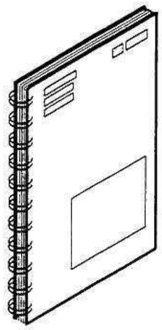
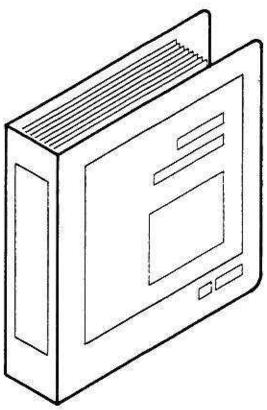
8703A
Lightwave Component Analyzer
User's Guide

Agilent Technologies

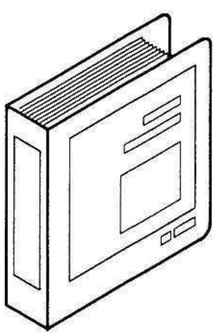
HP 8703A Lightwave Component Analyzer Documentation Map



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



The **Operating Manual** provides general information, specifications, and HP-IB programming information. In-depth reference information is also included on key menus, measurement calibration, and time domain.



The **Service Manual** explains how to verify conformance to published specifications, adjust, troubleshoot, and repair the instrument. In-depth theory of operation is also included.

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INTRODUCTION

This User's Guide gives an introduction to the operation of the HP 8703 Lightwave Component Analyzer. It also shows how to make common optical and electrical measurements.

If you are unfamiliar with the operation of a lightwave component analyzer, you will find Chapter 1 helpful. It has tutorial information about two major kinds of measurements: electrical measurements traditionally made with a network analyzer, and optical measurements made with a lightwave component analyzer. Because the HP 8703 is capable of making both optical and electrical measurements, this information will help you understand the instrument's capabilities.

Understanding the HP 8703

Overview

The HP 8703 Lightwave Component Analyzer is a versatile, integrated system that measures the response of lightwave system components to electrical and modulated lightwave signals. The HP 8703 also has the capability to measure electrical devices.

The lightwave component analyzer characterizes components by comparing an incident signal to a transmitted or reflected signal. This is accomplished for electrical measurements through the use of a built-in microwave source and receiver, and for optical measurements through the use of a built-in modulated light source and lightwave receiver. The HP 8703 light carrier wavelength and average power are fixed, and the modulation frequency is swept over a given frequency range.

CAUTION

Damage to the lightwave modulator can occur when a lightwave carrier of less than 1200 nm wavelength is input to the external laser input. (This applies to option 100 instruments only).

The HP 8703 reconfigures its internal microwave and lightwave hardware on an operator's command. The commands enable measurements of all four device types found in lightwave communication systems:

- O/O devices: optical input/optical output
- O/E devices: optical input/electrical output
- E/O devices: electrical input/optical output
- E/E devices: electrical input/electrical output

A lightwave stimulus is created by applying the analyzer's RF source output to the lightwave source. The optical signal reflected from, or transmitted by, the DUT (Device Under Test) is then demodulated by the lightwave receiver. The modulation source and demodulated signal are compared in the same way that the analyzer processes conventional electrical measurements.

In addition, the HP 8703 provides new calibration routines and measurement features for characterizing opto-electrical and electro-optical devices directly.

To help you better understand the HP 8703, a comparison of the analyzer's microwave and lightwave measurements follows.

HP 8703 Microwave and Lightwave Measurements

The HP 8703 uses a swept frequency source as a stimulus signal to the device under test (DUT). This incident sinewave signal is also used as a known reference signal. The signal that is transmitted through the DUT is routed to the analyzer's receiver and compared to the reference signal. If a reflection measurement is made, an internal coupler is used to separate the incident from the reflected signal. The result of this process is a ratio measurement comparing an incident signal to a transmitted or reflected signal.

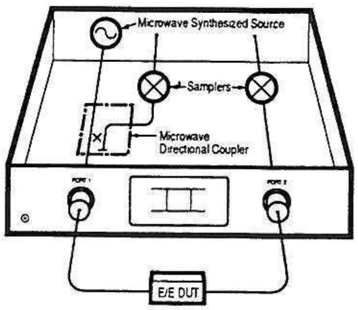
In microwave measurements, this is called an S-parameter (scattering parameter) measurement. It is an OUT/IN ratio. For example, S21 means that the scattering parameter is a ratio of the signal OUT of port 2 (device output) compared to the signal IN to port 1 (device input). S11 is a reflection measurement, where S11 represents the signal coming OUT of (reflected from) port 1 of a device compared to the signal (incident) going IN to port 1 (same port) of the device.

For lightwave measurements, the analyzer provides a modulated optical stimulus by indirectly modulating a laser beam with the swept RF source. An optical response is measured by demodulating the optical signal from the DUT.

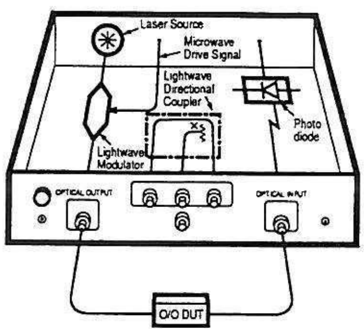
The processing capabilities of the lightwave component analyzer provide flexible, accurate correlation of optical or electrical stimulus with optical or electrical response.

The connections used for measuring the four device types are illustrated in Figure 1.

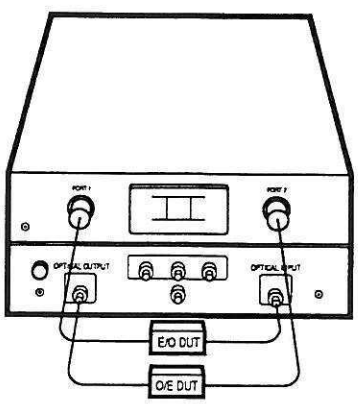
NOTE: Anti-rotation clamps (included with the instrument accessories) can be used to stabilize the electrical test port/RF cable connection. Refer to "Maintaining Good Connections" in chapter 6 of this User's Guide.



Microwave Test Set
E/E Device Connections



Lightwave Test Set
O/O Device Connections



Microwave and Lightwave
Integrated Test Sets
E/O and O/E Device Connections

Figure 1. HP 8703 Microwave and Lightwave DUT Connections

List of Typical System Instruments

A complete system, capable of making the measurements described in this user's guide, would consist of the following:

- HP 8703 Lightwave Component Analyzer
- HP 11871A or 11871B Interconnect Cable Kit (optical thru or jumper cable)
- HP 9122-series Dual-Sided Disk Drive (HP 9122C or D is currently recommended)
- HP 85052D or other compatible calibration kit (for electrical measurements)

Installation

Overview

These are the main topics of this chapter:

- Verify the Shipment
- Site Requirements
- Hewlett-Packard Interface Bus (HP-IB)
- Power Considerations

CAUTION

Damage to the analyzer can result from electrostatic discharge (ESD). Use static-safe work stations and procedures.

If you wish to have the analyzer installed, contact the HP customer engineer to arrange for this on a time and materials basis. Other service options are described in the "General Information" section of the *Operating Manual*.

Verify the Shipment

Keep the shipping containers in one place and verify the completeness of the system before unpacking. If any container or instrument is damaged or incomplete, save the packing materials and notify both the carrier and Hewlett-Packard.

Make sure the serial number on the analyzer's rear panel matches that of the shipping document. The rear panel is shown in Figure 2.

Site Requirements

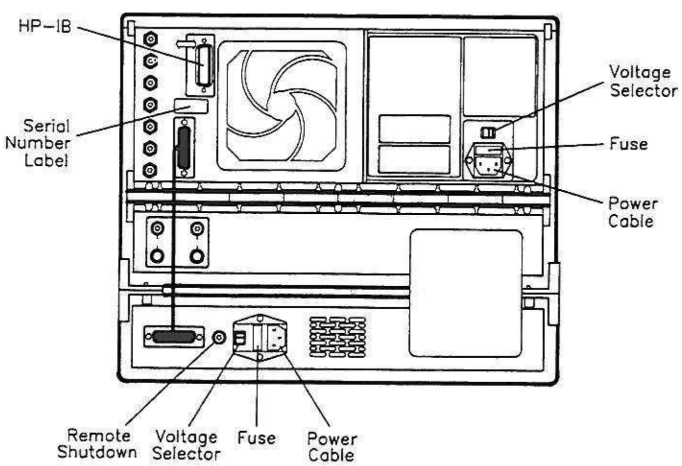


Figure 2. Rear Panel of Analyzer

The analyzer will operate within a range of temperatures, humidity, and altitudes. The "Measurement Accuracy and Specifications" section of the *Operating Manual* has operating and storage specifics. Note that accuracy enhanced performance and some instrument specifications require an environmental temperature of 23 degrees C +-3 degrees.

For bench systems, use an anti-static mat (such as HP 92175T) and wrist straps. Place the mat on the bench and the analyzer on the mat.

System racks are available for installing a measurement system in a compact space. The HP system rack is HP 85043B.

Other rack systems may promote shock hazards, overheating, dust contamination, and inferior system performance. Consult your HP customer engineer about installation, warranty, and support details.

Rack mount kits are available for mounting the analyzer with front handles in 19 inch racks. The kit is option 913, HP part number 5062-4074.

Hewlett-Packard Interface Bus (HP-IB)

The Hewlett-Packard Interface Bus (HP-IB) enables system instruments to communicate. Connect the system instruments with HP-IB cables in any order. All HP instruments have HP-IB connectors similar to that of the analyzer. Tighten the knurled screws on each of the HP-IB cables.

Cable Length (Approximate)	Part Number
4 m (13 feet)	HP 10833C
2 m (6 feet)	HP 10833B
1 m (3 feet)	HP 10833A
0.5 m (1.5 feet)	HP 10833D

HP-IB Address

To communicate via HP-IB, (1) each device must have a unique address and (2) the analyzer must recognize each address. To check each device's HP-IB address, refer to its manual (most addresses are set with switches). To check the analyzer's address, press the (LOCAL) key and the *[SET ADDRESSES] [ADDRESS 8703]* softkeys. The analyzer's address will appear on the CRT display.

The HP-IB addresses shown below are the factory-set addresses of the devices. They are also the default addresses recognized by the analyzer.

Device	HP-IB Decimal Address
Analyzer	16
Printer	5
Plotter	1
Disk (drive)	0
Controller (computer)	21
P Mtr (power meter)	13

To change the address recognized by the analyzer to match a device address, press the device softkey, enter the address, and then press (x1).

To learn how to operate the lightwave component analyzer, continue with the next chapter.

If you need an incoming inspection, refer to the *Service Manual*.

Power Considerations

Set the analyzer voltage selectors (shown in Figure 2) to match the AC line voltage before plugging in the analyzer. Fuse sizes are specified on the instrument rear panel. Each power cable receptacle has a working fuse and a spare.

Display Processor

AC Line Power	Voltage Selector Position
90V to 132V (at 48 to 66 Hz)	115V
198V to 264V (at 48 to 66 Hz)	230V

Lightwave Test Set

AC Line Power	Voltage Selector Position
90V to 110V (at 48 to 66 Hz)	100V
108V to 132V (at 48 to 66 Hz)	120V
198V to 242V (at 48 to 66 Hz)	220V
216V to 264V (at 48 to 66 Hz)	240V

WARNING

Avoid personal injury and instrument damage: use power outlets with a protective earth (third wire) contact only, and the three-wire power cable supplied with each instrument.

If the AC line voltage is not within a range indicated in the table above, use an autotransformer.

CAUTION

Avoid instrument damage: make certain the autotransformer provides third wire continuity to earth ground.

Instrument Power-on

Turn on the line switch of the HP 8703 and press (PRESET). Check that the instrument is on and has passed its self test. If the instrument malfunctions, refer to the *Service Manual*.

NOTE: The analyzer provides a remote shutdown of the laser. The BNC connector on the rear panel must be shorted for the laser to operate (shown in Figure 2). When the terminals of the connector are open-circuited (BNC short removed), the accessible radiation does not exceed the AEL for Class 1 and Class 2 according to IEC Publication 825 (1984). Use your own short, switch, or other circuitry with a BNC cable to operate (open or short) the remote shutdown as desired. Hewlett-Packard does not supply any other accessories with this connector/feature.

Operating the Lightwave Component Analyzer

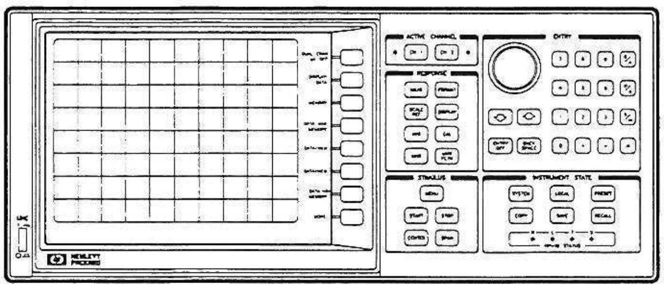
Overview

This chapter briefly explains how to operate the HP 8703. These are the major topics:

- Front Panel Tour
- Guided Setup
- Measurement Sequence

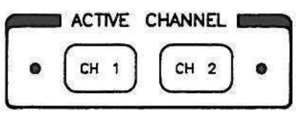
The *Operating Manual* contains indepth operating information on all the analyzer's features.

Front Panel Tour



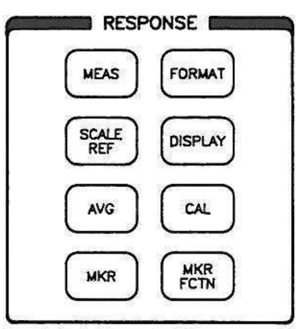
The HP 8703 uses CRT displayed "menus" for operator input. These menus list the possible choices for a particular function, with each choice corresponding to one of the eight "softkeys" located to the right of the CRT. The "hardkeys" on the front panel provide access to the various menus, and are grouped by function.

Active Channel



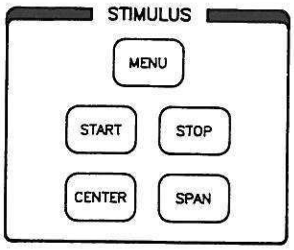
The lightwave component analyzer has dual trace capability, to display two channels simultaneously. Many of the measurement and display functions are independently selectable for each trace. To modify the parameters of a particular trace, first select either (CH 1) or (CH 2), and then make the desired measurement choices. Note that the LED adjacent to the selected (active) channel is lit.

Response



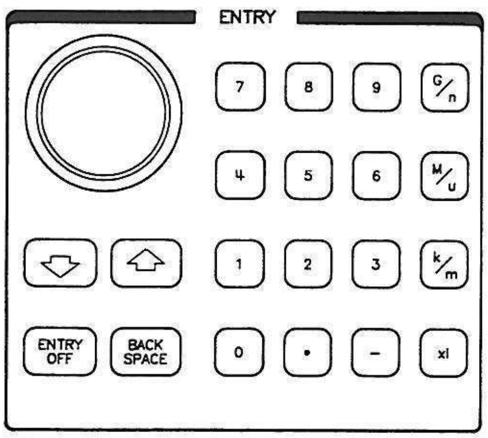
The analyzer's receiver section is controlled with these keys. The (MEAS), (FORMAT), and (SCALE REF) keys are used to choose a measurement configuration, presentation format (amplitude or phase versus frequency, Smith chart, polar coordinates, etc.) and scale and reference values for a full screen display. The other keys in the RESPONSE group enhance the usability of the measured data. The displayed traces may be overlaid, manipulated with math function keys, averaged, normalized, or read out at specific points along the trace with up to four independent markers per channel.

Stimulus



The stimulus keys are used to define the microwave source output signal. The source frequency may be swept over any portion of the 130 MHz to 20 GHz range, at power levels between +5 and −65 dBm. The stimulus keys also control the start and stop times in the time domain mode. The choices for sweep time, frequency span, and sweep type are also selected here.

Data Entry

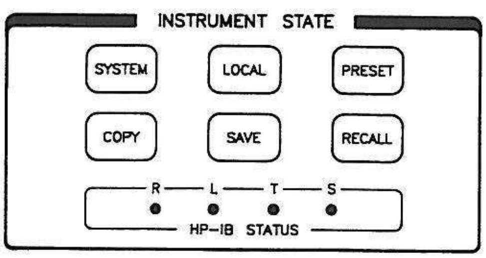


In some cases it is necessary to supply numeric values for a chosen parameter, such as frequency or amplitude. The ten digit keypad is used to supply these values. The keys to the right of the digits terminate the data entry with the appropriate units. The table below lists the data entry terminators and provides their significance for each parameter. In addition to entering data with the keypad, the knob can be used to make continuous adjustments, while the (↑) and (↓) keys allow values to be changed in steps.

Data entry terminators

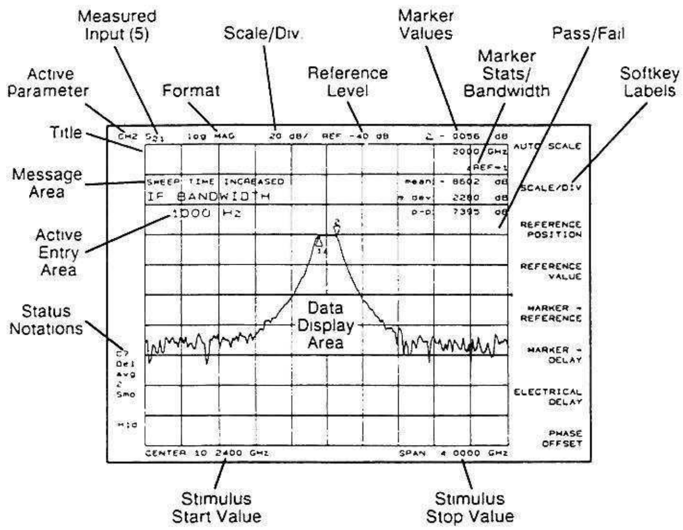
Key Name	Frequency	Power	Time
G/n	GHz	—	ns
M/u	MHz	—	us
k/m	kHz	—	ms
x1	Hz	dB(m)	s

Instrument State



Several utility functions are implemented with these keys, including instrument preset, time domain transform, save/recall memory, and HP-IB plotter and printer control.

CRT Display



With the selection of each hardkey or softkey, the CRT is updated to display the current measurement configuration and status information. For those parameters not continually displayed on the CRT, select the appropriate key to display the parameter in the active entry area.

Status Notations

The status notations area of the CRT is used to show the current status of various functions for the active channel. The table below lists each notation and its meaning.

Notation	Definition
*	Measurement parameters changed: measured data in doubt until a fresh sweep has been taken.
Cor	Measurement calibration (correction) is on.
C?	Measurement calibration is on, but may not be valid.
C2	2-port measurement calibration is on.
C2?	2-port measurement calibration is on but may not be valid.
Hld	Hold sweep.
↑	Fast sweep indicator.
Ext	Waiting for external trigger.
Avg	Sweep-to-sweep averaging is on. The averaging count is shown below the indicator.
Smo	Trace smoothing is on.
Del	Electrical delay has been added or subtracted.
Gat	Gating is on (time domain).
tsh	Test set held.
E=1	O/E using Port 1.
E=2	O/E using Port 2.
O=A	O/O, O, E/O using AUX OPTICAL INPUT
A/W	Calibrated E/O.
W/A	Calibrated O/E
dBo	Log mag format (dB) is relative to optical power.

Analyzer Power Up and Preset

WARNING

Turn the source laser ON only when you are making a measurement. Turn it OFF when not in use. Do not look directly into the laser output or any fiber connected to it because damage to the eye may result.

Turn on the HP 8703 LINE switch on the front panel.

The CRT on the HP 8703 will display a message, that gives you a choice between guided setup and normal operation. Press *[NORMAL OPERATION]* and note the change in the CRT display.

Press the green (PRESET) front panel key and notice the difference between the instrument now and when you first turned on the LINE switch. Pressing the (PRESET) key returns the instrument to a predefined state. In addition, the HP 8703 performs a self test that, if passed, sets the instrument to the following default conditions:

Major Default Conditions at [PRESET]	
DISPLAY	
Measurement	O/O on Channel 1
Format	Log Magnitude
Display Mode	Dual Channel Off
Scale	10 dB/division
Reference	0 dB, center of CRT
STIMULUS	
Start Frequency	130 kHz
Stop Frequency	20 GHz
Number of Data Points	201
Power	0 dBm
Sweep Time	2.6s - Auto
RECEIVER	
IF Bandwidth	3 kHz
Averaging	Off
Smoothing	Off
Cal Correction	Off

Guided Setup

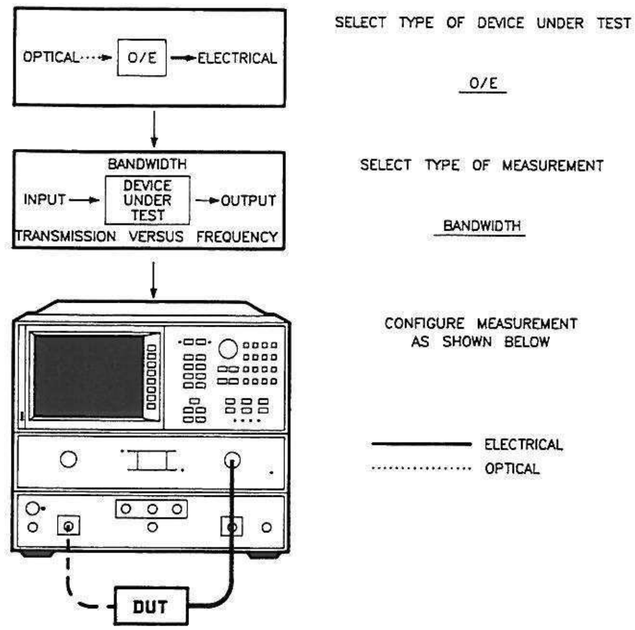


Figure 3. Example of Guided Setup Menus

A helpful feature is guided setup. It is a series of graphic menus with easy-to-read choices that guide you through setting up a basic measurement. When the instrument is first turned on, the guided setup menu can be accessed by the press of one button. For example, if you are measuring the bandwidth response of a receiver (O/E converter), the guided setup helps you select the type of device you are going to test, the type of measurement you want, and the connections you need to make. Figure 3 shows how three of these menus would look after making the selections.

The guided setup is not the only way to make measurements. You can also use the front panel menu keys directly. This is called normal operation.

The *HP 8703 Operating Manual* has detailed descriptions of the HP 8703 front panel features and functions.

Tour of Guided Setup

If you are already familiar with the operation of a lightwave component analyzer, you may want to go directly to the examples in the next chapter. Otherwise, continue with this portion of the *User's Guide*.

The following procedure shows how to use guided setup. It takes you right up to the point of making an optical measurement. When you are finished, you will be prepared to make the measurements in chapters 4 and 5.

Instructions: Read through the text on the right for an explanation of the procedure. Then press the keys listed on the left side of each paragraph.

[GUIDED SETUP]

Press the *[GUIDED SETUP]* softkey and notice the four choices of device types: E/O, O/O, O/E, E/E.

[O/O] [CONTINUE]

Press the *[O/O]* softkey and then *[CONTINUE]*. Notice the different measurements you can make with an O/O device. Press *[PRIOR MENU]* and then press each of the device type softkeys followed by the *[CONTINUE]* key to observe the guided measurements that can be made with each device type. Then press the *[O/O]* and *[CONTINUE]* keys.

[BANDWIDTH] [CONTINUE]

Press the *[BANDWIDTH]* softkey and then *[CONTINUE]*. This menu includes a diagram of the necessary connections for the measurement you selected. Because you selected bandwidth and O/O in prior menus, the configuration is a DUT connected between the two optical test ports. In order to see the other configurations, return to the previous menus.

[CONTINUE]
(START) (300) (M/µ)
(STOP) (4) (G/n)

*[CONTINUE]*Press *[CONTINUE]* to reach the menu where the start and stop RF modulation frequencies are set. Notice that a start frequency of 130 MHz is the default. Use the knob, the step ((↑) (↓)) keys, or the key pad to change the start frequency to 300 MHz and the stop frequency to 4 GHz. Then press *[CONTINUE]*. Notice the new frequencies are displayed on the bottom of the analyzer CRT.

[SWEEP TIME] (2) (x1)

The sweep time and sweep type (linear or logarithmic) are also set in this menu. Set the sweep time to 2.0 seconds for this example. Leave the instrument in linear frequency sweep.

[CONTINUE] [RESPONSE]
[CONTINUE]

Continue and notice that a set of measurement calibration selections are now displayed. In this example, you will be making a response calibration.

[THRU] Connect the thru (optical jumper) as shown in the configuration on the CRT. The HP 8703 will make a measurement calibration and underline the word THRU when it is finished. The *[DONE: RESPONSE]* key is used to complete the calibration procedure. When the measurement calibration is complete, notice that the trace is a flat line across the CRT. The calibration normalizes or corrects the displayed trace. Therefore, when you insert your O/O device, only the response of your DUT will be displayed on the CRT.

[DONE: RESPONSE] At this point, you would normally save the calibration in a register (memory). This is done by using the (SAVE) key and selecting a register. Also, notice that the annotation 'Cor' is displayed on the side of the CRT when the measurement calibration (error correction coefficient) is turned ON.

The guided setup is now complete: the system is properly configured, the measurement parameters have been defined, and a measurement calibration (similar to normalization) has been performed.

Guided setup helps to measure devices within the parameters the guided setup feature allows you to set.

The normal operation mode requires that you select the HP 8703 features by pressing the individual response, stimulus, and instrument state keys and the softkey selections in those blocks. However, your choices are much greater because you can use all of the features available. In general, normal operation has more versatility than the guided setup sequence.

Tips on Using Guided Setup

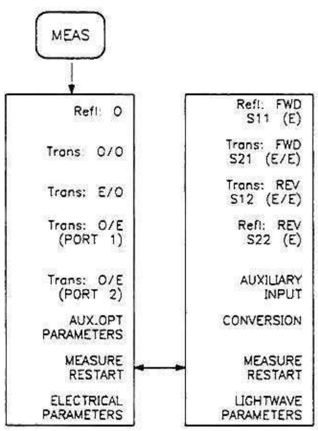
- If you leave the guided setup sequence, you can press the (SYSTEM) key to return to the guided setup menu. When you reaccess the guided setup, the modifications you made in the normal operation will stay active. If you press the (PRESET) key, any of the modifications you made will return to the default preset state.
- Guided setup has certain default conditions, including: no active markers, channel 1 and 2 coupled together (one active channel), and time domain off.
- You can modify the conditions (parameters) using normal operation but you will have to re-enter the guided setup sequence from the beginning (use (SYSTEM) key).
- You can make different types of measurements, including pulse dispersion, phase, etc. Some of these other measurements are described in the "Measurement Applications" section of the *Operating Manual*.

Measurement Sequence

The following sequence is used throughout this *User's Guide* to illustrate the use of the analyzer in its various operating modes.

1. **Set Controls** in three steps:
   - Measurement Setting.
   - Format Setting.
   - Stimulus Setting.
2. **Measurement Calibration** characterizes the systematic errors and removes their effects from the displayed data.
3. **Save** the instrument configuration and calibration.
4. **Measure the Device Under Test** and use the markers and marker functions to extract specific measurement information.
5. **Output Results** to a plotter or printer to create a permanent record.

Set Controls



Measurement Settings are based on the DUT connections. Use the (MEAS) key to choose the appropriate measurement.

The (MEAS) key provides a selection of transmission and reflection measurements. For electrical device measurements, each choice corresponds to a specific S-parameter. The table below shows the electrical measurement options and their associated S-parameters. When performing these measurements, all of the DUT's ports must be properly terminated.

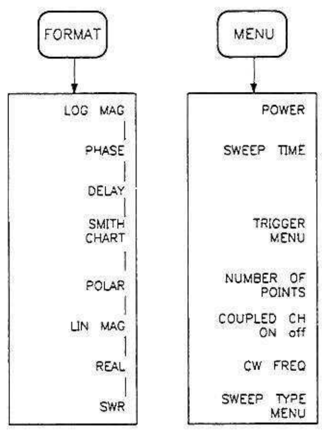
The test direction column in the table indicates which microwave measurement port provides the internal source signal output. For forward (FWD) measurements, the source signal is provided at port 1, and for reverse (REV) measurements, port 2.

Electrical Measurement	S-Parameter	Test Direction
Input reflection (port 1)	S_{11}	FWD
Forward gain/loss (Transmission)	S_{21}	FWD
Reverse gain/loss (Transmission)	S_{12}	REV
Output reflection (port 2)	S_{22}	REV

The *[CONVERSION]* softkey in the (MEAS) menu allows you to convert the measurement data to impedance or admittance parameters. Use the *[MEASURE RESTART]* softkey to restart the measurement following a two-port measurement calibration and connection of the DUT. Also use this softkey to restart a measurement's averaging count.

NOTE: Look at the measurement trace for fluctuations (this indicates noise). If the trace appears unsteady, you need to adjust some or all of the following:

1. Source output power.
2. Frequency range.
3. IF bandwidth and sweep time.



- **Format settings** use the (FORMAT) key to define the display format; logarithmic magnitude, phase, group delay, etc.

- **Stimulus settings** specify the measurement frequency or frequencies using the stimulus group's (CENTER) and (SPAN) keys or (START) and (STOP) keys. For a narrowband measurement such as a bandpass filter, it is usually easiest to set a center frequency and total span; for measurements over a broader frequency range it may be easier to choose individual start and stop frequencies.

The stimulus (MENU) key also allows the additional choices of measurement port power level, sweep time, trigger type, number of measurement points, coupled or uncoupled operation of channels 1 and 2, CW (continuous wave) frequency selection, and the sweep type.

Measurement Calibration

Measurement calibration is a process that removes the systematic instrument errors and dramatically enhances the accuracy of your measurement. (The guided setup steps you through making the calibration.) An optical measurement calibration is performed by measuring a standard device such as a thru connection (short length of cable) for a transmission measurement or a Fresnel reflection (polished connector face) for a reflection measurement. For electrical measurement calibrations the typical devices are a short circuit, open circuit, 50 ohm load, and thru connection. These standards have been previously characterized and their mathematical definitions are already loaded into the memory of the HP 8703. These mathematical definitions are called a cal kit (or standard definition) as they reside in memory. Using the mathematical definitions, the analyzer measures the standard and compares the measured data to the mathematical definition. Any differences caused by repeatable systematic errors in the measurement system are removed from DUT measurements by error correction terms. In this manner, the HP 8703 can mathematically remove systematic errors and enhance the accuracy of a measurement.

Examples of various measurement calibrations are in chapter 6 of this User's Guide.

Save The instrument configuration and calibration can be saved by using the internal memory or an external disk drive. This step will save time and effort when reconfiguring frequently used measurement setups or recalling a configuration that was lost after inadvertently pressing (PRESET) or cycling the line power.

Internal Storage can be used for a temporary copy of the instrument configuration and calibration.

(SAVE) *[REG 1]*

Use one of the five internal registers to save the instrument's configuration and calibration as long as the line switch is on. Cycling the line switch off will cause the instrument's calibration to be lost, but the configuration will be maintained for >72 hours.

External Storage is used for creating a permanent copy of the instrument configuration and calibration.

(LOCAL) *[SYSTEM CONTROLLER]*

This key sequence sets up the analyzer to control a peripheral device (an external disk drive, plotter, or printer) when there is no external controller present.

[SET ADDRESSES] *[ADDRESS: DISK]* (0) (1) *[RETURN]*

Use *[SET ADDRESSES]* to define the address of the external disk drive. This example shows how to set the address to 0 which, in most cases, is the default address of the disk drive. 0 is also the default disk drive address setting for the analyzer.

[DISK UNIT NUMBER] (0) (x1)

When using a disk drive with multiple disk units, you must specify the disk unit to access. This key sequence sets the analyzer to access unit 0 (default value). When using an HP 9122 as the external disk drive, 0 corresponds to the right hand drive.

[VOLUME NUMBER] (0) (x1)

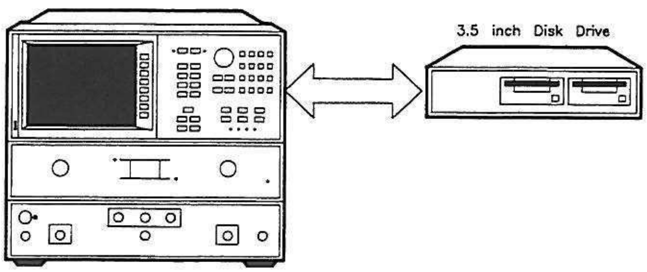
The volume number to access must be specified for disk drives that can be sectioned into volumes. Examples are the HP 9153 and the HP 9154. When using the HP 9122, leave the volume number at 0.

Initializing a Blank Disk

(SAVE) *[STORE TO DISK] [DEFINE STORE] [INITIALIZE DISK] [YES]*

NOTE: The following key sequence will erase any data that may be on the disk.

The analyzer provides the ability to initialize a 3.5 inch disk from its front panel. Only initialize the disk if it is blank (unitialized) or you no longer wish to keep the data resident on the disk.



Storing the Instrument Configuration

(SAVE) *[STORE TO DISK] [STORE FILE1]*

This key sequence will store the instrument configuration and calibration in FILE1 on an external disk.

Once stored, the instrument configuration can be recalled at any time by selecting the (RECALL) and *[LOAD FROM DISK]* keys.

Measurement of the Device Under Test

After the test setup is calibrated, connect the device under test and make your measurements.

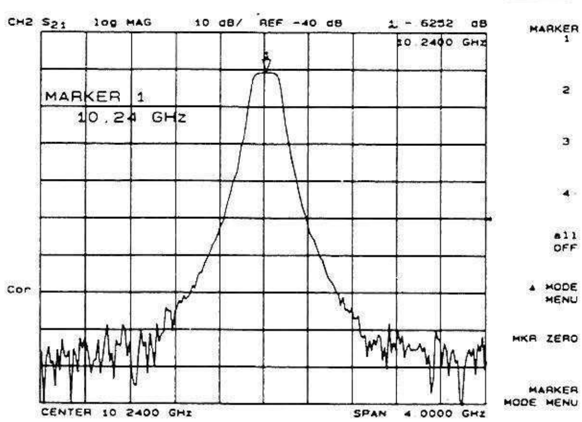
(MEAS) *[MEASUREMENT RESTART]*

Once the DUT is connected, restart the measurement.

(SCALE REF) *[AUTO SCALE]*

Optimize the presentation of the data by adjusting the scale/division and the reference level and position. *[AUTO SCALE]* provides a quick and convenient method for adjusting these levels. To manually set the scale and reference, use the *[SCALE/DIV]*, *[REFERENCE POSITION]*, and *[REFERENCE VALUE]* softkeys.

(MKR)



The (MKR) key allows you to control up to four independent markers, measuring the DUT's performance directly, relative to another marker, or relative to a fixed offset. The marker frequency (or other horizontal axis parameter) is displayed in the active entry area of the CRT. The amplitude (or other vertical axis parameter) corresponding to the marker position is displayed in the upper right corner of the CRT. Many of the analyzer's "smart" features involve the marker functions. You can read the time when using the time domain feature and also the equivalent length in air. The full power of the markers is best illustrated in the example measurements of chapters 4 and 5.

Output Results

A permanent record of the measurement is created by outputting the results to a plotter or printer. The analyzer allows you to control these peripherals without connecting an external controller.

To create a hard copy of your test results:

(LOCAL)
[SYSTEM CONTROLLER]

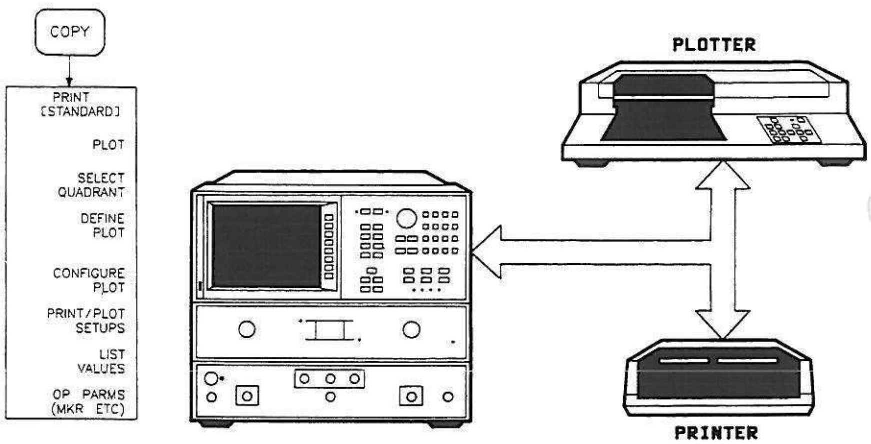
Set up the analyzer as the system controller when an external controller is not connected.

[SET ADDRESSES]
[ADDRESS: PLOTTER]
(5)(x1)

Next set the address for the printer or plotter using the *[SET ADDRESSES]* softkey. The HP 8703 is factory-set to operate with a printer set to decimal address 01 and a plotter set to 05.

(COPY)

The (COPY) key provides a menu which allows output of the test results to a plotter or printer. Plots can also be customized by adding a descriptive title, selecting the plotter pens, or positioning up to four plots per page.



Transmission Measurement Examples

Overview

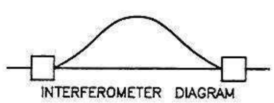
Transmission measurements reveal the insertion loss, flatness, responsivity, and modulation bandwidth of a test device. Transmission phase measurements show device delay and device length information. Also, by using the frequency response calibration feature of the HP 8703, you can enhance the accuracy of the measurement so that only the response of the DUT remains.

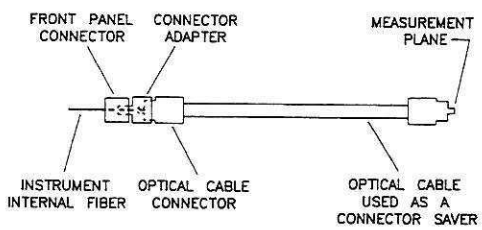
The examples in this section show how to make four types of transmission measurements:

- The optical path length of an optical device.
- The modulation frequency response of an E/O device.
- The demodulation frequency response of an O/E device.
- The insertion loss and gain measurement of an electrical device.

O/O: Optical Path Length Measurement

In this example, normal operation is used to measure the DUT, which is an optical interferometer. This device contains two different optical lengths (reference and sensor paths). The HP 8703 measures the difference in path lengths with the use of guided setup and the transform menu.





Optical Cables used as Connector Savers

CAUTION

COSTLY REPLACEMENT of an entire lightwave assembly will result from damage to an optical test port connector.

Front panel test port connectors are integral parts of the lightwave components and ARE NOT separately replaceable.

Keep optical cables connected to the test ports to protect the connectors from damage.

Procedure

TRANSFORM PARAMETER	Channel 1
RANGE	2.0082 km
RESPONSE RESOLUTION	9.8124 m
TRANSFORM SPAN	5 ns
RANGE RESOLUTION	2.5667 mm
TRANSFORM MODE	BANDPASS
START FREQUENCY	130 MHz
STOP FREQUENCY	170.899613 MHz
FREQUENCY SPAN	40.899613 MHz
NUMBER of POINTS	401
INDEX of REFRACTION	1.46
PULSE WIDTH	47.787 ns
TEST PORT POWER	0 dBm
SWEEP TIME	200 ms
IF BANDWIDTH	3000 Hz

Range Set-up in Transform Parameters

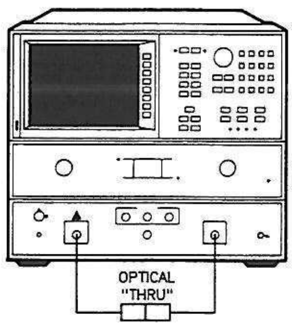


Figure 4. O/O Response Measurement Calibration Configuration

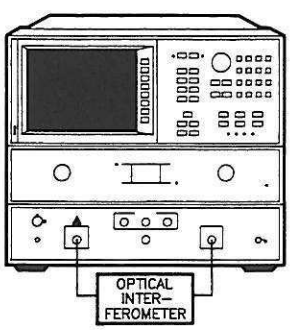


Figure 5. Optical Path Length Measurement Configuration

1. Press the following keys to begin setting up the measurement:

   (PRESET) (MEAS) *[Trans:O/O]*
   (SYSTEM) *[TRANSFORM MENU]*
   [TRANSFORM PARAMETERS]
   [INDEX OF REFRACTION] (1.46) (x1).

2. Press the following keys to set up the desired range for the DUT measurement:

   [NUMBER OF POINTS] (401) (x1) (the more points set, the larger the initial range is). Then press:

   [STOP FREQUENCY] and turn the front panel knob while viewing the second line in the transform parameters. Adjust the range beyond the length of the measurement device.

3. Connect the optical thru as shown in Figure 4. Notice that the analyzer shows the response of the entire measurement system. If you inserted your device at this point, the measurement would include the DUT's response added to the response now being displayed on the CRT. The following calibration procedure removes the system's response from the measurement. Press:

   (CAL) *[CALIBRATE MENU] [RESPONSE] [THRU]*.

   The thru connection acts as the optical thru standard which is already defined in the HP 8703 cal kit.

4. When the analyzer has finished the measurement, it will beep and underline the word THRU. Complete the calibration by pressing:

   [DONE: RESPONSE].

   The measured data is now normalized, setting the magnitude values to unity or 0 dB. Notice the abbreviation Cor at the left of the CRT. This means that the calibration (error correction) is active.

5. Insert the interferometer between the optical cables as shown in Figure 5. Be sure all the connections are clean.

6. Engage the time domain feature to transform the frequency domain data to the time domain. Press:

   (SYSTEM) *[TRANSFORM MENU] [TRANSFORM ON]*.

7. View the results by using the display features. Press:

   (SCALE REF) *[AUTO SCALE]*.

8. Look for the measurement device responses. Press:

   (STOP) and turn the front panel knob to adjust the stop time/distance further out in the available range.

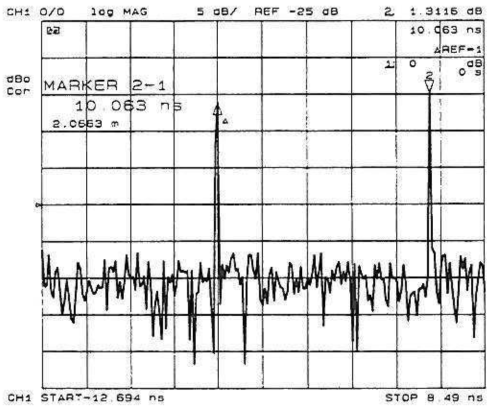


Figure 6. Optical Path Length Measurement

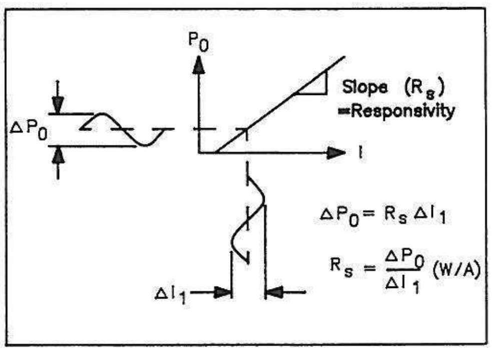
9. Use the delta marker functions to determine the difference in optical path lengths. Press:

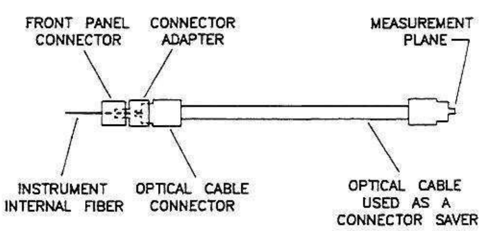
   (MKR) and turn the front panel knob to place marker 1 on the first response. Then press:

   [ΔMODE MENU] [ΔREF=1] [MARKER 2] and turn the front panel knob again to place marker 2 on the second response.

   The results should be similar to the plot in Figure 6.

E/O: Source Measurement





Optical Cables used as Connector Savers

In this example, the guided setup is used to perform a measurement calibration and measure the broadband modulation transfer characteristics of a source or E/O converter. A source's transfer function is expressed in terms of source slope responsivity. Source slope responsivity is the ratio of intensity-modulated optical power out to RF current in and is expressed in watt/amp or dB referenced to 1 W/A.

CAUTION

COSTLY REPLACEMENT of an entire lightwave assembly will result from damage to an optical test port connector.

Front panel test port connectors are integral parts of the lightwave components and ARE NOT separately replaceable.

Keep optical cables connected to the test ports to protect the connectors from damage.

Procedure

1. Press the following keys to begin setting up the measurement:

   (PRESET) *[GUIDED SETUP] [E/O] [CONTINUE] [BANDWIDTH] [CONTINUE].*

2. Press *[CONTINUE]* to reach the menu where the modulation start and stop frequencies are set. In this example, leave the default frequency range of 130 MHz to 20 GHz. Then press *[CONTINUE]* again.

3. Set a 3 second sweep time, press:

   [SWEEP TIME] (3) (x1).

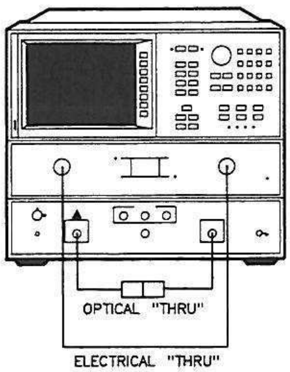


Figure 7. E/O Response Measurement Calibration Connections

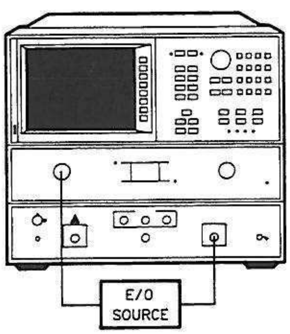


Figure 8. Source Measurement Configuration

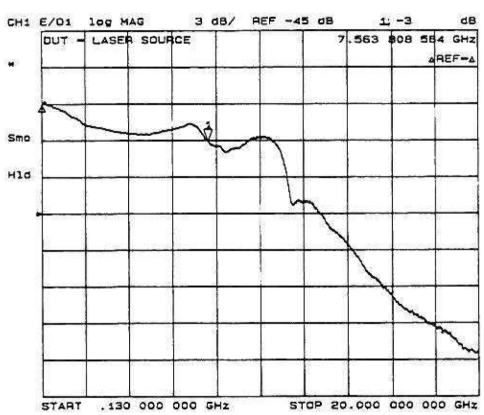


Figure 9. Typical E/O Source DUT Measurement

4. The sweep type can be left in the linear frequency (LIN FREQ) mode unless you want to view the results with a logarithmic scale. Then press:

   [CONTINUE].

5. Press *[RESPONSE]* and *[CONTINUE]* to select a response calibration. You are going to use the HP 8703's measurement accuracy enhancement capabilities to get an accurate measurement of your DUT.

6. Make the thru connections shown in Figure 7.

7. Perform the measurement calibration. Press:

   [THRUS].

   After the thru measurement is complete, the analyzer will beep and underline the word THRUS. Press:

   [DONE: RESPONSE].

8. The guided setup is complete. The analyzer has normalized out the electrical response of the measurement system. The analyzer is now ready to measure the DUT.

9. Insert the test device as shown in Figure 8. Be sure all the connections are clean.

   After one complete sweep, the analyzer will display the test device response.

10. Press (SCALE REF) *[AUTO SCALE]* to better view the device response. Figure 9 is a typical result of the DUT measurement.

11. Use the markers to identify the full usable modulation frequency range of the device under test. Press:

    (MKR) *[ΔMODE MENU] [ΔREF=ΔFIXED MKR].*

    Turn the front panel knob while looking at the top right corner of the CRT. Position the marker to read 3 dB.

    The area between the reference marker and marker 1 reveals the full usable modulation frequency range of the device under test.

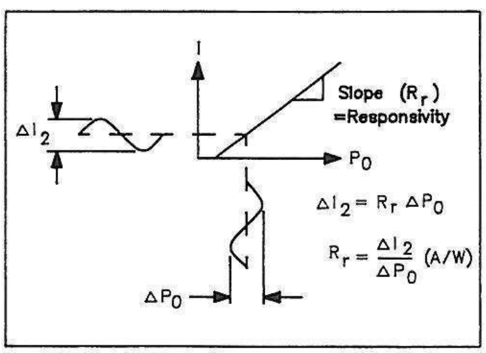
    Notice that the annotation shows the following items:

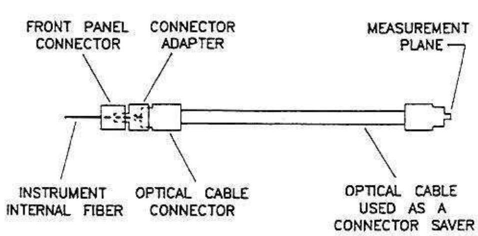
CH1:	Measurement is on channel 1.
E/O:	Device type measurement.
log mag:	The display is a logarithmic display of power versus frequency.
3 dB/:	The graticule scale is 3 dB per division.
REF:	The graticule reference value is marked by a small triangle (left edge of graticule) and has a value of −45 dB.
1:	This is marker 1 (active). Its value is the difference from the reference: 7.563808564 GHz, and −3 dB below the delta reference marker. The reference is placed at the left end of the trace in this example.

    Notice that the start and stop frequencies are displayed on the bottom of the graticule. The plot title, DUT - LASER SOURCE, was generated using the (DISPLAY) key title menu.

O/E: Receiver Measurement

This example is similar to the previous measurement of the lightwave source modulation transfer characteristics. However, this example measures an O/E receiver using normal operation (not guided setup). A receiver's transfer function is expressed in terms of receiver slope responsivity. This is the ratio of the RF current out to the intensity-modulated optical power in and is expressed in amp/watt or dB referenced to 1 A/W.





Optical Cables used as Connector Savers

CAUTION

COSTLY REPLACEMENT of an entire lightwave assembly will result from damage to an optical test port connector.

Front panel test port connectors are integral parts of the lightwave components and ARE NOT separately replaceable.

Keep optical cables connected to the test ports to protect the connectors from damage.

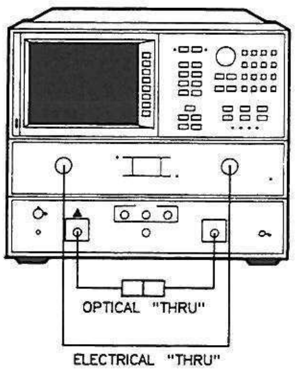


Figure 10. O/E Response Measurement Calibration Connections

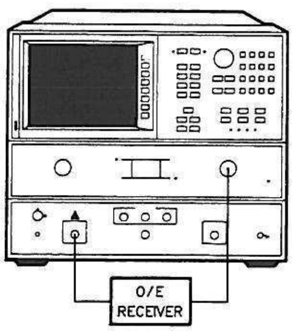


Figure 11. O/E Transducer Measurement Configuration

Procedure

1. Select the type of measurement. (In guided setup, this is done in two steps: first the device type is selected, then the measurement type is selected.) In normal operation, after you press the (PRESET) key, the analyzer defaults to an O/O transmission measurement. Press:

   (PRESET) (MEAS) *[Trans: O/E (PORT 2)]*

2. In order to reduce the effects of noise, you can decrease the IF bandwidth of the analyzer. Make the following selections:

   (AVG) *[IF BW]* (100) (x1).

3. Set the sweep time to 3 seconds. (In the previous example, guided setup prompted you to set this function.) From the stimulus block, set the sweep time by pressing:

   (MENU) *[SWEEP TIME]* (3) (x1).

   Look at the measurement trace for fluctuations. If the trace appears unsteady (noisy), you may need to adjust the IF bandwidth and sweep time.

4. Make the thru connections on the analyzer, as shown in Figure 10 before performing a measurement calibration.

5. To make a measurement calibration, press:

   (CAL) *[CALIBRATE MENU] [RESPONSE] [THRUS]*.

   Wait for the analyzer to beep, and press *[DONE: RESPONSE] [SAVE REG3]* to save the calibration in register 3.

   Five internal registers are available from the save menu where you can store the calibration and the complete instrument state settings. The front panel recall key can be used to recall a calibration stored in any one of these registers. Calibrations remain in these registers if the preset key is pressed but not if the analyzer is turned off.

6. Insert the DUT (O/E receiver) as shown in Figure 11. Be sure all connections are clean.

7. When the DUT is properly connected, wait for at least one complete sweep of the analyzer.

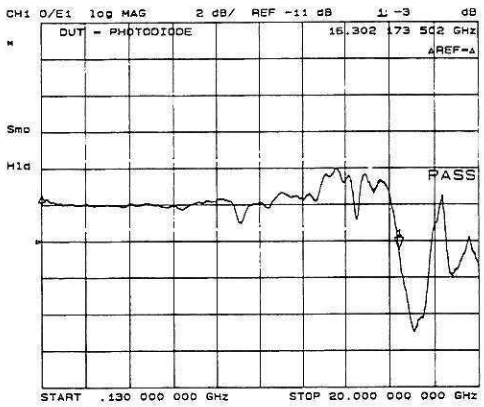


Figure 12. Modulation Transfer Characteristics of a Typical Receiver

8. View the trace by pressing:

   (SCALE REF) *[AUTO SCALE]*.

   The trace displayed on the analyzer is the accuracy enhanced (calibrated) response of the O/E device.

   Figure 12 is a plot of the modulation transfer characteristics of a typical receiver.

9. A marker is referenced to locate the −3 dB point and determine the modulation bandwidth of the receiver. This is done by pressing:

   (MKR) *[ΔMODE MENU] [ΔREF=ΔFIXED MKR]* and turning the front panel knob to the −3 dB point. Notice the triangle near the middle graticule line. Marker 1 is referenced to it. The *HP 8703 Operating Manual* describes in detail how to use markers.

Responsivity Calculation

The marker reads out the actual value in dB. Suppose marker 1 has a value of 36 dB, indicating the gain of the receiver at a specific frequency. This is the responsivity (R) of the receiver, at the given frequency, and can be calculated as follows:

Responsivity = R (dB) at a given frequency =

$$R\,(dB) = 20 \log_{10} \frac{R\,(A/W)}{1\,(A/W)}$$

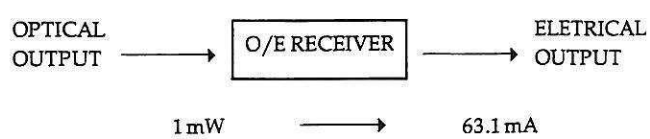
$$\frac{R\,(dB)}{20} = \log_{10} \frac{R\,(A/W)}{1\,(A/W)}$$

$$1\,(A/W) \times 10^{R\,(dB)/20} = \frac{R(A/W)}{1(A/W)} \times 1(A/W)$$

$$R(dB) = 10^{R\,(dB)/20} = 10^{R\,(dB)/20}$$ A/W for O/E DUTS or, W/A for E/O DUTs

For example: If R(dB) = +36 dB, then

$$R\,(dB) = 10^{(36/20)} = 10^{(1.8)} = 63.1\ A/W = 63.1\ \frac{mA}{mW}$$



E/E: Insertion Loss and Gain Measurement

This example is a measurement of insertion loss and gain. The DUT is the filter supplied with the instrument. When the equipment is set up as shown below, the results can be read directly in decibels (dB).

Procedure

1. Press the following keys to begin setting up the measurement:

   (PRESET) *[GUIDED SETUP] [E/E] [CONTINUE] [BANDWIDTH] [CONTINUE].*

2. Press *[CONTINUE]* to reach the start and stop frequency menu. Press:

   [START] (8) (G/n)
   [STOP] (12.4) (G/n)
   [CONTINUE].

3. Set the power of the microwave source. Press:

   [POWER] (-10) (x1) and then *[CONTINUE].*

4. Select a response measurement calibration. Press:

   [RESPONSE] [CONTINUE].

5. Connect two electrical cables between port 1 and port 2 and press:

   [THRU].

   Wait for the beep, and press *[DONE: RESPONSE]* and *[SAVE MENU] [SAVE REG2]* to save the calibration in register 2.

6. Connect the measurement configuration as shown in Figure 13. The analyzer shows the complete transmission response of the bandpass filter. To better view the measurement trace, press:

   (SCALE REF) *[AUTO SCALE].*

7. Set marker 1 to the center frequency of the filter by directly entering the frequency. (The marker frequency can also be adjusted using the front panel knob.) Press:

   (MKR) (10.24) (G/n).

   The display shows the complete transmission response of the bandpass filter. From this display you can derive several important filter parameters using the marker functions.

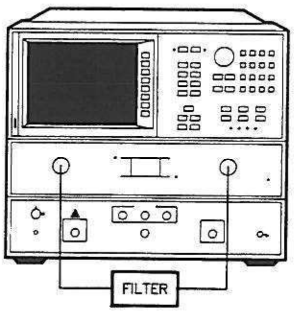


Figure 13. E/E Device Measurement Configuration

Insertion Loss and Passband Flatness

8. The following steps measure the filter's insertion loss and passband flatness with the delta marker and statistics function.

   Use the front panel knob to move the marker to the edge of the filter's passband (3 dB).

9. Access the delta marker mode menu and establish marker 1 as the reference for the measurement. Press:

   [ΔMODE MENU] [ΔREF=1] [MARKER 2].

10. Turning the statistics function on provides the passband's mean insertion loss, standard deviation, and peak-to-peak ripple. (This function can also measure the gain of an amplifier, cable insertion loss, etc.) Press:

    (MKR FCTN) *[STATS ON].*

    In this example the statistics function provides the DUT's performance between the active marker (marker 2) and the reference marker (marker 1) as shown in Figure 14. (If there is no reference marker, the statistics are calculated for the entire trace.)

    With an HP-IB plotter or printer connected, you could now use the (COPY) key to create a permanent copy of the test results.

11. Turn the statistics function off. Press:

    [STATS OFF].

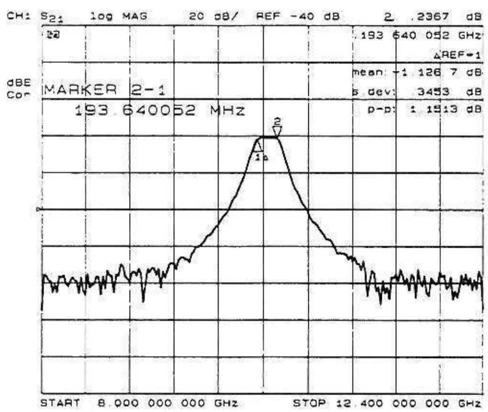


Figure 14. Insertion Loss and Passband Flatness Measurement

3 dB Bandwidth

12. The marker search function can be used to find the filter's 3 dB bandwidth. Turn off the markers and marker delta mode. Set marker 1 to the filter's center frequency (10.24 GHz) and establish it as the reference for the measurement. Press:

    (MKR) *[all OFF]*
    [MARKER 1] (10.24) (G/n)
    [ΔMODE MENU] [ΔREF=1].

13. Activating the widths function causes the analyzer to immediately find the upper and lower −3 dB frequency points relative to marker 1 as shown in Figure 15. (-3 dB is the default value for the widths function.) The analyzer also provides the filter's Q (quality factor). Press:

    (MKR FCTN) *[MORE] [BANDWIDTH].*

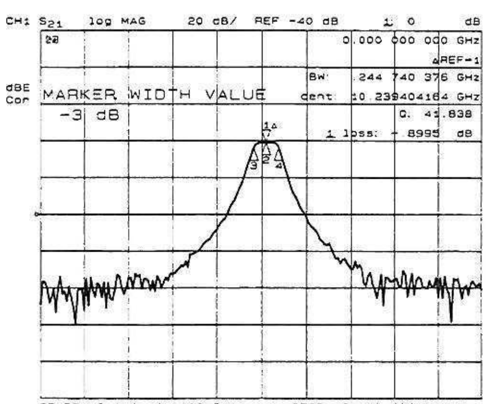


Figure 15. 3 dB Bandwidth Measurement

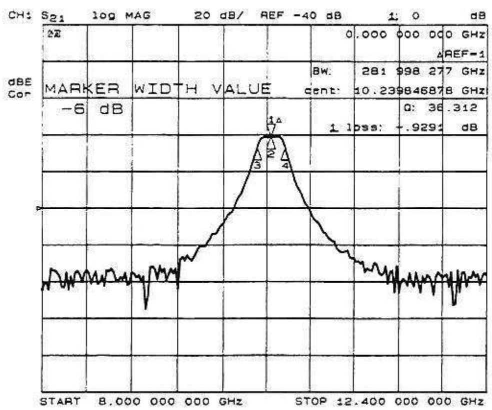


Figure 16. 6 dB Bandwidth Measurement

14. Once the widths function is activated, find other points of interest. To find the filter's 6 dB bandwidth press:

    [BANDWIDTH VALUE] (-6) (x1).

    Turn the widths and their markers off. Press:

    [MEASURE: OFF] (MKR) *[all OFF]*.

Out-of-Band Rejection

15. The analyzer's wide dynamic range allows it to measure stopband rejection over 80 dB below the passband response. Maximum dynamic range requires proper selection of the measurement port power level, the IF bandwidth, and averaging factor (each is discussed in chapter 6 under "Increasing Dynamic Range"). As shown below, the search capability allows you to quickly find the rejection level of interest.

    Find the frequency and level of the lowest point on the trace. (In this case, the filter's maximum rejection.) Press:

    (MKR FCTN) *[MKR SEARCH] [MIN]*.

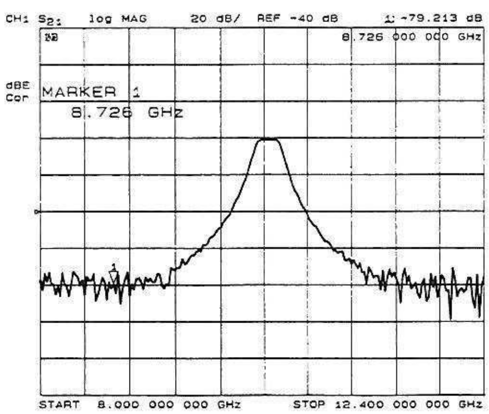


Figure 17. Filter Maximum Rejection Level

16. Specify the search value. Set a target value of −60 dB. Press:

    [TARGET] (-60) (x1).

    Find the lower frequency where the target value occurs. If there is no occurrence of the specified value, the message "TARGET VALUE NOT FOUND" is displayed. Press:

    [SEARCH LEFT].

    Find the upper frequency where the target value occurs. Press:

    [SEARCH RIGHT].

17. Turn the markers off. Press:

    (MKR) *[all OFF]*.

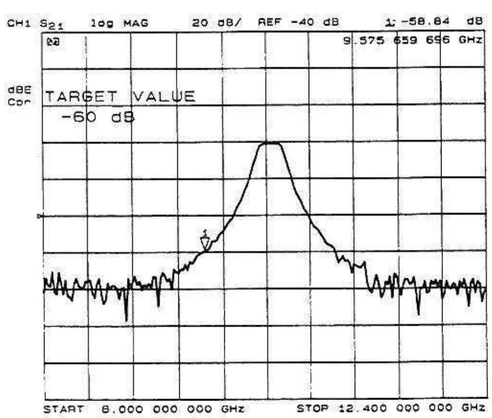


Figure 18. Lower Frequency of Target Value

Reflection Measurement Examples

Overview

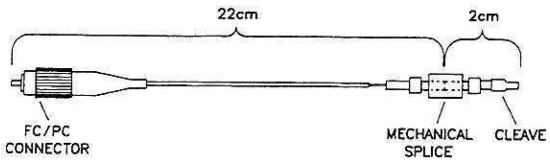
The HP 8703 can measure the reflections of optical components such as connectors, splices, and photodiodes. By transforming the data from the frequency domain to the time domain, you can locate the position (in time or distance) of the fault that is causing the reflection.

The analyzer can also measure the return loss of electrical components such as bandpass filters. By using different display formats (linear magnitude, polar, Smith chart) the analyzer can measure various component characteristics.

The reflection measurement examples in this chapter show how to find faults or bad connections; determine the return loss of an O/E receiver; and determine the electrical return loss, reflection coefficient, and SWR of a bandpass filter.

Optical Reflection Measurement Between a Splice and a Cleave

This example demonstrates the time domain resolution capabilities of the analyzer. The DUT is a one-port SMF cable (index of refraction = 1.46), approximately 24 cm total length. The connecting end of the DUT is an FC/PC connector, and the opposite end of the cable is a cleave resulting in a Fresnel reflection (3.5%). In addition, there is a mechanical splice 2 cm back from the Fresnel end.



DUT Diagram

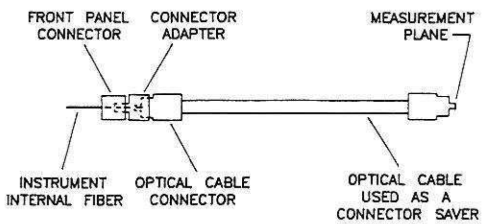
In this example a calibration establishes a measurement plane at 0 cm and 0 seconds. The DUT is connected to the coupler test port (reference plane). After the measurement sweep, the display shows the mechanical splice at 22 cm, and the Fresnel reflection from the cleave at the end of the fiber.

CAUTION

COSTLY REPLACEMENT of an entire lightwave assembly will result from damage to an optical test port connector.

Front panel test port connectors are integral parts of the lightwave components and ARE NOT separately replaceable.

Keep optical cables connected to the test ports to protect the connectors from damage.



Optical Cables used as Connector Savers

Procedure

1. Press the following keys to begin setting up the measurement:

   (PRESET) *[GUIDED SETUP] [O/O] [CONTINUE] [REFLECTION] [CONTINUE]*.

2. Press *[CONTINUE]* to reach the menu where the modulation start and stop frequencies are set. In this example, leave the default frequency range of 130 MHz to 20 GHz. Then press *[CONTINUE]* again.

3. Set a five second sweep time. Press:

   [SWEEP TIME] (5) (x1).

4. The sweep type can be left in the linear frequency mode. Press:

   [CONTINUE].

5. Press *[RESPONSE]* and *[CONTINUE]* to select a response measurement calibration.

6. Do not connect the DUT to the coupler test port as shown in Figure 19.

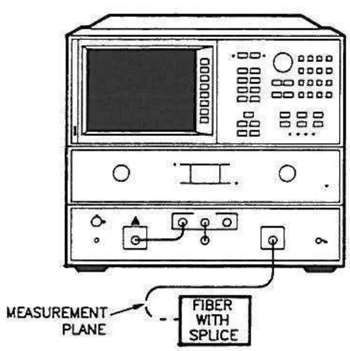


Figure 19. Optical Response Measurement Calibration Configuration

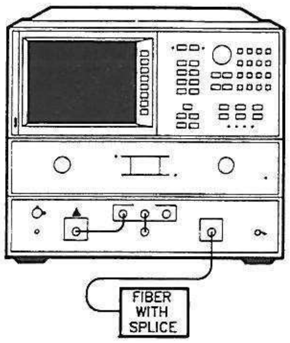


Figure 20. Optical Reflection Measurement Configuration

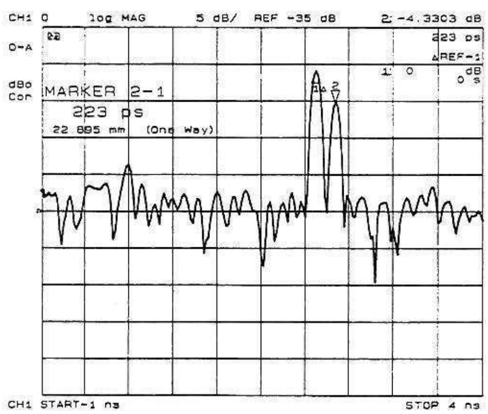


Figure 21. Optical Reflection Measurement

7. Perform a measurement calibration. Press:

   [FRESNEL].

   After the measurement is complete, the analyzer will beep and underline the word FRESNEL. Press:

   [DONE: RESPONSE].

8. The guided setup is complete. The analyzer has normalized out the response of the measurement system.

   Connect the DUT as shown in Figure 20. Be sure the connections are clean.

9. Set the index of refraction for the fiber and then transform the data from the frequency domain to the time domain. Press:

   (SYSTEM) *[TRANSFORM MENU] [TRANSFORM PARAMETERS]*
   [INDEX OF REFRACTION] (1.46) (x1)
   [RESTORE DISPLAY] [TRANSFORM ON].

10. To better view the device reflections, press:

    (SCALE REF) *[AUTO SCALE].*

11. Set the markers to locate the mechanical splice about 22 cm from the FC/PC connector, and the end of the fiber (a cleave for 3.5% reflected power) about 2 cm beyond the splice. Press:

    (MARKER) and turn the front panel to place marker 1 on the first reflection. Press:

    [ΔMODE MENU] [ΔREF=1] to establish marker 1 as a reference. Press:

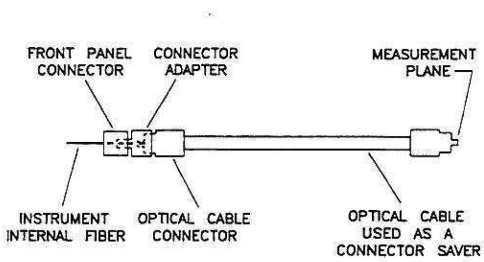
    [MARKER 2] and turn the front panel to place marker 2 on the second reflection.

12. With the markers placed on the peaks, and the delta marker mode engaged, the distance between the splice (marker 1) and the cleave (marker 2) can be determined. Read the response from the display.

Optical Input Port Return Loss Measurement

This example demonstrates how the analyzer can measure the return loss of the optical input port of a lightwave receiver in both frequency and time domain. The measurement result is a plot of the receiver's input response to a 130 MHz to 20 GHz modulated signal.

This measurement can be of great value in designing lightwave systems (especially receivers) or for troubleshooting lightwave systems where optical match values are desired.



Optical Cables used as Connector Savers

CAUTION

COSTLY REPLACEMENT of an entire lightwave assembly will result from damage to an optical test port connector.

Front panel test port connectors are integral parts of the lightwave components and ARE NOT separately replaceable.

Keep optical cables connected to the test ports to protect the connectors from damage.

Procedure

1. Press the following keys to begin setting up the measurement:

   (PRESET) (SYSTEM) *[TRANSFORM MENU]* *[SET FREQ LOW PASS]* *[LOW PASS IMPULSE]* (AVG) *[IF BW]* (10) (x1) (SYSTEM) *[GUIDED SETUP]* *[O/E]* *[CONTINUE]* *[REFLECTION]* *[CONTINUE]*.

2. Press *[CONTINUE]* to reach the menu where the modulation start and stop frequencies are set. In this example, leave the default frequency range of 130 MHz to 20 GHz. Then press *[CONTINUE]* again.

3. The sweep time and sweep type can be left in the default mode. Press *[CONTINUE]* again.

4. Select the response measurement calibration. Press:

   [RESPONSE] *[CONTINUE]*.

5. Do not connect the cable to the DUT as shown in Figure 22. Press:

   [FRESNEL].

   Wait for the analyzer to beep and underline the word FRESNEL. Press:

   [DONE: RESPONSE].

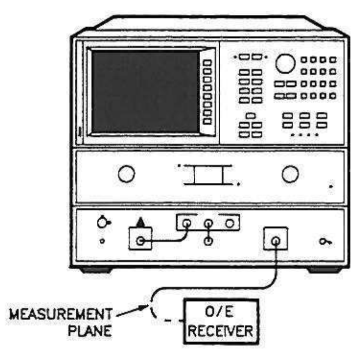


Figure 22. Receiver Optical Reflection Measurement Setup

6. Save the measurement calibration in one of the registers accessed in the save menu. Press:

   [SAVE MENU] [SAVE REG 1]

   Connect the DUT to the cable.

NOTE: The receiver can have its electrical output terminated in its characteristic impedance (50 ohms, for example) and its DC power supplied. However, the optical reflection of photodiodes is typically the same if the electrical output is not terminated and if there is no DC bias power supplied.

7. The frequency domain response shows the return loss of the input signal as a ripple pattern trace, where beating occurs because of the three reflections in the example system: 1) the test port, 2) the receiver input, and 3) the photodiode itself. The signal enters the receiver connector with some attenuation and then reaches the actual receiver (for example: photodiode) where it is reflected back to the test port. Each of these reflections beats against the other, resulting in a beat pattern.

   In general, frequency domain reflection measurements show only the overall magnitude of the reflected signal and not the magnitude of the individual reflections. A single reflection can disguise the pattern so that you cannot distinguish which reflection is greatest. However, in using the time domain, the reflections can be measured separately to determine their individual magnitude and location as follows. Press:

   (SYSTEM) *[TRANSFORM MENU] [TRANSFORM PARAMETERS] [INDEX OF REFRACTION]* (1.46) (x1) *[RESTORE DISPLAY] [TRANSFORM ON].*

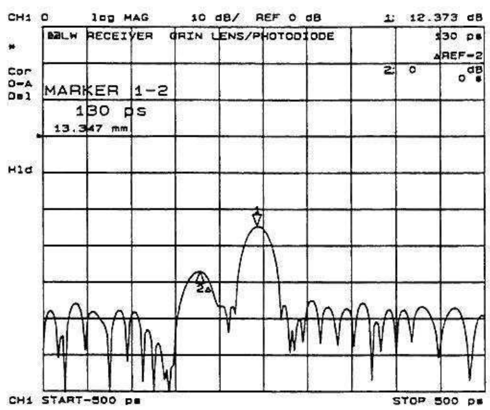


Figure 23. Time Domain Response of Example Receiver

8. You can set the start and stop distances to better view the reflections of the photodiode receiver. Press:

   (START) and then turn the front panel knob until the desired display is obtained. Press:

   (STOP) and turn the front panel knob again if necessary to achieve a better view of the reflections.

9. Set the markers to locate the reflection created by the interface of the fiber to the first surface of a GRIN lens (0 seconds), and the combined reflections inside the photodiode receiver. Press:

   (MARKER) *[MARKER 2]* (0) (x1) to place marker 2 at the measurement plane.

   Press *[ΔMODE] [MARKER 2]* to make marker 2 a reference.

   Then press *[MARKER 1]* and turn the front panel knob to place marker 1 on the second reflection.

Continued
The two reflections are located about 14 mm apart. Marker 2 shows the reflection created by the interface of the fiber to the first surface of a GRIN lens. Marker 1 shows the combined reflections of the second grin lens surface, which is antireflection coated, and the reflection from the photodiode surface.

E/E: Electrical Return Loss, Reflection Coefficient, and SWR

The signal reflected from the DUT (filter provided with the instrument) is measured as a ratio with the incident signal and can be expressed as return loss, reflection coefficient, or SWR (standing wave ratio). These measurements are mathematically defined as:

reflection coefficient = reflected/incident = $\Gamma = \rho \angle \varphi$

return loss (dB) = $-20 \log \rho$

SWR = $(1 + \rho)/(1 - \rho)$

Procedure

1. Press the following keys to begin setting up the measurement.

   (PRESET) (MEAS)
   [ELECTRICAL PARAMETERS] [Refl: FWD S11 (E)]
   (START) (9.24) (G/n)
   (STOP) (11.24) (G/n).

2. Perform a full 2-port measurement calibration. Press:

   (CAL) *[CALIBRATE MENU] [FULL 2-PORT] [REFLECTION].*

3. In turn, connect an open, short, and broadband (or sliding) load to each of the measurement planes (port 1 and port 2) and press the corresponding keys. After each standard is measured, the softkey label will be underlined.

4. Complete the second half of the measurement calibration. Press:

   [TRANSMISSION].

5. Connect a thru cable between port 1 and port 2 and press each of the labeled softkeys. After each measurement is made, the softkey label will be underlined.

6. After the measurement calibration is completed, save the instrument configuration and calibration in register 2. Press:

   [SAVE MENU] [SAVE REG2].

7. Connect the DUT as shown in Figure 24. To better view the data press:

   (SCALE REF) *[AUTO SCALE].*

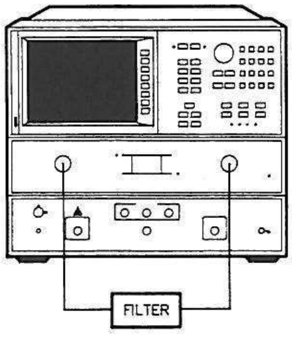


Figure 24. Electrical Reflection Measurement Setup

Return Loss

Figure 25 shows the return loss of the bandpass filter. In the filter's passband, the return loss is a large value (approximately 20 to 30 dB). This means that only a small portion of the incident signal is being reflected back to the measurement port, indicating a good match between the filter and the test system. In the filter's reject band, the return loss is approximately 0 dB, meaning that almost all of the incident signal is being reflected. A return loss of >∞ indicates that the filter's impedance does not match the measurement system. In the passband, most (if not all) of the signal should be transmitted (i.e., small reflection, large return loss) and in the reject band, little or none of the signal should be transmitted (i.e., large reflection, small return loss).

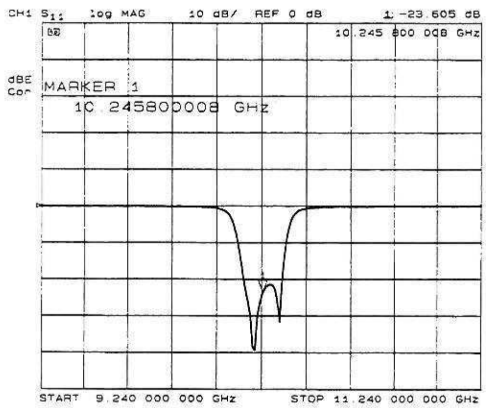


Figure 25. Return Loss of Bandpass Filter

Reflection Coefficient

If you press (FORMAT) *[LIN MAG]*, the measurement displays the reflection coefficient magnitude (ρ) of the reflected signal in a linear format as shown in Figure 26. A ρ = 1 indicates that all of the incident signal is being reflected back to the measurement port (poor impedance match) while ρ = 0 indicates that none of the signal is being reflected (perfect impedance match).

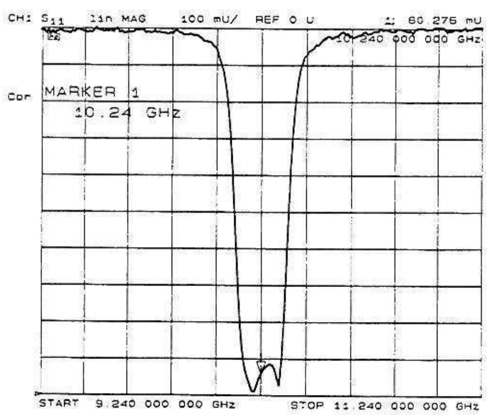


Figure 26. Magnitude of the Reflected Signal in a Linear Format

SWR

To display the reflection measurement data in terms of SWR (as shown in Figure 27), select the *[SWR]* softkey in the format menu. As with reflection coefficient, SWR is a unitless value. A SWR = 1 corresponds to no reflection (perfect match) while infinite SWR corresponds to 100% reflection (poor match).

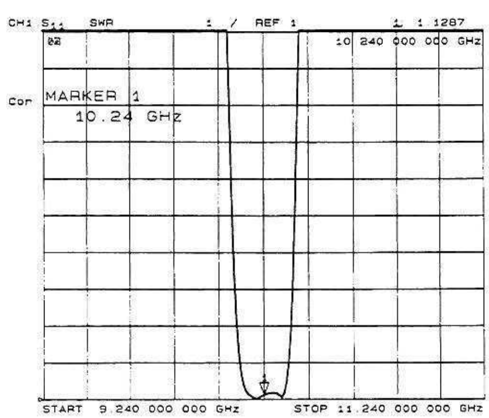


Figure 27. SWR of the Reflection Measurement Data

Measuring S-Parameters in Polar Format

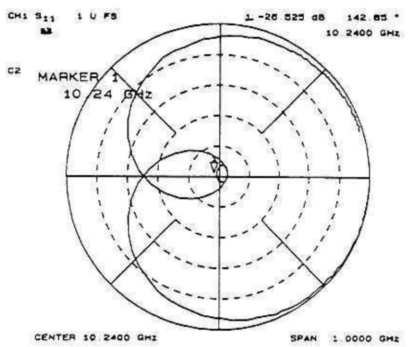


Figure 28. Polar Markers in Logarithmic Magnitude

Up to this point, we have only determined the magnitude of the reflected signal. Displaying the reflection measurement in the polar format now provides both the magnitude and the phase of the reflected signal relative to the incident signal.

Press (FORMAT) *[POLAR]* to select the polar format that provides the display shown in Figure 28. The center of the circle corresponds to a $\Gamma = 0$ ($\rho = 0$, no reflection). Moving outward, ρ increases linearly until it reaches a maximum of 1 (100% reflection) at the outer circumference of the circle. Phase changes are indicated by movement around the circle. The 3 o'clock position corresponds to 0° phase shift relative to the incident signal and the 9 o'clock position corresponds to 180° phase shift. Notice that there is no frequency information in the polar format. To obtain an accurate measurement of magnitude, phase, and frequency, use the analyzer's markers.

Press (MKR) *[MARKER MODE MENU] [POLAR MKR MENU] [LOG MAG]* to change the display format of the marker to logarithmic magnitude (return loss).

Electrical Impedance Measurements

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: $\rho = 0$ only occurs when the device and measurement system impedance are exactly the same. A short circuit has a reflection coefficient of $\rho = 1 \angle 180°$. Every other value of ρ also corresponds uniquely to a complex device impedance, according to the equation

$$Z_n = Z_0 (1 + \Gamma)/(1 - \Gamma)$$

where Z_n is the DUT impedance and Z_0 is the measuring system's characteristic impedance (50Ω for the analyzer). The analyzer uses the above formula to convert the reflection coefficient measurement data to impedance data.

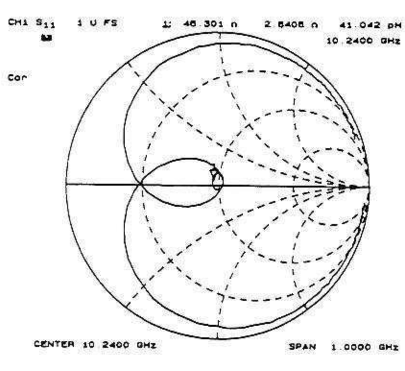


Figure 29. Smith Chart Format

Press (FORMAT) *[SMITH CHART]* to overlay the Smith chart on the polar display axes and read the impedance data in the R ± jX format, where R is the resistive component and X is the reactive component of the DUT's complex impedance. As with the polar display, the Smith chart provides no frequency information. Use the markers to obtain the resistance, reactance, and frequency information. An example of the Smith chart format is shown in Figure 29.

Admittance Measurements

In the Smith chart format, changing the marker format to *[G+jB MKR]* inverts the Smith chart display and allows the data to be read in admittance parameters. The marker reads the admittance data in the form G+jB, where G is conductance and B is susceptance, both measured in units of Siemens (equivalent to mhos).

Using the Dual Trace Display

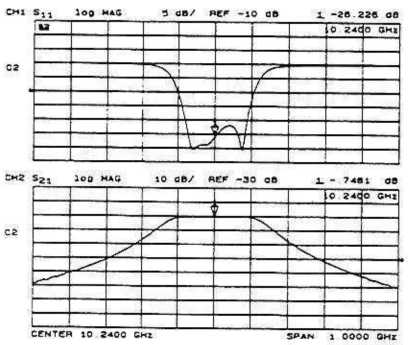


Figure 30. Dual Channel Display

In some cases, it is useful to be able to view more than one measured parameter at a time. For example, simultaneous insertion loss and return loss measurements are useful when adjusting the impedance match of a device for maximum power transfer. Such measurements are easily made using the analyzer's dual trace display.

Pressing (RECALL) *[REG 2]* recalls the instrument configuration and calibration stored in register 2 at the beginning of this measurement example.

Press (CH 2) (MEAS) *[ELECTRICAL PARAMETERS]* *[Trans: FWD S21]* (SCALE REF) *[AUTO SCALE]* to set up channel 2 for an S21 measurement. For this measurement, channel 2 does not need to be calibrated separately. The 2-port measurement calibration applies to reflection and transmission measurements on both channels. When using any of the other calibrations, you will need to calibrate the second channel separately.

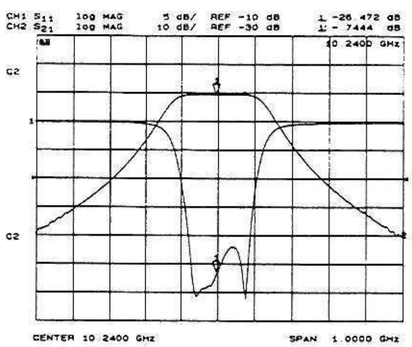


Figure 31. Single Display of Both Channels

Press (DISPLAY) *[DUAL CHAN ON]* to turn on the dual channel display. Channel 1 is displayed on the upper display and channel 2 on the lower, as shown in Figure 30.

Sometimes it is more convenient to view both channels on a single graticule. Press *[MORE] [SPLIT DISP OFF]* to turn the split display off and provide the display shown in Figure 31.

Press *[SPLIT DISP OFF] [RETURN] [DUAL CHAN OFF]* to turn the split display and dual channel off and return the analyzer to a single display of the active channel.

Comparison to an OTDR (Optical Time Domain Reflectometer)

The HP 8703 can display a DUT's transmission and reflection characteristics in the modulation frequency domain or the time domain. Although the HP 8703 can show reflection in the time domain, it should not be confused with an OTDR (optical time domain reflectometer). An OTDR is primarily a fiber installation or maintenance tool used for measuring splice loss, or checking for faults. The HP 8703 distance-time feature is a laboratory bench tool used for component and device characterization or location of reflections.

How to Get the Most Out of Your Lightwave Component Analyzer

Overview

This chapter concentrates on achieving maximum performance with your lightwave component analyzer. These are the major topics covered:

- Increasing measurement accuracy.
- Decreasing sweep time (increasing sweep speed).
- Increasing dynamic range.
- Reducing trace noise.
- Maintaining good connections.

Increasing Measurement Accuracy

These prioritized factors affect measurement accuracy:

- Accurate measurement calibration.
- Adjustment of measurement settings.
- Connections.
- Temperature and frequency drift.
- Measurement uncertainty of the analyzer.

Measurement Calibration Types

The calibration step effectively characterizes and removes the effects of repeatable measurement variations in the test system. The "systematic errors" with which the calibration step is concerned are:

- Frequency Response (Tracking).
- Leakages (Directivity and Crosstalk).
- Mismatches (Source Match and Load Match).

The HP 8703 has several methods of measuring and compensating for these test system imperfections. These include two optical, four optical/electrical (electrical/optical), and four electrical calibrations that remove from one to twelve systematic errors. The full 2-port electrical calibration effectively removes all twelve correctable systematic errors. Some measurements do not require correction for all twelve errors. Each method utilizes the measurement of standard devices and specific equations (error models) to remove one or more of the sytematic errors mentioned above. By applying the data obtained from the standards to a specific error model, the calibration step is able to characterize the measurement system and increase the accuracy (by reducing the uncertainty) of the DUT's measurement results.

The measurement calibrations available through the guided setup are described in this chapter. The "Measurement Calibration" section in the *Operating Manual* explains in detail all calibrations and their uses. Use the proper calibration for each measurement.

Select the Calibration Kit

Prior to performing a measurement calibration, ensure the analyzer is set for the calibration kit being used. When calibrating, the analyzer uses the mathematical model that applies to the devices contained in the kit to calculate the error correction coefficients. Some standard device models have been loaded into the analyzer at the factory (for example: Fresnel reflection). Other devices can be defined by the user and the mathematical characterization (model) can be loaded into the HP 8703. This is done using the Cal menu, as explained in the *Operating Manual*.

NOTE: If cables, connectors, or adapters are removed from the measurement configuration after the measurement calibration, the effect must be accounted for by adding a port extension equivalent to the electrical length of the missing component(s). See section 7 for procedures on adding delay/length before performing a measurement calibration.

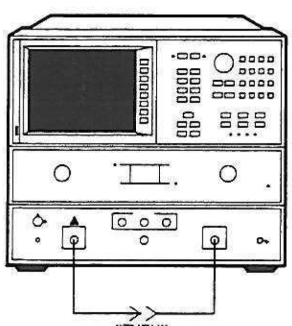
(CAL) *[MORE] [OPT KIT]* — Access the optical calibration kit menu.

Select the softkey that corresponds to the kit being used.

[DEFAULT OPT. KIT] — Select the optical cal kit already loaded in the analyzer memory, or

[MODIFY OPT. KIT] — Select the menu where you can define your own optical standards.

O/O Response Calibration



- Establishes magnitude and phase reference.
- Requires a "thru" for transmission measurements.
- Requires a Fresnel reflection (a clean, unterminated connector on the output of an optical fiber that results in 3.5% reflected optical power or about −14.6 dB) for reflection measurements.

An optical response calibration removes the repeatable frequency response and insertion loss variations of the test system.

For transmission measurements, the calibration establishes a 0 dB magnitude reference.

For reflection measurements, the calibration establishes a measurement reference plane where zero seconds (zero meters) is the value at the output connector of the fiber.

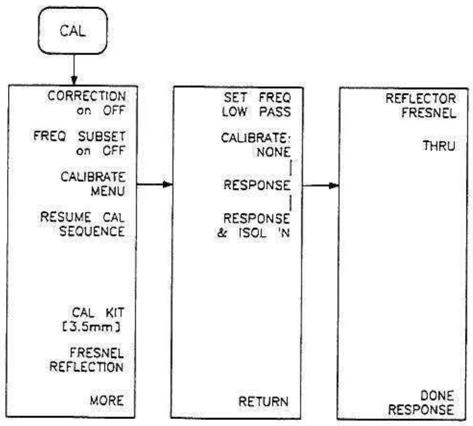
To perform an optical measurement calibration:

(CAL) *[CALIBRATE MENU] [RESPONSE]* — Access the calibration menu and select the response calibration.

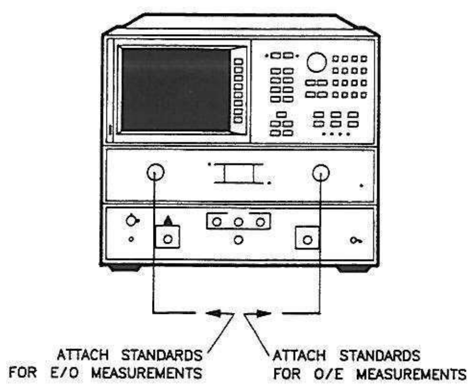
Connect the standard to be used. For this transmission measurement example, connect a thru (remove the DUT and directly connect the measurement port cables). When calibrating the measurement system, perform the calibration at the point of DUT connection (measurement plane).

[THRU]
[DONE: RESPONSE]

Select the softkey corresponding to the connected standard. Once the standard is measured, the analyzer underlines the selected softkey. Press *[DONE: RESPONSE]* to complete the calibration sequence.



E/O & O/E Response Calibration
E/O (O/E) Response and Match Calibration



- More accurate than the frequency response calibration.
- Requires three precision standards (a short, an open, and a load) and two thru cables (electrical and optical).
- Good choice for measurements of devices with impedance mismatches.

This calibration routine removes the repeatable frequency response, insertion loss variations, and impedance mismatches of the test system. If the isolation portion of this calibration is performed, the effect of leakage (crosstalk) is also removed. Precision standards are measured for reflection and then the optical and electrical thrus are measured for forward transmission.

To perform a frequency response and match calibration:

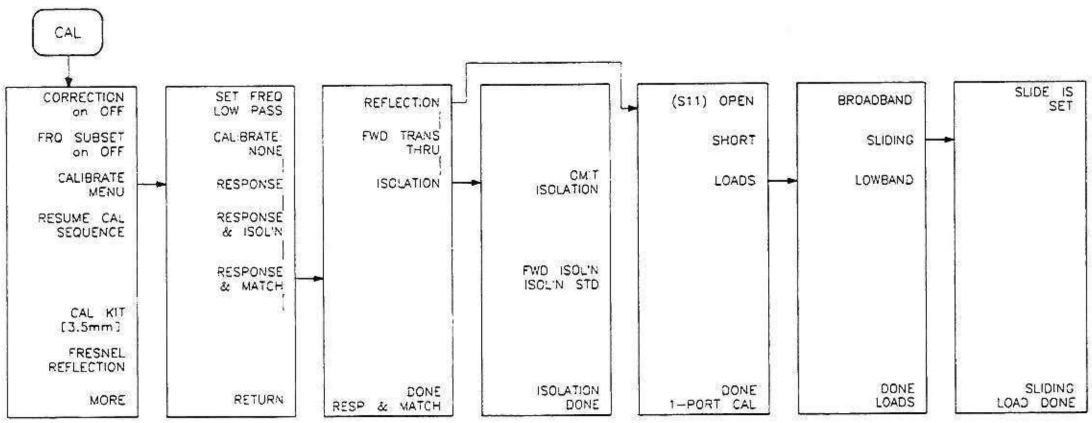
(CAL) *[CALIBRATE MENU] [RESPONSE & MATCH]*

Access the calibration menu and select the response and match calibration.

At this point a menu is presented with the following options: *[REFLECTION] [FWD. TRANS. THRUS]* (or *[TRANSMISSION]* for O/E) and *[ISOLATION]*. One at a time, select the *[REFLECTION]*, *[FWD. TRANS. THRUS]* (or *[TRANSMISSION]*) and *[ISOLATION]* softkeys and follow the prompts.

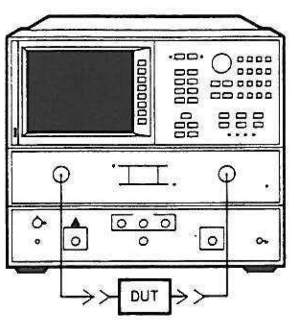
The connection of the standards for an E/O measurement calibration are made on port 1. Conversely, the standards are connected to port 2 when performing a measurement calibration for an O/E device.

The implementation of the response and match measurement calibration is very similar to the frequency response, 1-port calibration and the isolation calibration described in this chapter.



Example Menus for E/O Device Type

Electrical Frequency Response Calibration



- Establishes a magnitude and phase reference for either an electrical transmission or an electrical reflection measurement.
- Requires a "thru" for transmission measurements.
- Requires a short or open for reflection measurements.

A frequency response calibration removes the repeatable frequency response and insertion loss variations of the test system.

For transmission measurements, the calibration establishes a 0 dB loss (or gain) and a 0° phase reference.

For reflection measurements, the calibration establishes a 0 dB return loss at either a 0° or 180° phase shift.

To perform an electrical frequency response calibration:

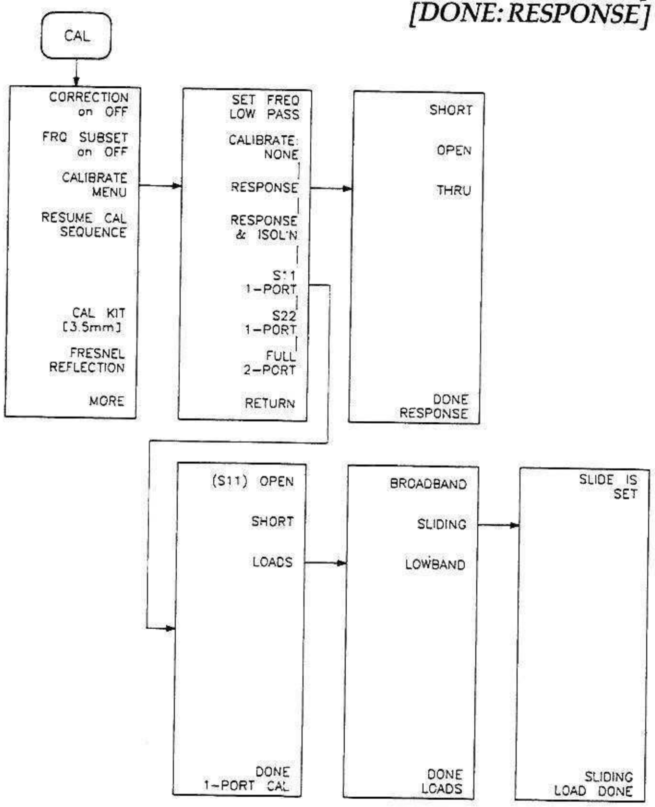
(CAL) *[CALIBRATE MENU]* *[RESPONSE]*

Access the calibration menu and select the response calibration. Connect the standard to be measured. For this example, connect a "thru" (i.e., remove the DUT and directly connect the measurement port cables). When calibrating the measurement system, perform the calibration at the point of DUT connection (measurement plane).

[THRU] *[DONE: RESPONSE]*

Select the softkey corresponding to the connected standard (either *[OPEN]*, *[SHORT]*, or *[THRU]*). Once the standard is measured, the analyzer underlines the selected softkey. *[DONE: RESPONSE]* completes the calibration sequence.

Only one standard, the last one measured, is used to correct the frequency response variations of the test system.



1-Port Reflection Calibration

- More accurate than the frequency response calibration.
- Requires three precision standards (a short, an open, and a load).
- Good choice for reflection measurements of high insertion loss DUTs.

This calibration routine removes all three of the systematic error terms for an electrical reflection measurement of a one-port device. It is best applied to a one-port device since it does not remove the mismatch effects seen from the second port of a two-port DUT. The output mismatch effects of the second port are negligible when the DUT's insertion loss is >6 dB.

To perform the 1-port reflection calibration:

(CAL) *[CALIBRATE MENU]* *[S11 1-PORT]*

Access the calibration menu and select the *[S11 1-PORT]* (test port 1 calibration) or the *[S22 1-PORT]* (test port 2) softkey. The S11 calibration is used in this example. For an S22 calibration, all connections are made to port 2.

Connect an open, and then a short, to port 1 and press the appropriate softkey after each connection. The selected softkey is underlined when the measurement is complete.

[LOADS]

The *[LOADS]* menu provides the following selection of loads: *[BROADBAND]*, *[SLIDING]*, or *[LOWBAND]*. Connect the load(s) you are measuring to port 1 and select the appropriate softkey. For stop frequencies <3 GHz, use a fixed load (lowband or broadband). For start frequencies >3 GHz, use either a broadband or a sliding load. Finally, for calibrations covering frequencies above *and* below 3 GHz, use either a broadband load or a lowband *and* a sliding load. When choosing between the use of a broadband or a sliding load, you should determine the level of measurement accuracy required. Although more complex, a sliding load typically provides >40 dB effective directivity (best accuracy). A broadband load is simpler to use and provides approximately 35 dB effective directivity.

[DONE: LOADS] *[DONE 1-PORT CAL]*

After measurement of the load(s), return to the 1-port calibration menu. The *[DONE 1-PORT CAL]* softkey completes the calibration sequence.

Upon completion of the 1-port calibration, the analyzer determines the contribution of all three error terms and removes their effect from the measured data. Note that the *[CORRECTION ON off]* softkey is turned on when the calibration procedure is complete and "Cor" is displayed in the status notations area of the CRT.

2-Port Calibration

- Most accurate calibration procedure for multi-port electrical devices.
- Requires "thru" and precision short, open, and load measurements on each port.
- Measures twelve error terms.

Full 2-port is the most complete and accurate calibration for transmission and reflection measurements of 2-port devices. It measures the three systematic errors (frequency response, leakage, and mismatch) in both the forward and reverse directions and removes their effects from the measured data.

To implement a full 2-port measurement calibration:

(CAL) *[CALIBRATE MENU]* *[FULL 2-PORT]*

Access the calibration menu and select the full 2-port calibration.

A menu is presented with the following options: *[REFLECT'N]*, *[TRANSMISSION]*, and *[ISOLATION]*. One at a time, select the *[REFLECT'N]* and *[TRANSMISSION]* softkeys and follow the prompts. The implementation of this portion of the 2-port calibration is very similar to the frequency response and 1-port calibrations described above. The only difference is that both forward and reverse transmission measurements are made, as well as reflection measurements on both test ports.

Isolation Calibration

For most applications, you can omit the isolation measurement (*[OMIT ISOLATION]* softkey). The analyzer has >70 dB isolation between ports 1 and 2 without accuracy enhancement. For high dynamic range devices that require >70 dB isolation (e.g. some filters and switches), perform the isolation accuracy enhancement as shown below.

(AVG) *[AVERAGING FACTOR]* (16) (x1) *[AVERAGING ON]*

The purpose of the isolation calibration is to characterize and remove the effect of leakage (crosstalk) between ports 1 and 2. Selecting an averaging factor of 16 (or greater) prior to the isolation calibration helps to reduce the analyzer's noise floor, thereby improving crosstalk characterization.

[IF BW] (30) (x1)

Further improvement in crosstalk characterization can be achieved by reducing the analyzer's IF bandwidth during the isolation calibration. Reducing the IF bandwidth causes additional reduction in the noise floor. (For more information on reducing the noise floor refer to "Reducing Trace Noise" later in this chapter).

Connect 50 ohm loads to ports 1 and 2.

(CAL) *[RESUME CAL SEQUENCE]*

The *[RESUME CAL SEQUENCE]* key allows the continuation of a calibration sequence. All calibration steps previously implemented are saved.

[ISOLATION] *[FWD ISOL'N ISOL'N STD]* *[REV ISOL'N ISOL'N STD]*

The isolation calibration results in >90 dB effective isolation between ports.

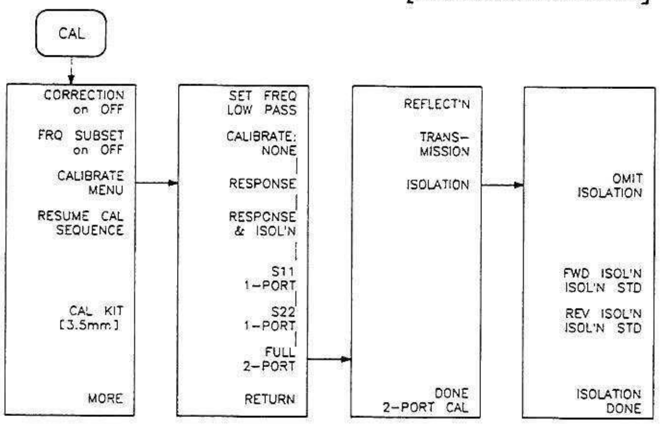
(AVG) *[AVERAGING OFF]* *[IF BW]* (3) (k/m)

Prior to completing the calibration sequence, turn averaging off and return the analyzer's IF bandwidth to 3 kHz.

(CAL)
[RESUME CAL SEQUENCE]
[ISOLATION DONE]

Complete the calibration by first resuming the sequence and then selecting *[ISOLATION DONE]*.

After calibration, the analyzer turns correction on and switches the source output power between ports 1 and 2 for fully calibrated measurements of all four S-parameters.



Frequency Subset

Press (CAL) *[FRQ SUBSET]* to measure a portion (or subset) of a previously calibrated frequency range. Change the start/stop or center/span frequencies as required. For more information, see the "Measurement Calibration" section in the *Operating Manual*.

Calibration Standards

The quality of the error correction provided by a measurement calibration is limited by the difference between the model of the calibration standards and the actual characteristics of those standards. Thus taking care of the connectors of the calibration standards is critical to prevent degeneration of the standards. Using sliding and fixed loads rather than broadband loads improves measurement accuracy as indicated in the "Measurement Accuracy and Specifications" section of the *Operating Manual*.

To use calibration standards other than the default sets, refer to the modify cal kit menu (described in the "Measurement Calibration" section of the *Operating Manual*). Enter the mathematical model for the new calibration standards as directed. The model used by the analyzer will then be the same as the new standards.

Adapters

Adapters should be included in the test setup when you make a measurement calibration. Adapters added after a measurement calibration contribute reflections and electrical length that could have been compensated for. The adapters' electrical length shifts the reference plane. However, this shift can be compensated for (see "Reference Plane").

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 all S-parameter measurements.

Sweep Time

Short sweep times at some narrow IF bandwidths can give rise to measurement inaccuracy as explained in "IF Bandwidth" below. Also, if long lengths of fiber are used in measurements, the sweep time may have to be substantially increased for accurate results.

IF Bandwidth

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

Sweep Type: LIST FREQ
IF Bandwidth: 10 Hz or 30 Hz
15 msec/point (at 201 points, for example, 3.015 second [0.015x201]).

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.

Connector Repeatability

Parts of the measurement setup such as interconnecting cables and adapters all introduce variations in magnitude and phase that can mask the actual performance of the DUT. Connector repeatability is a major source of random measurement error that calibrations do not compensate for. High quality adapters and cables are required to maintain good measurement accuracy. Refer to Application Note 326 in the *Operating Manual* "Appendix" for instructions regarding inspection, cleaning, gauging, and torquing of microwave 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 analyzer and the device under test can contribute random error to your measurement. Inspect for lossy cables and damaged cable connectors. Use proper connector care techniques.

Temperature Drift

Variations in the ambient temperature will affect the error-corrected measurement uncertainty because of the thermal expansion characteristics of devices within the analyzer system. 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 "Measurement Accuracy and Specifications" section). If you require even greater frequency accuracy, override the internal crystal with an external source or frequency standard.

Verification

To check the accuracy of a calibration, perform measurement verification. Use accurately known verification standards with diverse magnitude and phase responses. This procedure does not improve measurement accuracy; it is a measure of the accuracy of the existing calibration.

Measurement Uncertainty

To determine the measurement uncertainties for the lightwave component analyzer after accuracy enhancement, refer the "Measurement Accuracy and Specifications" section of the *Operating Manual*.

Decreasing Sweep Time

The following suggestions for decreasing sweep time are general rules. Experiment with these suggestions to achieve a shorter sweep time. 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, the default mode. Don't select manual mode.

IF Bandwidth

Press (AVG) to access IF bandwidth. With the analyzer in its preset instrument state, sweep time changes with IF bandwidth 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 decreases measurement time. But just having averaging on imposes additional computation and increases sweep time. Turning off averaging and using smoothing or a smaller IF bandwidth may produce comparable results in less time.

Number of Points

Press (MENU) to access the number of points function. Sweep time does not change proportionally with number of points but as indicated below. See also "Sweep Type".

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 the two channels (instead of using dual channel mode).

Measurement Calibration

Sweep time increases with measurement calibration complexity (and measurement accuracy). Refer to the measurement calibration explanation earlier in this chapter to evaluate the type of calibration required.

Sweep Type

Press (MENU) *[SWEEP TYPE MENU]* to access the sweep type menu. The relative sweep times of the three types of sweep are indicated above. Each type of sweep has its advantages and disadvantages.

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

LIST FREQ. List frequency sweep can be fastest when specific frequency points are of interest (and those points are not listed above or 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 bandswitches as possible while maintaining measurement integrity. The hardware of the lightwave component analyzer sweeps the frequency range in a number of bands. Switching from band to band takes time.

To see the bandswitch points (steps), press (SYSTEM) *[SERVICE MENU] [ANALOG]* (21) (x1) and autoscale. If desired, use the markers to read out the frequency of these points. 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. The analyzer continues to control the device. That control takes enough time that the analyzer sweep may be visibly slower or motionless.

Other Factors

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

Limit lines	Limit testing
Marker search	Marker stats

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. Dynamic range is affected by several factors.

Test Port Power

Increase the test port power so 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, power is too high. Reduce power and reset the power trip under the *[POWER]* softkey.

DUT Output Level

For microwave measurements, amplifiers such as the HP 8349A can be used to boost the DUT output within the measurement range of the analyzer.

Noise

Reducing the noise floor can increase dynamic range. This can be accomplished using one or more of the features described in "Reducing Trace Noise".

Reducing Trace Noise

The analyzer has three functions that help reduce the effect of noise on the data: IF bandwidth reduction, averaging, and smoothing.

IF Bandwidth

Reducing the receiver 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. Each tenfold reduction in IF (receiver) bandwidth (like 3 kHz to 300 Hz) lowers the noise floor by about 10 dB. (Press (AVG) *[IF BW]* and use the entry keys to set the bandwidth). Sweep time is automatically increased as the IF bandwidth is narrowed.

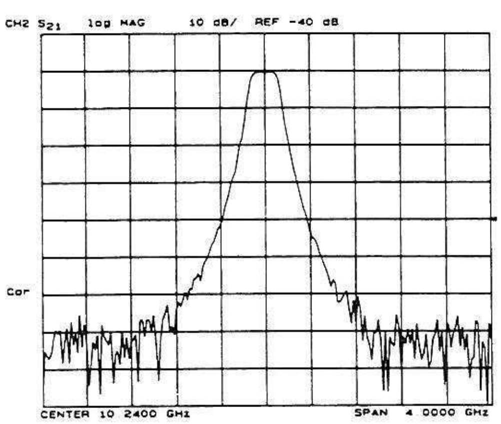
Averaging

The analyzer applies exponential averaging of successive traces to reduce the effects of random noise. Each doubling of the averaging factor lowers the noise floor by about 3 dB. (Press (AVG) *[AVERAGING FACTOR]* and use the entry keys to set the averaging level). The effective averaging factor is displayed under the "AVG" notation (which is displayed when averaging is turned on). This annotation begins at one, and counts up to the user-defined factor, incrementing once per sweep. The noise is reduced, often visibly, with each new sweep as the effective averaging factor increments.

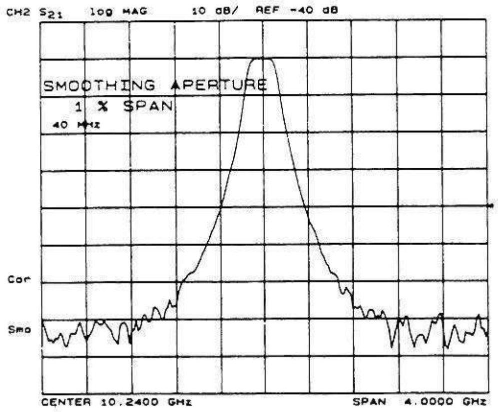
The full effect of averaging is realized when the CRT indicates the desired number of sweeps have been taken. Averaging increases measurement time by requiring more sweeps.

Averaging is explained more fully in the "Stimulus and Response Functions" section in the *Operating Manual*.

Smoothing



Although smoothing does not lower the noise floor, it can make noisy signals easier to interpret by reducing trace ripple. Smoothing is often likened to video filtering, and is different from averaging. Averaging computes each data point based on the average value during several sweeps. Smoothing computes each data point based on one sweep, but on the average of a window of several data points for the current sweep. The window or smoothing aperture is a percent of the swept frequency span, less than or equal to 20%. Use smoothing with caution; too large a smoothing aperture may distort the data. The first figure shows the response of a bandpass filter with no smoothing. The second figure shows the response with 1% smoothing. For this example, the 1% smoothing reduces the noise seen in the filter's reject band. Increasing smoothing beyond 1% will visibly distort the passband response.



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.
3. If the default aperture is acceptable press *[SMOOTHING ON]*.

Maintaining Good Connections

The connections made in a measurement system can be the cause of bad measurement data. Make all connections in a consistent and repeatable manner; do not over-tighten or under-tighten. Whenever possible, keep protective caps on all connectors. In addition, cables should be kept as still as possible when making measurements.

CAUTION

Do not touch the center pin of the HP 8703 RF connectors. Static discharge can damage the internal RF components.

Making Optical Connections

The type of lightwave connectors on the HP 8703 are ordered by option. If a measurement device requires a different connector type, HP has the following connector adapters available.

HP 81000AI HMS-10/HP (HP part number 08154-61701)
HP 81000FI FC/PC (HP part number 08154-61702)
HP 81000SI DIN 47256 (HP part number 08154-61703)
HP 81000VI ST (HP part number 08154-61704)

Each adapter has a slot that mates with the corresponding key piece. After mating the connectors, tighten them (finger tight) in a consistent and repeatable manner for every measurement.

Cleaning Optical Connectors

All optical connectors, like electrical connectors, should always be cleaned properly before a connection is made. This is especially important because a small particle of lint or dust can cause poor measurement data. Use non-corrosive alcohol and clean the mechanical connectors with a lint-free swab or cloth. Then blow them dry with clean compressed air.

Cleaning Fiber Ends and Using Index Matching Compounds

The fiber ends should always be clean before making a connection. If you are using index matching compound, be sure to apply it as precisely and as evenly as possible. Remove it completely when you are finished.

Alcohol on a lint free swab or cloth is often used to clean fiber ends. The ends are then blown dry with clean compressed air.

HP currently offers the HP 15475A, a complete optical cleaning kit that uses an adhesive tape to clean the fiber ends. This kit includes the following parts:

HP 15475A Optical Connector Cleaning Kit

Description	HP Part Number
Head Cleaner	8500-0270
Hexdriver	8710-1256
Lens Cleaning Paper	9300-0761
Cleaning Kit Box	9300-1130
Blow Brush	9300-1131
Cleaning Tips	9300-1351
Cleaning Tip Box	1540-1100
Adhesive Tape Kit	15475-68701
Cleaning Instructions	15475-90002

Cleaning Instructions

The following information is taken from the cleaning instructions that come with the kit above:

NOTE: Never use abrasive materials to clean optical connectors or lenses.

Fiber Connectors

1. Turn off the laser and remove the connector adapter.
2. Apply a small amount of head cleaner to the cleaning paper and clean the surface and ferrule of the connector.
3. Use another new piece of dry cleaning paper to wipe the connector face clean.
4. Lightly press the adhesive tape against the connector surface several times to remove any remaining dirt or particles left by the cleaning paper. Return the tape to its box.
5. Protect the connector surface by attaching the adapter and cap.

Anti-Rotation Clamps Connection

The HP 08515-60003 Anti-Rotation Clamps are used to secure the connections at the electrical test ports of the analyzer. When installed, each clamp holds the large nut that secures the electrical test port connector to the front panel, and the RF cable connector or the front panel adapter mated with the port connector.

Without the clamps, the test port connections may come loose after moving the connected device and could invalidate calibrations and measurements.

Procedure

NOTE: Although the anti-rotation clamps may be used with front panel adapters, these instructions refer to an installation using the HP RF Cables. Adapter installations will be similar.

1. Two anti-rotation clamps are included in the analyzer accessories box. Remove one and loosen the thumbscrew until it is almost out of the counter-bored hole in the clamp body.

   Gently push the clamp (round-hole end first) over and past the RF cable connector being connected to the analyzer test port. The rubber O-ring in the round end of the clamp will fit tightly over the connector. Wiggle the clamp if necessary to get it over the connector.

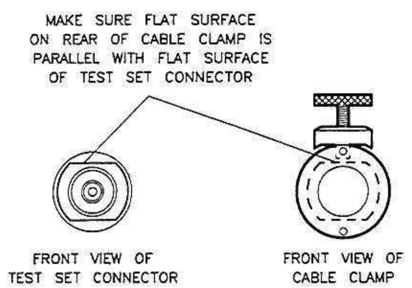
   Connect the cable to the test port and tighten as specified in the cable manual. Do not twist the cable when attaching it to the test port. Use the torque wrench supplied with the calibration kit to tighten the cable to no more than 90 N-cm (8 in.-lb.).

2. The analyzer electrical connector is easily loosened. Hold the RF cable throughout the rest of this procedure. Do not allow the cable to rotate.

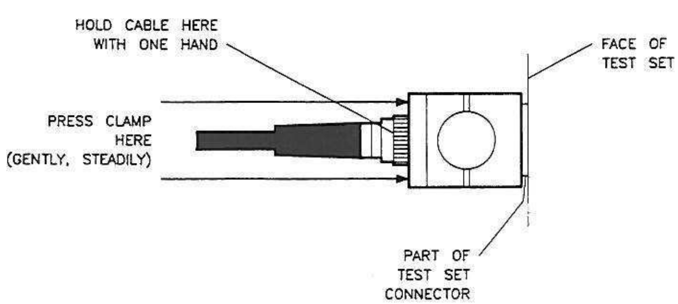
3. Turn the clamp so that the thumbscrew is pointing up. Turn the clamp to visually align the clamp flats with the flats on the test port connector nut. This will minimize rotating the connector in the next step.

NOTE: The flats may be in any orientation in respect to the front panel.

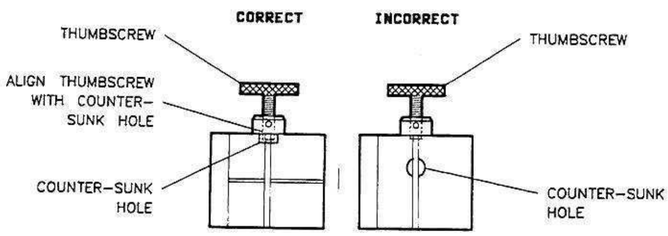
4. Hold the cable with one hand and with the other, press the clamp gently and steadily while wiggling the clamp straight over the RF connector and onto the test port connector nut. The internal flats in the clamp must fit over the flats on the test port connector nut. Try not to rotate the clamp or the RF connection may come loose.



Visually Aligning Clamp and Nut Flats



Mating the Clamp and Nut Flats



Aligning the Thumbscrew with the Counter-bored Hole

5. Make sure that the thumbscrew is aligned with the counter-sunk hole in the clamp body. Push the clamp toward the test set front panel and tighten the thumbscrew with your fingers. The cable cannot be damaged by tightening the thumbscrew too tightly.

6. Repeat steps 1 through 5 for the other clamp.

The internal O-ring (HP Part Number 0900-0007) is field replaceable without disassembling the anti-rotation clamp. Pry it out with fine tweezers or a similar tool when it no longer holds the RF cable securely. Insert the new O-ring by engaging one side of it in the slot of the phenolic clamp donut. Use your fingers to push the O-ring into the rest of the slot.

Index Matching Compounds

Hewlett-Packard recommends the proper use of index matching compounds for best return loss characteristics when making measurements with the HP 8703. Refer to "Lightwave Connector Techniques" in the "Appendix" of the *Operating Manual*.

Microwave Connectors

Microwave connectors should be cleaned and inspected before every use, in order to make the best possible microwave connections and to improve the accuracy and repeatability of measurements.

Refer to the application note on microwave connector care (located in the appendix of the *Operating Manual*) for instructions on inspecting, cleaning, and gaging microwave connectors.

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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.

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