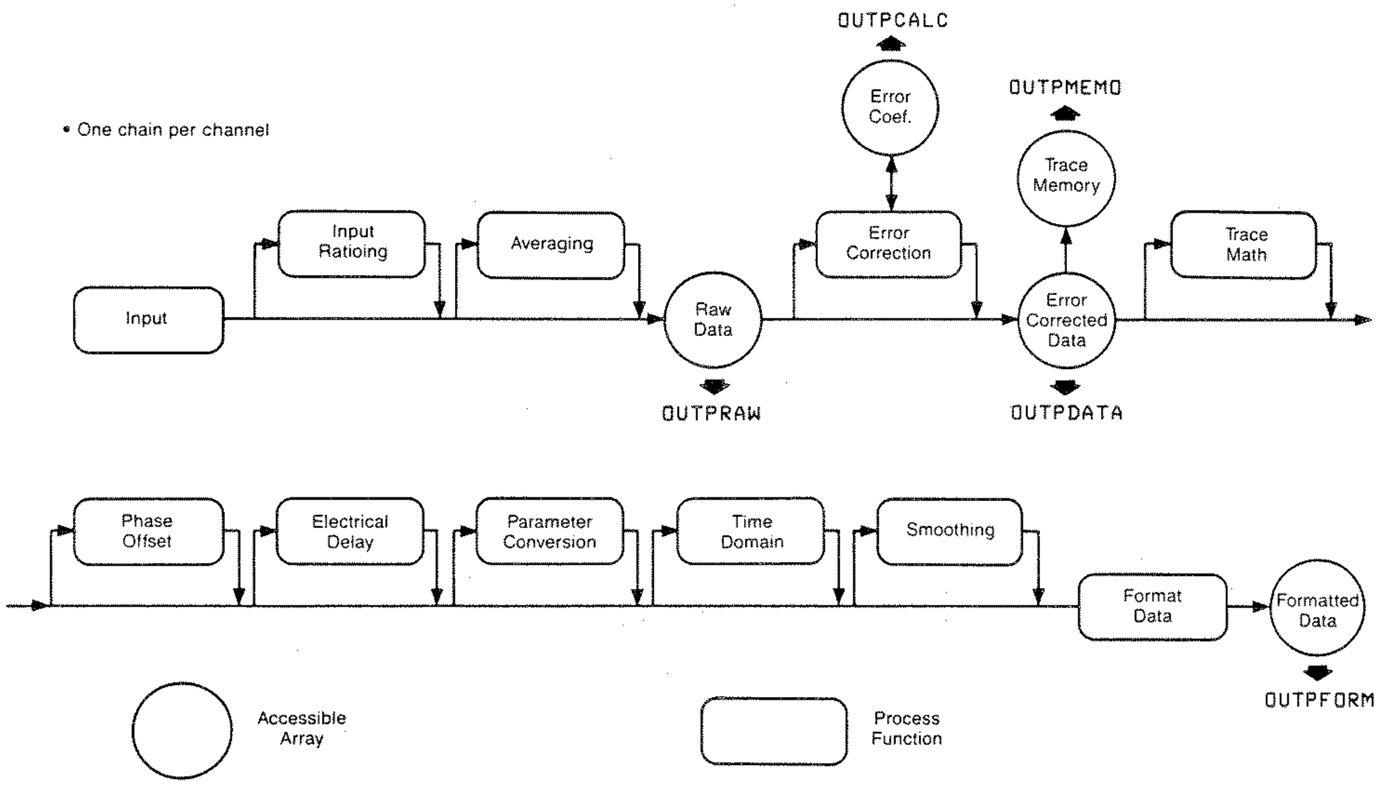

Figure 2. Data processing chain.

Example 3B: Data transfer using form 3 (IEEE 64 bit floating point format)

Example program 3B illustrates data transfer using form 3, in which data is transmitted in the IEEE 64 bit floating point format.

To use form 3, the computer is told to stop formatting the incoming data with the `ENTER` statement. This is done by defining an I/O path with formatting off. Form 3 also has a four byte header to deal with. The first two bytes are the ASCII characters "#A" that indicate that a fixed length block transfer follows, and the next two bytes form an integer containing number of bytes in the block to follow. The header must read in so that data order is maintained.

This example program is stored on the Example Programs disc as **IPG3B**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare for HP-IB control.
`30 DIM Dat(1:201,1:2)`	As before, prepare the receiving array.
`40 INTEGER Hdr,Lgth`	Since an integer takes two bytes, `Hdr` and `Lgth` will take care of the four byte header. `Lgth` will hold the number of bytes in the data block.
`50 ASSIGN @Dt TO 716;FORMAT OFF`	This statement defines a data I/O path with ASCII formatting off. The I/O path points to the HP 8753B, and can be used to read or write data to the instrument, as long as that data is in binary rather than ASCII format.
`60 OUTPUT 716;"SING;FORM3;OUTPFORM;"`	The analyzer is told to output formatted data using form 3.
`70 ENTER @Dt;Hdr,Lgth,Dat(*)`	The data is read in much as before, but the I/O path has format off to accept the binary data from form 3. The HP 8753B and the computer must be in agreement as to the format of the data being transmitted.
`80 DISP Lgth,Dat(1,1),Dat(1,2)`	
`90 END`	

Running the program

Preset the instrument and run the program. The computer displays 3,216 and the trace values at 300 kHz. The number 3,216 comes from 201 points, 2 values per point, 8 bytes per value. Note that this transfer is much faster than a form 4 transfer: more than twice as fast.

To illustrate a point, go to the instrument and press **[LOCAL] [MENU]** *[NUMBER of POINTS]*, and key in **101 [x1]**. Now run the program again: a BASIC error will be generated because the HP 8753B ran out of data to transmit before the variable list was full.

Go to the instrument again, and this time change the number of points to 401. Running the program again does not generate an error, but not all of the data was read in. The HP 8753B is still waiting to transmit data, but the program has not been designed to detect the situation.

As illustrated above, it is imperative that the receiving array be correctly dimensioned. There are two things that assure correct dimensions. First, the number of points is readily available through `POIN?` or through the header that precedes forms 1, 2 and 3. Second, BASIC allows dimensioning, redimensioning, allocating, and deallocating statements anywhere in a program. We can take advantage of this in simple programs to wait until we know how many points to expect before we dimension.

BASIC offers two options to those who want to dimension an array with a variable expression, such as the number of points in the sweep. One is the `REDIM` statement, available with AP2—1 or the MAT binary, which redimensions a given array to any size less than or equal to its originally dimensioned size. The other option is to `ALLOCATE` the array just before using it, and `DEALLOCATE` when it's no longer needed. `ALLOCATE` works exactly like `DIM`, except that when you deallocate, the memory space is returned to general use and you can re-use the variable name. All of the following examples use `ALLOCATE`.

For example, delete line 30 and type in the following lines over the last program:

```
70  ENTER@Dt;Hdr,Lgth
80  ALLOCATE Dat(1:Lgth/16,1:2) ........ This guarantees that the receiving array is the
                                          correct size. In form 3, each number is 8
                                          bytes, and there are two numbers per point,
                                          so we divide Lgth by 16 to get number of
                                          points.
90  ENTER@Dt;Dat(*)
100 DISP Dat(Lgth/16,1) ................ Display the last number read in.
110 END
```

Set the number of points to 51 and run the program: this time no errors are generated. Set the number of points to 401, and run the program again. Move a marker to the last point on the trace, and check to see that the last point read in was the last point on the trace, as expected.

There are two other formats available. Form 2 is not used with 200/300 computers, and form 1 is a special high speed transfer. Form 1 is a condensed transfer format that is useful if data is being transferred out of the HP 8753B for direct storage and later re-transmission to the HP 8753B. Example 3C gives an example of a data transfer using form 1.

Example 3C: Data transfer using form 1 (HP 8753B internal format)

In form 1, each data point is sent out as it is stored inside the HP 8753B, in a six byte binary string. Hence, it is a very fast transfer, using only 1206 bytes to transfer 201 points, but it is difficult to decode. (Real/imaginary data uses the first two bytes for the imaginary fraction mantissa, the middle two bytes for the real fraction mantissa, the fifth byte is used for additional resolution when transferring raw data, and the last byte as the common power of two). The data could be recombined and displayed in the computer, but this requires significant reformatting time.

In this example, we use form 1 to get data to store on disc. Before running this program, be sure that the mass storage device is a disc drive with a formatted disc in it. We also introduce a method of loading data back into the HP 8753B. For most `OUTPxxxx` commands, there is a corresponding `INPUxxxx` command, and here we take advantage of that to load error corrected data back into the instrument.

This example program is stored on the Example Programs disc as **IPG3C**.

```
10  ABORT 7
20  CLEAR 716 .......................... Prepare for HP-IB control.
30  INTEGER Hdr,Lgth ................... Set up to integers to take the header, the same
                                          as with form 3.
40  ASSIGN @Dt TO 716;FORMAT OFF
50  OUTPUT 716;"SING;FORM1;OUTPDATA;" .. Now we have the HP 8753B take a sweep, and
                                          prepare to transmit the trace data to the com-
                                          puter.
```

`60 ENTER @Dt;Hdr,Lgth`	
`70 CREATE BDAT "TESTDATA",1,Lgth+4`	This statement creates a disc file to store the form 1 data in. It creates a binary data file name `TESTDATA`. The file is 1 record long, using a record length of Lgth+4 bytes. The extra 4 bytes are for the header. This example will not run unless `MASS STORAGE IS` points to a disc drive with a formatted disc it, and that disc cannot have a file named `TESTDATA` on it.
`80 ASSIGN @Disc TO "TESTDATA"`	This statement creates a data I/O path pointing to the file `TESTDATA`.
`90 ALLOCATE INTEGER Dat(1:Lgth/6,1:3)`	We create an integer receiving array. There are six bytes per point in form 1, so allocating 3 integers per point will hold the data correctly, since an integer is two bytes.
`100 ENTER @Dt;Dat(*)`	The data is received much as before.
`110 OUTPUT @Disc;Hdr,Lgth,Dat(*)`	Write the data to the disc drive.
`120 INPUT "CHANGE TRACE AND HIT RETURN",Dum$`	At this point, disconnect the test device, and take a sweep. We will then go on to read the data off the disc, and put it back in the instrument.
`130 OUTPUT 716;"SING;"`	Take one sweep and hold.
`140 ASSIGN @Disc TO "TESTDATA"`	Re-establish the data path. This is necessary in order to begin reading data from the start of the file, rather than the end of the file where the file pointer was left by line 110.
`150 ENTER @Disc;Hdr,Lgth,Dat(*)`	Get the information.
`160 OUTPUT 716;"INPUDATA"`	
`170 OUTPUT @Dt;Hdr,Lgth,Dat(*)`	And copy it out to the HP 8753B.
`180 ASSIGN @Disc TO *`	Close the file.
`190 DEALLOCATE Dat(*)`	Release the memory for the data array.
`200 PURGE "TESTDATA"`	And purge the data file.
`210 END`	

Running the program

Preset the HP 8753B, and run the program. When the program pauses press **[LOCAL]**, change the trace, and press **[RETURN]**. When the data is reloaded into the HP 8753B, it will be formatted and displayed as the current trace. Note that this form of data transfer is even faster than the transfer using form 3.

Advanced Programming Examples

Using list frequency mode

The HP 8753B normally takes data points spaced at regular intervals across the overall frequency range of the measurement. For example, for a 2 GHz frequency span, using 201 points, data will be taken at intervals of 10 MHz. The list frequency mode allows the operator to select the specific points or frequency spacing between points at which measurements are to be made. This mode of operation allows flexibility in setting up tests to ensure device performance in an efficient manner. By only sampling specific points, measurement time is reduced, since additional time is not spent measuring device performance at frequencies which are of no concern.

The following two examples illustrate the use of the HP 8753B's list frequency mode to perform arbitrary frequency testing. Example 4A lets the operator construct a table of list frequency segments which is then loaded into the HP 8753B's list frequency table. Each segment stipulates a start and stop frequency, and the number of data points to be taken over that frequency range. Example 4B lets the operator select a specific segment to "zoom-in" on. A single instrument can thus be ready to measure several different devices, each with its own frequency range, using a single calibration performed with all of the segments active. When a specific device is connected, the operator selects the appropriate segment for that device. Note that list frequency segments can be overlapped, but the total number of points in all the segments must not exceed 1632 points.

Example 4A: Setting up a list frequency sweep

The purpose of this example is to show how to create a list frequency table and transmit it to the HP 8753B.

The command sequence for entering a list frequency table imitates the key sequence followed when entering a table from the front panel: there is a command for every key press. Editing a segment is also the same as the key sequence, but remember the HP 8753B automatically reorders each edited segment in order of increasing start frequency.

The list frequency table is also carried as part of the learn string. While it cannot be modified as part of the learn string, it can be stored and recalled with very little effort.

This example takes advantage of the computer's capabilities to simplify creating, adding to, and editing the table. The table is entered and completely edited before being transmitted to the HP 8753B. To simplify the programming task, options such as entering center/span or step size are not included. For information on reading list frequency data out of the HP 8753B, see the section *Data transfer from analyzer to computer*.

This program is stored on the Example Programs disc as **IPG4A**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for HP-IB control
`30 OUTPUT 716;"EDITLIST;"`	Activate the frequency list edit mode.
`40 FOR I=1 to 30`	Setup a `FOR NEXT` loop.
`50 OUTPUT 716;"SDEL;"`	Delete any existing segments.
`60 NEXT I`	
`70 INPUT "Number of segments?",Numb`	Find out how many segments to expect
`80 ALLOCATE Table(1:Numb,1:3)`	Create a table to hold the segments. We only keep start frequency, stop frequency, and number of points.
`90 PRINTER IS 1`	Make sure we print on the screen.
`100 OUTPUT 2;CHR$(255)&"K";`	Clear the screen.
`110 PRINT USING "10A,10A,10A,20A";"SEGMENT","START(MHZ)", "STOP(MHZ)","NUMBER OF POINTS"`	Print the table header.
`120 FOR I=1 TO Numb`	Read in each segment.
`130 GOSUB Loadpoin`	`Loadpoin` (line 300) reads in the start frequency, stop frequency, and number of points for segment I. Since `Loadpoin` is a subroutine, I is used as a global variable.
`140 NEXT I`	
`150 LOOP`	Use the `LOOP, EXIT IF, END LOOP` structure to loop and edit the table until the operator indicates that editing is no longer desired. This structure sets up a loop with the exit point in the middle of the loop rather than at the beginning (as with `WHILE, END WHILE`), or at the end (as with `REPEAT, UNTIL`).

`160 INPUT "DO YOU WANT TO EDIT? Y OR N",An$`	Let the operator edit the table. Editing is actually re-entering the entire segment. The old segment values are left in place if the operator presses return without typing anything.
`170 EXIT IF An$="N"`	Exit the edit loop if editing is finished. Execution is continued at line 210.
`180 INPUT "ENTRY NUMBER?",I`	For editing, get the entry number.
`190 GOSUB Loadpoin`	And have `Loadpoin` re-enter the values.
`200 END LOOP`	
`210 OUTPUT 716;"EDITLIST"`	Begin the table entry by opening the list frequency table for editing. The list frequency table must be empty, or these segments will just be added on top of the old ones.
`220 FOR I=1 TO Numb`	Loop for each segment.
`230 OUTPUT 716;"SADD;STAR";Table(I,1);"MHZ;"`	
`240 OUTPUT 716;"STOP";Table(I,2);"MHZ;"`	
`250 OUTPUT 716;"POIN",Table(I,3),";"`	Enter the segment values.
`260 OUTPUT 716;"SDON;"`	Declare the segment done.
`270 NEXT I`	
`280 OUTPUT 716;"EDITDONE;LISFREQ;"`	Close the table, and turn on the list frequency mode.
`290 STOP`	
`300 Loadpoin: !`	Enter in a segment.
`310 INPUT "START FREQUENCY? (MHZ)",Table(I,1)`	
`320 INPUT "STOP FREQUENCY? (MHZ)",Table(I,2)`	
`330 INPUT "NUMBER OF POINTS?",Table(I,3)`	Enter the segment values.
`340 IF Table(I,3)=1 THEN Table(I,2)=Table(I,1)`	If only one point in the segment, make the stop frequency equal to the start frequency to avoid ambiguity.
`350 PRINT TABXY(0,I+1);I;TAB(10);Table(I,1);TAB(20); Table(I,2);TAB(30),Table`	Print the segment out. Because of the `TABXY`, this will print over old segments if a segment is being edited.
`360 RETURN`	
`370 END`	

Running the program

The program displays the frequency list table as it is entered. During editing, the displayed table is updated as each line is edited. The table is not re-ordered. At the completion of editing, the table is entered into the HP 8753B, and list frequency mode turned on. During editing, simply pressing **[RETURN]** leaves an entry at the old value.

Any segments already in the list frequency table in the HP 8753B will be deleted by the program. If this is not desired, delete lines 40 thru 60. New segments will then simply be entered on top of the old list frequency segments.

Example 4B: Selecting a single segment from a table of segments

This example program shows how a single segment can be chosen to be the operating frequency range of the HP 8753B, out of a table of segments. The program assumes that a list frequency table has already been entered into the HP 8753B, either manually, or using the program in Example 4A, *Setting up a list frequency sweep*.

The program first loads the list frequency table into the computer by reading the start and stop frequencies of each segment, and the number of points for each segment. The segments' parameters are then displayed on the computer screen, and the user can choose which segment is to be used by the analyzer. Note that only one segment can be chosen at a time.

This program is stored on the Example Programs disc as **IPG4B**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare for HP-IB control
`30 PRINTER IS 1`	Make sure we print on the screen.
`40 OUTPUT 2;CHR$(255)$"K";`	Clear the screen.
`50 PRINT USING "10A,15A,15A,20A";"SEGMENT", "START(MHZ)","STOP(MHZ)","NUMBER OF POINTS"`	Print out the table header.
`60 OUTPUT 716;"EDITLIST;SEDI30;OUTPACTI;"`	Interrogate the number of the highest segment. This allows the program to determine the number of list frequency segments.
`70 ENTER 716;Numsegs`	Read the active parameter (segment number) into the variable `Numsegs`.
`80 ALLOCATE Table(1:Numsegs,1:3)`	Create an array large enough to hold all the segment parameters.
`90 FOR I=1 to Numsegs`	This `FOR NEXT` loop calls the subroutine `Readlist` which reads in the segment parameters.
`100 GOSUB Readlist`	
`110 NEXT I`	
`120 LOOP`	Use the `LOOP` structure to allow continuous selection of the desired segment to be measured.
`130 INPUT "SELECT SEGMENT NUMBER: (0 TO EXIT)",Segment`	
`140 EXIT IF Segment=0`	Allow the operator to exit the loop by entering 0 as the segment number.
`150 OUTPUT 716;"SSEG";Segment;";EDITDONE;"`	The `SSEG` command causes the specific segment to become the new operating frequency range of the measurement.
`160 END LOOP`	
`170 OUTPUT 716;"ASEG;"`	When the loop is exited, resume operation using all list frequency segments. The `ASEG` command turns on all the segments.
`180 DISP "PROGRAM ENDED"`	
`190 STOP`	
`200 Readlist: !`	This subroutine reads out all the segment parameters.
`210 OUTPUT 716;"EDITLIST;SEDI;",I,";"`	Activate the `I` th segment.
`220 OUTPUT 716;"STAR;OUTPACTI;"`	Make the start frequency active, and output its value using the `OUTPACTI` command.
`230 ENTER 716;Table(I,1)`	Read the start frequency into the list table.
`240 OUTPUT 716;"STOP;OUTPACTI;"`	Make the stop frequency active, and output its value.
`250 ENTER 716;Table(I,2)`	Read the stop frequency value.
`260 OUTPUT 716;"POIN;OUTPACTI;"`	Make the number of points active, and output its value.
`270 ENTER 716;Table(I,3)`	Read the number of points.

`280 IF I=18 THEN INPUT "HIT RETURN FOR MORE",A$`	Stop printing when 17 segments have been listed on the display, this allows the operator to examine the first 17 segments before they are scrolled off the computer display by addition segments (remember, there are up to 30 segments).
`290 IMAGE 4D,6X,4D.6D,3X,4D.6D,3X,4D`	Specify the print format and margins for the list frequency table.
`300 PRINT USING 290;I;Table(I,1)/1.E+9;Table(I,2)/ 1.E+9;Table(I,3)`	Print out the segment parameters for the Ith segment.

```
310 RETURN
320 END
```

Running the program

The program will read the parameters for each list frequency segment from the HP 8753B, and build a table containing all the segments. The parameters of each segment will be printed on the computer screen. If there are more than 17 segments, the program will pause. Press **[RETURN]** to see more segments. The maximum number of segments that can be read is 30 (which is the maximum number of segments that the HP 8753B can hold). Use the computer's **[Prev]** and **[Next]** keys to scroll the list of segments back and forth if there are more than 17 segments.

After all the segments are displayed, the program will prompt for a specific segment to be used. Type in the number of the segment, and the HP 8753B will then "zoom-in" on that segment. The program will continue looping, allowing continuous selection of different segments. To exit the loop, type **0**. This will restore all the segments (with the command ASEG), allowing the HP 8753B to sweep all of the segments, and the program will terminate.

Using limit lines to perform PASS/FAIL tests

There are two steps to performing limit testing on the HP 8753B under HP-IB control. First, limit specifications must be specified and loaded into the analyzer. Second, the limits are activated, the device is measured, and its performance to the specified limits is signaled by a pass or fail message on the HP 8753B's display.

Example 5A illustrates the first step, setting up limits, and Example 5B performs the actual limit testing.

Example 5A: Setting up limit lines

The purpose of this example is to show how to create a limit table and transmit it to the HP 8753B.

The command sequence for entering a limit table imitates the key sequence followed when entering a table from the front panel: there is a command for every key press. Editing a limit is also the same as the key sequence, but remember that the HP 8753B automatically re-orders the table in order of increasing start frequency.

The limit table is also carried as part of the learn string. While it cannot be modified as part of the learn string, it can be stored and recalled with very little effort.

This example takes advantage of the computer's capabilities to simplify creating and editing the table. The table is entered and completely edited before being transmitted to the HP 8753B. To simplify the programming task, options such as entering offsets are not included.

This program is stored as **IPG5A** on the Example Programs disc.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for HP-IB control.
`30 OUTPUT 716;"EDITLIML;CDEL;"`	Delete any existing limits.
`40 INPUT "Number of limits?",Numb`	Find out how many limits to expect.
`50 ALLOCATE Table(1:Numb,1:3)`	Create a table to hold the limits. It will contain stimulus value (frequency), upper limit value, and the lower limit value.
`60 ALLOCATE Limtype$(Numb)[2]`	Create a string array to indicate the limit types.

`70 PRINTER IS 1`	Make sure we print on the screen.
`80 OUTPUT 2;CHR$(255)&"K";`	Clear the screen.
`90 PRINT USING "10A,20A,15A,20A";"SEG","STIMULUS(MHZ)", "UPPER (dB)","LOWER (dB)","TYPE"`	Print the table header.
`100 FOR I=1 TO Numb`	Read in each segment.
`110 GOSUB Loadlimit`	`Loadlimit` (line 310) reads in the stimulus value (frequency), upper value, lower value, and the limit type for limit `I`. Since `Loadlimit` is a subroutine, `I` is used as a global variable.
`120 NEXT I`	
`130 LOOP`	Use the `LOOP`, `EXIT IF`, `END LOOP` structure to loop and edit the table until the operator indicates that editing is no longer desired. This structure sets up a loop with the exit point in the middle of the loop rather than at the beginning (as with `WHILE`, `END WHILE`), or at the end (as with `REPEAT`, `UNTIL`).
`140 INPUT "DO YOU WANT TO EDIT? Y OR N",An$`	Let the operator edit the table. Editing is actually re-entering the entire limit. The old limit values are left in place if the operator presses return without typing anything.
`150 EXIT IF An$="N"`	Exit the edit loop if editing is finished. Execution is continued at line 190.
`160 INPUT "ENTRY NUMBER?",I`	For editing, get the entry number.
`170 GOSUB Loadlimit`	And have `Loadlimit` re-enter the values.
`180 END LOOP`	
`190 OUTPUT 716;"EDITLIML;"`	Begin the table entry by opening the limit table for editing. The limit table must be empty, or these limits will just be added on top of the old ones.
`200 FOR I=1 TO Numb`	Loop for each limit.
`210 OUTPUT 716;"SADD;LIMS";Table(I,1);"MHZ;"`	Enter the stimulus value.
`220 OUTPUT 716;"LIMU";Table(I,2);"DB;"`	Enter the upper limit value.
`230 OUTPUT 716;"LIML",Table(I,3),"DB;"`	Enter the lower limit value.
`240 IF Limtype$(I)="FL" THEN OUTPUT 716;"LIMTFL;"`	Set flat limit type.
`250 IF Limtype$(I)="SL" THEN OUTPUT 716;"LIMTSL;"`	Set sloped limit type.
`260 IF Limtype$(I)="SP" THEN OUTPUT 716;"LIMTSP;"`	Set point limit type.
`270 OUTPUT 716;"SDON;"`	Declare the limit done.
`280 NEXT I`	
`290 OUTPUT 716;"EDITDONE;LIMILINEON; LIMITESTON;"`	Close the table, display the limits, and activate limit testing.
`300 STOP`	
`310 Loadlimit: !`	Enter in a segment.
`320 INPUT "STIMULUS VALUE? (MHZ)",Table(I,1)`	
`330 INPUT "UPPER LIMIT VALUE (DB)?",Table(I,2)`	
`340 INPUT "LOWER LIMIT VALUE (DB)?",Table(I,3)`	Enter the limit values.
`350 INPUT "LIMIT TYPE" (FL=FLAT, SL=SLOPED, SP=SINGLE POINT)",Limtype$(I)`	Enter the limit type.
`360 PRINT TABXY(0,I+1);I;TAB(10);Table(I,1);TAB(30); Table(I,2);TAB(45),Table(I,3),TAB(67);Limtype$(I)`	Print the limit values out. Because of the `TABXY`, this will print over old limits if a limit is being edited.
`370 RETURN`	
`380 END`	

Running the program

The program displays the limit table as it is entered. During editing, the displayed table is updated as each line is edited. The table is not reordered. At the completion of editing, the table is entered into the HP 8753B, and limit testing mode turned on. During editing, simply pressing **[RETURN]** leaves an entry at the old value.

This example program will delete any existing limit lines before entering the new limits. If this is not desired, omit lines 30 through 50.

Example 5B: Performing PASS/FAIL tests while tuning

The purpose of this example is to demonstrate the use of the limit/search fail bits in event status register B, to determine whether a device passes the specified limits. Limits can be entered manually, or using the Example 5A.

The limit/search fail bits are set and latched when limit testing or a marker search fails. There are four bits, one for each channel for both limit testing and marker search. Their purpose is to allow the computer to determine whether the test/search just executed was successful. The sequence of their use is to clear event status register B, trigger the limit test or marker search, and then check the appropriate fail bit.

In the case of limit testing, the best way to trigger the limit test is to trigger a single sweep. By the time the `SING` command finishes, limit testing will have occurred. A second consideration when dealing with limit testing is that if the device is tuned during the sweep, it may be tuned into and then out of limit, causing a limit test pass when the device is not in fact within limits.

In the case of the marker searches (max, min, target, and widths), outputting marker or bandwidth values automatically triggers any related searches. Hence, all that is needed is to check the fail bit after reading the data.

In this example, the requirement that several sweeps in a row must pass is used in order to give confidence that the limit test pass was not extraneous due to the device settling or the operator tuning during the sweep. Upon running the program, the number of passed sweeps for qualification is entered. For very slow sweeps, a small number of sweeps such as two is appropriate. For very fast sweeps, where the device needs time to settle after tuning and the operator needs time to get away from the device, as many sweeps as six or more sweeps might be
appropriate.

A limit test table can be entered over HP-IB: the sequence is very similar to that used in entering a list frequency table and is shown in Example 5A. The manual sequence is closely followed.

This program is stored under **IPG5B** on the Example Programs disc.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for remote control.
`30 INPUT "Number of consecutive passed sweeps for qualification?",Qual`	Find out how many sweeps must pass before the device is considered to have passed the limit test.
`40 DISP "TUNE DEVICE"`	Tell operator to begin tuning.
`50 Reap=0`	`Reap` is a counter holding how many sweeps have passed the limit test.
`60 OUTPUT 716;"OPC?;SING;"`	Take a sweep. When it is done, limit test will have occurred.
`70 ENTER 716;Reply`	Wait for the end of the sweep.
`80 OUTPUT 716;"ESB?;"`	Check to see if the fail bit is set.
`90 ENTER 716;Estat`	
`100 IF BIT(Estat,4) THEN`	If the fail bit for channel one is set, reset the number of sweeps passed counter.
`110 IF Reap<>0 THEN BEEP 1200,.05`	If sweeps had been passing, warn the operator that the device is now failing.
`120 Reap=0`	
`130 GOTO 40`	
`140 END IF`	If the fail bit was not set, tell the operator.
`150 BEEP 2500,.01`	
`160 Reap=Reap+1`	Increment the sweeps passed counter.
`170 DISP "STOP TUNING"`	Encourage the operator to stop tuning the device.
`180 IF Reap<Qual THEN GOTO 60`	If not enough sweeps have passed, loop.
`190 DISP "DEVICE PASSED!"`	The device has passed.
`200 FOR I=1 TO 10`	Warble, telling the operator the device has passed, using an audible signal.
`210 BEEP 1000,.05`	
`220 BEEP 2000,.01`	
`230 NEXT I`	
`240 INPUT "HIT RETURN FOR NEXT DEVICE",Dum$`	Wait for the next device.
`250 GOTO 40`	
`260 END`	

Running the program

Set up a limit table on channel 1 for a specific device either manually, or using the program in Example 5A. Run the program, and enter the number of passed sweeps desired for qualification. After entering the qualification number, connect the filter. When a sweep passes, the computer beeps. When enough sweeps in a row pass to qualify the device, the computer warbles at the operator, and then asks for a new device.

The program assumes a response calibration (thru calibration) or full 2-port calibration has been performed prior to running the program. Try causing the DUT to fail by loosening the cables connecting the DUT to the HP 8753B, and then retightening them.

Storing and recalling instrument states

The purpose of this example is to demonstrate ways of storing and recalling entire instrument states over HP-IB. The two methods discussed are to use the learn string, and to use the computer to coordinate direct store/load of instrument states to disc.

Using the learn string is a very rapid way of saving the instrument state, but using direct disc access has the advantage of automatically storing calibrations, cal kits, and data along with the instrument state.

Example 6A: Using the learn string

The learn string is a very fast and easy way to read an instrument state. The learn string includes all front panel settings, the limit table for each channel, and the list frequency table. The learn string is read out with `OUTPLEAS`, and put back into the instrument with `INPULEAS`. The string itself is in form 1, and is no longer than 3000 bytes long.

This example program is stored on the Example Programs disc as **IPG6A**.

Program line	Comment
`10 DIM State$[3000]`	Set up the receive string.
`20 OUTPUT 716;"OUTPLEAS;"`	Request the learn string.
`30 ENTER 716 USING "-K";State$`	Read in the learn string. Normally, the enter state-ment will terminate if a line feed is received, so `USING "-K"` is used, which allows termination only on End Or Identify.
`40 LOCAL 716`	Put the analyzer in LOCAL mode.
`50 INPUT "CHANGE STATE AND HIT RETURN",Dum$`	Give the operator a chance to modify the state.
`60 OUTPUT 716;"INPULEAS";STATE$`	Transmit the state back to the HP 8753B.
`70 DISP "INITIAL INSTRUMENT STATE RESTORED"`	
`80 END`	

Running the program

Run the program. When the program stops, change the instrument state and press **[RETURN]**. The HP 8753B will return its original state.

Example 6B: Coordinating disc storage

To have the HP 8753B store an instrument state on disc, specify the state name by titling a file using `TITFn`, then specify a `STORn` of that file, where `n` is the file number, 1 to 5. On receipt of the store command, the HP 8753B will request active control. When control is received, the HP 8753B will store the instrument state on disc as defined under the *[DEFINE STORE]* menu.

Similarly, to have the HP 8753B load a file from disc, specify the state name as before, and then request a `LOADn` of that file. The best way of learning what the register titles on the disc are is to use the *[READ FILE TITLES]* under the **[RECALL]** key.

This example program is stored on the Example Programs disc as **IPG6B**.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for remote control.
`30 INPUT "STATE TITLE? PRESS RETURN",Nam$`	Get the name of the file to create.
`40 OUTPUT 716;"USEPASC;"`	Tell the HP 8753B to use pass control mode.
`50 OUTPUT 716;"TITF1""";Nam$;""";STOR1;"`	Title register 1, and store it. The title must be preceded and followed by double quotation marks, and the only way to do that with an output statement is to use two sets of quotation marks: "".
`60 DISP "SAVING ON DISC"`	
`70 SEND 7;TALK 16 CMD 9`	Pass control to the HP 8753B, assuming it has interpreted the `STOR1` command and set the request control bit.
`80 STATUS 7,6;Stat`	
`90 IF NOT BIT(Stat,6) THEN GOTO 80`	Wait for active control to return.
`100 INPUT "STATE STORED. HIT RETURN TO RECALL",Dum$`	
`110 INPUT "STATE TITLE?",Nam$`	Get the name of the file to read.
`120 OUTPUT 716;"TITF1""";Nam$;""";LOAD1;"`	Title register one, and request a load.
`130 DISP "READING DISC"`	
`140 SEND 7;TALK 16 CMD 9`	Pass control.
`150 STATUS 7,6;Stat`	
`160 IF NOT BIT(Stat,6) THEN GOTO 150`	Wait for control to return.
`170 DISP "DONE"`	The program is done, and the state has been loaded back into the instrument.
`180 END`	

Running the program

Put a formatted disc in the disc drive, and point the HP 8753B's disc address, unit number, and volume number towards that drive. Run the example, and when the program pauses, change the instrument state so that a change will be noticeable. Pressing return will recall the state just stored, or a completely different state can be recalled.

Example 6C: Reading calibration data

This example demonstrates how to read measurement calibration data out of the HP 8753B, how to put it back into the instrument, and how to determine which calibration is active.

The data used to perform measurement error correction is stored inside the HP 8753B in up to twelve calibration coefficient arrays. Each array is a specific error coefficient, and is stored and transmitted as an error corrected data array: each point is a real/imaginary pair, and the number of points in the array is the same as the number of points in the sweep. The four data formats also apply to the transfer of calibration coefficient arrays. Appendix C, *Calibration*, of the *Quick Reference Guide* specifies where the calibration coefficients are stored for different calibration types.

A computer can read out the error coefficients using the commands `OUTPCALC01, OUTPCALC02, ... OUTPCALC12`. Each calibration type uses only as many arrays as needed, starting with array 1. Hence, it is necessary to know the type of calibration about to be read out: attempting to read an array not being used in the current calibration causes the "REQUESTED DATA NOT CURRENTLY AVAILABLE" warning.

A computer can also store calibration coefficients in the HP 8753B. To do this, declare the type of calibration data about to be stored in the HP 8753B just as if you were about to perform that calibration. Then, instead of calling up different classes, transfer the calibration coefficients using the `INPUCALCnn` commands. When all the coefficients are in the HP 8753B, activate the calibration by issuing the mnemonic `SAVC`, and have the HP 8753B take a sweep.

This example reads the calibration coefficients into a very large array, from which they can be examined, modified, stored, or put back into the instrument. If the data is to be directly stored onto disc, it is usually more efficient to use form 1 (HP 8753B internal binary format), and to store each coefficient array as it is read in.

This program is stored on the Example Programs disc as **IPG6C**.

Program	Explanation
`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for HP-IB control.
`30 DATA "CALIRESP",1,"CALIRAI",2,"CALIS111",3`	
`40 DATA "CALIS221",3,"CALIFUL2",12`	
`50 DATA "NOOP",0`	Set up the data base of possible calibrations, and the number of arrays associated with each calibration.
`60 INTEGER Hdr,Lgth,I,J`	Define integers to hold the header, and to act as counters.
`70 ASSIGN @Dt TO 716;FORMAT OFF`	
`80 READ Calt$,Numb`	Get a calibration type and the number of associated arrays.
`90 IF Numb=0 THEN GOTO 360`	If correction was not on, stop the program.
`100 OUTPUT 716;Calt$;"?;"`	Interrogate the HP 8753B to see if this calibration is active.
`110 ENTER 716;Active`	
`120 IF NOT Active THEN GOTO 80`	If the calibration was not active, loop.
`130 DISP Calt$,Numb`	Show the operator that we have found the calibration and number of arrays.
`140 OUTPUT 716;"FORM3;POIN?;"`	Find out how many points to expect.
`150 ENTER 716;Poin`	
`160 ALLOCATE Cal(1:Numb,1:Poin,1:2)`	Create a very large array to hold all the coefficients.
`170 FOR I=1 TO Numb`	Loop once for each calibration coefficient.
`180 OUTPUT 716 USING "K,ZZ";"OUTPCALC",I`	Request the calibration coefficient. The `K` transmits `OUTPCALC` literally, and `ZZ` transmits `I` as two digits, using a leading zero if needed.
`190 ENTER @Dt;Hdr,Lgth`	Read the header.
`200 FOR J=1 TO Poin`	
`210 ENTER @Dt;Cal(I,J,1),Cal(I,J,2)`	Since we are not filling the entire array, we have to read each point individually.
`220 NEXT J`	
`230 NEXT I`	
`240 INPUT "HIT RETURN TO RE-TRANSMIT CALIBRATION",Dum$`	The calibration data is now all in the computer.
`250 OUTPUT 716;Calt$,";"`	Begin the calibration retransmission by declaring what calibration type is about to be loaded.
`260 FOR I=1 TO Numb`	Now load each calibration coefficient.
`270 DISP "TRANSMITTING ARRAY: ",I`	
`280 OUTPUT 716 USING "K,ZZ";"FORM3;INPUCALC",I`	
`290 OUTPUT @Dt;Hdr,Lgth`	
`300 FOR J=1 TO Poin`	
`310 OUTPUT @Dt;Cal(I,J,1),Cal(I,J,2)`	
`320 NEXT J`	
`330 NEXT I`	All of the calibration data has been loaded.
`340 OUTPUT 716;"SAVC;"`	End the sequence by activating the calibration.
`350 OUTPUT 716;"CONT;"`	Trigger a sweep so the calibration becomes active.
`360 DISP "DONE"`	
`370 END`	

Running the program

Before executing the program, perform a calibration.

The program is able to detect what calibration is active, and with that information it predicts how many arrays to read out. When all the arrays are inside the computer, the program prompts the user. At this point, turn calibration off, or perform a completely different calibration on the HP 8753B. Then press continue on the computer, and the computer will reload the old calibration.

Note that the retransmitted calibration is associated with the current instrument state: the instrument has no way of knowing the original state associated with the calibration data. For this reason, it is recommended that the learn string be used to store the instrument state whenever calibration data is stored. See Example 6A, *Using the learn string*.

Miscellaneous Programming Examples

Controlling peripherals

The purpose of this section is to demonstrate how to coordinate printers, plotters, power meters, and disc drives with the HP 8753B.

The HP 8753B has three operating modes with respect to HP-IB, as set under the **[LOCAL]** menu. System controller mode is used when no computer is present. The other two modes allow the computer to coordinate certain actions: in talker/listener mode the computer can control the HP 8753B, as well as coordinate plotting and printing, and in pass control mode the computer can pass active control to the HP 8753B so that the HP 8753B can plot, print, control a power meter, or load/store to disc. Peripheral control is the major difference between the two modes.

Note that the HP 8753B assumes that the address of the computer is correctly stored in its HP-IB addresses menu under the *[ADDRESS: CONTROLLER]* entry. If this address is incorrect, control will not return to the computer. Similarly, if control is passed to the HP 8753B while it is in talker/listener mode, control will not return to the computer.

Example 7A: Operation using Talker/Listener mode

The commands `OUTPPLOT` and `OUTPPRIN` allow talker/listener mode plotting and printing via a one way data path from the HP 8753B to the plotter or printer. The computer sets up the path by addressing the HP 8753B to talk and the plotter to listen and then placing the bus into data mode. The HP 8753B will then make the plot or print. When it is finished, it asserts the End or Identify (EOI) control line on HP-IB.

This program makes a plot using the talker/listener mode. It is stored on the Example Programs disc as **IPG7A**.

`10 OUTPUT 716;"OUTPPLOT;"`	Command the HP 8753B to plot using the talker/listener mode plot command. For a printer, use `OUTPPRIN;`.
`20 SEND 7;UNL LISTEN 5 TALK 16 DATA`	Use the HP-IB control commands to establish a data path from the HP 8753B to the plotter. `SEND 7` sends bus control commands. `UNL` clears out the last data path. `LISTEN 5` tells the device at address 5, the default address for a plotter, to accept the data. For printing, substitute the address 1, the default for a printer, and change `"OUTPPLOT;"` in line 10 to `"OUTPPRIN;"`. `TALK 16` tells the HP 8753B to talk; that is, transmit the contents of its output queue. When `DATA` is executed, the bus changes from command to data mode, and the HP 8753B makes the plot.
`30 DISP "PLOTTING"`	This statement serves the dual purpose of informing the user of the state of the program and preventing interrogation of status register 7 immediately after the `SEND` statement, when the register state is unstable.
`40 STATUS 7,7;Stat`	Now wait for the HP 8753B to assert the EOI line, indicating the end of transmission. The `STATUS` command accesses the status registers for the interfaces installed on the computer. In this case, we access interface 7 (HP-IB), register 7, HP-IB status. The value of the register is placed in the variable `Stat`. We are specifically interested in bit 11, which is assigned to the EOI line.
`50 IF NOT BIT(Stat,11) THEN GOTO 40`	If bit 11 is not set, then the EOI line is not being asserted by the HP 8753B, so loop and check again.
`60 DISP "DONE"`	The HP 8753B has asserted EOI to indicate that it has finished with the plot.
`70 END`	

Running the program

The HP 8753B will go into remote, and make the plot. During the plot, the computer will display the message PLOTTING. One of the attributes of the OUTPPLOT command is that the plot can include the current softkey menu. The plotting of the softkeys is enabled with the command PSOFTON and disabled with PSOFTOFF.

When the plot is completed, the HP 8753B asserts the EOI line on HP-IB. The computer detects this and displays the DONE message. The HP 8753B will go on asserting EOI until some other activity on the bus causes it to clear the line.

If a problem arises with the plotter, such as no pen or paper, the HP 8753B cannot detect the situation because it only has a one-way path of communication. Hence, the HP 8753B will attempt to continue plotting until the operator intervenes and aborts the plot by pressing the **[LOCAL]** key. This key aborts the plot, causes the warning message "CAUTION: PLOT ABORTED," asserts EOI, and hence frees the computer. Because of possible malfunctions, it is generally advisable to use pass control mode, which allows two way communication between the plotter and the HP 8753B.

Example 7B: Operation using pass control mode

If the HP 8753B is in pass control mode and it receives a command telling it to plot, print, control a power meter, or store/load to disc, it sets bit 1 in the event status register to indicate that it needs control of the bus. If the computer then uses the HP-IB control command to pass control to the HP 8753B, the HP 8753B will take control of the bus, and access the peripheral. When the HP 8753B no longer requires control, it will pass control back to the computer. When performing a power meter cal over HP-IB, the HP 8753B requests control at each measurement point in a sweep which is typically ≅3* the number of readings.

Control should not be passed to the HP 8753B before it has set event status register bit 1, Request Active Control. If the HP 8753B receives control before the bit is set, control is passed immediately back.

While the HP 8753B has control, it is free to address devices to talk and listen as needed. The only functions denied it are the ability to assert the interface clear line (IFC), and the remote line (REN). These are reserved for the system controller. As active controller, the HP 8753B can send messages to and read replies back from printers, plotters, and disc drives.

This example prints the display. It is stored on the Example Programs disc as **IPG7B**. The program could request a plot with PLOT, or a disc access with a command such as REFT (read file titles.)

```
10  OUTPUT 716;"CLES;ESE2;" ......................  Clear the status reporting system, and enable
                                                    the Request Active Control bit in the event sta-
                                                    tus register.
20  OUTPUT 716;"USEPASC;PRINALL;" ................  Put the HP 8753B in pass control mode, and
                                                    request a print.
30  Stat=SPOLL(716) ..............................  Get the status byte of the HP 8753B.
40  IF NOT BIT(Stat,5) THEN GOTO 30 ..............  If the HP 8753B is not requesting control, loop
                                                    and wait.
50  SEND 7;TALK 16 CMD 9 .........................  This is the bus command to pass active con-
                                                    trol to device 16. With BASIC 3.0 or higher, or
                                                    2.0 with extensions 2.1, the command PASS
                                                    CONTROL 716 can be used instead.
60  DISP "PRINTING"
70  STATUS 7,6;Hpib ..............................  To determine when the print is finished, watch
                                                    for return of active control. The STATUS
                                                    command loads the interface 7 (HP-IB) regis-
                                                    ter 6, the computer's status with respect to
                                                    HP-IB, into the variable Hpib. Bit 6 tells if the
                                                    computer is the active controller: it will be set
                                                    when the HP 8753B returns control.
80  IF NOT BIT(Hpib,6) THEN GOTO 70 ..............  If control has not returned, loop and wait.
90  DISP "DONE" ..................................  Control has returned.
100 END
```

Running the program

The HP 8753B will very briefly flash the message WAITING FOR CONTROL, before actually receiving control and making the print. The computer will display the PRINTING message.

When the print is complete, the HP 8753B passes control back to the address stored as the controller address under the **[LOCAL]** *[SET ADDRESSES]* menu. The computer will detect the return of active control and exit the wait loop.

Because the program waits for the HP 8753B's request for control, it can be used to respond to front panel requests as well. Delete PRINALL; from line 20, and run the program. Nothing will happen until you go to the front panel of the HP 8753B and request a print, plot, or disc access. For example, press **[LOCAL]** **[COPY]** and *[PRINT]*.

Example 8: Creating a user interface

This example shows how to create a custom user interface involving only the front panel keys and display of the HP 8753B.

User graphics

The HP 8753B's display can be treated as an HP-GL plotter. The BASIC graphics commands can be used to create a custom display. Some of the more useful commands are as follows. `VIEWPORT` defines what area of the display is to be plotted on. `WINDOW` allows you to specify the plotting units (i.e. how many units per axis) in the `VIEWPORT` defined area. `DRAW` draws lines from point to point. `MOVE` moves the logical pen without drawing anything. `GCLEAR` clears the graphics display area. `PEN` selects the line intensity, and `LINE TYPE` selects various line types.

All of the BASIC graphics statements are accepted. The LABEL statement is not recommended because it fills the display memory up very rapidly as opposed to when the HP-GL `LB` command is used. See the Waitforkey subroutine of Example 2A for an example of the `LB` command.

HP-GL (Hewlett-Packard Graphics Language) commands, such as the `LB` command mentioned above, can be directly sent to the HP 8753B display with the `OUTPUT` statement. See Appendix D, *Display Graphics*, of the *Quick Reference Guide* for a list of the HP-GL commands accepted, and their functions.

Front panel control

It is possible to take over the front panel keys. The user request bit in the event status register is set whenever a front panel key is pressed or the knob is turned, whether the instrument is in remote or local mode. Each key has a number associated with it, as shown in Figure E.4, *Front Panel Keycodes* of the *Quick Reference Guide*. The number of the key last pressed can be read with the `KOR?` and the `OUTPKEY?` commands. With `KOR?`, a knob turn is reported as a negative number encoded with the number of counts turned. With `OUTPKEY?`, a knob turn is always reported as a negative one.

The keycode encoding with `KOR?` is as follows. Clockwise rotations are reported as numbers from −1 to −64, −1 being a very small rotation. Counter-clockwise rotations are reported as the numbers −32,767 to −32,703, −32,767 being a very small rotation. Hence, clockwise rotations don't need any decoding at all, and counter-clockwise rotations can be decoded by adding 32,768.

There are approximately 120 counts per knob rotation, and sign of the count depends on the direction the knob was turned.

This example uses the knob and the up and down keys on the HP 8753B to position a grid on the display. Pressing **[ENTRY OFF]** on the HP 8753B causes the computer to put a trace on the grid.

This example program is stored on the Example Programs disc as **IPG8**.

`10 INTEGER Hdr,Lgth,Keyc`	Declare variables to hold the header and the key code.
`20 ASSIGN @Dt TO 716;FORMAT OFF`	Define an IO path with formatting off, to receive the form 3 trace data for plotting.
`30 OUTPUT 716;"HOLD;AUTO;CLES;ESE64;POIN?;"`	Prepare the instrument. `HOLD;AUTO;` freezes and scales the trace for plotting. `CLES;ESE 64;` clears the status reporting system and enables the User Request bit in the event status register. Lastly, `POIN?;` requests the number of points.
`40 ENTER 716;Poin`	Read in the number of points.
`50 GINIT`	Initialize the graphics functions in the computer.
`60 PLOTTER IS 717,"HPGL"`	Specify the HP 8753B display as the plotting device.
`70 OUTPUT 717;"CS;"`	Turn off the measurement display.
`80 Cx=55`	Initialize the x position of the center of the rectangle.
`90 Cy=60`	Initialize the y position of the center of the rectangle.
`100 S=20`	Set the size of the rectangle.
`110 REPEAT`	The `REPEAT, UNTIL` structure sets up a loop that keeps repeating until the condition specified in the `UNTIL` statement is found to be true. The condition is checked at the end of the loop. In this case, loop and redraw the rectangle until **[ENTRY OFF]** has been pressed.
`120 LINE TYPE 4`	Select a dashed line for the rectangle.
`130 GCLEAR`	Clear the graphics area on the HP 8753B.
`140 IF Cx>160 THEN Cx=160`	Prevent box from going off the screen.
`150 IF Cx<-17 THEN Cx=-17`	Note that these values are linked to the increments set in lines 270/310 and 320!

`160 IF Cy>115 THEN Cy=115`	
`170 IF Cy<-15 THEN Cy=-15`	
`180 VIEWPORT Cx-S,Cx+S,Cy-S,Cy+S`	Define the area of the rectangle, which will become the plotting area for the grid and trace.
`190 WINDOW 0,Poin-1,0,1`	Define the units along the edges of the rectangle. In this case, the horizontal edge has as many units as points in the sweep, and the vertical edge is simply unity.
`200 FRAME`	Draw the rectangle around the plotting area.
`210 Stat=SPOLL(716)`	Read the status byte.
`220 IF NOT BIT(Stat,5) THEN GOTO 170`	If bit 5 is not set, a key has not been pressed, so loop and wait.
`230 OUTPUT 716;"ESR?;"`	A key press has occurred, so read the event status register in order to clear the latched bit.
`240 ENTER 716;Estat`	Read in the register value, but do nothing with it.
`250 OUTPUT 716;"KOR?;"`	Now read in the key or knob count.
`260 ENTER 716;Keyc`	
`270 IF Keyc=26 THEN Cy=Cy+5`	Key 26 is the up key, so shift the rectangle up.
`280 IF Keyc=18 THEN Cy=Cy-5`	Key 18 is the down key, so shift the rectangle down.
`290 IF Keyc<0 THEN`	If the keycode was negative, then it is a knob count.
`300 Knb=Keyc`	Decode the knob count into the variable `Knb`.
`310 IF Knb<-64 THEN Knb=Knb+32768`	If the count is less then −64, add 32768 (2^{15}) to recover the knob count. If the count is more than −64, then no decoding is needed.
`320 Cx=Cx-Knb*3`	Shift the rectangle according the knob count, multiplying the knob count to make the rectangle move farther.
`330 END IF`	
`340 UNTIL Keyc=34`	This is the end of the `REPEAT, UNTIL` structure. Leave the loop only when key 34, **[ENTRY OFF]** has been pressed.
`350 GRID (Poin-1)/10,.1`	**[ENTRY OFF]** has been pressed, so draw the grid and the trace. This statement draws a grid with 10 divisions on each axis.
`360 LINE TYPE 1`	Use a solid line for the trace.
`370 OUTPUT 716;"FORM3;OUTPFORM;"`	Now get the trace data.
`380 ENTER @Dt;Hdr,Lgth`	Get the header information.
`390 ALLOCATE Dat(1:Poin,1:2)`	Define the receiving array.
`400 ENTER @Dt;Dat(*)`	And read in the data.
`410 OUTPUT 716;"SCAL?;"`	Instead of scaling the data in this program, interrogate the scale factor the HP 8753B was using.
`420 ENTER 716;Scal`	
`430 OUTPUT 716;"REFV?;"`	Similarly, use the value at the reference position to decide where to draw the trace.
`440 ENTER 716;Ref`	
`450 OUTPUT 716;"REFP?;"`	Interrogate the current reference position being used.
`460 ENTER 716;Refp`	
`470 Bot=Rev-Refp*Scal`	Calculate the value of the bottom grid line.
`480 Full=10*Scal`	And define the full scale span across the grid.
`490 MOVE 0,(Dat(1,1)-Bot)/Full`	Go to the first point on the trace without drawing anything.
`500 FOR I=1 TO Poin-1`	And draw all the rest of the points in the trace.
`510 DRAW I,(Dat(I,1)-Bot)/Full`	
`520 NEXT I`	The trace is drawn, so end the program.
`530 END`	

Running the program

Before running the program, set the instrument up to make a measurement. The HP 8753B will not accept a graphics dump of a trace of greater than 1601 points.

Run the program, and go to the front panel of the HP 8753B.

The measurement display has been turned off, and there is a box on the screen. The knob moves the box left and right, and the up/down keys move the box up and down. When you are satisfied with the position of the box, press **[ENTRY OFF]**. The computer will fill the box with a grid, and plot the current measurement data on the grid.

Transferring disc data files

An external disc drive is often used to store data files in addition to instrument states (see Example 6B). Instrument states, graphics files, data trace files, calibration data files, and memory trace files can be stored on disc. The file name is then appended with up to two characters to indicate what is in the file. For example, if channel 2 error-corrected data is saved to disc as DEVICE, the actual error-corrected data would be stored in DEVICED2. As with all data files stored on disc, they are stored in form 3. See Appendix E.3: *Disc file names* in the *Quick Reference Guide* for a complete list of the types of files saved to disc as well as the corresponding appendages to file names.

Example 9: Reading data files into a computer

This example demonstrates how to recall a specific disc file into a computer. First, EXTMADTAON defines the storage of the current trace as error-corrected data. After the file is stored to disc, the computer reads the error-corrected data into an array. The program can easily be modified to read and transfer raw data, memory traces, and formatted data.

`10 ABORT 7`	
`20 CLEAR 716`	Prepare the HP 8753B for remote control.
`30 INPUT "STATE TITLE?",Nam$`	Get the name of the file to create.
`40 OUTPUT 716;"USEPASC;"`	Tell the HP 8753B to use pass control mode.
`50 OUTPUT 716;"TITF1""";Nam$;""";EXTMDATAON;STOR1;"`	Title register 1, and store the instrument state and error-corrected data. The title must be preceded and followed by double quotation marks. The only way to do this within an output statement is to use two sets of quotation marks: " ".
`60 DISP "SAVING ON DISC"`	
`70 SEND 7;TALK 16 CMD 9`	Pass control to the HP 8753B, assuming it has interpreted the STOR 1 command and set the request control bit.
`80 STATUS 7,6;Stat`	
`90 IF NOT BIT(Stat,6) THEN GOTO 80`	Wait for active control to return.
`100 DISP "READING DATA INTO Disc_dat ARRAY"`	
`110 ASSIGN @Dt TO Nam$&"D1";FORMAT OFF`	This statement defines an I/O path with ASCII formatting off. The I/O path points to the chosen error-corrected data file, and can be used to read or write data from the file, since it is in binary rather than ASCII format.
`120 ALLOCATE Disc=dat(1:201,1:2)`	Allocate an array for a 201 point data trace. Real and imaginary pairs will be transferred for each data point.
`130 ENTER @Dt;Disc_dat(*)`	The computer takes the data from disc and transfers it into the receiving array. By specifying `Disc_dat (*)`, the ENTER statement will fill every location in the array.
`140 ASSIGN @Dt TO *`	Close the I/O path.
`150 DISP Disc_dat(1,1),Disc_dat(1,2)`	Show the first real imaginary pair.
`160 END`	

Running the program

Perform a measurement calibration with 201 points. Connect a test device and run the program. The first/real imaginary pair will be displayed. Place a marker at the beginning of the trace and look at both real and imaginary formats to verify this point.

Appendix A: Status Reporting

The HP 8753B has a status reporting mechanism that gives information about specific functions and events inside the HP 8753B. The status byte is an 8 bit register with each bit summarizing the state of one aspect of the instrument. For example, the error queue summary bit will always be set if there are any errors in the queue. The value of the status byte can be read with the `SPOLL(716)` statement. This command does not automatically put the instrument in remote mode, thus giving the operator access to the HP 8753B front panel functions. The status byte can also be read by sending the command `OUTPSTAT`. Reading the status byte does not affect its value. The sequencing bit can be set by the operator during execution of a test sequence.

The status byte summarizes the error queue, as mentioned before. It also summarizes two event status registers that monitor specific conditions inside the instrument. The status byte also has a bit that is set when the instrument is issuing a service request over HP-IB, and a bit that is set when the HP 8753B has data to send out over HP-IB. See Figure A.1 for a definition of the status registers.

Example A1: Using the error queue

The error queue holds up to 20 instrument errors and warnings in the order that they occurred. Each time the HP 8753B detects an error condition and displays a message on the CRT, it also puts the error in the error queue. If there are any errors in the queue, bit 3 of the status byte will be set. The errors can be read from the queue with the `OUTPERRO` command, which causes the HP 8753B to transmit the error number and the error message of the oldest error in the queue.

This example program is stored on the Example Programs disc as **IPGA1**.

`10 DIMErr$[50]`	Prepare a string to hold the error message.
`20 Stat=SPOLL(716)`	Use the serial poll statement to read the status byte into the variable `Stat`. Serial poll is an HP-IB function dedicated specifically to getting the status byte of an instrument quickly, and does not cause the HP 8753B to go into remote.
`30 IF NOT BIT(Stat,3) THEN GOTO 20`	If the error queue summary bit is not set, we loop until it gets set.
`40 OUTPUT 716;"OUTPERRO;"`	If the error queue has something in it, we instruct the HP 8753B to output the error number and the error message. This communication with the HP 8753B will put it in remote mode.
`50 ENTER 716;Err,Err$`	`Err` holds the error number, `Err$` the error message.
`60 PRINTErr,Err$`	
`70 LOCAL 716`	Return the HP 8753B to local mode so that the front panel is available to the operator.
`80 BEEP600,.01`	Give an audible signal that there is a problem.
`90 GOTO 20`	
`100 END`	

Running the program

Preset the HP 8753B and run the program. Nothing should happen at first. To get something to happen, press a blank softkey. The message "CAUTION: INVALID KEY" will appear on the HP 8753B, the computer will beep and print two lines. The first line will be the invalid key error, and the second message will be the "NO ERRORS" message. Hence, to clean the error queue, you can either loop until the no errors message is received, or until the bit in the status register is cleared. In this case, we wait until the status bit is clear. Note that all through this, the front panel of the HP 8753B is in local mode.

Because the error queue will keep up to 20 errors until either all the errors are read out or the instrument is preset, it is important to clear out the error queue whenever errors are detected so that old errors are not associated with the current instrument state.

Not all messages displayed by the HP 8753B are put in the error queue: operator prompts and cautions are not included.

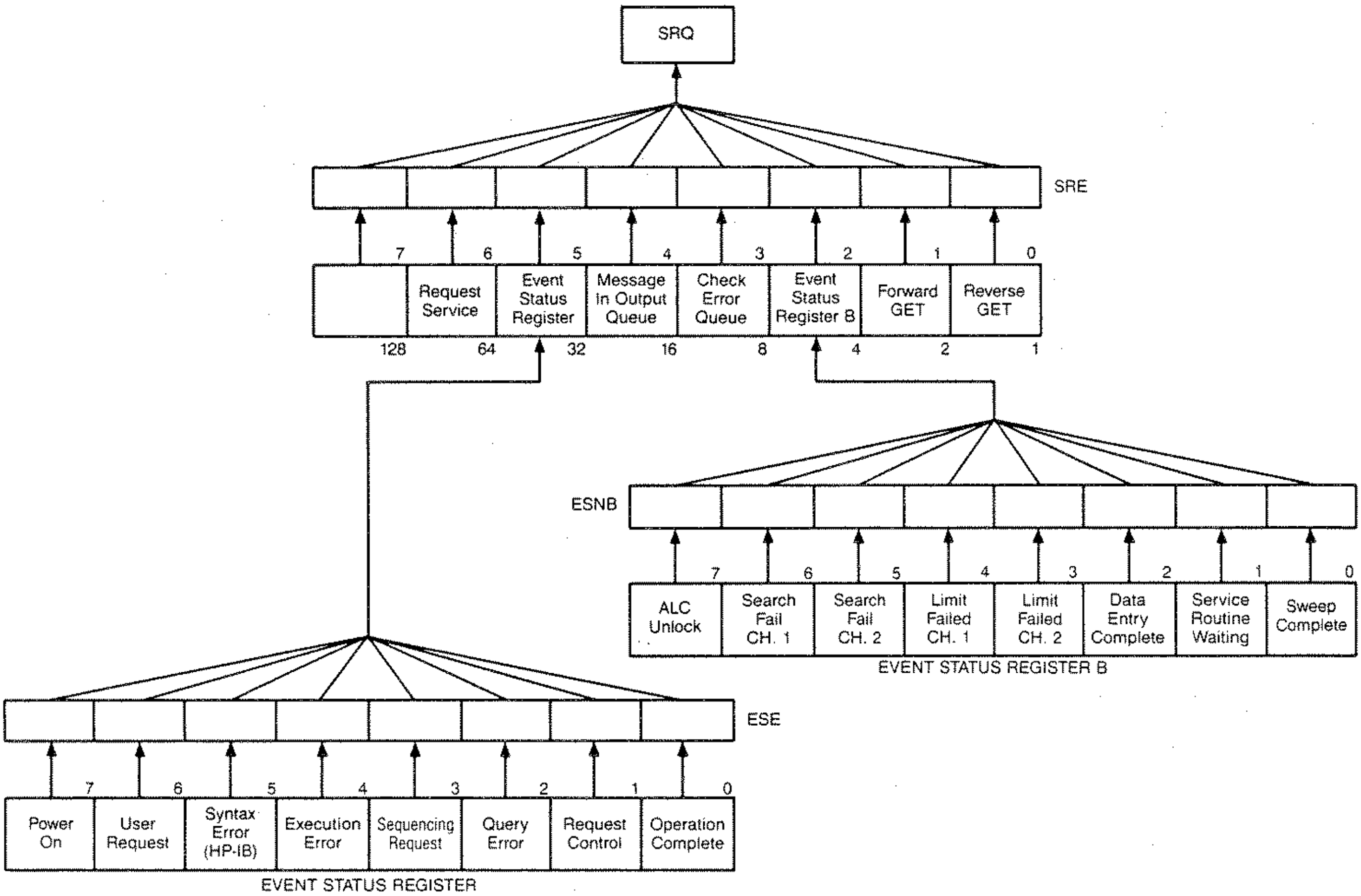

Figure A.1. Status reporting system.

Example A2: Using the status registers

The other two key components of the status reporting system are the event status register, and event status register B. These 8 bit registers consist of latched event bits. A latched bit is set at the onset of the monitored condition, and is cleared only by a read of the register or by clearing the status registers with `CLES`.

This example program is stored on the Example Programs disc as **IPGA2**.

Program	Explanation
`10 CLEAR716`	Clear out any old conditions.
`20 OUTPUT716;"ESR?;"`	Read out the event status register.
`30 ENTER716;Estat`	
`40 IF NOT BIT(Estat,6)THEN GOTO20`	If the user request bit of the event status register is not set, loop back.
`50 OUTPUT716;"KOR?;"`	If the user request bit has been set, there has been some front panel activity, and we read out the key code. The HP 8753B's reply to `KOR?;` includes the knob count if the knob was turned. The information comes as a negative number, and has to be decoded.
`60 ENTER716;Keyc`	
`70 IFKeyc≥0 thenPRINT"KEY";`	If the code was positive, we know it was a key press rather than a knob turn, and print the leader `KEY`. By placing a semicolon after the statement, we suppress the carriage return, line feed, allowing the code to be printed on the same line.
`80 IFKeyc<-400THENKeyc=Keyc+32768`	If the keycode is negative, it represents a knob count. If it isn't less than −400, then the count is a clockwise rotation and needs no modification. However, if the count is less than −400, we have to add 32,768 (2^{15}) to get the counter-clockwise count.
`90 PRINT"CODE=",Keyc`	Print the decoded key code.
`100 GOTO20`	Wait for the next key press.
`110 END`	

Running the program

Run the program. Pressing a key on the HP 8753B causes the computer to display the keycode associated with that key. Note that since the HP 8753B is in remote mode, the normal function of the key is not executed. In effect, we have taken over the front panel and can now redefine the keys.

Example A3: Generating interrupts

It is also possible to generate interrupts using the status reporting mechanism. The status byte bits can be enabled to generate a service request (SRQ) when set. The 200/300 series computers can in turn be set up to generate an interrupt on the SRQ.

To be able to generate an SRQ, a bit in the status byte has to be enabled using `SREn`. A one in a bit position enables that bit in the status byte. Hence, `SRE 8` enables an SRQ on bit 3, check error queue, since 8 equals 00001000 in binary representation. That means that whenever an error is put into the error queue and bit 3 gets set, the SRQ line is asserted, and the (S) indicator on the front panel of the HP 8753B comes on. The only way to clear the SRQ is to disable bit 3, re-enable bit 3, or read out all the errors from the queue.

A bit in the event status register can be enabled so that it is summarized by bit 5 of the status byte. If any enabled bit in the event status register is set, bit 5 of the status byte will also be set. For example `ESE66` enables bits 1 and 6 of the event status register, since in binary, 66 equals 01000010. Hence, whenever active control is requested or a front panel key is pressed, bit five of the status byte will be set. Similarly, `ESNBn` enables bits in event status register B so that they will be summarized by bit 2 in the status byte.

To generate an SRQ from an event status register, enable the desired event status register bit. Then enable the status byte to generate an SRQ. For instance, `ESE 32;SRE 32;` enables the syntax error bit, so that when the syntax error bit is set, the summary bit in the status byte will be set, and it enables an SRQ on bit 5 of the status byte, the summary bit for the event status register.

The following example program is stored on the Example Programs disc as **IPGA3**.

`10 OUTPUT 716;"CLES;ESE32;SRE32;"`	Clear the status reporting system, and then enable bit 5 of the event status register, and bit 5 of the status byte so that an SRQ will be generated on a syntax error.
`20 ON INTR 7 GOTO Err`	Tell the computer where to branch it gets the interrupt.
`30 ENABLE INTR 7;2`	Tell the 200/300 series to enable an interrupt from interface 7 (HP-IB) when bit 1 (value 2, the SRQ bit) of the interrupt register is set. If there is more than one instrument on the bus capable of generating an SRQ, it is necessary to use serial poll to determine which device has issued the SRQ. In this case, we assume the HP 8753B did it. A branch to `Err` will disable the interrupt, so the return from `Err` re-enables it.
`40 GOTO 40`	Do nothing loop.
`50 Err:!`	
`70 OUTPUT 716;"ESR?"`	The interrupt has come in! Read the register to clear the bit.

```
80  ENTER 716;Estat
90  PRINT "SYNTAX ERROR DETECTED"
100 ENABLE INTR 7
110 GOTO 30
120 END
```

Running the program

Preset the instrument, and run the program. The computer will do nothing. With the program still running, execute:

```
OUTPUT 716;"STIP 2 GHZ;"
```

The computer will display `SYNTAX ERROR DETECTED`, and the HP 8753B will display CAUTION: SYNTAX ERROR, and display the incorrect command, pointing at the first character it did not understand.

The SRQ can be cleared by reading the event status register and hence clearing the latched bit, or by clearing the enable registers with `CLES`. The syntax error message on the HP 8753B display can only be cleared by `CLEAR 7` or `CLEAR 716`. `CLEAR 7` is not commonly used because it clears every device on the bus.

Note that an impossible data condition does not generate a syntax error. For example, execute:

```
CLEAR 716
OUTPUT 716;"STAR 10 HZ;"
```

The HP 8753B simply sets the start frequency to 300 kHz, without generating a syntax error.

For more information
call your local HP sales office listed
in the telephone directory white pages.
Or write to Hewlett-Packard:

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HP-IB Programming Note

Quick Reference Guide
For the HP 8753B Network Analyzer

HEWLETT PACKARD

Introduction

This document is a guide to HP-IB control of the HP 8753B Network Analyzer. Its purpose is to provide concise information about the operation of the instrument under HP-IB control: the reader should already be familiar with making measurements with the HP 8753B and with the general operation of HP-IB. For more complete information on the HP 8753B, see the Introductory Operating Guide and the Operating and Programming Reference section in the HP 8753B operating manual. For more information on using HP-IB, see the Tutorial Description of the Hewlett-Packard Interface Bus (HP literature number 5952-0156.)

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Appendices:

HP-IB Capabilities

The HP-IB capabilities of the HP 8753B are as follows:

SH1	Full source handshake capability.
AH1	Full acceptor handshake capability.
T6	Can be a basic talker, answers serial poll, unaddresses if MLA issued.
TE0	No extended talker capabilities.
L4	Acts as a basic listener and unaddresses if MTA issued.
LE0	No extended listener capabilities.
SR1	Can issue service requests.
RL1	Will do remote, local, and local lockout.
PP0	No parallel poll capability.
DC1	Device clear capability.
DT1	Will respond to device trigger in hold mode.
CO	No controller capabilities in talker/listener mode.
C1	System controller mode.
C10	Pass control capability in pass control mode.
E2	Tri-state drivers.

These codes are completely explained in the IEEE Std 488-1978 document, published by the Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, New York 11017.

General Information

The HP 8753B interprets and executes commands as they are received. If a command is received without a needed operand, the HP 8753B will put the function in the active entry area and wait for the operand. An operand is entered as the value when the units or a terminator is received. The active entry area is turned off when a terminator is received. In the event of a syntax error, the HP 8753B displays the error, then recovers at the next terminator and continues command execution. Characters and commands between the syntax error and the next terminator are lost. The error can only be reset with a device clear (DCL or SDC) or by presetting the instrument.

HP-IB Addresses

The HP 8753B occupies two HP-IB addresses: the instrument itself and the display. The display address is derived from the instrument address by complementing the least significant bit. Hence, if the instrument is at an even address, the display occupies the next higher address. If the instrument is at an odd address, the display occupies the next lower address. Changes of the HP 8753B's address do not become effective until after the next preset following the address change.

Held Commands

The HP 8753B cannot process HP-IB commands while executing certain key commands, called held commands. Once a held command is received, the HP 8753B will read new commands into the input buffer, but it will not begin the execution of any commands until the completion of the held command. When the 15 character input buffer is full, the HP 8753B will hold off the bus until it is able to process the commands in the buffer.

Operation Complete

There is an operation complete function that allows synchronization of programs with the execution of certain held commands. The function is enabled by issuing **OPC;** or **OPC?;** prior to an OPC'able command. The operation complete bit will then be set at the completion of the OPC'able command's execution. For example, issuing **OPC;SING;** causes the OPC bit to be set when the single sweep is finished. Issuing **OPC?;** causes the HP 8753B to output a one when the command execution is complete. Addressing the HP 8753B to talk after issuing **OPC?;** will not cause an "addressed to talk without selecting output" error, but the HP 8753B will halt the computer by not transmitting the one until the command has completed. For example, issuing **OPC?;PRES;**, and then immediately interrogating the HP 8753B causes the bus to halt until the instrument preset is complete and the HP 8753B outputs a one.

Table 1: OPC'able Commands

CHAN1	MANTRIG
CHAN2	NOOP
CLEARALL	NUMG
DATI	PRES
DONE	RAID
EDITDONE	RECA<1 to 5>
EXTTOFF	REFD
EXTTON	RESPDONE
EXTTPOIN	RST
FREQOFFS<ON|OFF>	SAV1
HARMOFF	SAV2
HARMSEC	SAVC
HARMTHIR	SAVE<1 to 5>
INSMEXSA	SING
INSMEXSM	STAN<A to G>
INSMNETA	TRAD
INSMTUNR	WAIT
ISOD	

NOTE: Commands that call a calibration class are held if there is just one standard in the class, since such commands trigger a measurement.

Command Interrogate

To interrogate one of the front panel equivalent commands listed in Appendix A, Key Select Codes, append a question mark to the command root. This causes the HP 8753B to output the state of that function as a single number in ASCII format. If the function is a settable function, such as power or sweep time, the HP 8753B will output the current value of that function. If the function is either on/off (e.g. averaging) or one selection of several (e.g. log mag display format), the HP 8753B outputs a one for on or selected, and a zero for off. If a command that does not have a defined response is interrogated, the HP 8753B outputs a zero. Interrogating a function does not put it in the active entry area.

Identification

The HP 8753B's response to **IDN?;** is "HEWLETT PACKARD,8753B,0,X.XX" where X.XX is the firmware revision of the instrument.

Output Queue

Whenever a command to output data is received, the HP 8753B puts the data into the output queue to be copied out by the next read operation. The queue, however, is only one event long: the next command to output data will overwrite the data already in the queue. Hence, it is important to read the output queue immediately after every interrogation or request to output data.

Units

The HP 8753B outputs data in basic units such as Hz, dB, seconds, ohms, etc.

Input data is assumed to be in basic units unless one of the following units expressions qualifies the data input (upper and lower case are equivalent):

S	Seconds	**HZ**	Hertz	**DB**	dB or DBm
MS	Milliseconds	**KHZ**	Kilohertz		
US	Microseconds	**MHZ**	Megahertz	**V**	Volts
NS	Nanoseconds	**GHZ**	Gigahertz		
PS	Picoseconds				
FS	Femtoseconds				

Input Data

Input Syntax

The HP-IB commands accepted by the HP 8753B can be grouped into four input syntax types. The HP 8753B does not distinguish between upper and lower case letters.

General Structure:
[code][appendage][data][unit][terminator]

[code]
The root mnemonic, as found in the appendices.

[appendage]
A qualifier attached to the root mnemonic. Possible appendages are **ON** or **OFF**, which toggle a function on or off, or integers, which specify one option out of several. There can be no spaces or symbols between the code and the appendage.

[data]
A single operand used by the root mnemonic, usually to set the value of a function. The data can be a number or a character string. Numbers are accepted as integers or decimals, with power of ten specified by **E**, as in **STAR 0.2E+10**, which sets the start frequency to 2 GHz. Character strings must be preceded and followed by double quotation marks (e.g. **"DEVICE LABEL"** must be sent to the HP 8753B, not **DEVICE LABEL**.)

[unit]
The units of the operand, if applicable. If no units are specified, the HP 8753B assumes the basic units as

described under General Information. The data is entered into the function when either units or a terminator is received.

[terminator]
Indicates the end of the command, enters the data, and turns off the active entry area. The terminator should be a semicolon. Terminators are not necessary for the HP 8753B to interpret commands correctly, but in the case of a syntax error, the HP 8753B will attempt to recover at the next terminator. The HP 8753B also interprets line feeds and HP-IB END OR IDENTIFY (EOI) messages as terminators.

The specific syntaxes are as follows:

SYNTAX TYPE 1: [code][terminator]

These are simple action commands that require no complementary information, such as **AUTO** (autoscales the active channel.)

SYNTAX TYPE 2: [code][appendage][terminator]

These are simple action commands requiring limited customization, such as **CORRON**, **CORROFF** (turn error correction on or off,) or **RECA1**, **RECA2**, **RECA3**. . .(recall register 1,2,3. . .) There can be no characters or symbols between the code and the appendage.

SYNTAX TYPE 3: [code][data][unit][terminator]

These are data input commands such as **STAR 1.0 GHZ;** (set the start frequency to 1 GHz).

SYNTAX TYPE 4: [code][appendage][data][terminator]

These are titling and marker commands that have an appendage, such as **TITL "FILTER"** (enter **FILTER** as the CRT title), **TITR1 "STATE1"**, **TITR2 "EMPTY"** (title register 1 **STATE1**, title register 2 **EMPTY**.)

INTERROGATE SYNTAX: [code][?]

To interrogate a front panel equivalent function, simply append a question mark to the root mnemonic. For example **POWE?**, **AVERO?**, or **REAL?** will return, respectively, the power level in dB, a one if averaging is on, and a one if the current display format is real. Interrogating a function does not put it in the active entry area. To interrogate commands with integer appendages, place the question mark after the appendage.

Valid Characters

The HP 8753B will accept letters, changing lower case to upper case, numbers, decimal points, ±, semicolons, carriage returns and linefeeds. Leading zeros, spaces, carriage returns, and unnecessary terminators are ignored, except when inserted into or between a mnemonic and/or an appendage. If the HP 8753B does not recognize a character as appropriate, it generates a syntax error message and recovers at the next terminator (see General Information.)

Programming Data

The command mnemonics are presented in the appendices. Appendix A, Key Select Codes, represents front panel equivalent commands. These commands perform the same function as a front panel key, and are arranged functionally by front panel key. Appendix B, HP-IB Only Codes, represents functions that have no logical equivalent in manual operation. They concern data transmission, status reporting, and special HP-IB functions. Appendix G, Alphabetical Command List, contains all the mnemonics from the Appendices A and B, plus some redundant mnemonics included for compatibility with standards and other instruments.

In general, the commands were named following these rules:

1. Simple commands are the first four letters of the function they control, as in **POWE**. If the function label is two words, the first three mnemonic letters are the first three letters of the first word, and the fourth mnemonic letter is the first letter of the second word. For example, **ELED** is derived from electrical delay.

2. If there are many commands grouped together in a class, as in markers or plotting pen numbers, the command is increased to 8 letters. The first 4 letters are the class label derived using rule 1. The last 4 letters are the function specifier, again derived using rule 1. An example of this is the class pen numbers **PENN**, which is used with several functions such as **PENNDATA, PENNMEMO**.

These rules were not always followed, in order to maintain compatibility with other products, to make commands more meaningful and easier to remember, and when technical considerations prevented their use.

Array Transfer

There are several arrays of information that can be read out of the HP 8753B, such as trace data, calibration data, and learn string. These arrays can be transmitted back to the HP 8753B, where the incoming data becomes the array for the current instrument state. The instrument must be properly configured to receive the array. For instance, the instrument will not accept a 401 point data array if the current instrument state is 201 points.

Arrays need not be transmitted back to the instrument in the same format in which they were read out: the only requirement is that the HP 8753B be set to receive the format the computer is transmitting. Refer to Data Formats.

Note: the correct header must precede forms 1, 2, and 3. The header is described in Data Formats.

CRT Graphics

The CRT is accessed as if it were a graphics plotter, responding to a limited set of HP-GL commands outlined in Appendix D, Display Graphics. The CRT has its own HP-IB address, and is independent of the rest of the HP 8753B. To calculate the CRT address, take the HP 8753B's address, and complement the least significant bit. If the HP 8753B has an odd address, the CRT is the next lower address. If the HP 8753B has an even address, the CRT is the next higher address. For example, with an HP 8753B address of 16, the CRT is 17. With an address of 15, the CRT is 14.

Instrument Preset

The **PRES** command causes the HP 8753B to execute an instrument preset, which returns the HP 8753B to instrument preset state. During an instrument preset, a device clear is executed, the status registers are cleared, the error queue is cleared, and the HP-IB hardware is reset.

Output

Output Syntax

Data transmitted by the HP 8753B in response to an interrogation, certain output commands, and form 4 array transfers is in ASCII format. This means that each character and each digit is transmitted as a separate byte, leaving the receiving computer to reconstruct the numbers and strings. Numbers are transmitted as 24 character strings, consisting of:

-DDD.DDDDDDDDDDDDDDDE-DD

CONTENTS	MEANING
Sign	'-' for negative, blank for positive.
3 digits	Digits to the left of the decimal point.
Decimal point	
15 digits	Digits to the right of the decimal point.
E	Exponent notation.
Sign	'-' for negative, '+' for positive.
Exponent	Two digits for the exponent.

Data Formats

The HP 8753B transmits and receives arrays in any of four different numeric formats. The current format is set with the **FORM1**, **FORM2**, **FORM3**, and **FORM4** commands. These commands do not affect learn string, cal kit string, or non-array transfers such as command interrogate or output marker values. A transmitted array will go out in the current format, and the HP 8753B will attempt to read incoming arrays according to the current format. Each data point in an array is a pair of numbers, normally a real/imaginary pair. The number of data points in each array is the same as the number of points in the current sweep. The formats are as follows:

FORM 1 HP 8753B internal binary format, 6 bytes per data point. The array is preceded by a four byte header. The first two bytes represent the string "#A", the standard block header. The second two bytes are an integer holding the number of bytes in the block to follow. Form 1 is meant for rapid data transfers, not to be modified by the computer.

FORM 2 IEEE 32 bit floating point format, 8 bytes per data point. The data is preceded by the same header as in form 1. Each number consists of a 1 bit sign, an 8 bit biased exponent, and a 23 bit mantissa.

FORM 3 IEEE 64 bit floating point format, 16 bytes per data point. The data is preceded by the same header as in form 1. Each number consists of a 1 bit sign, an 11 bit biased exponent, and a 52 bit mantissa.

FORM 4 ASCII floating point format. The data is transmitted as ASCII numbers, as described in Output Syntax. There is no header.

The HP 8753B terminates each transmission by asserting the EOI interface line with the last byte transmitted.

Data Arrays

Figure E.1, Data Processing Chain, shows the different kinds of data available within the instrument: raw measured data, error corrected data, formatted data, trace memory, and calibration coefficients. Trace memory can be directly read out with **OUTPMEMO**, but it cannot be directly transmitted back. If time domain (option 10) is on with 1601 points, the formatted data array will only have 401 points.

Learn String and Cal Kit String

The learn string is summary of the instrument state. It includes all the front panel settings, the limit test tables, and the list frequency table for the current instrument state. It does not include calibration data, nor does it include the information stored in the save/recall registers.

The learn string is read out with **OUTPLEAS**, which causes the HP 8753B to start transmitting the binary string. The string has a fixed length for a given firmware revision, and is no more than 3000 bytes long. The array has the same header as in form 1.

The calibration kit is a set of key characteristics of the calibration standards used to increase the accuracy improvement associated with calibration. There are default kits for several different connector types, and there is space for a user-defined cal kit. The command **OUTPCALK** outputs the currently active cal kit as a binary string in form 1. As with the learn string, the cal kit string has a fixed length for a given firmware revision, and is no more than 1000 bytes long.

Error Reporting

Status Reporting

The HP 8753B status reporting structure depicted in Appendix F consists of three registers:

```
              STATUS BYTE
              /         \
 EVENT STATUS     EVENT STATUS
   REGISTER        REGISTER B
```

The top level register is the status byte, which consists of summary bits. Each bit reflects the condition of another register or a queue. If a summary bit is set (equals 1), the corresponding register or queue should be read to obtain the status information and to clear the condition. Reading the status byte, which can be done with a serial poll or by issuing **OUTPSTAT**, does not affect the state of the summary bits: they always reflect the condition of the summarized queue or register.

Any bit in the status byte can be selectively enabled to generate a service request (SRQ) when set. Setting a bit in the service request enable register with **SREnn** enables the corresponding bit in the status byte. For example, **SRE24** enables status byte bits 3 and 4 (since 2 ^ 3 + 2 ^ 4 = 24) and disables all the other bits. **SRE** will not affect the state of the status register bits.

The event status register and event status register B are the other two registers in the status reporting structure. They are selectively summarized by bits in the status byte via enable registers. The event status registers consist of latched bits. A latched bit is set at the onset of a specific trigger condition in the instrument, and is cleared only by a read of the register. The bit will not be set again until the condition occurs again. If a bit in one of these two registers is enabled, it is summarized by the summary bit in the status byte. The registers are enabled by **ESEnn** and **ESNBnn**, which work the same as **SREnn**.

If a bit in one of the event status registers is enabled and the summary bit in the staus byte is enabled, an SRQ will be generated when the event status register bit is set. The SRQ will not be cleared until one of four things happens:

1. The event status register is read, clearing the latched bit.

2. The summary bit in the status byte is disabled.

3. The event status register bit is disabled.

or

4. The status registers are cleared with **CLES** or a preset.

SRQ's generated when there are error messages or when the instrument is waiting for Group Execute Trigger (GET) are cleared by reading the errors or issuing GET, disabling the bits, or by clearing the status registers.

The status byte also summarizes two queues, the output queue and the error queue. When the HP 8753B outputs information, it puts it in the output queue, where it resides until the controller reads it. The output queue is only one event long, so that the next output request will clear the current data. The summary bit is set whenever there is something in the output queue. The error queue is described in the next section.

See Appendix F for the definition of each of the registers.

Error Output

When an error condition is detected in the HP 8753B, a message is displayed on the screen, and that message is placed in the error queue. The error queue holds up to 20 errors in the order they occur until the errors are read out using the **OUTPERRO** command. The **OUTPERRO** command outputs one error message, which consists of an error number followed by an ASCII string which is no more than 50 characters long. The string is the same message that appears on the display.

The error queue is not cleared by any event except a preset or cycling the line switch. In order to keep the queue up-to-date, it is important to read all of the messages out of the queue each time errors are detected.

HP-IB Information

Modes

Under HP-IB control, the HP 8753B can operate in one of two modes: talker/ listener and pass control.

In talker/listener mode, the HP 8753B behaves as a simple element on the bus. It is possible to have the HP 8753B make a plot or print in talker/listener mode, using the **OUTPPLOT** or **OUTPPRIN** commands. Unlike **PLOT** and **PRINALL**, which require that control be passed, the HP 8753B will wait to be addressed to talk, assume the plotter or printer has been addressed to listen, and dump the display. It is not possible to have the HP 8753B access a disc drive when it is in talker/listener mode.

In pass control mode, the HP 8753B will take control of the bus if control is passed to it. This allows the HP 8753B to take control of printers, plotters, and disc drives on an as-needed basis. The HP 8753B sets event status register bit 1 when it needs control, and the HP 8753B will transfer control back at the completion of the operation. It passes control back to its controller address, specified by **ADDRCONT**.

The HP 8753B can also operate in the system controller mode. This mode is meant for use only when there is no computer on the bus. In this mode, the HP 8753B simply takes control of the bus, and uses it whenever it needs to access a peripheral. While the HP 8753B is in this mode, no other devices on the bus can attempt to take control. Specifically, the REN, ATN, and IFC lines must remain unasserted, and the data lines must be freed by all but the addressed talker.

Response to HP-IB Commands

Abort
The HP 8753B responds to the abort message (IFC) by halting all listener, talker, and controller functions.

Device Clear
The HP 8753B responds to the device clear commands (DCL, SDC) by clearing the input and output queues and clearing any HP-IB errors. The status registers and the error queue are unaffected.

Local
The HP 8753B will go into local mode if the local command (GTL) is received, the remote line is unasserted, or the front panel local key is pressed. Only unasserting the remote line will clear a local lockout condition, although GTL will place the instrument temporarily in local mode. Changes from remote to local do not affect any of the front panel functions or values.

Local Lockout
If the HP 8753B is in remote mode, and it receives the local lockout command (LLO), it will disable the entire front panel except the line power switch.

Parallel Poll
The HP 8753B does not respond to parallel poll configure (PPC) or parallel poll unconfigure (PPU) messages.

Pass Control
If the HP 8753B is in pass control mode, is addressed to talk, and receives the take control command (TCT), it will take active control of the bus. If the HP 8753B was not requesting control, it immediately passes control to its controller address. Otherwise, the HP 8753B will execute the function it needed control of the bus for, and then pass control back.

Remote
The HP 8753B will go into remote mode, disabling all keys but **[LOCAL]**, when the remote line is asserted and it is addressed to listen. Changes from remote to local do not affect any front panel settings or functions.

Serial Poll
The HP 8753B will respond to a serial poll with its status byte, as defined in Appendix F, Status Reporting. To initiate the serial poll sequence, address the HP 8753B to talk and issue a serial poll enable (SPE), at which time the HP 8753B puts out its status byte. End the sequence by issuing a serial poll disable (SPD.) A serial poll does not affect the value of the status byte, and it does not put the instrument into remote.

Trigger
If in hold mode, the HP 8753B responds to device trigger by taking a single sweep. If a one path, 2-port calibration is active, the HP 8753B will set the waiting for GET bits in the status byte. If waiting for forward GET is set, the HP 8753B will assume the device is connected for forward measurement and take a sweep when GET is received. Similarly, if waiting for reverse GET is set, the HP 8753B will assume the device is connected for reverse measurement. The HP 8753B responds only to selected device trigger (SDT,) which means that it will not respond to group execute trigger (GET) unless it is addressed to listen. The HP 8753B will not respond to GET if it is not in hold mode.

Appendix A: Key Select Codes for the HP 8753B

This appendix is a functionally arranged table of HP-IB mnemonics that have a direct front panel key equivalent. The functions are arranged alphabetically by front panel hard key.

Keys:

Column headings:

FUNCTION	The front panel function affected by the mnemonic.
ACTION	The effects of the mnemonic on that function.
MNEMONIC	The mnemonic.
S	Syntax type. See Input Syntax.
?	Interrogate response. If a response is defined, it is listed.
O	OPC'able command.
RANGE	The range of acceptable inputs and corresponding units.

Symbol conventions are:

[]	An optional operand.
D	A numerical operand.
$	A character string operand, which must be enclosed by quotes.
<>	A necessary appendage.
|	An either/or choice in appendages.

Function	Action	Mnemonic	S	?	O	Range
		AVG				
Averaging	Restart	**AVERREST**	1			
	Factor	**AVERFACT[D]**	3	D		0 to 999
	On/off	**AVERO<ON|OFF>**	2	1,0		
Smoothing	Set aperature	**SMOOAPER[D]**	3	D		0.05 to 20 percent
	Activate	**SMOOO<ON|OFF>**	2	1,0		
IF bandwidth	Set bandwidth	**IFBW[D]**	3	D		D=10, 30, 100, 300, 1000, 3000 Hz
		CAL-error correction, calibration				
Correction	On/off	**CORR<ON|OFF>**	2	1,0		
Interpolative correction	On/off	**CORI<ON|OFF>**	2	1,0		
Cal sequence	Resume	**RESC**	1			
Port extensions	Port 1	**PORT1[D]**	3	D		± 10 s
	Port 2	**PORT2[D]**	3	D		± 10 s
	Input A	**PORTA[D]**	3	D		± 10 s
	Input B	**PORTB[D]**	3	D		± 10 s
	Off	**PORE<ON|OFF>**	2	1,0		
Velocity factor	Set value	**VELOFACT[D]**	3	D		0 to 10

Function	Action	Mnemonic	S	?	O	Range
Z0	Set Value	**SETZ[D]**	3	D		.1 to 500 ohm
Begin cal sequence	Response	**CALIRESP**	1	0,1		
	Response and Isol	**CALIRAI**	1	0,1		
	S11 1-port	**CALIS111**	1	0,1		
	S22 1-port	**CALIS221**	1	0,1		
	Full 2-port	**CALIFUL2**	1	0,1		
	One path 2-port	**CALIONE2**	1	0,1		
Intermediate cal steps, 2-port cal	Transmission	**TRAN**	1			
	Reflection	**REFL**	1			
	Isolation	**ISOL**	1			
Select response & isol class	Response	**RAIRESP**	1			
	Isolation	**RAIISOL**	1			
Select reflection class	S11A (open)	**CLASS11A**	1		See Note 1	
	S11B (short)	**CLASS11B**	1		"	
	S11C (load)	**CLASS11C**	1		"	
	S22A (open)	**CLASS22A**	1		"	
	S22B (short)	**CLASS22B**	1		"	
	S22C (load)	**CLASS22C**	1		"	
Select transmission class	Fwd transmission	**FWDT**	1		"	
	Rev transmission	**REVT**	1		"	
	Fwd match	**FWDM**	1		"	
	Rev match	**REVM**	1		"	
Select isolation class	Forward isol.	**FWDI**	1		"	
	Reverse isolation	**REVI**	1		"	
	Omit isolation	**OMII**	1		"	
Select standard in class	Standard A	**STANA**	1		OPC	
	B	**STANB**	1		OPC	
	C	**STANC**	1		OPC	
	D	**STAND**	1		OPC	
	E	**STANE**	1		OPC	
	F	**STANF**	1		OPC	
	G	**STANG**	1		OPC	
Sliding load	Set	**SLIS**	1			
	Done	**SLID**	1			
Done with:	Class	**DONE**	1		OPC	
	Isolation	**ISOD**	1		OPC	
	Reflection	**REFD**	1		OPC	
	Transmission	**TRAD**	1		OPC	
Save cal	Response	**RESPDONE**	1		OPC	
	Resp and isol	**RAID**	1		OPC	
	1-port cal	**SAV1**	1		OPC	
	2-port cal	**SAV2**	1		OPC	

CAL-calibration kits

Select default kits	7 mm	**CALK7MM**	1	1,0		
	3.5 mm	**CALK35MM**	1	1,0		
	Type N, 50 ohm	**CALKN50**	1	1,0		
	Type N, 75 ohm	**CALKN75**	1	1,0		
	User defined	**CALKUSED**	1	1,0		
Modify kit	Modify current	**MODI1**	1			

Function	Action	Mnemonic	S	?	O	Range
Define std. number (begin standard definition)		DEFS[D]	3			
Define standard type	Open	STDTOPEN	1	1,0		
	Short	STDTSHOR	1	1,0		
	Load	STDTLOAD	1	1,0		
	Delay/thru	STDTDELA	1	1,0		
	Arbitrary imped.	STDTARBI	1	1,0		
Define standard parameters	Open cap. C0	C0[D]	3			± 10e-12 F
	Open cap. C1	C1[D]	3			± 10e-12 F/Hz
	Open cap. C2	C2[D]	3			± 10e-12 F/Hz^2
	Open cap. C3	C3[D]	3			± 10e-12 F/Hz^3
	Fixed load	FIXE	1			
	Sliding load	SLIL	1			
	Terminal imped.	TERI[D]	3			0 to 1 kohm
Define standard offsets	Delay	OFSD[D]	3			± 1 s
	Loss	OFSL[D]	3			0 to 1000 Tohm/s
	Z0	OFSZ[D]	3			.1 to 500 ohm
	Min. frequency	MINF[D]	3			0 to 1000 GHz
	Max frequency	MAXF[D]	3			0 to 1000 GHz
	Coaxial	COAX	1	0,1		
	Waveguide	WAVE	1	0,1		
Std done	standard defined	STDD	1			
Label std		LABS[$]	3			10 char.
Specify class	Response	SPECRESP[I,I...]	3			I=std numbers (all same form)
	Resp & Isol	SPECRESI				
	S11A (open)	SPECS11A				
	S11B (short)	SPECS11B				
	S11C (load)	SPECS11C				
	S22A (open)	SPECS22A				
	S22B (short)	SPECS22B				
	S22C (load)	SPECS22C				
	Forward tran.	SPECFWDT				
	Forward match	SPECFWDM				
	Reverse tran.	SPECREVT				
	Reverse match	SPECREVM				
Class done		CLAD	1			
Label class	Response	LABERESP[$]	3			10 char.
	Resp. & isolation	LABERESI[$]	3			"
	S11A	LABES11A[$]	3			"
	S11B	LABES11B[$]	3			"
	S11C	LABES11C[$]	3			"
	S22A	LABES22A[$]	3			"
	S22B	LABES22B[$]	3			"
	S22C	LABES22C[$]	3			"
	Forward tran.	LABEFWDT[$]	3			"
	Forward match	LABEFWDM[$]	3			"
	Reverse tran.	LABEREVT[$]	3			"
	Reverse match	LABEREVM[$]	3			"
Label kit		LABK[$]	3			10 char.
Kit done		KITD	1			
Save kit	Into user kit	SAVEUSEK	1			

Function	Action	Mnemonic	S	?	O	Range
		CAL-power meter calibration				
Power meter cal	Off	**PWMCOFF[D]**	1	D		Cal power: −100 to 100 dB
	Each sweep	**PWMCEACS[D]**	1	D		"
	One sweep	**PWMCONES[D]**	1	D		"
	Take cal sweep	**TAKCS**	1			"
	Number of readings	**NUMR[D]**	3	D		1 to 100
Edit power loss table	On/off	**PWRLOSS<ON|OFF>**	2	1,0		
	Edit list	**POWLLIST**	1			
	Add segment	**SADD**	1			
	Edit segment N	**SEDI[D]**	3	D		1 to 12
	Done with segment	**SDON**	1			
	Delete segment	**SDEL**	1			
	Done	**EDITDONE**	1		OPC	
	Clear list	**CLEL**	1			
Edit power loss segment	Frequency	**POWLFREQ[D]**	3	D		See Note 2
	Value	**POWLLOSS[D]**	3	D		−9900 to 9900 dB
Edit cal sensor table	Sensor A	**USESENSA**	1			
	Sensor B	**USESENSB**	1			HP 438A only
	Edit sensor menu A	**CALFSENA**	1			
	Edit sensor menu B	**CALFSENB**	1			HP 438A only
	Add segment	**SADD**	1			
	Edit segment N	**SEDI[D]**	3	D		1 to 12
	Done with segment	**SDON**	1			
	Delete segment	**SDEL**	1			
	Done	**EDITDONE**	1		OPC	
	Clear list	**CLEL**	1			
Edit cal sensor segment	Frequency	**CALFFREQ[D]**	3	D		See Note 2.
	Cal factor	**CALFCALF[D]**	3	D		0 to 200 percent
		CHANNEL				
Channel	CH 1 active	**CHAN1**	1		OPC	
	CH 2 active	**CHAN2**	1		OPC	
		COPY				
Copy display	To printer	**PRINALL**	1			
	To plotter	**PLOT**	1			
Copy display talker/ listener	To plotter	**OUTPPLOT**	1			
	To printer	**OUTPPRIN**	1			
List values		**LISV**	1			
Operating parameters		**OPEP**	1			
Next page		**NEXP**	1			

Function	Action	Mnemonic	S	?	O	Range
Restore display		**RESD**	1			
Quadrant	Left lower	**LEFL**	1	0,1		
	Left upper	**LEFU**	1	0,1		
	Right lower	**RIGL**	1	0,1		
	Right upper	**RIGU**	1	0,1		
	Full page	**FULP**	1	0,1		
Pen number	Data	**PENNDATA[D]**	3			0,1,2...10
	Memory	**PENNMEMO[D]**	3			0,1,2...10
	Graticule	**PENNGRAT[D]**	3			0,1,2...10
	Text	**PENNTEXT[D]**	3			0,1,2...10
	Marker	**PENNMARK[D]**	3			0,1,2...10
Line type	Data	**LINTDATA[D]**	3			0,1,2...10
	Memory	**LINTMEMO[D]**	3			0,1,2...10
Features to be plotted	Data	**PDATA<ON|OFF>**	2	1,0		
	Memory	**PMEM<ON|OFF>**	2	1,0		
	Graticule	**PGRAT<ON|OFF>**	2	1,0		
	Text	**PTEXT<ON|OFF>**	2	1,0		
	Marker	**PMKR<ON|OFF>**	2	1,0		
Plot scale	Full page	**SCAPFULL**	1			
	Graticule to p1,p2	**SCAPGRAT**	1			
Plot speed	Slow	**PLOSSLOW**	1			
	Fast	**PLOSFAST**	1			
		DISPLAY				
Channels	Dual on/off	**DUAC<ON|OFF>**	2	1,0		
	Split on/off	**SPLD<ON|OFF>**	2	1,0		
	D2/D1 to D2	**D1DIVD2<ON|OFF>**	2	1,0		
Display	Data	**DISPDATA**	1	0,1		
	Memory only	**DISPMEMO**	1	0,1		
	Data and mem	**DISPDATM**	1	0,1		
	Data/mem	**DISPDDM**	1	0,1		
	Data — mem	**DISPDMM**	1	0,1		
	Data to mem	**DATI**	1	0,1	OPC	
Beeper	On done	**BEEPDONE<ON|OFF>**	2	1,0		
	On warning message	**BEEPWARN<ON|OFF>**	2	1,0		
CRT	Intensity	**INTE[D]**	3	D		0 to 100 percent
	Focus	**FOCU[D]**	3	D		0 to 100 percent
	Title	**TITL[$]**	4	$		48 char.
Frequency notation	blank	**FREO**	1			
		ENTRY				
Step keys	Up	**UP**	1			
	Down	**DOWN**	1			
Entry off		**ENTO**	1			

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<tr><td></td><td>Phase</td><td>PHAS</td><td>1</td><td>0,1</td><td></td><td></td></tr>
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<tr><td>Disc drive</td><td>Unit</td><td>DISCUNIT[D]</td><td>3</td><td>D</td><td></td><td>0 to 30</td></tr>
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<tr><td>HP-IB addresses</td><td>Plotter</td><td>ADDRPLOT[D]</td><td>1</td><td>D</td><td></td><td>0 to 30</td></tr>
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<tr><td></td><td>Disc drive</td><td>ADDRDISC[D]</td><td>1</td><td>D</td><td></td><td>0 to 30</td></tr>
<tr><td></td><td>Controller</td><td>ADDRCONT[D]</td><td>1</td><td>D</td><td></td><td>0 to 30</td></tr>
<tr><td>Power meter</td><td>Address</td><td>ADDRPOWM[D]</td><td>1</td><td>D</td><td></td><td>0 to 30</td></tr>
<tr><td></td><td>Type</td><td>POWM<ON|OFF></td><td>2</td><td>0,1</td><td></td><td>On=436A, off=438A/437B</td></tr>
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<tr><td></td><td>Z:reflection</td><td>CONVZREF</td><td>1</td><td>0,1</td><td></td><td></td></tr>
<tr><td></td><td>Z:transmission</td><td>CONVZTRA</td><td>1</td><td>0,1</td><td></td><td></td></tr>
<tr><td></td><td>Y:reflection</td><td>CONVYREF</td><td>1</td><td>0,1</td><td></td><td></td></tr>
<tr><td></td><td>Y:transmission</td><td>CONVYTRA</td><td>1</td><td>0,1</td><td></td><td></td></tr>
<tr><td></td><td>1/S</td><td>CONV1DS</td><td>1</td><td>0,1</td><td></td><td></td></tr>
<tr><td>Analog input</td><td></td><td>ANAI</td><td>1</td><td>0,1</td><td></td><td></td></tr>
</table>

Function	Action	Mnemonic	S	?	O	Range
		MENU (stimulus)				
Power	Level	**POWE[D]**	3	D		-10 to +25 dBm
	Trip	**POWT<ON|OFF>**	2	1,0		
	Always couple power	**COUP<ON|OFF>**	2	1,0		
Time	Specify	**SWET[D]**	3	D		.01 to 86,400 s
Measurement	Restart	**REST**	1			
Trigger	Hold	**HOLD**	1	0,1		
	Single	**SING**	1		OPC	
	Number of groups	**NUMG[D]**	3		OPC	1 to 999
	Continuous	**CONT**	1	0,1		
	External trigger off	**EXTTOFF**	2	0,1	OPC	
	External trigger on	**EXTTON**	2	0,1	OPC	
	External trigger on point	**EXTTPOIN**	1	0,1	OPC	
	Manual trigger on point	**MANTRIG**	1	0,1	OPC	
Points	Specify	**POIN[D]**	3	D		3, 11, 26, 51, 101, 201, 401, 801, 1601
Coupled channels	On/off	**COUC<ON|OFF>**	2	1,0		
CW freq	Set value	**CWFREQ[D]**	3	D		See Note 2.
Power slope	Value	**SLOPE[D]**	3	D		0 to 2 dB/GHz
	On/off	**SLOPO<ON|OFF>**	2	1,0		
Test set attenuation	Port 1	**ATTP1[D]**	3	D		0,10,20...70 dB
	Port 2	**ATTP2[D]**	3	D		0,10,20...70 dB
Sweep type	Linear	**LINFREQ**	1	0,1		
	Log	**LOGFREQ**	1	0,1		
	List	**LISFREQ**	1	0,1		
	Select a segment	**SSEG[D]**	3	0,1		1 to 30
	Select all segments	**ASEG**	1	0,1		
	Power	**POWS**	1	0,1		
	CW time	**CWTIME**	1	0,1		
Edit list	Begin	**EDITLIST**	1			
	Add segment	**SADD**	1			
	Edit segment N	**SEDI[D]**	3	D		1 to 30
	Done with segment	**SDON**	1			
	Delete segment	**SDEL**	1			
	Done	**EDITDONE**	1		OPC	
	Clear list	**CLEL**	1			
Edit segment	Start	**STAR[D]**	3	D		See Note 2.
	Stop	**STOP[D]**	3	D		"
	Center	**CENT[D]**	3	D		"
	Span	**SPAN[D]**	3	D		"
	Points	**POIN[D]**	3	D		1 to 1632
	Stepsize	**STPSIZE[D]**	3	D		See Note 2.
	CW	**CWFREQ[D]**	3	D		"

Function	Action	Mnemonic	S	?	O	Range
MKR						
Select active	1 to 4	**MARK<I>[D]**	4	D		See Note 2.
	All off	**MARKOFF**	1	0,1		
Marker zero	Zero offsets	**MARKZERO**	1			
Delta reference	1 to 4	**DELR<I>**	2	0,1		I=1 to 4
	Fixed marker	**DELRFIXM**	1	0,1		
	Mode off	**DELO**	1	0,1		
Fixed mkr position	Stimulus	**MARKFSTI[D]**	3	D		See Note 2.
	Value	**MARKFVAL[D]**	3	D		See Note 3.
	Aux value	**MARKFAUV[D]**	3	D		"
Marker placement	Continuous	**MARKCONT**	1	0,1		
	Discrete	**MARKDISC**	1	0,1		
Coupled	Couple channels	**MARKCOUP**	1	0,1		
	Uncouple	**MARKUNCO**	1	0,1		
Polar markers	Log	**POLMLOG**	1	0,1		
	Linear	**POLMLIN**	1	0,1		
	Re/Im	**POLMRI**	1	0,1		
Smith markers	Linear	**SMIMLIN**	1	0,1		
	Log	**SMIMLOG**	1	0,1		
	Re/Im	**SMIMRI**	1	0,1		
	R+jX	**SMIMRX**	1	0,1		
	G+jB	**SMIMGB**	1	0,1		
MKR FCTN						
Set function to marker value	Start	**MARKSTAR**	1			
	Stop	**MARKSTOP**	1			
	Center	**MARKCENT**	1			
	Span	**MARKSPAN**	1			
	Reference	**MARKREF**	1			
	Delay	**MARKDELA**	1			
Search	Off	**SEAOFF**	1	0,1		
	Maximum	**SEAMAX**	1	0,1		
	Minimum	**SEAMIN**	1	0,1		
	Target	**SEATARG[D]**	3	D		See Note 3.
	Search left	**SEAL**	1			
	Search right	**SEAR**	1			
Width search	Value	**WIDV[D]**	3	D		See Note 3.
	Search on/off	**WIDT<ON|OFF>**	2	1,0		
Tracking search	On/off	**TRACK<ON|OFF>**	2	1,0		
Statistics	On/off	**MEASTAT<ON|OFF>**	2	1,0		

Function	Action	Mnemonic	S	?	O	Range
		SAVE/RECALL				
Save	Selected reg	**SAVE<I>**	2		OPC	I=1 to 5
Clear	Selected reg	**CLEA<I>**	2			I=1 to 5
	All regs	**CLEARALL**	1		OPC	
Purge	Selected file	**PURG<I>**	2			I=1 to 5
Store	To disc	**STOR<I>**	2			I=1 to 5
Title	Internal reg	**TITR<I>[$]**	2			I=1 to 5, 10 char.
	Disc reg	**TITF<I>[$]**	2			"
Include with disc registers	Data	**EXTMDATA<ON|OFF>**	2	1,0		
	Raw data	**EXTMRAW<ON|OFF>**	2	1,0		
	Formatted data	**EXTMFORM<ON|OFF>**	2	1,0		
	User graphics	**EXTMGRAP<ON|OFF>**	2	1,0		
	Data only	**EXTMDATO<ON|OFF>**	2	1,0		
Recall	Selected reg	**RECA<I>**	2		OPC	I=1 to 5
Load	From disc	**LOAD<I>**	2			I=1 to 5
	Register titles	**REFT**	2			
Initialize	Disc	**INID**	1			
	Directory size	**DIRS[D]**				8 to 32,760
		SCALE REF				
Scale	Auto	**AUTO**	1			
	Value	**SCAL[D]**	3	D		See Note 3.
Reference	Position	**REFP[D]**	3	D		0<D< 10
	Value	**REFV[D]**	3	D		See Note 3.
	Set to mkr	**MARKREF**	1			
Delay	Set delay	**ELED[D]**	3	D		±1.0 s
	Set to mkr	**MARKDELA**	1			
Phase	Offset	**PHAO[D]**	3	D		± 360 deg
		STIMULUS				
Stimulus	Center	**CENT[D]**	3	D		Stim range, Note 2.
	Span	**SPAN[D]**	3	D		"
	Start	**STAR[D]**	3	D		"
	Stop	**STOP[D]**	3	D		"
		SYSTEM				
Frequency range	Doubler on/off	**FREQRANG<3GHZ|6GHZ>**	2	1,0	OPC	See Note 4.
Harmonic mode	Off	**HARMOFF**	1	0,1	OPC	
	Second	**HARMSEC**	1	0,1	OPC	
	Third	**HARMTHIR**	1	0,1	OPC	

Function	Action	Mnemonic	S	?	O	Range
Instrument Mode	Network analyzer	**INSMNETA**	1	0,1	OPC	
	Ext. source auto	**INSMEXSA**	1	0,1	OPC	
	Ext. source manual	**INSMEXSM**	1	0,1	OPC	
	Tuned receiver	**INSMTUNR**	1	0,1	OPC	
Frequency offset	On/off	**FREQOFFS<ON|OFF>**	2	1,0	OPC	
	Value	**VOFF[D]**	3			See note 2.
		SYSTEM-sequencing				
Sequencing Menu	Do sequence	**DOSEQ<I>**	3			I=1 to 6
	New/modify sequence	**NEWSEQ<I>**	3			I=1 to 6
	Done modify	**DONM**	1			
Save/recall sequences	Store to disc	**STORSEQ<I>**	3			I=1 to 6
	Recall from disc	**LOADSEQ<I>**	3			I=1 to 6
Special functions	Title to printer	**TITTPRIN**	1			
	Title to power meter/HP-IB	**TITTPMTR**	1			
	Wait D seconds	**SEQWAIT[D]**	3			0.1 to 3000 sec.
	Pause	**PAUS**	1			
	Marker to CW freq.	**MARKCW**	1			
	Emit beep	**EMIB**	1			
	TTL out high	**TTLOH**	1			See Note 4.
	TTL out low	**TTLOL**	1			See Note 4.
	Show menus	**SHOM**	1			
	Assert seq. status bit	**ASSS**	1			
	Read pwr mtr/HP-IB into title string	**PMTRTTIT**	1			
	Send number into trace memory	**TITTMEM**	1			
	Duplicate seq. X to seq. Y	**DUPLSEQ<X>SEQ<Y>**	3			X, Y=1 to 6
	Print sequence I	**PRINSEQ<I>**	3			I=1 to 6
	Title sequence I	**TITSEQ<I>**	3			I=1 to 6
	Clear sequence I	**CLEASEQ<I>**	3			I=1 to 6
Decision making	If limit test pass then do sequence	**IFLTPASSSEQ<I>**	3			I=1 to 6
	If limit test fail then do sequence	**IFLTFAILSEQ<I>**	3			I=1 to 6
Loop counter	Set value	**LOOC[D]**	3			0 to 32,760
	Increment by 1	**INCRLOOC**	1			
	Decrement by 1	**DECRLOOC**	1			
	If counter equals 0 then do sequence	**IFLCEQZESEQ<I>**	3			I=1 to 6
	If counter not eq. 0 then do sequence	**IFLCNEZESEQ<I>**	3			I=1 to 6

Function	Action	Mnemonic	S	?	O	Range
		SYSTEM-limit testing				
Limit line	On/off	**LIMILINE<ON|OFF>**	2	1,0		
Limit test	On/off	**LIMITEST<ON|OFF>**	2	1,0		
	Beeper	**BEEPFAIL<ON|OFF>**	2	1,0		
Limit offset	Stimulus	**LIMISTIO[D]**	3	D		See Note 2.
	Amplitude	**LIMIAMPO[D]**	3	D		See Note 3.
	Marker to offset	**LIMIMAOF**	1			
Edit table	Begin edit	**EDITLIML**	1			
	Add segment	**SADD**	1			
	Edit segment D	**SEDI[D]**	3	D		1 to 18
	Segment done	**SDON**	1			
	Delete segment	**SDEL**	1			
	Done with edit	**EDITDONE**	1			
	Clear list	**CLEL**	1			
Edit segment	Stimulus value	**LIMS[D]**	3	D		See Note 2.
	Marker to stimulus	**MARKSTIM**	1			
	Upper limit	**LIMU[D]**	3	D		See Note 3.
	Lower limit	**LIML[D]**	3	D		"
	Delta limits	**LIMD[D]**	3	D		"
	Middle value	**LIMM[D]**	3	D		"
	Marker to middle	**MARKMIDD**	1			
	Flat line type	**LIMTFL**	1	0,1		
	Sloping line type	**LIMTSL**	1	0,1		
	Single point type	**LIMTSP**	1	0,1		
		SYSTEM-transform				
Transform	On/off	**TIMDTRAN<ON|OFF>**	2			
Set freq	Low pass	**SETF**	1			
Mode	Low pass impulse	**LOWPIMPU**	1	0,1		
	Low pass step	**LOWPSTEP**	1	0,1		
	Bandpass	**BANDPASS**	1	0,1		
Window	Maximum	**WINDMAXI**	1			
	Normal	**WINDNORM**	1			
	Minimum	**WINDMINI**	1			
	Any value	**WINDOW[D]**	3	D		State dependent
Window shape	Use trace memory	**WINDUSEM<ON|OFF>**	2	1,0		
Demodulation	Off	**DEMOOFF**	1	0,1		
	Amplitude	**DEMOAMPL**	1	0,1		
	Phase	**DEMOPHAS**	1	0,1		
Gate	On/off	**GATEO<ON|OFF>**	2	1,0		
	Start	**GATESTAR[D]**	3	D		See Note 2.
	Stop	**GATESTOP[D]**	3	D		"
	Center	**GATECENT[D]**	3	D		"
	Span	**GATESPAN[D]**	3	D		"
Gate shape	Maximum	**GATSMAXI**	1	0,1		
	Wide	**GATSWIDE**	1	0,1		
	Normal	**GATSNORM**	1	0,1		
	Minimum	**GATSMINI**	1	0,1		

NOTE 1:
The class commands are OPC'able if there is only one standard in the class. If there is just one standard, that standard is measured automatically. If there is more than one standard in the class, the class command only calls another menu.

NOTE 2, Stimulus range:
For frequency sweeps: 300 kHz to 3 GHz. (3 MHz to 6 GHz for Option 006 and an HP 85047A Test Set with the doubler turned on).
For power sweeps: −10 to 25 dBm (−100 to +100 with power meter cal on).
For CW time: 0 to 24 hours.
For frequency sweep, transform on: ± 1/frequency step.
For CW time sweep, transform on: ± 1/time step.

NOTE 3, Amplitude range:
For log mag: ± 500 dB.
For phase: ± 500 degrees.
For Smith chart and Polar: ± 500 units.
For linear magnitude: ± 500 units.
For SWR: ± 500 units.
The scale is always positive, and has minimum values of .001 dB, 10e-12 degrees, 10e-15 seconds, and 10 picounits.

NOTE 4:
These commands are applicable when the HP 8753B is configured with an HP 85047A Test Set.

Action	Mnemonic	Syntax	Description
	MISCELLANEOUS		
Identity	**IDN?**	1	Outputs the identification string: "HEWLETT PACKARD, 8753B,0,X.XX", where X.XX is the firmware revision of the instrument.
Key	**KEY[D]**	1	Imitates pressing a key. The data transmitted is the key code, as defined in Figure E.4.
Key code	**KOR?**	1	Outputs last key code or knob count. If the reply is positive, it is a key code. If it is negative, then set bit 15 equal to bit 14, and the resulting two byte integer is the RPG knob count. It can be either positive or negative. There are about 120 counts per turn.
Move marker	**MARKBUCK[D]**	2	Moves the marker to the selected point on the trace. On a 201 point sweep, D can range from 0 to 200.
On completion	**OPC**	1	Reports completion of the last OPC'able command received since **OPC;** or **OPC?;** was received.
Plot keys	**PSOFT<ON|OFF>**	2	Includes the menu keys in **OUTPPLOT;** and **OUTPPRIN;** strings.
Revision	**SOFR**	1	Displays the software revision on the HP 8753B.
Sampler	**SAMC<ON|OFF>**	2	Turns sampler correction off. To be used only when data is being taken to create custom calibration coefficients.
Test Set	**TESS?**	1	Returns a one if an HP 85046A/B S-parameter test set is present. Returns a two if an HP 85047A S-parameter test set is present.
	INPUT		
Data	**INPUDATA[D]**	3	Accepts error corrected data.
Formatted	**INPUFORM[D]**	3	Accepts formatted data.
Uncorrected	**INPURAW1[D]**	3	Accepts raw data.
	INPURAW2[D]	3	
	INPURAW3[D]	3	
	INPURAW4[D]	3	
Error coef.	**INPUCALC<01, 02,...12>**		Accepts the individual error coefficient arrays. Issue the command that begins the calibration the coefficients are from (e.g. **CALIS11;**), then input the data. Lastly, issue **SAVC;** and trigger a sweep.
Pwr meter cal	**INPUPMCAL<1,2>**	3	Accepts power meter cal array. Values should be entered as 100*desired source power.
Cal kit	**INPUCALK[D]**	3	Accepts a cal kit.
Learn string	**INPULEAS[D]**	3	Accepts the learn string.
	MENUS		
Averaging	**MENUAVG**	1	
Calibration	**MENUCAL**	1	
Copy	**MENUCOPY**	1	
Display	**MENUDISP**	1	
Format	**MENUFORM**	1	

Action	Mnemonic	Syntax	Description
Marker	**MENUMARK**	1	
Meas	**MENUMEAS**	1	
Marker fctn	**MENUMRKF**	1	
Off	**MENUO<ON|OFF>**	2	
Recall	**MENURECA**	1	
Save	**MENUSAVE**	1	
Scale	**MENUSCAL**	1	
Stimulus	**MENUSTIM**	1	
System	**MENUSYST**	1	

OUTPUT

NOTE: Except as noted, these commands output data according to the current output format. The data is transmitted in pairs of numbers, the number of pairs being the same as the number of points in the sweep.

Action	Mnemonic	Syntax	Description
Active funct.	**OUTPACTI**	1	Outputs value of function in active entry area in ASCII format.
Error coef.	**OUTPCALC<01,02. . .12>**		Outputs the selected error coefficient array from the active channel. Each array is the same as a data array. See Appendix C, Calibration, for the contents of the arrays.
Cal kit	**OUTPCALK**	1	Outputs the active cal kit, a less than 1000 byte string in form 1.
Data	**OUTPDATA**	1	Outputs the error corrected data from the active channel in real/imaginary pairs. See Figure E.1, Processing Chain.
Error	**OUTPERRO**	1	Outputs the oldest error in the error queue. The error number is transmitted, then the error message, in ASCII format.
Formatted	**OUTPFORM**	1	Outputs the formatted trace data from the active channel in current display units. See Figure E.2 for data transmitted.
Pwr mtr cal	**OUTPMCAL<1,2>**	1	Outputs power meter cal array for channel 1 or channel 2. Values are sent as 100*power.
Identity	**OUTPIDEN**	1	Outputs identification string, same as **IDN?**.
Keycode	**OUTPKEY**	1	Outputs the code of the last key pressed, in ASCII format. See Figure E.4 for key codes. A −1 is transmitted for a knob turn.
Learn strng	**OUTPLEAS**	1	Outputs the learn string, a less than 3,000 byte string in form 1.
Ext. source	**OUTPRFFR**	1	Outputs external source RF frequency when in external source instrument mode.
Sequencing	**OUTPSEQ<I>**	1	Outputs sequence I (I=1 to 6) listing over HP-IB.
Limit failures	**OUTPLIMF**	1	Outputs the limit results as described under **OUTPLIML** for only those stimulus points that failed.
Limit list	**OUTPLIML**	1	Outputs the limit test results for each stimulus point. The results consist of four numbers. The first is the stimulus value tested, the second is the test result: −1 for no test, 0 for fail, 1 for pass. The third number is the upper limit value, and the fourth is the lower limit value. This is a form 4 transfer.
Limit marker	**OUTPLIMM**	1	Outputs the limit test results as described for **OUTPLIML** at the marker.

Action	Mnemonic	Syntax	Description
Marker	**OUTPMARK**	1	Outputs the active marker values in 3 numbers. The first two numbers are the marker values, and the last is the stimulus value. See Figure E.2 for the marker values.
Memory	**OUTPMEMO**	1	Outputs the memory trace from the active channel. It is error corrected data in real/imaginary pairs, and can be treated the same as data from **OUTPDATA**.
Marker stats.	**OUTPMSTA**	1	Outputs marker statistics: mean, standard deviation, and peak to peak deviation. ASCII format.
Bandwidth	**OUTPMWID**	1	Outputs results of bandwidth search: bandwidth, center, and Q. ASCII format.
Plot	**OUTPPLOT**	1	Outputs the plot string in ASCII format. Can be directed to an HP-GL plotter.
Print	**OUTPPRIN**	1	Outputs a raster display dump in ASCII format. Can be directed to a graphics printer.
Raw data	**OUTPRAW1**	1	Outputs uncorrected data arrays for the active channel. Raw 1 holds the data unless a 2-port calibration is on, in which case the arrays hold S11, S21, S12, and S22, respectively. The data is in real/imaginary pairs.
	OUTPRAW2	1	
	OUTPRAW3	1	
	OUTPRAW4	1	
Status byte	**OUTPSTAT**	1	Outputs the status byte. ASCII format.
Display title	**OUTPTITL**	1	Outputs the display title. ASCII format.

OUTPUT FORMATS

	FORM1	1	HP 8753A internal format, with header.
	FORM2	1	32 bit floating point, with header.
	FORM3	1	64 bit floating point, with header.
	FORM4	1	ASCII format. No header.

SOFTKEYS

Press	**SOFT[I]**	2	Activates softkey I, I=1 to 8.
label	**WRSK<1 TO 8>[$]**	3	Writes label (10 char) to indicated softkey.

STATUS REPORTING

Clear	**CLES**	1	Clears the status byte.
Interrogate	**ESB?**	1	Returns event status register B.
	ESR?	1	Returns the event status register.
	OUTPSTAT	1	Returns the status byte.
Enable	**ESE[D]**	3	Enables event status register. (0<D<255)
	ESNB[D]	3	Enables event status register B. (0<D<255)
	SRE[D]	3	Enables SRQ. (0<D<255)

Appendix C: Calibration

Measurement calibration over HP-IB follows the same command sequence as a calibration from the front panel:

1. Start by selecting a cal kit, such as 50 ohm type N (**CALKN50;** over HP-IB.)

2. Select a calibration type, such as S11 1-port (**CALIS111;** over HP-IB.)

3. Call each class used by the calibration type, such as [**OPENS**] (**CLASS11A;** over HP-IB.) During a 2-port calibration, the reflection, transmission, and isolation subsequences must be opened before the classes in the subsequence are called, and then closed at the end of each subsequence.

4. If a class has more than one standard in it, select a standard from the menu presented (**STANA** to **STANG** over HP-IB.)

5. If, during a calibration, two standards are measured to satisfy one class, the class must be closed with **DONE;**.

6. Declare the calibration done, such as with [**DONE 1-PORT**] (**SAV1;** over HP-IB.)

The **STANA** to **STANG** commands are all held commands because they trigger a sweep. If a class has only one standard in it, which means that it will trigger a sweep when called, the class command will be held also.

Note that since different cal kits can have a different number of standards in a given class, any automated calibration sequence is valid only for a specific cal kit.

Table C.1 Relationship between calibrations and classes

Class	Response	Response and Isolation	S11 1-port	S22 1-port	One path 2-port	Full 2-port
Reflection:[1]					•	•
S11A, opens			•		•	•
S11B, shorts			•		•	•
S11C, loads			•		•	•
S22A, opens				•		•
S22B, shorts				•		•
S22C, loads				•		•
Transmission:[1]					•	•
Forward match					•	•
Forward thru					•	•
Reverse match						•
Reverse thru						•
Isolation:[1]					•	•
Forward					•	•
Reverse						•
Response	•					
Response and isolation:						
Response		•				
Isolation		•				

[1] *These subheadings must be called when doing 2-port calibrations.*

Table C.2 Calibration arrays

Array	Response	Response and Isolation	1-port	2-port[1]
1	E_R or E_T	E_X (E_D)[2]	E_D	E_{DF}
2		E_T (E_R)	E_S	E_{SF}
3			E_R	E_{RF}
4				E_{XF}
5				E_{LF}
6				E_{TF}
7				E_{DR}
8				E_{SR}
9				E_{RR}
10				E_{XR}
11				E_{LR}
12				E_{TR}

[1] One path, 2-port cal duplicates arrays 1 to 6 in arrays 7 to 12.

[2] Response and isolation corrects for crosstalk and transmission tracking in transmission measurements, and for directivity and reflection tracking in reflection measurements.

Meaning of first subscript: D=directivity, S=source match, R=reflection tracking, X=crosstalk, L=load match, T=transmission tracking.

Meaning of second subscript: F=forward, R=reverse.

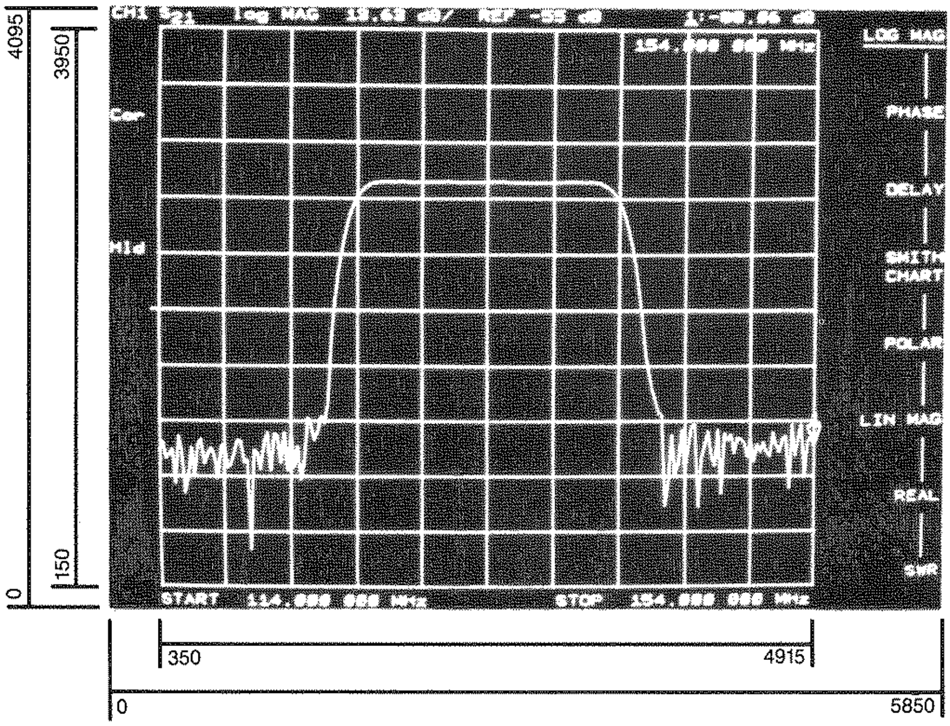
HP-GL subset:

Command	Description
AF;	Erases the user graphics display.
CS;	Turns off the measurement display.
DF;	Sets the default values.
LB[text][etx];	Labels the display, placing the symbols starting at the current pen position. All incoming characters are printed until the etx symbol is received. The default etx symbol is the ASCII value 3 (not the character 3).
LTa;	Specifies line type: a — line 0 — solid 1 — solid 2 — short dashes 3 — long dashes
OP;	Outputs P1 and P2, the scaling limits: 0,0,5850,4095.
PAx,y;	Draws from the current pen position to x,y. There can be many pairs of x,y coordinates within one command. They are separated by commas, and the entire sequence is terminated with a semicolon.
PD;	Pen down. A line is drawn only if the pen is down.
PG;	Erases the user graphics display.
PRx,y;	Plot relative: draws a line from the current pen position to a position y up and x over.
PU;	Pen up. Stops anything from being drawn.
RS;	Turns on the measurement display.
SIh,w;	Sets the character size, for height h and width w in centimeters: h — w — size .16 — .20 — smallest .25 — .30 .33 — .39 .41 — .49 — largest
SPn;	Selects pen n: n — brightness 0 — blank 1 — brightest 2 3 — dimmest

Accepted but ignored HP-GL commands:

IM	Input service request mask
IP	Input P1,P2 scaling points
IW	Input window
OC	Output current pen position
OE	Output error
OI	Output identity
OS	Output status
SL	Character slant
SR	Relative character size

Figure D.1: Location of graticule in user graphics units



Appendix E: Useful Tables and Figures

Figure E.1: Processing Chain

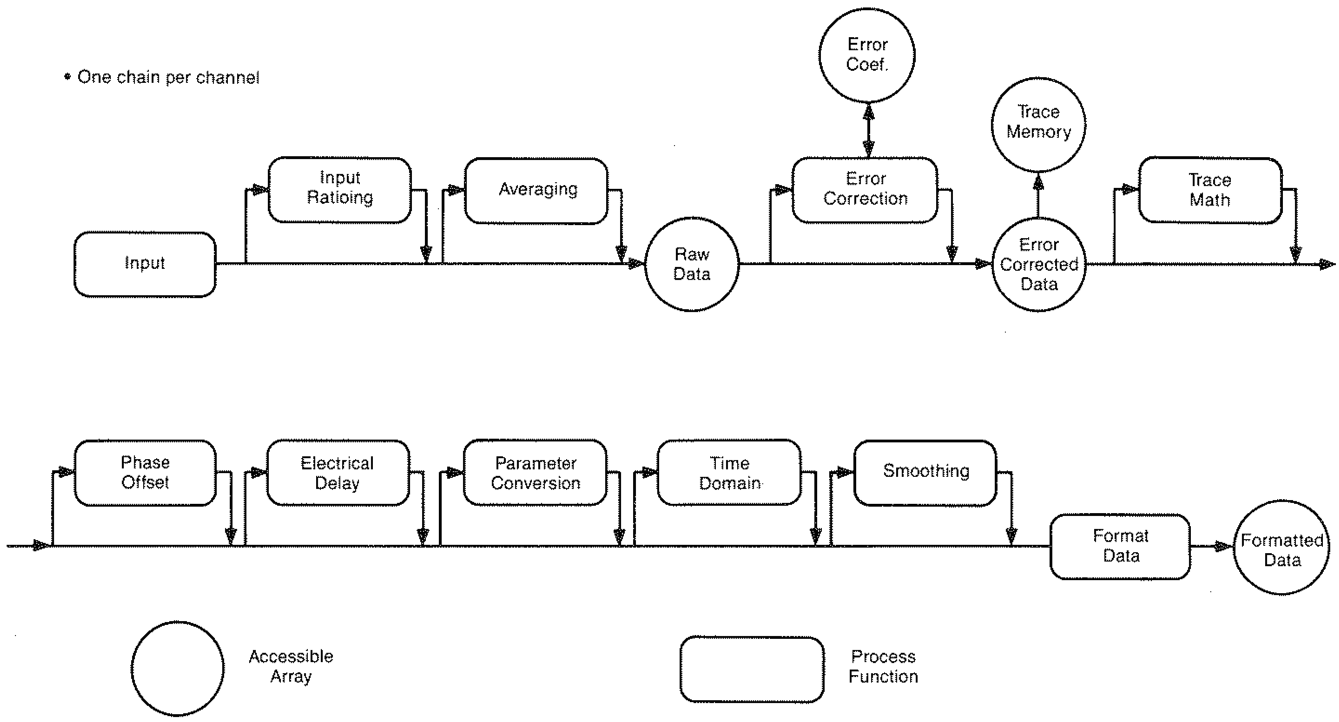


Figure E.2: Marker and data array units as a function of display format

Display Format	Marker Mode	OUTPMARK value 1, value 2	OUTPFORM value 1, value 2	Marker Readout** value, aux value
LOG MAG		dB, *	dB, *	dB, *
PHASE		degrees, *	degrees, *	degrees, *
DELAY		seconds, *	seconds, *	seconds, *
SMITH CHART	LIN MKR	lin mag, degrees	real,imag	lin mag, degrees
	LOG MKR	dB, degrees	"	dB, degrees
	Re/Im	real, imag	"	real, imag
	R + jX	real, imag ohms	"	real, imag ohms
	G + jB	real, imag Siemans	"	real, imag Siemans
POLAR	LIN MKR	lin mag, degrees	real, imag	lin mag, degrees
	LOG MKR	dB, degrees	"	dB, degrees
	Re/Im	real, imag	"	real, imag
LIN MAG		lin mag, *	lin mag, *	lin mag, *
REAL		real, *	real, *	real, *
SWR		SWR, *	SWR, *	SWR, *

* = Value not significant in this format, but is included in data transfers.

** = The marker readout values are the marker values displayed in the upper left hand corner of the display. They also correspond to the value and aux value associated with the fixed marker.

Figure E.3: Disc file names

Disc files created by the HP 8753B consist of a state name of up to 8 characters, such as FILTER, appended with up to two characters, which indicate what is in the file. Data and calibration files are form 3 data (without a header) which can be read off the disc. The other files are not meant to be decoded, and it is recommended that disc registers not be created or modified with a computer.

FILTERXX

The first character is the file type, telling the kind of information in the file.

The second character is a data index, used to distinguish files of the same type.

Char 1	Meaning	Char 2	Meaning
I	Instrument state		
G	Graphics	**1**	Display graphics
		0	Graphics index
D	Error corrected data	**1**	Channel 1
		2	Channel 2
R	Raw data	**1 to 4**	Channel 1, raw arrays 1 to 4
		5 to 8	Channel 2, raw arrays 1 to 4
F	Formatted data	**1**	Channel 1
		2	Channel 2
M	Memory trace	**1**	Channel 1
		2	Channel 2
1	Cal data, channel 1	**K**	Cal kit
		0	Stimulus state
		1 to 9	Coefficients 1 to 9
		A	Coefficient 10
		B	Coefficient 11
		C	Coefficient 12
2	Cal data, channel 2	**0 to C,K**	Same as channel 1

Figure E.4: Key codes

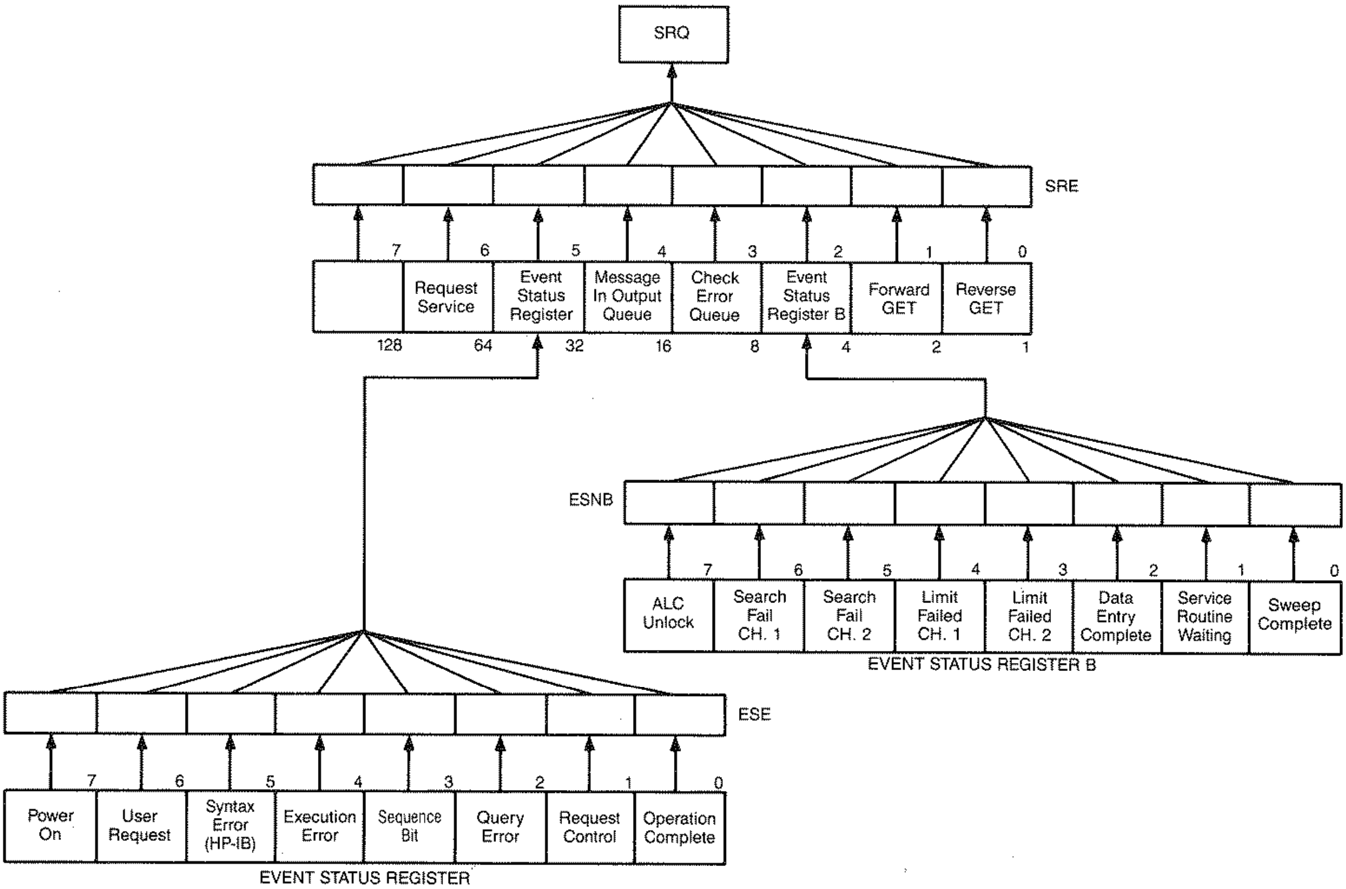
Note 1: Key code 63 is invalid key.

Note 2: **OUTPKEY;** reports a knob turn as a −1.

Note 3: If the two byte integer sent back from **KOR?** is negative, it is a knob count. If the knob count was negative, no modification is needed. If the knob count was positive, however, bit 14 will not be set. In this case, the number must be decoded by clearing the most significant byte, as by AND'ing the integer with 255.

Appendix F: Status Reporting

Figure F.1: Status Reporting Structure



Status Byte

Bit	Name	Description
0	Waiting for reverse GET	A one path, 2-port calibration is active, and the instrument has stopped, waiting for the operator to connect the device for reverse measurement.
1	Waiting for forward GET	A one path, 2-port calibration is active, and the instrument has stopped, waiting for the operator to connect the device for forward measurement.
2	Check event status register B	One of the enabled bits in event status register B has been set.
3	Check error queue	An error has occurred and the message has been placed in the error queue, but has not been read yet.
4	Message in output queue	A command has prepared information to be output, but it has not been read yet.
5	Check event status register	One of the enabled bits in the event status register has been set.
6	Request service	One of the enabled status byte bits is causing an SRQ.

Event Status Register

Bit	Name	Description
0	Operation complete	A command for which OPC has been enabled completed operation.
1	Request control	The HP 8753B has been commanded to perform an operation that requires control of a peripheral, and needs control of HP-IB. Requires pass control mode.
2	Query error	The HP 8753B has been addressed to talk, but there is nothing in the output queue to transmit.
4	Execution error	A command was received that could not be executed. Commonly due to invalid operands.
5	Syntax error	The incoming HP-IB commands contained a syntax error. The syntax error is cleared only by a device clear or an instrument preset.
6	User request	The operator has pressed a front panel key or turned the knob. Works if front panel in local or remote mode.
7	Power on	A power on sequence has occurred since the last read of the register.

Event Status Register B

Bit	Name	Description
0	Sweep or group complete	A single sweep or group has been completed since the last read of the register. Operates in conjunction with SING or NUMG.
1	Service routine waiting or done	An internal service routine has completed operation, or is waiting for an operator response.
2	Data entry complete	A terminator key has been pressed, or a value entered over HP-IB since last read of the register.
3	Limit failed, Ch 2	Limit test failed on channel 2.
4	Limit failed, Ch 1	Limit test failed on channel 1.
5	Search failed, Ch 2	A marker target search or bandwidth search was executed, but the desired value was not found.
6	Search failed, Ch 1	Same as on channel 2.
7	ALC unlock	The output power went unleveled at the beginning or end of a sweep. Data may be invalid.

Appendix G: Alphabetical Code Listing

Mnemonic — **Description**

- A -

AB .... Measure and display A/B on the active channel.
AR .... Measure and display A/R on the active channel.
ADDRCONT[D] .... Controller HP-IB address: the address where control is returned after a pass control.
ADDRDISC[D] .... Disc HP-IB address.
ADDRPLOT[D] .... Plotter HP-IB address.
ADDRPOWM[D] .... Power meter HP-IB address.
ADDRPRIN[D] .... Printer HP-IB address.
ALTAB .... Places the HP 8753B in the alternate inputs measurement mode, where inputs A and B are measured on alternate sweeps. As opposed to **CHOPAB;**.
ANAI .... Measure and display the data at the auxiliary input (ANALOG IN).
ASEG .... Use all segments for list frequency sweep.
ASSS .... Assert the sequence status bit.
ATTP1[D] .... Set the S-parameter test set port 1 attenuator.
ATTP2[D] .... Set the S-parameter test set port 2 attenuator.
AUTO .... Autoscale the active channel.
AVERFACT[D] .... Set the averaging factor on the active channel.
AVERO<ON|OFF> .... Turn averaging on and off on the active channel.
AVERREST .... Restart the averaging on the active channel.

- B -

BANDPASS .... Select the time domain bandpass mode.

These commands control the warning beeper, causing it to sound if the indicated condition occurs:
BEEPDONE<ON|OFF> .... The completion of functions such as save, done with calibration standard, and data trace saved.
BEEPFAIL<ON|OFF> .... A limit test failure.
BEEPWARN<ON|OFF> .... The generation of a warning message.
BR .... Measure and display B/R on the active channel.

- C -

These commands set the open capacitance values of an open circuit while it is being defined as a calibration standard.
C0[D]
C1[D]
C2[D]
C3[D]

CAL1 .... Accepted for compatibility with the HP 8510A, where its function is to begin a calibration sequence.

These commands set the power meter calibration factor corrections for the particular sensor used. Sensor B is only valid for the HP 438A which has two input channels:
CALFCALC[D] .... Set the calibration factor.
CALFFREQ[D] .... Select the frequency for the calibration factor correction.
CALFSENA .... Edit the sensor A calibration factor table.
CALFSENB .... Edit the sensor B calibration factor table.

These commands begin a calibration sequence:
CALIFUL2 .... Full 2-port.
CALIONE2 .... One-path 2-port.
CALIRAI .... Response and isolation.
CALIRESP .... Response.
CALIS111 .... S11 1-port.
CALIS221 .... S22 1-port.

CALK35MM to **COUC<ON|OFF>**

Mnemonic **Description**

These commands select a default calibration kit:

CALK35MM .... 3.5 mm.
CALK7MM .... 7 mm.
CALKN50 .... Type-N 50 ohm.
CALKN75 .... Type-N 75 ohm.
CALKUSED .... The user defined calibration kit.

CENT[D] .... Sets the center stimulus value. If a list frequency segment is being edited, sets the center of the list segment.
CHAN1 .... Make channel 1 the active channel. OPC'able.
CHAN2 .... Make channel 2 the active channel. OPC'able.
CHOPAB .... Places the HP 8753B in the chop measurement mode. As opposed to **ALTAB;**.
CLAD .... Class done, modify cal kit, specify class.

These commands call reflection standard classes during a calibration sequence. If only one standard is in the class, it is measured. If there is more than one, the standard being used must be selected with **STAN<A|B|C|D|E|F|G>**. If there is only one standard in the class, these commands are OPC'able.

CLASS11A .... S11A: S11 1-port, opens.
CLASS11B .... S11B: S11 1-port, shorts.
CLASS11C .... S11C: S11 1-port, loads.
CLASS22A .... S22A: S22 1-port, opens.
CLASS22B .... S22B: S22 1-port, shorts.
CLASS22C .... S22C: S22 1-port, loads.

These commands clear the indicated save/recall registers:

CLEA1 .... 1.
CLEA2 .... 2.
CLEA3 .... 3.
CLEA4 .... 4.
CLEA5 .... 5.
CLEARALL .... All the registers. OPC'able.

These commands clear the sequence from the internal registers:

CLEASEQ1 .... Sequence 1.
CLEASEQ2 .... Sequence 2.
CLEASEQ3 .... Sequence 3.
CLEASEQ4 .... Sequence 4.
CLEASEQ5 .... Sequence 5.
CLEASEQ6 .... Sequence 6.

CLEL .... Clear the desired list. This could be a frequency list, power loss list, or limit test list.

CLES .... Clears the status register, the event status registers, and the enable registers.
CLS .... Same as CLES.
COAX .... Selects coaxial offsets instead of waveguide while defining a standard during a cal kit modification.
CONT .... Continuous sweep trigger mode.

These commands convert the S-parameter data to:

CONV1DS .... Inverted S-parameters.
CONVOFF .... Conversion off.
CONVYREF .... Y:reflection.
CONVYTRA .... Y:transmission.
CONVZREF .... Z:reflection.
CONVZTRA .... Z:transmission.

COPYFRFT .... Copies the file titles into the register titles.
COPYFRRT .... Copy save/recall register titles to the disc register titles.
CORI<ON|OFF> .... Turns interpolative error correction on and off.
CORR<ON|OFF> .... Turns error correction on and off.
COUC<ON|OFF> .... Couples and uncouples the stimulus between the channels.

Mnemonic	Description
COUP<ON|OFF>	Couple the power when coupled channels is turned off, **COUCOFF**.
CWFREQ[D]	Sets the CW frequency for power sweep and CW frequency modes. While the list frequency table segment is being edited, it sets the center frequency of the current segment.
CWTIME	Selects the CW time sweep type.

- D -

D1DIVID2<ON|OFF>	This command divides the data in channel 1 by the data in channel 2 and displays the result on channel 2.
DATI	Stores trace in channel memory. OPC'able.
DEBU<ON|OFF>	Turns the HP-IB debug mode on and off. When on, the HP 8753B scrolls incoming HP-IB commands across the display.
DECRLOOC	Decrements the sequencing loop counter by 1. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
DEFS[D]	Begins standard definition during cal kit modification. D is the standard number.
DELA	Displays the data formatted as group delay.
DELO	Turns the delta marker mode off.

These commands make the indicated marker the delta reference:

DELR1	Marker 1.
DELR2	Marker 2.
DELR3	Marker 3.
DELR4	Marker 4.
DELRFIXM	Fixed marker.

DEMOAMPL	Sets the transform demodulation to amplitude demodulation. Only has an effect with a CW time transform.
DEMOOFF	Turns the transform demodulation function off.
DEMOPHAS	Sets the transform demodulation to phase demodulation.
DIRS[D]	Sets the number of files in the directory at disc initialization.
DISCUNIT[D]	Specifies which disc in a multiple-disc disc drive is to be used for disc registers.
DISCVOLU[D]	Specifies which volume of a multiple-volume disc drive (e.g. a Winchester) is to be used for disc registers.

These commands display the indicated combinations of data and trace memory on the active channel:

DISPDATA	Data only.
DISPDATM	Data and memory.
DISPMEMO	Memory only.
DISPDDM	Data divided by memory (linear division, log subtraction).
DISPDMM	Data minus memory (linear subtraction).

DIVI	Same as **DISPDDM**.
DONE	Done with a class of standards, during a calibration. Only needed when multiple standards are measured to complete the class. OPC'able.
DONM	Done modifying a test sequence.
DOSEQ<I>	Begin execution of the selected sequence.
DOWN	Decrements the value in the active entry area (down key).
DUAC<ON|OFF>	Dual channel display on or off.
DUPLSEQ[X]SEQ[Y]	Duplicates sequence X to sequence Y.

- E -

EDITDONE	Done editing list frequency or limit table. OPC'able.
EDITLIML	Begin editing limit table.
EDITLIST	Begin editing list frequency table.
ELED[D]	Sets the electrical delay offset.
EMIB	Send out a beep during a sequence. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
ENTO	Turns the active entry area off.
ESB?	Outputs event status register B.

Mnemonic — Description

ESE[D] .... Enables the selected event status register bits to be summarized by bit 5 in the status byte. An event status register bit is enabled when the corresponding bit in the operand D is set.

ESNB[D] .... Enables the selected event status register B bits to be summarized by bit 2 of the status byte. Much like **ESE;**.

ESR? .... Outputs the value of the event status register.

These commands include the indicated information when a register is stored on disc. See Figure E.1 for data types:

EXTMDATA<ON|OFF> ..... Error corrected data.
EXTMDATO<ON|OFF> ..... Data array only.
EXTMFORM<ON|OFF> .... Formatted trace data.
EXTMGRAP<ON|OFF> ..... User graphics.
EXTMRAW<ON|OFF> ...... Raw data arrays.

EXTTOFF .... Deactivates the external trigger mode. OPC'able.
EXTTON .... Activates the external trigger mode. OPC'able.
EXTTPOIN .... Sets the external trigger to auto trigger on point. OPC'able.

- F -

FIXE .... Specifies a fixed load, as opposed to a sliding load, when defining a standard during a cal kit modification.

FOCU[D] .... CRT focus, 0 to 100 percent.

These commands set the data format for array transfers in and out of the instrument:

FORM1 .... HP 8753B internal format. Preceded by 4 byte header.
FORM2 .... 32 bit floating point format. Preceded by 4 byte header.
FORM3 .... 64 bit floating point format. Preceded by 4 byte header.
FORM4 .... ASCII format. No header.

FREQOFFS<ON|OFF> ..... Activates the frequency offset instrument mode. OPC'able.
FREQRANG<3GHZ|6GHZ> . Turns on and off the frequency doubler in the HP 85047A Test Set. OPC'able.
FRER .... HP-IB free run. Acts the same as **CONT;**.
FREO .... Frequency blank. Turns off frequency notation.
FULP .... Selects full page plotting, as opposed to plotting in one of the four quadrants.

These commands select a forward calibration class, during a 2-port calibration sequence. They are OPC'able if there is only one standard in the class:

FWDI .... Isolation.
FWDM .... Match.
FWDT .... Transmission.

- G -

These commands control the time domain gate (available only with option 010, time domain):

GATECENT[D] .... Center time.
GATEO<ON|OFF> .... Gate on/off.
GATESPAN[D] .... Span time.
GATESTAR[D] .... Start time.
GATESTOP[D] .... Stop time.

These commands set the gate shape:

GATSMAXI .... Maximum.
GATSMINI .... Minimum.
GATSNORM .... Normal.
GATSWIDE .... Wide.

Mnemonic Description

- H -

These commands activate the harmonic measurement mode, Option 002. They are all OPC'able:
HARMOFF .... Turns off harmonic mode.
HARMSEC .... Measures the second harmonic.
HARMTHIR .... Measures the third harmonic.

HOLD .... Puts the sweep trigger into hold.

- I -

IDN? .... Outputs the identification string: "HEWLETT PACKARD,8753B,0,X.XX", where X.XX is the firmware revision of the instrument.
IFBW[D] .... Sets the IF bandwidth.

These commands branch an executing sequence to a new sequence if the following condition is satisfied. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified:
IFLCEQZESEQ<I> .... Loop counter equals zero.
INFLCNEZESEQ<I> .... Loop counter does not equal zero.
IFLTFAILSEQ<I> .... Limit test fails.
IFLTPASSSEQ<I> .... Limit test passes.

IMAG .... Selects the imaginary display format.
INCRLOOC .... Increments the sequencing loop counter by 1. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
INID .... Initialize disc. All information on disc will be destroyed. Requires pass control mode.

These commands input individual calibration coefficient arrays. Before sending the array, issue a **CALI**XXXX**;** command, where XXX specifies the calibration type of the data. Then input the cal arrays. Lastly store the data with **SAVC;**. The instrument goes into hold, displaying uncorrected data: **SING;** completes the process by displaying error corrected data. See Appendix C, Calibration, for the contents of the different arrays.
INPUCALC01[D] .... Array 1.
INPUCALC02[D] .... 2.
INPUCALC03[D] .... 3.
INPUCALC04[D] .... 4.
INPUCALC05[D] .... 5.
INPUCALC06[D] .... 6.
INPUCALC07[D] .... 7.
INPUCALC08[D] .... 8.
INPUCALC09[D] .... 9.
INPUCALC10[D] .... 10.
INPUCALC11[D] .... 11.
INPUCALC12[D] .... 12.

INPUCALK[D] .... Inputs a cal kit read out with **OUTCALK;**. After the transfer, the data should be saved into the user cal kit area with **SAVEUSEK;**.
INPUDATA[D] .... Inputs an error corrected data array, using current format. The instrument stops sweeping, and then formats and displays the data.
INPUFORM[D] .... Inputs a formatted data array, using current format. The instrument stops sweeping and displays the data.
INPULEAS[D] .... Inputs a learn string read out by **OUTPLEAS;**.

These commands input power meter calibration arrays into the instrument. Values should be entered as 100*desired source power.
INPUPMCAL1 .... Channel 1.
INPUPMCAL2 .... Channel 2.

These commands input a raw data array using the current format. See **OUTPRAW** for the meaning of the arrays. The instrument stops sweeping, error corrects the data, then formats and displays the data.
INPURAW1[D] .... 1.
INPURAW2[D] .... 2.
INPURAW3[D] .... 3.
INPURAW4[D] .... 4.

Mnemonic Description

These commands select the instrument mode. They are all OPC'able.:

INSMEXSA .... External source, auto.
INSMEXSM .... External source, manual.
INSMNETA .... Standard network analyzer.
INSMTUNR .... Tuned receiver.

INTE[D] .... Sets the display intensity, 0 to 100 percent.
ISOD .... Done with isolation subsequence in a 2-port calibration. OPC'able.
ISOL .... Begins the isolation subsequence step in a 2-port calibration.

- K -

KEY[D] .... Sends a keycode, equivalent to actually pressing the key. It does not matter if the front panel is in remote mode. See Figure E.4 for the key codes.
KITD .... Calibration kit done: the last step in modifying a cal kit.
KOR? .... Outputs a two byte key code/knob count. If the number is positive, it is a key code. Otherwise, it has to be converted to a knob count by clearing the upper 8 bits if bit 14 is not set. The resulting integer is the knob count, either positive or negative, depending on the direction of turn. There are approximately 120 counts per knob turn.

- L -

These commands enter labels for the standard classes during a cal kit modification:

LABEFWDM[$] .... Forward match.
LABEFWDT[$] .... Forward transmission.
LABERESP[$] .... Response.
LABERESI[$] .... Response, response and isolation.
LABEREVM[$] .... Reverse match.
LABEREVT[$] .... Reverse transmission.
LABES11A[$] .... S11A (opens).
LABES11B[$] .... S11B (shorts).
LABES11C[$] .... S11C (loads).
LABES22A[$] .... S22A (opens).
LABES22B[$] .... S22B (shorts).
LABES22C[$] .... S22C (loads).

LABK[$] .... Enters a cal kit label during a cal kit modification.
LABS[$] .... Enters a standard's label during standard definition.
LEFL .... Selects a plot in the left lower quadrant.
LEFU .... Selects a plot in the left upper quadrant.
LIMD[D] .... Sets the limit delta value while editing a limit line segment.
LIMIAMPO[D] .... Enters the limit line amplitude offset.
LIMILINE<ON|OFF> .... Turns the display of the limit lines on and off.
LIMIMAOF[D] .... Marker to limit offset. Centers the limit lines about the current marker position using the limit amplitude offset function.
LIMISTIO[D] .... Enters the stimulus offset of the limit lines.
LIMITEST<ON|OFF> .... Turns limit testing on and off.

These commands edit a limit test segment. The limit table editing is begun with **EDITLIML;**, and a segment is brought up for editing with either **SADD;** or **SEDI N;**. The segment is closed with **SDON;**, the table is closed with **EDITDONE;**.

LIMM[D] .... Set the middle limit value.
LIML[D] .... Set the lower limit value.
LIMS[D] .... Set the limit stimulus break point.
LIMTFL .... Make the segment a flat line.
LIMTSL .... Make the segment a sloping line.
LIMTSP .... Make the segment a single point.
LIMU[D] .... Set the upper limit value.

LINM .... Selects the linear magnitude display format.
LINFREQ .... Selects a linear frequency sweep.
LINTDATA[D] .... Enters the line type for plotting data.

Mnemonic Description

LINTMEMO[D] .... Enters the line type for plotting memory.
LISFREQ .... Selects the list frequency sweep mode.
LISV .... Activates the list values function. The next page of values can be called with **NEXP;**. The current page can be plotted or printed with **PLOT;**, or **PRINTALL;**.

These commands load the indicated file from disc. Requires pass control. The actual file recalled depends on the file title in the file position specified:
LOAD1 .... 1.
LOAD2 .... 2.
LOAD3 .... 3.
LOAD4 .... 4.
LOAD5 .... 5.

LOGFREQ .... Selects a log frequency sweep.
LOGM .... Selects the log magnitude display format.
LOOC[D] .... Sets the value of the sequencing loop counter. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
LOWPIMPU .... Turns on the low pass impulse transform (option 010).
LOWPSTEP .... Turns on the low pass step transform (option 010).
LRN? .... Same as **OUTPLEAS**.
LRN[D] .... Same as **INPULEAS**.

- M -

MANTRIG .... Sets the external trigger to manual trigger on point. OPC'able.

These commands make the indicated marker active and sets its stimulus:
MARK1[D] .... Marker 1.
MARK2[D] .... Marker 2.
MARK3[D] .... Marker 3.
MARK4[D] .... Marker 4.

MARKBUCK[D] .... Places the marker on a specific sweep point (bucket). D is the bucket number, ranging from 0 to number of points less 1.
MARKCENT .... Enters the marker stimulus as the center stimulus.
MARKCONT .... Places the markers continuously on the trace, not on discrete sample points.
MARKCOUP .... Couples the markers between the channels, as opposed to **MARKUNCO.**
MARKCW .... Sets the CW frequency to the marker frequency.
MARKDELA .... Sets electrical length so group delay is zero at the marker stimulus.
MARKDISC .... Places the markers in discrete placement mode.
MARKFAUV[D] .... Sets the auxiliary value of the fixed marker position. Works in coordination with **MARKFVAL** and **MARKFSTI**.
MARKFSTI[D] .... Sets the stimulus position of the fixed marker.
MARKFVAL[D] .... Sets the value of the fixed marker position. See Figure E.2 for the meaning of value and auxilary value as a function of display format.
MARKMAXI .... Same as **SEAMAX**.
MARKMIDD .... During a limit segment edit, makes the marker amplitude the limit segment middle value.
MARKMINI .... Same as **SEAMIN**.
MARKOFF .... Turns all markers and marker functions off.
MARKREF .... Enters the marker amplitude as the reference value.
MARKSPAN .... Enters the span between the active marker and the delta reference as the sweep span.
MARKSTIM .... During a limit segment edit, enters the marker stimulus as the limit stimulus break point.
MARKSTAR .... Enters the marker stimulus as the start stimulus.
MARKSTOP .... Enters the marker stimulus as the stop stimulus.
MARKUNCO .... Uncouples the markers between channels, as opposed to **MARKCOUP**.
MARKZERO .... Places the fixed marker at the active marker position and makes it the delta reference.
MAXF[D] .... Sets the maximum valid frequency of a standard being defined during a cal kit modification.

Mnemonic Description

MEASA .Measures and displays input A on the active channel.
MEASB .Measures and displays input B on the active channel.
MEASR .Measures and displays input R on the active channel.
MEASTAT<ON|OFF> . . . . . . .Turns trace statistics on and off.

These commands bring up the menu associated with the indicated front panel key:
MENUAVG . . . . .AVG
MENUCAL . . . . .CAL
MENUCOPY . . . . .COPY
MENUDISP . . . . .DISPLAY
MENUFORM . . . . .FORMAT
MENUMARK . . . . .MKR
MENUMEAS . . . . .MEAS
MENUMRKF . . . . .MKR FCTN
MENU<ON|OFF> . . . . .Blanks the softkey menu.
MENURECA . . . . .RECALL
MENUSAVE . . . . .SAVE
MENUSCAL . . . . .SCALE
MENUSTIM . . . . .STIMULUS MENU
MENUSYST . . . . .SYSTEM

MINF[D] .Sets the minimum valid frequency of a standard being defined during a cal kit modification.
MINU . . . . .Displays data minus memory, the same as **DISPDMM**.
MODI1 .Begins the modify cal kit sequence.

- N -

NEWSEQ<I> . . . . .Begin modifying a sequence.
NEXP . . . . .Displays the next page of the operating parameters list.
NOOP .No operation. OPC'able.
NUMG[D] . . . . .Activates D number of groups of sweeps. A group is whatever is needed to update the current parameter once. This function restarts averaging if on. OPC'able.
NUMR[D] . . . . .Sets the number of power meter readings per point used during a power meter calibration.

- O -

These commands specify the offset value for the indicated parameter for a standard being defined during a cal kit modification:
OFSD[D] . . . . .Delay offset.
OFSL[D] . . . . .Loss offset.
OFSZ[D] . . . . .Impedance offset.

OMII . . . . .Omits the isolation step of a calibration sequence.
OPC . . . . .Operation complete. Reports the completion of the next command received by setting bit 0 in the event status register, or by replying to an interrogation if **OPC?;** is issued. See General Information.
OPEP . . . . .Presents a list of key operating parameters. **NEXP;** scrolls to the next page of parameters. Requesting a plot or print copies the current page.
OUTPACTI . . . . .Outputs the value of the active function, or the last active function if the active entry area is off.
OUTPAPER . . . . .Outputs the smoothing aperture in stimulus units, rather than as a percentage.

These commands output the error correction arrays for the active calibration on the active channel. See Appendix C, Calibration, for the contents of the arrays. Each array comes out in the current output format. They contain real/imaginary pairs, the same number of pairs as points in the sweep.
OUTPCALC01 . . . . .1.
OUTPCALC02 . . . . .2.
OUTPCALC03 . . . . .3.
OUTPCALC04 . . . . .4.
OUTPCALC05 . . . . .5.

Mnemonic	Description
OUTPCALC06	6.
OUTPCALC07	7.
OUTPCALC08	8.
OUTPCALC09	9.
OUTPCALC10	10.
OUTPCALC11	11.
OUTPCALC12	12.
OUTPCALK	Outputs the currently active calibration kit, as a less than 1000 byte string. The data is in form 1.
OUTPDATA	Outputs the error corrected data from the active channel in the current format. See Figure E.1, Processing Chain.
OUTPERRO	Outputs the oldest error message in the error queue. Sends first the error number, and then the error message itself as a string no longer than 50 characters.
OUTPFORM	Outputs the formatted display data array from the active channel in the current format. See Figure E.2 for the contents of the array positions as a function of display format.
OUTPIDEN	Outputs the identification string for the HP 8753B: "HEWLETT PACKARD,8753B,0,X.XX" where X.XX is the firmware revision.
OUTPKEY	Outputs the key code of the last key pressed. An invalid key is reported with a 63, a knob turn with a −1. See Figure E.4 for the front panel key codes.
OUTPLEAS	Outputs the learn string, which contains the entire front panel state, the limit table, and the list frequency table. It is always in form 1.

These commands output the limit test results. The results consist of four fields. First is the stimulus value for the point. Second is an integer indicating test status. Third is the upper limit at that point. Fourth is the lower limit at that point. If there are no limits at that point, the third and fourth fields are zero. The test status is −1 for no test, 0 for fail, and 1 for pass.

OUTPLIMF	Outputs the limit test results for each failed point.
OUTPLIML	Outputs the limit test results for each point in the sweep. This is a form 4 transfer.
OUTPLIMM	Outputs the limit test results at the marker.
OUTPMARK	Outputs the marker values. The first two numbers are the marker response values, and the last is the stimulus value. See Figure E.2 for the meaning of the response values as a function of display format.
OUTPMEMO	Outputs the memory trace from the active channel. The data is in real/imaginary pairs, and can be treated the same as data read with the **OUTPDATA** command.
OUTPMSTA	Outputs the marker statistics: mean, standard deviation, and peak-to-peak variation in that order. If statistics is not on, it is turned on to generate current values and turned off again.
OUTPMWID	Outputs the marker bandwidths search results: bandwidth, center, and Q in that order. If widths is not on, it is turned on to generate current values and turned off again.
OUTPPLOT	Outputs the plot string. Can be directed to a plotter, or read into the computer. **PSOFT<ON|OFF>** controls whether the soft keys are included in the plot.

These commands output the power meter calibration array. Note the numbers are actually 100* the source power. A default array is used if a power meter calibration sweep, **TAKCS**, has not been taken:

OUTPPMCAL1	Channel 1.
OUTPPMCAL2	Channel 2.
OUTPPRIN	Outputs a raster dump of the display, intended for a graphics printer. **PSOFT<ON|OFF>** controls whether the soft keys are included in the plot.

These commands output the raw measurement data. See Figure E.1, Processing Chain, for the meaning of the data. Normally, array 1 holds the current parameter. If a 2-port calibration is active, the arrays hold S11, S21, S12, and S22, respectively:

OUTPRAW1	1.
OUTPRAW2	2.
OUTPRAW3	3.
OUTPRAW4	4.

Mnemonic	Description
OUTPRFFR	Outputs the external source RF frequency. The instrument must be in external source mode, either **INSMECSA** or **INSEXSM**.
OUTPSEQ<I>	Outputs a sequence listing over HP-IB.
OUTPSTAT	Outputs the status byte.
OUTPTITL	Outputs the display title.

- P -

PAUS	Inserts a pause into a sequence. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
PCB	Same as **ADDRCONT**. Indicates where control will be passed in pass control mode.
PDATA<ON|OFF>	Selects whether trace data is plotted.

These commands select the pen for plotting the indicated display feature:

PENNDATA[D]	Data trace.
PENNGRAT[D]	Graticule.
PENNMARK[D]	Markers and marker text.
PENNMEMO[D]	Memory trace.
PENNTEXT[D]	Text and user graphics.

PGRAT<ON|OFF>	Selects whether the graticule is plotted.
PHAS	Selects the phase display format.
PHAO[D]	Sets the phase offset.
PLOS<SLOW|FAST>	Selects the pen speed for plotting.
PLOT	Requests a plot. Requires pass control mode.
PMEM<ON|OFF>	Selects whether memory is plotted.
PMKR<ON|OFF>	Selects whether markers are plotted.
PMTRTTIT	Reads power meter/HP-IB value into title string. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
POIN[D]	Sets the number of points in the sweep.
POLA	Selects the polar display format.

These commands select the marker readout format for polar display:

POLMLIN	Linear markers.
POLMLOG	Log markers.
POLMRI	Real/imaginary markers.

PORE<ON|OFF>	Turn port extensions on and off.

These commands set the port extension length for the indicated port or input. Ports 1 and 2 refer to the test set port(s):

PORT1[D]	Port 1.
PORT2[D]	Port 2.
PORTA[D]	Input A.
PORTB[D]	Input B.

POWE[D]	Sets the output power level.
POWLFREQ[D]	Selects the frequency for which a power loss correction is entered. This must be followed by a **POWLLOSS[D]**, which sets the value.
POWLLIST	Begins editing a power loss list for a power meter calibration.
POWLLOSS[D]	Sets the loss value for a particular frequency, **POWLFREQ[D]**, in the power loss list.
POWM<ON|OFF>	Selects whether the HP 436A (on) or the HP 438A (off) is to be used as the power meter in service procedures.
POWS	Selects power sweep, from the sweep type menu.
POWT<ON|OFF>	Turning power trip off clears a power trip after an overload condition is detected at one of the input ports.
PRES	Presets the instrument. OPC'able.
PRINALL	Copies the display on a printer. Requires pass control mode.
PRINSEQ<I>	Begins printing the sequence selected.

Mnemonic Description

PSOFT<ON|OFF> .... Controls whether softkeys are included in the **OUTPPLOT;** and **OUTPPRIN;** strings.
PTEXT<ON|OFF> .... Selects whether text is plotted.

These commands purge the indicated file from disk. Requires pass control.
PURG1 .... 1.
PURG2 .... 2.
PURG3 .... 3.
PURG4 .... 4.
PURG5 .... 5.

These commands select the type of power meter calibration desired. A calibration sweep should be taken, **TAKCS**, after selecting a "one sweep" power meter calibration, to ensure a valid calibration. No calibration sweep is needed for "each sweep" power meter calibrations. They are all OPC'able:
PWMCEACS .... Each sweep.
PWMCOFF .... Off.
PWMCONES .... One sweep.

PWRLOSS<ON|OFF> ...... Selects whether or not to use the power loss table for a power meter calibration.

- R -

RAID .... Completes the response and isolation cal sequence. OPC'able.
RAIISOL .... Calls the isolation class for the response and isolation calibration. OPC'able if only one standard in class.
RAIRESP .... Calls the response class for the response and isolation calibration. OPC'able if only one standard in class.
REAL .... Selects the real display format.

These commands recall the indicated internal register. They are all OPC'able:
RECA1 .... 1.
RECA2 .... 2.
RECA3 .... 3.
RECA4 .... 4.
RECA5 .... 5.

REFD .... Completes the reflection calibration subsequence of a 2-port calibration. OPC'able.
REFL .... Begins the reflection calibration subsequence of a 2-port calibration.
REFP[D] .... Enters the reference position. 0 is the bottom, 10 is the top of the graticule.
REFT .... Recall file titles from disc. Requires pass control mode.
REFV[D] .... Enters the reference line value.
RESC .... Resume cal sequence.
RESD .... Restores the measurement display after viewing the operating parameters or list values.
RESPDONE .... Completes the response calibration sequence. OPC'able.
REST .... Measurement restart.

These commands call the reverse calibration classes, during a full 2-port calibration. They are OPC'able if there is only one standard in the class:
REVI .... Isolation.
REVM .... Match.
REVT .... Transmission.

RIGL .... Selects a plot in the lower right quadrant.
RIGU .... Selects a plot in the upper right quadrant.
RST .... Presets the instrument. OPC'able.

Mnemonic Description

- S -

These commands select the parameter displayed on the active channel:
S11
S12
S21
S22

SADD .... During either a list frequency or limit table edit, adds a new segment to the table.
SAMC<ON|OFF> .... Turns sampler correction on and off. Sampler correction is only turned off to take data for custom calibration coefficients.
SAV1 .... Completes the 1-port calibration sequence. OPC'able.
SAV2 .... Completes the 2-port calibration sequence. OPC'able.
SAVC .... Completes the transfer of error correction coefficients back into the instrument. OPC'able.

These commands store the current instrument state in the indicated internal register. These commands are all OPC'able:
SAVE1 .... 1.
SAVE2 .... 2.
SAVE3 .... 3.
SAVE4 .... 4.
SAVE5 .... 5.

SAVEUSEK .... Stores the active calibration kit as the user kit.
SCAL[D] .... Sets the trace scale factor.
SCAP<FULL|GRAT> .... Selects a full plot, or a plot where the graticule is expanded to P1 and P2.
SDEL .... During either a list frequency or a limit table edit, deletes the current segment.
SDON .... During either a list frequency or a limit table edit, closes a segment after editing.

These commands control the marker searches. The marker searches place the active marker according to the indicated search criteria. The search is continuously updated if tracking is on:
SEAL .... Search left for next occurrence of the target value.
SEAMAX .... Trace maximum.
SEAMIN .... Trace minimum.
SEAOFF .... Turns the marker search off.
SEAR .... Search right for next occurrence of the target value.
SEATARG[D] .... Arbitrary target amplitude.
SEDI[N] .... During either a frequency or a limit table edit, selects segment N for editing.
SEQWAIT[D] .... Tells the instrument to wait D seconds during a sequence. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
SETF .... Set frequency for low pass transform, option 010.
SETZ .... Set the characteristic impedance of the measurement system.
SHOM .... Displays the desired softkey menu during a sequence. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
SING .... Single sweep. OPC'able.
SLID .... Sliding load done.
SLIL .... Specifies the standard as a sliding load during a standard definition as part of a cal kit modification.
SLIS .... Sliding load set.
SLOPE[D] .... Enters the power slope value.
SLOPO<ON|OFF> .... Turns the power slope on and off.
SMIC .... Select Smith chart display format.

The following select the marker readout format on a Smith chart:
SMIMGB .... G+jB.
SMIMLIN .... Linear.
SMIMLOG .... Log.
SMIMRI .... Real/imaginary pairs.
SMIMRX .... R+jX.

SMOOAPER[D] . . . . Sets the smoothing aperture as a percent of the trace.
SMOOO<ON|OFF> . . . . Turns smoothing on and off.

The following commands press the indicated soft key:
SOFT1 . . . . 1.
SOFT2 . . . . 2.
SOFT3 . . . . 3.
SOFT4 . . . . 4.
SOFT5 . . . . 5.
SOFT6 . . . . 6.
SOFT7 . . . . 7.
SOFT8 . . . . 8.

SOFR . . . . Displays the firmware revision on the screen.
SPAN[D] . . . . Sets the stimulus span. If a list frequency segment is being edited, sets the span of the segment.

The following commands initiate the [**SPECIFY CLASS**] part of modifying a cal kit. After issuing each command, send the HP 8753B a series of standard numbers to be included in the class. When the class is full, send **CLAD;** to terminate the sequence.
SPECFWDM . . . . Forward match.
SPECFWDT . . . . Forward transmission.
SPECRESP . . . . Response.
SPECRESI . . . . Resp & Isol, response.
SPECREVM . . . . Reverse match.
SPECREVT . . . . Reverse transmission.
SPECS11A . . . . S11A (opens).
SPECS11B . . . . S11B (shorts).
SPECS11C . . . . S11C (loads).
SPECS22A . . . . S22A (opens).
SPECS22B . . . . S22B (shorts).
SPECS22C . . . . S22C (loads).

SPLD<ON|OFF> . . . . Turns the split display mode on and off.
SRE[D] . . . . Service request enable. A bit set in D enables the corresponding bit in the status byte to generate an SRQ.
SSEG[D] . . . . Selects the desired segment of the frequency list for a list frequency sweep.
STB? . . . . Outputs the status byte.

The following commands select a standard from a class during a calibration sequence. If a class is requested, as in **CLASS11A** (open, S11 1-port cal,) the HP 8753B will do one of two things. If there is only one standard in the class, it will measure that standard automatically. If there are several standards in the class, then one of the following commands must be used to select one, causing it to be measured. All of these commands are OPC'able:
STANA . . . . Standard listed under softkey 1.
STANB . . . . Softkey 2.
STANC . . . . Softkey 3.
STAND . . . . Softkey 4.
STANE . . . . Softkey 5.
STANF . . . . Softkey 6.
STANG . . . . Softkey 7.

STAR[D] . . . . Enters the start stimulus value. If a list frequency segment is being edited, sets the start of the segment.
STDD . . . . Standard done, define standard sequence, while modifying a cal kit.

Mnemonic Description

The following commands select the standard type after the standard number has been entered during a modify cal kit sequence:

STDTARBI . . . . Arbitrary impedance.
STDTDELA . . . . Delay/thru.
STDTLOAD . . . . Load.
STDTOPEN . . . . Open.
STDTSHOR . . . . Short.

STPSIZE . . . . While editing a list frequency segment, sets step size.
STOP[D] . . . . Sets the stimulus stop value. If a list frequency segment is being edited, sets the stop of the segment.

These commands store the indicated file on disc:

STOR1 . . . . 1.
STOR2 . . . . 2.
STOR3 . . . . 3.
STOR4 . . . . 4.
STOR5 . . . . 5.

SWET[D] . . . . Sets the sweep time.
SWR . . . . Selects the SWR display format.

- T -

TAKCS . . . . Begins a power meter calibration sweep. OPC'able.
TALKLIST . . . . Puts the HP 8753B in talker listener mode.
TERI[D] . . . . Specifies the terminal impedance of an arbitrary impedance standard during a cal kit modification.
TESS? . . . . Returns a one if an HP 85046A/B S-parameter test set is present.
TIMDTRAN<ON|OFF> . . . . . . Turns the option 010 (time domain) transform on and off.

These commands title the indicated file positions:

TITF1[$] . . . . 1.
TITF2[$] . . . . 2.
TITF3[$] . . . . 3.
TITF4[$] . . . . 4.
TITF5[$] . . . . 5.

TITL[$] . . . . Enters a new CRT title.

These commands title the indicated internal register:

TITR1[$] . . . . 1.
TITF2[$] . . . . 2.
TITF3[$] . . . . 3.
TITR4[$] . . . . 4.
TITR5[$] . . . . 5.

TITSEQ<I> . . . . Selects the sequence to be titled.
TITTMEM . . . . Sends the title string to trace memory. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
TITTPMTR . . . . Sends the title string to the power meter address. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
TITTPRIN . . . . Sends the title string to the printer address. **NEWSEQ<I>** must precede to ensure that a sequence is currently being created or modified.
TRACK<ON|OFF> . . . . Turns marker search tracking on and off.
TRAD . . . . Completes the transmission calibration subsequence of a 2-port calibration. OPC'able.
TRAN . . . . Begins the transmission calibration subsequence of a 2-port calibration.
TRIG . . . . HP-IB trigger. Puts instrument into hold mode.
TST? . . . . Causes a self test and returns a zero if the test is passed.

Mnemonic **Description**

These commands set the TTL output on the HP 85047A Test Set:
TTLOH .... High.
TTLOL .... Low.

- U -

UP .... Increments the value in the active entry area (up key).
USEPASC .... Puts the HP 8753B in pass control mode.

These commands select the sensor input being used with the HP 438A Power Meter. For the HP 436A or 437B, the A sensor is always used:
USESENSA .... Sensor A.
USESENSB .... Sensor B.

- V -

VELOFACT[D] .... Enters the velocity factor of the transmission medium.
VOFF[D] .... Sets the frequency offset value.

- W -

WAIT .... Waits for a clean sweep. OPC'able.
WAVE .... Specifies a waveguide standard while defining a standard as part of a cal kit modification.
WIDT<ON|OFF> .... Turns the bandwidths search on and off.
WIDV[D] .... Enters the widths search parameter.

These commands set the window for the transform (option 010, time domain):
WINDMAXI .... Maximum.
WINDMINI .... Minimum.
WINDNORM .... Normal.
WINDOW[D] .... Enters arbitrary window.
WINDUSEM<ON|OFF> ..... Turns the trace memory on as the window shape.

These commands enter new softkey labels into the indicated softkey positions.
WRSK1[$] .... 1.
WRSK2[$] .... 2.
WRSK3[$] .... 3.
WRSK4[$] .... 4.
WRSK5[$] .... 5.
WRSK6[$] .... 6.
WRSK7[$] .... 7.
WRSK8[$] .... 8.

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HP-IB Programming Note

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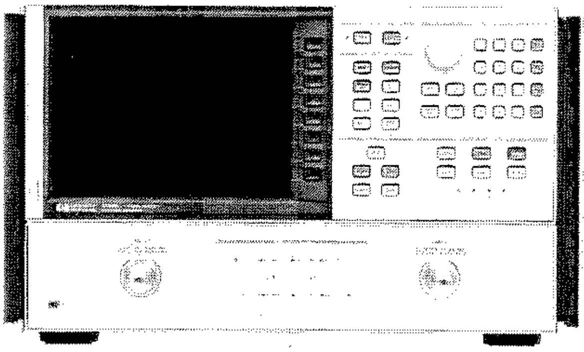
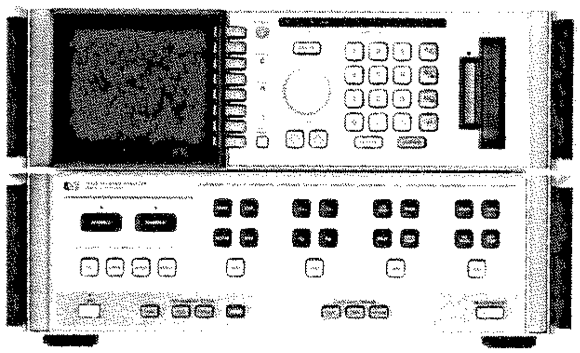
Network Analyzer Compatibility Guide
For the HP 8510 and 8700 series network analyzers





Introduction

This document is designed for use as a reference when information regarding HP-IB command compatibility between network analyzers in the HP 8510 and HP 8700 series is required. The HP 8700 series network analyzer family consists of the HP 8702A Lightwave Component Analyzer, the HP 8720A Microwave Network Analyzer, and the HP 8753A RF Network Analyzer. *Section 1* gives a brief overview on the similarities and differences in programming the HP 8510 and the HP 8700 series network analyzers. *Section 2* lists alphabetically those commands which are shared by the HP 8510B and the HP 8720A network analyzers and perform the same function. *Section 3* lists alphabetically the HP-IB commands for the HP 8510B, HP 8720A, HP 8753A and HP 8702A, and indicates which commands are valid on each analyzer.

For more complete information HP-IB programming of the respective instruments, consult the following documents:

HP 8510B:

Introductory Programming Guide	HP Lit. No. 5954-1549
Operating and Programming Reference	HP Part No. 08510-90070
Keyword Dictionary	HP Part No. 08510-90072

HP 8720A:

Introductory Programming Guide	HP Part No. 08720-90013
Quick Reference Guide	HP Part No. 08720-90014

HP 8753A:

Introductory Operating Guide	HP Part No. 08753-90009
Quick Reference Guide	HP Part No. 08753-90011

HP 8702A:

Introductory Programming Guide	HP Part No. 08702-90012
Quick Reference Guide	HP Part No. 08702-90014

For more information on using HP-IB, the *Tutorial Description of the Hewlett-Packard Interface Bus*	HP Lit. No. 5952-0156

Section 1: Programming the HP 8510 and the HP 8700 series

Basic instrument control

HP-IB programming of the HP 8510 and HP 8700 series network analyzers is similar in many respects. All of these instruments are programmed using four to eight character HP-IB mnemonics (also known as commands or keywords). About 290 commands are shared by the HP 8510 and HP 8700 series network analyzers, about 295 are valid only on the HP 8510, and 175 are valid only on the HP 8700 series. The HP 8702A Lightwave Component Analyzer uses all of the HP 8753A HP-IB commands, and has approximately 70 additional commands related to the optical measurements that only it can perform. Programming the three instruments of the HP 8700 series is virtually the same in all respects, since all three have the same basic HP-IB hardware and firmware.

The sequence of commands recommended to prepare the HP 8510 and HP 8700 series network analyzer for HP-IB control is as follows:

```
10  ABORT 7 ..................................... Abort any HP-IB bus activity
20  CLEAR 716 ................................... Clear the analyzer's HP-IB interface.
30  OUTPUT 716;"PRES;" .......................... Preset the analyzer (return to a known state).
```

Note that the remote (R) and listen (L) HP-IB status indicates should now be lit.

Once the remote status indicator is on, the front panel of the analyzers is disabled. If front panel control is desired, press the **[LOCAL]** key, and then press the desired front panel key(s). The **[LOCAL]** key on the HP 8510 and the HP 8700 series analyzers can be locked out using `LOCAL LOCKOUT 7`. This will completely disable the analyzer's front panel keys. The only way to re-enable the front panel is to issue `LOCAL 7`, or cycle power.

The basic structure of a typical command is as follows:

```
OUTPUT 716;"STAR 2 GHZ;"
```

This command tells the instrument to start the frequency sweep at 2 GHz. The number 716 is the HP-IB address of the HP 8510 or HP 8700 series network analyzer, `STAR` indicates start frequency, `2` indicates the numeric value of the start frequency, and `GHZ` gives the units in which the start frequency is specified. The semicolon following `GHZ` terminates the command.

When operated under computer control, the sequence of events that occur is similar to that which happens when the instruments are operated manually. A typical measurement sequence consists of the following steps:

1. Set up the instrument
2. Calibrate
3. Connect the device
4. Take data
5. Post process data
6. Transfer data

This first chapter will outline the similarities and differences between the HP 8510 and the HP 8700 series in terms of this sequence. Use of plotters, printers, and disc drives, user graphics, and status bytes will also be discussed.

Set up the instrument

The HP 8510 and HP 8700 series share most of the basic setup commands (`STAR`, `STOP`, `POIN`, `PHAS`, `S21`, and so on). However, instrument states and calibration sets created on one type of instrument cannot be transferred to another. For example, HP 8510 instrument states and calibration data cannot be used on an HP 8720A. The same applies to transfer of instrument states and calibration sets from one HP 8700 series network analyzer to another. Learn strings are also not compatible between the different network analyzers.

Note that the HP 8700 series network analyzers do not have a system bus like the HP 8510 has. In the case of the HP 8753A and 8702A, communication between the receiver/display and test set is handled over the test set interconnect cable, independent of HP-IB operation.

Default Address	HP 8510	HP 8700 series
Analyzer	16	16
Plotter	05	05
Printer	01	01
Disc drive	00	00
System bus	17	–
Display	31	17

These are the default, factory set HP-IB addresses. To check the address of the HP 8510, press **[LOCAL]** *[ADDRESS of HP 8510]* on the instrument's keyboard. To check the address of the HP 8700 series network analyzers, press **[LOCAL]** *[SET ADDRESSES] [ADDRESS:87nn]*. If the address has changed, it can be reset to 16 being entering **[1] [6] [x1]** on the instrument's keyboard.

Sweep modes

In terms of measurement method, the HP 8510 can be operated in either ramp sweep, step sweep, single point, or frequency list mode. In ramp sweep mode, the HP 8510 source (HP 8350/835XX or HP 8340/41) performs an analog sweep over the frequency range of interest. In the step sweep mode (HP 8340/41 only), the source is phase-locked at each frequency, and is rapidly stepped from one frequency to the next. The HP 8700 series instruments operate only in the stepped sweep, single point, or list frequency modes. They do not have a ramp sweep mode. The HP 8510 ramp sweep mode is turned on with the command `RAMP`, and stepped sweep mode is activated with `STEP`. The default sweep mode (after instrument preset) is ramp sweep with the HP 8510, and stepped sweep with the HP 8700 series.

The HP 8510 and HP 8700 series both can operate in the frequency list mode, and this mode is activated with `LISFREQ`, assuming a list frequency table has already been created. The HP 8720A has the ability to sweep specific, single segments from a frequency list. The HP 8510B with Revision 4.0 firmware also has this capability. To sweep a single segment, use `SSEGn` where `n` is the segment number. To return to normal list frequency operation (sweep all list frequency segments), issue `ASEG`.

On the HP 8510, single frequency (CW) operation is accessed with `SINP`, followed by `CENT xx GHZ;` where `xx` is the desired CW frequency. With the HP 8700 series, use `CWFREQ xx GHZ;`.

Averaging

When averaging is desired, it can be turned on with `AVERON`, with the HP 8510 and the HP8700 series analyzers. To specify an averaging factor, use `AVERON xx` for the HP 8510, where `xx` is the averaging factor (1 to 4096). With the HP 8700 series analyzers, an averaging factor can be specified using `AVERFACT xx`, where `xx` is the averaging factor (1 to 999). The universal command `AVEROFF` is used to turn off averaging.

When averaging is used with the HP 8700 series, as many groups of sweeps are executed as the value of the averaging factor plus 1 during calibration and measurement before a valid data trace is ready. The same applies to the HP 8510 when it is operating in ramp sweep mode. In the step sweep mode, the HP 8510 takes multiple readings (number of samples equals the averaging factor) at each frequency step before moving on to the next frequency. Averaging can be restarted with `REST` on the HP 8510 and the HP 8700 series analyzers.

Calibration

The HP 8510 and HP 8700 series network analyzers share many of the calibration commands. However, some of the calibration types that are possible on the HP 8510 are not available with the HP 8700 series. The following table shows the cal types available with the different analyzers:

Calibration Type	HP 8510B	HP 8720A	HP 8753A	HP 8702A
Response	X	X	X	X
Response & isolation	X	X	X	X
S11 1-port	X	X	X	X
S22 1-port	X	X	X	X
One-path 2-port	X		X	
Full 2-port	X	X	X	X
TRL 2-port	X			
Non-insertable	X			
Optical calibrations				X

Calibration sets

The HP 8510 can store two calibration kits internally (these are usually loaded from tape). These cal kits are activated with the commands `CAL1` and `CAL2`. The `CAL1` command specifies cal kit 1 with the HP 8510; it performs no function with the HP 8700 series but is accepted for compatibility with the HP 8510. `CAL2` is not accepted by the HP 8700 series. The HP 8700 series contain three or more internal kits: 3.5 mm, 7 mm, and type-N 50 ohm in the case of the HP 8720A. When using the HP 8700 series analyzers, a specific cal kit is chosen by issuing a command such as `CALK35MM` (3.5 mm calibration kit). This is the main difference between the HP 8510 and the HP 8700 series analyzers in terms of initiating a calibration.

Once the calibration kit to be used has been identified, the calibration sequences are generally the same for all of the analyzers. The sequence is started with a command such as `CALIRESP`, `CALIS111`, `CALIFUL2`, etc. to specify the calibration type. The next step is to open a class with a command such as `CLASS11A`. This will measure the open connected at port 1 if there is only one open in the class. If there is more than one standard in the class (for example, there are two standards in the type-N 50 ohm class of opens), the specific standard is chosen with the command `STANx`, where `x` can be A thru G. For example, `STANA` causes the standard selected with the top softkey (softkey 1) during manual operation to be measured.

It is necessary to ensure that the measurement of the standard is completed before the program prompts for connection of the next standard, and there are different techniques that must be used with the HP 8510 and the HP 8700 series. With the HP 8510, use a subroutine which serial polls bit 4 of the status byte to determine when the sweep(s) are completed. (Refer to Example 7, *Calibrating over the HP-IB*, in the HP 8510 *Introductory Programming Guide*). With the HP 8700 series, the OPC? command is used prior to issuing the class command. For more information on calibrating the HP 8700 series analyzers over HP-IB, refer to the appropriate examples on calibration in their programming guides.

To conclude the calibration sequence on the HP 8510 and the HP 8700 series analyzers, issue SAV1 or SAV2 in the case of 1-port or 2-port calibrations respectively. With the HP 8510, follow with CALSn, which stores the calibration and the stimulus settings into Cal Set n (n can be from 1 to 8). With the HP 8700 series, error-correction is automatically activated when the calibration is completed. To save a calibration with the HP 8700 series analyzers, issue SAVEn which will store the calibration coefficients, along with the current instrument state into register n (n can be from 1 to 5). It is important to note that in the HP 8510, calibration sets are not recalled when the instrument states are recalled. They are stored separately and must be activated after the desired instrument state has been recalled. With the HP 8700 series, calibrations are a part of the instrument state, and are recalled automatically when the instrument state is recalled.

Calibration error coefficients

The actual calibration error coefficients can be read from the HP 8510 and HP 8700 series analyzers with the OUTPCALCnn command, where nn is the coefficient number (1 to 12). Use INPUCALCnn to input calibration coefficients. These coefficients are arrayed identically in the HP 8510 and HP 8700 series analyzers.

Taking Data

Once the device under test is connected to the analyzer, a completely fresh sweep must be triggered to ensure valid data is taken. This is accomplished with all four instruments using the command SING. This command activates a single group of sweeps. If a full 2-port calibration is active, a group is four sweeps, so that all four S-parameters can be measured. SING automatically forces four sweeps if a full two-port calibration is active. In the HP 8510 step sweep mode, all four S-parameters are measured at each frequency step, so only one sweep is performed. After this command, the analyzer goes into hold mode (sweeping is stopped).

If more groups of sweeps are desired, issue the command NUMGn, where n is the desired number of groups. A case where NUMGn might be used is when averaging is turned on, in which case n would be 1 plus the averaging factor. NUMGn is valid on both the HP 8510 and the HP 8700 series analyzers. Note that NUMG1 is equivalent to SING. With the HP 8700 series, the SING and NUMGn commands can be prefaced with OPC?, and followed by ENTER 716; Reply. This will ensure that the program waits for the sweeps to complete before continuing. Refer to the HP 8700 series analyzers's programming guides for more information about OPC. When used with the HP 8510, SING and NUMGn force a hold off of all further HP 8510 HP-IB command processing, but to prevent the program from executing other commands (such as those for generating prompts), a subroutine is required which polls bit 4 of the status byte when the sweep is finished. Refer to Example 7 in the HP 8510 *Introductory Programming Guide for more information.*

Post processing data

After the device has been measured, the data can be processed. Post-processing is performed within the analyzers and includes such operations as the application of smoothing, time domain gating, etc. The commands to perform these operation are shared by the HP 8510 and the HP 8700 series network analyzers. For example, smoothing is is turned on with SMOOON, and is turned off with SMOOOF. To set the smoothing aperture on the HP 8510, use SMOOON XX, where XX is the desired smoothing aperture in percent. With the HP 8700 series, use SMOOAPER XX to set the smoothing aperture XX in percent. To activate a time domain gate, use GATEON. Gating can be turned off with GATEOFF.

Transferring Data

After the device has been measured, and any desired post-processing applied, the data can be transferred to the computer for further analysis and storage. Data transfer is initiated with commands such as OUTPRAWn, OUTPDATA, OUTPFORM, OUTPMARK. To transfer data without post-processing applied, use OUTPDATA. To include post-processing, use OUTPFORM. Most of the data output commands are shared by the HP 8510 and the HP 8700 series network analyzers.

Data levels

Formatted measurement data can be read out in log or linear magnitude, phase, real/imaginary pair formats with `OUTPFORM`. The format is a function of the format in which data is currently being presented on the analyzer's display. The formats are identical between the HP 8510 and HP 8700 series. Data which is read by the computer using `OUTPFORM` will reflect all post processing such as time domain gating, electrical delay, trace math and smoothing.

Raw data is accessible with `OUTPRAW1`, `OUTPRAW2`, `OUTPRAW3`, `OUTPRAW4`. Normally, only raw 1 is available, and it holds the current parameter. If a full 2-port calibration is in effect, the four arrays refer to S11, S21, S12, and S22 respectively. The data will be in real/imaginary pairs.

Error corrected data is the raw data with error correction applied. It can be read with `OUTPDATA`. The array is for the currently measured parameter, and is in real/imaginary pairs. `OUTPMEMO` reads the trace memory if available. Note that this data does not reflect any post processing such as electrical delay offset, trace math, or time domain gating.

Data transfer formats

The HP 8510 and HP 8700 series network analyzers share the same four data transfer formats. These formats are chosen with the commands `FORM1`, `FORM2`, `FORM3`, and `FORM4`. Prior to transfer of data, it is imperative that the receiving arrays be dimensioned to the right number of data points. Refer to the appropriate examples in the instrument's *Introductory Programming Guides* for examples on data transfers using the various formats.

Other data types

Limit test data and trace statistics can be obtained only from the HP 8700 series network analyzers with commands such as `OUTPLIML`, `OUTPLIMM`, `OUTPLIMF`, for limit data, and `OUTPMSTA` for trace statistics.

Learn strings can be obtained from the HP 8510 and HP 8700 series analyzers with `OUTPLEAS`, and can be read into the analyzers from the computer with `INPULEAS`. For the HP 8510 learn string, the receive array for the learn string should be declared as an integer array of 2195 elements with

```
10 INTEGER P,B,Learn_string(1:2195)
20 OUTPUT 716;''OUTPLEAS;
30 ENTER 716 USING "W";P;B;Learn_string(*)
```

`Learn_string` is the variable which will contain the learn string. `P` and `B` are integer variables which contain the learn string preamble and the number of bytes respectively. To read the learn string back into the HP 8510, use

```
40 OUTPUT 716;"INPULEAS;"

50 OUTPUT 716 USING
"W";9025;3400;Learn_string(*)
```

To read the learn string from an HP 8700 series network analyzer, use

```
10 DIM Learn_string$[3000]
20 OUTPUT 716;"OUTPLEAS;"
30 ENTER 716 USING "-K";Learn_string$
```

To input a learn string into an HP 8700 series network analyzer, use

```
40 OUTPUT 716;"INPULEAS";Learn_string$
```

Using plotters, printers, and disc drives

Access to peripherals from the computer when using the HP 8510 is different than the HP 8700 series analyzers are used. The following section discusses the differences in peripheral control between the HP 8510 and the HP 8700 series.

Plotters, printers and disc drives used with the HP 8510 are connected to the system bus, which is separate from the HP 8510 HP-IB. This way, the HP 8510 has direct control over the peripherals. This allows plots to be made from the HP 8510 relatively easily, since the computer is on a different bus. To tell the HP 8510 to make a plot on a plotter on the system bus, issue `PLOTALL`. To make a plot on a plotter connected to the HP-IB, issue `OUTPPLOT`. To obtain a tabular listing of the trace data values and frequencies of the active channel on a printer connected to the system bus, use `LIST`. To have computer access to these peripherals on the HP 8510 system bus, the pass-thru mode is used to transfer the computer's commands over from the HP-IB.

Pass-thru on the HP 8510

With the peripherals on the system bus, the only way the computer (controller) can obtain direct access to them is by using the pass-thru mode. In pass-thru mode, commands are routed through the HP 8510 processor from the HP-IB to the system bus.

In order to use the pass-thru mode, two addresses must be set. The address the computer will talk to is the System bus address (normally 17), and it is specified with ADDRSYSB. The address of the device on the system bus is the pass-thru address, and is specified with ADDRPASS. For example, if the plotter on the system bus is at address 05 and it is desired to make a plot from the computer, use ADDSYSB 17; ADDRPASS 05;. This will allow the computer direct access to the plotter with the command OUTPUT 717;"HPGL".

Note that the computer cannot control a disc drive on the HP 8510 system bus, because disc drive operation requires two-way handshaking. Thus, a second disc drive which is connected to the HP-IB is recommended.

Peripheral control on the HP 8700 series

The HP 8700 series network analyzers do not have a system bus, and so peripherals are connected to the HP-IB bus and the computer has direct access to these peripherals always. However, analyzer access to these peripherals is sometimes necessary, as when making a plot of measurement data.

Thus the computer must relinquish active control of the HP-IB and allow the analyzer to become the active controller, so in essence what is needed is a pass-thru capility whereby the analyzer can temporarily assume control of the HP-IB. This can be accomplished as follows.

The HP 8700 series has three operating modes with respect to HP-IB, as set under the LOCAL menu which is accessible via the [LOCAL] key. *System controller* mode is used when no computer is present. In this mode, the analyzer has full control over all peripherals on the HP-IB. The other two modes are used when a computer is on the HP-IB. *Talker/listener* mode allows the analyzer a one-way communcation path to plotters and printers. *Pass control* mode allows the computer to pass active control of the peripherals to the analyzer, so that the analyzer can plot, print, or access the disc drive, and these peripherals can talk back to the analyzer. For disc drive operation, the pass control mode MUST be used, since two-way communication between the analyzer and the disc drive is required. For most plotting and printing operations, talker/listener mode is the easiest to use.

The HP 8700 series analyzers assume that the address of the computer is correctly stored in its HP-IB addresses menu under the *[ADDRESS: CONTROLLER]* entry. If this address is not correct, control will not return to the computer when the instrument is finished using the peripheral.

HP 8700 series analyzer talker/listener mode

If it is desired to make plots or printouts from the analyzer in talker/listener mode, the commands OUTPPLOT and OUTPPRIN can be used. Talker/listener mode allows only one-way communication between the analyzer and the peripheral, so error conditions such as no paper in the plotter cannot be detected by the analyzer. The following program shows how to generate a plot in talker/listener mode.

```
10  OUTPUT 716;"OUTPPLOT;"  ............ Command the analyzer to plot.
20  SEND 7;UNL LISTEN 5 TALK 16 DATA ... Establish a data path from the analyzer to the
                                         plotter.
30  DISP "PLOTTING"
40  STATUS 7,7;Stat ................... Wait for the analyzer to assert the EOI line,
                                         indicating the end of transmission.
50  IF NOT BIT(Stat,11) THEN GOTO 40 .. If bit 11 is not set, the the EOI line is not being
                                         asserted by the analyzer, so loop and check
                                         again.
60  DISP "DONE"
70  END
```

HP 8700 series analyzer pass control mode

Pass control mode allows two-way communication between the analyzer and the peripheral being accessed. While the analyzer is in this mode, it is free to address devices to talk and listen as needed. This allows the analyzer to send messages as well as read replies back from printers, plotters, and disc drives. Use `PRINALL` to generate printouts of the analyzer display, `PLOT` for plots. `LISV` can be used to obtain tabular listings on a printer of trace values and frequencies. The following program gives an example.

`10 OUTPUT 716;"CLES;ESE2;"`	Clear the status reporting system, and enable the Request Active Control bit in the event status register.
`20 OUTPUT 716;"USEPASC;PRINALL;"`	Put the analyzer in pass control mode, and request a printer dump of the analyzer's display.
`30 Stat=SPOLL(716)`	Get the status byte.
`40 IF NOT BIT(Stat,5) THEN GOTO 30`	If the analyzer is not requesting control, loop and wait.
`50 SEND 7;TALK 16 CMD 9`	Pass active control to device 16.
`60 DISP "PRINTING"`	
`70 STATUS 7,6;Hpib`	Load the interface 7 (HP-IB) register 6 into the variable `Hpib`. Bit 6 indicates whether or not the computer is the active controller.
`80 IF NOT BIT(Hpib,6) THEN GOTO 70`	If control has not returned, loop and wait.
`90 DISP "DONE"`	
`100 END`	

User graphics

The screens of the HP 8510 and the HP 8700 series network analyzers can be written to as if they were a plotter using either a subset of the HP-GL commands, or all the HP-GL commands. This allows the operator to draw lines or text directly on the analyzer screen, for example when showing hookup diagrams.

With the HP 8510, plotting instructions are written to the system bus address after the pass-thru address is set to 31 (the default address of the display). The HP 8510 behaves as if the display were an external device hooked to the system bus at address 31. Plotting data must be scaled to the HP 8510 display coordinates ($0<X<4095$ and $0<Y<4095$). Send `ADDRSYSB 17; ADDRPASS 31;` to allow the computer to write HP-GL subset graphic commands such as `OUTPUT 717;''PG;''` to the screen. To use full HP-GL, send `ADDRPASS 31` followed by `PLOTTER IS 717,''HPGL''` to allow commands such as `DRAW`, `FRAME`, and so on. For more information on HP 8510 user graphics, refer to Example 10, *User Graphics*, in the HP 8510 *Introductory Programming Guide*.

With the HP 8700 series, plotting instructions are written to HP-IB address 17 (the default address of the display). Plotting data must be scaled to the HP 8700 series analyzer's display coordinates ($0<X<5850$ and $0<Y<4095$). To use the HP-GL subset (commands such as `PG`, `PU`, and so on), use `OUTPUT 717;''...''` where `...` is the desired sequence of commands. To write to the analyzer display with full access to HP-GL commands (commands such as `DRAW`, `FRAME` and so on), issue `PLOTTER IS 717,''HPGL''`. For more information on HP 8700 series, refer to the appropriate examples in their programing guides or appendices in their reference guides.

Using the instrument status bytes

There are substantial differences between the status reporting mechanisms of the HP 8510 and the HP 8700 series. The HP 8510 has two status bytes, the primary status byte (#1) and the extended status byte (#2). The primary status byte can be read using `SPOLL(716)`. To read both status bytes simultaneously, use `OUTPSTAT;` followed by `ENTER 716;S1,S2` where `S1` and `S2` are two integer variables to contain the status bytes. Once the status byte(s) has been read into an integer varible, check the values of specific bits within the status byte(s) using `BIT(XX,n)` where `XX` is the status byte (`S1` or `S2`) and `n` is the bit to be checked. For an example on reading the HP 8510 front panel using the status byte, refer to Example 11 in the HP 8510 *Introductory Programming Guide*.

The HP 8700 series analyzers have one status byte, and two event status registers. The status byte can be read using `SPOLL(716)` or `OUTPSTAT`. The event status register can be read with `ESR?` and event status register B can be read with `ESB?`. Bits 2 and 5 of the status byte indicate the condition of the event status registers and can be checked using `BIT(XX,n)` where `XX` is the variable containing the status byte, and `n` is either 2 or 5, depending on which event status register is to be checked. The event status register is summarized by bit 5, and event status register B is summarized by bit 2. The event status registers can be used to determine if keypresses, limit test failures, marker search failures or errors have occured. For more information regarding the HP 8700 series analyzers' status bytes and event status registers, consult the limit testing and user interface examples in their programming guides and appendices on status reporting in their quick reference guides.

Section 2: Commands Common to Both the HP 8510B and HP 8720A

This section lists the HP-IB commands that can be used on both the HP 8510B and the HP 8720A to perform the same functions. The listing is is set up as follows:

COMMAND Description

The left column gives the HP-IB mnemonic, and the right column gives a brief description of the function that the command performs. For more specific information about these commands refer to the documentation listed earlier.

COMMAND	Description
ADDRDISC	Disc address.
ADDRPLOT	Plotter address.
ADDRPRIN	Printer address.
ASEG	Sweep all segments in frequency list mode.[1]
AUTO	Auto scale.
AVEROFF	Averaging off.
AVERON	Averaging on.
AVER?	Query averaging on/off.
C0	Define open circuit capacitance values.
C1	"
C2	"
C3	"
CAL1	Begin cal sequence with cal kit 1.
CALIFUL2	Select full 2-port calibration.
CALIRAI	Select response & isolation calibration.
CALIRESP	Select response calibration.
CALIS111	Select S11 1-port calibration.
CALIS221	Select S22 1-port calibration.
CENT	Set center stimulus value (frequency or time).
CHAN1	Channel 1 active channel.
CHAN2	Channel 2 active channel.
CLAD	Class done.
CLASS11A	S11A: S11 opens.
CLASS11B	S11A: S11 shorts.
CLASS11C	S11A: S11 loads.
CLASS22A	S22A: S22 opens.
CLASS22B	S22A: S22 shorts.
CLASS22C	S22A: S22 loads.
CLES	Clear status, event status, and enable registers.
COAX	Select coaxial offsets, modify cal kit.
CONT	Continual sweep trigger mode.
CORROFF	Error correction off.
CORRON	Error correction on.
CORR?	Query correction on/off.
CWFREQ	Set CW frequency in frequency list mode.

1. HP 8510B Rev. 4.0 and higher only.

COMMAND	Description
DATI	Store trace data into memory.
DEBUOFF	HP-IB debug mode off.
DEBUON	HP-IB debug mode on.
DEFS	Begin standard definition, modify cal kit.
DELA	Display data in group delay format.
DELO	Delta marker mode off.
DELR1	Delta reference marker.
DELR2	"
DELR3	"
DELR4	"
DISCUNIT	Specify disc unit number.
DISPDATA	Display data only.
DISPDATM	Display data and memory.
DISPMEMO	Display memory only.
DIVI	Display data divided by memory.
DONE	Class done, modify cal kit.
DOWN	Down step key.
EDITDONE	Done with list edit.
EDITLIST	Begin edit of frequency list table.
ELED	Electrical delay under RESPONSE.
ENTO	Entry off.
FIXE	Specify fixed load standard type.
FORM1	Data transfer: internal 6 byte binary format.
FORM2	Data transfer: IEEE 8 byte floating point format.
FORM3	Data transfer: IEEE 16 byte floating point format.
FORM4	Data transfer: ASCII format.
FREO	Frequency annotation off.
FRER	Select continual sweep (HP-IB free run) after **TRIG**.
FULP	Select full page plot under COPY.
FWDI	Forward isolation standard, modify cal kit.
FWDM	Forward match standard, modify cal kit.
FWDT	Forward transmission standard, modify cal kit.
GATE?	Query gating on/off.
GATECENT	Specify center time of time domain gate.
GATEOFF	Gating off.
GATEON	Gating on.
GATESPAN	Specify span time of time domain gate.
GATESTAR	Specify start time of time domain gate.
GATESTOP	Specify stop time of time domain gate.
GATSMAXI	Gate shape maximum.
GATSMINI	Gate shape minimum.
GATSNORM	Gate shape normal.
GATSWIDE	Gate shape wide.

COMMAND	Description
HOLD	Hold sweep (sweep trigger in hold mode).
INID	Initialize disc media.
INPUCALC01	Input calibration coefficient data arrays.
INPUCALC02	"
INPUCALC03	"
INPUCALC04	"
INPUCALC05	"
INPUCALC06	"
INPUCALC07	"
INPUCALC08	"
INPUCALC09	"
INPUCALC10	"
INPUCALC11	"
INPUCALC12	"
INPUDATA	Input error corrected data array.
INPUFORM	Input formatted data array.
INPULEAS	Input learn string.
INPURAW1	Input raw data array.
INPURAW2	"
INPURAW3	"
INPURAW4	"
ISOD	Isolation done, full 2-port cal.
ISOL	Begin isolation, full 2-port cal.
KITD	Cal kit definition done, modify cal kit.
LABEFWDM	Label class forward match.
LABEFWDT	Label class forward transmission.
LABERESP	Label class response.
LABEREVM	Label class reverse match.
LABEREVT	Label class reverse transmission.
LABES11A	Label class S11A: opens.
LABES11B	Label class S11B: shorts.
LABES11C	Label class S11C: loads.
LABES22A	Label class S22A: opens.
LABES22B	Label class S22B: shorts.
LABES22C	Label class S22C: loads.
LABK	Label cal kit, modify cal kit.
LABS	Label standard, modify cal kit.
LEFL	Left lower quadrant plot.
LEFU	Left upper quadrant plot.
LINM	Display data in linear magnitude format.
LISFREQ	Enable list frequency mode.
LOGM	Display data in log magnitude format.
LOWPIMPU	Low pass impulse time domain.
LOWPSTEP	Low pass step time domain.

COMMAND	Description
MARK1	Marker 1 active.
MARK2	"
MARK3	"
MARK4	"
MARKCONT	Markers in continuous mode.
MARKDISC	Markers in discrete mode.
MARKMAXI	Marker to maximum.
MARKMINI	Marker to mininum.
MARKOFF	Turn all markers and marker functions off.
MAXF	Specify max frequency of cal standard, modify cal kit.
MENUCAL	CAL key menu.
MENUCOPY	COPY key menu.
MENUDISP	DISPLAY key menu.
MENUFORM	FORMAT key menu.
MENUMARK	MKR key menu
MENUOFF	Turn off soft key labels.
MENUON	Menu on.
MENURECA	RECALL key menu.
MENUSAVE	SAVE key menu.
MENUSTIM	Stimulus MENU key.
MENUSYST	SYSTEM key menu.
MINF	Specify min frequency of cal standard, modify cal kit.
MINU	Display DATA minus memory.
MODI1	Begin modify cal kit sequence.
NEXP	Next page op parameters (HP 8720A), tape directory (HP 8510).
NUMG	Specify number of groups of sweeps.
OMII	Omit isolation under CAL.
OPEP	Display operating parameters.
OUTPACTI	Output active function.
OUTPCALC01	Output calibration coefficient.
OUTPCALC02	"
OUTPCALC03	"
OUTPCALC04	"
OUTPCALC05	"
OUTPCALC06	"
OUTPCALC07	"
OUTPCALC08	"
OUTPCALC09	"
OUTPCALC10	"
OUTPCALC11	"
OUTPCALC12	"
OUTPDATA	Output error corrected data array.
OUTPERRO	Output error number, string.
OUTPFORM	Output formatted array.
OUTPIDEN	Output identification string.
OUTPKEY	Output key code.

COMMAND	Description
OUTPLEAS	Output learn string.
OUTPMARK	Output marker value.
OUTPMEMO	Output memory trace if on.
OUTPPLOT	Output HP-GL plot string.
OUTPRAW1	Output raw array.
OUTPRAW2	"
OUTPRAW3	"
OUTPRAW4	"
OUTPSTAT	Output status byte.
OUTPTITL	Output of last title.
PHAO	Phase offset.
PHAS	Display data in phase format.
POIN	Set the number of points.
POIN?	Query number of points.
PORT1	Set port 1 extension length.
PORT2	Set port 2 extension length.
POWE	Specify source power.
PRES	Instrument preset.
RAID	Response & isolation calibration done.
RAIISOL	Call isolation class, response & isolation cal.
RAIRESP	Call response class, response & isolation cal.
REAL	Display data in real format.
RECA1	Recall from internal registers.
RECA2	"
RECA3	"
RECA4	"
RECA5	"
REFD	Reflection done, full 2-port calibration.
REFL	Begin reflection, full 2-port calibration.
REFP	Reference position.
REFV	Reference value (level).
RESC	Resume cal sequence.
RESD	Restore display after
OPEP.	
REST	Measurement restart.
REVI	Reverse isolation class, full 2-port cal.
REVM	Reverse match class, full 2-port cal.
REVT	Reverse transmission class, full 2-port cal.
RIGL	Right lower quadrant plot.
RIGU	Right upper quadrant plot.

COMMAND	Description
S11	Measure S11.
S12	Measure S12.
S21	Measure S21.
S22	Measure S22.
SADD	Add segment to list.
SAV1	Done with 1-port CAL.
SAV2	Done with 2-port CAL.
SAVC	Done with transfer of error coefficients.
SAVE1	Save to internal registers.
SAVE2	"
SAVE3	"
SAVE4	"
SAVE5	"
SCAL	Sets trace scale factor.
SDEL	Delete current segment.
SDON	Edit segment done.
SEAL	Search left for target value.
SEAR	Search right for target value.
SEDI	Enter segment number.
SETF	Set frequency (low pass).
SETZ	SET system Z_0.
SING	Single group of sweeps.
SLID	Sliding load done.
SLIL	Specify sliding load as standard.
SLIS	Slide is set (triggers a measurement).
SMIC	Display data in Smith chart format.
SMOO?	Query smoothing on/off.
SMOOOFF	Smoothing off.
SMOOON	Smoothing on.
SOFR	Display software revision on screen.
SOFT1	Select softkey (same as pressing softkey).
SOFT2	"
SOFT3	"
SOFT4	"
SOFT5	"
SOFT6	"
SOFT7	"
SOFT8	"
SPAN	Set span value (frequency or time).
SPECFWDM	Specify forward match standard.
SPECFWDT	Specify forward transmission standard.
SPECRESP	Specify response standard.
SPECREVM	Specify reverse match standard.
SPECREVT	Specify reverse transmission standard.
SPECS11A	Specify S11A standard: opens.
SPECS11B	Specify S11B standard: shorts.
SPECS11C	Specify S11C standard: loads.

COMMAND	Description
SPECS22A	Specify S22A standard: opens.
SPECS22B	Specify S22B standard: shorts.
SPECS22C	Specify S22C standard: loads.
SSEG	Select a single segment in frequency list mode.[1]
STANA	Select standard from class.
STANB	"
STANC	"
STAND	"
STANE	"
STANF	"
STANG	"
STAR	Start start value (frequency or time).
STDD	Standard definition done, modify cal kit.
STDTARBI	Define standard type arbitary Z_0 modify cal kit.
STDTDELA	Define standard type delay/thru.
STDTLOAD	Define standard type load.
STDTOPEN	Define standard type open.
STDTSHOR	Define standard type short.
STOP	Specify stop value (frequency or time).
STPSIZE	Step size for frequency list segments.
SWET	Set sweep time.
SWR	Display data in SWR format.
TERI	Terminal impedance, modify cal kit.
TITL	Title function.
TRAD	Transmission done.
TRAN	Call transmission standard.
TRIG	Wait for sweep trigger.
UP	Up step key.
VELOFACT	Enter velocity factor for transmission medium.
WAIT	Wait for clean sweep.
WAVE	Specify waveguide offsets, modify cal kit.
WINDMAXI	Set maximum time domain window.
WINDMINI	Set minimum time domain window.
WINDNORM	Set normal time domain window.

1. HP 8510B Rev. 4.0 or higher only.

Section 3: Complete listing of HP-IB commands

This section gives a complete listing of all the HP-IB commands including query commands for the HP 8510B[1], HP 8720A, HP 8753A, and HP 8702A network analyzers. The list is set up as follows:

COMMAND • • • • Description

The HP-IB mnemonic is in the left column, the next four columns indicate which particular instrument the command can be used with, and the right column gives a brief description of the command's function. For more detailed information about specific commands, refer to the documents listed earlier.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
—A—					
ADAP1	•				Specify adapter in cal kit 1 for adapter removal.
ADAP2	•				Specify adapter in cal kit 2 for adapter removal.
ADAR	•				Select adapter removal modify cal set.
ADDR8510	•				HP-IB address of HP 8510.
ADDRCONT		•	•	•	Controller address (same as **PCB**).
ADDRDISC	•	•	•	•	Disc address.
ADDRPASS	•				System bus passthrough address.
ADDRPLOT	•	•	•	•	Plotter address.
ADDRPOWM			•	•	Power meter address.
ADDRPRIN	•	•	•	•	Printer address.
ADDRRFS	•				System bus address for RF switch (dual test set).
ADDRSOU2	•				Source #2 system bus address.
ADDRSOUR	•				Source #1 system bus address.
ADDRSYSB	•				HP-IB address of system bus.
ADDRTESS	•				System bus address of test set.
ALIASPANON				•	Alias free range limit on.
ALIASPANOFF				•	Alias free range off.
ALTAB			•	•	Alternate samplers during measurement.
ANAI		•	•	•	Measure auxilliary analog input. (ANALOG IN).
ANAO?	•				Query analog output.
ANAOOFF	•				Analog output off.
ANAOON	•				Analog output on.
ANNOSPAR				•	Parameter annotation set to S-parameters.
ANNOTRAR				•	Parameter annotation set to transmission/reflection.
APOWDONE	•				Done with A power cal.

1. Including those new commands available with Revision 4.0 firmware.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
ARPODONE				•	Done with A/R power cal.
AR			•	•	A/R ratio measurement.
ASEG		•			Sweep over all segments, list frequency mode.
ATTP1	•		•	•	Port 1 attenuator.
ATTP2	•		•	•	Port 2 attenuator.
AUTD	•				Auto delay.
AUTO	•	•	•	•	Auto scale.
AUXV	•				Aux. volt output under DOMAIN.
AVER?	•	•	•	•	Query averaging on/off.
AVERFACT		•	•	•	Set averaging factor on active channel.
AVEROFF	•	•	•	•	Averaging off.
AVERON	•	•	•	•	Averaging on.
AVERREST		•	•	•	Restart averaging.
—B—					
BANDPASS		•	•	•	Select time domain bandpass mode.
BEEP?	•				Query beeper.
BEEPDONEON		•	•	•	Beep when done with certain functions.
BEEPDONEOFF		•	•	•	Beep off.
BEEPFAILON		•	•	•	Beep if failure.
BEEPFAILOFF		•	•	•	Beep off.
BEEPOFF	•				Beeper off.
BEEPON	•				Beeper on.
BEEPWARNON		•	•	•	Beep if warning.
BEEPWARNOFF		•	•	•	Beep warning off.
BPOWDONE				•	Done with B power cal.
BRPODONE				•	Done with B/R power cal.
BR			•	•	B/R ratio measurement.
—C—					
C0	•	•	•	•	Define open circuit capacitance values.
C1	•	•	•	•	"
C2	•	•	•	•	"
C3	•	•	•	•	"
CAL1	•	•	•	•	Begin cal sequence with cal kit 1.
CAL2	•				Begin cal sequence with cal kit 2.
CALI?	•				Query cal type.
CALIFUL2	•	•	•	•	Select full 2-port cal.
CALIONE2	•		•	•	Select one path 2-port cal.
CALIAPOW				•	Power cal on A input.
CALIARPO				•	Power cal on B/R.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
CALIBPOW				•	Power cal on B input.
CALIBRPO				•	Power cal A/R.
CALIRAI	•	•	•	•	Select response & isolation calibration.
CALIRESP	•	•	•	•	Select response cal.
CALIS111	•	•	•	•	Select S11 1-port cal.
CALIS221	•	•	•	•	Select S22 1-port cal.
CALITRL2	•				Select TRL 2-port cal.
CALK1	•				Cal kit 1 data type under TAPE/DISC.
CALK2	•				Cal kit 2 data type under TAPE/DISC.
CALK35MM		•	•	•	Cal kit −3.5 mm.
CALK7MM		•	•	•	Cal kit −7 mm.
CALKN50		•	•	•	Cal kit −type N, 50 ohm.
CALKN75			•	•	Cal kit −type N, 75 ohm.
CALKOPTS				•	Cal kit −optical standard kit.
CALKOPTU				•	Cal kit −optical user kit.
CALKUSED		•	•	•	Cal kit −user defined.
CALPRECE				•	Select receiver class (O/E DUT's only).
CALPRESP				•	Select response class (A/R and B/R only).
CALPRFSC				•	Select RF source cable power cal class.
CALPRFTC				•	Select RF total cable power cal class.
CALS1	•				Select cal set under TAPE/DISC and CAL.
CALS2	•				"
CALS3	•				"
CALS4	•				"
CALS5	•				"
CALS6	•				"
CALS7	•				"
CALS8	•				"
CALS?	•				Query active calibration set.
CALSALL	•				Cal set all data type under TAPE/DISC.
CALSDIRE?	•				List of stored cal sets.
CALSPORT1	•				Select port 1 Cal Set in adapter removal.
CALSPORT2	•				Select port 2 Cal Set in adapter removal.
CALSRECC				•	Select receiver coefficient standard.
CALSRECD				•	Select receiver disc standard.
CALSSOUC				•	Select source coefficient standard.
CALSSOUD				•	Select source disc standard.
CALZ?	•				Cal TRL Z_0 (characteristic impedance) thru or system.
CALZLINE	•				TRL Z_0 set to thru line Z_0.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
CALZSYST	•				TRL Z_0 corrected to system Z_0.
CENT	•	•	•	•	Set center stimulus value (frequency or time).
CHAN1	•	•	•	•	Channel 1 active channel.
CHAN2	•	•	•	•	Channel 2 active channel.
CHAN?	•				Query active channel.
CHOPAB			•	•	Chop samplers during measurement.
CLAD	•	•	•	•	Class done.
CLASS11A	•	•	•	•	S11A: S11 opens.
CLASS11B	•	•	•	•	S11A: S11 shorts.
CLASS11C	•	•	•	•	S11A: S11 loads.
CLASS22A	•	•	•	•	S22A: S22 opens.
CLASS22B	•	•	•	•	S22A: S22 shorts.
CLASS22C	•	•	•	•	S22A: S22 loads.
CLEARALL		•	•	•	Clear all registers.
CLEAn		•	•	•	Clear selected register **n**, **n** = 1-5.
CLEL	•				Clear frequency list under FREQ LIST.
CLES	•	•	•	•	Clear status, event status, and enable registers.
CLS		•	•	•	Same as **CLES**.
COAD	•				Coaxial (linear) electrical delay.
COAX	•	•	•	•	Select coaxial offsets, modify cal kit.
COEFA				•	Coefficient for source/receiver model.
COEFB				•	"
COEFC				•	"
COEFD				•	"
COEFE				•	"
COEFF				•	"
COEFG				•	"
COEFH				•	"
COEFI				•	"
CONF	•				Constant frequency value under multiple source.
CONT	•	•	•	•	Continual sweep trigger mode.
CONV1DS		•	•	•	Convert S-parameter data to 1/S.
CONV1S	•				Convert S-parameter data to 1/S.
CONV?	•				Query parameter conversion type.
CONVOFF		•	•	•	Disable parameter conversion.
CONVS	•				Convert to S-parameters.
CONVY	•				Convert to Y-parameters.
CONVYREF		•	•	•	Convert to Y:reflection.
CONVYTRA		•	•	•	Convert to Y:transmission.
CONVZ	•				Convert to z parameters.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
CONVZREF		•	•	•	Convert to Z:reflection.
CONVZTRA		•	•	•	Convert to Z:tansmission.
COPYFRFT		•	•	•	Copy file titles to register titles.
COPYFRRT		•	•	•	Copy register titles to disc register titles.
CORION				•	Error correction interpolation enabled.
CORIOFF				•	Error correction interpolation disabled.
CORR?	•	•	•	•	Query correction on/off.
CORROFF	•	•	•	•	Error-correction off.
CORRON	•	•	•	•	Error-correction on.
COUC	•				Couple channels.
COUCOFF		•	•	•	Uncouple channels.
COUCON		•	•	•	Couple channels.
COUP?	•				Query coupled/uncoupled channels.
CRES	•				Create and save under FREQUENCY SUBSET.
CRT?	•				Query crt on/off.
CRTO	•				CRT off.
CWEXT			•	•	CW via external input.
CWFREQ	•	•	•	•	Set CW frequency in frequency list mode.
CWTIME		•	•	•	Select CW time sweep type.
—D—					
DATACHAN1	•				Trace math uses data from channel 1.
DATACHAN2	•				Trace math uses data from channel 2.
DATADATA	•				Corrected data type under TAPE/DISC.
DATAFORM	•				Formatted data type under TAPE/DISC.
DATARAW	•				Raw data type under TAPE/DISC.
DATI	•	•	•	•	Store trace data to memory.
DEBUOFF	•	•	•	•	HP-IB debug mode off.
DEBUON	•	•	•	•	HP-IB debug mode on.
DEFA	•				Equation default in multiple source.
DEFIRECV	•				Define receiver equation in multiple source.
DEFISOUR1	•				Multiple source define source #1 equation (test signal).
DEFISOUR2	•				Multiple source define source #2 equation (local osc.).
DEFM1	•				Define memory used for memory on selected channel.
DEFM2	•				" Memories 1-4, non-volatile.
DEFM3	•				"
DEFM4	•				"
DEFM5	•				" Memories 5-8, volatile.
DEFM6	•				"
DEFM7	•				"
DEFM8	•				"

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
DEFM?	•				Query default memory selection.
DEFS	•	•	•	•	Begin standard definition, modify cal kit.
DELA	•	•	•	•	Display data in group delay format.
DELC	•				Delete cal set (followed by **CALSn**).
DELE	•				Delete file under TAPE/DISC.
DELM?	•				Query electrical delay type.
DELO	•	•	•	•	Delta marker mode off.
DELR1	•	•	•	•	Delta reference marker.
DELR2	•	•	•	•	"
DELR3	•	•	•	•	"
DELR4	•	•	•	•	"
DELR5	•				"
DELR?	•				Query delta reference marker.
DELRFIXM		•	•	•	Delta fixed marker.
DELT	•				Delay table data type under TAPE/DISC.
DEMOAMPL		•	•	•	Sets transform demodulation to amplitude demodulation.
DEMOOFF		•	•	•	Transform demodulation off.
DEMOPHAS		•	•	•	Sets transform demodulation to phase demodulation.
DENO?	•				Query parameter denominator.
DENOA1	•				Define denominator under PARAMETER as a1.
DENOA2	•				Define denominator under PARAMETER as a2.
DENOB1	•				Define denominator under PARAMETER as b1.
DENONOR	•				Define denominator under PARAMETER as b2.
DEV1PE				•	Select device type, 1-port electrical.
DEV1PO				•	Select device type, 1-port optical.
DEVTEE				•	Select device type, electrical/electrical.
DEVTEO				•	Select device type, electrical/optical.
DEVTOE				•	Select device type, optical/electrical.
DEVTOO				•	Select device type, optical/optical.
DFLT		•	•	•	Select default plotter setups.
DIRE	•				Display directory for current tape/disc.
DISCUNIT	•	•	•	•	Specify disc unit number.
DISCVOL	•				Specify disc volume number.
DISCVOLU		•	•	•	Specify disc volume number.
DISF	•				Disc file name entry.
DISP?	•				Query display trace.
DISPDATA	•	•	•	•	Display data only.
DISPDATM	•	•	•	•	Display data and memory.
DISPDDM		•	•	•	Display data divided by memory (trace math).
DISPDMM		•	•	•	Display data minus memory (trace math).

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
DISPMATH	•				Display current with math.
DISPMEMO	•	•	•	•	Display memory only.
DIVI	•	•	•	•	Display data divided by memory.
DOMA?	•				Query domain.
DONE	•	•	•	•	Class done, modify cal kit.
DOWN	•	•	•	•	Down step key.
DRIV?	•				Query parameter drive.
DRIVNONE	•				Select drive port for current parameter.
DRIVPORT1	•				Select drive port for current parameter.
DRIVPORT2	•				Select drive port for current parameter.
DUAC		•	•	•	Activate dual channel display mode.
DUPD	•				Delete duplicates under FREQ LIST.
DUPM	•				Measure duplicate points under FREQ LIST.
DUPP?	•				Query duplicate points (list freq).
—E—					
EDITDONE	•	•	•	•	Done with list edit.
EDITLIML		•	•	•	Begin edit of limit line table.
EDITLIST	•	•	•	•	Begin edit of frequency list table.
EDITMULS	•				Edit multiple source equations.
ELEA				•	Electrical attenuator.
ELED	•	•	•	•	Electrical delay under RESPONSE.
ENTO	•	•	•	•	Entry off.
EQUA	•				Set current active function equal to active marker value.
ESB?		•	•	•	Output event status register B.
ESE		•	•	•	Event status register summarized by bit 5 of status byte.
ESNB		•	•	•	Event status register B summarized by bit 2 of status byte.
ESR?		•	•	•	Output value of event status register.
EXTMDATA		•	•	•	Error corrected data array storage on disc.
EXTMFORM		•	•	•	Formatted data array storage on disc.
EXTMGRAP		•	•	•	User graphics storage on disc.
EXTMRAW		•	•	•	Raw data array storage on disc.
EXTT		•	•	•	Activate external trigger mode.
—F—					
FASC	•				Fast CW data acquisition (ext. trigger). Exit with **SINP**.
FILEn	•				Select data type file **n** under TAPE/DISC, **n** = 1-8.
FIRP	•				Select first page of tape directory and operating parameters.
FIXE	•	•	•	•	Specify fixed load standard type.
FOCU		•	•	•	Display focus, in percent.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
FORM1	•	•	•	•	Data transfer: Internal 6 byte binary format.
FORM2	•	•	•	•	Data transfer: IEEE 8 byte floating point format.
FORM3	•	•	•	•	Data transfer: IEEE 16 byte floating point format.
FORM4	•	•	•	•	Data transfer: ASCII format.
FORM?	•				Query format.
FREA?	•				Query frequency annotation on/off.
FREO	•	•	•	•	Frequency annotation off.
FREQ	•				Frequency domain.
FRER	•	•	•	•	Select continual sweep (HP-IB free run) after **TRIG**.
FRES	•				Frequency subset under MODIFY CAL SET.
FREU	•				Update frequency annotation with no sweep.
FULP	•	•	•	•	Select full page plot under COPY.
FWDI	•	•	•	•	Forward isolation standard, modify cal kit.
FWDM	•	•	•	•	Forward match standard, modify cal kit.
FWDT	•	•	•	•	Forward transmission standard, modify cal kit.
—G—					
GATE?	•	•	•	•	Query gating on/off.
GATECENT	•	•	•	•	Specify center time of time domain gate.
GATEOFF	•	•	•	•	Gating off.
GATEON	•	•	•	•	Gating on.
GATESPAN	•	•	•	•	Specify span time of time domain gate.
GATESTAR	•	•	•	•	Specify start time of time domain gate.
GATESTOP	•	•	•	•	Specify stop time of time domain gate.
GATS?	•				Query gate shape.
GATSMAXI	•	•	•	•	Gate shape maximum.
GATSMINI	•	•	•	•	Gate shape minimum.
GATSNORM	•	•	•	•	Gate shape normal.
GATSWIDE	•	•	•	•	Gate shape wide.
GROU?	•				Query continual or hold mode.
—H—					
HARS	•				Hardware state data type under TAPE/DISC.
HOLD	•	•	•	•	Hold sweep (sweep trigger in hold mode).
—I—					
IDN?		•	•	•	Output identification string. Same as **OUTPIDEN** (common cmd).
IFBW		•	•	•	Specify IF bandwidth.
IFGREFA?	•				Query reference gain.
IFGTESA?	•				Query test gain.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
IMAG	●				Display data in imaginary format.
INDEREFR				●	Index of refraction, reciprocal of velocity factor.
INID	●	●	●	●	Initialize disc media.
INIT	●				Initialize tape.
INPUCALC01	●	●	●	●	Input calibration coefficient data arrays.
INPUCALC02	●	●	●	●	"
INPUCALC03	●	●	●	●	"
INPUCALC04	●	●	●	●	"
INPUCALC05	●	●	●	●	"
INPUCALC06	●	●	●	●	"
INPUCALC07	●	●	●	●	"
INPUCALC08	●	●	●	●	"
INPUCALC09	●	●	●	●	"
INPUCALC10	●	●	●	●	"
INPUCALC11	●	●	●	●	"
INPUCALC12	●	●	●	●	"
INPUCALK		●	●	●	Input cal kit.
INPUCALR				●	Input receiver cal data, stored as disc data.
INPUCALS				●	Input source cal data, stored as disc data.
INPUDATA	●	●	●	●	Input error corrected data array.
INPUDELA	●				Input delay table.
INPUFORM	●	●	●	●	Input formatted data array.
INPUFREL	●				Input frequency list. (Use **INPULEAS** with HP 8700's).
INPULEAS	●	●	●	●	Input learn string.
INPURAW1	●	●	●	●	Input raw data array 1.
INPURAW2	●	●	●	●	"
INPURAW3	●	●	●	●	"
INPURAW4	●	●	●	●	"
INSS1	●				Instrument states under TAPE/DISC.
INSS2	●				"
INSS3	●				"
INSS4	●				"
INSS5	●				"
INSS6	●				"
INSS7	●				"
INSS8	●				"
INSSALL	●				All instrument states under TAPE/DISC.
INTE		●	●	●	Intensity level for display, in percent.
INVS	●				Display data in inverted Smith chart format.
ISOD	●	●	●	●	Isolation done, full 2-port cal.
ISOL	●	●	●	●	Begin isolation, full 2-port cal.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
—K—					
KEY		•	•	•	Sends a keycode, same as actually pressing the key.
KEYC	•				"
KITD	•	•	•	•	Cal kit definition done, modify cal kit.
KOR?		•	•	•	Same as **OUTPKEY** (common command).
—L—					
L0	•				L0 short circuit inductance.
L1	•				L1 short circuit inductance.
L2	•				L2 short circuit inductance.
L3	•				L3 short circuit inductance.
LABEADAP	•				Label class adapters.
LABEFWDI	•				Label class forward isolation.
LABEFWDM	•	•	•	•	Label class forward match.
LABEFWDT	•	•	•	•	Label class forward transmission.
LABERESI		•	•	•	Label response standard for the response & isolation cal.
LABERESP	•	•	•	•	Label class response.
LABEREVI	•				Label class reverse isolation.
LABEREVM	•	•	•	•	Label class reverse match.
LABEREVT	•	•	•	•	Label class reverse transmission.
LABES11A	•	•	•	•	Label class S11A: opens.
LABES11B	•	•	•	•	Label class S11B: shorts.
LABES11C	•	•	•	•	Label class S11C: loads.
LABES22A	•	•	•	•	Label class S22A: opens.
LABES22B	•	•	•	•	Label class S22B: shorts.
LABES22C	•	•	•	•	Label class S22C: loads.
LABETRLL	•				Label TRL line.
LABETRLR	•				Label reflect.
LABETRLT	•				Label thru.
LABK	•	•	•	•	Label cal kit, modify cal kit.
LABS	•	•	•	•	Label standard, standard definition.
LABO				•	Label optical kit under CAL.
LASP	•				Last page of tape directory.
LEFL	•	•	•	•	Left lower quadrant plot.
LEFU	•	•	•	•	Left upper quadrant plot.
LIMD		•	•	•	Set limit delta value.
LIMIAMPO		•	•	•	Set limit table amplitude offset.
LIMILINEOFF		•	•	•	Disable limit lines.
LIMILINEON		•	•	•	Enable limit lines.
LIMIMAOF		•	•	•	Marker to limit amplitude offset.
LIMISTIO		•	•	•	Limit table stimulus offset.
LIMITESTOFF		•	•	•	Disable limit line test.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
LIMITESTON		•	•	•	Enable limit line test.
LIML		•	•	•	Set limit lower value.
LIMM		•	•	•	Set limit middle value.
LIMS		•	•	•	Set limit stimulus value.
LIMTFL		•	•	•	Make the segment a flat line.
LIMTSL		•	•	•	Make the segment a sloping line.
LIMTSP		•	•	•	Make the segment a single point.
LIMU		•	•	•	Set upper limit value.
LINFREQ		•	•	•	Select linear frequency sweep.
LINM	•	•	•	•	Display data in linear magnitude format.
LINP	•				Linear marker on polar format.
LINTDATA		•	•	•	Select line type—trace data plot.
LINTMEMO		•	•	•	Select line type—trace memory plot.
LISFREQ	•	•	•	•	Select list frequency mode.
LIST	•				List trace values under COPY.
LISV		•	•	•	List trace values (use **PLOT/PRINALL** for hard copy).
LOAD	•				Load a TAPE/DISC data file.
LOADn		•	•	•	Recall from disc file **n**, **n** = 1-5.
LOADREC1				•	Load calibrated receiver data from disc.
LOADREC2				•	"
LOADREC3				•	"
LOADREC4				•	"
LOADREC5	•				"
LOADSOU1				•	Load calibrated source data from disc.
LOADSOU2				•	"
LOADSOU3				•	"
LOADSOU4				•	"
LOADSOU5				•	"
LOAN	•				Measure load with no offset.
LOAO	•				Measure load with offset (offset load std).
LOAT?	•				Query load type.
LOCK?	•				Query parameter lock to.
LOCKS?	•				Query phase lock speed.
LOCKA1	•				Select phase lock to a1.
LOCKA2	•				Select phase lock to a2.
LOCKNONE	•				Select phase lock to none.
LOCKSNORM	•				Redefine lockspeed, normal.
LOCKSFAST	•				Redefine lockspeed, fast.
LOCT?	•				Query system phase lock.
LOCTEXTE	•				Select 1st IF phase lock to external LO.
LOCTINTE	•				Select 1st IF phase lock to internal LO.
LOCTNONE	•				Do not phase lock 1st IF.
LOGFREQ		•	•	•	Log frequency sweep.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
LOGM	•	•	•	•	Display data in log magnitude format.
LOGP	•				Log marker on polar format.
LOWF	•				Specify TRL Lowband Frequency.
LOWP?	•				Query time stimulus.
LOWPIMPU	•	•	•	•	Low pass impulse time domain.
LOWPSET?	•				Query low pass freq set on/off.
LOWPSTEP	•	•	•	•	Low pass step time domain.
LOWR	•				Begin TRL 2-port lowband reflection.
LRN		•	•	•	Same as **INPULEAS.**
–M–					
MACD	•				Machine dump data type under TAPE/DISC.
MAGO	•				Set magnitude offset for current parameter on active chan.
MAGS	•				Set magnitude slope dB/GHz for current parameter/actv. ch.
MARK1	•	•	•	•	Make marker 1 the active marker.
MARK2	•	•	•	•	Make marker 2 active.
MARK3	•	•	•	•	Make marker 3 active.
MARK4	•	•	•	•	Make marker 4 active.
MARK5	•				Select marker 5.
MARK?	•				Query active marker.
MARKBUCK		•	•	•	Place marker on specific sweep point (bucket).
MARKCENT		•	•	•	Marker stimulus value sets the center stimulus value.
MARKCONT	•	•	•	•	Markers in continuous mode.
MARKCOUP		•	•	•	Enable channel coupled markers.
MARKDELA		•	•	•	Sets electrical delay so group delay is zero at marker.
MARKDISC	•	•	•	•	Markers in discrete mode.
MARKFAUV		•	•	•	Sets auxiliary value of fixed marker position.
MARKFSTI		•	•	•	Sets stimulus position of the fixed marker.
MARKFVAL		•	•	•	Sets the val. of the fixed marker position.
MARKMAXI	•	•	•	•	Marker to maximum. Same as **SEAMAX.**
MARKMIDD		•	•	•	Sets the limit segment middle value to marker amplitude.
MARKMINI	•	•	•	•	Marker to minimum. Same as **SEAMIN.**
MARKMODE?	•				Query marker mode.
MARKOFF	•	•	•	•	Turn all markers and marker functions off.
MARKREF		•	•	•	Sets the reference value to marker amplitude.
MARKSEAR?	•				Query marker search mode.
MARKSPAN		•	•	•	Sets the span to that between the act. mkr and delta ref.
MARKSTAR		•	•	•	Sets the start stimulus value to that of the marker stimulus.
MARKSTIM		•	•	•	Sets the limit stimulus break pt to that of the mkr stimulus.
MARKSTOP		•	•	•	Sets the stop stimulus value to that of the marker stimulus.
MARKTARG	•				Active marker to target trace value.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
MARKUNCO		•	•	•	Enable channel uncoupled markers.
MARKZERO		•	•	•	Place fixed marker at active marker and make it the delta reference.
MATH?	•				Query trace math type.
MAXF	•	•	•	•	Specify max frequency of cal standard, modify cal kit.
MEASA			•	•	A non-ratio measurement.
MEASB			•	•	B non-ratio measurement.
MEASOFF				•	Marker measure off, not Boolean.
MEASR			•	•	R non-ratio measurement.
MEASTATOFF		•	•	•	Disable trace/marker statistics.
MEASTATON		•	•	•	Enable trace/marker statistics.
MEDT?	•				Query cal std type—coax or waveguide.
MEMO1	•				Trace memory data type under tape/disc.
MEMO2	•				"
MEMO3	•				"
MEMO4	•				"
MEMO5	•				"
MEMO6	•				"
MEMO7	•				"
MEMO8	•				"
MEMOALL	•				"
MENU?	•				Query menu on/off.
MENUAVG		•	•	•	AVG key menu.
MENUCAL	•	•	•	•	CAL key menu.
MENUCOPY	•	•	•	•	COPY key menu.
MENUDISP	•	•	•	•	DISPLAY key menu.
MENUDOMA	•				DOMAIN menu.
MENUFORM	•	•	•	•	FORMAT key menu.
MENUMARK	•	•	•	•	MKR key menu.
MENUMEAS		•	•	•	MEAS key menu.
MENUMRKF		•	•	•	MKR FCTN key menu.
MENUOFF	•	•	•	•	Turn off softkey labels.
MENUON	•	•	•	•	Menu on.
MENUPARA	•				PARAMETER menu.
MENUPRIO	•				Prior menu.
MENURECA	•	•	•	•	RECALL key menu.
MENURESP	•				RESPONSE menu.
MENUSAVE	•	•	•	•	SAVE key menu.
MENUSCAL		•	•	•	SCALE REF key menu.
MENUSTIM	•	•	•	•	Stimulus MENU key.
MENUSYST	•	•	•	•	SYSTEM key menu.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
MENUTAPE	•				TAPE/DISC menu.
MENUTEST	•				TEST menu.
MINF	•	•	•	•	Specify min freq of cal standard, modify cal kit.
MINU	•	•	•	•	Display data minus memory.
MODI1	•	•	•	•	Begins modify cal kit sequence.
MODI2	•				Modify cal kit 2.
MODIO					Begin modify optical kit.
MODS	•				Modify selected cal set and save (follow with **CALSn**).
MULD	•				Multiplier denominator under MULTI SRC.
MULN	•				Multiplier numerator under MULTI SRC.
MULS?	•				Query multiple source on/off.
MULSOFF	•				Multiple source mode off.
MULSON	•				Multiple source mode on.
MULT	•				Multiple data & memory under DISPLAY.
—N—					
NEXP		•	•	•	Displays next page of operating parameters.
NEXP	•				Displays next page of tape directory.
NOOP		•	•	•	No operation.
NUME?	•				Query parameter numerator.
NUMEA1	•				Define numerator under PARAMETER as a1.
NUMEA2	•				Define numerator under PARAMETER as a2.
NUMEB1	•				Define numerator under PARAMETER as b1.
NUMEB2	•				Define numerator under PARAMETER as b2.
NUMG	•	•	•	•	Specifies number of groups of sweeps.
NUMS?	•				Query number of frequency list segments.
—O—					
OFFD	•				Offset delay under CAL.
OFFF	•				Freq offset under MULTI SRC.
OFFL	•				Offset loss under CAL.
OFFS	•				Define load or arbitrary impedance standard as offset type.
OFFZ	•				Real imped (Z) of offset cal standard.
OFLD	•				Offset load done.
OFSD		•	•	•	Offset delay under CAL.
OFSL		•	•	•	Offset loss under CAL.
OFSOINDR				•	Set refractive index of offset (optical cal standard)
OFSOLENG				•	Length of optical offset (optical cal standard).
OFSOLOSS				•	Loss per length (optical cal standard).
OFSORPOW				•	Per cent reflectance (optical cal standard).
OFSZ		•	•	•	Impedance offset under CAL.
OMIA				•	Omit optical attenuation for power cal.
OMII	•	•	•	•	Omit isolation under CAL.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
OPC		•	•	•	Operation complete (IEEE 488.2).
OPEP	•	•	•	•	Display operating parameters.
OPTA				•	Optical attenuator.
OUTPACTI	•	•	•	•	Output active function.
OUTPAPER		•	•	•	Output smoothing aperture.
OUTPCALC01	•	•	•	•	Output calibration coefficient.
OUTPCALC02	•	•	•	•	"
OUTPCALC03	•	•	•	•	"
OUTPCALC04	•	•	•	•	"
OUTPCALC05	•	•	•	•	"
OUTPCALC06	•	•	•	•	"
OUTPCALC07	•	•	•	•	"
OUTPCALC08	•	•	•	•	"
OUTPCALC09	•	•	•	•	"
OUTPCALC10	•	•	•	•	"
OUTPCALC11	•	•	•	•	"
OUTPCALC12	•	•	•	•	"
OUTPCALK		•	•	•	Output currently active calibration kit.
OUTPCALR				•	Output receiver cal data (disc standard).
OUTPCALS				•	Output source cal data (disc standard).
OUTPDATA	•	•	•	•	Output error corrected data array.
OUTPDELA	•				Output delay table.
OUTPERRO	•	•	•	•	Output error number,string.
OUTPFORM	•	•	•	•	Output formatted array.
OUTPFREL	•				Output frequency list.
OUTPIDEN	•	•	•	•	Output identification string.
OUTPKEY	•	•	•	•	Output key code.
OUTPLEAS	•	•	•	•	Output learn string.
OUTPLIMF		•	•	•	Output limit failures.
OUTPLIML		•	•	•	Output all limit points.
OUTPLIMM		•	•	•	Output limits at marker.
OUTPMARK	•	•	•	•	Output marker value.
OUTPMEMO	•	•	•	•	Output memory trace if on.
OUTPMPUL				•	Pulse width, 3 values.
OUTPMRIS				•	Rise time, 3 values.
OUTPMSTA		•	•	•	Output trace/marker statistics.
OUTPMWID		•	•	•	Output marker bandwidths search values.
OUTPPLOT	•	•	•	•	Output HP-GL plot string.
OUTPPRIN		•	•	•	Output raster data to printer.
OUTPRAW1	•	•	•	•	Output raw data array.
OUTPRAW2	•	•	•	•	"
OUTPRAW3	•	•	•	•	"
OUTPRAW4	•	•	•	•	"
OUTPSTAT	•	•	•	•	Output status byte.
OUTPTITL	•	•	•	•	Output of last title.
OVER	•				Dual channel overlay under DISPLAY.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
—P—					
PAGP	•				Page thru operating system parameters.
PARA?	•				Query parameter selected.
PARL	•				Label current user parameter.
PDATAOFF		•	•	•	Disable plot of trace data.
PDATAON		•	•	•	Enable plot of trace data.
PEN1	•				Plotter pen selection under COPY.
PEN2	•				"
PEN3	•				"
PEN4	•				"
PEN5	•				"
PEN6	•				"
PEN7	•				"
PEN8	•				"
PEN?	•				Query pen.
PENNDATA		•	•	•	Select pen for trace data plot.
PENNGRAT		•	•	•	Select pen for graticule plot.
PENNMARK		•	•	•	Select pen for marker plot.
PENNMEMO		•	•	•	Select pen for trace memory plot.
PENNTEXT		•	•	•	Select pen for text plot.
PGRAT		•	•	•	Enable/disable plot of graticule.
PHAO	•	•	•	•	Phase offset.
PHAS	•	•	•	•	Display data in phase format.
PLOP	•				Plot operating/system parameters.
PLOSFAST		•	•	•	Select fast plot speed.
PLOSSLOW		•	•	•	Select slow plot speed.
PLOT		•	•	•	Requests a plot (requires pass control mode).
PLOTALL	•				Plot complete meas. display.
PLOTGRAT	•				Plot graticule.
PLOTMARK	•				Plot marker(s).
PLOTTEXT	•				Plot text.
PLOTTRAC	•				Plot trace.
PLUS	•				Display data plus memory under DISPLAY.
PMEMOFF		•	•	•	Disable plot of trace memory.
PMEMON		•	•	•	Enable plot of trace memory.
PMKROFF		•	•	•	Disable plot of markers.
PMKRON		•	•	•	Enable plot of markers.
POIN	•	•	•	•	Set the number of points.
POIN?	•	•	•	•	Query number of points.
POLA		•	•	•	Display data in the polar format.
POLMLIN		•	•	•	Linear markers on polar format.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
POLMLOG		•	•	•	Log markers on polar format.
POLMRI		•	•	•	Real/imaginary markers on polar format.
POREOFF		•	•	•	Disable port extensions under CAL.
POREON		•	•	•	Enable port extensions under CAL.
PORTA			•	•	Set port A extension length.
PORTB			•	•	Set port B extension length.
PORT1	•	•	•	•	Set port 1 extension length.
PORT2	•	•	•	•	Set port 2 extension length.
POW2	•				Source 2 power under POWER MENU.
POWE	•	•	•	•	Specify source power.
POWMOFF			•	•	Select HP 438A power meter.
POWMON			•	•	Select HP 436A power meter.
POWS			•	•	Activate power sweep.
POWTOFF		•	•	•	Clears source power trip after overload.
POWTON		•	•	•	Source power trip.
PREC	•				Continue one-path 2-port measurement (after reversing D.U.T.).
PREP	•				Previous page in a tape directory.
PRES	•	•	•	•	Instrument preset.
PRINALL		•	•	•	Copy display to printer (requires pass control mode).
PRIP	•				Print operating/system parameters.
PSOFTOFF		•	•	•	Disable plot/print of softkeys.
PSOFTON		•	•	•	Enable plot/print of softkeys.
PTEXTOFF		•	•	•	Disable plot of text.
PTEXTON		•	•	•	Enable plot of text.
PULV				•	Value for pulse search.
PULW				•	Measure pulse width.
PURGn		•	•	•	Delete disc file **n**, **n** = 1-5.
—Q—					
QUAD?	•				Query quadrant for plots.
—R—					
RAID	•	•	•	•	Response & isolation calibration done.
RAIISOL	•	•	•	•	Call isolation class, response & isolation cal.
RAIRESP	•	•	•	•	Call response class, response & isolation cal.
RAMP	•				Ramp sweep under STIMULUS.
READRECT				•	Read receiver file titles from disc.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
READSOUT				●	Read source file titles from disc.
REAL	●	●	●	●	Display data in real format.
RECA1	●	●	●	●	Recall instrument state from internal registers.
RECA2	●	●	●	●	"
RECA3	●	●	●	●	"
RECA4	●	●	●	●	"
RECA5	●	●	●	●	"
RECA6	●				"
RECA7	●				"
RECA8	●				"
RECCSTDI				●	Receiver coefficient standard into memory.
RECDSTDI				●	Receiver disc standard into memory.
REDD	●				Done with redefining parameters.
REFA	●				Reference amp. gain under system.
REFD	●	●	●	●	Reflection done, full 2-port calibration.
REFL	●	●	●	●	Begin reflection ,full 2-port calibration.
REFP	●	●	●	●	Reference position.
REFT		●	●	●	Recall reg titles from disc.
REFV	●	●	●	●	Reference value (level).
REIP	●				Re/Im marker on POLAR format.
RESC	●	●	●	●	Resume cal sequence.
RESD	●	●	●	●	Restore display after **OPEP**.
RESI	●				Reset IF correction.
RESPDONE		●	●	●	Response calibration done.
REST	●	●	●	●	Measurement restart.
REVI	●	●	●	●	Reverse isolation class, 2-port cal.
REVM	●	●	●	●	Reverse match class, 2-port cal.
REVT	●	●	●	●	Reverse transmission class, 2-port cal.
RIGL	●	●	●	●	Right lower quadrant plot.
RIGU	●	●	●	●	Right upper quadrant plot.
RIST				●	Measure rise (fall) time.
RST		●	●	●	Same as **PRES** (instrument preset)

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
—S—					
S11	•	•	•	•	Measure S11.
S12	•	•	•	•	Measure S12.
S21	•	•	•	•	Measure S21.
S22	•	•	•	•	Measure S22.
SADD	•	•	•	•	Add segment to list.
SAV1	•	•	•	•	Done with 1-port cal.
SAV2	•	•	•	•	Done with 2-port cal.
SAVC	•	•	•	•	Done with transfer of error coefficients.
SAVE1	•	•	•	•	Save to internal registers.
SAVE2	•	•	•	•	"
SAVE3	•	•	•	•	"
SAVE4	•	•	•	•	"
SAVE5	•	•	•	•	"
SAVE6	•				"
SAVE7	•				"
SAVE8	•				"
SAVEOPTK				•	Save optical user kit.
SAVERECC				•	Save receiver coefficient standard.
SAVESOUC				•	Save source coefficient standard.
SAVEUSEK		•	•	•	Store user defined cal kit.
SAVT	•				Done with TRL 2-port cal.
SAVU?	•				Query save using binary/ASCII.
SAVUASCI	•				Save data ASCII (disc only).
SAVUBINA	•				Save data BINARY (disc only).
SCAL	•	•	•	•	Sets trace scale factor.
SCAPFULL		•	•	•	Select full scale plot.
SCAPGRAT		•	•	•	Plot graticule expanded to P1, P2.
SDEL	•	•	•	•	Delete current segment.
SDON	•	•	•	•	Edit segment done.
SEAL	•	•	•	•	Search left for target value.
SEAMAX		•	•	•	Search active marker to maximum.
SEAMIN		•	•	•	Search active marker to minimum.
SEAOFF		•	•	•	Turn off marker search.
SEAR	•	•	•	•	Search right for target value.
SEATARG		•	•	•	Specify search marker target value.
SEDI	•	•	•	•	Enter segment number.
SEGM	•				Segment number entry under FREQ LIST—STIM.
SEG?	•				Query segment sweep mode (single or all).
SETF	•	•	•	•	Set frequency low pass.
SETR?	•				Query TRL reference plane, thru or reflect.
SETRREFL	•				TRL ref plane reference to reflect.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
SETRTHRU	•				TRL ref plane reference to thru.
SETZ	•	•	•	•	Set system Z0.
SIMS	•				HP-IB only — simulate standard measured.
SINC	•				Single channel display.
SING	•	•	•	•	Single group of sweeps.
SINP	•				Single point under STIMULUS.
SLID	•	•	•	•	Sliding load done.
SLIL	•	•	•	•	Specify sliding load as standard.
SLIS	•	•	•	•	Slide is set (triggers a measurement).
SLOP?	•				Query slope on/off.
SLOPE			•	•	Enter the power slope value.
SLOPOFF	•		•	•	Power slope off under STIMULUS.
SLOPON	•		•	•	Power slope on under STIMULUS.
SMIC	•	•	•	•	Display data in Smith chart format.
SMIMGB		•	•	•	G +jB markers on Smith format.
SMIMLIN		•	•	•	Linear markers on Smith format.
SMIMLOG		•	•	•	Log markers on Smith format.
SMIMRI		•	•	•	Real/imaginary markers on Smith format.
SMIMRX		•	•	•	R +jX markers on Smith format.
SMOO?	•	•	•	•	Query smoothing on/off.
SMOOAPER		•	•	•	Set smoothing aperature.
SMOOOFF	•	•	•	•	Smoothing off.
SMOOON	•	•	•	•	Smoothing on.
SOFR	•	•	•	•	Display software revision on screen.
SOFT1	•	•	•	•	Select softkey. (Same as pressing softkey).
SOFT2	•	•	•	•	"
SOFT3	•	•	•	•	"
SOFT4	•	•	•	•	"
SOFT5	•	•	•	•	"
SOFT6	•	•	•	•	"
SOFT7	•	•	•	•	"
SOFT8	•	•	•	•	"
SOUCSTDI				•	Source coefficient into memory.
SOUDSTDI				•	Source disc into memory.
SPAN	•	•	•	•	Set span value (frequency or time).
SPAR				•	S-parameter annotation on.
SPECADAP	•				Specify adapter standard, modify cal kit.
SPECFWDI	•				Specify forward isolation standard.
SPECFWDM	•	•	•	•	Specify forward match standard.
SPECFWDT	•	•	•	•	Specify forward transmission standard.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
SPECRESI		•	•	•	Specify response for response & isolation cal.
SPECRESP	•	•	•	•	Specify response standard.
SPECREVI	•				Specify reverse isolation standard.
SPECREVM	•	•	•	•	Specify reverse match standard.
SPECREVT	•	•	•	•	Specify reverse transmission standard.
SPECS11A	•	•	•	•	Specify S11A (opens).
SPECS11B	•	•	•	•	Specify S11B (shorts).
SPECS11C	•	•	•	•	Specify S11C (loads).
SPECS22A	•	•	•	•	Specify S22A (opens).
SPECS22B	•	•	•	•	Specify S22B (shorts).
SPECS22C	•	•	•	•	Specify S22C (loads).
SPECTRLL	•				Specify TRL line standard.
SPECTRLR	•				Specify TRL reflect standard.
SPECTRLT	•				Specify TRL thru standard.
SPLDOFF		•	•	•	Disable split graticule display.
SPLDON		•	•	•	Enable split graticule display.
SPLI	•				Dual channel split under DISPLAY.
SRE		•	•	•	Status request enable.
SRQM	•				Define SRQ mask.
SSEG		•			Sweep single segment of frequency list.
STANA	•	•	•	•	Select standard from class.
STANB	•	•	•	•	"
STANC	•	•	•	•	"
STAND	•	•	•	•	"
STANE	•	•	•	•	"
STANF	•	•	•	•	"
STANG	•	•	•	•	"
STAR	•	•	•	•	Specify start value (frequency or time).
STB?		•	•	•	Output status byte.
STDD	•	•	•	•	Standard done, modify cal kit.
STDODEFI				•	Done with optical cal standards.
STDT?	•				Query standard type.
STDTARBI	•	•	•	•	Define standard type arbitary Z_0, modify cal kit.
STDTDELA	•	•	•	•	Define standard type delay/thru.
STDTFRES				•	Define standard type fresnel.
STDTLOAD	•	•	•	•	Define standard type load.
STDTOPEN	•	•	•	•	Define standard type open.
STDTOTHR				•	Define standard type optical thru.
STDTRECE				•	Define coefficient receiver model.
STDTREFL				•	Define optical reflector.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
STDTSHOR	•	•	•	•	Define standard type short.
STDTSOUR				•	Define coeffient source model.
STDTTHRR				•	Define standard type thru (thru/receiver).
STEP	•				Stepped sweep under STIMULUS.
STOI?	•				Query storage media disc/tape.
STOIDISC	•				Select external disc as mass storage.
STOITAPE	•				Select internal tape as mass storage.
STOP	•	•	•	•	Specify stop value (frequency or time).
STOR	•				Store tape/disc data file.
STORn		•	•	•	Store inst. state and related data to file **n** on disc, **n** = 1-5.
STPSIZE	•	•	•	•	Step size for frequency list segments.
SUBSCENT	•				Frequency subset center under FREQUENCY SUBSET.
SUBSPAN	•				Frequency subset span under FREQUENCY SUBSET.
SUBSSTAR	•				Frequency subset start under FREQUENCY SUBSET.
SUBSSTOP	•				Frequency subset stop under FREQUENCY SUBSET.
SWEA		•			Auto sweep time.
SWEM?	•				Query sweep mode (ramp,stepped,single,list freq, etc.).
SWET	•	•	•	•	Set sweep time.
SWR	•	•	•	•	Display data in SWR format.
SYNM?	•				Query sync mode (triggered sweep,free run).
SYSB?	•				Query system bus (local/remote).
SYSBLOCA	•				System bus "LOCAL".
SYSBREMO	•				System bus "REMOTE".
SYSP	•				Display system parameters under COPY.
—T—					
TABD	•				Use delay table for electrical delay.
TALKLIST		•	•	•	Talker/listener HP-IB mode.
TARV	•				Marker target value for marker to target.
TERI	•	•	•	•	Terminal impedance, modify cal kit.
TESA	•				Test amp. gain under SYSTEM.
TESS?		•	•	•	Query test set present (always a 1 on HP 8720A).
TIMB	•				Time band pass under DOMAIN.
TIMDTRANOFF		•	•	•	Disable time domain.
TIMDTRANON		•	•	•	Enable time domain.
TIML	•				Time low pass under DOMAIN (TDR).
TITFn		•	•	•	Title for file **n**, **n** = 1-5.
TITL	•	•	•	•	Title function.
TITRn		•	•	•	Title for register **n**, **n** = 1-5.
TRACKOFF		•	•	•	Disable marker tracking.
TRACKON		•	•	•	Enable marker tracking.
TRAD	•	•	•	•	Transmision done.
TRAM?	•				Query trace mode.
TRAN	•	•	•	•	Call transmission standard.
TRAR				•	Transmission/reflection annotation.
TRIG	•	•	•	•	Wait for sweep trigger.

COMMAND	HP 8510B	HP 8720A	HP 8753A	HP 8702A	Description
TRIS	•				Trim sweep under CAL.
TRLL	•				Measure TRL line cal std.
TRLO	•				Modify cal kit, TRL options defined.
TRLR1	•				Meas TRL Port 1 Reflection std.
TRLR2	•				Meas TRL Port 2 Reflection std.
TRLRT	•				Meas TRL Thru standard.
TST?		•	•	•	Perform self test.
—U—					
UNCC	•				Uncouple channels (Use **COUC** for HP 8700 series).
UNDE	•				Undelete last deleted tape/disc file.
UP	•	•	•	•	Up step key.
USED	•				User display data type for TAPE/DISC.
USEPASC		•	•	•	Enable pass control HP-IB mode.
USER1	•				Measure user parameters.
USER2	•				"
USER3	•				"
USER4	•				"
—V—					
VELOFACT	•	•	•	•	Enter velocity factor for transmission medium.
—W—					
WAIT	•	•	•	•	Wait for clean sweep, and completion of previous instruction.
WAVD	•				Waveguide delay for electrical delay.
WAVE	•	•	•	•	Specify waveguide offsets, modify cal kit.
WIDTOFF		•	•	•	Disable bandwidth search.
WIDTON		•	•	•	Enable bandwidth search.
WIDV		•	•	•	Set width value.
WIND?	•				Query window.
WINDMAXI	•	•	•	•	Set maximum time domain window.
WINDMINI	•	•	•	•	Set minimum time domain window.
WINDNORM	•	•	•	•	Set normal time domain window.
WINDOW		•	•	•	Enter arbitrary time domain window.
WINDUSEM		•	•	•	Use trace memory as window.
WRSKn		•	•	•	Write soft key label **n**, **n** = 1-8.

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SYSTEM OPERATING AND PROGRAMMING MANUAL

HP 8753B NETWORK ANALYZER

Operating and Programming Reference

HEWLETT PACKARD

HP 8753B Operating and Programming Reference

TABLE OF CONTENTS

Chapter 1. System Overview

CHAPTER CONTENTS

GUIDE TO THE CHAPTERS IN THIS DOCUMENT

For information on specific topics, refer to the index at the end of this volume.

This section of the *HP 8753B System Operating and Programming Manual* is a complete reference for operation of the HP 8753B network analyzer using either front panel controls, test sequence function, or an external controller. The information in this reference is intended to supplement the separately bound tutorial documents in this volume with additional details. It is divided into chapters providing the following information:

- **Chapter 1** includes a block diagram and functional description of the HP 8753B system. This is followed by descriptions of the front panel features and CRT labels, and the rear panel features and connectors.
- **Chapters 2 through 10** provide detailed information on front panel keys and softkeys, their purpose and use, HP-IB equivalents in parentheses, and expected indications and results. Specific areas of operation described in these chapters include calibration procedures for accuracy enhancement, using markers, limit testing, time domain measurements (option 010), plotting and printing, and saving instrument states. Power meter calibration and interpolated error correction are described in chapter 5.
- **Chapter 11** contains information for operating the system remotely with a controller through HP-IB.
- **Chapter 12** lists HP 8753B error messages, with explanations.
- **Chapter 13** describes the test sequencing function.
- **Chapter 14** describes tuned receiver, external source, frequency offset, as well as optional harmonic and 6 GHz instrument modes. 6 GHz mode only functions when the HP 8753B is used with an HP 85047A 6 GHz S-parameter test set. The test set contains a frequency doubler. External source and tuned receiver modes allow an HP 8753B option 006 to make measurements up to 6 GHz without an HP 85047A test set. An external source and a signal separation device are required. In addition, tuned receiver mode requires a synthesized source.

An appendix at the end of the *Operating and Programming Reference* provides a complete listing of the instrument preset state, a data processing flow diagram, a map of the operating softkey menu structure, and an alphabetical index.

HP 8753B SYSTEM OVERVIEW

Network analyzers measure the reflection and transmission characteristics of devices and networks by applying a known swept signal and measuring the responses of the test device. The signal transmitted through the device or reflected from its input is compared with the incident signal generated by a swept RF source. The signals are applied to a receiver for measurement, signal processing, and display. A network analyzer system consists of a source, signal separation devices, a receiver, and a display.

The HP 8753B vector network analyzer integrates a high resolution synthesized RF source and a dual channel three-input receiver to measure and display magnitude, phase, and group delay of transmitted and reflected power. The HP 8753B option 010 has the additional capability of transforming measured data from the frequency domain to the time domain. Other options are explained in the *General Information and Specifications* section. Figure 1-1 is a simplified block diagram of the HP 8753B network analyzer system. A detailed block diagram of the HP 8753B is provided in the *On-Site System Service Manual*, together with complete theory of system operation.

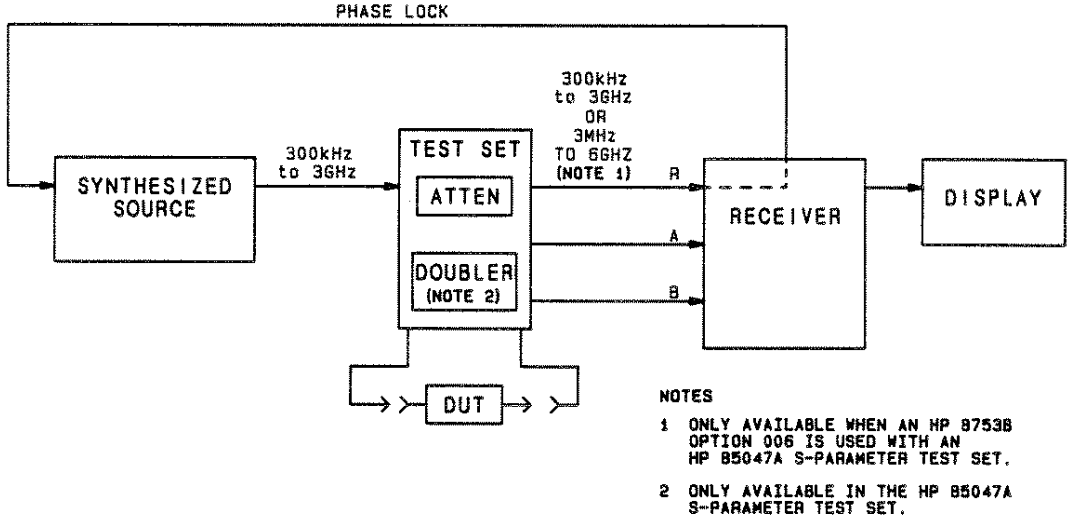


Figure 1-1. Simplified Block Diagram of the HP 8753B System

The Built-In Synthesized Source

The built-in synthesized source of the HP 8753B produces a swept RF signal in the range of 300 kHz to 3.0 GHz. Option 006, 6 GHz receiver operation, does not change the frequency range of the HP 8753B internal source. Frequency coverage to 6 GHz must be provided by the doubler within the HP 85047A 6 GHz test set, or by an external source. The RF output power is leveled by an internal ALC (automatic leveling control) circuit. To achieve frequency accuracy and phase measuring capability, the HP 8753B is phase locked to a highly stable crystal oscillator. For this purpose, a portion of the transmitted signal is routed via the test set or other external coupling to the R input of the receiver, where it is sampled by the phase detection loop and fed back to the source.

Test Sets

A test set provides connections to the device under test, as well as the signal separation devices that separate the incident signal from the transmitted and reflected signals. The incident signal is applied to the R (reference) input, and transmitted and reflected signals are applied to the A and/or B inputs.

The HP 85046A/B and 85047A S-parameter test sets contain the hardware required to make simultaneous transmission and reflection measurements in both the forward and reverse directions. An RF path switch in the test set is controlled by the network analyzer so that reverse measurements can be made without changing the connections to the device under test. The HP 85044A/B transmission/reflection test set contains the hardware required to make simultaneous transmission and reflection measurements in one direction only. The HP 11850C/D three-way power splitter or the HP 11667A two-way power splitter can be used for making transmission-only measurements.

Test Set Step Attenuator. The step attenuator contained in the test set is used to adjust the power level to the DUT without changing the level of the incident power in the reference path. The attenuator in the HP 85046A/B or 85047A test sets is controlled from the front panel of the HP 8753B. The attenuator in the HP 85044A/B test set is controlled manually.

The Receiver Block

The receiver block contains three identical sampler/mixers for the R, A, and B inputs. The signals are sampled, and mixed to produce a 4 kHz IF (intermediate frequency). A multiplexer sequentially directs each of the three signals to the ADC (analog to digital converter) where it is converted from an analog to a digital signal to be measured and processed for display on the CRT. Both amplitude and phase information are measured simultaneously, regardless of what is displayed on the CRT.

The Microprocessor. A microprocessor takes the raw data and performs all the required error correction, trace math, formatting, scaling, and marker operations, according to the instructions from the front panel. The formatted data is then displayed on the CRT. The data processing sequence is described below.

Calibration Standards

In addition to the HP 8753B and the test set (or power splitter), a measurement may require calibration standards for vector accuracy enhancement, and cables for interconnections. Model numbers and details of compatible power splitters, calibration kits, and cables are provided in the *General Information and Specifications* section of this manual.

HP 8753B DATA PROCESSING

Overview

The receiver of the HP 8753B converts the R, A, and B input signals into useful measurement information. This conversion occurs in two main steps. First, the swept high frequency input signals are translated to fixed low frequency IF signals, using analog sampling and/or mixing techniques. (Refer to *Theory of Operation* in the *On-Site System Service Manual* for details.) Second, the IF signals are converted into digital data by an analog-to-digital converter (ADC). From this point on, all further signal processing is performed mathematically by microprocessors in the HP 8753B. The following paragraphs describe the sequence of math operations and the resulting data arrays as the information flows from the ADC to the display. They provide a good foundation for understanding most of the response functions, and the order in which they are performed.

Figure 1-2 is a data processing flow diagram that represents the flow of numerical data from IF detection to display. The data passes through several math operations, denoted in the figure by single-line boxes. Most of these operations can be selected and controlled with the front panel RESPONSE block menus. The data is also stored in arrays along the way, denoted by double-line boxes. These arrays are places in the flow path where data is accessible, usually via HP-IB.

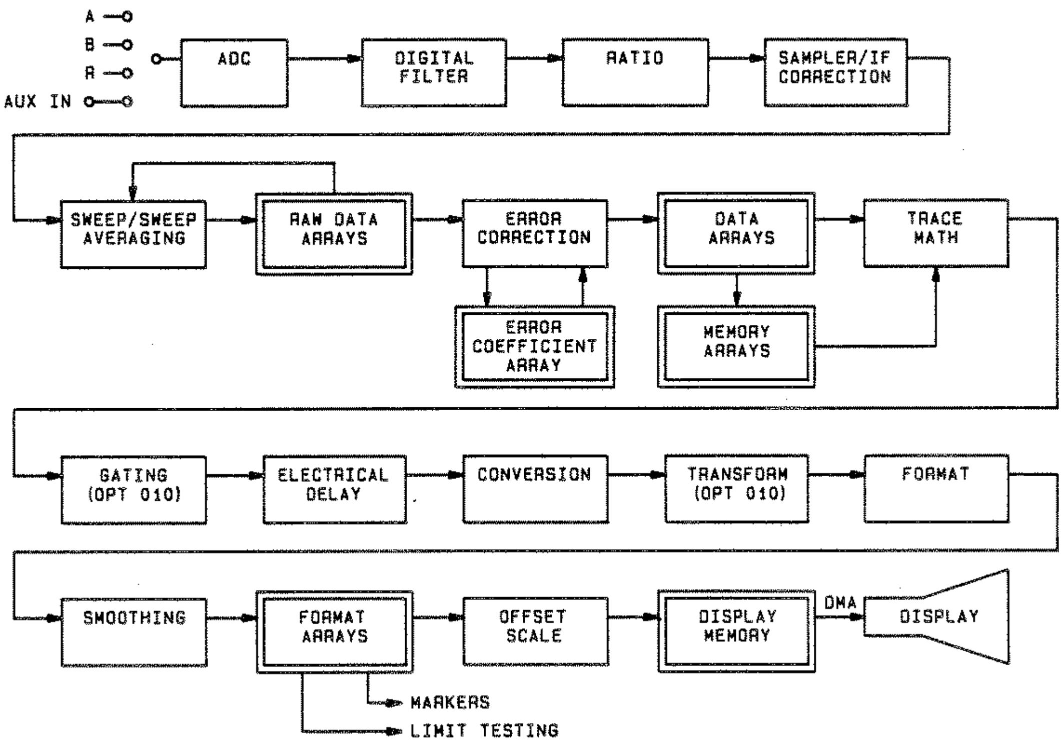


Figure 1-2. Data Processing Flow Diagram

While only a single flow path is shown, two identical paths are available, corresponding to channel 1 and channel 2. When the channels are uncoupled, each channel can be independently controlled, so that the data processing operations for one are different from the other.

Two definitions are necessary:

A "data point" or "point" is a single piece of data representing a measurement at a single stimulus value. Most data processing operations are performed point-by-point; some involve more than one point.

A "sweep" is a series of consecutive data point measurements, taken over a sequence of stimulus values. A few data processing operations require that a full sweep of data is available. The number of points per sweep can be defined by the user. Note that the meaning of the stimulus values (independent variables) can change, depending on the sweep mode, although this does not generally affect the data processing path.

Processing Details

The ADC. The ADC converts the R, A, and B inputs (already down-converted to a fixed low frequency IF) into digital words. (The AUX INPUT connector on the rear panel is a fourth input.) The ADC switches rapidly between these inputs, so they are converted nearly simultaneously. (Refer to *[MEAS]* Key in Chapter 4 for more information on inputs.)

IF Detection. This occurs in the digital filter, which performs the discrete Fourier transform (DFT) on the digital words. The samples are converted into complex number pairs (real plus imaginary, R+jl). The complex numbers represent both the magnitude and phase of the IF signal. If the AUX INPUT is selected, the imaginary part of the pair is set to zero. The DFT filter shape can be altered by changing the IF bandwidth, which is a highly effective technique for noise reduction. (Refer to *[AVG] Key* in Chapter 4 for information on different noise reduction techniques.)

Ratio Calculations. These are performed if the selected measurement is a ratio of two inputs (e.g. A/R or B/R). This is simply a complex divide operation. If the selected measurement is absolute (e.g. A or B), no operation is performed. The R, A, and B values are also split into channel data at this point. (Refer to *[MEAS] Key* in Chapter 4 for more information.)

Sampler/IF Correction. The next digital processing technique used is sampler/IF correction. This process digitally corrects for frequency response errors (both magnitude and phase, primarily sampler rolloff) in the analog down-conversion path.

Sweep-to-sweep Averaging. this is another noise reduction technique. This calculation involves taking the complex exponential average of several consecutive sweeps. This technique cannot be used with single-input measurements. (Refer to *[AVG] Key* in Chapter 4.)

Raw Data Arrays. These store the results of all the preceding data processing operations. (Up to this point, all processing is performed real-time with the sweep by the IF processor. The remaining operations are not necessarily synchronized with the sweep, and are performed by the main processor.) When full 2-port error correction is on, the raw arrays contain all four S-parameter measurements required for accuracy enhancement. When the channels are uncoupled (coupled channels off), there may be as many as eight raw arrays. These arrays are directly accessible via HP-IB. Note that the numbers here are still complex pairs.

Vector Error Correction (accuracy enhancement). Error Correction is performed next, if a measurement calibration has been performed and correction is turned on. Error correction removes repeatable systematic errors (stored in the error coefficient arrays) from the raw arrays. This can vary from simple vector normalization to full 12-term error correction. (Refer to Chapter 5 for details.)

The error coefficient arrays themselves are created during a measurement calibration using data from the raw arrays. These are subsequently used whenever correction is on, and are accessible via HP-IB.

The results of error correction are stored in the data arrays as complex number pairs. These arrays are accessible via HP-IB.

If the data-to-memory operation is performed, the data arrays are copied into the memory arrays. (Refer to *[DISPLAY] Key* in Chapter 4.)

Trace Math Operation. This selects either the data array, memory array, or both to continue flowing through the data processing path. In addition, the complex ratio of the two (data/memory) or the difference (data − memory) can also be selected. If memory is displayed, the data from the memory arrays goes through exactly the same data processing flow path as the data from the data arrays. (Refer to *[DISPLAY] Key* in Chapter 4 for information on memory math functions.)

Gating. This is a digital filtering operation associated with time domain transformation (option 010 only). Its purpose is to mathematically remove unwanted responses isolated in time. In the time domain, this can be viewed as a time-selective bandpass or band-stop filter. (If both data and memory are displayed, gating is applied to the memory trace only if gating was on when data was stored into memory.) (Refer to Chapter 8.)

The Delay Block. This involves adding or subtracting phase in proportion to frequency. This is equivalent to "line-stretching" or artificially moving the measurement reference plane. (Refer to *[ELECTRICAL DELAY]* under *[SCALE/REF] Key* in Chapter 4.)

Conversion Transforms. This transforms the measured S-parameter data to the equivalent complex impedance (Z) or admittance (Y) values, or to inverse S-parameters (1/S). (Refer to *Conversion Menu* under *[MEAS] Key* in Chapter 4.)

Windowing. This is a digital filtering operation that prepares (enhances) the frequency domain data for transformation to time domain. (Refer to Chapter 8, *Time and Frequency Domain Transforms*.)

Time Domain Transform. This converts frequency domain information into the time domain when transform is on (option 010 only). The results resemble time domain reflectometry (TDR) or impulse-response measurements. The transform employs the chirp-Z inverse fast Fourier transform (FFT) algorithm to accomplish the conversion. The windowing operation, if enabled, is performed on the frequency domain data just before the transform. (A special transform mode is available to "demodulate" CW sweep data, with time as the stimulus parameter, and display spectral information with frequency as the stimulus parameter.) (Refer to Chapter 8 for details.)

Formatting. This converts the complex number pairs into a scalar representation for display, according to the selected format. This includes group delay calculations. These formats are often easier to interpret than the complex number representation. (Polar and Smith chart formats are not affected by the scalar formatting.) Note that after formatting, it is impossible to recover the complex data. (Refer to *[FORMAT] Key* in Chapter 4 for information on the different formats available and on group delay principles.)

Smoothing. This is another noise reduction technique, that smoothes noise on the trace. When smoothing is on, each point in a sweep is replaced by the moving average value of several adjacent (formatted) points. The number of points included depends on the smoothing aperture, which can be selected by the user. The effect is similar to video filtering. If data and memory are displayed, smoothing is performed on the memory trace only if smoothing was on when data was stored into memory. (Refer to *[AVG] Key* in Chapter 4 for information about smoothing.)

Format Arrays. The results so far are stored in the format arrays. It is important to note that marker values and marker functions are all derived from the format arrays. Limit testing is also performed on the formatted data. The format arrays are accessible via HP-IB.

Offset and Scale. These operations prepare the formatted data for display on the CRT. This is where the reference line position, reference line value, and scale calculations are performed, as appropriate to the format. (Refer to *[SCALE/REF] Key* in Chapter 4.)

Display Memory. The display memory stores the display image for presentation on the CRT. The information here includes graticules, annotation, and softkey labels – everything visible on the CRT – in a form similar to plotter commands. If user display graphics are written, these are also stored in display memory. When hardcopy records are made, the information sent to the plotter or printer is taken from display memory.

Finally, the display memory data is sent to the CRT display. The display is updated (refreshed) frequently and asynchronously with the data processing operations, to provide a flicker-free image.

Chapter 2. Front Panel and Softkey Operation

CHAPTER CONTENTS

INTRODUCTION

This chapter describes how to operate the HP 8753B using front panel controls, and explains the use of softkey menus. It provides illustrations and descriptions of the front panel features, the CRT display and its labels, and the rear panel features and connectors. In addition it provides details of the active channel keys and the entry block.

Functions of the HP 8753B are activated from the front panel by the operator using front panel keys or softkeys. (In this manual, all front panel keys and softkey labels are shown in brackets. Front panel keys are shown in bold print, softkeys are shown in italics.)

ACTIVE FUNCTION

The function currently activated is called the active function, and is displayed in the active entry area at the upper left of the CRT. As long as a function is active it can be modified with the ENTRY keypad (refer to Figure 2-1). A function remains active until another function is selected, or **[ENTRY OFF]** is pressed.

FRONT PANEL KEYS AND SOFTKEY MENUS

Some of the front panel keys are used to change instrument functions directly, and others provide access to additional functions available in softkey menus. Softkey menus are lists of up to eight related functions that can be displayed in the softkey label area at the right-hand side of the CRT. The eight keys to the right of the CRT are the softkeys. Pressing one of the softkeys selects the adjacent menu function. This either executes the labeled function and makes it the active function, or causes instrument status information to be displayed, or presents another softkey menu.

The HP 8753B provides more than 90 softkey menus for control of numerous operating capabilities. Some of the menus are accessed directly from front panel keys, and some from other menus. For example, the stimulus menu accessed by pressing the **[MENU]** key presents all the stimulus functions such as sweep type, number of points, power, sweep time, and trigger. Pressing ***[SWEEP TYPE]*** presents another menu for defining sweep type parameters, while pressing ***[SWEEP TIME]*** allows the required sweep time to be entered directly from the number pad. The ***[RETURN]*** softkeys are used to return to previous menus, while ***[DONE]*** is used both to indicate completion of a specific procedure and to return to an earlier menu. In this *Operating and Programming Reference*, the menus available from each front panel key are illustrated in "menu maps" to clearly show the sequence of keys that must be pressed to access each function. The first menu map, in Chapter 3, shows the softkey menus accessed from the **[MENU]** key. Detailed descriptions of each softkey function are provided with illustrations of the individual menus.

Usually, whenever a menu changes, the present active function is cleared, unless it is an active marker function.

Why Some Softkeys are Joined by Vertical Lines

In cases where several possible choices are available for a function, they are joined by vertical lines. For example, in the input menu the available inputs and input ratios are listed: A, B, R, A/R, B/R, A/B, and only one can be selected at a time. When a selection has been made from the listed alternatives, that selection is underlined until another selection is made.

Softkeys that Toggle On or Off

Some softkey functions can be toggled on or off, for example averaging, and this is indicated in the softkey label. The current state is reflected in the softkey label.

Example:	***[AVERAGING ON off]***	The word ON is capitalized, showing that averaging is currently on.
	[AVERAGING on OFF]	The word OFF is capitalized, showing that averaging is currently off.

Softkeys that Show Status Indications in Brackets

Some softkey labels show the current status of a function in brackets. These include simple toggle functions and status-only indicators. An example of a toggled function is the ***[PLOT SPEED FAST]*** or ***[PLOT SPEED SLOW]*** softkey. The ***[IF BW]*** softkey is an example of a status-only indicator, where the selected value of the IF bandwidth is shown in brackets in the softkey label.

Main Key Function Groups

The front panel keys that provide access to softkey menus are grouped in the STIMULUS, RESPONSE, and INSTRUMENT STATE function blocks.

Stimulus Block. The stimulus block keys and softkey menus control all the functions of the RF source.

Response Block. The response block keys and softkey menus control the measurement and display functions specific to the active channel.

Instrument State Block. Allows access to major instrument modes of operation shown below. The external source, tuned receiver, and frequency offset modes are described in Chapter 14.

- Network Analyzer Mode (standard analyzer operating mode).
- External Source Mode – allows phase lock to an external CW signal.
- Tuned Receiver Mode – Turns off phase locking circuitry, allows use on internal or external source.
- Frequency Offset Mode – Allows phase-locked operation for testing a frequency translating DUT such as a mixer. An external local oscillator is required.

The instrument state keys control channel-independent system functions such as copying, save/recall, HP-IB controller mode, limit testing, time domain transform (option 010) functions, 6 GHz mode (option 006), and the test sequence function.

The 6 GHz mode can only be used with HP 8753B option 006 instruments, and then only if used with an HP 85047A 6 GHz S-parameter test set. 6 GHz mode is explained in Chapter 14.

The test sequence function allows the operator to enter the keystrokes required for any given measurement, and then execute the entire test by pressing a single key. Test sequencing may also be configured to run automatically at power on. Chapter 13 describes this feature.

HP-IB Control

The functions accessible from the front panel can also be accessed remotely by an external controller using HP-IB. Equivalent HP-IB commands are available for most of the front panel keys and softkey menu selections. The HP-IB programming command equivalent to each front panel and softkey function is provided in parentheses after the first reference. Additional information about HP-IB programming is provided in chapter 11.

Information on Keys and Softkeys that will be Provided in this Document

The following chapters describe all the front panel keys and softkey menus in detail. The purpose and use of each function is detailed, together with expected indications and results, allowable values, and possible limitations. This information is presented in function block order. Each function block is illustrated and described in general terms. This is followed by information about each front panel key in the function block, together with a map and description of all the menus accessed from that key. Each menu is illustrated, and each softkey function in each menu is explained in detail. A complete map of the softkey menu structure is provided in Appendix A at the end of the *Operating and Programming Reference*, together with an alphabetical index.

FRONT PANEL FEATURES

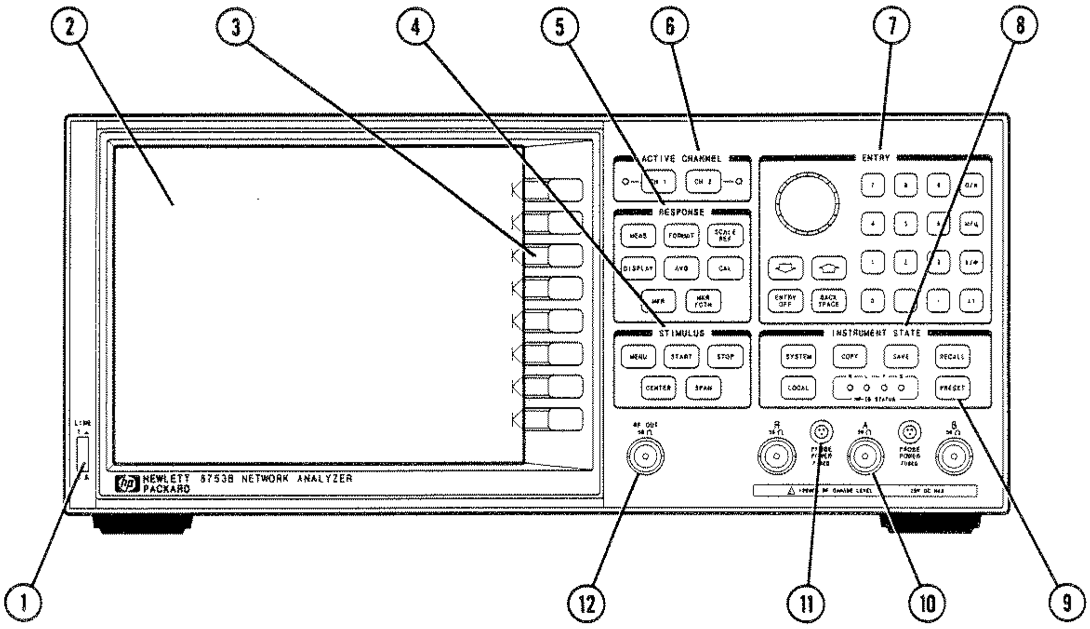


Figure 2-1. HP 8753B Front Panel

Figure 2-1 illustrates the following features and function blocks of the HP 8753B front panel. These features are described in more detail in this and subsequent chapters. Instructions for removal and cleaning of the CRT filter are provided in the *Operator's Check* section of this manual.

1. LINE switch. This controls AC power to the HP 8753B. 1 is on, 0 is off.
2. CRT display. This is used for display of data traces, measurement annotation, softkey labels, and other information. The display is divided into specific information areas, illustrated in Figure 2-2.
3. Softkeys. These keys expand the capabilities of the HP 8753B with additional functions beyond those of the front panel keys. They provide access to menu selections displayed on the CRT.
4. STIMULUS function block. The keys in this block are used to control the RF signal from the HP 8753B source, and other stimulus functions.
5. RESPONSE function block. The keys in this block are used to control the measurement and display functions of the active display channel.
6. ACTIVE CHANNEL keys. The HP 8753B has two independent display channels. These keys are used to select the active channel. Any functions that are then entered apply to this active channel.
7. The ENTRY block includes the knob, the step [▲][▼] keys, and the number pad. These are used for entering numerical data and controlling the marker.

8. INSTRUMENT STATE function block. These keys are used to control channel-independent system functions such as:

   Copying, save/recall, and HP-IB controller mode.
   Limit testing
   External source mode
   Tuned receiver mode
   Frequency offset mode
   Test sequence function
   Time domain transform (option 010)
   Harmonic Measurements (option 002)
   6 GHz mode (option 006)

   Also included in this block are the HP-IB STATUS indicators.

9. **[PRESET]** key. This key returns the instrument to a known standard preset state from any step of any manual procedure. A complete listing of the instrument preset condition is provided in Appendix A at the end of this *Operating and Programming Reference*.

10. Network analyzer inputs R, A, and B. These are used to receive input signals from a test set or source or device under test. Input R is used as the reference input, and a portion of the RF output signal must be routed to input R for proper phase-locked operation. The exception to this is when using tuned receiver mode. This mode is not phase-locked, and the signal may be input directly into the R, A, or B inputs. Inputs A or B are actually preferred because they offer greater dynamic range.

11. PROBE POWER connector (fused inside the instrument) supplies power to an active probe for in-circuit measurements of AC circuits.

12. RF OUT connector. This connects the RF output signal from the HP 8753B internal source to a test set or power splitter.

CRT DISPLAY

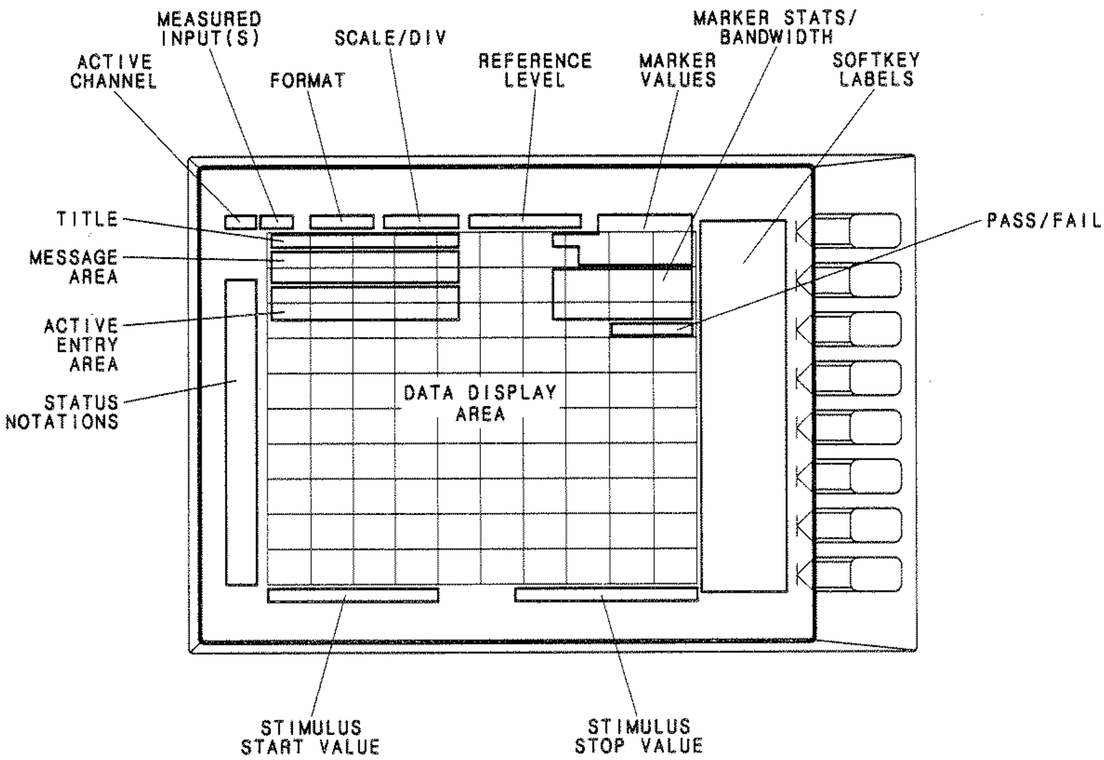


Figure 2-2. CRT Display (Single Channel, Cartesian Format)

The CRT displays the grid on which the measurement data is plotted, the currently selected measurement traces, and other information describing the measurement. Figure 2-2 illustrates the locations of the different CRT information labels, described below.

In addition to the full-screen display shown in Figure 2-2, a split display is available, as described under *[DISPLAY] Key, Display More Menu* in Chapter 4. In this case, information labels are provided for each half of the display.

Several different display formats for different measurements are illustrated and described in Chapter 4, under *[FORMAT] Key*.

Stimulus Start Value is the start frequency of the source in frequency domain measurements, the start time in CW mode (0 seconds) or time domain measurements, or the lower power value in power sweep. When the stimulus is in center/span mode, the center stimulus value is shown in this space.

Stimulus Stop Value is the stop frequency of the source in frequency domain measurements, the stop time in time domain measurements or CW sweeps, or the upper limit of a power sweep. When the stimulus is in center/span mode, the span is shown in this space. The stimulus values can be blanked, as described under *[DISPLAY] Key, Display More Menu*.

(For CW time and power sweep measurements, the CW frequency is displayed centered between the start and stop times or power values.)

Status Notations. This area is used to show the current status of various functions for the active channel. The following notations are used:

Avg	=	Sweep-to-sweep averaging is on. The averaging count is shown immediately below (see Chapter 4, *[AVG] Key*).
Cor	=	Error correction is on (see Chapter 5).
C?	=	Stimulus parameters have changed, or interpolated error correction is on. (see Chapter 5, *[CAL] Key*).
C2	=	Two-port error correction is on (see Chapter 5).
C2?	=	Two-port error correction is on, but stimulus parameters have changed.
Del	=	Electrical delay has been added or subtracted (see Chapter 4, *[SCALE REF] Key*).
x2	=	6 GHz mode is on (6 GHz receiver operation, option 006 only) (see Chapter 14).
x2?	=	6 GHz mode is on, but the user has changed the power setting. System performance is no longer specified (6 GHz receiver operation, option 006 only) (see Chapter 14).
Ext	=	Waiting for an external trigger.
OFs	=	Frequency Offset mode is on (see Chapter 14).
OF?	=	Frequency Offset mode error, the IF frequency is not within 10 MHz of expected frequency. LO inaccuracy is the most likely cause (see Chapter 14).
Gat	=	Gating is on (time domain option 010 only) (see Chapter 8).
H=2	=	Harmonic mode is on, and the second harmonic is being measured. (harmonics option 002 only) (see Chapter 14).
H=3	=	Harmonic mode is on, and the third harmonic is being measured. (harmonics option 002 only) (see Chapter 14).
Hld	=	Hold sweep (see Chapter 3, *Trigger Menu*).
man	=	Waiting for manual trigger.
PC	=	Power meter calibration is on. (Refer to Chapter 5, *[CAL] key*)
PCo	=	Power has been offset from the original power meter calibration sweep. (see Chapter 5).
PC?	=	The HP 8753B source is in saturation. Power meter calibration is requesting more power than the internal source can supply. (see Chapter 5).
P?	=	Source power is unleveled at start or stop of sweep. (Refer to the *On-Site Service Manual* for troubleshooting.)
P↓	=	Source power has been automatically set to minimum due to overload (see Chapter 3, *Power Menu*).
Smo	=	Trace smoothing is on (see Chapter 4, *[AVG] Key*).
tsH	=	Applies only to systems equipped with an S-parameter test set. "tsH" indicates that the test set hold mode is engaged – the user has selected a mode of operation which would cause repeated switching of either the test port transfer switch or step attenuator. This hold mode may be overridden by either the ***[MEASUREMENT RESTART]*** or ***[NUMBER OF GROUPS]*** softkeys, described in Chapter 3, *Stimulus Function Block*.
↑	=	Fast sweep indicator. This symbol is displayed in the status notation block when sweep time is less than 1.0 second. When sweep time is greater than 1.0 second, this symbol moves along the displayed trace.
*	=	Source parameters changed: measured data in doubt until a complete fresh sweep has been taken

Active Entry Area displays the active function and its current value.

Message Area displays prompts or error messages.

Title is a descriptive alpha-numeric string title defined by the user and entered as described under *[DISPLAY] Key*, *Title Menu*. (In HP-IB, the title block is replaced by HP-IB commands entered from the external controller, if the special debug mode is on. Refer to Chapter 11.

Active Channel is the number of the current active channel, selected with the **[ACTIVE CHANNEL]** keys. If dual channel is on with an overlaid display, both channel 1 and channel 2 appear in this area.

Measured Input(s) shows the S-parameter or input or ratio of inputs currently measured, as selected using the **[MEAS]** key. Also indicated in this area is the current display memory status.

Format is the display format selected using the **[FORMAT]** key.

Scale/Div is the scale selected using the **[SCALE/REF]** key, in units appropriate to the current measurement.

Reference Level is the value of a reference line in Cartesian formats or the outer circle in polar formats, selected using the **[SCALE/REF]** key. The reference level is also indicated by a small triangle adjacent to the graticule, at the left for channel 1 and at the right for channel 2.

Marker Values are the values of the active marker, in units appropriate to the current measurement. Refer to *Using Markers*, in Chapter 6 of this section.

Marker Stats, Bandwidth are statistical marker values determined using the menus accessed with the **[MKR FCTN]** key. Refer to *Using Markers*.

Softkey Labels are menu labels displayed on the CRT that redefine the function of the softkeys immediately to the right of the CRT.

NOTE: The information provided here applies to Cartesian formats. In polar and Smith chart formats labeling may differ.

ACTIVE CHANNEL KEYS (CHAN1, CHAN2)

The HP 8753B has two digital channels for independent measurement and display of data. Two different sets of data can be measured simultaneously, for example the reflection and transmission characteristics of a device, or one measurement with two different frequency spans. The data can be displayed separately or simultaneously, as described below.

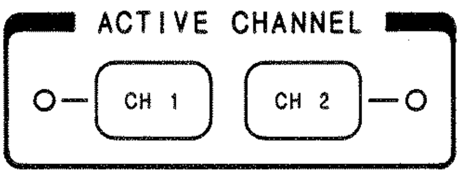


Figure 2-3

The **[CH 1]** and **[CH 2]** keys illustrated in Figure 2-3 are used to select one channel to be the "active channel". This is the channel currently controlled by the front panel keys, and its trace and data annotations are displayed on the CRT. All channel-specific functions selected apply to the active channel. The current active channel is indicated by an amber LED adjacent to the corresponding channel key.

The HP 8753B has dual trace capability, so that both the active and inactive channel traces can be displayed, either overlaid or on separate graticules one above the other (split display). When both channel traces are displayed, the annotations of the active channel are brighter. The dual channel and split display features are available in the display menus. Refer to Chapter 4 for illustrations and descriptions of the different display capabilities.

Source values can be coupled or uncoupled between the two channels, independent of the dual channel and split display functions. Refer to *Stimulus Menu* in Chapter 3 for a listing of the source values that are coupled in stimulus coupled mode.

A third coupling capability is coupled markers. Measurement markers can have the same stimulus values for the two channels, or they can be uncoupled for independent control in each channel. Refer to Chapter 6 for more information about markers.

ENTRY BLOCK KEYS

The ENTRY block, illustrated in Figure 2-4, provides the numeric and units keypad, the knob, and the step keys. These are used in combination with other front panel keys and softkeys to modify the active entry, to enter or change numeric data, and to change the value of the active marker. In general the keypad, knob, and step keys can be used interchangeably.

Before a function can be modified, it must be made the active function by pressing a front panel key or softkey. It can then be modified directly with the knob, the step keys, or the digits keys and a terminator, as described below.

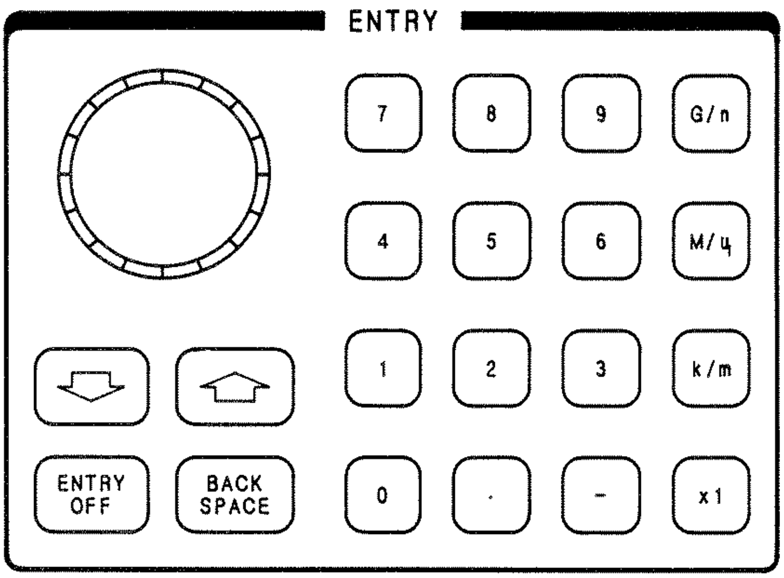


Figure 2-4

The numeric keypad is used to select digits, decimal point, and minus sign for numerical entries. A units terminator is required, as described below.

The units terminator keys are the four keys in the right-hand column of the keypad. These are used to specify units of numerical entries from the keypad and at the same time terminate the entries. A numerical entry is incomplete until a terminator is supplied, and this is indicated by the data entry arrow ← pointing at the last entered digit in the active entry area. When the units terminator key is pressed, the arrow is replaced by the units selected. The units are abbreviated on the terminator keys as follows:

G/n (HP-IB G, N)	=	Giga/nano (10^9 / 10^{-9})
M/µ(M, U)	=	Mega/micro (10^6 / 10^{-6})
k/m (K, M)	=	kilo/milli (10^3 / 10^{-3})
x1 (HZ, S, DB, V)	=	basic units: dB, dBm, degrees, seconds, Hz, or dB/GHz (may be used to terminate unitless entries such as averaging factor)

The knob is used to make continuous adjustments to current values for various functions such as scale, reference level, and others. If there is a marker turned on, and no other function is active, the knob can be used to adjust the marker stimulus values. Values changed by the knob are effective immediately, and require no units terminator.

The step keys **[▲]** (UP) and **[▼]** (DOWN) are used to step the current value of the active function up or down. The steps are defined by the HP 8753B for different functions and cannot be altered. No units terminator is required. For editing a test sequence, these keys allow you to scroll through the displayed sequence.

[ENTRY OFF] (ENTO) clears and turns off the active entry area, as well as any displayed prompts, error messages, or warnings. Use this function to clear the display before plotting. Another purpose of this softkey is to prevent changing of active values by accidentally moving the knob. The next selected function turns the active entry area back on.

[BACK SPACE] deletes the last entry, or the last digit entered from the number pad. For modifying a test sequence, the backspace key may be used in one of two ways:

- If pressed when modifying a single-key command like ***[A/R]***, the backspace key deletes the command.
- If pressed when entering a number like **[START] [1] [2]**, and you have not yet pressed a terminator key (**[G/n]**, etc), the backspace key will delete the last digit (in this example the 2 will be deleted).

REAR PANEL FEATURES AND CONNECTORS

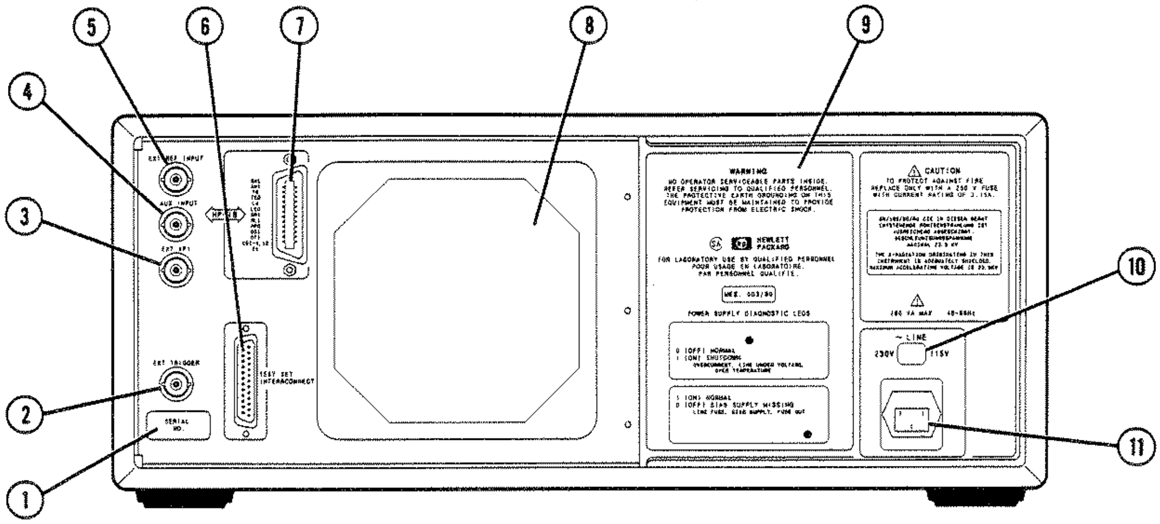


Figure 2-5

Figure 2-5 illustrates the features and connectors of the rear panel, described below. Requirements for input signals to the rear panel connectors are provided in the *Supplemental Characteristics* table of the *General Information and Specifications* section.

1. Serial number plate. For information about serial numbers, refer to *Instruments Covered by Manual* in the *General Information and Specifications* section.

2. EXT TRIGGER connector. This is used to connect an external negative-going TTL-compatible signal to trigger a measurement sweep. The trigger can be set to external through softkey functions (see Chapter 3, *Trigger Menu*).

3. EXT AM connector. This is used to connect an external analog signal to the ALC circuitry of the HP 8753B source to amplitude modulate the RF output signal.

4. AUX INPUT connector. This is used to connect a DC or AC voltage from an external signal source such as a detector or function generator, which can then be displayed and measured using the S-parameter menu. (It is also used as an analog output in service routines, as described in the service manual.)

5. EXT REF INPUT connector. This is used to input a frequency reference signal to phase lock the HP 8753B to an external frequency standard for increased frequency accuracy.

   The external frequency reference feature is automatically enabled when a signal is connected to this input. When the signal is removed, the HP 8753B automatically switches back to its internal frequency reference.

6. TEST SET INTERCONNECT connects the HP 8753B to an HP 85046A/B or 85047A S-parameter test set using the interconnect cable supplied with the test set. The S-parameter test set is then fully controlled by the HP 8753B. The HP 85044A/B transmission/reflection test set does not use this interconnection.

7. HP-IB connector. This is used to connect the HP 8753B to an external controller and other instruments in an automated system. This connector is also used when the HP 8753B itself is the controller of compatible peripherals. Refer to *HP-IB Considerations* in the *System Installation* section of this manual for information and limitations. Information on different controller modes is provided in Chapter 7 under *Instrument State Function Block, [LOCAL] Key*.

8. Fan filter. This filter helps to protect the instrument from dust contamination, and should be cleaned regularly. Instructions for cleaning the filter, and other routine maintenance, are provided in the *Operator's Check* section of the manual. A minimum clearance of 15 cm (6 inches) should be maintained behind and on both sides of the instrument or rack to allow for air circulation.

NOTE: If using an HP 8753B with a serial prefix of 2828A and above, ignore manual references to the fan filter.

9. Safety warnings.

10. Line voltage selector switch. For more information refer to *Line Voltage and Fuse Selection* in the *System Installation* section of this manual.

11. Power cord receptacle, with fuse. For information on replacing the fuse, refer to the *System Installation* section of this manual.

Chapter 3. Stimulus Function Block

CHAPTER CONTENTS

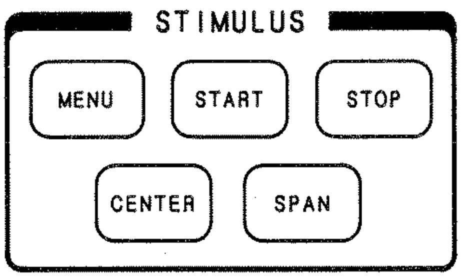


Figure 3-1

INTRODUCTION

The stimulus function block keys and associated menus are used to define and control the source RF output signal to the device under test. The source signal can be swept over any portion of the instrument's frequency and power range. The stimulus keys also control the start and stop times in the optional time domain mode. The menus are used to set all other source characteristics such as sweep time and resolution, source RF power level, the number of data points taken during the sweep, and S-parameter test set attenuation.

TEST SET ATTENUATOR, TEST PORT TRANSFER SWITCH, AND DOUBLER SWITCH PROTECTION

Test Port Transfer Switch

An S-parameter test set can only send power to one test port at a time. A mechanical transfer switch sends power to either port 1 or port 2. Under some measurement conditions it would be necessary to repetitively switch power between port 1 and port 2. This cannot be allowed continuously or the switch would wear out prematurely. Two examples are listed below:

- During full two-port calibration operation: Full 12 term calibration requires that all four S-parameters (S_{21}, S_{11}, S_{12}, S_{22}) be measured for each sweep. This would require the transfer switch to engage twice each sweep. To avoid this, only the first measurement uses the transfer switch to measure all four S-parameters (12 term correction). Subsequent sweeps do not use the switch, and only two S-parameters are measured (8 term correction). The operator can make the instrument measure all four S-parameters again using the ***[MEASUREMENT RESTART]*** or ***[NUMBER OF GROUPS]*** softkeys described below.

- When port 1 and port 2 are driven by different channels: For example, when channel 1 is set to measure S_{21} and channel 2 is set to measure S_{12} – and dual channel display is turned on. This creates a condition which would cause repeated switching of the transfer switch. When this occurs, the "test set hold mode" engages. This mode will not allow switching to occur, and displays the status notation "tsH" on the left side of the screen. ***[MEASUREMENT RESTART]*** and ***[NUMBER OF GROUPS]*** softkeys will override the test set hold mode, and allow switching to occur. If averaging is on, the hold mode will not engage until the specified number of sweeps are completed.

Attenuator

The S-parameter test set contains one programmable step attenuator, which is switched between port 1 and port 2 depending on measurement needs. In some circumstances, the two ports could be used alternately, with each requiring a different attenuation value. This would cause repeated switching of the mechanical attenuator, and therefore excessive wear. An example is given below:

- Channels 1 and 2 are decoupled, different attenuation values have been selected for each channel, and dual channel display is engaged. When this occurs, the test set hold mode engages, and does not allow repetitive attenuator switching. ***[MEASURE RESTART]*** and ***[NUMBER OF GROUPS]*** softkeys will override the test set hold mode. If averaging is on, the hold mode will not engage until the specified number of sweeps is completed.

[MEASURE RESTART] and *[NUMBER OF GROUPS]* Softkeys

Both of these softkeys will allow measurements which demand repetitive switching of either the test port transfer switch or step attenuator.

- ***[MEASURE RESTART]*** will allow one such measurement to occur.
- ***[NUMBER OF GROUPS]*** will allow a specified number of such measurements to occur.

These two softkeys are explained in detail later in this chapter.

Doubler Switch Protection (Only Applies to the HP 85047A)

The HP 85047A S-parameter test set uses a frequency doubler to switch between 3 and 6 GHz operation. Because the doubler uses a mechanical switch, operations which would require repetitive switching between the two modes are not permitted. For this reason, 6 GHz mode is either on or off for both channels. There is no override for this protective feature.

[START], [STOP], [CENTER], AND [SPAN] KEYS

[START] (STAR)
[STOP] (STOP)
[CENTER] (CENT)
[SPAN] (SPAN)

These keys are keys used to define the frequency range or other horizontal axis range of the stimulus. The range can be expressed as either start/stop or center/span. When one of these keys is pressed, its function becomes the active function. The value is displayed in the active entry area and can be changed with the knob, step keys, or number pad. Current stimulus values for the active channel are also displayed along the bottom of the graticule. Frequency values can be set to zero for security purposes, using the display menus.

The preset stimulus mode is frequency, and the start and stop stimulus values are set to 300 kHz and 3 GHz respectively. In the time domain (option 010) or in CW time mode, the stimulus keys refer to time (with certain exceptions that are explained in Chapter 8, *Time and Frequency Domain Transforms*). In power sweep, the stimulus value is in dBm.

Because the display channels are independent, the stimulus signals for the two channels can be uncoupled and their values set independently. The values are then displayed separately on the CRT if the instrument is in dual channel display mode. In the uncoupled mode with dual channel display the instrument takes alternate sweeps to measure the two sets of data. Channel stimulus coupling is explained in this chapter, and dual channel display capabilities are explained in Chapter 4, *Response Function Block*.

[MENU] KEY

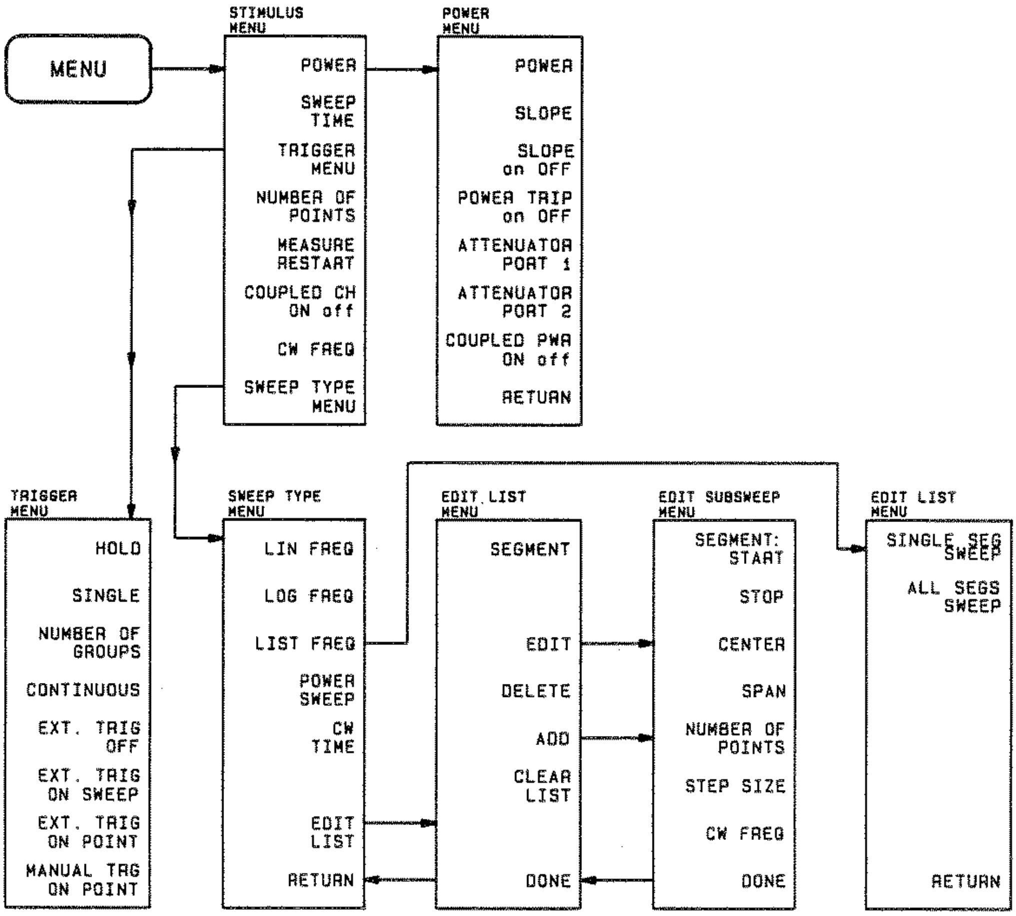


Figure 3-2. Softkey Menus Accessed from the [MENU] Key

The **[MENU]** (MENUSTIM) key provides access to the series of menus illustrated in Figure 3-2, which are used to define and control all stimulus functions other than start, stop, center, and span. When the **[MENU]** key is pressed, the stimulus menu is displayed. This in turn provides access to the other illustrated softkey menus. The functions available in these menus are described in the following pages.

Stimulus Menu

The stimulus menu is used to specify the sweep time, number of measurement points per sweep, and CW frequency. It includes the capability to couple or uncouple the stimulus functions of the two display channels, and the measurement restart function. In addition, it leads to other softkey menus that define power level, trigger type, and sweep type. The individual softkey functions of the stimulus menu are described below.

Continuous Switching of Test Set Attenuator or Port Transfer Switch. To avoid premature wearing out of either the transfer switch or attenuator, measurement configurations requiring continuous switching are not allowed without direct intervention of the operator. Measurement configurations which would cause this to occur are listed in *Test Set Attenuator, Test Port Transfer Switch, and Doubler Switch Protection*, in the beginning of this chapter. Full two-port error correction is one such configuration, as well as any measurement which causes the status annotation "tsH" (test set hold) to appear on the left side of the screen. ***[MEASUREMENT RESTART]*** and ***[NUMBER OF GROUPS]*** softkeys can override this protection feature, and are described later in this chapter.

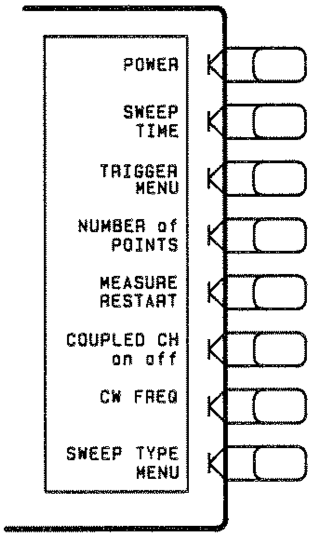


Figure 3-3

[POWER] (POWE) makes power level the active function and presents the power menu, which is used to set the output power level and slope compensation of the source, and control the attenuator in an HP 85046A/B or 85047A programmable S-parameter test set.

[SWEEP TIME [ ]] (SWET) toggles between automatic and manual sweep time. The difference between automatic and manual sweep time is:

- **Manual Sweep Time.** As long as the selected sweep speed is within the capability of the instrument, it will remain fixed, regardless of changes to other measurement parameters. If the operator changes measurement parameters such that the instrument can no longer maintain the selected sweep time, the HP 8753B will change to the best sweep time possible.

- **Auto Sweep Time.** Auto sweep time continuously maintains the fastest sweep speed possible with the selected measurement parameters.

Sweep time refers only to the time that the instrument is sweeping and taking data, and does not include the time required for internal processing of the data. A sweep speed indicator ↑ is displayed on the trace for sweep times slower than 1.0 second. For sweep times faster than 1.0 second the ↑ indicator is displayed in the status notations area at the left of the CRT.

Minimum Sweep Time. The minimum sweep time is dependent on several factors. These factors are referred to as "measurement parameters" in the following paragraphs.

- The number of points selected
- IF bandwidth
- Sweep-to-sweep averaging in dual channel display mode
- Smoothing
- Limit lines
- Error correction
- Trace math
- Marker statistics
- Time domain
- Type of sweep

The following table is a partial guide for determining the minimum sweep time for the listed measurement parameters. The values listed represent the minimum time required for a CW time measurement with averaging off. Values are given in seconds.

Number of Points	IF Bandwidth			
	3000 Hz	1000 Hz	300 Hz	10 Hz
11	0.0055	0.012	0.036	1.14
51	0.0255	0.06	0.166	5.3
101	0.0505	0.12	0.328	10.5
201	0.1005	0.239	0.653	20.9
401	0.2005	0.476	1.303	41.7
801	0.4005	0.951	2.603	83.3
1601	0.8005	1.901	5.203	166.5

Sweep time may be used in manual or auto modes. These are explained below.

Manual Sweep Time Mode. When this mode is active, the softkey label reads ***[SWEEP TIME [MANUAL]]***. This mode is engaged whenever the operator enters a sweep time greater than zero. This mode allows the operator to select a fixed sweep time. If the operator changes the measurement parameters such that the current sweep speed is no longer possible, the HP 8753B will automatically change to the fastest sweep speed possible.

Auto Sweep Time Mode. When this mode is active, the softkey label reads ***[SWEEP TIME [AUTO]]***. This mode is engaged whenever the operator enters **[0] [x1]** as a sweep speed. Auto sweep time continuously maintains the fastest sweep speed possible with the selected measurement parameters.

[TRIGGER MENU] goes to the trigger menu, which is used to select the type and number of the sweep trigger.

[NUMBER OF POINTS] (POIN) is used to select the number of data points per sweep to be measured and displayed. Using fewer points allows a faster sweep time but the displayed trace shows less horizontal detail. Using more points gives greater data density and improved trace resolution, but slows the sweep and requires more memory for error correction or saving instrument states.

The possible values that can be entered for number of points are 3, 11, 26, 51, 101, 201, 401, 801, and 1601. The number of points can be different for the two channels if the stimulus values are uncoupled.

In list frequency sweep, the number of points displayed is the total number of frequency points for the defined list (see *Sweep Type Menu*).

[MEASURE RESTART] (REST) aborts the sweep in progress, then restarts the measurement. This can be used to update a measurement following an adjustment of the device under test. When a full two-port calibration is in use, the ***[MEASURE RESTART]*** key will initiate another update of both forward and reverse S-parameter data. This softkey will also override the test set hold mode, which inhibits continuous switching of either the test port transfer switch or step attenuator. The measurement configurations which cause this are described in *Test Set Attenuator, Test Port Transfer Switch, and Doubler Switch Protection*, at the beginning of this section. This softkey will override the test set hold mode for one measurement.

If the HP 8753B is taking a number of groups (see *Trigger Menu*), the sweep counter is reset at 1. If averaging is on, ***[MEASURE RESTART]*** resets the sweep-to-sweep averaging and is effectively the same as ***[AVERAGING RESTART]***. If the sweep trigger is in ***[HOLD]*** mode, ***[MEASURE RESTART]*** executes a single sweep.

[COUPLED CH on OFF] (COUCON, COUCOFF) toggles the channel coupling of stimulus values. With ***[COUPLED CH ON]*** (the preset condition), both channels have the same stimulus values (the inactive channel takes on the stimulus values of the active channel).

In the stimulus coupled mode, the following parameters are coupled:

Frequency	Number of points
Source power	Number of groups
Power slope	IF bandwidth
Sweep time	Time domain transform
Trigger type	Gating
Sweep type	Harmonic measurement
Power meter calibration	

Coupling of stimulus values for the two channels is independent of ***[DUAL CHAN on OFF]*** in the display menu and ***[MARKERS: UNCOUPLED]*** in the marker mode menu. ***[COUPLED CH OFF]*** becomes an alternate sweep function when dual channel display is on: in this mode the HP 8753B alternates between the two sets of stimulus values for measurement of data, and both are displayed.

[CW FREQ] (CWFREQ) is used to set the frequency for power sweep and CW time sweep modes. If the instrument is not in either of these two modes, it is automatically switched into CW time mode.

[SWEEP TYPE MENU] presents the sweep type menu, where one of the available types of stimulus sweep can be selected.

Power Menu

The power menu is used to set the output power level of the source, to set power slope to compensate for measured power loss with frequency, and to control the programmable attenuator in an HP 85046A/B or 85047A S-parameter test set.

Power Output During 6 GHz Operation. When the HP 8753B option 006 and HP 85047A 6 GHz test set are used together in a system, the 6 GHz mode may be engaged. In this mode, the HP 8753B sets the RF output power to +20 dBm. This is the power level which allows optimum performance of the 6 GHz test set. Limited changes to power level may be allowed: refer to Chapter 14. If the system is changed back to the 3 GHz mode, the RF power output of the HP 8753B automatically changes to 0 dBm.

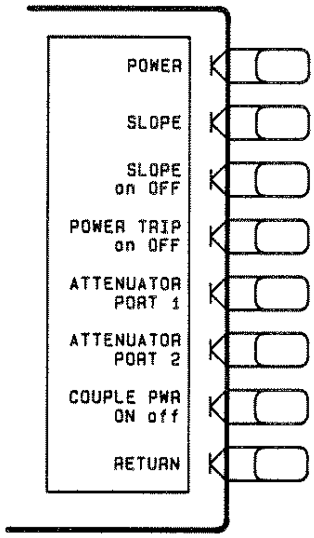


Figure 3-4

[POWER] (POWE) makes power level the active function and sets the RF output power level of the HP 8753B internal source. The HP 8753B will detect an input power overload at any of the three receiver inputs, and automatically reduce the output power of the source to −5 dBm. This is indicated with the message "OVERLOAD ON INPUT (R, A, B)." In addition, the ***[POWER TRIP ON]*** flag (see below) is set, and the annotation "P↓" appears at the left side of the CRT. When this occurs, toggle the power trip off and reset the power at a lower level.

If the source power is unleveled at the start or stop of a sweep, the notation "P?" is displayed at the left of the CRT. This indicates that the automatic leveling control circuit of the source is unable to keep the source power leveled to instrument specifications, and the power is therefore potentially uncalibrated. The "P?" notation is removed only after a sweep in which the source power is detected to be leveled at both the start and stop of the sweep. Refer to the *On-Site System Service Manual* for troubleshooting information.

[SLOPE] (SLOPE) compensates for power loss versus the frequency sweep, by sloping the output power upwards proportionally to frequency. Use this softkey to enter the power slope in dB per GHz of sweep.

[SLOPE on OFF] (SLOPON, SLOPOFF) toggles the power slope function on or off. With slope on, the output power increases with frequency, starting at the selected power level.

[POWER TRIP on OFF] (POWTON, POWTOFF) toggles the power trip function on or off. Power trip is a reduced power state triggered by a power overload. It forces the source output power to −5 dBm regardless of the user-specified power level. The trip is set automatically whenever a power overload is detected on an input channel. When trip is on, the annotation "P↓" appears in the status notations area of the display.

To reset the power level following a power trip, toggle the power trip **OFF**.

[ATTENUATOR PORT 1] (ATTP1) controls the attenuation at port 1 of an HP 85046A/B or 85047A S-parameter test set connected to the HP 8753B. The attenuator range is 0 to 70 dB, controllable in 10 dB steps. Attenuation is used to reduce the signal level at the test port without reducing the reference signal, for example to perform measurements of amplifiers.

The S-parameter test set must be interfaced with the HP 8753B through the test set interconnect cable for the attenuator control signal to be enabled. Note that no warning is given if no test set is present, or if the test set has no programmable attenuator (as in the HP 85044A/B transmission/reflection test set).

[ATTENUATOR PORT 2] (ATTP2) serves the same function for the attenuation at port 2 of the HP 85046A/B or 85047A S-parameter test set.

NOTE: The HP 8753B does not allow port 1 and 2 to be set to different attenuator values. This is required because the same attenuator is used for both ports, and is mechanically switched between them. To prevent premature wearing out, continuous switching of attenuator values between ports is not allowed.

[COUPLE PWR ON off] (COUPON COUPOFF) is intended for use with the *[D2/D1 toD2 on OFF]* softkey. The D2/D1 to D2 function is used in harmonic measurements, where the fundamental is displayed on channel 1 and the harmonic on channel 2. D2/D1 to D2 ratios the two, displaying the fundamental and relative power of the measured harmonic in dBc. When making such measurements, channel 1 and 2 must be uncoupled with the *[COUPLED CHAN ON off]* softkey set to OFF to allow alternating sweeps.

After uncoupling channel 1 and 2, the operator may wish to change the power level of the fundamental and see resultant change in relative harmonic power (in dBc). *[COUPLE PWR ON off]* allows the operator to change the power of both channels simultaneously (coupled power), even though they are uncoupled in all other respects.

Turning *[COUPLE PWR ON off]* off can uncouple power only if channels 1 and 2 are uncoupled.

[RETURN] goes back to the stimulus menu.

Trigger Menu

This menu is used to select the type and number of the sweep trigger.

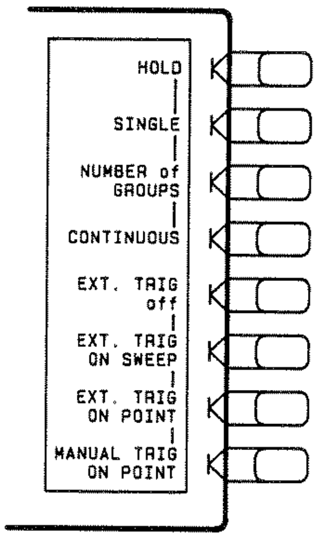


Figure 3-5

[HOLD] (HOLD) freezes the data trace on the display, and the HP 8753B stops sweeping and taking data. The notation "Hld" is displayed at the left of the graticule. If the * indicator is on at the left side of the CRT, trigger a new sweep with ***[SINGLE]***.

[SINGLE] (SING) takes one sweep of data and returns to the hold mode.

[NUMBER OF GROUPS] (NUMG) triggers a user-specified number of sweeps, and returns to the hold mode. This function can be used to override the test set hold mode, which protects the electromechanical transfer switch and attenuator against continuous switching. This is explained fully in the *Test Set Attenuator, Test Port Transfer Switch, and Double Switch Protection* description in the beginning of this chapter.

If averaging is on, the number of groups should be at least equal to the averaging factor selected, to allow measurement of a fully averaged trace. Entering a number of groups resets the averaging counter to 1.

[CONTINUOUS] (CONT) is the standard sweep mode of the HP 8753B, in which the sweep is triggered automatically and continuously and the trace is updated with each sweep.

[EXT. TRIG OFF] (EXTTOFF) turns off external trigger mode.

[EXT TRIG ON SWEEP] (EXTTON) is used when the sweep is triggered on an externally generated signal connected to the rear panel EXT TRIGGER input. The sweep is started with a high-to-low transition of a TTL signal. If this key is pressed when no external trigger signal is connected, the notation "Ext" is displayed at the left side of the CRT to indicate that the HP 8753B is waiting for a trigger. When a trigger signal is connected, the "Ext" notation is replaced by the sweep speed indicator ↑ either in the status notations area or on the trace. External trigger mode is allowed in every sweep mode.

[EXT TRIG ON POINT] (EXTTPOIN) is similar to the trigger on sweep, but triggers each data point in a sweep.

[MANUAL TRG ON POINT] waits for a manual trigger for each point. Subsequent pressing of this softkey triggers each measurement. The annotation "man" will appear at the left side of the CRT when the instrument is waiting for the trigger to occur. This feature is useful in a test sequence when an external device or instrument requires changes at each point.

Sweep Type Menu

Five sweep types are available:

- Linear frequency sweeps in Hz. In the linear frequency sweep mode it is possible, with option 010, to transform the data for time domain measurements using the inverse Fourier transform technique.
- Logarithmic frequency sweeps in Hz.
- Power sweeps in dBm.
- CW time sweep in seconds. In the CW time sweep mode, the data can be transformed for frequency domain measurements. Refer to Chapter 8 for detailed information about time domain transform with option 010.
- List frequency sweep in Hz. A new feature is the single segment mode, where any single segment in a frequency list may be selected. The single segment will retain the same error correction as the original list of frequencies.

Interpolated Error Correction. The interpolated error correction feature will function with the following sweep types:

- Linear frequency
- Power sweep
- CW time

Interpolated error correction will not work in log or list sweep modes. Refer to Chapter 5 for more information on interpolated error correction.

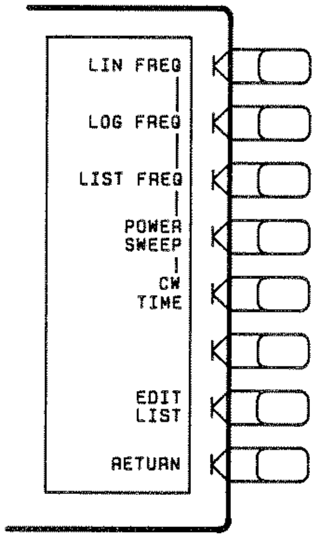


Figure 3-6

[LIN FREQ] (LINFREQ) activates a linear frequency sweep displayed on a standard graticule with ten equal horizontal divisions. This is the default preset sweep type.

For a linear sweep, sweep time is combined with the channel's frequency span to compute a source sweep rate:

sweep rate = (frequency span) / (sweep time)

Since the sweep time may be affected by various factors (see *Stimulus Menu*), the equation provided here is merely an indication of the ideal (maximum) sweep rate. If the user-specified sweep time is greater than 15 ms times the number of points, the sweep changes from a continuous ramp sweep to a stepped CW sweep. Also for narrow IF bandwidths the sweep is automatically converted to a stepped CW sweep.

[LOG FREQ] (LOGFREQ) activates a logarithmic frequency sweep mode. The source is stepped in logarithmic increments and the data is displayed on a logarithmic graticule. This is slower than a continuous sweep with the same number of points, and the entered sweep time may therefore be changed automatically. For frequency spans of less than two octaves, the sweep type automatically reverts to linear sweep.

[LIST FREQ] (LISTFREQ) provides a user-definable arbitrary frequency list mode. This list is defined and modified using the edit list menu and the edit subsweep menu. Up to 30 frequency subsweeps (called "segments") of several different types can be specified, for a maximum total of 1632 points. One list is common to both channels. Once a frequency list has been defined and a measurement calibration performed on the full frequency list, one or all of the frequency segments can be measured and displayed without loss of calibration.

When the ***[LIST FREQ]*** key is pressed the network analyzer sorts all the defined frequency segments into CW points in order of increasing frequency. It then measures each point and displays a single trace that is a composite of all data taken. If duplicate frequencies exist, the HP 8753B makes multiple measurements on identical points to maintain the specified number of points for each subsweep. Since the frequency points may not be distributed evenly across the CRT, the display resolution may be uneven, and more compressed in some parts of the trace than in others. However, the stimulus and response readings of the markers are always accurate. Because the list frequency sweep is a stepped CW sweep, the sweep time is slower than for a continuous sweep with the same number of points.

The ***[LIST FREQ]*** softkey presents the segment menu, which allows the operator to select any single segment in the frequency list. Refer to *Edit List Menu* and *Edit Subsweep Menu* later in this chapter to see how to enter or modify the list frequencies. If no list has been entered, the message "CAUTION: LIST TABLE EMPTY" is displayed.

A tabular printout of the frequency list data can be obtained using the ***[LIST VALUES]*** function in the copy menu.

[POWER SWEEP] (POWS) turns on a power sweep mode that is used to characterize power-sensitive circuits. In this mode, power is swept at a single frequency, from a start power value to a stop power value, selected using the ***[START]*** and ***[STOP]*** keys and the entry block. This feature is convenient for such measurements as gain compression or AGC (automatic gain control) slope. To set the frequency of the power sweep, use ***[CW FREQ]*** in the stimulus menu. Refer to the *User's Guide* for an example of a gain compression measurement.

Note that the attenuator switch in the S-parameter test set is not switched in power sweep mode.

In power sweep, the entered sweep time may be automatically changed if it is less than the minimum required for the current configuration (number of points, IF bandwidth, averaging, etc.).

[CW TIME] (CWTIME) turns on a sweep mode similar to an oscilloscope. The HP 8753B is set to a single frequency, and the data is displayed versus time. The frequency of the CW time sweep is set with ***[CW FREQ]*** in the stimulus menu. In this sweep mode, the data is continuously sampled at precise, uniform time intervals determined by the sweep time and the number of points minus 1. The entered sweep time may be automatically changed if it is less than the minimum required for the current instrument configuration.

In time domain using option 010, the CW time mode data is translated to frequency domain, and the x-axis becomes frequency. This can be used like a spectrum analyzer to measure signal purity, or for low frequency (>1 kHz) analysis of amplitude or pulse modulation signals. For details, refer to Chapter 8.

[EDIT LIST] presents the edit list menu. This is used in conjunction with the edit subsweep menu to define or modify the frequency sweep list. The list frequency sweep mode is selected with the ***[LIST FREQ]*** softkey described above.

[RETURN] goes back to the stimulus menu.

Single/All Segment Menu

When this menu is presented, the frequency list table is displayed in the center of the CRT. A segment can then be selected to be measured, and the choice of a full-trace measurement or a single-segment measurement can be made.

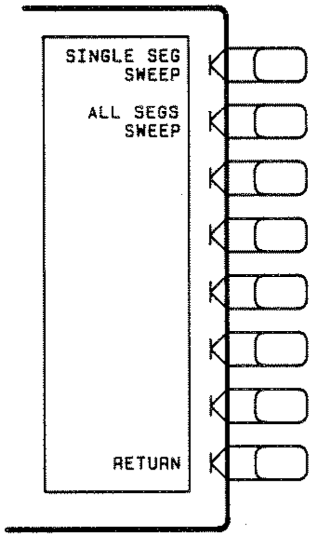


Figure 3-7

[SINGLE SEG SWEEP] (SSEG) enables a measurement of a single segment of the frequency list, without loss of calibration. The segment to be measured is selected using the entry block.

In single segment mode, selecting a measurement calibration will force the full list sweep before prompting for calibration standards. The calibration will then be valid for any single segment.

If an instrument state is saved in memory with a single-segment trace, a recall will re-display that segment while also recalling the entire list.

[ALL SEGS SWEEP] (ASEG) retrieves the full frequency list sweep.

[RETURN] goes back to the sweep type menu

Edit List Menu

This menu is used to edit the list of frequency segments (subsweeps) defined with the edit subsweep menu, described next. Up to 30 frequency subsweeps can be specified, for a maximum of 1632 points. The segments do not have to be entered in any particular order: the HP 8753B automatically sorts them and lists them on the CRT in increasing order of start frequency. This menu determines which entry on the list is to be modified, while the edit subsweep menu is used to make changes in the frequency or number of points of the selected entry.

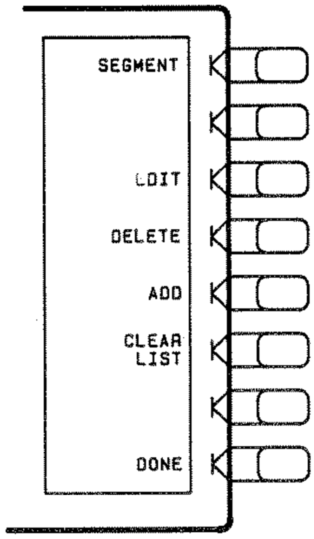


Figure 3-8

[SEGMENT] determines which segment on the list is to be modified. Enter the number of a segment in the list, or use the step keys to scroll the pointer > at the left to the required segment number. The indicated segment can then be edited or deleted.

[EDIT] goes to the edit subsweep menu, where the segment indicated by the pointer > at the left can be modified.

[DELETE] deletes the segment indicated by the pointer >.

[ADD] is used to add a new segment to be defined with the edit subsweep menu. If the list is empty, a default segment is added, and the edit subsweep menu is displayed so it can be modified. If the list is not empty, the segment indicated by the pointer > is copied and the edit subsweep menu is displayed.

[CLEAR LIST] clears the entire list.

[DONE] sorts the frequency points and returns to the sweep type menu.

Edit Subsweep Menu

This menu lets you select measurement frequencies arbitrarily. Using this menu it is possible to define the exact frequencies to be measured on a point-by-point basis. For example the sweep could include 100 points in a narrow passband, 100 points across a broad stop band, and 50 points across the third harmonic response. The total sweep is defined with a list of subsweeps. Up to 30 subsweeps can be defined, with a total of up to 1632 data points.

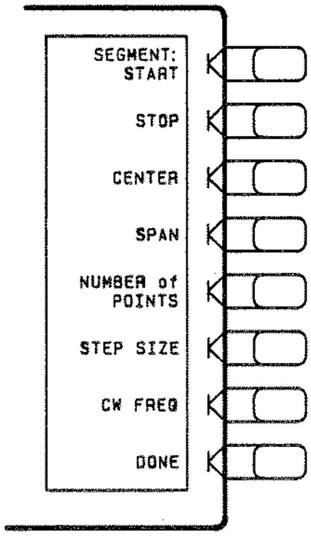


Figure 3-9

The frequency subsweeps, or segments, can be defined in any of the following terms:

start / stop / number of points
start / stop / step
center / span / number of points
center / span / step
CW frequency

The subsweeps can overlap, and do not have to be entered in any particular order. The HP 8753B sorts the segments automatically and lists them on the CRT in order of increasing start frequency, even if they are entered in center/span format. If duplicate frequencies exist, the HP 8753B makes multiple measurements on identical points to maintain the specified number of points for each subsweep. The data is displayed on the CRT as a single trace that is a composite of all data taken. The trace may appear uneven because of the distribution of the data points, but the frequency scale is linear across the total range.

The list frequency sweep mode is selected with the ***[LIST FREQ]*** softkey in the sweep type menu.

The frequency list parameters can be saved with an instrument state.

[SEGMENT START] sets the start frequency of a subsweep.

[STOP] sets the stop frequency of a subsweep.

[CENTER] sets the center frequency of a subsweep.

[SPAN] sets the frequency span of a subsweep about a specified center frequency.

[NUMBER OF POINTS] sets the number of points for the subsweep. The total number of points for all the subsweeps cannot exceed 1632.

[STEP SIZE] is used to specify the subsweep in frequency steps instead of number of points. Changing the start frequency, stop frequency, span, or number of points may change the step size. Changing the step size may change the number of points and stop frequency in start/stop/step mode; or the frequency span in center/span/step mode. In each case, the frequency span becomes a multiple of the step size.

[CW] is used to set a subsweep consisting of a single CW frequency point.

[DONE] returns to the edit list menu.

Chapter 4. Response Function Block

CHAPTER CONTENTS

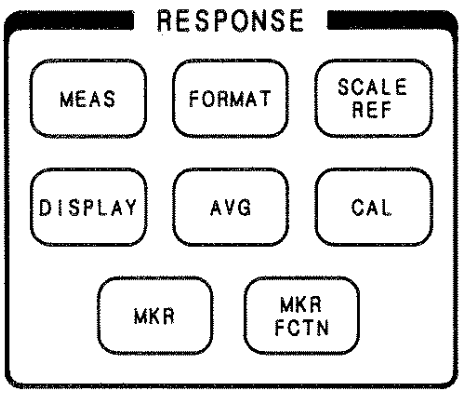


Figure 4-1

INTRODUCTION

The keys in the RESPONSE block are used to control the measurement and display functions of the active channel. They provide access to many different softkey menus that offer selections for the parameters to be measured, the display mode and format of the data, the control of the display markers, and a variety of calibration functions.

The current values for the major response functions of the active channel are displayed in specific locations along the top of the CRT. In addition, certain functions accessed through the keys in this block are annotated in the status notations area at the left-hand side of the CRT. An illustration of the CRT showing the locations of these information labels is provided in Chapter 2, together with an explanation.

The RESPONSE block keys and their associated menus are described briefly below, and in more detail in this and the following chapters. General and specific measurement sequences are described in the *User's Guide*.

The **[MEAS]** (MENUMEAS) key provides access to a series of softkey menus for selecting the parameters or inputs to be measured.

The **[FORMAT]** (MENUFORM) key leads to a menu used to select the display format for the data. Various rectangular and polar formats are available for display of magnitude, phase, impedance, group delay, real data, and SWR.

The **[SCALE REF]** (MENUSCAL) key displays a menu used to modify the vertical axis scale and the reference line value, as well as to add electrical delay.

The **[DISPLAY]** (MENUDISP) key leads to a series of menus for instrument and active channel display functions. The first menu defines the displayed active channel trace in terms of the mathematical relationship between data and trace memory. Other functions include dual channel display (overlaid or split), display focus and intensity, active channel display title, and frequency blanking.

The **[AVG]** (MENUAVG) key is used to access three different noise reduction techniques: sweep-to-sweep averaging, trace smoothing, and variable IF bandwidth.

The **[CAL]** (MENUCAL) key leads to a series of menus to perform measurement calibrations for vector error correction (accuracy enhancement), and for specifying the calibration standards used. Calibration procedures are used to improve measurement accuracy by effectively removing systematic errors prior to making measurements. Several different levels of calibration are available for use in a variety of different measurement applications. Each calibration procedure features CRT prompts to guide you through the calibration sequence.

An explanation of vector error correction techniques to enhance measurement accuracy is included with the description of the calibration menus and procedures. Refer to Chapter 5, and to the Appendix to Chapter 5.

The **[CAL]** key also leads to softkeys which activate interpolated error correction and power meter calibration. These two features are fully explained in Chapter 5.

The **[MKR]** (MENUMARK) key displays an active marker (▽) on the screen and provides access to a series of menus to control from one to four display markers for each channel. Markers provide numerical readout of measured values at any point of the trace.

The menus accessed from the **[MKR]** key provide several basic marker operations. These include special marker modes for different display formats, and a marker delta mode that displays marker values relative to a specified value or another marker.

The **[MKR FCTN]** (MENUMRKF) key provides access to additional marker functions. These use the markers to search the trace for specified information, to analyze the trace statistically, or to quickly change the stimulus parameters.

[MEAS] KEY

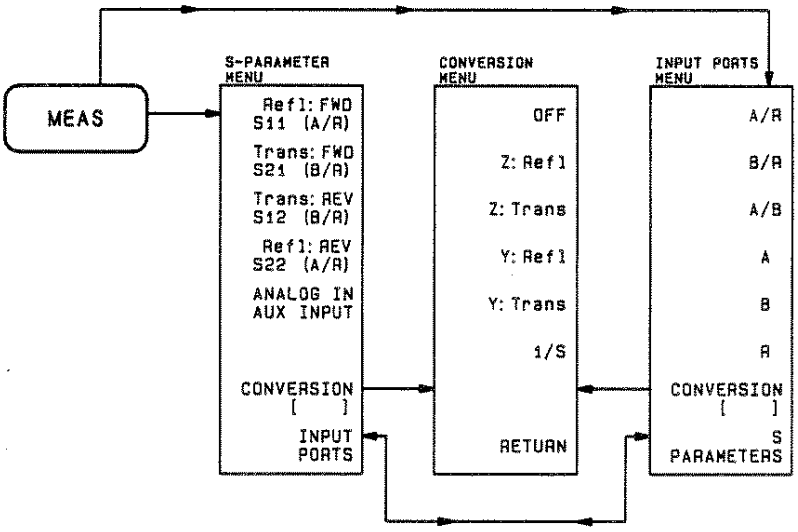


Figure 4-2. Softkey Menus Accessed from the [MEAS] Key

The **[MEAS]** (MENUMEAS) key leads to a series of softkey menus used to determine the parameters or inputs to be measured. If an HP 85046A/B or 85047A S-parameter test set is connected, all four S-parameters can be measured with a single connection. Or S-parameters can be measured using a transmission/reflection test set by reversing the device under test between measurements. S-parameters are explained briefly below.

Alternatively, the power ratio of any two inputs or the absolute power at a single input can be measured and displayed, using either test set.

S-parameters can be converted to impedance (Z), admittance (Y), or inverse S-parameters through internal math capabilities of the HP 8753B.

S-Parameters

S-parameters (scattering parameters) are a convention used to characterize the way a device modifies signal flow. A brief explanation is provided here of the S-parameters of a two-port device. For additional details refer to Hewlett-Packard Application Notes A/N 95-1 and A/N 154.

S-parameters are always a ratio of two complex (magnitude and phase) quantities. S-parameter notation identifies these quantities using the numbering convention:

$$S_{\text{out in}}$$

where the first number (out) refers to the port where the signal is emerging and the second number (in) is the port where the signal is incident. For example, the S-parameter S21 identifies the measurement as the complex ratio of the signal emerging at port 2 to the signal incident at port 1.

Figure 4-3 is a representation of the S-parameters of a two-port device, together with an equivalent flowgraph. In the illustration, "a" represents the signal entering the device and "b" represents the signal emerging. Note that a and b are not related to the A and B input ports on the HP 8753B.

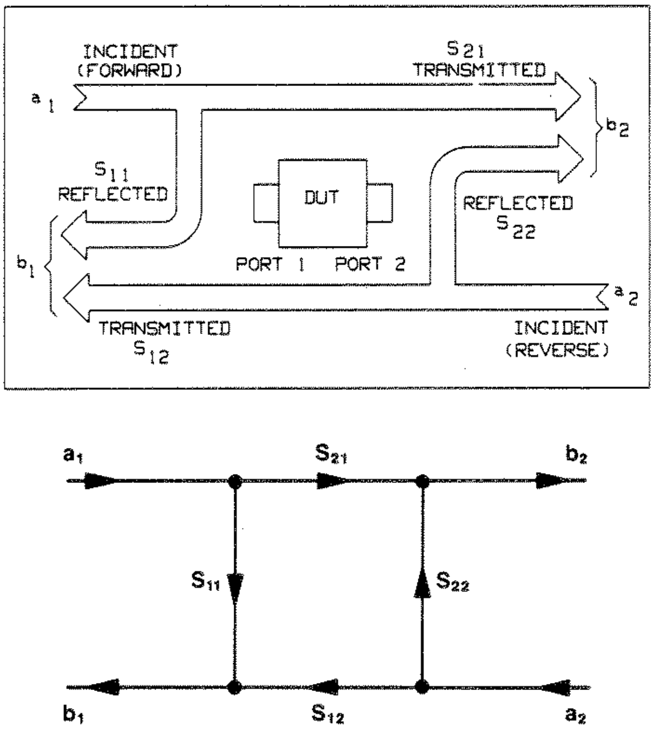


Figure 4-3. S-Parameters of a Two-Port Device

S-parameters are exactly equivalent to the more common description terms below, requiring only that the measurements be taken with all DUT ports properly terminated.

S-Parameter	Definition	Test Set Description	Direction
S_{11}	$\left.\frac{b_1}{a_1}\right\rvert_{a_2=0}$	Input reflection coefficient	FWD
S_{21}	$\left.\frac{b_2}{a_1}\right\rvert_{a_2=0}$	Forward gain	FWD
S_{12}	$\left.\frac{b_1}{a_2}\right\rvert_{a_1=0}$	Reverse gain	REV
S_{22}	$\left.\frac{b_2}{a_2}\right\rvert_{a_1=0}$	Output reflection coefficient	REV

S-Parameter Menu

The S-parameter menu is presented automatically when the **[MEAS]** key is pressed, if an HP 85046A/B or 85047A S-parameter test set is connected to the HP 8753B or if two-port error correction is on. This menu is used to define the input ports and test set direction for S-parameter measurements. The HP 8753B controls the HP 85046A/B or 85047A S-parameter test set, and automatically switches the direction of the measurement according to the selections made in this menu. All four S-parameters can be measured with a single connection. The S-parameter being measured is labeled at the top left corner of the CRT.

S-parameter measurements can also be made using an HP 85044A/B transmission/reflection test set, by reversing the device under test after making the forward reflection and transmission measurements. In this case, the softkey labels are changed to indicate the actual input ratios being measured (A/R for reflection or B/R for transmission measurements). Thus ***[Refl: REV S22 (B/R)]*** becomes ***[Refl: REV S22 (A/R)]***, and ***[Trans: REV S12 (A/R)]*** becomes ***[Trans: REV S12 (B/R)]***. However, the annotation in the top left corner indicates the S-parameter being measured.

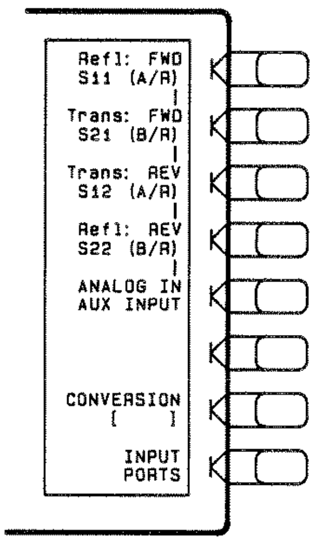


Figure 4-4. S-Parameter Menu

[Refl: FWD S11 (A/R)] (S11) configures the S-parameter test set for a measurement of S11, the complex reflection coefficient (magnitude and phase) of the test device input.

[Trans: FWD S21 (B/R)] (S21) configures the S-parameter test set for a measurement of S21, the complex forward transmission coefficient (magnitude and phase) of the device under test.

[Trans: REV S12 (A/R)] (S12) configures the S-parameter test set for a measurement of S12, the complex reverse transmission coefficient (magnitude and phase) of the device under test.

If an HP 85044A/B transmission/reflection test set is being used to make S-parameter measurements, reverse the device under test before making this measurement.

[Refl: REV S22 (B/R)] (S22) defines the measurement as S22, the complex reflection coefficient (magnitude and phase) of the output of the device under test.

If an HP 85044A/B transmission/reflection test set is being used to make S-parameter measurements, the device under test must be reversed before S12 and S22 are measured.

[ANALOG IN] (ANAI) displays a DC or low frequency AC auxiliary voltage on the vertical axis, using the real format. An external signal source such as a detector or function generator can be connected to the rear panel AUXILIARY INPUT connector. (For service purposes, one of numerous internal voltage nodes on the analog bus can be selected for measurement and display. Applications of this function are described in the *On-Site System Service Manual*.)

[CONVERSION] brings up the conversion menu which converts the measured data to impedance (Z) or admittance (Y). When a conversion parameter has been defined, it is shown in brackets under the softkey label. If no conversion has been defined, the softkey label reads *[CONVERSION OFF]*.

[INPUT PORTS] goes to the input ports menu, which is used to define a ratio or single-input measurement rather than an S-parameter measurement.

Input Ports Menu

The input ports menu is presented when the **[MEAS]** key is pressed if there is no S-parameter test set connected and two-port error correction is not on. This menu is used to define the input ports for power ratio measurements, or a single input for magnitude only measurements of absolute power. Single inputs cannot be used for phase or group delay measurements, or any measurements with averaging turned on.

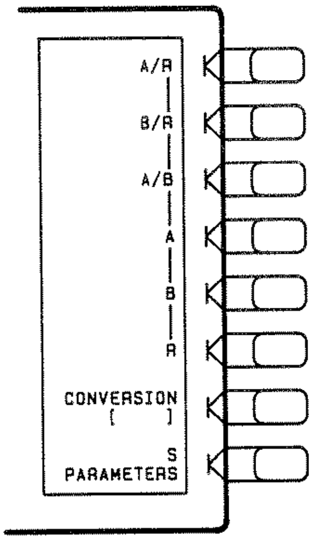


Figure 4-5

[A/R] (AR) calculates and displays the complex ratio of the signal at input A to the reference signal at input R.

[B/R] (BR) calculates and displays the complex ratio of input B to input R.

[A/B] (AB) calculates and displays the complex ratio of input A to input B.

[A] (MEASA) measures the absolute power amplitude at input A.

[B] (MEASB) measures the absolute power amplitude at input B.

[R] (MEASR) measures the absolute power amplitude at input R. The R input is part of the source phase locking scheme, and therefore has a limited dynamic range.

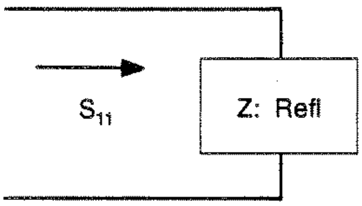
[CONVERSION] brings up the conversion menu, which converts the measured data to impedance (Z) or admittance (Y). When a conversion parameter has been defined, it is shown in brackets under the softkey label. If no conversion has been defined, the softkey label reads *[CONVERSION OFF]*.

[S PARAMETERS] goes to the S-parameter menu, which is used to define the input ports and test set direction for S-parameter measurements.

Conversion Menu

This menu converts the measured reflection or transmission data to the equivalent complex impedance (Z) or admittance (Y) values. This is not the same as a two-port Y or Z parameter conversion, as only the measured parameter is used in the equations. Two simple one-port conversions are available, depending on the measurement configuration.

An S11 or S22 trace measured as reflection can be converted to equivalent parallel impedance or admittance using the model and equations shown in Figure 4-6.



Z: Refl

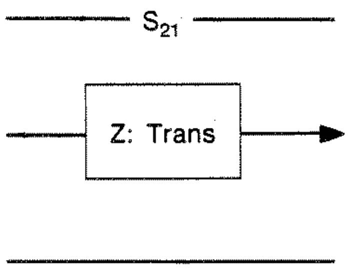
$$Z_R = Z0 \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

Y: Refl

$$Y_R = \frac{1}{Z_R}$$

Figure 4-6. Reflection Impedance and Admittance Conversions

In a transmission measurement, the data can be converted to its equivalent series impedance or admittance using the model and equations shown in Figure 4-7.



Z: Trans

$$Z_T = Z0 \cdot \frac{2(1 - S_{21})}{S_{21}}$$

Y: Trans

$$Y_T = \frac{1}{Z_T}$$

Figure 4-7. Transmission Impedance and Admittance Conversions

Avoid the use of Smith chart, SWR, and delay formats for display of Z and Y conversions, as these formats are not easily interpreted.

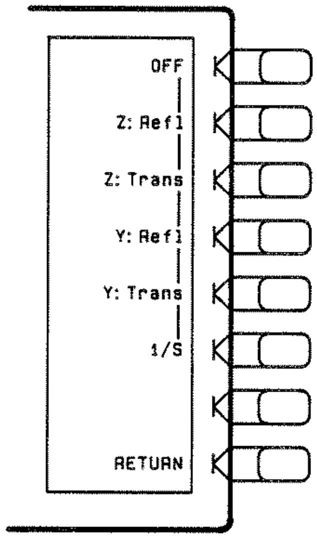


Figure 4-8. Conversion Menu

[OFF] (CONVOFF) turns off all parameter conversion operations.

[Z: Refl] (CONVZREF) converts reflection data to its equivalent impedance values.

[Z: Trans] (CONVZTRA) converts transmission data to its equivalent impedance values.

[Y: Refl] (CONVYREF) converts reflection data to its equivalent admittance values.

[Y: Trans] (CONVYTRA) converts transmission data to its equivalent admittance values.

[1/S] (CONV1DS) expresses the data in inverse S-parameter values, for use in amplifier and oscillator design. A convenient way to check for transistor stability is to compare S11 and 1/S22 on a Smith chart using a dual channel overlaid display (see *Display Menu*).

[RETURN] returns to the last menu, either the S-parameter or the input ports menu.

[FORMAT] KEY

Format Menu

The **[FORMAT]** (MENUFORM) key presents a menu used to select the appropriate display format for the measured data. Various rectangular and polar formats are available for display of magnitude, phase, real data, imaginary data, impedance, group delay, and SWR. The units of measurement are changed automatically to correspond with the displayed format. Special marker menus are available for the polar and Smith formats, each providing several different marker types for readout of values (see Chapter 6).

The format defined for display of a particular S-parameter or input is remembered with that parameter. Thus if different parameters are measured, even if only one channel is used, each parameter is shown in its selected format each time it is displayed.

The illustrations below show a reflection measurement of a bandpass filter displayed in each of the available formats.

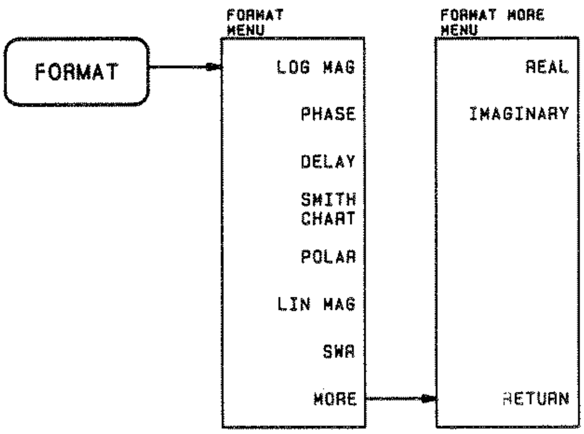


Figure 4-9. Format and Format More Menus

[LOG MAG] (LOGM) displays the log magnitude format. This is the standard Cartesian format used to display magnitude-only measurements of insertion loss, return loss, or absolute power in dB versus frequency. Figure 4-10 illustrates the bandpass filter reflection data in a log magnitude format.

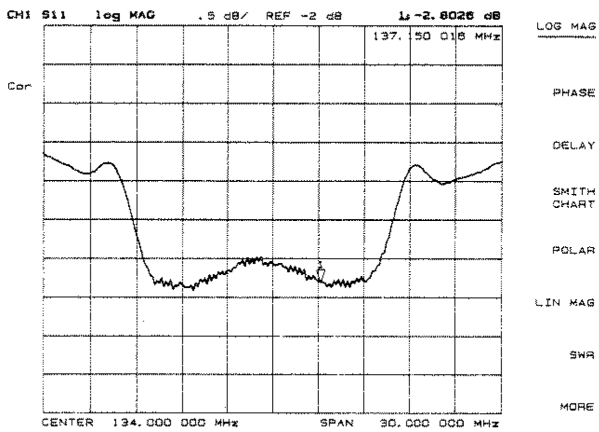


Figure 4-10. Log Magnitude Format

[PHASE] (PHAS) displays a Cartesian format of the phase portion of the data, measured in degrees. This format displays the phase shift versus frequency. Figure 4-11 illustrates the phase response of the same filter in a phase-only format. A measurement of phase response is described in the User's Guide.

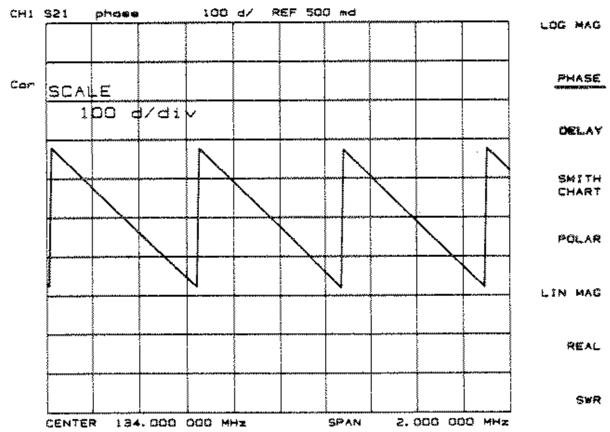


Figure 4-11. Phase Format

[DELAY] (DELA) selects the group delay format, with marker values given in seconds. Figure 4-12 shows the bandpass filter response formatted as group delay. Group delay principles are described in the next few pages.

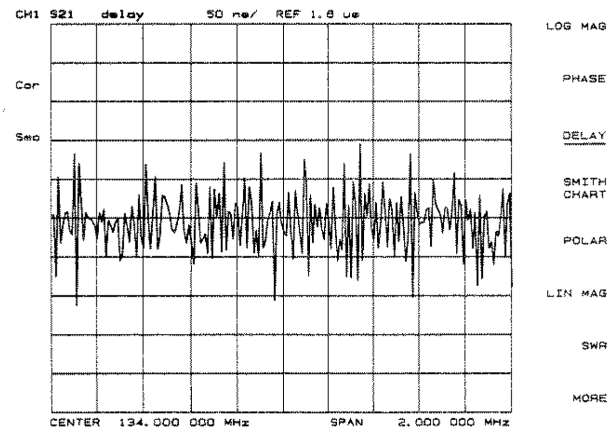


Figure 4-12. Group Delay Format

[SMITH CHART] (SMIC) displays a Smith chart format (Figure 4-13). This is used in reflection measurements to provide a readout of the data in terms of impedance. The intersecting dotted lines on the Smith chart represent constant resistance and constant reactance values, normalized to the characteristic impedance, Z0, of the system. Reactance values in the upper half of the Smith chart circle are positive (inductive) reactance, and in the lower half of the circle are negative (capacitive) reactance. The default marker readout is in units of resistance and reactance (R+jX). Additional marker types are available in the Smith marker menu (refer to Chapter 6).

The Smith chart is most easily understood with a full scale value of 1.0. If the scale per division is less than 0.2, the format switches automatically to polar.

If the characteristic impedance of the system is not 50 ohms, modify the impedance value recognized by the HP 8753B using the ***[SET Z0]*** softkey in the calibrate more menu. Refer to Chapter 5.

An inverted Smith chart format for admittance measurements (Figure 4-13) is also available. Access this by selecting ***[SMITH CHART]*** in the format menu, and pressing **[MKR]** ***[MARKER MODE MENU]*** ***[SMITH MKR MENU]*** ***[G+jB MKR]***. The Smith chart is reversed and marker values are read out in units of conductance and susceptance (G+jB).

Procedures for measuring impedance and admittance are provided in the *User's Guide*.

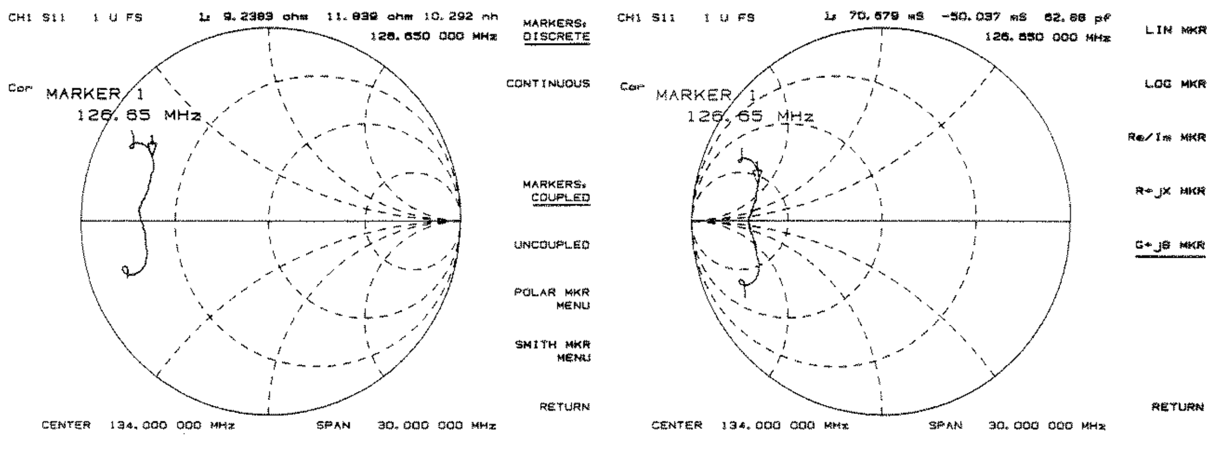


Figure 4-13. Standard and Inverse Smith Chart Formats

[POLAR] (POLA) displays a polar format (Figure 4-14). Each point on the polar format corresponds to a particular value of both magnitude and phase. Quantities are read vectorally: the magnitude at any point is determined by its displacement from the center (which has zero value), and the phase by the angle counterclockwise from the positive x-axis. Magnitude is scaled in a linear fashion, with the value of the outer circle usually set to a ratio value of 1. Since there is no frequency axis, frequency information is read from the markers.

The default marker readout for the polar format is in linear magnitude and phase. A log magnitude marker and a real/imaginary marker are available in the polar marker menu (refer to Chapter 6).

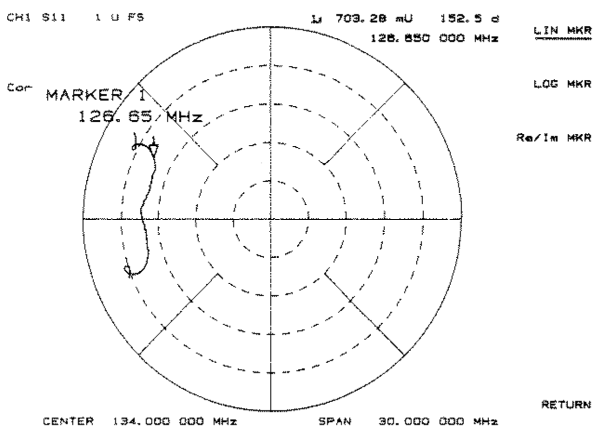


Figure 4-14. Polar Format

[LIN MAG] (LINM) displays the linear magnitude format (Figure 4-15). This is a Cartesian format used for unitless measurements such as reflection coefficient magnitude ρ or transmission coefficient magnitude τ, and for linear measurement units. It is used for display of conversion parameters and time domain transform data.

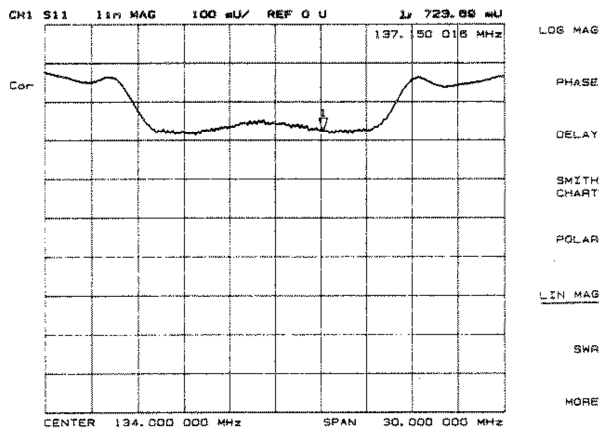


Figure 4-15. Linear Magnitude Format

[SWR] (SWR) reformats a reflection measurement into its equivalent SWR (standing wave ratio) value (Figure 4-16). SWR is equivalent to (1+ρ)/(1-ρ), where ρ is the reflection coefficient. Note that the results are valid only for reflection measurements. If the SWR format is used for measurements of S21 or S12 the results are not valid.

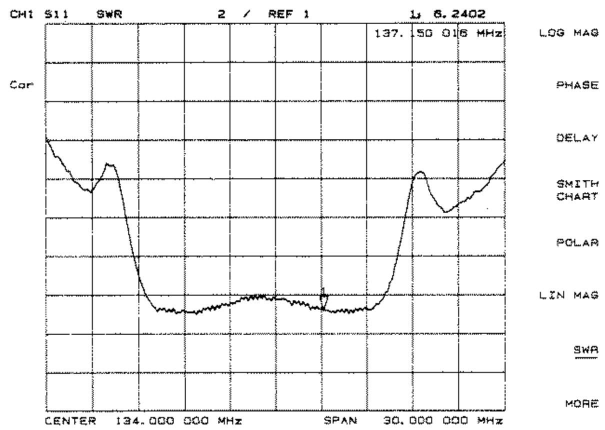


Figure 4-16. Typical SWR Display

[MORE] goes to the format more menu described on the next page.

Format More Menu

This menu provides two additional softkey selections not available on the HP 8753A.

[REAL] (REAL) displays only the real (resistive) portion of the measured data on a Cartesian format (Figure 4-16). This is similar to the linear magnitude format, but can show both positive and negative values. It is primarily used for analyzing responses in the time domain, and also to display an auxiliary input voltage signal for service purposes.

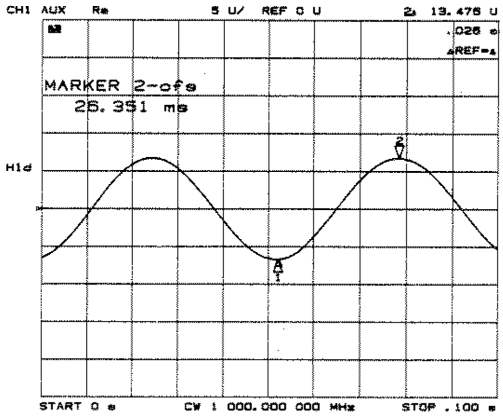


Figure 4-17. Real Format

[IMAGINARY] (IMAG) displays only the imaginary (reactive) portion of the measured data on a Cartesian format. This format is similar to the real format except that reactance data is displayed on the trace instead of impedance data.

[RETURN] goes back to the format menu.

GROUP DELAY PRINCIPLES

For many networks, the amount of insertion phase is not as important as the linearity of the phase shift over a range of frequencies. The HP 8753B can measure this linearity and express it in two different ways: directly, as deviation from linear phase, or as group delay, a derived value. Refer to the ***[SCALE REF] Key*** description in this chapter for information on deviation from linear phase.

Group delay is the measurement of signal transmission time through a test device. It is defined as the derivative of the phase characteristic with respect to frequency. Since the derivative is basically the instantaneous slope (or rate of change of phase with frequency), a perfectly linear phase shift results in a constant slope, and therefore a constant group delay (Figure 4-18).

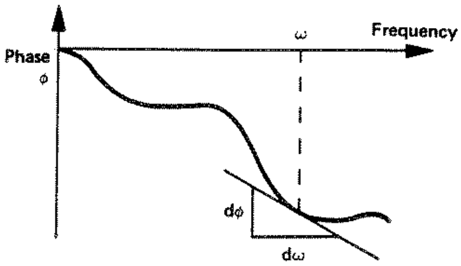
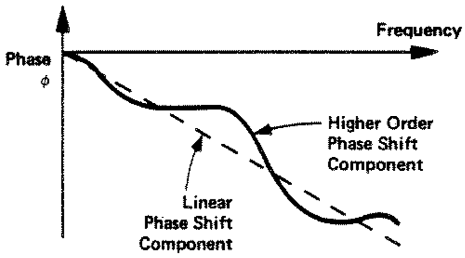


Figure 4-18

Note, however, that the phase characteristic typically consists of both linear and higher order (deviations from linear) components. The linear component can be attributed to the electrical length of the test device, and represents the average signal transit time. The higher order components are interpreted as variations in transit time for different frequencies, and represent a source of signal distortion (Figure 4-19).



$$\text{Group Delay} = \tau_g = \frac{-d\phi}{d\omega} \qquad \phi \text{ in Radians}, \ \omega \text{ in Radians}$$

$$= \frac{-1}{360^\circ} \cdot \frac{d\phi}{df} \qquad \phi \text{ in Degrees}, \ f \text{ in Hz } (\omega = 2\pi f)$$

Figure 4-19

The HP 8753B network analyzer computes group delay from the phase slope. Phase data is used to find the phase change, $\Delta\varphi$, over a specified frequency aperture, Δf, to obtain an approximation for the rate of change of phase with frequency (Figure 4-20). This value, τ_g, represents the group delay in seconds assuming linear phase change over Δf. It is important that $\Delta\varphi$ be $\leq 180°$, or errors will result in the group delay data. These errors can be significant for long delay devices. You can verify that $\Delta\varphi$ is $\leq 180°$ by increasing the number of points or narrowing the frequency span (or both) until the group delay data no longer changes.

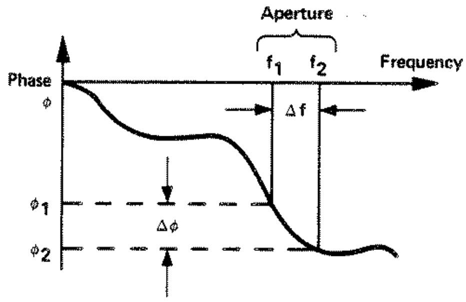


Figure 4-20

When deviations from linear phase are present, changing the frequency step can result in different values for group delay. Note that in this case the computed slope varies as the aperture Δf is increased (Figure 4-21). A wider aperture results in loss of the fine grain variations in group delay. This loss of detail is the reason that in any comparison of group delay data it is important to know the aperture used to make the measurement.

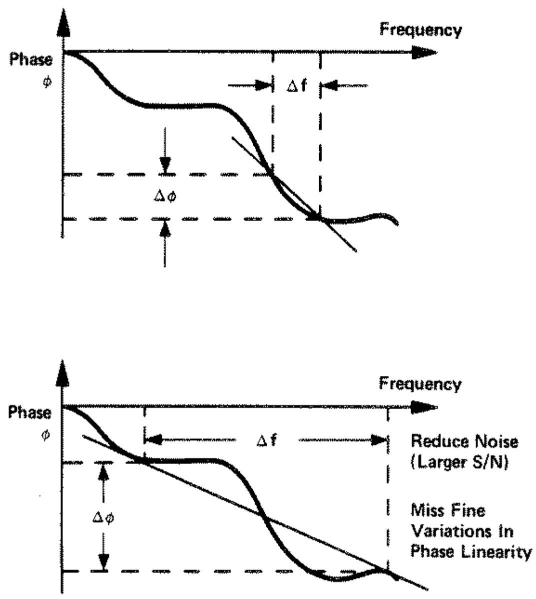


Figure 4-21

In determining the group delay aperture, there is a tradeoff between resolution of fine detail and the effects of noise. Noise can be reduced by increasing the aperture, but this will tend to smooth out the fine detail. More detail will become visible as the aperture is decreased, but the noise will also increase, possibly to the point of obscuring the detail. A good practice is to use a smaller aperture to assure that small variations are not missed, then increase the aperture to smooth the trace.

The default group delay aperture is the frequency span divided by the number of points across the display. To set the aperture to a different value, turn on smoothing in the average menu, and vary the smoothing aperture (see *[AVG] Key*). The aperture can be varied up to 20% of the span swept.

Group delay measurements can be made on linear frequency, log frequency, or list frequency sweep types (not in CW or power sweep). Group delay aperture varies depending on the frequency spacing and point density, therefore the aperture is not constant in log and list frequency sweep modes. In list frequency mode, extra frequency points can be defined to ensure the desired aperture.

To obtain a readout of aperture values at different points on the trace, turn on a marker. Then press **[AVG]** ***[SMOOTHING APERTURE]***. Smoothing aperture becomes the active function, and as the aperture is varied its value in Hz is displayed below the active entry area.

A group delay measurement procedure is provided in the *User's Guide*.

[SCALE REF] KEY

Scale Reference Menu

The **[SCALE REF]** (MENUSCAL) key makes scale per division the active function. A menu is displayed that is used to modify the vertical axis scale and the reference line value and position. In addition this menu provides electrical delay offset capabilities for adding or subtracting linear phase to maintain phase linearity.

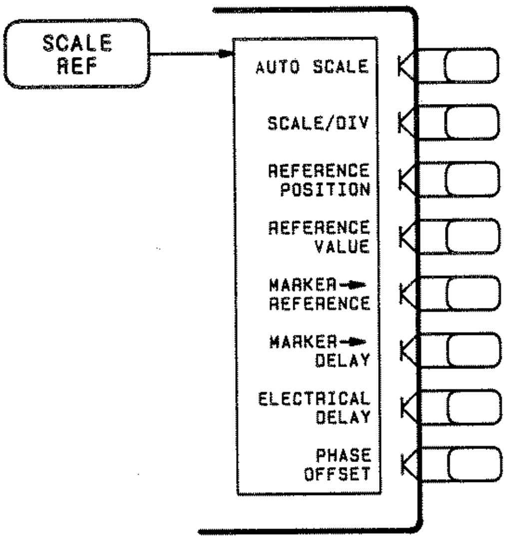


Figure 4-22

[AUTO SCALE] (AUTO) brings the trace data in view on the CRT with one keystroke. Stimulus values are not affected, only scale and reference values. The HP 8753B determines the smallest possible scale factor that will put all displayed data onto 80% of the vertical graticule. The reference value is chosen to put the trace in center screen, then rounded to an integer multiple of the scale factor.

[SCALE/DIV] (SCAL) changes the response value scale per division of the displayed trace. In polar and Smith chart formats, this refers to the full scale value at the outer circumference, and is identical to reference value.

[REFERENCE POSITION] (REFP) sets the position of the reference line on the graticule of a Cartesian display, with 0 the bottom line of the graticule and 10 the top line. It has no effect on a polar or Smith display. The reference position is indicated with a small triangle just outside the graticule, on the left side for channel 1 and the right side for channel 2.

[REFERENCE VALUE] (REFV) changes the value of the reference line, moving the measurement trace correspondingly. In polar and Smith chart formats, the reference value is the same as the scale, and is the value of the outer circle.

[MARKER → REFERENCE] (MARKREF) makes the reference value equal to the active marker's absolute value (regardless of the delta marker value). The marker is effectively moved to the reference line position. This softkey also appears in the marker function menu accessed from the **[MKR FCTN]** key. In polar and Smith chart formats this function makes the full scale value at the outer circle equal to the active marker response value.

[MARKER → DELAY] (MARKDELA) adjusts the electrical delay to balance the phase of the DUT. This is performed automatically, regardless of the format and the measurement being made. Enough line length is added to or subtracted from the receiver input to compensate for the phase slope at the active marker position. This effectively flattens the phase trace around the active marker, and can be used to measure electrical length or deviation from linear phase. Additional electrical delay adjustments are required on DUTs without constant group delay over the measured frequency span. Since this feature adds phase to a variation in phase versus frequency, it is applicable only for ratioed inputs.

[ELECTRICAL DELAY] (ELED) adjusts the electrical delay to balance the phase of the DUT. It simulates a variable length lossless transmission line, which can be added to or removed from a receiver input to compensate for interconnecting cables, etc. This function is similar to the mechanical or analog "line stretchers" of other network analyzers. Delay is annotated in units of time with secondary labeling in distance for the current velocity factor.

With this feature, and with *[MARKER → DELAY]*, an equivalent length of air is added or subtracted according to the following formula:

$$\text{Length (metres)} = \frac{\phi}{\text{F(MHz)} \times 1.20083}$$

Once the linear portion of the DUT's phase has been removed, the equivalent length of air can be read out in the active marker area. If the average relative permittivity (ε_r) of the DUT is known over the frequency span, the length calculation can be adjusted to indicate the actual length of the DUT more closely. This can be done by entering the relative velocity factor for the DUT using the calibrate more menu. The relative velocity factor for a given dielectric can be calculated by:

$$\text{Velocity factor} = 1/\sqrt{\varepsilon_r}$$

assuming a relative permeability of 1.

A procedure for measuring electrical length or deviation from linear phase using the *[ELECTRICAL DELAY]* or *[MARKER → DELAY]* features is provided in the *User's Guide*.

[PHASE OFFSET] (PHAO) adds or subtracts a phase offset that is constant with frequency (rather than linear). This is independent of *[MARKER → DELAY]* and *[ELECTRICAL DELAY]*.

[DISPLAY] KEY

The **[DISPLAY]** (MENUDISP) key provides access to the memory math functions, and other display functions including dual channel display, active channel display title, frequency blanking, and display focus and intensity.

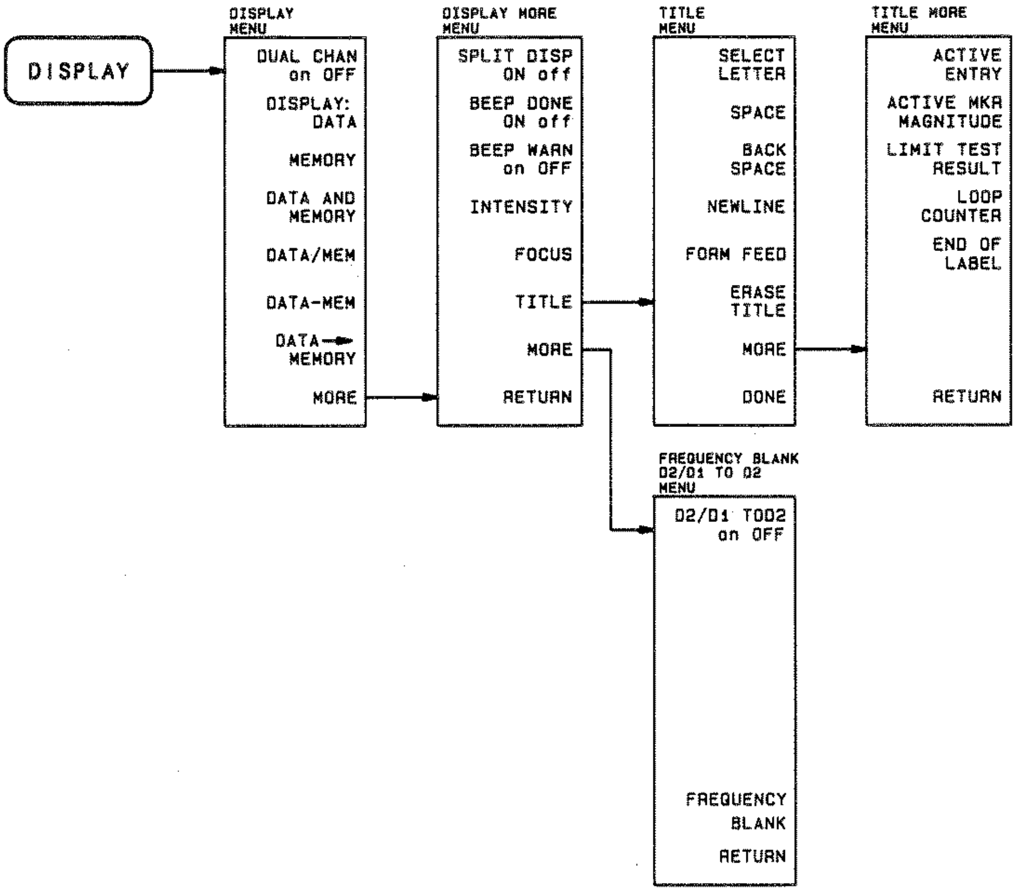


Figure 4-23. Softkey Menus Accessed from the [DISPLAY] Key

Display Menu

This menu provides trace math capabilities for manipulating data, as well as the capability of displaying both channels simultaneously, either overlaid or split.

The HP 8753B has two available memory traces, one per channel. Memory traces are totally channel dependent: channel 1 cannot access the channel 2 memory trace or vice versa. Memory traces can be saved with instrument states: one memory trace can be saved per channel per saved instrument state. Five save/recall registers are available for each channel, so the total number of memory traces that can be saved is 12 including the two active for the current instrument state. The memory data is stored as full precision, complex data. (Refer to Chapter 10.)

Two trace math operations are implemented, data/memory and data-memory. (Note that normalization is data/memory not data-memory.) Memory traces are saved and recalled and trace math is done immediately after error correction. This means that any additional post-processing done after error correction, including parameter conversion, time domain transformation (option 010), scaling, etc., can be performed on the memory trace. (Refer to *HP 8753B Data Processing* in Chapter 1.) Trace math can also be used as a simple means of error correction, although that is not its main purpose.

All data processing operations that occur after trace math, except smoothing and gating, are identical for the data trace and the memory trace. If smoothing or gating is on when a memory trace is saved, this state is maintained regardless of the data trace smoothing or gating status. If a memory trace is saved with gating or smoothing on, these features can be turned on or off in the memory-only display mode.

The actual memory for storing a memory trace is allocated only as needed. The memory trace is cleared on instrument preset, power on, or instrument state recall.

If sweep mode or sweep range is different between the data and memory traces, trace math is allowed, and no warning message is displayed. If the number of points in the two traces is different, the memory trace is not displayed nor rescaled. However, if the number of points for the data trace is changed back to the number of points in the memory, the memory trace can then be displayed.

If trace math or display memory is requested and no memory trace exists, the message "CAUTION: NO VALID MEMORY TRACE" is displayed.

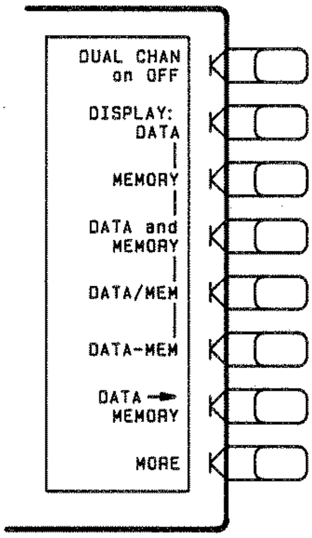


Figure 4-24. Display Menu

[DUAL CHAN on OFF] (DUACON, DUACOFF) toggles between display of both measurement channels or the active channel only. This is used in conjunction with ***[SPLIT DISP ON off]*** in the display more menu to display both channels. With ***[SPLIT DISP OFF]*** the two traces are overlaid on a single graticule (Figure 4-25 part a); with ***[SPLIT DISP ON]*** the measurement data is displayed on two half-screen graticules one above the other (Figure 4-25 part b). Current parameters for the two displays are annotated separately.

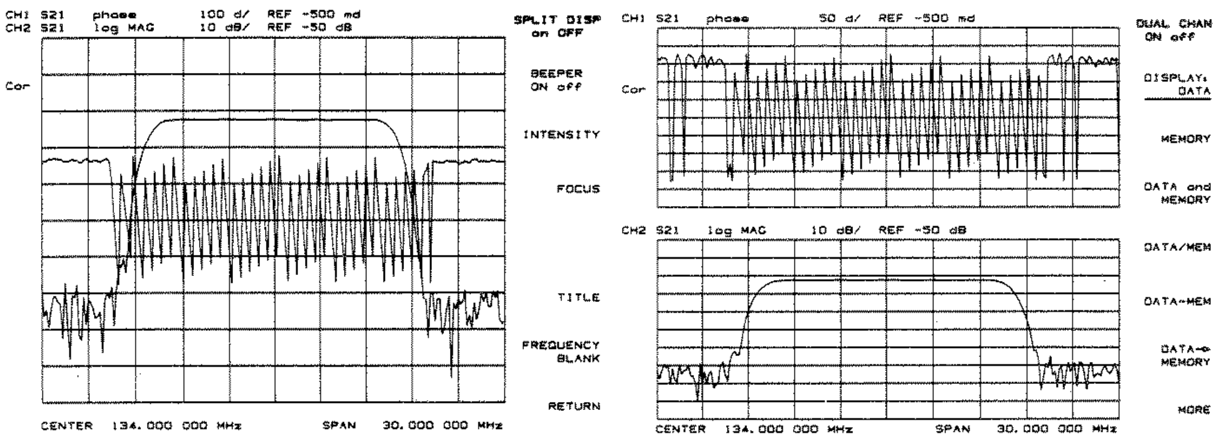
The stimulus functions of the two channels can also be controlled independently using ***[COUPLED CH ON]*** in the stimulus menu. In addition, the markers can be controlled independently for each channel using ***[MARKERS: UNCOUPLED]*** in the marker mode menu.

If the Measurement does not Function Properly in Dual Channel Mode. If you have decoupled channels 1 and 2, and are using dual channel, there are two measurement configurations which may not appear to function "properly".

The two configurations, shown below, would cause repeated switching of either the test port transfer switch or the step attenuator. To avoid premature wearing out of these mechanical devices, the test set will not allow such measurements to occur without direct intervention by the operator. The two affected measurement conditions are:

- If channel 1 is driving one test port and channel 2 is driving the other. For example, you are making an S_{21} measurement on channel 1 and an S_{12} measurement on channel 2. This configuration, if allowed unchecked, would cause the test port transfer switch to continually cycle.
- Channel 1 requires one attenuation value, and channel 2 requires a different value. Since one attenuator is used for both test ports, this would cause the attenuator to continuously switch settings.

If either of the above conditions exist, the test set hold mode will engage, and the status notation "tsH" will appear on the left side of the screen. The hold mode may be overridden by either the ***[MEASUREMENT RESTART]*** or ***[NUMBER OF GROUPS]*** softkeys, described in Chapter 3, *Stimulus Function Block*. For more information, refer to *Test Set Attenuator, Test Port Transfer Switch, and Doubler Switch Protection*, in the beginning of Chapter 3.



(a) Overlaid Traces *(b) Split Display*

Figure 4-25. Dual Channel Displays

[DISPLAY: DATA] (DISPDATA) displays the current measurement data for the active channel.

[MEMORY] (DISPMEMO) displays the trace memory for the active channel. This is the only memory display mode where the smoothing and gating of the memory trace can be changed. If no data has been stored in memory for this channel, a warning message is displayed.

[DATA and MEMORY] (DISPDATM) displays both the current data and memory traces.

[DATA/MEM] (DISPDDM) divides the data by the memory, normalizing the data to the memory, and displays the result. This is useful for ratio comparison of two traces, for instance in measurements of gain or attenuation.

[DATA — MEM] (DISPDMM) subtracts the memory from the data. The vector subtraction is performed on the complex data. This is appropriate for storing a measured vector error, for example directivity, and later subtracting it from the device measurement.

[DATA → MEMORY] (DATI) stores the current active measurement data in the memory of the active channel. It then becomes the memory trace, for use in subsequent math manipulations or display. If a parameter has just been changed and the * status notation is displayed at the left of the CRT, the data is not stored in memory until a clean sweep has been executed. The gating and smoothing status of the trace are stored with the measurement data.

[MORE] leads to the display more menu.

Display More Menu

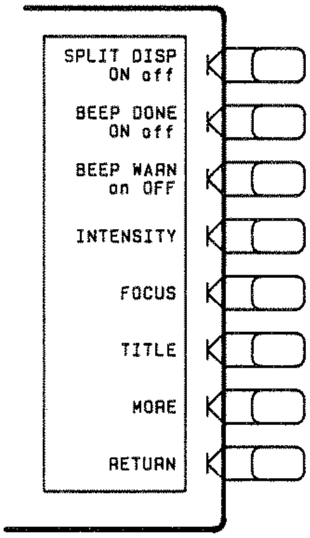


Figure 4-26. Display More Menu

[SPLIT DISP on OFF] (SPLDON, SPLDOFF) toggles between a full-screen single graticule display of one or both channels, and a split display with two half-screen graticules one above the other. Both displays are illustrated in Figure 4-25. The split display can be used in conjunction with *[DUAL CHAN ON]* in the display menu to show the measured data of each channel simultaneously on separate graticules. In addition, the stimulus functions of the two channels can be controlled independently using *[COUPLED CH ON]* in the stimulus menu. The markers can also be controlled independently for each channel using *[MARKERS: UNCOUPLED]* in the marker mode menu.

[BEEP DONE ON off] (BEEPDONEON, BEEPDONEOFF) toggles an annunciator which sounds to indicate completion of certain operations such as calibration or instrument state save.

[BEEP WARN on OFF] (BEEPWARNON, BEEPWARNOFF) toggles the warning annunciator. When the annunciator is on it sounds a warning when a cautionary message is displayed.

[INTENSITY] (INTE) sets the CRT intensity as a percent of the brightest setting. The factory-set default value is stored in non-volatile memory.

[FOCUS] (FOCU) sets the CRT focus as a percent of the maximum focus voltage. The factory-set default value is stored in non-volatile memory.

[TITLE] (TITL) presents the title menu in the softkey labels area and the character set in the active entry area. These are used to label the active channel display. A title more menu allows up to four values to be included in the printed title; active entry, active marker amplitude, limit test results, and loop counter value.

[MORE] goes to the "frequency blank, D2/D1 to D2 menu"

[RETURN] goes back to the display menu.

Frequency Blank, D2/D1 to D2 Menu

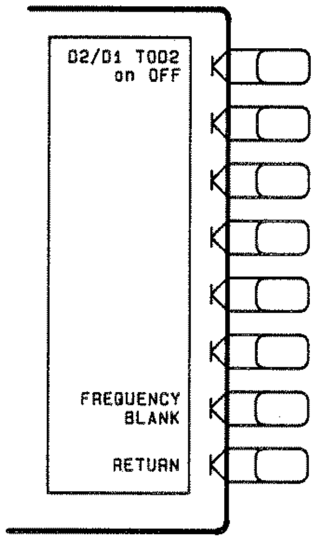


Figure 4-27. Frequency Blank, D2/D1 to D2 Menu

[FREQUENCY BLANK] (FREO) blanks the displayed frequency notation for security purposes. Frequency labels cannot be restored except by instrument preset or turning the power off and then on.

[D2/D1 toD2] (D1DIVD2) this math function ratios channels 1 and 2, and puts the results in the channel 2 data array. Both channels must be on and have the same number of points. This feature is particularly useful for making harmonic measurements in an HP 8753B equipped with option 002. With the fundamental frequency displayed on channel 1 and the measured harmonic on channel 2, this key displays the relative amplitude of the harmonic with respect to the fundamental.

[RETURN] goes back to the display menu.

Title Menu

Use this menu to specify a title for the active channel. The title identifies the display regardless of stimulus or response changes, and is printed or plotted with the data. If the display is saved in a register with the instrument state, the title is saved with it.

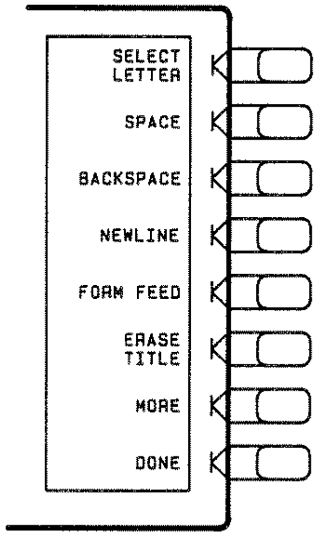


Figure 4-28. Title Menu

[SELECT LETTER]. The active entry area displays the letters of the alphabet, digits 0 through 9, and mathematical symbols. To define a title, rotate the knob until the arrow ↑ points at the first letter, then press ***[SELECT LETTER]***. Repeat this until the complete title is defined, for a maximum of 50 characters. As each character is selected, it is appended to the title at the top of the graticule.

[SPACE] inserts a space in the title.

[BACK SPACE] deletes the last character entered.

[NEWLINE] sends a new line command to the printer.

[FORM FEED] advances the printer paper to the next page.

[ERASE TITLE] deletes the entire title.

[MORE] leads to the title more menu.

[DONE] terminates the title entry, and returns to the display more menu.

Title More Menu

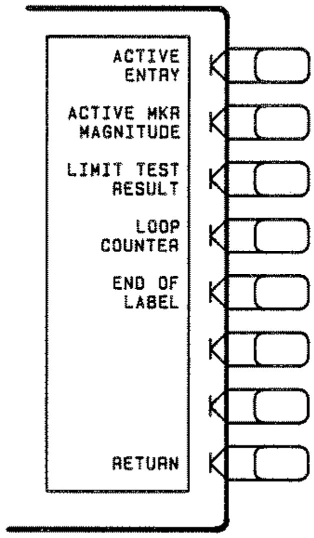


Figure 4-29. Title More Menu

The following softkeys cause the named data to be printed out with the title. This is especially useful when used with the test sequence function, described in Chapter 13.

[ACTIVE ENTRY] prints the name of the active entry.

[ACTIVE MRK AMPLITUDE] prints the active marker amplitude.

[LIMIT TEST RESULT] prints the result of a limit test.

[LOOP COUNTER] prints the current value of the loop counter. Refer to chapter 13.

[END OF LABEL] terminates the HP-GL "LB" command. Refer to chapter 13.

[RETURN] returns to the previous menu.

[AVG] KEY

The **[AVG]** (MENUAVG) key is used to access three different noise reduction techniques: sweep-to-sweep averaging, display smoothing, and variable IF bandwidth. Any or all of these can be used simultaneously. Averaging and smoothing can be set independently for each channel, and the IF bandwidth can be set independently if the stimulus is uncoupled.

Averaging computes each data point based on an exponential average of consecutive sweeps weighted by a user-specified averaging factor. Each new sweep is averaged into the trace until the total number of sweeps is equal to the averaging factor, for a fully averaged trace. Each point on the trace is the vector sum of the current trace data and the data from the previous sweep. A high averaging factor gives the best signal-to-noise ratio, but slows down the trace update time. Doubling the averaging factor reduces the noise by 3 dB. Averaging is used for ratioed measurements: if it is attempted for a single-input measurement (e.g. A or B), the message "CAUTION: AVERAGING INVALID ON NON-RATIO MEASURE" is displayed. Figure 4-30 illustrates the effect of averaging on a log magnitude format trace.

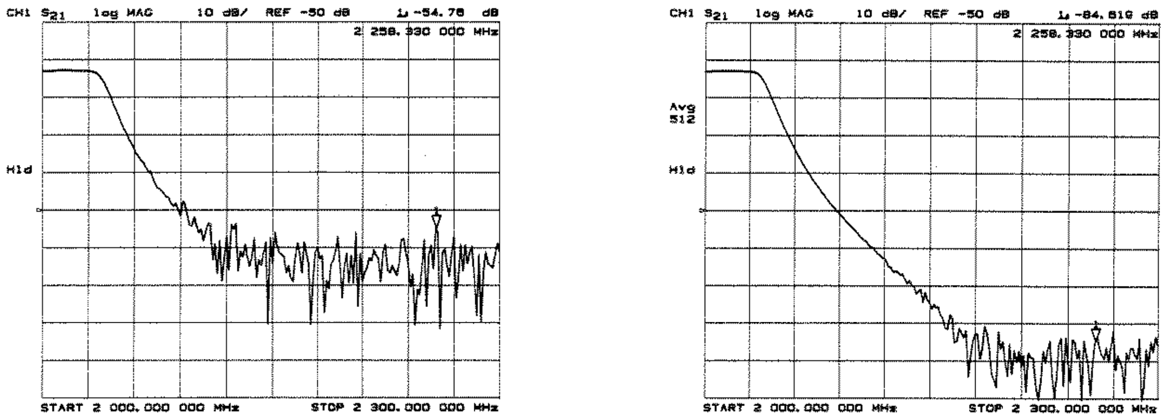


Figure 4-30. Effect of Averaging on a Trace

Smoothing (similar to video filtering) averages the formatted active channel data over a portion of the displayed trace. Smoothing computes each displayed data point based on one sweep only, using a moving average of several adjacent data points for the current sweep. The smoothing aperture is a percent of the stimulus span swept, up to a maximum of 20%.

Rather than lowering the noise floor, smoothing finds the mid-value of the data. Use it to reduce relatively small peak-to-peak noise values on broadband measured data. Use a sufficiently high number of display points to avoid misleading results. Do not use smoothing for measurements of high resonance devices or other devices with wide variations in trace, as it will introduce errors into the measurement.

Smoothing is used with Cartesian and polar display formats. It is also the primary way to control the group delay aperture, given a fixed frequency span (refer to *Group Delay Principles* earlier in this chapter). In polar display format, large phase shifts over the smoothing aperture will cause shifts in amplitude, since a vector average is being computed. Figure 4-31 illustrates the effect of smoothing on a log magnitude format trace.

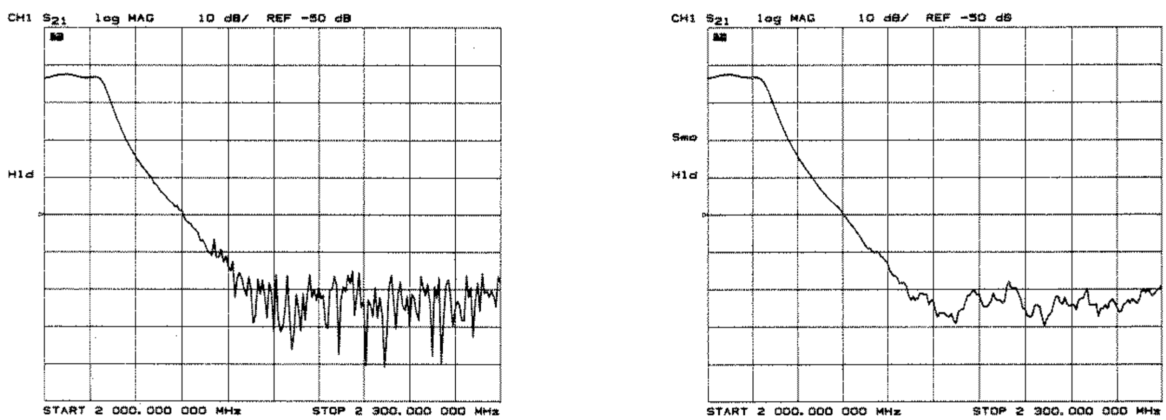


Figure 4-31. Effect of Smoothing on a Trace

IF Bandwidth Reduction lowers the noise floor by digitally reducing the receiver input bandwidth, and works in all ratio and non-ratio modes. It has an advantage over averaging in reliably filtering out unwanted responses such as spurs, odd harmonics, higher frequency spectral noise, and line-related noise. Sweep-to-sweep averaging, however, is better at filtering out very low frequency noise. A tenfold reduction in IF bandwidth lowers the measurement noise floor by about 10 dB. Bandwidths less than 300 Hz provide better harmonic rejection than higher bandwidths.

Another difference between sweep-to-sweep averaging and variable IF bandwidth is the sweep time. Averaging displays the first complete trace faster but takes several sweeps to reach a fully averaged trace. IF bandwidth reduction lowers the noise floor in one sweep, but the sweep time may be slower. Figure 4-32 illustrates the difference in noise floor between a trace measured with a 3000 Hz IF bandwidth and with a 10 Hz IF bandwidth.

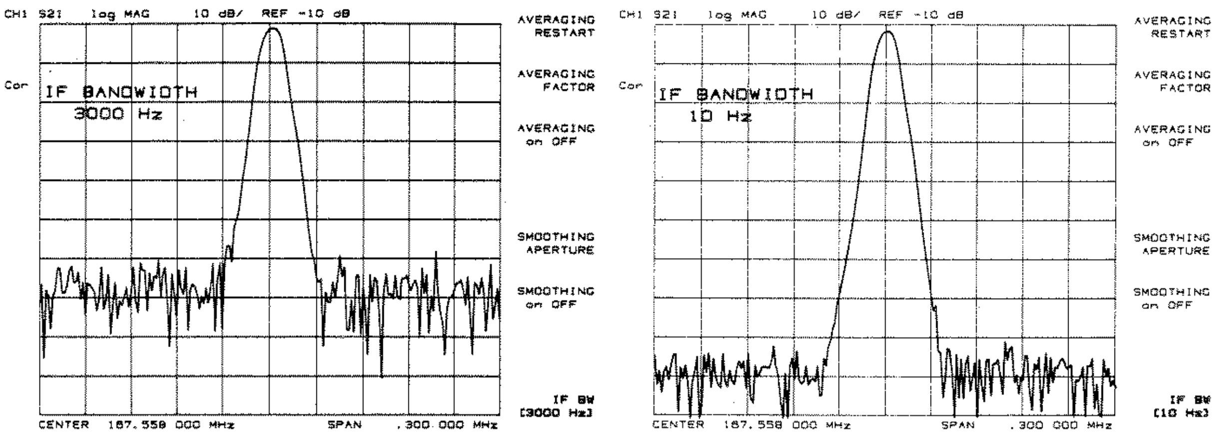


Figure 4-32. IF Bandwidth Reduction

Another capability that can be used for effective noise reduction is the marker statistics function, which computes the average value of part or all of the formatted trace. Refer to Chapter 6.

Another way of increasing dynamic range is to increase the input power to the device under test using an HP 8347A amplifier. Refer to the *User's Guide* for an example.

Average Menu

The average menu (Figure 4-33) is used to select the desired noise-reduction technique, and to set the parameters for the technique selected. It is also used to set the aperture for group delay measurements.

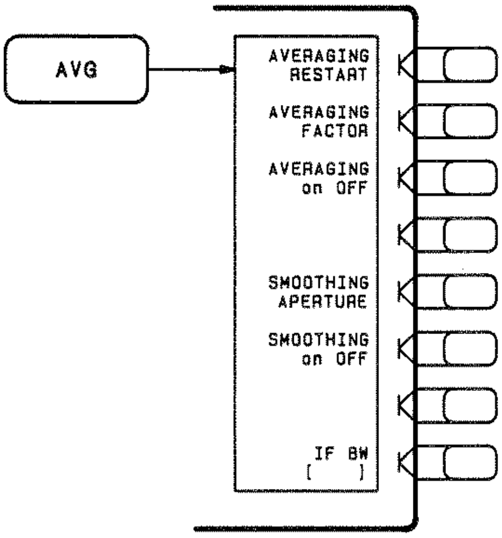


Figure 4-33. Average Menu

[AVERAGING RESTART] (AVERREST) resets the sweep-to-sweep averaging and restarts the sweep count at 1 at the beginning of the next sweep. The sweep count for averaging is displayed at the left of the CRT.

[AVERAGING FACTOR] (AVERFACT) makes averaging factor the active function. Any value up to 999 can be used. The algorithm used for averaging is:

$$A(n) = S(n)/F + (1-1/F) \times A(n-1)$$

where

A(n) = current average
S(n) = current measurement
F = average factor

[AVERAGING on OFF] (AVERON, AVEROFF) turns the averaging function on or off for the active channel. "Avg" is displayed in the status notations area at the left of the CRT, together with the sweep count for the averaging factor, when averaging is on. The sweep count for averaging is reset to 1 whenever an instrument state change affecting the measured data is made.

At the start of averaging or following ***[AVERAGING RESTART]***, averaging starts at 1 and averages each new sweep into the trace until it reaches the specified averaging factor. The sweep count is displayed in the status notations area below "Avg" and updated every sweep as it increments. When the specified averaging factor is reached, the trace data continues to be updated, weighted by that averaging factor.

[SMOOTHING APERTURE] (SMOOAPER) lets you change the value of the smoothing aperture as a percent of the span. When smoothing aperture is the active function, its value in stimulus units is displayed below its percent value in the active entry area.

Smoothing aperture is also used to set the aperture for group delay measurements (refer to *Group Delay Principles* earlier in this chapter). Note that the displayed smoothing aperture is not the group delay aperture unless smoothing is on.

[SMOOTHING on OFF] (SMOOON, SMOOOFF) turns the smoothing function on or off for the active channel. When smoothing is on, the annotation "Smo" is displayed in the status notations area.

[IF BW] (IFBW) is used to select the bandwidth value for IF bandwidth reduction. Settable values (in Hz) are 3000, 1000, 300, 100, 30, and 10. Any other value will default to the next allowable value. A narrow bandwidth slows the sweep speed but provides better signal-to-noise ratio. The selected bandwidth value is shown in brackets in the softkey label.

Chapter 5. Measurement Calibration

CHAPTER CONTENTS

INTRODUCTION

Measurement calibration is an accuracy enhancement procedure that effectively removes the system errors that cause uncertainty in measuring a device under test. It measures known standard devices, and uses the results of these measurements to characterize the system.

This chapter explains the theoretical fundamentals of accuracy enhancement and the sources of measurement errors. It describes the different measurement calibration procedures available in the HP 8753B, which errors they correct, and the measurements for which each should be used. An appendix at the end of this chapter provides further information on characterizing systematic errors and using error models to analyze overall measurement performance.

ACCURACY ENHANCEMENT

If it were possible for a perfect measurement system to exist, it would have infinite dynamic range, isolation, and directivity characteristics, no impedance mismatches in any part of the test setup, and flat frequency response. Vector accuracy enhancement, also known as measurement calibration or error correction, provides the means to simulate a perfect measurement system.

In any high frequency measurement there are certain measurement errors or ambiguities associated with the system that contribute uncertainty to the results. Parts of the measurement setup such as interconnecting cables and signal separation devices (as well as the network analyzer itself) all introduce variations in magnitude and phase that can mask the actual performance of the device under test.

For example, crosstalk due to the channel isolation characteristics of the network analyzer can contribute an error equal to the transmission signal of a high-loss test device. Similarly, for reflection measurements, the primary limitation of dynamic range is the directivity of the test setup. The measurement system cannot distinguish the true value of the signal reflected by the device under test from the signal arriving at the receiver input due to leakage in the system. For both transmission and reflection measurements, impedance mismatches within the test setup cause measurement uncertainties that appear as ripples superimposed on the measured data.

Measurement calibration simulates a perfect network analyzer system. It measures the magnitude and phase responses of known standard devices, and compares the measurement with actual device data. It uses the results to characterize the system and effectively remove the system errors from the measurement data of a test device, using vector math capabilities internal to the network analyzer.

When measurement calibration is used, the dynamic range and accuracy of the measurement are limited only by system noise and stability, connector repeatability, and the accuracy to which the characteristics of the calibration standards are known.

SOURCES OF MEASUREMENT ERRORS

Network analysis measurement errors can be separated into systematic, random, and drift errors.

Correctable systematic errors are the repeatable errors that the system can measure. These are errors due to mismatch and leakage in the test setup, isolation between the reference and test signal paths, and system frequency response.

Random and drift errors are the non-repeatable errors that the system itself cannot measure, and therefore cannot correct for. These errors affect both reflection and transmission measurements. Random errors are measurement variations due to noise and connector repeatability. Drift errors include frequency drift, temperature drift, and other physical changes in the test setup between calibration and measurement.

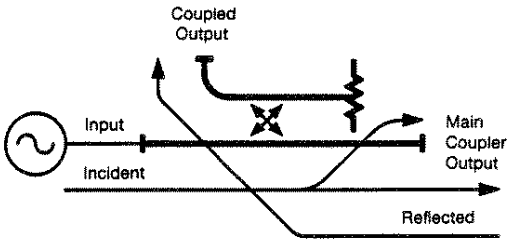
The resulting measurement is the vector sum of the device under test response plus all error terms. The precise effect of each error term depends upon its magnitude and phase relationship to the actual test device response.

In most high frequency measurements the systematic errors are the most significant source of measurement uncertainty. Since each of these errors can be characterized, their effects can be effectively removed to obtain a corrected value for the test device response. For the purpose of vector accuracy enhancement these uncertainties are quantified as directivity, source match, load match, isolation (crosstalk), and frequency response (tracking). Each of these systematic errors is described below.

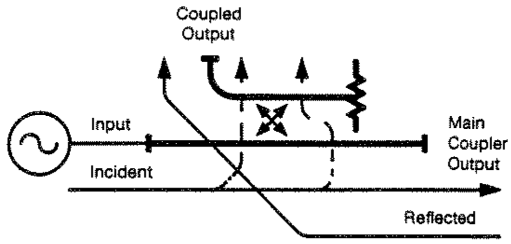
Random and drift errors cannot be precisely quantified, so they must be treated as producing a cumulative ambiguity in the measured data.

Directivity

Normally a device that can separate the reverse from the forward traveling waves (a directional bridge or coupler) is used to detect the signal reflected from the device under test. Ideally the coupler would completely separate the incident and reflected signals, and only the reflected signal would appear at the coupled output, as illustrated in Figure 5-1a.



(a) Ideal Coupler



(b) Real Coupler

Figure 5-1. Directivity

However, a real coupler is not perfect, as illustrated in Figure 5-1b. A small amount of the incident signal appears at the coupled output due to leakage as well as to reflection from the termination in the coupled arm. Also reflections from the coupler output connector appear at the coupled output, adding uncertainty to the signal reflected from the device. The figure of merit for how well a coupler separates forward and reverse waves is directivity. The greater the directivity of the device, the better the signal separation. System directivity is the vector sum of all leakage signals appearing at the network analyzer receiver input due to the inability of the signal separation device to absolutely separate incident and reflected waves, and to residual reflection effects of test cables and adapters between the signal separation device and the measurement plane. The error contributed by directivity is independent of the characteristics of the test device and it usually produces the major ambiguity in measurements of low reflection devices.

Source Match

Source match is defined as the vector sum of signals appearing at the network analyzer receiver input due to the impedance mismatch at the test device looking back into the source, as well as to adapter and cable mismatches and losses. In a reflection measurement, the source match error signal is caused by some of the reflected signal from the DUT being reflected from the source back towards the DUT and re-reflected from the DUT (Figure 5-2). In a transmission measurement, the source match error signal is caused by reflection from the test device that is re-reflected from the source. Source match is most often given in terms of return loss in dB: thus the larger the number, the smaller the error.

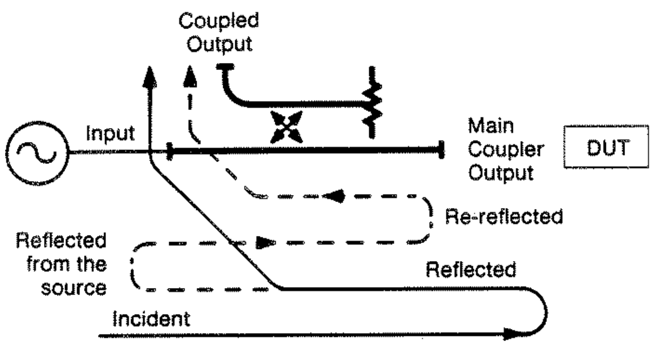


Figure 5-2. Source Match

The error contributed by source match is dependent on the relationship between the actual input impedance of the test device and the equivalent match of the source, and it is a factor in both transmission and reflection measurements. Source match is particularly a problem in measurements where there is a large impedance mismatch at the measurement plane.

Load Match

Load match error results from an imperfect match at the output of the test device. It is caused by impedance mismatches between the test device output port and port 2 of the measurement system. As illustrated in Figure 5-3, some of the transmitted signal is reflected from port 2 back to the test device. A portion of this wave may be re-reflected to port 2, or part may be transmitted through the device in the reverse direction to appear at port 1. If the DUT has low insertion loss (for example a transmission line), the signal reflected from port 2 and re-reflected from the source causes a significant error because the DUT does not attenuate the signal significantly on each reflection. Load match is usually given in terms of return loss in dB: thus the larger the number, the smaller the error

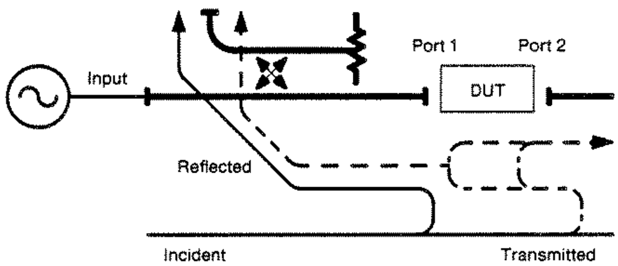


Figure 5-3. Load Match

The error contributed by load match is dependent on the relationship between the actual output impedance of the test device and the effective match of the return port (port 2), and is a factor in all transmission measurements and in reflection measurements of two-port devices. Load and source match are usually ignored when the test device insertion loss is greater than about 6 dB, because the error signal is greatly attenuated each time it passes through the DUT. However, load match effects produce major transmission measurement errors for a test device with a highly reflective output port.

Isolation (Crosstalk)

Leakage of energy between network analyzer signal paths contributes to error in a transmission measurement much like directivity does in a reflection measurement. Isolation is the vector sum of signals appearing at the network analyzer samplers due to crosstalk between the reference and test signal paths, including signal leakage within the test set and in both the RF and IF sections of the receiver.

The error contributed by isolation depends on the characteristics of the device under test. Isolation is a factor in high-loss transmission measurements. However, HP 8753B system isolation is more than sufficient for most measurements, and correction for it may be unnecessary. For measuring devices with high dynamic range, accuracy enhancement can provide improvements in isolation that are limited only by the noise floor.

Frequency Response (Tracking)

This is the vector sum of all test setup variations in which magnitude and phase change as a function of frequency. This includes variations contributed by signal separation devices, test cables, and adapters, and variations between the reference and test signal paths. This error is a factor in both transmission and reflection measurements.

For further explanation of systematic error terms and the way they are combined and represented graphically in error models, refer to the appendix at the end of this chapter, titled *Accuracy Enhancement Fundamentals – Characterizing Microwave Systematic Errors*.

CORRECTING FOR MEASUREMENT ERRORS

In all, there are twelve different error terms for a two-port measurement that can be corrected by accuracy enhancement in the HP 8753B. These are directivity, source match, load match, isolation, reflection tracking, and transmission tracking, each in both the forward and reverse direction. The HP 8753B has several different measurement calibration routines to characterize one or more of the systematic error terms and remove their effects from the measured data. The procedures range from a simple frequency response calibration to a full two-port calibration that effectively removes all twelve error terms.

The Response Calibration effectively removes the frequency response errors of the test setup for reflection or transmission measurements. This calibration procedure may be adequate for measurement of well matched low-loss devices. This is the simplest error correction to perform, and should be used when extreme measurement accuracy is not required.

The Response and Isolation Calibration effectively removes frequency response and crosstalk errors in transmission measurements, or frequency response and directivity errors in reflection measurements. This procedure may be adequate for measurement of well matched high-loss devices.

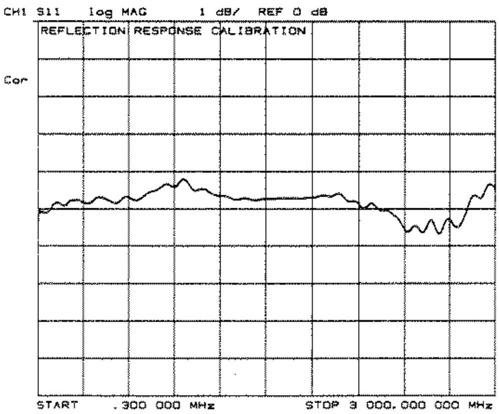
The S_{11} and S_{22} One-Port Calibration procedures provide directivity, source match, and frequency response vector error correction for reflection measurements. These procedures provide high accuracy reflection measurements of one-port devices or properly terminated two-port devices.

The Full Two-Port Calibration provides directivity, source match, load match, isolation, and frequency response vector error correction, in both forward and reverse directions, for transmission and reflection measurements of two-port devices. This calibration provides the best magnitude and phase measurement accuracy for both transmission and reflection measurements of two-port devices, and requires an S-parameter test set.

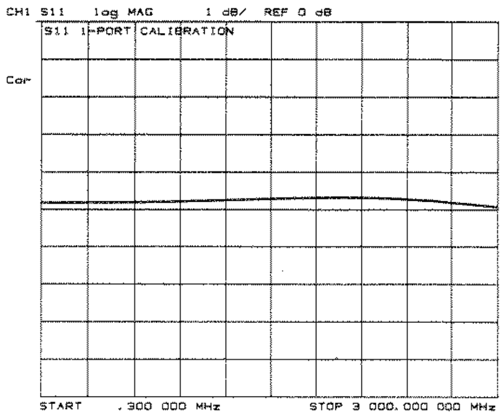
The One-Path Two-Port Calibration provides directivity, source match, load match, isolation, and frequency response vector error correction in one direction. It is used for high accuracy transmission and reflection measurements using a transmission/reflection test set, such as the HP 85044A. (The device under test must be manually reversed between sweeps to accomplish measurements in both the forward and reverse directions.)

All the calibration procedures described above are accessed from the **[CAL]** key and are described in the following pages.

The uncorrected performance of the HP 8753B is sufficient for many measurements. However, the vector accuracy enhancement techniques described in this chapter will provide a much higher level of accuracy. Figures 5-4, 5-5, and 5-6 illustrate the improvements that can be made in measurement accuracy by using a more complete calibration routine. Figure 5-4a shows a measurement in log magnitude format with a response calibration only. Figure 5-4b shows the improvement in the same measurement using an S_{11} one-port calibration. Figure 5-5a shows the measurement on a Smith chart with response calibration only, and Figure 5-5b shows the same measurement with an S_{11} one-port calibration.

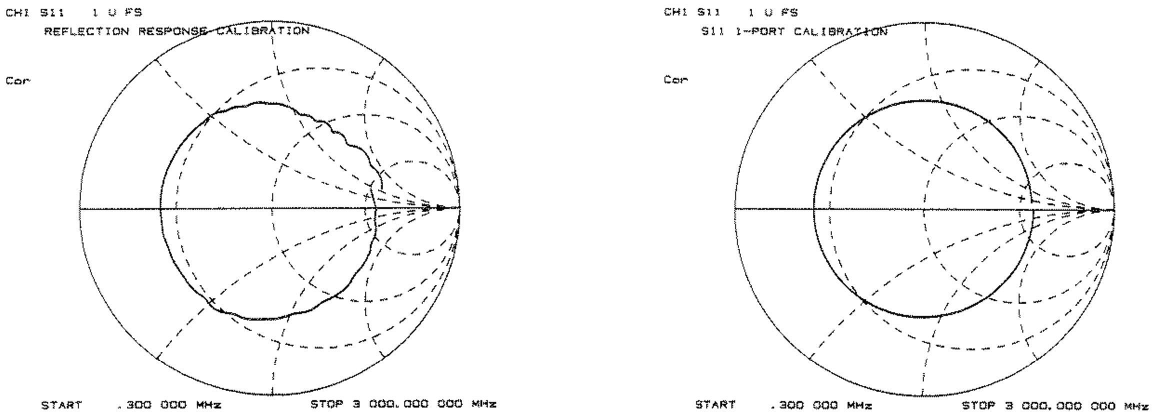


(a)



(b)

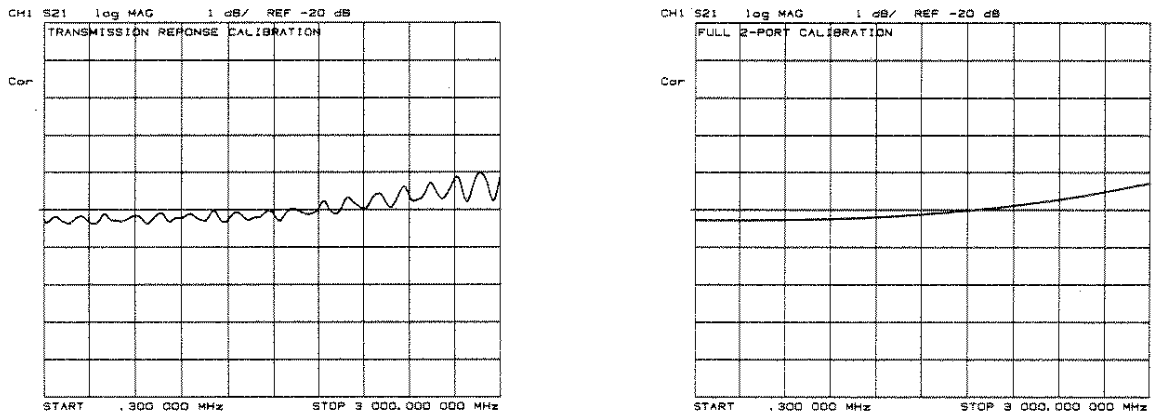
Figure 5-4. Response vs. S_{11} 1-Port Calibration on Log Magnitude Format



(a) *(b)*

Figure 5-5. Response vs. S_{11} 1-Port Calibration on Smith Chart

Figure 5-6 shows the response of a low-loss device in a log magnitude format, using a response calibration in Figure 5-6a and a full two-port calibration in Figure 5-6b.



(a) *(b)*

Figure 5-6. Response vs. Full Two-Port Calibration

After the correctable systematic errors are effectively removed using accuracy enhancement, residual uncertainties remain. In addition to random and drift errors, these include residual systematic errors resulting from imperfections in the calibration standards, the connector interface, the interconnecting cables, and the instrumentation. Refer to *System Performance* in the *General Information and Specifications* section of this manual. This provides information for calculating the system's total error-corrected measurement uncertainty performance.

Why, After Calibration, Does the Frequency Response of Some Calibration Standards Appear as a Curve Rather Than a Dot?

In order for the response of a reference standard to show as a dot on the display, it must have no phase shift with respect to frequency. Standards that exhibit such "perfect" response are shown below:

7 mm short (with no offset)
type-N male short (with no offset)

There are two reasons why other types of reference standards show phase shift after calibration:

- The reference plane of the standard is electrically offset from the mating plane of the test port. Such devices exhibit the properties of a small length of transmission line, including a certain amount of phase shift.
- The standard is an open termination, which by definition exhibits a certain amount of fringe capacitance (and therefore phase shift). Open terminations which are offset from the mating plane will exhibit a phase shift due to the offset in addition to the phase shift caused by the fringe capacitance.

The most important point to remember is that these properties will not affect your measurements. The HP 8753B compensates for them during measurement. Figure 5-7 shows sample displays of various calibration standards after calibration.

Electrical Offset. Some standards have reference planes that are electrically offset from the mating plane of the test port. These devices will show a phase shift with respect to frequency. The master reference table (Table 5-1) shows which reference devices exhibit an electrical offset phase shift. The amount of phase shift can be calculated with the formula:

φ = (360 x f x l)/c where:

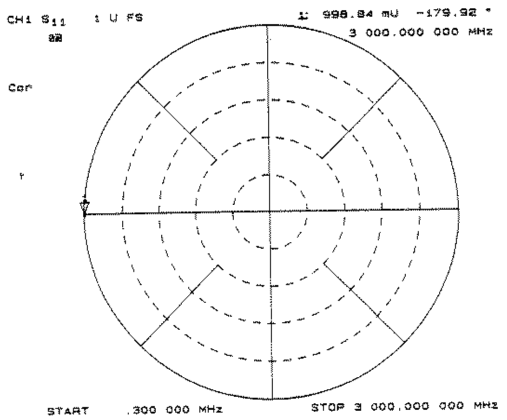
f = frequency
l = electrical length of the offset
c = speed of light (3×10^8 meters/second).

Fringe Capacitance. All open circuit terminations exhibit a phase shift over frequency due to fringe capacitance. And offset open circuits additionally have increased phase shift because the offset acts as a small length of transmission line. Refer to the master reference table.

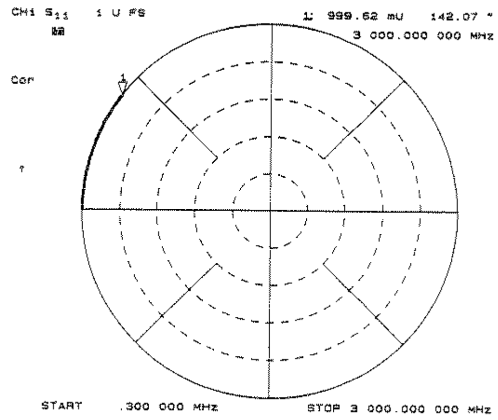
Table 5-1. Master Reference Table Showing Calibration Standard Types and Expected Phase Shift

Test Port Connector Type	Standard Type	Expected Phase Shift
7 mm type-N male	Short	180° (ideal)
3.5 mm male 3.5 mm female type-N female	Offset Short	180°+(360 x f x l)/c
7 mm type-N male	Open	$0° + \varphi_{capacitance}$
3.5 mm male 3.5 mm female type-N female	Offset Open	$0° + \varphi_{capacitance}$ +(360 x f x l)/c

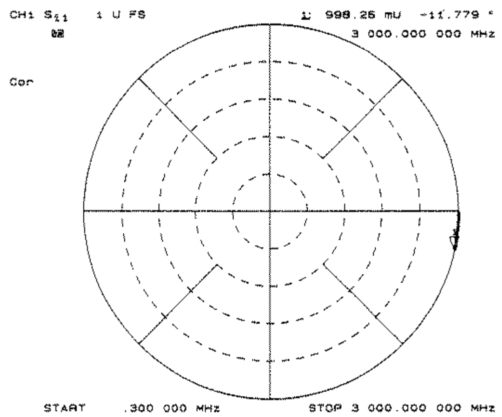
NOTE: The sex associated with a reference standard refers to the sex of the test port, not the sex of the standard itself.



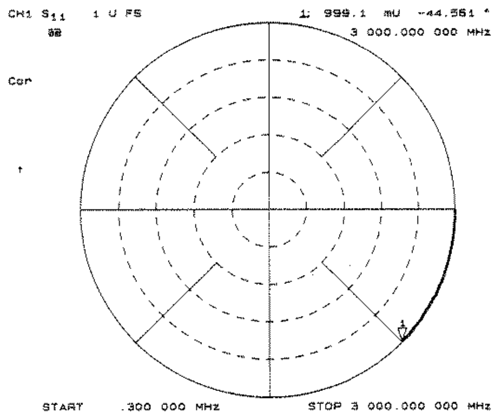
7 mm or Type-N Male
Short (No Offset)



Type-N Female,
3.5 mm Male or Female Offset Short



7 mm or Type-N Male
Open (No Offset)



Type-N Female,
3.5 mm Male or Female Offset Open

Figure 5-7. Typical Responses of Calibration Standards after Calibration

MENUS AND SOFTKEYS

[CAL] Key

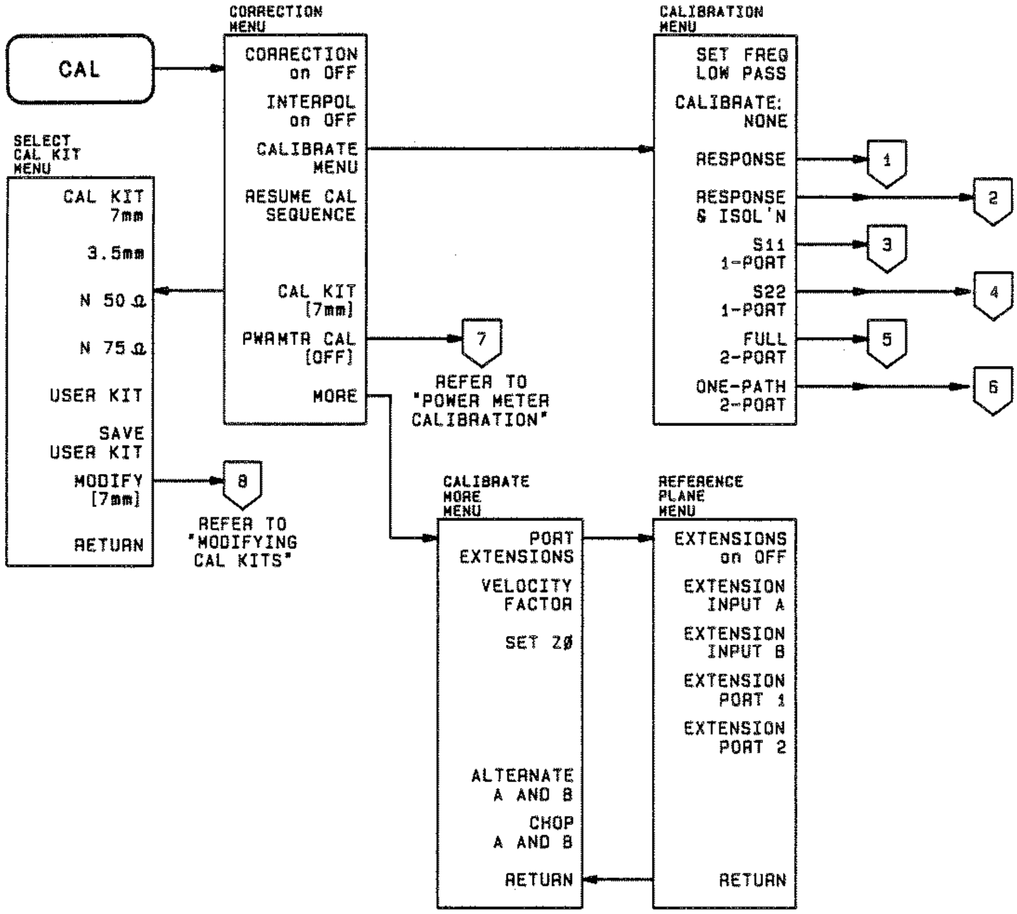


Figure 5-8. Relationship of the Menus Accessed from the [CAL] Key

The **[CAL]** (MENUCAL) key leads to a series of menus that implement the accuracy enhancement procedures described in the preceding pages (see Figure 5-8). Accuracy enhancement (error correction) is performed as a calibration step before measurement of a test device. The HP 8753B uses one of several different procedures to measure the systematic (repeatable) errors of the system and remove their effects from the measured data. The calibration menus and procedures are described and illustrated in the following pages. Each procedure compensates for one or more of the systematic error terms. These range from a simple response calibration that removes the frequency response errors of the test setup to a full two-port vector calibration that removes all twelve error terms. Measurements of standard devices are used to solve for the error terms.

Standard Devices. The standard devices required for calibration of the HP 8753B system are available in compatible calibration kits with different connector types. The model numbers and contents of these calibration kits are listed in the *General Information and Specifications* section of this manual. Each kit contains at least one short circuit, one open circuit, and two impedance-matched loads. In kits that require adapters for interface to the test set ports, the adapters are phase-matched for calibration prior to measurement of non-insertable and non-reversible devices. Other standard devices can be used by specifying their characteristics in a user-defined kit, as described later in this chapter under *Modifying Calibration Kits*.

The accuracy improvement of the correction is limited by the quality of the standard devices, and by the connection techniques used. For information about connector care and connection techniques, refer to the *Microwave Connector Care* manual or the application note, *Principles of Microwave Connector Care*. Both of these documents are provided in the *HP 8753B Test Sets and Accessories Manual*. For maximum accuracy, use a torque wrench for final connections. The techniques for torquing connections and the part numbers for torque wrenches recommended for different connector types are provided in the connector care documents listed above.

Calibration Validity. Unless interpolated error correction is on, measurement calibrations are valid only for a specific stimulus state, which must be set before calibration is begun. The stimulus state consists of the selected frequency range, number of points, sweep time, output power, and sweep type. Changing the frequency range, number of points, or sweep type with correction on invalidates the calibration and turns it off. Changing the sweep time or output power changes the status notation "Cor" at the left of the screen to "C?", to indicate that the calibration is in question. If correction is turned off or in question after the stimulus changes are made, pressing ***[CORRECTION ON]*** recalls the original stimulus state for the current calibration.

Interpolated Error Correction. The interpolated error correction feature allows the operator to select a subset of the frequency range or a different number of points without recalibration. Interpolation must be activated by softkey before it will function. When interpolation is on, the system errors for the newly selected frequencies are calculated from the system errors of the original calibration.

System performance is unspecified when using interpolated error correction. The quality of the interpolated error correction is dependent on the amount of phase shift and the amplitude change between measurement points. If phase shift is no greater than 180° per approximately 5 measurement points, interpolated error correction offers a great improvement over uncorrected measurements. The accuracy of interpolated error correction improves as the phase shift and amplitude change between adjacent points decrease. When using an HP 8753B in linear frequency sweep with an HP 85046A/B or 85047A test set, it is recommended that the original calibration be performed with at least 67 points per 1 GHz of frequency span.

Interpolated error correction functions in three sweep modes: linear frequency, power sweep, and CW time.

If there is a valid correction array for a linear frequency sweep, this may be interpolated to provide correction at the CW frequency used in power sweep or CW time modes. This correction is part of the interpolated error correction feature and is not specified.

Channel Coupling. Up to two sets of measurement calibration data can be defined for each instrument state, one for each channel. If the two channels are stimulus coupled and the input ports are the same for both channels, they share the same calibration data. If the two channel inputs are different, they can have different calibration data. If the two channels are stimulus uncoupled, the measurement calibration applies to only one channel. For information on stimulus coupling, refer to Chapter 3, *Stimulus Function Block*.

Measurement Parameters. Calibration procedures are parameter-specific, rather than channel-specific. When a parameter is selected, the instrument checks the available calibration data, and uses the data found for that parameter. For example, if a transmission response calibration is performed for B/R, and an S_{11} 1-port calibration for A/R, the HP 8753B retains both calibration sets and corrects whichever parameter is displayed. Once a calibration has been performed for a specific parameter or input, measurements of that parameter remain calibrated in either channel, as long as stimulus values are coupled. In the response and response and isolation calibrations, the parameter must be selected before calibration: other correction procedures select parameters automatically. Changing channels during a calibration procedure invalidates the part of the procedure already performed.

Device Measurements. In procedures that require measurement of several different devices, for example a short, an open, and a load, the order in which the devices are measured is not critical. Any standard can be re-measured, until the **[DONE]** key is pressed. The change in trace during measurement of a standard is normal.

Response and response and isolation calibrations require measurement of only one standard device. If more than one device is measured, only the data for the last device is retained.

Omitting Isolation Calibration. Isolation calibration can be omitted for most measurements, except where wide dynamic range is a consideration. Use the following guidelines. When the measurement requires a dynamic range of:

- 80 dB: Omit isolation calibration for most measurements.
- 80 to 100 dB: Isolation calibration is recommended with approximately 0 dBm into the R input.
- 100 dB: Averaging should be on with an averaging factor ≥16, both for isolation calibration and for measurement after calibration.

Restarting a Calibration. A calibration that is interrupted to go to another menu can be continued with the ***[RESUME CAL SEQUENCE]*** key in the correction menu.

Saving Calibration Data. It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*. If a calibration is not saved, it will be lost if another calibration procedure is selected for the same channel, or if stimulus values are changed. Instrument preset, power on, and instrument state recall will also clear the calibration data.

Specifying Calibration Kits. In addition to the menus for the different calibration procedures, the **[CAL]** key provides access to a series of menus used to specify the characteristics of the calibration standards used. Several default calibration kits with different connector types are predefined, or the definitions can be modified to any set of standards used.

Correction Menu

The correction menu is the first menu presented by the **[CAL]** key, and it provides access to numerous menus of additional calibration features.

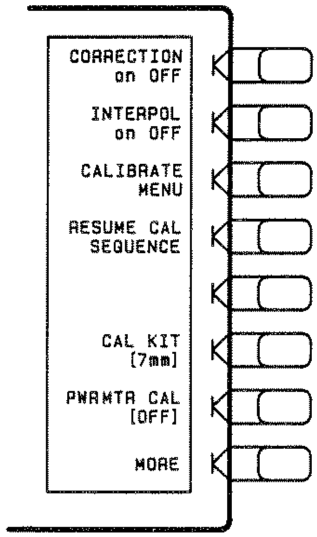


Figure 5-9. Correction Menu

[CORRECTION on OFF] (CORRON, CORROFF) turns error correction on or off. The HP 8753B uses the most recent calibration data for the displayed parameter. If the stimulus state has been changed since calibration, the original state is recalled, and the message "SOURCE PARAMETERS CHANGED" is displayed.

A calibration must be performed before correction can be turned on. If no valid calibration exists, the message "CALIBRATION REQUIRED" is displayed on the CRT. If interpolated error correction is on, this message is not displayed if you have selected a subset of a previously calibrated frequency range. See the *[INTERPOL on OFF]* description, below.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc, using capabilities described in Chapter 10, *Saving Instrument States*.

[INTERPOL on OFF] (CORION, CORIOFF) turns interpolated error correction on or off. The interpolated error correction feature allows the operator to calibrate the system, then select a subset of the frequency range or a different number of points. Interpolated error correction functions in linear frequency, power sweep and CW time modes. If using an HP 8753B in linear sweep with an HP 85046A/B or 85047A test set, it is recommended that the original calibration be performed with at least 67 points per 1 GHz of frequency span.

[CALIBRATE MENU] leads to the calibration menu, which provides several accuracy enhancement procedures ranging from a simple frequency response calibration to a full two-port calibration. At the completion of a calibration procedure, this menu is returned to the screen, correction is automatically turned on, and the notation "Cor" or "C2" is displayed at the left of the screen.

[RESUME CAL SEQUENCE] (RESC) eliminates the need to restart a calibration sequence that was interrupted to access some other menu. This softkey goes back to the point where the calibration sequence was interrupted.

[CAL KIT] leads to the select cal kit menu, which is used to select one of the default HP 8753B compatible calibration kits available for different connector types. This in turn leads to additional menus used to define calibration standards other than those in the default kits (refer to *Modifying Calibration Kits*, later in this chapter). When a calibration kit has been specified, its connector type is displayed in brackets in the softkey label.

[PWR METER CAL] leads to the power meter calibration menu which provides two types of power meter calibration, continuous and single-sample. Power meter calibration is described later in this chapter.

[MORE] provides access to the calibrate more menu, which is used to extend the test port reference plane, to specify the characteristic impedance of the system, to select the optimum receiver sweep mode, and to specify the relative propagation velocity factor for distance-to-fault measurements using the time domain option.

Cal Kit Menu

The cal kit menu is used to select the calibration kit to be used for a measurement calibration. Selecting a cal kit chooses the model that mathematically describes the standard devices actually used. (Refer to the beginning of this chapter, and the appendix at the end of this chapter, for more background on measurement calibrations and error correction.)

The HP 8753B has the capability to calibrate with four predefined cal kits in four different connector types. The models for these cal kits correspond to the standard calibration kits available as accessories for the HP 8753B:

7 mm	HP 85031B 7 mm calibration kit
3.5 mm	HP 85033C 3.5 mm calibration kit
N 50Ω	HP 85032B 50 ohm type-N calibration kit
N 75Ω	HP 85036B 75 ohm type-N calibration kit

How closely must the model match the actual device? The answer depends on the accuracy required. Certainly *any* calibration provides better accuracy than none at all, in fact simple normalization is adequate for many applications. The errors introduced by using the internal 7 mm model with a Hewlett-Packard 7 mm cal kit other than the HP 85031B are vanishingly small. Yet for the highest accuracy, the more closely the model matches the device, the better.

In addition to the four predefined cal kits, a fifth choice is a "user kit" that is defined or modified by the user. This is described under *Modifying Calibration Kits* later in this chapter.

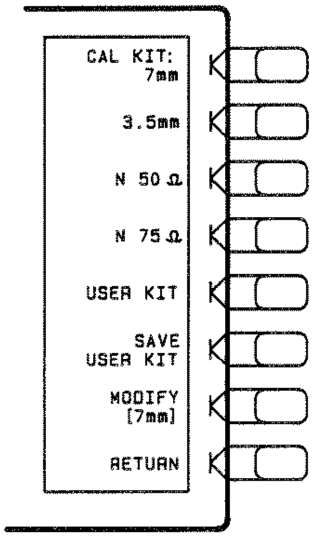


Figure 5-10. Select Cal Kit Menu

[CAL KIT: 7mm] (CALK7MM) selects the 7 mm cal kit model.

[3.5mm] (CALK35MM) selects the 3.5 mm cal kit model.

[N 50Ω] (CALKN50) selects the 50 ohm type-N model.

[N 75Ω] (CALKN75) selects the 75 ohm type-N model.

NOTE: If *[N 50Ω]* or *[N 75Ω]* is selected, additional menus are provided during calibration procedures to select the connector sex. (This is the connector sex of the input port, not the actual calibration standard.)

[USER KIT] (CALKUSED) selects a cal kit model defined or modified by the user. For information, refer to *Modifying Calibration Kits*, later in this chapter.

[SAVE USER KIT] (SAVEUSEK) stores the user-modified or user-defined kit into memory, after it has been modified.

[MODIFY] (MODI1) leads to the modify cal kit menu, where a predefined cal kit can be user-modified.

[RETURN] returns to the correction menu.

Calibrate More Menu

This menu is used to extend the test port reference plane, to specify the characteristic impedance of the system, to select the optimum receiver sweep mode, and to specify the relative propagation velocity factor for distance-to-fault measurements.

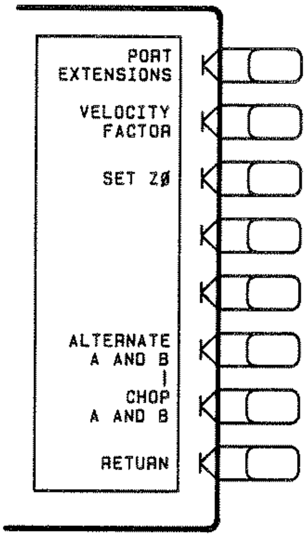


Figure 5-11

[PORT EXTENSIONS] goes to the reference plane menu, which is used to extend the apparent location of the measurement reference plane or input.

The differences between the ***[PORT EXTENSIONS]*** and ***[ELECTRICAL DELAY]*** functions are shown below:

	[PORT EXTENSIONS]	***[ELECTRICAL DELAY]***
Main Effect	The end of a cable becomes the test port plane for all S-parameter measurements.	Compensates for the electrical length of a cable for the current type of measurement only. Reflection = 2 times cable's electrical length. Transmission = 1 times cable's electrical length.
Measurements Affected	All S-parameters.	Only the currently selected S-parameter.
Electrical Compensation	Intelligently compensates for 1 times or 2 times the cable's electrical delay, depending on which S-parameter is computed.	Only compensates as necessary for the currently selected S-parameter.

[VELOCITY FACTOR] (VELOFACT) Enters the velocity factor used by the HP 8753B to calculate equivalent electrical length in distance-to-fault measurements using the time domain option. Values entered should be less than 1. For example, the velocity factor of teflon is:

$$V_f = \frac{1}{\sqrt{\varepsilon_R}} = 0.666$$

[SET Z0] (SETZ) sets the characteristic impedance used by the HP 8753B in calculating measured impedance with Smith chart markers and conversion parameters. If the test set used is an HP 85046B S-parameter test set or an HP 85044B transmission/reflection test set, set Z0 to 75 ohms. Characteristic impedance must be set correctly before calibration procedures are performed.

[ALTERNATE A and B] (ALTAB) measures only one input per frequency sweep, in order to reduce spurious signals. Thus, this mode optimizes the dynamic range for all four S-parameter measurements. This is the default measurement mode.

The disadvantages of this mode are associated with simultaneous transmission/reflection measurements or full two-port calibrations: this mode takes twice as long as the chop mode to make these measurements. In addition, the port match changes due to either input A or B being inactive during each sweep, which are in the order of <-55 dB, may affect transmission measurements.

[CHOP A and B] (CHOPAB) measures both inputs A and B during each sweep. Thus, if each channel is measuring a different parameter and both channels are displayed, the chop mode offers the fastest measurement time. This is the preferred measurement mode for full two-port calibrations because both inputs remain active.

The disadvantage of this mode is that in measurements of high rejection devices, such as filters with a low-loss passband (>400 MHz wide), maximum dynamic range may not be achieved.

NOTE: If more dynamic range is desired for a measurement of S_{21} in either the chop or the alternate mode, a 10 dB attenuator can be connected to input A and another to input R. This improves the crosstalk into input B. The dynamic range of input B is increased, but the usable dynamic range of input A is reduced.

[RETURN] goes back to the correction menu.

Reference Plane Menu

This menu adds electrical delay in seconds to the measurement ports to extend the apparent location of the measurement reference plane to the ends of the cables. This is equivalent to adding a length of perfect air line, and makes it possible to measure the delay response of the device only instead of the device plus the cable.

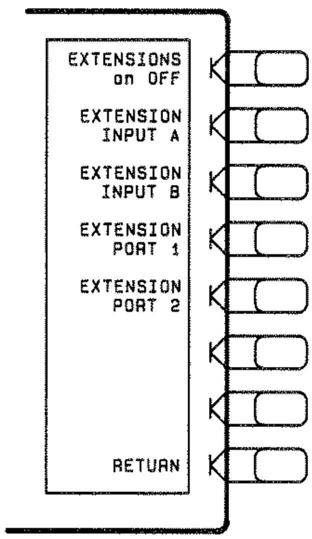


Figure 5-12

[EXTENSIONS on OFF] (POREON, POREOFF) toggles the reference plane extension mode. When this function is on, all extensions defined below are enabled; when off, none of the extensions is enabled.

[EXTENSION INPUT A] (PORTA). Use this feature to add electrical delay in seconds to extend the reference plane at input A to the end of the cable. This is used for any input measurements including S-parameters.

[EXTENSION INPUT B] (PORTB) adds electrical delay to the input B reference plane for any B input measurements including S-parameters.

[EXTENSION PORT 1] (PORT1) extends the reference plane for measurements of S_{11}, S_{21}, and S_{12}.

[EXTENSION PORT 2] (PORT2) extends the reference plane for measurements of S_{22}, S_{12}, and S_{21}.

[RETURN] goes back to the calibrate more menu.

Calibration Menu

The calibration menu is used to select the appropriate accuracy enhancement procedure for calibration before a measurement is performed. Six different calibration routines are available, each of which effectively removes from one to twelve systematic errors from the measurement data. Each calibration procedure features CRT prompts to guide you through the calibration sequence. The available calibrations are described below, and a comparative summary is provided in Table 5-2. Procedures for performing each of the calibrations are provided in the following pages, together with illustrations of the corresponding menus.

Note that all instrument parameters should be established before a calibration procedure is started, including stimulus values, calibration kit, system characteristic impedance Z0, and receiver sweep mode. (To modify the characteristic impedance and receiver sweep mode, refer to *Calibrate More Menu*.) If interpolated error correction is on, and you are in linear frequency sweep, power sweep, or CW time sweep, you may choose a subset of frequency range or a different number of points after the system has been calibrated. The performance of interpolated error correction is not specified.

NOTE: By convention, when the connector sex is provided in parentheses for a calibration standard, it refers to the sex of the test port connector, not the sex of the standard. For example, short (m) indicates that the test port connector is male, not the short circuit connector.

NOTE: The compatible type-N and 3.5 mm calibration kits for the HP 8753B provide open circuits with center conductor extenders. For maximum accuracy in calibration with these devices, follow these steps: First connect the outer conductor by hand and torque wrench. Then insert the center conductor extender into the outer conductor. The fit should be snug but free. Push gently until the center conductors mate.

For measurement of test devices following calibration, refer to the *User's Guide*.

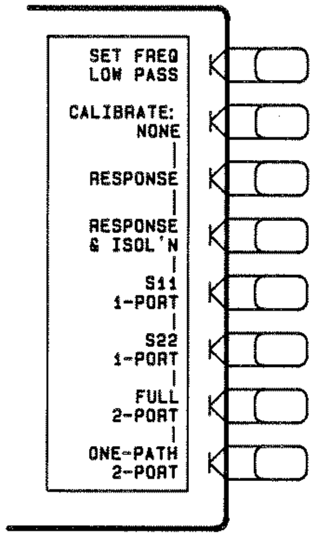


Figure 5-13. Calibration Menu

[SET FREQ LOW PASS] changes the frequency sweep to harmonic intervals to accommodate time domain low-pass operation (option 010). If this mode is to be used, the frequencies must be set before calibration. Refer to Chapter 8, *Time and Frequency Domain Transforms*, for more information.

[CALIBRATE: NONE] is underlined if no calibration has been performed or if the calibration data has been cleared. Unless a calibration is saved in memory, the calibration data is lost on instrument preset, power on, instrument state recall, or if stimulus values are changed.

[RESPONSE] (CALIRESP) leads to the frequency response calibration. This is the simplest and fastest accuracy enhancement procedure, but should be used when extreme accuracy is not required. It effectively removes the frequency response errors of the test setup for reflection or transmission measurements.

For transmission-only measurements or reflection-only measurements, only a single calibration standard is required with this procedure. The standard for transmission measurements is a thru, and for reflection measurements can be either an open or a short. If more than one device is measured, only the data for the last device is retained. The procedures for response calibration for a reflection measurement and a transmission measurement are described in the following pages.

[RESPONSE & ISOL'N] (CALIRAI) leads to the menus used to perform a response and isolation measurement calibration, for measurement of devices with wide dynamic range. This procedure effectively removes the same frequency response errors as the response calibration. In addition, it effectively removes the isolation (crosstalk) error in transmission measurements or the directivity error in reflection measurements. As well as the devices required for a simple response calibration, an isolation standard is required. The standard normally used to correct for isolation is an impedance-matched load (usually 50 or 75 ohms). Response and directivity calibration procedures for reflection and transmission measurements are provided in the following pages.

[S11 1-PORT] (CALIS111) provides a measurement calibration for reflection-only measurements of one-port devices or properly terminated two-port devices, at port 1 of an S-parameter test set or the test port of a transmission/reflection test set. This procedure effectively removes the directivity, source match, and frequency response errors of the test setup, and provides a higher level of measurement accuracy than the response and isolation calibration. It is the most accurate calibration procedure for reflection-only measurements. Three standard devices are required: a short, an open, and an impedance-matched load. The procedure for performing an S_{11} one-port calibration is described in the following pages.

[S22 1-PORT] (CALIS221) is similar to *[S11 1-PORT]*. It is used for reflection-only measurements of one-port devices or properly terminated two-port devices in the reverse direction: that is, for devices connected to port 2 of the S-parameter test set.

[FULL 2-PORT] (CALIFUL2) leads to the series of menus used to perform a complete calibration for measurement of all four S-parameters of a two-port device. This is the most accurate calibration for measurements of two-port devices. It effectively removes all correctable systematic errors (directivity, source match, load match, isolation, reflection tracking, and transmission tracking) in both the forward and the reverse direction. Isolation correction can be omitted for measurements of devices with limited dynamic range.

The standards for this procedure are a short, an open, a thru, and an impedance-matched load (two loads if isolation correction is required). An S-parameter test set is required. The procedure is described in the following pages.

[ONE-PATH 2-PORT] (CALIONE2) leads to the series of menus used to perform a high-accuracy two-port calibration without an S-parameter test set. This calibration procedure effectively removes directivity, source match, load match, isolation, reflection tracking, and transmission tracking errors in one direction only. Isolation correction can be omitted for measurements of devices with limited dynamic range. (The device under test must be manually reversed between sweeps to accomplish measurement of both input and output responses.) The required standards are a short, an open, a thru, and an impedance-matched load. The procedure for performing a one-path 2-port calibration is described in the following pages.

Table 5-2. Purpose and Use of Different Calibration Procedures

Calibration Procedure	Corresponding Measurement	Errors Removed	Standard Devices
Response	Transmission or reflection measurement when the highest accuracy is not required.	Freq. response	Thru for trans., open OR short for reflection
Response & isolation	Transmission of high insertion loss devices or reflection of high return loss devices. Not as accurate as 1-port or 2-port calibration.	Freq. response PLUS isolation in transmission or directivity in reflection	Same as response PLUS isolation std (load)
S_{11} 1-port	Reflection of any one-port device or well terminated two-port device.	Directivity,source match, freq. response.	Short AND open AND load
S_{22} 1-port	Reflection of any one-port device or well terminated two-port device.	Directivity, source match, freq. response.	Short AND open AND load
Full 2-port	Transmission or reflection of highest accuracy for two-port devices. HP 85046A/B or 85047A S-parameter test set is required.	Directivity, source match, load match, isolation, freq. response, forward and reverse.	Short AND open AND load AND thru (2 loads for isolation)
One-path 2-port	Transmission or reflection of highest accuracy for two-port devices. (Reverse test device between forward and reverse measurements.)	Directivity, source match, load match, isolation, freq. response, forward direction only.	Short AND open AND load AND thru

Response Calibration for Reflection Measurements

The procedure described here uses the menu illustrated in Figure 5-14 to perform a frequency response only calibration with an S-parameter test set for a measurement of S_{11}. It can also be used for S_{22} by substituting the corresponding softkey in the S-parameters menu.

A similar procedure can be performed with a transmission/reflection test set, using the input ports menu instead of the S-parameters menu (described in Chapter 4, *Response Function Block*).

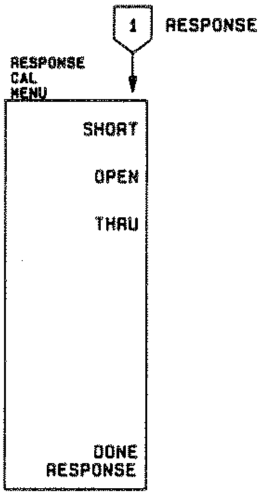


Figure 5-14

- Press **[MEAS]** ***[Refl: FWD S11 A/R]***.
- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [RESPONSE]***.
- At port 1, connect either a short OR a shielded open circuit.
- When the trace settles, press ***[SHORT]*** or ***[OPEN]***, depending on the standard used. (If more than one device is measured, only the data for the last device is retained.)
- The message "WAIT - MEASURING CAL STANDARD" is displayed while the data is measured. The softkey label ***[SHORT]*** or ***[OPEN]*** is then underlined.
- Press ***[DONE: RESPONSE]***. The error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. A corrected trace is displayed.

- This completes the response calibration for a reflection measurement. Now the test device can be connected and measured.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

Response Calibration for Transmission Measurements

The procedure described here uses the menu in Figure 5-14 to perform a frequency response only calibration with an S-parameter test set for a measurement of S_{21}. To calibrate for a combined transmission and reflection measurement, perform the transmission calibration on one channel and the reflection calibration described above on the other channel.

A similar procedure can be performed with a transmission/reflection test set, using the input ports menu instead of the S-parameters menu (see Chapter 4, *Response Function Block*).

- Press **[MEAS]** ***[Trans: FWD S21 B/R]***.
- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [RESPONSE]***.
- Make a thru connection (connect together the points at which the test device will be connected).
- When the trace settles, press ***[THRU]***.
- The message "WAIT - MEASURING CAL STANDARD" is displayed while the S_{21} data is measured. The softkey label ***[THRU]*** is then underlined.
- Press ***[DONE: RESPONSE]***. The error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. Corrected S_{21} data is displayed.
- This completes the response calibration for a transmission measurement. Now the test device can be connected and measured.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

Response and Isolation Calibration for Reflection Measurements

The procedure described here effectively removes the frequency response and directivity errors for reflection measurements. The menus illustrated in Figure 5-15 are used to perform a calibration with an S-parameter test set for a measurement of S_{11}. The same calibration can be used for S_{22} by substituting the corresponding softkey in the S-parameters menu.

A similar procedure can be performed with a transmission/reflection test set, using the input ports menu instead of the S-parameters menu (described in Chapter 4, *Response Function Block*).

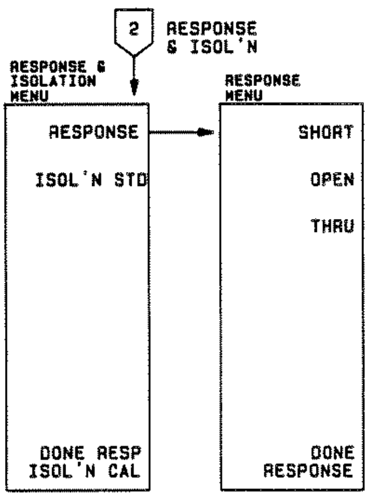


Figure 5-15

- Press **[MEAS]** ***[Refl: FWD S11 A/R]***.
- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [RESPONSE & ISOL'N] [RESPONSE]***.
- At port 1, connect either a short OR a shielded open circuit.
- When the trace settles, press ***[SHORT]*** or ***[OPEN]***, depending on the standard used. (If more than one standard is measured, only the data for the last device is retained.)
- The message "WAIT - MEASURING CAL STANDARD" is displayed while the response data is measured. The softkey label ***[SHORT]*** or ***[OPEN]*** is then underlined.
- Press ***[DONE: RESPONSE]***. The error coefficients are computed and stored. The response and isolation menu is displayed.

- Connect the isolation standard to port 1. This is an impedance-matched load (usually 50 or 75 ohms).
- Press ***[ISOL'N STD]***. The S_{11} isolation data is measured. The softkey label is underlined.
- Press ***[DONE RESP ISOL'N CAL]***. The directivity error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. A corrected trace is displayed.

- This completes the response and isolation calibration for correction of frequency response and directivity errors for reflection measurements. Now the test device can be connected and measured.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

Response and Isolation Calibration for Transmission Measurements

The procedure described here effectively removes the frequency response and isolation errors for transmission measurements of devices with wide dynamic range, using the menus illustrated in Figure 5-15. To calibrate for a combined transmission and reflection measurement, perform the transmission calibration on one channel and the reflection calibration described above on the other channel.

This procedure uses an S-parameter test set. A similar procedure can be performed with a transmission/reflection test set, using the input ports menu instead of the S-parameters menu (see Chapter 4, *Response Function Block*).

- Press **[MEAS]** ***[Trans: FWD S21 B/R]***.
- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [RESPONSE & ISOL'N] [RESPONSE]***.
- Make a thru connection between port 1 and port 2 (connect together the points at which the test device will be connected).
- When the trace has settled, press ***[THRU]***. S_{21} response data is measured. The softkey label ***[THRU]*** is underlined.
- Press ***[DONE: RESPONSE]***.
- Connect impedance-matched loads to port 1 and port 2. Press ***[ISOL'N STD]***. The S_{21} isolation data is measured. The softkey label is underlined.
- Press ***[DONE RESP ISOL'N CAL]***. The S_{21} error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. Corrected S_{21} data is displayed and the notation "Cor" at the left of the screen indicates that correction is on for this channel.

A similar procedure is used to calibrate for measurement of S_{12}, using the ***[Trans: REV S12 B/R]*** softkey in the S-parameters menu.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

S_{11} 1-Port Calibration for Reflection Measurements

This procedure uses the S_{11} 1-port menu illustrated in Figure 5-16 to perform a complete vector error correction for reflection measurements of one-port devices or properly terminated two-port devices. This is a high-accuracy calibration that effectively removes the directivity, source match, and frequency response errors from the measured data. The calibration described here uses an S-parameter test set: a similar procedure can be performed with a transmission/reflection test set, using the input ports menu instead of the S-parameters menu (described in Chapter 4, *Response Function Block*).

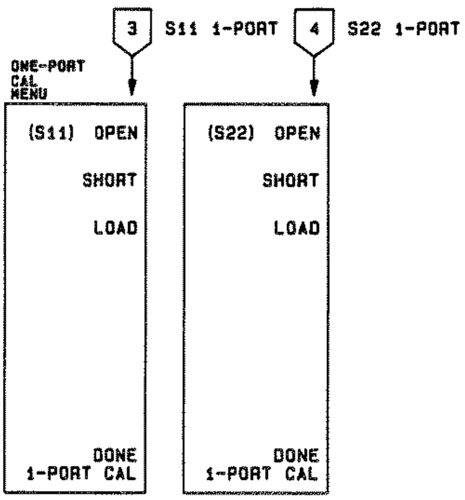


Figure 5-16

- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [S11 1-PORT]***.
- Connect a shielded open circuit to port 1.
- When the trace settles, press (S_{11}) ***[OPEN]***.
- The message "WAIT – MEASURING CAL STANDARD" is displayed while the open circuit data is measured. The softkey label ***[OPEN]*** is then underlined.
- Disconnect the open, and connect a short circuit to port 1.
- When the trace settles, press ***[SHORT]***. The short circuit data is measured and the softkey label is underlined.
- Disconnect the short, and connect an impedance-matched load (usually 50 or 75 ohms) at port 1.
- When the trace settles, press ***[LOAD]***. The load data is measured and the softkey label is underlined.
- Press ***[DONE 1-PORT CAL]***. (If you press ***[DONE]*** without measuring all the required standards, the message "CAUTION: ADDITIONAL STANDARDS NEEDED" will be displayed.) The error coefficients are computed, and the correction menu is returned to the screen with ***[CORRECTION ON]***. A corrected S_{11} trace is displayed, and the notation "Cor" appears at the left side of the screen.

- This completes the S_{11} 1-port calibration. The test device can now be connected and measured.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

S_{22} 1-Port Calibration

This procedure performs a complete vector error correction for a reverse reflection measurement of a one-port device or a properly terminated two-port device. It is similar to the S_{11} 1-port calibration except that S_{22} is selected automatically.

This calibration is used only with an S-parameter test set. For S-parameter measurements in the reverse direction with a transmission/reflection test set use the S_{11} 1-port or one-path 2-port calibration and reverse the device under test between measurement sweeps.

Full 2-Port Calibration for Reflection and Transmission Measurements

This procedure uses the menu sequence illustrated in Figure 5-17 to perform complete vector error correction for measurement of all four S-parameters. This is the most accurate calibration for measurements of two-port devices, and effectively removes all correctable systematic errors in both the forward and reverse directions.

An S-parameter test set is required for this calibration. The procedure automatically switches the test set to select the appropriate S-parameter at each step. A similar two-port procedure can be performed with a transmission/reflection test set using the one-path 2-port calibration.

To extend the life of the mechanical transfer switch in the HP 85046A/B or 85047A S-parameter test sets, switching occurs only once in a measurement sequence using full two-port error correction. On the first sweep all four S-parameters are measured. On subsequent sweeps, the assumption is made that the reverse parameters have not changed, and only the forward parameters are measured. It is possible to override this protection feature for applications where extreme accuracy is required or in cases where the data changes significantly. To perform an override, use ***[MEASURE RESTART]*** in the stimulus menu, or for repeated update of all four S-parameters set an appropriate number of groups using the ***[NUMBER OF GROUPS]*** softkey. These menus are described in Chapter 3.

Isolation calibration can be omitted for most measurements, except where wide dynamic range is a consideration. Refer to the explanation under *[CAL] Key*.

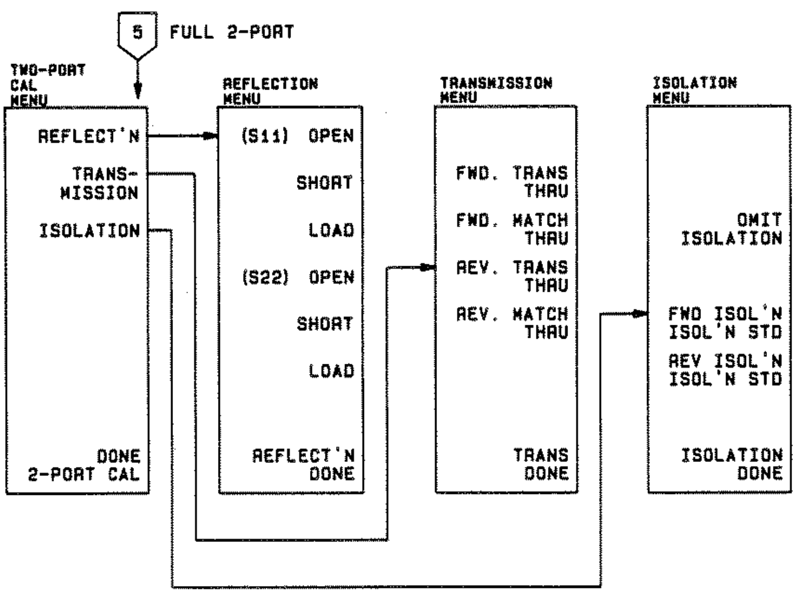


Figure 5-17

- Press [CAL].
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [FULL 2-PORT] [REFLECT'N]***.
- Connect a shielded open circuit to port 1.
- When the trace settles, press (S_{11}) ***[OPEN]***. The open circuit data is measured, and the softkey label ***[OPEN]*** is underlined.
- Disconnect the open, and connect a short circuit to port 1.
- When the trace settles, press (S_{11}) ***[SHORT]***. The short circuit data is measured and the softkey label ***[SHORT]*** is underlined.
- Disconnect the short, and connect an impedance-matched load (usually 50 or 75 ohms) at port 1.
- When the trace settles, press (S_{11}) ***[LOAD]***. The load data is measured, and the softkey label ***[LOAD]*** is underlined.

- Repeat the open-short-load measurements described above, connecting the devices in turn to port 2 and using the (S_{22}) softkeys.
- Press ***[REFLECT'N DONE]***. (If you press ***[DONE]*** without measuring all the required standards, the message "CAUTION: ADDITIONAL STANDARDS NEEDED" will be displayed.)
- The reflection calibration coefficients are computed and stored. The two-port cal menu is displayed, with the ***[REFLECT'N]*** softkey underlined.

- Press ***[TRANSMISSION]***.
- Make a thru connection between port 1 and port 2 (connect together the points at which the test device will be connected).
- When the trace settles, press ***[FWD. TRANS. THRU]***. S_{21} frequency response is measured, and the softkey is underlined.
- Press ***[FWD. MATCH THRU]***. S_{11} load match is measured, and the softkey is underlined.
- Press ***[REV. TRANS. THRU]***. S_{12} frequency response is measured, and the softkey is underlined.
- Press ***[REV. MATCH THRU]***. S_{22} load match is measured, and the softkey is underlined.
- Press ***[TRANS. DONE]***. The transmission coefficients are computed and stored. The two-port cal menu is displayed, with the ***[TRANSMISSION]*** softkey underlined.

- If correction for isolation is not required, press ***[ISOLATION] [OMIT ISOLATION] [ISOLATION DONE]***.
- If correction for isolation is required, connect impedance-matched loads to port 1 and port 2.
- Press ***[FWD ISOL'N ISOL'N STD]***. S_{21} isolation is measured, and the softkey label is underlined.
- Press ***[REV ISOL'N ISOL'N STD]***. S_{12} isolation is measured, and the softkey label is underlined.
- Press ***[ISOLATION DONE]***. The isolation error coefficients are stored. The two-port cal menu is displayed, with the ***[ISOLATION]*** softkey underlined.

- Press ***[DONE 2-PORT CAL]***. The error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. A corrected trace is displayed, and the notation "C2" at the left of the screen indicates that two-port error correction is on.

- This completes the full two-port calibration procedure. Now the test device can be connected and measured.

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

One-Path 2-Port Calibration for Reflection and Transmission Measurements

This procedure performs a two-port calibration without an S-parameter test set, using the series of menus illustrated in Figure 5-18. This is a highly accurate calibration for measurements of two-port devices, and effectively removes all correctable systematic errors in one direction only.

Isolation calibration can be omitted for most measurements, except where wide dynamic range is a consideration. Refer to the explanation under *[CAL] Key*.

For measurements of all four S-parameters, the device under test must be reversed between sweeps. The HP 8753B compatible calibration kits contain sets of phase-matched adapters that can be interchanged for measurements of non-insertable, non-reversible devices.

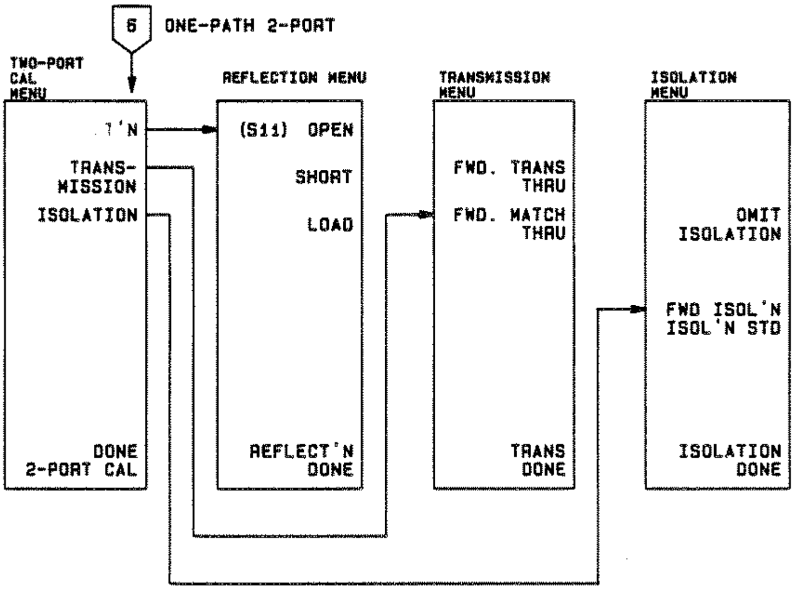


Figure 5-18

- Press **[CAL]**.
- Select the proper calibration kit. If the connector type or cal kit name shown in the ***[CAL KIT]*** softkey label is not the same as the calibration kit to be used, refer to *Select Cal Kit Menu*.
- Press ***[CALIBRATE MENU] [ONE-PATH 2-PORT] [REFLECT'N]***.
- Connect a shielded open circuit to the test port.
- When the trace settles, press (S_{11}) ***[OPEN]***. The open circuit data is measured, and the softkey label ***[OPEN]*** is underlined.
- Disconnect the open, and connect a short circuit to the test port.
- When the trace settles, press ***[SHORT]***. The short circuit data is measured and the softkey label ***[SHORT]*** is underlined.
- Disconnect the short, and connect an impedance-matched load (50 or 75 ohms) to the test port.
- When the trace settles, press ***[LOAD]***. The load data is measured, and the softkey label ***[LOAD]*** is underlined.
- Press ***[REFLECT'N DONE]***. (If you press ***[DONE]*** without measuring all the required standards, the message "CAUTION: ADDITIONAL STANDARDS NEEDED" will be displayed.)

- The reflection calibration coefficients are computed and stored. The two-port cal menu is displayed, with the ***[REFLECT'N]*** softkey underlined.

- Make a thru connection between the test port and the return cable to the network analyzer (connect together the points at which the test device will be connected). Press ***[TRANSMISSION]***.
- When the trace settles, press ***[FWD. TRANS. THRU]***. S_{21} frequency response is measured, and the softkey is underlined.
- Press ***[FWD. MATCH THRU]***. S_{11} load match is measured, and the softkey is underlined.
- Press ***[TRANS. DONE]***. The transmission coefficients are computed and stored. The two-port cal menu is displayed, with the ***[TRANSMISSION]*** softkey underlined.

- If correction for isolation is not required, press ***[ISOLATION] [OMIT ISOLATION] [ISOLATION DONE]***.
- If correction for isolation is required, connect impedance-matched loads to the test port and the return port.
- Press ***[FWD ISOL'N ISOL'N STD]***. S_{21} isolation is measured, and the softkey label is underlined.
- Press ***[ISOLATION DONE]***. The isolation error coefficients are stored. The two-port cal menu is displayed, with the ***[ISOLATION]*** softkey underlined.

- Press ***[DONE 2-PORT CAL]***. The error coefficients are computed and stored. The correction menu is displayed with ***[CORRECTION ON]***. A corrected trace is displayed, and the notation "C2" at the left of the screen indicates that 2-port error correction is on.

- This completes the one-path 2-port calibration procedure. Now the test device can be connected and measured in the forward direction. When forward measurement is complete, disconnect the test device and manually reverse it, then press the softkey ***[PRESS to CONTINUE]***, or trigger another sweep using the trigger menu (Chapter 3).

It is recommended that calibration data be saved, either in internal volatile memory or on an external disc. Refer to Chapter 10, *Saving Instrument States*.

POWER METER CALIBRATION

An HP-IB compatible power meter can monitor and correct RF source power to achieve leveled power at the test port. To correct the power going to the DUT, power meter calibration samples the power at each measurement point across the frequency band of interest. It then constructs a correction data table which the instrument uses to correct the power output of the internal source. The correction table may be saved in an instrument state register with the **[SAVE]** key.

The correction table may be updated on each sweep (in a leveling application) or during an initial single sweep. In the sample-and-sweep mode the power meter is not needed for subsequent sweeps. The correction table may be read or modified through HP-IB. Refer to the *HP-IB Quick Reference Guide* for details.

NOTE: Instructions for using power meter calibration are provided later in this chapter. Refer to the chapter table of contents for the page number.

Primary Applications

- When using a test system with significant frequency response errors. For example, if using a coupler with significant roll-off, or a long cable with a significant amount of loss.

- When measuring devices that are very sensitive to actual input power for proper operation.

- To allow measurements where power meter accuracy is required to meet a specification.

Calibrated Power Level

By setting the HP 8753B calibrated power to the desired value at the power meter, this power level will be maintained at that port during the entire sweep. It is recommended that the operator first set the source power such that the power at the DUT is approximately correct. This reduces residual power errors when only one number of readings is taken (see *[NUMBER OF READINGS]* softkey description). When power meter calibration is on, the annotation "PC" is displayed. This indicates that the source power is being changed during the sweep. Calibrated power level becomes the active entry if any of the following softkeys are pressed:

[PWRMTR CAL OFF] *[EACH SWEEP]* *[ONE SWEEP]*

Regardless of the measurement application, the HP 8753B source can only supply power from +20 to −5 dBm. If power outside this range is requested, the annotation will change to "PC?".

Compatible Sweep Types

Power meter calibration may be used in linear, log, list, CW, and power sweep modes. In power sweep, the power at each point is the true power at the power meter, not the power at the HP 8753B source output.

Loss of Power Meter Calibration Data

Turning Power Off. Turning off the instrument erases the power meter calibration table and all instrument save/recall registers.

Changing Sweep Type When Power Meter Calibration is Turned On. If the sweep type is changed (linear, log, list, CW, power) while power meter calibration is on, the calibration data will be lost. However, calibration data is retained if you change the sweep type while power meter calibration is off.

Frequency is Changed in Log or List Sweep Type. Power meter calibration data will also be lost if the frequency is changed in log or list mode, but it is retained in linear sweep mode.

Pressing [PRESET] if the Table Has Not Been Saved in an Instrument State Register. Presetting the instrument will erase power meter calibration data. If the instrument state has been saved in a register using the [SAVE] key, the user may recall the instrument state and the data will be restored. Saving the instrument state will not protect the data if the instrument is turned off.

Interpolation Feature in Power Meter Calibration

If the frequency is changed in linear sweep, or the start/stop power is changed in power sweep, then the calibration data is interpolated for the new range.

If calibration power is changed in any of the sweep types, the data array is increased or decreased to reflect the new power level. Some accuracy is lost when this occurs.

Power Meter Calibration Use Above 3 GHz

When an HP 85047A 6 GHz test set is used with an HP 8753B option 006, a doubler in the test set provides 3 MHz to 6 GHz frequency range. This doubler mode requires a constant, high input power to work properly. In the 6 GHz mode, the default power output of the internal source is +20 dBm. The test set is designed to operate with this input level in the 3 MHz to 6 GHz range. If power meter calibration forces the power level to change more than a few dB, the performance of the RF signal may degrade. Refer to Chapter 14.

THE TWO MODES OF OPERATION IN POWER METER CALIBRATION

Continuous Correction *[EACH SWEEP]*

Refer to Figure 5-19. A power splitter or directional coupler samples the actual power going to the DUT and is measured by the power meter. This sampling occurs once at each measurement point. The operator may ask for more than one sample/correction iteration at each frequency point. This is explained in the ***[NUMBER OF READINGS]*** softkey description. Continuous correction slows the sweep speed considerably, especially when low power levels are being measured by the power meter. It may take up to 10 seconds per point if the power level is less than −20 dBm. For faster operation, the sample-and-sweep mode may be used. If a directional coupler is used, the attenuation of the coupled arm with respect to the through arm must be entered using the ***[POWER LOSS]*** softkey.

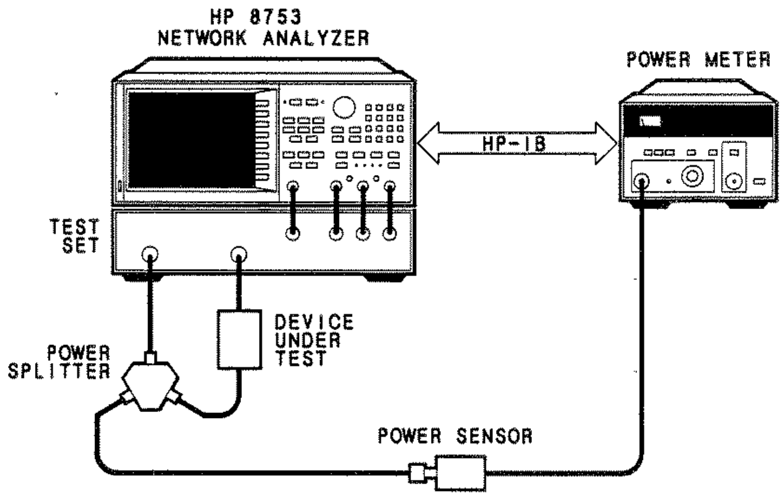


Figure 5-19. Typical Test Setup for Continuous Correction

Sample-and-Sweep Correction *[ONE SWEEP]*

Refer to Figure 5-20. You may use a power splitter or directional coupler, or simply remove the DUT and measure the power at that point in the measurement setup. The sample-and-sweep mode allows you to measure the power characteristics across the frequency band of interest with a single sweep. The speed of the calibration will be slow while power meter readings are taken (see the *Typical Speed and Accuracy* table shown on a following page). However, once the sample sweep is finished, subsequent sweeps are power-corrected using the data table, and sweep speed increases significantly. Once the initial sweep is taken, sample-and-sweep correction is much faster than continuous sweep correction.

If the calibrated power level is changed after the initial measurement sweep is done, the entire correction table is increased or decreased by that amount and the annotation "PCo" appears on the CRT. The resulting power will no longer be as accurate as the original calibration.

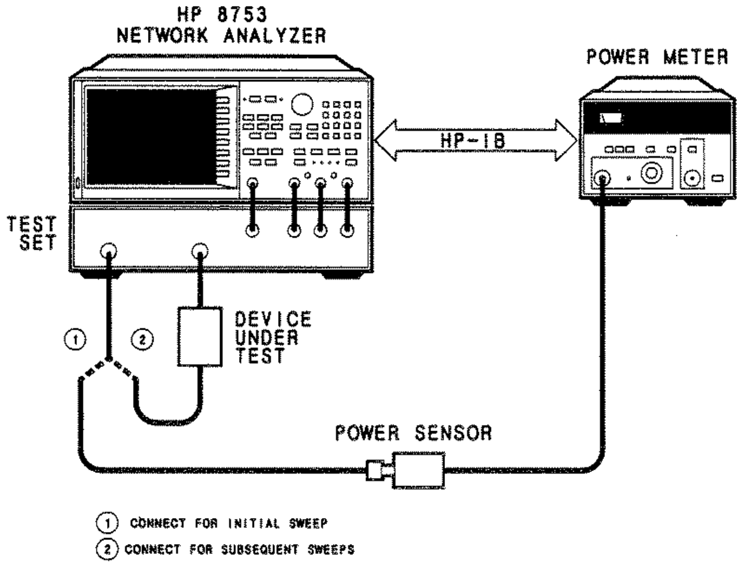


Figure 5-20. Typical Test Setup for Sample-and-Sweep Correction

Other Details

Power Meter HP-IB Address. Before using power meter calibration, you must select the power meter address using the **[LOCAL]** *[SET ADDRESSES]* keys and address menu. Then select the type of power meter in use with the *[P MTR/HPIB]* softkey.

System Controller Mode. The HP 8753B must be set to the system controller mode using the **[LOCAL]** *[SYSTEM CONTROLLER]* keys.

Power Loss Correction List. If a directional coupler or power splitter is used to sample the RF power output of the HP 8753B, the RF signal going to the power meter may be different than that going to the DUT. A directional coupler will attenuate by its specified coupling factor. The difference in attenuation between the through arm and the coupled arm (coupling factor) must be entered using the loss/sensor list menu. Non-linearities in either the directional coupler or power splitter may be corrected in the same way.

Power loss information is entered in much the same way as limit line parameters. Up to 12 segments may be entered, each with a different attenuation value.

Power Sensor Calibration Factor List. Two power sensor calibration data lists can be created in the HP 8753B. The second list is primarily for use with an HP 8753B option 006 (6 GHz) system. Since no single power sensor covers the entire frequency range of 300 kHz to 6 GHz, the calibration data for two different power sensors must be available. Refer to the loss/sensor list menu explained later in this chapter.

Typical Speed and Accuracy of Power Meter Calibration

The speed and accuracy of a power meter calibration vary depending on the test setup and the measurement parameters. When the number of readings = 1, accuracy is improved if the operator sets the source power such that it is approximately correct at the measurement port. Power meter calibration should then be turned on.

Table 5-3 shows typical sweep speed and power accuracy. The times given apply only to the test setup described, for continuous calibration or for the first sweep of sample-and-sweep correction. Subsequent sweeps in the sample-and-sweep mode will be much faster than the values shown in Table 5-3. Several power levels and numbers of readings are shown.

The typical values given in the table were derived under the following conditions:

Test Setup: The test setup used the following instruments:

- Instrument/Test Set: HP 8753B with HP 85046A.
- Power Meter/Power Sensor: HP 436A with HP 8482A.

Stimulus Parameters: The time required to perform a power meter calibration is greatly affected by the source power and number of points tested. The parameters used to derive the typical values in Table 5-3 are as follows:

- Number of Points: 51
- Source Power: +10 dBm
- Attenuator Port 1: 0 dB

Sweep time is linearly proportional to the number of points measured. For example, a sweep taking 33 seconds at 51 points will take approximately 66 seconds if 101 points are measured.

Table 5-3. Typical Speed and Accuracy

Power Desired at Test Port (dBm)	Number of Readings	Sweep Time (seconds)[1]	Typical Accuracy (dB)
	1	33	±0.7
+5	2	64	±0.2
	3	95	±0.1
	1	48	±0.7
−15	2	92	±0.2
	3	123	±0.1
	1	194	±0.7
−30[2]	2	360	±0.2
	3	447	±0.1

1 Sweep speed applies to every sweep in continuous correction mode, and to the first sweep in sample-and-sweep mode. Subsequent sweeps in sample-and-sweep mode will be much faster.

2 The port 1 attenuator was set at 20 dB, allowing the HP 8753B source to deliver −30 dBm at the test port.

Notes on Accuracy. The accuracy values in Table 5-3 were derived by combining the accuracy of the power meter and linearity of the HP 8753B internal source, as well as the mismatch uncertainty associated with the test set and the power sensor.

Power meter calibration measures the source power output (at the measurement port) at a single stimulus point, and compares it to the calibrated power selected by the operator. If the two values are different, power meter calibration changes the source output power by the difference. This process is repeated at every stimulus point. The accuracy of the result depends on the amount of correction required. If the selected number of readings = 1, the final measurement accuracy is significantly affected by a large power change. However, if the selected number of readings is >1, the power change on the second or third reading is much smaller: thus accuracy is much better.

Two methods can be used to to perform power meter calibration. If the selected number of readings is >1, then it makes little difference which method is used. However, if number of readings = 1, then the first method provides better accuracy. The values in Table 5-3 were derived using the second (worst case) method.

- **The operator sets source power such that it is approximately correct at the measurement port, then activates power meter calibration.** This method can significantly increase the accuracy of the measurement when the selected number of readings = 1. Smaller accuracy improvements occur with a higher number of readings. Remember that mismatch errors affect accuracy as well.
- **The operator activates power meter calibration without regard for the source's current power setting.** There may be a large difference between the current power level and the desired calibrated power level. Power meter calibration will automatically adjust the power at the measurement port to match the desired calibrated power level. However, a large change in power affects accuracy, especially if the number of readings = 1. The accuracy values given in Table 5-3 were calculated with an initial power setting of +10 dB. The power range of the HP 8753B source is +20 to −5 dBm, so the worst-case power correction is 25 dB.

USING POWER METER CALIBRATION

To use power meter calibration you must perform the following steps:

Before Turning Power Meter Calibration On

- Enter the HP-IB address of the power meter into the HP 8753B. Press **[LOCAL]** *[SET ADDRESSES] [P MTR/HPIB]* **[#] [#] [x1]**, where ## is the two digit HP-IB address currently in use by the power meter.
- Press *[POWER MTR: [43X]]* until the softkey label shows the power meter in use. Currently three power meters are supported: HP 436A, 437B, and 438A.
- Set the HP 8753B to system controller mode. Press **[LOCAL]** *[SYSTEM CONTROLLER]*.
- Enter the power sensor calibration data. Press **[CAL]** *[PWR MTR [43X]] [LOSS/SENSR LISTS] [CAL FACTOR SENSOR A]* and enter the power sensor calibration factors for each desired frequency segment. Details on the segment edit menus are provided later in this chapter.

  If using an HP 8753B option 006 (6 GHz operation), enter the power meter calibration factors for the higher frequency power sensor. Select *[CAL FACTOR SENSOR B]* and enter the calibration factors for each desired segment.
- Press **[CAL]** *[PWR METER [43X]]* to enter the main power meter calibration menu.

Using the Power Loss Feature to Compensate for Power Splitter/ Directional Coupler Attenuation Non-Linearities

Power loss data can be entered at up to 12 segments. The correction values between segments are interpolated by the HP 8753B.

Directional Couplers. If a directional coupler is used, the power loss through the coupled arm should be entered for at least one frequency point with the *[POWER LOSS]* softkey. You can enter the loss information in a single segment, and the HP 8753B will assume that the value applies to the entire frequency range of the instrument. Or actual measured power loss values may be input at several frequencies using multiple segments, enhancing power accuracy.

Power Splitters. Power accuracy can be improved when using a power splitter to sample the RF output. Using the power loss feature, the user can compensate for tracking errors.

- Press *[LOSS/SENSR LISTS] [POWER LOSS]*. Enter the attenuation of the power splitter or directional coupler at as many frequency segments as needed, depending on the required accuracy. The power loss submenus are explained later in this chapter. When finished, press *[DONE]* to get back to the power loss menu and *[RETURN]* to get back to the power meter calibration menu.
- Press *[POWER LOSS on OFF]* to turn on power loss compensation.

Using Continuous Sample Mode

The *[EACH SWEEP]* function continuously checks power at every point in each sweep. The power meter must remain connected as shown in Figure 5-19.

- Cal power becomes the active function. Enter the desired test port power level (the power level you wish to maintain at the input to the DUT).

- Use a power splitter or directional coupler to tap off RF power going to the DUT. Compensate for power loss if using a directional coupler.
- If you wish more than one power measurement at each frequency point in the stimulus range, press ***[NUMBER OF READINGS]*** **[n] [x1]**, where n = the number of desired iterations. (Note that this will substantially increase the power meter calibration time.)
- Press ***[EACH SWEEP]*** to turn on power meter calibration.

Using Sample-and-Sweep Mode

When the ***[ONE SWEEP]*** softkey is pressed, the instrument corrects the output power using the power meter calibration data table. Pressing ***[TAKE CAL SWEEP]*** causes the initial measurement sweep to occur, which updates the data table. After that, remove the power meter sensor and connect the DUT. Subsequent sweeps will use the data table to correct the output power level at each point. A typical setup is shown in Figure 5-20.

- Cal power becomes the active function. Enter the desired test port power level (the power level you wish to maintain at the input to the DUT).
- Measure the power at the DUT input node directly.
- If you wish more than one power measurement at each frequency point in the stimulus range, press ***[NUMBER OF READINGS]*** **[#] [x1]**. (Note that this will substantially increase the power meter calibration time.)
- Press ***[ONE SWEEP] [TAKE CAL SWEEP]***. The actual power at each frequency point will be measured with the initial sweep. During this sweep, sweep speed will slow significantly.
- Remove the power meter sensor and connect the DUT.

Calibration Data Table

Valid calibration data will be in the power correction table if one of the following has occurred:

- Either ***[TAKE CAL SWEEP]*** or ***[EACH SWEEP]*** has been pressed.
- Calibration data has been placed in the table via HP-IB.

Power Meter Calibration Menus

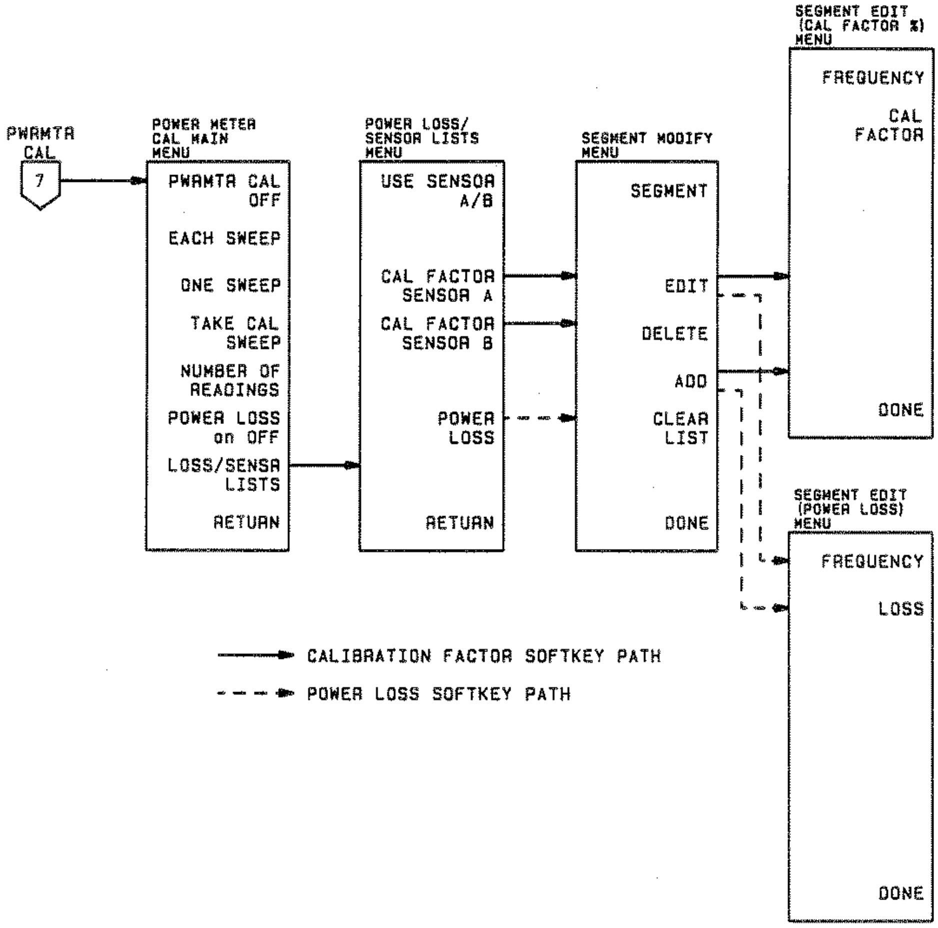


Figure 5-21. Relationship of the Menus Accessed with the [PWRMTR CAL] Softkey.

Power Meter Calibration Main Menu

Refer to Figure 5-21.

[PWRMTR CAL OFF] (PWMCOFF) turns off power meter calibration.

[EACH SWEEP] (PWMCEACS). Power meter calibration occurs on each sweep. Each measurement point is measured by the power meter, which provides the HP 8753B with the actual power reading. The HP 8753B corrects the power level at that point. The number of measurement/correction iterations performed on each point is determined by the *[NUMBER OF READINGS]* softkey. This measurement mode sweeps slowly, especially when the measured power is small. Small power levels require more time for the power meter to settle. The power meter correction table in memory is updated after each sweep. This table can be read or changed via HP-IB.

[ONE SWEEP] (PWMCONES). This mode does not measure each sweep, but corrects each point with the data currently in the power meter correction table. The *[TAKE CAL SWEEP]* softkey may be used to measure the power level at each point during a single sweep, and place correction data in the table. If the *[EACH SWEEP]* function was used earlier, correction data already exists in the table.

As with the *[EACH SWEEP]* softkey, the number of measurement iterations at each point can be selected using the *[NUMBER OF READINGS]* softkey.

[TAKE CAL SWEEP] (TAKCS) Each data point is measured during the initial sweep and the correction data is placed in the power meter correction table. This provides data usable in the *[ONE SWEEP]* mode.

[NUMBER OF READINGS] (NUMR) determines the number of measurement/correction iterations performed on each point. This feature helps eliminate residual power errors after the initial correction. The amount of residual error is directly proportional to the magnitude of the initial correction. It is assumed that the user has initially set the source power so that it is approximately correct when it arrives at the DUT. If power uncertainty at the DUT is expected to be greater than a few dB, it is recommended that the number of readings be greater than 1.

[PWR LOSS on OFF] (PWRLOSSON, PWRLOSSOFF) turns on or off power loss correction. Power loss correction should be used when the power output is measured by a directional coupler. The power loss caused by the coupled arm should be entered by using the *[LOSS/SENSR LISTS]* softkey submenus described below.

[LOSS/SENSR LISTS] presents the power loss/sensor lists menu. This menu performs two functions:

- Corrects coupled-arm power loss when a directional coupler is used to sample the RF output.
- Allows calibration factor data to be entered for one or two power sensors.

Each function provides up to 12 separate frequency points, called segments, at which the user may enter a different power loss or calibration factor. The instrument interpolates between the selected points. Two power sensor lists are provided because no single power sensor can cover the frequency range possible with an HP 8753B option 006 (6 GHz operation)/ HP 85047A test set system.

[RETURN] goes back to the main calibration menu.

Power Loss/Sensor Lists Menu

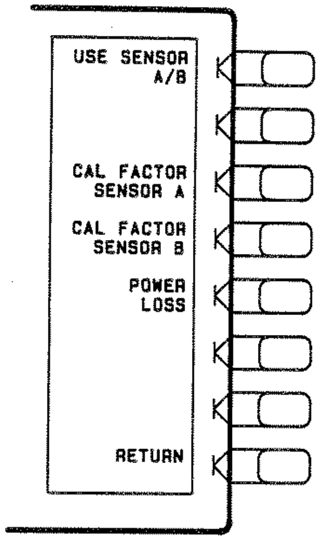


Figure 5-22. Power Loss/Sensor List Menu

[USE SENSOR A / B] (USESENSA, USESENSB) selects the A or B power sensor calibration factor list for use in power meter calibration measurements.

[CAL FACTOR SENSOR A] (CALFSENA) brings up the segment modify menu and segment edit (calibration factor %) menu explained on the following pages. The calibration factor data entered in this menu will be stored for power sensor A.

[CAL FACTOR SENSOR B] (CALFSENB) brings up the segment modify menu and segment edit (calibration factor %) menu explained on the following pages. The calibration factor data entered in this menu will be stored for power sensor B.

[POWER LOSS] (POWLLIST) brings up the segment modify menu and segment edit (power loss) menu explained in the following pages. This softkey is intended for use when the power output is being sampled by a directional coupler or power splitter. In the case of the directional coupler, enter the power loss caused by the coupled arm. Refer to *Power Loss Feature* on a previous page.

This feature may be used to compensate for attenuation non-linearities in either a directional coupler or a power splitter. Up to 12 segments may be entered, each with a different frequency and power loss value.

Segment Modify Menu

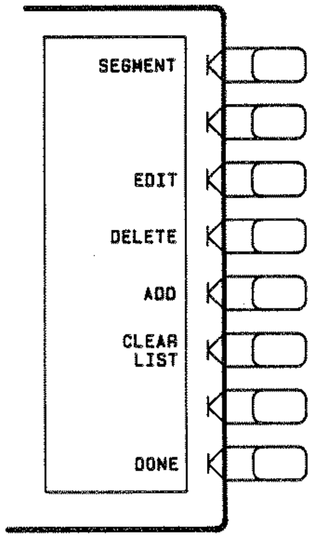


Figure 5-23. Segment Modify Menu

This menu performs two tasks:

- It allows the user to enter power sensor calibration data for one or two power sensors.
- It enters power loss data (refer to the ***[POWER LOSS]*** softkey description, above).

For either power loss or power sensor calibration data, the user may select from one to 12 frequency segments. Multiple segments do not have to be entered in any particular order: the HP 8753B automatically sorts them and lists them on the CRT in increasing order of frequency.

You may wish to use only one segment. In this case, the instrument assumes that the single value is valid over the entire frequency range of the calibration.

For high accuracy, actual measured power loss and/or power sensor calibration data may be entered for as many as 12 separate frequency points (segments). The frequencies between the points are interpolated by the instrument.

Instructions for Using the Segment Modify Menu. Before any segment information is entered in the list, the word "EMPTY" is displayed on the CRT. You can create the first segment by pressing either ***[EDIT]*** or ***[ADD]***. Enter the desired frequency and cal factor/power loss data when the appropriate segment edit menu appears.

Example, in the segment edit (power loss) menu, press: ***[FREQUENCY]*** **[1] [G/n]** ***[LOSS]*** **[6] [x1]** to add a segment to the power loss list. Now press ***[DONE]***.

Once an entry has been made, use the ***[ADD]*** softkey to enter additional segments. The default segment number when ***[ADD]*** is pressed is the next consecutive whole number above the last segment number. Follow the above instructions to define the next segment in the list.

To delete an entry in the list, press ***[SEGMENT]*** and use the entry block controls to select the desired segment. Press ***[DELETE]***.

To erase all entries, press the ***[CLEAR LIST]*** softkey.

[SEGMENT] specifies which segment in the list is to be modified. A maximum of two segments is displayed at one time, and the list can be scrolled up or down to show other segment entries. Use the entry block controls to move the pointer > to the desired segment number. The selected segment can now be edited or deleted.

[EDIT] (SEDIn, where "n" is the segment number). This softkey brings up the appropriate segment edit menu described in the following pages. The edit command modifies the segment previously selected with the ***[SEGMENT]*** softkey.

[DELETE] (SDEL) Deletes the segment previously selected with the ***[SEGMENT]*** softkey.

[ADD] (SADD) adds another segment to the bottom of the list and presents the appropriate segment edit menu described in the following pages.

[CLEAR LIST] (CLEL) deletes all segments in the list.

[DONE] (EDITDONE) goes back to the power loss/sensor list menu.

Segment Edit (Calibration Factor %) Menu

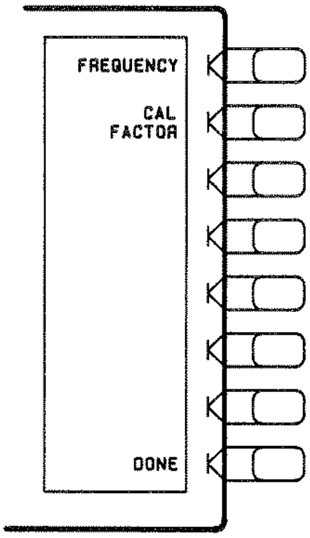


Figure 5-24. Segment Edit (Calibration Factor %) Menu

This menu defines the frequency and calibration factor % for the segment being added or edited.

[FREQUENCY] (CALFFREQ) accepts a frequency value for the segment.

[CAL FACTOR] (CALFCALF) accepts a calibration factor % for the segment.

[DONE] (SDON) goes back to the segment modify menu and sorts the list according to increasing frequency.

Segment Edit (Power Loss) Menu

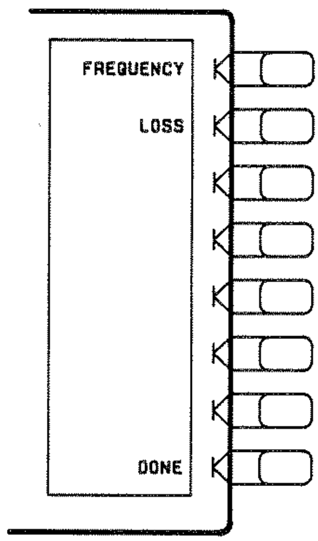


Figure 5-25. Segment Edit (Power Loss) Menu

This menu defines the frequency and power loss for the segment being added or edited.

[FREQUENCY] (POWLFREQ) accepts a frequency value for the segment.

[LOSS] (POWLLOSS) accepts a power loss value for the segment. This value, for example, could be the difference (in dB) between the coupled arm and through arm of a directional coupler.

[DONE] (SDON) goes back to the segment modify menu and sorts the list according to increasing frequency.

MODIFYING CALIBRATION KITS

NOTE: Hewlett-Packard strongly recommends that you read application note 8510-5A before attempting to view or modify calibration standard definitions. The part number of this application note is 5956-4352. Although the application note is written for the HP 8510 family of network analyzers, it also applies to the HP 8753B. This portion of the calibration chapter provides a summary of the information in the application note, as well as HP 8753B menu-specific information.

For most applications, use the default cal kit models provided in the select cal kit menu described earlier in this chapter. Modifying calibration kits is necessary only if unusual standards are used or the very highest accuracy is required. Unless a cal kit model is provided with the calibration devices used, a solid understanding of error correction and the system error model are absolutely essential to making modifications. Read the introductory part of this chapter for more information, and refer to the Appendix to Chapter 5 and to *System Performance* in the *General Information and Specifications* section.

NOTE: Numerical data for most Hewlett-Packard calibration kits is provided in the calibration kit manuals.

During measurement calibration, the HP 8753B measures actual, well-defined standards and mathematically compares the results with ideal "models" of those standards. The differences are separated into error terms which are later removed during error correction. Most of the differences are due to systematic errors - repeatable errors introduced by the network analyzer, test set, and cables - which are correctable. However, differences between the model for a standard and the actual performance of the standard reduce the system's ability to remove systematic errors, and thus degrade error-corrected accuracy. Therefore, in addition to the predefined default cal kit models, a "user kit" is provided that can be modified to an alternate calibration standards model.

Several situations exist that may require a user-defined cal kit:

- A calibration is required for a connector interface different from the four built-in cal kits. (Examples: SMA, TNC, or waveguide.)
- A calibration with standards (or combinations of standards) that are different from the predefined cal kits is required. (Example: Using three offset shorts instead of open, short, and load to perform a 1-port calibration.)
- The built-in standard models for predefined kits can be improved or refined. Remember that the more closely the model describes the actual performance of the standard, the better the calibration. (Example: The 7 mm load is determined to be 50.4 ohms instead of 50.0 ohms.)
- Unused standards for a given cal type can be eliminated from the predefined set, to eliminate possible confusion during calibration. (Example: A certain application requires calibrating a male test port. The standards used to calibrate a female test port can be eliminated from the set, and will not be displayed during calibration.)

Definitions

It is necessary to define some of the terms used:

- A "standard" is a specific, well-defined, physical device used to determine systematic errors.
- A standard "type" is one of five basic types that define the form or structure of the model to be used with that standard (e.g. short or load).
- Standard "coefficients" are numerical characteristics of the standards used in the model selected.
- A standard "class" is a grouping of one or more standards that determines which standards are used in a particular calibration procedure.

Procedure

Basically, the following steps are used to modify or define a user kit:

1. To modify a cal kit, first select the predefined kit to be modified. This is not necessary for defining a new cal kit.
2. Define the standards. For each standard, define which "type" of standard it is and its electrical characteristics.
3. Specify the class where the standard is to be assigned.
4. Store the modified cal kit.

Following the descriptions of the menus for modifying calibration kits, a procedure is provided that enters the HP 85033C 3.5 mm calibration kit values as a "user kit."

Modify Cal Kit Menu

This menu is accessed from the **[CAL]** key (refer to Figure 5-8). This leads in turn to additional series of menus associated with modifying cal kits.

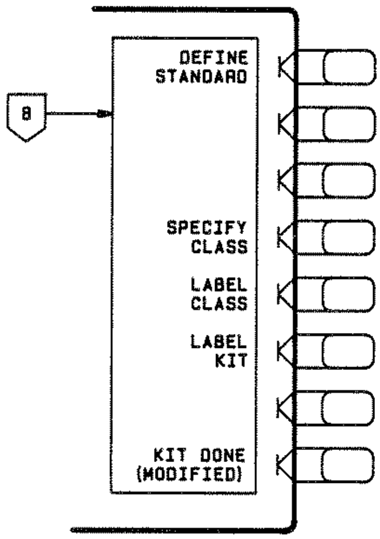


Figure 5-26. Modify Cal Kit Menu

[DEFINE STANDARD] (DEFS) makes the standard number the active function, and brings up the define standard menus. The standard number (1 to 8) is an arbitrary reference number used to reference standards while specifying a class. The standard numbers for the predefined calibration kits are as follows:

1	short	5	sliding load
2	open	6	lowband load
3	broadband load	7	short
4	thru	8	open

[SPECIFY CLASS] leads to the specify class menu. After the standards are modified, use this key to specify a class to consist of certain standards.

[LABEL CLASS] leads to the label class menu, to give the class a meaningful label for future reference.

[LABEL KIT] (LABEK) leads to a menu for constructing a label for the user-modified cal kit. If a label is supplied, it will appear as one of the five softkey choices in the select cal kit menu. The approach is similar to defining a display title, except that the kit label is limited to ten characters. Refer to *[DISPLAY] Key, Title Menu* in Chapter 4 for details.

[KIT DONE] (KITD) terminates the cal kit modification process, after all standards are defined and all classes are specified. Be sure to save the kit with the *[SAVE USER KIT]* softkey, if it is to be used later.

Define Standard Menus

Standard definition is the process of mathematically modeling the electrical characteristics (delay, attenuation, and impedance) of each calibration standard. These electrical characteristics (coefficients) can be mathematically derived from the physical dimensions and material of each calibration standard, or from its actual measured response. The parameters of the standards can be listed in *Standards Definitions*, Table 5-4. The menus illustrated in Figure 5-27 are used to specify the type and characteristics for each user-defined standard.

Table 5-4. Standard Definitions

STANDARD		C0 $x10^{-15}F$	C1 $x10^{-27}F$/Hz	C2 $x10^{-36}F$/Hz	C3 $x10^{-45}F$/Hz	FIXED OR SLIDING	OFFSET			FREQUENCY (GHz)		COAX or WAVEGUIDE	STANDARD LABEL
NO.	TYPE						DELAY ps	LOSS MΩ/s	Z_0 Ω	MINIMUM	MAXIMUM		
1													
2													
3													
4													
5													
6													
7													
8													

Each standard must be identified as one of five "types": open, short, load, delay/thru, or arbitrary impedance.

After a standard number is entered, selection of the standard type will present one of five menus for entering the electrical characteristics (model coefficients) corresponding to that standard type. These menus are tailored to the current type, so that only characteristics applicable to the standard type can be modified.

Any standard type can be further defined with offsets in delay, loss, and standard impedance; assigned minimum or maximum frequencies over which the standard applies; and defined as coax or waveguide. Press the *[SPECIFY OFFSET]* key, and refer to the specify offset menu.

A distinct label can be defined and assigned to each standard, so that the HP 8753B can prompt the user with explicit standard labels during calibration (e.g. "SHORT"). Press the ***[LABEL STD]*** softkey. The function is similar to defining a display title, except that the label is limited to ten characters. Refer to *[DISPLAY] Key, Title Menu* in Chapter 4 for details.

After each standard is defined, including offsets, press ***[STD DONE (DEFINED)]*** to terminate the standard definition.

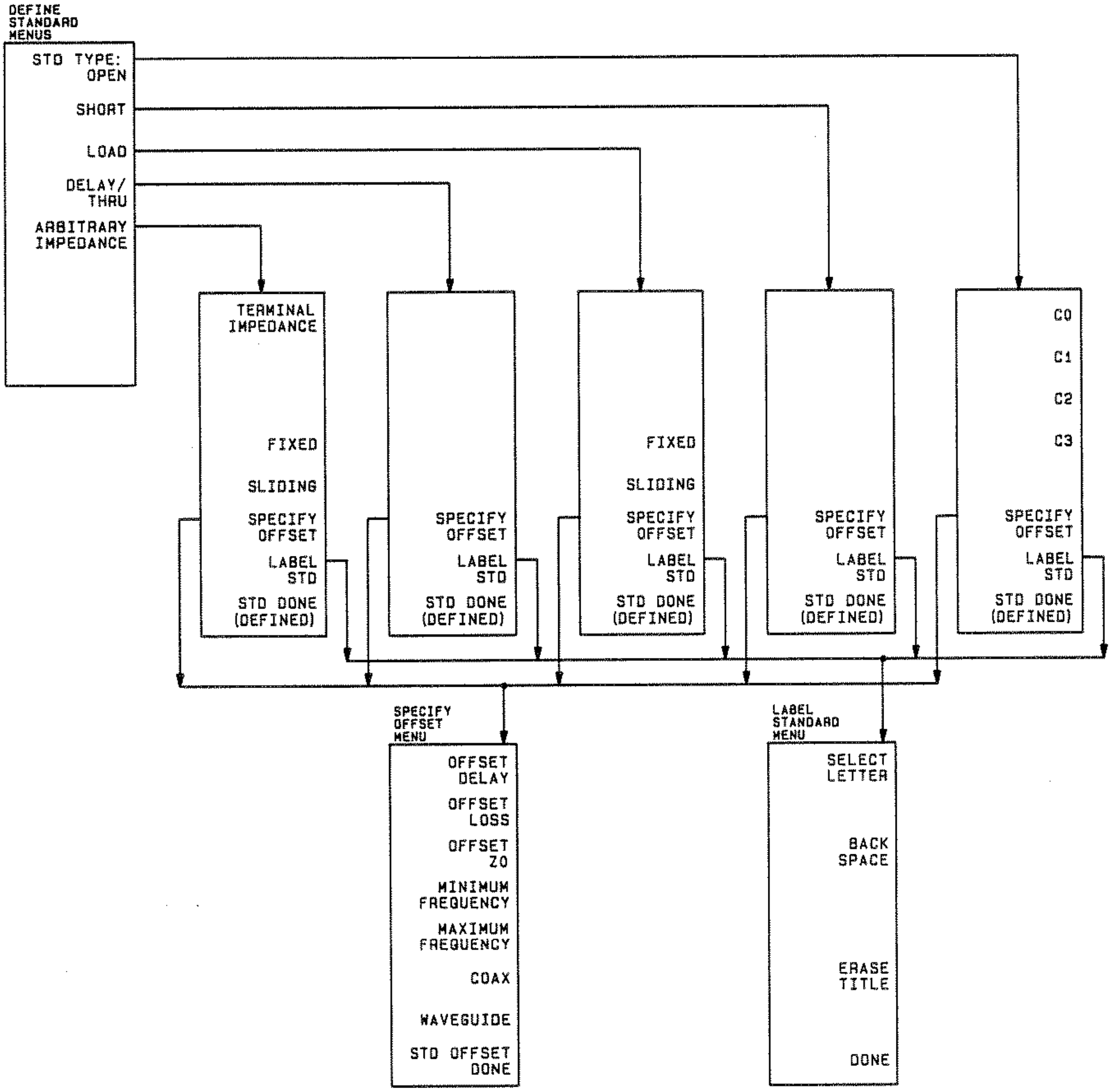


Figure 5-27. Define Standard Menus

[OPEN] (STDTOPEN) defines the standard type as an open, used for calibrating reflection measurements. Opens are assigned a terminal impedance of infinity ohms, but delay and loss offsets may still be added. Pressing this key also brings up a menu for defining the open, including its capacitance.

As a reflection standard, an open termination offers the advantage of broadband frequency coverage. At microwave frequencies, however, an open rarely has perfect reflection characteristics because fringing (capacitance) effects cause phase shift that varies with frequency. This can be observed in measuring an open termination after calibration, when an arc in the lower right circumference of the Smith chart indicates capacitive reactance. These effects are impossible to eliminate, but the calibration kit models include the open termination capacitance at all frequencies for compatible calibration kits. The capacitance model is a cubic polynomial, as a function of frequency, where the polynomial coefficients are user-definable. The capacitance model equation is:

$$C = (C0) + (C1*F) + (C2*F\wedge 2) + (C3*F\wedge 3)$$

where F is the measurement frequency.

The terms in the equation are defined with the specify open menu as follows:

[C0] (C0) is used to enter the C0 term, which is the constant term of the cubic polynomial and is scaled by 10^{-15} Farads.

[C1] (C1) is used to enter the C1 term, expressed in F/Hz (Farads/Hz) and scaled by 10^{-27}.

[C2] (C2) is used to enter the C2 term, expressed in F/Hz∧2 and scaled by 10^{-36}.

[C3] (C3) is used to enter the C3 term, expressed in F/Hz∧3 and scaled by 10^{-45}.

[SHORT] (STDTSHOR) defines the standard type as a short, for calibrating reflection measurements. Shorts are assigned a terminal impedance of 0 ohms, but delay and loss offsets may still be added.

[LOAD] (STDTLOAD) defines the standard type as a load (termination). Loads are assigned a terminal impedance equal to the system characteristic impedance Z0, but delay and loss offsets may still be added. If the load impedance is not Z0, use the arbitrary impedance standard definition.

[FIXED] (FIXE) defines the load as a fixed (not sliding) load.

[SLIDING] (SLIL) defines the load as a sliding load. When such a load is measured during calibration, the HP 8753B will prompt for several load positions, and calculate the ideal load value from it.

[DELAY/THRU] (STDTDELA) defines the standard type as a transmission line of specified length, for calibrating transmission measurements.

[ARBITRARY IMPEDANCE] (STDTARBI) defines the standard type to be a load, but with an arbitrary impedance (different from system Z0).

[TERMINAL IMPEDANCE] (TERI) is used to specify the (arbitrary) impedance of the standard, in ohms.

[FIXED] (FIXE) defines the load as a fixed (not sliding) load.

[SLIDING] (SLIL) defines the load as a sliding load. When such a load is measured during calibration, the HP 8753B will prompt for several load positions, and calculate the ideal load value from it.

Specify Offset Menu

The specify offset menu allows additional specifications for a user-defined standard. Features specified in this menu are common to all five types of standards.

Offsets may be specified with any standard type. This means defining a uniform length of transmission line to exist between the standard being defined and the actual measurement plane. (Example: a waveguide short circuit terminator, offset by a short length of waveguide.) For reflection standards, the offset is assumed to be between the measurement plane and the standard (one-way only). For transmission standards, the offset is assumed to exist between the two reference planes (in effect, the offset *is* the thru). Three characteristics of the offset can be defined: its delay (length), loss, and impedance.

In addition, the frequency range over which a particular standard is valid can be defined with a minimum and maximum frequency. This is particularly important for a waveguide standard, since its behavior changes rapidly beyond its cutoff frequency. Note that several band-limited standards can together be defined as the same "class" (see specify class menu). Then, if a measurement calibration is performed over a frequency range exceeding a single standard, additional standards can be used for each portion of the range.

Lastly, the standard must be defined as either coaxial or waveguide. If it is waveguide, dispersion effects are calculated automatically and included in the standard model.

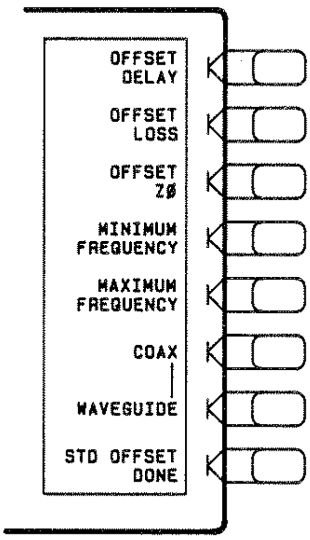


Figure 5-28. Specify Offset Menu

[OFFSET DELAY] (OFSD) is used to specify the one-way electrical delay from the measurement (reference) plane to the standard, in seconds (s). (In a transmission standard, offset delay is the delay from plane to plane.) Delay can be calculated from the precise physical length of the offset, the permittivity constant of the medium, and the speed of light.

In coax, group delay is considered constant. In waveguide, however, group delay is dispersive, that is, it changes significantly as a function of frequency. Hence, for a waveguide standard, offset delay must be defined at an infinitely high frequency.

[OFFSET LOSS] (OFSL) is used to specify energy loss, due to skin effect, along a one-way length of coax offset. The value of loss is entered as ohms/nanosecond (or Giga ohms/second) at 1 GHz. (Such losses are negligible in waveguide, so enter 0 as the loss offset.)

[OFFSET Z0] (OFSZ) is used to specify the characteristic impedance of the coax offset. (Note: This is *not* the impedance of the standard itself.) (For waveguide, the offset impedance is always assigned a value equal to the system Z0.)

[MINIMUM FREQUENCY] (MINF) is used to define the lowest frequency at which the standard can be used during measurement calibration. In waveguide, this *must* be the lower cutoff frequency of the standard, so that the HP 8753B can calculate dispersive effects correctly (see *[OFFSET DELAY]* above).

[MAXIMUM FREQUENCY] (MAXF) is used to define the highest frequency at which the standard can be used during measurement calibration. In waveguide, this is normally the upper cutoff frequency of the standard.

[COAX] (COAX) defines the standard (and the offset) as coaxial. This causes the HP 8753B to assume linear phase response in any offsets.

[WAVEGUIDE] (WAVE) defines the standard (and the offset) as rectangular waveguide. This causes the HP 8753B to assume a dispersive delay (see *[OFFSET DELAY]* above).

Label Standard Menu (LABS)

This menu is used to label (reference) individual standards during the menu-driven measurement calibration sequence. The labels are user-definable using a character set displayed on the CRT that includes letters, numbers, and some symbols, and they may be up to ten characters long. The HP 8753B will prompt you to connect standards using these labels, so they should be meaningful to you, and distinct for each standard.

By convention, when sexed connector standards are labeled male (m) or female (f), the designation refers to the test port connector sex, not the connector sex of the standard.

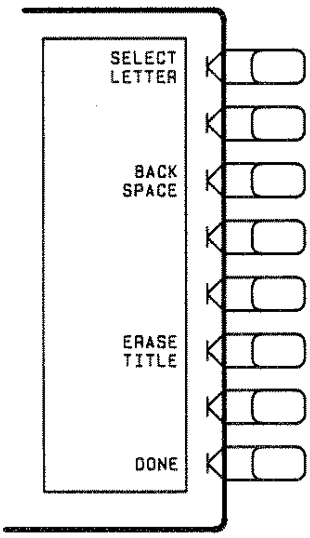


Figure 5-29. Label Standard Menu

Standard labels are created in the same way as titles. Refer to *[DISPLAY] Key, Title Menu* in Chapter 4.

Specify Class Menus

Once a standard is specified, it must be assigned to a standard "class". This is a group of from one to seven standards that is required to calibrate for a single error term. The standards within a single class are assigned to locations A through G as listed on the *Standard Class Assignments Table* (Table 5-5). A class often consists of a single standard, but may be composed of more than one standard if band-limited standards are used. (Example: All predefined calibration kits for the HP 8753B have a single load standard per class, since all are broadband in nature. However, if there were two load standards – a fixed load for low frequencies, and a sliding load for high frequencies – then that class would have two standards.)

Table 5-5. Standard Class Assignments Table

	A	B	C	D	E	F	G	STANDARD CLASS LABEL
$S_{11}A$								
$S_{11}B$								
$S_{11}C$								
$S_{22}A$								
$S_{22}B$								
$S_{22}C$								
Forward Transmission								
Reverse Transmission								
Forward Match								
Reverse Match								
Response								
Response & Isolation								

The number of standard classes required depends on the type of calibration being performed, and is identical to the number of error terms corrected. (Examples: A response cal requires only one class, and the standards for that class may include an open and/or short and/or thru. A 1-port cal requires three classes. A full 2-port cal requires 10 classes, not including two for isolation.)

The number of standards that can be assigned to a given class may vary from none (class not used) to one (simplest class) to seven. When a certain class of standards is required during calibration, the HP 8753B will display the labels for *all* the standards in that class (except when the class consists of a single standard). This does not, however, mean that all standards in a class must be measured during calibration. Unless band-limited standards are used, only a single standard per class is required. Note that it is often simpler to keep the number of standards per class to the bare minimum needed (often one) to avoid confusion during calibration.

Standards are assigned to a class simply by entering the standard's reference number (established while defining a standard) under a particular class.

Each class can be given a user-definable label as described under *Label Class Menus*.

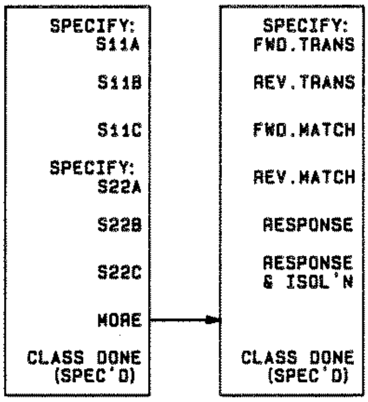


Figure 5-30. Specify Class Menus

[SPECIFY: S11A] (SPECS11A) is used to enter the standard number(s) for the first class required for an S_{11} 1-port calibration. (For predefined cal kits, this is the open.)

[S11B] (SPECS11B) is used to enter the standard number(s) for the second class required for an S_{11} 1-port calibration. (For predefined cal kits, this is the short.)

[S11C] (SPECS11C) is used to enter the standard number(s) for the third class required for an S_{11} 1-port calibration. (For predefined kits, this is the load.)

[SPECIFY: S22A] (SPECS22A) is used to enter the standard number(s) for the first class required for an S_{22} 1-port calibration. (For predefined cal kits, this is the open.)

[S22B] (SPECS22B) is used to enter the standard number(s) for the second class required for an S_{22} 1-port calibration. (For predefined cal kits, this is the short.)

[S22C] (SPECS22C) is used to enter the standard number(s) for the third class required for an S_{22} 1-port calibration. (For predefined kits, this is the load.)

[MORE] leads to the following softkeys.

[FWD.TRANS.] (SPECFWDT) is used to enter the standard number(s) for the forward transmission thru calibration. (For predefined kits, this is the thru.)

[REV.TRANS.] (SPECREVT) is used to enter the standard number(s) for the reverse transmission (thru) calibration. (For predefined kits, this is the thru.)

[FWD.MATCH] (SPECFWDM) is used to enter the standard number(s) for the forward match (thru) calibration. (For predefined kits, this is the thru.)

[REV.MATCH] (SPECREVM) is used to enter the standard number(s) for the reverse match (thru) calibration. (For predefined kits, this is the thru.)

[RESPONSE] (SPECRESP) is used to enter the standard number(s) for a response calibration. This calibration corrects for frequency response in either reflection or transmission measurements, depending on the parameter being measured when a calibration is performed. (For predefined kits, the standard is either the open or short for reflection measurements, or the thru for transmission measurements.)

[RESPONSE & ISOL'N] (SPECRESI) is used to enter the standard number(s) for a response & isolation calibration. This calibration corrects for frequency response and directivity in reflection measurements, or frequency response and isolation in transmission measurements.

Label Class Menus

The label class menus are used to define meaningful labels for the calibration classes. These then become softkey labels during a measurement calibration. Labels can be up to ten characters long.

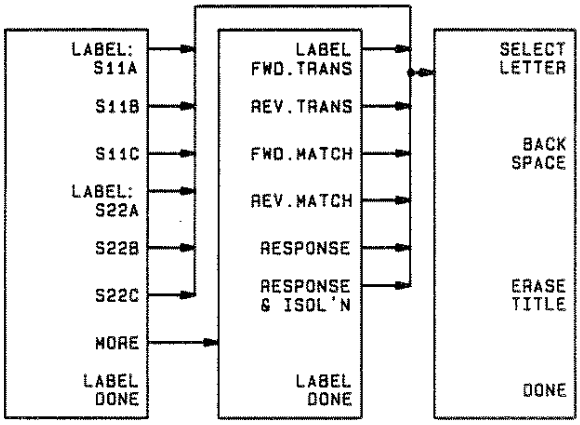


Figure 5-31. Label Class Menus

Labels are created in the same way as display titles. Refer to *[DISPLAY] Key, Title Menu* in Chapter 4.

Label Kit Menu

After a new calibration kit has been defined, be sure to specify a label for it. Choose a label that describes the connector type of the calibration devices. This label will then appear in the ***[CAL KIT]*** softkey label in the correction menu and the ***[MODIFY]*** label in the select cal kit menu. It will be saved with calibration sets.

This menu is accessed with the ***[LABEL KIT]*** softkey in the modify cal kit menu, and is identical to the label class menu and the label standard menu described above. It allows definition of a label up to eight characters long.

Verify Performance

Once a measurement calibration has been generated with a user-defined calibration kit, its performance should be checked before making device measurements. To check the accuracy that can be obtained using the new calibration kit, a device with a well-defined frequency response (preferably unlike any of the standards used) should be measured. The verification device must not be one of the calibration standards: measurement of one of these standards is merely a measure of repeatability.

To achieve more complete verification of a particular measurement calibration, accurately known verification standards with a diverse magnitude and phase response should be used. NBS traceable or HP standards are recommended to achieve verifiable measurement accuracy.

NOTE: The published specifications for the HP 8753B network analyzer system include accuracy enhancement with compatible calibration kits. Measurement calibrations made with user-defined or modified calibration kits are not subject to the HP 8753B specifications, although a procedure similar to the system verification procedure may be used.

Example Procedure for Specifying a User-Defined Calibration Kit

The following procedure enters the HP 85033C 3.5 mm calibration kit values as a "user kit." This is provided as an example to illustrate the steps required in defining a calibration kit model.

NOTE: Numerical data for most Hewlett-Packard calibration kits is provided in the calibration kit manuals.

The first keystroke sequence enters the values for standard #1, the short circuit.

- **[CAL]** ***[CAL KIT] [MODIFY]***
- ***[DEFINE STANDARD] [SHORT]***
- ***[SPECIFY OFFSET] [OFFSET DELAY]*** **[.] [0] [1] [6] [6] [9] [5] [G/n]**
- ***[STD OFFSET DONE] [STD DONE (DEFINED)]***

The next sequence specifies standard #2, the open circuit.

- ***[DEFINE STANDARD]*** **[2] [x1]** ***[OPEN]***
- ***[C0]*** **[5] [3] [x1]**
- ***[C1]*** **[1] [5] [0] [x1]**
- ***[C2]*** **[0] [x1]**
- ***[C3]*** **[0] [x1]**
- ***[SPECIFY OFFSET] [OFFSET DELAY]*** **[.] [0] [1] [4] [4] [9] [1] [G/n]**
- ***[STD OFFSET DONE] [STD DONE (DEFINED)]***

The next sequence specifies standard #3, the lowband load.

- ***[DEFINE STANDARD]*** **[3] [x1]** ***[LOAD]***
- ***[SPECIFY OFFSET] [MAXIMUM FREQUENCY]*** **[6] [.] [0] [0] [1] [G/n]**
- ***[STD OFFSET DONE] [STD DONE (DEFINED)]***

The final sequence labels the kit and saves it in memory.

- ***[LABEL KIT]***
- Use the knob and softkeys to modify the label to read "3.5mmC"
- ***[DONE] [KIT DONE (MODIFIED)]***

- **[CAL]**
- ***[CAL KIT [3.5mmC]]***
- ***[SAVE USER KIT] [USER KIT]***

The ***[USER KIT]*** softkey is now underlined, and the user-specified kit definition is saved in non-volatile memory.

ACCURACY ENHANCEMENT FUNDAMENTALS–CHARACTERIZING MICROWAVE SYSTEMATIC ERRORS

One-Port Error Model

In a measurement of the reflection coefficient (magnitude and phase) of an unknown device, the measured data differs from the actual, no matter how carefully the measurement is made. Directivity, source match, and reflection signal path frequency response (tracking) are the major sources of error (Figure 5-32).

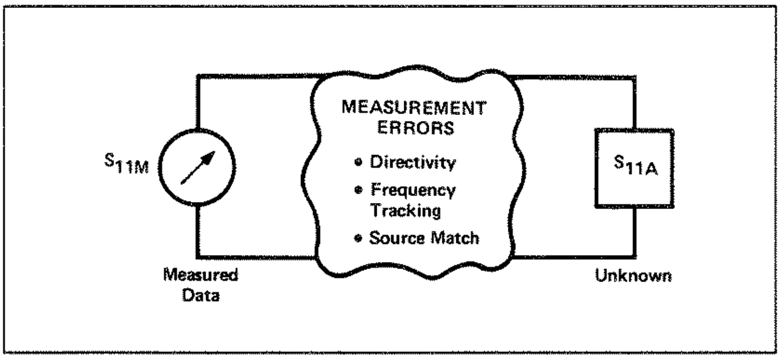


Figure 5-32. Sources of Error in a Reflection Measurement

The reflection coefficient is measured by first separating the incident signal (I) from the reflected signal (R), then taking the ratio of the two values (Figure 5-33). Ideally, (R) consists only of the signal reflected by the test device (S11A).

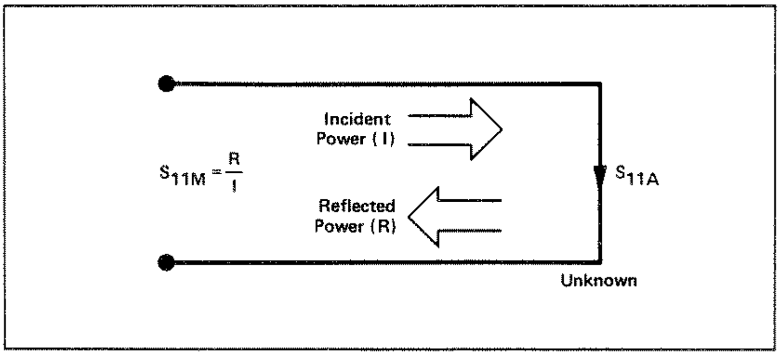


Figure 5-33

However, all of the incident signal does not always reach the unknown (see Figure 5-34). Some of (I) may appear at the measurement system input due to leakage through the test set or other signal separation device. Also, some of (I) may be reflected by imperfect adapters between signal separation and the measurement plane. The vector sum of the leakage and miscellaneous reflections is directivity, EDF. Understandably, the measurement is distorted when the directivity signal combines vectorally with the actual reflected signal from the unknown, S11A.

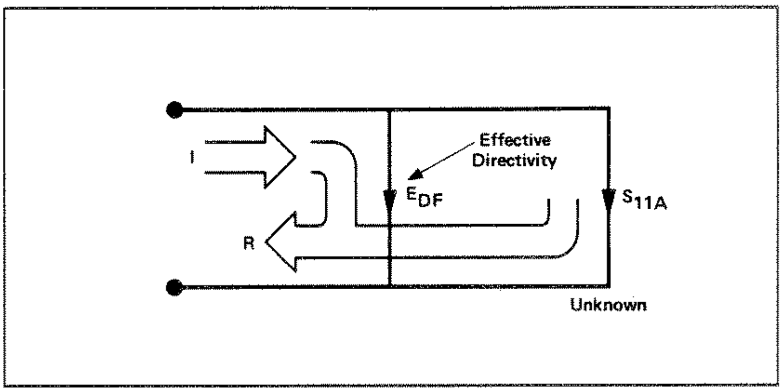


Figure 5-34

Since the measurement system test port is never exactly the characteristic impedance (50 ohms or 75 ohms), some of the reflected signal bounces off the test port, or other impedance transitions further down the line, and back to the unknown, adding to the original incident signal (I). This effect causes the magnitude and phase of the incident signal to vary as a function of S11A and frequency. Leveling the source to produce constant (I) reduces this error, but since the source cannot be exactly leveled at the test device input, leveling cannot eliminate all power variations. This re-reflection effect and the resultant incident power variation are caused by the source match error, ESF (Figure 5-35).

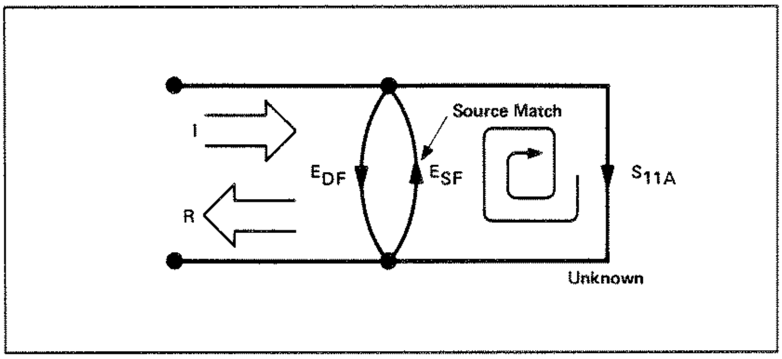


Figure 5-35

Frequency response (tracking) error is caused by variations in magnitude and phase flatness versus frequency between the test and reference signal paths. These are due mainly to imperfectly matched samplers and differences in length and loss between incident and test signal paths. The vector sum of these variations is the reflection signal path tracking error, ERF (Figure 5-36).

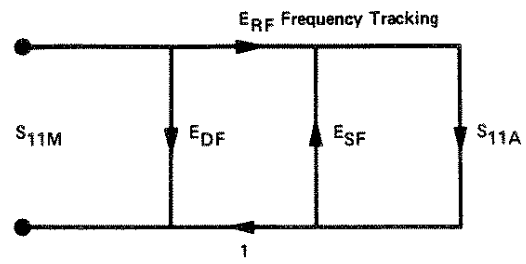


Figure 5-36

It can be shown that these three errors are mathematically related to the actual data, S11A, and measured data, S11M, by the following equation:

$$S_{11M} = E_{DF} + \frac{S_{11A}(E_{RF})}{1 - E_{SF}S_{11A}}$$

If the value of these three "E" errors and the measured test device response were known for each frequency, the above equation could be solved for S11A to obtain the actual test device response. Because each of these errors changes with frequency, it is necessary that their values be known at each test frequency. These values are found by measuring the system at the measurement plane using three independent standards whose S11A is known at all frequencies.

The first standard applied is a "perfect load", which makes S11A = 0 and essentially measures directivity (Figure 5-37). "Perfect load" implies a reflectionless termination at the measurement plane. All incident energy is absorbed. With S11A = 0 the equation can be solved for EDF, the directivity term. In practice, of course, the "perfect load" is difficult to achieve, although very good broadband loads are available in the HP 8753B compatible calibration kits.

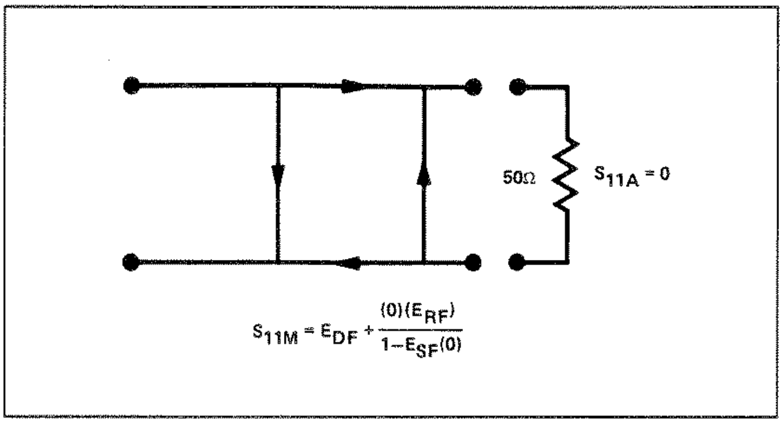


Figure 5-37

Since the measured value for directivity is the vector sum of the actual directivity plus the actual reflection coefficient of the "perfect load," any reflection from the termination represents an error. System effective directivity becomes the actual reflection coefficient of the "perfect load" (Figure 5-38). In general, any termination having a return loss value greater than the uncorrected system directivity reduces reflection measurement uncertainty.

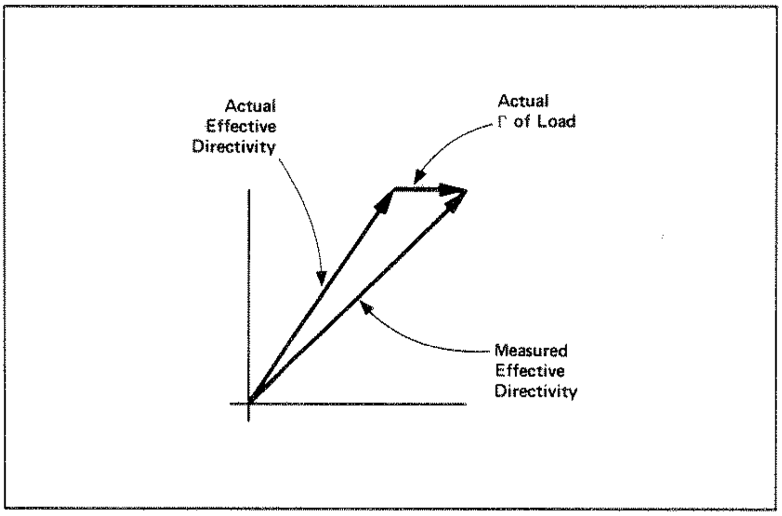


Figure 5-38

Next, a short circuit termination whose response is known to a very high degree is used to establish another condition (Figure 5-39).

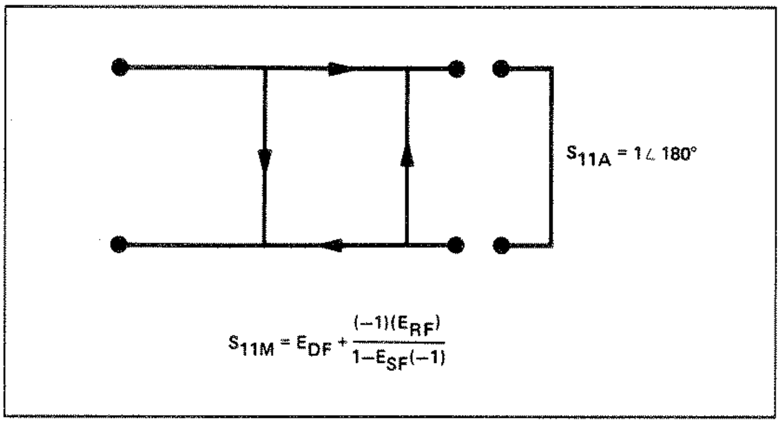


Figure 5-39

The open circuit gives the third independent condition. In order to accurately model the phase variation with frequency due to radiation from the open connector, a specially designed shielded open circuit is used for this step. (The open circuit capacitance is different with each connector type). Now the values for EDF, directivity, ESF, source match, and ERF, reflection frequency response, are computed and stored (Figure 5-40).

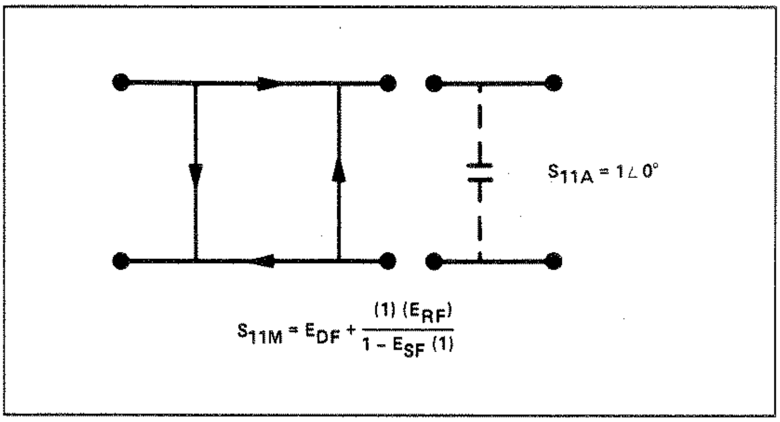


Figure 5-40

Now the unknown is measured to obtain a value for the measured response, S11M, at each frequency (Figure 5-41).

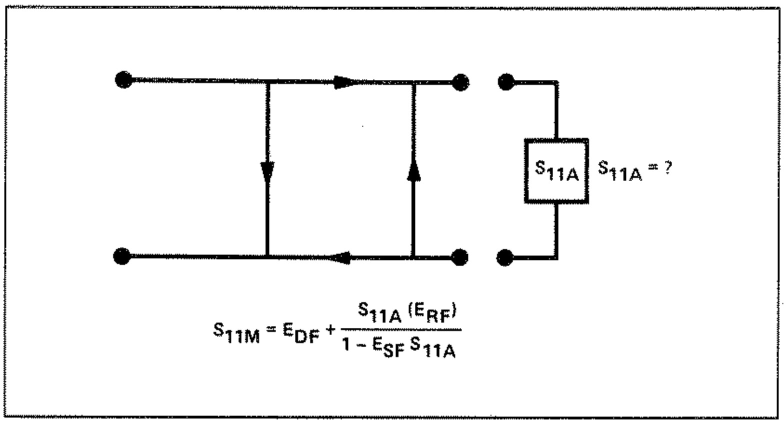


Figure 5-41

This is the one-port error model equation solved for S11A. Since the three errors and S11M are now known for each test frequency, S11A can be computed as follows:

$$S_{11A} = \frac{S_{11M} - E_{DF}}{E_{SF}(S_{11M} - E_{DF}) + E_{RF}}$$

For reflection measurements on two-port devices, the same technique can be applied, but the test device output port must be terminated in the system characteristic impedance. This termination should be at least as good (have as low a reflection coefficient) as the load used to determine directivity. The additional reflection error caused by an improper termination at the test device output port is not incorporated into the one-port error model.

Two-Port Error Model

The error model for measurement of the transmission coefficients (magnitude and phase) of a two-port device is derived in a similar manner. The major sources of error are frequency response (tracking), source match, load match, and isolation (Figure 5-42). These errors are effectively removed using the full two-port error model.

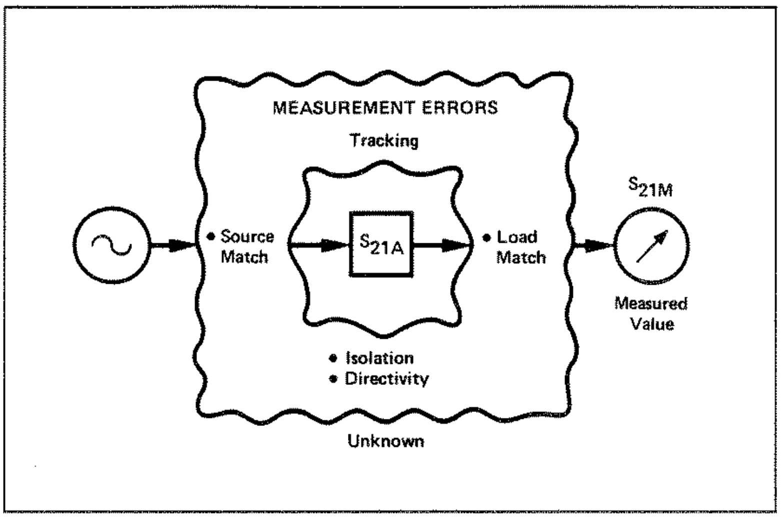


Figure 5-42

The transmission coefficient is measured by taking the ratio of the incident signal (I) and the transmitted signal (T) (Figure 5-43). Ideally, (I) consists only of power delivered by the source, and (T) consists only of power emerging at the test device output.

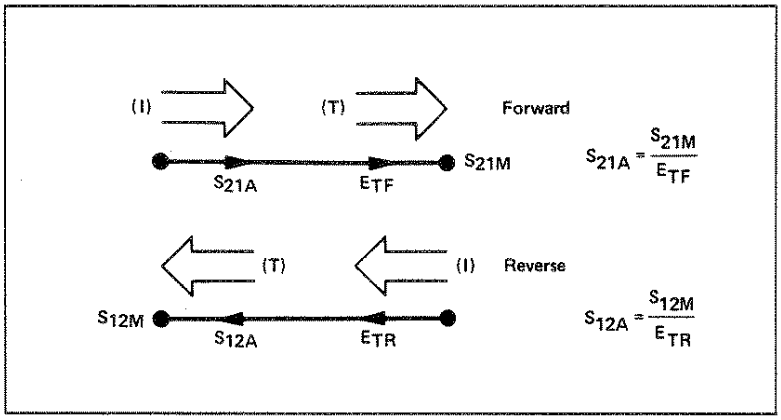


Figure 5-43

As in the reflection model, source match can cause the incident signal to vary as a function of test device S11A. Also, since the test setup transmission return port is never exactly the characteristic impedance, some of the transmitted signal is reflected from the test set port 2, and from other mismatches between the test device output and the receiver input, to return to the test device. A portion of this signal may be re-reflected at port 2, thus affecting S21M, or part may be transmitted through the device in the reverse direction to appear at port 1, thus affecting S11M. This error term, which causes the magnitude and phase of the transmitted signal to vary as a function of S22A, is called load match, ELF (Figure 5-44).

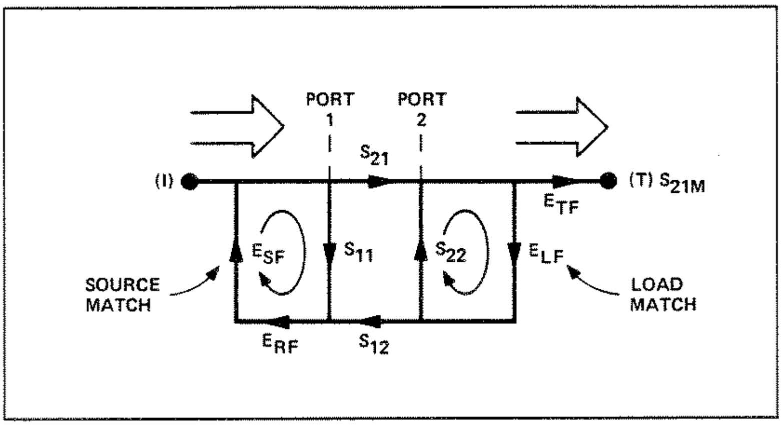


Figure 5-44

The measured value, S21M, consists of signal components that vary as a function of the relationship between ESF and S11A as well as ELF and S22A, so the input and output reflection coefficients of the test device must be measured and stored for use in the S21A error correction computation. Thus, the test setup is calibrated as described above for reflection to establish the directivity, EDF, source match, ESF, and reflection frequency response, ERF, terms for the reflection measurements.

Now that a calibrated port is available for reflection measurements, the thru is connected and load match, ELF, is determined by measuring the reflection coefficient of the thru connection.

Transmission signal path frequency response is then measured with the thru connected. The data is corrected for source and load match effects, then stored as transmission frequency response, ETF.

Isolation, EXF, represents the part of the incident signal that appears at the receiver without actually passing through the test device (Figure 5-45). Isolation is measured with the test set in the transmission configuration and with terminations installed at the points where the test device will be connected.

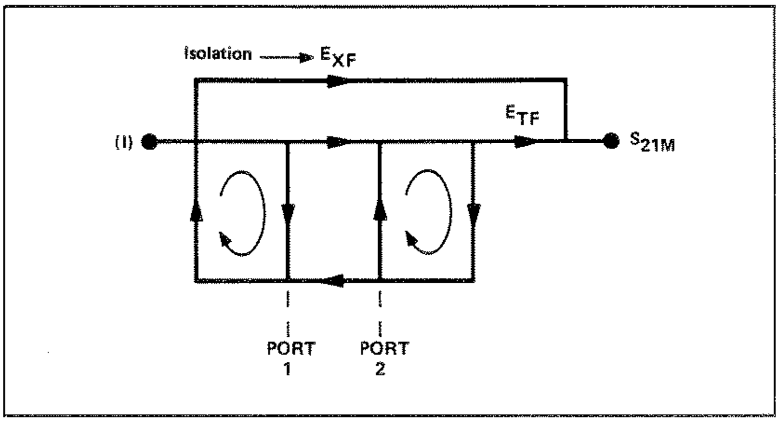


Figure 5-45

Thus there are two sets of error terms, forward and reverse, with each set consisting of six error terms, as follows:

Directivity, EDF (forward) and EDR (reverse)
Isolation, EXF and EXR
Source Match, ESF and ESR
Load Match, ELF and ELR
Transmission Tracking, ETF and ETR
Reflection Tracking, ERF and ERR.

The HP 85046A/B and 85047A S-parameter test sets can measure both the forward and reverse characteristics of the test device without the need to manually remove and physically reverse it. With these test sets, the full two-port error model illustrated in Figure 5-46 effectively removes both the forward and reverse error terms for transmission and reflection measurements.

The HP 85044A/B transmission/reflection test sets cannot switch between forward and reverse directions, so the reverse error terms cannot be automatically measured. Therefore, with the one-path two-port calibration, the forward error terms are duplicated and used for both forward and reverse measurements by manually reversing the test device.

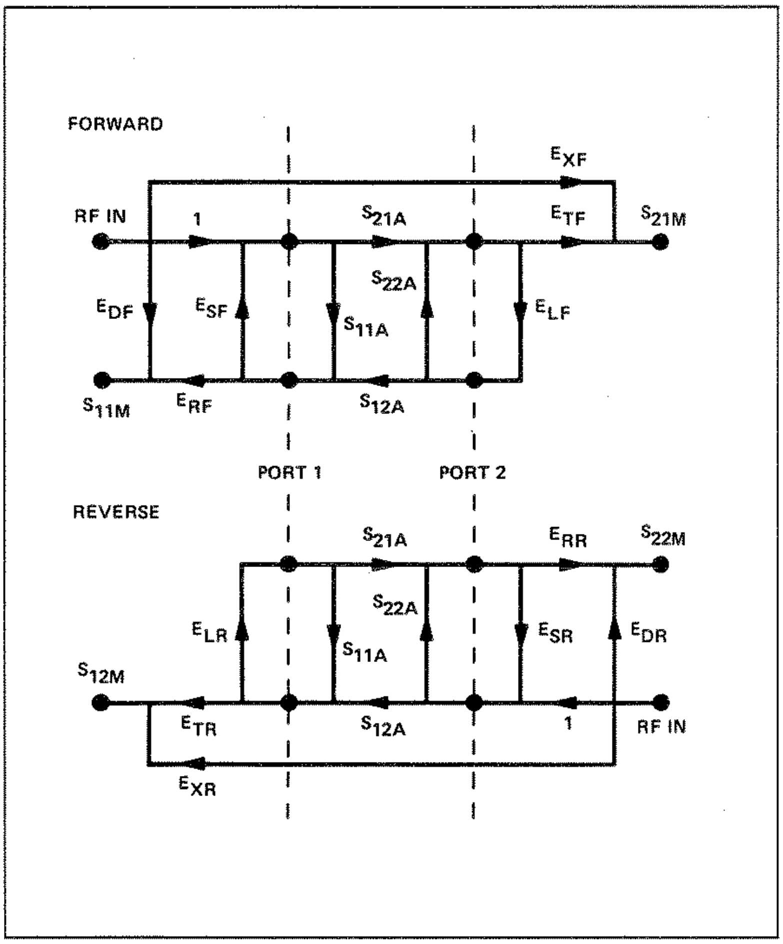


Figure 5-46

Figure 5-47 shows the full two-port error model equations for all four S-parameters of a two-port device. Note that the mathematics for this comprehensive model use all forward and reverse error terms and measured values. Thus, to perform full error correction for any one parameter, all four S-parameters must be measured.

Applications of these error models are provided in the calibration procedures described in Chapter 5.

$$S_{11A} = \frac{\left[\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)E_{SR}\right]\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LF}\right]}{\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)E_{SF}\right]\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)E_{SR}\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LF}E_{LR}\right]}$$

$$S_{21A} = \frac{\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)\left(E_{SR}-E_{LF}\right)\right]\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)}{\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)E_{SF}\right]\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)E_{SR}\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LF}E_{LR}\right]}$$

$$S_{12A} = \frac{\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)\left(E_{SF}-E_{LR}\right)\right]\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)}{\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)E_{SF}\right]\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)E_{SR}\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LF}E_{LR}\right]}$$

$$S_{22A} = \frac{\left[\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)E_{SF}\right]\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LR}\right]}{\left[1+\left(\frac{S_{11M}-E_{DF}}{E_{RF}}\right)E_{SF}\right]\left[1+\left(\frac{S_{22M}-E_{DR}}{E_{RR}}\right)E_{SR}\right]-\left[\left(\frac{S_{21M}-E_{XF}}{E_{TF}}\right)\left(\frac{S_{12M}-E_{XR}}{E_{TR}}\right)E_{LF}E_{LR}\right]}$$

Figure 5-47

In addition to the errors removed by accuracy enhancement, other systematic errors exist due to limitations of dynamic accuracy, test set switch repeatability, and test cable stability. These, combined with random errors, also contribute to total system measurement uncertainty. Therefore, after accuracy enhancement procedures are performed, residual measurement uncertainties remain. *System Performance* in the *General Information and Specifications* section of this manual provides information for calculating the system's total error-corrected measurement uncertainty performance.

CHAPTER CONTENTS

[MKR] KEY

The **[MKR]** (MENUMARK) key displays a movable active marker (∇) on the screen and provides access to a series of menus to control from one to four display markers for each channel (a total of eight). Markers are used to obtain numerical readings of measured values. They also provide capabilities for reducing measurement time by changing stimulus parameters, searching the trace for specific values, or statistically analyzing part or all of the trace. Figure 6-1 illustrates the displayed trace with all markers on and marker 1 the active marker.

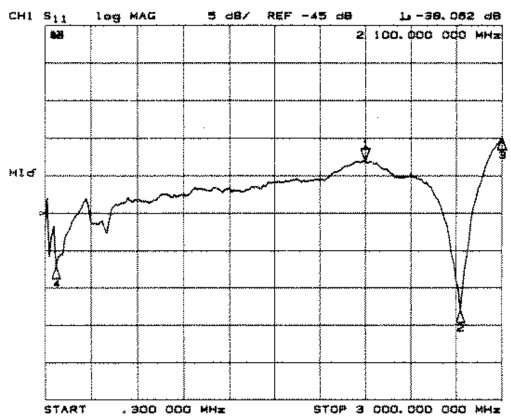


Figure 6-1. Markers on Trace

Markers have a stimulus value (the x-axis value in a Cartesian format) and a response value (the y-axis value in a Cartesian format). In a polar or Smith chart format, the second part of a complex data pair is also provided as an auxiliary response value. When a marker is turned on and no other function is active, its stimulus value is displayed in the active entry area and can be controlled with the knob, the step keys, or the numerical keypad. The active marker can be moved to any point on the trace, and its response and stimulus values are displayed at the top right corner of the graticule for each displayed channel, in units appropriate to the display format. The displayed marker response values are valid even when the measured data is above or below the range displayed on the graticule.

Marker values are normally continuous: that is, they are interpolated between measured points. Alternatively, they can be set to read only discrete measured points. The markers for the two channels normally have the same stimulus values, or they can be uncoupled so that each channel has independent markers, regardless of whether stimulus values are coupled or dual channel display is on.

If both data and memory are displayed, the marker values apply to the data trace. If memory only is displayed, the marker values apply to the memory trace. In a memory math display (data/memory or data–memory), the marker values apply to the trace resulting from the memory math function.

With the use of a reference marker, a delta marker mode is available that displays both the stimulus and response values of the active marker relative to the reference. Any of the four markers or a fixed point can be designated as the delta reference marker. If the delta reference is one of the four markers, its stimulus value can be controlled by the user and its response value is the value of the trace at that stimulus value. If the delta reference is a fixed marker, both its stimulus value and its response value can be set arbitrarily by the user anywhere in the display area (not necessarily on the trace).

Markers can be used to search for the trace maximum or minimum point or any other point on the trace. The four markers can be used together to search for specified bandwidth cutoff points and calculate the bandwidth and Q values. Statistical analysis uses markers to provide a readout of the mean, standard deviation, and peak-to-peak values of all or part of the trace.

Basic marker operations are available in the menus accessed from the **[MKR]** key. The marker search and statistical functions, together with the capability for quickly changing stimulus parameters with markers, are provided in the menus accessed from the **[MKR FCTN]** key.

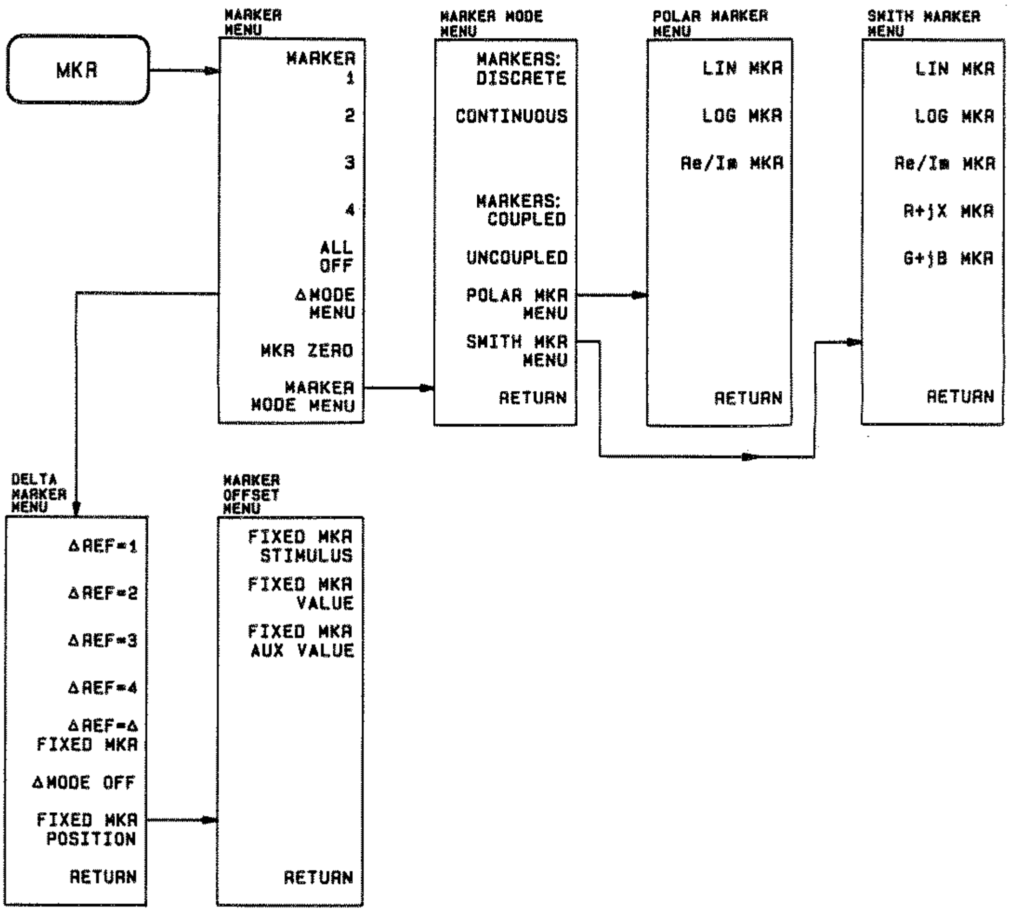


Figure 6-2. Menus Accessed from the [MKR] Key

The menus accessed from the **[MKR]** key (Figure 6-2) provide several basic marker operations. These include different marker modes for different display formats, and the delta marker mode that displays marker values relative to a specified value.

Marker Menu

The marker menu (Figure 6-3) is used to turn the display markers on or off, to designate the active marker, and to gain access to the marker delta mode and other marker modes and formats.

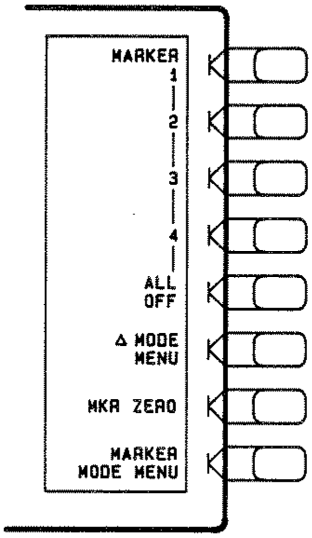


Figure 6-3

[MARKER 1] (MARK1) turns on marker 1 and makes it the active marker. The active marker appears on the CRT as ∇. The active marker stimulus value is displayed in the active entry area, together with the marker number. If there is a marker turned on, and no other function is active, the stimulus value of the active marker can be controlled with the knob, the step keys, or the number pad. The marker response and stimulus values are displayed in the upper right-hand corner of the screen.

[MARKER 2] (MARK2) turns on marker 2 and makes it the active marker. If another marker is present, that marker becomes inactive and is represented on the CRT as Δ.

[MARKER 3] (MARK3) turns on marker 3 and makes it the active marker.

[MARKER 4] (MARK4) turns on marker 4 and makes it the active marker.

[ALL OFF] (MARKOFF) turns off all the markers and the delta reference marker, as well as the tracking and bandwidth functions that are accessed with the **[MKR FCTN]** key.

[Δ MODE MENU] goes to the delta marker menu, which is used to read the difference in values between the active marker and a reference marker.

[MKR ZERO] (MARKZERO) puts a fixed reference marker at the present active marker position, and makes the fixed marker stimulus and response values at that position equal to zero. All subsequent stimulus and response values of the active marker are then read out relative to the fixed marker. The fixed marker is shown on the CRT as a small triangle Δ (delta), smaller than the inactive marker triangles. The softkey label changes from ***[MKR ZERO]*** to ***[MKR ZERO ΔREF = Δ]*** and the notation "ΔREF=Δ" is displayed at the top right corner of the graticule. Marker zero is canceled by turning delta mode off in the delta marker menu or turning all the markers off with the ***[ALL OFF]*** softkey.

[MARKER MODE MENU] provides access to the marker mode menu, where several marker modes can be selected including special markers for polar and Smith formats.

Delta Marker Mode Menu

The delta marker mode is used to read the difference in stimulus and response values between the active marker and a designated delta reference marker. Any of the four markers or a fixed point can be designated as the reference marker. If the reference is one of the four markers, its stimulus value can be controlled by the user and its response value is the value of the trace at that stimulus value. If the reference is a fixed marker, both its stimulus value and its response value can be set arbitrarily by the user anywhere in the display area. The delta reference is shown on the CRT as a small triangle Δ (delta), smaller than the inactive marker triangles. If one of the markers is the reference, the triangle appears next to the marker number on the trace.

The marker values displayed in this mode are the stimulus and response values of the active marker minus the reference marker. If the active marker is also designated as the reference marker, the marker values are zero.

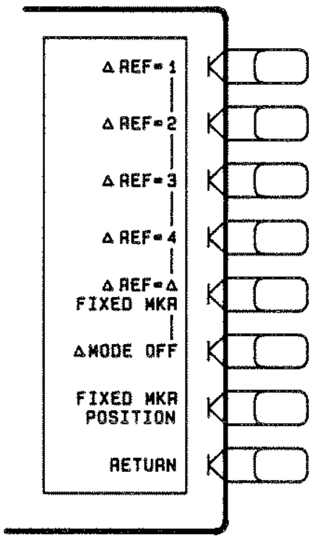


Figure 6-4. Delta Marker Mode Menu

*[Δ **REF** = 1]* (DELR1) establishes marker 1 as a reference. The active marker stimulus and response values are then shown relative to this delta reference. Once marker 1 has been selected as the delta reference, the softkey label *[Δ **REF** = 1]* is underlined in this menu, and the marker menu is returned to the screen. In the marker menu, the first key is now labeled *[**MARKER** Δ **REF** = 1]*. The notation "ΔREF=1" appears at the top right corner of the graticule.

*[Δ **REF** = 2]* (DELR2) makes marker 2 the delta reference. Active marker stimulus and response values are then shown relative to this reference.

*[Δ **REF** = 3]* (DELR3) makes marker 3 the delta reference.

*[Δ **REF** = 4]* (DELR4) makes marker 4 the delta reference.

[Δ REF = Δ FIXED MKR] (DELRFIXM) sets a user-specified fixed reference marker. The stimulus and response values of the reference can be set arbitrarily, and can be anywhere in the display area. Unlike markers 1 to 4, the fixed marker need not be on the trace. The fixed marker is indicated by a small triangle Δ, and the active marker stimulus and response values are shown relative to this point. The notation "ΔREF=Δ" is displayed at the top right corner of the graticule.

Pressing this softkey turns on the fixed marker. Its stimulus and response values can then be changed using the fixed marker menu, which is accessed with the ***[FIXED MKR POSITION]*** softkey described below. Alternatively, the fixed marker can be set to the current active marker position, using the ***[MKR ZERO]*** softkey in the marker menu.

[Δ MODE OFF] (DELO) turns off the delta marker mode, so that the values displayed for the active marker are absolute values.

[FIXED MKR POSITION] leads to the fixed marker menu, where the stimulus and response values for a fixed reference marker can be set arbitrarily.

Alternatively, the current position of the active marker can be entered as the fixed reference by using ***[MARKER ZERO]*** in the marker menu.

[RETURN] goes back to the marker menu.

Fixed Marker Menu

This menu is used to set the position of a fixed reference marker, indicated on the display by a small triangle Δ. Both the stimulus value and the response value of the fixed marker can be set arbitrarily anywhere in the display area, and need not be on the trace. The units are determined by the display format, the sweep type, and the marker type.

There are two ways to turn on the fixed marker. One way is with the ***[Δ REF = Δ FIXED MKR]*** softkey in the delta marker menu. The other is with the ***[MKR ZERO]*** function in the marker menu, which puts a fixed reference marker at the present active marker position and makes the marker stimulus and response values at that position equal to zero.

The softkeys in this menu make the values of the fixed marker the active function. The marker readings in the top right corner of the graticule are the stimulus and response values of the active marker minus the fixed reference marker. Also displayed in the top right corner is the notation "ΔREF=Δ."

The stimulus value, response value, and auxiliary response value (the second part of a complex data pair) can be individually examined and changed. This allows active marker readings that are relative in amplitude yet absolute in frequency, or any combination of relative/absolute readouts. Following a ***[MKR ZERO]*** operation, this menu can be used to reset any of the fixed marker values to absolute zero for absolute readings of the subsequent active marker values.

If the format is changed while a fixed marker is on, the fixed marker values become invalid. For example, if the value offset is set to 10 dB with a log magnitude format, and the format is then changed to phase, the value offset becomes 10 degrees. However, in polar and Smith chart formats, the specified values remain consistent between different marker types for those formats. Thus an R+jX marker set on a Smith chart format will retain the equivalent values if it is changed to any of the other Smith chart markers.

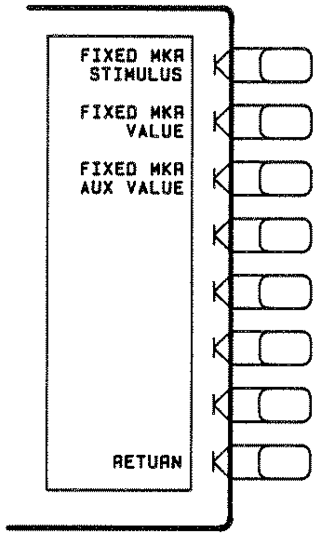


Figure 6-5. The Fixed Marker Menu

[FIXED MKR STIMULUS] (MARKFSTI) changes the stimulus value of the fixed marker. Fixed marker stimulus values can be different for the two channels if the channel markers are uncoupled using the marker mode menu.

To read absolute active marker stimulus values following a ***[MKR ZERO]*** operation, the stimulus value can be reset to zero.

[FIXED MKR VALUE] (MARKFVAL) changes the response value of the fixed marker. In a Cartesian format this is the y-axis value. In a polar or Smith chart format with a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker, this applies to the first part of the complex data pair. Fixed marker response values are always uncoupled in the two channels.

To read absolute active marker response values following a ***[MKR ZERO]*** operation, the response value can be reset to zero.

[FIXED MKR AUX VALUE] (MARKFAUV) is used only with a polar or Smith format. It changes the auxiliary response value of the fixed marker. This is the second part of a complex data pair, and applies to a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker. Fixed marker auxiliary response values are always uncoupled in the two channels.

To read absolute active marker auxiliary response values following a ***[MKR ZERO]*** operation, the auxiliary value can be reset to zero.

[RETURN] goes back to the delta marker menu.

Marker Mode Menu

This menu provides different marker modes and makes available two additional menus of special markers for use with Smith chart or polar formats.

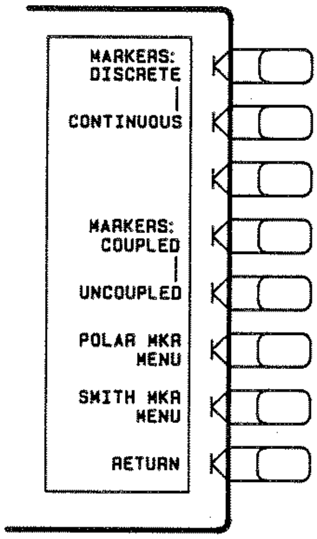


Figure 6-6

[MARKERS: DISCRETE] (MARKDISC) places markers only on measured trace points determined by the stimulus settings.

[CONTINUOUS] (MARKCONT) interpolates between measured points to allow the markers to be placed at any point on the trace. Displayed marker values are also interpolated. This is the default marker mode.

[MARKERS: COUPLED] (MARKCOUP) couples the marker stimulus values for the two display channels. Even if the stimulus is uncoupled and two sets of stimulus values are shown, the markers track the same stimulus values on each channel as long as they are within the displayed stimulus range.

[UNCOUPLED] (MARKUNCO) allows the marker stimulus values to be controlled independently on each channel.

[POLAR MKR MENU] leads to a menu of special markers for use with a polar format.

[SMITH MKR MENU] leads to a menu of special markers for use with a Smith chart format.

[RETURN] goes back to the marker menu.

Polar Marker Menu

This menu is used only with a polar display format, selectable using the **[FORMAT]** key. In a polar format, the magnitude at the center of the circle is zero and the outer circle is the full scale value set in the scale reference menu. Phase is measured as the angle counterclockwise from 0° at the positive x-axis. The HP 8753B automatically calculates different mathematical forms of the marker magnitude and phase values, selected using the softkeys in this menu. Marker frequency is displayed in addition to other values regardless of the selection of marker type.

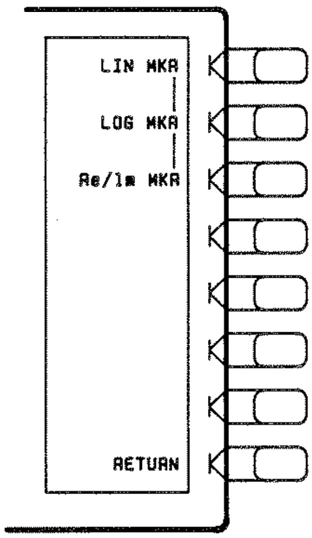


Figure 6-7

[LIN MKR] (POLMLIN) displays a readout of the linear magnitude and the phase of the active marker. This is the preset marker type for a polar display. Magnitude values are read in units and phase in degrees.

[LOG MKR] (POLMLOG) displays the logarithmic magnitude and the phase of the active marker. Magnitude values are expressed in dB and phase in degrees. This is useful as a fast method of obtaining a reading of the log magnitude value without changing to log magnitude format.

[Re/Im MKR] (POLMRI) displays the values of the active marker as a real and imaginary pair. The complex data is separated into its real part and imaginary part. The first marker value given is the real part M cos θ, and the second value is the imaginary part M sin θ, where M = magnitude.

[RETURN] goes back to the marker mode menu.

Smith Marker Menu

This menu is used only with a Smith chart format, selected from the format menu. The HP 8753B automatically calculates different mathematical forms of the marker magnitude and phase values, selected using the softkeys in this menu. Marker frequency is displayed in addition to other values for all marker types.

For additional information about the Smith chart display format, refer to *[FORMAT]* Key.

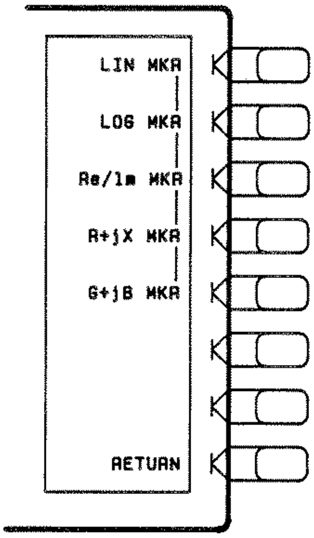


Figure 6-8

[LIN MKR] (SMIMLIN) displays a readout of the linear magnitude and the phase of the active marker. Marker magnitude values are expressed in units and phase in degrees.

[LOG MKR] (SMIMLOG) displays the logarithmic magnitude value and the phase of the active marker. Magnitude values are expressed in dB and phase in degrees. This is useful as a fast method of obtaining a reading of the log magnitude value without changing to log magnitude format.

[Re/Im MKR] (SMIMRI) displays the values of the active marker on a Smith chart as a real and imaginary pair. The complex data is separated into its real part and imaginary part. The first marker value given is the real part M cos θ, and the second value is the imaginary part M sin θ, where M = magnitude.

[R+jX MKR] (SMIMRX) converts the active marker values into rectangular form. The complex impedance values of the active marker are displayed in terms of resistance, reactance, and equivalent capacitance or inductance. This is the default Smith chart marker.

The normalized impedance Z0 for characteristic impedances other than 50 ohms can be selected in the calibrate more menu (chapter 5).

[G+jB MKR] (SMIMGB) displays the complex admittance values of the active marker in rectangular form. The active marker values are displayed in terms of conductance (in Siemens), susceptance, and equivalent capacitance or inductance. Siemens are the international units of admittance, and are equivalent to mhos (the inverse of ohms).

[RETURN] goes back to the marker mode menu.

[MKR FCTN] KEY

The **[MKR FCTN]** (MENUMRKF) key activates a marker if one is not already active, and provides access to additional marker functions. These can be used to quickly change the measurement parameters, to search the trace for specified information, and to analyze the trace statistically.

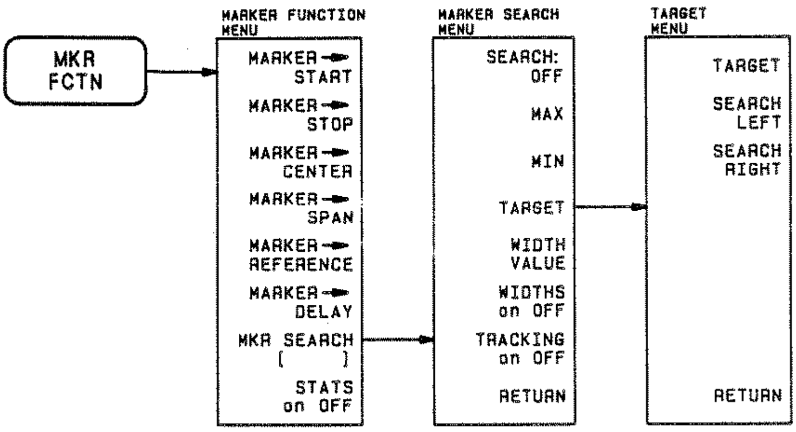


Figure 6-9. Menus Accessed from the [MKR FCTN] Key

Marker Function Menu

This menu provides softkeys that use markers to quickly modify certain measurement parameters without going through the usual key sequence. In addition, it provides access to two additional menus used for searching the trace and for statistical analysis.

The ***[MARKER →]*** functions change certain stimulus and response parameters to make them equal to the current active marker value. Use the knob or the keypad to move the marker to the desired position on the trace, and press the appropriate softkey to set the specified parameter to that trace value. When the values have been changed, the marker can again be moved within the range of the new parameters.

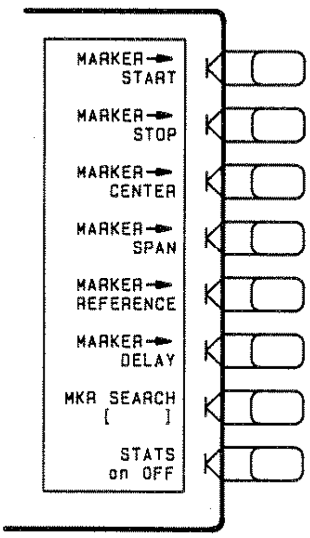


Figure 6-10

[MARKER → START] (MARKSTAR) changes the stimulus start value to the stimulus value of the active marker.

[MARKER → STOP] (MARKSTOP) changes the stimulus stop value to the stimulus value of the active marker.

[MARKER → CENTER] (MARKCENT) changes the stimulus center value to the stimulus value of the active marker, and centers the new span about that value.

[MARKER → SPAN] (MARKSPAN) changes the start and stop values of the stimulus span to the values of the active marker and the delta reference marker. If there is no reference marker, the message "NO MARKER DELTA – SPAN NOT SET" is displayed.

[MARKER → REFERENCE] (MARKREF) makes the reference value equal to the active marker's response value, without changing the reference position. In a polar or Smith chart format, the full scale value at the outer circle is changed to the active marker response value. This softkey also appears in the scale reference menu.

[MARKER → DELAY] (MARKDELA) adjusts the electrical delay to balance the phase of the DUT. This is performed automatically, regardless of the format and the measurement being made. Enough line length is added to or subtracted from the receiver input to compensate for the phase slope at the active marker position. This effectively flattens the phase trace around the active marker, and can be used to measure electrical length or deviation from linear phase. Additional electrical delay adjustments are required on DUTs without constant group delay over the measured frequency span. Since this feature adds phase to a variation in phase versus frequency, it is applicable only for ratioed inputs. This softkey also appears in the scale reference menu.

NOTE: A new marker function, ***[MARKER →CW]***, is available in the test sequence function softkey menus described in Chapter 13. This feature is intended for use in automated compression measurements. Test sequences allow the instrument to automatically find a maximum or minimum point on a response trace. The ***[MARKER →CW]*** command sets the instrument to the CW frequency of the active marker. When power sweep is engaged, the CW frequency will already be selected.

[MARKER SEARCH] leads to the marker search menu, which is used to search the trace for a particular value or bandwidth.

[STATS on OFF] (MEASTATON, MEASTATOFF) calculates and displays the mean, standard deviation, and peak-to-peak values of the section of the displayed trace between the active marker and the delta reference marker. If there is no delta reference, the statistics are calculated for the entire trace. A convenient use of this feature is to find the peak-to-peak value of passband ripple without searching separately for the maximum and minimum values.

The statistics are absolute values: the delta marker here serves to define the span. For polar and Smith formats the statistics are calculated using the first value of the complex pair (magnitude, real part, resistance, or conductance).

Marker Search Menu

This menu is used to search the trace for a specific amplitude-related point, and place the marker on that point. The capability of searching for a specified bandwidth is also provided. Tracking is available for a continuous sweep-to-sweep search. If there is no occurrence of a specified value or bandwidth, the message "TARGET VALUE NOT FOUND" is displayed.

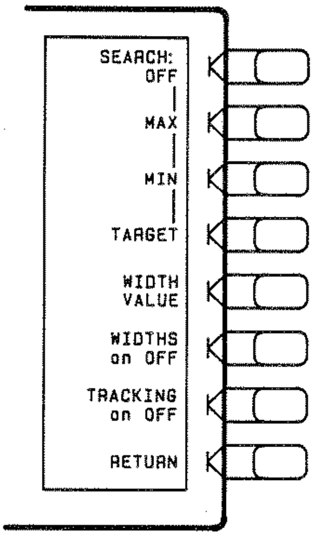


Figure 6-11

[SEARCH: OFF] (SEAOFF) turns off the marker search function.

[MAX] (SEAMAX) moves the active marker to the maximum point on the trace.

[MIN] (SEAMIN) moves the active marker to the minimum point on the trace.

[TARGET] (SEATARG) makes target value the active function, and places the active marker at a specified target point on the trace. The default target value is −3 dB. The target menu is presented, providing search right and search left options to resolve multiple solutions.

For relative measurements, a search reference must be defined with a delta marker or a fixed marker before the search is activated.

[WIDTH VALUE] (WIDV) is used to set the amplitude parameter (for example 3 dB) that defines the start and stop points for a bandwidth search. The bandwidth search feature analyzes a bandpass or band reject trace and calculates the center point, bandwidth, and Q (quality factor) for the specified bandwidth. Bandwidth units are the units of the current format.

[WIDTHS on OFF] (WIDTON, WIDTOFF) turns on the bandwidth search feature and calculates the center stimulus value, bandwidth, and Q of a bandpass or band reject shape on the trace. The amplitude value that defines the passband or rejectband is set using the ***[WIDTH VALUE]*** softkey.

All four markers are turned on, and each has a dedicated use. Marker 1 is a starting point from which the search is begun. Marker 2 goes to the bandwidth center point. Marker 3 goes to the bandwidth cutoff point on the left, and marker 4 to the cutoff point on the right.

If a delta marker or fixed marker is on, it is used as the reference point from which the bandwidth amplitude is measured. For example, if marker 1 is the delta marker and is set at the passband maximum, and the width value is set to −3 dB, the bandwidth search finds the bandwidth cutoff points 3 dB below the maximum and calculates the 3 dB bandwidth and Q.

If marker 2 (the dedicated bandwidth center point marker) is the delta reference marker, the search finds the points 3 dB down from the center.

If no delta reference marker is set, the bandwidth values are absolute values.

[TRACKING on OFF] (TRACKON, TRACKOFF) is used in conjunction with other search features to track the search with each new sweep. Turning tracking on makes the HP 8753B search every new trace for the specified target value and put the active marker on that point. If bandwidth search is on, tracking searches every new trace for the specified bandwidth, and repositions the dedicated bandwidth markers.

When tracking is off, the target is found on the current sweep and remains at the same stimulus value regardless of changes in trace response value with subsequent sweeps.

A maximum and a minimum point can be tracked simultaneously using two channels and uncoupled markers.

[RETURN] goes back to the marker function menu.

Target Menu

The target menu places the marker at a specified target response value on the trace, and provides search right and search left options. If there is no occurrence of the specified value, the message "TARGET VALUE NOT FOUND" is displayed.

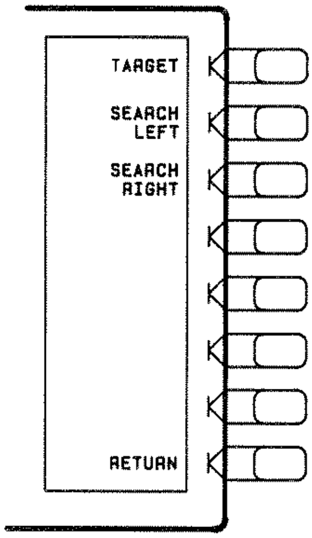


Figure 6-12

[TARGET] (SEATARG) places the marker at the specified target response value. If tracking is on (see previous menu) the target is automatically tracked with each new trace. If tracking is off, the target is found each time this key is pressed. The target value is in units appropriate to the current format. The default target value is −3 dB.

In delta marker mode, the target value is the value relative to the reference marker. If no delta reference marker is on, the target value is an absolute value.

[SEARCH LEFT] (SEAL) searches the trace for the next occurrence of the target value to the left.

[SEARCH RIGHT] (SEAR) searches the trace for the next occurrence of the target value to the right.

[RETURN] goes back to the marker search menu.

Chapter 7. Instrument State Function Block

CHAPTER CONTENTS

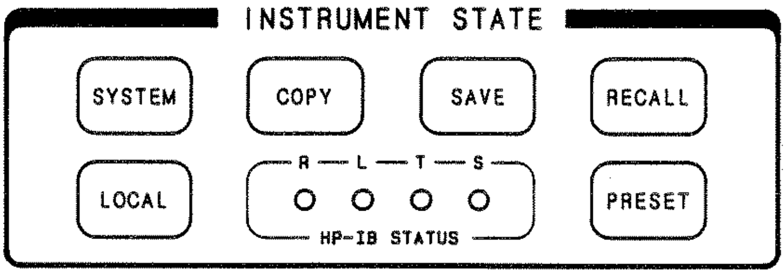


Figure 7-1

INTRODUCTION

The instrument state function block keys and associated menus provide control of channel-independent system functions. These include instrument modes, sequencing, controller modes, instrument addresses, HP-IB status information, plotting or printing, and saving instrument states either in internal memory or on an external disc.

INSTRUMENT STATE FUNCTIONS AND WHERE THEY ARE DESCRIBED

Functions accessible in the instrument state function block are described in several different chapters of this *Operating and Programming Reference*, and in portions of the *On-Site System Service Manual*.

Table 7-1 lists each function and where it is discussed. Unless otherwise noted, all references are in this *Operating and Programming Reference* and are marked with the acronym "OPR".

Table 7-1. Instrument State Functions and Where They Are Described

Instrument State Key	Function	Chapter or Manual
[SYSTEM]	6 GHz Operation (option 006) Test Sequence Function Limit Lines and Limit Testing Time Domain Transform Harmonic Measurements External Source Mode Tuned Receiver Mode Frequency Offset Operation Service Menu	Chapter 14, OPR Chapter 13, OPR This Chapter Chapter 8, OPR Chapter 14, OPR Chapter 14, OPR Chapter 14, OPR Chapter 14, OPR *On-Site System Service Manual*
[COPY]	All Features - including printing and plotting	Chapter 9, OPR
[SAVE]	All Features - including saving instrument states and saving to external disc.	Chapter 10, OPR
[RECALL]	All Features - including recall of instrument state, and recall from external disc drive.	Chapter 10, OPR
[LOCAL]	All Features - including HP-IB and address menus.	This Chapter
[PRESET]	Preset State	Appendix A, OPR

[LOCAL KEY]

This key is used to return the HP 8753B to local (front panel) operation from remote (computer controlled) operation. This key will also abort a test sequence or hardcopy print/plot. In this local mode, with a controller still connected on HP-IB, the HP 8753B can be operated manually (locally) from the front panel. This is the only front panel key that is not disabled when the HP 8753B is remotely controlled over HP-IB by a computer. The exception to this is when local lockout is in effect: this is a remote command that disables the **[LOCAL]** key, making it difficult to interfere with the HP 8753B while the network analyzer is under computer control.

In addition, this key gives access to the HP-IB menu, which sets the controller mode, and to the address menu, where the HP-IB addresses of peripheral devices are entered.

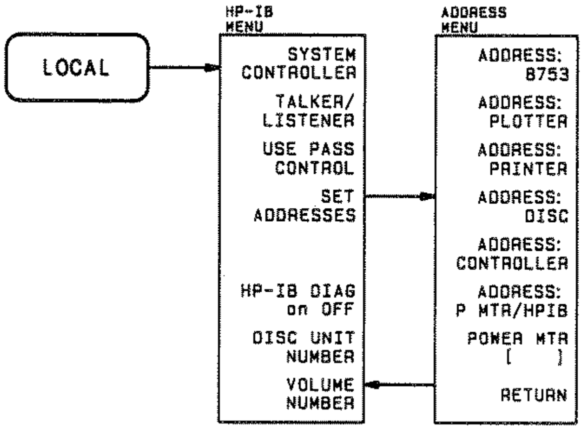


Figure 7-2. Softkey Menus Accessed from the [LOCAL] Key

HP-IB Menu

The HP 8753B is factory-equipped with a remote programming interface using the Hewlett-Packard Interface Bus (HP-IB). This enables communication between the HP 8753B and a controlling computer as well as other peripheral devices. This menu indicates the present HP-IB controller mode of the HP 8753B. Three HP-IB modes are possible: system controller, talker/listener, and pass control.

Talker/listener is the mode of operation most often used. In this mode, a computer controller communicates with the HP 8753B and other compatible peripherals over the bus. The computer sends commands or instructions to and receives data from the HP 8753B. All of the capabilities available from the HP 8753B front panel can be used in this remote operation mode, except for control of the power line switch and some internal tests.

In the system controller mode, the HP 8753B itself can use HP-IB to control compatible peripherals, without the use of an external computer. It can output measurement results directly to a compatible printer or plotter, store instrument states using a compatible disc drive, or control a power meter for performing service routines. The power meter calibration function requires system controller or pass control mode.

A third mode of HP-IB operation is the pass control mode. In an automated system with a computer controller, the controller can pass control of the bus to the HP 8753B on request from the network analyzer. The HP 8753B is then the controller of the peripherals, and can direct them to plot, print, or store without going through the computer. When the peripheral operation is complete, control is passed back to the computer. Only one controller can be active at a time. The computer remains the system controller, and can regain control at any time.

Preset does not affect the selected controller mode, but cycling the power returns the HP 8753B to talker/listener mode.

Information on compatible peripherals is provided in the *General Information and Specifications* section of this manual.

HP-IB Status Indicators. When the HP 8753B is connected to other instruments over HP-IB, the HP-IB STATUS indicators in the instrument state function block light up to display the current status of the HP 8753B.

R = Remote operation.
L = Listen mode.
T = Talk mode.
S = Service request (SRQ) asserted by the HP 8753B.

Information on HP-IB operation is provided in Chapter 11.

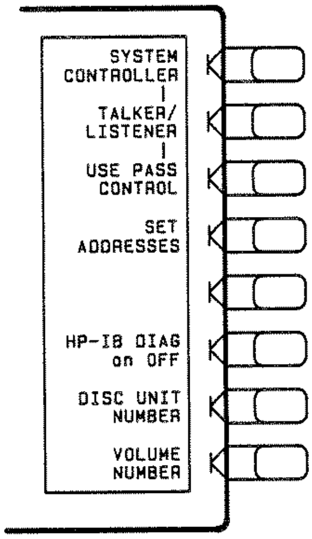


Figure 7-3. HP-IB Menu

[SYSTEM CONTROLLER] is the mode used when peripheral devices are to be used and there is no external controller. In this mode, the HP 8753B can directly control peripherals (plotter, printer, disc drive, or power meter). System controller mode must be set in order for the HP 8753B to access peripherals from the front panel to plot, print, store on disc, or perform power meter functions, if there is no other controller on the bus.

The system controller mode can be used without knowledge of HP-IB programming. However, the HP-IB address must be entered for each peripheral device.

This mode can only be selected manually from the network analyzer front panel, and can be used only if no active computer controller is connected to the system through HP-IB. If you try to set system controller mode when another controller is present, the message "CAUTION: CAN'T CHANGE - ANOTHER CONTROLLER ON BUS" is displayed. Do not attempt to use this mode for programming.

[TALKER/LISTENER] (TALKLIST) is the mode normally used for remote programming of the HP 8753B. In this mode, the HP 8753B and all peripheral devices are controlled from the external controller. The controller can command the HP 8753B to talk, and the plotter or other device to listen. The HP 8753B and peripheral devices cannot talk directly to each other unless the computer sets up a data path between them.

This mode allows the HP 8753B to be either a talker or a listener, as required by the controlling computer for the particular operation in progress.

A talker is a device capable of sending out data when it is addressed to talk. There can be only one talker at any given time. The HP 8753B is a talker when it sends information over the bus.

A listener is a device capable of receiving data when it is addressed to listen. There can be any number of listeners at any given time. The HP 8753B is a listener when it is controlled over the bus by a computer.

[USE PASS CONTROL] (USEPASC) lets you control the HP 8753B with the computer over HP-IB as with the talker/listener mode, and also allows the HP 8753B to become a controller in order to plot, print, or directly access an external disc. During this peripheral operation, the host computer is free to perform other internal tasks that do not require use of the bus (the bus is tied up by the network analyzer during this time).

The pass control mode requires that the external controller is programmed to respond to a request for control and to issue a take control command. When the peripheral operation is complete, the HP 8753B passes control back to the computer. Refer to the *HP-IB Introductory Programming Guide* for more information.

In general, use the talker/listener mode for programming the HP 8753B unless direct peripheral access is required.

[SET ADDRESSES] goes to the address menu, which is used to set the HP-IB address of the HP 8753B, and to display and modify the addresses of peripheral devices in the system.

[HP-IB DIAG on off] (DEBUON, DEBUOFF) toggles the HP-IB diagnostic feature (debug mode). This mode should only be used the first time a program is written: if a program has already been debugged, it is unnecessary.

When diagnostics are on, the network analyzer scrolls a history of incoming HP-IB commands across the display in the title line. Nonprintable characters are represented as π. If a syntax error is received, the commands halt and a pointer ∧ indicates the misunderstood character. To clear a syntax error, refer to the *HP-IB Introductory Programming Guide.*

[DISC UNIT NUMBER] (DISCUNIT) specifies the number of the disc unit in the disc drive that is to be accessed in an external disc store or load routine. This is used in conjunction with the HP-IB address of the disc drive, and the volume number, to gain access to a specific area on a disc. The access hierarchy is HP-IB address, disc unit number, disc volume number. More information on storing information to an external disc is provided in Chapter 10, *Saving Instrument States*.

[VOLUME NUMBER] (DISCVOLU) specifies the number of the disc volume to be accessed. In general, all 3.5 inch floppy discs are considered one volume (volume 0). For hard disc drives, such as the HP 9153A (Winchester), a switch in the disc drive must be set to define the number of volumes on the disc. For more information, refer to the manual for the individual hard disc drive.

Address Menu

In communications through the Hewlett-Packard Interface Bus (HP-IB), each instrument on the bus is identified by an HP-IB address. This decimal-based address code must be different for each instrument on the bus.

This menu sets the HP-IB address of the HP 8753B, and to enter the addresses of peripheral devices so that the HP 8753B can communicate with them.

Most of the HP-IB addresses are set at the factory and need not be modified for normal system operation. The standard factory-set addresses for instruments that may be part of the system are as follows:

Instrument	HP-IB Address (decimal)
HP 8753B	16
Plotter	05
Printer	01
External Disc Dive	00
Controller	21
Power Meter	13

The address displayed in this menu for each peripheral device must match the address set on the device itself. If the addresses do not match, they can be matched in one of two ways. Either the address in the HP 8753B softkey label for the device can be modified using the entry controls; or the address of the device can be changed using instructions provided in the device's manual. The HP 8753B does not have an HP-IB switch: its address is set only from the front panel.

These addresses are stored in short-term non-volatile memory and are not affected by preset or by cycling the power.

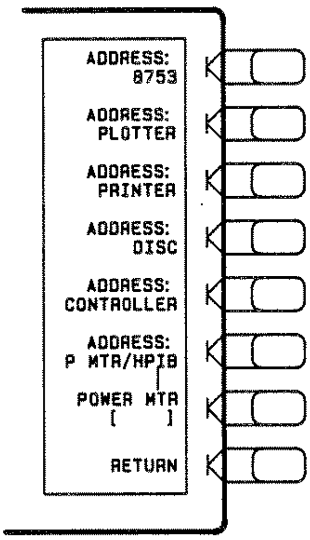


Figure 7-4. Address Menu

[ADDRESS: 8753] sets the HP-IB address of the HP 8753B, using the entry controls. There is no physical address switch to set in the HP 8753B.

[ADDRESS: PLOTTER] (ADDRPLOT) sets the HP-IB address the HP 8753B will use to communicate with the plotter.

[ADDRESS: PRINTER] (ADDRPRIN) sets the HP-IB address the HP 8753B will use to communicate with the printer.

[ADDRESS: DISC] (ADDRDISC) sets the HP-IB address the HP 8753B will use to communicate with the disc drive.

[ADDRESS: CONTROLLER] (ADDRCONT) sets the HP-IB address the HP 8753B will use to communicate with the external controller.

[ADDRESS: P MTR/HPIB] (ADDRPOWM) sets the HP-IB address the HP 8753B will use to communicate with the power meter used in service routines.

[POWER MTR] (POWM) toggles between **[436A]** or **[438A/437]**. These power meters are HP-IB compatible with the HP 8753B. The model number in the softkey label must match the power meter to be used.

[RETURN] goes back to the HP-IB menu.

[SYSTEM] KEY (MENUSYST)

This key presents the system menu.

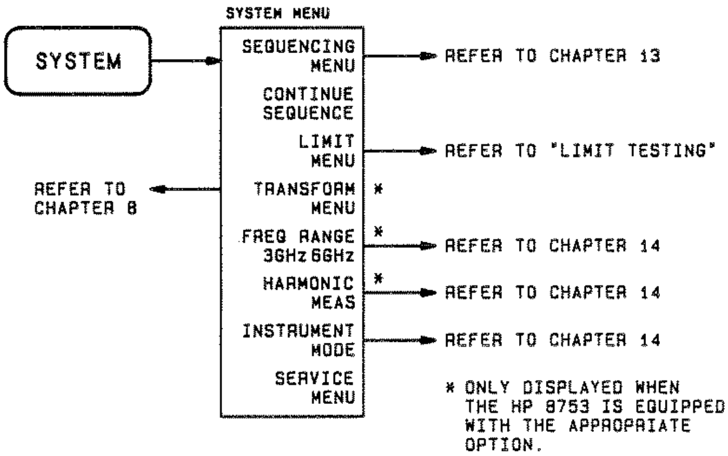


Figure 7-5. The System Menu

[SEQUENCING MENU] leads to the test sequence function menus. Sequencing allows the operator to define a series of test keystrokes which may then be run automatically. This function is described in Chapter 13.

[LIMIT MENU] leads to a series of menus used to define limits or specifications with which to compare a test device. Refer to *Limit Lines and Limit Testing*.

[TRANSFORM MENU] (option 010) leads to a series of menus that transform the measured data from the frequency domain to the time domain. Time domain modes and features are explained in Chapter 8, *Time and Frequency Domain Transforms*. This softkey is present only in instruments purchased with option 010.

[FREQ RANGE 3GHz6GHz] (option 006) only appears on the menu if an HP 85047A 6 GHz test set is connected to the HP 8753B. This softkey toggles the system between a maximum frequency of 3 and 6 GHz. Refer to Chapter 14.

[HARMONIC MEASUREMENTS] (option 002 only) leads to the harmonics menu. This feature phase locks to the 2nd or 3rd harmonic of the fundamental signal. Measured harmonics can not exceed the frequency range of the HP 8753B receiver. Refer to Chapter 14.

[INSTRUMENT MODE] presents the instrument mode menu. This provides access to the primary modes of operation (analyzer modes), each of which is described fully in Chapter 14. The following is a list of available instrument (analyzer) modes:

- Network Analyzer. This is the "normal" operating mode.
- External Source Auto. This allows the HP 8753B to phase lock to an external CW signal. This feature works only in CW time sweep type. The external source auto mode searches for the incoming CW signal. The search range is $\pm 10\%$ of the selected CW frequency (± 5 MHz below 50 MHz). The manual mode does not have this search capability, and the incoming signal must be within -0.5 to $+5.0$ MHz of the entered frequency value. The manual mode is faster than the auto mode.

  The external source should not exhibit noise or significant sidebands, as the HP 8753B may phase-lock onto a spur instead of the fundamental.
- External Source Manual. This allows the HP 8753B to phase lock to an external CW signal. This feature works only in CW time sweep type. The incoming signal should not have large spurs or sidebands for the reason explained above. This mode is faster than the auto mode, but it does not search for the incoming signal. The frequency of the incoming signal should be within -0.5 to $+5.0$ MHz of the selected frequency or the HP 8753B will not be able to phase lock to it.
- Tuned Receiver. In this mode the receiver operates independently of any source. All phase lock routines are bypassed, increasing sweep speed significantly. This function only works in CW time sweep. The external source must be synthesized and drive the HP 8753B's external frequency reference. Refer to Chapter 14.

In Addition to the above instrument modes, frequency offset operation is available under the *[INSTRUMENT MODE]* softkey. Frequency offset is a feature of the network analyzer mode, it is not an instrument mode itself. The HP 8753B must be in network analyzer mode before frequency offset can be turned on.

- Frequency Offset. This allows phase locked operation with a frequency offset between the internal source and receiver. In a typical mixer application; the internal source is input to the mixer's RF input, an external source is input to the mixer's LO input, and the resultant IF signal is input to the receiver. The upper frequency limit of this function is 3 GHz. When using frequency offset mode, the frequency of the internal source must be greater than the LO frequency. Both of these frequencies must be greater than the IF used for phase-locking.

[SERVICE MENU] leads to a series of service menus described in detail in the *On-Site System Service Manual*.

LIMIT LINES AND LIMIT TESTING

Limit lines are lines drawn on the CRT to represent upper and lower limits or device specifications with which to compare the device under test. Limits are defined in segments, where each segment is a portion of the stimulus span. Each limit segment has an upper and a lower starting limit value. Three types of segments are available: flat line, sloping line, and single point.

Limits can be defined independently for the two channels, up to 18 segments for each channel (a total of 36 for both channels). These can be in any combination of the three limit types.

Limit testing compares the measured data with the defined limits, and provides pass or fail information for each measured data point. An out-of-limit test condition is indicated in five ways: with a FAIL message on the screen, with a beep, by blanking of portions of the trace, with an asterisk in tabular listings of data, and with a bit in the HP-IB event status register B. An HP 85047A test set has a BNC output that includes this status.

Limit lines and limit testing can be used simultaneously or independently. If limit lines are on and limit testing is off, the limit lines are displayed on the CRT for visual comparison and adjustment of the measurement trace. However, no pass/fail information is provided. If limit testing is on and limit lines are off, the specified limits are still valid and the pass/fail status is indicated even though the limit lines are not displayed on the CRT.

Limits are entered in tabular form. Limit lines and limit testing can be either on or off while limits are defined. As new limits are entered, the tabular columns on the CRT are updated, and the limit lines (if on) are modified to the new definitions. The complete limit set can be offset in either stimulus or amplitude value.

Limits are checked only at the actual measured data points. It is possible for a device to be out of specification without a limit test failure indication if the point density is insufficient. Be sure to specify a high enough number of measurement points in the stimulus menu.

Limit lines are displayed only on Cartesian formats. In polar and Smith chart formats, limit testing of one value is available: the value tested depends on the marker mode and is the magnitude or the first value in a complex pair. The message "NO LIMIT LINES DISPLAYED" is shown on the CRT in polar and Smith formats.

The list values feature in the copy menu provides tabular listings to the CRT or a printer for every measured stimulus value. These include limit line and/or limit test information if these functions are turned on. If limit testing is on, an asterisk * is listed next to any measured value that is out of limits. If limit lines are on, and other listed data allows sufficient space, the upper limit and lower limit are listed, together with the margin by which the device data passes or fails the nearest limit. For more information about the list values feature, refer to Chapter 9, *Making a Hard Copy Output*.

If limit lines are on, they are plotted with the data on a plot. If limit testing is on, the PASS or FAIL message is plotted, and the failing portions of the trace that are blanked on the CRT are also blanked on the plot. If limits are specified, they are saved in memory with an instrument state.

An example of a measurement using limit lines and limit testing is provided in the *User's Guide*.

The series of menus for defining limits is accessed from the **[SYSTEM]** key. These menus are illustrated in Figure 7-6.

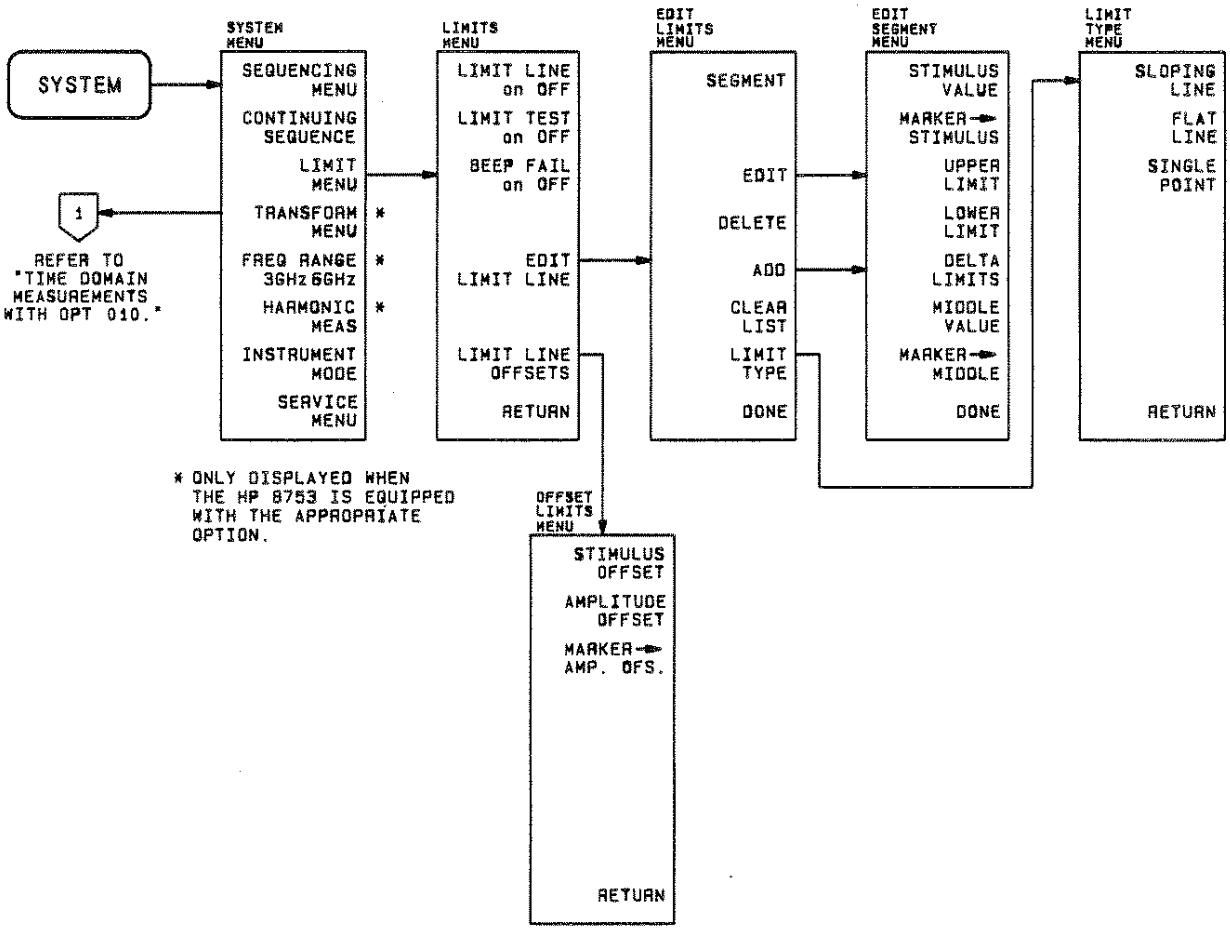


Figure 7-6. The Limit Softkey Menu Series

Limits Menu

This menu independently toggles the limit lines, limit testing, and limit fail beeper. In addition, it leads to the menus used to define and modify the limits.

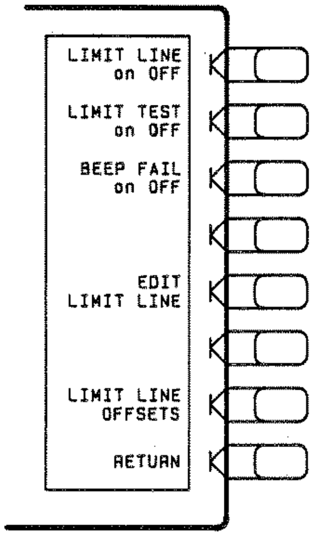


Figure 7-7

[LIMIT LINE on OFF] (LIMILINEON, LIMILINEOFF) turns limit lines on or off. To define limits, use the ***[EDIT LIMIT LINE]*** softkey described below. If limits have been defined and limit lines are turned on, the limit lines are displayed on the CRT for visual comparison of the measured data in all Cartesian formats.

If limit lines are on, they are plotted with the data on a plot, and saved in memory with an instrument state. In a listing of values from the copy menu with limit lines on, the upper limit and lower limit are listed together with the pass or fail margin, as long as other listed data allows sufficient space.

[LIMIT TEST on OFF] (LIMITESTON, LIMITESTOFF) turns limit testing on or off. When limit testing is on, the data is compared with the defined limits at each measured point. Limit tests occur at the end of each sweep, whenever the data is updated, when formatted data is changed, and when limit testing is first turned on.

Limit testing is available for both magnitude and phase values in Cartesian formats. In polar and Smith chart formats, the value tested depends on the marker mode and is the magnitude or the first value in a complex pair. The message "NO LIMIT LINES DISPLAYED" is displayed in polar and Smith formats if limit lines are turned on.

Five indications of pass or fail status are provided when limit testing is on. A PASS or FAIL message is displayed at the right of the CRT. The trace vector leading to any measured point that is out of limits is blanked at the end of every limit test, both on a CRT plot and a hard copy plot. The limit fail beeper sounds if it is turned on. In a listing of values using the copy menu, an asterisk * is shown next to any measured point that is out of limits. A bit is set in the HP-IB status byte.

[BEEP FAIL on OFF] (BEEPFAILON, BEEPFAILOFF) turns the limit fail beeper on or off. When limit testing is on and the fail beeper is on, a beep is sounded each time a limit test is performed and a failure detected. The limit fail beeper is independent of the warning beeper and the operation complete beeper, both of which are in the display more menu (Chapter 4).

[EDIT LIMIT LINE] (EDITLIML) displays a table of limit segments on the CRT, superimposed on the trace. The edit limits menu is presented so that limits can be defined or changed. It is not necessary for limit lines or limit testing to be on while limits are defined.

[LIMIT LINE OFFSETS] leads to the offset limits menu, which is used to offset the complete limit set in either stimulus or amplitude value.

[RETURN] goes back to the system menu.

Edit Limits Menu

This menu is used to specify limits for limit lines and/or limit testing, and presents a table of limit values on the CRT. Limits are defined in segments. Each segment is a portion of the stimulus span. Up to 18 limit segments can be specified for each channel (a total of 36 for both channels). The limit segments do not have to be entered in any particular order: the HP 8753B automatically sorts them and lists them on the CRT in increasing order of start stimulus value.

For each segment, the table lists the segment number, the starting stimulus value, upper limit, lower limit, and limit type. The ending stimulus value is the start value of the next segment, or a segment can be terminated with a single point segment. Limit values are entered as upper and lower limits or delta limits and middle value. As new limit segments are defined the tabular listing is updated, and if limit lines are switched on they are plotted on the CRT.

If no limits have been defined, the table of limit values shows the notation "EMPTY." Limit segments are added to the table using the *[ADD]* softkey or edited with the *[EDIT]* softkey, as described below. The last segment on the list is followed by the notation "END."

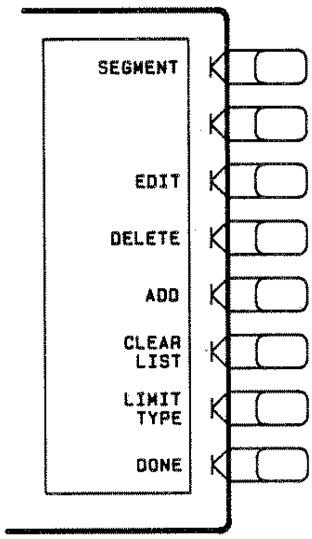


Figure 7-8. Edit Limits Menu

[SEGMENT] specifies which limit segment in the table is to be modified. A maximum of three sets of segment values are displayed at one time, and the list can be scrolled up or down to show other segment entries. Use the entry block controls to move the pointer > to the required segment number. The indicated segment can then be edited or deleted. If the table of limits is designated "EMPTY," new segments can be added using the ***[ADD]*** or ***[EDIT]*** softkey.

[EDIT] (SEDI) displays the edit segment menu, which is used to define or modify the stimulus value and limit values of a specified segment. If the table was empty, a default segment is displayed. The default segment is a sloping line with zero limits and stimulus values that vary according to the current stimulus mode (frequency, power, or time).

[DELETE] (SDEL) deletes the limit segment indicated by the pointer >.

[ADD] (SADD) displays the edit segment menu and adds a new segment to the end of the list. The new segment is initially a duplicate of the segment indicated by the pointer > and selected with the ***[SEGMENT]*** softkey. If the table was empty, a default segment is displayed, as described under ***[EDIT]*** above.

[CLEAR LIST] (CLEL) Clears all of the segments in the limit test.

[LIMIT TYPE] leads to the limit type menu, where one of three segment types can be selected.

[DONE] (EDITDONE) sorts the limit segments and displays them on the CRT in increasing order of stimulus value. The limits menu is returned to the screen.

Edit Segment Menu

This menu sets the values of the individual limit segments. The segment to be modified, or a default segment, is selected in the edit limits menu. The stimulus value can be set with the controls in the entry block or with a marker (the marker is turned on automatically when this menu is presented). The limit values can be defined as upper and lower limits, or delta limits and middle value. Both an upper limit and a lower limit (or delta limits) must be defined: if only one limit is required for a particular measurement, force the other out of range (for example +500 dB or −500 dB).

As new values are entered, the tabular listing of limit values is updated.

Segments do not have to be listed in any particular order: the HP 8753B sorts them automatically in increasing order of start stimulus value when the ***[DONE]*** key in the edit limits menu is pressed. However, the easiest way to enter a set of limits is to start with the lowest stimulus value and define the segments from left to right of the display, with limit lines turned on as a visual check.

Phase limit values can be specified between +500° and −500°. Limit values above +180° and below −180° are mapped into the range of −180° to +180° to correspond with the range of phase data values.

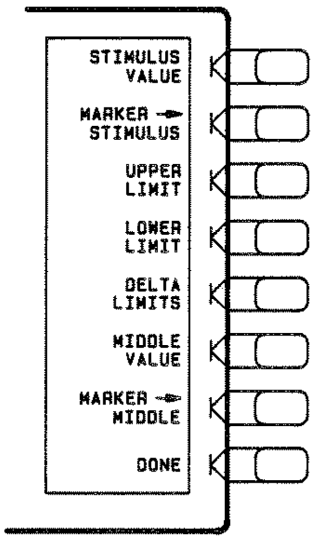


Figure 7-9. Edit Segment Menu

[STIMULUS VALUE] (LIMS) sets the starting stimulus value of a segment, using entry block controls. The ending stimulus value of the segment is defined by the start of the next line segment. No more than one segment can be defined over the same stimulus range.

[MARKER → STIMULUS] (MARKSTIM) sets the starting stimulus value of a segment using the active marker. Move the marker to the desired starting stimulus value before pressing this key, and the marker stimulus value is entered as the segment start value.

[UPPER LIMIT] (LIMU) sets the upper limit value for the start of the segment. If a lower limit is specified, an upper limit must also be defined. If no upper limit is required for a particular measurement, force the upper limit value out of range (for example +500 dB).

When ***[UPPER LIMIT]*** or ***[LOWER LIMIT]*** is pressed, all the segments in the table are displayed in terms of upper and lower limits, even if they were defined as delta limits and middle value.

If you attempt to set an upper limit that is lower than the lower limit, or vice versa, both limits will be automatically set to the same value.

[LOWER LIMIT] (LIML) sets the lower limit value for the start of the segment. If an upper limit is specified, a lower limit must also be defined. If no lower limit is required for a particular measurement, force the lower limit value out of range (for example −500 dB).

[DELTA LIMITS] (LIMD) sets the limits an equal amount above and below a specified middle value, instead of setting upper and lower limits separately. This is used in conjunction with ***[MIDDLE VALUE]*** or ***[MARKER → MIDDLE]***, to set limits for testing a device that is specified at a particular value plus or minus an equal tolerance.

For example, a device may be specified at 0 dB ±3 dB. Enter the delta limits as 3 dB and the middle value as 0 dB.

When ***[DELTA LIMITS]*** or ***[MIDDLE VALUE]*** is pressed, all the segments in the table are displayed in these terms, even if they were defined as upper and lower limits.

[MIDDLE VALUE] (LIMM) sets the midpoint for *[DELTA LIMITS]*. It uses the entry controls to set a specified amplitude value vertically centered between the limits.

[MARKER → MIDDLE] (MARKMIDD) sets the midpoint for *[DELTA LIMITS]* using the active marker to set the middle amplitude value of a limit segment. Move the marker to the desired value or device specification, and press this key to make that value the midpoint of the delta limits. The limits are automatically set an equal amount above and below the marker.

[DONE] (SDON) terminates a limit segment definition, and returns to the edit limits menu.

Limit Type Menu

This menu defines the selected limit segment as a sloping line, a flat line, or a single point.

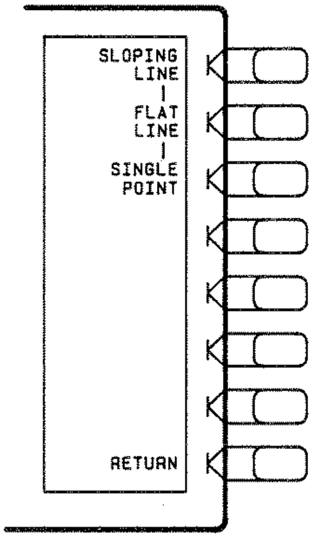


Figure 7-10

[SLOPING LINE] (LIMTSL) defines a sloping limit line segment that is linear with frequency or other stimulus value, and is continuous to the next stimulus value and limit. If a sloping line is the final segment it becomes a flat line terminated at the stop stimulus. A sloping line segment is indicated as SL on the displayed table of limits.

[FLAT LINE] (LIMTFL) defines a flat limit line segment whose value is constant with frequency or other stimulus value. This line is continuous to the next stimulus value, but is not joined to a segment with a different limit value. If a flat line segment is the final segment it terminates at the stop stimulus. A flat line segment is indicated as FL on the table of limits.

[SINGLE POINT] (LIMTSP) sets the limits at a single stimulus point. If limit lines are on, the upper limit value of a single point limit is displayed as ∨, and the lower limit is displayed as ∧. A limit test at a single point not terminating a flat or sloped line tests the nearest actual measured data point.

A single point limit can be used as a termination for a flat line or sloping line limit segment. When a single point terminates a sloping line or when it terminates a flat line and has the same limit values as the flat line, the single point is not displayed as ∨ and ∧. The indication for a sloping line segment in the displayed table of limits is SP.

[RETURN] goes back to the edit limits menu.

Offset Limits Menu

This menu allows the complete limit set to be offset in either stimulus value or amplitude value. This is useful for changing the limits to correspond with a change in the test setup, or for device specifications that differ in stimulus or amplitude. It can also be used to move the limit lines away from the data trace temporarily for visual examination of trace detail.

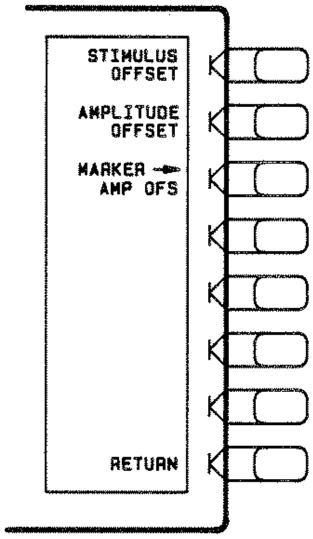


Figure 7-11

[STIMULUS OFFSET] (LIMISTIO) adds or subtracts an offset in stimulus value. This allows limits already defined to be used for testing in a different stimulus range. Use the entry block controls to specify the offset required.

[AMPLITUDE OFFSET] (LIMIAMPO) adds or subtracts an offset in amplitude value. This allows limits already defined to be used for testing at a different response level. For example, if attenuation is added to or removed from a test setup, the limits can be offset an equal amount. Use the entry block controls to specify the offset.

[MARKER → AMP. OFS.] (LIMIMAOF) uses the active marker to set the amplitude offset. Move the marker to the desired middle value of the limits and press this key. The limits are then moved so that they are centered an equal amount above and below the marker at that stimulus value.

[RETURN] goes back to the limits menu.

Chapter 8. Time and Frequency Domain Transforms

INTRODUCTION

With option 010, the HP 8753B can transform frequency domain data to the time domain or time domain data to the frequency domain. In normal operation, the analyzer measures the characteristics of a device under test (DUT) as a function of frequency. Using a mathematical technique (the inverse Fourier transform), the HP 8753B transforms frequency domain information into the time domain, with time as the horizontal display axis. Response values (measured on the vertical axis) now appear separated in time or distance, providing valuable insight into the behavior of the DUT beyond simple frequency characteristics.

NOTE: An HP 8753B can be ordered with option 010, or the option can be added at a later date using the HP 85019B time domain retrofit kit.

The transform used by the HP 8753B resembles time domain reflectometry (TDR) measurements. TDR measurements, however, are made by launching an impulse or step into the DUT and observing the response in time with a receiver similar to an oscilloscope. In contrast, the HP 8753B makes swept frequency response measurements, and mathematically transforms the data into a TDR-like display.

The HP 8753B has three frequency-to-time transform modes:

Time Domain Bandpass Mode is designed to measure band-limited devices and is the easiest mode to use. This mode simulates the time domain response to an impulse input.

Time Domain Low Pass Step Mode simulates the time domain response to a step input. As in a traditional TDR measurement, the distance to the discontinuity in the DUT, and the type of discontinuity (resistive, capacitive, inductive) can be determined.

Time Domain Low Pass Impulse Mode simulates the time domain response to an impulse input (like the bandpass mode). Both low pass modes yield better time domain resolution for a given frequency span than does the bandpass mode. In addition, using the low pass modes you can determine the type of discontinuity. However, these modes have certain limitations that are defined in the low pass section of this chapter.

The HP 8753B has one time-to-frequency transform mode:

Forward Transform Mode transforms CW signals measured over time into the frequency domain, to measure the spectral content of a signal. This mode is known as the CW time mode.

In addition to these transform modes, this chapter discusses special transform concepts such as masking, windowing, and gating.

GENERAL THEORY

The relationship between the frequency domain response and the time domain response of a network analyzer is defined by the Fourier transform. Because of this transform, it is possible to measure, in the frequency domain, the response of a linear DUT and mathematically calculate the inverse Fourier transform of the data to find the time domain response. The HP 8753B internal computer makes this calculation using the chirp-Z Fourier transform technique. The resulting measurement is the fully error-corrected time domain reflection or transmission response of the DUT, displayed in near real time.

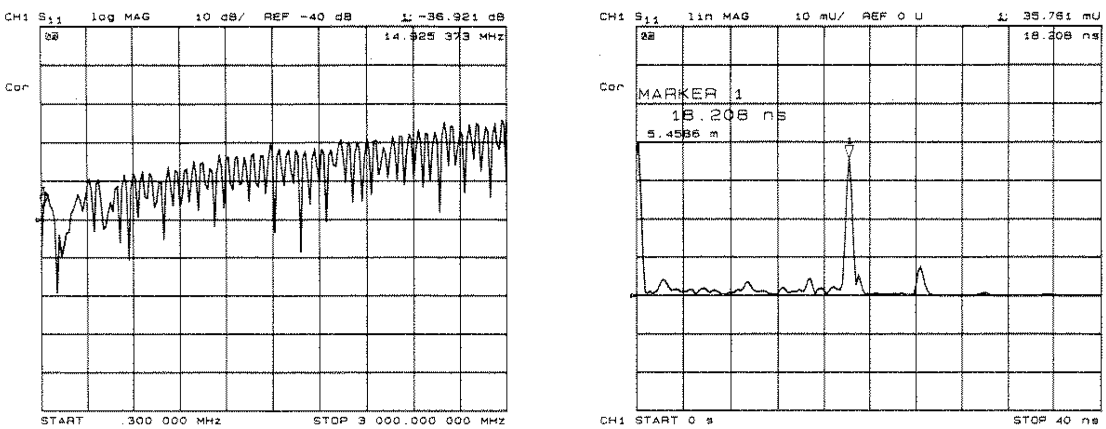
Table 8-1 lists the useful formats for time domain reflection measurements. Time domain transmission measurements are displayed using the linear magnitude or log magnitude formats, as described later in this chapter.

Table 8-1. Time Domain Reflection Formats

Format	Parameter
LIN MAG	Reflection Coefficient (unitless) $(0 < \rho < 1)$
REAL	Reflection Coefficient (unitless) $(-1 < \rho < 1)$
LOG MAG	Return Loss (dB)
SWR	Standing Wave Ratio (unitless)

Figure 8-1 illustrates the frequency and time domain reflection responses of a device. The frequency domain reflection measurement is the composite of all the signals reflected by the discontinuities present in the DUT over the measured frequency range.

NOTE: In this chapter, all points of reflection are referred to as discontinuities.

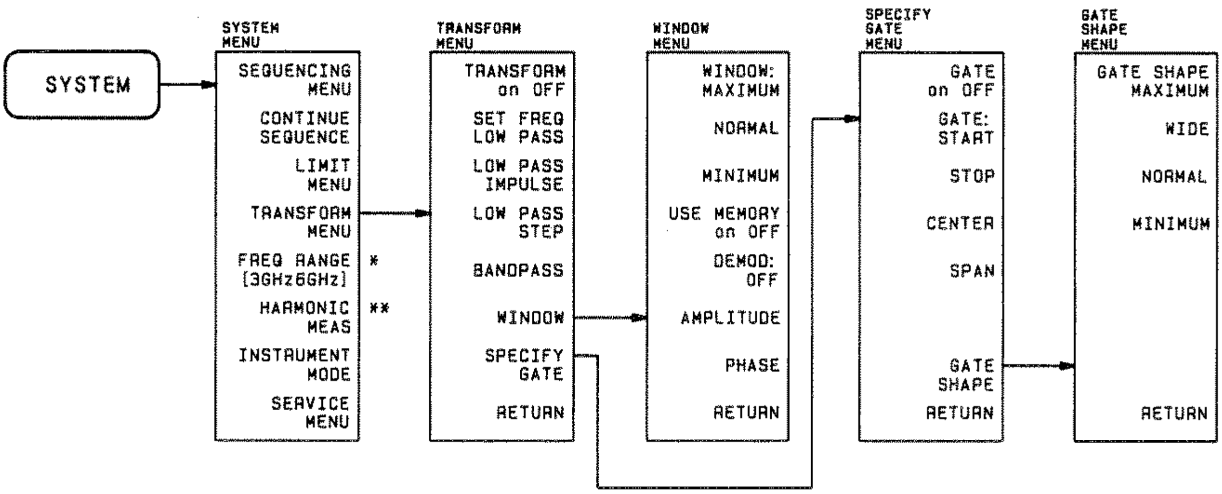


(a) Frequency Domain *(b) Time Domain Bandpass*

Figure 8-1. Device Frequency Domain and Time Domain Reflection Responses

The time domain measurement shows the effect of each discontinuity as a function of time (or distance), and shows that the device response consists of three separate impedance changes. The second discontinuity has a reflection coefficient magnitude of 0.035 (i.e. 3.5% of the incident signal is reflected). Marker 1 on the time domain trace shows the round-trip time to the discontinuity and back to the reference plane (where the calibration standards are connected): 18.2 nanoseconds. The distance shown (5.45 metres) assumes that the signal travels at the speed of light. The signal travels slower than the speed of light in most media (e.g. coax cables). This slower velocity (relative to light) can be compensated for by adjusting the HP 8753B relative velocity factor. This procedure is described later in this chapter.

Figure 8-2 illustrates the transform menus, which are accessed from the **[SYSTEM]** key.



* Displayed only in instruments equipped with option 006.
**Displayed only in instruments equipped with option 002.

Figure 8-2. The Time Domain Transform Menus

TIME DOMAIN BANDPASS

This mode is called bandpass because it works with band-limited devices. Traditional TDR requires that the DUT be able to operate down to DC. Using bandpass mode, there are no restrictions on the measurement frequency range. Bandpass mode characterizes the DUT impulse response.

Reflection Measurements Using Bandpass Mode

NOTE: Before making time domain reflection measurements, perform the appropriate calibration.

Example:

1. Press **[PRESET]**. The default measurement at preset (with an S-parameter test set) is S11 on channel 1.

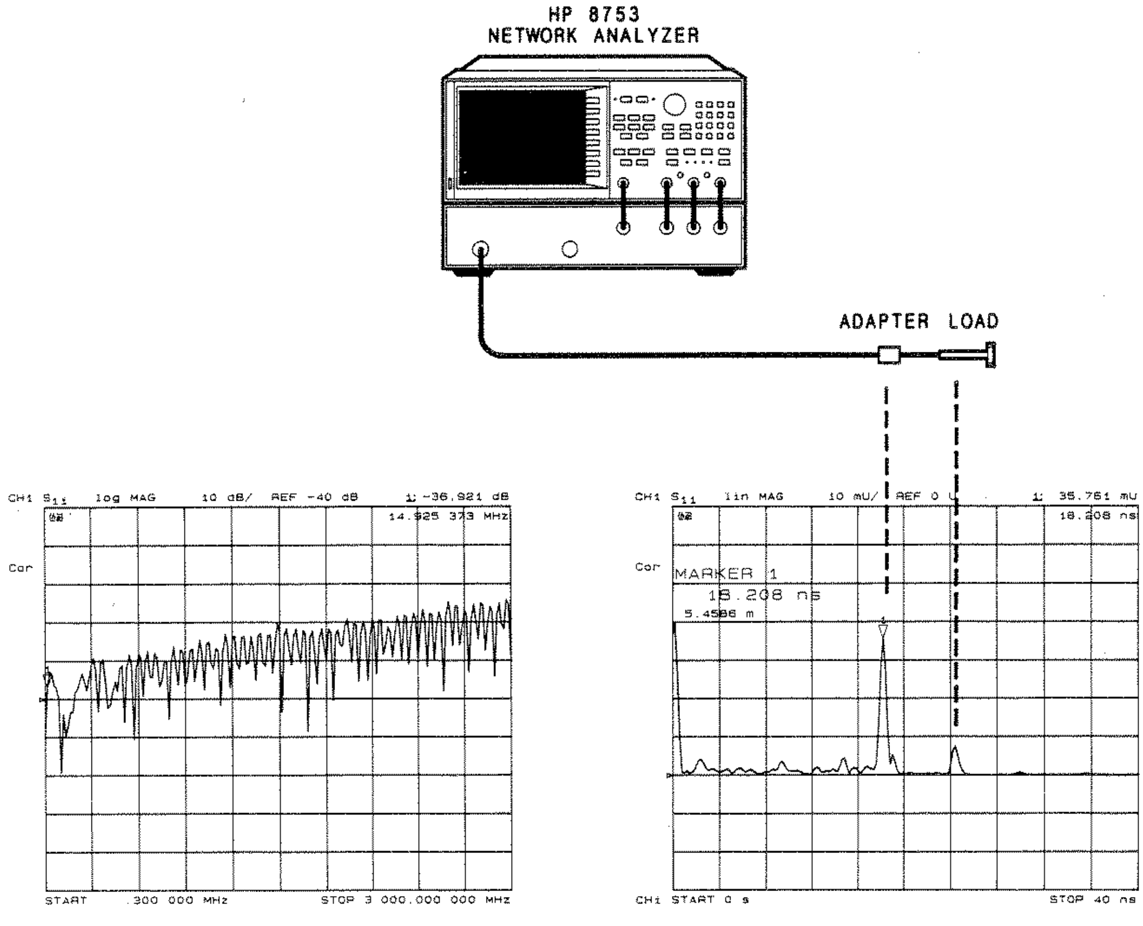
2. Press **[CAL]** ***[CALIBRATE MENU] [S11 1-PORT]*** and perform an S11 1-port calibration using an open, a short, and a load connected to port 1. Press ***[DONE 1-PORT CAL]***, then save the configuration in one of the save registers.

3. Connect one or more lengths of cable, with adapters between cable sections, as shown at the top of Figure 8-3.
4. Press **[SYSTEM]** ***[TRANSFORM MENU] [BANDPASS] [TRANSFORM ON]***.
5. Press **[START] [0] [x1]** to select a start time of zero seconds.
6. Press **[STOP] [4] [0] [G/n]** to select a stop time of 40 nanoseconds.

NOTE: In the time domain, the STIMULUS keys (**[START]**, **[STOP]**, **[CENTER]** and **[SPAN]**) refer to time, and can be used to change the horizontal (time) axis of the display, independent of the chosen frequency range. To set the STOP time long enough to let you "see" the end of the cable under test, enter a STOP time of 10 nanoseconds per metre of cable under test. This is a good rule-of-thumb number that accounts for the approximate round-trip time for most cables.

7. Press **[FORMAT]** ***[LIN MAG]*** for a display of reflection coefficient versus time (or distance).
8. Press **[SCALE REF]** ***[AUTO SCALE]***.

Figure 8-3 shows typical frequency and time domain responses of a reflection measurement of two sections of cable.



(a) Frequency Domain *(b) Time Domain Bandpass*

Figure 8-3. A Reflection Measurement of Two Cables

The ripples in reflection coefficient versus frequency in the frequency domain measurement are caused by the reflections at each connector "beating" against each other.

One at a time, loosen the connectors at each end of the cable and observe the response in both the frequency domain and the time domain. The frequency domain ripples grow as each connector is loosened, corresponding to a larger reflection adding in and out of phase with the other reflections. The time domain responses grow as you loosen the connector that corresponds to each response.

Interpreting the Bandpass Reflection Response Horizontal Axis. In bandpass reflection measurements, the horizontal axis represents the time it takes for an impulse launched at the test port to reach a discontinuity and return to the test port (the two-way travel time). In Figure 8-3, each connector is a discontinuity.

Interpreting the Bandpass Reflection Response Vertical Axis. The quantity displayed on the vertical axis depends on the selected format. The common formats are listed in Table 8-1. The default format is LOG MAG (logarithmic magnitude), which displays the return loss in decibels (dB). LIN MAG (linear magnitude) is a format that displays the response as reflection coefficient (ρ). This can be thought of as an average reflection coefficient of the discontinuity over the frequency range of the measurement. Use the REAL format only in low pass mode.

Adjusting the Relative Velocity Factor

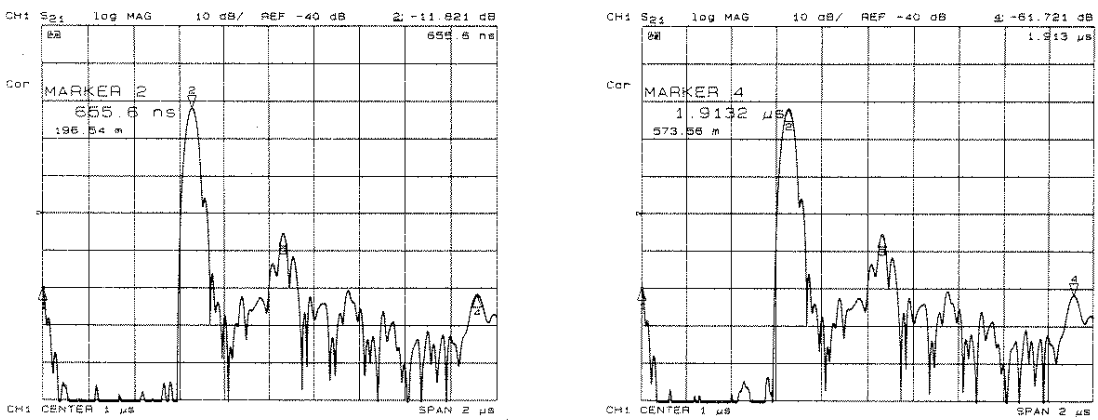
A marker provides both the time (x2) and the electrical length (x2) to a discontinuity. To determine the physical length, rather than the electrical length, change the velocity factor to that of the medium under test:

1. Press **[CAL]** *[MORE] [VELOCITY FACTOR]*.
2. Enter a velocity factor between 0 and 1.0 (1.0 corresponds to the speed of light in a vacuum). Most cables have a velocity factor of 0.66 (polyethylene dielectrics) or 0.70 (teflon dielectrics).

NOTE: To cause the markers to read the actual one-way distance to a discontinuity, rather than the round trip distance, enter one-half the actual velocity factor.

Transmission Measurements Using Bandpass Mode

The bandpass mode can also transform transmission measurements to the time domain. For example, this mode can provide information about a surface accoustic wave (SAW) filter that is not apparent in the frequency domain. Figure 8-4 illustrates a time domain bandpass measurement of a 321 MHz SAW filter.



(a) (b)

Figure 8-4. Transmission Measurement in Time Domain Bandpass Mode

Interpreting the Bandpass Transmission Response Horizontal Axis. In time domain transmission measurements, the horizontal axis is displayed in units of time. The time axis indicates the propagation delay through the device. Note that in time domain transmission measurements, the value displayed is the actual delay (not x2). The marker provides the propagation delay in both time and distance.

Marker 2 in Figure 8-4 (a) indicates the main path response through the device, which has a propagation delay of 655.6 ns, or about 196.5 meters in electrical length. Marker 4 in Figure 8-4 (b) indicates the triple-travel path response at 1.91 μs, or about 573.5 meters. The response at marker 1 (at 0 seconds) is an RF feedthrough leakage path. In addition to the triple travel path response, there are several other multi-path responses through the device, which are inherent in the design of a SAW filter.

Interpreting the Bandpass Transmission Response Vertical Axis. In the log magnitude format, the vertical axis displays the transmission loss or gain in dB; in the linear magnitude format it displays the transmission coefficient (τ). Think of this as an average of the transmission response over the measurement frequency range.

TIME DOMAIN LOW PASS

This mode is used to simulate a traditional time domain reflectometry (TDR) measurement. It provides information to determine the type of discontinuity (resistive, capacitive, or inductive) that is present. Low pass provides the best resolution for a given bandwidth in the frequency domain. It may be used to give either the step or impulse response of the DUT.

The low pass mode is less general-purpose than the bandpass mode because it places strict limitations on the measurement frequency range. The low pass mode requires that the frequency domain data points are harmonically related from DC to the stop frequency. That is, stop = n x start, where n = number of points. For example, with a start frequency of 300 kHz and 101 points, the stop frequency would be 30.3 MHz. Since the frequency range of the HP 8753B starts at 300 kHz (3 MHz in the option 006 6 GHz mode with an HP 85047A test set), the DC frequency response is extrapolated from the lower frequency data. The requirement to pass DC is the same limitation that exists for traditional TDR.

Setting Frequency Range for Time Domain Low Pass

Before a low pass measurement is made, the measurement frequency range must meet the (stop = n x start) requirement described above. The ***[SET FREQ LOW PASS]*** softkey performs this function automatically: the stop frequency is set close to the entered stop frequency, and the start frequency is set equal to stop/n. For convenience, the ***[SET FREQ LOW PASS]*** softkey is in both the transform menu and the calibration menu.

If the low end of the measurement frequency range is critical, it is best to calculate approximate values for the start and stop frequencies before pressing ***[SET FREQ LOW PASS]*** and calibrating. This avoids distortion of the measurement results. To see an example, select the preset values of 201 points and a 300 kHz to 3 GHz frequency range. Now press ***[SET FREQ LOW PASS]*** and observe the change in frequency values. The stop frequency changes to 2.999 GHz, and the start frequency changes to 14.925 MHz. This would cause a distortion of measurement results for frequencies from 300 kHz to 14.925 MHz.

NOTE: If the start and stop frequencies do not conform to the low pass requirement before a low pass mode (step or impulse) is selected and transform is turned on, the analyzer resets the start and stop frequencies. If error correction is on when the frequency range is changed, this turns it off.

Minimum Allowable Stop Frequencies. The lowest HP 8753B measurement frequency is 300 kHz (3 MHz in the option 006 6 GHz mode), therefore for each value of n there is a minimum allowable stop frequency that can be used. That is, the minimum stop frequency =n x 300 kHz (or n x 3 MHz). Table 8-2 lists the minimum frequency range that can be used for each value of n for low pass time domain measurements.

NOTE: In the 6 GHz mode (option 006 only), the minimum frequency can be set below 3 MHz, although instrument specifications do not apply in this case.

Table. 8-2. Minimum Frequency Ranges for Time Domain Low Pass

Number of Points	Minimum Frequency Range	
	Standard Instrument	**Option 006 6 GHz Mode**
3	300 kHz to 0.9 MHz	3 MHz to 9 MHz
11	300 kHz to 3.3 MHz	3 MHz to 33 MHz
26	300 kHz to 7.8 MHz	3 MHz to 78 MHz
51	300 kHz to 15.3 MHz	3 MHz to 153 MHz
101	300 kHz to 30.3 MHz	3 MHz to 303 MHz
201	300 kHz to 60.3 MHz	3 MHz to 603 MHz
401	300 kHz to 120.3 MHz	3 MHz to 1.203 GHz
801	300 kHz to 240.3 MHz	3 MHz to 2.403 GHz
1601	300 kHz to 480.3 MHz	3 MHz to 4.803 GHz

Reflection Measurements in Time Domain Low Pass

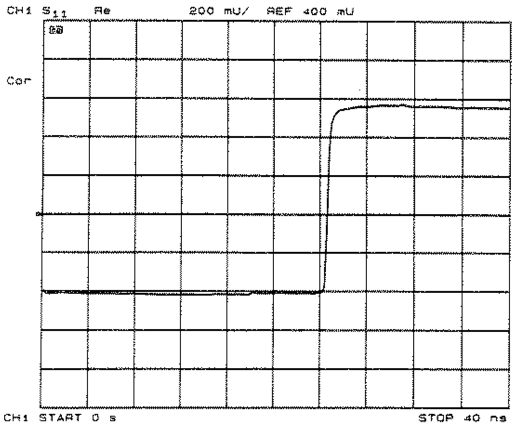
Example:

1. Press **[PRESET]**. The default measurement at preset (with an S-parameter test set) is S11 on channel 1.
2. Press **[CAL]** ***[CALIBRATE MENU] [SET FREQ LOW PASS]***. The message "LOW PASS: FREQ LIMITS CHANGED" will be displayed.
3. Press ***[S11 1-PORT]***, and perform an S11 1-port calibration.
4. Connect one or more lengths of cable, with adapters between cable sections. Leave the last cable unterminated.
5. Press **[SYSTEM]** ***[TRANSFORM MENU] [LOW PASS STEP] [TRANSFORM ON]***.
6. Press **[START] [0] [x1]** to select a start time of 0 seconds.
7. Press **[STOP] [4] [0] [G/n]** to select a stop time of 40 nanoseconds.

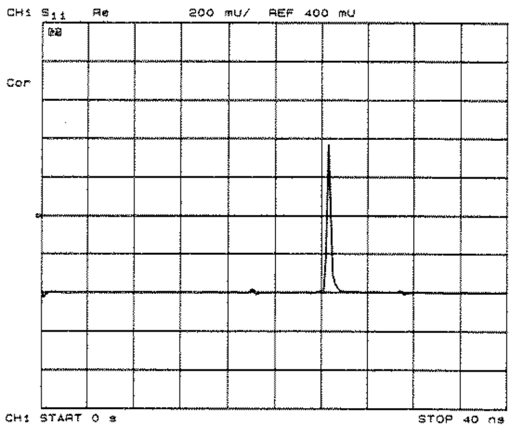
NOTE: In the time domain, the STIMULUS keys (**[START]**, **[STOP]**, **[CENTER]** and **[SPAN]**) refer to time, and can be used to change the horizontal (time) axis of the display, independent of the chosen frequency range.

8. Press **[FORMAT]** ***[MORE] [REAL]*** **[SCALE REF]** ***[AUTO SCALE]*** to view the step response, which will be similar to Figure 8-5 (a). (The step response is reflected back from the unterminated cable.)

9. Press **[SYSTEM]** ***[TRANSFORM MENU]*** ***[LOW PASS IMPULSE]*** to view the impulse response, similar to Figure 8-5 (b).



(a) Low Pass Step



(b) Low Pass Impulse

Figure 8-5. Time Domain Low Pass Measurements of an Unterminated Cable

10. Now connect a short circuit to the unterminated cable and press **[SCALE REF]** ***[AUTO SCALE]*** to center the display. The polarity of the impulse response is now reversed.

11. Press **[SYSTEM]** ***[TRANSFORM MENU]*** ***[LOW PASS STEP]*** to view the low pass step response with the polarity reversed.

Interpreting the Low Pass Response Horizontal Axis. The low pass measurement horizontal axis is the two-way travel time to the discontinuity (as in the bandpass mode). The marker displays both the two-way time and the electrical length along the trace. To determine the actual physical length, enter the appropriate velocity factor as described earlier in this chapter under *Adjusting the Relative Velocity Factor*.

Interpreting the Low Pass Response Vertical Axis. The vertical axis depends on the chosen format. In the low pass mode, the frequency domain data is taken at harmonically related frequencies and extrapolated to DC. Because this results in the inverse Fourier transform having only a real part (the imaginary part is zero), the most useful low pass step mode format in this application is the real format. It displays the response in reflection coefficient units. This mode is similar to the traditional TDR response, which displays the reflected signal in a real format (volts) versus time (or distance) on the horizontal axis.

The real format can also be used in the low pass impulse mode, but for the best dynamic range for simultaneously viewing large and small discontinuities, use the log magnitude format.

Fault Location Measurements Using Low Pass

As described, the low pass mode can simulate the TDR response of the device under test. This response contains information useful in determining the type of discontinuity present. Figure 8-6 illustrates the low pass responses of known discontinuities. Each circuit element was simulated to show the corresponding low pass time domain S11 response waveform. The low pass mode gives the device response either to a step or to an impulse stimulus. Mathematically, the low pass impulse stimulus is the derivative of the step stimulus.

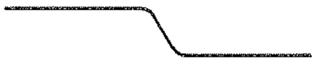
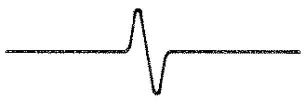
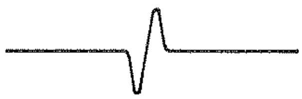
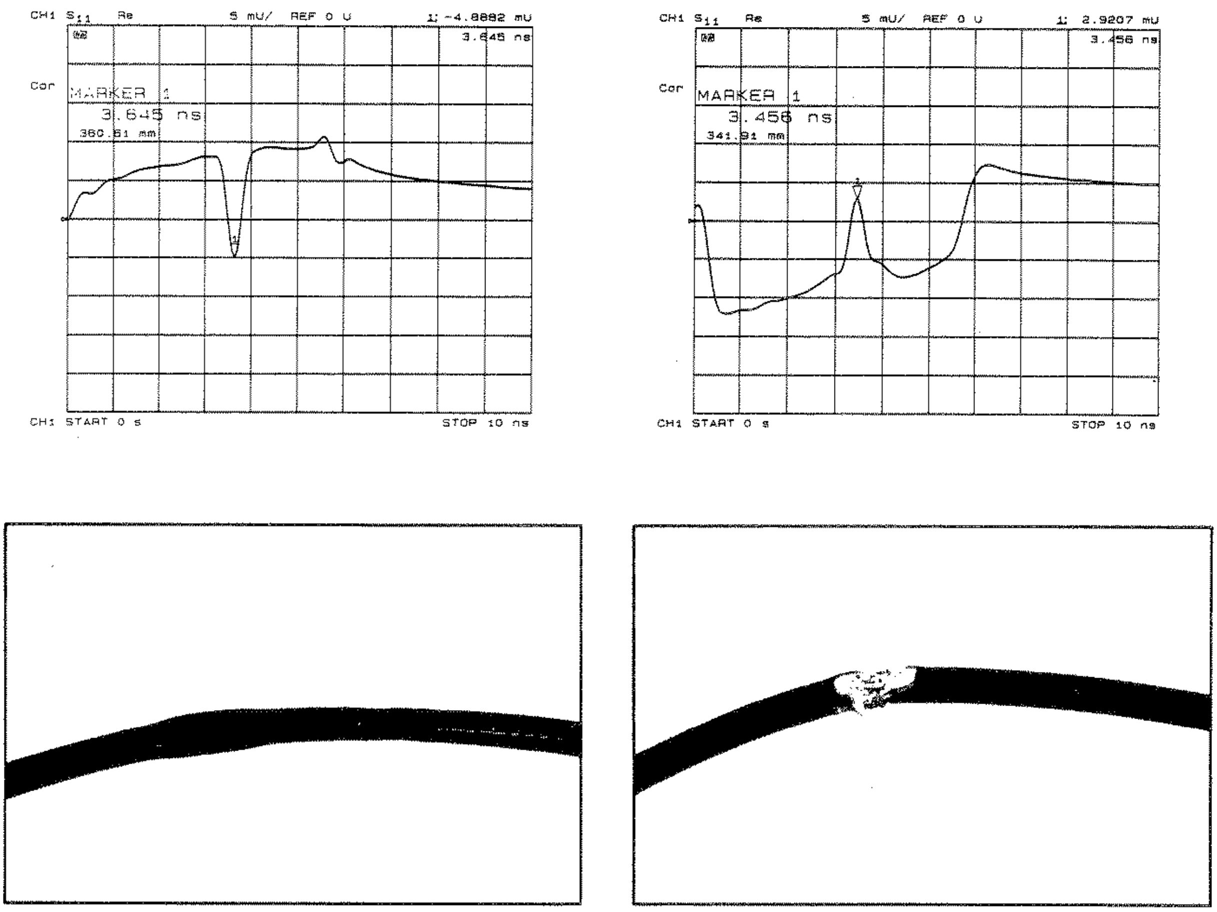
Element	Step Response	Impulse Response
Open	 Unity Reflection	 Unity Reflection
Short	 Unity Reflection, −180°	 Unity Reflection, −180°
Resistor $R > Z_0$	 Positive Level Shift	 Positive Peak
Resistor $R < Z_0$	 Negative Level Shift	 Negative Peak
Inductor	 Positive Peak	 Positive Then Negative Peaks
Capacitor	 Negative Peak	 Negative Then Positive Peaks

Figure 8-6. Simulated Low Pass Step and Impulse Response Waveforms (Real Format)

Figure 8-7 shows example cables with discontinuities (faults) using the low pass step mode with the real format.



(a) Crimped Cable (Capacitive)

(b) Frayed Cable (Inductive)

Figure 8-7. Low Pass Step Measurements of Common Cable Faults (Real Format)

Transmission Measurements in Time Domain Low Pass

Measuring Small Signal Transient Response Using Low Pass Step. Use the low pass mode to analyze the DUT small signal transient response. The transmission response of a device to a step input is often measured at lower frequencies, using a function generator (to provide the step to the DUT) and a sampling oscilloscope (to analyze the DUT output response). The low pass step mode extends the frequency range of this type of measurement to 3 GHz (6 GHz with an HP 8753B option 006 and 85047A test set).

The step input shown in Figure 8-8 is the inverse Fourier transform of the frequency domain response of a thru measured at calibration. The step rise time is proportional to the highest frequency in the frequency domain sweep; the higher the frequency, the faster the rise time. The frequency sweep in Figure 8-8 is from 10 MHz to 1 GHz.

Figure 8-8 also illustrates the time domain low pass response of an amplifier under test. The average group delay over the measurement frequency range is the difference in time between the step and the amplifier response. This time domain response simulates an oscilloscope measurement of the amplifier's small signal transient response. Note the ringing in the amplifier response that indicates an underdamped design.

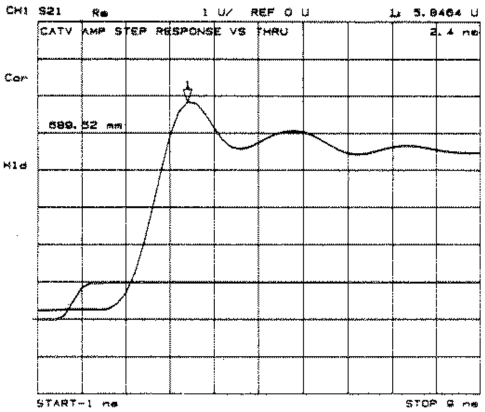


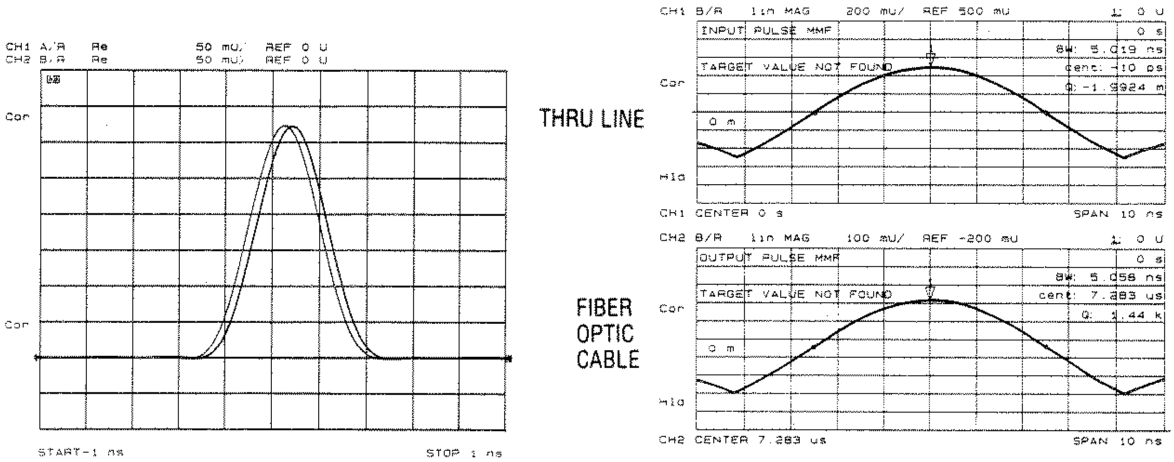
Figure 8-8. Time Domain Low Pass Measurement of an Amplifier Small Signal Transient Response

Interpreting the Low Pass Step Transmission Response Horizontal Axis. The low pass transmission measurement horizontal axis displays the average transit time through the device over the frequency range used in the measurement. The response of the thru connection used in the calibration is a step that reaches 50% unit height at approximately time = 0. The rise time is determined by the highest frequency used in the frequency domain measurement. The step is a unit high step, which indicates no loss for the thru calibration. When a device is inserted, the time axis indicates the propagation delay or electrical length of the device. The markers read the electrical delay in both time and distance. The distance can be scaled by an appropriate velocity factor as described earlier in this chapter under *Adjusting the Relative Velocity Factor*.

Interpreting the Low Pass Step Transmission Response Vertical Axis. In the real format, the vertical axis displays the transmission response in real units (e.g. volts). For the amplifier example in Figure 8-8, if the amplifier input is a step of 1 volt, the output, 2.4 nanoseconds after the step (indicated by marker 1), is 5.84 volts.

In the log magnitude format, the amplifier gain is the steady state value displayed after the initial transients die out.

Measuring Separate Transmission Paths through the DUT Using Low Pass Impulse Mode. The low pass impulse mode can be used to identify different transmission paths through a DUT that has a response at frequences down to DC (or at least has a predictable response, above the noise floor, below 300 kHz). For example, use the low pass impulse mode to measure the relative transmission times through a multipath device such as a power divider. Another example is to measure the pulse dispersion through a broadband transmission line, such as a fiber optic cable. Both examples are illustrated in Figure 8-9. The horizontal and vertical axes can be interpreted as already described in this chapter under *Transmission Measurements Using Bandpass Mode*.



(a) Comparing Transmission Paths through a Power Divider

(b) Measuring Pulse Dispersion on a 1.5 km Fiber Optic Cable

Figure 8-9. Transmission Measurements Using Low Pass Impulse Mode

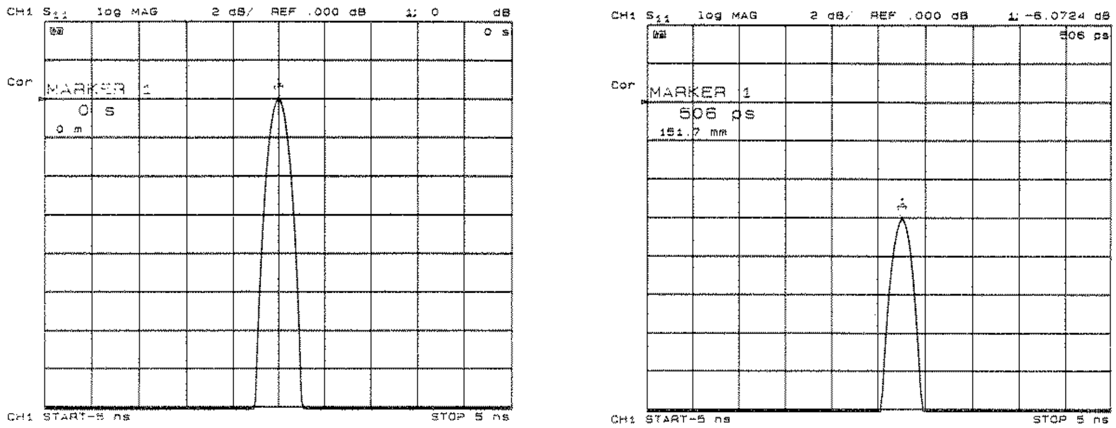
TIME DOMAIN CONCEPTS

Masking

Masking occurs when a discontinuity (fault) closest to the reference plane affects the response of each subsequent discontinuity. This happens because the energy reflected from the first discontinuity never reaches subsequent discontinuities. For example, if a transmission line has two discontinuities that each reflect 50% of the incident voltage, the time domain response (real format) shows the correct reflection coefficient for the first discontinuity ($\rho=0.50$). However, the second discontinuity appears as a 25% reflection ($\rho=0.25$) because only half the incident voltage reached the second discontinuity.

NOTE: This example assumes a lossless transmission line. Real transmission lines, with non-zero loss, attenuate signals as a function of the distance from the reference plane.

As an example of masking due to line loss, consider the time domain response of a 3 dB attenuator and a short circuit. The impulse response (log magnitude format) of the short circuit alone is a return loss of 0 dB, as shown in Figure 8-10 (a). When the short circuit is placed at the end of the 3 dB attenuator, the return loss is −6 dB, as shown in Figure 8-10 (b). This value actually represents the forward and return path loss through the attenuator, and illustrates how a lossy network can affect the responses that follow it.



(a) Short Circuit

(b) Short Circuit at the End of a 3 dB Pad

Figure 8-10. Masking Example

Windowing

The HP 8753B provides a windowing feature that makes time domain measurements more useful for isolating and identifying individual responses. Windowing is needed because of the abrupt transitions in a frequency domain measurement at the start and stop frequencies. The band limiting of a frequency domain response causes overshoot and ringing in the time domain response, and causes a non-windowed impulse stimulus to have a sin(kt)/kt shape, where $k = \pi/\text{frequency span}$ (see Figure 8-11). This has two effects that limit the usefulness of the time domain measurement:

1. Finite impulse width (or rise time). This limits the ability to resolve between two closely spaced responses. The effects of the finite impulse width cannot be improved without increasing the frequency span of the measurement (see Table 8-3).
2. Sidelobes. The impulse sidelobes limit the dynamic range of the time domain measurement by hiding low-level responses within the sidelobes of higher level responses. The effects of sidelobes can be improved by windowing (see Table 8-3).

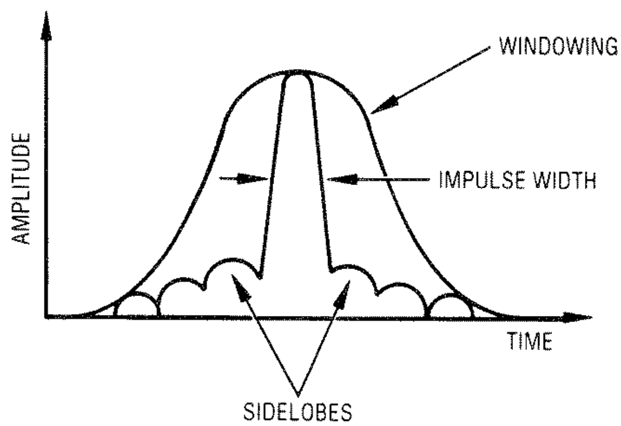


Figure 8-11. Impulse Width, Sidelobes, and Windowing

Windowing improves the dynamic range of a time domain measurement by filtering the frequency domain data prior to converting it to the time domain, producing an impulse stimulus that has lower sidelobes. This makes it much easier to see time domain responses that are very different in magnitude. The sidelobe reduction is achieved, however, at the expense of increased impulse width. The effect of windowing on the step stimulus (low pass mode only) is a reduction of overshoot and ringing at the expense of increased rise time.

To select a window, press **[SYSTEM]** ***[TRANSFORM MENU] [WINDOW]***. A menu is presented that allows the selection of three window types (see Table 8-3).

Table 8-3. Impulse Width, Sidelobe Level, and Windowing Values

Window Type	Impulse Sidelobe Level	Low Pass Impulse Width (50%)	Step Sidelobe Level	Step Rise Time (10 – 90%)
Minimum	−13 dB	1.20/Freq Span	−21 dB	0.45/Freq Span
Normal	−44 dB	1.92/Freq Span	−60 dB	0.99/Freq Span
Maximum	−90 dB	2.88/Freq Span	−90 dB	1.48/Freq Span
NOTE: The bandpass mode simulates an impulse stimulus. Bandpass impulse width is twice that of lowpass impulse width. The bandpass impulse sidelobe levels are the same as lowpass impulse sidelobe levels.				

Choose one of the three window shapes listed in Table 8-3. Or you can use the knob to select any windowing pulse width (or rise time for a step stimulus) between the softkey values. The time domain stimulus sidelobe levels depend only on the window selected.

[MINIMUM] is essentially no window. Consequently, it gives the highest sidelobes.

[NORMAL] (the preset mode) gives reduced sidelobes and is the mode most often used.

[MAXIMUM] window gives the minimum sidelobes, providing the greatest dynamic range.

[USE MEMORY on OFF] remembers a user-specified window pulse width (or step rise time) different from the standard window values.

A window is turned on only for viewing a time domain response, and does not affect a displayed frequency domain response. Figure 8-12 shows the typical effects of windowing on the time domain response of a short circuit reflection measurement.

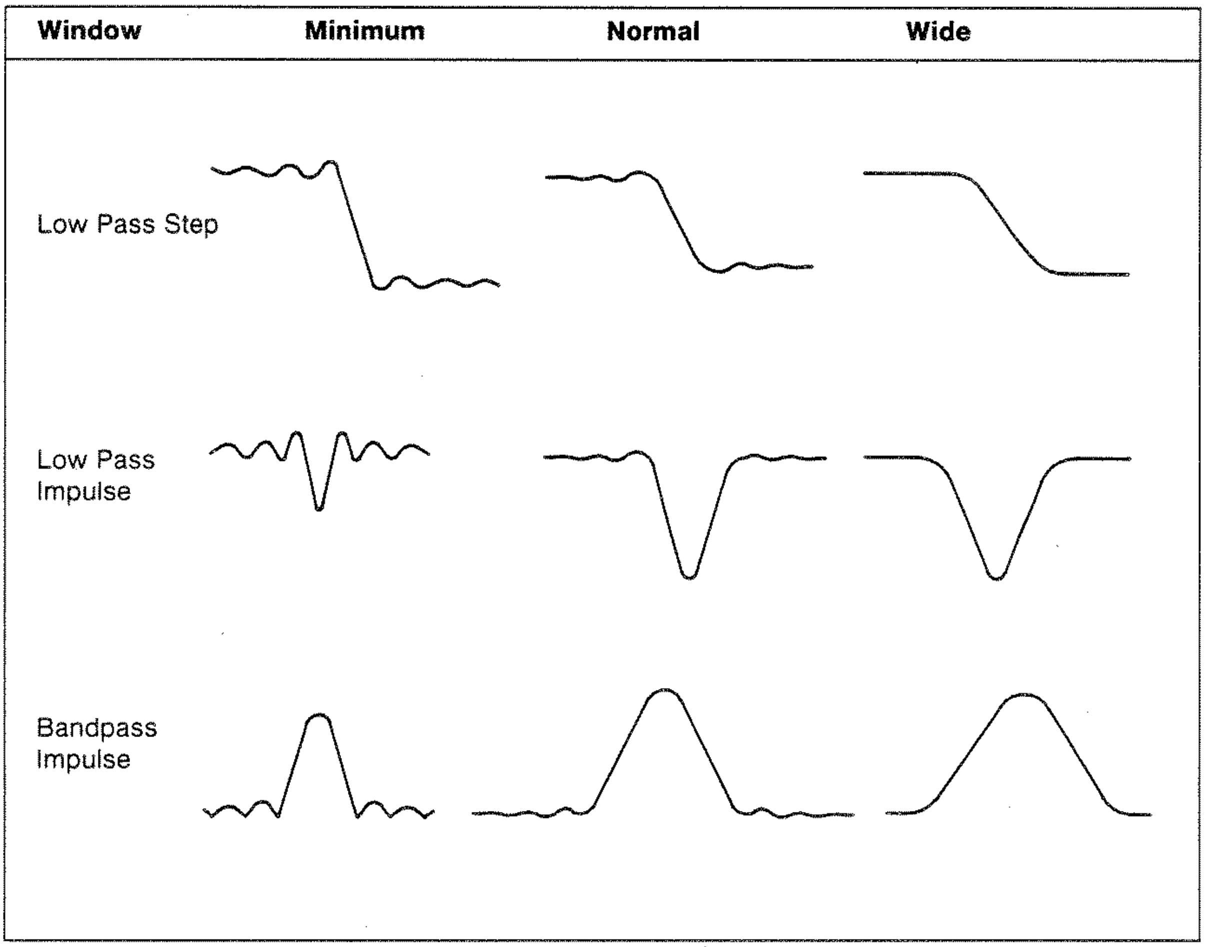


Figure 8-12. The Effects of Windowing on the Time Domain Responses of a Short Circuit

Range

In the time domain, range is defined as the length in time that a measurement can be made without encountering a repetition of the response, called aliasing. A time domain response repeats at regular intervals because the frequency domain data is taken at discrete frequency points, rather than continuously over the frequency band.

Measurement range is equal to $1/\Delta F$ (ΔF is the spacing between frequency data points). Measurement range = (number of points − 1)/frequency span (Hz).

Example:

Measurement = 201 points
1 MHz to 2.001 GHz

Range = $1/\Delta F$ or (number of points −1)/frequency span
= $1/(10 \times 10^6)$ or $(201 - 1)/(2 \times 10^9)$
= 100×10^{-9} seconds

Electrical length = range x the speed of light (3×10^8 m/s)
= $(100 \times 10^{-9}$ s$) \times (3 \times 10^8$ m/s$)$
= 30 metres

In this example, the range is 100 ns, or 30 metres electrical length. To prevent the time domain responses from overlapping, the DUT must be 30 metres or less in electrical length for a transmission measurement (15 metres for a reflection measurement). The HP 8753B limits the stop time to prevent the display of aliased responses.

To increase the time domain measurement range, first increase the number of points, but remember that as the number of points increases, the sweep speed decreases. Decreasing the frequency span also increases range, but reduces resolution.

Resolution

Two different resolution terms are used in the time domain:

1. Response Resolution
2. Range Resolution

Response Resolution. Time domain response resolution is defined as the ability to resolve two closely-spaced responses, or a measure of how close two responses can be to each other and still be distinguished from each other. For responses of equal amplitude, the response resolution is equal to the 50% (−6 dB) impulse width. It is inversely proportional to the measurement frequency span, and is also a function of the window used in the transform. The approximate formulas for calculating the 50% impulse width are given in Table 8-3.

For example, using the formula for the bandpass mode with a normal windowing function for a 1 MHz to 3.001 GHz measurement (3 GHz span):

$$\begin{aligned} \text{50\% calculated impulse width} &= 1.2 \times (1/3\ \text{GHz}) \times 1.6 \\ &= 0.64\ \text{nanoseconds} \end{aligned}$$

$$\begin{aligned} \text{Electrical length (in air)} &= (0.64 \times 10^{-9}\ \text{s}) \times (30 \times 10^{9}\ \text{cm/s}) \\ &= 19.2\ \text{centimetres} \end{aligned}$$

With this measurement, two equal responses can be distinguished when they are separated by at least 19.2 centimetres. In a 6 GHz measurement with an option 006 instrument and an HP 85047A test set, two equal responses can be distinguished when they are separated by at least 9.6 cm.

Using the low pass mode (the low pass frequencies are slightly different) with a minimum windowing function, you can distinguish two equal responses that are about 6 centimetres or more apart.

For reflection measurements, which measure the round trip time to the response, divide the response resolution by 2. Using the example above, you can distinguish two faults of equal magnitude provided they are 3 centimetres (electrical length) or more apart.

NOTE: Remember, to determine the physical length, enter the relative velocity factor of the transmission medium under test.

For example, a cable with a teflon dielectric (0.7 relative velocity factor), measured under the conditions stated above, has a fault location measurement response resolution of 2.1 centimetres. This is the maximum fault location response resolution. Factors such as reduced frequency span, greater frequency domain data windowing, and a large discontinuity shadowing the response of a smaller discontinuity, all act to degrade the effective response resolution.

Figure 8-13 illustrates the effects of response resolution. The solid line shows the actual reflection measurement of two approximately equal discontinuities (the input and output of an SMA barrel). The dashed line shows the approximate effect of each discontinuity, if they could be measured separately.

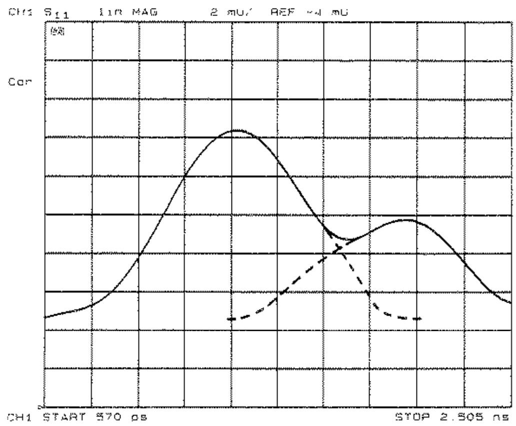


Figure 8-13. Response Resolution

While increasing the frequency span increases the response resolution, keep the following points in mind:

1. The time domain response noise floor is directly related to the frequency domain data noise floor. Because of this, if the frequency domain data points are taken at or below the measurement noise floor, the time domain measurement noise floor is degraded.
2. The time domain measurement is an average of the response over the frequency range of the measurement. If the frequency domain data is measured out-of-band, the time domain measurement is also the out-of-band response.

You may (with these limitations in mind) choose to use a frequency span that is wider than the DUT bandwidth to achieve better resolution.

Range Resolution. Time domain range resolution is defined as the ability to locate a single response in time. If only one response is present, range resolution is a measure of how closely you can pinpoint the peak of that response. The range resolution is equal to the digital resolution of the display, which is the time domain span divided by the number of points on the display. To get the maximum range resolution, center the response on the display and reduce the time domain span. The range resolution is always much finer than the response resolution.

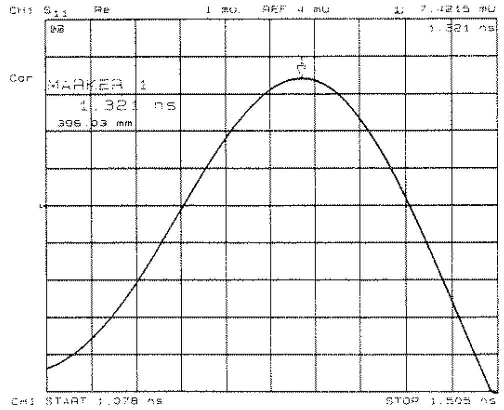
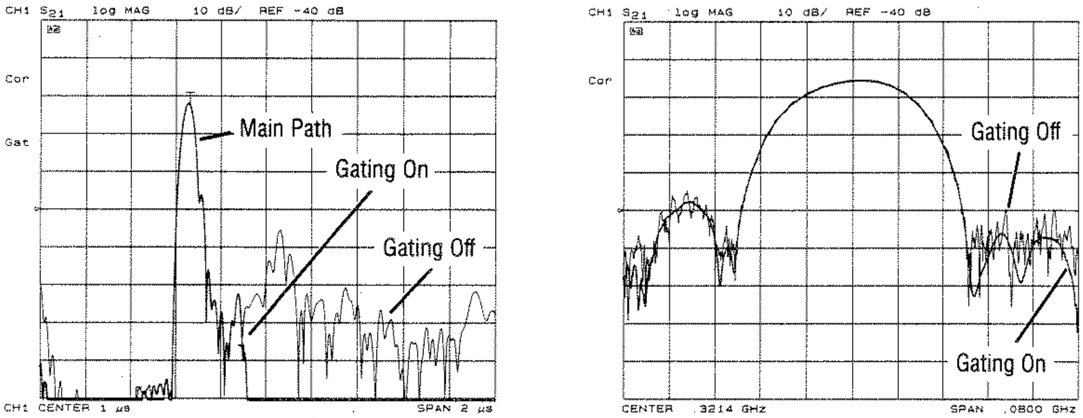


Figure 8-14. Range Resolution of a Single Discontinuity

Gating

Gating provides the flexibility of selectively removing time domain responses. The gated time domain responses can then be transformed back to the frequency domain. For reflection (or fault location) measurements, use this feature to remove the effects of unwanted discontinuities in the time domain. You can then view the frequency response of the remaining discontinuities. In a transmission measurement, you can remove the effects of multiple transmission paths.

Figure 8-15 illustrates the time domain response of a SAW filter. Gating has been applied in the time domain to remove the effects of all but the main signal path response. When the gated response is transformed back to the frequency domain, the display shows only the direct path response.



(a) Time Domain *(b) Frequency Domain*

Figure 8-15. SAW Filter Transmission Measurement with Gating

Setting the Gate. Think of a gate as a bandpass filter in the time domain (Figure 8-16). When the gate is on, responses outside the gate are mathematically removed from the time domain trace. Enter the gate position as a start and stop time (not frequency) or as a center and span time. The start and stop times are the bandpass filter −6 dB cutoff times. Gates can have a negative span, in which case the responses *inside* the gate are mathematically removed.

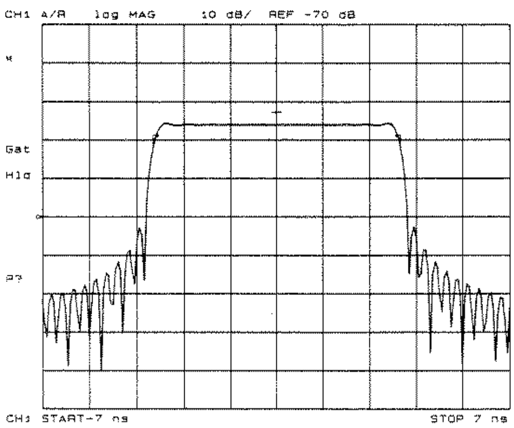


Figure 8-16. Gate Shape

Selecting Gate Shape. The four gate shapes available are listed in Table 8-4. Each gate has a different passband flatness, cutoff rate, and sidelobe levels.

Table 8-4. Gate Characteristics

Gate Shape	Passband Ripple	Sidelobe Levels	Cutoff Time	Minimum Gate Span
Gate SpanMinimum	±0.40 dB	−24 dB	0.6/Freq Span	1.2/Freq Span
Normal	±0.04 dB	−45 dB	1.4/Freq Span	2.8/Freq Span
Wide	±0.02 dB	−52 dB	4.0/Freq Span	8.0/Freq Span
Maximum	±0.01 dB	−80 dB	11.2/Freq Span	22.4/Freq Span
NOTE: With 1601 frequency points, gating is available only in the passband mode.				

The passband ripple and sidelobe levels are descriptive of the gate shape. The cutoff time is the time between the stop time (−6 dB on the filter skirt) and the peak of the first sidelobe, and is equal on the left and right side skirts of the filter. Because the minimum gate span has no passband, it is just twice the cutoff time. Always choose a gate span wider than the minimum. For most applications, do not be concerned about the minimum gate span, simply use the knob to position the gate markers around the desired portion of the time domain trace.

TRANSFORMING CW TIME MEASUREMENTS INTO THE FREQUENCY DOMAIN

The HP 8753B can display the amplitude and phase of continuous wave (CW) signals versus time. For example, use this mode for measurements such as amplifier gain as a function of warm-up time (i.e. drift). In the past, drift measurements were often made using strip chart recorders. The HP 8753B can display the measured parameter (e.g. amplifier gain) for periods of up to 24 hours and then output the data to a digital plotter for hardcopy results.

These "strip chart" plots are actually measurements as a function of time (time is the independent variable), and the horizontal display axis is scaled in time units. Transforms of these measurements result in frequency domain data. Such transforms are called forward transforms because the transform from time to frequency is a forward Fourier transform, and can be used to measure the spectral content of a CW signal. For example, when transformed into the frequency domain, a pure CW signal measured over time appears as a single frequency spike. The transform into the frequency domain yields a display that looks similar to a spectrum analyzer display of signal amplitude versus frequency.

Forward Transform Measurements

This is an example of a measurement using the Fourier transform in the forward direction, from the time domain to the frequency domain (see Figure 8-17):

1. Press **[PRESET]**.
2. Press **[MEAS]** and select the desired measurement (in this case B/R).
3. Press **[MENU]** ***[CW FREQ]*** and set the CW frequency to the desired value (here 250 MHz). The CW time mode is now active.

4. Press **[STOP]** and enter the time over which you wish to take data (up to 24 hours, in this case 0.1 second).

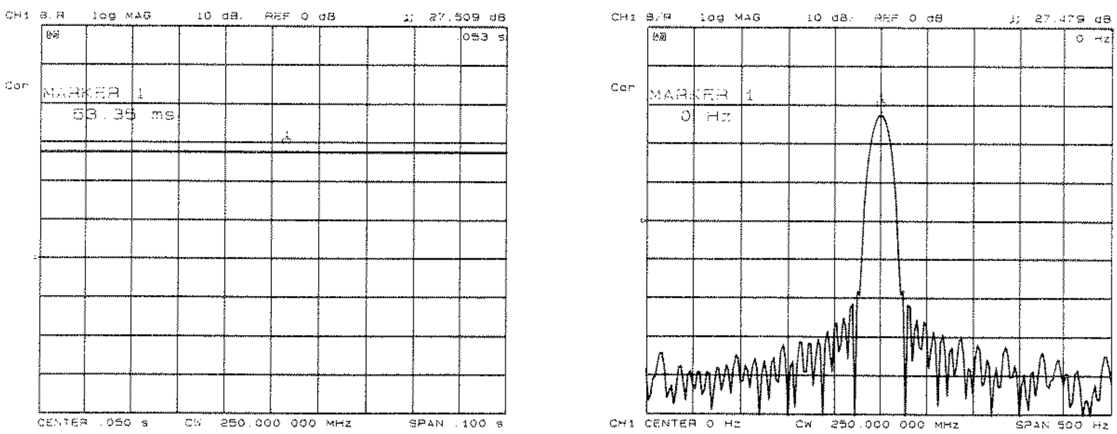
5. Press **[SYSTEM]** ***[TRANSFORM MENU]*** ***[TRANSFORM ON]*** to transform the data into the frequency domain.

6. Press **[SPAN]** and set the desired frequency span. For this example, press **[5] [0] [0] [x1]** to increase the frequency span to 500 Hz. The displayed center frequency of 0 Hz represents the CW frequency of 250 MHz entered earlier. The maximum span is 4000 Hz for the default sweep time (100 ms) and number of points (201) (see *Forward Transform Range*).

NOTE: In the forward transform mode, the k/m, M/μ, and G/n keys terminate a selection as millihertz, microhertz, and nanohertz.

7. Press **[SCALE REF]** and adjust the scale per division and reference position to view the trace centered on the screen.

8. Press **[MKR FCTN]** ***[MKR SEARCH]*** ***[MAX]*** to see the peak value.



(a) CW Time *(b) Transform to Frequency Domain*

Figure 8-17. Amplifier Gain Measurement

Interpreting the Forward Transform Vertical Axis. With the log magnitude format selected, the vertical axis displays dB. This format simulates a spectrum analyzer display of power versus frequency.

Interpreting the Forward Transform Horizontal Axis. In a frequency domain transform of a CW time measurement, the horizontal axis is measured in units of frequency. The center frequency is the offset of the CW frequency. For example, with a center frequency of 0 Hz, the CW frequency (250 MHz in the example) is in the center of the display. If the center frequency entered is a positive value, the CW frequency shifts to the right half of the display; a negative value shifts it to the left half of the display. The span value entered with the transform on is the total frequency span shown on the display. (Alternatively, the frequency display values can be entered as start and stop.)

Demodulating the Results of the Forward Transform

The forward transform can separate the effects of the CW frequency modulation amplitude and phase components. For example, if a DUT modulates the transmission response (S21) with a 500 Hz AM signal, you can see the effects of that modulation as shown in Figure 8-18. To simulate this effect, connect a 500 Hz sine wave to the HP 8753B rear panel EXT AM input.

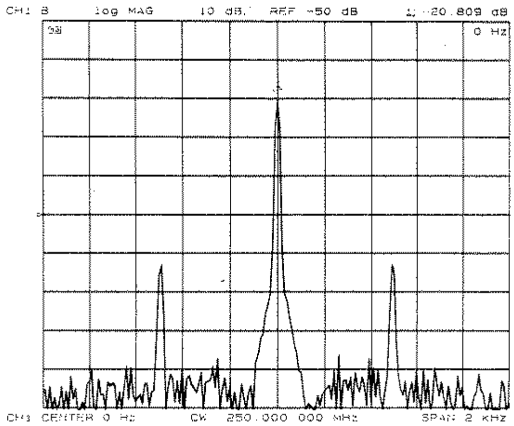


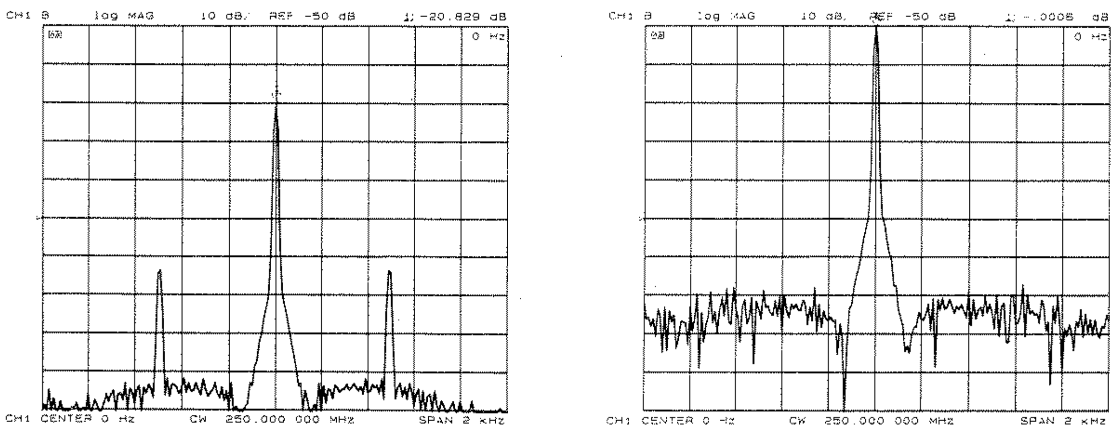
Figure 8-18. Combined Effects of Amplitude and Phase Modulation

Using the demodulation capabilities of the HP 8753B, it is possible to view the amplitude or the phase component of the modulation separately. The window menu (see Figure 8-2) includes the following softkeys to control the demodulation feature:

[DEMOD: OFF] This is the normal preset state, in which both the amplitude and phase components of any DUT modulation appear on the display.

[AMPLITUDE] displays only the amplitude modulation (AM), as illustrated in Figure 8-19 (a).

[PHASE] displays only the phase modulation (PM), as shown in Figure 8-19 (b).



(a) Amplitude Modulation Component

(b) Phase Modulation Component

Figure 8-19. Separating the Amplitude and Phase Components of DUT-Induced Modulation

Forward Transform Range

In the forward transform (from CW time to the frequency domain), range is defined as the frequency span that can be displayed before aliasing occurs, and is similar to range as defined for time domain measurements. In the range formula, substitute time span for frequency span.

Example:

$$\begin{aligned} \text{Range} &= (\text{Number of points} - 1)/\text{time span} \\ &= (201 - 1)/(200 \times 10^{-3}) \\ &= 1000 \text{ Hertz} \end{aligned}$$

For the example given above, a 201 point CW time measurement made over a 200 ms time span, choose a span of 1 kHz or less on either side of the center frequency (Figure 8-20). That is, choose a total span of 2 kHz or less.

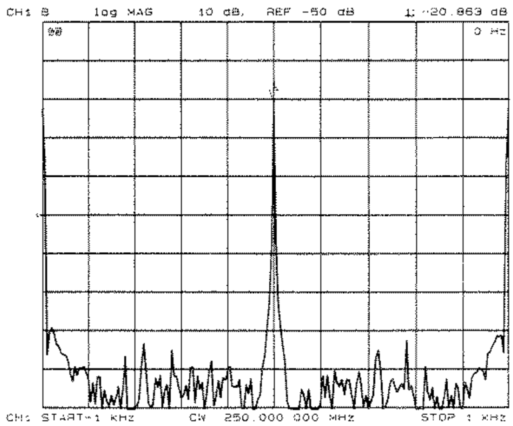


Figure 8-20. Range of a Forward Transform Measurement

To increase the frequency domain measurement range, increase the span. The maximum range is inversely proportional to the sweep time, therefore it may be necessary to increase the number of points or decrease the sweep time. Because increasing the number of points increases the auto sweep time, the maximum range is 2 kHz on either side of the selected CW time measurement center frequency (4 kHz total span). To display a total frequency span of 4 kHz, enter the span as 4000 Hz.

Chapter 9. Making a Hard Copy Output

CHAPTER CONTENTS

INTRODUCTION

The HP 8753B can use HP-IB to output measurement results directly to a compatible printer or plotter, without the use of an external controller. The information displayed on the CRT can be copied to a compatible Hewlett-Packard plotter or graphics printer. A plotter provides better resolution than a printer for data displays, while a printer provides higher speed for tabular listings. Refer to the *General Information and Specifications* section of this manual for information about compatible plotters and printers.

To generate a plot or printout from the front panel when there is no other controller on the bus, the HP 8753B must be in system controller HP-IB mode. To take control from the computer and initiate a plot or printout, the HP 8753B must be in pass control mode. If it is not in one of these modes, the message "SYST CTRL or PASS CTRL in LOCAL menu" is displayed. Refer to *[LOCAL] Key* in Chapter 7 for information on HP-IB controller modes and setting addresses.

Print/Plot Buffer

The instrument can continue operation while a plot or printout is run. To abort a plot or print in progress, press **[LOCAL]**. If a print or plot is in progress and a second print or plot is attempted, the message "PRINT/PLOT IN PROGRESS, ABORT WITH LOCAL" is displayed and the second attempt is ignored. An aborted plot or printout cannot be continued: the process must be initiated again if a copy is still required.

[COPY] KEY

The **[COPY]** key provides access to the menus used for controlling external plotters and printers and defining the plot parameters.

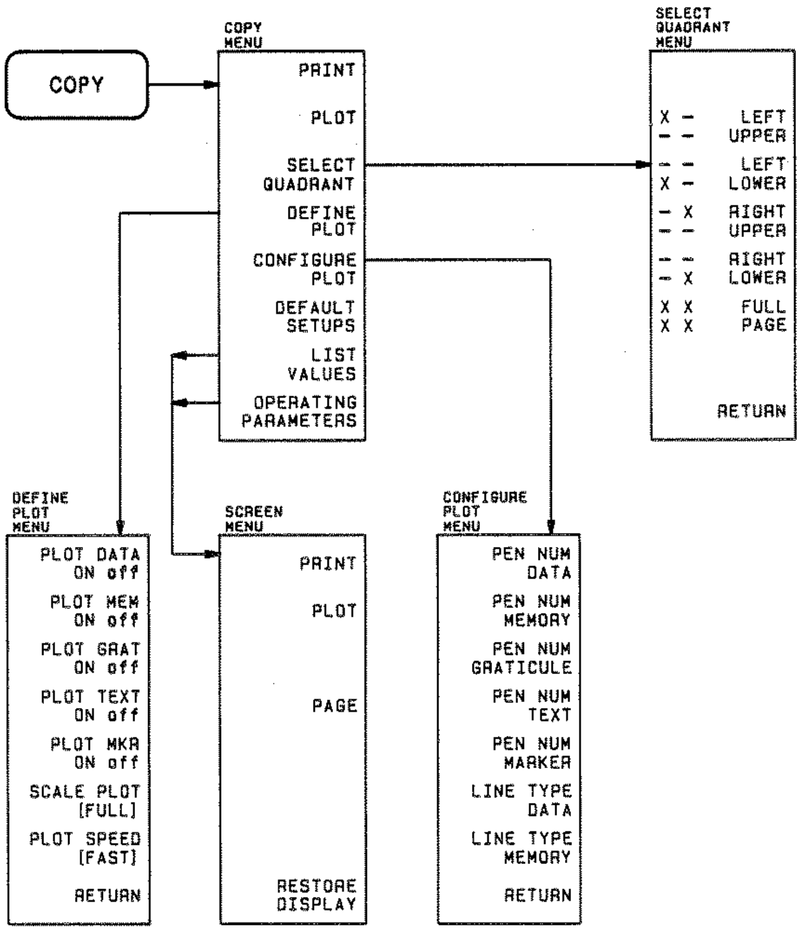


Figure 9-1. Softkey Menus Accessed from the [COPY] Key

Copy Menu

The copy menu can be used to copy to a printer or to plot using default plot parameters, without the need to access other menus. For user-defined plot parameters, a series of additional menus is available.

This menu also provides tables of operating parameters and measured data values, which can be copied from the screen to a printer or plotter.

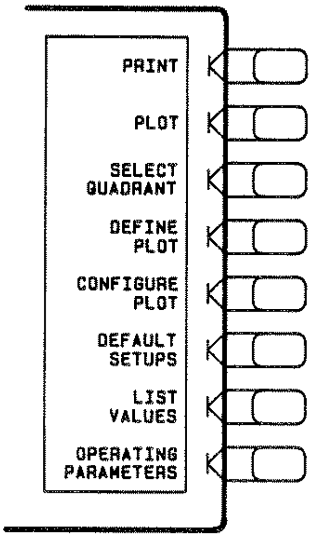


Figure 9-2. Copy Menu

[PRINT] (PRINALL) copies the CRT display to a compatible HP graphics printer. Tabular listings or data displays can be printed, although a plotter provides better resolution for data displays. All information from the CRT display is printed except the softkey labels.

[PLOT] (PLOT) plots the CRT display to a compatible HP graphics plotter, using the currently defined plot parameters (or default parameters). Any or all displayed information can be plotted, except the softkey labels and CRT listings such as the frequency list table or limit table. (List values and operating parameters can be plotted using the screen menu explained later in this chapter. However, this is considerably slower than printing.)

[SELECT QUADRANT] leads to the the select quadrant menu, which provides the capability of drawing quarter-page plots. This is not used for printing.

[DEFINE PLOT] leads to the define plot menu, which is used to specify which elements of the display are to be plotted. This is not used for printing.

[CONFIGURE PLOT] leads to the configure plot menu, which defines the pen number and line type for each of the plot elements. This is not used for printing.

[DEFAULT SETUPS] (DFLT) resets the plotting parameters to their default values. These defaults are as follows:

Select quadrant:	Full page
Define plot:	All plot elements on
Plot scale:	Full
Plot speed:	Fast
Line type:	7 (solid line)
Pen numbers:	Default values

Default setups do not apply to printing.

[LIST VALUES] (LISV) provides a tabular listing of all the measured data points and their current values, together with limit information if it is turned on. At the same time, the screen menu is presented, to enable hard copy listings and access new pages of the table. 30 lines of data are listed on each page, and the number of pages is determined by the number of measurement points specified in the stimulus menu.

Up to five columns of data are provided. The specific information listed for each measured data point varies depending on the display format, the limit testing status, and whether or not dual channel display or stimulus coupling is selected. If limit testing is on, an asterisk * is listed next to any measured value that is out of limits. If limit lines are on, and other listed data allows sufficient space, the limits are listed together with the margin by which the device data passes or fails the nearest limit.

[OPERATING PARAMETERS] (OPEP) provides a tabular listing on the CRT of the key parameters for both HP 8753B channels. The screen menu is presented to allow hard copy listings and access new pages of the table. Four pages of information are supplied. The first two pages list operating parameters. The third page lists marker parameters. The fourth page lists system parameters that relate to control of peripheral devices rather than selection of measurement parameters.

Select Quadrant Menu

This menu offers the selection of a full-page plot, or a quarter-page plot in any quadrant of the page.

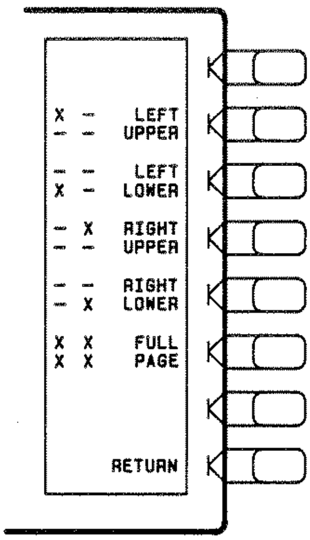


Figure 9-3. Select Quadrant Menu

[LEFT UPPER] (LEFU) draws a quarter-page plot in the upper left quadrant of the page.

[LEFT LOWER] (LEFL) draws a quarter-page plot in the lower left quadrant of the page.

[RIGHT UPPER] (RIGU) draws a quarter-page plot in the upper right quadrant of the page.

[RIGHT LOWER] (RIGL) draws a quarter-page plot in the lower right quadrant of the page.

[FULL PAGE] (FULP) draws a full-size plot according to the scale defined with *[SCALE PLOT]* in the define plot menu (described next).

[RETURN] goes back to the copy menu.

Define Plot Menu

This menu allows selective plotting of portions of the measurement display. Different plot elements can be turned on or off as required. In addition, different selections are available for plot speed and plot scale, to allow plotting on transparencies and preprinted forms.

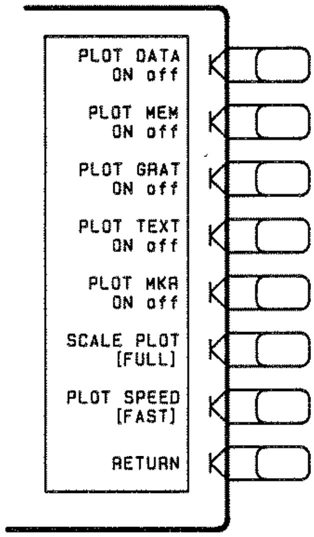


Figure 9-4. Define Plot Menu

[PLOT DATA ON off] (PDATAON, PDATAOFF) specifies whether the data trace is to be drawn (on) or not drawn (off) on the plot.

[PLOT MEM ON off] (PMEMON, PMEMOFF) specifies whether the memory trace is to be drawn (on) or not drawn (off) on the plot. Memory can only be plotted if it is displayed (refer to *Display Menu* in Chapter 4).

[PLOT GRAT ON off] (PGRATON, PGRATOFF) specifies whether the graticule and the reference line are to be drawn (on) or not drawn (off) on the plot. Turning *[PLOT GRAT ON]* and all other elements off is a convenient way to make preplotted grid forms. However, when data is to be plotted on a preplotted form, *[PLOT GRAT OFF]* should be selected.

[PLOT TEXT ON off] (PTEXTON, PTEXTOFF) selects plotting of all displayed text except the marker values, softkey labels, and CRT listings such as the frequency list table or limit table. (Softkey labels can be plotted under the control of an external controller. Refer to the *Introductory Programming Guide*.)

[PLOT MKR ON off] (PMKRON, PMKROFF) specifies whether the markers and marker values are to be drawn (on) or not drawn (off) on the plot.

[SCALE PLOT] (SCAPFULL, SCAPGRAT) provides two selections for plot scale, ***[FULL]*** and ***[GRAT]***. ***[FULL]*** is the normal scale selection for plotting on blank paper, and includes space for all display annotations such as marker values, stimulus values, etc. The entire CRT display fits within the user-defined boundaries of P1 and P2 on the plotter, while maintaining the exact same aspect ratio as the CRT display.

With the selection of ***[GRAT]***, the horizontal and vertical scale are expanded or reduced so that the graticule lower left and upper right corners exactly correspond to the user-defined P1 and P2 scaling points on the plotter. This is convenient for plotting on preprinted rectangular or polar forms (for example, on a Smith chart).

To plot on a rectangular preprinted graticule, set P1 of the plotter at the lower left corner of the preprinted graticule, and set P2 at the upper right corner.

To plot on a polar format, set P1 to either the left (or bottom) end point of a diameter and P2 to the right (or top) end point. The HP 8753B will then compute and set new P1 and P2 values to obtain the current circularity. If P1 and P2 are set to within 10% of already being a perfect square, the HP 8753B will not change the boundaries but will distort the circles to fit the user-defined boundaries.

The procedure for plotting on a Smith chart format depends on the plotter capabilities. Some HP plotters have a 90° rotate feature that enables plotting on a portrait (vertical) format rather than a landscape (horizontal) format. Since most Smith charts are printed in portrait format, this rotate feature should be used prior to setting the P1 and P2 points as described above for a polar format.

[PLOT SPEED] (PLOSFAST, PLOSSLOW) provides two plot speeds, ***[FAST]*** and ***[SLOW]***. Fast is the proper plot speed for normal plotting. Slow plot speed is used for plotting directly on transparencies: the slower speed provides a more consistent line width. A color plot can be prepared directly on a transparency so that the color is not lost in converting a paper plot to a transparency.

[RETURN] goes back to the copy menu.

Configure Plot Menu

This menu is used to select the pens to be used for plotting different elements of a plot, and the line types for the data and memory traces.

Pen numbers 0 through 10 can be selected (0 indicates no pen). It is possible to select a pen number higher than the number of pens in the plotter used. The convention in most Hewlett-Packard plotters is that when the pen number count reaches its maximum number it starts again at 1. Thus in a four-pen plotter, pen #5 actually calls pen #1.

The default pen numbers for the different plot elements vary between channels 1 and 2, so that when a color plotter is used the plots for the two channels can be identified quickly by their colors.

Line types 0 through 10 can be selected. The line types depend on the model of plotter used. In general, however, line type 0 specifies dots only at the points that are plotted; line types 1 through 6 specify broken lines with different spacing; and lines 7 through 10 are solid lines. Refer to the plotter manual for specific line type information.

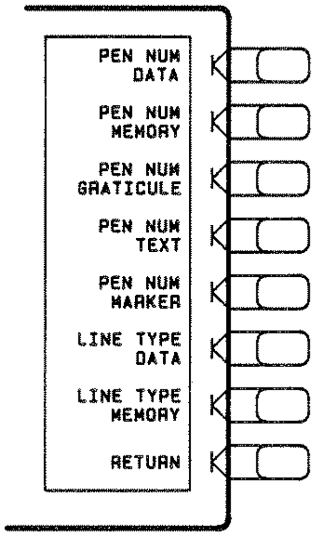


Figure 9-5. Configure Plot Menu

[PEN NUM DATA] (PENNDATA) selects the number of the pen to plot the data trace. The default pen for channel 1 is pen #1, and for channel 2 is pen #2.

[PEN NUM MEMORY] (PENNMEMO) selects the number of the pen to plot the memory trace. The default pen for channel 1 is pen #1, and for channel 2 is pen #2.

[PEN NUM GRATICULE] (PENNGRAT) selects the pen number for plotting the graticule. The default pen for channel 1 is pen #3, and for channel 2 is pen #4.

[PEN NUM TEXT] (PENNTEXT) selects the pen number for plotting the text. The default pen for channel 1 is pen #1, and for channel 2 is pen #2.

[PEN NUM MARKER] (PENNMARK) selects the pen number for plotting both the markers and the marker values. The default pen for channel 1 is pen #5, and for channel 2 is pen #6.

[LINE TYPE DATA] (LINTDATA) selects the line type for the data trace plot. The default line type is 7, which is a solid unbroken line.

[LINE TYPE MEMORY] (LINTMEMO) selects the line type for the memory trace plot. The default line type is 7.

[RETURN] goes back to the copy menu.

Screen Menu

This menu is used in conjunction with the ***[LIST VALUES]*** and ***[OPERATING PARAMETERS]*** features, to make hard copy listings of the tables displayed on the screen. To make copies from the front panel, make sure that the HP 8753B is in system controller or pass control mode (see Chapter 7).

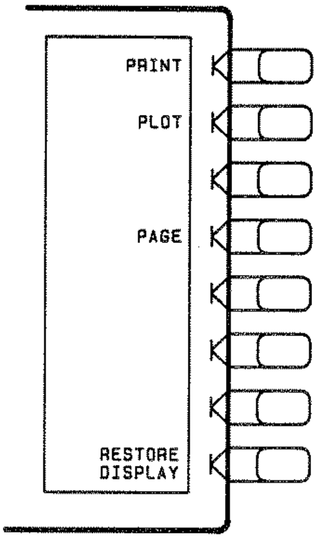


Figure 9-6. Screen Menu

[PRINT] (PRINALL) copies one page of the tabular listings to a compatible HP graphics printer connected to the HP 8753B over HP-IB.

[PLOT] (PLOT) makes a hard copy plot of one page of the tabular listing on the CRT, using a compatible HP plotter connected to the HP 8753B through HP-IB. This method is appropriate when speed of output is not a critical factor.

[PAGE] (NEXP) displays the next page of information in a tabular listing onto the CRT.

[RESTORE DISPLAY] (RESD) turns off the tabular listing and returns the measurement display to the screen.

Chapter 10. Saving Instrument States

INTRODUCTION

The HP 8753B has the capability of saving complete instrument states for later retrieval. It has five internal registers for this purpose, and can use direct disc access as an extension to internal memory. This chapter discusses instrument state definition, memory allocation, and internal and external memory storage. Refer to the *Introductory Programming Guide* for information on external disc storage using a computer controller. Refer to Chapter 13 for information on saving and recalling keystroke sequences.

TYPES OF MEMORY

The HP 8753B can utilize three types of memory to store instrument states:

- **Volatile Memory.** This is dynamic read/write memory, containing the current instrument state, calibration sets, and the variables listed in Table 2. It is cleared upon power cycle to the instrument and, except as noted, upon instrument preset.
- **Non-Volatile Memory.** This is CMOS read/write memory, providing short term (minimum 72 hour) storage of data when line power to the instrument is turned off.
- **External Memory.** This utilizes disc media for unlimited storage of instrument states, as well as calibration and measurement data.

Table 1 lists the information that is or can be stored in each type of memory.

Table 1. HP 8753B Memory Usage

Volatile Memory (see Table 2)
User graphics (16 Kbytes)
Calibration data
Current instrument state
Data processing and display
5 keystroke sequences
Non-Volatile Memory
Five learn string registers
CRT focus and intensity defaults
HP-IB configuration
User calibration kit definition
Power sensor cal factor and loss tables
External Memory
Instrument states
Calibration sets
Measurement data

INSTRUMENT STATES

An instrument state consists of all the stimulus and response parameters that set up the HP 8753B to make a specific measurement. This part of the instrument state is called the learn string and, when saved, is saved to non-volatile memory. (Power sensor cal factor and loss tables are independent of the instrument state, although they are also stored in non-volatile memory.)

The learn string is an encoded array containing only the data needed to re-create the state. For example, to re-create a frequency list the HP 8753B only needs to save the start frequency, frequency span, and number of points in each seqment. Each point is not recorded. Thus the size of the learn string is not proportional to the number of points in the sweep.

An instrument state also includes calibration data and memory traces, which do vary in size with the number of points.

NOTE: Calibration data and memory traces are stored in *volatile* memory. While this data will survive an instrument preset if it has been saved, it is *lost* when line power to the instrument is turned off.

MEMORY REQUIREMENTS

Because instrument states can be of varying complexities, it is possible to fill the available internal memory with less than five states. Also, it is possible to fill memory with instrument states and prevent such memory-intensive functions as two-port error correction, interpolated error correction, 1601 measurement points, or time domain (option 010).

Calibration sets compete with other instrument processes for volatile memory space. Table 2 contains the memory requirements of calibration arrays and other functions such as list frequency mode and limit testing. As you turn on more functions, it is very likely that more memory space is being used. Use Table 2 to approximate available space. Following Table 2, examples are given of different instrument states and their memory requirements.

Table 2. HP 8753B User Allocatable Memory (≅960 Kbytes Total) (1 of 2)

Variable	Data Length (Bytes)	Approximate Total (Bytes)			
		401 pts	801 pts	1601 pts	
		1 chan		1 chan	2 chans
Calibration Arrays					
Response	N x 6 +52	2.5k	5k	10k	19k
Response and Isolation	N x 6 x 2 +52	5k	10k	19k	38k
1-Port	N x 6 x 3 +52	7k	14k	29k	58k
2-Port	N x 6 x 12 +52	29k	58k	115k	230k
Interpolated Cal	Same as above in addition to regular cal				
Power Meter Cal[1]	N x 2 +208	1k	1.8k	3.4k	6.6k
Measurement Data					
Raw Data[1]	N x 6 +52	2.5k	4.9k	9.7k	19k
Plus 2-Port Cal	N x 6 x 3 +52	7.3k	14.5k	29k	58k
Data Array[1]	N x 6 +52	2.5k	4.9k	9.7k	19k
Formatted Array[1]	N x 6 +52	2.5k	4.9k	9.7k	19k
Memory Array[1]	N x 6 +52	2.5k	4.9k	9.7k	19k
Scratchpad Array[2]	N x 6 +52	2.5k	4.9k	9.7k	19k

Table 2. HP 8753B User Allocatable Memory (≅960 Kbytes Total) (2 of 2)

Variable	Data Length (Bytes)	Approximate Total (Bytes)			
		401 pts	801 pts	1601 pts	
		1 chan		1 chan	2 chans
Display Memory[1]					
Trace (data or memory)	N x 2	0.8k	1.6k	3.2k	6.4k
In polar format, log frequency, or frequency list mode	N x 4	1.6k	3.2k	6.4k	12.8k
Graticule					
Rectangular	196	0.2k	0.2k	0.2k	0.4k
Semilog	420	0.4k	0.4k	0.4k	0.8k
Polar	1956	2k	2k	2k	4k
Smith/Inverted Smith	4000	4k	4k	4k	8k
Limit Lines[1]	32 x number of segments (max 18 per chan)	0.6k	0.6k	0.6k	1.1k
Operating Modes					
Sampler Correction Arrays[1]	N x 2	0.8k	1.6k	3.2k	6.4k
With 2-Port Cal	N x 4	1.6k	3.2k	6.4k	12.8k
In Frequency List Mode	N x 4	1.6k	3.2k	6.4k	12.8k
Freq List + 2-Port	N x 4 x 2	3.2k	6.4k	12.8k	25.6k
Frequency List Mode[1]	N x 12	4.8k	9.6k	19k	38k
Log Frequency Mode[1]	N x 12	4.8k	9.6k	19k	38k
Smoothing on[1] (20% aperture, 1601 points)	2000	2k	4k	2k	4k
Print/Plot Buffer[3] (in addition to trace, graticule, limit lines, etc.)		1k	1k	1k	1k
Sequencing (5 of 2 Kbytes each)		10k	10k	10k	10k
Time Domain					
FFT Array					
≤51 points	128 x 6 = 0.8k				
101 points	256 x 6 = 1.5k				
201 points	512 x 6 = 3k				
401 points	1024 x 6	6k			
801 points	2048 x 6		12.3k		
1601 points	2048 x 6			12.3k	24.6k
Window & Chirp Array	N x 4 +FFT array	6.4k	13k	18k	37k
Gating Array	≅5/3 x FFT array	8k	16k	20k	41k

Notes:

N = number of points

1. This variable is allocated once per active channel.
2. Insufficent memory for allocation of this array is not fatal. The array is used to recalculate the data for display any time formatting factors are changed. If sufficient memory is not allocated, trace data will not be redisplayed after a scaling change until a new sweep occurs.
3. Insufficient memory for allocation of this array is not fatal, but instrument operation cannot be continued while printing or plotting is in progress.

Memory Allocation Examples

The following examples show the basic memory requirements of various memory-intensive instrument states, and the extra memory needed as features are added. These examples assume that no other instrument states or calibration sets are saved.

	Total (Bytes)
• 401 points, 2 channels, full 2-port cal, no interpolated cal, no time domain, no list mode, no memory arrays	93k
add memory trace	100k
add interpolated cal	158k
add time domain, with windowing and gating	199k
add frequency list mode	215k
• 401 points, 1 channel, full 2-port interpolated cal with original cal arrays at 1601 points, no time domain, no list mode, no memory arrays	159k
add memory trace	162k
add frequency list mode	169k
add time domain, with windowing and gating	189k
all of the above on both channels	378k
• 801 points, 1 channel, full 2-port cal, no interpolated cal, no time domain, no list mode, no memory arrays	93k
add memory trace	100k
add interpolated cal	158k
add time domain, with windowing and gating	199k
add frequency list mode	212k
all of the above on both channels	418k
• 1601 points, 1 channel, full 2-port cal, no interpolated cal, no time domain, no list mode, no memory arrays	183k
add memory trace	196k
add interpolated cal	311k
add time domain, with windowing and gating	361k
add list mode	387k
all of the above on both channels	773k

INTERNAL SAVE

A maximum of six instrument states can reside in internal memory at any one time: five saved states and the active instrument state. Up to 12 calibrations can exist if they are saved at the end of the calibration procedure (the actual number may be limited by available memory). Remember, however, that calibrations are lost when instrument power is turned off.

Calibration sets are linked to the instrument state and measurement parameter for which the calibration was done. Therefore a saved calibration can be used for multiple instrument states as long as the measurement parameter, frequency range, and number of points are the same. A full 2-port calibration is valid for any S-parameter measurement with the same frequency range and number of points. When an instrument state is deleted from memory (see *[CLEAR REGISTER]*), the associated calibration set is also deleted.

If a measurement is saved with calibration and interpolated calibration on, it will be restored with interpolated calibration on.

EXTERNAL STORE

When the HP 8753B is in system controller mode or pass control mode, it can access an external CS80 disc drive such as the HP 9122. Storing to disc records not only the instrument state, but also calibration sets and measurement data (see *[DEFINE STORE]*).

The HP 8753B uses one file name per stored instrument state when communicating with the user via the front panel display. In reality, several files are actually stored to the disc when an instrument state is stored. Thus, when the disc catalog is accessed from a remote system controller, the directory will show several files associated with a particular saved state. The maximum number of files that can be stored on a disc depends on the directory size: the default is 256. Refer to the *Introductory Programming Guide* for further information.

A disc file created by the HP 8753B appends a suffix to the file name. (This is used by an external controller for cataloguing files, and is not visible to a local user.) The suffix consists of one or two characters: the first character is the file type and the second is a data index. The *Quick Reference Guide* includes a list of the characters used in file name suffixes, and their meanings.

If correction is on at the time of an external store, the calibration set is stored to disc. (Note that inactive calibrations are not stored to disc.) When an instrument state is loaded into the HP 8753B from disc, the learn string is restored first. If correction is on for the loaded state, the HP 8753B will load a calibration set from disc that carries the same title as the one stored for the instrument state.

If an instrument state is stored with interpolated calibration on, the restored instrument state will be interpolated.

NOTE: A calibration stored from one instrument and recalled by a different one will be invalid. To ensure maximum accuracy, always recalibrate in these circumstances.

NOTE: No record is kept in memory of the temperature when a calibration set was stored. Instrument characteristics change as a function of temperature, and a calibration stored at one temperature may be inaccurate if recalled and used at a different temperature. Refer to the *Specifications* tables in the *General Information* section for allowable temperature ranges for individual specifications.

NOTE: HP 8753B and 8753A instrument states are not compatible, therefore discs stored by one cannot be used by the other.

[SAVE] AND [RECALL] KEYS

The **[SAVE]** key provides access to all the menus used for saving instrument states in internal memory and for storing to exernal disc. This includes the menus used to define titles for internal registers and external disc files, to define the content of disc files, to initialize discs for storage, and to clear data from the registers or purge files from disc.

The **[RECALL]** key leads to the menus that recall the contents of internal registers, or load files from external disc back into the HP 8753B.

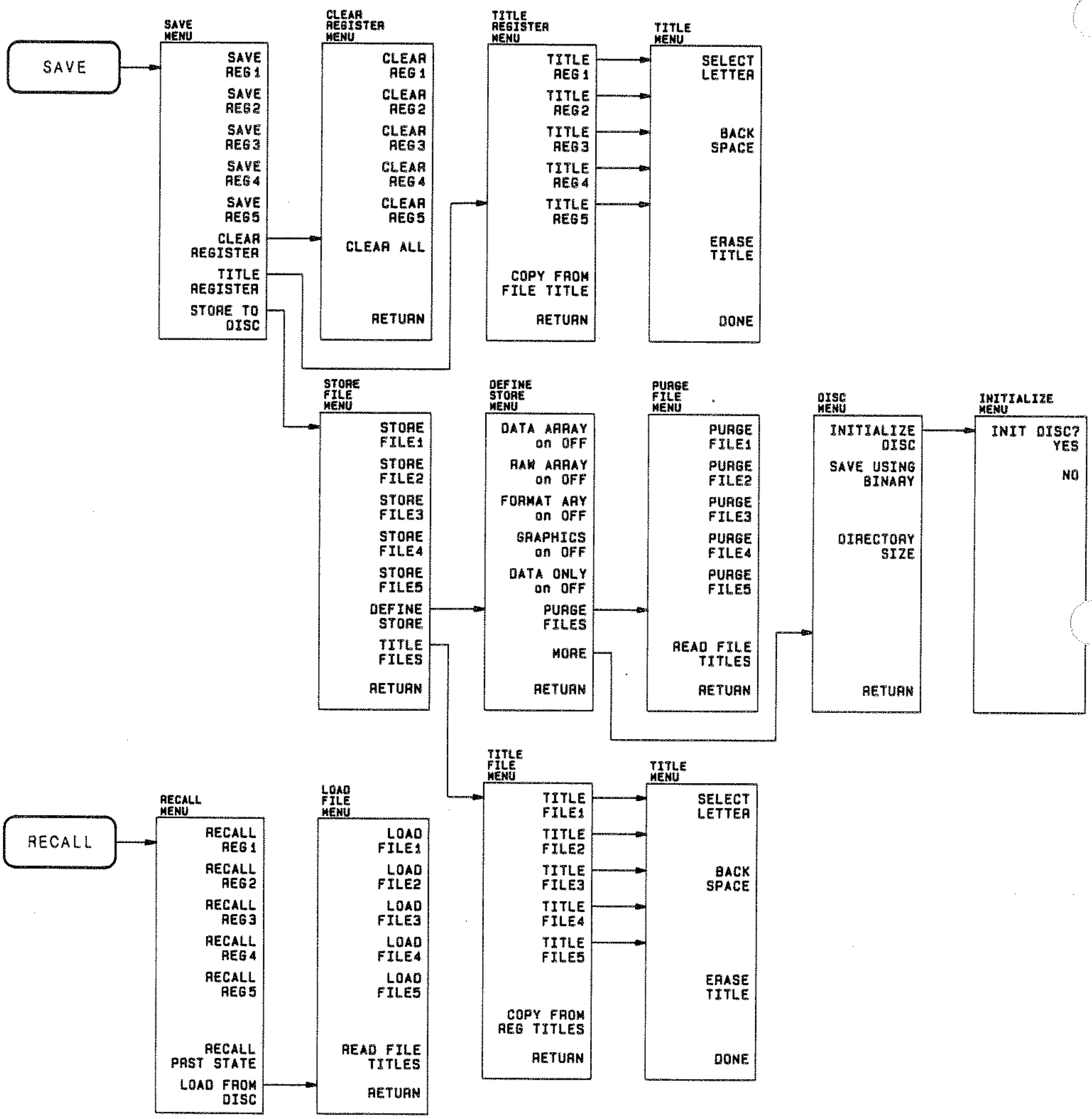


Figure 10-1. Softkey Menus Accessed from the [SAVE] and [RECALL] Keys

Save Menu

This menu (Figure 10-2) selects an internal memory register to store the current instrument state. If a register contains a previously saved instrument state, the softkey label changes to ***[RESAVE]***. This is intended to prevent inadvertent destruction of saved states. Pressing ***[RESAVE]*** removes the contents of the register and saves the new instrument state.

This also leads to the series of menus for external disc storage.

The default titles for the save registers are REG1 through REG5, but these titles can be modified using the title register menu and the title menu.

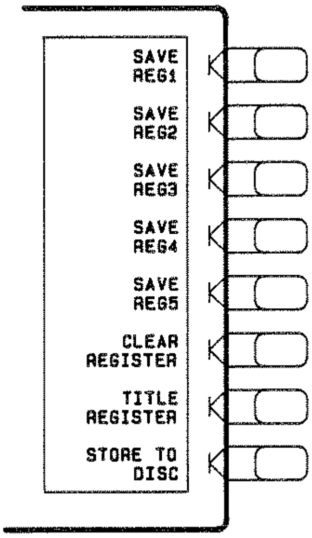


Figure 10-2. Save Menu

[SAVE REG1] (SAVE1) saves the present instrument state in an internal register titled REG1.

[SAVE REG2] (SAVE2) saves the present instrument state in internal register REG2.

[SAVE REG3] (SAVE3) saves the present instrument state in internal register REG3.

[SAVE REG4] (SAVE4) saves the present instrument state in internal register REG4.

[SAVE REG5] (SAVE5) saves the present instrument state in internal register REG5.

[CLEAR REGISTER] leads to the clear register menu, described on the next page.

[TITLE REGISTER] leads to the title register menu, where the default register titles can be modified.

[STORE TO DISC] leads to the store file menu, which introduces a series of menus for disc storage.

Clear Register Menu

This menu (Figure 10-3) allows unused instrument states to be cleared from save registers, making the assigned memory available for other uses. When an instrument state is deleted from memory, the associated calibration set is also deleted. You can choose to selectively clear individual registers, or clear all registers with one keystroke.

Clearing of registers is performed internally with 100 alternating 0 and 1 rewrite operations over the entire non-volatile portion of the specified register memory.

Only registers that have instrument states previously stored in them are listed in this menu.

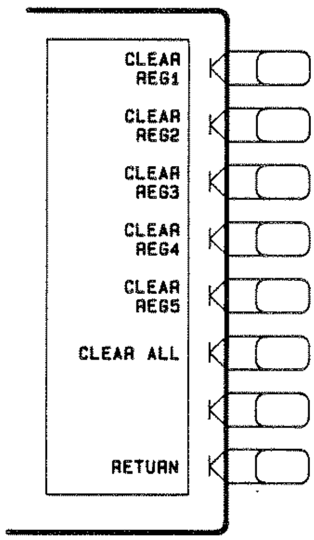


Figure 10-3. Clear Register Menu

[CLEAR REG1] (CLEA1) clears a previously saved instrument state from register 1.

[CLEAR REG2] (CLEA2) clears a saved instrument state from register 2.

[CLEAR REG3] (CLEA3) clears a saved instrument state from register 3.

[CLEAR REG4] (CLEA4) clears a saved instrument state from register 4.

[CLEAR REG5] (CLEA5) clears a saved instrument state from register 5.

[CLEAR ALL] (CLEARALL) clears all instrument states.

[RETURN] goes back to the save menu.

Title Register Menu

This menu can be used to select a register to be retitled. All registers are listed, regardless of whether or not they contain saved instrument states. When any of the title register softkeys is pressed, the title menu is presented and the character set is displayed in the active entry area.

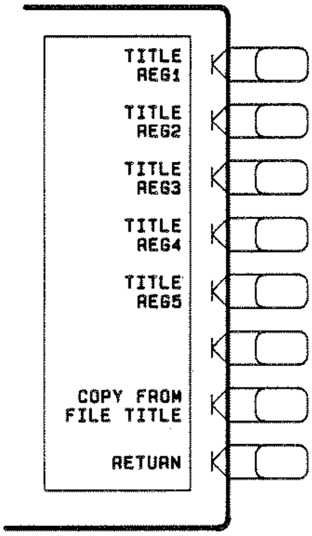


Figure 10-4. Title Register Menu

[TITLE REG1] (TITR1) selects register 1 to be retitled and presents the title menu and the character set.

[TITLE REG2] (TITR2) selects register 2 to be retitled.

[TITLE REG3] (TITR3) selects register 3 to be retitled.

[TITLE REG4] (TITR4) selects register 4 to be retitled.

[TITLE REG5] (TITR5) selects register 5 to be retitled.

[COPY FROM FILE TITLE] (COPYFRFT) renames the internal registers to match the current names of the store files. For example, the default names of the internal registers are REG1 through REG5. The default names of the store files are FILE1 through FILE5. Pressing this key would rename the internal registers FILE1 through FILE5. If you have modified the names of the store files, the modified names would be copied as the internal save register names.

[RETURN] goes back to the save menu.

Title Menu

Use this menu (Figure 10-5) to define a title for the register selected in the title register menu. The title replaces the default register title in the softkey label, and is recalled with the saved instrument state.

The register title is limited to eight characters. If more than eight characters are selected, the last character is repeatedly written over. The title must be all alpha-numeric, and must start with an alpha character. If the first character selected is not an alpha character, the message "CAUTION: FIRST CHARACTER MUST BE A LETTER" is displayed when the ***[DONE]*** key is pressed. No special characters or spaces are allowed. If a disallowed character is selected, the message "CAUTION: ONLY LETTERS & NUMBERS ARE ALLOWED" is displayed. (The special characters are used only for the display title, described in Chapter 4.)

The save register title is independent of the display title, which is also saved and recalled as part of the display.

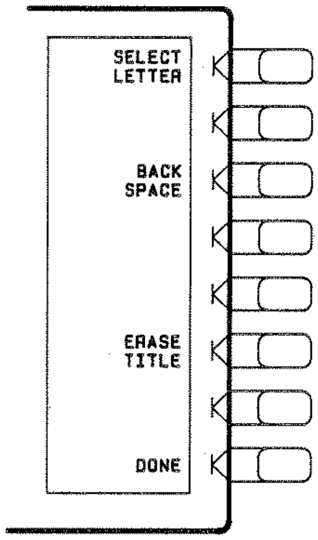


Figure 10-5. Title Menu

[SELECT LETTER]. The active entry area displays the letters of the alphabet, digits 0 through 9, and mathematical symbols. The mathematical symbols are not used in register titles. To define a title, rotate the knob until the arrow ↑ points at the first letter, then press ***[SELECT LETTER]***. Repeat this until the complete title is defined, for a maximum of eight characters. As each character is selected, it is appended to the title at the top left corner of the graticule.

[BACK SPACE] deletes the last character entered.

[ERASE TITLE] deletes the entire register title.

[DONE] terminates the title entry, and returns to the title register menu. The new title appears in the softkey label in all applicable menus.

Store File Menu

This menu (Figure 10-6) is used to store instrument states to an external disc rather than to internal memory registers. The HP 8753B can use HP-IB to store directly to a compatible disc drive, without the use of an external controller. Refer to the *General Information* section of this manual for information about compatible disc drives. Refer to the first part of this chapter for information about disc storage.

To store information on an external disc from the front panel when there is no other controller on the bus, the HP 8753B must be in system controller HP-IB mode. To take control from the computer and initiate a store operation, the HP 8753B must be in pass control mode. If it is not in one of these modes, the message "SYST CTRL OR PASS CTRL IN LOCAL MENU" is displayed. Refer to *[LOCAL] Key* in Chapter 7 for information on HP-IB controller modes and setting addresses.

If you attempt to store a file and the message "CAUTION: DISC: not on, not connected, wrong addrs" is displayed, check the disc drive line power and HP-IB cable connection. Also make sure that the HP-IB address of the disc drive matches the address set in the address menu (see Chapter 7).

The HP 8753B uses one file name per instrument state for communicating with the user via the front panel display. In reality, several files might actually be stored to the disc when an instrument state is saved, depending on the functions being saved. This does not affect operation from the front panel. The default names for the stored files are FILE1 through FILE5. These file names can be modified using the title file menu.

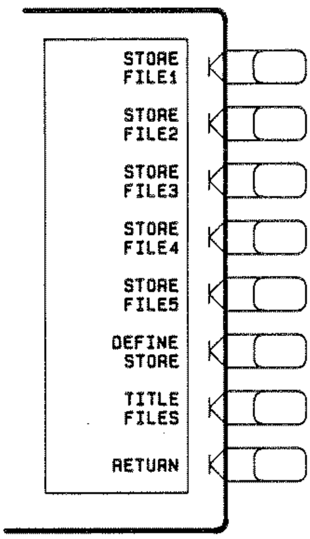


Figure 10-6. Store File Menu

[STORE FILE1] (STOR1) stores the current instrument state in disc file 1, together with any data specified in the define store menu (see next page).

[STORE FILE2] (STOR2) stores the current instrument state and specified data in file 2.

[STORE FILE3] (STOR3) stores the current instrument state and specified data in file 3.

[STORE FILE4] (STOR4) stores the current instrument state and specified data in file 4.

[STORE FILE5] (STOR5) stores the current instrument state and specified data in file 5.

[DEFINE STORE] leads to the define store menu. Use this menu to specify the data to be stored on disc in addition to the instrument state.

[TITLE FILES] leads to the title file menu, where the default file titles can be modified.

[RETURN] goes back to the save menu.

Define Store Menu

Data and user graphics can be stored on disc along with the basic instrument state. The data can be stored from different points in the data processing flow. It is possible to store raw, error-corrected, or formatted data, or any combination of the three. This menu allows the option of specifying what data is to be stored. Refer to *Data Processing Flow* in Chapter 1 for more information about data arrays and the sequence of data processing events.

If a memory trace exists and is displayed, either alone or in a memory math function, it is automatically stored with the data.

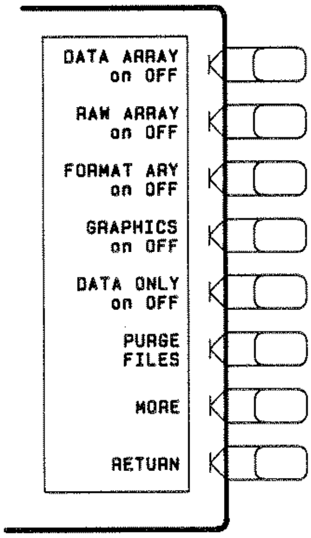


Figure 10-7. Define Store Menu

[DATA ARRAY on OFF] (EXTMDATAON, EXTMDATAOFF) specifies whether or not to store the error-corrected data on disc with the instrument state.

[RAW ARRAY on OFF] (EXTMRAWON, EXTMRAWOFF) specifies whether or not to store the raw data (ratioed and averaged) on disc with the instrument state.

[FORMAT ARY on OFF] (EXTMFORMON, EXTMFORMOFF) specifies whether or not to store the formatted data on disc with the instrument state.

[GRAPHICS on OFF] (EXTMGRAPON, EXTMGRAPOFF) specifies whether or not to store display graphics on disc with the instrument state.

[DATA ONLY on OFF] stores only the measurement data of the device under test. The instrument state and calibration are not stored. This is faster than storing with the instrument state, and uses less disc space. It is intended for use in archiving data that will later be used with an external controller, and cannot be read back by the HP 8753B.

[PURGE FILES] leads to the purge files menu, which is used to remove the information stored on an external disc.

[MORE] leads to the disc menu, where additional parameters are defined for storing to disc. This in turn leads to the initialize menu.

[RETURN] goes back to the store file menu.

Purge File Menu

This menu is used to remove (purge) stored information from a disc. When the purge file menu is entered, the file titles currently in HP 8753B memory are displayed. (File titles are stored in non-volatile memory.) These titles may or may not reside on the disc currently being used. The file titles can be updated to match the files on disc by reading the disc's directory with the *[READ FILE TITLES]* key.

The purge file menu is the external storage equivalent of the clear register menu.

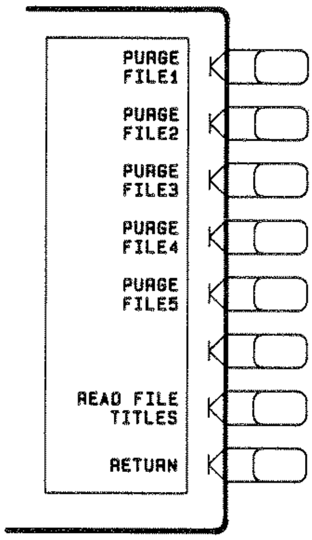


Figure 10-8. Purge File Menu

[PURGE FILE1] (PURG1) purges FILE1 from the disc. If no file of that name exists on the disc, the message "CAUTION: NO FILE(S) FOUND ON DISC" will appear.

[PURGE FILE2] (PURG2) purges FILE2 from the disc.

[PURGE FILE3] (PURG3) purges FILE3 from the disc.

[PURGE FILE4] (PURG4) purges FILE4 from the disc.

[PURGE FILE5] (PURG5) purges FILE5 from the disc.

[READ FILE TITLES] (REFT) searches the directory of the disc for file names recognized as belonging to an instrument state, and displays them in the softkey labels. No more than five titles are displayed at one time. If there are more than five, repeatedly pressing this key causes the next five to be displayed. If there are fewer than five, the remaining softkey labels are blanked.

[RETURN] goes back to the define store menu.

Disc Menu

This menu provides additional parameters for defining disc storage.

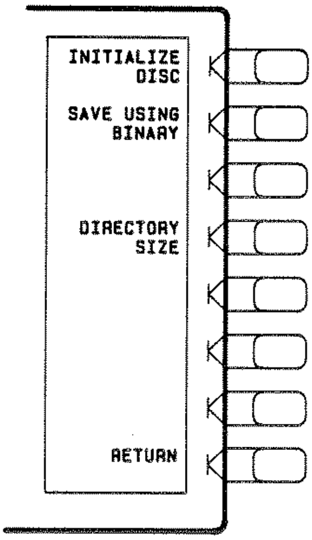


Figure 10-9. Disc Menu

[INITIALIZE DISC] leads to the initialize menu. Before data can be stored on a disc, the disc must be initialized for format compatibility. (This is *disc* format: the *data* format is binary, as explained below.) If you attempt to store without initializing the disc, the message "CAUTION: DISC MEDIUM NOT INITIALIZED" is displayed.

[SAVE USING BINARY] stores the instrument state and data in binary format. This is presently the appropriate data format for all file storage. (This softkey is for information only.)

If a disc was formatted with another operating system such as UNIX or MS-DOS, the HP 8753B will not read from it nor write to it, nor alter it in any way. If a store operation is attempted with such a disc, the message "WRONG DISC FORMAT, INITIALIZE DISC" is displayed.

[DIRECTORY SIZE] lets you specify the number of directory files to be initialized on a disc. This is particularly useful with a hard disc, where you may want a directory larger than the default 256 files. Or with a floppy disc you may want to reduce the directory to allow extra space for data files. The number of directory files must be a multiple of 8. The minimum number is 8, and there is no practical maximum limit. Set the directory size before initializing a disc.

[RETURN] goes back to the define store menu.

Initialize Menu

Initializing a disc prepares it to store data. A disc must be initialized for format compatibility before it can be used for storage. (This is *disc* format: the *data* format is binary, as explained above.) This menu initializes discs using LIF (logical interchange format) to provide compatibility with HP 9000 series 200/300 computers. A disc initialized on one of these computers will work with the HP 8753B. The recommended interleave factor is 7. Either the Hewlett-Packard black or gray double-sided discs can be used with the HP 9122 disc drive: if high transfer speed is a consideration, gray is recommended. Refer to the *General Information and Specifications* section for information about discs.

Initializing a disc removes all existing data. When this menu is presented, the message "INIT DISC removes all data from disc" is displayed. If other error messages are encountered, refer to Chapter 12, *Error Messages*, for help.

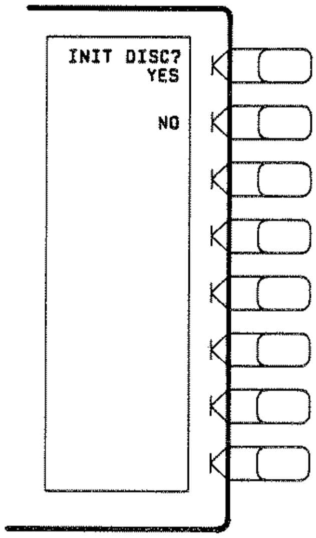


Figure 10-10. Initialize Menu

[INIT DISC? YES] initializes the disc unit number and volume number selected in the HP-IB menu (see Chapter 7), then returns to the disc menu. If more than one hard disc volume is to be initialized, each volume must be selected and initialized individually.

During the initialization process, the message "WAITING FOR DISC" is displayed: this is normal. If the disc is damaged, the message "INITIALIZATION FAILED" is displayed.

[NO] leaves this menu without initializing the disc, and returns to the disc menu.

Title File Menu

This menu (Figure 10-11) is used to select a disc file to be retitled. When the softkey for the selected file is pressed, the title menu is presented and the character set is displayed in the active entry area. The title menu is described earlier in this chapter. The same restrictions apply to file titles as to internal register titles: that is, a file title is limited to eight characters, must be all alpha-numeric, and must begin with an alpha character.

A file title defined with the title menu replaces the default file title in the softkey label, and is stored to disc with the corresponding file.

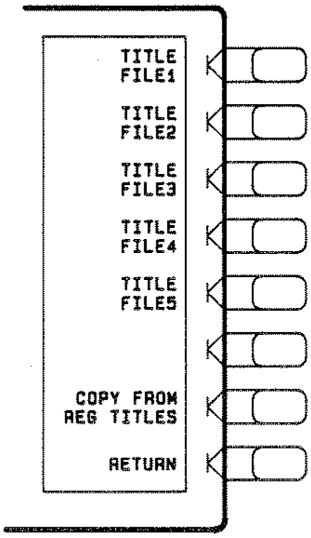


Figure 10-11. Title File Menu

[TITLE FILE1] (TITF1) selects file 1 to be retitled, and leads to the title menu.

[TITLE FILE2] (TITF2) selects file 2 to be retitled.

[TITLE FILE3] (TITF3) selects file 3 to be retitled.

[TITLE FILE4] (TITF4) selects file 4 to be retitled.

[TITLE FILE5] (TITF5) selects file 5 to be retitled.

[COPY FROM REG TITLES] renames the store files to match the current names of the internal registers. (It does not alter the names of any files already stored to disc). For example, the default names of the internal registers are REG1 through REG5. The default file names of the store files are FILE1 through FILE5. Pressing this key would rename the store files REG1 through REG5. If you have modified the names of the internal save registers, the modified names are copied as the store file names.

[RETURN] goes back to the store file menu.

Recall Menu

This menu is used to recall instrument states from internal memory. It is also used to access the load file menu, which loads files from external disc.

When the recall menu is displayed, only the names of registers containing instrument states are displayed in the top five softkey labels. Any register that does not currently contain a saved instrument state has its softkey label blanked.

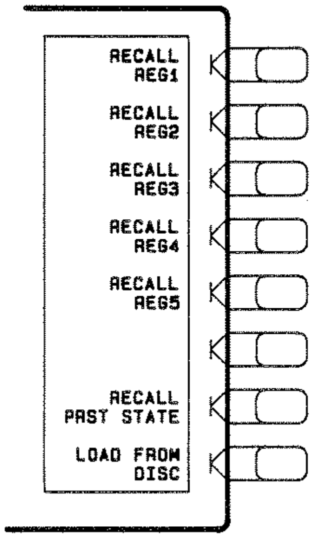


Figure 10-12. Recall Menu

[RECALL REG1] (RECA1) recalls the instrument state saved in register 1. The current instrument state is overwritten.

[RECALL REG2] (RECA2) recalls the instrument state saved in register 2.

[RECALL REG3] (RECA3) recalls the instrument state saved in register 3.

[RECALL REG4] (RECA4) recalls the instrument state saved in register 4.

[RECALL REG5] (RECA5) recalls the instrument state saved in register 5.

[RECALL PRST STATE] is used in conjunction with sequencing, to return the instrument to the known preset state without turning off the sequencing function. This is not the same as pressing the **[PRESET]** key: no preset tests are run, and the HP-IB and sequencing activities are not changed.

[LOAD FROM DISC] accesses the load file menu. Use this menu to restore instrument states previously stored to disc.

Load File Menu

This menu (Figure 10-13) is used to search the directory of a disc and restore previously stored instrument state files.

There are three ways to locate a file on disc.

1. The HP 8753B remembers the names of the last five files it previously found on any disc. (File titles are stored in non-volatile memory.) Therefore, when you enter this menu, the file titles in memory will appear in the top five softkeys, whether or not they reside on the disc currently in the drive.
2. The ***[READ FILE TITLES]*** key in this menu causes the HP 8753B to search the directory of the current disc and display any file titles recognized as compatible.
3. From the store file menu, use the ***[TITLE FILES]*** key to title a store file softkey with the name of the file you want to restore. Return to the load file menu. The title you just created will appear in one of the load file softkey labels. Press that softkey. If the file does not exist, the message "CAUTION: NO FILE(S) FOUND ON DISC" will be displayed. This method is useful only if you know the exact name of the instrument state to be restored. Using ***[READ FILE TITLES]*** is a more efficient method of finding file names, unless a large number of instrument states has been stored to the disc.

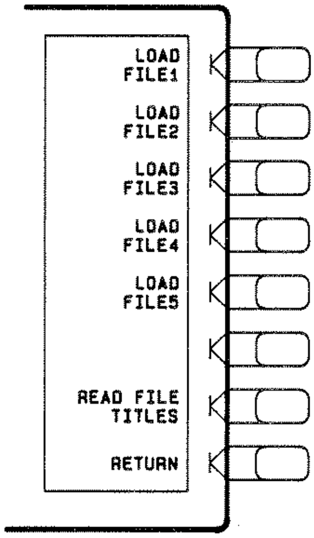


Figure 10-13. Load File Menu

[LOAD FILE1] (LOAD1) restores the instrument state contained in FILE1. The current instrument state is overwritten.

[LOAD FILE2] (LOAD2) restores the instrument state contained in FILE2.

[LOAD FILE3] (LOAD3) restores the instrument state contained in FILE3.

[LOAD FILE4] (LOAD4) restores the instrument state contained in FILE4.

[LOAD FILE5] (LOAD5) restores the instrument state contained in FILE5.

[READ FILE TITLES] (REFT) searches the directory of the disc for file names recognized as belonging to an instrument state. No more than five titles are displayed at one time. If there are more than five, repeatedly pressing this key causes the next five to be displayed. If there are fewer than five, the remaining softkey labels are blanked.

[RETURN] goes back to the recall menu.

Chapter 11. HP-IB Remote Programming

CHAPTER CONTENTS

INTRODUCTION

The HP 8753B is factory-equipped with a remote programming digital interface using the Hewlett-Packard Interface Bus (HP-IB). (HP-IB is Hewlett-Packard's hardware, software, documentation, and support for IEEE 488.1 and IEC-625, worldwide standards for interfacing instruments.) This allows the HP 8753B to be controlled by an external computer that sends commands or instructions to and receives data from the HP 8753B using the HP-IB. In this way, a remote operator has the same control of the instrument available to a local operator from the front panel, except for control of the line power switch.

In addition, the HP 8753B itself can use HP-IB to directly control compatible peripherals, without the use of an external controller. It can output measurement results directly to a compatible printer or plotter, or store instrument states to a compatible disc drive.

This chapter provides an overview of HP-IB operation. Chapter 7 provides information on different controller modes, and on setting up the HP 8753B as a controller of peripherals. Chapters 9 and 10 explain how to use the HP 8753B as a controller to print, plot, and store to an external disc. In addition, HP-IB equivalent mnemonics for front panel functions are provided in parentheses throughout this *Operating and Programming Reference.*

More complete information on programming the HP 8753B remotely over HP-IB is provided in the following documents:

- *Introductory Programming Guide for the HP 8753B Using Series 200/300 Computers*. This is a tutorial introduction to remote operation of the HP 8753B network analyzer using an HP 9000 series 200 or 300 computer. It includes examples of remote measurements using BASIC programming. These examples are also stored on the example programs disc provided with the HP 8753B. The *Introductory Programming Guide* assumes familiarity with front panel operation of the instrument.

- *HP 8753B Quick Reference Guide.* This is a complete reference summary for remote operation of the HP 8753B with a controller. It includes both functional and alphabetical lists of all HP 8753B HP-IB commands. This guide is intended for use by those familiar with HP-IB programming and the basic functions of the HP 8753B.
- *Network Analyzer Compatibility Guide.* This document is designed for use as a reference when information is required regarding HP-IB compatibility between network analyzers in the HP 8510 and 8700 series. Commands are listed for the HP 8510, 8753A, and 8720A network analyzers and the HP 8702A lightwave component analyzer. Future revisions will include HP-IB commands specific to the HP 8753B.

A complete general description of the HP-IB is available in *Tutorial Description of the Hewlett-Packard Interface Bus*, HP publication 5952-0156. For more information on the IEEE-488.1 standard refer to *IEEE Standard Digital Interface for Programmable Instrumentation*, published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

HOW HP-IB WORKS

The HP-IB uses a party-line bus structure in which up to 15 devices can be connected on one contiguous bus. The interface consists of 16 signal lines and 8 ground lines in a shielded cable. With this cabling system, many different types of devices including instruments, computers, plotters, printers, and disc drives can be connected in parallel.

Every HP-IB device must be capable of performing one or more of the following interface functions:

Talker

A talker is a device capable of sending device-dependent data when addressed to talk. There can be only one talker at any given time. Examples of this type of device are voltmeters, counters, and tape readers. The HP 8753B is a talker when it sends trace data or marker information over the bus.

Listener

A listener is a device capable of receiving device-dependent data when addressed to listen. There can be any number of listeners at any given time. Examples of this type of device are printers, power supplies, and signal generators. The HP 8753B is a listener when it is controlled over the bus by a computer.

Controller

A controller is a device capable of managing the operation of the bus and addressing talkers and listeners. There can be only one active controller at any time. Examples of controllers include desktop computers and minicomputers. In a multiple-controller system, active control can be passed between controllers, but there can only be one *system controller*, which acts as the master, and can regain active control at any time. The HP 8753B is an active controller when it plots, prints, or stores to an external disc drive in the pass control mode. The HP 8753B is a system controller when it is in the system controller mode. These modes are discussed in more detail in Chapter 7 under *HP-IB Menu*.

HP-IB BUS STRUCTURE

Data Bus

The data bus consists of eight bidirectional lines that are used to transfer data from one device to another. Programming commands and data are typically encoded on these lines in ASCII, although binary encoding is often used to speed up the transfer of large arrays. Both ASCII and binary data formats are available to the HP 8753B. In addition, every byte transferred over HP-IB undergoes a *handshake* to ensure valid data.

Handshake Lines

A three-line handshake scheme coordinates the transfer of data between talkers and listeners. This technique forces data transfers to occur at the speed of the slowest device, and ensures data integrity in multiple listener transfers. With most computing controllers and instruments, the handshake is performed automatically, which makes it transparent to the programmer.

Control Lines

The data bus also has five control lines that the controller uses both to send bus commands and to address devices.

IFC. Interface Clear. Only the system controller uses this line. When this line is true (low), all devices (addressed or not) unaddress and go to an idle state.

ATN. Attention. The active controller uses this line to define whether the information on the data bus is a *command* or is *data*. When this line is true (low), the bus is in the command mode and the data lines carry bus commands. When this line is false (high), the bus is in the data mode and the data lines carry device-dependent instructions or data.

SRQ. Service Request. This line is set true (low) when a device requests service: the active controller services the requesting device. The HP 8753B can be enabled to pull the SRQ line for a variety of reasons.

REN. Remote Enable. Only the system controller uses this line. When this line is set true (low), the bus is in the remote mode, and devices are addressed either to listen or to talk. When the bus is in remote and a device is addressed, it receives instructions from HP-IB rather than from its front panel (the **[LOCAL]** key returns the device to front panel operation). When this line is set false (high), the bus and all devices return to local operation.

EOI. End or Identify. This line is used by a talker to indicate the last data byte in a multiple byte transmission, or by an active controller to initiate a parallel poll sequence. The HP 8753B recognizes the EOI line as a terminator, and it pulls the EOI line with the last byte of a message output (data, markers, plots, prints, error messages). The HP 8753B does not respond to parallel poll.

Figure 11-1 illustrates the structure of the HP-IB bus lines.

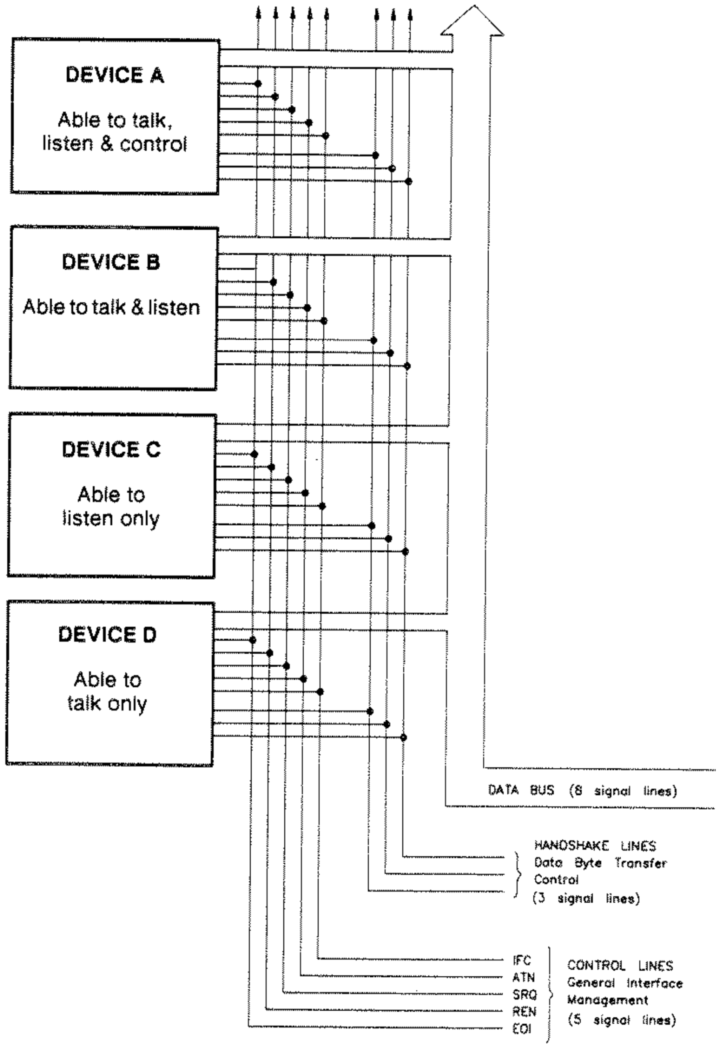


Figure 11-1. HP-IB Structure

HP-IB REQUIREMENTS

Number of Interconnected Devices:	15 maximum.
Interconnection Path/ Maximum Cable Length:	20 metres maximum or 2 metres per device, whichever is less.
Message Transfer Scheme:	Byte serial/ bit parallel asynchronous data transfer using a 3-line handshake system.
Data Rate:	Maximum of 1 megabyte per second over limited distances with tri-state drivers. Actual data rate depends on the transfer rate of the slowest device involved.
Address Capability:	Primary addresses: 31 talk, 31 listen. A maximum of 1 talker and 14 listeners at one time.
Multiple Controller Capability:	In systems with more than one controller (like the HP 8753B system), only one can be active at a time. The active controller can pass control to another controller, but only the system controller can assume unconditional control. Only one system controller is allowed. The system controller is hard-wired to assume bus control after a power failure.

HP 8753B HP-IB CAPABILITIES

As defined by the IEEE 488.1 standard, the HP 8753B has the following capabilities:

SH1	Full source handshake.
AH1	Full acceptor handshake.
T6	Basic talker, answers serial poll, unaddresses if MLA is issued. No talk-only mode.
L4	Basic listener, unaddresses if MTA is issued. No listen-only mode.
SR1	Complete service request (SRQ) capabilities.
RL1	Complete remote/local capability including local lockout.
PP0	Does not respond to parallel poll.
DC1	Complete device clear.
DT1	Responds to a group execute trigger in the hold trigger mode.
C1,C2,C3	System controller capabilities in system controller mode.
C10	Pass control capabilities in pass control mode.
E2	Tri-state drivers.

BUS MODE

The HP 8753B uses a single-bus architecture. The single bus allows both the HP 8753B and the host controller to have complete access to the peripherals in the system.

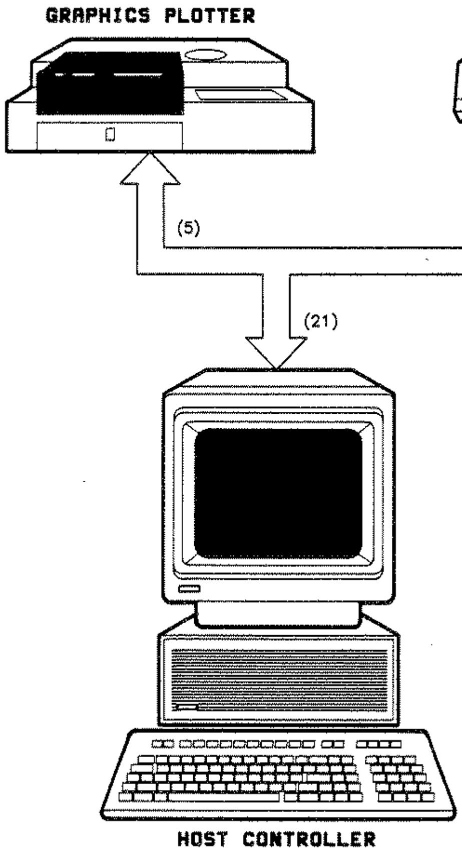


Figure 11-2. HP 8753B Single Bus Concept

Three different controller modes are possible, system controller, talker/listener, and pass control.

System Controller. This mode allows the HP 8753B to control peripherals directly in a stand-alone environment (without an external controller). This mode can only be selected manually from the network analyzer front panel. Use this mode for operation when no computer is connected to the HP 8753B. Do not use this mode for programming.

Talker/Listener. This is the traditional programming mode, in which the computer is involved in all peripheral access operations. Peripheral access (plotting and printing only) is also possible by addressing the HP 8753B to talk, addressing the peripheral to listen, and placing the HP-IB in the data mode.

Pass Control. This mode allows you to control the HP 8753B over HP-IB as with the talker/listener mode, and also allows the HP 8753B to take or pass control in order to plot, print, and access a disc. During the peripheral operation, the host computer is free to perform other internal tasks such as data or display manipulation (the bus is tied up by the analyzer during this time). After a task is completed, the host controller accepts control again when the analyzer returns it.

In general, use the talker/listener mode for programming the HP 8753B unless you desire direct peripheral access. Preset does not affect the selected bus mode, but the bus mode returns talker/listener if power is cycled.

Chapter 7 explains the three different bus modes in detail, and provides information on setting the correct bus mode. Programming information for talker/listener mode and pass control mode is provided in the *Introductory Programming Guide.*

SETTING ADDRESSES

In communications through HP-IB, each instrument on the bus is identified by an HP-IB address. This address code must be different for each instrument on the bus. Refer to *Address Menu* in Chapter 7 for information on default addresses, and on setting and changing addresses. These addresses are stored in short-term non-volatile memory and are not affected when you press **[PRESET]** or cycle the power (although the **[PRESET]** key must be pressed to implement a change to the HP 8753B address).

VALID CHARACTERS

The HP 8753B accepts ASCII letters, numbers, decimal points, +/−, semicolons, quotation marks ("), carriage returns (CR), and linefeeds (LF). Both upper and lower case are acceptable. Leading zeros, spaces, carriage returns, and unnecessary terminators are ignored, except those within a command or appendage. Carriage returns are ignored. An invalid character causes a syntax error. Syntax errors are described in more detail under in the *Introductory Programming Guide.*

HP 8753B CODE NAMING CONVENTION

The HP 8753B HP-IB commands are derived from their front panel key titles (where possible), according to the naming convention below.

Convention	Key Title	For HP-IB Code Use	Example
One Word	Power Start	First Four Letters	POWE STAR
Two Words	Electrical Delay Search Right	First Three Letters of First Word First Letter of Second Word	ELED SEAR
Two Words in a Group	Marker →Center Gate →Span	First Four Letters of Both	MARKCENT GATESPAN
Three Words	Cal Kit N 50Ω Pen Num Data	First Three Letters of First Word First Letter of Second Word First Four Letters of Third Word	CALKN50 PENNDATA

Some codes require appendages (on, off, 1, 2, etc.). Codes that have no front panel equivalent are HP-IB only commands, and use a similar convention based on the common name of the function. Where possible, HP 8753B codes are compatible with HP 8510A/B codes.

Front panel equivalent codes and HP-IB only codes are summarized in the *HP-IB Quick Reference Guide.*

UNITS AND TERMINATORS

The HP 8753B outputs data in basic units and assumes these basic units when it receives an input, unless the input is otherwise qualified. The basic units and allowable expressions follow; either upper or lower case is acceptable.

Basic Units	Allowable Expressions
Seconds	S
Milliseconds	MS
Microseconds	US
Nanoseconds	NS
Picoseconds	PS
Femtoseconds	FS
Hertz	HZ
Kilohertz	KHZ
Megahertz	MHZ
Gigahertz	GHZ
dB or dBm	DB
Volts	V

Terminators are used to indicate the end of a command to allow the HP 8753B to recover to the next command in the event of a syntax error. The semicolon is the recommended command terminator. The line feed (LF) character and the HP-IB EOI line can also be used as terminators. The HP 8753B ignores the carriage return (CR) character.

HP-IB DEBUG MODE

An HP-IB diagnostic feature (debug mode) is available in the HP-IB menu. Activating the debug mode causes the analyzer to scroll incoming HP-IB commands across the display. Nonprintable characters are represented with a π. Any time the HP 8753B receives a syntax error, the commands halt, and a pointer $\wedge$ indicates the misunderstood character. The *Introductory Programming Guide* explains how to clear a syntax error.

CRT GRAPHICS

The HP 8753B CRT can be used as a graphics display for displaying connection diagrams or custom instructions to an operator. The CRT accepts a subset of Hewlett-Packard Graphics Language (HP-GL) commands.

NOTE: The HP 8753B display occupies an additional address on the HP-IB. Determine the CRT bus address by adding 1 to the HP 8753B address if the analyzer address is an even number, or subtracting 1 if it is an odd number. Thus the factory default CRT address for graphics is 17.

Chapter 12. Error Messages

INTRODUCTION

This chapter lists the error messages that may be displayed on the HP 8753B CRT or transmitted by the instrument over HP-IB. Each error message is accompanied by an explanation, and suggestions are provided to help in solving the problem. Where applicable, references are given to related sections of the operating and service manuals.

When displayed, error messages are usually preceded with the word CAUTION:. That part of the error message has been omitted here for the sake of brevity. Some messages are for information only, and do not indicate an error condition. Two listings are provided: the first is in alphabetical order, and the second in numerical order.

In addition to error messages, instrument status is indicated by status notations in the left margin of the CRT. Examples are "*," "tsH," and "P↓." Sometimes these appear in conjunction with error messages. A complete listing of status notations and their meanings is provided in Chapter 2, *Front Panel and Softkey Operation*.

ERROR MESSAGES IN ALPHABETICAL ORDER

(Error numbers are provided in parentheses.)

ADDITIONAL STANDARDS NEEDED (error #68). Error correction for the selected calibration class cannot be computed until all the necessary standards have been measured.

ADDRESSED TO TALK WITH NOTHING TO SAY (error #31). An enter command was sent to the HP 8753B without first requesting data with an appropriate output command (such as OUTPDATA). The HP 8753B has no data in the output queue to satisfy the request.

AIR FLOW RESTRICTED: CHECK FAN FILTER (error #20). An inadequate air flow condition has been detected. Clean the fan filter. For most efficient cooling, the instrument covers should be in place. If the problem persists, troubleshoot the power supply.

AVERAGING INVALID ON NON-RATIO MEASURE (error #13). This error occurs only in single-input measurements. Sweep-to-sweep averaging is valid only for ratioed measurements (A/R, B/R, A/B, and S-parameters). Other noise reduction techniques are available for single input measurements. Refer to *[AVG] Key* in Chapter 4 for a discussion of trace smoothing and variable IF bandwidths.

BLOCK INPUT ERROR (error #34). The HP 8753B did not receive a complete data transmission. This is usually caused by an interruption of the bus transaction. Clear by pressing the **[LOCAL]** key or aborting the IO process at the controller.

BLOCK INPUT LENGTH ERROR (error #35). The length of the header received by the HP 8753B did not agree with the size of the internal array block. Refer to the *Introductory Programming Guide* for instructions on using HP 8753B input commands.

CALIBRATION ABORTED (error #74). The calibration in progress was terminated due to change of the active channel.

CALIBRATION REQUIRED (error #63). A calibration set could not be found that matched the current stimulus state or measurement parameter. Refer to Chapter 5, *Measurement Calibration*. Calibration sets can be saved in internal or external memory. Refer to *[SAVE] Key* in Chapter 10.

CAN'T CHANGE-ANOTHER CONTROLLER ON BUS (error #37). The HP 8753B cannot assume the mode of system controller until the active controller is removed from the bus or relinquishes the bus.

CAN'T STORE/LOAD SEQUENCE, INSUFFICIENT MEMORY (error #127). A sequence transfer to or from an external disc could not be completed because of insufficient memory.

CH1 (CH2) TARGET VALUE NOT FOUND (error #159). The target value for the marker search function does not exist on the current data trace.

CONTINUOUS SWITCHING NOT ALLOWED (error #10). The current measurement requires the S-parameter test set to switch automatically between forward and reverse measurements (driving test port 1, then test port 2). To protect the transfer switch against undue mechanical wear, it will not switch continuously. The "tsH" (test set hold) indicator in the left margin of the display indicates that the inactive channel has been put in the sweep hold mode.

CORRECTION CONSTANTS NOT STORED (error #3). A store operation to the EEPROM was not successful. The position of the jumper on the A9 CPU assembly must be changed. Refer to *A9 CC Jumper Position Procedure* in the *Adjustments and Correction Constants* section of the service manual.

CORRECTION TURNED OFF (error #66). Critical parameters in the current instrument state do not match the parameters for the calibration set, therefore correction has been turned off. The critical instrument state parameters are sweep type, start frequency, frequency span, and number of points.

CURRENT PARAMETER NOT IN CAL SET (error #64). Correction is not valid for the selected measurement parameter. Refer to Chapter 5, *Measurement Calibration*.

D2/D1 INVALID WITH SINGLE CHANNEL (error #130). A D2/D1 measurement can only be made if both channels are on.

D2/D1 INVALID. CH1 CH2 NUM PTS DIFFERENT (error #152). A D2/D1 measurement can only be made if both channels have the same number of points.

DEADLOCK (error #111). A fatal firmware error occurred before instrument preset completed. Refer to *Troubleshooting* in the service manual.

DEMODULATION NOT VALID (error #17). Demodulation is only valid for the CW time mode. Refer to Chapter 8, *Time and Frequency Domain Transforms*.

DEVICE: not on, not connect, wrong addrs (error #119). The device at the power meter address cannot be accessed by the HP 8753B. Verify power to the device, and check the HP-IB connection between the HP 8753B and the device. Ensure that the device address recognized by the network analyzer matches the HP-IB address set on the device itself. Refer to *[LOCAL] Key* in Chapter 7 for instructions on setting peripheral addresses.

DISC HARDWARE PROBLEM (error #39). The disc drive is not responding correctly. Refer to the disc drive operating manual.

DISC IS WRITE PROTECTED (error #48). The store operation cannot write to a write-protected disc. Slide the write-protect tab over the write-protect opening in order to write data on the disc.

DISC MEDIUM NOT INITIALIZED (error #40). The disc must be initialized before it can be used. Refer to *Initialize Menu* in Chapter 10.

DISC: not on, not connected, wrong addrs (error #38). The disc cannot be accessed by the HP 8753B. Verify power to the disc drive, and check the HP-IB connection between the HP 8753B and the disc drive. Ensure that the disc drive address recognized by the network analyzer matches the HP-IB address set on the disc drive itself. Refer to *[LOCAL] Key* in Chapter 7 for instructions on setting peripheral addresses.

DISC WEAR - REPLACE DISC SOON (error #49). Cumulative use of the disc is approaching the maximum. Copy files as necessary using an external controller. If no controller is available, load instrument states from the old disc and store them to a newly initialized disc using the save/recall features of the HP 8753B. Refer to Chapter 10, *Saving Instrument States*, for information. Discard the old disc.

DUPLICATING TO THIS SEQUENCE NOT ALLOWED (error #125). A sequence cannot be duplicated to itself.

EXCEEDED 7 STANDARDS PER CLASS (error #72). A maximum of seven standards can be defined for any class. Refer to *Modifying Calibration Kits* in Chapter 5.

EXTERNAL SOURCE MODE REQUIRES CW TIME (error #148). An external source can only be phase locked and measured in the CW time sweep mode. Refer to Chapter 14 for information on the external source mode. Refer to *Sweep Type Menu* in Chapter 3 for information on CW time sweep.

FIRST CHARACTER MUST BE A LETTER (error #42). The first character of a disc file title or an internal save register title must be an alpha character.

FREQ OFFSET ONLY VALID IN NETWORK ANALYZER MODE (error #140). Frequency offset measurements can only be made in the network analyzer mode because this is the only mode that controls the source.

FUNCTION NOT VALID (error #14). The requested function is incompatible with the current instrument state.

FUNCTION NOT VALID DURING MOD SEQUENCE (error #131). Sequencing operations cannot be performed while a sequence is being modified.

ILLEGAL UNIT OR VOLUME NUMBER (error #46). The disc unit or volume number set in the HP 8753B is not valid. Refer to *HP-IB Menu* in Chapter 7 and to the disc drive operating manual.

INIT DISC removes all data from disc (information message, not an error). Continuing with the initialize operation will DESTROY any data currently on the disc.

INITIALIZATION FAILED (error #47). Disc initialization failed, probably because the disc is damaged.

INPUT OVERLOAD, ATTENUATOR SET TO MAX (error #160). This message occurs only with an HP 85047A test set when the instrument is in 6 GHz mode. The power level at the A or B input has exceeded the maximum allowed, and the attenuator has been set automatically to 70 dB to reduce the power. The annotation P↓ appears in the left margin of the display to indicate that power trip has been activated. Refer to *Power Menu* in Chapter 3. Toggle the *[POWER TRIP]* softkey off, and insert attenuation either with the internal attenuator or an external pad.

INSTRUMENT STATE MEMORY CLEARED (error #56). The five instrument state registers have been cleared from memory along with any saved calibration data or calibration kit definitions.

INSUFFICIENT MEMORY (error #51). The last front panel or HP-IB request could not be implemented due to insufficient memory space. In some cases, this is a fatal error which can only be escaped by presetting the instrument. See Chapter 10 for information on memory allocation.

INSUFFICIENT MEMORY, PWR MTR CAL OFF (error #154). A power meter calibration array requires more memory space than is currently available. Increase the available memory by clearing one or more save/recall registers, or by reducing the number of points.

INVALID KEY (error #2). An undefined softkey was pressed.

LIST TABLE EMPTY (error #9). The frequency list is empty. To implement list frequency mode, add segments to the list table. Refer to *Edit List Menu* in Chapter 3.

LOG SWEEP REQUIRES 2 OCTAVE MINIMUM SPAN (error #150). A logarithmic sweep is only valid if the stop frequency is greater than 4 times the start frequency. For frequency spans of less than two octaves, the sweep type automatically reverts to linear sweep.

LOW PASS: FREQ LIMITS CHANGED (information message, not an error). The frequency domain data points must be harmonically related from DC to the stop frequency. That is, stop = n x start, where n = number of points. If this condition is not true when a low pass mode (step or impulse) is selected and transform is turned on, the network analyzer resets the start and stop frequencies. The stop frequency is set close to the entered stop frequency, and the start frequency is set equal to stop/n. Refer to *Time Domain Low Pass* in Chapter 8.

LOW PASS MODE NOT ALLOWED (error #18). Low pass time domain mode is allowed only with 801 points or less.

MEMORY FOR CURRENT SEQUENCE IS FULL (error #132). All the memory in the sequence being modified is filled with instrument commands.

MORE SLIDES NEEDED (error #71). When a sliding load is used (in a user-defined calibration kit), at least three slide positions are required to complete the calibration.

NO 6 GHZ TEST SET PRESENT (error #120). Sampler correction cannot be performed on an option 006 (6 GHz) instrument unless an HP 85047A 6 GHz test set is connected. Refer to *Sampler Magnitude and Phase Correction Constants* in the *Adjustments* section of the service manual.

NO CALIBRATION CURRENTLY IN PROGRESS (error #69). The *[RESUME CAL SEQUENCE]* softkey is not valid unless a calibration was already in progress. Start a new calibration. Refer to *Correction Menu* in Chapter 5.

NO DISC MEDIUM IN DRIVE (error #41). No disc was found in the current disc unit. Insert a disc, or check the disc unit number stored in the HP 8753B. Refer to *HP-IB Menu* in Chapter 7.

NO FAIL FOUND (service error #114). The self-diagnose function of the instrument operates on an internal test failure. At this time, no failure has been detected. Refer to *Internal Tests* in the *Service Key Menus* section of the *On-Site System Service Manual.*

NO FILE(S) FOUND ON DISC (error #45). No files of the type created by an HP 8753B store operation were found on the disc. Or if a specific file title was requested, that file was not found on the disc.

NO IF FOUND: CHECK R INPUT LEVEL (error #5). The first IF signal was not detected during pretune. Make sure the RF output is connected externally to the R input, with at least −35 dBm input power to R.

NO LIMIT LINES DISPLAYED (error #144). Limit lines are turned on but cannot be displayed on polar or Smith chart display formats.

NO MARKER DELTA —SPAN NOT SET (error #15). The *[MARKER → SPAN]* softkey function requires that delta marker mode be turned on, with at least two markers displayed. Refer to Chapter 6, *Using Markers*.

NO MEMORY AVAILABLE FOR INTERPOLATION (error #123). Interpolated error correction cannot be performed due to insufficient memory. Increase the available memory by clearing one or more save/recall registers.

NO MEMORY AVAILABLE FOR SEQUENCING (error #126). The sequence cannot be modified due to insufficient memory. Increase the available memory by clearing one or more save/recall registers.

NO PHASE LOCK: CHECK R INPUT LEVEL (error #7). The first IF signal was detected at pretune, but phase lock could not be acquired. Refer to *Troubleshooting* in the *On-Site System Service Manual*.

NO SPACE FOR NEW CAL. CLEAR REGISTERS (error #70). Insufficient memory is available to store a calibration set. Memory can be freed by clearing a saved instrument state, which will result in the deletion of a saved calibration set. The saved instrument state and calibration set can be stored to an external disc before being cleared from the internal register. Refer to Chapter 10 for information on the allocation of memory.

NO VALID MEMORY TRACE (error #54). If a memory trace is to be displayed or otherwise used, a data trace must first be stored to memory. Refer to *Display Menu* in Chapter 4.

NO VALID STATE IN REGISTER (error #55). A request to load an instrument state from an internal register was received over HP-IB, and that register is empty.

NOT ENOUGH SPACE ON DISC FOR STORE (error #44). The store operation will overflow the available disc space. Insert a new disc or purge the files appearing last in the directory, to create free disc space.

NOT VALID FOR PRESENT TEST SET (error #62). The calibration requested is inconsistent with the test set present. This message occurs in the following situations:

- A full 2-port calibration is requested with a test set other than an HP 85046A/B or 85047A S-parameter test set.
- A one-path 2-port calibration is requested with an S-parameter test set (this procedure is typically used with a transmission/reflection test set).

ONLY LETTERS AND NUMBERS ARE ALLOWED (error #43). Only alpha-numeric characters are allowed in disc file titles or internal save register titles. Other symbols are not allowed.

OPTIONAL FUNCTION; NOT INSTALLED (error #1). The function you requested requires a capability provided by an option to the standard HP 8753B. That option is not currently installed. (Options are 002 harmonic measurement capability, 006 6 GHz receiver operation, and 010 time domain transform.)

OVERLOAD ON INPUT A, POWER REDUCED (error #58)
OVERLOAD ON INPUT B, POWER REDUCED (error #59)
OVERLOAD ON INPUT R, POWER REDUCED (error #57). When the power level at one of the three receiver inputs exceeds approximately +4 dBm, the RF output power level is automatically reduced to −5 dBm. The annotation P↓ appears in the left margin of the display to indicate that the power trip function has been activated. When this occurs, toggle the *[POWER TRIP]* softkey off and reset the power at a lower level. Refer to *Power Menu* in Chapter 3. (In certain circumstances, power trip is indicated by error #160, INPUT OVERLOAD, ATTENUATOR SET TO MAX.)

PHASE LOCK CAL FAILED (error #4). An internal phase lock calibration routine is automatically executed at power-on and preset any time a loss of phase lock is detected. This message indicates that phase lock calibration was initiated and the first IF detected, but a problem prevented the calibration from completing successfully. Refer to the *Troubleshooting* section of the *On-Site System Service Manual*, and execute pretune correction test 48.

If a mixer is connected between the RF output and R input before frequency offset mode is turned on, this message may appear. Ignore it: it will go away when frequency offset is turned on. Or it may appear if frequency offset mode is entered before the offset is defined. Refer to Chapter 14 for information.

PHASE LOCK LOST (error #8). Phase lock was acquired but then lost. Refer to the *Troubleshooting* section of the service manual, and to *Service Modes Menu* in the *Service Key Menus* section.

PLOT ABORTED (error #27). Pressing the **[LOCAL]** key causes the HP 8753B to abort the plot in progress.

PLOTTER: not on, not connect, wrong addrs (error #26). The plotter does not respond to control. Verify power to the plotter, and check the HP-IB connection between the HP 8753B and the plotter. Ensure that the plotter address recognized by the network analyzer matches the HP-IB address set on the plotter itself. Refer to *[LOCAL] Key* in Chapter 7 for instructions on setting peripheral addresses.

PLOTTER NOT READY-PINCH WHEELS UP (error #28). The plotter pinch wheels clamp the paper in place. When the pinch wheels are raised, the plotter indicates a "not ready" status on the bus.

POSSIBLE FALSE LOCK (error #6). Phase lock has been achieved, but the source may be phase locked to the wrong harmonic of the synthesizer. Perform the source pretune correction routine in the *Adjustments* section of the service manual.

POW MET INVALID (error #116). The power meter indicates an out-of-range condition. Check the test setup.

POW MET NOT SETTLED (error #118). Sequential power meter readings are not consistent. Verify that the equipment is set up correctly. If so, preset the instrument and restart the routine.

POW MET: not on, not connected, wrong addrs (error #117). The power meter cannot be accessed by the HP 8753B. Verify that the power meter address and model number set in the HP 8753B match the address and model number of the actual power meter. Refer to *[LOCAL] Key* in Chapter 7 for more information.

POWER SUPPLY HOT! (error #21). The temperature sensors on the A8 post-regulator assembly have detected an overtemperature condition. The power supplies regulated on the post-regulator have been shut down.

POWER SUPPLY SHUT DOWN! (error #22). One or more supplies on the A8 post-regulator assembly have been shut down due to an overcurrent, overvoltage, or undervoltage condition.

PRESENT LIST FREQ INVALID IN 3 GHZ RANGE (error #139). Frequency list segments above 3 GHz were set while the instrument was in 6 GHz mode using the HP 85047A test set. These frequencies can only be used in the 6 GHz mode. Either change the frequency list or press **[FREQ RANGE 3GHz6GHz]** to turn on the 6 GHz mode.

PRINT ABORTED (error #25). Pressing the **[LOCAL]** key causes the HP 8753B to abort output to the printer.

PRINTER: not on, not connected, wrong addrs (error #24). The printer does not respond to control. Verify power to the printer, and check the HP-IB connection between the HP 8753B and the printer. Ensure that the printer address recognized by the network analyzer matches the HP-IB address set on the printer itself. Refer to *[LOCAL] Key* in Chapter 7 for instructions on setting peripheral addresses.

PRINT/PLOT IN PROGRESS, ABORT WITH LOCAL (information message, not an error). If a print or plot is in progress and a second print or plot is attempted, this message is displayed and the second attempt is ignored. To abort a print or plot in progress, press **[LOCAL]**.

PROBE POWER SHUT DOWN! (error #23). The HP 8753B biasing supplies to the HP 85024A external probe are shut down due to excessive current. Troubleshoot the probe, and refer to the *Power Supply* troubleshooting section of the service manual.

REQUESTED DATA NOT CURRENTLY AVAILABLE (error #30). The HP 8753B does not currently contain the data being requested. For example, this condition occurs when error term arrays are requested and no calibration is active.

SAVE FAILED. INSUFFICIENT MEMORY (error #151). The instrument state could not be saved in an internal register because of insufficient memory. Increase the available memory by clearing one or more save/recall registers, or by storing files to an external disc. Refer to Chapter 10 for information.

SELECTED SEQUENCE IS EMPTY (error #124). The sequence you tried to run does not contain instrument commands.

SELF TEST #n FAILED (service error #112). Internal test #n has failed. Several internal test routines are executed at instrument preset. The HP 8753B reports the first failure detected. Refer to the *Troubleshooting* section of the *On-Site System Service Manual* for more information on internal tests and the self-diagnose feature.

SEQUENCE ABORTED (error #157). The running sequence was stopped prematurely when the operator pressed the **[LOCAL]** key.

SEQUENCE MAY HAVE CHANGED, CAN'T CONTINUE (error #153). The sequence that was paused cannot be continued because it has been modified. The sequence must be started again.

SLIDES ABORTED (MEMORY REALLOCATION) (error #73). Insufficient memory is available for sliding load measurements. Reduce memory usage by clearing save/recall registers (see Chapter 10, *Saving Instrument States*), then repeat the sliding load measurements.

SOURCE PARAMETERS CHANGED (error #61). Some of the stimulus parameters of the instrument state have been changed, due to a request to turn correction on. A calibration set for the current measurement parameter was found and activated. The instrument state was updated to match the stimulus parameters of the calibration state.

This message also appears when harmonic mode or frequency offset is turned on and the present frequency range cannot be used with one of these modes.

SOURCE POWER TRIPPED, RESET UNDER POWER MENU (information message, not an error). The power level at one of the inputs has exceeded the maximum allowed, and power has been automatically reduced. The annotation P↓ indicates that power trip has been activated. Press **[MENU]** *[POWER] [POWER TRIP ON]* to turn off the power trip, then reset the power at a lower level. This message follows error #57-59, OVERLOAD ON INPUT A (B, R), POWER REDUCED and error #160, INPUT OVERLOAD, ATTENUATOR SET TO MAX, and repeats every sweep until the power trip is cleared.

SWEEP TIME INCREASED (error #11). Sweep time is automatically increased to compensate for other instrument state changes. Some parameter changes that cause an increase in sweep time are narrower IF bandwidth, an increase in the number of points, and a change in sweep type.

SWEEP TIME TOO FAST (error #12). The fractional-N and digital IF circuits have lost synchronization. Refer to the *Troubleshooting* section in the *On-Site System Service Manual*.

SWEEP TRIGGER SET TO HOLD (information message, not an error). The instrument is in a hold state and is no longer sweeping.

SWEEP TYPE CHANGED TO LINEAR SWEEP (error #145). If the frequency list mode is active when the *[FREQ RANGE 3GHz6GHz]* softkey is pressed, or when the instrument mode is changed to harmonic measurements, and the list frequencies do not fall in the allowable frequency range of these modes, the list mode is turned off.

SYNTAX ERROR (error #33). An improperly formatted command was received over HP-IB. Refer to the *HP-IB Quick Reference Guide* for proper command syntax.

SYST CTRL OR PASS CTRL IN LOCAL MENU (error #36). The HP 8753B cannot control a peripheral device on the bus while it is in talker/listener mode. Use the local menu to change to system controller or pass control mode. Refer to *[LOCAL] Key* in Chapter 7 for information on HP-IB controller modes.

SYSTEM IS NOT IN REMOTE (error #52). The HP 8753B is in local mode. In this mode, the HP 8753B will not respond to HP-IB commands with front panel key equivalents. It will, however, respond to commands that have no such equivalents, such as status requests.

TEST ABORTED (error #113). A service test has been prematurely stopped at the operator's request.

THIS LIST FREQ INVALID IN HARM/3 GHZ RNG (error #133). The frequencies in the list do not fall in the allowable frequency range for harmonic measurements, or for 6 GHz operation with an HP 85047A test set. Reduce the frequency range of the list.

TOO MANY SEGMENTS OR POINTS (error #50). Frequency list mode is limited to 30 segments or 1632 points. Refer to *Edit List Menu* in Chapter 3 for more information.

In power meter calibration, the power sensor cal factor and power loss functions are limited to 12 segments. Refer to *Power Meter Calibration* in Chapter 5.

TRANSFORM, GATE NOT ALLOWED (error #16). Transformation to the time domain is only possible in linear and CW sweep types.

TROUBLE! CHECK SETUP AND START OVER (service error #115). The equipment setup for the adjustment procedure in progress is not correct. Check the setup diagram and instructions in the *Adjustments and Correction Constants* section of the *On-Site System Service Manual*. Start the procedure again.

WAITING FOR CLEAN SWEEP (information message, not an error). In single sweep mode, the instrument ensures that all changes to the instrument state, if any, have been implemented before taking the sweep. The command that the instrument is currently processing will not complete until the new sweep completes. An asterisk * is displayed in the left margin of the CRT until a complete fresh sweep has been taken.

WAITING FOR DISC (information message, not an error). This message is displayed between the start and finish of a read or write operation to a disc.

WAITING FOR HP-IB CONTROL (information message, not an error). The HP 8753B has been instructed to use pass control (USEPASC). When the instrument next receives an instruction requiring active controller mode, it requests control of the bus and simultaneously displays this message. If the message remains, the system controller is not relinquishing the bus.

WRITE ATTEMPTED WITHOUT SELECTING INPUT TYPE (error #32). The data header "#A" for the HP 8753B was received with no preceding input command (such as INPUDATA). The instrument recognized the header but did not know what type of data to receive. Refer to the *HP-IB Quick Reference Guide* for command syntax information.

WRONG DISC FORMAT, INITIALIZE DISC (error #77). A command to store, load, or read file titles has been received, but the disc format does not conform to the Logical Interchange Format (LIF). The instrument must initialize the disc before reading or writing to it. Refer to *Initialize Menu* in Chapter 10.

3GHZ MAX FREQ. USE FREQ RANGE KEY (UNDER SYSTEM) (information message, not an error). Frequencies above 3 GHz can only be set when the instrument has been set to 6 GHz mode. Press **[SYSTEM]** *[FREQ RANGE 3GHZ]* so that it changes to *[FREQ RANGE 6GHZ]*. This message occurs only with an option 006 instrument used with an HP 85047A test set.

ERROR MESSAGES IN NUMERICAL ORDER

Refer to the alphabetical listing for explanations and suggestions for solving the problems.

ERROR #1. OPTIONAL FUNCTION; NOT INSTALLED

ERROR #2. INVALID KEY

ERROR #3. CORRECTION CONSTANTS NOT STORED

ERROR #4. PHASE LOCK CAL FAILED

ERROR #5. NO IF FOUND: CHECK R INPUT LEVEL

ERROR #6. POSSIBLE FALSE LOCK

ERROR #7. NO PHASE LOCK: CHECK R INPUT LEVEL

ERROR #8. PHASE LOCK LOST

ERROR #9. LIST TABLE EMPTY

ERROR #10. CONTINUOUS SWITCHING NOT ALLOWED

ERROR #11. SWEEP TIME INCREASED

ERROR #12. SWEEP TIME TOO FAST

ERROR #13. AVERAGING INVALID ON NON-RATIO MEASURE

ERROR #14. FUNCTION NOT VALID

ERROR #15. NO MARKER DELTA — SPAN NOT SET

ERROR #16. TRANSFORM, GATE NOT ALLOWED

ERROR #17. DEMODULATION NOT VALID

ERROR #18. LOW PASS MODE NOT ALLOWED

ERROR #20. AIR FLOW RESTRICTED: CHECK FAN FILTER

ERROR #21. POWER SUPPLY HOT!

ERROR #22. POWER SUPPLY SHUT DOWN!

ERROR #23. PROBE POWER SHUT DOWN!

ERROR #24. PRINTER: not on, not connected, wrong addrs

ERROR #25. PRINT ABORTED

ERROR #26. PLOTTER: not on, not connect, wrong addrs

ERROR #27. PLOT ABORTED

ERROR #28. PLOTTER NOT READY-PINCH WHEELS UP

ERROR #30. REQUESTED DATA NOT CURRENTLY AVAILABLE

ERROR #31. ADDRESSED TO TALK WITH NOTHING TO SAY

ERROR #32. WRITE ATTEMPTED WITHOUT SELECTING INPUT TYPE

ERROR #33. SYNTAX ERROR

ERROR #34. BLOCK INPUT ERROR

ERROR #35. BLOCK INPUT LENGTH ERROR

ERROR #36. SYST CTRL OR PASS CTRL IN LOCAL MENU

ERROR #37. CAN'T CHANGE-ANOTHER CONTROLLER ON BUS

ERROR #38. DISC: not on, not connected, wrong addrs

ERROR #39. DISC HARDWARE PROBLEM

ERROR #40. DISC MEDIUM NOT INITIALIZED

ERROR #41. NO DISC MEDIUM IN DRIVE

ERROR #42. FIRST CHARACTER MUST BE A LETTER

ERROR #43. ONLY LETTERS AND NUMBERS ARE ALLOWED

ERROR #44. NOT ENOUGH SPACE ON DISC FOR STORE

ERROR #45. NO FILE(S) FOUND ON DISC

ERROR #46. ILLEGAL UNIT OR VOLUME NUMBER

ERROR #47. INITIALIZATION FAILED

ERROR #48. DISC IS WRITE PROTECTED

ERROR #49. DISC WEAR-REPLACE DISC SOON

ERROR #50. TOO MANY SEGMENTS OR POINTS

ERROR #51. INSUFFICIENT MEMORY

ERROR #52. SYSTEM IS NOT IN REMOTE

ERROR #54. NO VALID MEMORY TRACE

ERROR #55. NO VALID STATE IN REGISTER

ERROR #56. INSTRUMENT STATE MEMORY CLEARED

ERROR #57. OVERLOAD ON INPUT R, POWER REDUCED
ERROR #58. OVERLOAD ON INPUT A, POWER REDUCED
ERROR #59. OVERLOAD ON INPUT B, POWER REDUCED

ERROR #61. SOURCE PARAMETERS CHANGED

ERROR #62. NOT VALID FOR PRESENT TEST SET

ERROR #63. CALIBRATION REQUIRED

ERROR #64. CURRENT PARAMETER NOT IN CAL SET

ERROR #66. CORRECTION TURNED OFF

ERROR #68. ADDITIONAL STANDARDS NEEDED

ERROR #69. NO CALIBRATION CURRENTLY IN PROGRESS

ERROR #70. NO SPACE FOR NEW CAL. CLEAR REGISTERS

ERROR #71. MORE SLIDES NEEDED

ERROR #72. EXCEEDED 7 STANDARDS PER CLASS

ERROR #73. SLIDES ABORTED (MEMORY REALLOCATION)

ERROR #74. CALIBRATION ABORTED

ERROR #77. WRONG DISC FORMAT, INITIALIZE DISC

ERROR #111. DEADLOCK.

ERROR #112. SELF TEST #n FAILED

ERROR #113. TEST ABORTED

ERROR #114. NO FAIL FOUND

ERROR #115. TROUBLE! CHECK SETUP AND START OVER

ERROR #116. POW MET INVALID

ERROR #117. POW MET: not on, not connected, wrong addrs

ERROR #118. POW MET NOT SETTLED

ERROR #119. DEVICE: not on, not connect, wrong addrs

ERROR #120. NO 6 GHZ TEST SET PRESENT

ERROR #123. NO MEMORY AVAILABLE FOR INTERPOLATION

ERROR #124. SELECTED SEQUENCE IS EMPTY

ERROR #125. DUPLICATING TO THIS SEQUENCE NOT ALLOWED

ERROR #126. NO MEMORY AVAILABLE FOR SEQUENCING

ERROR #127. CAN'T STORE/LOAD SEQUENCE, INSUFFICIENT MEMORY

ERROR #130. D2/D1 INVALID WITH SINGLE CHANNEL

ERROR #131. FUNCTION NOT VALID DURING MOD SEQUENCE

ERROR #132. MEMORY FOR CURRENT SEQUENCE IS FULL

ERROR #133. THIS LIST FREQ INVALID IN HARM/3 GHZ RNG

ERROR #139. PRESENT LIST FREQ INVALID IN 3 GHZ RANGE

ERROR #140. FREQ OFFSET ONLY VALID IN NETWORK ANALYZER MODE

ERROR #144. NO LIMIT LINES DISPLAYED

ERROR #145. SWEEP TYPE CHANGED TO LINEAR SWEEP

ERROR #148. EXTERNAL SOURCE MODE REQUIRES CW TIME

ERROR #150. LOG SWEEP REQUIRES 2 OCTAVE MINIMUM SPAN

ERROR #151. SAVE FAILED. INSUFFICIENT MEMORY

ERROR #152. D2/D1 INVALID. CH1 CH2 NUM PTS DIFFERENT

ERROR #153. SEQUENCE MAY HAVE CHANGED, CAN'T CONTINUE

ERROR #154. INSUFFICIENT MEMORY, PWR MTR CAL OFF

ERROR #157. SEQUENCE ABORTED

ERROR #159. CH1 (CH2) TARGET VALUE NOT FOUND

ERROR #160. INPUT OVERLOAD, ATTENUATOR SET TO MAX

Chapter 13. Test Sequence Function

CHAPTER CONTENTS

WHAT IS TEST SEQUENCING?

Test sequencing automates repetitive tasks. In sequencing mode you make the measurement once and the HP 8753B memorizes the keystrokes. Later the entire sequence can be repeated by pressing a single key. Because the sequence is defined with normal measurement keystrokes, no additional programming expertise is required. Limited decision-making increases the flexibility of test sequences.

The test sequence function allows the user to create, title, save, and execute up to six independent sequences internally. Test sequences can dramatically reduce the time required to make a multiple step measurement, and can greatly reduce operator errors.

Sequences may be saved to external disc and can be transferred between the HP 8753B and an external computer controller.

The following procedures are based on an actual measurement example, and show you how to create, title, edit, clear, and (optionally) store, load, or purge a sequence. Performing these sample procedures will teach you how to use basic test sequencing in a very short amount of time.

CREATING A SEQUENCE

1. Press [SYSTEM] *[SEQUENCING MENU]* *[NEW SEQ/MODIFY SEQ]*.
2. The HP 8753B will display the six available sequences. Press *[SEQUENCE 1 SEQ1]* to select sequence number one. ("SEQ1" is the default title of that sequence.)
3. The following list will appear on the screen with an arrow cursor.

   ```
   => Start of Sequence
      1996 empty bytes available
   ```

4. Press the appropriate keys for the desired measurement. Note that the *[RECALL PRST STATE]* (recall preset state) softkey is available under the **[RECALL]** key. This command is the only way to preset the instrument in a sequence. It is recommended that sequences begin with this command.

   Example Sequence:

   Connect a test cable between the RF output and R input. Enter the following commands on the HP 8753B:

   [RECALL] *[RECALL PRST STATE]*
   [MEAS] *[R]*
   [SCALE REF] *[SCALE/DIV]* [1] [x1]
   [START] [1] [G/n]
   [AVG] *[SMOOTHING APERTURE]* [5] [x1]
   [SMOOTHING ON]
   [DISPLAY] *[DUAL CHAN ON]*
   [CH 2] [FORMAT] *[SMITH CHART]*

   As you enter front panel commands, the list on the screen will show each entry. The available number of bytes for that sequence is displayed at the bottom of the list. If you make a mistake, refer to *Editing a Sequence*.

5. Press [SYSTEM] *[SEQUENCING MENU]* *[DONE MODIFY]*. The sequence is now ready to run.

NOTE: A sequence created in sequence position 6 is stored in nonvolatile memory and will survive if line power is turned off.

RUNNING A SEQUENCE

To run the sequence right after creating it, press the *[DO SEQUENCE]* softkey. While a sequence is running the HP 8753B's remote light is on, indicating that the HP 8753B can not be operated manually.

If **[PRESET]** is pressed, all sequences currently in memory are immediately presented in the softkey menu. To run a sequence, press the appropriate softkey.

1. Press **[PRESET]** now, followed by *[SEQUENCE 1 SEQ1]*. Notice the display changes (split display and Smith chart) caused by the sequence.

STOPPING A SEQUENCE

To stop a sequence before it has finished, press **[LOCAL]**.

CHANGING THE SEQUENCE TITLE

If sequences are to be stored to disc, it is recommended that they be given titles other than the default (SEQ1, SEQ2...). Titles entered from the front panel can be no longer than eight characters, must begin with a letter, and can contain only letters and numbers.

1. Press **[SYSTEM]** ***[SEQUENCING MENU]*** ***[MORE]*** ***[TITLE SEQUENCE]*** ***[TITLE SEQ1]***. The screen now provides the available title characters. The current title is displayed in the upper left-hand corner of the screen.
2. Press the ***[ERASE TITLE]*** softkey. Move the knob until the arrow cursor is under the "A," and press ***[SELECT LETTER]***. Continue until the title "ALPHA" has been entered, then press ***[DONE]*** **[PRESET]**. ***[SEQUENCE ALPHA]*** is now displayed as a softkey label.

EDITING A SEQUENCE

The sample measurement entered earlier will be used to demonstrate sequence editing.

1. Press **[PRESET]** **[SYSTEM]** ***[SEQUENCING MENU]*** ***[NEW SEQ/MODIFY SEQ]***.
2. Press ***[SEQUENCE 1 ALPHA]*** to edit the sequence created earlier. The following is the list of commands entered in *Creating a Sequence*. Note that only part of the list can be shown on the screen at one time.

```
=> Start of Sequence
   RECALL PRST STATE
   R
   SCALE/DIV
   SCALE/DIV
   1 x1
   START
   1 G/n
   SMOOTHING APERTURE
   5 x1
   SMOOTHING
   ON
   DUAL CHAN
```

The following lines are off screen:

```
   ON
   CH 2
   SMITH CHART
   1944 empty bytes available
```

The Active Line

The active line is always the line next to the => cursor.

Scrolling the Sequence Command List

The position of the cursor is fixed, and the command list moves up or down when the operator uses the rotary knob or the [▲] and [▼] keys. If you press the [▲] key, the list moves up, and the cursor points to the next command line.

3. Press the [▲] key until you reach the bottom of the list. Notice that the commands in the list are actually performed when the cursor points to them. This feature allows the sequence to be tested one command at a time. If you scroll past the end of the list, it will wrap-around back to the beginning. If the list is scrolled by pressing [▼] key the commands will not execute.

Editing Features

Three editing features are available in sequencing:

- Insert a command
- Delete a command
- Backspace (before the entry is terminated)

Inserting lines. Inserting requires no special keystrokes. Just type in the command to be inserted, and it will appear below the active line.

Deleting lines. Pressing the **[BACK SP]** (backspace) key deletes the entry next to the cursor.

To replace a command, delete the original and insert a new command in its place.

Backspacing Before the Entry is Terminated. When entering a command such as start frequency, you can backspace over an incorrect number before the units terminator key is pressed. For example, if **[START] [1] [2]** is pressed, followed by the backspace key, the 2 is deleted. However, if a terminator key is pressed (such as G/n), backspacing deletes the whole command.

4. Press the [▼] key until the cursor points to the line shown:

```
  SCALE/DIV
=> 1 x1
   START
   1 G/n
```

5. Press **[BACK SP]**. The line will disappear.
6. Press **[2] [x1]**. The sequence, when run, will now choose a scale factor of 2 dB/div.
7. Press **[SYSTEM]** *[SEQUENCING MENU]* *[DONE MODIFY]* to exit the modify (edit) mode.

CLEARING A SEQUENCE FROM MEMORY

This procedure is given for reference only. Do not clear the sequence "ALPHA" created in previous steps, as it is used in later examples.

1. Press **[SYSTEM]** *[SEQUENCING MENU]* *[MORE]* *[CLEAR SEQUENCE]*. Press the softkey of the sequence to be cleared.

STORING A SEQUENCE TO DISC

Set Up the Disc Drive and Set the HP 8753B to System Controller Mode

1. Connect an HP 9122 (or other CS-80 compatible disc drive) to the HP 8753B. The disc drive must be HP-IB compatible. Make sure the HP 8753B is programmed with the disc drive's HP-IB address using the **[LOCAL]** *[SET ADDRESSES]* *[ADDRESS: DISC]* keys.

2. Disconnect the HP 8753B from any computer controller. Set the instrument to system controller mode by pressing **[LOCAL]** *[SYSTEM CONTROLLER]*.

Format a Blank Disc

3. If necessary, format a blank disc by inserting it into drive 0 and pressing **[SAVE]** ***[STORE TO DISC]*** ***[DEFINE STORE]*** ***[MORE]*** ***[INITIALIZE DISC]*** ***[INIT DISC? YES]***.

Save Sequence to Disc

4. Press **[SYSTEM]** ***[SEQUENCING MENU]*** ***[STORE SEQ TO DISC]***. The sequences currently in memory will be displayed in the softkey labels.

5. Select the desired sequence to store. To store the sequence created in the above example, press ***[STORE SEQ ALPHA]***. If "CAUTION: SYST CTRL OR PASS CTRL in LOCAL menu" appears on the screen, the HP 8753B is not is system controller mode. Perform step 2 before saving a sequence to disc.

CAUTION

The save sequence to disc function will overwrite a file on the disc that has the same title. There is no warning to the user when a file is to be overwritten.

6. The disc drive access light should turn on briefly. When it goes out, the sequence has been saved.

LOADING A SEQUENCE FROM DISC

This procedure assumes the disc drive and HP 8753B have been set up as described in *Storing a Sequence to Disc*, and that a sequence titled "ALPHA" has been saved. Sequences are saved to disc independently of instrument state information.

There are two methods of loading a sequence:

- **If the sequence title is known**. Use the title menu to rename one of the six sequence softkeys with the name of the desired sequence. The procedure is described below.

- **If the sequence title is not known**, the contents of the disc can be viewed (six titles at a time). When the desired title appears on the display it can be loaded. Files are stored on disc in chronological order. The procedure is described below.

Loading a Sequence When the Title Is Known

1. Press **[SYSTEM]** ***[SEQUENCING MENU]*** ***[LOAD SEQ FROM DISC]***. If the desired sequence name is not on the load sequence from disc menu, perform step 2.

2. Change one of the six sequence titles to match that of the desired sequence by pressing **[SYSTEM]** ***[SEQUENCING MENU]*** ***[MORE]*** ***[TITLE SEQUENCE]*** followed by one of the six sequence softkeys. Press ***[ERASE TITLE]*** if necessary and change the title as explained in *Creating a Sequence*. Press ***[DONE]*** ***[RETURN]*** ***[LOAD SEQ FROM DISC]***.

3. Press the softkey next to the title of the desired sequence. The disc access light should come on briefly. When it goes out the sequence is loaded.

Loading a Sequence When the Title Is Not Known

This procedure assumes the desired file exists on the disc in drive 0.

1. Press **[SYSTEM]** *[SEQUENCING MENU]* *[LOAD SEQ FROM DISC]* *[READ SEQ FILE TITLS]*. The titles of the first six sequences on the disc will appear. If the desired sequence is not among the first six files, keep pressing *[READ SEQ FILE TITLS]* until the desired file name appears. Files are stored in chronological order.

2. Press the softkey next to the title of the desired sequence. The disc access light should come on briefly. When it goes out the sequence is loaded.

PURGING A SEQUENCE FROM DISC

1. Press **[SYSTEM]** *[SEQUENCING MENU]* *[STORE SEQ TO DISC]* *[PURGE SEQUENCES]*. The name of the desired sequence must show on the menu before it can be purged. As with loading a file, the title in one of the sequence softkey labels can be changed to the desired filename, or the disc can be searched. Refer to *Loading a Sequence From Disc* for details.

2. Once the proper sequence name is in one of the purge sequence softkey labels, press the softkey. The disc access light will turn on briefly. When it goes out the file is purged. Once purged, a file cannot be retrieved.

PRINTING A SEQUENCE

Set Up the Printer and Set the HP 8753B to System Controller Mode

1. Connect a compatible printer to the HP 8753B (refer to *Plotters and Printers* in the *Other Accessories Available* portion of *General Information and Specifications*). Make sure the HP 8753B is programmed with the printer's HP-IB address using the **[LOCAL]** *[SET ADDRESSES]* *[ADDRESS: PRINTER]* keys.

2. Disconnect the HP 8753B from any external computer controller. Set the instrument to system controller mode by pressing **[LOCAL]** *[SYSTEM CONTROLLER]*.

3. The sequence to be printed must be in HP 8753B memory. When the printer is ready to print, press **[SYSTEM]** *[SEQUENCING MENU]* *[MORE]* *[PRINT SEQUENCE]*. Press the softkey for the desired sequence.

IN-DEPTH SEQUENCING INFORMATION

The following information explains details of the basic sequencing operation.

Features That Operate Differently When Executed in a Sequence

The knob, step keys, **[PRESET]** key, and *[BACK SP]* softkey cannot be used in a sequence.

Commands That Sequencing Completes Before the Next Sequence Command Begins. Sequencing completes all operations related to the following commands before continuing.

- Single sweep
- Number of groups
- Auto scale
- Marker search
- Marker function
- Data → memory
- Recall or save (internal or external)
- Copy list values and operating parameters
- CH1, CH2, Wait 0*

*Wait 0 is the special sequencing function ***[WAIT x]*** with a zero entered for the delay value.

Commands That Require a Clean Sweep. Many front panel commands disrupt the sweep in progress. Changing the channel or measurement type are examples. When a disruptive command is executed in a sequence, it inhibits some instrument functions until a complete sweep is taken. This applies to the following functions:

- Autoscale
- Data → memory

Forward Stepping in Edit Mode

Forward stepping through the sequence list executes each step. Decision making calls to other sequences do not occur, however. Instead, the cursor jumps to the end of the sequence.

Titles

A title may contain non-printable or special ASCII characters if it is downloaded from an external controller. A non-printable character is represented on the display as π.

Sequence Size

A sequence may contain up to 2 kbytes of instructions. Typically, this is around 200 sequence command lines. To estimate a sequence's size (in kBytes), use the following guidelines.

Type of Command	Size in Bytes
Typical command	2
Title string character	1
Active entry command	1 per digit

Embedding the Value of the Loop Counter in a Title

The title of stored data can have a sequentially increasing or decreasing numeric value appended to it by placing a **[DISPLAY]** ***[MORE] [TITLE] [MORE] [LOOP COUNTER]*** command after the title string. (The title itself must be limited to three characters if it is to be used as a disc filename. The three-character title and five-digit loop counter number reach the eight-character limit for disc filenames.) This feature is useful in data logging applications. The loop counter example given later in this chapter shows how to perform this operation.

BASIC SEQUENCING MENUS

Figure 13-1 shows all basic sequencing menus. Special functions and their menus are described later in this chapter.

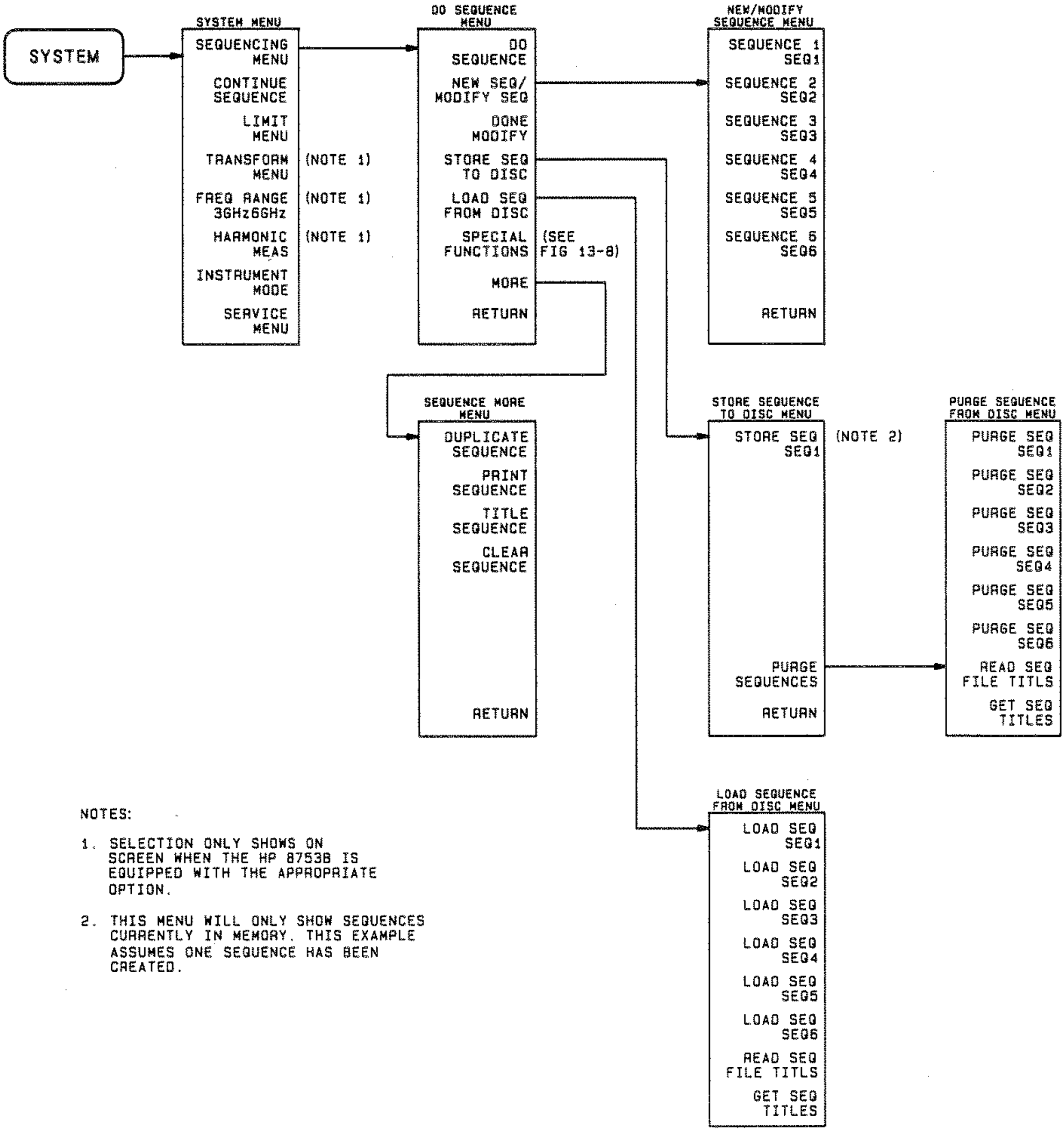


Figure 13-1. Basic Sequencing Menus

Do Sequence Menu

Figure 13-2 shows the commands available in the do sequence menu.

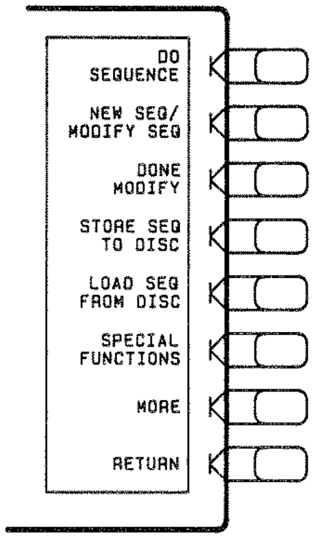


Figure 13-2. Do Sequence Menu

[DO SEQUENCE] (DOSEQn) has two functions:

- It shows the current sequences in memory. To run a sequence, press the softkey next to the desired sequence title.
- When entered into a sequence, this command performs a one-way jump to the sequence residing in the specified sequence position (SEQUENCE 1 through 6). ***[DO SEQUENCE]*** jumps to a softkey position, not to a specific sequence title. Whatever sequence is in the selected softkey position will run when the ***[DO SEQUENCE]*** command is executed. This command prompts the operator to select a destination sequence position.

[NEW SEQ/MODIFY SEQ] (NEWSEQn) activates the edit mode and presents the new/modify sequence menu with a list of sequences that can be created or modified.

[DONE MODIFY] (DONM) terminates the edit mode.

[STORE SEQ TO DISC] (STORSEQn) presents the store sequence to disc menu with a list of sequences that can be stored.

[LOAD SEQ FROM DISC] (LOADSEQn) presents the load sequence from disc menu. Select the desired sequence and the HP 8753B will load it from disc.

[SPECIAL FUNCTIONS] presents the special function menu. Available selections include:

- Jump to a sequence (***[DO SEQUENCE]***)
- Limit test decision (***[IF LIMIT TEST PASS] [IF LIMIT TEST FAIL]***)
- Loop counter value manipulation (increment/decrement, set value)
- Loop counter decision (***[IF COUNTER = 0]***, ***[IF COUNTER <>0]***)

- Send command to printer (*[TITLE TO PRINTER]*)
- Send command to HP-IB device (*[TITLE TO P MTR/HPIB]*)
- Wait
- Pause
- Set CW stimulus frequency to frequency of active marker (*[MARKER → CW]*)
- Emit beep
- Assert SRQ
- Output TTL high or TTL low
- Show menu to operator/show menu in sequence listing (*[SHOW MENUS]*)
- Read data from HP-IB device (*[P MTR/HPIB TO TITLE]* followed by *[TITLE TO MEMORY]*)
- Move data to data array memory (*[TITLE TO MEMORY]*)

[MORE] presents the sequence more menu.

[RETURN] returns to the system menu.

New/Modify Sequence Menu

Procedures for creating and editing sequences are provided at the beginning of this chapter. Figure 13-3 shows the commands available in this menu: Use this to select the sequence to be created or modified. Sequences in positions 1 through 5 are stored in volatile memory and are erased if line power is turned off. Sequence position 6 is stored in non-volatile memory and will survive if line power is turned off.

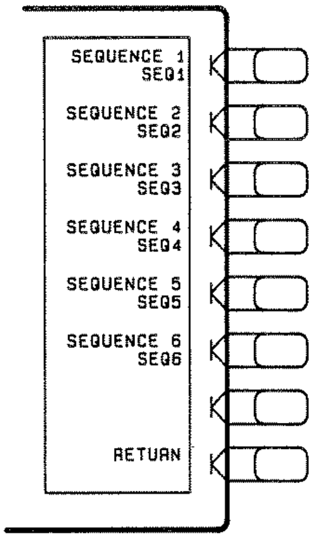


Figure 13-3. New/Modify Sequence Menu

[SEQUENCE 1 SEQ1] (NEWSEQ1) activates editing mode for the segment titled "SEQ1" (default title).

[SEQUENCE 2 SEQ2] (NEWSEQ2) activates editing mode for the segment titled "SEQ2" (default title).

[SEQUENCE 3 SEQ3] (NEWSEQ3) activates editing mode for the segment titled "SEQ3" (default title).

[SEQUENCE 4 SEQ4] (NEWSEQ4) activates editing mode for the segment titled "SEQ4" (default title).

[SEQUENCE 5 SEQ5] (NEWSEQ5) activates editing mode for the segment titled "SEQ5" (default title).

[SEQUENCE 6 SEQ6] (NEWSEQ6) activates editing mode for the segment titled "SEQ6" (default title).

[RETURN] returns to the do sequence menu

Store Sequence to Disc Menu

A procedure for storing a sequence to disc is provided at the beginning of this chapter. Figure 13-4 shows the commands available in this menu. Select the desired sequence and the HP 8753B will store it to a compatible disc drive.

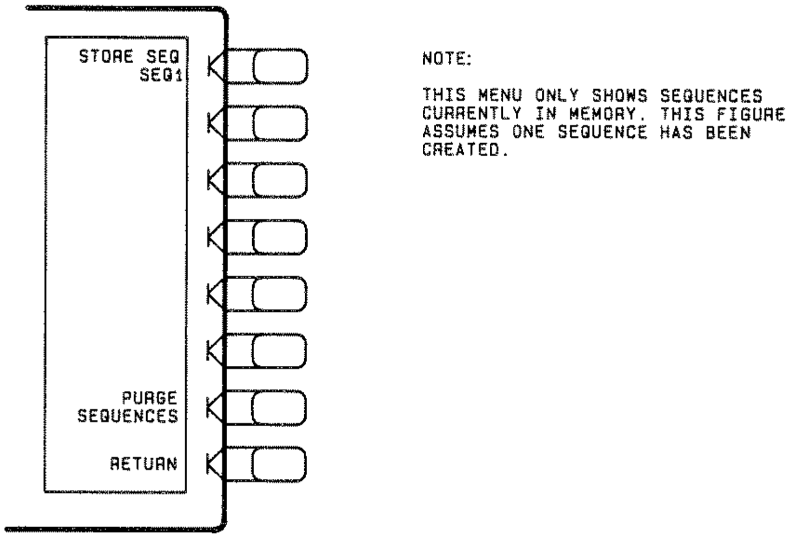


Figure 13-4. Store Sequence to Disc menu

The store sequence to disc menu shows only the titles of sequences currently in memory. Figure 13-4 is an example menu showing a single sequence in memory. Storing to disc requires a CS-80 compatible HP-IB disc drive such as the HP 9122. The HP 8753B must have the address of the disc drive and be in system controller mode.

[STORE SEQ SEQ1] (STORSEQ1) the sequence "SEQ1" is in memory. Pressing this softkey will store "SEQ1" to the disc.

[PURGE SEQUENCES] presents the purge sequence from disc menu.

[RETURN] returns to the do sequence menu.

Load Sequence from Disc Menu

Loading a sequence from disc is explained at the beginning of this chapter. Use this menu to select the desired sequence and the HP 8753B will load it from disc.

This menu shows default sequence names unless:

1. The operator has changed one or more of the titles, or...
2. A sequence with a different title has been loaded.

In these cases, the softkey labels will show any 8-character title the operator has entered.

Figure 13-5 shows the load sequence from disc menu.

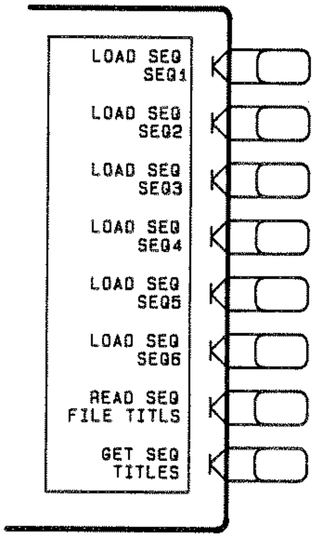


Figure 13-5. Load Sequence from Disk Menu

[LOAD SEQ SEQ1] (LOADSEQ1) loads SEQ1 from disc to internal memory.

[LOAD SEQ SEQ2] (LOADSEQ2) loads SEQ2 from disc to internal memory.

[LOAD SEQ SEQ3] (LOADSEQ3) loads SEQ3 from disc to internal memory.

[LOAD SEQ SEQ4] (LOADSEQ4) loads SEQ4 from disc to internal memory.

[LOAD SEQ SEQ5] (LOADSEQ5) loads SEQ5 from disc to internal memory.

[LOAD SEQ SEQ6] (LOADSEQ6) loads SEQ6 from disc to internal memory.

[READ SEQ FILE TITLS] is a disc file directory command. Pressing this softkey will read the first six sequence titles and display them in the softkey labels as described in *Loading a Sequence When the Title Is Not Known*. These sequences can then be loaded into internal memory.

If ***[READ SEQ FILE TITLS]*** is pressed again, the next six sequence titles on the disc will be displayed. To read the contents of the disc starting again with the first sequence: remove the disc, reinsert it into the drive, and press ***[READ SEQ FILE TITLS]***.

[GET SEQ TITLES] copies the sequence titles currently in memory into the six softkey positions.

Purge Sequence from Disc Menu

A procedure for purging a sequence from disc is provided at the beginning of this chapter. Use this menu to select the sequence to be purged from disc. This menu shows default sequence names unless:

1. The operator has changed one or more of the titles, or...
2. A sequence with a different title has been loaded.

In these cases, the softkey labels will show any 8-character title the operator has entered.

Figure 13-6 shows the purge sequence from disc menu.

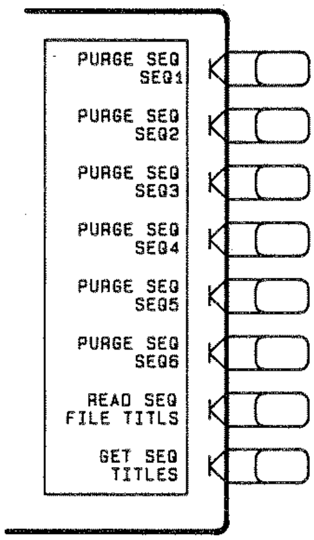


Figure 13-6. Purge Sequence from Disk Menu

[PURGE SEQ SEQ1] purges SEQ1 from disc.

[PURGE SEQ SEQ2] purges SEQ2 from disc.

[PURGE SEQ SEQ3] purges SEQ3 from disc.

[PURGE SEQ SEQ4] purges SEQ4 from disc.

[PURGE SEQ SEQ5] purges SEQ5 from disc.

[PURGE SEQ SEQ6] purges SEQ6 from disc.

[READ SEQ FILE TITLS] is a disc file directory command. Pressing this softkey will read the first six sequence titles and display them in the softkey labels as described in *Loading a Sequence When the Title Is Not Known*. These sequences can then be loaded into internal memory.

If ***[READ SEQ FILE TITLS]*** is pressed again, the next six sequence titles on the disc will be displayed. To read the contents of the disc starting again with the first sequence: remove the disc, reinsert it into the drive, and press ***[READ SEQ FILE TITLS]***.

[GET SEQ TITLES] copies the sequence titles currently in memory into the six softkey positions.

Sequence More Menu

Figure 13-7 shows the commands available in the sequence more menu.

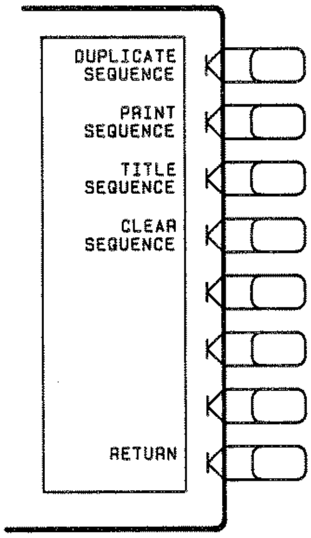


Figure 13-7. Sequence More Menu

[DUPLICATE SEQUENCE] (DUPLSEQxSEQy) duplicates a sequence currently in memory into a different softkey position. Duplicating a sequence is straightforward. Follow the prompts on the HP 8753B screen. This command does not affect the original sequence.

[PRINT SEQUENCE] (PRINSEQn) prints any sequence currently in memory to a compatible printer. Refer to *Accessories Available* in the *General Information and Specifications* section for a list of compatible printers. A procedure for printing a sequence is provided at the beginning of this chapter.

[TITLE SEQUENCE] (TITSEQn) allows the operator to rename any sequence with an eight character title. All titles entered from the front panel must begin with a letter, and may only contain letters and numbers. A procedure for changing the title of a sequence is provided at the beginning of this chapter.

[CLEAR SEQUENCE] (CLEASEn) clears a sequence from memory. The titles of cleared sequences will remain in load, store, and purge menus. This is done as a convenience for those who often reuse the same titles. A procedure for clearing a sequence is provided at the beginning of this chapter.

[RETURN] returns to the do sequence menu.

SEQUENCING SPECIAL FUNCTIONS

The purposes of some special functions are not obvious from the softkey label. Figure 13-8 shows all special function menus.

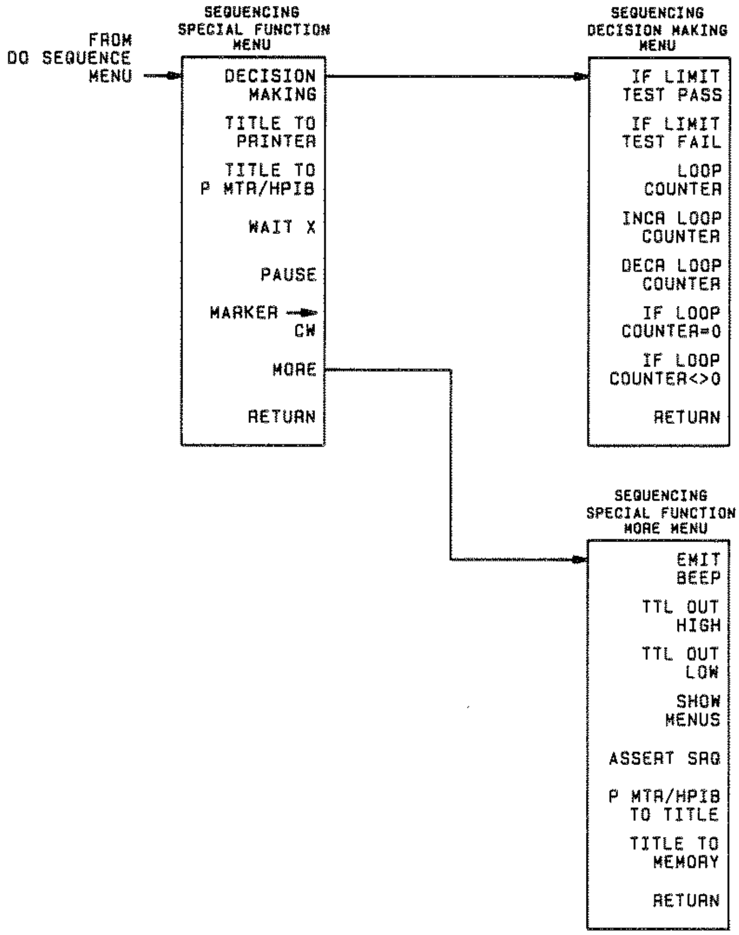


Figure 13-8. Sequencing Special Function Menus

Important Concepts

Some concepts presented in this chapter require explanation. Key concepts are explained below:

Sequence Title and Sequence Position. There are two attributes to any sequence. Each sequence has a title, and exists in one of the six sequence softkey positions. Softkey positions are referred to as SEQUENCE 1 through SEQUENCE 6, with position 1 at the top.

Decision Making Functions. Decision making functions are explained in more detail below. These functions check a condition and jump to a specified sequence if the condition is true. The sequence called must be in memory. A sequence call is a one-way jump, there is no equivalent to computer subroutines in sequencing. A sequence can jump to itself, or to any of the other five sequences currently in memory. Use of these features is explained under the specific softkey descriptions.

Decision making functions jump to a softkey location, not to a specific sequence title. Limit test, loop counter, and do sequence commands jump to any sequence residing in the specified sequence position (SEQUENCE 1 through 6). These commands do not jump to a specific sequence title. Whatever sequence is in the selected softkey position will run when these commands are executed.

Having a Sequence Jump to Itself. A decision making command can jump to the sequence it is in. When this occurs, the sequence starts over and all commands in the sequence are repeated. This is used a great deal in conjunction with loop counter commands. See the loop counter description below.

Limit Test Decision Making. A sequence can jump to another sequence or start over depending on the result of a limit test. When entered into a sequence, the ***[IF LIMIT TEST PASS] and [IF LIMIT TEST FAIL]*** commands require the operator to enter the destination sequence.

Loop Counter/Loop Counter Decision Making. The HP 8753B has a numeric register called a loop counter. The value of this register can be set by a sequence, and it can be incremented or decremented each time a sequence repeats itself. The decision making commands ***[IF LOOP COUNTER = 0]*** and ***[IF LOOP COUNTER <>0]*** jump to another sequence if the stated condition is true. When entered into the sequence, these commands require the operator to enter the destination sequence. Either command can jump to another sequence, or restart the current sequence.

As explained later, the loop counter value can be appended to a title. This allows customized titles for data printouts or for data files saved to disc.

Autostarting Sequences

A sequence can be defined that will run automatically when power is applied to the HP 8753B. To make an autostarting sequence, create a sequence in position six and title it "AUTO". To stop an autostarting sequence, press **[LOCAL]**. To stop an autostarting sequence from engaging at power on, you must clear it from memory or rename it. Instructions for performing either task are provided near the beginning of this chapter.

Sequencing Special Function Menu

Figure 13-9 shows the commands available in this menu.

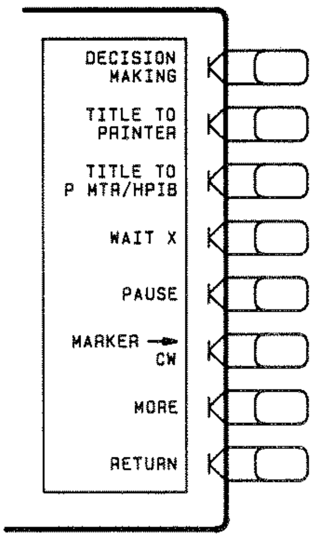


Figure 13-9. Sequencing Special Function Menu

[DECISION MAKING] presents the sequencing decision making menu.

[TITLE TO PRINTER] (TITTPRIN) outputs a title string to any device with an HP-IB address that matches the address set with the HP 8753B **[LOCAL]** *[SET ADDRESSES]* *[ADDRESS: PRINTER]* commands. This softkey is generally used for two purposes:

- Sending a title to a printer for data logging or documentation purposes.
- Sending commands to a printer or other HP-IB device.

When entering a sequence, create a display title and press *[TITLE TO PRINTER]*. When the sequence is run, the title will be sent to the printer. This command appends a carriage-return line feed (CR-LF) to the end of the string. The HP 8753B must be in system controller or pass control mode. To send a command to a printer or other HP-IB device, use the same procedure but enter the desired command as the title string.

[TITLE TO P MTR/HPIB] (TITTPMTR) outputs a title string to any device with an HP-IB address that matches the address set with the HP 8753B **[LOCAL]** *[SET ADDRESSES]* *[ADDRESS: P MTR/HPIB]* commands. This softkey is generally used for two purposes:

- Sending a title to a printer when a CR-LF is not desired.
- Sending commands to an HP-IB device.

When entering a sequence, create a display title containing a command or text string and press *[TITLE TO P MTR/HPIB]*. When the sequence is run, the string will be sent to the HP-IB device. The HP 8753B must be in system controller or pass control mode.

[WAIT X] (SEQWAIT) pauses the execution of subsequent sequence commands for x number of seconds. Terminate this command with **[x1]**.

Entering a 0 in wait x causes the instrument to wait for prior sequence command activities to finish before allowing the next command to begin. The wait 0 command only affects the command immediately following it, and does not affect commands later in the sequence.

[PAUSE] (PAUS) pauses the sequence so the operator can perform a needed task, such as changing the DUT, changing the calibration standard, or other similar task. Press *[CONTINUE SEQUENCE]* when ready.

[MARKER → CW] (MARKCW) sets the CW frequency of the HP 8753B to the frequency of the active marker.

[MORE] presents the sequencing special function more menu.

[RETURN] returns to the do sequence menu.

Sequencing Decision Making Menu

Figure 13-10 shows the commands available in this menu.

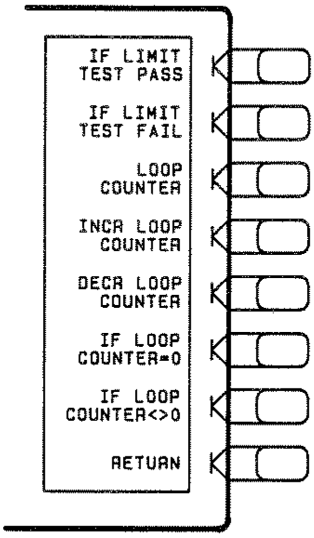


Figure 13-10. Sequencing Decision Making Menu

Limit Test Commands. Limit lines must be set up in the sequence before limit test pass/fail commands are performed. The limit test decision-making commands jump to a specified sequence if the conditions of the command are met.

Decision-Making Sequence Examples. Examples of limit test and loop counter sequences are provided at the end of this chapter.

[IF LIMIT TEST PASS] (IFLTPASS) jumps to one of the six sequence positions (SEQUENCE 1 through 6) if the limit test passes. This command executes any sequence residing in the selected position. Sequences may jump to themselves as well as to any of the other sequences in memory. When this softkey is pressed, the HP 8753B presents a softkey menu showing the six sequence positions, and the titles of the sequences located in them. Choose the sequence to be called if the limit test passes (destination sequence).

[IF LIMIT TEST FAIL] (IFLTFAIL) jumps to one of the six sequence positions (SEQUENCE 1 through 6) if the limit test fails. This command executes any sequence residing in the selected position. Sequences may jump to themselves as well as to any of the other sequences in memory. When this softkey is pressed, the HP 8753B presents a softkey menu showing the six sequence positions and the titles of the sequences located in them. Choose the destination sequence to be called if the limit test fails.

[LOOP COUNTER] (LOOC) sets the value of the loop counter. Enter any number from 0 to 32767 and terminate with the **[x1]** key. The default value of the counter is zero. This command should be placed in a sequence that is separate from the measurement sequence. For this reason: the measurement sequence containing a loop decision command must call itself in order to function. The ***[LOOP COUNTER]*** command must be in a separate sequence or the counter value would always be reset to the initial value.

[INCR LOOP COUNTER] (INCRLOOC) increments the value of the loop counter by 1.

[DECR LOOP COUNTER] (DECRLOOC) decrements the value of the loop counter by 1.

[IF LOOP COUNTER = 0] (IFLCEQZE) prompts the user to select a destination sequence position (SEQUENCE 1 through 6). When the value of the loop counter reaches zero, the sequence in the specified position will run.

[IF LOOP COUNTER <> 0] (IFLCNEZE) prompts the user to select a destination sequence position (SEQUENCE 1 through 6). When the value of the loop counter is no longer zero, the sequence in the specified position will run.

Sequencing Special Function More Menu

Figure 13-11 shows the commands available in this menu.

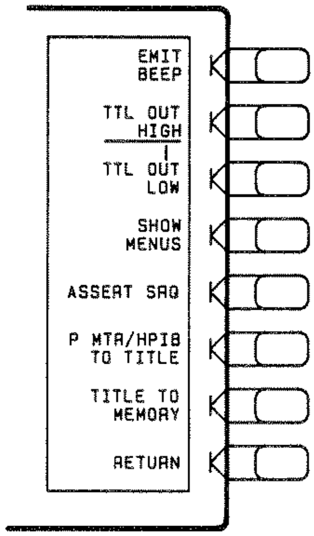


Figure 13-11. Sequencing Special Function More Menu

[EMIT BEEP] (EMIB) causes the instrument to beep once.

[TTL OUT HIGH] (TTLOH) sets the TTL output BNC on the back of the HP 85047A high.

[TTL OUT LOW] (TTLOL) sets the TTL output BNC on the back of the HP 85047A low.

[SHOW MENUS] (SHOM) used to display a specific menu prior to a pause statement.

Normally, the sequence list does not show menu softkeys. When ***[SHOW MENUS]*** is entered into a sequence, subsequent menu names will appear in the sequence list until a key is pressed that actually performs a function.

[ASSERT SRQ] (ASSS) sends an SRQ (service request) to the system controller.

[P MTR/HPIB TO TITLE] (PMTRTTIT) gets data from an HP-IB device set to the address at which the HP 8753B expects to find a power meter. The data is stored in a title string. The HP 8753B must be in system controller or pass control mode.

The external device should be given an interrogation command with the ***[TITLE TO P MTR/HPIB]*** or ***[TITLE TO PRINTER]*** command. When ***[P MTR/HPIB TO TITLE]*** is sent, the HP 8753B will wait indefinitely (or until **[LOCAL]** is pressed) for a string of up to 80 characters. The HP 8753B expects an EOI or line feed as a string terminator. This command can be used in conjunction with ***[TITLE TO MEMORY]***, below.

[TITLE TO MEMORY] (TITTMEM) moves the title string data obtained with the ***[P MTR/HPIB TO TITLE]*** command into a data array. ***[TITLE TO MEMORY]*** strips off leading characters that are not numeric, reads the numeric value, and then discards everything else. The number is converted into HP 8753B internal format, and is placed into the real portion of the memory trace at:

Display point = total points − 1 − loop counter

If the value of the loop counter is zero, then the title number goes in the last point of memory. If the loop counter is greater than or equal to the current number of measurement points, the number is placed in the first point of memory. A data to memory command must be executed before using the title to memory command.

[RETURN] returns to the sequencing special functions menu.

HP-GL CONSIDERATIONS

HP-GL Commands Can Be Entered Locally, or Be Included in a Sequence

HP-GL (Hewlett-Packard Graphics Language) can create customized messages or illustrations on the screen of the HP 8753B. To use HP-GL, the instrument must be in system controller mode.

HP-GL commands should be entered into a title string using the **[DISPLAY]** *[MORE]* *[TITLE]* and character selection menu.

The ***[TITLE TO P MTR/HPIB]*** or ***[TITLE TO PRINTER]*** sequencing commands send the HP-GL command string to the instrument's HP-GL address. The HP 8753B needs no HP-IB cables connected to it to perform HP-GL commands. The address of the HP 8753B HP-GL graphics interface is always offset from the instrument's HP-IB address by 1:

- If the current instrument address is an even number:
  HP-GL address = instrument address +1.
- If the current instrument address is an odd number:
  HP-GL address = instrument address −1.

Special Commands Required for HP-GL

Two HP-GL commands require special consideration when used in local operation or in sequencing. These are explained below:

Plot Absolute (HP-GL command: PA). The syntax for this command is PAx,y where x and y are screen location coordinates separated by a comma. The title function on the HP 8753B does not have a comma, so the HP 8753B allows x and y coordinates to be separated with a forward slash "/".

Label (HP-GL command: LB). The syntax for this command is LB[text][etx]. The label command will print ASCII characters until the etx command is seen. The etx is the ASCII value 3 (not the ASCII character 3).

The HP 8753B title function does not have the ASCII value 3, so the instrument allows the LB command to be terminated with the ***[END OF LABEL]*** command (accessed by pressing **[DISPLAY]** ***[MORE]*** ***[TITLE]*** ***[MORE]*** ***[END OF LABEL]***).

HP-GL is described in Appendix D of the *HP-IB Quick Reference Guide* and in *Example 3, User Interface,* in the *HP-IB Introductory Programming Guide.*

ENTERING SEQUENCES USING HP-IB

A sequence can be created in a computer controller using HP-IB codes and entered into the HP 8753B over HP-IB. The process is the same a entering a sequence locally – the same keystrokes are used. This method replaces the keystrokes with HP-IB commands. The following is a procedure for entering a sequence over HP-IB:

1. Send the HP-IB command NEWSEQx where x is a number from 1 to 6.
2. Send the HP-IB commands for the measurement.
3. Terminate with the HP-IB command DONM (done modify).

READING SEQUENCES USING HP-IB

An external controller can read the commands in any sequence (in HP-IB command format). Send the following command to the HP 8753B:

OUTPSEQx where x is a number from 1 to 6.

Allocate an adequate amount of string variable space in the external controller and execute an ENTER statement.

DECISION-MAKING SEQUENCE EXAMPLES

Limit Test Example Sequence:

This example assumes limit line setup commands have been entered earlier in the sequence:

Keys Pressed	Sequence List On Screen	Explanation
[SYSTEM] *[LIMIT MENU]*		
[LIMIT LINE ON]	LIMIT LINE ON	Turn on previously set up limit lines.
[LIMIT TEST ON]	LIMIT TEST ON	Turn limit testing on.
[MEAS] *[B/R]*	B/R	Measurement commands.
[SCALE REF]	SCALE/DIV	
[2] [x1]	2 x1	
[MENU] *[TRIGGER MENU]* *[SINGLE]*	SINGLE	Update the data and limit test.
[SYSTEM] *[SEQUENCING MENU]* *[SPECIAL FUNCTIONS]* *[DECISION MAKING]*		
[IF LIMIT TEST PASS] *[SEQUENCE 4 SEQ4]*	IF LIMIT TEST PASS THEN DO SEQUENCE 4	Jump to the sequence in sequence position 4 if the limit test passes.
[RETURN] *[MORE]* *[EMIT BEEP]*	EMIT BEEP	Test failed, beep to inform operator.
[RETURN] *[PAUSE]*	PAUSE	Pause to let the operator change DUT.
[RETURN] *[DO SEQUENCE]* *[SEQUENCE 1 SEQ1]*	DO SEQUENCE SEQUENCE 1	Jump back to the start of this sequence.
[DONE MODIFY]		Exit the modify (edit) mode.

Loop Counter Example Sequence:

Initial Sequence Position and Title: SEQUENCE 1 SEQ1

Key Pressed	Sequence List On Screen	Explanation
[SYSTEM] *[SEQUENCING MENU]* *[NEW SEQ/MODIFY SEQ]* *[SEQUENCE 1 SEQ1]*	Start of Sequence	Enter modify (edit) mode.
[RECALL] *[RECALL PRST STATE]*	RECALL PRST STATE	Preset the instrument
[MEAS] *[Trans: FWD S21 (B/R)]*	Trans: FWD S21 (B/R)	Set up an S21 measurement
[LOCAL] *[SYSTEM CONTROLLER]*	SYSTEM CONTROLLER	Set the HP 8753B to system controller mode
[SET ADDRESSES] *[ADDRESS: PRINTER]* [1] [x1]	ADDRESS: PRINTER 1 x1	Set the HP 8753B's address for the printer
[SYSTEM] *[SEQUENCE MENU]* *[SPECIAL FUNCTIONS]* *[DECISION MAKING]* *[LOOP COUNTER]* [5] [x1]	LOOP COUNTER 5 x1	Set loop counter value to 5
[RETURN] [RETURN] *[DO SEQUENCE]* *[SEQUENCE 2 SEQ2]*	DO SEQUENCE SEQUENCE 2	Jump to the sequence in sequence position 2
[DONE MODIFY]		Leave the modify (edit) mode.

Second Sequence Position and Title: SEQUENCE 2 SEQ2

Key Pressed	Sequence List On Screen	Explanation
[SYSTEM] *[SEQUENCING MENU]* *[NEW SEQ/MODIFY SEQ]* *[SEQUENCE 1 SEQ1]*	Start of Sequence	Enter modify (edit) mode.
[DISPLAY] *[MORE]* *[TITLE]*	TITLE	Enter the title "DUT[LOOP]"*
Press *[ERASE TITLE]*. Enter "DUT" with knob and *[SELECT LETTER]*. Press *[MORE]* *[LOOP COUNTER]* *[RETURN] [DONE]*	DUT[LOOP]*	Create customized title.
[SYSTEM] *[SEQUENCING MENU]* *[SPECIAL FUNCTIONS]* *[PAUSE]*	SYSTEM PAUSE	The operator should connect or change the DUT

* When the test results are printed, each title will have a different numeric value at the end (DUT00005, DUT00004, DUT00003, DUT00002, and DUT00001). Note that the loop counter value always contains five digits.

Key Pressed	Sequence List On Screen	Explanation
[MENU] *[TRIGGER MENU]*		
[SINGLE]	SINGLE	Take a sweep to update the data
[COPY] [PRINT]	PRINT	Results are printed with title DUTx (x=loop #)
[SYSTEM] *[SEQUENCING MENU]* *[SPECIAL FUNCTIONS]* *[DECISION MAKING]*		
[DECR LOOP COUNTER]	DECR LOOP COUNTER	Decrement loop counter
[IF LOOP COUNTER <> 0]	IF LOOP COUNTER <> 0 THEN DO SEQUENCE 2	If the value of the loop counter is not equal to zero, loop back and test another DUT.
[DISPLAY] *[MORE] [TITLE]*	TITLE	If loop counter = zero, exit loop and display "TEST IS FINISHED"
Press *[ERASE TITLE]*. Enter "TEST IS FINISHED" with knob and *[SELECT LETTER]* softkey. Press *[DONE]*	TEST IS FINISHED	"TEST IS FINISHED" is displayed on the screen
[SYSTEM] *[SEQUENCING MENU]* *[DONE MODIFY]*		Exit modify (edit) mode.

Chapter 14. Instrument Modes, 6 GHz, Frequency Offset, and Harmonic Operation

CHAPTER CONTENTS

INTRODUCTION

This chapter describes the three major instrument modes of the HP 8753B:

- Network analyzer mode
- External source mode
- Tuned receiver mode

In addition, three features are described:

- Frequency offset operation
- 6 GHz mode operation (option 006 only)
- Harmonic mode operation (option 002 only)

For each of these topics, the following information is provided:

- The primary measurement application in which each mode or feature is used.
- A complete description of each mode or feature with a typical test setup.
- Formulas for calculating spurious signal passbands for external source mode, tuned receiver mode, and for frequency offset operation.

All of the features described in this chapter are accessible under the **[SYSTEM]** key. Figure 14-1 shows the relationship of the menus described in this chapter.

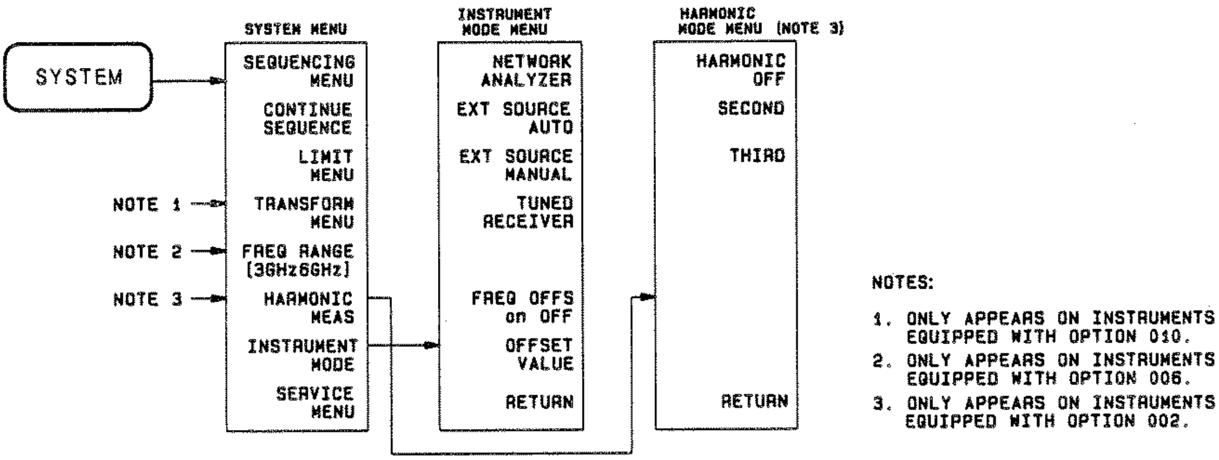


Figure 14-1. Relationship of Applicable [SYSTEM] Key Menus

Instrument Modes

INSTRUMENT MODE OVERVIEW

There are three major modes of operation in the HP 8753B:

Network Analyzer Mode

This is the standard mode of operation for the HP 8753B, and is active after preset or power-on. Network analyzer mode in the HP 8753B is similar to the operation of the HP 8753A.

External Source Mode

This mode allows the HP 8753B to phase lock to an external CW signal. External source mode has the following features and limitations:

- It is phase-locked.
- It functions only in CW time sweep.
- It does not require a synthesized source.

The external source's signal should not have large sidebands or spurs.

Tuned Receiver Mode

In tuned receiver mode, the HP 8753B receiver operates independently of any signal source. The following features and limitations apply to the tuned receiver mode:

- It is not phase-locked
- It functions in all sweep types
- It requires a synthesized CW source
- It is much faster than external source mode

Getting to the Instrument Mode Menu

Pressing **[SYSTEM]** *[INSTRUMENT MODE]* brings up the instrument mode menu, illustrated in Figure 14-2.

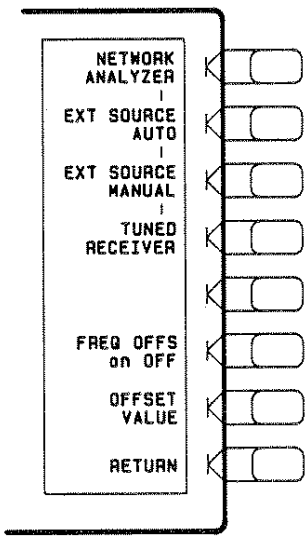


Figure 14-2. Instrument Mode Menu

[NETWORK ANALYZER] returns the HP 8753B to the "normal" network analyzer operating mode. This mode uses the HP 8753B built-in source.

[EXTERNAL SOURCE AUTO] turns on the external source auto mode. This mode allows the HP 8753B to phase lock to an external CW signal. This works only in CW time sweep. The incoming signal should not have large spurs or sidebands, as the HP 8753B may phase lock on a spur instead of the fundamental. The auto mode has a wider capture range than the manual mode. Refer to *External Source Mode* for details.

[EXTERNAL SOURCE MANUAL] Turns on the external source manual mode. This mode has a smaller capture range than the auto mode. However, manual mode is much faster than auto mode. This feature works only in CW time sweep type.

[TUNED RECEIVER] The HP 8753B receiver operates independently of any signal source. This mode is not phase locked and functions in all sweep types. The HP 8753B tunes the receiver for a synthesized CW input signal at a precisely specified frequency. All phase lock routines are bypassed, increasing sweep speed significantly. The external source must be synthesized, and must drive the HP 8753B's external frequency reference.

[FREQ OFFS on OFF] (frequency offset operation) allows phase-locked operation with a frequency offset between the internal source and receiver. Frequency offset is not an instrument mode, it is a feature accessible in the network analyzer mode. This feature is used in swept RF mixer measurements and has an upper frequency limit of 3 GHz.

[OFFSET VALUE] Press this softkey to enter the offset (LO) frequency for frequency offset operation.

NETWORK ANALYZER MODE

The network analyzer mode is the standard mode of operation for the HP 8753B, and is active at power-on or preset.

EXTERNAL SOURCE MODE

The receiver (input R) detects and phase locks to an externally generated CW signal. Receiver inputs A and B can measure this same frequency for comparison or tracking measurements. Two types of external source operation are provided, automatic and manual. Refer to the *External Source Mode In-Depth Description* on the next page.

If a synthesized external source is used, the tuned receiver mode is recommended because it is faster. External source mode is best used for unknown signals, or for signals that drift.

Primary Applications

External source mode is useful in several applications:

- When the DUT is a mixer or other frequency translation device.
- In automated test applications where a source is already connected to the system, and the operator does not wish to switch between the system source and the HP 8753B's internal source.
- When an HP 8753B option 006 is used above 3 GHz without an HP 85047A test set. (This requires an external source and signal separation device.)

Typical Test Setup

Figure 14-3 shows a typical test setup using the external source mode. The same test setup is applicable to either manual or automatic external source mode operation.

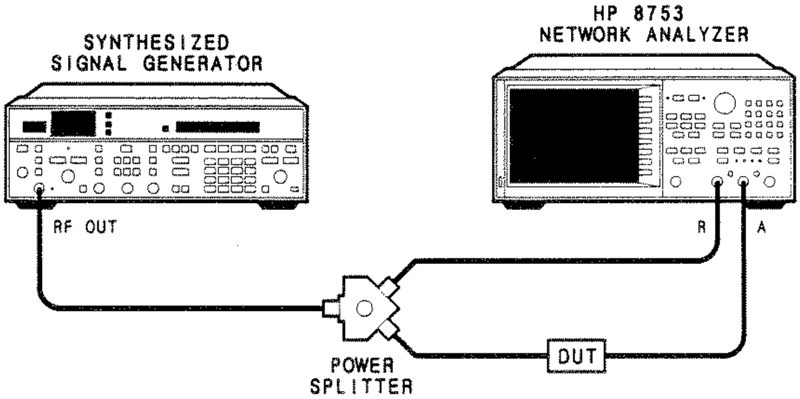


Figure 14-3. Typical Test Setup for External Source Mode

External Source Mode In-Depth Description

External source may be used in automatic or manual mode. External source mode phase locks the HP 8753B to an external CW signal. This feature only works in CW time sweep.

External Source Auto. The external source auto mode searches for the incoming CW signal. The capture range is typically 10% of the selected CW frequency. The manual mode is faster than the auto mode. The frequency the instrument has locked onto is displayed on the CRT, and is also available via HP-IB.

The external source should not exhibit noise or significant sidebands, as this may cause the 8753B to phase lock on a spur or not lock at all.

External Source Manual. The incoming signal should not have large spurs or sidebands for the reasons explained above. This mode is faster than the auto mode, but it does not search for the incoming signal. The frequency of the incoming signal should be within −0.5 to +5.0 MHz of the selected frequency or the HP 8753B will not be able to phase lock to it.

Frequency Range. 300 kHz to 3 GHz (6 GHz for option 006)

Compatible Sweep Types. The external source mode will only function in CW time sweep. If the instrument is in any other sweep type when external source is activated, the warning message "CHANGED TO CW TIME MODE" will appear on the display.

External Source Requirements. The external source mode has spectral purity and power input requirements, which are described in the specifications table in the *General Information and Specifications* section of his manual.

Input Channels: R, A, B

Capture Range. In either automatic or manual mode, the operator enters the frequency of the external CW signal using the ***[CW FREQ]*** softkey (located under the Stimulus **[MENU]** key). The actual signal must be within a certain frequency capture range.

External Source Capture Ranges

Automatic Mode	
Above 50 MHz: Below 50 MHz:	±10% of nominal CW frequency ±5 MHz of nominal CW frequency
Manual Mode	
All frequencies	−0.5 to +5 MHz of nominal CW frequency

If the incoming signal is not within the capture range, the HP 8753B will not phase lock properly. Also, the signal should not be sweeping.

Locking Onto a Signal with a Frequency Modulation Component. Although the HP 8753B may phase-lock onto a signal with FM on it, it may not accurately show the signal's amplitude. The accuracy of such measurements depends greatly on the chosen IF bandwidth. Use the widest IF bandwidth available (3 kHz) if this problem occurs.

Spurious Signal Passband Frequencies. Because of the characteristics of the sampler, spurious signals present at certain frequencies can cause measurement inaccuracy. These frequencies can be calculated. Refer to *Spurious Signal Passbands In External Source Mode, Tuned Receiver Mode, and Frequency Offset Operation* at the end of this chapter.

TUNED RECEIVER MODE

In tuned receiver mode, the HP 8753B's receiver operates independently of any signal source. This mode is not phase locked and functions in all sweep types. The HP 8753B tunes the receiver to a synthesized CW input signal at a precisely specified frequency. All phase lock routines are bypassed, increasing sweep speed significantly. The external source must be synthesized, and must drive the HP 8753B external frequency reference.

Primary Applications

The tuned receiver mode is useful for:

- Automated test applications where an external synthesized source is available.
- In applications where speed is important. This mode does not phase lock and is much faster than the external source mode.

Typical Test Setup

Figure 14-4 shows a typical test setup using tuned receiver mode in a CW measurement. The incoming signal can be input to either the A, B, or R inputs. Inputs A and B have greater dynamic range.

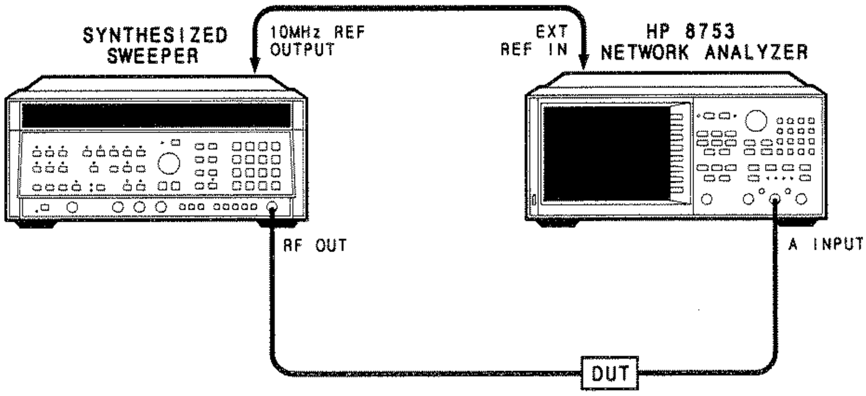


Figure 14-4. Typical Test Setup for Tuned Receiver Mode

The tuned receiver mode is typically used in CW applications. An example of non-CW operation is a third order intermodulation measurement using list mode, manual trigger, and an external synthesized source. Refer to the third order intermodulation measurement description in product note 8753-1, *Amplifier Measurements with the HP 8753*, HP part number 5956-4361.

Tuned Receiver Mode In-Depth Description

Frequency Range. 300 kHz to 3 GHz (6 GHz for option 006)

Compatible Sweep Types. All sweep types may be used.

External Source Requirements. The tuned receiver mode has the following input requirements:

Input: A, B, or R

Input power range specifications are provided in the specifications table, located in the *General Information and Specifications* section of this manual.

Spurious Signal Passband Frequencies. Because of the characteristics of the sampler, spurious signals present at certain frequencies can cause measurement inaccuracy. These frequency passbands in the sampler can be calculated. Refer to *Spurious Signal Passbands In External Source Mode, Tuned Receiver Mode, and Frequency Offset Operation* at the end of this chapter.

Other Features Available Under the System Key

FEATURE OVERVIEW

Three features are described:

- Frequency offset operation
- 6 GHz operation (option 006 only)
- Harmonic operation (option 002 only)

The applicable system-related softkeys are shown in Figure 14-1, at the beginning of this chapter.

Frequency Offset Operation

Sets the RF source to a fixed offset frequency above the receiver as required in a mixer test using a swept RF/IF and fixed LO. This allows a device to be stimulated over one frequency range and its response to be viewed over another. Frequency offset can be used in any sweep type, and in external source or tuned receiver instrument modes.

6 GHz Operation (Option 006 Only)

6 GHz operation is activated by the ***[FREQ RANGE 3GHz6GHz]*** softkey. This feature toggles the receiver between two frequency ranges:

- 300 kHz to 3 GHz
- 3 MHz to 6 GHz

The frequency range softkey appears only on an HP 8753B equipped with option 006, and then only when connected to an HP 85047A 6 GHz test set. The receiver may be used up to 6 GHz without the HP 85047A test set, in external source or tuned receiver modes or in harmonic operation. 6 GHz operation can be used in any sweep type or instrument mode.

Harmonic Measurements (Option 002 Only)

The harmonics feature measures the second or third harmonic as the HP 8753B source sweeps fundamental frequencies above 16 MHz. Harmonic measurements may be made in any sweep type or instrument mode.

FREQUENCY OFFSET OPERATION

This sets the RF source to a fixed offset frequency above the receiver as required in a mixer test using a swept RF/IF and fixed LO. This allows a device to be stimulated over one frequency range and its response to be viewed over another. The maximum delay between the RF source and the R input is 3 microseconds. The displayed signal is a composite of the desired RF signal, image response, and spurious signals.

Frequency offset can be used in any sweep type in network analyzer mode. The two user-defined variables in this mode are receiver frequency (IF) and offset frequency (LO). Source frequency (RF) is automatically set by the instrument and equals IF + LO.

Mixer measurements and frequency offset mode applications are explained in application note 8753-2, *RF Component Measurements – Mixer measurements using the HP 8753B network analyzer*, HP part number 5956-4362.

Primary Applications

Frequency offset mode is useful for the following types of measurements on a frequency-translating device:

- Conversion loss
- Conversion compression
- Amplitude and phase tracking

Typical Test Setup

Figure 14-5 shows a typical test setup using frequency offset mode. Instructions are provided in *Using Frequency Offset Mode*. The attenuators shown reduce mismatch uncertainties. The low pass filter keeps unwanted mixing products out of the HP 8753B sampler.

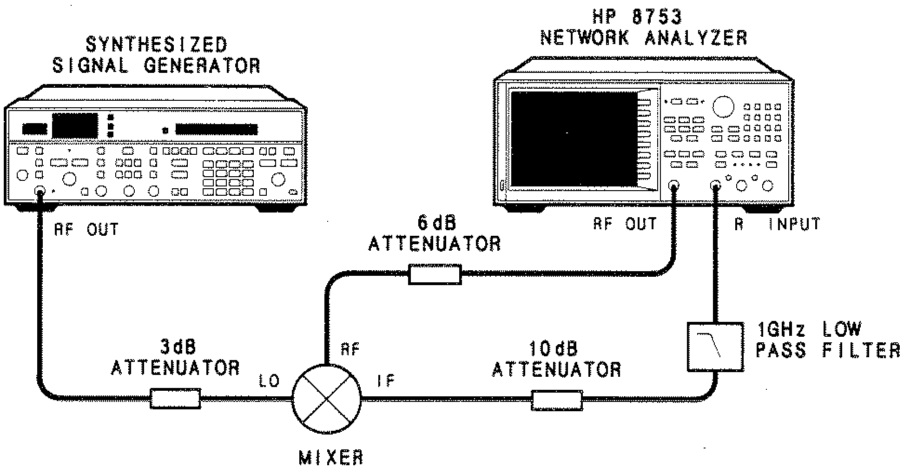


Figure 14-5. Typical Test Setup for a Frequency Offset Measurement

Frequency Offset In-Depth Description

In frequency offset operation, the source and the receiver operate at two different frequencies. The difference between the source and receiver frequencies is the user-specified offset frequency.

The two user-defined variables in frequency offset are the receiver (IF) frequency, and the offset (LO) frequency. The source frequency (RF) is automatically set by the instrument and equals IF + LO.

- **The receiver frequency (IF)** is the CW or start and stop frequencies chosen by the operator. These are entered in the normal way using the ***[CW FREQ]*** softkey or **[START]** and **[STOP]** keys. It is very important to understand that the stimulus values only affect the receiver (IF). The CRT always displays IF frequencies.

- **The offset frequency (LO)** is the difference between the source and receiver frequencies.

NOTE: The HP 8753B source locks to the IF + LO frequency, regardless of the selected offset value. Once the source is phase locked and sweeping, the HP 8753B source frequency is not known precisely. As the LO frequency changes, the source tracks it to maintain the requested IF frequency (the receiver start/stop or CW frequency).

Frequency Hierarchy. The source frequency must be greater than the LO frequency, and both source and LO frequencies must be greater than the receiver frequency. This means that the frequency offset mode can only measure the lower of the two IF mixing products (lower sideband).

Example:

Right (lower sideband)	Wrong (upper sideband)
Source frequency (RF) = 3 GHz	Source frequency (RF) = 3 GHz
Offset frequency (LO) = 2.5 GHz	Offset frequency (LO) = 0.5 GHz
Receiver frequency (IF) = 0.5 GHz	Receiver frequency (IF)= 2.5 GHz

Frequency Ranges. Receiver (IF) frequency range = 300 KHz to 2.984 GHz.
Minimum recommended offset (LO) frequency = 16 MHz.

The receiver frequency plus the offset frequency cannot exceed 3 GHz. (This is because the source must be able to supply the sum of the receiver frequency plus the offset frequency.) If the operator enters IF and LO frequencies that would require >3 GHz from the source, the HP 8753B automatically limits the requested IF frequency.

Compatible Instrument Modes and Sweep Types. Frequency offset is compatible with all sweep types in network analyzer mode.

Receiver and Source Requirements. Refer to the specifications table located in the *General Information and Specifications* section of this manual.

IF Input: A, B, or R

CRT Annotations. The annotation "ofs" is displayed when the frequency offset mode is on. The annotation "of?" indicates that the source frequency is approximately ≥10 MHz away from the sum of the requested IF and LO frequencies. This is most likely caused by the LO frequency being outside the −1 to +5 MHz accuracy requirement.

Error Message. If the operator connects a DUT before turning on the frequency offset function, the error message "PHASE LOCK CAL FAILED" will appear on the screen. This is normal, and will go away when the ***[FREQ OFFS on OFF]*** softkey is pressed.

Spurious Signal Passband Frequencies. Because of the characteristics of a sampler, unwanted mixing products (or spurious LO signals) at specific frequencies can cause measurement inaccuracy. These specific frequencies can be calculated. Refer to *Spurious Signal Passbands In External Source Mode, Tuned Receiver Mode, and Frequency Offset Operation*, at the end of this chapter. A low pass filter on the DUT's IF output can reduce unwanted mixing products going to the sampler.

Using Frequency Offset Mode

Activate frequency offset mode using the following sequence:

1. Press ***[FREQ OFFS on OFF]*** to turn on the frequency offset mode.
2. Connect the DUT and set the external LO source to the desired frequency and power level.
3. Set the receiver (IF) frequencies using the ***[CW FREQ]*** softkey or **[START]** and **[STOP]** keys. Set the output power of the RF source and select the input (R, A, or B).
4. Set the offset (nominally the LO frequency) using the ***[OFFSET VALUE]*** softkey.

Example Measurement. The following example measures conversion loss in a typical mixer application. The frequencies to be used in this measurement are:

RF = 1400 MHz (automatically set by the HP 8753B)
LO = 800 MHz (entered by the operator using the ***[OFFSET VALUE]*** softkey)
IF = 600 MHz (entered by the operator using the stimulus keys)

Remember that during frequency offset measurements the HP 8753B displays IF frequencies on the CRT.

1. Press **[PRESET]** on the front panels of the HP 8753B and local oscillator (LO) source.

2. Press ***[FREQ OFFS on OFF]*** to activate the frequency offset mode. Connect the equipment as shown in Figure 14-5.

NOTE: If you connect the DUT before turning on frequency offset, the error message "PHASE LOCK CAL FAILED" may be displayed. This is normal, and will go away when frequency offset mode is turned on.

3. Set the LO signal generator to a CW frequency of 800 MHz at +13 dBm.

4. From the front panel of the HP 8753B, set the IF frequency and RF source output power. Select the R input.

   [MENU]
   [CW FREQ] [6] [0] [0] [M/u]
   [POWER] **[6] [x1]**
   [MEAS] ***[R]***

5. Enter the LO (offset) frequency.

   [SYSTEM] ***[INSTRUMENT MODE]***
   [OFFSET VALUE] **[8] [0] [0] [M/U]**

6. Figure 14-6 shows the attenuated output power of the mixer's IF at the receiver. The conversion loss of the mixer is found by subtracting the attenuation from the total loss between the RF source and IF receiver.

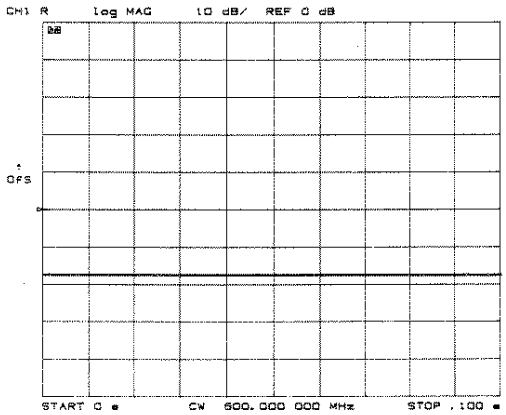


Figure 14-6. Mixer Output

Source power	=	6 dBm
Output power	=	−17.5 dBm
Total loss	=	23.5 dB
Total attenuation	=	16 dB
Conversion loss	=	7.5 dB

Refer to application note 8753-2, *RF Component Measurements – Mixer Measurements using the HP 8753B network analyzer* (HP part number 5956-4362), for more information and examples of mixer measurements.

6 GHz OPERATION (OPTION 006)

6 GHz operation is activated by the ***[FREQ RANGE 3GHz6GHz]*** softkey. The frequency range softkey appears only on an HP 8753B equipped with option 006, and then only when it is connected to an HP 85047A 6 GHz test set. The softkey appears in two instances:

- On the screen after power-on or instrument preset.
- Under the system menu as shown in Figure 14-1.

[FREQ RANGE 3GHz6GHz] (FREQRANG3GHZ, FREQRANGE6GHZ) toggles between two frequency ranges:

- 300 kHz to 3 GHz
- 3 MHz to 6 GHz

The current maximum frequency is highlighted in the softkey title. For example, when 300 kHz to 3 GHz is selected, the ***[3GHz]*** portion of the softkey title will be highlighted, while the ***[6GHz]*** portion will appear dim.

Compatible Instrument Modes

6 GHz operation works in all instrument modes: network analyzer, external source, and tuned receiver.

Activating 6 GHz Operation

In network analyzer mode, 6 GHz operation must be turned on directly with the ***[FREQ RANGE 3GHz6GHz]*** softkey, or by HP-IB command. It can not be activated by simply selecting frequencies above 3 GHz. If this is attempted, the message "3GHz MAX FREQ. USE FREQ RANGE KEY (UNDER SYSTEM)" will be displayed. This stipulation also applies to using frequencies above 3 GHz during frequency offset operation.

When activated, the power output of the internal source will automatically change to +20 dBm. Start and Stop frequencies change to 3 MHz and 6 GHz respectively. The reason the power level changes is explained under *RF Power Requirements*, below. When the operator changes the HP 8753B back to the 3 GHz mode, power changes to 0 dBm and Start/Stop frequencies change to 300 kHz and 3 GHz respectively. In addition, the sweep type changes to linear sweep.

When using an HP 8753B option 006 in external source mode, tuned receiver mode, or harmonic operation, frequencies above 3 GHz can be measured without turning on 6 GHz operation.

When 6 GHz mode is on, the status annotation "x2" is displayed on the CRT.

Doubler Switch Protection (Only Applies to the HP 85047A)

The HP 85047A S-parameter test set uses a frequency doubler to switch between 3 and 6 GHz operation. Because the doubler uses a mechanical switch, operations that would require repetitive switching between the two modes are not permitted. For this reason, 6 GHz mode is either on or off for both channels. There is no override for this protection feature.

RF Power Requirements

The doubler requires high, fixed power (+20 dBm). When the operator selects 6 GHz operation, the HP 8753B RF power output automatically changes to +20 dBm and the message "SOURCE FREQUENCIES AND POWER CHANGED" is displayed. If the operator then changes the source power, a warning message appears, and the status annotation changes from "x2" to "x2?"

Receiver-Only Use of the HP 8753B Option 006. Three modes allow the HP 8753B option 006 receiver to measure up to 6 GHz without an HP 85047A test set. Each mode can measure signals up to 6 GHz without activating the 6 GHz mode. (In fact, without the HP 85047A test set, the HP 8753B will not display the ***[FREQ RANGE 3GHz6GHz]*** softkey.)

Receiver-Only use in External Source and Tuned Receiver modes. The external source or tuned receiver modes allow the HP 8753B to measure frequencies up to 6 GHz without an HP 85047A test set. However, an external source and signal separation device must be supplied. Refer to *External Source Mode* or *Tuned Receiver Mode* descriptions in this chapter.

Receiver-Only use in Harmonic Mode (option 002). With option 002, harmonic operation, the fundamental frequency can not exceed 3 GHz. However, harmonic frequencies up to 6 GHz can be measured without activating 6 GHz operation. Receiver-only use is limited to simple transmission measurements. The HP 85047A test set is required for reflection measurements because its couplers can operate to 6 GHz. If using the 6 GHz test set, it should be left in the 3 GHz mode. Refer to *Harmonic Operation (Option 002 Only)* on the next page.

The second harmonic of fundamental frequencies up to 3 GHz can be measured, as well as the third harmonic of fundamental frequencies up to 2 GHz.

HARMONIC OPERATION (OPTION 002 ONLY)

The harmonic measurement mode measures the second or third harmonic as the HP 8753B source sweeps fundamental frequencies above 16 MHz.

Typical Test Setup

Figure 14-7 shows a typical test setup using the HP 85047A 6 GHz test set.

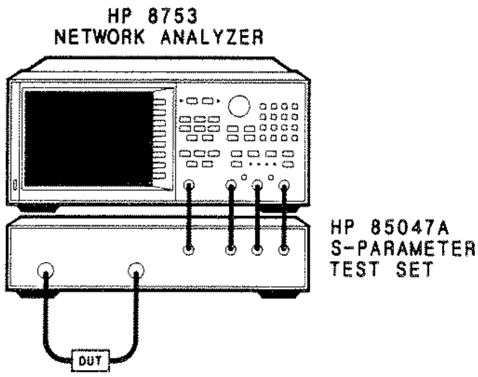


Figure 14-7. Typical Harmonic Mode Test Setup

When an HP 85047A Test Set Is Required

For measuring harmonic responses above 3 GHz, the HP 85047A 6 GHz test set is required for reflection measurements since its couplers work above 3 GHz. A test set is not required for a simple transmission measurement. This is because the selected frequency is the fundamental, which never exceeds 3 GHz. If using an HP 8753B option 006 with an HP 85047A test set, keep the HP 8753B in the 300 kHz to 3 GHz range.

Harmonic measurements may be made in any sweep type.

Single-Channel Operation

The second or third harmonic can be displayed alone using channel 1 or 2.

Dual-Channel Operation

To make the following types of measurements, channels 1 and 2 must be uncoupled, and dual channel must be turned on.

- The fundamental can be displayed on one channel while the second or third harmonic is displayed on the other channel.
- The second harmonic can be displayed on one channel while the third harmonic is displayed on the other.

- The *[D2/D1 toD2]* softkey allows the fundamental to be measured on channel 1 while the second or third harmonic is measured in dBc on channel 2.
- The *[COUPLE PWR ON off]* softkey couples power between channels 1 and 2. This is useful when using the D2/D1 to D2 feature; the user can change fundamental power and see the resultant change in the harmonic power.

The display (stimulus annotation and marker stimulus) will display the fundamental frequency. However, a marker in the active entry area will show the harmonic frequency in addition to the fundamental. If the harmonic mode is used, the annotation "H=2" or "H=3" will appear on the left-hand side of the display. The measured harmonic cannot not exceed the frequency limitations of the network analyzer's receiver.

Coupling Power Between Channels 1 and 2

[COUPLE PWR ON off] is intended for use with the *[D2/D1 toD2 on OFF]* softkey. The D2/D1 to D2 function is used in harmonic measurements, where the fundamental is displayed on channel 1 and the harmonic on channel 2. D2/D1 to D2 ratios the two, displaying the fundamental and the relative power of the measured harmonic in dBc. For these measurements, channels 1 and 2 must be uncoupled with the *[COUPLED CHAN ON off]* softkey set to OFF to allow alternating sweeps.

After uncoupling channels 1 and 2, you may wish to change the fundamental power and see the resultant change in relative harmonic power (in dBc). *[COUPLE PWR ON off]* allows the operator to change the power of both channels simultaneously, even though they are uncoupled in all other respects.

Frequency Range

The frequency range is determined by the upper frequency range of the instrument or system (3 or 6 GHz) and by the harmonic being displayed. 6 GHz operation requires an HP 8753B option 006. The following table shows the highest fundamental frequency for maximum frequency and harmonic mode.

	Maximum Frequency	
	3 GHz	**6 GHz (Option 006)**
2nd Harmonic	1.5 GHz	3 GHz
3rd Harmonic	1.0 GHz	2.0 GHz

Example: A standard HP 8753B has a maximum frequency range of 3 GHz. If the second harmonic is being measured, the highest fundamental frequency allowed is 1.5 GHz.

Accuracy and Input Power

Refer to the specifications table located in the *General information and specifications* section of this manual. Related specifications are the maximum recommended input power and maximum recommended source power.

Using power levels greater than the recommended values causes undesired harmonics in the source and receiver. The recommended power levels ensure that these harmonics are less than 45 dBc. Use port attenuation in an S-parameter test set to limit the input power to the DUT.

Harmonic Measurement Menu

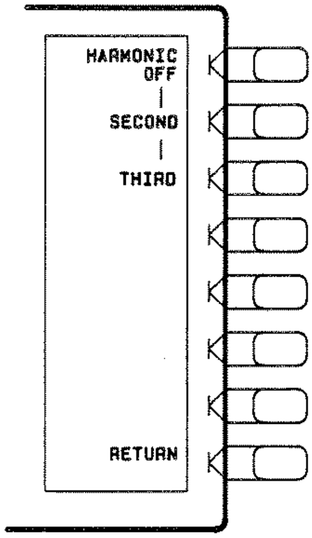


Figure 14-8. Harmonic Measurement Menu

[HARMONIC OFF] (HARMOFF) turns off the harmonic measurement mode.

[SECOND] (HARMSEC) selects measurement of the second harmonic.

[THIRD] (HARMTHIR) selects measurement of the third harmonic.

[RETURN] goes back to the system menu.

Getting to the *[D2/D1 toD2]* or *[COUPLE PWR ON off]* Softkeys.

- Press **[DISPLAY]** ***[MORE] [MORE]*** to access the ***[D2/D1 toD2]*** softkey.
- Press **[MENU]** ***[POWER]*** to access the ***[COUPLE PWR ON off]*** softkey.

SPURIOUS SIGNAL PASSBANDS IN EXTERNAL SOURCE MODE, TUNED RECEIVER MODE, AND FREQUENCY OFFSET OPERATION

The external source mode, tuned receiver mode, and frequency offset feature respond to spurious signals at certain passband frequencies. A signal at any of these frequencies affects the accuracy of the measurement. Filters can be used to reduce the effect of spurious signals at passband frequencies. Refer to the following information to calculate the passband frequencies.

Calculating the Spurious Signal Passband at RF Frequencies Below 16 MHz

Below 16 MHz, spurious signals in a single frequency range will affect the accuracy of measurements. This frequency range is centered around the selected RF frequency, and is the width of the selected IF bandwidth.

Spurious signal Passband = RF $\pm$ 0.5 x IF Bandwidth

For example: A 10 MHz signal is measured with an IF bandwidth of 1 kHz. The spurious signal passband = 10 MHz $\pm$ 500 Hz

Calculating Susceptible Spurious Signal Frequencies at RF Frequencies Above 16 MHz

Above 16 GHz, there are a series of frequencies at which spurious signals will affect the accuracy of the measurement. The following information explains how to calculate these frequencies.

The variables in this calculation are:

n = numbers 1 through 300.
FN = fractional-N frequency (calculate as explained later)

The basic formula is:

Spurious Signal frequencies = (n x FN) + 1 MHz

The calculation must be repeated with n values from 1 to 300. This will provide the frequency of all significant spurious passbands.

Calculating FN. FN is dependent upon RF frequency, the Mth harmonic number, and the IF frequency. The formula is:

$$FN = \frac{RF - IF}{\text{Mth Harmonic}}$$

Convenient lookup tables are provided so the operator may easily find IF and Mth harmonic values.

Three lookup tables are provided because the values of IF and Mth harmonic depend on if the harmonics operation (option 002) mode is turned on. The three tables are:

- Table 14-1, Harmonics Mode Off
- Table 14-2, Harmonics Mode On, Second Harmonic Selected (option 002 only)
- Table 14-3, Harmonics Mode On, Third Harmonic Selected (option 002 only)

Using a table. The following are instructions for using the FN lookup tables.

1. Choose the proper table given non-harmonic, second harmonic, or third harmonic mode.
2. Find the appropriate RF frequency row.
3. Look in the IF and Mth harmonic columns for the applicable values.

Example Passband Calculation for a CW Frequency Above 16 MHz

In this example, harmonics mode is off and the RF frequency is 62 MHz. Table 14-1 indicates an IF value of 1 MHz and an Mth harmonic value of 2.

$$\text{FN} = \frac{\text{RF} - \text{IF}}{\text{Mth Harmonic}}$$

$$\frac{62\text{ MHz} - 1\text{ MHz}}{2} = \mathbf{30.5\ MHz}$$

Now using the formula for determining spurious passbands:

Passband Frequencies = (n x FN) + 1 MHz
(where n = 1 to 300)

(1 x 30.5 MHz) + 1 MHz = **31.5 MHz**

(2 x 30.5 MHz) + 1 MHz = **62 MHz**

(3 x 30.5 MHz) + 1 MHz = **92.5 MHz**

and so on...

Table 14-1. IF and Mth Harmonic Values with Harmonic Mode Off (Or if Option 002, Harmonic Operation, is Not Installed)

RF (MHz)	Mth Harmonic	IF (MHz)
≥16 to <61	1	1
≥61 to <121	2	1
≥121 to <178	3	1
≥178 to <296	5	1
≥296 to <536	9	1
≥536 to <893	15	1
≥893 to <1607	27	1
≥1607 to <3060	51	1
≥3060 to 6000	101	1

Table 14-2. IF and Mth Harmonic Values with Harmonic Mode On, Second Harmonic Selected

RF (MHz)	Mth Harmonic	IF (MHz)
≥15.5 to <60.5	1	0.5
≥60.5 to <120.5	2	0.5
≥120.5 to <177.5	3	0.5
≥177.5 to <295.5	5	0.5
≥295.5 to <535.5	9	0.5
≥535.5 to <892.5	15	0.5
≥892.5 to <1606.5	27	0.5
≥1606.5 to <3059.5	51	0.5
≥3059.5 to 6000	101	0.5

Table 14-3. IF and Mth Harmonic Values with Harmonic Mode On, Third Harmonic Selected

RF (MHz)	Mth Harmonic	IF (MHz)
≥15.333 to <60.333	1	0.333
≥60.333 to <120.333	2	0.333
≥120.333 to <177.333	3	0.333
≥177.333 to <295.333	5	0.333
≥295.333 to <535.333	9	0.333
≥535.333 to <892.333	15	0.333
≥892.333 to <1606.333	27	0.333
≥1606.333 to <3059.333	51	0.333
≥3059.333 to 6000	101	0.333

Appendix A

PRESET STATE

When the **[PRESET]** key is pressed, the HP 8753B reverts to a known state. This state is defined in Table A-1, below. There are subtle differences between the preset state and the power-up state. These differences are documented in Table A-2. If power to non-volatile memory is lost, the HP 8753B will have certain parameters set to default settings. Table A-3 shows the affected parameters.

When line power is cycled, or the **[PRESET]** key pressed,the HP 8753B performs a self-test routine. Upon successful completion of that routine, the instrument state is set to the following preset conditions. The same conditions are true following a "PRES;" or "RST;" command over HP-IB, although the self-test routines are not executed.

Table A-1. Preset Conditions (1 of 2)

Operating Parameter	Preset Value	Operating Parameter	Preset Value
Analyzer Mode		CONVERSION	off
ANALYZER MODE	Network Analyzer Mode	FORMAT	log magnitude (all inputs)
FREQUENCY OFFSET OPERATION	off	DISPLAY	data
OFFSET VALUE	0	DUAL CHANNEL	off
HARMONIC OPERATION	off	ACTIVE CHANNEL	channel 1
3 GHz/6 GHz OPERATION	3 GHz	FREQUENCY BLANK	disabled
Stimulus Conditions		SPLIT DISPLAY	on
SWEEP TYPE	linear frequency	INTENSITY	If set to ≥15%, **[PRESET]** has no effect. If set to <15%, **[PRESET]** increases intensity to 15%.
DISPLAY MODE	start/stop		
TRIGGER TYPE	continuous		
EXTERNAL TRIGGER	off		
SWEEP TIME	100 milliseconds, manual mode	BEEPER: DONE	on
START FREQUENCY	.300 MHz	BEEPER: WARNING	off
FREQUENCY SPAN	2999.7 MHz	D2/D1 TO D2	off
START TIME	0	TITLE	channel 1 = [hp] channel 2 = empty
TIME SPAN	100 milliseconds	NUMBER OF POINTS	201
CW FREQUENCY	1000 MHz	IF BANDWIDTH	3000 Hz
SOURCE POWER	0 dBm	IF AVERAGING FACTOR	16; off
POWER SLOPE	0 dB/GHz; off	SMOOTHING APERTURE	1% SPAN; off
START POWER	−5.0 dBm	PHASE OFFSET	0 degrees
POWER SPAN	5 dB	ELECTRICAL DELAY	0 seconds (all parameters)
COUPLED POWER	on	**Calibration**	
POWER TRIP	off	CORRECTION	off
COUPLED CHANNELS	on	CALIBRATION TYPE	none
Frequency List		CALIBRATION KIT	7 millimeter
FREQUENCY LIST	empty	SYSTEM Z0	50 ohms
EDIT MODE	start/stop, number of points	VELOCITY FACTOR	1
Response Conditions		EXTENSIONS	off
PARAMETER (with S-parameter test set)	channel 1: S11; channel 2: S21	PORT 1	0
		PORT 2	0
(without S-parameter test set)	channel 1: A/R; channel 2: B/R	INPUT A	0
		INPUT B	0

Table A-1. Preset Conditions (2 of 2)

Operating Parameter	Preset Value
Calibration (Cont'd)	
ALTERNATE A and B	on
POWER METER CALIBRATION[1]	off
NUMBER OF READINGS	1
POWER LOSS CORRECTION	off
SENSOR A/B	A
INTERPOLATED ERROR CORRECTION	off
Markers (coupled)	
MARKERS 1,2,3,4	1 GHz; all markers off
LAST ACTIVE MARKER	1
REFERENCE MARKER	none
MARKER MODE	continuous
DELTA MARKER MODE	off
COUPLING	on
MARKER SEARCH	off
MARKER TARGET VALUE	−3 dB
MARKER WIDTH VALUE	−3 dB; off
MARKER TRACKING	off
MARKER STIMULUS OFFSET	0
MARKER VALUE OFFSET	0
MARKER AUX OFFSET (PHASE)	0 degrees
MARKER STATISTICS	off
POLAR MARKER	LIN MKR
SMITH MARKER	R+jX
Limit Lines	
LIMIT LINES	off
LIMIT TESTING	off
LIMIT LIST	empty
EDIT MODE	upper/lower limits
STIMULUS OFFSET	0 Hz
AMPLITUDE OFFSET	0
LIMIT TYPE	sloping line
BEEP FAIL	off
Time Domain	
TRANSFORM	off
TRANSFORM TYPE	bandpass
START TRANSFORM	−20 nanoseconds
TRANSFORM SPAN	40 nanoseconds
GATING	off
GATE SHAPE	normal
GATE START	−10 nanoseconds
GATE SPAN	20 nanoseconds
DEMODULATION	off
WINDOW	normal
USE MEMORY	off
System Parameters	
HP-IB ADDRESSES	last active state
HP-IB MODE	last active state
INTENSITY and FOCUS	last active state
Test Set Attenuation	
PORT 1	0
PORT 2	0

Operating Parameter	Preset Value
External Memory Array (Define Store)	
DATA	off
RAW DATA	off
FORMATTED DATA	off
GRAPHICS	off
DATA ONLY	off
DIRECTORY SIZE	256 files
Sequencing[2]	
LOOP COUNTER	0
TTL OUT	high
Service Modes	
HP-IB DIAGNOSTIC	off
SOURCE PHASE LOCK LOOP	on
SAMPLER CORRECTION	on
SPUR AVOIDANCE	on
AUX INPUT RESOLUTION	high
ANALOG BUS NODE	11 (aux input)
Plot	
PLOT DATA	on
PLOT MEMORY	on
PLOT GRATICULE	on
PLOT TEXT	on
PLOT MARKER	on
PLOT QUADRANT	FULL PAGE
SCALE PLOT	FULL
PLOT SPEED	FAST

Plot (Cont'd)		
PEN NUMBER:	Channel 1	Channel 2
Data	1	2
Memory	1	2
Graticule	3	4
Text	1	2
Marker	5	6
LINE TYPE		
Data, Memory	7	7

Format Table	Scale	Reference		Marker Offset
		Position	Value	
LOG MAGNITUDE (dB)	10.0	5.0	0.0	0.0
PHASE (degree)	90.0	5.0	0.0	0.0
GROUP DELAY (ns)	10.0	5.0	0.0	0.0
SMITH CHART	1.00	—	1.0	0.0
POLAR	1.00	—	1.0	0.0
LINEAR MAGNITUDE	0.1	0.0	0.0	0.0
REAL	0.2	5.0	0.0	0.0
IMAGINARY	0.2	5.0	0.0	0.0
SWR	1.00	0.0	1.0	0.0

1. The power sensor calibration data and power loss tables are not affected by preset or by cycling line power.
2. Pressing preset turns off sequencing modify (edit) mode and stops any running sequence.

Table A-2. Power-on Conditions (versus Preset)

HP-IB MODE: Talker/listener.

SAVE REGISTERS: Memory, error correction data, and power meter calibration data in save registers are cleared.

TEST SET: The HP 8753B checks for presence of HP 85046A/B or 85047A.

INTENSITY and FOCUS: These values are set to factory encoded values. The factory values can be changed by running the appropriate service routine. Refer to the Troubleshooting Reference section of the service manual.

SEQUENCES: Sequence 1 through 5 are erased.

Table A-3. Results of Power Loss to Non-Volatile Memory

HP-IB ADDRESSES are set to the following defaults:

HP 8753B	16
USER DISPLAY	17
PLOTTER	5
PRINTER	1
POWER METER	13
DISC	0
DISC UNIT NUMBER	0
DISC VOLUME NUMBER	0

POWER METER TYPE is set to HP 438/437A

INTERNAL REGISTER TITLES are set to defaults: REG1 through REG5.

EXTERNAL REGISTER TITLES (store files) are set to defaults: FILE1 through FILE 5.

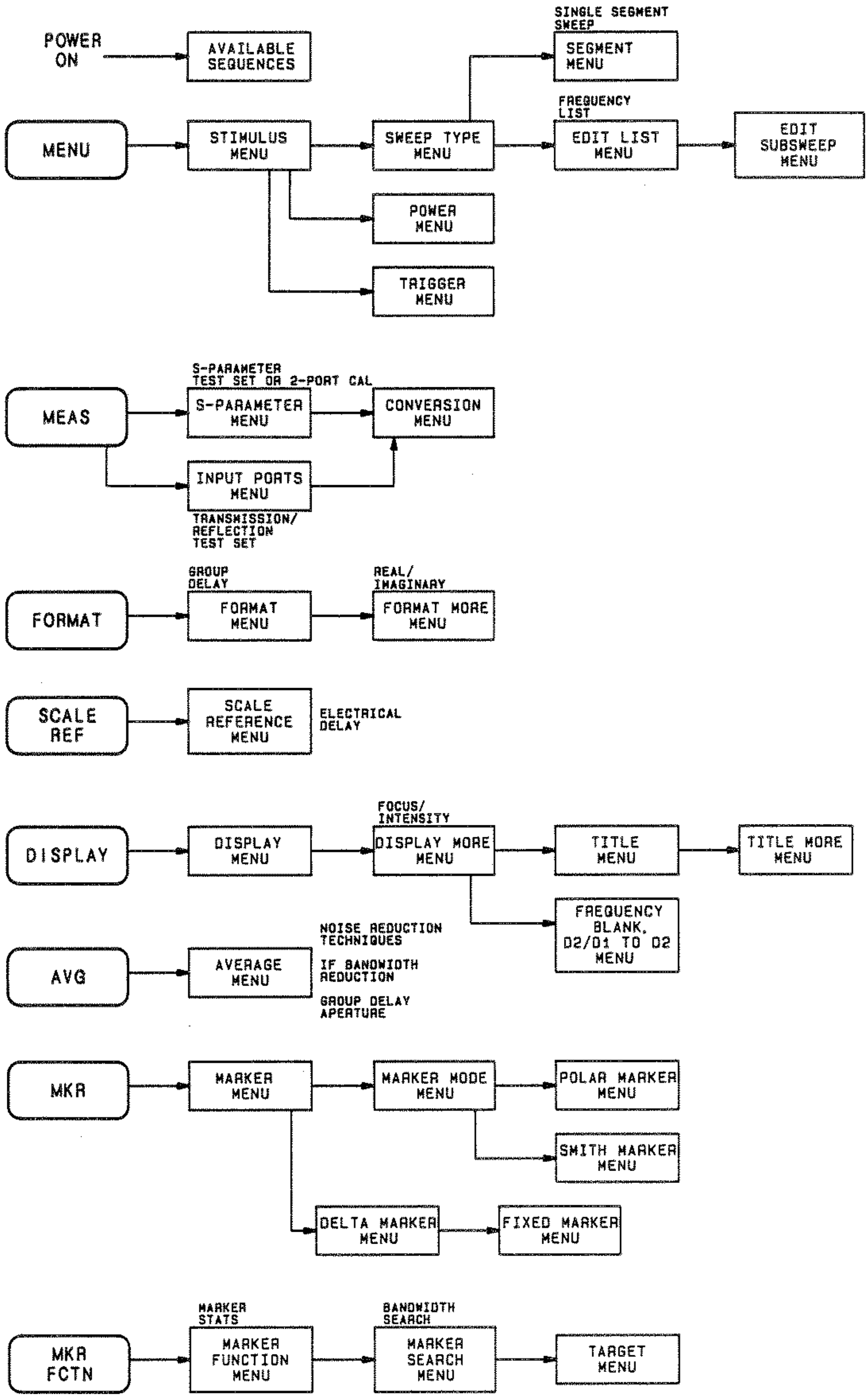


Figure A-1. Operating Softkey Menu Map (1 of 4)

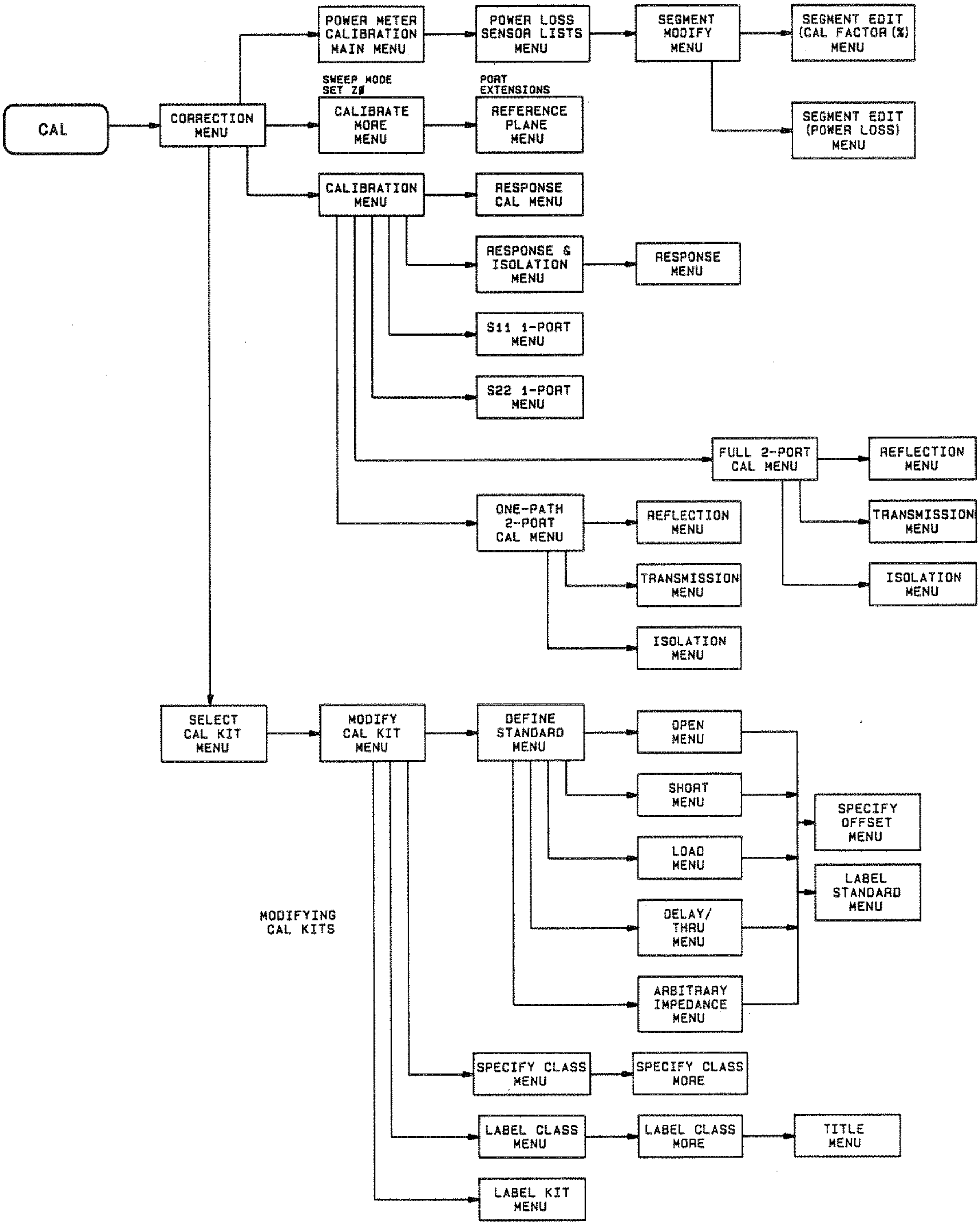


Figure A-1. Operating Softkey Menu Map (2 of 4)

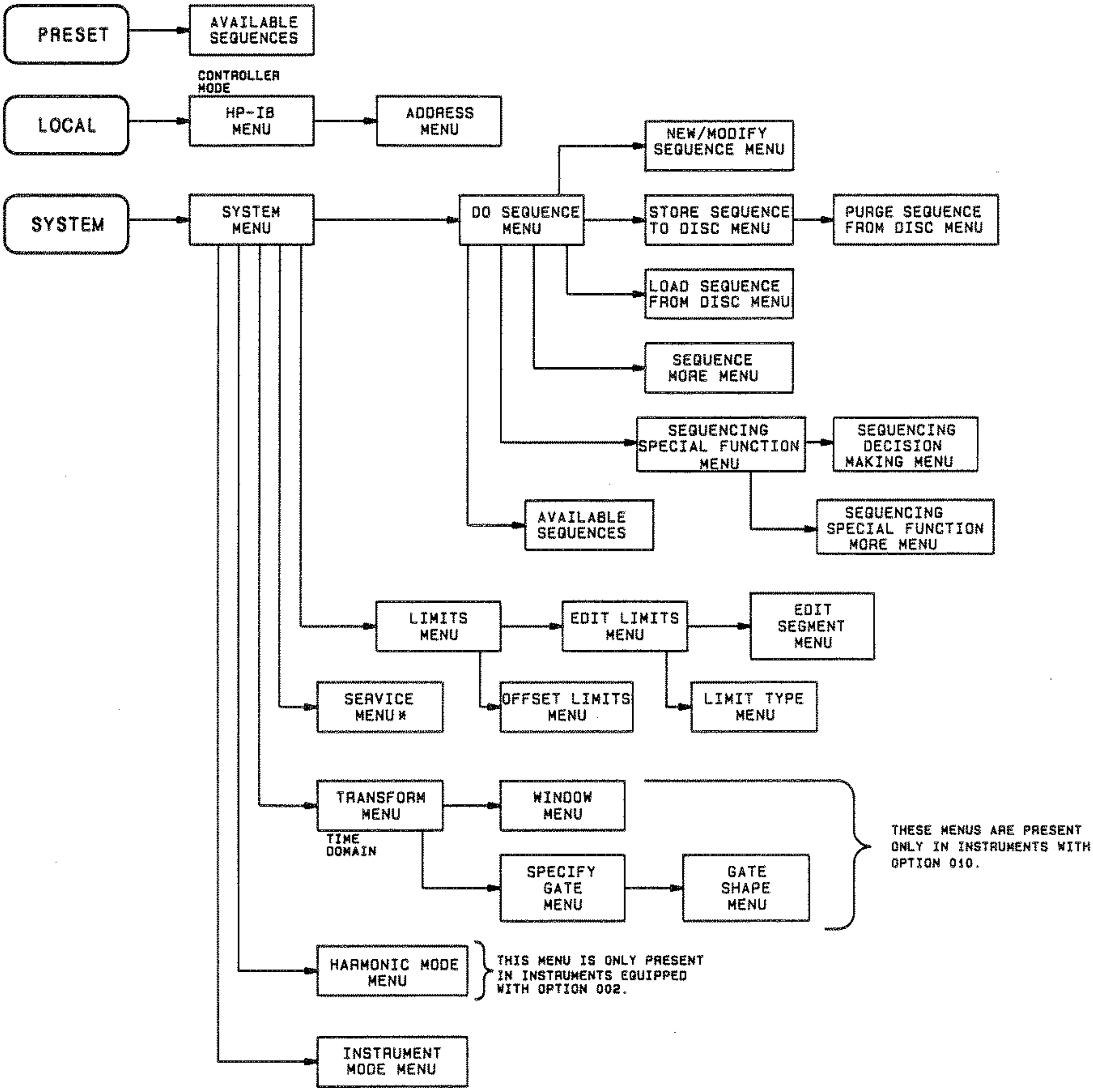


Figure A-1. Operating Softkey Menu Map (3 of 4)

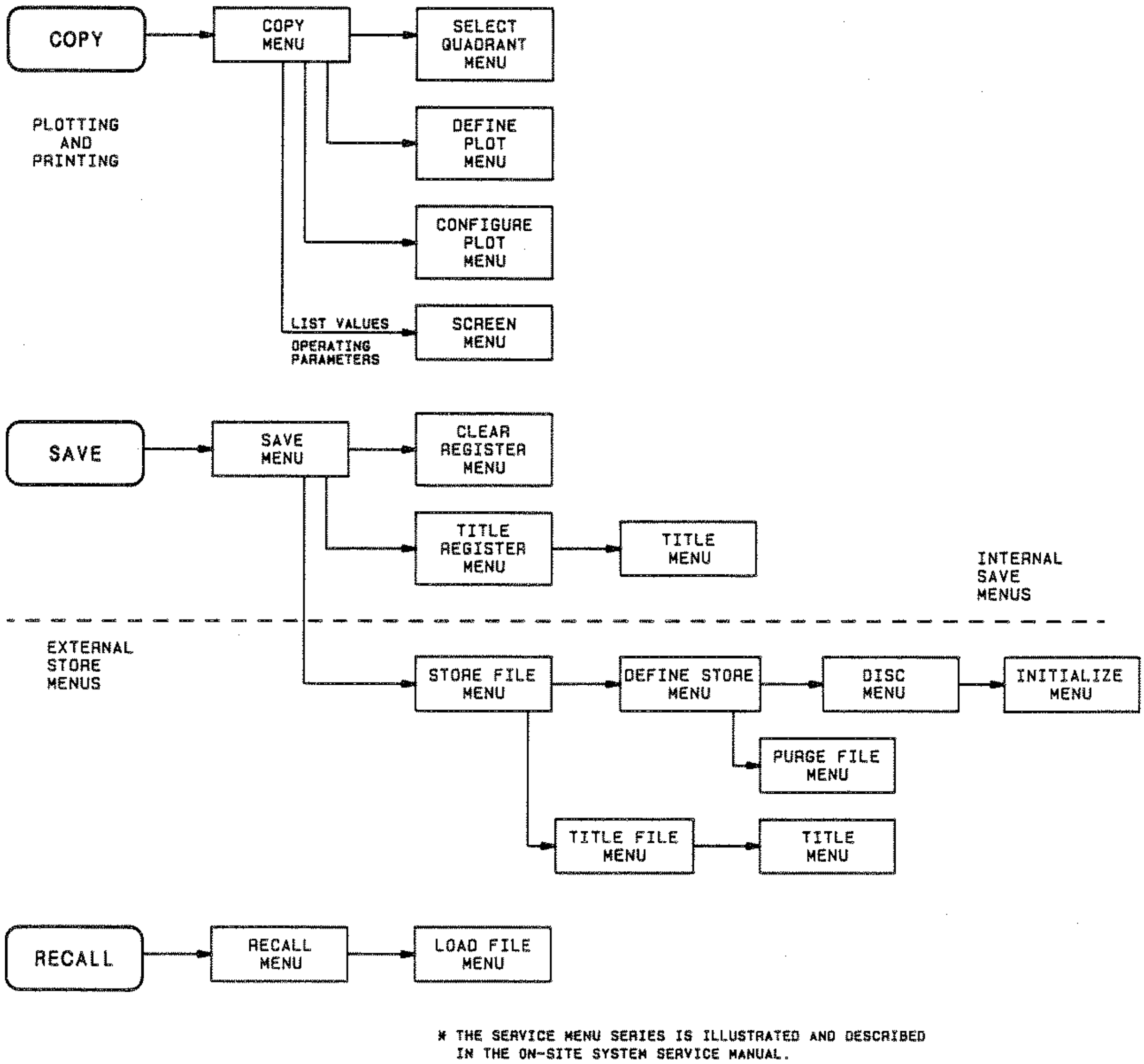


Figure A-1. Operating Softkey Menu Map (4 of 4)

HP 8753B System Operating and Programming Manual
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Key	
ACC	System Accessories Manual
GIS	General Information and Specifications
OPR	Operating and Programming Reference
OC	Operator's Check
SI	System Installation
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