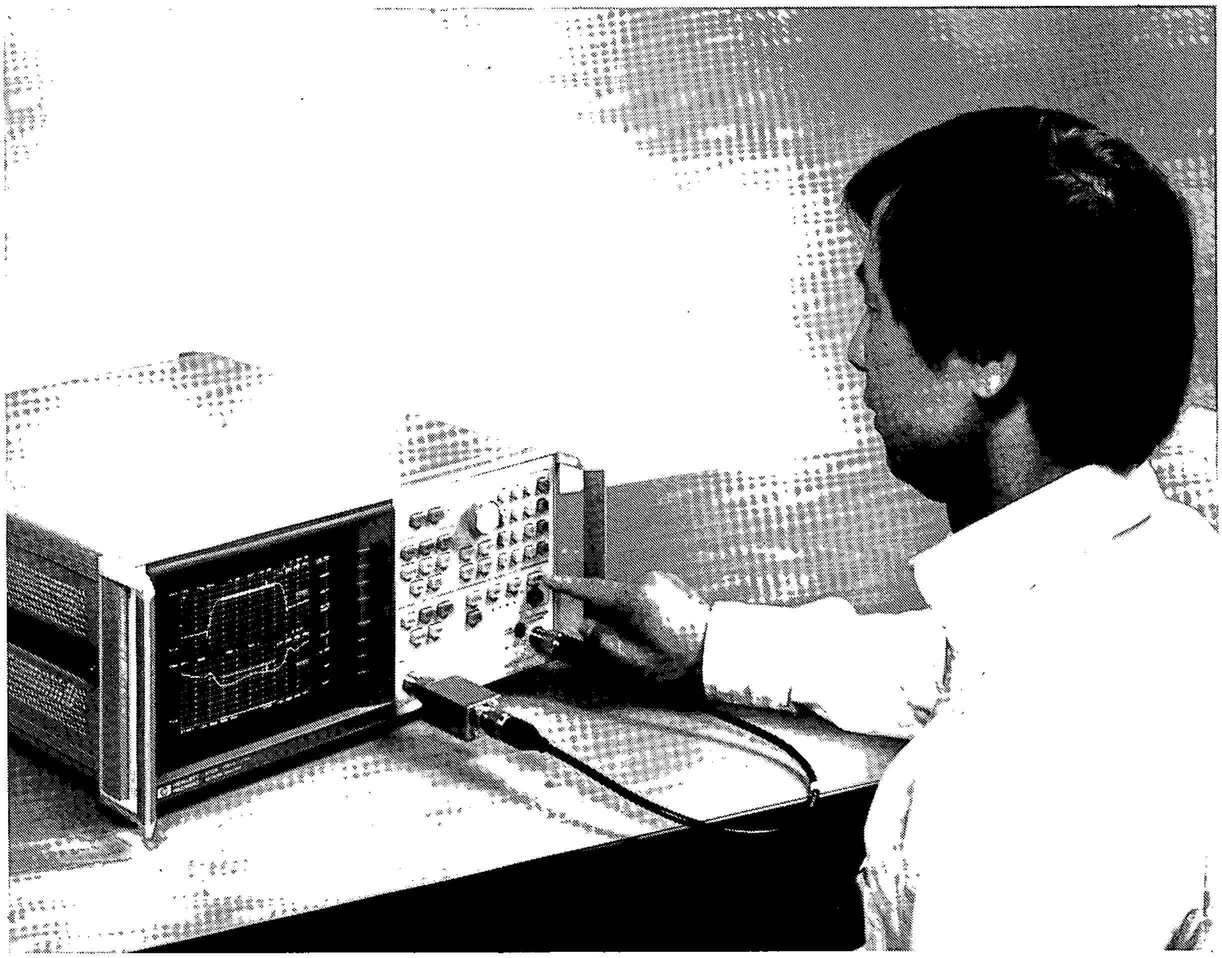
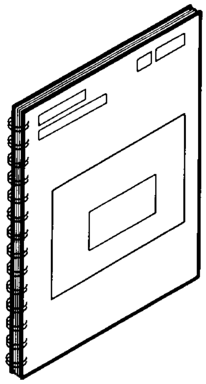
User's Guide

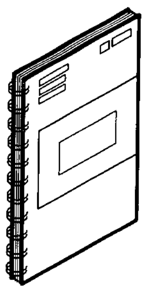
HP 8752A/B Network Analyzer



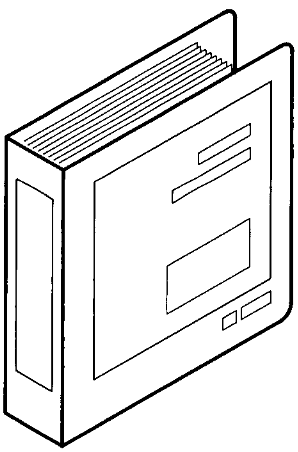
HP 8752 Network Analyzer Documentation Map



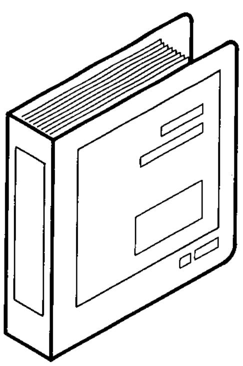
The **User's Guide** walks you through system setup and initial power-on, shows how to make basic measurements, explains commonly-used features, and tells you how to get the most performance from your analyzer.



The **User's Quick Reference** provides a summary of all available user features. It is organized alphabetically by front panel key.



The **Operating Manual** provides general information, specifications, HP-IB Programming information, and in-depth reference information.



The **Service Manual** explains how to verify conformance to published specifications, adjust, troubleshoot, and repair the instrument.

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Chapter 1. Installation

Chapter Contents

Unpacking your Instrument

IMPORTANT: The network analyzer and supplied cable are a matched set. Do not swap cables between instruments. Instrument accuracy is optimized at Hewlett-Packard for the instrument and cable pair. An adjustment should be performed after replacing a bad cable, refer to the "Adjustments" in the *Service Manual*.

Make sure the serial number on the analyzer's rear panel matches that of the shipping document. If the instrument or accessories were damaged during shipment, or if the shipment is incomplete, inform the shipping company and Hewlett-Packard. We will repair or replace damaged units without waiting for claim settlements from the shipper. In addition, HP will replace any missing items. If you must ship the instrument back to Hewlett-Packard, follow the instructions provided in "Packaging For Shipment", in the "Getting Started" chapter of the *Operating Manual*.

Installing the Instrument

CAUTION

Electrostatic discharge (ESD) can damage the analyzer and other sensitive electronic devices. Minimize ESD by using an antistatic bench mat and an anti-static wrist strap. Part numbers are listed below. FAILURE TO OBSERVE THESE PRECAUTIONS CAN RESULT IN DAMAGE TO THE ANALYZER.

Anti-Static accessory part numbers

Wrist Straps	Small	9300-0969
	Medium	9300-1117
	Large	9300-0970
Table Mat	92175T	

Line Power Requirements

Refer to the "Specifications" chapter in the *Operating Manual.*

This instrument is shipped with its line voltage switch set properly for the destination country, and with the appropriate type of line cord and fuse.

Fuse Requirements

Required fuse values are printed on the rear panel of the instrument.

CAUTION

The instrument's AC mains power source must have a properly grounded earth ground connection or the instrument may be damaged during operation. A power outlet must have a connected earth ground socket. If an autotransformer is used, it must provide a connection to earth ground. If a two-prong to three-prong adapter is used, the earth ground terminal must be connected to earth ground.

Other Details

Details on rack power requirements, fuse replacement, and environmental requirements are provided near the end of "General Information" in the *Operating Manual.*

Stand-Alone Installation

(No external HP-IB equipment connected)

1. There should be 15 cm clearance (6 inches) on the sides and rear of the instrument to allow proper cooling airflow.
2. Plug in the instrument and operate.

System Installation

(Installation with external HP-IB equipment)

Important Note Regarding Operation with an External Computer Controller: This *User's Guide* explains normal front panel operation of the analyzer, it does not explain use with an external computer controller. A computer, when connected to the analyzer's HP-IB bus, has significant effects on the way the analyzer operates. For this reason, do not connect a computer controller when using the tutorial examples in this guide. Refer to the HP-IB chapter of the *Operating Manual* to learn how to use the analyzer with a computer controller.

Procedure

Perform step 1 only when installing in a rack.

1. If installing in a system rack, follow the installation instructions with the supplied rack mount kit. Make sure the cabinet fan (if any) blows in the same direction as the instrument fan. If you must reverse the instrument fan direction, refer to the fan replacement procedures in the *Service Manual.* Rack mount kits are available for mounting the analyzer in 19 inch racks:

   Rack mount kit for instruments with front handles, HP part number 5062-4072 (order option 913 with new HP 8752s).

   Rack mount kit for instruments without front handles, HP part number 5062-3978 (order option 908 with new HP 8752s). This kit (or option) does not supply handles, and is not compatible for mounting with handles.

2. There should be 15 cm clearance (6 inches) on the sides and rear of the instrument to allow proper cooling airflow.

3. Connect an HP-IB cable between each of the system components (analyzer, printer, plotter, or disk drive).

NOTE: No more than 15 devices can be connected in a single system. The total allowable HP-IB cable length is 2 meters times the number of devices or 20 meters, whichever is less. To extend the allowable cable length, an HP-IB extender such as the HP 37204A or 37201A must be used.

Turn on the Analyzer

The analyzer should power up with no error messages showing. If this is so, the analyzer has passed its internal diagnostics and is functioning properly. The analyzer should now display the revision number of its operating program, and list installed options. Proceed to "Check HP-IB Addresses", below.

If an error message is displayed, or if the instrument does not appear to operate properly. Error messages are explained in the "Error Messages" chapter of the *Operating Manual*. Look up the error message to determine the cause.

[KEYS] and *[SOFTKEYS]*

In this manual, front panel keys are represented by bold print surrounded by brackets. Display softkeys are shown in ***bold italic*** print and are also surrounded by brackets. Number keys are shown in bold type without brackets.

For example: "Press **[SCALE REF]** ***[REFERENCE POSITION]*** **−10 [x1]**" means you should press the **[SCALE REF]** key, then the ***[REFERENCE POSITION]*** softkey, followed by the **[−]**, **[1]**, **[0]**, and **[x1]** keys. The last key, **[x1]**, terminates the command in basic units (dB, dBm, Hz, degrees). More on display keys is explained in "Getting Acquainted with the Front Panel", later in this guide.

Check HP-IB Addresses

Check the HP-IB address of each device in the system. When shipped, the analyzer is programmed to recognize peripheral devices at their factory-default settings:

Device	Address
Printer	5
Plotter	1
Disk Drive	0

Check the addresses recognized by the analyzer: Press **[LOCAL]** ***[SET ADDRESSES]*** followed by any of the following: ***[ADDRESS: PRINTER]***, ***[ADDRESS: PLOTTER]***, or ***[ADDRESS: DISK]***.

The address physically set on the device must match the address recognized by the analyzer.

- You can change the address of the device to match the address recognized by the analyzer or:
- You can change the address recognized by the analyzer by pressing the keys mentioned above, entering the desired two-digit address, and pressing the **[x1]** key.

If a Malfunction Occurs

If the instrument malfunctions during the one-year on-site warranty period, simply contact Hewlett-Packard and the instrument will be checked and repaired within the limitations of the warranty.

Where to Go From Here

Using the analyzer

To learn how to use the network analyzer, continue with the next chapter. The analyzer has already passed its self-test and should be ready to make measurements.

Incoming inspection

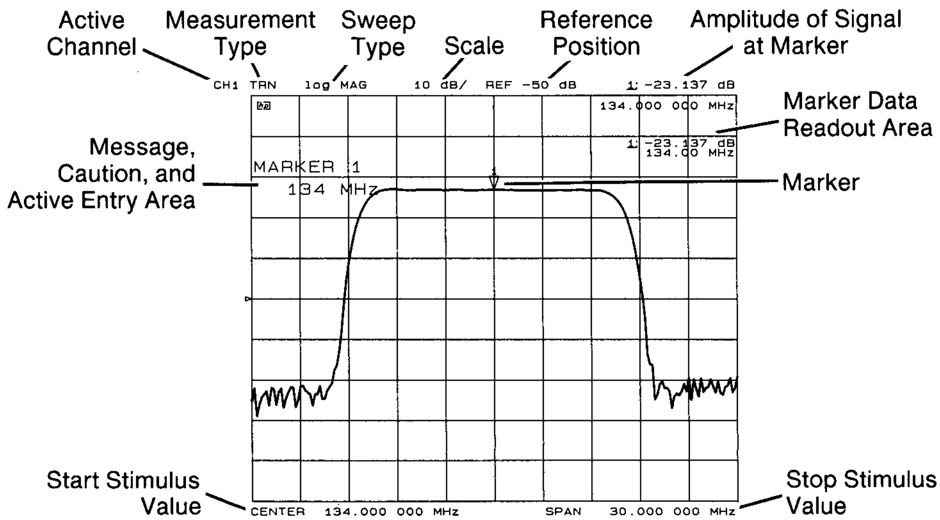
If you need to check the instrument more rigorously (incoming inspection, for example), refer to the *Service Manual*.

Chapter 2. Getting Acquainted with the Front Panel

Chapter Contents

Display Annotations

The instrument display shows the measurement trace, softkey labels, and the values of important settings.



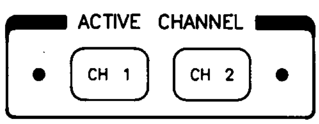
*Appears when a marker is turned on.

Front Panel Key and Softkey Overview

The analyzer uses a combination of front panel keys and *softkeys*. A softkey is a key whose function can be changed by the instrument. This instrument has eight softkeys, located to the right of the display screen. When a softkey is active, it will have a title next to it.

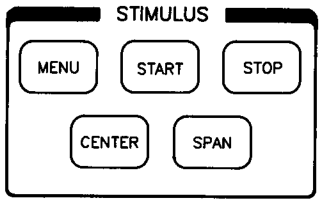
Front panel keys provide access to the various softkey menus, and are grouped by basic function.

Channel Control



The *Active Channel* Block controls two independent measurement channels, each of which can have its own trace on the screen. *All other front panel keys control the channel that is currently selected.*

RF Source Control

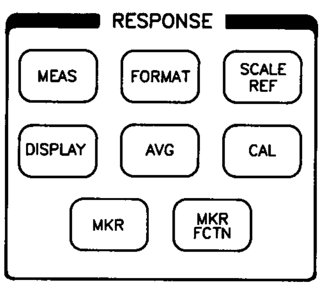


The *Stimulus* keys allow you to define an appropriate source output signal for the device under test (DUT). Source frequency can be swept over any portion of the 300 kHz to 1.3 GHz (optionally to 3 GHz) range, at power levels from −20 to +5 dBm. The stimulus keys can also control the start and stop times in the (optional) time domain mode. In addition, stimulus keys allow you to select sweep time, linear versus logarithmic sweep, power sweep, and number of measurement points. All features mentioned above except stimulus START, STOP, CENTER, and SPAN, are under the MENU key.

What is "Stimulus"

Whatever you are measuring across the x-axis of the display is the "stimulus". Usually this is frequency, but other units of measurement can be used as well. This instrument can place power or time on the x-axis, (for power sweep measurements, and for measurements of a CW frequency over a period of time).

Receiver Control

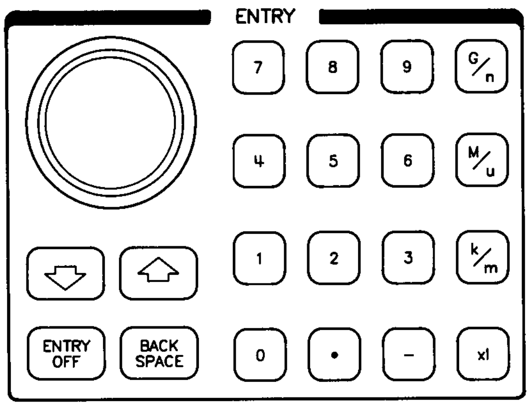


The *Response* keys control the instrument's receiver. The receiver measures the transmitted and reflected signals from the DUT.

The top three keys allow you to choose a MEASurement type (transmission or reflection), presentation FORMAT (Cartesian, Polar, Smith chart, and SWR formats), as well as display SCALE and REFerence settings.

The lower five keys enhance the usability of the measured data. The trace on the DISPLAY may be stored or mathematically manipulated, AVEraged, normalized, or read out at specific points along the trace with four independent MARKERs. In addition, unusual test setups may have accuracy enhanced using measurement CALibration. Further, bandwidth, trace statistics, and other trace information can be determined using the MKR FCTN key.

Entering and Changing Values



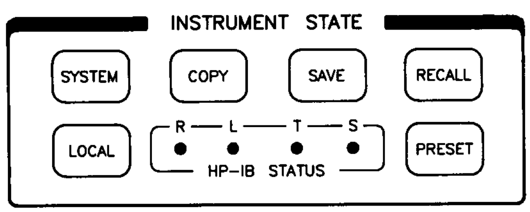
The *Entry* keys allow you to enter numeric values or adjust values using a knob. Entered values appear in a portion of the screen called the *active entry area*. The keys to the right of the numeric keypad terminate an entry with the desired units.

G/n: Giga/nano
M/μ: Mega/micro
k/m: Kilo/milli
x1: basic units, dB, dBm, degree, second, Hz.

The ▼ and ▲ buttons allow values to be changed in steps. **[ENTRY OFF]** clears the active entry area on the screen. **[BACK SPACE]** deletes the digit to the left of the cursor in the active entry display.

The Entry keys and knob affect the last function you activated. This is called the *active function*.

Instrument State



These keys allow you to save or recall current instrument settings (to or from internal memory or external disk). In addition you can print, plot, or set the HP-IB addresses used for the HP 8752 and peripheral devices. The Preset key causes most instrument settings to revert to default settings.

Several major instrument features are under the System key, including:

- Test Sequencing (memorizes your measurement steps).
- Limit lines and limit testing.
- Time Domain (option 010).

Displaying Comprehensive Instrument Information

Press **[COPY]** ***[OP PARMS]***. The measurement screen will be replaced by a full page display showing instrument settings, marker values, and more.

Press ***[PAGE]*** to display the next page of information. In all, there are four pages of detailed instrument information. Each page can be individually printed or plotted.

Chapter 3. Measurement Tutorial

Chapter Contents

Basic Types of Measurements

NOTE: Some instrument specifications are only warranted at inside certain temperature ranges. Outside the specified range, the instrument may still meet these specifications, or at least be very close to them.

The analyzer measures the effect a device under test (DUT) has on an incident RF signal. There are two main categories of measurements, transmission and reflection.

Transmission Measurements

Transmission measurements quantify the effect the DUT has on a signal passing through it. The analyzer can show the DUT's effect on power level (loss through the device), delay, phase, and gain.

Reflection Measurements

Reflection measurements show how much of the signal is reflected from the DUT back toward the built-in source. The reflected signal is measured relative to the original (incident) signal arriving at the input port of the DUT.

These measurements are discussed in more detail later in Chapter 4, ''Example Measurements''.

Important Concepts

Stimulus

Stimulus refers to the units displayed on the x-axis of the display. In most cases this is frequency. However, this analyzer can sweep power, and measure a CW response over a period of time. *Stimulus* is a generic term that refers to any of these x-axis parameters.

Number of Points

The instrument measures the response of the DUT at specific points over the selected stimulus range. The number of points used can be selected by the operator in predefined increments (3, 11, 26, 51, 101, 201, 401, 801, and 1601). These measurement points are spaced equally across the chosen stimulus range. The instrument measures the DUT by taking data at each measurement point. Increasing the number of points provides a more thorough test of the DUT, but it slows down the sweep.

For example, you select a start frequency of 100 MHz and a stop frequency of 200 MHz. The instrument is set to 201 points. The instrument will measure DUT performance at 201 equally spaced points (every 0.5 MHz) from 100 to 200 MHz.

Basic Measurement Sequence

Assuming the instrument has been properly installed, there are three basic steps when making a measurement. These steps are listed below. A step-by-step example is provide in the "Basic Measurement Example", following this description.

1. Connect the DUT and Test Equipment

Connect the DUT and any required external test equipment. Usually this is only the supplied test cable. Remember, the supplied cable is matched to the individual analyzer. Do not swap cables with another instrument, even if it is another HP 8752.

2. Choose Measurement Settings

Press **[PRESET]**, choose desired measurement settings, and observe the test results. Instrument settings can be saved to memory registers or to disk. Pressing **[PRESET]** is not mandatory once you are familiar with instrument operation. You are asked to press it at the beginning of each test example in this guide so each measurement starts from a known state.

3. Output Results

This is an optional step. Print or plot a copy of the front panel display (or a tabular listing of measurement data). Test data can be stored to memory or external disk.

NOTE: The analyzer automatically compensates for errors caused by its connectors and cable. For optimum accuracy, the following conditions must be met:

- The DUT must be connected directly to the instrument's Reflection Port with no adapters or intervening cables.
- The DUT must nominally be a 50 ohm device (for HP 8752A) or a 75 ohm device (for HP 8752B).

If these conditions cannot be met, measurement accuracy may be reduced. Even under these conditions, however, measurement accuracy may be quite satisfactory for many measurement needs. When it is not, the analyzer provides a feature called *measurement calibration*. This feature allows the operator to measure high-quality reference standards, and thereby compensate for repeatable errors caused by the measurement setup. Measurement calibration is explained in the "Measurement Calibration" chapter of the *Operating Manual*.

Basic Measurement Example

Introduction

This example provides hands-on experience with making a measurement, and gives useful tutorial information about major features. The measurement used is intentionally simple, so learning basic instrument operation won't be cluttered with extraneous or advanced information. When going through this example concentrate on learning the purpose of the front panel keys and the major features they access.

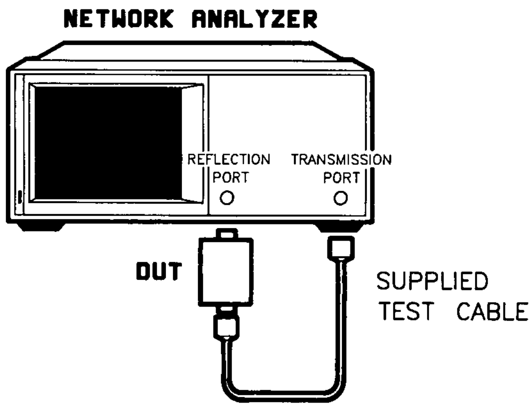
You may use any convenient passive device for a Device Under Test (DUT).

1. Connect the DUT and Test Equipment

a. **Inspect Connectors.** Before setting up the equipment inspect the DUT's connectors to make sure they are clean and free of burrs or defects. Replace the connectors on any device that has defective threads (or they will ruin your instrument connectors). Clean connectors if necessary. Proper connector maintenance is a vital part of maintaining your instrument and test equipment. Refer to the application note on connector care in the *Operating Manual* for inspection, cleaning, and gaging instructions.

Turn the connector sleeve (or nut), not the device. When connecting and disconnecting devices, turn the threaded sleeve (or nut) on the male connector, *never* turn the device. Turning the device turns the male connector pin inside the female receptacle, greatly accelerating connector wear.

b. Set up the DUT and test cable as shown in the figure below.

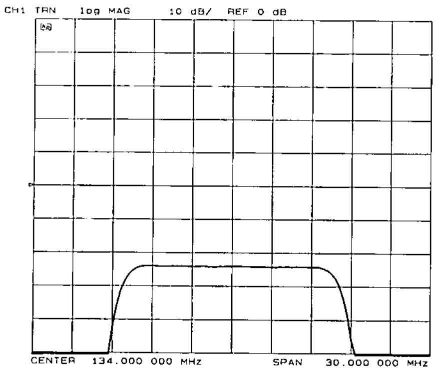


Basic Test Setup

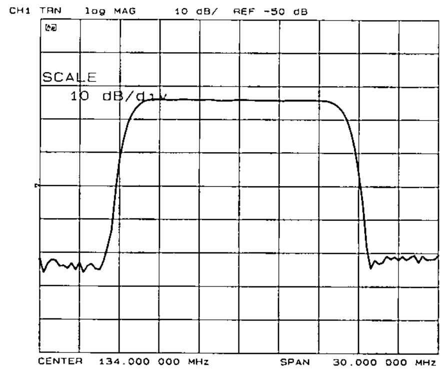
2. Choose Measurement Settings

a. Press **[PRESET]** and change instrument settings as shown below. Remember, if you enter the wrong number before pressing a units terminator key, simply press **[BACK SPACE]** and re-enter the number. If you have already pressed the terminator key, re-enter the whole command.

	Desired Change	Instructions
STIMULUS BLOCK	Set center frequency to 134 MHz	Press **[CENTER] 134 [M/µ]**
	Set span to 30 MHz	Press **[SPAN 30 [M/µ]**
	Change power level to −5 dBm	Press **[MENU]** ***[POWER]*** **−5 [x1]**
	Change number of points to 101	Press **[MENU]** ***[NUMBER OF POINTS]*** ⯆
RESPONSE BLOCK	Select transmission measurement	Press **[MEAS]** ***[TRANSMISSN]***
	Select Autoscale	Press **[SCALE REF]** ***[AUTOSCALE]***



a. Display before Autoscale



b. Display after Autoscale

Storing instrument settings for later recall

You may store the current measurement settings to memory for later recall by pressing **[SAVE]** ***[SAVE REG1]***. Please press these keys now. The ***[SAVE REG1]*** softkey will change to ***[RE-SAVE REG1]***, indicating that register 1 now contains data. This data may be overwritten at any time by pressing ***[RE-SAVE REG1]***.

To recall these settings at any time, press **[RECALL]** ***[RECALL REG1]***.

3. Output Results

This step is optional.

Printing, plotting, or storing data to disk requires a properly connected printer, plotter, or disk drive. The printing example below assumes a printer is connected and is set up properly. Compatible equipment is described in the "General Information" chapter of the *Operating Manual*. To install an external device, refer to the installation instructions at the beginning of this guide.

Printing a Copy of the Display

Make sure there is no computer controller connected to the instrument and perform the following steps.

1. Press **[LOCAL]** ***[SYSTEM CONTROLLER]***. This setting will stay in effect until the instrument is turned off.
2. Align the paper in the printer and turn the printer on.
3. In the Instrument State block in the lower-right portion of the front panel, press **[COPY]** ***[PRINT [STANDARD]***.

NOTE: Measurement data can be printed as a tabular listing of values. If you have a color printer, the analyzer can print a color copy of the display. Details on printing and plotting are provided in the "Printing and Plotting Tutorial" later in this guide.

Chapter 4. Example Measurements

Chapter Contents

Introduction

This chapter provides in-depth knowledge regarding common types of measurements. This chapter explains:

- How to make many types of transmission measurements (insertion loss, gain, flatness, bandwidth, phase, electrical length, phase distortion, group delay, and gain compression).
- How to make many types of reflection measurements (return loss, reflection coefficient, SWR, impedance, and admittance).
- How to use measurement aids such as markers, marker functions, trace memory, and trace math.
- How to plot data and store data to disk.
- How to show both channels on the screen at once.
- How to use Polar and Smith chart display formats.

Example DUT

The DUT used in the examples is a bandpass SAW filter with a 134 MHz center frequency, and the analyzer used is an HP 8752A. For more detailed information on specific instrument features, refer to the tutorials in this guide. Also refer to the "Reference" portion of the *Operating Manual*.

Transmission Measurements

When making a transmission measurement, the analyzer supplies the signal to the DUT and uses this signal as a reference. The analyzer compares the output of the DUT to this reference signal to determine the DUT's electrical performance.

Measuring Insertion Loss

Insertion loss and gain are ratios of the output to input signals. These values are usually expressed in decibels.

1. Connect the DUT and Test Equipment

Connect the DUT and test cable as shown in the "Basic Measurement Example". The example DUT is a SAW filter with a 134 MHz center frequency.

2. Choose Measurement Settings

Press **[PRESET]** and then choose these measurement settings:

Stimulus	CENTER 134 MHz (press **[CENTER] 134 [M/μ]**) SPAN 30 MHz (press **[SPAN] 30 [M/μ]**)
Response	
Measurement	Transmission (press **[MEAS]** ***[TRANSMISSN]***)
Format	LOG MAG (default setting)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)

3. Output the Result This step is optional. If you choose to print, plot, or store instrument settings to disk. Again, any printer, plotter or disk drive must be set up as explained in the installation chapter at the beginning of this guide.

Make sure there is no computer controller connected to the instrument.

1. Press **[LOCAL]** ***[SYSTEM CONTROLLER]***.
2. **To Printer:** Press **[COPY]** ***[PRINT [STANDARD]]***.

   To Plotter: Press **[COPY]** ***[PLOT]***.

Other useful information on printing and plotting is provided in the "Printing and Plotting Tutorial", later in this guide.

Storing Instrument Settings To Disk:

1. Turn the disk drive on. Insert a new disk into the disk drive (use drive 0 in a dual-drive unit). In the case of the HP 9122, this is the left-hand slot.

NOTE: Skip step 2 if you have a disk which has previously been initialized on an HP 8752.

CAUTION

Initializing a previously-used disk destroys all data that currently exists on the disk.

2. Initialize the disk by pressing: **[SAVE]** ***[STORE TO DISK] [DEFINE STORE] [MORE] [INITIALIZE DISK] [INIT DISK? YES]***. The disk drive busy light will come on for about 1.5 minutes. when it goes out, proceed with the following step.
3. Press **[SAVE]** ***[STORE TO DISK] [STORE FILE1]***. Instrument settings will be stored to a file named "FILE1".

Other useful details are provided in the "Disk Drive Tutorial", later in this guide.

Trace Memory The analyzer can store the DUT's performance data to memory. You can display this data on the screen. Since the actual measurement data is saved, mathematical manipulation (trace math) is possible.

Saving trace data — Press **[DISPLAY]** ***[DATA →MEMORY]***, and the DUT's response data is stored in memory.

Viewing the stored trace — Press ***[MEMORY]*** to display the saved trace, or press ***[DATA and MEMORY]*** to see the current measurement trace superimposed on the stored trace. The two traces are different colors.

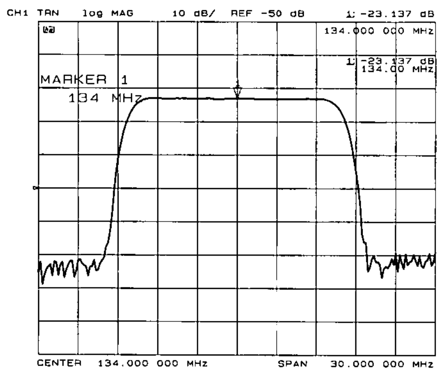
Restoring the current trace — Press ***[DISPLAY: DATA]*** to show only the current measurement trace.

Trace Math: Now that trace data is stored in memory, trace math functions can be used. ***[DATA-MEM]*** subtracts the stored trace data from the current trace data. ***[DATA/MEM]*** divides the current trace data by the stored trace data.

If you pressed ***[DATA-MEM]*** or ***[DATA/MEM]***, Press ***[DISPLAY: DATA]*** before continuing.

Using Markers When one or more markers are turned on, they show quantitative stimulus and magnitude (or phase) values for a chosen spot on the displayed trace. This information is displayed in the *marker data readout*, which is located in the upper-right hand corner of the display. The most recent marker selected becomes the *active marker*. Only the active marker is affected by the entry keys or knob.

In the Response block, press **[MKR] 134 [M/μ]** to set marker 1 as shown. Note that the display (and figure) show the complete response of the bandpass filter under test.



Using a Marker to Show Insertion Loss

From this display you can derive several important filter parameters. The marker functions make it very easy to read these parameters.

Using markers to measure insertion loss

Insertion loss can be read to 0.001 dB resolution by moving the marker to any frequency of interest. The marker amplitude and frequency are shown in the marker data readout.

Using markers to measure 3 dB Bandwidth

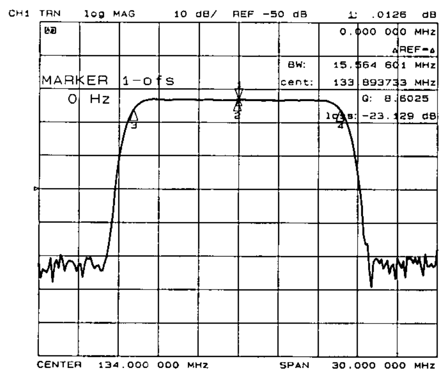
The analyzer calculates the bandwidth of the DUT between two equal power levels. In this example, we calculate the −3 dB bandwidth relative to the filter's center frequency.

a. Press **[MKR]**. The marker should be in the center of the frequency passband. If it isn't, move it to the center using the front panel knob.

b. Press ***[MKR ZERO]***. This places a marker reference point at the position of the marker. Subsequent measurements using any marker will be relative (in frequency and amplitude) to this reference point. The marker reference point is displayed on the trace as a Δ.

c. Press **[MKR FCTN]** ***[MKR SEARCH]***. The marker search menu will appear. This menu is used to search the trace for a particular value or bandwidth.

d. Press *[WIDTHS ON off]*. The analyzer automatically calculates and displays the −3 dB bandwidth (BW:), center frequency (CENT:), Q, and loss of the DUT. (Q stands for "quality factor", defined as the ratio of a circuit's resonant frequency to its bandwidth). These values are shown in the marker data readout. Markers 3 and 4 show the location of the −3 dB points. Refer to the figure below:



Using Markers to Determine 3 dB Bandwidth

e. To have the analyzer calculate bandwidth using a different power level (for example, −6 dB instead of −3 dB):

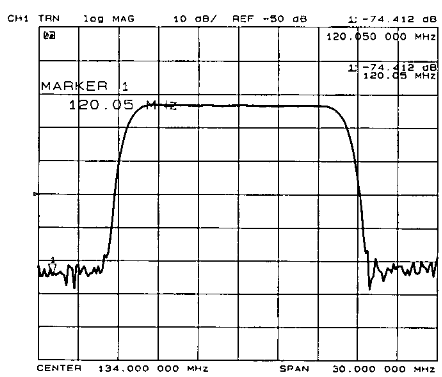
Press *[WIDTH VALUE]* **−6 [x1]** and observe the changes in the displayed marker readings.

f. Press *[WIDTHS on OFF]* **[MKR]** *[all OFF]* when finished.

Using markers to measure out of band rejection

The wide dynamic range of this instrument allows it to measure stopband rejection up to 110 dB below the passband response. As discussed in "Increasing Dynamic Range" (located in "Getting the Most Out of Your Network Analyzer", later in this guide), maximum dynamic range requires proper selection of input power level, IF bandwidth, and averaging factor.

a. Press **[MKR] [MKR FCTN]** *[MKR SEARCH] [MIN]*. The active marker (marker 1) automatically moves to the minimum point on the trace. The frequency and power level of this point (relative to the Δ reference point) appears in marker data readout. Refer to the figure below.



Using Markers to Determine Out-of-Band Rejection

The marker search feature can search the trace for the maximum, minimum, or for a specified power value. The search for a specified value can be to the left or right of the active marker. In addition, search-left or search-right can be used repeatedly to find multiple occurrences at the same level. The specified level is entered by pressing *[TARGET]* followed by the desired level. Terminate with the **[x1]** key. The target level can be entered as an absolute value (such as −3 dBm), or as a value relative to the Δ reference point.

For example, Pressing *[TARGET]* **−3 [x1]** *[SEARCH LEFT]* would search to the left of the active marker for a value of −3 dBm.

Using marker statistics to measure ripple (flatness)

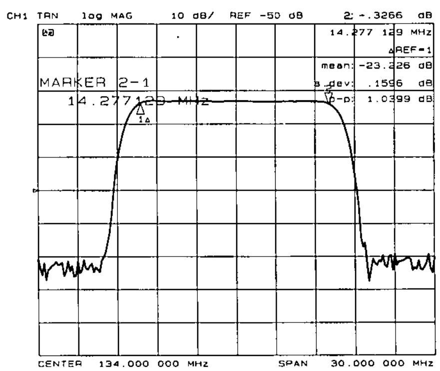
Passband ripple (also called flatness) is the variation in insertion loss over a specified portion of the passband.

a. Press **[MKR]**. Move marker 1 to the left edge of the passband using the knob.

b. Press *[ΔMODE MENU]* *[ΔREF = 1]* to move the Δ reference point to the new position of marker 1.

c. Press *[2]* to activate marker 2. Move marker 2 to the right edge of the passband.

d. Press **[MKR FCTN]** *[STATS ON off]*. The instrument automatically calculates the mean, standard deviation, and peak-to-peak variation between the markers and lists the results in the marker data readout. The passband ripple is automatically given as the peak-to-peak variation between the markers.



Using Markers to Calculate Mean, Standard Deviation, and Peak-to-Peak Variation.

e. Press *[STATS on OFF]* when finished with this measurement.

Measuring Phase Response

As with any other type of transmission measurement, the analyzer monitors the signal going to the DUT and uses this as a reference. It compares the output of the DUT to this reference signal to determine the DUT's electrical performance. The only difference in phase measurements (compared to amplitude measurements) is that the analyzer displays phase data rather than amplitude data.

The analyzer can convert phase data into a related parameter, group delay (defined as the difference in propagation delay from one frequency to another).

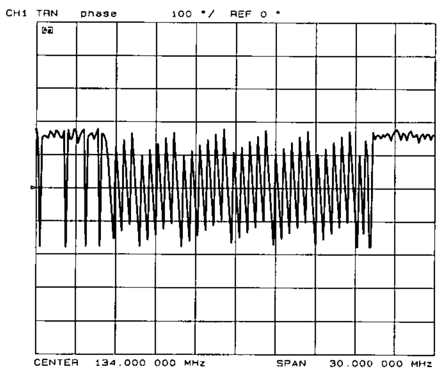
1. Connect the DUT and Test Equipment

Connect the DUT and test cable as shown in the "Basic Measurement Example".

2. Choose Measurement Settings

Press **[PRESET]** and then choose these measurement settings:

Stimulus	CENTER 134 MHz (press **[CENTER] 134 [M/μ]**) SPAN 30 MHz (press **[SPAN] 30 [M/μ]**)
Response	
Measurement	Transmission (press **[MEAS]** ***[TRANSMISSN]***)
Format	PHASE (press **[FORMAT]** ***[PHASE]***)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)



Phase Response of a SAW Filter

3. Output the Result

This step is not performed in this example.

Just as in measuring insertion loss or gain, the various marker functions (marker search, min/max, offset, and others) can provide quantitative information about the phase response of the DUT.

The analyzer measures and displays phase over the range +180 to −180 degrees. As phase increases beyond these values, a sharp 360 degree transition occurs in the display as the trace "wraps" between +180 and −180 degrees. This causes the "sawtooth" response usually seen on devices with linearly increasing (or decreasing) phase responses.

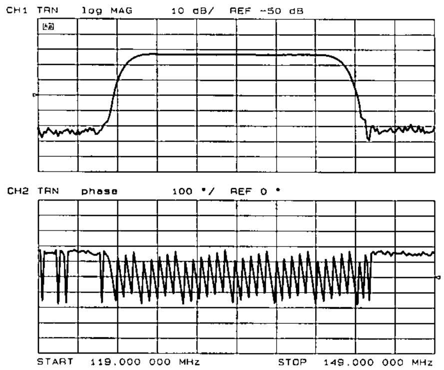
Using the Dual Trace Display

Often it is useful to view more than one measurement parameter at a time. Simultaneous gain and phase measurements are useful for evaluating stability in negative feedback amplifiers, for example.

a. Press **[FORMAT]** ***[LOG MAG]*** **[SCALE REF]** ***[AUTOSCALE]***.

b. Press **[DISPLAY]** ***[DUAL CHAN ON off]***. Two separate measurement graticule boxes appear on the screen. Channel 1 is shown in the upper graticule box and channel 2 is shown in the lower graticule box.

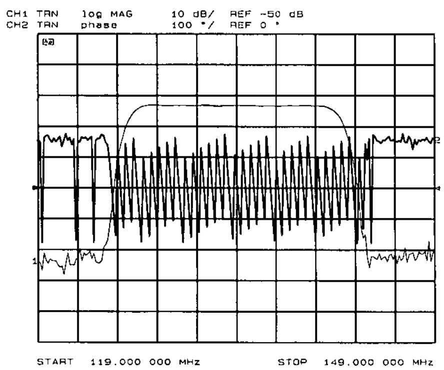
c. Press **[CH 2] [FORMAT]** ***[PHASE]*** **[SCALE REF]** ***[AUTOSCALE]***. Note that channel 2's default measurement type is transmission. Amplitude and phase are now displayed simultaneously for the DUT.



Dual Display Mode with Split Screen On

Sometimes it is more convenient to view the traces from both channels in the same graticule box.

d. Press **[DISPLAY]** ***[MORE] [SPLIT DISP on OFF]***. Both traces are now shown in the same graticule box.



Dual Display Mode with Split Screen Off

Measuring Electrical Length

This instrument has a feature similar to the mechanical "line stretchers" of earlier analyzers. The feature simulates a variable length transmission line (which has no losses). Electrical length can be added or removed to compensate for interconnecting cables or other devices. In this example, the electronic line stretcher measures the electrical length of a test device.

1. Connect the DUT and Test Equipment

Connect the DUT and test cable as shown in the "Basic Measurement Example".

2. Choose Measurement Settings

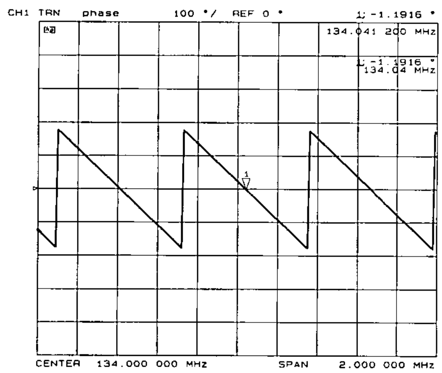
Press **[PRESET]** and then choose these measurement settings:

Stimulus	CENTER 134 MHz (press **[CENTER] 134 [M/μ]**) SPAN 2 MHz (press **[SPAN] 2 [M/μ]**)
Response	
Measurement	Transmission (**[MEAS]** ***[TRANSMISSN]***)
Format	PHASE (press **[FORMAT]** ***[PHASE]***)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)

3. Output the Result This step will not be performed in this example.

Electrical Length Adjustment

The steps above result in the phase response measurement shown below. Note that the SAW filter under test has considerable phase shift within only a 2 MHz span. Other filters may require a larger frequency span to see the effects of the phase shift.



Phase Response of a SAW Filter over a 2 MHz Span

The linearly increasing phase is caused by the DUT's electrical length, which will be measured by "adding length" to the instrument's internal reference path. This compensates for the actual electrical length of the DUT. (As explained earlier, the instrument samples the output RF signal for reference. This is the reference path which will have electrical length "added" to it.)

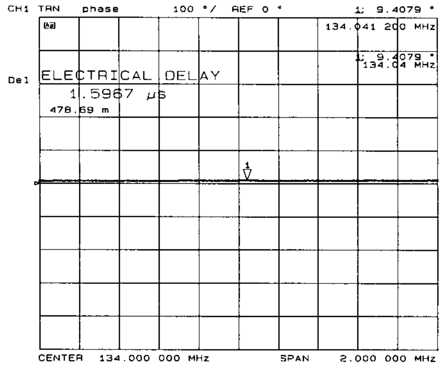
a. Turn on the line stretch function by pressing **[SCALE REF]** ***[ELECTRICAL DELAY]***.

b. Turn the knob clockwise until the displayed trace is flat (as shown below. It may take many revolutions of the knob).

   or

   Press **[MKR]** and move marker 1 to any of the points where the sloping trace crosses the red reference line (place the marker on the sloping portion of the trace, not the vertical phase "wrap-around"). The sawtooth waveform shown in the figure above shows the proper position of the marker.

   Press **[SCALE REF]** ***[MARKER → DELAY]***. The analyzer adds enough electrical length to match the group delay present at the marker frequency (group delay is discussed in the next measurement example). This results in the flat response shown below. To display the amount of electrical length added, press ***[ELECTRICAL DELAY]***.



Using Electrical Delay to Cancel Out Linear Phase Response

NOTE: The next example, "Measuring Phase Distortion", uses the settings you just completed. do not change instrument settings before going to that example.

Measuring Phase Distortion

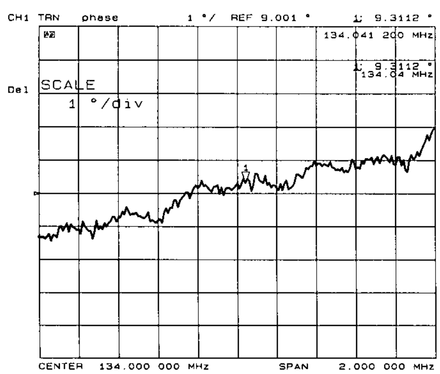
For many networks, the amount of insertion phase is a minor consideration compared to the linearity of phase shift over a range of frequencies. The analyzer can measure this linearity and display it in two ways:

- Directly, as deviation from linear phase.
- As *group delay*, which is derived from the above value.

Deviation From Linear Phase

This example assumes the settings made in "Measuring Electrical Length" (the previous example) are still in effect. By adding electrical length to flatten the phase response we have already removed the linear phase shift caused by the DUT. The remaining response is deviation from linear phase. The only step remaining is to change display scale to make the deviations more visible.

a. Press **[SCALE]** ***[AUTOSCALE]*** to more easily see deviation from linear phase.



Deviation from Linear Phase

Group Delay The phase linearity of some devices is specified in terms of *group delay* or *envelope delay*. This is especially true of telecommunications components and systems.

Group delay is the difference in propagation time (through a device) as a function of frequency. It is measured as a ratio of phase change over a sample delta frequency (*aperture*).

A small aperture setting looks at many samples over the total measurement frequency span. Each sample measures the average phase slope over a very narrow delta frequency. Because the samples are so narrow, shifts in phase slope (caused by phase noise) have a great effect on the displayed trace. This makes narrow-aperture group delay measurements very noisy.

A wide aperture setting looks at fewer samples over the total measurement frequency span. Each sample covers a wider delta frequency. Because of this, rapid changes in phase are averaged, and have less effect on the measurement. Some loss in measurement detail occurs with wide apertures however.

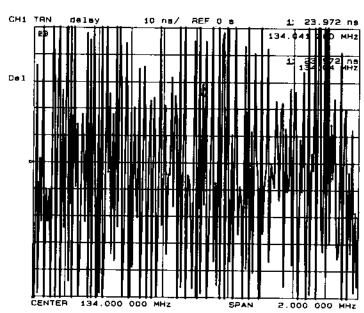
a. Press **[FORMAT]** ***[DELAY]*** to display group delay. The default aperture is very narrow, so the group delay measurement displayed on the screen is very noisy.

The three illustrations below show the affect of aperture setting on a group delay measurement. As the aperture is increased from 0.5% to 2% (and higher), the trace becomes much smoother, at the expense of measurement detail.

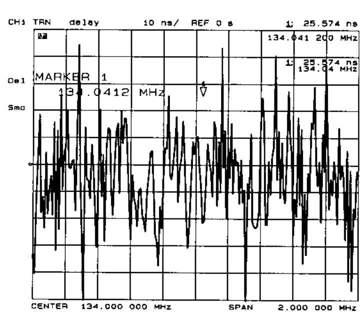
b. Press **[AVE]** ***[SMOOTHING ON off]***. The display becomes much less noisy, because smoothing increases the default aperture width to 1% when turned on.

c. Press ***[SMOOTHING APERTURE]*** **2 [x1]** to increase aperture to 2%.

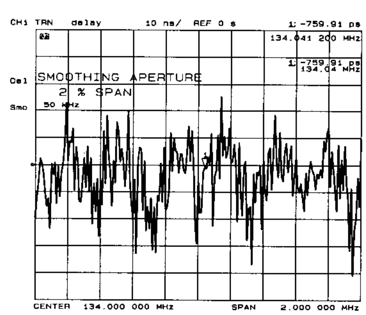
A Note About Smoothing The smoothing feature is not specific to group delay measurements. It can also be used during normal measurements to make the trace appear less noisy. "Reducing Trace Noise" provided in "Getting the Most out of Your Network Analyzer" explains smoothing in more detail.



a. Group Delay with Narrow Default Aperture



b. Group Delay with 1% Aperture



c. Group Delay with 2% Aperture

Where to Find More Information

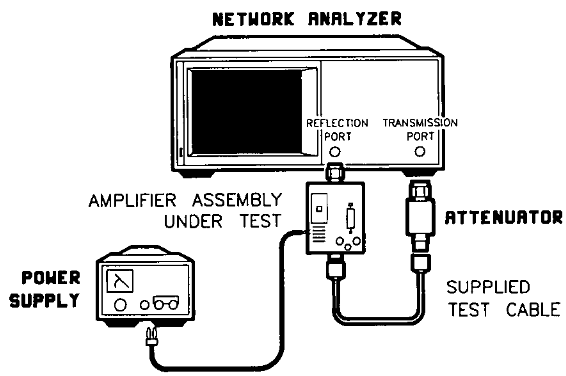
More information on Deviation from linear phase, aperture, and group delay is provided in "Group Delay Principles" in the Time Domain section of the *Operating Manual*.

Measuring Gain Compression

Measurements in previous examples have all been made with a constant input amplitude (to the DUT) and swept frequency. An important measure of active devices is their performance at a single frequency with a varying input amplitude. By using power as the (x-axis) stimulus, measurements such as gain compression or automatic gain control (AGC) slope can be made. In this instrument, power sweep mode provides power (x-axis) stimulus.

Test Setup

Refer to the illustration below. An attenuator may be required on the output of the DUT so the transmission port is not overdriven. Refer to the "Specifications" chapter in the Operating Manual for receiver power limitations.



Gain Compression Test Setup

1. Connect the DUT and Test Equipment

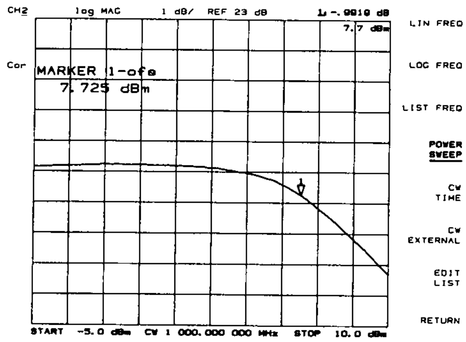
Connect the DUT and test cable as shown above.

2. Choose Measurement Settings

a. Press **[PRESET]** and choose these measurement settings:

Stimulus	Press **[MENU]** ***[CW FREQ]*** **100 [M/µ]** ***[SWEEP TYPE MENU]*** ***[POWER SWEEP]*** **START −10 [x1]** **STOP +0 [x1]**
Response	
Measurement	TRANSMISSION (press **[MEAS]** ***[TRANSMISSN]***)
Format	LOG MAG (default setting)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)

b. Press **[MKR]** ***[MKR ZERO]*** and rotate the knob to measure the gain compression of the amplifier.

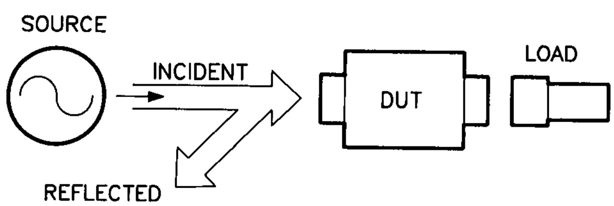


Typical Gain Compression Measurement

3. Output the Result Optional Step: Output the result as explained previously.

Reflection Measurements

The transmission measurements discussed earlier are only part of the network analyzer picture. Measuring the return loss or reflection coefficient completes the device characterization, and provides the basis for calculating parameters such as impedance and SWR. This section demonstrates how to set up, make, and interpret reflection measurements.



When making a reflection measurement, the analyzer monitors the signal going to the DUT and uses this as a reference. It compares the reflected signal from the DUT to the reference signal. The ratio of the incident and reflected signals is the reflection coefficient of the DUT or, when expressed in decibels, the return loss.

Multi-Port Devices Reflection measurements are made with only one port of the test device. When the DUT has more than one port, the unused ports must be terminated in their characteristic impedance (usually 50 or 75 ohms). If this is not done, reflections off the unterminated ports will cause measurement errors.

Connect high-quality terminations (loads) to all unused DUT ports.

Measuring Return Loss, Reflection Coefficient, and SWR

The signal reflected from the DUT is usually measured as a ratio to the incident signal. It can be expressed as reflection coefficient or return loss. These measurements are mathematically defined as:

$$\text{Reflection coefficient} = \frac{\text{reflected power}}{\text{incident power}} = \rho \text{ (magnitude only)}$$

$$= \Gamma = \text{Reflection (magnitude and phase)}$$

$$\text{Return loss (dB)} = -20 \log (\rho)$$

$$\text{SWR} = \frac{1 + \rho}{1 - \rho}$$

1. Connect the DUT and Test Equipment

Connect the DUT directly to the Reflection Port. Terminate the DUT's output port with a 50 ohm load (for HP 8752A), or a 75 ohm load (for HP 8752B).

2. Choose Measurement Settings

Press **[PRESET]** and choose these measurement settings:

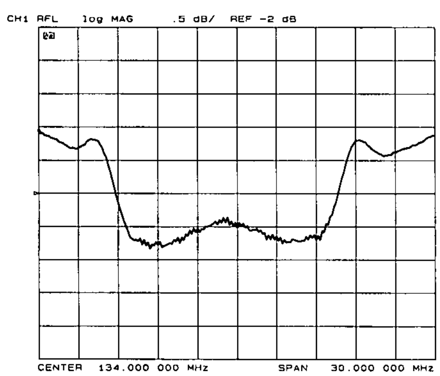
Stimulus	CENTER 134 MHz (press **[CENTER] 134 [M/µ]**) SPAN 30 MHz (press **[SPAN] 30 [M/µ]**)
Response	
Measurement	Reflection (default)
Format	LOG MAG (default)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)

3. Output the Result

This step is not performed in this example.

Return Loss

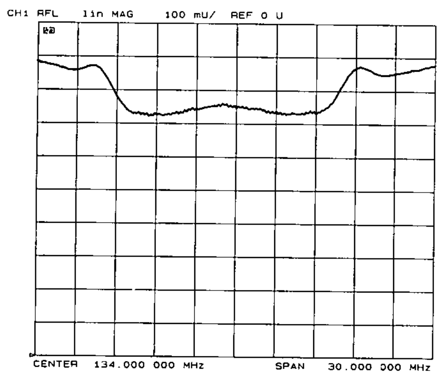
The results of a typical reflection measurement are shown below. This device does not have very good match inside the filter passband, although it does illustrate that within the filter passband, the device matches the system impedance more closely than outside the passband. Therefore, the reflected signal in the filter passband is smaller than outside the passband. In terms of return loss, the value inside the passband is larger than outside the passband. A large value for return loss corresponds to a small reflected signal.



Return Loss

Reflection Coefficient

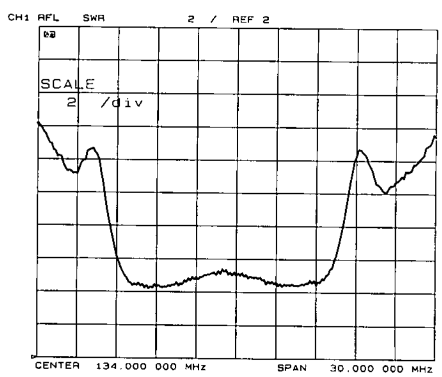
To display the same data as reflection coefficient, press **[FORMAT]** ***[LIN MAG]***. This displays the existing measurement in a linear magnitude format that varies from $\Gamma = 1.00$ at the top of the display (100% reflection) to 0.000 at the bottom of the display (0% reflection, a perfect match).



Reflection Coefficient

Standing Wave Ratio

To display the reflection measurement as standing wave ratio (SWR), press **[FORMAT]** ***[SWR] [SCALE REF] [AUTOSCALE]***. The analyzer reformats the display in the unitless measure of SWR with SWR = 1 (perfect match) at the bottom of the display.



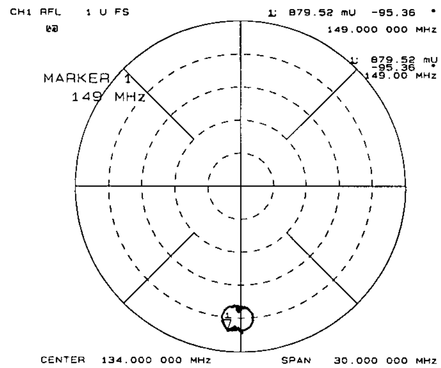
SWR

Displaying Results in Polar Format

When making reflection measurements, polar format displays the complex (phase and magnitude) reflection coefficient of the DUT. Remember, any unused ports must be terminated with an appropriate load.

Press **[FORMAT]** ***[POLAR]***.

The results of a typical reflection measurement are shown below, with each point on the polar trace having a specific magnitude and phase value. The center of the circle represents a coefficient Γ of 0 (a perfect match, no reflected signal). The outermost circumference of the scale represents Γ of 1 (100% reflection). The phase angle is read directly from the display, refer to the figure below.



Polar Display Format

Press **[MKR]**.

Magnitude and phase will be displayed in the marker data readout. Move the marker with the knob to find the magnitude and phase values at any desired frequency. Alternatively, enter a frequency after pressing the marker key, and the marker will go to that specific frequency.

Linear, logarithmic or real/imaginary data readout. The marker data readout can display values in any of these formats. The default format is linear. The menu for changing this format can be accessed by pressing **[MKR]** ***[MARKER MODE MENU] [POLAR MKR MENU]***

Measuring Impedance

The amount of power reflected from a device is directly related to the impedances of both the device and the measuring system. In fact, each value of the reflection coefficient (Γ) uniquely defines a device impedance; $\Gamma = 0$ only occurs when the device and analyzer impedance are exactly the same. A short circuit has a Γ of $1 \angle 180°$. Every other value for Γ also corresponds uniquely to a complex device impedance, as defined in the following equation:

$$Zn = \frac{1 + \Gamma}{1 - \Gamma}$$

Where Zn is the DUT impedance normalized to (divided by) the measurement system's characteristic impedance (50 or 75 ohms).

Setting System Impedance

The HP 8752A has a default impedance of 50 ohms, while the HP 8752B has a default impedance of 75 ohms. To set the impedance to other than the system default value, press **[CAL]** ***[MORE] [SET Z0] nn [x1]***, where nn=new impedance value. The analyzer uses the formula above to convert the reflection coefficient measurement data to impedance data.

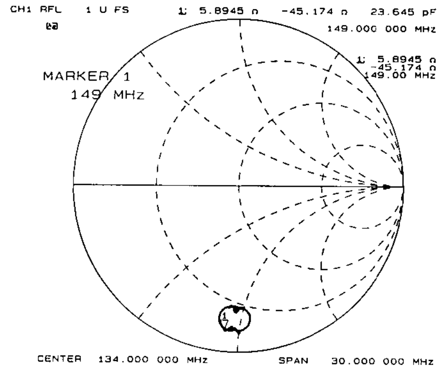
Smith Chart Display

A Smith chart overlay on the polar display axes allows you to read the impedance data in the R ±jX format, where R is of the resistive component and X is the reactive component of the complex impedance.

Press **[FORMAT]** ***[SMITH CHART]***.

The Smith chart graticule is easiest to use with a full scale value of 1.00:

Press **[SCALE REF]** ***[SCALE/DIV]*** **1 [x1]**.



Smith Chart Format

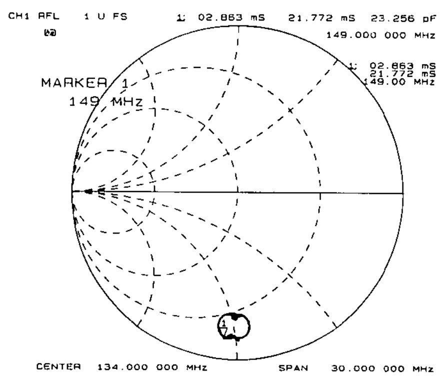
The display (shown above) shows the complex impedance of the DUT over the selected frequency range. Use a marker to read the resistive and reactive components of the complex impedance at any point along the trace. The complex impedance is capacitive in the bottom half of the display, and inductive in the top half.

Admittance Measurements

The marker can display measured data as admittance:

Press **[MKR]** ***[MARKER MODE MENU] [SMITH MKR MENU] [G+JB MKR]***.

This provides an inverse Smith chart overlay. The marker displays the admittance data in the form G ±jB, where G is conductance and B is susceptance. Both values are measured in units of Siemens (equivalent to mhos).



Admittance Format

Press ***[R+jX MKR]*** to revert to the (default) impedance data display.

Chapter 5. Instrument Feature Tutorials

Chapter Contents

Introduction

This chapter explains how to use some of the features and options of a network analyzer system.

Disk Drive Tutorial

What is Saved

The instrument always saves the following information to disk:

- All instrument settings.
- All measurement calibration information.
- Limit lines information.
- User-Defined frequency list.

The following information is saved when the stated condition exists.

- Memory trace data (created using the ***[DATA → MEMORY]*** softkey) is saved *if* the memory trace is currently displayed on the screen. This occurs when any one of the following keys have been pressed: ***[MEMORY]***, ***[DATA AND MEMORY]***, ***[DATA-MEM]***, or ***[DATA/MEM]***.
- When selected by the operator, raw data, error-corrected data, formatted data, or user-generated graphics can be saved along with the instrument settings. Refer to the "Save and Recall" chapter in the *Operating Manual* for more information.

Preparing the Disk Drive and Diskette For Use

1. **Selecting Drive 0 or 1.** The analyzer's default setting is drive 0. If you have a disk drive with two drive slots, and you wish to access drive 1, press **[LOCAL]** ***[DISK UNIT NUMBER]*** **1 [x1]**, otherwise leave it set to drive 0. Neither PRESET nor cycling line power will change this drive setting.
2. **Selecting a Hard Disk Volume Number.** Skip this step if you are using floppy disks:

Press **[LOCAL]** ***[VOLUME NUMBER]*** **n [x1]** where n is the desired volume number. Volume is another term for hard disk partition.

Initialize a New Floppy Disk

You must initialize new floppy disks before use.

1. Make sure the write protect tab on the disk is *fully* closed.
2. Make sure there is no external computer connected to the analyzer and press **[LOCAL]** ***[SYSTEM CONTROLLER]***.
3. Press **[SAVE]** ***[STORE TO DISK] [DEFINE STORE] [MORE] [INITIALIZE DISK] [YES]***.

The disk drive busy light will come on for about a minute and a half. When it goes out, the disk is ready for use. Disks need only be initialized once.

NOTE: You may also initialize disks on an HP 9000 Series 200 or 300 computer using an interleave factor of 7.

Store Instrument data to disk

Make sure there is no external computer connected to the HP-IB bus.

1. Press **[SAVE]** ***[STORE TO DISK] [STORE FILE1]***. ("FILE1" is the default name of the disk file.)

Selecting a Filename

In this example the title "DUT1" will be entered. A title must begin with a letter, may contain only letters and numbers, and can be no longer than eight characters in length.

1. Press: **[SAVE]** ***[STORE TO DISK] [TITLE FILES] [TITLE FILE1] [ERASE TITLE]***.

   A series of letters and numbers appear on the display.
2. Turn the front panel knob counter-clockwise until the letter selection arrow is under the "D", press ***[SELECT LETTER]***.
3. Repeat step 2 for the rest of the characters in "DUT1". Press the ***[BACK SPACE]*** key to back over an incorrect entry.
4. When finished, press ***[DONE] [RETURN] [STORE DUT1]*** to store current instrument data to filename "DUT1".

Where to Find More Information

The "Save and Recall" chapter in the *Operating Manual* contains detailed descriptions of each softkey under the **[SAVE] and [RECALL]** keys. HP-IB codes for each softkey and other detailed information is supplied.

Disk Storage Troubleshooting

When you encounter a problem, look in the message area on the screen. Usually a red error message will give you a hint as to what is wrong. Most messages clearly state the cause of the problem.

1. Make sure the disk drive is plugged in, turned on, and has an HP-IB cable connected between it and the instrument. Make sure there is no external computer connected to the analyzer's HP-IB bus.
2. Make sure there is no computer controller connected to the instrument. Make sure the instrument is in system controller mode by pressing **[LOCAL]** ***[SYSTEM CONTROLLER]***.

3. Make sure the analyzer knows the HP-IB address of the disk drive:

   a. Press **[LOCAL]** ***[SET ADDRESSES] [ADDRESS: DISK]***, the default value is 0.

      Make sure the displayed address matches the actual address of the disk drive. It's best to keep the drive set to the default value. If you cannot do this for some reason, change the address the analyzer recognizes for the drive (after entering the three keystrokes mentioned earlier in this step, press **nn [x1]** (where nn is the actual HP-IB address of the device).

4. If attempting store data to a disk, make sure you are using an initialized disk. Also make sure you have the proper disk drive slot selected (0 or 1). To select a different drive slot, press **[LOCAL]** ***[DISK UNIT NUMBER]***, followed by **n [x1]** (where n is 0 or 1).

5. If attempting to initialize a disk, make sure you have the proper disk drive slot selected as explained in step 4. Make sure the diskette write protect tab is *fully* closed.

6. If all this fails replace the HP-IB cable. If this does not fix the problem try a replacement disk drive unit, if available.

7. If all the above fails, contact Hewlett-Packard for assistance.

Preparing a Hard Disk For Use

Compatible Hard Disk Drives

You may use any CS/80 hard disk drive that is compatible with HP Model 9000 Series 200 and 300 computers. Virtually all new Hewlett-Packard disk drives are CS/80 compatible, your local Hewlett-Packard sales office can give you specific information.

Special Requirements

Initializing a hard disk requires the use of a series 200 or 300 computer, the analyzer cannot perform this function.

1. Initialize the hard disk using and HP Model 9000 Series 200 or 300 computer. Use the instructions supplied with the hard disk drive.

2. Connect the hard disk drive's HP-IB cable to the analyzer.

3. Make sure the hard disk HP-IB address matches the disk drive address recognized by the analyzer. (Press **[LOCAL]** ***[SET ADDRESSES] [ADDRESS: DISK]***.)

Limit Lines Tutorial

Introduction

This section provides information in three steps:

- Fundamental concepts are explained that are crucial to understanding limit lines and limit testing.
- A hands on example is provided for creating, editing and saving limit setups.
- Additional information is provided on limit lines/testing. Knowing much of this information is not crucial when using limit lines, but is very useful.

Important Concepts

What are Limit Lines and Limit Testing?

Limit Lines

These are lines drawn on the display to represent upper and lower test limits. Used by itself, limit lines simply display the selected upper and lower limits on the screen, and no pass/fail information is provided. Limit line parameters are entered in tabular format.

Limit Testing

When limit testing is turned on, the instrument compares DUT performance to specified limits and shows pass/fail results. Limit testing can be used in conjunction with the test sequencing feature: Different sequences can be performed depending on whether the DUT passed or failed.

NOTE: Limit lines (which are simply lines drawn on the display) and limit testing can be turned on independently of one another.

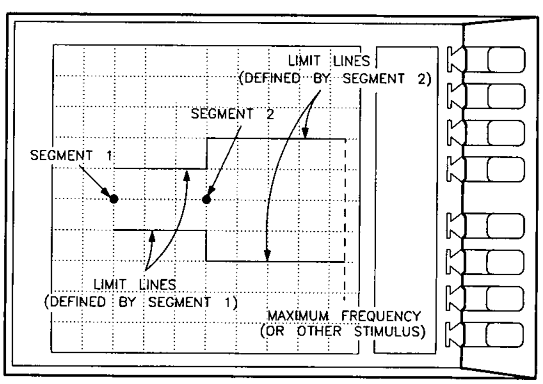
Out of Limit Indications

An out-of-limit test condition is normally indicated in five ways:

- With a FAIL message on the screen.
- With a beep.
- By changing trace color.
- With an asterisk in tabular listings of data.
- With a bit in the HP-IB event status register B.

Understanding Segments

Before limit lines can be explained the concept of "segments" must be made clear. A segment is a single point, it is *not* a line connecting two points. Refer to the figure below:



The Concept of Segments as a Single Stimulus Point, with Limit Lines Connecting Them

As you can see in the figure above, segments are distinct points that define where measurement limits (limit lines) begin and end. *Limit lines* span the distance between segment points and represent the upper and lower test limits. The figure also shows another important aspect of limit lines: If no end segment is specified, a set of limit lines will continue until the maximum frequency (stimulus) is reached. This is the case with the limit lines started by segment 2 shown in the above figure.

A segment is placed at a specific stimulus value (a single frequency, for example). The first segment sets the starting point for a set of limit lines. Once a stimulus value is entered, the following needs to be supplied:

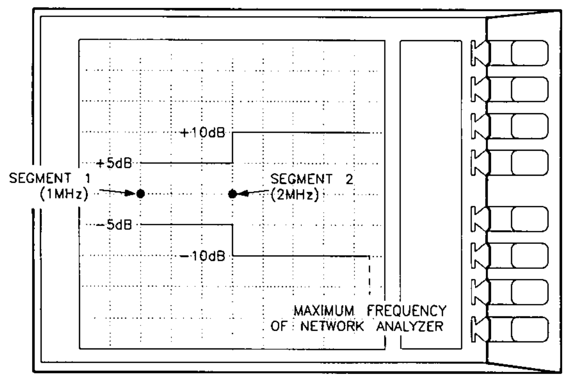
Upper and lower test limits (+5 dB and −5 dB, for example).

Limit type The last parameter to be selected is the "limit type". The limits you specify can apply between segments in one of three ways:

- Flat line limit type.
- Sloping line limit type.
- Single point limit type.

Flat line: The limits stay the same from one segment to the next. The change in limits from one segment to the next will occur instantly, in a distinct step.

Example: Segment 1 is at 1 MHz and has an upper and lower limit of +5 and −5 dB, respectively. Segment 2 is at 2 MHz, and has an upper and lower limit of +10 and −10 dB. Segment 1's limits (+5 and −5 dB) will apply, unchanged, up to 2 MHz, at which time they instantly change to +10 and −10 dB. Refer to the figure below.

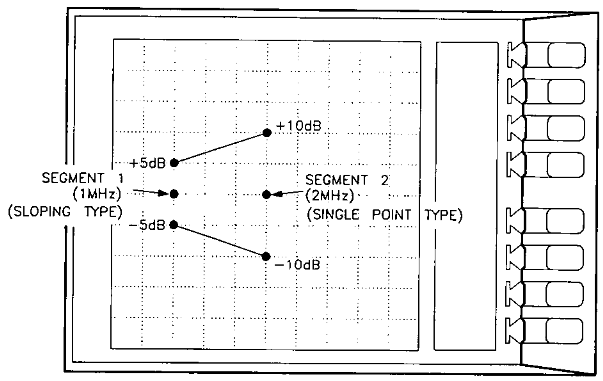


Flat Line Limit Type

Notice the second set of limit lines shown in the above figure (+10 dB and −10 dB). These limit lines start at 2 MHz (the frequency of segment 2) and continue until the maximum frequency of the instrument is reached. Maximum stimulus value (in this case frequency) is the default end point unless an end segment is specified. To stop the limit lines at a specific frequency, enter another segment at the desired stop frequency and make it a single point (limit type) segment (see "Single point" below).

Sloping line: Upper and lower limits change (in a linear sloping fashion) from one segment to the next.

Example: Segment 1 is at 1 MHz and has an upper and lower limit of +5 and −5 dB, respectively. Segment 2 is at 2 MHz, and has an upper and lower limit of +10 and −10 dB. The upper limit will start out at segment 1's frequency (1 MHz) at a value of +5 dB. It will slope upwards, linearly, until it is equal to +10 dB at 2 MHz (segment 2's frequency). The same will occur on the lower limit. At 1.5 MHz, the upper and lower limits will be +7.5 and −7.5 dB, respectively.



Sloping Line Limit Type

Single point: DUT performance is checked only at the exact stimulus values of the stimulus points. The limits do not apply between the segments.

NOTE: Each segment can have a different limit type. In addition, limits can be defined independently for the two channels. These can be in any combination of the three limit types.

Entering Subsequent Segments

Entering another segment defines where the first set of limit lines ends. This process is repeated to create different sets of limit lines, each having new upper and lower limits. Up to 18 segment points can be entered.

Turning Limit Lines and Limit Testing On and Off

Limit lines and limit testing features are off unless explicitly turned on by the user. After entering limit line information you may turn on limit lines and (optionally) limit testing. Turning these features off has no effect on the entered limit line information.

Creating a Limit Test

To test a DUT against specified limits, segments are entered as start and stop points for each specification band across the DUT's frequency range.

For example: Your company tests an RF device that operates from 500 to 1000 MHz and has approximately unity gain. The gain has a flatness specification that changes in two steps:

- 500 to 699 MHz: ±1.5 dB.
- 700 to 1000 MHz: ±3 dB.

To ensure conformance to specification, you want to measure the device's performance at 401 points across its frequency range.

Connect the DUT and Test Equipment

Connect the equipment as shown in the "Basic Measurement Example".

Choose Measurement Settings

1. Press **[PRESET]** and set the analyzer up as needed. The following settings are applicable in this example:

   Start Frequency: 500 MHz
   Stop Frequency: 1 GHz
   Number of Points: 401
   Scale Reference: 1 dB/div

2. Enter the limit test menu by pressing:

   [SYSTEM] ***[LIMIT MENU]***.

3. Enter the limit line editing mode by pressing:

   [EDIT LIMIT LINE].

4. Place a segment at 500 MHz by pressing:

   [ADD] [STIMULUS VALUE] **500 [M/μ]**.

HINT. If you make a mistake when entering the value, you can back space over it assuming you have not yet pressed **[M/μ]**. If you see the mistake after pressing **[M/μ]**, press ***[STIMULUS VALUE]*** again and enter the correct value.

5. Specify the test limits using one the two methods below:

   a. Enter them as upper and lower limits. Since our DUT is nominally 0 dB ±1.5 dB at this frequency, the upper and lower limits are +1.5 dB and −1.5 dB, respectively.

      Enter this upper and lower limit by pressing:

      [UPPER LIMIT] **1.5 [x1]**
      [LOWER LIMIT] **−1.5 [x1]**

   b. Alternatively, enter the test limit as a middle value ± a delta limit. In this example, the middle value is 0 dB. To enter this as the middle value, press:

      [MIDDLE VALUE] **0 [x1]**

      The delta limit is ±1.5 dB, to enter this, press:
      [DELTA LIMITS] **1.5 [x1]**

6. Specify the limit type. In this example, the specification remains the same from 500 to 700 MHz, so flat line limit type is appropriate. Press:

   [DONE] [LIMIT TYPE] [FLAT LINE] [RETURN]

7. Enter the second segment point to terminate the ±1.5 dB specification band and begin the ±3 dB specification band. Press:

   [ADD] [STIMULUS VALUE] **700 [M/μ]**
   [DELTA LIMITS] **3 [x1]**
   [DONE] [LIMIT TYPE] [FLAT LINE] [RETURN]

8. Enter the last segment, selecting single point limit type. When this is done, the last segment becomes stop frequency for the ±3 dB limit lines. (If this step is not performed, the ±3 dB limit lines will extend up to the maximum frequency of the analyzer.) Press:

   [ADD] [STIMULUS VALUE] **1 [G/n]**
   [DONE] [LIMIT TYPE] [SINGLE POINT] [RETURN]

9. Leave the segment edit mode by pressing: ***[DONE]***

10. Press ***[LIMIT LINE ON off]*** to display the limit lines.
Press ***[LIMIT TEST ON off]*** to commence limit testing.

This completes the create limit test example

Editing Limit Lines

Any individual segment (and its associated limit lines) can be edited after creation.

For example: The example above will be modified. Instead of a flat specification of ±3 dB from 700 to 1000 MHz, the 700 MHz specification will begin at ±1.5 dB and slope to ±3 dB at 1000 MHz.

1. Press ***[LIMIT TEST on OFF] [EDIT LIMIT LINE]***.
2. Select segment 2 as the segment to be edited:
   a. Press ***[SEGMENT]*** **2 [x1]** (or rotate the knob until the >cursor is next to segment 2).
   b. Press ***[EDIT]***.
3. Change the delta limit to ±1.5 by pressing:

   [DELTA LIMITS] **1.5 [x1]**

4. Change the limit type to sloping line by pressing:

   [DONE] [LIMIT TYPE] [SLOPING LINE] [RETURN]

5. Leave the segment edit mode by pressing: ***[DONE]***
6. Press ***[LIMIT LINE ON off]*** to display the limit lines.

Press ***[LIMIT TEST ON off]*** to commence limit testing.

This completes the editing example.

Additional Information

Limit Lines Need Not be Entered in Order

The limit segments do not have to be entered in any particular order: the analyzer automatically sorts them and lists them on the display in increasing order of stimulus value.

For example: The first segment is set to a frequency stimulus value of 5 MHz, the second is set to 10 MHz. If you add the third segment at 7 MHz, the three segments will be automatically rearranged as follows:

Segment 1	5 MHz
Segment 2	7 MHz
Segment 3	10 MHz

Saving the Limit Line Table

Limit line information is lost if you press **[PRESET]** or turn off the power switch. However, the **[SAVE]** and **[RECALL]** keys can save limit line information along with all other current instrument settings. This "instrument state" information can be saved to non-volatile memory or to an optional disk drive.

Offsetting Stimulus or Amplitude

All limit line entries can be offset in either stimulus or amplitude value. The offset affects all segments simultaneously.

Supported Display Formats

Limit *lines* are displayed only on Cartesian formats (LOG MAG, PHASE, DELAY, SWR, LIN MAG). 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 DISPLAY in polar and Smith formats.

Number of Measurement Points

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 you do not select a sufficient number of points.

Displaying or Printing Limit Test Data

The "list values" feature in the copy menu prints or displays a table of each measured stimulus value. The table includes 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.

Printing and Plotting Tutorial

Important Note: Before printing or plotting, make sure there is no external computer connected to the analyzer's HP-IB bus.

Printing

NOTE: In the following text, "print" is sometimes used as a generic term for printing or plotting.

What is Printed Two options are available when printing or plotting. Usually, the print or plot features duplicate whatever is on the instrument display. The only exception to this is the List Values feature, described below.

The Printer Buffer This instrument contains a printer buffer – an area of memory that can send printing information to the printer (or plotter) while you use the instrument to perform other tasks. The buffer can hold one plot or print at a time.

Adding a Title This is explained in the "Printing and Plotting" chapter of the *Operating Manual*.

Advantages of Printing Printers are faster than plotters, and are usually less expensive.

Selecting Standard or Color Print Type By default the instrument drives a standard (non-color) printer. If you are using a compatible color printer, press **[COPY]** ***[PRINT/PLOT SETUPS] [COLOR] [RETURN]*** to allow color printing.

Select System Controller Mode Before printing or plotting, make sure there is no external computer controller connected to the analyzer.

Press **[LOCAL]** ***[SYSTEM CONTROLLER]***.

Aborting a Plot or Print Pressing **[LOCAL] aborts a plot or a print out.**

Printing a Duplicate Copy of the Display

1. Align the paper in the printer to the top of the page. If the paper is aligned properly, you can fit two print-outs on a single page.
2. Press **[COPY]** ***[PRINT]***.

Printing a List of Measurement Values

1. Align the paper.
2. Press **[COPY]** ***[LIST VALUES] [STANDARD PRINT]*** to print the first page.
3. Press ***[PAGE] [STANDARD PRINT]*** to print subsequent pages.

Why Does the Printer Print Over Paper Perforations? The analyzer sends a graphic image to the printer, not standard text. This is true even when using the List Values feature. Most printers cannot handle perforations properly when printing graphics. The analyzer has no perforation handling features, mostly because it has no way of knowing how the paper is aligned in the printer. Hand aligning the paper before each print will minimize these problems.

If Printing Does Not Function

Refer to "Plotting and Printing Troubleshooting", later in this tutorial.

Plotting

The analyzer segregates several portions of the measurement display into the following categories.

- Data - the displayed trace, or traces.
- Memory trace - a measurement trace stored in memory that appears on the display.
- Graticule - the display graticule.
- Text - all text shown on the display.
- Markers - the four display markers and their values.

A different pen number may be selected for each of these categories, limited only by the number of available pens in the plotter. This allows you to use pens of various colors or thickness. Each category may be turned on or off independently, allowing you to plot only desired items. The default configuration plots all categories.

Changing Pen Number

The following keystrokes causes the trace to be drawn with pen 2.

[COPY] ***[CONFIGURE PLOT] [PEN NUM DATA]*** **2 [x1]**.

Turning a Category Off

The following keystrokes inhibit plotting of the graticule.

Press:

[COPY] ***[DEFINE PLOT] [PLOT GRAT ON off]***.

Advantages of Plotting

A plotter has the following advantages over a printer:

- Higher resolution.
- Selectable pens (for different line widths or colors).
- The analyzer can selectively plot screen categories.
- More accurate picture placement on the page.
- Up to four plots on a single page (Select Quadrant).

Plotting a Duplicate Copy of the Display

Perform the following:

1. Align/load the paper in the plotter.
2. Make sure there is at least one pen in the plotter, placed in the pen 1 position.
3. Press **[COPY]** ***[PLOT]***.

Plotting a List of Measurement Values

Perform the following steps:

1. Align/load the paper in the plotter.
2. Press **[COPY]** ***[LIST VALUES] [PLOT]***. The first page will plot.
3. Press ***[PAGE] [PLOT]***. Page 2 will plot.
4. Repeat step 3 until all desired pages have been plotted.

Where to Find More Information

The "Printing and Plotting" chapter in the *Operating Manual* contains detailed descriptions of each softkey under the **[COPY]** key. HP-IB codes for each softkey and other detailed information is supplied.

Plotting and Printing Troubleshooting

When you encounter a problem, look in the message area on the screen. Usually a red error message will give you a hint as to what is wrong. Most of the time the message will state clearly what is causing the problem.

1. Make sure the printer or plotter is plugged in, is turned on, and has an HP-IB cable connected between it and the instrument.
2. Make sure the device has paper.
3. Make sure there is no external computer connected to the analyzer's HP-IB bus.
4. Make sure there is no computer controller connected to the instrument. Make sure the instrument is in system controller mode by pressing **[LOCAL]** ***[SYSTEM CONTROLLER]***.
5. Make sure the analyzer knows the HP-IB address of the printer or plotter. Press **[LOCAL]** ***[SET ADDRESSES]***, followed by **one of the following:**

- ***[ADDRESS: PLOTTER]*** - default value is 5.
- ***[ADDRESS: PRINTER]*** - default value is 1.

Make sure the displayed address matches the address the printer or plotter is actually set to. It's best to keep a device set to the default value. If you cannot do this for some reason, change the address the analyzer recognizes for that device (after entering the three keystrokes mentioned earlier in this step, press **nn [x1]** (where nn is the actual HP-IB address of the device).

6. If all this fails replace the HP-IB cable. If this does not fix the problem try a replacement for the device, if available.
7. If all the above fails, contact Hewlett-Packard for assistance.

Test Sequencing Tutorial

What is Test Sequencing?

Test sequencing automates repetitive tasks. In sequencing mode you make the measurement once and the analyzer 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. 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 disk and can be transferred between the analyzer 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

NOTE. A sequence created in the bottom position (SEQ6) is the only sequence that will survive if the instrument is turned off.

1. Press **[SYSTEM]** ***[NEW SEQ/MODIFY SEQ]***.
2. The analyzer will display the six available sequence positions. Press ***[SEQUENCE 1 SEQ1]*** to select sequence 1. ("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 mentioned below is available under the **[RECALL]** key. Entering ***[RECALL PRST STATE]*** in a sequence is the only way to preset the instrument while running a sequence. It is recommended that sequences begin with this command so the instrument will always start out with the same settings.

Example Sequence:

Connect a test cable between the Transmission and Reflection Ports. Enter the following commands on the analyzer:

[RECALL] ***[RECALL PRST STATE]***
[MEAS] ***[TRANSMISSN]***
[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, go ahead and perform step 5, then refer to "Editing a Sequence", below.

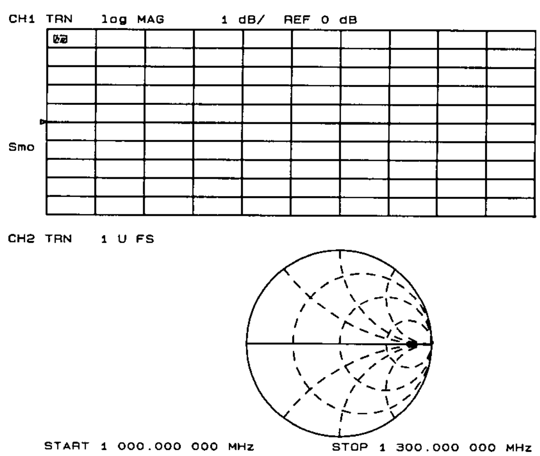
5. Press **[SYSTEM]** ***[DONE SEQ MODIFY]***. The sequence is now ready to run.

Autostarting Sequences

A sequence created in sequence position 6 is stored in nonvolatile memory and will survive if line power is turned off. If you name this sequence AUTO it will run automatically when the instrument is turned on. **[LOCAL]** will abort the sequence.

Running a Sequence

To run the sequence immediately after creating it, press the ***[DO SEQUENCE]*** softkey, a menu will appear showing all available sequences (in this case, only SEQ1 is displayed, because it is the only sequence in existence). Press the ***[SEQUENCE SEQ1]*** softkey. While a sequence is running the analyzer's remote light is on, indicating that the analyzer cannot be operated manually.



The Results of Running the Example Sequence

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 disk, 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 **[PRESET] [SYSTEM]** ***[SEQUENCING MENU] [MORE] [TITLE SEQUENCE] [SEQUENCE 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 in this way until the title "ALPHA" has been entered. **If you make a mistake,** press the ***[BACK SPACE]*** softkey as needed and re-enter the required letters.

Press ***[DONE]*** **[PRESET]**. "SEQUENCE 1 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 [SYSTEM]** ***[NEW SEQ/MODIFY SEQ]***.

2. Press ***[SEQUENCE 1 ALPHA]*** to edit the sequence created earlier. The following is the list of commands you entered in "Creating a Sequence", above. Note that only part of the list can be shown on the screen at one time.

```
=> Start of Sequence
   RECALL PRST STATE
   TRANSMISSN
   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.

NOTE: The ▲ key also causes the next command in the list to execute. In this case, the "RECALL PRST STATE" command preset the analyzer. This feature allows the sequence to be tested one command at a time. The ▼ key does not perform any function except scrolling the command list.

4. 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. If you scroll past the end of the list, it will wrap-around back to the beginning.

Editing Commands

Three editing features are available in sequencing:

- Insert a command
- Delete a command
- Backspace (before the entry is terminated)

Inserting a command

Inserting requires no special keystrokes. Just type in the command to be inserted, and it will appear below the active line.

Deleting a command

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]** ***[DONE SEQ 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. A sequence can be cleared by pressing **[SYSTEM]** ***[SEQUENCING MENU] [MORE] [CLEAR SEQUENCE]***, followed by the softkey label of the sequence to be cleared.

Storing a Sequence to Disk

1. Connect an HP 9122 (or other CS-80 compatible disk drive) to the analyzer. The disk drive must be HP-IB compatible. Make sure the analyzer is programmed with the disk drive's HP-IB address using the **[LOCAL]** ***[SET ADDRESSES] [ADDRESS: DISK]*** keys.

2. Make sure there is no external computer controller connected to the analyzer and press **[LOCAL]** ***[SYSTEM CONTROLLER]***.

Initialize a Blank Disk

3. If necessary, initialize a blank disk by inserting it into drive 0 and pressing **[SAVE]** ***[STORE TO DISK] [DEFINE STORE] [MORE] [INITIALIZE DISK] [INIT DISK? YES]***. The disk drive busy light will come on for about a minute and a half. When the light goes out, the disk is initialized.

Save Sequence to Disk

4. Press **[SYSTEM]** ***[SEQUENCING MENU] [STORE SEQ TO DISK]***. 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 analyzer is not in the proper controller mode. Perform step 2 before saving a sequence to disk.

CAUTION

The save sequence to disk function will overwrite a file on the disk that has the same title. There is no warning to the user when a file is to be overwritten.

6. The disk drive access light should turn on briefly. When it goes out, the sequence has been saved.

Loading a Sequence from Disk

This procedure assumes the disk drive and analyzer have been set up as described in "Storing a Sequence to Disk", and that a sequence titled "ALPHA" has been saved. Sequences are saved to disk independently of instrument state information. In other words, the file containing sequence data is different from a file created with the **[SAVE]** key. The sequence file only contains a list of sequence commands. The file created with the **[SAVE]** key's "store to disk" feature contains current instrument settings, data representing any trace stored in memory, and any user-performed measurement calibration data.

There are two methods of loading a sequence:

- **If you know the sequence title:** 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 you do not know the sequence title:** The contents of the disk can be viewed (six titles at a time). When the desired title appears on the display it can be loaded. Files are stored on disk in chronological order. The directory feature shows file titles in the same order. The procedure for displaying a directory of files is described below.

Loading a Sequence when the Title is Known

1. Press **[SYSTEM]** ***[SEQUENCING MENU] [LOAD SEQ FROM DISK]***. If the desired sequence name is not on the resultant menu, perform step 2.
2. Change one of the six sequence titles to match that of the sequence you want to load. To do this, press **[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 DISK]***.
3. Press the softkey next to the title of the desired sequence. In this case, press ***[LOAD SEQ ALPHA]***. Since "Alpha" already exists in memory, a warning will be displayed on the screen: "PRESS LOAD SEQ AGAIN TO OVERWRITE EXISTING SEQ". Confirm that you wish to overwrite the "ALPHA" sequence in memory by pressing ***[LOAD SEQ ALPHA]*** once more. The disk 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 disk in drive 0.

1. Press **[SYSTEM]** ***[SEQUENCING MENU] [LOAD SEQ FROM DISK] [READ SEQ FILE TITLS]***. The titles of the first six sequences on the disk 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 disk access light should come on briefly. When it goes out the sequence is loaded. As with the example above, a warning will be given before an existing sequence in memory will be overwritten by a disk-based sequence.

Purging a Sequence From Disk

1. Press **[SYSTEM]** ***[SEQUENCING MENU] [STORE SEQ TO DISK] [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 disk can be searched. Refer to "Loading a Sequence From Disk", above, for details.

2. Once the proper sequence name is in one of the purge sequence softkey labels, press that softkey. The disk access light will turn on briefly. When it goes out the file is purged. Once purged, a file cannot be retrieved. *The analyzer purges files when told to do so, there are no "Are You Sure" type messages given.*

Printing a Sequence

1. Connect a compatible printer to the analyzer (refer to the "General Information" chapter in the *Operating Manual* for a list of compatible printers). Make sure the analyzer is programmed with the printer's HP-IB address using the **[LOCAL]** ***[SET ADDRESSES] [ADDRESS: PRINTER]*** keys.

2. Make sure there is no external computer controller connected to the analyzer and press **[LOCAL]** ***[SYSTEM CONTROLLER]***.

3. The sequence to be printed must be in analyzer memory. When the printer is ready to print, press **[SYSTEM]** ***[SEQUENCING MENU] [MORE] [PRINT SEQUENCE]***. Then press the softkey for the desired sequence.

Where to Find More Information

Advanced sequencing features include:

- Branching based on limit testing results.
- Branching based on loop counter value.
- Wait (for x seconds) and Pause (until user presses continue).
- Set CW frequency to active marker frequency.
- Beep.
- Assert service request.

Refer to the "Test Sequencing" chapter in the *Operating Manual* for these features as well as other in-depth sequencing information.

Time Domain Tutorial

Introduction

Time domain is an option (010). With it, the analyzer can display the time domain response of the DUT.

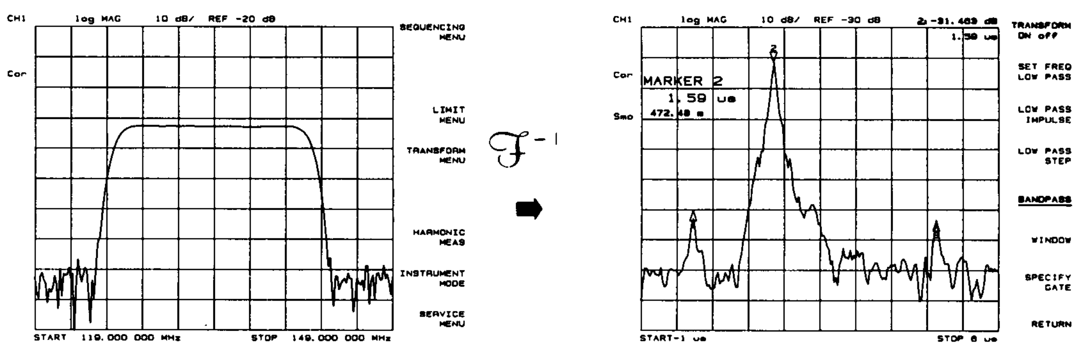
In-Depth Information

Because of space limitations, in-depth information on time domain is not provided in this guide. Refer to the "Time Domain" chapter in the *Operating Manual* for this information.

Basic Information

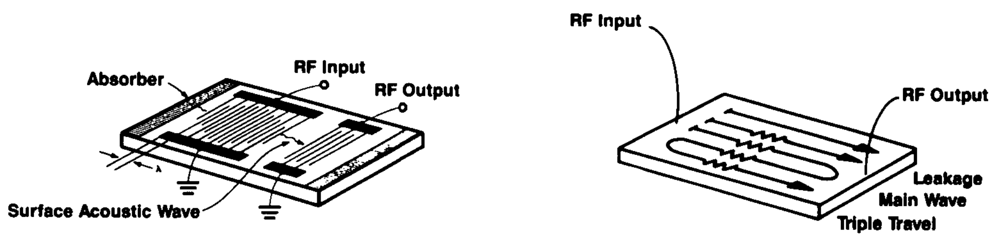
Overall description of time domain analysis

Time domain analysis is useful for isolating a problem in the DUT in time or in distance. Time and distance are related by the velocity factor of the DUT. The analyzer measures the frequency response of the DUT and uses an inverse Fourier transform to convert the data to the time domain. As examples, use time domain analysis to locate points of reflection (at connectors and bends) along a transmission line. Or, separate the individual transmission paths (main path, leakage and triple travel) through a surface acoustic wave (SAW) filter. This section introduces the time domain concept with a SAW filter example.



a. Transmission Response *b. Time Domain Response*

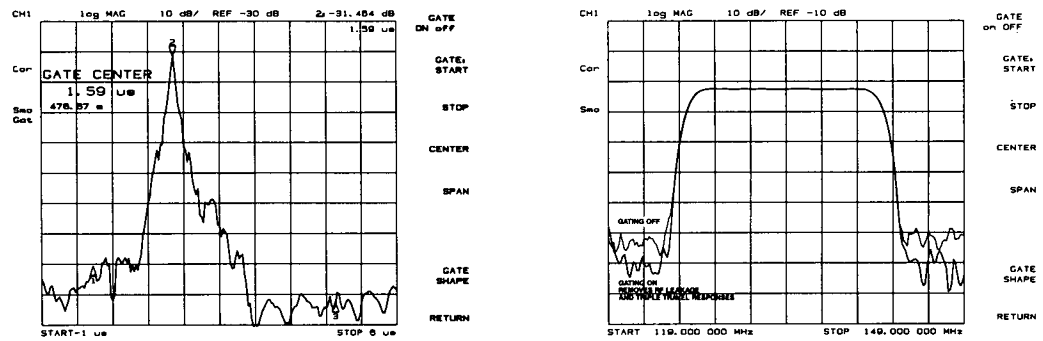
The figure above compares the transmission response of a SAW filter to the time domain response of the same device. Note the three components of the transmission response: RF leakage at near zero time, the main travel path through the device (1.6 μs travel time) and the "triple travel" path (4.8 μs travel time). Each of these signal paths is illustrated in the figure below.



SAW Filter Diagram with Leakage, Main, and Triple Travel Paths

Mathematically removing specific responses

Time domain analysis also lets you mathematically remove individual parts of the time domain response to see the effect of potential design changes. We do this by "gating" out the undesirable responses. In the example shown below we see the effect of removing the RF leakage and the triple travel signal path using gating. By transforming back to the frequency domain we see that this design change would yield better out-of-band rejection.



Using Gating to Simulate Design Improvements, and Viewing the Results in the Frequency Domain

Changing to time domain mode

To change the data from the frequency domain to the time domain, press:

[SYSTEM] ***[TRANSFORM MENU]***

Three different time domain modes may be selected at this point, *bandpass*, *low pass step*, and *low pass impulse*.

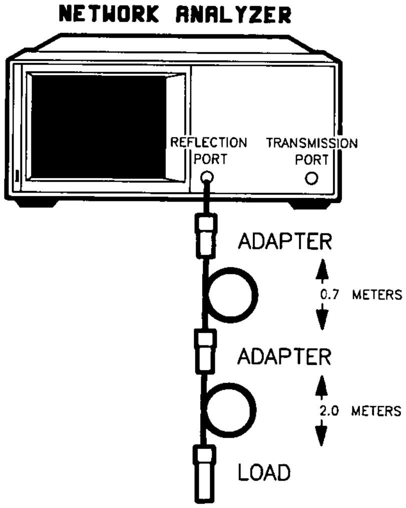
Press ***[BANDPASS]***.

The other modes are described in the *Operating Manual's* "Time Domain" chapter.

Reflection Response

The analyzer with optional time domain analysis can display the time domain response of the reflection measurement data. The result is often compared with time domain reflectometry (TDR) measurements. As with TDR, the time domain feature measures the size of the reflections versus time (or distance). Unlike TDR, the feature allows you to chose the frequency range used in the measurement. With its "gating" capability, time domain lets you perform "what if" analysis by mathematically removing selected reflections and seeing the effect back in the frequency domain.

Example Measurement



Example Time Domain Measurement Setup

1. Connect the DUT and Test Equipment

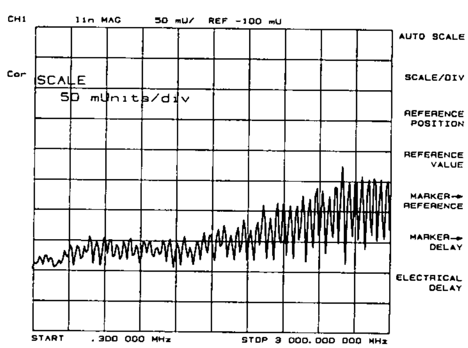
Connect the DUT and test cable as shown in the figure above.

2. Choose Measurement Settings

a. Press **[PRESET]** and then choose these measurement settings:

Response

Meas	Reflection on CH 1 (press **[MEAS]** ***[REFLECTION]***)
Format	LIN MAG (press **[FORMAT]** ***[LIN MAG]***)
Scale	Autoscale (press **[SCALE REF]** ***[AUTOSCALE]***)



Frequency Domain Response

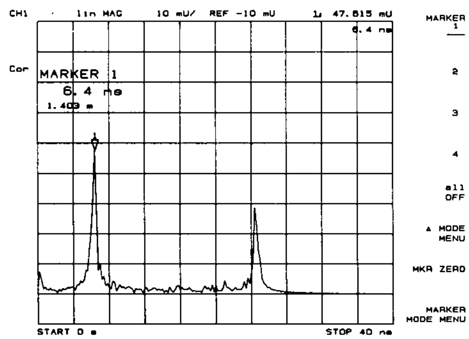
The figure above shows the frequency domain reflection response of the cables under test. The complex ripple pattern is caused by reflections from the adapters interacting with each other. By transforming this data to the time domain, you can determine the magnitude of the reflections versus distance along the cables.

b. Press: **[SYSTEM]** ***[TRANSFORM MENU] [BANDPASS] [TRANSFORM ON off].***

Since this feature places time on its x-axis, a desired start and stop time must be entered. The start time is zero, and the stop time depends on the length of the cable. To enter start and stop time perform steps c and d, below:

c. Enter start time by pressing: ***[START]*** **0 [x1]**

d. To determine stop time, use 3 ns/foot, or 10 ns/meter for the stop (round trip) time. In this example, use 40 ns. Press: ***[STOP]*** **40 [G/n]**



Time Domain Response

Markers show round trip distance

Enter the relative velocity factor of the cable under test. The analyzer's markers, when used, display the actual round trip distance to the reflection of interest rather than the "electrical length" (which assumes a relative velocity of 1).

e. Press **[CAL]** ***[MORE] [VELOCITY FACTOR]*** followed by the velocity factor of the test cables (usually this is 0.66 for polyethylene dielectrics or 0.7 for teflon dielectrics). Terminate the entry with **[x1]**.

To have markers show one-way distance

Enter one-half the actual velocity factor in step e, above.

f. Press **[MKR]** and position the marker on the reflection of interest. Note that the marker displays the time and distance to the reflection in the upper-left hand side of the graticule. Loosen one of the connectors to see the corresponding reflection increase.

This concludes the Time Domain Analysis Tutorial.

Chapter 6. Getting the Most out of Your Network Analyzer

Chapter Contents

Introduction

This guide concentrates on achieving maximum performance with the network analyzer.

Increasing Measurement Accuracy

When Accuracy Improvement is Necessary, and when it is Not

If all of the following conditions are met, the analyzer can provide highly accurate measurements without performing any additional steps:

- The DUT is connected directly to the Reflection Port with no adapters or intervening cables.
- The DUT is nominally a 50 ohm device (for HP 8752A), or a 75 ohm device (for HP 8752B).
- In transmission measurements, the supplied test cable connects the DUT to the Transmission Port with no intervening cables or adapters.

If your test setup meets these conditions, you do not need to proceed any further in this section.

If your test setup does not meet these conditions

For various reasons your test setup may not meet these conditions. Examples are:

- You must adapt to a different connector type or impedance.
- You must connect a cable between the DUT and the Reflection Port.
- You must use a test cable other than the cable supplied with the HP 8752.
- An attenuator or other such device must be connected on the input or output of the DUT.

If Accuracy Improvement is Needed

What aspect of system performance is of concern to you?

When your test setup diverges from the "optimum" setup described above, several system parameters are affected, these are:

- Phase and amplitude at the input of the DUT.
- Frequency response accuracy.
- Directivity.
- Crosstalk (isolation).
- Source match.

The analyzer has several methods of measuring and compensating for these test system errors. Each method removes one or more of the systematic errors using an equation called an *error model*. Measurement of high quality standards such as a short, open or load allows the analyzer to solve for the error terms in the error model. The accuracy of the calibrated measurements is dependent on the quality of the standards used for calibrating. Since calibration standards are very precise, great accuracy is achieved.

Three types of measurement calibration are explained below, starting with the simplest (response) and ending with the most complex (Reflection 1-Port).

Response Calibration

Also called "frequency response calibration", this type of calibration is:

- Simple.
- Requires no calibration device for transmission measurements.
- Requires only a short or open for reflection measurements.

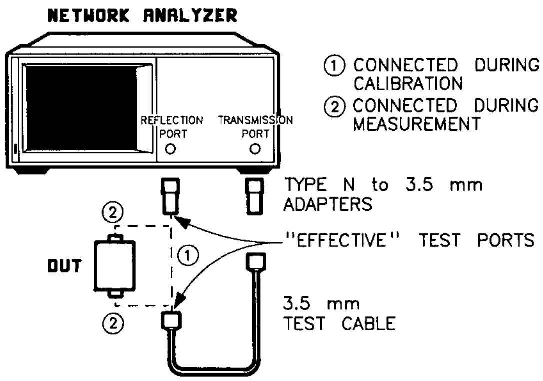
A response calibration establishes a simple phase and magnitude reference (0 dB, 0 degrees phase) at the point you will be connecting the DUT. In addition, it removes frequency response and and insertion loss errors of the test setup. This is also called normalization.

Performing a Response Calibration for Transmission Measurements

For transmission measurements the DUT is removed temporarily and the test cable ("thru") is connected in its place.

1. First, make all measurement selections for stimulus range, number of points, power level, sweep type, and IF bandwidth. This is vital since changing these values *after* calibration will reduce its accuracy. (Sweep type refers to LIN FREQ, LOG FREQ, POWER SWEEP, CW TIME, and FREQUENCY LIST sweep selections, available under **[MENU]** ***[SWEEP TYPE MENU]***.) Changing stimulus range or number of points, for example, will turn calibration off altogether.

2. Connect all equipment as needed in your test setup, but leave out the DUT. (Connect the test cable in it's place.) An example setup is shown below. In this example, the reason for the calibration is that 3.5 mm adapters are on the Transmission and Reflection Ports.



Example Test Setup for a Transmission Response Calibration with the HP 8752A

3. Press **[CAL]** ***[CALIBRATE MENU] [RESPONSE]***.
4. Press ***[THRU]***. The analyzer will beep, letting you know it is done. Also, "THRU" will be underlined, indicating that this step is completed.
5. Press ***[DONE: RESPONSE]*** to complete the Response calibration.
6. Press ***[SAVE REG1]*** to save the calibration to a memory register.

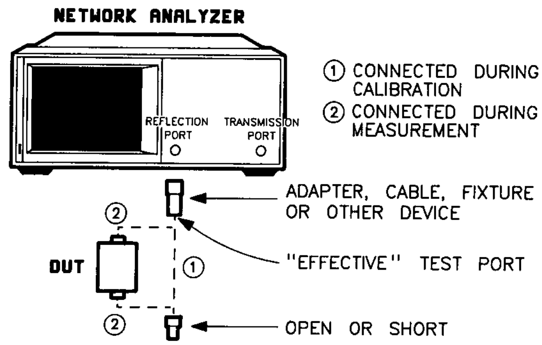
NOTE: Calibration will be turned on automatically at this time.

7. Insert the DUT between the Reflection Port adapter (the "effective" test port) and the test cable. Use markers, limit lines (or other features not mentioned in step 1) to measure the DUT.

Performing a Response Calibration for Reflection Measurements

For reflection measurements an open or short is substituted for the DUT.

1. First, make all measurement selections for stimulus range, number of points, power level, sweep type, and IF bandwidth. This is vital since changing these values *after* calibration will reduce its accuracy. Changing stimulus range or number of points, for example, will turn calibration off altogether.
2. Connect all equipment as needed in your test setup, but substitute an open or a short in place of the DUT. An example setup is shown below.



Example Test Setup for a Response Calibration (for Reflection)

3. Press **[CAL]** ***[CALIBRATE MENU] [RESPONSE]***.

4. **If using a short:** press ***[SHORT (M)]*** or ***[SHORT (F)]* depending on the sex of the *"effective" test port***. The "effective" test port is defined as the connector to which you will later connect the DUT. The softkey (M) and (F) *does not* refer to the sex of the short.

For example, if the effective test port has a female connector press ***[SHORT (F)]***.

If using an open: Press ***[OPEN (M)]*** or ***[OPEN (F)]***, according to the above guidelines.

NOTE: If you choose to use an open, use only the "corrected" open supplied with the calibration kit. Simply leaving the "effective" test port open (with no corrected open device) introduces capacitance errors.

The analyzer will beep, letting you know it is done. The softkey label of the selected device will now be underlined, showing that this step has been completed.

5. Press ***[DONE: RESPONSE]*** to complete the Response calibration.

6. Press the top softkey now displayed (it will be labeled ***[SAVE REG1]*** or ***[RE-SAVE REG1]***. If you performed the transmission Response calibration explained above, the softkey will be labeled ***[RE-SAVE REG1]***. This indicates that there is already information stored in register 1, and that pressing the softkey will replace the old data with the new.

NOTE: Calibration will be turned on automatically at this time.

7. Replace the open or short with the DUT. Remember to terminate unused ports with an appropriate load.

Response and Isolation Calibration

This type of calibration establishes phase and magnitude reference, and optimizes measurement accuracy by minimizing the following errors:

For Reflection measurements:

- Frequency Response.
- Directivity.

For Transmission Measurements:

- Frequency Response.
- Crosstalk (isolation).

Response and Isolation calibration does not correct source match errors.

Performing a Response and Isolation calibration

The first half of the procedure is to perform a simple response calibration, as explained above.

1. Perform steps 1 through 5 of either type of Response calibration explained above (transmission or reflection type). SUBSTITUTE THE FOLLOWING INSTRUCTIONS WHEN PERFORMING STEP 3:

Press **[CAL]** ***[CALIBRATE MENU] [RESPONSE & ISOL'N] [RESPONSE]***.

2. **If you performed a Response calibration for transmission measurements**, connect an appropriate load (50 or 75 ohm) to the Transmission Port and proceed to step 4.

If you performed a Response calibration for reflection measurements, connect an appropriate load (50 or 75 ohm) to the Reflection Port.

4. Press ***[ISOL'N STD]***. The analyzer will beep after measuring the load.

5. Press ***[DONE RESP ISOL'N CAL]*** to complete the calibration.

6. Press the top softkey, it will have the label ***[SAVE REG1]*** or ***[RE-SAVE REG1]***.

NOTE: Calibration will be turned on automatically at this time.

7. Remove the load and connect the DUT. Measure the DUT using markers, limit lines, or other features.

Reflection 1-Port Calibration

Establishes phase and magnitude reference, and optimizes measurement accuracy by minimizing the following types of errors:

- Frequency response.
- Directivity.
- Source match.

This calibration routine removes all three of the systematic error terms seen from a single input port for a reflection measurement. It does not remove the mismatch effects seen from the DUT output. These mismatch effects are negligible if either the reflected signal is large or the DUT greatly attenuates the mismatch signals seen form the output port.

The Reflection 1-Port calibration:

- Is more accurate than the Response Calibration.
- Requires three precision devices (short, open, and load).
- Is a good choice for reflection measurements of large reflection or high insertion loss DUT's.

A recommended use for Reflection 1-Port calibration is measuring amplifiers or SAW filters because they typically have large reflections or high insertion loss, respectively.

Performing a Reflection 1-Port Calibration.

1. First, make all measurement selections for stimulus range, number of points, power level, sweep type, and IF bandwidth. This is vital since changing these values *after* calibration will reduce its accuracy.

2. Connect any needed equipment to the Reflection Port. Substitute an open in place of the DUT.

3. Press **[CAL]** ***[CALIBRATE MENU] [REFLECTION 1-PORT]***.

Measure the open:

NOTE: Use only the "corrected" open supplied with the calibration kit. Simply leaving the "effective" test port open (with no corrected open device) introduces capacitance errors.

4. Press ***[OPENS]*** followed by either ***[OPEN (M)]*** or ***[OPEN (F)]***, depending on the sex of the "effective" test port. For example, if the effective test port has a female connector, press ***[OPEN (F)]***. The analyzer will beep, letting you know it is done. Also, the softkey label of the selected device will now be underlined, showing that this step has been completed.

5. Press ***[DONE: OPENS]***.

Measure the short:

6. Replace the open with a short.

7. Press ***[SHORTS]*** followed by either ***[SHORT (M)]*** or ***[SHORT (F)]*** depending on the sex of the "effective" test port. The analyzer will beep to indicate it is finished.

8. Press ***[DONE: SHORTS]***.

Measure the load:

9. Replace the short with a load.

10. Press ***[LOAD]***. The analyzer will beep after a few seconds, indicating that it is finished.

11. Press ***[DONE 1-PORT CAL]*** to finish the calibration procedure.

12. Press the top softkey now presented on the display (labeled either ***[SAVE REG1]*** or ***[RE-SAVE REG1]***).

NOTE: Calibration will be turned on automatically at this time.

13. Remove the load and set up the test equipment for the actual measurement.

Required Equipment

It is recommended that you use a Hewlett-Packard calibration kit when performing a measurement calibrations. The calibration error model in this analyzer is already configured to match Hewlett-Packard calibration kits. Each connector type or different impedance requires a unique calibration kit. Kits available for the analyzer are listed in the "General Information" chapter of the *Operating Manual*.

If you already have a non-HP calibration kit, the analyzer's error model can be changed to match the kit's model parameters. Refer to the "Measurement Calibration" chapter in the *Operating Manual* for details.

Interpolated Error Correction

As mentioned previously, any change in the following measurement settings will adversely affect the accuracy of a measurement calibration:

- Stimulus range. (In frequency sweeps this is start and stop frequency, in power sweeps this is start and stop power, or in CW Time this is start and stop time.)
- Number of points.
- Power level.
- Sweep type. (Sweep type refers to LIN FREQ, LOG FREQ, POWER SWEEP, CW TIME, and FREQUENCY LIST sweep selections, available under **[MENU]** ***[SWEEP TYPE MENU]***.)
- IF bandwidth.

What interpolated error correction does

This feature allows you to change any of the above settings and retain much of the accuracy of the original calibration.

Limitations

You may only select a subset of the stimulus range. For example, you calibrated the analyzer for a frequency sweep measurement. The start and stop frequencies are 100 MHz and 500 MHz, respectively. You can select any start or stop frequency between 100 and 500 MHz. You cannot select a start frequency below 100 MHz, or a stop frequency greater than 500 MHz. The systematic errors are calculated from the errors of the original calibration.

Turning interpolated calibration on.

Press **[CAL]** ***[INTERPOL ON off]***

Factors which affect the accuracy of interpolated error correction

The quality of the interpolated error correction depends on the amount of phase shift and amplitude change between measurement points. If phase shift is no greater than approximately 180°per 5 measurement points, interpolated error correction can offer a great improvement over uncorrected measurements. Generally, using at least 67 points per Gigahertz of frequency span will ensure this condition is met.

The smaller the amount of phase shift or amplitude change, the greater the accuracy provided by interpolation. For more information, see the "Measurement Calibration" chapter in the *Operating Manual*.

Connector Repeatability

Connector repeatability is a source of random measurement error. Calibrations do *not* compensate for these errors. Refer to the *Microwave Connector Care* manual for instructions regarding inspection, cleaning, gauging, and torquing of connectors.

CAUTION

The connectors provide a direct path to electrostatic discharge (ESD) sensitive devices in the instrument. Always wear a grounding strap and use a static-safe workstation when handling the connectors.

Interconnecting Cables

Cables connecting the DUT and the Transmission Port can contribute random error to your measurement. Inspect for lossy cables and damaged cable connectors. Use proper connector care techniques.

Adapters

Whenever possible, include adapters in the test setup before calibration

Adapters added after measurement calibration add reflections and electrical length to the measurement path.

If you cannot add adapters until after the calibration is done

The two errors (reflections and added electrical length) have the following ramifications:

- Reflections: The reflections cannot be compensated for. You must characterize the adapter and add its maximum uncertainty to the uncertainty of the DUT measurement.
- The adapters' electrical length shifts the apparent phase response of the DUT. This shift can be compensated for by the Port Extensions feature (see "Reference Plane", below).

Reference Plane

To compensate for the phase shift of an extended measurement reference plane due to such additions as cables, adapters, and fixtures, use the port extensions feature. This feature adds electrical delay for transmission and reflection measurements intelligently (twice as much delay added for reflection measurements). This feature is described in detail in the "Measurement Calibration" chapter of the *Operating Manual*. It is accessed by pressing **[CAL]** ***[MORE] [PORT EXTENSIONS]***.

Sweep Time

Short sweep times at some narrow IF bandwidths can give rise to measurement inaccuracy as explained in "IF Bandwidth", below.

IF Bandwidth

At some narrow IF bandwidths and short sweep times, time delay in the DUT signal path can introduce measurement inaccuracy. This problem can be avoided by forcing the analyzer to sweep in stepped CW mode. Each of these conditions ensures stepped CW mode:

- LIST FREQ sweep type
- 10 Hz or 30 Hz IF BW (bandwidth)
- 15 msec/point (at 201 points, for example, 3.015 second [0.015x201] sweep time).

To determine whether stepped CW mode is required for your test setup, gradually increase the sweep time and see whether the measurement difference is significant.

Temperature Drift Variations in ambient temperature will affect the measurement uncertainty because of the thermal expansion characteristics of devices within the analyzer system. Graphs of reflection magnitude and phase uncertainty with temperature drift are located in the "Specifications" chapter of the *Operating Manual*. A temperature-controlled environment limits the measurement uncertainty.

Frequency Drift Minute changes in frequency accuracy and stability can occur as a result of temperature and aging (on the order of parts per million, see the "General Information and Specifications" section). If you require even greater frequency accuracy, override the internal crystal with an external source or frequency standard.

Verification Perform measurement verification to check the accuracy of a calibration. This procedure does not improve measurement accuracy; it is a measure of the accuracy of the existing calibration.

CHOP RFL & TRN Sweep Mode This is the default sweep mode. When dual channel display mode is active, and you are measuring highly reflective devices, CHOP mode may cause measurement inaccuracies. The Alternate mode is suggested in these cases.

To activate Alternate mode, press **[CAL]** ***[MORE] [ALTERNATE RFL & TRN]***.

Alternate mode has one disadvantage: It slows sweep speed. CHOP mode is best when measuring devices that are not highly reflective because it is twice as fast as Alternate A and B mode.

If the Phase Response of a Calibration Device is an Arc Some calibration standards exhibit a curved phase response after calibration. This is normal. Refer to "Why the Phase Response of Some Calibration Standards is an Arc" in the Calibration section of the *Operating Manual*.

Decreasing Sweep Time

The following suggestions for decreasing sweep time are general rules at best. Experimentation is the key to success. To measure sweep time press **[MENU]** ***[TRIGGER MENU] [NUMBER of GROUPS]*** and enter a number followed by [x1]. The analyzer will sweep that number of times and then halt. When experimenting, use auto sweep time mode.

Auto Sweep Time Mode Auto sweep time mode is the default instrument mode. This mode maintains the fastest sweep speed possible with the current measurement settings. Press [MENU] and look at the ***[SWEEP TIME]*** softkey label. if it reads ***[AUTO]*** the auto mode is on. However, if it reads ***[MANUAL]*** then the manual sweep time mode is on. Manual mode maintains a user-specified sweep time. To return to auto mode, simply press [0] [x1].

IF Bandwidth Press **[AVG]** ***[IF BANDWIDTH]*** followed by a value and **[x1]** to change the IF bandwidth. With the analyzer in its preset instrument state, sweep time changes with IF BW as follows:

IF BW	Relative Sweep Time
3000 Hz	1.0
1000 Hz	1.2
300 Hz	2.3
100 Hz	5.3
30 Hz	17.0
10 Hz	50.0

Averaging

Reducing the amount of averaging (or turning it off entirely) decreases measurement time. Averaging causes computational overhead and increases sweep time. Turning off averaging and using smoothing or a smaller IF bandwidth may produce better results.

Number of Points Press **[MENU]** ***[NUMBER of POINTS]*** followed by ▲ or ▼ to change number of points. Sweep time does not change proportionally with number of points but as indicated below. See also "Sweep Type".

Sweep Time Versus Number of Points

Number of Points	Relative Sweep Time*		
	LIN	LIST	LOG
51	0.8	1.1	1.4
101	0.9	1.6	1.9
201	1.0	2.4	2.8
401	1.3	3.8	4.4
801	1.6	6.4	7.5
1601	2.6	8.4	14.0

* Analyzer in preset state, only number of points and sweep type changed.

Single Channel Display Press **[CH 1] [CH 2]** to alternately observe different measurement parameters on two channels (instead of using dual channel mode). If you must observe two measurements simultaneously (with dual channel), use chop mode (below).

Chop RFL & TRN Sweep Mode Press **[CAL]** ***[MORE] [CHOP RFL & TRN]*** to turn on chop mode. This allows simultaneous measurements of transmission or reflection. This is the default instrument mode, it is twice is fast as alternate mode.

Measurement Calibration Sweep time increases when measurement calibration is in use, and with measurement calibration complexity. Measurement calibration is not usually needed, refer to the beginning of this chapter for more information on this feature.

Sweep Type Press **[MENU]** ***[SWEEP TYPE MENU]*** to access the various sweep types. The relative sweep times of the three types of non-power sweeps are indicated in the "Sweep Time Versus Number of Points" table above. But each type of sweep has its advantages and disadvantages.

LIN FREQ Linear frequency sweep is fastest for a given number of points, but the numbers are fixed. The numbers are 3, 11, and 26 in addition to the numbers listed in the "Sweep Time Versus Number of Points" table above.

LIST FREQ List frequency sweep can be fastest when specific frequency points are of interest (and those points are not listed above or are linearly or logarithmically related).

LOG FREQ Logarithmic frequency sweep can be fastest when the frequency points of interest are those in the lower part of the frequency span selected.

Frequency Span To decrease sweep time, eliminate as many band switches as possible while maintaining measurement integrity. The hardware of the network analyzer sweeps the frequency range in a number of bands. Switching from band to band takes time.

To see the band switch points (steps), press **[SYSTEM]** ***[SERVICE MENU] [INPUT PORTS] [ANALOG IN]*** **15 [x1] [FORMAT]** ***[MORE] [REAL]***. Then enter the intended DUT frequency span. Autoscale and modify the frequency span as appropriate. Bandswitch points are also listed in the "Theory of Operation" section of the *Service Manual*.

Printing and Plotting Avoid printing or plotting during measurements if the main goal is to minimize sweep time. The analyzer has a buffer and can dump data to the printer or plotter through it. But the analyzer continues to control the device and that control takes time. At such times the analyzer sweep may be visibly slower or motionless.

Other Factors In general, instrument features require computational time for implementation and updating. The time penalty may be small but it is cumulative. Use these features with discretion.

Limit lines	Limit testing
Marker search	Marker statistics

Increasing Dynamic Range

Maximum dynamic range is the difference between the analyzer's maximum allowable input level and its broadband noise floor. For a measurement to be valid, input signals must be within these boundaries. Thus actual dynamic range is affected by several factors.

Source Output Power

Increase the source output power so that the DUT output power is within the measurement range of the analyzer. (Press **[MENU]** ***[POWER]*** and use the entry keys to set the power). There are limits to the maximum power allowed; if a "SOURCE POWER TRIPPED" or "P?" appears, the power arriving at the receiver is too high. Reduce power and reset the power trip as follows: Press **[MENU]** ***[POWER]***, enter a lower power value, then press ***[POWER TRIP on OFF]***.

Noise

IF Bandwidth

Each tenfold reduction in IF (receiver) bandwidth (for example 3 kHz to 300 Hz) lowers the noise floor by about 10 dB.

To change IF bandwidth, press **[AVG]** ***[IF BW]*** and use the entry keys to enter the desired value. Terminate the entry with the **[x1]** key. With the 10 Hz bandwidth a noise floor of −100 dBm is specified.

Narrower IF bandwidths cause longer sweep times. When in auto sweep time mode, the analyzer uses the fastest sweep time possible for any selected IF bandwidth. Auto sweep time mode is the default analyzer setting.

Averaging

The analyzer can apply exponential averaging of successive traces to remove the effects of random noise. Doubling the number of averages (averaging factor) lowers the noise floor by about 3 dB.

To use averaging:

1. Press **[AVG]** ***[AVERAGING FACTOR]***.
2. Use the entry keys to set the averaging factor, terminate the entry with the **[x1]** key.
3. Press ***[AVERAGING ON off]***.

Averaging is explained more fully in the "Response" chapter of the *Operating Manual*.

The effective averaging factor is displayed under the AVG display annotation (which is displayed when averaging is turned on). This annotation begins at one, and counts up to the user-defined averaging factor, incrementing once per sweep. The noise is reduced, often visibly, with each new sweep as the effective averaging factor increments.

Reducing Trace Noise

The analyzer has three functions that help reduce the effect of noise on the data:

- Averaging.
- IF Bandwidth.
- Smoothing.

Averaging

The analyzer uses an exponentially weighted running vector average for IF averaging. The weight is one over the effective averaging factor. The effective averaging factor is displayed under the AVG display annotation (which is displayed when averaging is turned on). This annotation begins at one, and counts up to the user-defined averaging factor, incrementing once per sweep. The noise is reduced, often visibly, with each new sweep as the effective averaging factor increments.

To use averaging:

1. Press **[AVG]** ***[AVERAGING FACTOR]***.
2. Use the entry keys to set the averaging factor, terminate the entry with the **[x1]** key.
3. Press ***[AVERAGING ON off]***.

Averaging is explained more fully in the Response chapter of the *Operating Manual*.

IF Bandwidth

The IF bandwidth is the effective receiver bandwidth. Reducing the IF bandwidth reduces the noise that is measured during the sweep, but also may slow down the sweep. While averaging requires multiple sweeps to reduce noise, narrowing the IF bandwidth reduces the noise on every sweep.

More information on IF bandwidth is provided under "Increasing Dynamic Range".

Smoothing

Smoothing does not actually reduce the level of noise present, is simply removes sharp edges from the trace. Smoothing employs a linear block average that moves across the trace. The selected smoothing aperture defines the width of the linear block average. Larger apertures smooth out the trace more, but with greater loss of resolution.

To use smoothing:

1. Press **[AVG]** ***[SMOOTHING APERTURE]***.
2. Smoothing aperture is defined as a percentage of the measurement trace. The default value is 1%.

If you wish to increase the aperture (for additional smoothing), enter the new percentage using the entry keys and terminate with the **[x1]** key.

If the default aperture is acceptable go directly to step 3.

3. Press ***[SMOOTHING ON off]***.

Appendix A
Commonly Needed Options, Accessories, and Supplies

Options

Option 010 Time Domain

To add time domain capability to your instrument, order the HP 85019C Time Domain Upgrade Kit. This kit can be installed by the user.

Option 003 3 GHz Operation

To add 3 GHz capability to your instrument, order the HP 11885A 3 GHz Upgrade Kit. This kit is user-installable.

Option 908 and 913

Refer to "Rack Mount Kits", below.

Accessories

Rack Mount Kits

Rack mount kit for instruments equipped with handles

Available at time of order as option 913. This kit is available separately, order HP part number 5062-4072.

Replacement screws for the above kit: The 5062-4072 kit uses metric M4x0.7x16 P.H. screws, HP part number 0515-1106.

Rack mount kit for instruments without handles

Available at time of order as option 908. This kit is available separately, order HP part number 5062-3978.

Replacement screws for the above kit: The 5062-3978 kit uses metric M4x0.7x10 P.H. screws, HP part number 0515-1114.

Calibration Kits

The following calibration kits are available for the HP 8752:

- **HP 85032B option 001, 50 ohm type-N calibration kit.**
- **HP 85033C option 001, 50 ohm 3.5 mm calibration kit.** (This kit requires 2 type-N to 3.5 mm (m) adapters, and two type-N to 3.5 mm (f) adapters. All four adapters can be ordered under a single model number, HP 11878A.)
- **HP 85036B, 75 ohm type-N calibration kit.**

Verification Kit

Accurate operation of the HP 8752A can be verified using the HP 85032B (standard or option 1). Accurate operation of the HP 8752B can be verified using the HP 85036B. The verification procedures are in the *Service Manual*.

Adapter Kits These kits are explained more fully in the "General Information" chapter of the *Operating Manual*.

- **HP 11852B 50 to 75 ohm minimum loss pad.** This device convert 50 ohms to 75 ohms, or from 75 ohms to 50 ohms. Provides low SWR impedance match.
- **HP 11853A 50 ohm type-N adapter kit.** Supplies hardware for measuring 50 ohm type-N devices.
- **HP 11878A 50 ohm 3.5 mm adapter kit.** Supplies hardware for measuring 50 ohm 3.5 mm devices.
- **HP 11854A 50 ohm BNC adapter kit.** Supplies hardware for measuring 50 ohm BNC devices.
- **HP 11855A 75 ohm type-N adapter kit.** Supplies hardware for measuring 75 ohm type-N devices.
- **HP 11856A 75 ohm BNC adapter kit.** Supplies hardware for measuring 75 ohm BNC devices.

Service Kit A general purpose kit provides adapters, extender boards, and extender cables. HP part number 08753-60023.

Cables

Test Port Return Cable To replace the test port cable supplied with the HP 8752A, order HP part number 8120-4781. To replace the test port cable supplied with the HP 8752B, order HP part number 8120-2408.

HP-IB Cables The following HP-IB cables are available:

- **HP 18033A** HP-IB cable, 1m (3.3 ft).
- **HP 10833B** HP-IB cable, 2m (6.6 ft).
- **HP 10833C** HP-IB cable, 4m (13.2 ft).
- **HP 10833D** HP-IB cable, 0.5m (1.7 ft).

Replacement Battery

Instead of a battery, this analyzer uses a capacitor to power temporary memory. This capacitor can maintain Save/Recall registers and other such features for about three days when the line switch is turned off. No replacement battery is needed.

Touch-Up Paint

Name	HP Part Number	Applicable Use
Dove Gray	6010-1146	Frame around Front Panel Painted part of handles
French Gray	6010-1147	Side, top, and bottom covers
Parchment Gray	6010-1148	Rack mount flanges Rack support shelves Front Panel

Touch-up paint comes in a spray can. Spray on a swab and apply to damaged area.

Floppy Disks Disks will need to be ordered if using the optional disk drive. Order HP part number 92192A for a box of 10 double-sided disks.

Manuals

Title	HP Part Number
HP 8752A/B Operating and Service Manual Set	08752-90053
HP 8752A/B Operating Manual	08752-90054
HP 8752A/B Service Manual	08752-90055
HP 8752A/B User's Guide	08752-90056
HP 8752A/B (User's) Quick Reference	08752-90057
Microwave Connector Care Manual	08510-90064

Line Fuse Replacement line fuses are HP part number 2110-0780.

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For more information, call your local HP sales office listed in your telephone directory or an HP regional office listed below for the location of your nearest sales office.

United States:
Hewlett-Packard Company
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No. Hollywood, CA 91601
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