Errata

Title & Document Type: 8752C Network Analyzer User's Guide

Manual Part Number: 08752-90135

Revision Date: August 1994

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

Support for Your Product

Agilent no longer sells or supports this product. You will find any other available product information on the Agilent Test & Measurement website:

www.tm.agilent.com

Search for the model number of this product, and the resulting product page will guide you to any available information. Our service centers may be able to perform calibration if no repair parts are needed, but no other support from Agilent is available.

Agilent Technologies

User's Guide

HP 8752C Network Analyzer

HEWLETT
PACKARD

HP Part No. 08752-90135
Printed in USA August 1994

Notice.

The information contained in this document is subject to change without notice.

Hewlett-Packard makes no warranty of any kind with regard to this material, including but not limited to, the implied warranties of merchantability and fitness for a particular purpose. Hewlett-Packard shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material.

1212 Valley House Drive, Rohnert Park, CA 94928-4999, USA

Certification

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology, to the extent allowed by the Institute's calibration facility, and to the calibration facilities of other International Standards Organization members.

Warranty

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by Hewlett-Packard. Buyer shall prepay shipping charges to Hewlett-Packard and Hewlett-Packard shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to Hewlett-Packard from another country.

Hewlett-Packard warrants that its software and firmware designated by Hewlett-Packard for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error-free.

Limitation of Warranty

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Exclusive Remedies

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office.

Safety Symbols

The following safety symbols are used throughout this manual. Familiarize yourself with each of the symbols and its meaning before operating this instrument.

Caution Caution denotes a hazard. It calls attention to a procedure that, if not correctly performed or adhered to, would result in damage to or destruction of the instrument. Do not proceed beyond a caution note until the indicated conditions are fully understood and met.

Warning **Warning denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning note until the indicated conditions are fully understood and met.**

Instrument Markings

⚠ The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to the instructions in the documentation.

"CE" The CE mark is a registered trademark of the European Community. (If accompanied by a year, it is when the design was proven.)

"ISM1-A" This is a symbol of an Industrial Scientific and Medical Group 1 Class A product.

"CSA" The CSA mark is a registered trademark of the Canadian Standards Association.

General Safety Considerations

Warning **This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.**

Warning **No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.**

Caution Before switching on this instrument, make sure that the line voltage selector switch is set to the voltage of the power supply and the correct fuse is installed.

Warning **These servicing instructions are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**

Warning **The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.**

Warning **The power cord is connected to internal capacitors that may remain live for 10 seconds after disconnecting the plug from its power supply.**

Warning **For continued protection against fire hazard replace line fuse only with same type and rating (F 5A/250V). The use of other fuses or material is prohibited.**

Notice for Germany: Noise Declaration

LpA < 70 dB
am Arbeitsplatz (operator position)
normaler Betrieb (normal position)
nach DIN 45635 T. 19 (per ISO 7779)

DECLARATION OF CONFORMITY
according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name:	Hewlett-Packard Co.
Manufacturer's Address:	1400 Fountaingrove Parkway Santa Rosa, California 95403 U.S.A.

Declares that the product:

Product Name:	Network Analyzer
Model Numbers:	HP 8752C
Product Options:	This declaration covers all options of the above products.

Conforms to the following product specifications:

Safety:	IEC 348:1978/HD 401:1980 CAN/CSA-22.2 No. 231 Series M89
EMC:	CISPR 11:1990 /EN 55011:1991, Group 1 Class A IEC 801-2:1991 /EN 50082-1:1992, 4 kV CD, 8 kV AD IEC 801-3:1984 /EN 50082-1:1992, 3V/m, 27-500 MHz IEC 801-4:1988 /EN 50082-1:1992, 500 V signal, 1000 V AC

Supplementary Information:

The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC.

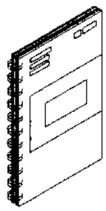
Santa Rosa, California	7/26/94	Dixon Browder
Location	**Date**	**Dixon Browder / Quality Manager**

European Contact:
Your local Hewlett-Packard Sales and Service Office or Hewlett-Packard GmbH, Department ZQ/Standards Europe, Herrenberger Straße 130, D-71034 Böblingen (FAX: +49-7031-143143)

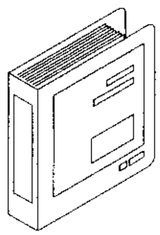
User's Guide Overview

- Chapter 1, "HP 8752C Descriptions and Options," describes features, functions, and available options.
- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, or Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 4, "Optimizing Measurement Results," describes techniques and functions for achieving the best measurement results.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.
- Chapter 6, "Specifications and Measurement Uncertainties," defines the performance capabilities of the analyzer.
- Chapter 7, "Menu Maps," shows softkey menu relationships.
- Chapter 8, "Key Definitions," describes all the front panel keys, softkeys, and their corresponding HP-IB commands.
- Chapter 9, "Error Messages," provides information for interpreting error messages.
- Chapter 10, "Compatible Peripherals," lists measurement and system accessories, and other applicable equipment compatible with the HP 8752C. Procedures for configuring the peripherals, and an HP-IB programming overview are also included.
- Chapter 11, "Preset State and Memory Allocation," contains a discussion of memory allocation, memory storage, instrument state definitions, and preset conditions.

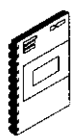
HP 8752C Network Analyzer Documentation Set



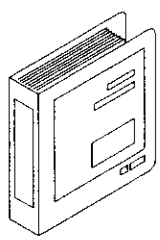
The **Installation and Quick Start Guide** familiarizes you with the HP 8752C network analyzer's front and rear panels, electrical and environmental operating requirements, as well as procedures for installing, configuring, and verifying the operation of the HP 8752C.



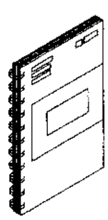
The **User's Guide** shows how to make measurements, explains commonly-used features, and tells you how to get the most performance from your analyzer.



The **Quick Reference Guide** provides a summary of all available user features.



The **Programmer's Guide** provides programming information including: an HP-IB command reference, an HP-IB programming reference, as well as programming examples.



The **System Verification and Test Guide** provides the system verification and performance tests and the Performance Test Record for your HP 8752C network analyzer.

Contents

5. Application and Operation Concepts

Figures

Tables

1

HP 8752C Description and Options

This chapter contains information on the following topics:

- Analyzer overview
- Analyzer description
- Front panel features
- Analyzer display
- Rear panel features and connectors
- Analyzer options available
- Service and support options
- Changes between the HP 8752A/B/C

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, or Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 4, "Optimizing Your Measurement Results," describes techniques and functions for achieving the best measurement results.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.

Analyzer Description

The HP 8752C is a high performance vector network analyzer for laboratory or production measurements of reflection and transmission parameters. It integrates a high resolution synthesized RF source, a reflection/transmission test set, and a dual channel receiver to measure and display magnitude, phase, and group delay responses of active and passive RF networks.

Two independent display channels and a large screen color display show the measured results of one or both channels, in rectangular or polar/Smith chart formats.

For information on options, refer to "Options Available" later in this chapter.

The HP 8752C has the additional following features:

- Combined digital signal processing and microprocessor controls to provide easy operation and measurement improvement.
- Measurement functions selection with front panel keys and softkey menus.
- Direct print or plot output of displayed measurement results to a compatible peripheral.
- Storage of instrument states, and any corresponding error-corrections, in analyzer internal memory for the following times, or on floppy disk indefinitely.

  Temperature at 70 °C .... 208 days (0.57 year)
  Temperature at 40 °C .... 1036 days (2.8 years)
  Temperature at 25 °C .... 10 years typical

- Automatic sweep time that selects the minimum sweep time for the given IF bandwidth, number of points, averaging mode, frequency range, and sweep type.
- Built-in service diagnostics that simplify troubleshooting procedures.
- Performance improvement and flexibility through trace math, data averaging, trace smoothing, electrical delay, and accuracy enhancement.
- Accuracy enhancement (error-correction) methods that range from normalizing data to one-port vector error correction with up to 1601 measurement points. (Vector error-correction reduces the effects of system directivity, frequency response, source match, and crosstalk.)
- Reflection and transmission measurements in either 50 or 75 ohm impedance environments.
- Test system automation with the addition of a personal computer with an HP-IB card, or an HP 9000 series 200 or 300 computer. This allows all of the analyzer's measurement capabilities to be programmed over the Hewlett-Packard Interface Bus (HP-IB). (Refer to the "Compatible Peripherals" chapter or the *HP 8752C Network Analyzer Programming Guide*.)
- LIF/DOS disk format for saving states and measurement data to an external disk drive.
- Internal automation, using test sequencing to program analyzer measurements and control other devices without an external controller.
- TTL lines on the test set connector that can control four output bits (0, 1, 2, 3) and read one input bits through test sequencing.

Front Panel Features

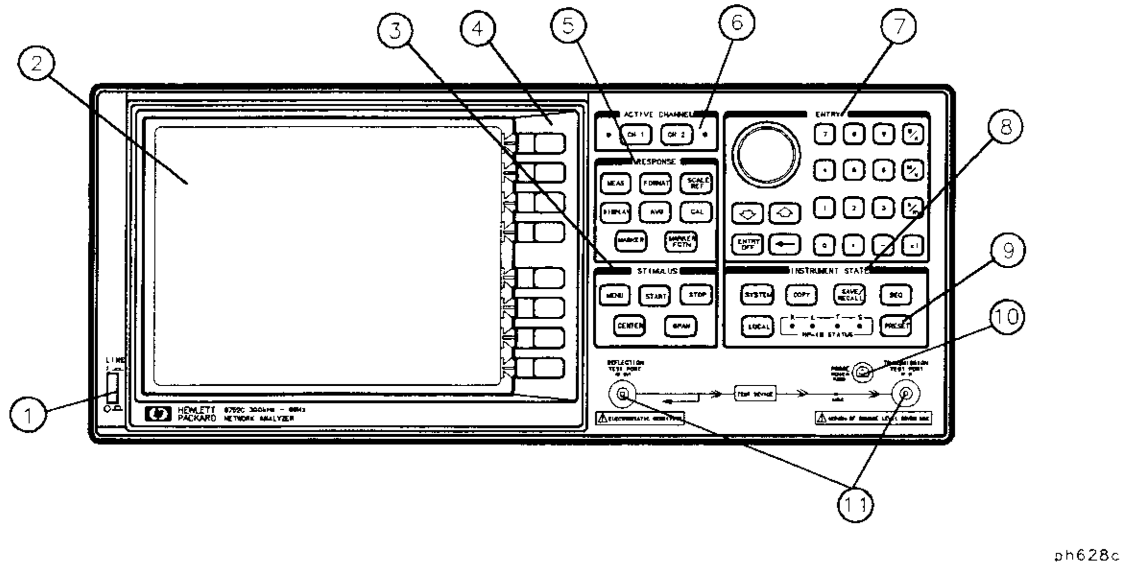


Figure 1-1. HP 8752C Front Panel

Figure 1-1 shows the location of the following HP 8752C front panel features and key function blocks. These features are described in more detail later in this chapter, and in the "Key Definitions" chapter.

1. **LINE switch.** This switch controls ac power to the analyzer. 1 is on, 0 is off.
2. **Display.** This shows the measurement data traces, measurement annotation, and softkey labels. The display is divided into specific information areas, illustrated in Figure 1-2.
3. **STIMULUS function block.** The keys in this block allow you to control the analyzer source's frequency, power, and other stimulus functions.
4. **Softkeys.** These keys provide access to menu selections that are shown on the display.
5. **RESPONSE function block.** The keys in this block allow you to control the measurement and display functions of the active display channel.
6. **ACTIVE CHANNEL keys.** The analyzer has two independent display channels. These keys allow you to select the active channel. Then any function you enter applies to this active channel.

7. **The ENTRY block.** This block includes the knob, the step ⇧ ⇩ keys, and the number pad. These allow you to enter numerical data and control the markers.

   You can use the numeric keypad to select digits, decimal points, and a minus sign for numerical entries. You must also select a units terminator to complete value inputs.

8. **INSTRUMENT STATE function block.** These keys allow you to control channel-independent system functions such as the following:

   - copying, save/recall, and HP-IB controller mode
   - limit testing
   - test sequence function
   - time domain transform (option 010)

   HP-IB STATUS indicators are also included in this block.

9. [PRESET] **key.** This key returns the instrument to either a known factory preset state, or a user preset state that can be defined. Refer to the "Preset State and Memory Allocation" chapter for a complete listing of the instrument preset condition.

10. **PROBE POWER connector.** This connector (fused inside the instrument) supplies power to an active probe for in-circuit measurements of ac circuits.

11. **REFLECTION TEST PORT and TRANSMISSION TEST PORT.** The reflection test port outputs a signal from the source and receives input signals from a device, during a reflection measurement. The transmission port receives input signals from a device, during a transmission measurement.

Analyzer Display

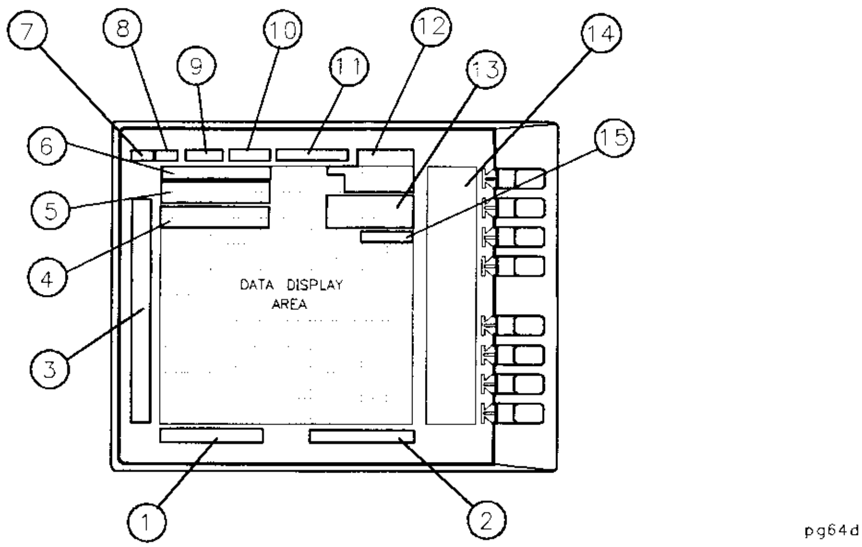


Figure 1-2. Analyzer Display (Single Channel, Cartesian Format)

The analyzer display shows various measurement information:

- The grid where the analyzer plots the measurement data.
- The currently selected measurement parameters.
- The measurement data traces.

Figure 1-2 illustrates the locations of the different information labels described below.

In addition to the full-screen display shown in Figure 1-2, a split display is available, as described in the "Making Measurements" chapter. In the split display mode, the analyzer provides information labels for each half of the display.

Several display formats are available for different measurements, as described under "(FORMAT)" in the "Key Definitions" chapter.

1. **Stimulus start value.** This value could be any one of the following:
   - the start frequency of the source in frequency domain measurements
   - the start time in CW mode (0 seconds) or time domain measurements
   - the lower power value in power sweep

   When the stimulus is in center/span mode, the center stimulus value is shown in this space.

2. **Stimulus stop Value.** This value could be any one of the following:

- The stop frequency of the source in frequency domain measurements.
- The stop time in time domain measurements or CW sweeps.
- The upper limit of a power sweep.

When the stimulus is in center/span mode, the span is shown in this space. The stimulus values can be blanked, as described under "FREQUENCY BLANK Key" in the "Key Definitions" chapter.

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

3. **Status Notations.** This area shows the current status of various functions for the active channel.

The following notations are used:

Avg = Sweep-to-sweep averaging is on. The averaging count is shown immediately below (See "(AVG) Key" in the "Key Definitions" chapter.)

Cor = Error-correction is on. (For error-correction procedures, refer to the "Optimizing Measurement Results" chapter. For error correction theory, refer to the "Application and Operation Concepts" chapter.)

C? = Stimulus parameters have changed from the error-corrected state, or interpolated error-correction is on. (For error-correction procedures, refer to the "Optimizing Measurement Results" chapter. For error-correction theory, refer to the "Application and Operation Concepts" chapter.)

Del = Electrical delay has been added or subtracted, or port extensions are active. (See the "Application and Operation Concepts" chapter and "(SCALE REF) Key" in the "Key Definitions" chapter.)

ext = Waiting for an external trigger.

Gat = Gating is on (time domain option 010 only). (For time domain measurement procedures, refer to the "Making Measurements" chapter. For time domain theory, refer to the "Application and Operation Concepts" chapter.

Hld = Hold sweep. (See HOLD in the "Key Definitions" chapter.)

man = Waiting for manual trigger.

P? = Source power is unleveled at start or stop of sweep. (Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting.)

P↓ = Source power has been automatically set to minimum, due to receiver overload. (See POWER in the "Key Definitions" chapter.)

PRm = Power range is in manual mode (option 004 only).

Smo = Trace smoothing is on. (See "(AVG)" in the "Key Definitions" chapter.)

↑ = Fast sweep indicator. This symbol is displayed in the status notation block when sweep time is less than 1.0 second. When sweep time is greater than 1.0 second, this symbol moves along the displayed trace.

* = Source parameters changed: measured data in doubt until a complete fresh sweep has been taken.

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

5. **Message Area.** This displays prompts or error messages.

6. **Title.** This is a descriptive alpha-numeric string title that you define and enter as described in the "Printing, Plotting, and Saving Measurement Results" chapter.

7. **Active Channel.** This is the number of the current active channel, selected with the (CH 1) and (CH 2) keys. If dual channel is on with an overlaid display, both channel 1 and channel 2 appear in this area.

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

9. **Format.** This is the display format that you selected using the (FORMAT) key.

10. **Scale/Div.** This is the scale that you selected using the (SCALE/REF) key, in units appropriate to the current measurement.

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

12. **Marker Values.** These are the values of the active marker, in units appropriate to the current measurement. Refer to "Using Analyzer Display Markers" in the "Making Measurements" chapter.

13. **Marker Stats, Bandwidth.** These are statistical marker values that the analyzer calculates when you access the menus with the (MKR FCTN) key. (Refer to "Using Analyzer Display Markers" in the "Making Measurements" chapter.)

14. **Softkey Labels.** These menu labels redefine the function of the softkeys that are located to the right of the analyzer display.

15. **Pass Fail.** During limit testing, the result will be annunciated as PASS if the limits are not exceeded, and FAIL if any points exceed the limits.

Rear Panel Features and Connectors

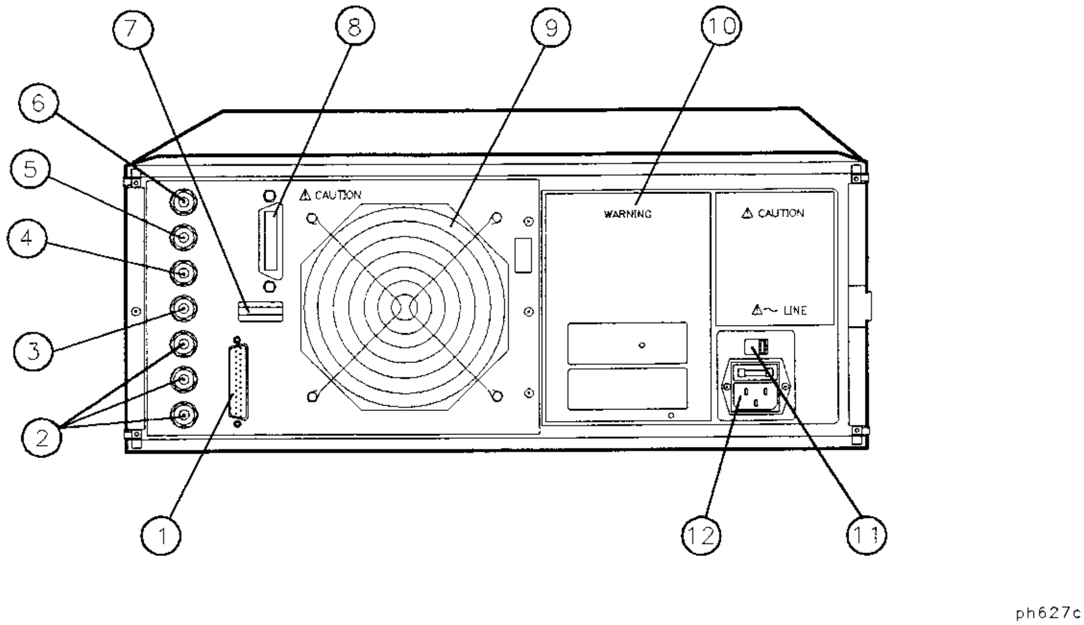


Figure 1-3. HP 8752C Rear Panel

Figure 1-3 illustrates the features and connectors of the rear panel, described below. Requirements for input signals to the rear panel connectors are provided in the "Specifications and Measurement Uncertainties" chapter.

1. **TEST SET INTERCONNECT.** The HP 8752 cannot be used with external test sets. However, with an adapter, you can use signal levels for sequencing. Refer to the "Application and Operation Concepts" chapter for information on applying the test set interconnect.

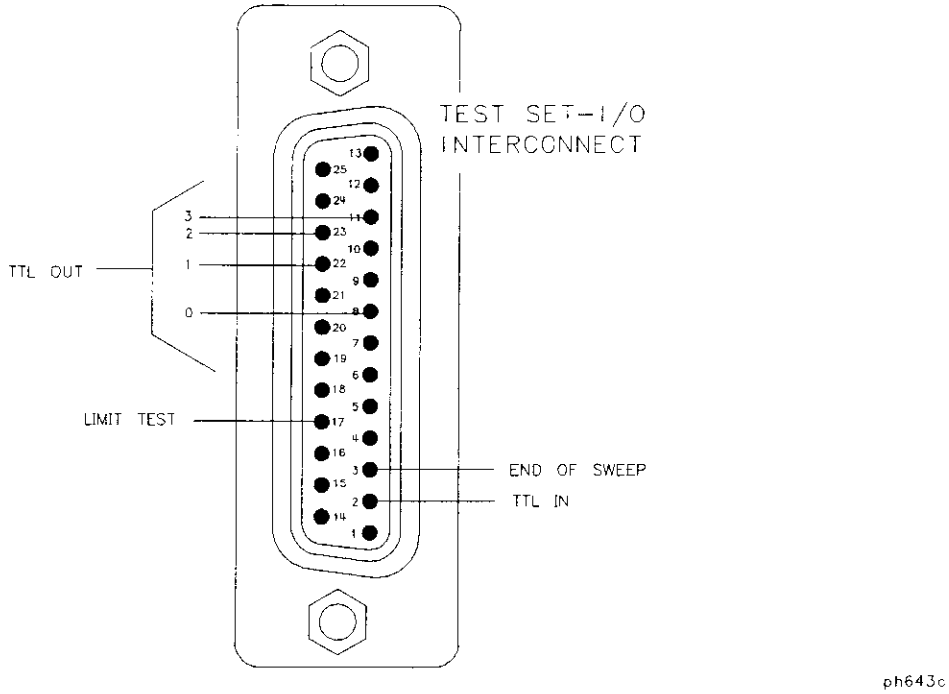


Figure 1-4. Test Set Interconnect Pin-Out

2. **EXTERNAL MONITOR: BLUE, GREEN, and RED.** Blue, green, and red video output connectors provide analog blue, green, and red video signals which you can use to drive an analog multi-sync monitor. The monitor must be compatible with the analyzer's 25.5 kHz scan rate and video levels: 1 Vp-p, 0.7 V=white, 0 V=black, −0.3 V sync, sync on green.

3. **EXTERNAL TRIGGER connector.** This allows connection of an external negative-going TTL-compatible signal that will trigger a measurement sweep. The trigger can be set to external through softkey functions. (Refer to the "Key Definitions" chapter.)

4. **EXTERNAL AM connector.** This allows for an external analog signal input that is applied to the ALC circuitry of the analyzer's source. This input analog signal amplitude modulates the RF output signal.

5. **AUXILIARY INPUT connector.** This allows for a dc or ac voltage input from an external signal source, such as a detector or function generator, which you can then measure. (You can also use this connector as an analog output in service routines, as described in the service manual.)

6. **EXTERNAL REFERENCE INPUT connector.** This allows for a frequency reference signal input that can phase lock the analyzer to an external frequency standard for increased frequency accuracy.

   The analyzer automatically enables the external frequency reference feature when a signal is connected to this input. When the signal is removed, the analyzer automatically switches back to its internal frequency reference.

7. **Serial number plate.**

8. **HP-IB connector.** This allows you to connect the analyzer to an external controller, compatible peripherals, and other instruments for an automated system. Refer to the "Compatible Peripherals" chapter in this document for HP-IB information, limitations, and configurations.

9. **Fan.** This fan provides forced-air cooling for the analyzer.

10. **Safety warnings.**

11. **Line voltage selector switch.** For more information refer to the *HP 8752C Network Analyzer Installation and Quick Start Guide.*

12. **Power cord receptacle, with fuse.** For information on replacing the fuse, refer to the *HP 8752C Network Analyzer Installation and Quick Start Guide* or the *HP 8752C Network Analyzer Service Guide.*

Analyzer Options Available

Option 003, 3 GHz Operation

Option 003 extends the maximum source and receiver frequency of the analyzer to 3 GHz.

Option 004, Source Attenuator

Option 004 adds a step attenuator that extends the output power range from −85 to +10 dBm, or −85 to +8 dBm with option 075.

Option 006, 6 GHz Operation

Option 006 extends the maximum source and receiver frequency of the analyzer to 6 GHz. This option is not compatible with option 075.

Option 010, Time Domain

This option displays the time domain response of a network by computing the inverse Fourier transform of the frequency domain response. It shows the response of a test device as a function of time or distance. Displaying the reflection coefficient of a network versus time determines the magnitude and location of each discontinuity. Displaying the transmission coefficient of a network versus time determines the characteristics of individual transmission paths. Time domain operation retains all accuracy inherent with the correction that is active in the frequency domain. The time domain capability is useful for the design and characterization of such devices as SAW filters, SAW delay lines, RF cables, and RF antennas.

Option 075, 75Ω Impedance

Option 075 offers 75 ohm impedance bridges with type-N test port connectors. This option is not compatible with option 006.

Option 1CM, Rack Mount Flange Kit Without Handles

Option 1CM is a rack mount kit containing a pair of flanges and the necessary hardware to mount the instrument, with handles detached, in an equipment rack with 482.6 mm (19 inches) horizontal spacing.

Option 1CP, Rack Mount Flange Kit With Handles

Option 1CP is a rack mount kit containing a pair of flanges and the necessary hardware to mount the instrument with handles attached in an equipment rack with 482.6 mm (19 inches) spacing.

Service and Support Options

The analyzer automatically includes a one-year on-site service warranty, where available. The following service and support products are available with an HP 8752C network analyzer at any time during or after the time of purchase. Additional service and support options may be available at some sites. Consult your local HP customer engineer for details.

On-Site System Verification (+23G)

On-site system verification (performed by a Hewlett-Packard customer engineer), confirms the system's error-corrected uncertainty performance by measuring traceable devices. It provides a hardcopy listing of both ideal and actual data, together with a certificate of traceability. Preventive maintenance is performed at the time of system verification. Travel through Zone 3 (up to 100 miles/160 km from Hewlett-Packard's nearest service-responsible office) is included.

Standard System Maintenance Service (+02A)

This option provides four-hour, on-site response through Travel Zone 3 on all service requests for the HP 8752C, by a Hewlett-Packard customer engineer.

Basic System Maintenance Service (+02B)

This option provides next day on-site response through Travel Zone 3 on all service requests for the HP 8752C, by a Hewlett-Packard customer engineer.

Return to HP Full Service Agreement (+22A)

This option is a one-year service contract for any repair of the HP 8752C at a Hewlett-Packard repair facility. One complete calibration procedure is included.

Return to HP Repair Agreement (+22B)

This option provides repair of the HP 8752C at a Hewlett-Packard repair facility for one year. Following repair, the instrument is tested functionally but is not fully calibrated.

Return to HP Calibration Agreement (+22C)

This option provides a once-a-year complete calibration procedure at a Hewlett-Packard facility.

Return to HP Calibration (+22G)

This option is a one-time complete calibration procedure performed at a Hewlett-Packard facility. The procedure verifies that the HP 8752C is performing according to its published specifications.

Changes between the HP 8752A/B/C

Table 1-1. Comparing the HP 8752 Family of Network Analyzers

Feature	HP 8752A	HP 8752B	HP 8752C
Test port power range (dBm)			
standard	−20 to +5	−20 to +5	−20 to +5
option 004			−85 to +10
Auto/manual power range selecting	No	No	Yes
Extended frequency range to 6 GHz (option 006)	No	No	Yes
75Ω system impedance (option 075)	No	Yes	Yes
Test sequencing subroutines	No	No	Yes
Non-volatile memory	16 kbytes	16 kbytes	512 kbytes
Faster processor clock rate	No	No	Yes
Non-volitile memory			
Correction data in non-volitile memory	No	No	Yes
Maximum number of internal registers	5	5	32
User-defined preset	No	No	Yes
Formats for external disk	LIF	LIF	LIF or DOS

2

Making Measurements

This chapter contains the following example procedures for making measurements or using particular functions:

- Basic measurement sequence and example
  - Setting frequency range
  - Setting source power
- Analyzer display functions
- Analyzer marker functions
- Magnitude and insertion phase response
- Electrical length and phase distortion
  - Deviation from linear phase
  - Group delay
- Limit testing
- Gain compression
- Gain and reverse isolation
- Test sequencing
- Time domain
  - Transmission response
  - Reflection response

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 3, "Printing, Plotting, or Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 4, "Optimizing Measurement Results," describes techniques and functions for achieving the best measurement results.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.
- Chapter 8, "Key Definitions," describes all the front panel keys and softkeys.
- Chapter 10, "Compatible Peripherals," lists measurement and system accessories, and other applicable equipment compatible with the HP 8752C. Procedures for configuring the peripherals, and an HP-IB programming overview are also included.

Principles of Microwave Connector Care

Proper connector care and connection techniques are critical for accurate, repeatable measurements.

Refer to the calibration kit documentation for connector care information. Prior to making connections to the network analyzer, carefully review the information about inspecting, cleaning and gaging connectors.

Having good connector care and connection techniques extends the life of these devices. In addition, you obtain the most accurate measurements.

This type of information is typically located in Chapter 3 of the calibration kit manuals.

For additional connector care instruction, contact your local Hewlett-Packard Sales and Service Office about course numbers HP 85050A+24A and HP 85050A+24D.

See the following table for quick reference tips about connector care.

Table 2-1. Connector Care Quick Reference

Handling and Storage	
Do	**Do Not**
Keep connectors clean Extend sleeve or connector nut Use plastic end-caps during storage	Touch mating-plane surfaces Set connectors contact-end down
Visual Inspection	
Do	**Do Not**
Inspect all connectors carefully Look for metal particles, scratches, and dents	Use a damaged connector - ever
Connector Cleaning	
Do	**Do Not**
Try compressed air first Use isopropyl alcohol Clean connector threads	Use any abrasives Get liquid into plastic support beads
Gaging Connectors	
Do	**Do Not**
Clean and zero the gage before use Use the correct gage type Use correct end of calibration block Gage all connectors before first use	Use an out-of-spec connector
Making Connections	
Do	**Do Not**
Align connectors carefully Make preliminary connection lightly Turn only the connector nut Use a torque wrench for final connect	Apply bending force to connection Over tighten preliminary connection Twist or screw any connection Tighten past torque wrench "break" point

Basic Measurement Sequence and Example

Basic Measurement Sequence

There are five basic steps when you are making a measurement.

1. Connect the device under test and any required test equipment.
2. Choose the measurement parameters.
3. Perform and apply the appropriate error-correction.
4. Measure the device under test.
5. Output the measurement results.

Basic Measurement Example

This example procedure shows you how to measure the transmission response of a bandpass filter.

Step 1. Connect the device under test and any required test equipment.

1. Make the connections as shown in Figure 2-1.

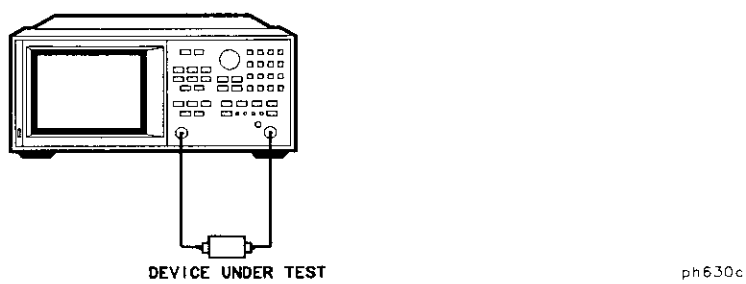


Figure 2-1. Basic Measurement Setup

Step 2. Choose the measurement parameters.

2. Press (PRESET)

   If the preset is set to "user preset," press PRESET: FACTORY (PRESET).

   Setting the Frequency Range

3. To set the center frequency to 134 MHz, press:

   (CENTER) (134) (M/μ)

4. To set the span to 30 MHz, press:

   (SPAN) (30) (M/μ)

Note You could also press the (START) and (STOP) keys and enter the frequency range limits as start frequency and stop frequency values.

Setting the Source Power

5. To change the power level to −5 dBm, press:

   (MENU) POWER (-5) (x1)

Note If your analyzer has option 004 installed, you could also press POWER RANGE MAN POWER RANGES and select one of the power ranges, keeping the power setting within the defined range.

Setting the Measurement

6. To change the number of measurement data points to 101, press:

   (MENU) NUMBER OF POINTS (⇩)

7. To select the transmission measurement, press:

   (MEAS) TRANSMISSN

8. To view the data trace, press:

   (SCALE REF) AUTO SCALE

Step 3. Perform and apply the appropriate error-correction.

9. Refer to the "Optimizing Your Measurement Results" chapter for procedures on correcting measurement errors.
10. To save the instrument state and additional error-correction in the analyzer internal memory, press:

    (SAVE/RECALL) SAVE STATE

Step 4. Measure the device under test.

11. Replace any standard used for error-correction with the device under test.
12. To measure the insertion loss of the bandpass filter, press:

    (MRK) (134) (M/μ)

Step 5. Output the measurement results.

13. To create a hardcopy of the measurement results, press:

    (COPY) PRINT (or PLOT)

    Refer to the "Printing, Plotting, and Saving Measurement Results" for procedures on how to define a print, plot, or save. For information on configuring a peripheral, refer to the "Compatible Peripherals" chapter.

Using the Display Functions

To View Both Measurement Channels

In some cases, you may want to view more than one measured parameter at a time. Simultaneous gain and phase measurements for example, are useful in evaluating stability in negative feedback amplifiers. You can easily make such measurements using the dual channel display.

1. To see both channels simultaneously, press:

   (DISPLAY) DUAL CHAN ON

   The analyzer shows channel 1 on the upper half of the display and channel 2 on the lower half of the display. The analyzer can measure transmission on channel 1 and reflection on channel 2, or different formats as shown in Figure 2-2.

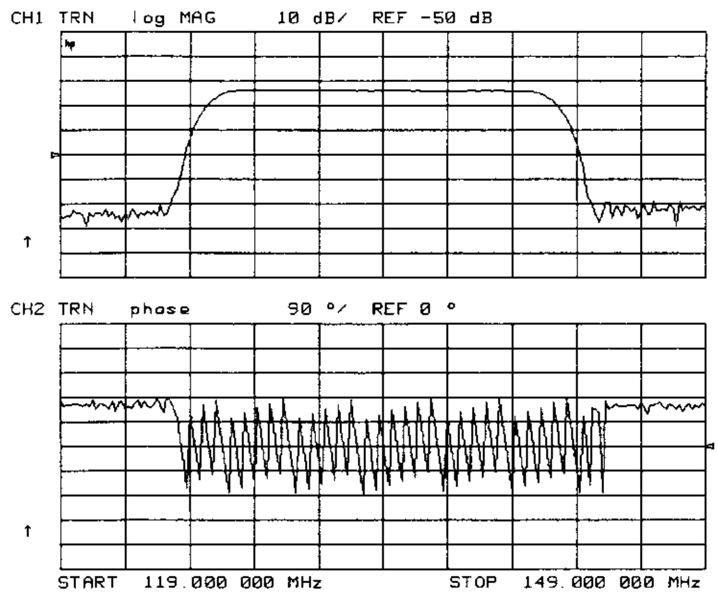


Figure 2-2. Example of Viewing Both Channels with a Split Display

2. To view both channels on a single graticule, press:

   MORE SPLIT DISP OFF

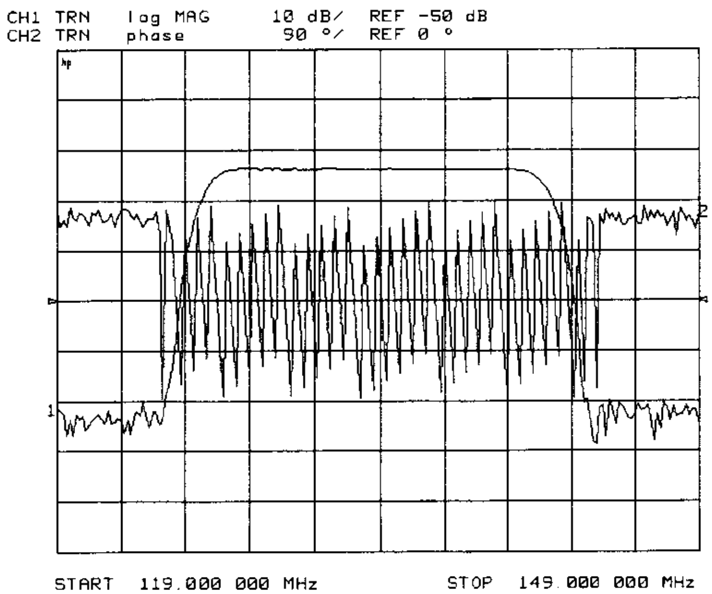


**Figure 2-3.
Example of Viewing Both Channels with a Single Graticule**

Note You can control the stimulus functions of the two channels independent of each other, by pressing (MENU) COUPLED CH OFF .

To Save a Data Trace to the Display Memory

Press (DISPLAY) DATA→MEMORY to store the current active measurement data in the memory of the active channel.

The data trace is now also the memory trace. You can use a memory trace for subsequent math manipulations.

To View the Measurement Data and Memory Trace

The analyzer default setting shows you the current measurement data for the active channel.

1. To view a data trace that you have already stored to the active channel memory, press:

   (DISPLAY) MEMORY

   This is the only memory display mode where you can change the smoothing and gating of the memory trace.

2. To view both the memory trace and the current measurement data trace, press:

   (DISPLAY) DATA and MEMORY

To Divide Measurement Data by the Memory Trace

You can use this feature for ratio comparison of two traces, for example, measurements of gain or attenuation.

1. You must have already stored a data trace to the active channel memory, as described in "To Save a Data Trace to the Display Memory."
2. Press (DISPLAY) DATA/MEM to divide the data by the memory.

   The analyzer normalizes the data to the memory, and shows the results.

To Subtract the Memory Trace from the Measurement Data Trace

You can use this feature for storing a measured vector error, for example, directivity. Then, you can later subtract it from the device measurement.

1. You must have already stored a data trace to the active channel memory, as described in "To Save a Data Trace to the Display Memory."
2. Press (DISPLAY) DATA-MEM to subtract the memory from the measurement data.

   The analyzer performs a vector subtraction on the complex data.

To Ratio Measurements in Channel 1 and 2

This math function ratios channels 1 and 2, and puts the results in the channel 2 data array. Both channels must be switched on and have the same number of points.

1. Press (CH 1) (MENU) NUMBER OF POINTS and notice the number of points setting, shown on the analyzer display.
2. Press (CH 2) (MENU) NUMBER OF POINTS and enter the same value that you observed for the channel 1 setting.

   Both channels must have the same number of points.
3. Press (DISPLAY) DUAL CHAN ON MORE D2/D1 TO D2 ON to ratio channels 1 and 2, and put the results in the channel 2 data array. This ratio is applied to the complex data.

To Title the Active Channel Display

1. Press (DISPLAY) MORE TITLE to access the title menu.
2. Press ERASE TITLE and enter the title you want for your measurement display.
3. Title the display by following the steps below.
   a. Turn the front panel knob to move the arrow pointer to the first character of the title.
   b. Press SELECT LETTER.
   c. Repeat the previous two steps to enter the rest of the characters in your title. You can enter a title that has a maximum of 50 characters.
   d. Press DONE to complete the title entry.

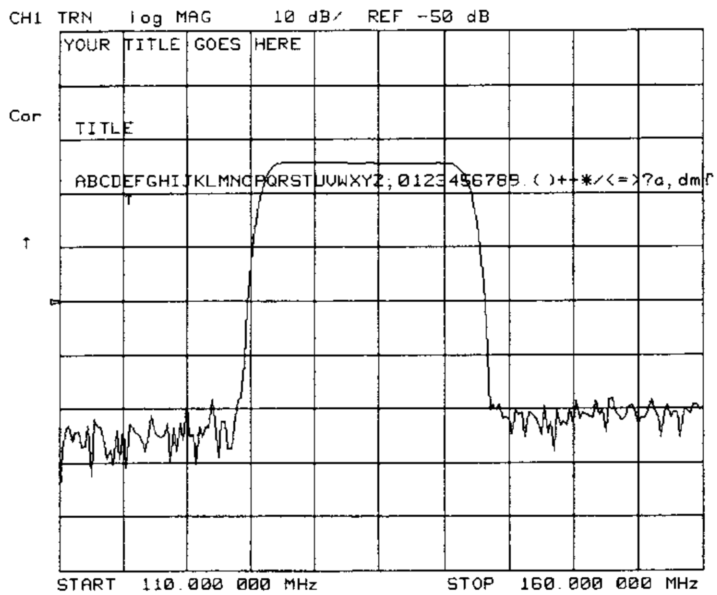


Figure 2-4. Example of a Display Title

Using Analyzer Display Markers

The analyzer markers provide numerical readout of trace data. You can control the marker search, the statistical functions, and the capability for quickly changing stimulus parameters with markers, from the (MRK FCTN) key.

Markers have a stimulus value (the x-axis value in a Cartesian format) and a response value (the y-axis value in a Cartesian format). In a polar or Smith chart format, the second part of a complex data pair is also provided as an auxiliary response value. When you switch on a marker, and no other function is active, the analyzer shows the marker stimulus value in the active entry area. You can control the marker with the front panel knob, the step keys, or the front panel numeric keypad.

- If you activate both data and memory traces, the marker values apply to the data trace.
- If you activate only the memory trace, the marker values apply to the memory trace.
- If you activate a memory math function (data/memory or data-memory), the marker values apply to the trace resulting from the memory math function.

The examples in this section are shown with filter measurement results. The measurement parameters are set as follows:

(MEAS) TRANSMISSN

(CENTER) (134) (M/μ)

(SPAN) (25) (M/μ)

To Use Continuous and Discrete Markers

The analyzer can either place markers on discrete measured points, or move the markers continuously along a trace by interpolating the data value between measured points.

Press (MRK) MARKER MODE MENU and select one of the following choices:

- Choose MARKERS: CONTINUOUS if you want the analyzer to place markers at any point on the trace, by interpolating between measured points. This default mode allows you to conveniently get round numbers for the stimulus value.
- Choose MARKERS: DISCRETE if you want the analyzer to place markers only on measured trace points determined by the stimulus settings. This may be the best mode to use with automated testing, using a computer or test sequencing.

To Activate Display Markers

To switch on marker 1 and make it the active marker, press:

(MRK) MARKER 1

The active marker appears on the analyzer display as ∇. The active marker stimulus value is displayed in the active entry area. You can modify the stimulus value of the active marker, using the front panel knob or numerical keypad. All of the marker response and stimulus values are displayed in the upper right corner of the display.

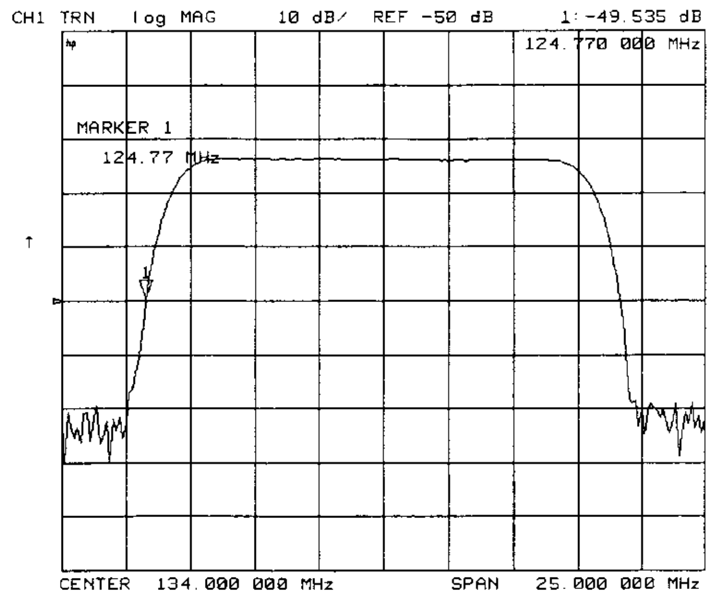


Figure 2-5. Active Marker Control

To switch on the corresponding marker and make it the active marker, press:

MARKER 2, MARKER 3, or MARKER 4

All of the markers, other than the active marker, become inactive and are represented on the analyzer display as Δ.

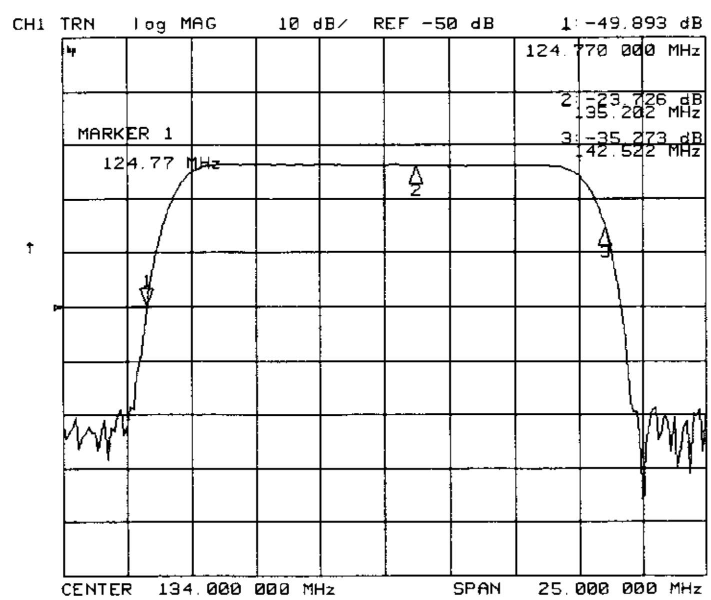


Figure 2-6. Active and Inactive Markers

To switch off all of the markers, press:

all OFF

To Use Delta Markers

This is a relative mode, where the marker values show the position of the active marker relative to the delta reference marker. You can switch on the delta mode, by defining one of the four markers as the delta reference.

1. Press (MRK) Δ MODE MENU Δ REF=1 to make marker 1 a reference marker.
2. To move marker 1 to any point that you want to reference:
   - □ turn the front panel knob

   OR

   - □ enter the frequency value (relative to the reference marker) on the numeric keypad
3. Press MARKER 2 and move marker 2 to any position that you want to measure in reference to marker 1.

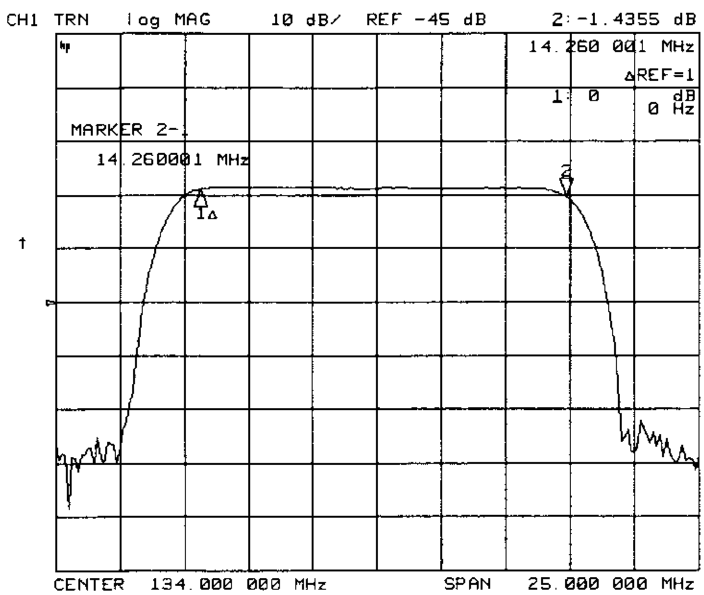


Figure 2-7. Marker 1 as the Reference Marker

4. To change the reference marker to marker 2, press:

   Δ MODE MENU Δ REF=2 MARKER 1

To Activate a Fixed Marker

The analyzer allows you to activate the fixed marker by pressing one of the following key combinations:

- (MRK) Δ MODE MENU ΔREF=ΔFIXED MKR
- (MRK) MKR ZERO

Using the ΔREF=ΔFIXED MKR Key to activate a Fixed Reference Marker

1. To set the frequency value of a fixed marker that appears on the analyzer display, press:

   (MRK) ΔMODE MENU ΔREF=ΔFIXED MKR

ΔMODE MENU FIXED MKR POSITION FIXED MKR STIMULUS and turn the front panel knob

The marker is shown on the display as a small delta (Δ), smaller than the inactive marker triangles.

2. To set the response value (dB) of a fixed marker, press:

   FIXED MKR VALUE and turn the front panel knob

   In a cartesian format the setting is the y-axis value. In polar or Smith chart format, with a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker, the setting applies to the first part of the complex data pair. (Fixed marker response values are always uncoupled in the two channels.)

3. To set the auxiliary response value of a fixed marker when you are viewing a polar or Smith format, press:

   FIXED MKR AUX VALUE and turn the front panel knob

   This value is the second part of complex data pair, and applies to a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker. (Fixed marker auxiliary response values are always uncoupled in the two channels.)

4. To make the fixed marker the reference marker, press:

   RETURN ΔREF=ΔFIXED MKR

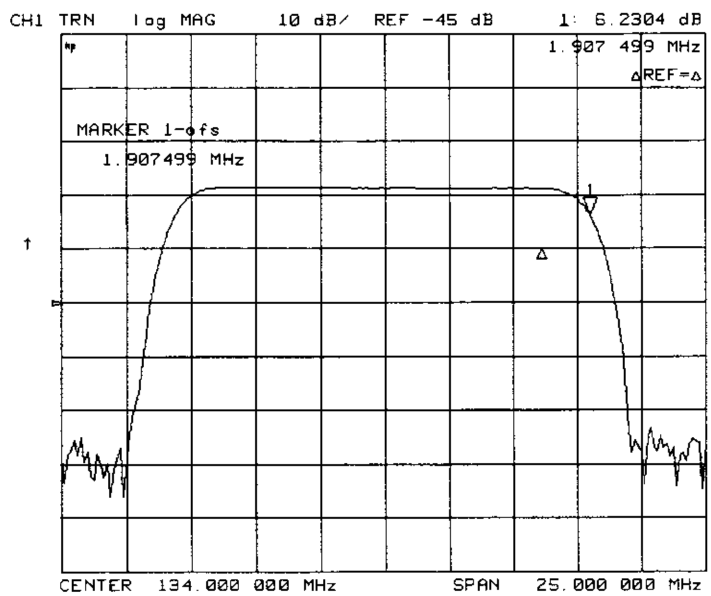


Figure 2-8.
Example of a Fixed Reference Marker Using ΔREF=ΔFIXED MKR

Using the MKR ZERO Key to Activate a Fixed Reference Marker

This is another relative mode, except that the marker values show position relative to a fixed point. Marker zero enters the position of the active marker as the Δ reference position. Alternatively, you can specify the fixed point with FIXED MKR POSITION. Marker zero is canceled by switching delta mode off.

1. To place marker 1 at a point that you would like to reference, press:

   (MRK) MARKER: 1 and turn the front panel knob

2. To measure values along the measurement data trace, relative to the reference point that you set in the previous step, press:

   MKR ZERO and turn the front panel knob

3. To move the reference position, press:

   ΔMODE MENU FIXED MKR POSITION FIXED MKR STIMULUS and turn the front panel knob or enter a value from the front panel keypad.

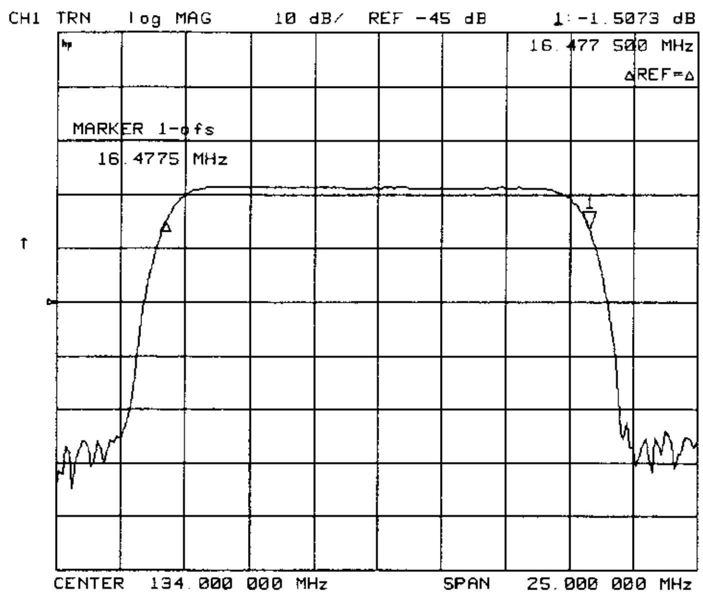


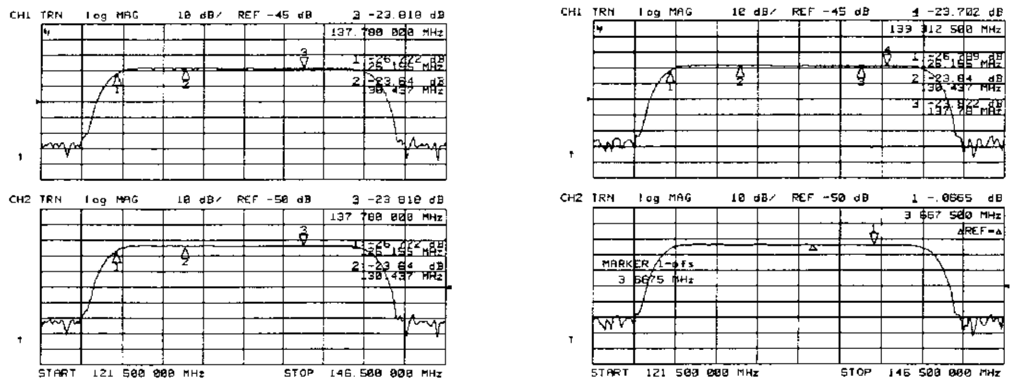
Figure 2-9. Example of a Fixed Reference Marker Using MKR ZERO

To Couple and Uncouple Display Markers

At a preset state, the markers have the same stimulus values on each channel, but they can be uncoupled so that each channel has independent markers.

1. Press (MRK) MARKER MODE MENU and select from the following keys:

   - Choose MARKERS: COUPLED if you want the analyzer to couple the marker stimulus values for the two display channels.
   - Choose MARKERS: UNCOUPLED if you want the analyzer to uncouple the marker stimulus values for the two display channels. This allows you to control the marker stimulus values independently for each channel.



ph692_c

Figure 2-10. Example of Coupled and Uncoupled Markers

To Use Polar Format Markers

The analyzer can display the marker value as magnitude and phase, or as a real/imaginary pair.

You can use these markers only when you are viewing a polar display format.

1. To access the polar markers, press:

   (FORMAT) POLAR

   (MRK) MARKER MODE MENU POLAR MKR MENU

2. Select the type of polar marker you want from the following choices:

   - Choose LIN MKR if you want to view the magnitude and the phase of the active marker. The magnitude values appear in units and the phase values appear in degrees.
   - Choose LOG MKR if you want to view the logarithmic magnitude and the phase of the active marker. The magnitude values appear in dB and the phase values appear in degrees.
   - Choose Re/Im MKR if you want to view the real and imaginary pair, where the complex data is separated into its real part and imaginary part. The analyzer shows the first marker value the real part (M cos θ), and the second value is the imaginary part (M sin θ, where M=magnitude).

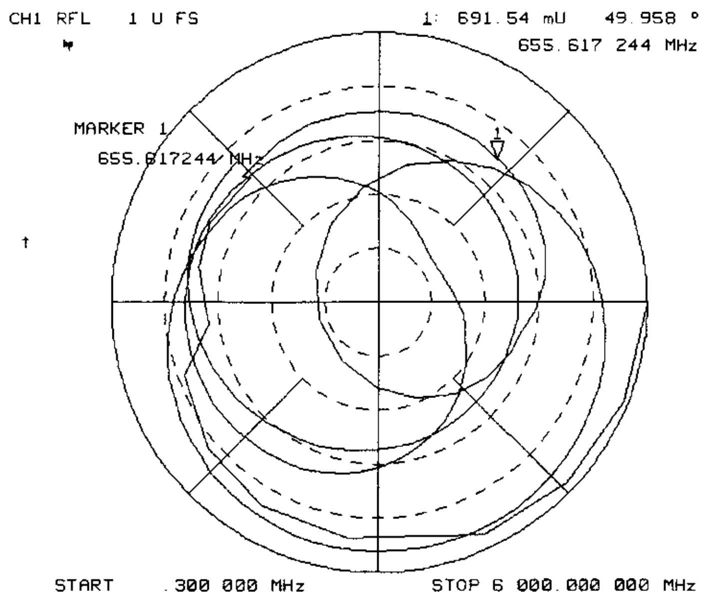


Figure 2-11. Example of a Linear Marker in Polar Format

To Use Smith Chart Markers

The analyzer can display the marker value as magnitude and phase, or as a real/imaginary pair.

You can use these markers only when you are viewing a Smith display format.

1. To access the Smith markers, press:

   (FORMAT) SMITH CHART

   (MRK) MARKER MODE MENU SMITH MKR MENU

2. Select the type of Smith chart marker you want from the following choices:

   - Choose LIN MKR to display linear magnitude and phase of the reflection coefficient.
   - Choose LOG MKR to display log magnitude and phase of the reflection coefficient.
   - Choose Re/Im MKR to display the real value first, then the imaginary value of the reflection coefficient.
   - Choose R+jX MKR to display the complex impedance values of an impedance Smith Chart (default setting).
   - Choose G+jB MKR to display the conductance, susceptance, and equivalent capacitance or inductance values on an admittance (inverse) Smith Chart.

For complex impedance, the displayed values are real impedance, imaginary impedance, and equivalent capacitance/inductance. The equivalent capacitance/inductance is calculated from the imaginary impedance and frequency. For admittance, the analyzer displays an inverse Smith chart.

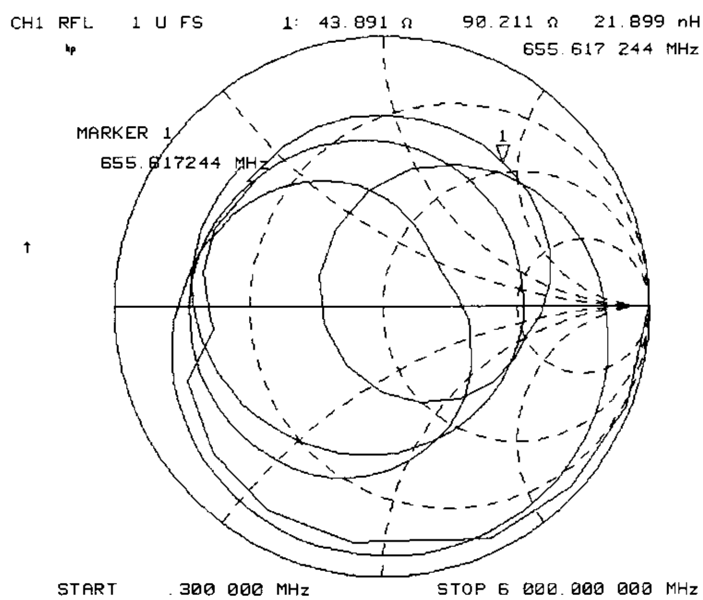


Figure 2-12. Example of Impedance Smith Chart Markers

To Set Measurement Parameters Using Markers

The analyzer allows you to set measurement parameters with the markers, without going through the usual key sequence. You can change certain stimulus and response parameters to make them equal to the current active marker value.

Setting the Start Frequency

1. Press (MRK FCTN) and turn the front panel knob to position the marker at the value that you want for the start frequency.
2. Press MARKER→START to change the start frequency value to the value of the active marker.

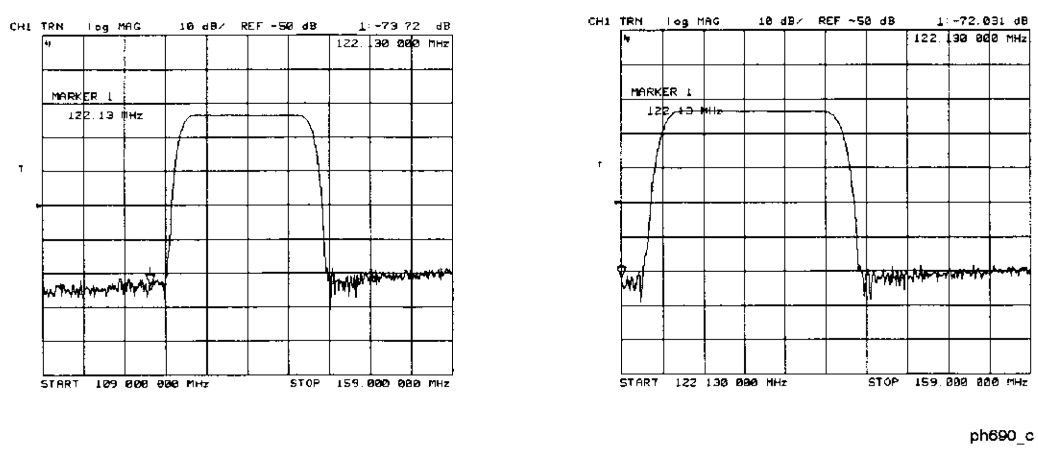
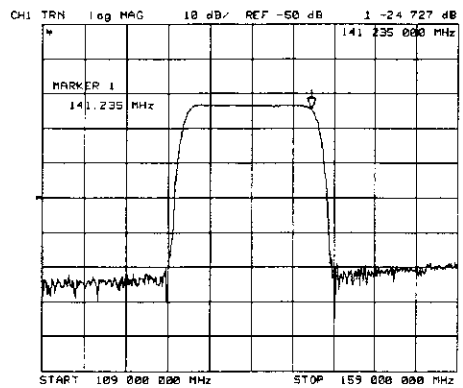


Figure 2-13. Example of Setting the Start Frequency Using a Marker

Setting the Stop Frequency

1. Press (MRK FCTN) and turn the front panel knob to position the marker at the value that you want for the stop frequency.
2. Press MARKER→STOP to change the stop frequency value to the value of the active marker.

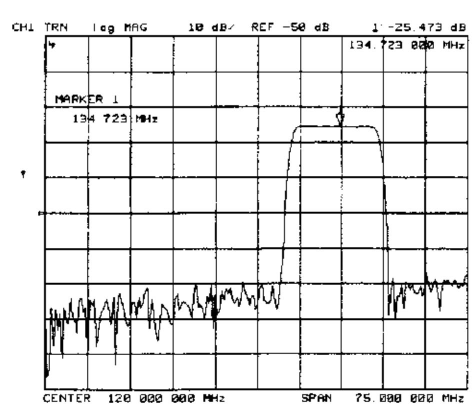


ph691_c

Figure 2-14. Example of Setting the Stop Frequency Using a Marker

Setting the Center Frequency

1. Press (MRK FCTN) and turn the front panel knob to position the marker at the value that you want for the center frequency.
2. Press MARKER→CENTER to change the center frequency value to the value of the active marker.



ph689_c

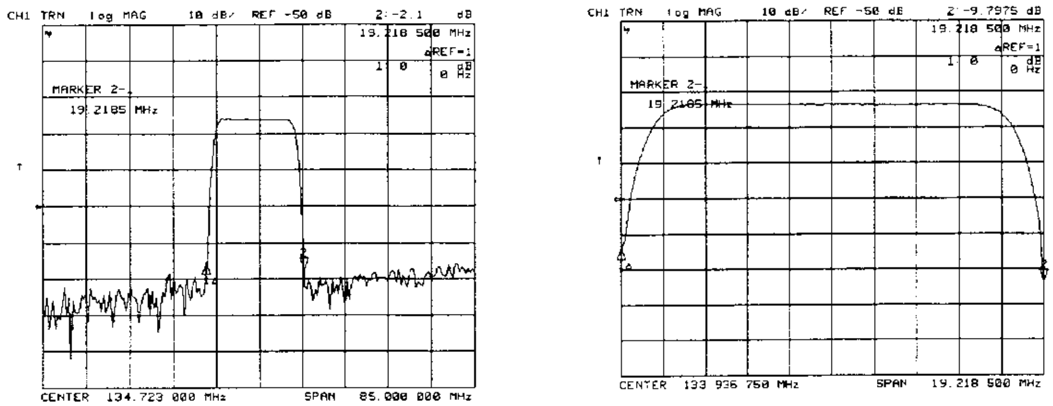
Figure 2-15. Example of Setting the Center Frequency Using a Marker

Setting the Frequency Span

You can the span equal to the spacing between two markers. If you set the center frequency before you set the frequency span, you will have a better view of the area of interest.

1. Press (MRK) ΔMODE MENU ΔREF=1 MARKER 2.
2. Turn the front panel knob to position the markers where you want the frequency span.

   Iterate between marker 1 and marker 2 by pressing MARKER 1 and MARKER 2, respectively, and turning the front panel knob to position the markers around the center frequency. But, you must leave marker 2 active to activate a delta marker mode, setting the span with markers.
3. Press (MRK FCTN) MARKER→SPAN to change the frequency span to the range between marker 1 and marker 2.

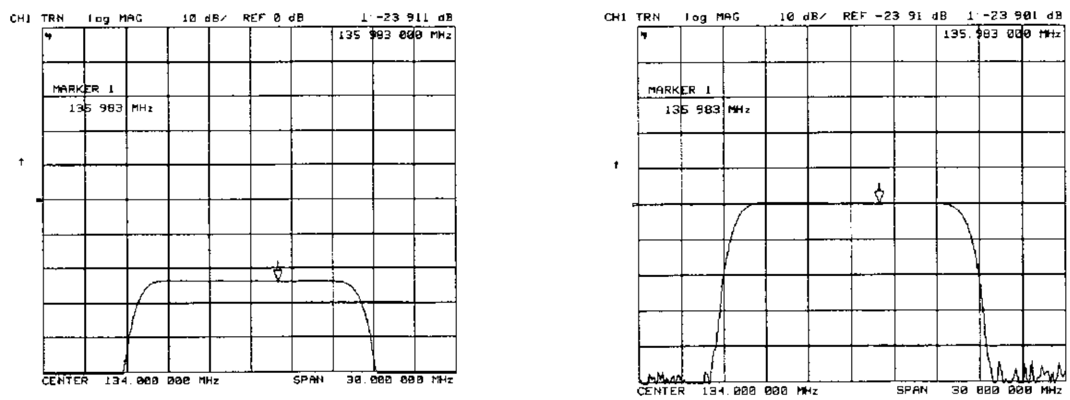


ph687_c

Figure 2-16. Example of Setting the Frequency Span Using Markers

Setting the Display Reference Value

1. Press (MRK FCTN) and turn the front panel knob to position the marker at the value that you want for the analyzer display reference value.
2. Press MARKER→REFERENCE to change the reference value to the value of the active marker.



ph688_c

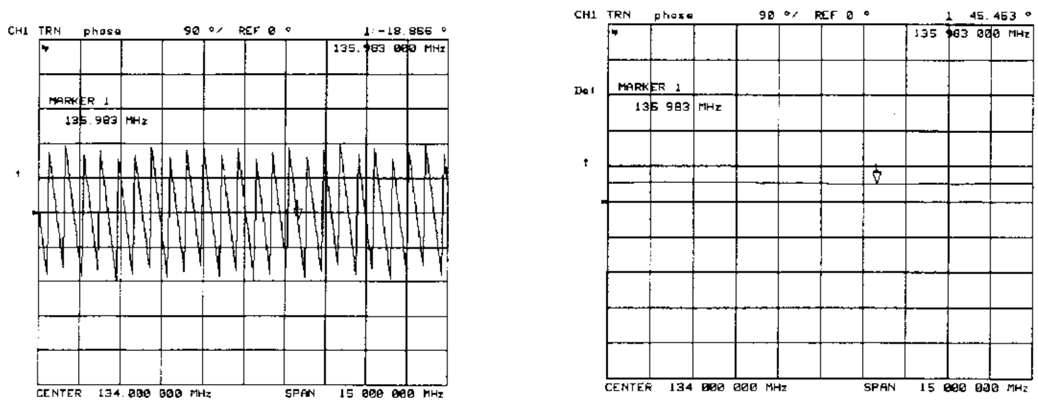
Figure 2-17. Example of Setting the Reference Value Using a Marker

Setting the Electrical Delay

This feature adds phase delay to a variation in phase versus frequency, therefore it is only applicable for ratioed inputs.

1. Press (FORMAT) PHASE.
2. Press (MRK FCTN) and turn the front panel knob to position the marker at a point of interest.
3. Press MARKER→DELAY to add or subtract enough line length to the receiver input to compensate for the phase slope at the active marker position. This effectively flattens the phase trace around the active marker. You can use this to measure the electrical length or deviation from linear phase.

   Additional electrical delay adjustments are required on devices without constant group delay over the measured frequency span.



ph686_c

Figure 2-18. Example of Setting the Electrical Delay Using a Marker

Setting the CW Frequency

1. To place a marker at the desired CW frequency,

   press (MRK) and either turn the front panel knob or enter the value, followed by (x1)

2. Press (SEQ) SPECIAL FUNCTIONS MARKER→CW.

   You can use this function to set the marker to a gain peak in an amplifier. After pressing MARKER→CW, activate a CW frequency power sweep to look at the gain compression with increasing input power.

To Search for a Specific Amplitude

These functions place the marker at an amplitude-related point on the trace. If you switch on tracking, the analyzer searches every new trace for the target point.

Searching for the Maximum Amplitude

1. Press (MRK FCTN) MKR SEARCH to access the marker search menu.

2. Press SEARCH: MAX to move the active marker to the maximum point on the measurement trace.

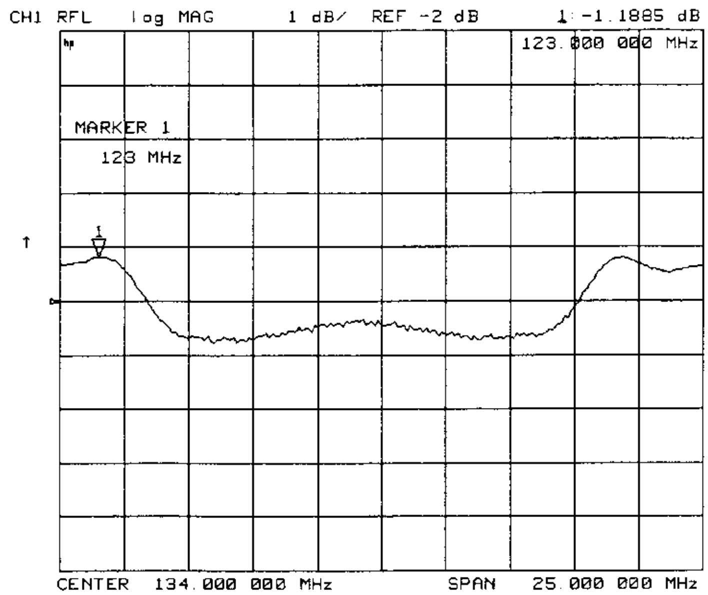


Figure 2-19.
Example of Searching for the Maximum Amplitude Using a Marker

Searching for the Minimum Amplitude

1. Press (MRK FCTN) MKR SEARCH to access the marker search menu.
2. Press SEARCH: MIN to move the active marker to the minimum point on the measurement trace.

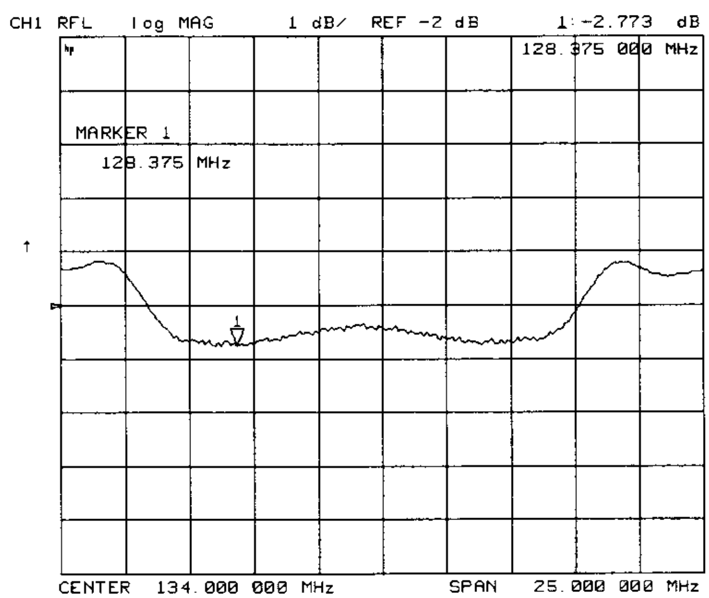


Figure 2-20.
Example of Searching for the Minimum Amplitude Using a Marker

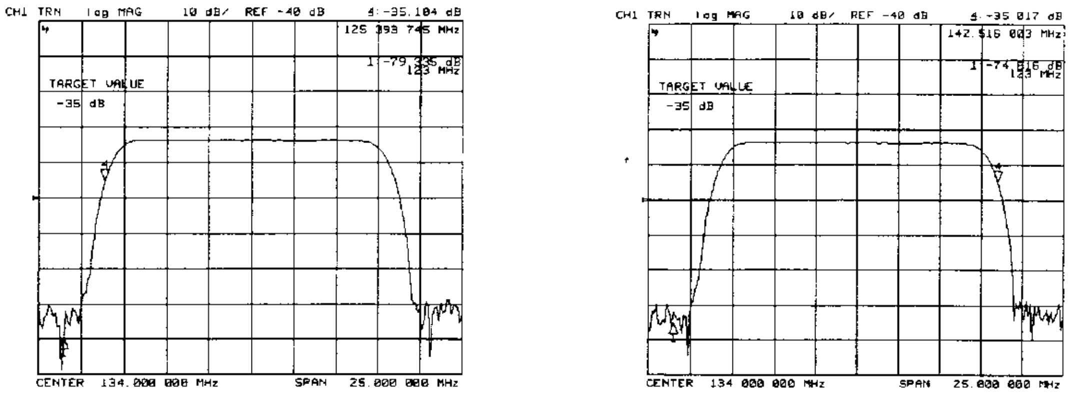
Searching for a Target Amplitude

1. Press (MRK FCTN) MKR SEARCH to access the marker search menu.

2. Press `SEARCH: TARGET` to move the active marker to the target point on the measurement trace.

3. If you want to change the target amplitude value (default is −3 dB), press `TARGET` and enter the new value from the front panel keypad.

4. If you want to search for multiple responses at the target amplitude value, press `SEARCH LEFT` and `SEARCH RIGHT`.



ph665_c

Figure 2-21.
Example of Searching for a Target Amplitude Using a Marker

Searching for a Bandwidth

The analyzer can automatically calculate and display the −3 dB bandwidth (BW:), center frequency (CENT:), Q, and loss of the device under test. (Q stands for "quality factor," defined as the ratio of a circuit's resonant frequency to its bandwidth.) These values are shown in the marker data readout.

1. Press (MRK) and turn the front panel knob to place the marker at the center of the filter passband.

2. Press `MKR ZERO` (MRK FCTN) `MKR SEARCH` to access the marker search menu.

3. Press `WIDTHS ON` to calculate the center stimulus value, bandwidth, and the Q of a bandpass or band reject shape on the measurement trace.

4. If you want to change the amplitude value (default is −3 dB) that defines the passband or rejectband, press `WIDTH VALUE` and enter the new value from the front panel keypad.

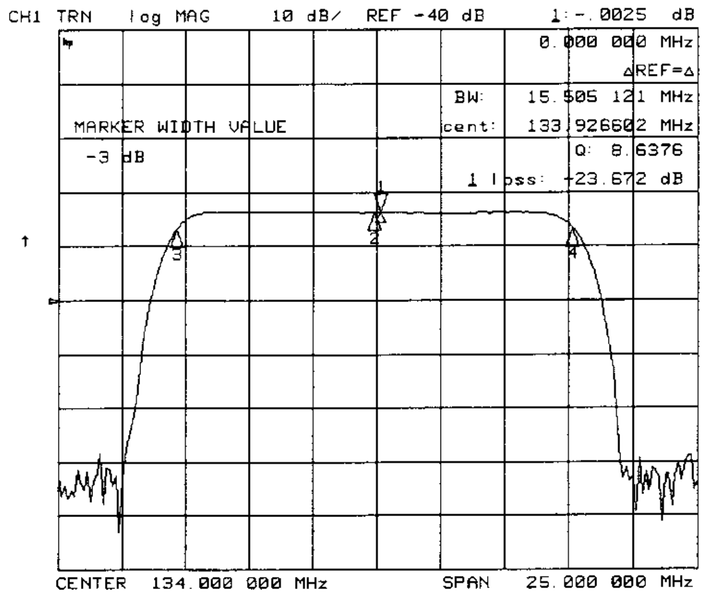


Figure 2-22. Example of Searching for a Bandwidth Using Markers

Tracking the Amplitude that You are Searching

1. Set up an amplitude search by following one of the previous procedures in "To Search for a Specific Amplitude."
2. Press (MRK FCTN) `MKR SEARCH TRACKING ON` to track the specified amplitude search with every new trace and put the active marker on that point.

   When tracking is not activated, the analyzer finds the specified amplitude on the current sweep and the marker remains at same stimulus value, regardless of changes in the trace response value with subsequent sweeps.

To Calculate the Statistics of the Measurement Data

This function calculates the mean, standard deviation, and peak-to-peak values of the section of the displayed trace between the active marker and the delta reference. If there is no delta reference, the analyzer calculates the statistics for the entire trace.

1. Press (MRK) `Δ MODE MENU` `Δ REF=1` to make marker 1 a reference marker.
2. Move marker 1 to any point that you want to reference:
   - Turn the front panel knob.

   OR

   - Enter the frequency value on the numeric keypad.
3. Press `MARKER 2` and move marker 2 to any position that you want to measure in reference to marker 1.
4. Press (MRK FCTN) `STATS ON` to calculate and view the mean, standard deviation, and peak-to-peak values of the section of the measurement data between the active marker and the delta reference marker.

An application for this feature is to find the peak-to-peak value of passband ripple without searching separately for the maximum and minimum values.

If you are viewing a measurement in the polar or Smith Chart format, the analyzer calculates the statistics using the first value of the complex pair (magnitude, real part, resistance, or conductance).

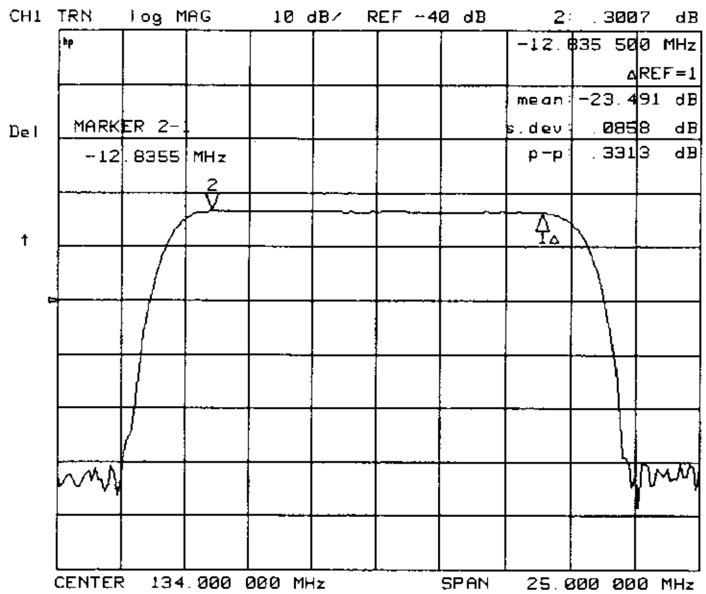


Figure 2-23. Example Statistics of Measurement Data

Measuring Magnitude and Insertion Phase Response

The analyzer allows you to make two different measurements simultaneously. You can make these measurements in different formats for the same parameter. For example, you could measure both the magnitude and phase of transmission. You could also measure two different parameters (transmission and reflection).

This measurement example shows you how to measure the maximum amplitude of a SAW filter and then how to view the measurement data in the phase format, which provides information about the phase response.

Measuring the Magnitude Response

1. Connect your test device as shown.

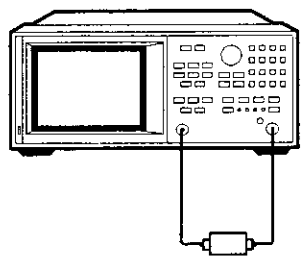


Figure 2-24. Device Connections for Measuring a Magnitude Response

2. Choose the measurement settings. For this example the measurement settings are as follows:

   (MEAS) TRANSMISSN
   (CENTER) (134) (M/μ)
   (SPAN) (50) (M/μ)
   (MENU) POWER (−3) (x1)
   (SCALE REF) AUTO SCALE
   (CH 2)
   (MEAS) TRANSMISSN
   (SCALE REF) AUTO SCALE

   You may also want to select settings for the number of data points, averaging, and IF bandwidth.

3. Substitute a thru for the device and perform a frequency response measurement correction for both channel 1 and channel 2. Refer to the "Optimizing Measurement Results" chapter for instructions on how to make a response measurement correction.
4. Reconnect your test device.
5. To better view the measurement trace, press:

   (CH 1) (SCALE REF) AUTO SCALE

6. To locate the maximum amplitude of the device response, as shown in Figure 2-25, press:

   (MRK FCTN) MKR SEARCH SEARCH: MAX

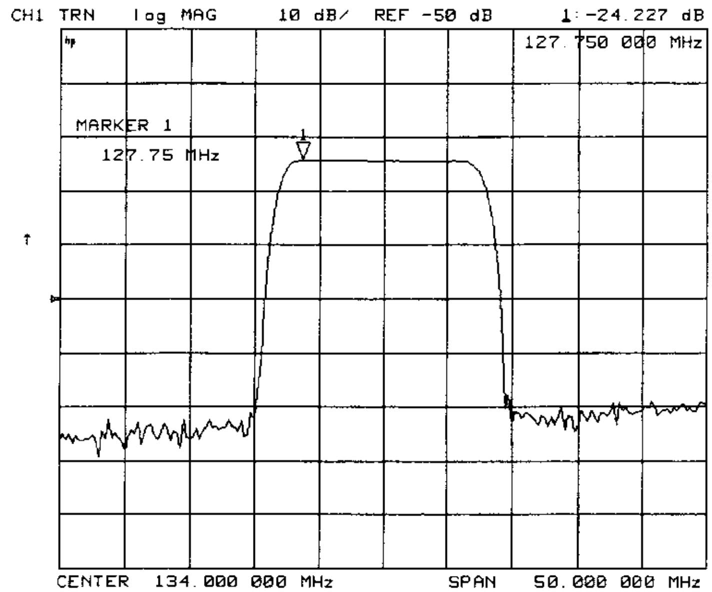


Figure 2-25. Example Magnitude Response Measurement Results

Measuring Insertion Phase Response

7. To view both the magnitude and phase response of the device, as shown in Figure 2-26, press:

   (CH 2)

   (DISPLAY) **DUAL CHAN**

   (FORMAT) **PHASE**

The channel 2 portion of Figure 2-26 shows the insertion phase response of the device under test. The analyzer measures and displays phase over the range of $-180°$ to $+180°$. As phase changes beyond these values, a sharp 360 ° transition occurs in the displayed data.

The phase response shown in Figure 2-27 is undersampled; that is, there is more than 180° phase delay between frequency points. The frequency span should be reduced, or the number of points increased until $\Delta\phi$ is less than 180° per point. Electrical delay may also be used to compensate for this effect (as shown in the next example procedure).

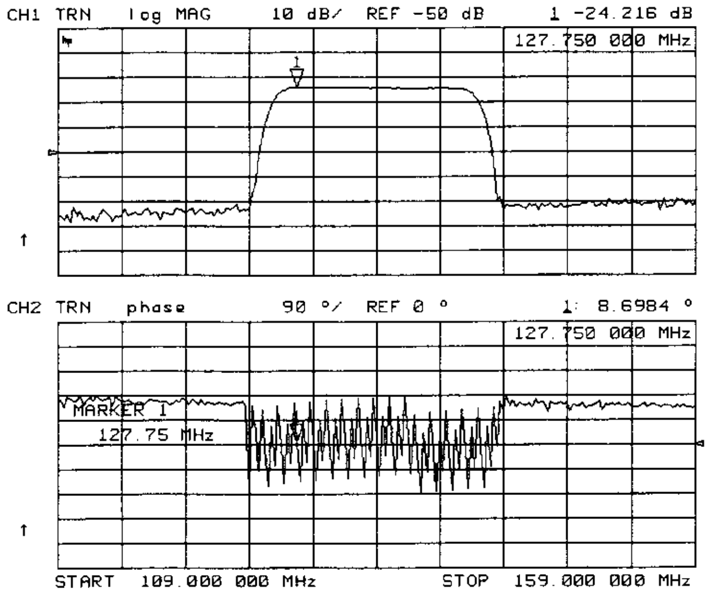


Figure 2-26. Example Insertion Phase Response Measurement

If the $\Delta\phi = >180°$, incorrect phase and delay information may result. The responses shown in Figure 2-26 have a $\Delta\phi = >180°$ between two adjacent frequency points. Figure 2-27 shows an example of phase samples being with $\Delta\phi$ less than 180° and greater than 180°.

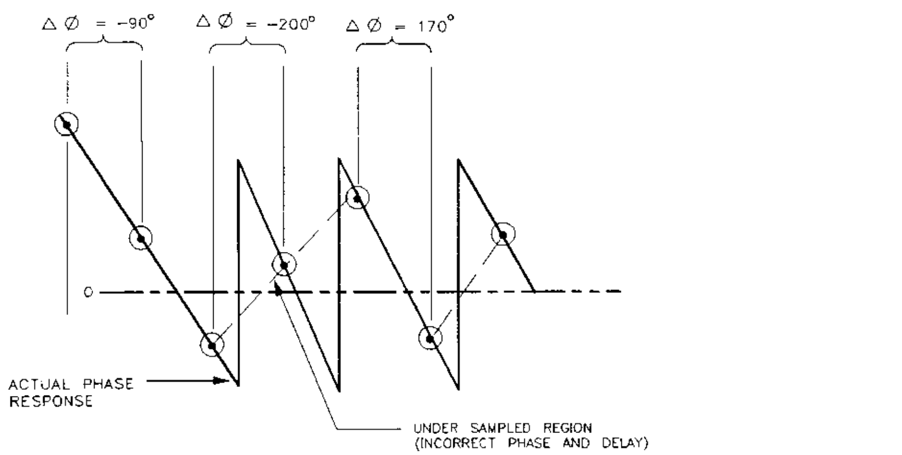


Figure 2-27. Phase Samples

Measuring Electrical Length and Phase Distortion

Electrical Length

The analyzer mathematically implements a function similar to the mechanical "line stretchers" of earlier analyzers. This feature simulates a variable length lossless transmission line, which you can add to or remove from the analyzer's receiver input to compensate for interconnecting cables. In this example, the electronic line stretcher measures the electrical length of a SAW filter.

Phase Distortion

The analyzer allows you to measure the linearity of the phase shift through a device over a range of frequencies and the analyzer can express it in two different ways:

- deviation from linear phase
- group delay

Measuring Electrical Length

1. Connect your test device as shown.

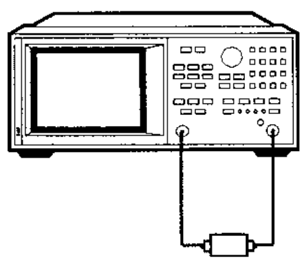


Figure 2-28. Device Connections for Measuring Electrical Length

2. Choose the measurement settings. For this example, the measurement settings include reducing the frequency span to eliminate under sampled phase response. Press the following keys as shown:

   (MEAS) TRANSMISSN
   (CENTER) (134) (M/μ)
   (SPAN) (2) (M/μ)
   (MENU) POWER (5) (x1)
   (FORMAT) PHASE
   (SCALE REF) AUTO SCALE

   You may also want to select settings for the number of data points, averaging, and IF bandwidth.

3. Substitute a thru for the device and perform a frequency response measurement correction. Refer to the "Optimizing Measurement Results" chapter for instructions on how to make a response measurement correction.

4. Reconnect your test device.

5. To better view the measurement trace, press:

   (SCALE REF) AUTO SCALE

Notice that in Figure 2-29 the SAW filter under test has considerable phase shift within only a 2 MHz span. Other filters may require a wider frequency span to see the effects of phase shift.

The linearly changing phase is due to the device's electrical length. You can measure this changing phase by adding electrical length (electrical delay) to compensate for it.

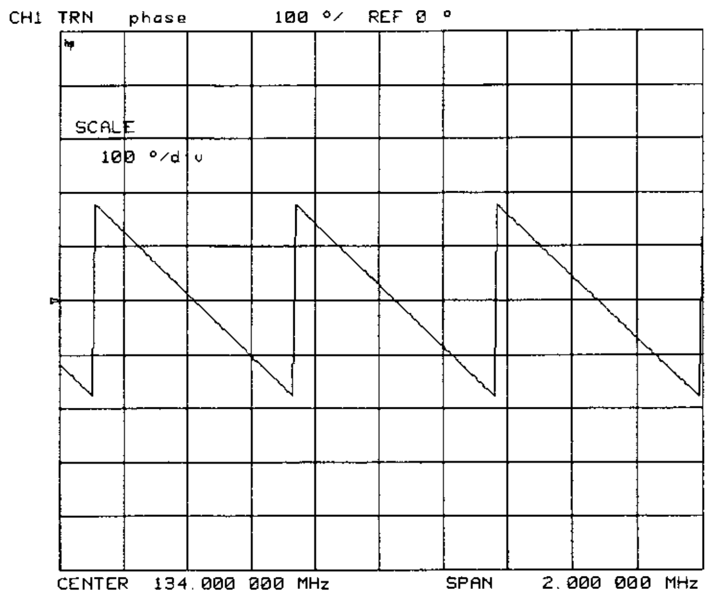


Figure 2-29. Linearly Changing Phase

6. To place a marker at the center of the band, press:

   (MRK) and turn the front panel knob

7. To activate the electrical delay function, press:

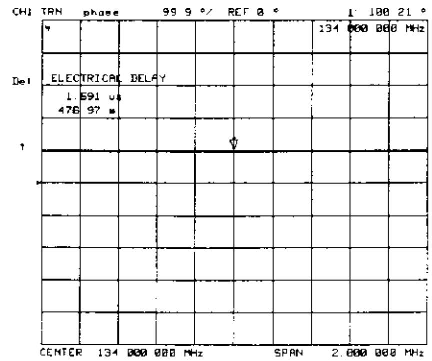
   (MRK FCTN) MARKER→DELAY

   This function calculates the electrical delay by taking a ±10% span about the marker, measuring the $\Delta\phi$, and computing the delay as $\Delta\phi/\Delta$frequency.

8. Press (SCALE REF) ELECTRICAL DELAY and turn the front panel knob to increase the electrical length until you achieve the best flat line, as shown in Figure 2-30.

   The measurement value that the analyzer displays represents the electrical length of your device relative to the speed of light in free space. The physical length of your device is related to this value by the propagation velocity of its medium.

Note You could change the velocity factor to compensate for propagation velocity, helping the analyzer to measure correctly. Press (CAL) MORE VELOCITY FACTOR and enter the value, followed by (x1).



ph682_c

Figure 2-30. Example Best Flat Line with Added Electrical Delay

9. To display the electrical length, press:

   (SCALE REF) ELECTRICAL DELAY

   In this example, there is a large amount of electrical delay due to the long electrical length of the SAW filter under test.

Measuring Phase Distortion

This portion of the example shows you how to measure the linearity of the phase shift over a range of frequencies. The analyzer allows you to measure this linearity and read it in two different ways: deviation from linear phase, or group delay.

Deviation From Linear Phase

By adding electrical length to "flatten out" the phase response, you have removed the linear phase shift through your device. The deviation from linear phase shift through your device is all that remains.

1. Follow the procedure in "Measuring Electrical Length."
2. To increase the scale resolution, press:

   (SCALE REF) SCALE/DIV and turn the front panel knob.

3. To use the marker statistics to measure the maximum peak-to-peak deviation from linear phase, press:

   (MRK FCTN) STATS ON

4. Activate and adjust the electrical delay to obtain a minimum peak-to-peak value.

Note It is possible to use Δmarkers to measure peak-to-peak deviation in only one portion of the trace, see "To Calculate the Statistics of the Measurement Data" located earlier in this chapter.

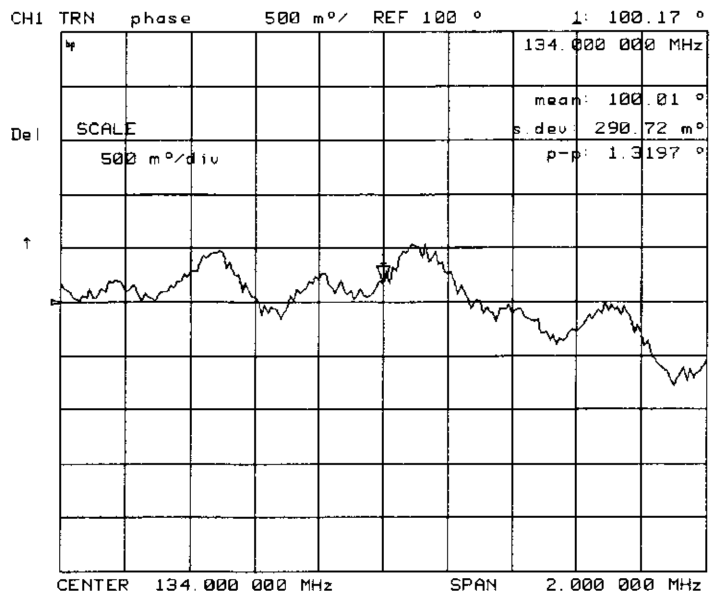


Figure 2-31. Deviation From Linear Phase Example Measurement

Group Delay

The phase linearity of many devices is specified in terms of group or envelope delay. The analyzer can translate this information into a related parameter, group delay. Group delay is the transmission time through your device under test as a function of frequency. Mathematically, it is the derivative of the phase response which can be approximated by the following ratio.

$\Delta\phi/(360 * \Delta F)$

where $\Delta\phi$ is the difference in phase at two frequencies separated by ΔF. The quantity ΔF is commonly called the "aperture" of the measurement. The analyzer calculates group delay from its phase response measurements.

The default aperture is the total frequency span divided by the number of points across the display (i.e. 201 points or 0.5% of the total span in this example).

1. Continue with the same instrument settings and measurements as in the previous procedure, "Deviation from Linear Phase."
2. To view the measurement in delay format, as shown in Figure 2-32, press:

   (FORMAT) DELAY

   (SCALE REF) SCALE/DIV (⇧) (⇧)

3. To activate a marker to measure the group delay at a particular frequency, press:

   (MRK) and turn the front panel knob

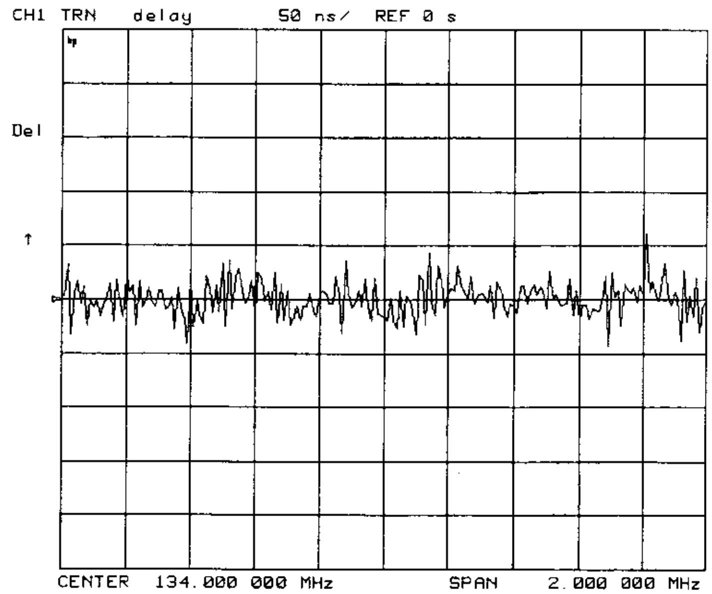


Figure 2-32. Group Delay Example Measurement

Group delay measurements may require a specific aperture (Δf) or frequency spacing between measurement points. The phase shift between two adjacent frequency points must be less than 180°, otherwise incorrect group delay information may result.

4. To vary the effective group delay aperture from minimum aperture (no smoothing) to approximately 1% of the frequency span, press: (AVG) SMOOTHING ON

   When you increase the aperture, the analyzer removes fine grain variations from the response. It is critical that you specify the group delay aperture when you compare group delay measurements.

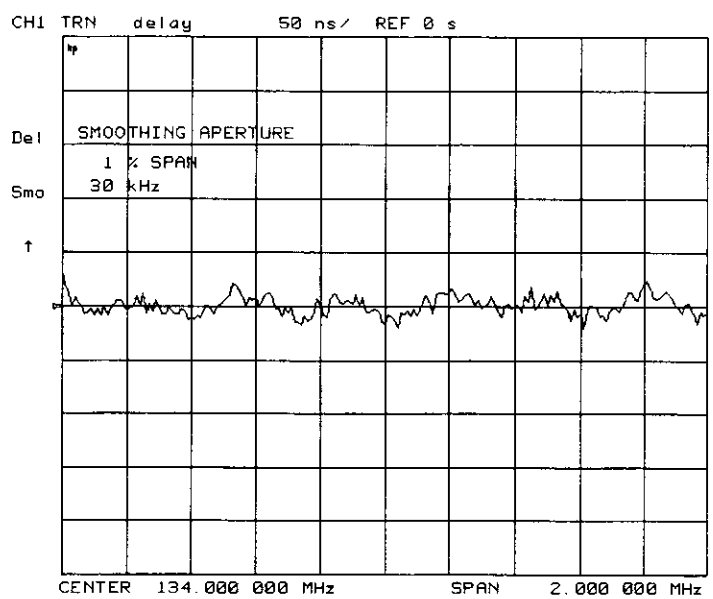


Figure 2-33. Group Delay Example Measurement with Smoothing

5. To increase the effective group delay aperture, by increasing the number of measurement points over which the analyzer calculates the group delay, press:

   SMOOTHING APERTURE (5) (x1)

   As the aperture is increased the "smoothness" of the trace improves markedly, but at the expense of measurement detail.

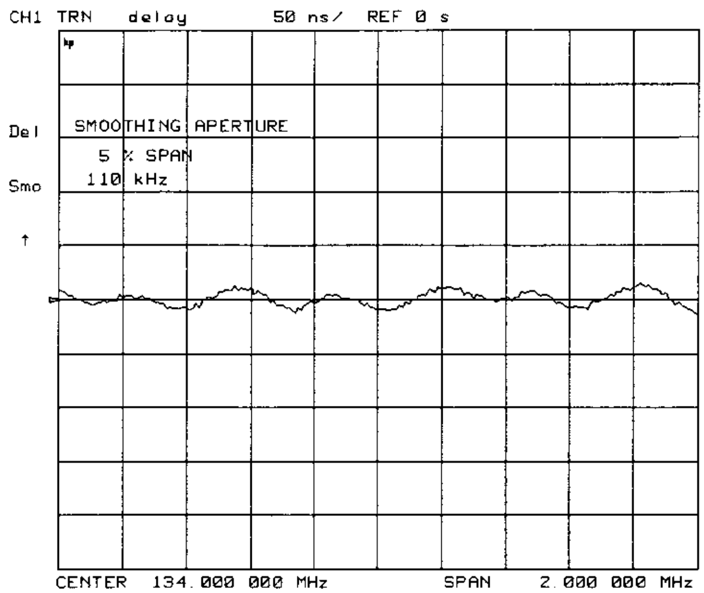


Figure 2-34.
Group Delay Example Measurement with Smoothing Aperture Increased

Testing A Device with Limit Lines

Limit testing is a measurement technique that compares measurement data to constraints that you define. Depending on the results of this comparison, the analyzer will indicate if your device either passes or fails the test.

Limit testing is implemented by creating individual flat, sloping, and single point limit lines on the analyzer display. When combined, these lines represent the required performance parameters for your device under test.

This example measurement shows you how to test a bandpass filter using the following procedures:

- creating flat limit lines
- creating sloping limit lines
- creating single point limit lines
- editing limit segments
- running a limit test

Setting Up the Measurement Parameters

1. Connect your test device as shown.

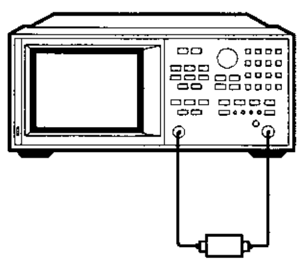


Figure 2-35. Connections for SAW Filter Example Measurement

2. Choose the measurement settings. For this example the measurement settings are as follows:

   (MEAS) TRANSMISSN
   (CENTER) (134) (M/μ)
   (SPAN) (50) (M/μ)
   (SCALE REF) AUTO SCALE

   You may also want to select settings for the number of data points, power, averaging, and IF bandwidth.

3. Substitute a thru for the device and perform a frequency response measurement correction. Refer to the "Optimizing Measurement Results" chapter for instructions on how to make a response measurement correction.
4. Reconnect your test device.
5. To better view the measurement trace, press:

   (SCALE REF) AUTO SCALE

Creating Flat Limit Lines

In this example procedure, the following flat limit line values are set:

Frequency Range	Magnitude Range
127 MHz to 140 MHz	−27 dB to −21 dB
100 MHz to 123 MHz	−200 dB to −65 dB
146 MHz to 160 MHz	−200 dB to −65 dB

Note The minimum value for measured data is −200 dB.

1. To access the limits menu and activate the limit lines, press:

   (SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE CLEAR LIST YES

2. To create a new limit line, press:

   ADD

   The analyzer generates a new segment that appears on the center of the display.

3. To specify the limit's stimulus value, test limits (upper and lower), and the limit type, press:

   STIMULUS VALUE (127) (M/μ)
   UPPER LIMIT (−21) (x1)
   LOWER LIMIT (−27) (x1)
   DONE

Note You could also set the upper and lower limits by using the MIDDLE VALUE and DELTA LIMITS keys. To use these keys for the entry, press:

MIDDLE VALUE (−24) (x1)
DELTA LIMITS (3) (x1)

This would correspond to a test specification of −24 ±3 dB.

4. To define the limit as a flat line, press:

   LIMIT TYPE FLAT LINE RETURN

5. To terminate the flat line segment by establishing a single point limit, press:

   ADD
   STIMULUS VALUE (140) (M/μ)
   DONE
   LIMIT TYPE SINGLE POINT RETURN

   Figure 2-36 shows the flat limit lines that you have just created with the following parameters:

   - stimulus from 127 MHz to 140 MHz
   - upper limit of −21 dB
   - lower limit of −27 dB

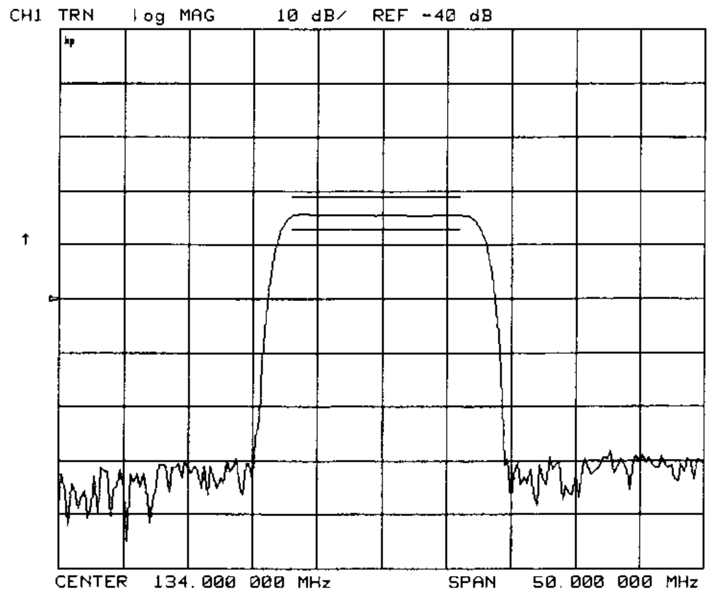


Figure 2-36. Example Flat Limit Line

6. To create a limit line that tests the low side of the filter, press:

   ADD
   STIMULUS VALUE (100) (M/μ)
   UPPER LIMIT (−65) (x1)
   LOWER LIMIT (−200) (x1)
   DONE
   LIMIT TYPE FLAT LINE RETURN
   ADD
   STIMULUS VALUE (123) (M/μ)
   DONE
   LIMIT TYPE SINGLE POINT RETURN

7. To create a limit line that tests the high side of the bandpass filter, press:

   ADD
   STIMULUS VALUE (146) (M/μ)
   UPPER LIMIT (−65) (x1)
   LOWER LIMIT (−200) (x1)
   DONE
   LIMIT TYPE FLAT LINE RETURN
   ADD
   STIMULUS VALUE (160) (M/μ)
   DONE
   LIMIT TYPE SINGLE POINT RETURN

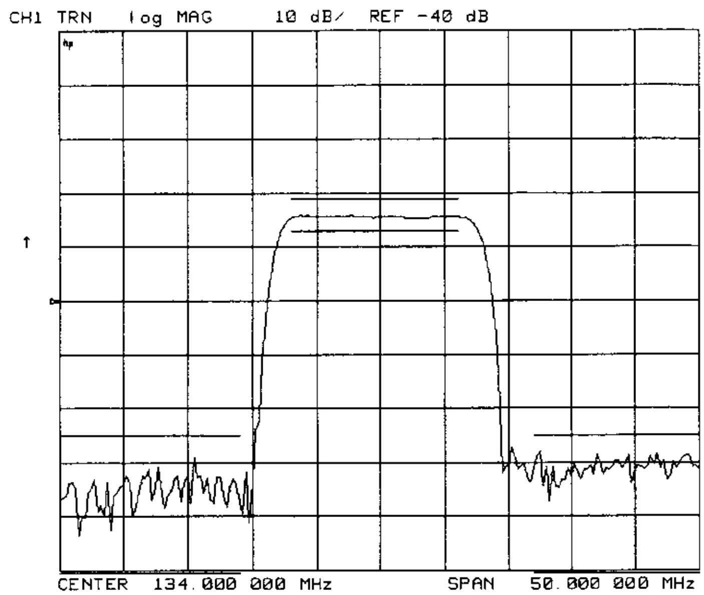


Figure 2-37. Example Flat Limit Lines

Creating a Sloping Limit Line

This example procedure shows you how to make limits that test the shape factor of a SAW filter. The following limits are set:

Frequency Range	Magnitude Range
123 MHz to 125 MHz	−65 dB to −26 dB
144 MHz to 146 MHz	−26 dB to −65 dB

1. To access the limits menu and activate the limit lines, press:

   (SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE CLEAR LIST YES

2. To establish the start frequency and limits for a sloping limit line that tests the low side of the filter, press:

   ADD
   STIMULUS VALUE (123) (M/μ)
   UPPER LIMIT (−65) (x1)
   LOWER LIMIT (−200) (x1)
   DONE
   LIMIT TYPE SLOPING LINE RETURN

3. To terminate the lines and create a sloping limit line, press:

   ADD
   STIMULUS VALUE (125) (M/μ)
   UPPER LIMIT (−26) (x1)
   LOWER LIMIT (−200) (x1)
   DONE
   LIMIT TYPE SINGLE POINT RETURN

4. To establish the start frequency and limits for a sloping limit line that tests the high side of the filter, press:

ADD

STIMULUS VALUE (144) (M/μ)

UPPER LIMIT (−26) (x1)

LOWER LIMIT (−200) (x1)

DONE

LIMIT TYPE SLOPING LINE RETURN

5. To terminate the lines and create a sloping limit line, press:

ADD

STIMULUS VALUE (146) (M/μ)

UPPER LIMIT (−65) (x1)

LOWER LIMIT (−200) (x1)

DONE

LIMIT TYPE SINGLE POINT RETURN

You could use this type of limit to test the shape factor of a filter.

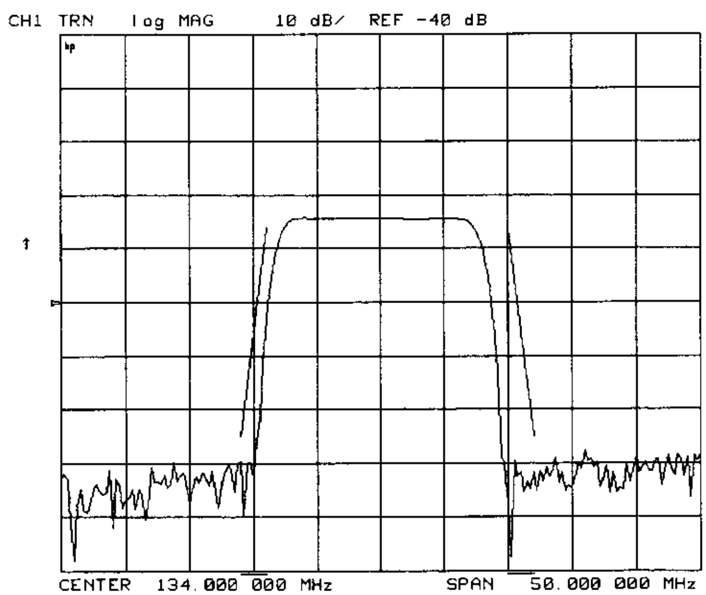


Figure 2-38. Sloping Limit Lines

Creating Single Point Limits

In this example procedure, the following limits are set:

Frequency Points	Magnitude Range
141 MHz	−23 dB to −28.5 dB
126.5 MHz	−23 dB to −28.5 dB

1. To access the limits menu and activate the limit lines, press:

(SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE CLEAR LIST YES

2. To designate a single point limit line, as shown in Figure 2-39, you must define two pointers;

- downward pointing, indicating the upper test limit
- upward pointing, indicating the lower test limit

Press:

ADD

STIMULUS VALUE (141) (M/μ)

UPPER LIMIT (−23) (x1)

LOWER LIMIT (−28.5) (x1)

DONE

LIMIT TYPE SINGLE POINT

RETURN

ADD

STIMULUS VALUE (126.5) (M/μ)

UPPER LIMIT (−23) (x1)

LOWER LIMIT (−28.5) (x1)

DONE

LIMIT TYPE SINGLE POINT

RETURN

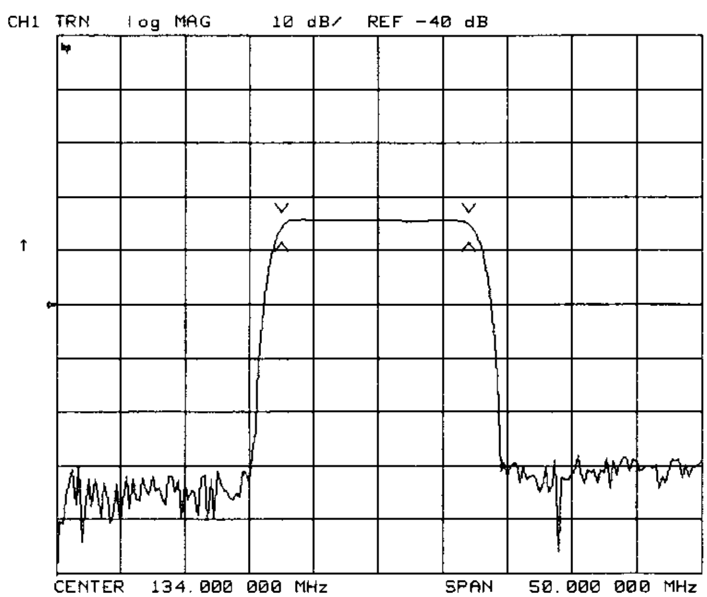


Figure 2-39. Example Single Points Limit Line

Editing Limit Segments

This example shows you how to edit the upper limit of a limit line.

1. To access the limits menu and activate the limit lines, press:

   (SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE

2. To move the pointer symbol (>) on the analyzer display to the segment you wish to modify, press:

SEGMENT (⇑) or (⇓) repeatedly
OR
SEGMENT and enter the segment number followed by (x1)

3. To change the upper limit (for example, −20) of a limit line, press:

   EDIT UPPER LIMIT (-20) (x1) DONE

Deleting Limit Segments

1. To access the limits menu and activate the limit lines, press:

   (SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE

2. To move the pointer symbol (>) on the analyzer display to the segment you wish to delete, press:

   SEGMENT (⇑) or (⇓) repeatedly

3. To delete the segment that you have selected with the pointer symbol, press:

   DELETE

Running a Limit Test

1. To access the limits menu and activate the limit lines, press:

   (SYSTEM) LIMIT MENU LIMIT LINE ON EDIT LIMIT LINE

Reviewing the Limit Line Segments

The limit table data that you have previously entered is shown on the analyzer display.

2. To verify that each segment in your limits table is correct, review the entries by pressing:

   SEGMENT (⇑) and (⇓)

3. To modify an incorrect entry, refer to the "Editing Limit Segments" procedure, located earlier in this section.

Activating the Limit Test

4. To activate the limit test and the beep fail indicator, press:

   (SYSTEM) LIMIT MENU LIMIT TEST ON BEEP FAIL ON

   The limit test results appear on the right side on the analyzer display. (The "beep fail" will add approximately 50 milliseconds of sweep cycle time.) The analyzer indicates whether the filter passes or fails the defined limit test:

   - The analyzer beeps if the limit test fails.
   - The analyzer alternates a red trace where the measurement trace is out of limits.
   - A TTL signal on the rear panel BNC connector "LIMIT TEST" provides a pass/fail (5 V/0 V) indication of the limit test results.

Offsetting Limit Lines

The limit offset functions allow you to adjust the limit lines to the frequency and output level of your device. For example, you could apply the stimulus offset feature for testing tunable filters. Or, you could apply the amplitude offset feature for testing variable attenuators, or passband ripple in filters with variable loss.

This example shows you the offset feature and the limit test failure indications that can appear on the analyzer display.

1. To offset all of the segments in the limit table by a fixed frequency, (for example, 3 MHz), press:

   (SYSTEM)

   LIMIT MENU LIMIT LINE OFFSETS

   STIMULUS OFFSET (3) (M/μ)

   The analyzer beeps and a FAIL notation appears on the analyzer display, as shown in Figure 2-40.

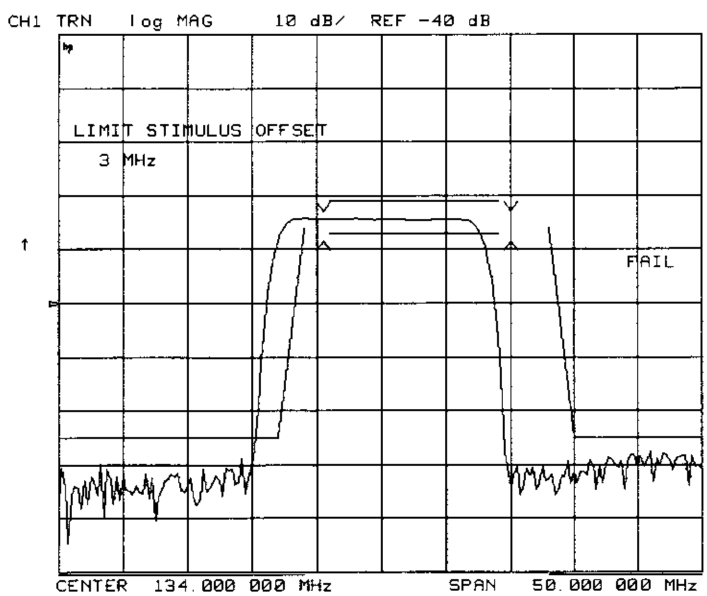


Figure 2-40. Example Stimulus Offset of Limit Lines

2. To return to 0 Hz offset, press:

   STIMULUS OFFSET (0) (x1)

3. To offset all of the segments in the limit table by a fixed amplitude, press:

   AMPLITUDE OFFSET (5) (x1)

   The analyzer beeps and a FAIL notation appears on the analyzer display, as shown in Figure 2-40.

4. To return to 0 dB offset, press:

   AMPLITUDE OFFSET (0) (x1)

Measuring Gain Compression

Gain compression occurs when an amplifier's output power is reduced as higher levels of power are input to the amplifier. The gain compression will vary with frequency, so it is necessary to find the worst case point in the frequency band. Once that point is identified, you can perform a power sweep of that CW frequency to measure the input power at which the 1 dB compression occurs and the absolute power out (in dBm) at compression. The following steps provide detailed instruction on how to apply various features of the analyzer to accomplish these measurements.

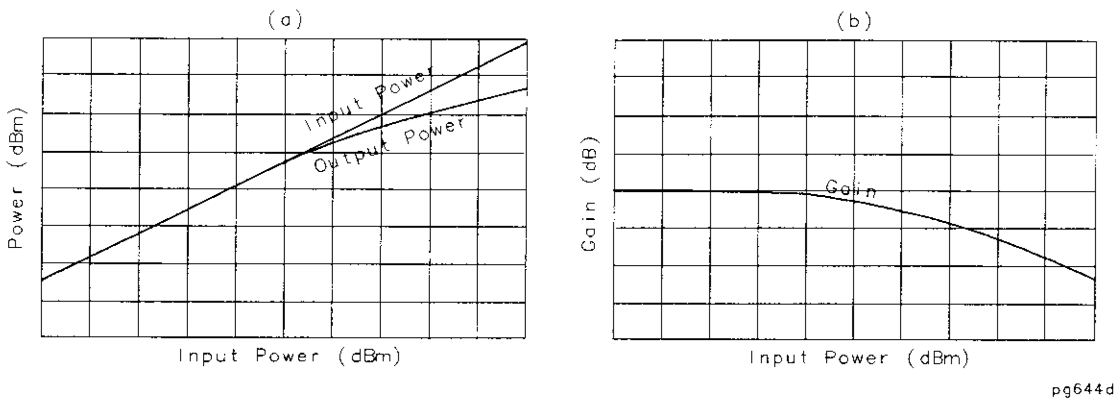


Figure 2-41. Diagram of Gain Compression

1. After you've set up your stimulus and response parameters, error-corrected the instrument, and hooked up the amplifier, press (DISPLAY) and select DUAL CHANNEL ON to view both channels simultaneously.
2. To reduce the effect of noise on the trace, press:

   (AVG) IF BW 1000 (x1)

3. To uncouple the channel stimulus, so that the channel power will be uncoupled, press:

   (MENU) COUPLED CH OFF

   This will allow you to separately increase the power for channel 2 and channel 1, so that you can observe the gain compression on channel 2 while channel 1 continues to display small-signal gain.

4. To display the ratio of channel 2 data to channel 1 data on the channel 2 display, press:

   (CH 2) DISPLAY MORE D2/D1 to D2 ON

   This produces a trace that represents gain compression on channel 2 and small-signal gain on channel 1.

5. Press (MRK) MARKER 1 and position the marker at approximately mid-span.
6. Press (MENU) POWER.
7. Increase the power until you observe approximately 1 dB of compression on channel 2, using the step keys or the front panel knob.
8. To locate the worst case point on the trace, press:

   (MRK FCTN) MKR SEARCH SEARCH:MIN

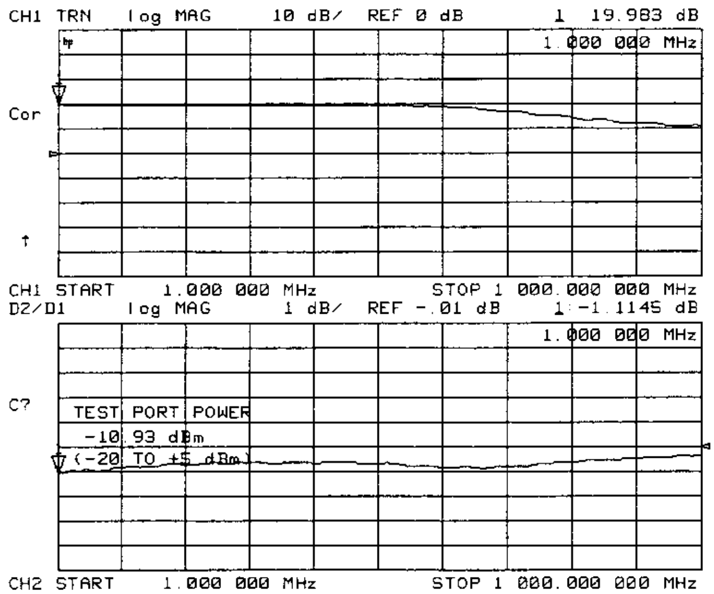


Figure 2-42. Gain Compression Using Linear Sweep

9. To recouple the channel stimulus, press:

   (MENU) COUPLED CH ON

10. To place the marker *exactly* on a measurement point, press:

    (MRK) MARKER MODE MENU MARKERS:DISCRETE

11. To set the CW frequency before going into the power sweep mode, press:

    (SEQ) SPECIAL FUNCTIONS MARKER → CW

12. To maintain the calibration for the CW frequency, press:

    (CAL) INTERPOL ON

13. Press (MENU) SWEEP TYPE MENU POWER SWEEP and enter the start and stop power levels for the sweep.

14. Press (DISPLAY) MORE D2/D1 toD2 OFF.

15. Press (SYSTEM) SERVICE MENU INPUT PORTS B.

    Now, channel 2 displays absolute output power (in dBm) as a function of power input.

16. Press (CH 1) (MRK) MARKER MODE MENU MARKERS:COUPLED.

17. To find the 1 dB compression point on channel 1, press:

    (MRK FCTN) MKR SEARCH SEARCH:MAX
    (MRK) ZERO
    (MRK FCTN) MKR SEARCH SEARCH:TARGET (−1) (x1)

    Notice that the marker on channel 2 tracked the marker on channel 1.

18. To take the channel 2 marker out of the Δ mode so that it reads the absolute output power of the amplifier (in dBm), press:

(CH 2) (MRK) Δ MODE MENU Δ MODE OFF

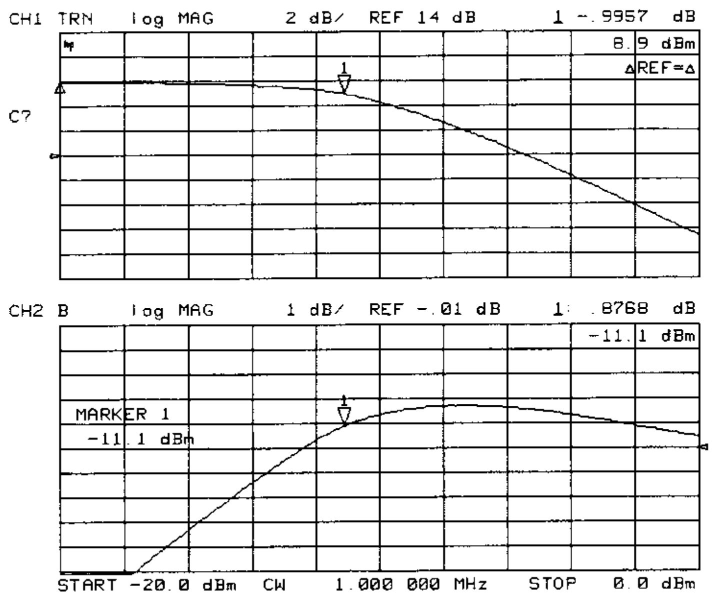


Figure 2-43. Gain Compression Using Power Sweep

Test Sequencing

Test sequencing allows you to automate repetitive tasks. As you make the measurement, the analyzer memorizes the keystrokes. Later you can repeat the entire sequence by pressing a single key. Because the sequence is defined with normal measurement keystrokes, you do not need additional programming expertise. Subroutines and limited decision-making increases the flexibility of test sequences. In addition, TTL lines can be controlled in a test sequence.

The test sequence function allows you to create, title, save, and execute up to six independent sequences internally.

You can also save sequences to disk and transfer them between the analyzer and an external computer controller.

The following procedures are based on an actual measurement example, that show you how to do the following:

- create a sequence
- title a sequence
- edit a sequence
- clear a sequence
- store a sequence
- load a sequence
- purge a sequence

There are also three example sequences:

- cascading multiple sequences
- loop counter sequence
- limit test sequence

Creating a Sequence

1. To enter the sequence creation mode, press:

   (SEQ) NEW SEQ/MODIFY SEQ

   As shown in Figure 2-44, a list of instructions appear on the analyzer display to help you create or edit a sequence.

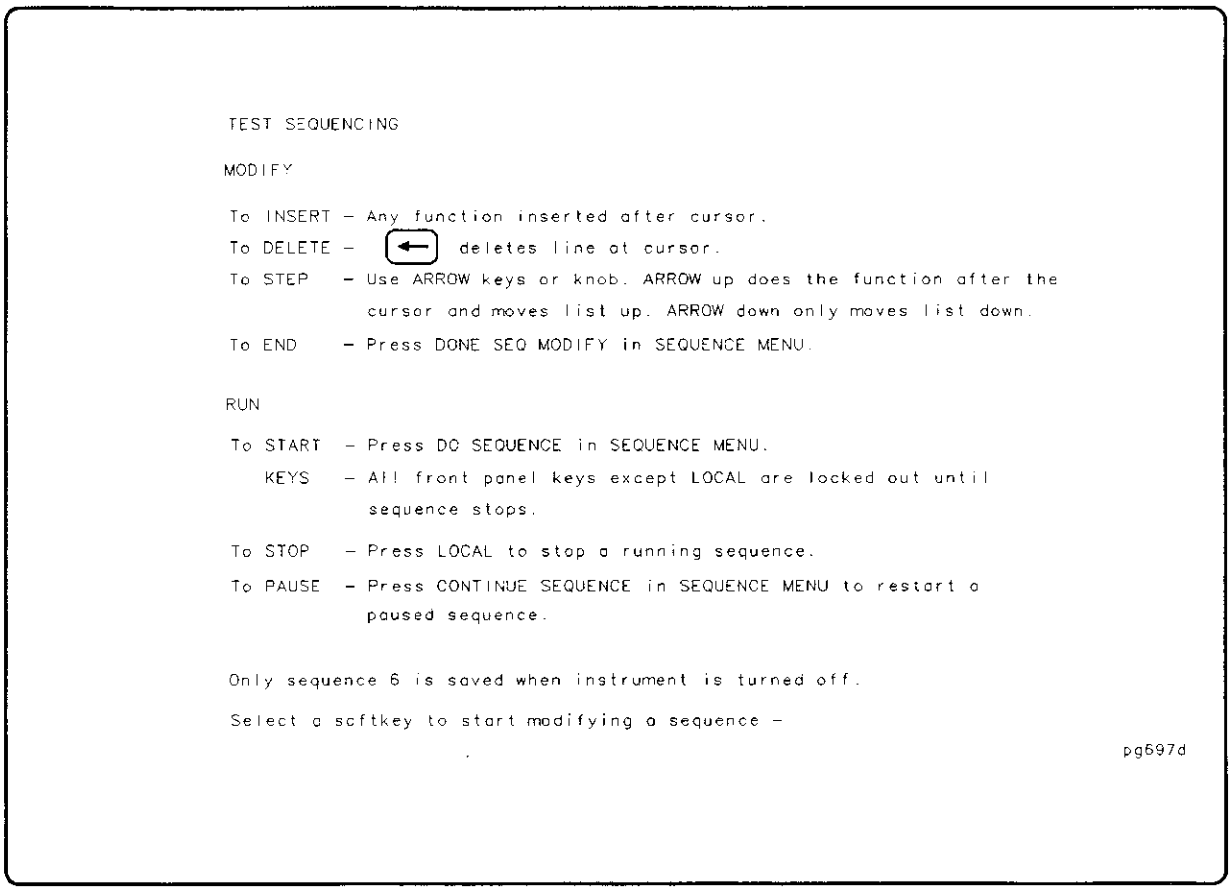


Figure 2-44. Test Sequencing Help Instructions

2. To select a sequence position in which to store your sequence, press:

   SEQUENCE 1 SEQ1

   This choice selects sequence position #1. The default title is SEQ1 for this sequence.

   Refer to "Storing and Recalling a Test Sequence," (located later in this chapter) for information on how to modify a sequence title.

3. To create a test sequence, enter the parameters for the measurement that you wish to make. For this example, a SAW filter measurement is set up with the following parameters:

   (SAVE/RECALL) RECALL STATE

   (MEAS) TRANSMISSN

   (FORMAT) LOG MAG

   (CENTER) (134) (M/μ)
   (SPAN) (50) (M/μ)
   (SCALE REF) AUTO SCALE

   The above keystrokes will create a displayed list as shown:

```
Start of Sequence
RECALL PRST STATE
TRANSMISSN
LOG MAG
CENTER
   134 M/u
SPAN
   50 M/u
SCALE/DIV
AUTO SCALE
```

4. To complete the sequence creation, press:

   (SEQ) DONE SEQ MODIFY

Caution When you create a sequence, the analyzer stores it in volatile memory where it will be lost if you switch off the instrument power (except for sequence 6, which is stored in non-volatile memory automatically). However, you may store up to six sequences in the analyzer non-volatile memory, or you may save sequences to a floppy disk.

Running a Sequence

To run a stored test sequence, press:

(PRESET) and the softkey labeled with desired sequence number

or, press:

(SEQ) DO SEQUENCE and the softkey labeled with the desired sequence number.

Stopping a Sequence

To stop a sequence before it has finished, press (LOCAL).

Editing a Sequence

Deleting Commands

1. To enter the creation/editing mode, press:

   (SEQ) NEW SEQ/MODIFY SEQ

2. To select the particular test sequence you wish to modify (sequence 1 in this example), press:

   SEQUENCE 1 SEQ1

3. To move the cursor to the command that you wish to delete, press:

   (⇧) or (⇩)

   - If you use the (⇧) key to move the cursor through the list of commands, the commands are actually performed when the cursor points to them. This feature allows the sequence to be tested one command at a time.
   - If you wish to scroll through the sequence without executing each line as you do so, you can press the (⇩) key and scroll through the command list backwards.

4. To delete the selected command, press:

   (←) (backspace key)

5. Press (SEQ) DONE SEQ MODIFY to exit the modify (edit) mode.

Inserting a Command

1. To enter the creation/editing mode, press:

   (SEQ) NEW SEQ/MODIFY SEQ

2. To select the particular test sequence you wish to modify (sequence 1 in this example), press:

   SEQUENCE 1 SEQ1

3. To insert a command, move the cursor to the line immediately above the line where you want to insert a new command, by pressing:

   (⇧) or (⇩)

   - If you use the (⇧) key to move the cursor through the list of commands, the commands are actually performed when the cursor points to them. This feature allows the sequence to be tested one command at a time.
   - If you wish to scroll through the sequence without executing each line as you do so, you can press the (⇩) key and scroll through the command list backwards.

4. To enter the new command, press the corresponding analyzer front panel keys. For example, if you want to activate the averaging function, press:

   (AVG) AVERAGING ON

5. Press (SEQ) DONE SEQ MODIFY to exit the modify (edit) mode.

Modifying a Command

1. To enter the creation/editing mode, press:

   (PRESET) (SEQ) NEW SEQ/MODIFY SEQ

2. To select the particular test sequence you wish to modify, (sequence 1 in this example), press:

   SEQUENCE 1 SEQ1

   The following list is the commands entered in "Creating a Sequence." Notice that for longer sequences, only a portion of the list can appear on the screen at one time.

   ```
   Start of Sequence
   RECALL PRST STATE
   TRANSMISSN
   LOG MAG
   CENTER
      134 M/u
   SPAN
      50 M/u
   SCALE/DIV
   AUTO SCALE
   ```

3. To change a command (for example, the span value from 50 MHz to 75 MHz) move the cursor (→) next to the command that you wish to modify, press:

   (⇧) or (⇩)

   - If you use the (⇧) key to move the cursor through the list of commands, the commands are actually performed when the cursor points to them. This feature allows the sequence to be tested one command at a time.
   - If you wish to scroll through the sequence without executing each line as you do so, you can press the (⇩) key and scroll through the command list backwards.

4. To delete the current command (for example, span value), press:

   (←)

5. To insert a new value (for example, 75 MHz), press:

   (75) (M/μ)

6. Press (SEQ) DONE SEQ MODIFY to exit the modify (edit) mode.

Clearing a Sequence from Memory

1. To enter the menu where you can clear a sequence from memory, press:

   (SEQ) MORE CLEAR SEQUENCE

2. To clear a sequence, press the softkey of the particular sequence.

Changing the Sequence Title

If you are storing sequences on a disk, you should replace the default titles (SEQ1, SEQ2 . . .).

1. To select a sequence that you want to retitle, press:

   (SEQ) MORE TITLE SEQUENCE and select the particular sequence softkey

   The analyzer shows the available title characters. The current title is displayed in the upper-left corner of the screen.

2. Press ERASE TITLE and turn the front panel knob to point to the characters of the new filename, pressing SELECT LETTER as you stop at each character.

   The analyzer cannot accept a title that is longer than eight characters. Your titles must also begin with a letter, and contain only letters and numbers.

3. To complete the titling, press DONE.

Storing a Sequence on a Disk

1. Configure a disk drive to the analyzer, (refer to the "Compatible Peripherals" chapter).
2. To format a disk, refer to the "Printing, Plotting, and Saving Measurement Results" chapter.
3. To save a sequence to a disk, press:

   (SEQ) MORE STORE SEQ TO DISK and select the particular sequence softkey

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

Caution The analyzer will overwrite a file on the disk that has the same title.

Loading a Sequence from Disk

1. To view the first six sequences on the disk, press:

   (SEQ) MORE LOAD SEQ FROM DISK READ SEQ FILE TITLS

   - If the desired sequence is not among the first six files, press:

     READ SEQ FILE TITLS until the desired file name appears.

2. Press the softkey next to the title of the desired sequence. The disk access light should illuminate briefly.

Note If you know the title of the desired sequence, you can title the sequence (1-6) with the name, and load the sequence. This is also how you can control the sequence number of an imported titled sequence.

If you have loaded a sequence into an arbitrary position, you can move the sequence by using DUPLICATE SEQUENCE to copy the sequence to the desired position. Then use CLEAR SEQUENCE to clear the arbitrary position.

Purging a Sequence from Disk

1. To view the contents of the disk (six titles at a time), press:

   (SEQ) MORE STORE SEQ TO DISK PURGE SEQUENCES

   - If the desired sequence is not among the first six files, press:

     READ SEQ FILE TITLS until the desired file name appears.

2. Press the softkey next to the title of the desired sequence. The disk access light should illuminate briefly.

Printing a Sequence

1. Configure a compatible printer to the analyzer (refer to the "Compatible Peripherals" chapter).
2. To print a sequence, press:

   (SEQ) MORE PRINT SEQUENCE and the softkey for the desired sequence

Note If the sequence is on a disk, load the sequence (as described in a previous procedure), and then follow the printing sequence.

Cascading Multiple Example Sequences

By cascading test sequences, you can create subprograms for a larger test sequence. You can also cascade sequences to extend the length of test sequences to greater than 200 lines.

Note You can also accomplish a subprogram sequence by using the GOSUB function.

In this example, you are shown two sequences that have been cascaded. You can do this by having the last command in sequence 1 call sequence position 2, regardless of the sequence title.

1. To create the example multiple sequences, press:

   (SEQ) NEW SEQ/MODIFY SEQ SEQUENCE 1 SEQ1
   (CENTER) (134) (M/μ)
   (SPAN) (50) (M/μ)
   (SEQ) DO SEQUENCE
   SEQUENCE 2 DONE SEQ MODIFY
   NEW SEQ/MODIFY SEQ SEQUENCE 2 SEQ2
   (MEAS) TRANSMISSN
   (FORMAT) LOG MAG
   (SCALE REF) AUTOSCALE
   (SEQ) DONE SEQ MODIFY

The following sequences will be created:

SEQUENCE SEQ1
Start of Sequence
CENTER
   134 M/u
SPAN
   50 M/u
DO SEQUENCE
SEQUENCE 2

SEQUENCE SEQ2
Start of Sequence
TRANSMISSN
LOG MAG
SCALE/DIV
AUTO SCALE

You can extend this process of calling the next sequence from the last line of the present sequence to 6 internal sequences, or an unlimited number of externally stored sequences.

2. To run both sequences, press:

   (PRESET) SEQUENCE 1 SEQ1

Loop Counter Example Sequence

This example shows you the basic steps necessary for constructing a looping structure within a test sequence. A typical application of this loop counter structure is for repeating a specific measurement as you step through a series of CW frequencies or dc bias levels.

1. To create a sequence that will set the initial value of the loop counter, and call the sequence that you want to repeat, press:

   (SEQ) NEW SEQ/MODIFY SEQ SEQUENCE 1 SEQ1

   SPECIAL FUNCTIONS DECISION MAKING

   LOOP COUNTER (10) (x1)

   (SEQ) DO SEQUENCE SEQUENCE 2

   DONE SEQ MODIFY

   This will create a displayed list as shown:

   SEQUENCE LOOP 1
   Start of Sequence
   LOOP COUNTER
      10x1
   DO SEQUENCE
      SEQUENCE 2

   To create a second sequence that will perform a desired measurement function, decrement the loop counter, and call itself until the loop counter value is equal to zero, press:

   (SEQ) NEW SEQ/MODIFY SEQ SEQUENCE 2 SEQ2

   (MEAS) TRANSMISSN

   (SCALE REF) AUTO SCALE

   (MRK FCTN) MKR SEARCH SEARCH: MAX

SEQ SPECIAL FUNCTIONS DECISION MAKING

DECR LOOP COUNTER IF LOOP COUNTER<> 0

SEQUENCE 2 SEQ2

SEQ DONE SEQ MODIFY

This will create a displayed list as shown:

SEQUENCE LOOP2
Start of Sequence
TRANSMISSN
SCALE/DIV
AUTO SCALE
MKR FCTN
SEARCH MAX
DECR LOOP COUNTER
IF LOOP COUNTER <> 0 THEN DO
SEQUENCE 2

To run the loop sequence, press:

PRESET SEQUENCE 1 SEQ1

Limit Test Example Sequence

This measurement example shows you how to create a sequence that will branch the sequence according to the outcome of a limit test. Refer to "Testing a Device with Limit Lines," located earlier in this chapter, for a procedure that shows you how to create a limit test.

For this example, you must have already saved the following in register 1:

- device measurement parameters
- a series of active (visible) limit lines
- an active limit test

1. To create a sequence that will recall the desired instrument state, perform a limit test, and branch to another sequence position based on the outcome of that limit test, press:

   SEQ NEW SEQ/MODIFY SEQ SEQUENCE 1 SEQ1

   SAVE/RECALL ⇩ RECALL STATE

   SEQ SPECIAL FUNCTIONS DECISION MAKING

   IF LIMIT TEST PASS SEQUENCE 2 SEQ2

   IF LIMIT TEST FAIL SEQUENCE 3 SEQ3

   SEQ DONE SEQ MODIFY

   This will create a displayed list for sequence 1, as shown:

   Start of Sequence
   RECALL REG 1
   IF LIMIT TEST PASS THEN DO
   SEQUENCE 2
   IF LIMIT TEST FAIL THEN DO
   SEQUENCE 3

2. To create a sequence that stores the measurement data for a device that has passed the limit test, press:

   SEQ NEW SEQ/MODIFY SEQ SEQUENCE 2 SEQ2

SAVE/RECALL STORE TO DISK DEFINE DISK-SAVE

DATA ARRAY ON RETURN SAVE STATE

SEQ DONE SEQ MODIFY

This will create a displayed list for sequence 2, as shown:

```
Start of Sequence
DATA ARRAY
ON
FILENAME
FILE 0
SAVE FILE
```

3. To create a sequence that prompts you to tune a device that has failed the limit test, and calls sequence 1 to retest the device, press:

   SEQ NEW SEQ/MODIFY SEQ SEQUENCE 3 SEQ3

   DISPLAY MORE TITLE

   T U N E space D E V I C E DONE

   SEQ SPECIAL FUNCTIONS PAUSE RETURN

   DO SEQUENCE SEQUENCE 1 SEQ1

   SEQ DONE SEQ MODIFY

This will create a displayed list for sequence 3, as shown:

```
Start of Sequence
TITLE
   TUNE DEVICE
SEQUENCE
PAUSE
DO SEQUENCE
   SEQUENCE 1
```

Measuring a Device in the Time Domain (Option 010 Only)

The HP 8752C option 010 allows you to measure the time domain response of a device. Time domain analysis is useful for isolating a device problem in time or in distance. Time and distance are related by the velocity factor of your device under test. The analyzer measures the frequency response of your device and uses an inverse Fourier transform to convert the data to the time domain.

Gating

Time domain analysis allows you to mathematically remove individual parts of the time domain response to see the effect of potential design changes. You can accomplish this by "gating" out the undesirable responses.

This section shows you how to use the time domain function to measure a device response by the following measurement examples:

- transmission measurement of RF crosstalk and multi-path signal through a surface acoustic wave (SAW) filter
- reflection measurement that locates reflections along a terminated transmission line

Transmission Response in Time Domain

In this example measurement there are three components of the transmission response:

- RF leakage at near zero time
- the main travel path through the device (1.6 μs travel time)
- the "triple travel" path (4.8 μs travel time).

This example procedure also shows you how time domain analysis allows you to mathematically remove individual parts of the time domain response to see the effect of potential design changes. This is accomplished by "gating" out the undesirable responses. With the "gating" capability, the analyzer time domain allows you perform "what if" analysis by mathematically removing selected reflections and seeing the effect in the frequency domain.

1. Connect the device as shown.

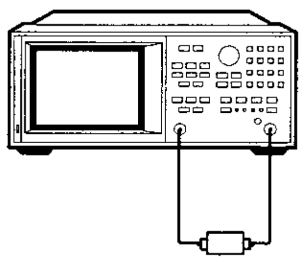


Figure 2-45. Device Connections for Time Domain Transmission Example Measurement

2. To choose the measurement parameters, press:

   (PRESET)
   (MEAS) TRANSMISSN
   (START) (119) (M/μ)
   (STOP) (149) (M/μ)
   (SCALE REF) AUTO SCALE

3. Substitute a thru for the device under test and perform a frequency response correction. Refer to the "Optimizing Measurement Results" chapter, for a detailed procedure.
4. Reconnect your device under test.
5. To transform the data from the frequency domain to the time domain, press:

   (SYSTEM) TRANSFORM MENU BANDPASS TRANSFORM ON
   (START) (0) (G/n)
   (STOP) (6) (M/μ)

   The other time domain modes, low pass step and low pass impulse, are described in the "Application and Operation Concepts" chapter.
6. To better view the measurement trace, press:

   (SCALE REF) REFERENCE VALUE and turn the front panel knob
7. To measure the peak response from the main path, press:

   (MRK FCTN) MKR SEARCH SEARCH: MAX

The three responses shown in Figure 2-46 are the RF leakage near zero seconds, the main travel path through the filter, and the triple travel path through the filter. Only the composite signal was evident to you in the frequency domain.

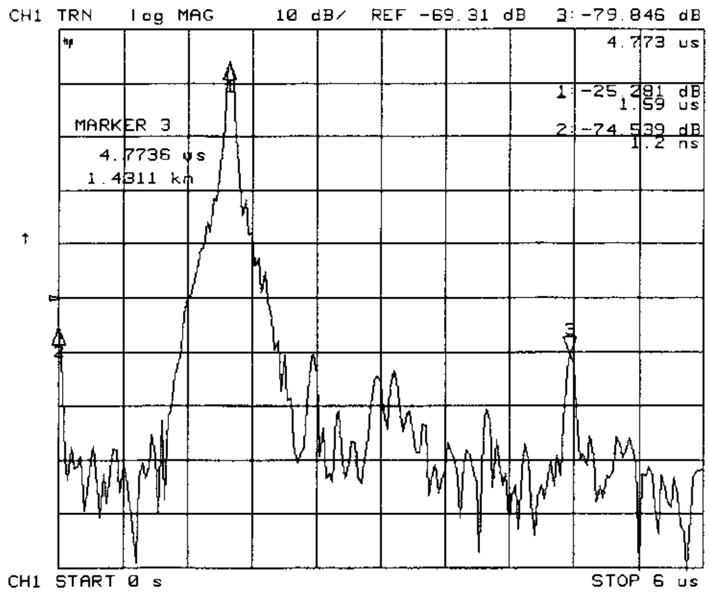


Figure 2-46. Time Domain Transmission Example Measurement

8. To access the gate function menu, press:

   (SYSTEM) TRANSFORM MENU SPECIFY GATE CENTER

9. To set the gate parameters, by entering the marker value, press:

   (1.6) (M/μ), or turn the front panel knob to position the "T" center gate marker

10. To set the gate span, press:

    SPAN (1.2) (M/μ) or turn the front panel knob to position the "flag" gate markers

11. To activate the gating function to remove any unwanted responses, press:

    GATE ON

    As shown in Figure 2-47, only response from the main path is displayed.

Note You may remove the displayed response from inside the gate markers, by pressing SPAN and turning the front panel knob to exchange the "flag" marker positions.

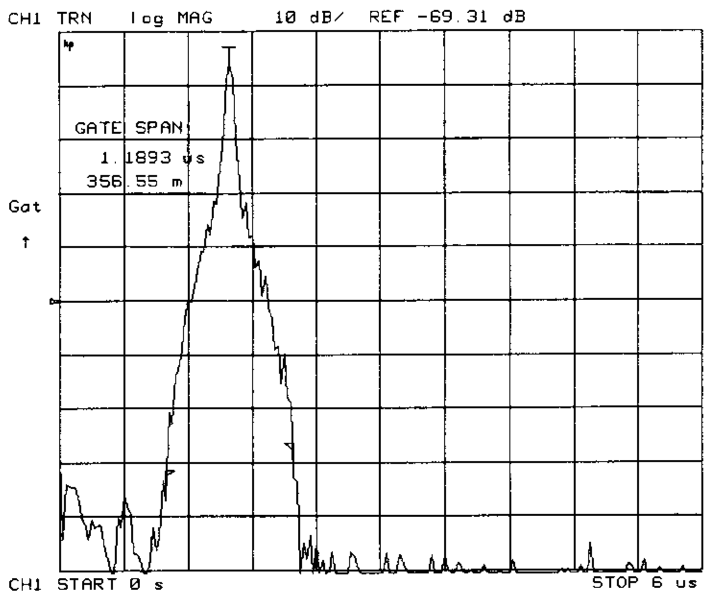


Figure 2-47.
Gating in a Time Domain Transmission Example Measurement

12. To adjust the gate shape for the best possible time domain response, press GATE SHAPE and select between minimum, normal, wide, and maximum. Each gate has a different passband flatness, cutoff rate, and sidelobe levels.

Table 2-2. Gate Characteristics

Gate Shape	Passband Ripple	Sidelobe Levels	Cutoff Time	Minimum Gate Span
Gate Span Minimum	±0.1 dB	−48 dB	1.4/Freq Span	2.8/Freq Span
Normal	±0.1 dB	−68 dB	2.8/Freq Span	5.6/Freq Span
Wide	±0.1 dB	−57 dB	4.4/Freq Span	8.8/Freq Span
Maximum	±0.01 dB	−70 dB	12.7/Freq Span	25.4/Freq Span
NOTE: With 1601 frequency points, gating is available only in the passband mode.				

The passband ripple and sidelobe levels are descriptive of the gate shape. The cutoff time is the time between the stop time (−6 dB on the filter skirt) and the peak of the first sidelobe, and is equal on the left and right side skirts of the filter. Because the minimum gate span has no passband, it is just twice the cutoff time.

13. To see the effect of the gating in the frequency domain, press:

(SYSTEM) TRANSFORM MENU TRANSFORM OFF

(SCALE REF) AUTO SCALE

(DISPLAY) DATA→MEM DISPLAY: DATA AND MEMORY

(SYSTEM) TRANSFORM MENU SPECIFY GATE GATE OFF

This places the gated response in memory. Figure 2-48 shows the effect of removing the RF leakage and the triple travel signal path using gating. By transforming back to the frequency domain we see that this design change would yield better out-of-band rejection.

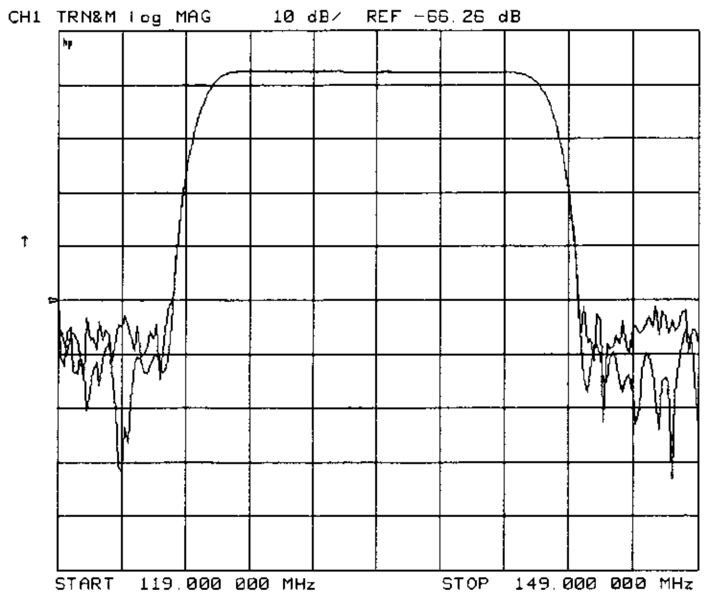


Figure 2-48.
Gating Effects in a Frequency Domain Example Measurement

Reflection Response in Time Domain

The time domain response of a reflection measurement is often compared with the time domain reflectometry (TDR) measurements. Like the TDR, the HP 8752C measures the size of the reflections versus time (or distance). Unlike the TDR, the time domain capability of the analyzer allows you to choose the frequency range over which you would like to make the measurement.

1. To choose the measurement parameters, press:

   (PRESET)
   (MEAS) **REFLECTION**
   (START) (300) (k/m)
   (STOP) (3) (G/n)

2. Perform an S_{11} 1-port correction on PORT 1. Refer to the "Optimizing Measurement Results" chapter, for a detailed procedure.
3. Connect your device under test as shown in Figure 2-49.

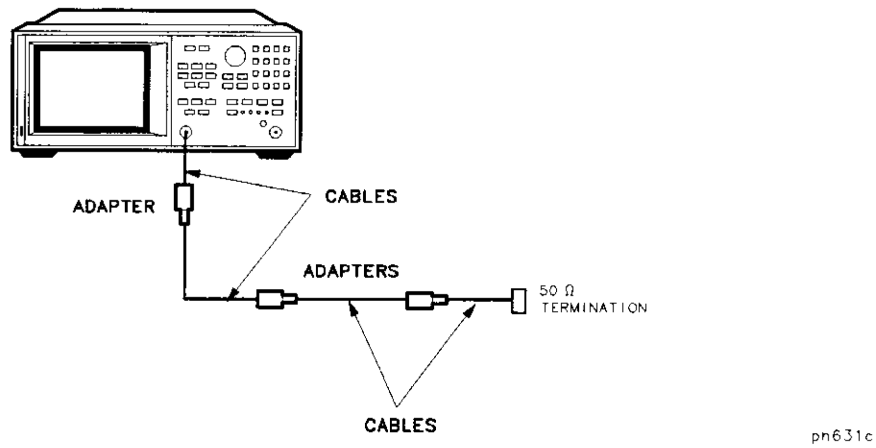


Figure 2-49. Device Connections for Reflection Time Domain Example Measurement

4. To better view the measurement trace, press:

   (SCALE REF) AUTO SCALE

   Figure 2-50 shows the frequency domain reflection response of the cables under test. The complex ripple pattern is caused by reflections from the adapters interacting with each other. By transforming this data to the time domain, you can determine the magnitude of the reflections versus distance along the cable.

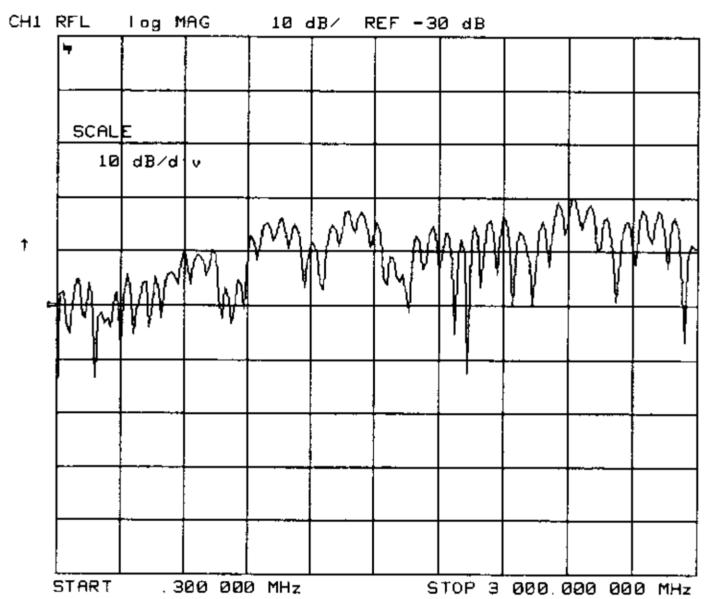


Figure 2-50. Device Response in the Frequency Domain

5. To transform the data from the frequency domain to the time domain, press:

   (SYSTEM) TRANSFORM MENU BANDPASS TRANSFORM ON

6. To view the time domain over the length (<4 meters) of the cable under test, press:

(FORMAT) LIN MAG
(START) (0) (x1)
(STOP) (35) (G/n)

The stop time corresponds to the length of the cable under test. The energy travels about 1 foot per nanosecond, or 0.3 meter/ns, in free space. Most cables have a relative velocity of about 0.66 the speed in free space. Calculate about 3 ns/foot, or 10 ns/meter, for the stop time when you are measuring the return trip distance to the cable end.

7. To enter the relative velocity of the cable under test, press:

   (CAL) MORE VELOCITY FACTOR
   and enter a velocity factor for your cable under test

Note Most cables have a relative velocity of 0.66 (for polyethylene dielectrics) or 0.7 (for teflon dielectrics). If you would like the markers to read actual one-way distance rather than return trip distance, enter one-half the actual velocity factor. Then the markers read the actual round trip distance to the reflection of interest rather than the "electrical length" that assumes a relative velocity of 1.

8. To position the marker on the reflection of interest, press:

   (MRK) and turn the front panel knob

   In this example, the velocity factor was set to one-half the actual value, so the marker reads the time and distance to the reflection.

9. To position a marker at each reflection of interest, as shown in Figure 2-51, press:

   MARKER 2 MARKER 3 MARKER 4, turning the front panel knob after each key press

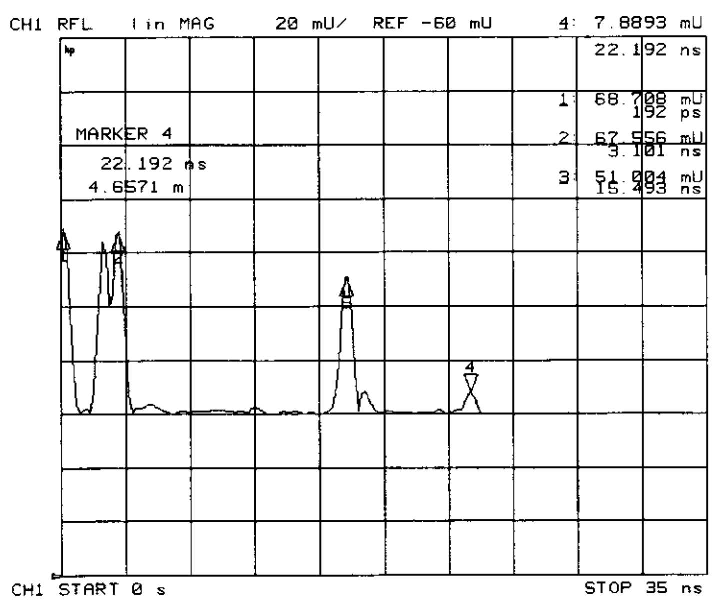


Figure 2-51. Device Response in the Time Domain

3

Printing, Plotting, and Saving Measurement Results

This chapter contains instructions for the following tasks:

- Printing or plotting your measurement results
  - Configuring a print function
  - Defining a print function
  - Printing one measurement per page
  - Configuring a plot function
  - Defining a plot function
  - Plotting one measurement per page using a pen plotter
  - Plotting Multiple measurements per page using a pen plotter
  - Plotting one measurement per page using a disk drive
  - Plotting Multiple Measurements per page using a disk drive
  - Titling the displayed measurement
  - Aboring a print or plot process
  - Printing or plotting the list values or operating parameters
  - Solving problems with printing or plotting
- Saving and recalling instrument states
  - Saving an instrument state
  - Saving measurement results
  - Re-saving an instrument state
  - Deleting a file
  - Renaming a file
  - Recalling a file
  - Formatting a disk
  - Solving problems with saving or recalling files

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 7, "Menu Maps," shows softkey menu relationships.
- Chapter 8, "Key Definitions," describes all the front panel keys, softkeys, and their corresponding HP-IB commands.
- Chapter 10, "Compatible Peripherals," lists measurement and system accessories, and other applicable equipment compatible with the HP 8752C. An HP-IB programming overview is also included.

Printing or Plotting Your Measurement Results

You can print your measurement results to the following peripherals:

- printers with HP-IB interfaces
- printers with parallel interfaces

You can plot your measurement results to the following peripherals:

- HPGL compatible printers with HP-IB interfaces
- HPGL compatible printers with parallel interfaces
- plotters with HP-IB interfaces
- plotters with parallel interfaces

Refer to the "Compatible Peripherals" chapter for a list of recommended peripherals.

Configuring a Print Function

All copy configuration settings are stored in non-volatile memory. Therefore, they are not affected if you press (PRESET) or switch off the analyzer power.

1. Connect the printer to the interface port.
2. If the printer has a parallel interface, connect the HP-IB to parallel adapter to the end of the HP-IB cable. The adapter has the following part numbers:
   - HP ITEL-45CHVU: U.S. and Canada
   - HP ITEL-45CHVE: International

Printer Interface	Recommended Cables
Parallel	HP 92284A
HP-IB	HP 10833A, 10833B, 10833D

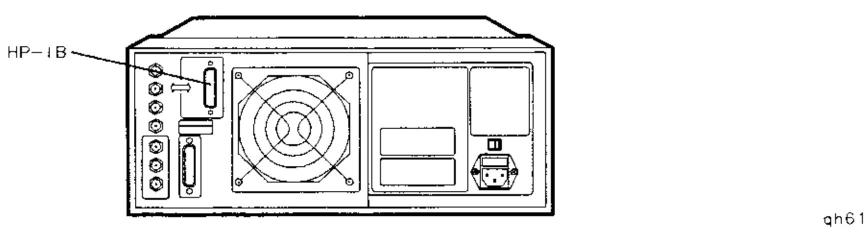


Figure 3-1. Printer Connections to the Analyzer

3. Press (LOCAL) and select one of the following:
   - Choose SYSTEM CONTROLLER if there is no external controller connected to the HP-IB bus.
   - Choose PASS CONTROL if there is an external controller is connected to the HP-IB bus.
4. Press SET ADDRESSES PRINTER PORT.
5. Press PRNTR TYPE until the correct printer choice appears:

- ThinkJet (QuietJet)
- DeskJet
- LaserJet
- PaintJet
- Epson-P2 (printers that conform to the ESC/P2 printer control language)

6. Press PRNTR PORT HP-IB and enter the HP-IB address of the printer, if the default address (01) is incorrect. Follow the address entry by pressing (x1).

Defining a Print Function

Note The print definition is set to default values whenever the power is cycled. However, you can save the print definition by saving the instrument state.

1. Press (COPY) DEFINE PRINT.
2. Press PRINT until the correct print mode appears:
   - Choose PRINT: MONOCHROME if you are using a black and white printer, or you want just black and white from a color printer.
   - Choose PRINT: COLOR if you are using a color printer.
3. Press AUTO-FEED until the correct choice (ON or OFF) is high-lighted:
   - Choose AUTO-FEED ON if you want to print one measurement per page.
   - Choose AUTO-FEED OFF if you want to print multiple measurements per page.

Note Laser printers and some DeskJet printers do not begin to print until a full page, or a partial page and a form feed, have been received.

If You are Using a Color Printer

1. Press PRINT COLORS .
2. If you want to modify the print colors, select the print element and then choose an available color.

Note You can set all the print elements to black to create a hardcopy in black and white.

Since the media color is white or clear, you could set a print element to white if you do not want that element to appear on your hardcopy.

To Reset the Printing Parameters to Default Values

1. Press (COPY) DEFINE PRINT DEFAULT PRNT SETUP .

Table 3-1. Default Values for Printing Parameters

Printing Parameter	Default
Printer Mode	Monochrome
Auto Feed	ON
Printer Colors	
Channel 1 Data	Magenta
Channel 1 Memory	Green
Channel 2 Data	Blue
Channel 2 Memory	Red
Graticule	Cyan
Warning	Black
Text	Black

Printing One Measurement Per Page

Press (COPY) PRINT.

- If you defined the AUTOFEED OFF, press PRINTER FORM FEED after the message COPY OUTPUT COMPLETED appears.

Printing Multiple Measurements Per Page

1. Press (COPY) DEFINE PRINT and then press AUTOFEED until the softkey label appears as AUTOFEED OFF.
2. Press RETURN PRINT to print a measurement on the first half page.
3. Make the next measurement that you want to see on your hardcopy. Figure 3-2 shows an example of a hardcopy where two measurements appear.
4. Press (COPY) PRINT to print a measurement on the second half page.

Note	This feature will not work for all printers due to differences in printer resolution.

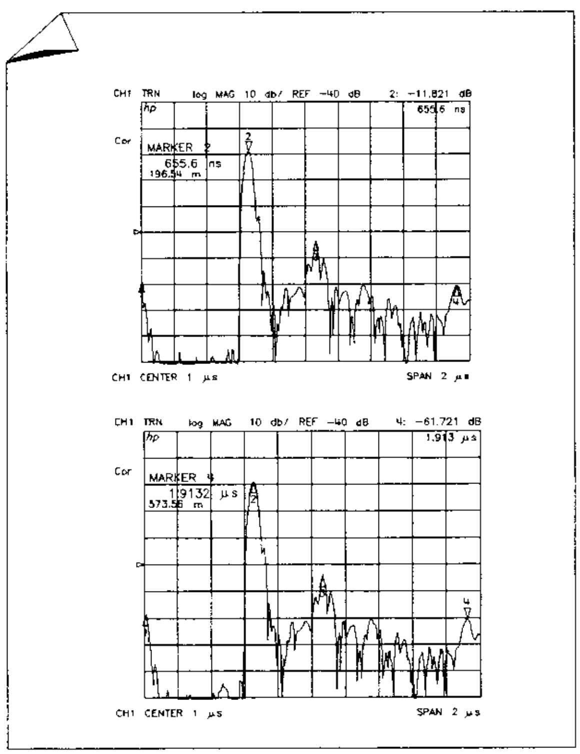


Figure 3-2. Printing Two Measurements

Configuring a Plot Function

All copy configuration settings are stored in non-volatile memory. Therefore, they are not affected if you press (PRESET) or switch off the analyzer power.

1. Connect the peripheral to the interface port.
2. If the peripheral has a parallel interface, connect the HP-IB to parallel interface adapter to the end of the HP-IB cable. The adapter has the following part numbers:
   - HP ITEL-45CHVU: U.S. & Canada
   - HP ITEL-45CHVE: international

Peripheral Interface	Recommended Cables
Parallel	HP 92284A
HP-IB	HP 10833A, 10833B, 10833D

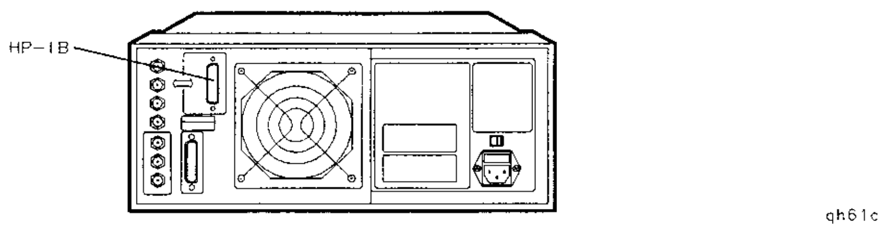


Figure 3-3. Peripheral Connections to the Analyzer

3. Press (LOCAL) and select one of the following:
   - Choose SYSTEM CONTROLLER if there is no external controller connected to the HP-IB bus.
   - Choose PASS CONTROL if there is an external controller connected to the HP-IB bus.

If You are Plotting to an HPGL/2 Compatible Printer

1. Press (LOCAL) SET ADDRESSES PRINTER PORT.
2. Press PRNTR TYPE until the correct printer choice appears:
   - ☐ ThinkJet (QuietJet)
   - ☐ DeskJet (only DeskJet 1200C)
   - ☐ LaserJet (only LaserJet III and IV)
   - ☐ PaintJet
   - ☐ Epson-P2 (printers that conform to the ESC/P2 printer control language)
3. Press PRINTER ADDRESS and enter the HP-IB address, if the default address (01) is incorrect. Follow the entry by pressing (x1).
4. Press PLTR TYPE until [HPGL PRT] appears on the softkey label.

If You are Plotting to a Pen Plotter

1. Press (LOCAL) SET ADDRESSES PLOTTER PORT.
2. Press PLTR TYPE until [PLOTTER] appears on the softkey label.
3. Press PLTR PORT HP-IB and enter the HP-IB address, if the default address (05) is incorrect. Follow the entry by pressing (x1).

If You are Plotting to an External Disk Drive

1. Press (LOCAL) DISK UNIT NUMBER and enter the drive where your disk is located, followed by (x1).
2. If your storage disk is partitioned, press VOLUME NUMBER and enter the volume number where you want to store the instrument state file.
3. Press SET ADDRESSES ADDRESS: DISK.
4. Enter the HP-IB address of the disk drive, if the default address (00) is incorrect. Follow the entry by pressing (x1).
5. Press PLOTTER PORT DISK.

Defining a Plot Function

Note The plot definition is set to default values whenever the power is cycled. However, you can save the plot definition by saving the instrument state.

1. Press (COPY) DEFINE PLOT.
2. Choose which of the following measurement display elements that you want to appear on your plot:
   - □ Choose PLOT DATA ON if you want the measurement data trace to appear on your plot.
   - □ Choose PLOT MEM ON if you want the displayed memory trace to appear on your plot.
   - □ Choose PLOT GRAT ON if you want the graticule and the reference line to appear on your plot.
   - □ Choose PLOT TEXT ON if you want all of the displayed text to appear on your plot. (This does not include the marker values or softkey labels.)
   - □ Choose PLOT MKR ON if you want the displayed markers, and marker values, to appear on your plot.

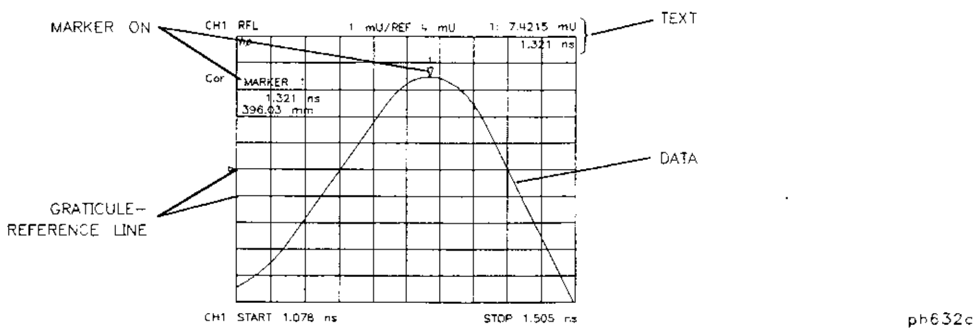


Figure 3-4. Plot Components Available through Definition

3. Press AUTO-FEED until the correct choice is high-lighted:

   - Choose AUTO-FEED ON if you want a "page eject" sent to the plotter or HPGL compatible printer after each time you press PLOT .
   - Choose AUTO-FEED OFF if you want multiple plots on the same sheet of paper.

Note The peripheral ignores AUTO-FEED ON when you are plotting to a quadrant.

---

4. Press MORE and select the plot element where you want to change the pen number. For example, PEN NUM DATA and then modify the pen number. The pen number selects the color if you are plotting to an HPGL/2 compatible color printer.

   Press (x1) after each modification.

Table 3-2. Default Pen Numbers and Corresponding Colors

Pen Number	Color
0	white
1	cyan
2	magenta
3	blue
4	yellow
5	green
6	red
7	black

Table 3-3. Default Pen Numbers for Plot Elements

Corresponding Key	Plot Element	Channel 1 Pen Numbers	Channel 2 Pen Numbers
PEN NUM DATA	Measurement Data Trace	2	3
PEN NUM MEMORY	Displayed Memory Trace	5	6
PEN NUM GRATICULE	Graticule and Reference Line	1	1
PEN NUM TEXT	Displayed Text	7	7
PEN NUM MARKER	Displayed Markers and Values	7	7

Note You can set all the pen numbers to black for a plot in black and white.

You must define the pen numbers for each measurement channel (channel 1 and channel 2).

5. Press MORE and select each plot element line type that you want to modify.
   - Select LINE TYPE DATA to modify the line type for the data trace. Then enter the new line type, followed by (x1).
   - Select LINE TYPE MEMORY to modify the line type for the memory trace. Then enter the new line type, followed by (x1).

Table 3-4. Default Line Types for Plot Elements

Plot Elements	Channel 1 Line Type Numbers	Channel 2 Line Type Numbers
Data Trace	7	7
Memory Trace	7	7

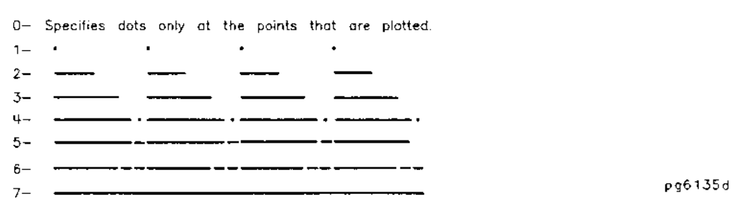


Figure 3-5. Line Types Available

Note You should set the parameter between 0 and 7; a parameter in this range sets the line type as shown in Figure 3-5.

You must define the line types for each measurement channel (channel 1 and channel 2).

6. Press SCALE PLOT until the selection appears that you want.

   - ☐ Choose SCALE PLOT [FULL] if you want the normal scale selection for plotting. This includes space for all display annotations such as marker values and stimulus values. The entire analyzer display fits within the defined boundaries of P1 and P2 on the plotter, while maintaining the exact same aspect ratio as the display.
   - ☐ Choose SCALE PLOT [GRAT] if you want the outer limits of the graticule to correspond to the defined P1 and P2 scaling point on the plotter. (Intended for plotting on preprinted rectangular or polar forms.

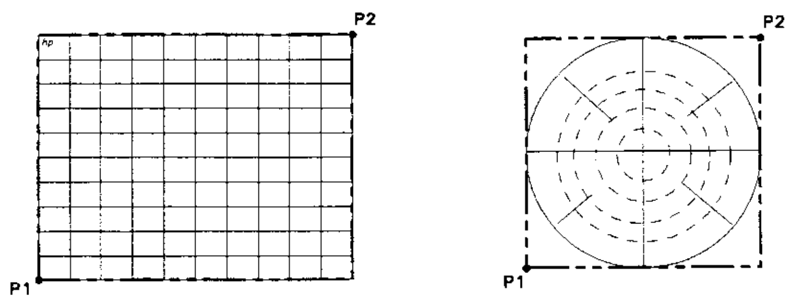


Figure 3-6. Locations of P1 and P2 in SCALE PLOT [GRAT] Mode

7. Press PLOT SPEED until the plot speed appears that you want.

   - ☐ Choose PLOT SPEED [FAST] for normal plotting.
   - ☐ Choose PLOT SPEED [SLOW] for plotting directly on transparencies: the slower speed provides a more consistent line width.

To Reset the Plotting Parameters to Default Values

Press (COPY) DEFINE PLOT MORE MORE DEFAULT PLOT SETUP .

Table 3-5. Plotting Parameter Default Values

Plotting Parameter	Default
Select Quadrant	Full page
Auto Feed	ON
Define Plot	All plot elements on
Plot Scale	Full
Plot Speed	Fast
Line Type	7 (solid line)
Pen Numbers: Channel 1	
Data	2
Memory	5
Graticule	1
Text	7
Marker	7
Pen Numbers: Channel 2	
Data	3
Memory	6
Graticule	1
Text	7
Marker	7

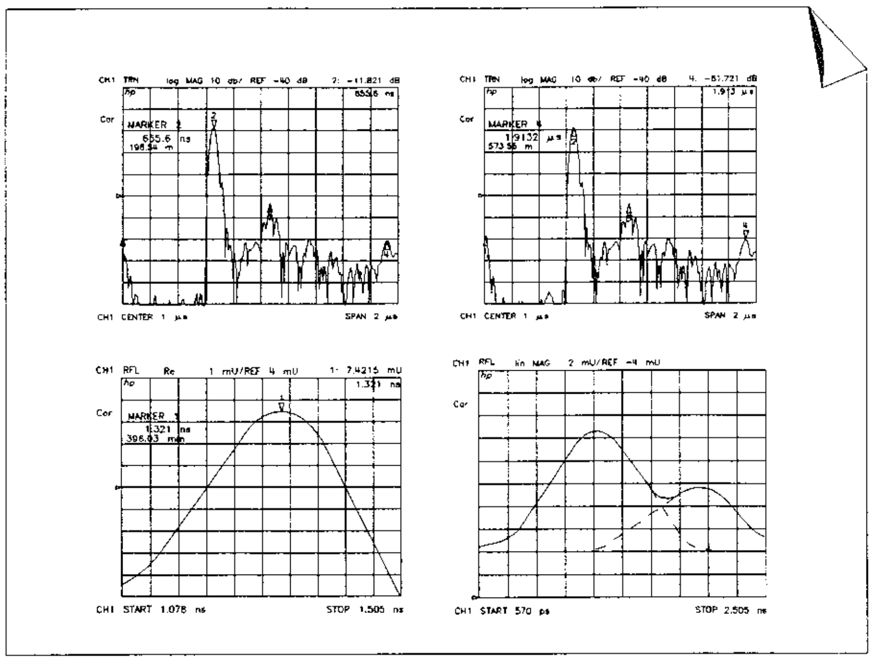
Plotting One Measurement Per Page Using a Pen Plotter

1. Define the plot, as explained in "Defining the Plot Function" located earlier in this chapter.
2. Press (COPY) PLOT .

- If you defined the AUTOFEED OFF , press PLOTTER FORM FEED after the message COPY OUTPUT COMPLETED appears.

Plotting Multiple Measurements Per Page Using a Pen Plotter

1. Define the plot, as explained in "Defining the Plot Function" located earlier in this chapter.
2. Press (COPY) SEL QUAD.
3. Choose the quadrant where you want your displayed measurement to appear on the hardcopy. The selected quadrant appears in the brackets under SEL QUAD.



ph634c

Figure 3-7. Plot Quadrants

4. Press PLOT.
5. Make the next measurement that you want to see on your hardcopy.
6. Press (COPY) SEL QUAD and choose another quadrant where you want to place the displayed measurement.
7. Repeat the previous three steps until you have captured the results of up to four measurements.

If You are Plotting to an HPGL Compatible Printer

Press PLOTTER FORM FEED to print the data the printer has received.

Plotting a Measurement to Disk

The plot files that you generate from the analyzer, contain the HPGL representation of the measurement display. The files will not contain any setup or formfeed commands.

1. Define the plot, as explained in "Defining the Plot Function" located earlier in this chapter.
2. Press (COPY) PLOT.

   The analyzer assigns the first available default filename for the displayed directory. For example, the analyzer would assign PLOT00FP (for a LIF format, or PLOT00.FP for DOS format), if there were no previous plot files saved to the disk.

   The figure below shows the three parts of the file name that is generated automatically by the analyzer whenever a plot is requested. The two digit sequence number is incremented by one each time a file with a default name is added to the directory.

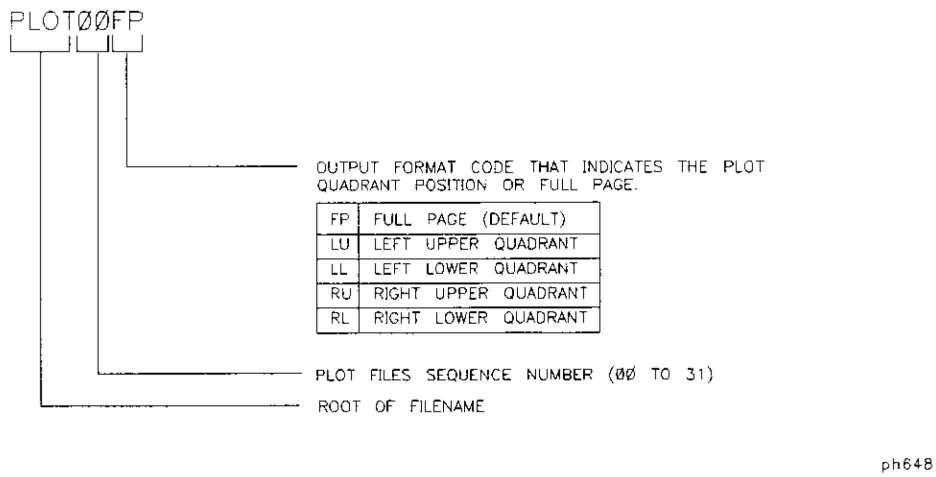


Figure 3-8. Automatic File Naming Convention for LIF Format

To Output the Plot Files

- You can plot the files to a plotter from a personal computer.
- You can output your plot files to an HPGL compatible printer, by following the sequence in "Outputting Plot Files from a PC to an HPGL Compatible Printer" located later in this chapter.
- You can run a program that plots all of the files, with the root filename of PLOT, to an HPGL compatible printer. This program is provided on the "Example Programs Disk" that is included in the Programmer's Guide. However, this program is for use with LIF formatted disks and is written in HP BASIC.

Outputting Plot Files from a PC to a Plotter

1. Connect the plotter to the COM1 port of the computer.
2. Output the file to the plotter by using the following command:

```
C:> TYPE PLOT00.FP > COM1
```

Outputting Plot Files from a PC to an HPGL Compatible Printer

To output the plot files to an HPGL compatible printer, you can use the HPGL initialization sequence linked in a series as follows:

Step 1. Store the HPGL initialization sequence in a file named `hpglinit`.

Step 2. Store the exit HPGL mode and form feed sequence in a file named `exithpgl`.

Step 3. Send the HPGL initialization sequence to the printer.

Step 4. Send the plot file to the printer.

Step 5. Send the exit HPGL mode and form feed sequence to the printer.

Step 1. Store the HPGL initialization sequence.

1. Create a test file, by typing in each character as shown in the left hand column of Table 3-6. Do not insert spaces or linefeeds. Most editors allow the inclusion of escape sequences.

   For example, in the MS-DOS editor (DOS 5.0 or greater), press CNTRL-P (hold down the CTRL key and press P) followed by the ESCape key to create the escape character.
2. Name the file `hpglinit`.

Table 3-6. HPGL Initialization Commands

Command	Remark
<esc>E	conditional page eject
<esc>&12A	page size 8.5 x 11
<esc>&l1O	landscape orientation (lower case l, one, capital O)
<esc>&a0L	no left margin (a, zero, capitol L)
<esc>&a400M	no right margin (a, 4, zero, zero, capitol M)
<esc>&l0E	no top margin (lower case l, zero, capitol E)
<esc>*c7680x5650Y	frame size 10.66"x 7.847" (720 decipoints/inch)
<esc>*p50x50Y	move cursor to anchor point
<esc>*c0T	set picture frame anchor point
<esc>*r-3U	set CMY palette
<esc>%1B	enter HPGL mode; cursor at PCL

Note As shown in Table 3-6, the <esc> is the symbol used for the escape character, decimal value 27.

Step 2. Store the exit HPGL mode and form feed sequence.

1. Create a test file, by typing in each character as shown in the left hand column of Table 3-7. Do not insert spaces or linefeeds.
2. Name the file `exithpgl`.

Table 3-7. HPGL Test File Commands

Command	Remark
<esc>%0A	exit HPGL mode
<esc>E	form feed

Step 3. Send the HPGL initialization sequence to the printer.

Step 4. Send the plot file to the printer.

Step 5. Send the exit HPGL mode and form feed sequence to the printer.

Outputting Single Page Plots Using a Printer

You can output plot files to an HPGL compatible printer, using the DOS command line and the files created in the previous steps. This example assumes that the escape sequence files and the plot files are in the current directory.

Command	Remark
C:>	type hpglinit > PRN
C:>	type PLOT00.FP > PRN
C:>	type exithpgl > PRN

Outputting Multiple Plots to a Single Page Using a Printer

Refer to the "Plotting Multiple Measurements Per Page Using a Disk Drive," located earlier in this chapter, for the naming conventions for plot files that you want printed on the same page. You can use the following batch file, to automate the plot file printing. For example, you have the following list of files to plot:

PLOT00.LL

PLOT00.LU

PLOT00.RL

PLOT00.RU

You would invoke the batch print as follows:

C:> do_plot PLOT00.*

```
rem ___________________________________________________________
rem  Name: do_plot
rem
rem  Description:
rem
rem  output HPGL initialization sequence to a file:spooler
rem  append all the requested plot files to the spooler
rem  append the formfeed sequence to the spooler
rem  copy the file to the printer
rem
rem  (this routine uses COPY instead of PRINT because COPY
rem  will not return until the action is completed. PRINT
rem  will queue the file so the subsequent DEL will likely
rem  generate an error. COPY avoids this.)
rem ___________________________________________________________

echo off
type hpglinit > spooler
for &i in (%1) do type &i >> spooler
type exithpgl >> spooler
copy spooler LPT1
del spooler
echo on
```

Plotting Multiple Measurements Per Page From Disk

The following procedures show you how to store plot files on a LIF formatted disk. A naming convention is used so you can later run an HP BASIC program on an external controller that will output the files to the following peripherals:

- a plotter with auto-feed capability, such as the HP 7550B
- an HP-GL/2 compatible printer, such as the LaserJet 4 series (monochrome) or the DeskJet 1200C (color)

The program is contained on the "Example Programs Disk" that is provided with the *HP 8752C Programmer's Guide*. The file naming convention allows the program to initiate the following:

- to initialize the printer for HP-GL/2 at the beginning of a page
- to plot multiple plot files on the same page
- to send a page eject (form feed) to the hardcopy device, when all plots to the same page have been completed

The plot file name is made up of four parts, the first three are generated automatically by the analyzer whenever a plot is requested. The two digit sequence number is incremented by one each time a file with a default name is added to the directory.

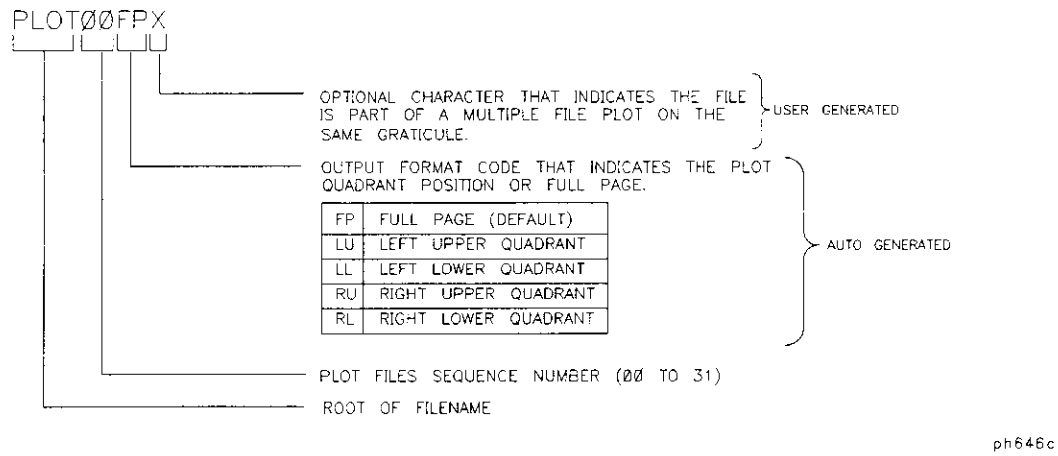


Figure 3-9. Plot Filename Convention

To Plot Multiple Measurements on a Full Page

You may want to plot various files to the same page, for example, to show measurement data traces for different input settings, or parameters, on the same graticule.

1. Define the plot, as explained in "Defining the Plot Function" located earlier in this chapter.
2. Press (COPY) PLOT. The analyzer assigns the first available default filename for the displayed directory. For example, the analyzer would assign PLOT00FP if there were no previous plot files on the disk.
3. Press (SAVE/RECALL) and turn the front panel knob to high-light the name of the file that you just saved.
4. Press FILE UTILITIES RENAME FILE and turn the front panel knob to place the ↑ pointer to the A character.
5. Press SELECT LETTER DONE.
6. Define the next measurement plot that you will be saving to disk.

   For example, you may want only the data trace to appear on the second plot for measurement comparison. In this case, you would press (COPY) DEFINE PLOT and choose PLOT DATA ON PLOT MEM OFF PLOT GRAT OFF PLOT TEXT OFF PLOT MKR OFF.
7. Press (COPY) PLOT. The analyzer will assign PLOT00FP because you renamed the last file saved.
8. Press (SAVE/RECALL) and turn the front panel knob to high-light the name of the file that you just saved.
9. Press FILE UTILITIES RENAME FILE and turn the front panel knob to place the ↑ pointer to the B character.
10. Press SELECT LETTER DONE.
11. Continue defining plots and renaming the saved file until you have saved all the data that you want to put on the same page. Renaming the files as shown below allows you to use the provided program, that organizes and plots the files, according to the file naming convention.

Plot File	Recognized Filename
First File Saved	PLOT00FPA
Second File Saved	PLOT00FPB
Third File Saved	PLOT00FPC
Fourth File Saved	PLOT00FPD

The figure below shows plots for both the frequency and time domain responses of the same device.

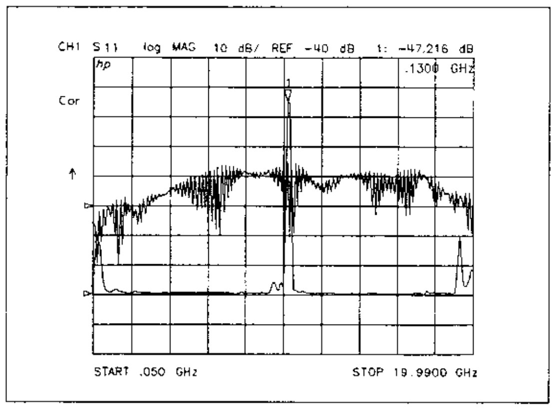
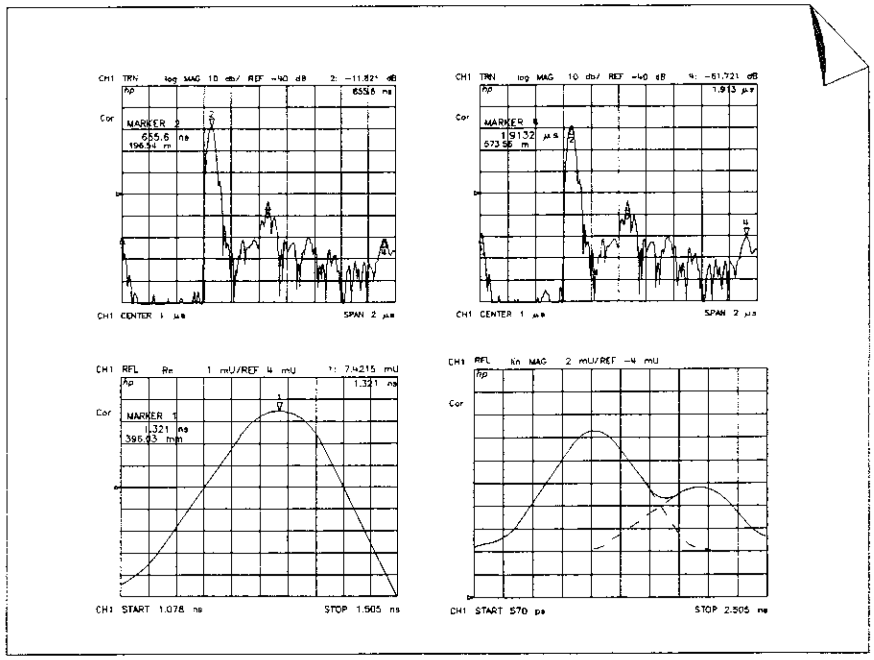


Figure 3-10. Plotting Two Files on the Same Page

To Plot Measurements in Page Quadrants

1. Define the plot, as explained in "Defining the Plot Function" located earlier in this chapter.
2. Press (COPY) SEL QUAD.
3. Choose the quadrant where you want your displayed measurement to appear on the hardcopy. The selected quadrant appears in the brackets under SEL QUAD.



ph634c

Figure 3-11. Plot Quadrants

4. Press PLOT. The analyzer assigns the first available default filename, for the selected quadrant. For example, the analyzer would assign PLOT01LU if there were no other left upper quadrant plots on the disk.
5. Make the next measurement that you want to see on your hardcopy.
6. Repeat this procedure for the remaining plot files that you want to see as quadrants on a page. If you want to see what quadrants you have already saved, press (SAVE/RECALL) to view the directory.

Titling the Displayed Measurement

You can create a title that is printed or plotted with your measurement result.

1. Press (DISPLAY) MORE TITLE to access the title menu.
2. Press ERASE TITLE.
3. Turn the front panel knob to move the arrow pointer to the first character of the title.
4. Press SELECT LETTER.
5. Repeat the previous two steps to enter the rest of the characters in your title. You can enter a title that has a maximum of 50 characters. Press BACK SPACE if you enter an incorrect character.
6. Press DONE to complete the title entry.

Caution The NEWLINE and FORMFEED keys are not intended for creating display titles. Those keys are for creating commands to send to peripherals, during a sequence program.

Aborting a Print or Plot Process

1. Press the (LOCAL) key.
2. If your peripheral is not responding, press (LOCAL) again.

Printing or Plotting the List Values or Operating Parameters

Press (COPY) LIST and select the information that you want to appear on your hardcopy:

- Choose LIST VALUES if you want a tabular listing of the measured data points, and their current values, to appear on your hardcopy. This list will also include the limit test information, if you have the limits function activated.
- Choose OP PARMS (MKRS etc) if you want a tabular listing of the parameters for both measurement channels to appear on your hardcopy. The parameters include: operating parameters, marker parameters, and system parameters that relate to the control of peripheral devices.

If You want a Single Page of Values

1. Choose PRINT for a printer or PLOT for a plotter peripheral, to create a hardcopy of the displayed page of listed values.
2. Press PAGE to display the next page of listed values. Or, you can press PAGE repeatedly to display a particular page of listed values that you want to appear on your hardcopy. Then repeat the previous step to create the hardcopy.
3. Repeat the previous two steps until you have created hardcopies for all the desired pages of listed values.

If you are printing the list of measurement data points, each page contains 30 lines of data. The number of pages is determined by the number of measurement points that you have selected under the (MENU) key.

If You Want the Entire List of Values

Choose PRINT ALL to print all pages of the listed values.

Note If you are printing the list of operating parameters, only the first four pages are printed. The fifth page, system parameters, is printed by displaying that page and then pressing PRINT.

If You Have Problems with Printing or Plotting

If you encounter a problem when you are printing or plotting, check the following list for possible causes:

- Look in the analyzer display message area. The analyzer may show a message that will identify the problem. Refer to the "Error Messages" chapter if a message appears.
- If necessary, refer to the configuration procedures in this chapter to check that you have done the following:
  - □ connected an interface cable between the peripheral and the analyzer
  - □ connected the peripheral to ac power
  - □ switched on the power
  - □ switched the peripheral on line
  - □ selected the correct printer or plotter type
- If you are using a laser printer for plotting, and the printer is outputting partial plots, the printer may require more memory and/or the page protection activated.
- Make sure that the analyzer address setting for the peripheral corresponds to the actual HP-IB address of the peripheral. The procedure is explained earlier in this chapter.
- Make sure that the analyzer is in system controller mode, by pressing (LOCAL) SYSTEM CONTROLLER, if the analyzer is not connected to an external controller. Otherwise, the analyzer must be in the pass control mode.
- Substitute the HP-IB cable.
- Substitute a different printer or plotter.

Saving an Instrument State

Places Where You Can Save

- analyzer internal memory
- floppy disk using an external disk drive

What You Can Save to the Analyzer's Internal Memory

You can save up to 31 registers in the analyzer internal memory. The number of registers that the analyzer allows you to save depends on the size of associated error-correction sets, and memory traces. Refer to the "Preset State and Memory Allocation" chapter for further information.

You can save instrument states in the analyzer internal memory, along with the following list of analyzer settings. The default filenames are REG(1-31).

- error-corrections on channels 1 and 2
- displayed memory trace
- print/plot definitions
- measurement setup
  - frequency range
  - number of points
  - sweep time
  - output power
  - sweep type
  - measurement parameter

Note When the ac line power is switched off, the internal non-volatile memory is retained by a battery. The data retention time with the 3 V, 1.2 Ah battery is as follows:

Temperature at 70 °C .... 208 days (0.57 year)
Temperature at 40 °C .... 1036 days (2.8 years)
Temperature at 25 °C .... 10 years typical

What You Can Save to a Floppy Disk

You can save an instrument state and/or measurement results to a disk. The default filenames are FILEn, where n gets incremented by one each time a file with a default name is added to the directory. The default filenames for data-only files are DATAnDn (DATAn.Dn for DOS), where the first n is incremented by one each time a file with a default name is added to the directory. The second n is the channel where the measurement was made. When you save a file to disk, you can choose to save some or all of the following:

- all settings listed above for internal memory
- active error-correction for the active channel only
- displayed measurement data trace
- displayed user graphics
- data only
- HPGL plots

To Save an Instrument State

1. Connect an external disk drive to the analyzer's HP-IB connector, and configure as follows:
   a. Press (LOCAL) DISK UNIT NUMBER and enter the drive where your disk is located, followed by (x1).
   b. If your storage disk is partitioned, press VOLUME NUMBER and enter the volume number where you want to store the instrument state file.
   c. Press SET ADDRESSES ADDRESS: DISK.
   d. Enter the HP-IB address of the peripheral, if the default address is incorrect (default = 00). Follow the entry by pressing (x1).
   e. Press (LOCAL) and select one of the following:
      - Choose SYSTEM CONTROLLER to allow the analyzer to control peripherals directly.
      - Choose TALKER/LISTENER to allow the computer controller to be involved in all peripheral access operations.
      - Choose PASS CONTROL to allow yourself to control the analyzer over HP-IB and also allows the analyzer to take or pass control.
2. Press (SAVE/RECALL) SELECT DISK and select one of the storage devices:
   - ☐ INTERNAL MEMORY
   - ☐ EXTERNAL DISK
3. Press RETURN SAVE STATE.

   The analyzer saves the state in the next available register, if you are saving to internal memory, or saves the state to disk.

Note If you have saved enough files that you have used all the default names (FILE00 - FILE31 for disk files, or REG1 - REG31 for memory files), you must do one of the following in order to save more states:

- use an external disk
- rename an existing file to make a default name available
- re-save a file/register
- delete an existing file/register

To Save Measurement Results

Note Files that contain data-only, and the various save options available under the DEFINE DISK SAVE key, are only valid for disk saves. However, you can save memory traces to internal memory. The analyzer internal memory can only store instrument states and memory traces.

The analyzer stores data in arrays along the processing flow of numerical data, from IF detection to display. These arrays are points in the flow path where data is accessible, usually via HP-IB. You can choose from the following arrays:

- raw data
- data (raw data with error-correction applied)
- format (data processed to the display format)

If you choose to save the raw data array, you will have the most flexibility in modifying the recalled measurement. This is because the raw data array has the least amount of processing associated with it. Conversely, if you choose to save the format array, your modification of the recalled measurement will be limited by all the processes that are associated with that measurement result. However, the format array is appropriate if you want to retrieve data traces that look like the currently displayed data.

Define Save	Modification Flexibility During Recall
Raw Data Array	Most
Data Array	Medium
Format Array	Least

You can also save data-only. This is saved to disk with default filenames DATA0D1 to DATA9D1, for channel 1, or DATA0D2 to DATA9D2, for channel 2. However, these files are not instrument states and cannot be recalled.

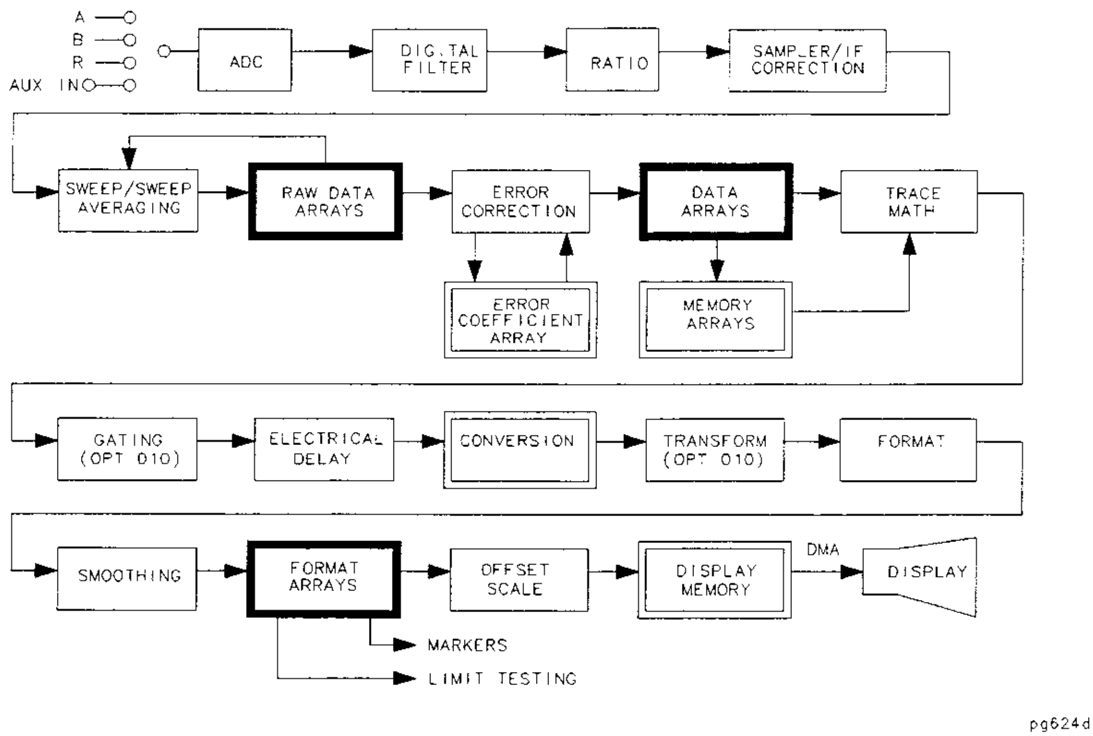


Figure 3-12. Data Processing Flow Diagram

1. If you want to title the displayed measurement, refer to "Titling the Displayed Measurement," located earlier in this chapter.
2. Press (SAVE/RECALL) SELECT DISK EXTERNAL DISK.
3. Press RETURN DEFINE DISK-SAVE.
4. Define the save by selecting one of the following choices:
   - ☐ DATA ARRAY ON
   - ☐ RAW ARRAY ON
   - ☐ FORMAT ARRAY ON
   - ☐ GRAPHICS ON
   - ☐ DATA ONLY ON

   If you select DATA ARRAY ON, or RAW ARRAY ON, or FORMAT ARRAY ON, the data is stored to disk in IEEE-64 bit real format (for LIF disks), and 32 bit PC format for DOS disks. This makes the DOS data files half the size of the LIF files.

   If you select GRAPHICS ON, the user graphics area is saved. (Refer to the *HP 8752C Programmer's Guide* for information on using display graphics.) The measurement display is not saved with this selection. (Refer to the information located earlier in this chapter for a procedure that shows you how to plot measurement displays to disk.)

Note	If you select DATA ONLY ON, you cannot recall and display the file contents on the analyzer. This type of data is intended for computer manipulation.

5. Choose the type of format you want:
   - ☐ Choose SAVE USING BINARY for all applications except CITIFILE or CAE applications.
   - ☐ Choose SAVE USING ASCII for CITIFILE and CAE applications or when you want to import the information into a spread sheet format.
6. Press RETURN SAVE STATE.

To Re-Save an Instrument State

If you re-save a file, the analyzer overwrites the existing file contents.

Note You cannot re-save a file that contains data only. You must create a new file.

1. Press (SAVE/RECALL) SELECT DISK and select the storage device:
   - INTERNAL MEMORY
   - EXTERNAL DISK
2. Press RETURN and then (⇓) repeatedly, until the name of the file that you want to re-save is high-lighted.
3. Press RE-SAVE STATE YES.

Deleting an Instrument State

1. Press (SAVE/RECALL) SELECT DISK.
2. Choose from the following storage devices:
   - INTERNAL MEMORY
   - EXTERNAL DISK
3. Press RETURN.

To Delete a Single Instrument State File

- Press the (⇓) repeatedly until the name of the file that you want to delete is high-lighted.
- Press FILE UTILITIES DELETE FILE YES.

To Delete all Instrument State Files

- Press FILE UTILITIES DELETE ALL FILES YES.

Renaming an Instrument State File

1. Press (SAVE/RECALL) SELECT DISK.
2. Choose from the following storage devices:
   - INTERNAL MEMORY
   - EXTERNAL DISK
3. Press the (⇩) repeatedly until the name of the file that you want to rename is high-lighted.
4. Press RETURN FILE UTILITIES RENAME FILE ERASE TITLE.
5. Turn the front panel knob to point to each character of the new filename, pressing SELECT LETTER when the arrow points to each character. Press BACK SPACE if you enter an incorrect character. After you have selected all the characters in the new filename, press DONE.

Recalling an Instrument State

1. Press (SAVE/RECALL) SELECT DISK.
2. Choose from the following storage devices:
   - INTERNAL MEMORY
   - EXTERNAL DISK
3. Press the (⇩) repeatedly until the name of the file that you want to recall is high-lighted.
4. Press RETURN RECALL STATE.

Formatting a Disk

1. Press (SAVE/RECALL) FILE UTILITIES FORMAT DISK.
2. Choose the type of format you want:
   - ☐ FORMAT:LIF
   - ☐ FORMAT:DOS
3. Press FORMAT EXT DISK YES.

If You Have Problems with Disk Storage

If you encounter a problem when you are storing files to disk, or the analyzer internal memory, check the following list for possible causes:

- Look in the analyzer display message area. The analyzer may show a message that will identify the problem. Refer to the "Error Messages" chapter if you view a message.
- Make sure that you are using a formatted disk.
- Make sure that the disk has not been formatted with the LIF-HFS (hierarchical file system) extensions as the analyzer does not support this format.
- Make sure that the analyzer is in system controller mode, by pressing (LOCAL) SYSTEM CONTROLLER.
- Make sure that you have connected the disk drive to ac power, switched on the power, and connected an HP-IB cable between the disk drive and the analyzer.
- Make sure that the analyzer recognizes the disk drive's HP-IB address, as explained earlier in this chapter.
- Make sure that the analyzer recognizes the disk (drive) unit that you selected (0 or 1).
- If the external disk is a hard disk, make sure that the disk volume number is set correctly.
- If the disk drive is an older HP 9122, it may not recognize the newer high density disks.
- Substitute the HP-IB cable.
- Substitute the disk drive.

4

Optimizing Measurement Results

This chapter describes techniques and analyzer functions that help you achieve the best measurement results. The following topics are included in this chapter:

- Increasing measurement accuracy
  - □ Connector repeatability
  - □ Interconnecting cables
  - □ Temperature drift
  - □ Frequency drift
  - □ Performance verification
  - □ Reference plane and port extensions
  - □ Measurement error-correction
  - □ Frequency response correction
  - □ Frequency response and isolation correction
  - □ One-port reflection correction
  - □ Modifying calibration kit standards
- Increasing sweep speed
- Increasing dynamic range
- Reducing trace noise

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, or Saving Measurement Results," contains instructions for saving to disk or to the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.

Increasing Measurement Accuracy

Connector Repeatability

Connector repeatability is a source of random measurement error. Measurement error-corrections do not compensate for these errors. For all connectors, you should frequently do the following:

- inspect the connectors
- clean the connectors
- gauge the connectors
- use correct connection techniques (see chapter 2)

Interconnecting Cables

Cables connecting the device under test to the analyzer can contribute random errors to your measurement. You should frequently do the following:

- inspect for lossy cables
- inspect for damaged cable connectors
- practice good connector care techniques
- minimize cable position changes between error-correction and measurements

Temperature Drift

Electrical characteristics will change with temperature due to the thermal expansion characteristics of devices within the analyzer, calibration devices, test devices, cables, and adapters. Therefore, the operating temperature is a critical factor in their performance. During an error-correction procedure, the temperature of the calibration devices must be stable and within 25 ±5 °C.

- use a temperature-controlled environment
- ensure the temperature stability of the calibration devices
- avoid handling the standard devices unnecessarily during error-correction
- ensure the ambient temperature is ±1° of error-correction temperature

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).

Performance Verification

You should periodically check the accuracy of the analyzer measurements, by doing the following:

- perform a measurement verification at least once per year

Refer to the *HP 8752C System Verification and Test Guide* for the measurement verification procedure.

Reference Plane and Port Extensions

Use the port extension feature to compensate for the phase shift of an extended measurement reference plane, due to such additions as cables, adapters, and fixtures, after completing an error-correction procedure (or when there is no active correction).

You can activate a port extension by pressing (CAL) MORE PORT EXTENSIONS EXTENSIONS ON. Then enter the delay to the reference plane.

Table 4-1. Differences between Port Extensions and Electrical Delay

	PORT EXTENSIONS	ELECTRICAL DELAY
Main Effect	The end of a cable becomes the test port plane.	Compensates for the electrical length of a cable. Set the cable's electrical length x 1 for transmission. Set the cable's electrical length x 2 for reflection
Measurements Affected	All measurements.	Only the currently selected measurement.
Electrical Compensation	Intelligently compensates for 1 times or 2 times the cable's electrical delay, depending on which measurement type is computed.	Only compensates as necessary for the currently selected measurement type.

Measurement Error-Correction

The accuracy of network analysis is greatly influenced by factors external to the network analyzer. Components of the measurement setup, such as interconnecting cables and adapters, introduce variations in magnitude and phase that can mask the actual response of the device under test.

Error-correction is an accuracy enhancement procedure that removes systematic errors (repeatable measurement variations) in the test setup. The analyzer measures known standard devices, and uses the results of these measurements to characterize the system.

Conditions Where Error-Correction is Suggested

Measurement accuracy and system characteristics can be affected when:

- You are adapting to a different connector type or impedance.
- You are connecting a cable between the test device and an analyzer test port.
- You are connecting any attenuator or other such device on the input or output of the test device.

If your test setup meets any of the conditions above, the system characteristics which may be affected include:

- amplitude at device input
- frequency response accuracy
- directivity
- crosstalk (isolation)
- source match

Types of Error-Correction

Several types of error-correction are available that remove various systematic errors. The following table explains each correction and its uses.

Table 4-2. Purpose and Use of Different Error Correction Procedures

Correction Procedure	Corresponding Measurement	Errors Corrected	Standard Devices
Response	Transmission or reflection measurement when the highest accuracy is not required.	Frequency response	Thru for transmission, open or short for reflection
Response & isolation (This is the most accurate correction offered for transmission.)	Transmission of high insertion loss devices or reflection of high return loss devices. Not as accurate as 1-port correction for reflection measurements.	Frequency response plus isolation in transmission or directivity in reflection	Same as response plus isolation standard (load)
Reflection 1-port	Reflection of any one-port device or well terminated two-port device.	Directivity, source match, frequency response.	Short and open and load

Error-Correction Stimulus State

Error-correction is only valid for a specific stimulus state, that you must select before you start a correction. If you change any of the following parameters, you will invalidate the correction and the analyzer will switch the correction off, unless you use the interpolated error-correction feature.

- frequency range
- number of points
- sweep type

The error-correction quality may be degraded (`Cor` display annotation changes to `C?`), if you change the following stimulus state parameters:

- sweep time
- system bandwidth
- output power

Note If you activate averaging, the analyzer may increase the sweep time if more time is needed to calculate the averages. If the sweep time changes, you will see the display annotation `Cor` change to `C?`. The number of averages does not affect a sweep cycle time. Therefore, if you use averaging for error-correction, leave it on for the measurement and set the averaging factor to 1, for a faster sweep.

Calibration Standards

The quality of the error-correction is limited by two factors: (1) the difference between the model of the calibration standards and the actual electrical characteristics of those standards, and (2) the condition of the calibration standards. To make the highest quality measurement error-correction, follow the suggestions below:

- use the correct standard model
- inspect the calibration standards
- clean the calibration standards
- gauge the calibration standards
- use correct connection techniques

If you want to use calibration standards other than the default sets contained in the analyzer memory, you must change the standard model (refer to "Modifying Calibration Kit Standards" located later in this chapter.) After you enter the mathematical model for the new calibration standards, the analyzer can then use a model that corresponds to the new standards.

Clarifying Type-N Connector Sex

When you are performing error-correction for a system that has type-N test port connectors, the softkey menus label the sex of the test port connector - *not* the calibration standard connector. For example, the label SHORT (F) refers to the short that will be connected to the *female* test port.

When to Use Interpolated Error-Correction

You may want to use interpolated error-correction when you choose a subset of a frequency range that you already corrected, or when you change the number of points. The analyzer calculates the systematic errors from the errors of the original correction. The quality of the interpolated error-correction depends on the amount of phase shift and amplitude change of the error coefficients between measurement points. If the phase shift is $<180°$ per five measurement points, the interpolated error-correction can be a great improvement over uncorrected measurement.

You can activate an interpolated measurement correction by pressing (CAL) INTERPOL ON.

Procedures for Error-Correcting Your Measurements

This section has example procedures or information on the following topics:

- frequency response correction
- frequency response and isolation correction
- one-port reflection correction
- modifying calibration kit standards

Note If you are making measurements on uncoupled measurement channels, you must make a correction for each channel.

Frequency Response Error-Corrections

You can remove frequency response of the test setup for the following measurements.

- reflection measurements
- transmission measurements
- combined reflection and transmission measurements

Response Error-Correction for Reflection Measurements

1. Press (PRESET).
2. To select the measurement, press:

   (MEAS) REFLECTION

3. Set any other measurement parameters that you want for the device measurement:

   - power
   - sweep type
   - number of points
   - IF bandwidth

4. To access the measurement correction menus, press:

   (CAL)

5. If your calibration kit is not the type-N default, press:

   CAL KIT select your type of kit

   RETURN

   If your type of calibration kit is not listed in the displayed menu, refer to the "Modifying Calibration Standards" procedure, located later in this chapter.

6. To select a response correction, press:

   CALIBRATE MENU RESPONSE

7. Connect the short or open calibration standard to the REFLECTION PORT.

Note Include any adapters, or cables, that you will have in the device measurement. That is, connect the standard device to the particular connector where you will connect your device under test.

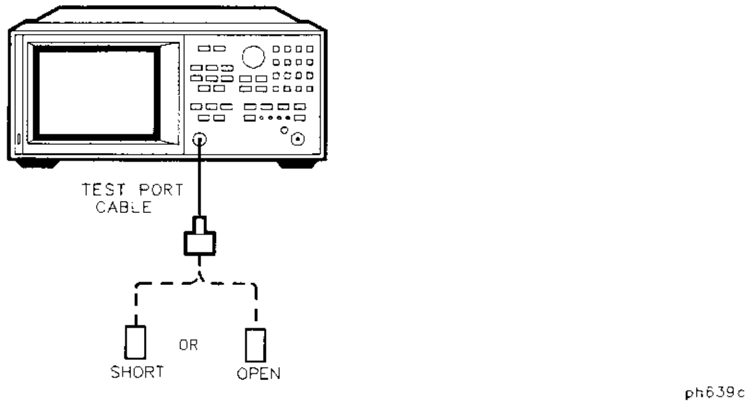


Figure 4-1.
Standard Connections for a Response Error-Correction for Reflection Measurement

8. To measure the standard when the displayed trace has settled, press one of the following:

   SHORT or OPEN

   If the calibration kit you selected has a choice between male and female calibration standards, remember to select the sex that applies to the test port and not the standard.

   The analyzer displays `WAIT - MEASURING CAL STANDARD` during the standard measurement. The analyzer underlines the softkey that you selected after it finishes the measurement.

Note Choose *only* one standard for response error-correction. If you choose a second standard, the correction will overwrite the first standard. *Do not* use a thru standard for a reflection response correction.

---

9. To compute the error coefficients, press:

   DONE: RESPONSE

Note You can save or store the measurement correction to use for later measurements that use the same measurement parameters. Refer to the "Printing, Plotting, and Saving Measurement Results" chapter for procedures.

---

10. This completes the response correction for reflection measurements. You can connect and measure your device under test.

    The alternate sweep is still activated, which will make a slower sweep time that the usual chop mode.

Response Error-Correction for Transmission Measurements

1. Press (PRESET).
2. To select the measurement, press:

   (MEAS) TRANSMISSN
3. Set any other measurement parameters that you want for the device measurement:
   - power
   - number of points
   - IF bandwidth
4. To access the measurement correction menus, press:

   (CAL)
5. If your calibration kit is not the type-N default, press:

   CAL KIT select your type of kit
   RETURN
6. To select a response correction, press:

   CALIBRATE MENU RESPONSE
7. Make a "thru" connection between the points where you will connect your device under test.

Note Include any adapters, or cables, that you will have in the device measurement. That is, make the "thru" connection where you will connect your device under test.

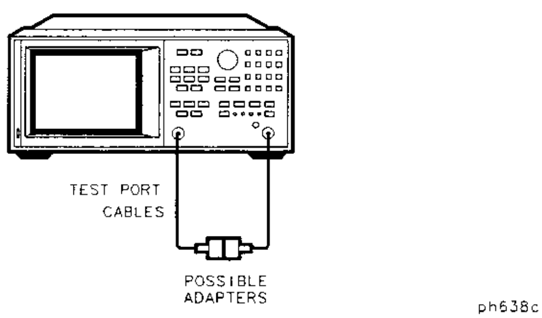


Figure 4-2.
Standard Connections for Response Error-Correction for Transmission Measurements

8. To measure the standard, press:

   THRU

   The analyzer displays WAIT - MEASURING CAL STANDARD during the standard measurement. The analyzer underlines the THRU softkey after it measures the calibration standard.

Note *Do not* use an open or short standard for a transmission response correction.

9. To compute the error coefficients, press:

   DONE: RESPONSE

Note You can save or store the measurement correction to use for later measurements. Refer to the "Printing, Plotting, and Saving Measurement Results" chapter for procedures.

10. This completes the response correction for transmission measurements. You can connect and measure your device under test.

Frequency Response and Isolation Error-Corrections

- removes frequency response of the test setup
- removes isolation in transmission measurements
- removes directivity in reflection measurements

You can make a response and isolation correction for the following measurements.

- reflection measurements
- transmission measurements
- combined reflection and transmission measurements

Response and Isolation Error-Correction for Reflection

Measurements

Although you can perform a response and isolation correction for reflection measurements, Hewlett-Packard recommends that you perform a one-port reflection error-correction: it is more accurate, and it is just as convenient.

1. Press (PRESET).
2. To select the measurement, press:

   (MEAS) REFLECTION

3. Set any other measurement parameters that you want for the device measurement:

   - power
   - sweep type
   - number of points
   - IF bandwidth

4. To access the measurement correction menus, press:

   (CAL)

5. If your calibration kit is not the type-N default, press:

   CAL KIT select your type of kit

   RETURN

If your type of calibration kit is not listed in the displayed menu, refer to the "Modifying Calibration Standards" procedure, located later in this chapter.

6. To select a response and isolation correction, press:

   CALIBRATE MENU RESPONSE & ISOL'N RESPONSE

7. Connect the short or open calibration standard to the REFLECTION PORT.

Note Include any adapters that you will have in the device measurement. That is, connect the standard device to the particular connector where you will connect your device under test.

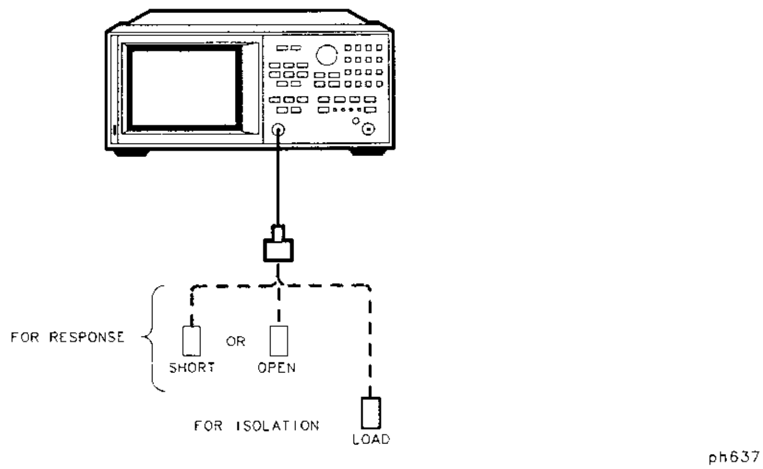


Figure 4-3.
Standard Connections for a Response and Isolation Error-Correction for Reflection Measurements

8. To measure the standard, press:

   SHORT or OPEN

   If the calibration kit you selected has a choice between male and female calibration standards, remember to select the sex that applies to the test port and not the standard.

   The analyzer displays WAIT - MEASURING CAL STANDARD during the standard measurement. The analyzer underlines the softkey that you selected after it finishes the measurement.

9. To compute the error coefficients, press:

   DONE: RESPONSE

10. Connect the load calibration standard to the test port.

11. To measure the standard for the isolation portion of the correction, press:

    ISOL'N STD

12. To compute the response and directivity error coefficients:

    DONE RESP ISOL'N CAL

The analyzer displays the corrected data. The analyzer also shows the notation Cor to the left of the screen, indicating that the correction is switched on for this channel.

Note You can save or store the error-correction to use for later measurements. Refer to the "Printing, Plotting, and Saving Measurement Results" chapter for procedures.

13. This completes the response and isolation error-correction for reflection measurements. You can connect and measure your device under test.

Response and Isolation Error-Correction for Transmission

Measurements

This procedure is intended for measurements that have a measurement range of greater than 90 dB.

1. Press (PRESET).
2. To select the measurement, press:

   (MEAS) TRANSMISSN

3. Set any other measurement parameters that you want for the device measurement:
   - power
   - number of points
   - IF bandwidth
4. To access the measurement correction menus, press:

   (CAL)

5. If your calibration kit is not the type-N default, press:

   CAL KIT select your type of kit

   RETURN

   If your type of calibration kit is not listed in the displayed menu, refer to the "Modifying Calibration Standards" procedure, located later in this chapter.

6. To select a response and isolation correction, press:

   CALIBRATE MENU RESPONSE & ISOL'N RESPONSE

7. Make a "thru" connection between the points where you will connect your device under test.

Note Include any adapters that you will have in the device measurement. That is, make the "thru" connection where you will connect your device under test.

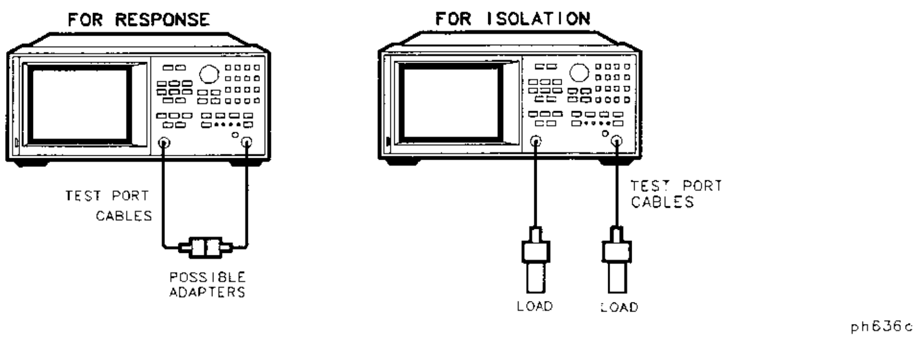


Figure 4-4.
Standard Connections for a Response and Isolation Error-Correction for Transmission Measurements

8. To measure the standard, when the displayed trace has settled, press:

   THRU

   The analyzer displays WAIT - MEASURING CAL STANDARD during the standard measurement. The analyzer underlines the THRU softkey after it measures the calibration standard.

9. To compute the error coefficients, press:

   DONE: RESPONSE

10. Connect impedance-matched loads to both test ports, as shown in Figure 4-4. Include the adapters that you would include for your device measurement.

Note If you will be measuring highly reflective devices, such as filters, use the test device, connected to the reference plane and terminated with a load, for the isolation standard.

11. To help remove crosstalk noise, set the analyzer as follows:

    a. Press (AVG) AVERAGING ON AVERAGING FACTOR and enter at least four times more averages than desired during the device measurement.

    b. Press (CAL) MORE ALTERNATE RFL/TRN .

12. To measure the calibration standard, press:

    (CAL) RESUME CAL SEQUENCE ISOL'N STD

13. To compute the isolation error coefficients, press:

    DONE RESP ISOL'N CAL

    The analyzer displays the corrected data trace. The analyzer also shows the notation Cor at the left of the screen, indicating that the correction is switched on for this channel.

Note You can save or store the measurement correction to use for later measurements. Refer to the "Printing, Plotting, and Saving Measurement Results" chapter for procedures.

14. This completes the response and isolation correction for transmission measurements. You can connect and measure your device under test.

One-Port Reflection Error-Correction

- removes directivity errors of the test setup
- removes source match errors of the test setup
- removes frequency response of the test setup

Note This is the recommended error-correction process for all reflection measurements.

1. Press (PRESET).
2. To select the measurement, press:

   (MEAS) REFLECTION

3. Set any other measurement parameters that you want for the device measurement:
   - power
   - number of points
   - IF bandwidth
4. To access the measurement correction menus, press:

   (CAL)

5. If your calibration kit is not the type-N default, press:

   CAL KIT select your type of kit
   RETURN

   If your type of calibration kit is not listed in the displayed menu, refer to the "Modifying Calibration Standards" procedure, located later in this chapter.

6. To select the correction type, press:

   CALIBRATE MENU REFLECTION 1-PORT

7. Connect a shielded open circuit to the REFLECTION PORT.

Note Include any adapters that you will have in the device measurement. That is, connect the calibration standard to the particular connector where you will connect your device under test.

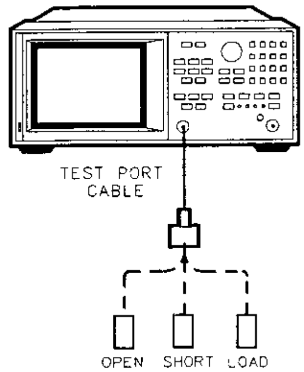


Figure 4-5. Standard Connections for a One-Port Reflection Error-Correction

8. To measure the standard, when the displayed trace has settled, press:

   OPEN

Note If the calibration kit that you selected has a choice between male or female calibration standards, remember to select the sex that applies to the test port and not the standard.

The analyzer displays WAIT - MEASURING CAL STANDARD during the standard measurement. The analyzer underlines the OPEN softkey after it measures the calibration standard.

9. Disconnect the open, and connect a short circuit to the test port.
10. To measure the standard when the displayed trace has settled, press:

    SHORT

    The analyzer measures the short circuit and underlines the SHORT softkey.

11. Disconnect the short, and connect an impedance-matched load to the test port.
12. When the displayed trace settles, press LOAD.

    The analyzer measures the load and underlines the LOAD softkey.

13. To compute the error coefficients, press:

    DONE: 1-PORT CAL

    The analyzer displays the corrected data trace. The analyzer also shows the notation Cor to the left of the screen, indicating that the correction is switched on for this channel.

Note You can make the open, short, and load measurements in any order, and do not need not follow the order in this example.

Note You can save or store the error-correction to use for later measurements. Refer to the "Printing, Plotting, and Saving Measurement Results" chapter for procedures.

---

14. This completes the one-port correction for reflection measurements. You can connect and measure your device under test.

Modifying Calibration Kit Standards

Note Hewlett-Packard strongly recommends that you read application note 8510-5A before attempting to view or modify standard definitions. The part number of this application note is 5956-4352.

Although the application note is written for the HP 8510 family of network analyzers, it also applies to the HP 8752. This portion of the correction chapter provides a summary of the information in the application note, as well as HP 8752 menu-specific information.

Note Numerical data for most Hewlett-Packard calibration kits is provided in the calibration kit manuals.

Definitions

The following are definitions of terms:

- A "standard" (represented by a number 1-8) is a specific, well-defined, physical device used to determine systematic errors.
- A standard "type" is one of five basic types that define the form or structure of the model to be used with that standard (short, open, load, delay/thru, and arbitrary impedance).
- Standard "coefficients" are numerical characteristics of the standards used in the model selected.
- A standard "class" is a grouping of one or more standards that determines which standards are used in a particular correction procedure.

Outline of Standard Modification

The following steps are used to modify or define user kit standard models, contained in the analyzer memory:

1. To modify a user calibration kit, first select the predefined kit to be modified. (This is not necessary for defining a new calibration kit.)
2. Define the standards. For each standard, define which "type" of standard it is and its electrical characteristics.
3. Specify the class where the standard is to be assigned.
4. Store the modified calibration kit.

Modifying Standards

1. Press CAL CAL KIT.
2. Select the softkey that corresponds to the kit you want to modify.
3. Press MORE MODIFY DEFINE STANDARD
4. Enter the number of the standard that you want to modify, followed by x1. Refer to your calibration kit manual for the numbers of the specific standards in your kit. For example, to select a short press 1 x1.

Table 4-3. Typical Calibration Kit Standard and Corresponding Number

Typical Standard Type	Default Number
short	1
open	2
load	3
delay/thru	4

5. Press the underlined softkey. For example, if you selected 1 x1 in the previous step, SHORT should be the underlined softkey.
6. This step applies only to the *open*. Go to the next step if you selected any other standard.
   a. Press OPEN C0. Observe the value on the analyzer screen. Use the entry keys on the analyzer front panel to change the value.
   b. Repeat the modification for C1, C2, and C3.
7. This step applies only to the *load*. Go to the next step if you selected any other standard.

   Ensure that the correct load type is underlined: FIXED or SLIDING.
8. Press SPECIFY OFFSET OFFSET DELAY and observe the value on the analyzer screen. To change the value, use the entry keys on the front panel.
9. Repeat the value modification for the characteristics listed below:
   - OFFSET LOSS
   - OFFSET Z0
   - MINIMUM FREQUENCY
   - MAXIMUM FREQUENCY
10. Ensure that the correct transmission line is underlined: COAX or WAVEGUIDE.
11. Press STD OFFSET DONE STD DONE (DEFINED).
12. Press DEFINE STANDARD and repeat steps 4 through 11 for the remaining standards.

Saving the modified calibration constants

If you made modifications to any of the standard definitions, follow the remaining steps in this procedure to assign a kit label, and store them in the non-volatile memory. The new set of standard definitions will be available under USER KIT until you save another user kit.

13. Press LABEL KIT ERASE TITLE and use the front panel knob to move the pointer to a character and press SELECT LETTER.
14. Press DONE KIT DONE (DEFINED) SAVE USER KIT.

Increasing Sweep Speed

You can increase the analyzer sweep speed by avoiding the use of some features that require computational time for implementation and updating, such as bandwidth marker tracking.

You can also increase the sweep speed by making adjustments to the measurement settings. The following suggestions for increasing sweep speed are general rules that you should experiment with.

- decrease the frequency span
- set the auto sweep time mode
- widen the system bandwidth
- reduce the averaging factor
- reduce the number of measurement points
- set the sweep type
- use chop sweep mode

To Decrease the Frequency Span

The hardware of the network analyzer sweeps the frequency range in octave bands, where switching from band to band takes time. Eliminate as many band switches as possible while maintaining measurement integrity.

1. To see the band switch points (steps), press:

   (SYSTEM) SERVICE MENU ANALOG BUS ON

   (MEAS) ANALOG IN (29) (x1)

   (FORMAT) MORE REAL

   (SCALE REF) AUTO SCALE

2. Enter the measurement frequency span of the device under test. Autoscale and modify the frequency span as appropriate.

To Set the Auto Sweep Time Mode

Auto sweep time mode is the default mode (the preset mode). This mode maintains the fastest sweep speed possible for the current measurement settings.

- Press (MENU) SWEEP TIME (0) (x1) to re-enter the auto mode.

To Widen the System Bandwidth

1. Press (AVG) IF BW.
2. Set the IF bandwidth to change the sweep time.

   The following table shows the relative increase in sweep time as you decrease system bandwidth.

IF BW	Sweep Time (Seconds)[1]	
	Full Span	Narrow Sweep
3000 Hz	0.44	0.18
1000 Hz	0.5	0.33
300 Hz	0.95	0.76
100 Hz	2.24	2.07
30 Hz	7.75	7.14
10 Hz	21.93	21.52

1 The listed sweep times correspond to the analyzer being set to a preset state for the full span (300 kHz to 6 GHz), and 900 MHz to 1 GHz for the narrow span.

To Reduce the Averaging Factor

By reducing the averaging factor (number of sweeps) or switching off averaging, you can increase the analyzer's measurement speed. The time needed to compute averages can also slow the sweep time slightly, in narrow spans.

1. Press (AVG) AVG FACTOR.
2. Enter an averaging factor that is less than the value displayed on the analyzer screen and press (x1).
3. If you want to switch off averaging, press (AVG) AVERAGING OFF.

To Reduce the Number of Measurement Points

1. Press (MENU) NUMBER OF POINTS.
2. Enter a number of points that is less than the value displayed on the analyzer screen and press (x1).

The analyzer sweep time does not change proportionally with the number of points, but as indicated below.

Number of Points	Sweep Time (Seconds)[1]			
	Full Span		Narrow Span	
	LIN	LIST/LOG	LIN	LIST
51	0.35	0.57	0.09	0.25
101	0.39	0.77	0.12	0.43
201	0.43	1.11	0.17	0.78
401	0.49	1.73	0.27	1.33
801	0.69	3.04	0.47	2.64
1601	1.09	5.7	0.87	5.3

1 The listed sweep times correspond to the analyzer being set to a preset state, with a 6 GHz span. A 3 GHz span would have faster sweep times.

To Set the Sweep Type

The relative sweep times of the three types of non-power sweeps are indicated in the table in "To Reduce the Number of Measurement Points."

1. Press (MENU) SWEEP TYPE MENU.
2. Select the sweep type:
   - □ Select LIN FREQ for the fastest sweep for a given number of fixed points. In addition to the numbers listed in the table "To Reduce the Number of Measurement Points," the linear frequency format also has point settings of 3, 11, and 26.
   - □ Select LIST FREQ for the fastest sweep when specific frequency points are of interest.
   - □ Select LOG FREQ for the fastest sweep when the frequency points of interest are in the lower part of the frequency span selected.

To View a Single Measurement Channel

Viewing a single channel will increase the measurement speed if the instrument's two channels are in alternate, or uncoupled mode.

1. Press (DISPLAY) DUAL CHAN OFF.
2. Press (CH 1) and (CH 2) to alternately view the two measurement channels.

   If you must view both measurement channels simultaneously (with dual channel), use the chop sweep mode, explained next.

To Activate Chop Sweep Mode

You can use the chop sweep mode to make two measurements at the same time, while maintaining a fast measurement speed. For example, the analyzer can measure two different reflection or transmission parameters, or reflection and transmission simultaneously. You can activate the chop mode by pressing (PRESET) or by the following the sequence below.

- Press (CAL) MORE CHOP RFL/TRN.

Increasing Dynamic Range

Dynamic range is the difference between the analyzer's maximum allowable input level and minimum measurable power. For a measurement to be valid, input signals must be within these boundaries. The dynamic range is affected by these factors:

- test port input power
- test port noise floor
- receiver crosstalk

To Increase the Test Port Input Power

You can increase the analyzer's source output power so that the test device output power is at the top of the measurement range of the analyzer test port (0 dBm at the transmission port, or +10 dBm at the reflection port).

Press (MENU) POWER and enter the new source power level, followed by (x1).

Caution **TEST PORT INPUT DAMAGE LEVEL: +20 dBm**

To Reduce the Receiver Noise Floor

Since the dynamic range is the difference between the analyzer's input level and its noise floor, using the following techniques to lower the noise floor will increase the analyzer's dynamic range.

Changing System Bandwidth

Each tenfold reduction in IF (receiver) bandwidth lowers the noise floor by 10 dB. For example, changing the IF bandwidth from 3 kHz to 300 Hz, you will lower the noise floor by about 10 dB.

1. Press (AVG) IF BW.
2. Enter the bandwidth value that you want, followed by (x1).

Changing Measurement Averaging

You can apply weighted averaging of successive measurement traces to remove the effects of random noise.

1. Press (AVG) AVERAGING FACTOR.
2. Enter a value followed by (x1).
3. Press AVERAGING ON.

   Refer to the "Application and Operation Concepts" chapter for more information on averaging.

Reducing Trace Noise

You can use two analyzer functions to help reduce the effect of noise on the data trace:

- activate measurement averaging
- reduce system bandwidth

If you will be making an error-corrected measurement, you must do the following noise reduction techniques during the correction process as well as during the measurement.

To Activate Averaging

The noise is reduced with each new sweep as the effective averaging factor increments.

1. Press (AVG) AVERAGING FACTOR.
2. Enter a value followed by (x1).
3. Press AVERAGING ON.

   Refer to the "Application and Operation Concepts" chapter for more information on averaging.

To Change System Bandwidth

By reducing the system bandwidth, you reduce the noise that is measured during the sweep. While averaging requires multiple sweeps to reduce noise, narrowing the system bandwidth reduces the noise on each sweep.

1. Press (AVG) IF BW.
2. Enter the IF bandwidth value that you want, followed by (x1).

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

Reducing Receiver Crosstalk

To reduce receiver crosstalk you can do the following:

- perform a response and isolation measurement calibration
- set the sweep to the alternate mode

Alternate sweep is intended for measuring wide dynamic range devices, such as high pass and bandpass filters. This sweep mode removes a type of leakage term through the device under test, from one channel to another.

To set the alternate sweep, press (CAL) MORE ALTERNATE RFL/TRN.

Refer to the procedures, located earlier in this chapter for a response and isolation measurement calibration procedure.

5

Application and Operation Concepts

This chapter provides conceptual information on the following primary operations and applications that are achievable with the HP 8752C network analyzer.

- How the HP 8752C works
- How the HP 8752C processes data
- Using the active channel keys
- Using the entry block keys
- Using the stimulus functions
- Using the response functions
- What is measurement calibration?
- Using markers
- Using the instrument state functions
- Understanding and using time domain
- What is test sequencing?
- Amplifier measurements
- Connection considerations
- Reference documents

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 4, "Optimizing Measurement Results," describes techniques and functions for achieving the best measurement results.
- Chapter 6, "Specifications and Measurement Uncertainties," defines the performance capabilities of the analyzer.
- Chapter 7, "Menu Maps," shows softkey menu relationships.
- Chapter 8, "Key Definitions," describes all the front panel keys and softkeys.

How the HP 8752C Works

Network analyzers measure the reflection and transmission characteristics of devices and networks. A network analyzer test system consists of the following:

- source
- signal-separation devices
- receiver
- display

The analyzer applies a signal that is transmitted through the test device, or reflected from its input, and then compares it with the incident signal generated by the swept RF source. The signals are then applied to a receiver for measurement, signal processing, and display.

The HP 8752C vector network analyzer integrates a high resolution synthesized RF source, test set, and a dual channel three-input receiver to measure and display magnitude, phase, and group delay of transmitted and reflected power. The HP 8752C Option 010 has the additional capability of transforming measured data from the frequency domain to the time domain. Other options are explained in Chapter 1, "HP 8752C Description and Options." Figure 5-1 is a simplified block diagram of the network analyzer system. A detailed block diagram of the analyzer is provided in the *HP 8752C Network Analyzer Service Guide* together with a theory of system operation.

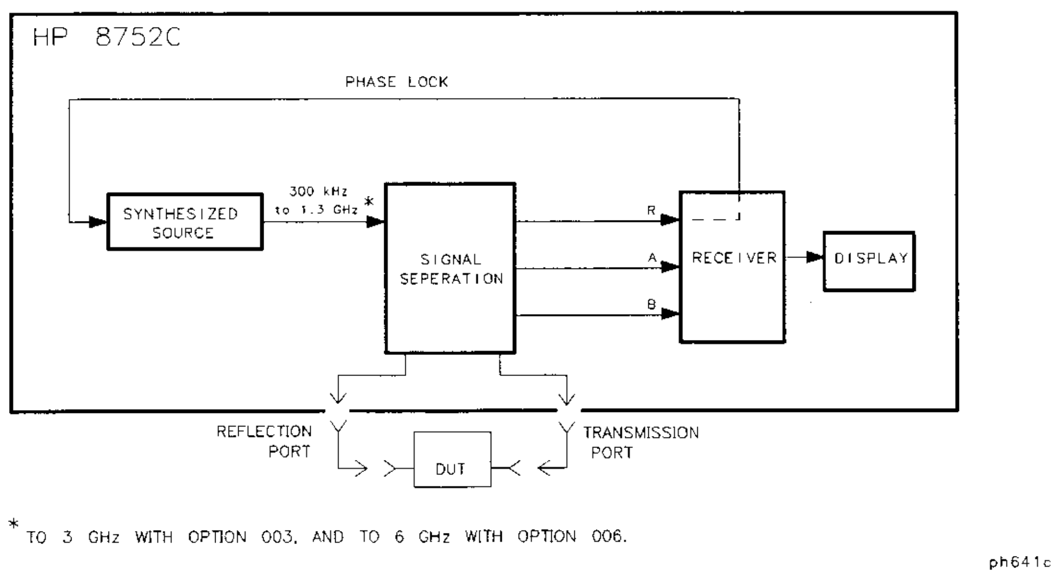


Figure 5-1. Simplified Block Diagram of the Network Analyzer System

The built-in synthesized source

The analyzer's built-in synthesized source produces a swept RF signal in the range of 300 kHz to 1.3 GHz. The HP 8752C Option 003 is able to generate signals up to 3 GHz and the Option 006 up to 6 GHz. The RF output power is leveled by an internal ALC (automatic leveling control) circuit. To achieve frequency accuracy and phase measuring capability, the analyzer is phase locked to a highly stable crystal oscillator. For this purpose, a portion of the transmitted signal is internally routed to the R channel input of the receiver, where it is sampled by the phase detection loop and fed back to the source.

The source step attenuator (option 004)

The step attenuator contained in the source is used for applying low power levels to the test device.

The built-in test set

The HP 8752C features a built-in test set that provides connections for the test device. Signal separation is accomplished through a dual coupler on the reflection test port. The dual coupler separately directs coupled portions of the incident signal and reflected signal to the R-channel and A-channel sampler/mixers of the receiver respectively. Meanwhile, the transmitted signal is routed directly from the transmission test port to the receiver's B-channel sampler/mixer.

The receiver block

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

The microprocessor

A microprocessor takes the raw data and performs all the required error correction, trace math, formatting, scaling, averaging, and marker operations, according to the instructions from the front panel or over HP-IB. The formatted data is then displayed. The data processing sequence is described in "How the HP 8752C Processes Data" in this chapter.

Required peripheral equipment

Measurements will require calibration standards for vector accuracy enhancement, and cables for interconnections. Model numbers and details of compatible power splitters, calibration kits, and cables are provided in Chapter 10, "Compatible Peripherals."

How the HP 8752C Processes Data

The analyzer's receiver converts the R, A, and B input signals into useful measurement information. This conversion occurs in two main steps:

- The swept high frequency input signals are translated to fixed low frequency IF signals, using analog sampling or mixing techniques. (Refer to the *HP 8752C Network Analyzer Service Guide* for more details on the theory of operation.)
- The IF signals are converted into digital data by an analog to digital converter (ADC). From this point on, all further signal processing is performed mathematically by the analyzer microprocessors.

The following paragraphs describe the sequence of math operations and the resulting data arrays as the information flows from the ADC to the display. They provide a good foundation for understanding most of the response functions, and the order in which they are performed.

Figure 5-2 is a data processing flow diagram that represents the flow of numerical data from IF detection to display. The data passes through several math operations, denoted in the figure by single line boxes. Most of these operations can be selected and controlled with the front panel RESPONSE block menus. The data is also stored in arrays along the way, denoted by double line boxes. These arrays are places in the flow path where data is accessible, usually via HP-IB.

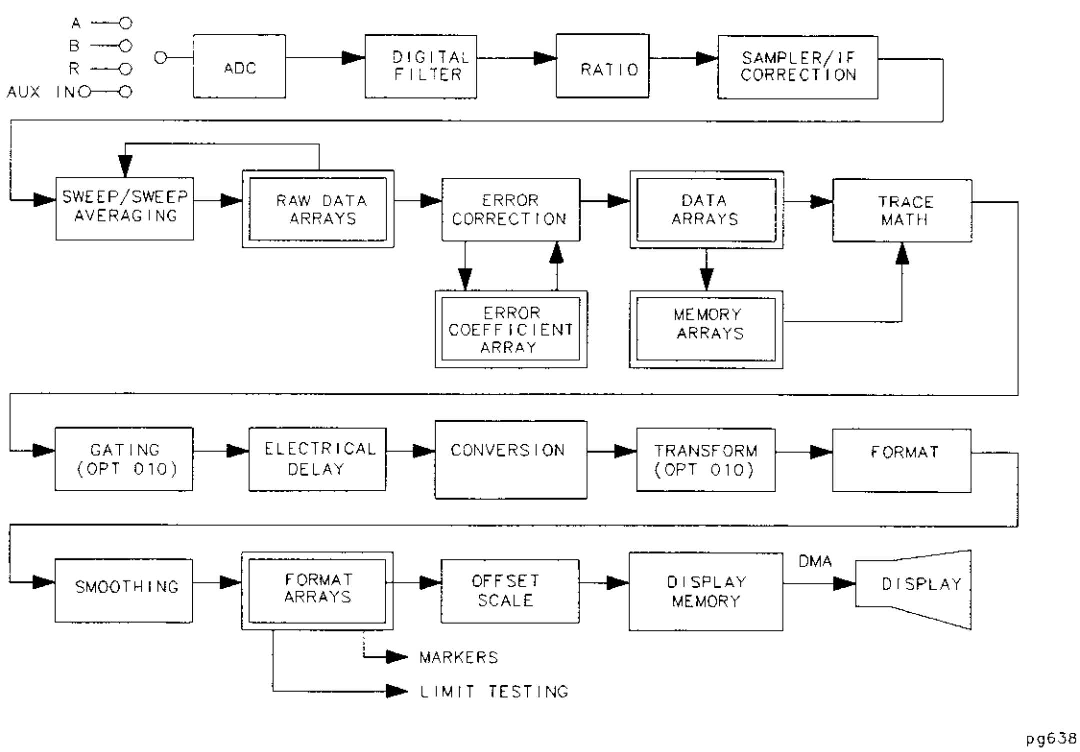


Figure 5-2. Data Processing Flow Diagram

While only a single flow path is shown, two identical paths are available, corresponding to channel 1 and channel 2. When the channels are uncoupled, each channel is processed and controlled independently.

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

Sweep definition: A "sweep" is a series of consecutive data point measurements, taken over a sequence of stimulus values. A few data processing operations require that a full sweep of data is available. The number of points per sweep can be defined by the user. The units of the stimulus values (such as power, frequency, and time) can change, depending on the sweep mode, although this does not generally affect the data processing path.

Processing details

The ADC

The ADC (analog-to-digital converter) converts the R, A, and B inputs (already down-converted to a fixed low frequency IF) into digital words. (The AUX INPUT connector on the rear panel is a fourth input.) The ADC switches rapidly between these inputs, so they are converted nearly simultaneously.

IF detection

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

Ratio calculations

These are performed if the selected measurement is a ratio of two inputs (for example, A/R or B/R). This is a complex divide operation. If the selected measurement is absolute (e.g. A or B), no operation is performed. The R, A, and B values are also split into channel data at this point.

Sampler/IF correction

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

Sweep-to-sweep averaging

This is another noise reduction technique. This calculation involves taking the complex exponential average of several consecutive sweeps. This technique cannot be used with single-input measurements.

Raw data arrays

These store the results of all the preceding data processing operations. (Up to this point, all processing is performed real-time with the sweep by the IF processor. The remaining operations are not necessarily synchronized with the sweep, and are performed by the main processor.) The only user-selected feature that affects the raw data array is averaging. When the channels are uncoupled (coupled channels off), two raw arrays may exist. The numbers in the raw data arrays are complex pairs. Raw data arrays can be saved to disk, or transferred to another computer over HP-IB.

Built-in error correction

This instrument contains a built-in error correction feature. Built-in error correction removes repeatable systematic errors (frequency response, source match, and directivity errors) caused by the built-in coupler, RF connectors, and supplied cable. This feature is automatic, and cannot be turned off. The information from the raw array is used to create the built-in correction array.

This array is not available over HP-IB, and it cannot be saved to disk.

User-performed measurement calibration

If the operator has performed a measurement calibration, and correction is turned on, the analyzer performs this data processing step. This form of accuracy enhancement removes repeatable systematic errors caused by adapters, extra test cables, or external test equipment. It is also used when measuring devices with nominal impedance different from the analyzer's system impedance (Z_0). The user-performed measurement calibration data is stored in the error coefficient arrays. These are subsequently used whenever correction is on, and are accessible via HP-IB. Error coefficient arrays can also be stored to disk.

The results of error correction are stored in the data arrays as complex number pairs. If the data-to-memory operation is performed, the data arrays are copied into the memory arrays.

Trace math operation

This selects either the data array, memory array, or both to continue flowing through the data processing path. In addition, the complex ratio of the two (data/memory) or the difference (data−memory) can also be selected. If memory is displayed, the data from the memory arrays goes through exactly the same data processing flow path as the data from the data arrays.

Gating

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

The delay block

This involves adding or subtracting phase in proportion to frequency. This is equivalent to "line-stretching" or artificially moving the measurement reference plane.

Conversion transforms

This transforms the measured reflection/transmission data to the equivalent complex impedance (Z) or admittance (Y) values, or to inverse S-parameters (1/S).

Windowing

This is a digital filtering operation that prepares (enhances) the frequency domain data for transformation to time domain (option 010).

Time domain transform

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

Formatting

This converts the complex number pairs into a scalar representation for display, according to the selected format. This includes group delay calculations. These formats are often easier to interpret than the complex number representation. (Polar and Smith chart formats are not affected by the scalar formatting.) Notice that after formatting, it is impossible to recover the complex data.

Smoothing

This is another noise reduction technique, that smoothes noise on the trace. The primary application of smoothing is to set the aperture for group delay measurements.

When smoothing is on, each point in a sweep is replaced by the moving average value of several adjacent (formatted) points. The number of points included depends on the smoothing aperture, which can be selected by the user. The effect is similar to video filtering. If data and memory are displayed, smoothing is performed on the memory trace only if smoothing was on when data was stored into memory.

Format arrays

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

Offset and scale

These operations prepare the formatted data for display. This is where the reference line position, reference line value, and scale calculations are performed, as appropriate to the format.

Display memory

The display memory stores the display image for presentation on the analyzer. The information stored includes graticules, annotation, and softkey labels. If user display graphics are written, these are also stored in display memory. When hardcopy records are made, the information sent to the plotter or printer is taken from display memory.

Finally, the display memory data is sent to the analyzer's display. The display is updated frequently and asynchronously with the data processing operations.

Using the Active Channel Keys

The analyzer has two digital channels for independent measurements. Two different sets of data can be measured simultaneously, for example, the reflection and transmission characteristics of a device, or one measurement with two different frequency spans. The analyzer can separately, or simultaneously, show the data. The corresponding HP-IB programming commands are CHAN1 and CHAN2.

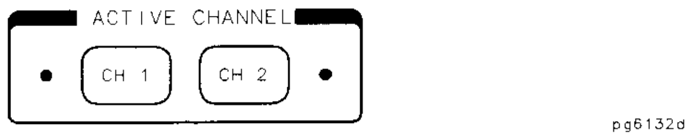


Figure 5-3. Active Channel Keys

The (CH 1) and (CH 2) keys shown in Figure 5-3 allow you to select the "active channel." The front panel keys currently allow you to control the active channel. All of the channel-specific functions that you select apply to the active channel. The current active channel is indicated by an amber LED adjacent to the corresponding channel key.

Dual trace

The analyzer has dual trace capability, so that you can view both the active and inactive channel traces, either overlaid or on separate graticules one above the other (split display). The dual channel and split display features are available in the display menus. Refer to "Display functions" later in this chapter for illustrations and descriptions of the different display capabilities.

Uncoupling stimulus values between channels

You can uncouple the stimulus values between the two display channels by pressing COUPLED CH ON off. This allows you to assign different stimulus values for each channel; it's almost like having the use of a second analyzer. The coupling and uncoupling of the stimulus values for the two channels is independent of the display and marker functions. Refer to "Channel stimulus coupling" later in this chapter for a listing of the stimulus parameters associated with the coupled channel mode.

Coupled markers

Measurement markers can have the same stimulus values (coupled) for the two channels, or they can be uncoupled for independent control in each channel. Refer to "Using Markers" later in this chapter for more information about markers.

Using the Entry Block Keys

The ENTRY block, illustrated in Figure 5-4, includes the numeric and units keypad, the knob, and the step keys. You can use these in combination with other front panel keys and softkeys for the following reasons:

- to modify the active entry
- to enter or change numeric data
- to change the value of the active marker

Generally, the keypad, knob, and step keys can be used interchangeably.

Before you can modify a function, you must activate the particular function by pressing the corresponding front panel key or softkey. Then you can modify the value directly with the knob, the step keys, or the digits keys and a terminator. If no other functions are activated, the knob moves the active marker.

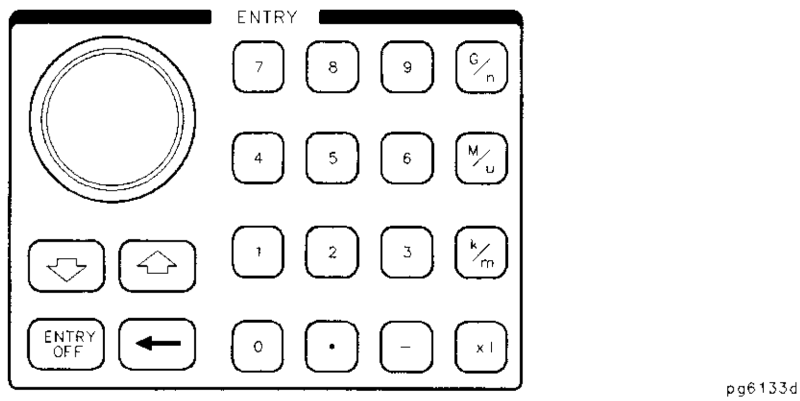


Figure 5-4. Entry Block

Units terminator

The units terminator keys are the four keys in the right column of the keypad. You must use these keys to specify units of numerical entries from the keypad. A numerical entry is incomplete until a terminator is supplied. The analyzer indicates that an input is incomplete by a data entry arrow ← pointing at the last entered digit in the active entry area. When you press the units terminator key, the arrow is replaced by the units you selected. The units are abbreviated on the terminator keys as follows:

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

Knob

You can use the knob to make continuous adjustments to current measurement parameter values or the active marker position. Values changed by the knob are effective immediately, and require no units terminator.

Step keys

You can use the step keys (▲) (up) and (▼) (down) to step the current value of the active function up or down. The analyzer defines the steps for different functions. No units terminator is required. For editing a test sequence, you can use these keys to scroll through the displayed sequence.

(ENTRY OFF)

You can use this key to clear and turn off the active entry area, as well as any displayed prompts, error messages, or warnings. Use this function to clear the display before plotting. This key is also helpful in preventing the changing of active values by accidentally moving the knob.

(←)

You can use this key to delete the last entry, or the last digit entered from the numeric keypad. You can also use this key in one of two ways for modifying a test sequence:

- deleting a single-key command that you may have pressed by mistake, (for example TRANSMISSN)
- deleting the last digit in a series of digits that you may have input, as long as you haven't yet pressed a terminator, (for example if you pressed (START) (1) (2) but did not press (G/n), etc)

(.)

You can use this key to add a decimal point to the number you entered.

(–)

You can use this key to add a minus sign to the number you entered.

Using the Stimulus Functions

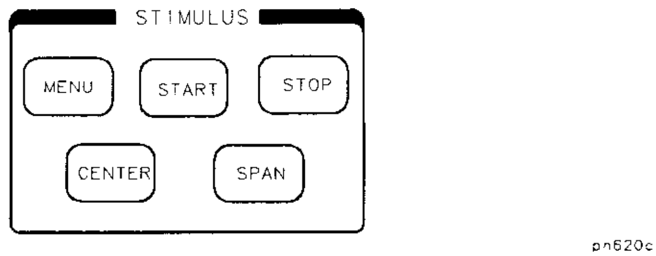


Figure 5-5. Stimulus Function Block

The stimulus function block keys are used to define the source RF output signal to the test device by providing control of the following parameters:

- swept frequency ranges
- time domain start and stop times
- RF power level
- power ranges (option 004)
- channel coupling
- sweep time
- sweep type
- number of data points
- sweep trigger

Defining the frequency range

The (START), (STOP), (CENTER), and (SPAN) keys are used to define the frequency range or other horizontal axis range of the stimulus. The range can be expressed as either start/stop or center/span. When one of these keys is pressed, its function becomes the active function. The value is displayed in the active entry area and can be changed with the knob, step keys, or numeric keypad. Current stimulus values for the active channel are also displayed along the bottom of the graticule. Frequency values can be blanked for security purposes, using the display menus.

The preset stimulus mode is frequency, and the start and stop stimulus values are set to 300 kHz and 1.3 GHz (or 3 GHz with option 003 and 6 GHz with option 006) respectively. In the time domain (option 010) or in CW time mode, the stimulus keys refer to time (with certain exceptions). In power sweep, the stimulus value is in dBm.

Because the display channels are independent, the stimulus signals for the two channels can be uncoupled and their values set independently. The values are then displayed separately if the instrument is in dual channel display mode. In the uncoupled mode with dual channel display the instrument takes alternate sweeps to measure the two sets of data. Channel stimulus coupling is explained in this section, and dual channel display capabilities are explained in the following section, "Using the Response Functions".

The stimulus menu

The (MENU) key provides access to the series of menus which are used to define and control all stimulus functions other than start, stop, center, and span. When the (MENU) key is pressed, the stimulus menu is displayed.

The stimulus menu is used to specify the sweep time, number of measurement points per sweep, and CW frequency. It includes the capability to couple or uncouple the stimulus functions of the two display channels, and the measurement restart function. In addition, it leads to other softkey menus that define power level, trigger type, and sweep type.

Understanding the power ranges (option 004)

The built-in synthesized source contains a programmable step attenuator that allows you to directly and accurately set power levels in eight different power ranges. Each range has a total span of 25 dB. The eight ranges cover the instrument's full operating range from +10 dBm to −85 dBm (see Figure 5-6). A power range can be selected either manually or automatically.

Automatic mode

If you select PWR RANGE AUTO, you can enter any power level within the total operating range of the instrument and the source attenuator will automatically switch to the corresponding range.

Each range overlaps its adjacent ranges by 15 dB, therefore, certain power levels are designated to cause the attenuator to switch to the next range so that optimum (leveled) performance is maintained. These transition points exist at −10 dB from the top of a range and at +5 dB from the bottom of a range. This leaves 10 dB of operating range. By turning the RPG knob with TEST PORT POWER being the active function, you can hear the attenuator switch as these transitions occur (see Figure 5-6).

Manual mode

If you select PWR RANGE MAN, you must first manually select the power range that corresponds to the power level you want to use. This is accomplished by pressing the POWER RANGES softkey and then selecting one of the eight available ranges. In this mode, you will not be able to use the step keys, RPG, or keypad entry to select power levels outside the range limits. This feature is necessary to maintain accuracy once a measurement calibration is turned on.

When a calibration is completed and turned on, the power range selection is switched from auto to manual mode, and PRm appears on the display.

Note A measurement calibration is valid *only* for the power level at which it was performed; but you can change the power within a range and still maintain nearly full accuracy.

If you decide to switch power ranges, the calibration is no longer valid and specified accuracy is forfeited. However, the analyzer leaves the correction *on* even though it's invalid.

The annotation C? will be displayed whenever you change the power after calibration.

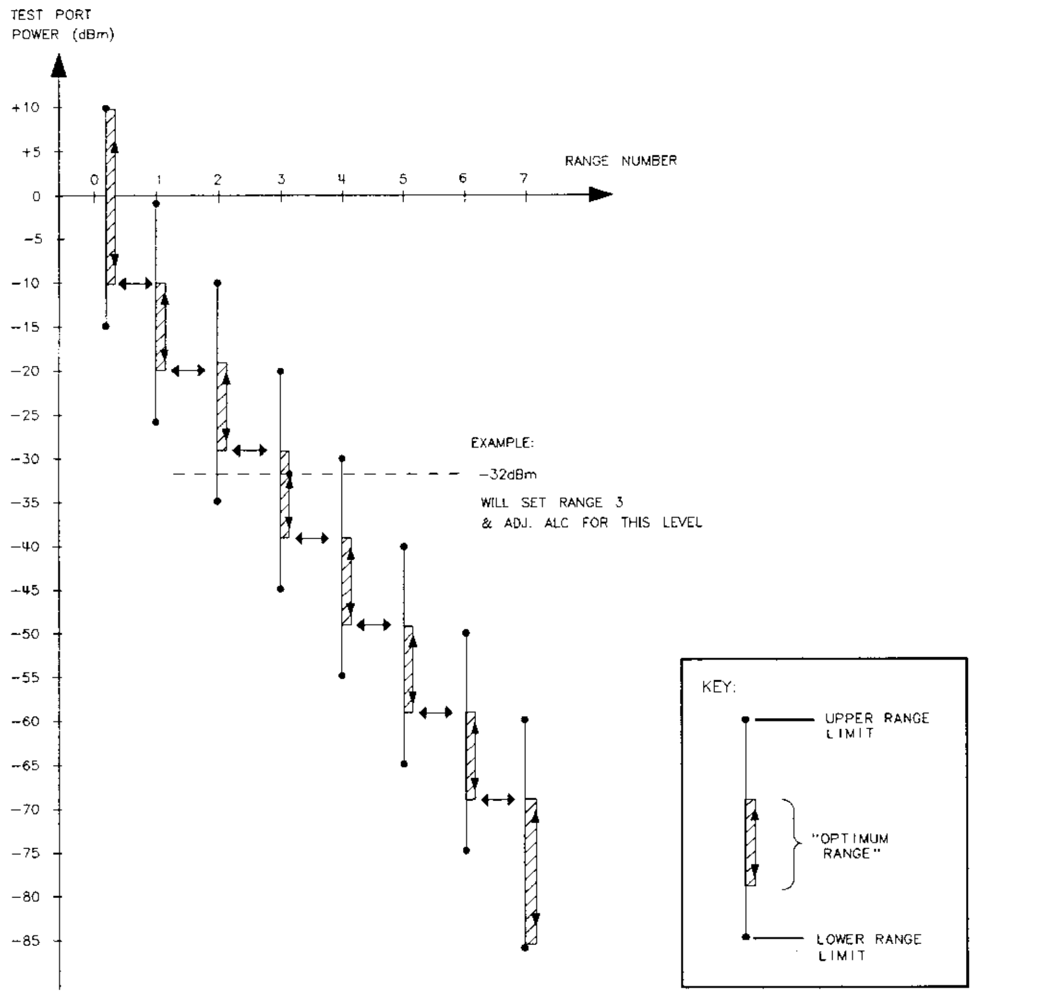


Figure 5-6. Power Range Transitions in the Automatic Mode

Channel coupling

`CHAN POWER [COUPLED]` toggles between coupled and uncoupled channel power. By uncoupling the channel powers, you effectively have two separate sources. With the channel power coupled, the power level is the same on each channel. With the channel power uncoupled, you can set different power levels for each channel. For the channel power to be uncoupled, the other channel stimulus functions must also be uncoupled (`COUPLED CH on OFF`).

Source attenuator switch protection (option 004)

The programmable step attenuator of the source can be switched between channel 1 and channel 2 when the channel power is uncoupled. To avoid premature wear of the attenuator, measurement configurations requiring continuous switching between different power ranges are not allowed.

For example, channels 1 and 2 of the analyzer are decoupled, power levels in two different ranges are selected for each channel, and dual channel display is engaged. To prevent continuous switching between the two power ranges, the analyzer automatically engages the test set hold mode after measuring both channels once. The active channel continues to be updated each sweep while the inactive channel is placed in the hold mode. (The status annotation tsH appears on the left side of the display.) If averaging is on, the test set hold mode does not engage until the specified number of sweeps is completed. The MEASURE RESTART and NUMBER OF GROUPS softkeys, explained later, can override this protection feature.

Allowing repetitive switching of the attenuator

The MEASURE RESTART and NUMBER OF GROUPS softkeys allow measurements which demand repetitive switching of the step attenuator. Use these softkeys with caution; repetitive switching can cause premature wearing of the attenuator.

- MEASURE RESTART causes one measurement to occur.
- NUMBER OF GROUPS causes a specified number of measurements to occur before activating the test set hold mode.

Channel stimulus coupling

COUPLED CH on OFF toggles the channel coupling of stimulus values. With COUPLED CH ON off (the preset condition), both channels have the same stimulus values (the inactive channel takes on the stimulus values of the active channel).

In the stimulus coupled mode, the following parameters are coupled:

- frequency
- number of points
- source power
- number of groups
- power slope
- IF bandwidth
- sweep time
- trigger type
- gating parameters
- sweep type

Coupling of stimulus values for the two channels is independent of DUAL CHAN on OFF in the display menu and MARKERS: UNCOUPLED in the marker mode menu. COUPLED CH on OFF becomes an alternate sweep function when dual channel display is on: in this mode the analyzer alternates between the two sets of stimulus values for measurement of data and both are displayed.

Sweep time

The SWEEP TIME softkey selects sweeptime as the active entry and shows whether the automatic or manual mode is active. The following explains the difference between automatic and manual sweep time:

- **Manual sweep time.** As long as the selected sweep speed is within the capability of the instrument, it will remain fixed, regardless of changes to other measurement parameters. If you change measurement parameters such that the instrument can no longer maintain the selected sweep time, the analyzer will change to the fastest sweep time possible.
- **Auto sweep time.** Auto sweep time continuously maintains the fastest sweep speed possible with the selected measurement parameters.

Sweep time refers only to the time that the instrument is sweeping and taking data, and does not include the time required for internal processing of the data. A sweep speed indicator ↑ is displayed on the trace for sweep times slower than 1.0 second. For sweep times faster than 1.0 second the ↑indicator appears in the status notations area at the left of the analyzer's display.

Minimum sweep time

The minimum sweep time is dependent on several factors. These factors are referred to as "measurement parameters" in the following paragraphs.

- the number of points selected
- IF bandwidth
- sweep-to-sweep averaging in dual channel display mode
- smoothing
- limit test
- error correction
- trace math
- marker statistics
- time domain
- type of sweep

Use Table 5-1 to determine the minimum sweep time for the listed measurement parameters. The values listed represent the minimum time required for a CW time measurement with averaging off. Values are given in seconds.

Table 5-1. Minimum Sweep Time (in seconds)

Number of Points	IF Bandwidth			
	3000 Hz	1000 Hz	300 Hz	10 Hz
11	0.0055 sec.	0.012 sec.	0.037 sec.	1.14 sec.
51	0.0255 sec.	0.060 sec.	0.172 sec.	5.30 sec.
101	0.0505 sec.	0.120 sec.	0.341 sec.	10.5 sec.
201	0.1005 sec.	0.239 sec.	0.679 sec.	20.9 sec.
401	0.2005 sec.	0.476 sec.	1.355 sec.	41.7 sec.
801	0.4005 sec.	0.951 sec.	2.701 sec.	83.3 sec.
1601	0.8005 sec.	1.901 sec.	5.411 sec.	166.5 sec.

Sweep time may be used in manual or auto modes. These are explained on the following page.

Manual sweep time mode

When this mode is active, the softkey label reads SWEEP TIME [MANUAL]. This mode is engaged whenever you enter a sweep time greater than zero. This mode allows you to select a fixed sweep time. If you change the measurement parameters such that the current sweep time is no longer possible, the analyzer will automatically increase to the next fastest sweep time possible. If the measurement parameters are changed such that a faster sweep time is possible, the analyzer will not alter the sweep time while in this mode.

Auto sweep time mode

When this mode is active, the softkey label reads SWEEP TIME [AUTO]. This mode is engaged whenever you enter (0) (x1) as a sweep time. Auto sweep time continuously maintains the fastest sweep time possible with the selected measurement parameters.

Sweep types

Five sweep types are available.

- linear sweep
- logarithmic frequency sweep
- list frequency sweep
- power sweep
- CW time sweep

Linear frequency sweep (Hz)

The LIN FREQ softkey activates a linear frequency sweep displayed on a standard graticule with ten equal horizontal divisions. This is the preset default sweep type.

For a linear sweep, sweep time is combined with the channel's frequency span to compute a source sweep rate:

sweep rate = (frequency span) / (sweep time)

Since the sweep time may be affected by various factors, the equation provided here is merely an indication of the ideal (fastest) sweep rate. If the user-specified sweep time is greater than 15 ms times the number of points, the sweep changes from a continuous ramp sweep to a stepped CW sweep. Also, for 10 Hz or 30 Hz IF bandwidths the sweep is automatically converted to a stepped CW sweep.

In the linear frequency sweep mode it is possible, with option 010, to transform the data for time domain measurements using the inverse Fourier transform technique.

Logarithmic frequency sweep (Hz)

The LOG FREQ softkey activates a logarithmic frequency sweep mode. The source is stepped in logarithmic increments and the data is displayed on a logarithmic graticule. This is slower than a continuous sweep with the same number of points, and the entered sweep time may therefore be changed automatically. For frequency spans of less than two octaves, the sweep type automatically reverts to linear sweep.

List frequency sweep (Hz)

The LIST FREQ softkey provides a user-definable arbitrary frequency list mode. This list is defined and modified using the edit list menu and the edit subsweep menu. Up to 30 frequency subsweeps (called "segments") of several different types can be specified, for a maximum total of 1632 points. One list is common to both channels. Once a frequency list has been defined and a measurement calibration performed on the full frequency list, one or all of the frequency segments can be measured and displayed without loss of calibration.

When the LIST FREQ key is pressed, the network analyzer sorts all the defined frequency segments into CW points in order of increasing frequency. It then measures each point and displays a single trace that is a composite of all data taken. If duplicate frequencies exist, the analyzer makes multiple measurements on identical points to maintain the specified number of points for each subsweep. Since the frequency points may not be distributed evenly across the display, the display resolution may be uneven, and more compressed in some parts of the trace than in others. However, the stimulus and response readings of the markers are always accurate. Because the list frequency sweep is a stepped CW sweep, the sweep time is slower than for a continuous sweep with the same number of points.

The LIST FREQ softkey presents the segment menu, which allows you to select any single segment in the frequency list. Refer to "Modifying list frequencies" in this section for information on how to enter or modify the list frequencies. If no list has been entered, the message CAUTION: LIST TABLE EMPTY is displayed.

A tabular printout of the frequency list data can be obtained using the LIST VALUES function in the copy menu.

Power sweep (dBm)

The POWER SWEEP softkey turns on a power sweep mode that is used to characterize power-sensitive circuits. In this mode, power is swept at a single frequency, from a start power value to a stop power value, selected using the (START) and (STOP) keys and the entry block. This feature is convenient for such measurements as gain compression or AGC (automatic gain control) slope. To set the frequency of the power sweep, use CW FREQ in the stimulus menu.

If you have Option 004, the span of the swept power is limited to being equal to or within one of the eight pre-defined power ranges. The attenuator will not switch to a different power range while in the power sweep mode. Therefore, when performing a power sweep, power range selection will automatically switch to the *manual* mode.

In power sweep, the entered sweep time may be automatically changed if it is less than the minimum required for the current configuration (number of points, IF bandwidth, averaging, etc.).

CW time sweep (seconds)

The CW TIME softkey turns on a sweep mode similar to an oscilloscope. The analyzer is set to a single frequency, and the data is displayed versus time. The frequency of the CW time sweep is set with CW FREQ in the stimulus menu. In this sweep mode, the data is continuously sampled at precise, uniform time intervals determined by the sweep time and the number of points minus 1. The entered sweep time may be automatically changed if it is less than the minimum required for the current instrument configuration.

In time domain using option 010, the CW time mode data is translated to frequency domain, and the x-axis becomes frequency. This can be used as a spectrum analyzer to measure signal purity, or for low frequency (<1 kHz) analysis of amplitude or pulse modulation signals.

Interpolated error correction

The interpolated error correction feature will function with the following sweep types:

- linear frequency
- power sweep
- CW time

Interpolated error correction will not work in log or list sweep modes.

Alternate and Chop Sweep Modes

CHOP RFL/TRN (the preset mode) measures both inputs A and B during each sweep. Thus, if each channel is measuring a different parameter and both channels are displayed, the chop mode offers the fastest measurement time.

The disadvantage of this mode is that in measurements of high rejection devices, such as filters with a low-loss passband (>400 MHz wide), maximum dynamic range may not be achieved.

ALTERNATE RFL/TRN measures only one input per frequency sweep, in order to reduce spurious signals. Thus, this mode optimizes the dynamic range for both reflection and transmission measurements.

The disadvantages of this mode are associated with simultaneous transmission/reflection measurements: this mode takes twice as long as the chop mode to make these measurements. In addition, the port match changes on the order of < -45 dB due to either input A or B being inactive during each sweep. This may affect transmission measurements on the order of $<$ 0.01 dB.

To access the ALTERNATE RFL/TRN and CHOP RFL/TRN softkeys press (CAL) MORE.

Modifying list frequencies

List frequencies can be entered or modified using the Edit List and Edit Subsweep menus. Application of the functions in these menus is described below.

Edit list menu

This menu is used to edit the list of frequency segments (subsweeps) defined with the edit subsweep menu, described next. Up to 30 frequency subsweeps can be specified, for a maximum of 1632 points. The segments do not have to be entered in any particular order: the analyzer automatically sorts them and shows them on the display in increasing order of start frequency. This menu determines which entry on the list is to be modified, while the edit subsweep menu is used to make changes in the frequency or number of points of the selected entry.

Edit subsweep menu

This menu lets you select measurement frequencies arbitrarily. Using this menu it is possible to define the exact frequencies to be measured on a point-by-point basis. For example the sweep could include 100 points in a narrow passband, 100 points across a broad stop band, and 50 points across the third harmonic response. The total sweep is defined with a list of subsweeps. Up to 30 subsweeps can be defined, with a total of up to 1632 data points.

The frequency subsweeps, or segments, can be defined in any of the following terms:

- start/stop/number of points
- start/stop/step
- center/span/number of points
- center/span/step
- CW frequency

The subsweeps can overlap, and do not have to be entered in any particular order. The analyzer sorts the segments automatically and lists them on the display in order of increasing start frequency, even if they are entered in center/span format. If duplicate frequencies exist, the analyzer makes multiple measurements on identical points to maintain the specified number of points for each subsweep. The data is shown on the display as a single trace that is a composite of all data taken. The trace may appear uneven because of the distribution of the data points, but the frequency scale is linear across the total range.

The list frequency sweep mode is selected with the LIST FREQ softkey in the sweep type menu.

The frequency list parameters can be saved with an instrument state.

Using the Response Functions

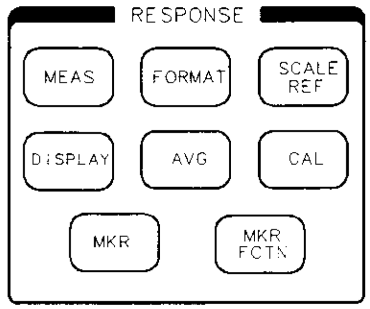


Figure 5-7. Response Function Block

The response function block keys are used to define and control the following functions of the *active channel.*

- measurement parameters
- data format
- display functions
- noise reduction alternatives
- calibration functions
- display markers

The current values for the major response functions of the active channel are displayed in specific locations along the top of the display. In addition, certain functions accessed through the keys in this block are annotated in the status notations area at the left side of the display. An illustration of the analyzer's display showing the locations of these information labels is provided in Chapter 1, "HP 8752C Descriptions and Options."

Selecting the measurement

The (MEAS) key leads to a series of softkey menus used to select the type of measurement being performed.

The first menu displayed gives you a choice between reflection and transmission measurements. The measurement selected is shown at the top left corner of the display (RFL or TRN).

Auxiliary Input

This allows for a dc or ac voltage input from an external signal source, such as a detector or function generator, which you can then measure. (You can also use this connector as an analog output in service routines, as described in the service manual.)

Input ports menu

This menu is used to define the input ports for power ratio measurements, or a single input for magnitude only measurements of absolute power. Single inputs cannot be used for phase or group delay measurements, or any measurements with averaging activated.

Conversion menu

This menu converts the measured reflection or transmission data to the equivalent complex impedance (Z) or admittance (Y) values. This is not the same as a two-port Y or Z parameter conversion, as only the measured parameter is used in the equations. Two simple one-port conversions are available, depending on the measurement configuration.

A reflection measurement trace can be converted to equivalent parallel impedance or admittance using the model and equations shown in Figure 5-8.

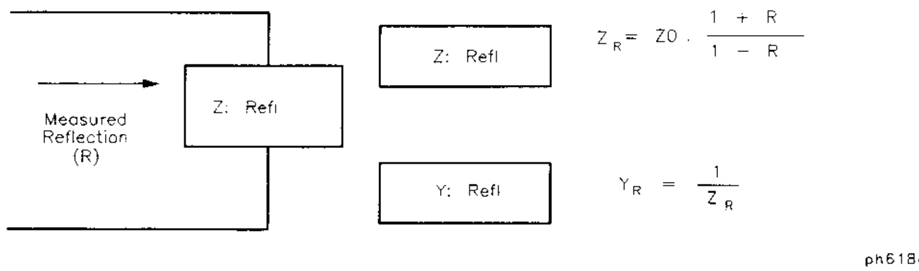


Figure 5-8. Reflection Impedance and Admittance Conversions

In a transmission measurement, the data can be converted to its equivalent series impedance or admittance using the model and equations shown in Figure 5-9.

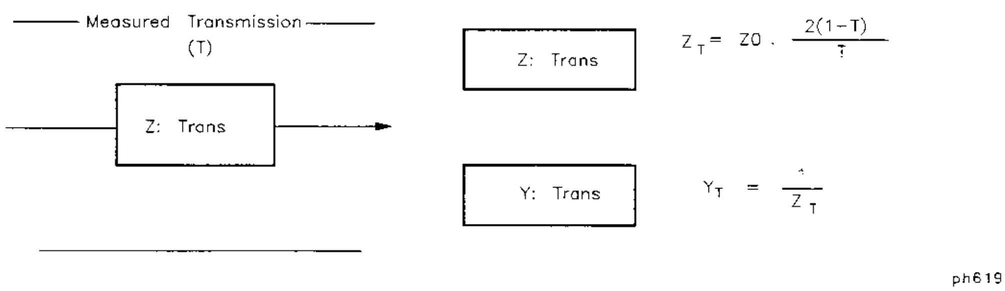


Figure 5-9. Transmission Impedance and Admittance Conversions

Avoid the use of Smith chart, SWR, and delay formats for display of Z and Y conversions, as these formats are not easily interpreted.

Selecting the display format

The (FORMAT) key presents a menu used to select the appropriate display format for the measured data. Various rectangular and polar formats are available for display of magnitude, phase, real data, imaginary data, impedance, group delay, and SWR. The units of measurement are changed automatically to correspond with the displayed format. Special marker menus are available for the polar and Smith formats, each providing several different marker types for readout of values.

The format defined for display of a particular parameter (RFL or TRN) or input is remembered with that parameter. Thus if different parameters are measured, even if only one channel is used, each parameter is shown in its selected format each time it is displayed.

The illustrations below show a reflection measurement of a bandpass filter displayed in each of the available formats.

Log magnitude format

The LOG MAG softkey displays the log magnitude format. This is the standard Cartesian format used to display magnitude-only measurements of insertion loss, return loss, or absolute power in dB versus frequency. Figure 5-10 illustrates the bandpass filter reflection data in a log magnitude format.

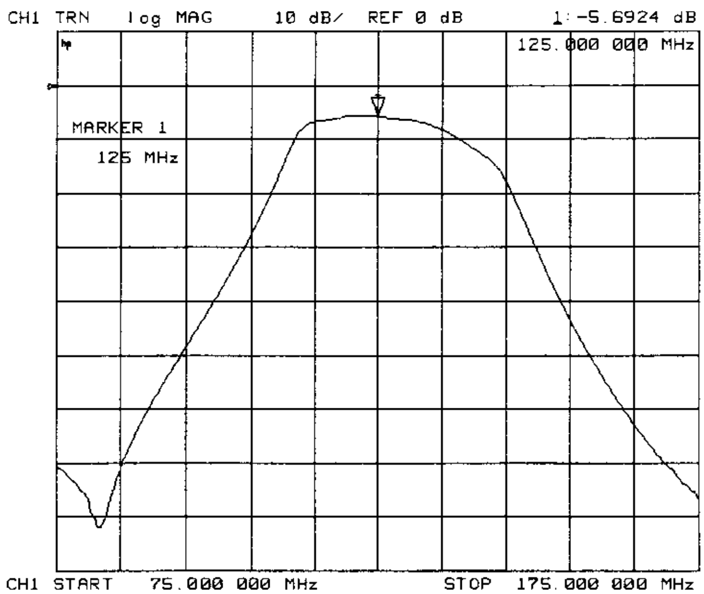


Figure 5-10. Log Magnitude Format

Phase format

The PHASE softkey displays a Cartesian format of the phase portion of the data, measured in degrees. This format displays the phase shift versus frequency. Figure 5-11 illustrates the phase response of the same filter in a phase-only format.

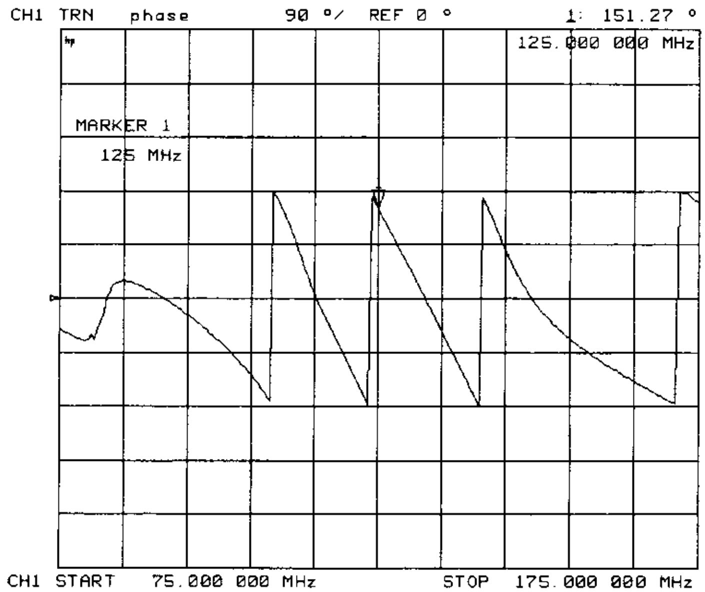


Figure 5-11. Phase Format

Group delay format

The DELAY softkey selects the group delay format, with marker values given in seconds. Figure 5-12 shows the bandpass filter response formatted as group delay. Group delay principles are described in the next few pages.

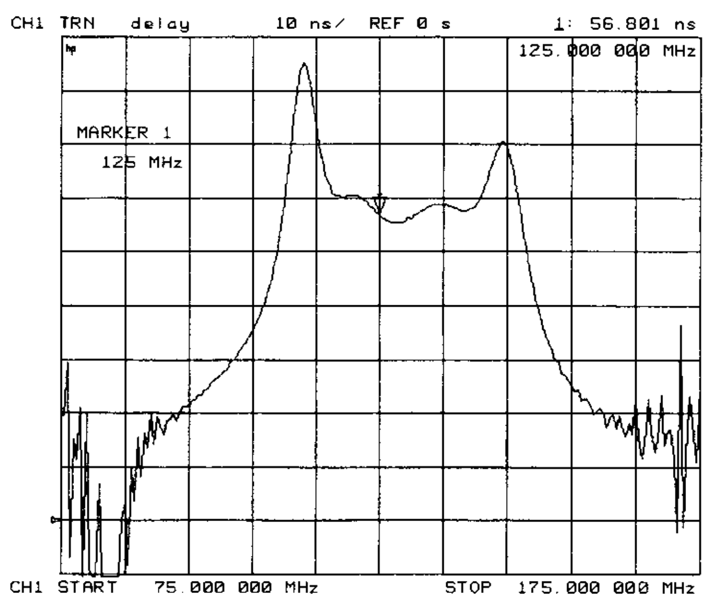


Figure 5-12. Group Delay Format

Smith chart format

The SMITH CHART softkey displays a Smith chart format (see Figure 5-13). This is used in reflection measurements to provide a readout of the data in terms of impedance. The intersecting dotted lines on the Smith chart represent constant resistance and constant reactance values, normalized to the characteristic impedance, Z_0, of the system. Reactance values in the upper half of the Smith chart circle are positive (inductive) reactance, and those in the lower half of the circle are negative (capacitive) reactance. The default marker readout is in ohms (Ω) to measure resistance and reactance (R+jX). Additional marker types are available in the Smith marker menu.

The Smith chart is most easily understood with a full scale value of 1.0. If the scale per division is less than 0.2, the format switches automatically to polar.

If the characteristic impedance of the system is not 50 ohms, modify the impedance value recognized by the analyzer by pressing (CAL) MORE SET ZO (50) (x1).

An inverted Smith chart format for admittance measurements (Figure 5-13) is also available. Access this by selecting SMITH CHART in the format menu, and pressing (MKR) MARKER MODE MENU SMITH MKR MENU G+jB MKR. The Smith chart is inverted and marker values are read out in siemens (S) to measure conductance and susceptance (G+jB).

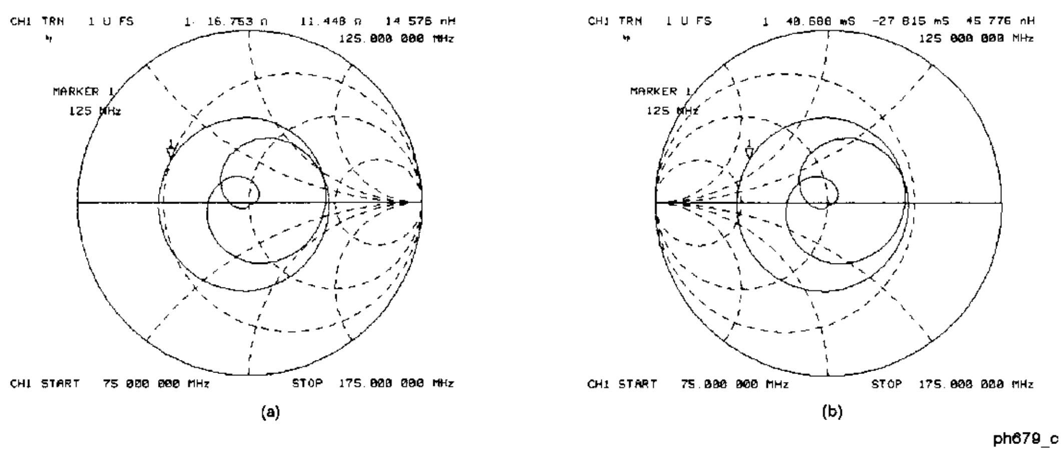


Figure 5-13. Standard and Inverse Smith Chart Formats

Polar format

The POLAR softkey displays a polar format (see Figure 5-14). Each point on the polar format corresponds to a particular value of both magnitude and phase. Quantities are read vectorally: the magnitude at any point is determined by its displacement from the center (which has zero value), and the phase by the angle counterclockwise from the positive x-axis. Magnitude is scaled in a linear fashion, with the value of the outer circle usually set to a ratio value of 1. Since there is no frequency axis, frequency information is read from the markers.

The default marker readout for the polar format is in linear magnitude and phase. A log magnitude marker and a real/imaginary marker are available in the polar marker menu.

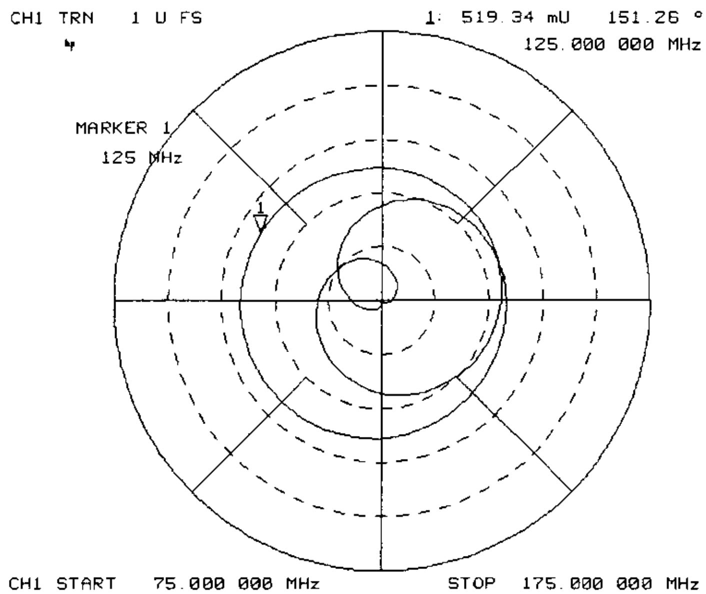


Figure 5-14. Polar Format

Linear magnitude format

The LIN MAG softkey displays the linear magnitude format (see Figure 5-15). This is a Cartesian format used for unitless measurements such as reflection coefficient magnitude ρ or transmission coefficient magnitude τ, and for linear measurement units. It is used for display of conversion parameters and time domain transform data.

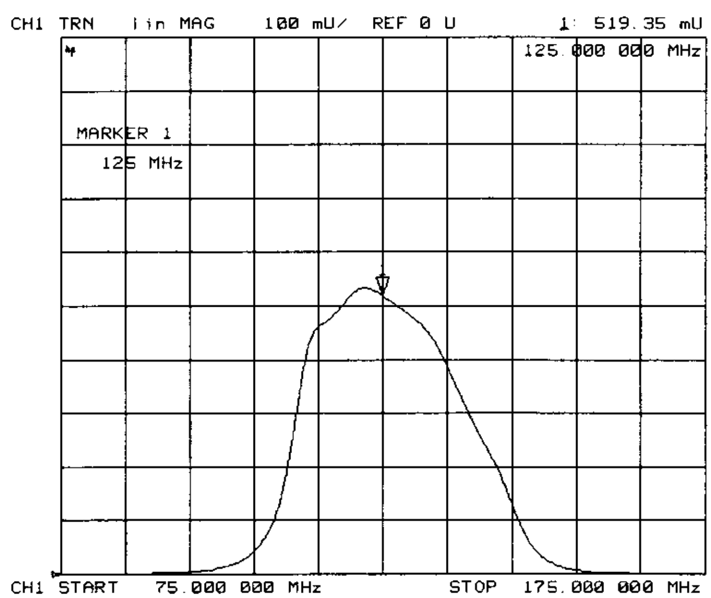


Figure 5-15. Linear Magnitude Format

SWR format

The SWR softkey reformats a reflection measurement into its equivalent SWR (standing wave ratio) value (see Figure 5-16). SWR is equivalent to $(1 + \rho)/(1 - \rho)$, where ρ is the reflection coefficient. Note that the results are valid only for reflection measurements. If the SWR format is used for transmission measurements, the results are not valid.

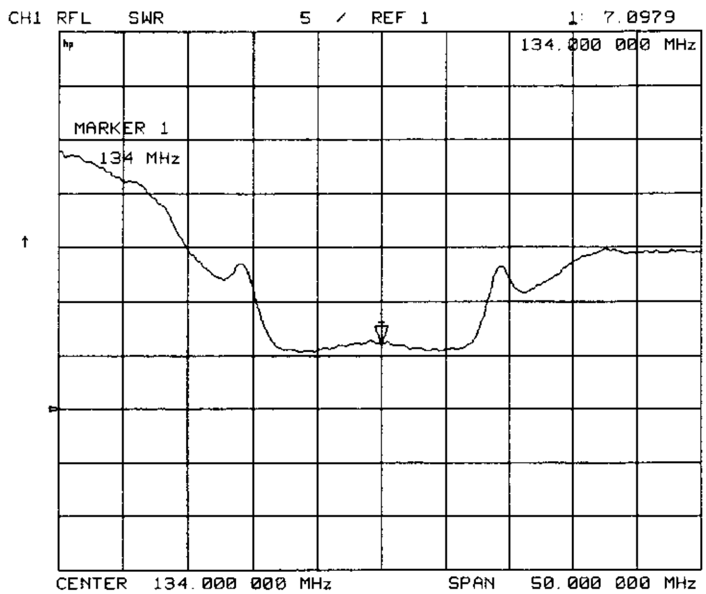


Figure 5-16. Typical SWR Display

Real format

The REAL softkey displays only the real (resistive) portion of the measured data on a Cartesian format (see Figure 5-17a). This is similar to the linear magnitude format, but can show both positive and negative values. It is primarily used for analyzing responses in the time domain, and also to display an auxiliary input voltage signal for service purposes.

Imaginary format

The IMAGINARY softkey displays only the imaginary (reactive) portion of the measured data on a Cartesian format (see Figure 5-17b). This format is similar to the real format except that reactance data is displayed on the trace instead of impedance data.

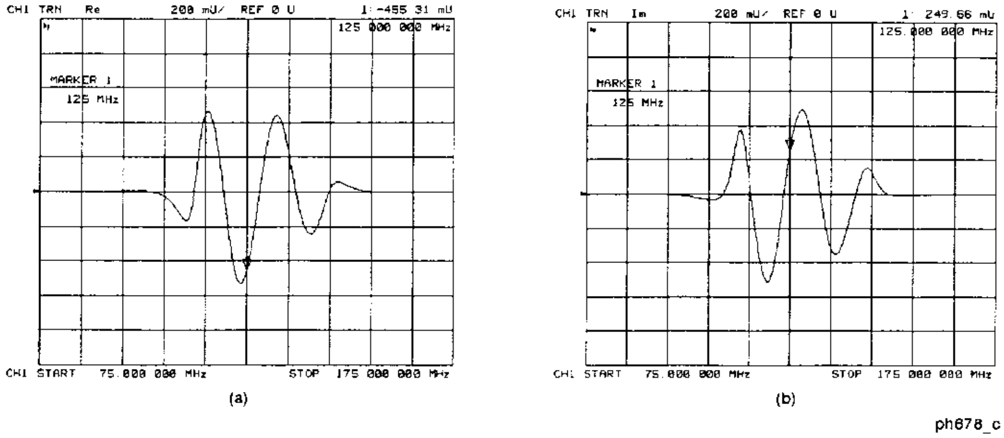


Figure 5-17. Real and Imaginary Formats

Group delay principles

For many networks, the amount of insertion phase is not as important as the linearity of the phase shift over a range of frequencies. The analyzer can measure this linearity and express it in two different ways: directly, as deviation from linear phase, or as group delay, a derived value.

Group delay is the measurement of signal transmission time through a test device. It is defined as the derivative of the phase characteristic with respect to frequency. Since the derivative is basically the instantaneous slope (or rate of change of phase with respect to frequency), a perfectly linear phase shift results in a constant slope, and therefore a constant group delay (see Figure 5-18).

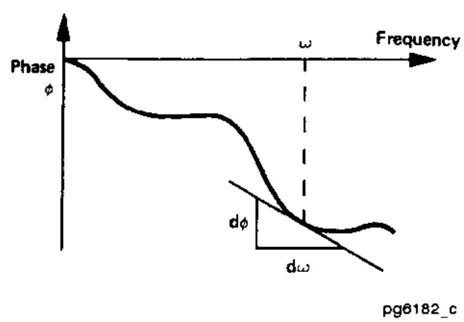
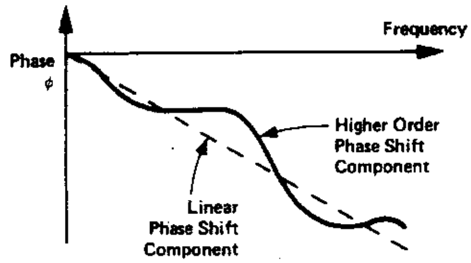


Figure 5-18. Constant Group Delay

Note, however, that the phase characteristic typically consists of both linear and higher order (deviations from linear) components. The linear component can be attributed to the electrical length of the test device, and represents the average signal transit time. The higher order components are interpreted as variations in transit time for different frequencies, and represent a source of signal distortion (see Figure 5-19).



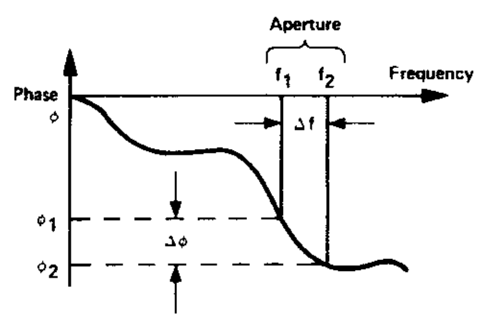
$$\text{Group Delay} = \tau_g = \frac{-d\phi}{d\omega} \qquad \phi \text{ in Radians},\ \omega \text{ in Radians}$$

$$= \frac{-1}{360^\circ} \cdot \frac{d\phi}{df} \qquad \phi \text{ in Degrees},\ f \text{ in Hz } (\omega = 2\pi f)$$

pg6183_c

Figure 5-19. Higher Order Phase Shift

The analyzer computes group delay from the phase slope. Phase data is used to find the phase change, $\Delta\phi$, over a specified frequency aperture, Δf, to obtain an approximation for the rate of change of phase with frequency (see Figure 5-20). This value, τ_g, represents the group delay in seconds assuming linear phase change over Δf. It is important that $\Delta\phi$ be $\leq 180^\circ$, or errors will result in the group delay data. These errors can be significant for long delay devices. You can verify that $\Delta\phi$ is $\leq 180^\circ$ by increasing the number of points or narrowing the frequency span (or both) until the group delay data no longer changes.



pg6180_c

Figure 5-20. Rate of Phase Change Versus Frequency

When deviations from linear phase are present, changing the frequency step can result in different values for group delay. Note that in this case the computed slope varies as the aperture Δf is increased (see Figure 5-21). A wider aperture results in loss of the fine grain variations in group delay. This loss of detail is the reason that in any comparison of group delay data it is important to know the aperture used to make the measurement.

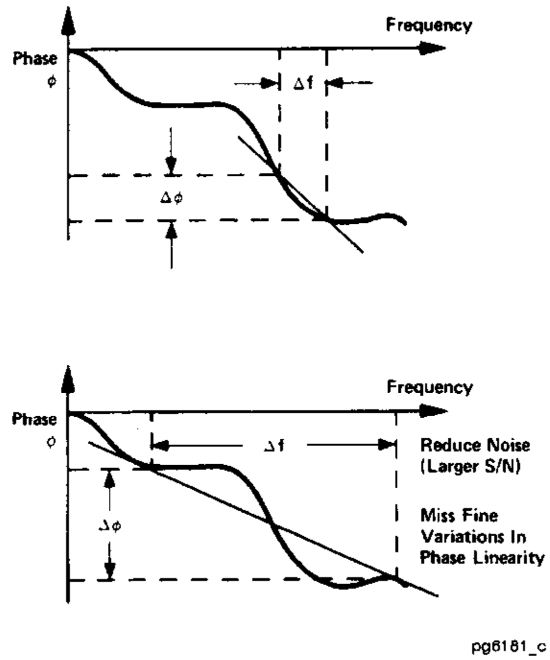


Figure 5-21. Variations in Frequency Aperture

In determining the group delay aperture, there is a tradeoff between resolution of fine detail and the effects of noise. Noise can be reduced by increasing the aperture, but this will tend to smooth out the fine detail. More detail will become visible as the aperture is decreased, but the noise will also increase, possibly to the point of obscuring the detail. A good practice is to use a smaller aperture to assure that small variations are not missed, then increase the aperture to smooth the trace.

The default group delay aperture is the frequency span divided by the number of points across the display. To set the aperture to a different value, turn on smoothing in the average menu, and vary the smoothing aperture. The aperture can be varied up to 20% of the span swept.

Group delay measurements can be made on linear frequency, log frequency, or list frequency sweep types (not in CW or power sweep). Group delay aperture varies depending on the frequency spacing and point density, therefore the aperture is not constant in log and list frequency sweep modes. In list frequency mode, extra frequency points can be defined to ensure the desired aperture.

To obtain a readout of aperture values at different points on the trace, turn on a marker. Then press (AVG) SMOOTHING APERTURE. Smoothing aperture becomes the active function, and as the aperture is varied its value in Hz is displayed below the active entry area.

Electrical delay

The ELECTRICAL DELAY softkey which is accessible from the (SCALE REF) key adjusts the electrical delay to balance the phase of the test device. It simulates a variable length lossless transmission line, which can be added to or removed from a receiver input to compensate for interconnecting cables, etc. This function is similar to the mechanical or analog "line stretchers" of other network analyzers. Delay is annotated in units of time with secondary labeling in distance for the current velocity factor.

With this feature, and with MARKER → DELAY, an equivalent length of air-filled, lossless transmission line is added or subtracted according to the following formula:

Length (metres) = $\phi \div$ (Freq in MHz × 1.20083)

Once the linear portion of the test device's phase has been removed, the equivalent length of the lossless, transmission line can be read out in the active marker area. If the average relative permittivity (ε_r) of the test device is known over the frequency span, the length calculation can be adjusted to indicate the actual length of the test device more closely. This can be done by entering the relative velocity factor for the test device using the calibrate more menu. The relative velocity factor for a given dielectric can be calculated by:

Velocity Factor = 1 ÷ square root of ε_r

assuming a relative permeability of 1.

Display functions

The (DISPLAY) key provides access to the memory math functions, and other display functions including dual channel display, active channel display title, frequency blanking, display intensity, background intensity, and color selection.

The analyzer has two available memory traces, one per channel. Memory traces are totally channel dependent: channel 1 cannot access the channel 2 memory trace or vice versa. Memory traces can be saved with instrument states: one memory trace can be saved per channel per saved instrument state. There are up to 32 save/recall registers available, so the total number of memory traces that can be present is 66 including the two active for the current instrument state. The memory data is stored as full precision, complex data.

Note You may not be able to store 32 instrument states if they include a lot of calibration data. The calibration data contributes considerably to the size of the instrument state file and therefore can use all the available memory prior to filling all 32 registers.

Two trace math operations are implemented, data/memory and data−memory. (Note that normalization is data/memory not data−memory.) Memory traces are saved and recalled and trace math is done immediately after error correction. This means that any data processing done after error correction, including parameter conversion, time domain transformation (option 010), scaling, etc., can be performed on the memory trace. Trace math can also be used as a simple means of error correction, although that is not its main purpose.

All data processing operations that occur after trace math, except smoothing and gating, are identical for the data trace and the memory trace. If smoothing or gating is on when a memory trace is saved, this state is maintained regardless of the data trace smoothing or gating status. If a memory trace is saved with gating or smoothing on, these features can be turned on or off in the memory-only display mode.

The actual memory for storing a memory trace is allocated only as needed. The memory trace is cleared on instrument preset, power on, or instrument state recall.

If sweep mode or sweep range is different between the data and memory traces, trace math is allowed, and no warning message is displayed. If the number of points in the two traces is different, the memory trace is not displayed nor rescaled. However, if the number of points for the data trace is changed back to the number of points in the memory, the memory trace can then be displayed.

If trace math or display memory is requested and no memory trace exists, the message `CAUTION: NO VALID MEMORY TRACE` is displayed.

Dual channel mode

The DUAL CHAN on OFF softkey toggles between display of both measurement channels or the active channel only. This is used in conjunction with SPLIT DISP ON off in the display more menu to display both channels. With SPLIT DISP on OFF the two traces are overlaid on a single graticule (see Figure 2-2a); with SPLIT DISP ON off the measurement data is displayed on two half-screen graticules one above the other (see Figure 5-22b). Current parameters for the two displays are annotated separately.

The stimulus functions of the two channels can also be controlled independently using COUPLED CH ON off in the stimulus menu. In addition, the markers can be controlled independently for each channel using MARKERS: UNCOUPLED in the marker mode menu.

Dual channel mode with decoupled channel power

By decoupling the channel power and using the dual channel mode, you can simultaneously view two measurements having different power levels. However, this configuration may not appear to function "properly" if the two different power levels are not in the same power range (option 004).

For example, if channel 1 requires a power level in one power range, and channel 2 requires a power level in another range, since one attenuator is used for both channels, this would cause the attenuator to continuously switch power ranges. Repeated switching of the mechanical step attenuator could cause it to prematurely wear out. Therefore, the instrument will not allow the attenuator to continuously switch ranges in order to update these measurements without the direct intervention of the operator.

If the above condition exists, the test set hold mode will engage, and the status notation tsH will appear on the left side of the screen. The hold mode may be overridden by either the MEASURE RESTART or NUMBER OF GROUPS softkeys. Refer to "Source attenuator switch protection (option 004)" earlier in this chapter for more information on this condition.

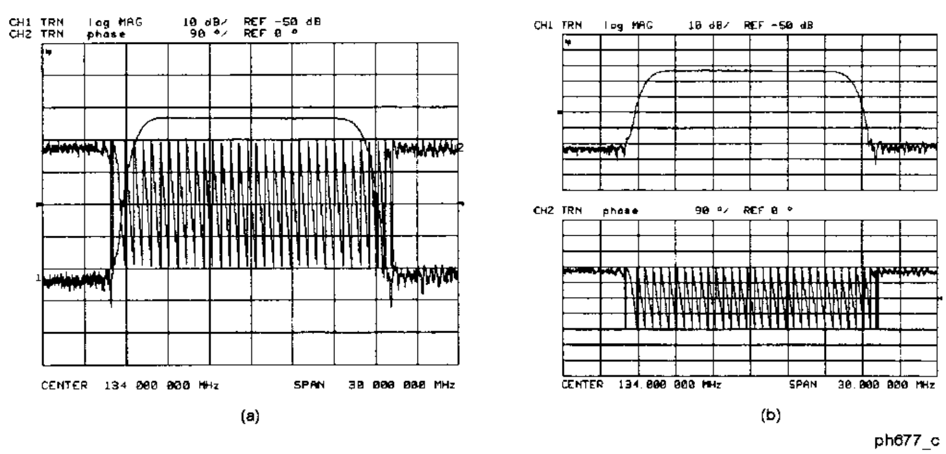


Figure 5-22. Dual Channel Displays

Adjusting the colors of the display

This procedure explains how to adjust the colors on your analyzer's display. The default colors in this instrument have been scientifically chosen to maximize your ability to discern the difference between the colors, and to comfortably and effectively view the colors. These colors are recommended for normal use because they will provide a suitable contrast that is easy to view for long periods of time.

You may choose to change the default colors to suit environmental needs, individual preferences, or to accommodate color deficient vision. You can use any of the available colors for any of the seven display elements listed by the softkey names below:

- CH1 DATA/LIMIT LN
- CH1 MEM
- CH2 DATA/LIMIT LN
- CH2 MEM/REF LINE
- GRATICULE/TEXT
- WARNING
- TEXT

To change the color of a display elements, press the softkey for that element (such as CH1 DATA). Then press TINT and turn the analyzer front panel knob, use the step keys or the numeric keypad, until the desired color appears.

Color is comprised of three parameters:

Tint: The continuum of hues on the color wheel, ranging from red, through green and blue, and back to red.

Brightness: A measure of the brightness of the color.

Color: The degree of whiteness of the color. A scale from white to pure color.

The most frequently occurring color deficiency is the inability to distinguish red, yellow, and green from one another. Confusion between these colors can usually be eliminated by increasing the brightness between the colors. To accomplish this, press the BRIGHTNESS softkey and turn the analyzer front panel knob. If additional adjustment is needed, vary the degree of whiteness of the color. To accomplish this, press the COLOR softkey and turn the analyzer front panel knob.

Note Color changes and adjustments remain in effect until changed again in these menus or the analyzer is powered off and then on again. Cycling the power changes all color adjustments to default values. Preset does not affect color selection.

Setting default colors

To set all the display elements to the factory-defined default colors, press:

(DISPLAY) MORE ADJUST DISPLAY DEFAULT COLORS

Note PRESET does not reset or change colors to the default color values.

Saving modified colors

To save the modified color set, press:

(DISPLAY) MORE ADJUST DISPLAY SAVE COLORS

Modified colors are not part of a saved instrument state and are lost unless saved using these softkeys.

Recalling modified colors

To recall the previously saved color set, press:

(DISPLAY) MORE ADJUST DISPLAY RECALL COLORS

Noise reduction functions

The (AVG) key is used to access three different noise reduction techniques: sweep-to-sweep averaging, display smoothing, and variable IF bandwidth. Any or all of these can be used simultaneously. Averaging and smoothing can be set independently for each channel, and the IF bandwidth can be set independently if the stimulus is uncoupled.

Averaging

Averaging computes each data point based on an exponential average of consecutive sweeps weighted by a user-specified averaging factor. Each new sweep is averaged into the trace until the total number of sweeps is equal to the averaging factor, for a fully averaged trace. Each point on the trace is the vector sum of the current trace data and the data from the previous sweep. A high averaging factor gives the best signal-to-noise ratio, but slows the trace update time. Doubling the averaging factor reduces the noise by 3 dB. Averaging is used for ratioed measurements: if it is attempted for a single-input measurement (e.g. A or B), the message CAUTION: AVERAGING INVALID ON NON-RATIO MEASURE is displayed. Figure 5-23 illustrates the effect of averaging on a log magnitude format trace.

Note If you have option 004 and switch power ranges with averaging on, the average will restart.

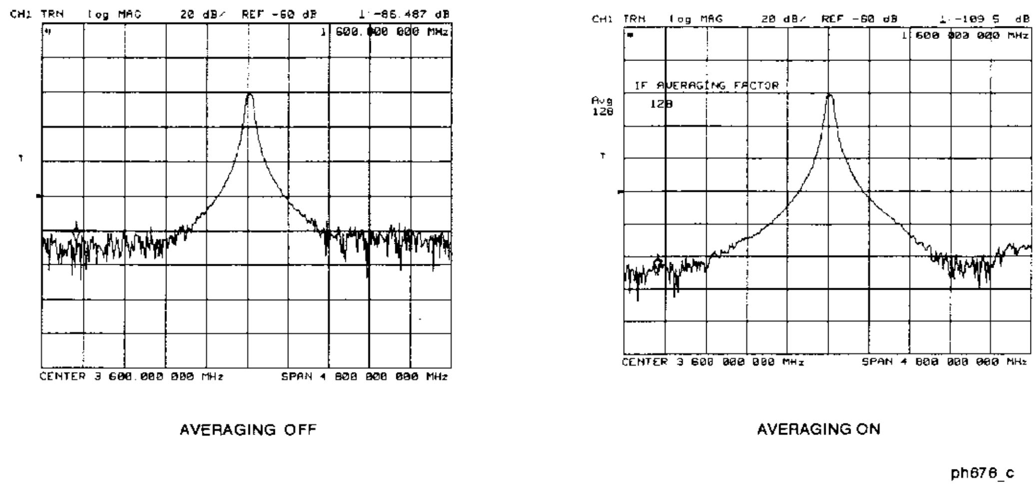


Figure 5-23. Effect of Averaging on a Trace

Smoothing

Smoothing (similar to video filtering) averages the formatted active channel data over a portion of the displayed trace. Smoothing computes each displayed data point based on one sweep only, using a moving average of several adjacent data points for the current sweep. The smoothing aperture is a percent of the swept stimulus span, up to a maximum of 20%.

Rather than lowering the noise floor, smoothing finds the mid-value of the data. Use it to reduce relatively small peak-to-peak noise values on broadband measured data. Use a sufficiently high number of display points to avoid misleading results. Do not use smoothing for measurements of high resonance devices or other devices with wide trace variations, as it will introduce errors into the measurement.

Smoothing is used with Cartesian and polar display formats. It is also the primary way to control the group delay aperture, given a fixed frequency span (refer to "Group delay principles" earlier in this section). In polar display format, large phase shifts over the smoothing aperture will cause shifts in amplitude, since a vector average is being computed. Figure 5-24 illustrates the effect of smoothing on a log magnitude format trace.

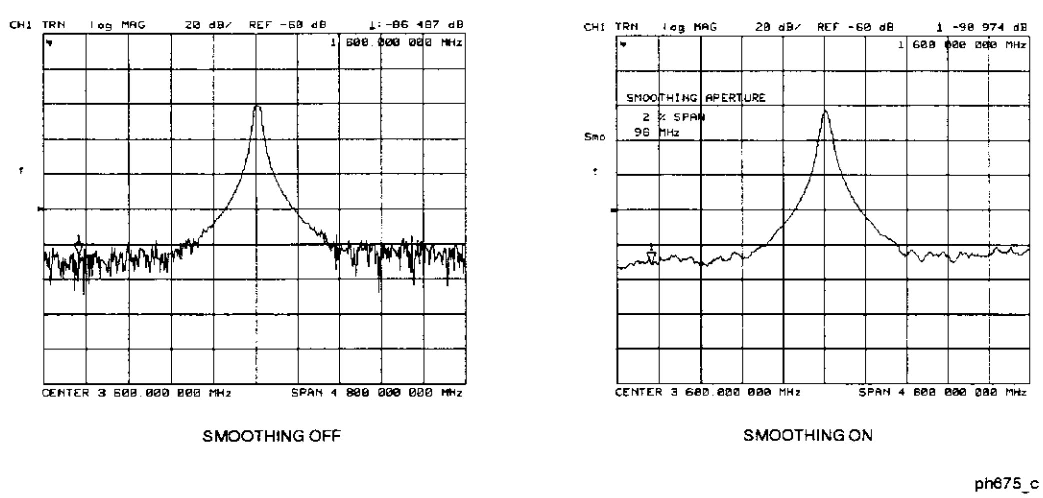


Figure 5-24. Effect of Smoothing on a Trace

IF bandwidth reduction

IF bandwidth reduction lowers the noise floor by digitally reducing the receiver input bandwidth. It works in all ratio and non-ratio modes. It has an advantage over averaging as it reliably filters out unwanted responses such as spurs, odd harmonics, higher frequency spectral noise, and line-related noise. Sweep-to-sweep averaging, however, is better at filtering out very low frequency noise. A tenfold reduction in IF bandwidth lowers the measurement noise floor by about 10 dB. Bandwidths less than 300 Hz provide better harmonic rejection than higher bandwidths.

Another difference between sweep-to-sweep averaging and variable IF bandwidth is the sweep time. Averaging displays the first complete trace faster but takes several sweeps to reach a fully averaged trace. IF bandwidth reduction lowers the noise floor in one sweep, but the sweep time may be slower. Figure 5-25 illustrates the difference in noise floor between a trace measured with a 3000 Hz IF bandwidth and with a 10 Hz IF bandwidth.

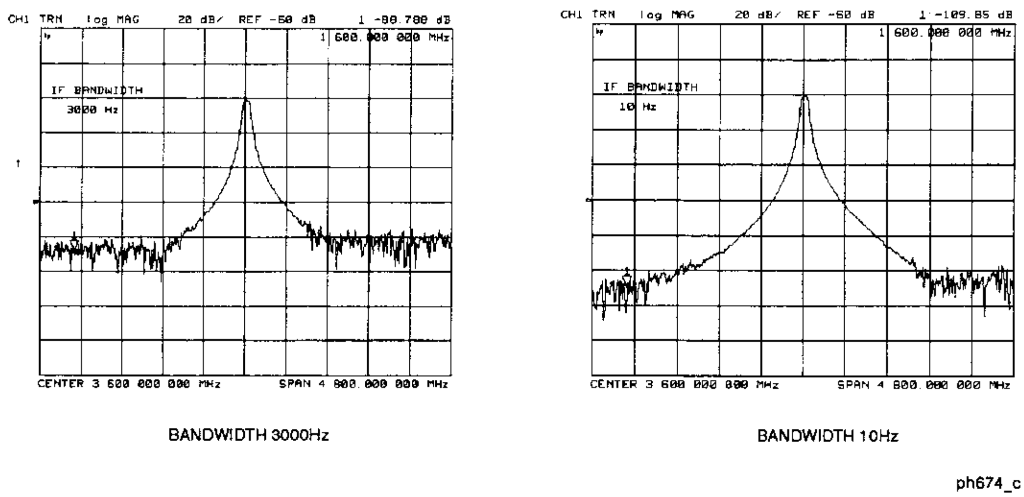


Figure 5-25. IF Bandwidth Reduction

Hints

Another capability that can be used for effective noise reduction is the marker statistics function, which computes the average value of part or all of the formatted trace.

Another way of increasing dynamic range is to increase the input power to the test device using an HP 8347A amplifier.

What is Measurement Calibration?

Measurement calibration is an accuracy enhancement procedure that effectively removes the system errors that cause uncertainty in measuring a test device. It measures known standard devices, and uses the results of these measurements to characterize the system.

This section discusses the following topics:

- definition of accuracy enhancement
- causes of measurement errors
- characterization of microwave systematic errors
- correcting for measurement errors
- ensuring a valid calibration
- calibration standards
- modifying calibration kits
- calibrating for non-insertable devices

What is accuracy enhancement?

A perfect measurement system would have infinite dynamic range, isolation, and directivity characteristics, no impedance mismatches in any part of the test setup, and flat frequency response. In any high frequency measurement there are measurement errors associated with the system that contribute uncertainty to the results. Parts of the measurement setup such as interconnecting cables and signal-separation devices (as well as the analyzer itself) all introduce variations in magnitude and phase that can mask the actual performance of the test device. Vector accuracy enhancement, also known as measurement calibration or error correction, provides the means to simulate a nearly perfect measurement system.

For example, crosstalk due to the channel isolation characteristics of the analyzer can contribute an error equal to the transmission signal of a high-loss test device. For reflection measurements, the primary limitation of dynamic range is the directivity of the test setup. The measurement system cannot distinguish the true value of the signal reflected by the test device from the signal arriving at the receiver input due to leakage in the system. For both transmission and reflection measurements, impedance mismatches within the test setup cause measurement uncertainties that appear as ripples superimposed on the measured data.

Measurement calibration simulates a perfect analyzer system. It measures the magnitude and phase responses of known standard devices, and compares the measurement with actual device data. It uses the results to characterize the system and effectively remove the system errors from the measurement data of a test device, using vector math capabilities internal to the network analyzer.

When you use measurement calibration, the dynamic range and accuracy of the measurement are limited only by system noise and stability, connector repeatability, and the accuracy to which the characteristics of the calibration standards are known.

What causes measurement errors?

Network analysis measurement errors can be separated into systematic, random, and drift errors.

Correctable systematic errors are the repeatable errors that the system can measure. These are errors due to mismatch and leakage in the test setup, isolation between the reference and test signal paths, and system frequency response.

The system cannot measure and correct for the non-repeatable random and drift errors. These errors affect both reflection and transmission measurements. Random errors are measurement variations due to noise and connector repeatability. Drift errors include frequency drift, temperature drift, and other physical changes in the test setup between calibration and measurement.

The resulting measurement is the vector sum of the test device response plus all error terms. The precise effect of each error term depends upon its magnitude and phase relationship to the actual test device response.

In most high frequency measurements the systematic errors are the most significant source of measurement uncertainty. Since each of these errors can be characterized, their effects can be effectively removed to obtain a corrected value for the test device response. For the purpose of vector accuracy enhancement these uncertainties are quantified as directivity, source match, load match, isolation (crosstalk), and frequency response (tracking). Each of these systematic errors is described below.

Random and drift errors cannot be precisely quantified, so they must be treated as producing a cumulative uncertainty in the measured data.

Directivity

Normally a device that can separate the reverse from the forward traveling waves (a directional bridge or coupler) is used to detect the signal reflected from the test device. Ideally the coupler would completely separate the incident and reflected signals, and only the reflected signal would appear at the coupled output, as illustrated in Figure 5-26a.

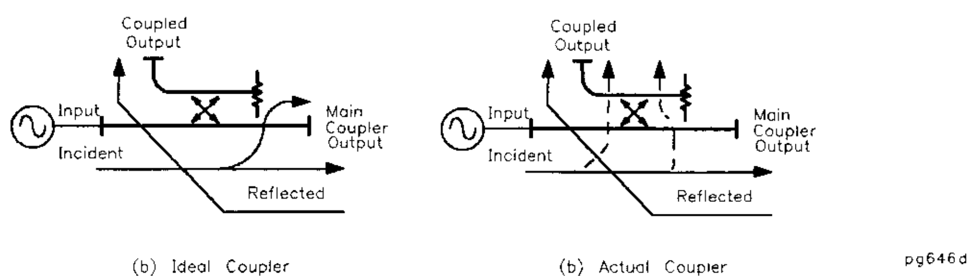


Figure 5-26. Directivity

However, an actual coupler is not perfect, as illustrated in Figure 5-26b. A small amount of the incident signal appears at the coupled output due to leakage as well as reflection from the termination in the coupled arm. Also, reflections from the coupler output connector appear at the coupled output, adding uncertainty to the signal reflected from the device. The figure of merit for how well a coupler separates forward and reverse waves is directivity. The greater the directivity of the device, the better the signal separation. System directivity is the vector sum of all leakage signals appearing at the analyzer receiver input. The error contributed by directivity is independent of the characteristics of the test device and it usually produces the major ambiguity in measurements of low reflection devices.

Source match

Source match is defined as the vector sum of signals appearing at the analyzer receiver input due to the impedance mismatch at the test device looking back into the source, as well as to adapter and cable mismatches and losses. In a reflection measurement, the source match error signal is caused by some of the reflected signal from the test device being reflected from the source back toward the test device and re-reflected from the test device (Figure 5-27). In a transmission measurement, the source match error signal is caused by reflection from the test device that is re-reflected from the source. Source match is most often given in terms of return loss in dB: thus the larger the number, the smaller the error.

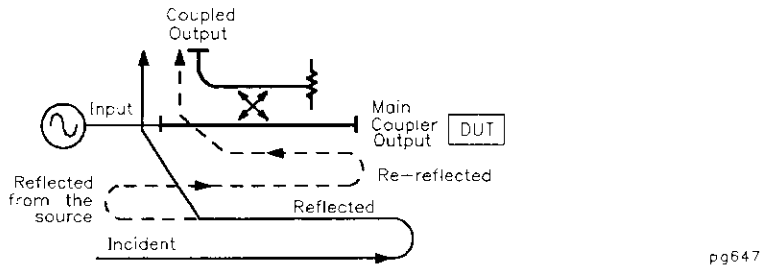


Figure 5-27. Source Match

The error contributed by source match is dependent on the relationship between the actual input impedance of the test device and the equivalent match of the source. It is a factor in both transmission and reflection measurements. Source match is a particular problem in measurements where there is a large impedance mismatch at the measurement plane.

Load match

Load match error results from an imperfect match at the output of the test device. It is caused by impedance mismatches between the test device output port and the transmission port of the measurement system. As illustrated in Figure 5-28, some of the transmitted signal is reflected from the transmission port back to the test device. A portion of this wave may be re-reflected to the transmission port, or part may be transmitted through the device in the reverse direction to appear at the reflection port. If the test device has low insertion loss (for example a transmission line), the signal reflected from the transmission port and re-reflected from the source causes a significant error because the test device does not attenuate the signal significantly on each reflection. Load match is usually given in terms of return loss in dB: thus the larger the number, the smaller the error.

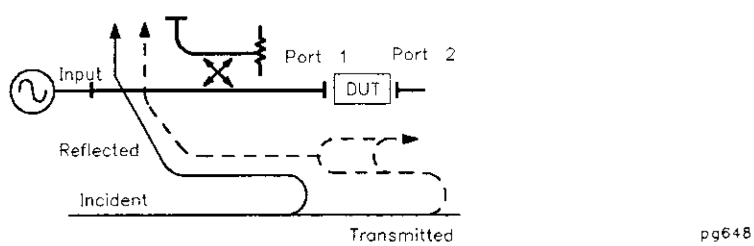


Figure 5-28. Load Match

The error contributed by load match is dependent on the relationship between the actual output impedance of the test device and the effective match of the return port (transmission port). It is a factor in all transmission measurements and in reflection measurements of two-port devices. Load match and source match are usually ignored when the test device insertion loss is greater than about 6 dB, because the error signal is greatly attenuated each time it passes through the test device. However, load match effects produce major transmission measurement errors for a test device with a highly reflective output port.

Note The HP 8752C *cannot* compensate for load match errors.

Isolation (crosstalk)

Leakage of energy between analyzer signal paths contributes to error in a transmission measurement much like directivity does in a reflection measurement. Isolation is the vector sum of signals appearing at the analyzer samplers due to crosstalk between the reference and test signal paths. This includes signal leakage within the test set and in both the RF and IF sections of the receiver.

The error contributed by isolation depends on the characteristics of the test device. Isolation is a factor in high-loss transmission measurements. However, analyzer system isolation is more than sufficient for most measurements, and correction for it may be unnecessary.

For measuring devices with high dynamic range, accuracy enhancement can provide improvements in isolation that are limited only by the noise floor.

Generally, the isolation falls below the noise floor, therefore, when performing an isolation calibration you should use a noise reduction function such as averaging or reduce the IF bandwidth.

Frequency response (tracking)

This is the vector sum of all test setup variations in which magnitude and phase change as a function of frequency. This includes variations contributed by signal-separation devices, test cables, and adapters, and variations between the reference and test signal paths. This error is a factor in both transmission and reflection measurements.

For further explanation of systematic error terms and the way they are combined and represented graphically in error models, refer to the "Characterizing microwave systematic errors" in this section.

Characterizing microwave systematic errors

One-port error model

In a measurement of the reflection coefficient (magnitude and phase) of a test device, the measured data differs from the actual, no matter how carefully the measurement is made. Directivity, source match, and reflection signal path frequency response (tracking) are the major sources of error (see Figure 5-29).

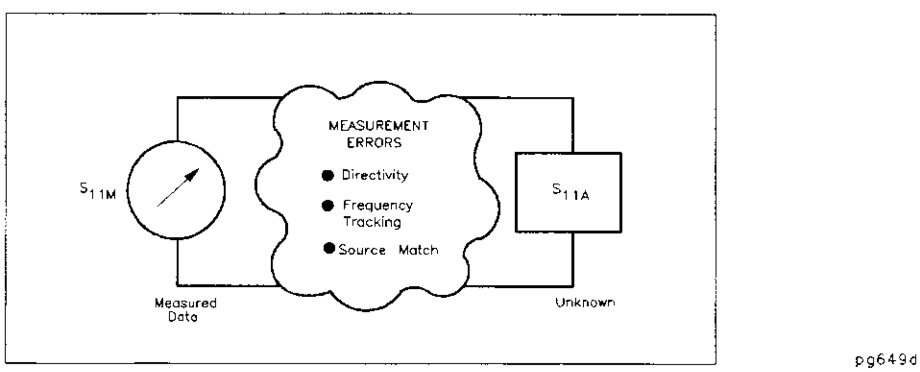


Figure 5-29. Sources of Error in a Reflection Measurement

To characterize the errors, the reflection coefficient is measured by first separating the incident signal (I) from the reflected signal (R), then taking the ratio of the two values (see Figure 5-30). Ideally, (R) consists only of the signal reflected by the test device ($S_{11}A$).

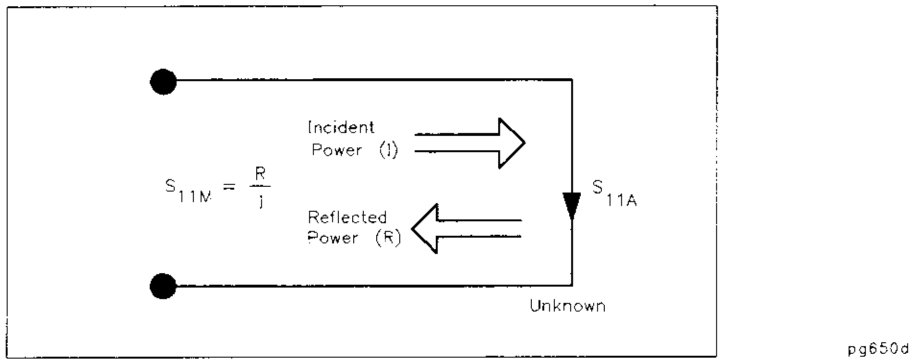


Figure 5-30. Reflection Coefficient

However, all of the incident signal does not always reach the unknown (see Figure 5-31). Some of (I) may appear at the measurement system input due to leakage through the test set or through a signal separation device. Also, some of (I) may be reflected by imperfect adapters between a signal separation device and the measurement plane. The vector sum of the leakage and the miscellaneous reflections is the effective directivity, E_{DF}. Understandably, the measurement is distorted when the directivity signal combines vectorally with the actual reflected signal from the unknown, $S_{11}A$.

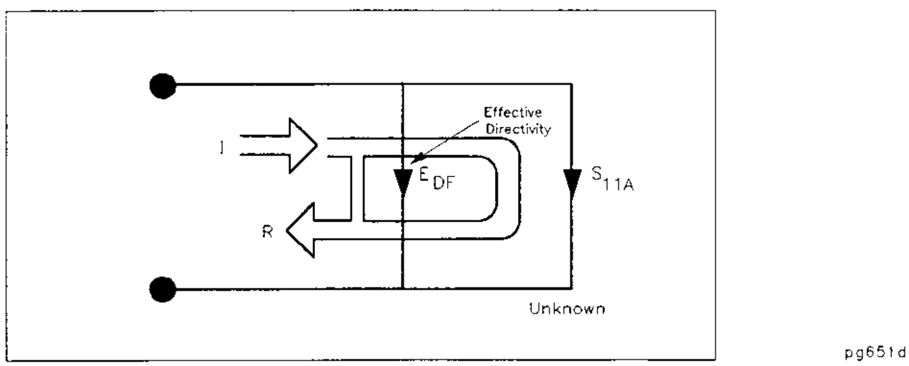


Figure 5-31. Effective Directivity E_{DF}

Since the measurement system test port is never exactly the characteristic impedance (50 ohms or 75 ohms), some of the reflected signal bounces off the test port, or other impedance transitions further down the line, and back to the unknown, adding to the original incident signal (I). This effect causes the magnitude and phase of the incident signal to vary as a function of $S_{11}A$ and frequency. Leveling the source to produce a constant incident signal (I) reduces this error, but since the source cannot be exactly leveled at the test device input, leveling cannot eliminate all power variations. This re-reflection effect and the resultant incident power variation are caused by the source match error, E_{SF} (see Figure 5-32).

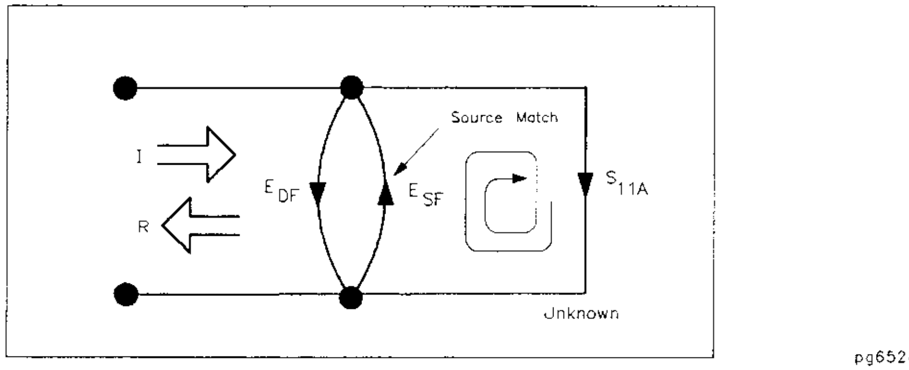


Figure 5-32. Source Match E_{SF}

Frequency response (tracking) error is caused by variations in magnitude and phase flatness versus frequency between the test and reference signal paths. These are due mainly to imperfectly matched samplers and differences in length and loss between the incident and test signal paths. The vector sum of these variations is the reflection signal path tracking error, E_{RF} (see Figure 5-33).

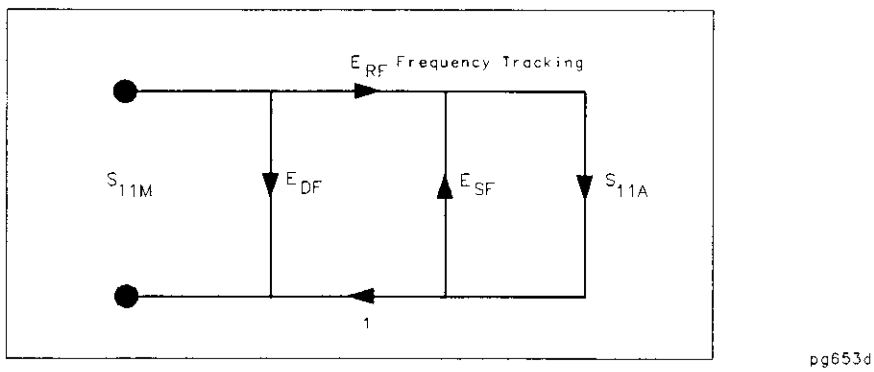


Figure 5-33. Reflection Tracking E_{RF}

These three errors are mathematically related to the actual data, $S_{11}A$, and measured data, $S_{11}M$, by the following equation:

$$S_{11M} = E_{DF} + [(S_{11A}\ E_{RF}) / (1 - E_{SF}\ S_{11A})]$$

If the value of these three "E" errors and the measured test device response were known for each frequency, the above equation could be solved for $S_{11}A$ to obtain the actual test device response. Because each of these errors changes with frequency, their values must be known at each test frequency. These values are found by measuring the system at the measurement plane using three independent standards whose $S_{11}A$ is known at all frequencies.

The first standard applied is a "perfect load," which makes $S_{11}A = 0$ and essentially measures directivity (see Figure 5-34). "Perfect load" implies a reflectionless termination at the measurement plane. All incident energy is absorbed. With $S_{11}A = 0$ the equation can be solved for E_{DF}, the directivity term. In practice, of course, the "perfect load" is difficult to achieve, although very good broadband loads are available in the HP 8752C compatible calibration kits.

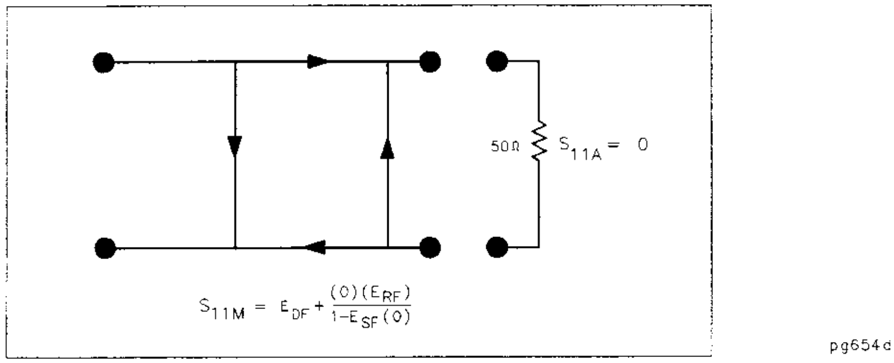


Figure 5-34. "Perfect Load" Termination

Since the measured value for directivity is the vector sum of the actual directivity plus the actual reflection coefficient of the "perfect load," any reflection from the termination represents an error. System effective directivity becomes the actual reflection coefficient of the "perfect load" (see Figure 5-35). In general, any termination having a return loss value greater than the uncorrected system directivity reduces reflection measurement uncertainty.

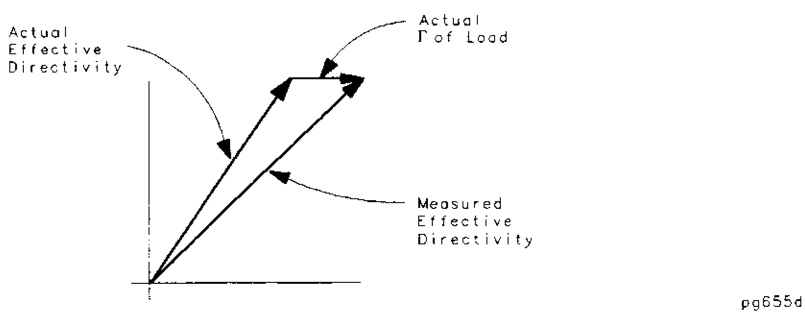


Figure 5-35. Measured Effective Directivity

Next, a short circuit termination whose response is known to a very high degree is used to establish another condition (see Figure 5-36).

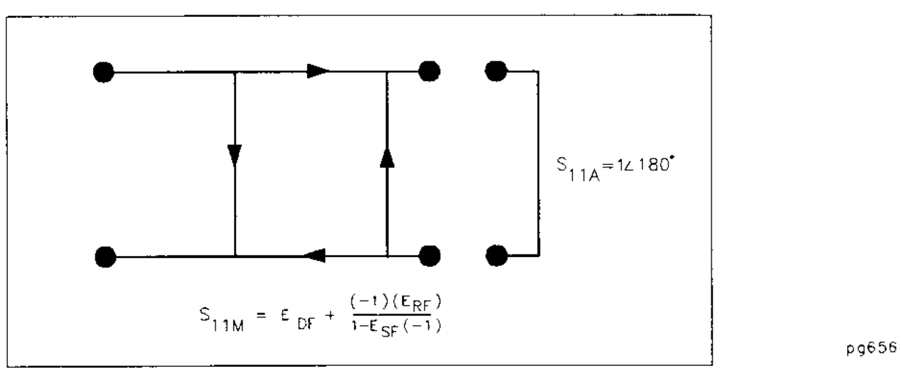


Figure 5-36. Short Circuit Termination

The open circuit gives the third independent condition. In order to accurately model the phase variation with frequency due to radiation from the open connector, a specially designed shielded open circuit is used for this step. (The open circuit capacitance is different with each connector type). Now the values for E_{DF}, directivity, E_{SF}, source match, and E_{RF}, reflection frequency response, are computed and stored (see Figure 5-37).

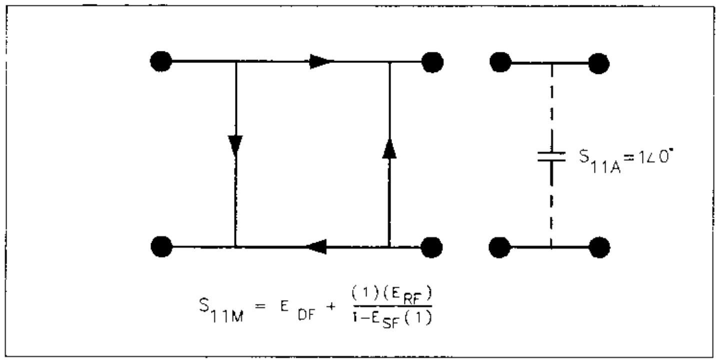


Figure 5-37. Open Circuit Termination

Now the unknown is measured to obtain a value for the measured response, $S_{11}M$, at each frequency (see Figure 5-38).

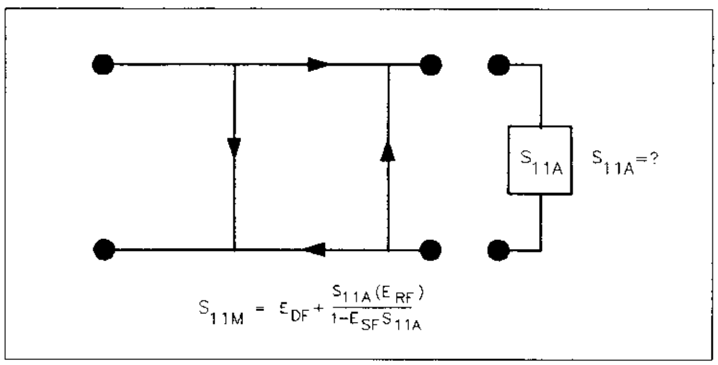


Figure 5-38. Measured S_{11} (Reflection)

This is the one-port error model equation solved for $S_{11}A$. Since the three errors and $S_{11}M$ are now known for each test frequency, $S_{11}A$ can be computed as follows:

$S_{11A} = S_{11M} - E_{DF} / [E_{SF} (S_{11M} - E_{DF}) + E_{RF}]$

For reflection measurements on two-port devices, the same technique can be applied, but the test device output port must be terminated in the system characteristic impedance. This termination should have as low a reflection coefficient as the load used to determine directivity. The additional reflection error caused by an improper termination at the test device's output port is not incorporated into the one-port error model.

Transmission response

Transmission signal path frequency response is then measured with the thru connected. The data is corrected for source and load match effects, then stored as transmission frequency response, E_{TF}.

Isolation response

Isolation, E_{XF}, represents the part of the incident signal that appears at the receiver without actually passing through the test device (see Figure 5-39). Isolation is measured with the test set in the transmission configuration and with terminations installed at the points where the test device will be connected.

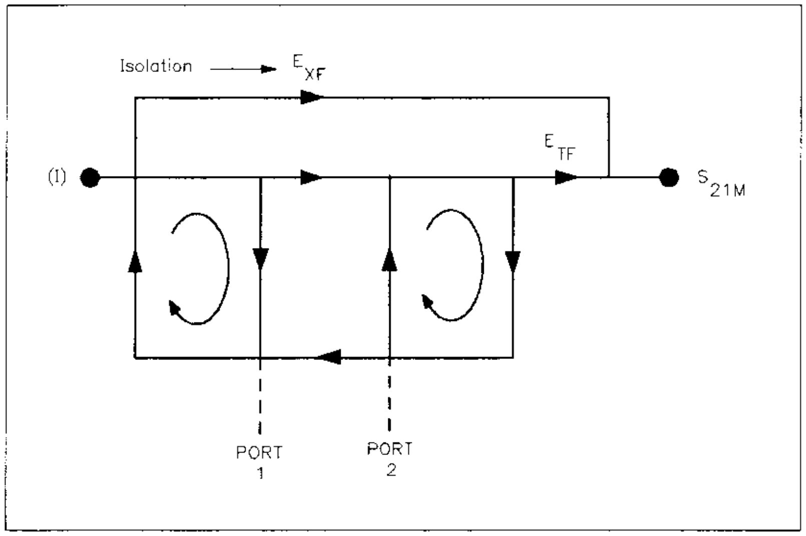


Figure 5-39. Response E_{TF} and Isolation E_{XF}

Correcting for measurement errors

Measurement errors can be corrected by measuring the repeatable systematic errors and mathematically removing their effects form the measured data. The HP 8752C can correct for the following error terms:

- Reflection

  Directivity, E_{DF}

  Reflection tracking, E_{RF}

  Source match, E_{SF}

- Transmission

  Transmission tracking, E_{TF}

  Isolation, E_{XF}

Calibration features on the HP 8752C

The HP 8752C has three calibration features that can be used to correct for the measurement errors listed above.

- **Built-in calibration** (requires no action on the part of the operator). The built-in calibration has certain requirements which must be met. These requirements are explained in "Built-in versus user-performed measurement calibration".
- **Three user-performed calibrations** are available for instances where external adapters, extra test cables, or other external test accessories are connected. These calibrations guide the operator through the calibration procedure. Normally a user-performed calibration will not tolerate changes to stimulus settings (for example, changing frequency range or number

of points). Such changes turn the calibration off immediately. Such changes are possible, however, using interpolated error correction.

- **Interpolated error correction** allows a user-performed calibration to be valid after changing stimulus settings. When this feature is turned on, you can use a narrower stimulus span than was originally selected. In addition, you can increase or decrease the number of points used.

Built-in versus user-performed measurement calibration

The HP 8752C contains a built-in calibration feature which compensates for repeatable system errors caused by the analyzer, the analyzer's test port connectors, and the test cable. Under some circumstances (explained below) your test setup may introduce other devices which create additional errors. When this occurs, you can remove the errors caused by the extra devices by performing your own measurement calibration. Three types of user-performed calibrations are available, each having different levels of complexity and equipment requirements.

When to use the built-in calibration. If all of the following conditions are met, the analyzer can provide highly accurate measurements using its own built-in accuracy enhancement.

- The test device is connected directly to the reflection port with no adapters or intervening cables.
- The test device is designed for use in a 50 ohm system or a 75 ohm system (option 075).
- In transmission measurements, the supplied test cable connects the test device to the transmission port with no adapters or intervening cables.

When a user-performed calibration is necessary. There are certain conditions where using the analyzer's built-in calibration is not adequate and a user-performed calibration would be more effective. Examples are:

- Adapting to a different connector type or impedance.
- Connecting a cable between the test device and the reflection port.
- Using a test cable other than the cable supplied with the HP 8752C.
- An attenuator or other device must be connected on the input or output of the test device.

User-performed measurement calibrations

The (CAL) key leads to a series of menus that implement the user-performed accuracy enhancement concepts described in this section. Accuracy enhancement (error correction) is performed as a calibration step before measurement of a test device.

The analyzer has three different measurement calibration routines to characterize one or more of the systematic error terms and remove their effects from the measured data.

Response calibration

The response calibration provides a normalization of the test setup for reflection or transmission measurements. This calibration procedure may be adequate for measurement of well matched low-loss devices. This is the simplest error correction to perform, and should be used when extreme measurement accuracy is not required.

Response and isolation calibration

The response and isolation calibration provides a normalization for frequency response and crosstalk errors in transmission measurements, or frequency response and directivity errors in reflection measurements. This procedure may be adequate for measurement of well matched high-loss devices.

Reflection one-port

The reflection one-port calibration provides a measurement calibration for reflection-only measurements of one-port devices or properly terminated multi-port devices. The calibration is performed on the reflection port. This procedure reduces the directivity, source match, and tracking errors of the test setup, and provides a higher level of measurement accuracy than the response and isolation calibration. It is the most accurate calibration procedure for reflection-only measurements. Three standard devices are required: an open, a short, and an impedance-matched load.

Ensuring a valid calibration

Unless interpolated error correction is on, measurement calibrations are valid only for a specific stimulus state, which must be set before calibration is begun. The stimulus state consists of the selected frequency range, number of points, sweep time, temperature, output power, and sweep type. Changing the frequency range, number of points, or sweep type with correction on invalidates the calibration and turns it off. Changing the sweep time or output power changes the status notation `Cor` at the left of the screen to `C?`, to indicate that the calibration is in question. If correction is turned off or in question after the stimulus changes are made, pressing `CORRECTION ON off` recalls the original stimulus state for the current calibration.

Interpolated error correction

The interpolated error correction feature allows you to select a subset of the frequency range or a different number of points without recalibration. Interpolation is activated by a softkey. When interpolation is on, the system errors for the newly selected frequencies are calculated from the system errors of the original calibration.

System performance is unspecified when using interpolated error correction. The quality of the interpolated error correction is dependent on the amount of phase shift and the amplitude change between measurement points. If phase shift is no greater than 180° per approximately 5 measurement points, interpolated error correction offers a great improvement over uncorrected measurements. The accuracy of interpolated error correction improves as the phase shift and amplitude change between adjacent points decrease. When you use the analyzer in linear frequency sweep, perform the original calibration with at least 67 points per 1 GHz of frequency span for greatest accuracy with interpolated error correction.

Interpolated error correction functions in three sweep modes: linear frequency, power sweep, and CW time.

If there is a valid correction array for a linear frequency sweep, this may be interpolated to provide correction at the CW frequency used in power sweep or CW time modes. This correction is part of the interpolated error correction feature and is not specified.

Channel coupling

Up to two sets of measurement calibration data can be defined for each instrument state, one for each channel. If the two channels are stimulus coupled and the input ports are the same for both channels, they share the same calibration data. If the two channel inputs are different, they can have different calibration data. If the two channels are stimulus uncoupled, the measurement calibration applies to only one channel.

Measurement parameters

Calibration procedures are parameter-specific, rather than channel-specific. When a parameter is selected, the instrument checks the available calibration data, and uses the data found for that parameter. For example, if a transmission response calibration is performed for `TRN`, and a reflection one-port calibration for `RFL`, the analyzer retains both calibration sets and corrects whichever parameter is displayed. Once a calibration has been performed for a specific parameter or input, measurements of that parameter remain calibrated in either channel, as long as stimulus values are coupled. In the response and response and isolation calibrations, the parameter must be selected before calibration: other correction procedures select parameters automatically. Changing channels during a calibration procedure invalidates the part of the procedure already performed.

Device measurements

In calibration procedures that require measurement of several different devices, for example a short, an open, and a load, the order in which the devices are measured is not critical. Any standard can be re-measured, until the DONE key is pressed. The change in trace during measurement of a standard is normal.

Response and response and isolation calibrations require measurement of only one standard device. If more than one device is measured, only the data for the last device is retained.

Omitting isolation calibration

Isolation calibration can be omitted for most measurements, except where wide dynamic range is a consideration. Use the following guidelines. When the measurement requires a dynamic range of:

- 80 dB: Omit isolation calibration for most measurements.
- 80 to 100 dB: Isolation calibration is recommended with approximately 0 dBm into the R input. If an isolation calibration is used, averaging should be turned on with an averaging factor of 16 for the isolation calibration, and four for the measurement after calibration.
- 100 dB: Averaging should be turned on with an averaging factor of 16, both for the isolation calibration and for the measurement after calibration.

Restarting a calibration

If you interrupt a calibration to go to another menu, you can continue the calibration by pressing the RESUME CAL SEQUENCE softkey in the correction menu.

Saving calibration data

You should save the calibration data, either in the internal non-volatile memory or on a disk. If you do not save it, it will be lost if you select another calibration procedure for the same channel, or if you change stimulus values. Instrument preset, power on, and instrument state recall will also clear the calibration data.

The calibration standards

During measurement calibration, the analyzer measures actual, well-defined standards and mathematically compares the results with ideal "models" of those standards. The differences are separated into error terms which are later removed during error correction. Most of the differences are due to systematic errors - repeatable errors introduced by the analyzer, test set, and cables - which are correctable.

The standard devices required for system calibration are available in compatible calibration kits with different connector types. Each kit contains at least one short circuit, one open circuit, and two impedance-matched loads. In kits that require adapters for interface to the test set ports, the adapters are phase-matched for calibration prior to measurement of non-insertable and non-reversible devices. Other standard devices can be used by specifying their characteristics in a user-defined kit, as described later in this section under "Modifying calibration kits".

The accuracy improvement of the correction is limited by the quality of the standard devices, and by the connection techniques used. For maximum accuracy, use a torque wrench for final connections.

Frequency response of calibration standards

In order for the response of a reference standard to show as a dot on the display, it must have no phase shift with respect to frequency. Standards that exhibit such "perfect" response are the following:

- 7 mm short (with no offset)
- type-N male short (with no offset)

There are two reasons why other types of reference standards show phase shift after calibration:

- The reference plane of the standard is electrically offset from the mating plane of the test port. Such devices exhibit the properties of a small length of transmission line, including a certain amount of phase shift.
- The standard is an open termination, which by definition exhibits a certain amount of fringe capacitance (and therefore phase shift). Open terminations which are offset from the mating plane will exhibit a phase shift due to the offset in addition to the phase shift caused by the fringe capacitance.

The most important point to remember is that these properties will not affect your measurements. The analyzer compensates for them during measurement. Figure 5-40 shows sample displays of various calibration standards after calibration.

Electrical offset. Some standards have reference planes that are electrically offset from the mating plane of the test port. These devices will show a phase shift with respect to frequency. Table 5-2 shows which reference devices exhibit an electrical offset phase shift. The amount of phase shift can be calculated with the formula:

$\phi = (360 \times f \times l)/c$ where:

f = frequency

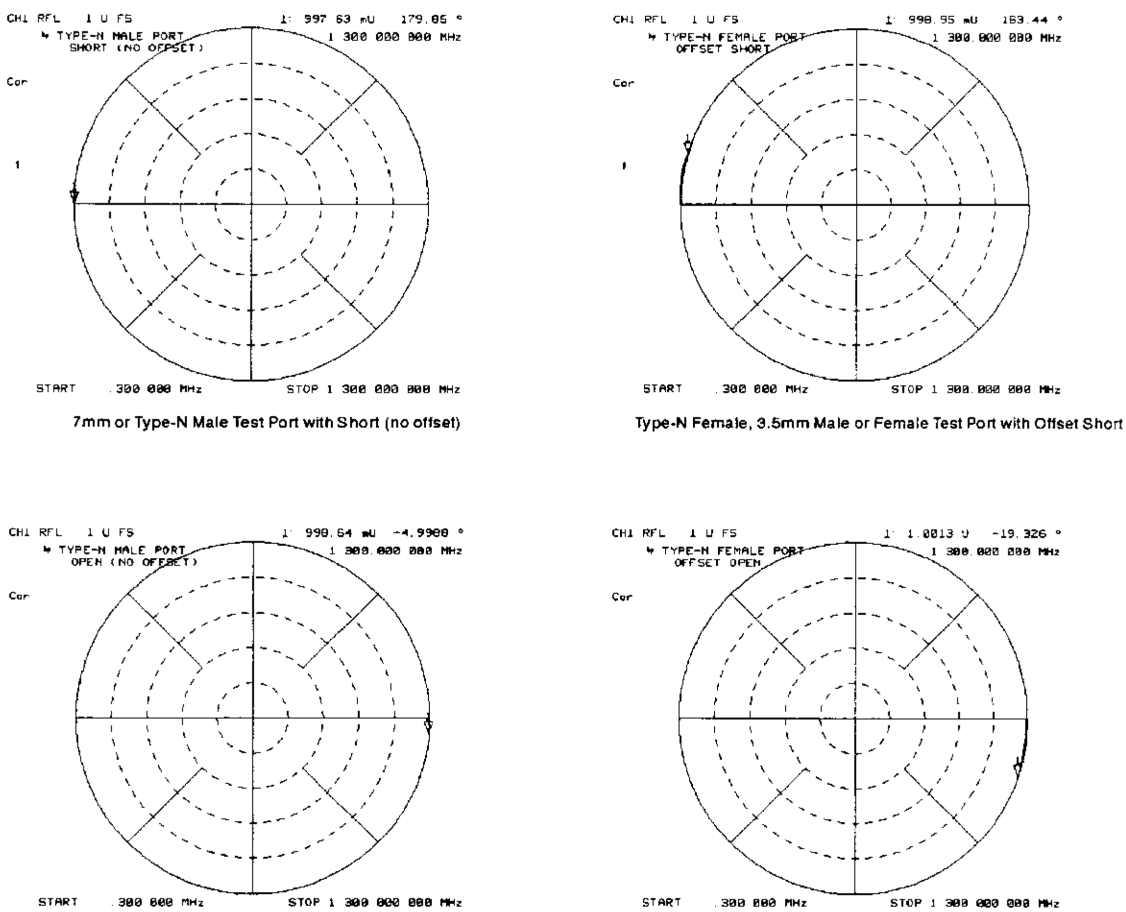
l = electrical length of the offset

c = speed of light (3×10^8 meters/second)

Fringe capacitance. All open circuit terminations exhibit a phase shift over frequency due to fringe capacitance. Offset open circuits have increased phase shift because the offset acts as a small length of transmission line. Refer to Table 5-2.

Table 5-2. Calibration Standard Types and Expected Phase Shift

Test Port Connector Type	Standard Type	Expected Phase Shift
7 mm Type N male	Short	180°
3.5 mm male 3.5 mm female Type N female	Offset Short	180° + (360 x f x l)/c
7 mm Type N male	Open	$0° + \phi_{capacitance}$
3.5 mm male 3.5 mm female Type N female	Offset Open	$0° + \phi_{capacitance}$ + (360 x f x l)/c Open $0° + \phi_{capacitance}$ + (360 x f x l)/c



7mm or Type-N Male Test Port with Short (no offset)

Type-N Female, 3.5mm Male or Female Test Port with Offset Short

7mm or Type-N Male Test Port with Open (no offset)

Type-N Female, 3.5mm Male or Female Test Port with Offset Open

ph680_c

Figure 5-40. Typical Responses of Calibration Standards after Calibration

Specifying calibration kits

In addition to the menus for the different calibration procedures, the (CAL) key provides access to a series of menus used to specify the characteristics of calibration standards. Several default calibration kits with different connector types have predefined standards and are valid for most applications. The numerical definitions for most Hewlett-Packard calibration kits can be referenced in the calibration kit operating and service manuals, or can be viewed on the analyzer. The standard definitions can also be modified to any set of standards used.

Modifying calibration kits

Modifying calibration kits is necessary only if unusual standards are used or the very highest accuracy is required. Unless a calibration kit model is provided with the calibration devices used, a solid understanding of error correction and the system error model are absolutely essential to making modifications.

To improve your understanding of modifying calibration kits, you should read application note 8510-5A before attempting to modify calibration standard definitions. The part number of this application note is 5956-4352. Although the application note is written for the HP 8510 family of network analyzers, it also applies to the HP 8752.

Several situations exist that may require a user-defined calibration kit:

- A calibration is required for a connector interface different from the four default calibration kits. (Examples: SMA, TNC, or waveguide.)
- A calibration with standards (or combinations of standards) that are different from the default calibration kits is required. (Example: Using three offset shorts instead of open, short, and load to perform a 1-port calibration.)
- The built-in standard models for default calibration kits can be improved or refined. Remember that the more closely the model describes the actual performance of the standard, the better the calibration. (Example: The 7 mm load is determined to be 50.4 ohms instead of 50.0 ohms.)

Definitions

The following are definitions of terms:

- A "standard" is a specific, well-defined, physical device used to determine systematic errors.
- A standard "type" is one of five basic types that define the form or structure of the model to be used with that standard (e.g. short or load).
- Standard "coefficients" are numerical characteristics of the standards used in the model selected.
- A standard "class" is a grouping of one or more standards that determines which standards are used in a particular calibration procedure.

Procedure

The following steps are used to modify or define a user kit:

1. To modify a cal kit, first select the predefined kit to be modified. This is not necessary for defining a new cal kit.
2. Define the standards. For each standard, define which "type" of standard it is and its electrical characteristics.
3. Specify the class where the standard is to be assigned.
4. Store the modified cal kit.

Refer to "Using the front panel to examine or modify calibration constants" later in this section for detailed instructions.

Modify calibration kit menu

This menu is accessed from the (CAL) key. This leads in turn to additional series of menus associated with modifying cal kits.

DEFINE STANDARD makes the standard number the active function, and brings up the define standard menus. The standard number (1 to 8) is an arbitrary reference number used to reference standards while specifying a class. The standard numbers for the predefined calibration kits are as follows:

1 short

2 open

3 broadband load

4 thru

5 sliding load

6 lowband load

7 short

8 open

SPECIFY CLASS leads to the specify class menu. After the standards are modified, use this key to specify a class to consist of certain standards.

LABEL CLASS leads to the label class menu, to give the class a meaningful label for future reference.

LABEL KIT leads to a menu for constructing a label for the user-modified cal kit. If a label is supplied, it will appear as one of the five softkey choices in the select cal kit menu. The approach is similar to defining a display title, except that the kit label is limited to ten characters.

KIT DONE terminates the cal kit modification process, after all standards are defined and all classes are specified. Be sure to save the kit with the SAVE USER KIT softkey, if it is to be used later.

Define standard menus

Standard definition is the process of mathematically modeling the electrical characteristics (delay, attenuation, and impedance) of each calibration standard. These electrical characteristics (coefficients) can be mathematically derived from the physical dimensions and material of each calibration standard, or from its actual measured response. The parameters of the standards can be listed in Table 5-3.

Table 5-3. Standard Definitions

System Z_0[a] = ___________ Calibration Kit Label: ___________

Disk File Name: ___________

STANDARD[b]		C0 ×10^{-15} F	C1 ×10^{-27} F/Hz	C2 ×10^{-36} F/Hz^2	C3 ×10^{-45} F/Hz^3	FIXED[c] or SLIDING	TERM[d] IMPED Ω	OFFSET			FREQ (GHz)		COAX or WG	STND LABEL
NO.	TYPE							DELAY s	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1														
2														
3														
4														
5														
6														
7														
8														

[a] Ensure system Z_0 of network analyzer is set to this value.
[b] Open, short, load, delay/thru, or arbitrary impedance.
[c] Load or arbitrary impedance only.
[d] Arbitrary impedance only, device terminating impedance.

Each standard must be identified as one of five "types": open, short, load, delay/thru, or arbitrary impedance.

After a standard number is entered, selection of the standard type will present one of five menus for entering the electrical characteristics (model coefficients) corresponding to that standard type. These menus are tailored to the current type, so that only characteristics applicable to the standard type can be modified.

Any standard type can be further defined with offsets in delay, loss, and standard impedance; assigned minimum or maximum frequencies over which the standard applies; and defined as coax or waveguide. Press the SPECIFY OFFSET key, and refer to the specify offset menu.

A distinct label can be defined and assigned to each standard, so that the analyzer can prompt the user with explicit standard labels during calibration (e.g. "SHORT"). Press the LABEL STD softkey. The function is similar to defining a display title, except that the label is limited to ten characters.

After each standard is defined, including offsets, press STD DONE (DEFINED) to terminate the standard definition.

OPEN defines the standard type as an open, used for calibrating reflection measurements. Opens are assigned a terminal impedance of infinite ohms, but delay and loss offsets may still be added. Pressing this key also brings up a menu for defining the open, including its capacitance.

As a reflection standard, an open termination offers the advantage of broadband frequency coverage. At microwave frequencies, however, an open rarely has perfect reflection characteristics because fringing (capacitance) effects cause phase shift that varies with frequency. This can be observed in measuring an open termination after calibration, when an arc in the lower right circumference of the Smith chart indicates capacitive reactance. These effects are impossible to eliminate, but the calibration kit models include the open termination capacitance at all frequencies for compatible calibration kits. The capacitance model is a cubic polynomial, as a function of frequency, where the polynomial coefficients are user-definable. The capacitance model equation is:

$$C = (C0) + (C1 \times F) + (C2 \times F^2) + (C3 \times F^3)$$

where F is the measurement frequency.

The terms in the equation are defined with the specify open menu as follows:

C0 is used to enter the C0 term, which is the constant term of the cubic polynomial and is scaled by 10^{-15} Farads.

C1 is used to enter the C1 term, expressed in F/Hz (Farads/Hz) and scaled by 10^{-27}.

C2 is used to enter the C2 term, expressed in F/Hz^2 and scaled by 10^{-36}.

C3 is used to enter the C3 term, expressed in F/Hz^3 and scaled by 10^{-45}.

SHORT defines the standard type as a short, for calibrating reflection measurements. Shorts are assigned a terminal impedance of 0 ohms, but delay and loss offsets may still be added.

LOAD defines the standard type as a load (termination). Loads are assigned a terminal impedance equal to the system characteristic impedance Z0, but delay and loss offsets may still be added. If the load impedance is not Z0, use the arbitrary impedance standard definition.

FIXED defines the load as a fixed (not sliding) load.

SLIDING defines the load as a sliding load. When such a load is measured during calibration, the analyzer will prompt for several load positions, and calculate the ideal load value from it.

DELAY/THRU defines the standard type as a transmission line of specified length, for calibrating transmission measurements.

ARBITRARY IMPEDANCE defines the standard type to be a load, but with an arbitrary impedance (different from system Z0).

TERMINAL IMPEDANCE is used to specify the (arbitrary) impedance of the standard, in ohms.

FIXED defines the load as a fixed (not sliding) load.

SLIDING defines the load as a sliding load. When such a load is measured during calibration, the analyzer will prompt for several load positions, and calculate the ideal load value from it.

Specify offset menu

The specify offset menu allows additional specifications for a user-defined standard. Features specified in this menu are common to all five types of standards.

Offsets may be specified with any standard type. This means defining a uniform length of transmission line to exist between the standard being defined and the actual measurement plane. (Example: a waveguide short circuit terminator, offset by a short length of waveguide.) For reflection standards, the offset is assumed to be between the measurement plane and the standard (one-way only). For transmission standards, the offset is assumed to exist between the two reference planes (in effect, the offset is the thru). Three characteristics of the offset can be defined: its delay (length), loss, and impedance.

In addition, the frequency range over which a particular standard is valid can be defined with a minimum and maximum frequency. This is particularly important for a waveguide standard, since its behavior changes rapidly beyond its cutoff frequency. Note that several band-limited standards can together be defined as the same "class" (see specify class menu). Then, if a measurement calibration is performed over a frequency range exceeding a single standard, additional standards can be used for each portion of the range.

Lastly, the standard must be defined as either coaxial or waveguide. If it is waveguide, dispersion effects are calculated automatically and included in the standard model.

OFFSET DELAY is used to specify the one-way electrical delay from the measurement (reference) plane to the standard, in seconds (s). (In a transmission standard, offset delay is the delay from plane to plane.) Delay can be calculated from the precise physical length of the offset, the permittivity constant of the medium, and the speed of light.

In coax, group delay is considered constant. In waveguide, however, group delay is dispersive, that is, it changes significantly as a function of frequency. Hence, for a waveguide standard, offset delay must be defined at an infinitely high frequency.

OFFSET LOSS is used to specify energy loss, due to skin effect, along a one-way length of coax offset. The value of loss is entered as ohms/nanosecond (or Giga ohms/second) at 1 GHz. (Such losses are negligible in waveguide, so enter 0 as the loss offset.)

OFFSET Z0 is used to specify the characteristic impedance of the coax offset. (Note: This is not the impedance of the standard itself.) (For waveguide, the offset impedance is always assigned a value equal to the system Z0.)

MINIMUM FREQUENCY is used to define the lowest frequency at which the standard can be used during measurement calibration. In waveguide, this must be the lower cutoff frequency of the standard, so that the analyzer can calculate dispersive effects correctly (see OFFSET DELAY above).

MAXIMUM FREQUENCY is used to define the highest frequency at which the standard can be used during measurement calibration. In waveguide, this is normally the upper cutoff frequency of the standard.

COAX defines the standard (and the offset) as coaxial. This causes the analyzer to assume linear phase response in any offsets.

WAVEGUIDE defines the standard (and the offset) as rectangular waveguide. This causes the analyzer to assume a dispersive delay (see OFFSET DELAY above).

Label standard menu

This menu is used to label (reference) individual standards during the menu-driven measurement calibration sequence. The labels are user-definable using a character set shown on the display that includes letters, numbers, and some symbols, and they may be up to ten characters long. The analyzer will prompt you to connect standards using these labels, so they should be meaningful to you, and distinct for each standard.

By convention, when sexed connector standards are labeled male (m) or female (f), the designation refers to the test port connector sex, not the connector sex of the standard.

Specify class menus

Once a standard is specified, it must be assigned to a standard "class". This is a group of from one to seven standards that is required to calibrate for a single error term. The standards within a single class are assigned to locations A through G as listed in Table 5-4. A class often consists of a single standard, but may be composed of more than one standard if band-limited standards are used. (Example: All default calibration kits for the analyzer have a single load standard per class, since all are broadband in nature. However, if there were two load standards - a fixed load for low frequencies, and a sliding load for high frequencies - then that class would have two standards.)

Table 5-4. Standard Class Assignments

Calibration Kit Label: ____________________

Disk File Name: ____________________

Class	A	B	C	D	E	F	G	Standard Class Label
$S_{11}A$								
$S_{11}B$								
$S_{11}C$								
$S_{22}A$*								
$S_{22}B$*								
$S_{22}C$*								
Forward Transmission*								
Reverse Transmission*								
Forward Match*								
Reverse Match*								
Response								
Response and Isolation								

* This class does not apply to the HP 8752C.

The number of standard classes required depends on the type of calibration being performed, and is identical to the number of error terms corrected. (Examples: A response cal requires only one class, and the standards for that class may include an open, or short, or thru. A 1-port cal requires three classes.) The number of standards that can be assigned to a given class may vary from none (class not used) to one (simplest class) to seven. When a certain class of standards is required during calibration, the analyzer will display the labels for all the standards in that class (except when the class consists of a single standard). This does not, however, mean that all standards in a class must be measured during calibration. Unless band-limited standards are used, only a single standard per class is required. Note that it is often simpler to keep the number of standards per class to the bare minimum needed (often one) to avoid confusion during calibration.

Standards are assigned to a class simply by entering the standard's reference number (established while defining a standard) under a particular class. Each class can be given a user-definable label as described under "Label class menus".

`SPECIFY: S11A` is used to enter the standard numbers for the first class required for an S_{11} 1-port calibration. (For default cal kits, this is the open.)

`S11B` is used to enter the standard numbers for the second class required for an S_{11} 1-port calibration. (For default cal kits, this is the short.)

`S11C` is used to enter the standard numbers for the third class required for an S_{11} 1-port calibration. (For default kits, this is the load.)

SPECIFY: S_{22}A is used to enter the standard numbers for the first class required for an S_{22} 1-port calibration. (For default cal kits, this is the open.) *This class does not apply to the HP 8752C.*

S_{22}B is used to enter the standard numbers for the second class required for an S_{22} 1-port calibration. (For default cal kits, this is the short.) *This class does not apply to the HP 8752C.*

S_{22}C is used to enter the standard numbers for the third class required for an S_{22} 1-port calibration. (For default kits, this is the load.) *This class does not apply to the HP 8752C.*

MORE leads to the following softkeys.

FWD.TRANS. is used to enter the standard numbers for the forward transmission thru calibration. (For default kits, this is the thru.) *This class does not apply to the HP 8752C.*

REV.TRANS. is used to enter the standard numbers for the reverse transmission (thru) calibration. (For default kits, this is the thru.) *This class does not apply to the HP 8752C.*

FWD.MATCH is used to enter the standard numbers for the forward match (thru) calibration. (For default kits, this is the thru.) *This class does not apply to the HP 8752C.*

REV.MATCH is used to enter the standard numbers for the reverse match (thru) calibration. (For default kits, this is the thru.) *This class does not apply to the HP 8752C.*

RESPONSE is used to enter the standard numbers for a response calibration. This calibration corrects for frequency response in either reflection or transmission measurements, depending on the parameter being measured when a calibration is performed. (For default kits, the standard is either the open or short for reflection measurements, or the thru for transmission measurements.)

RESPONSE & ISOL'N is used to enter the standard numbers for a response & isolation calibration. This calibration corrects for frequency response and directivity in reflection measurements, or frequency response and isolation in transmission measurements.

Label class menus

The label class menus are used to define meaningful labels for the calibration classes. These then become softkey labels during a measurement calibration. Labels can be up to ten characters long.

Label kit menu

After a new calibration kit has been defined, be sure to specify a label for it. Choose a label that describes the connector type of the calibration devices. This label will then appear in the CAL KIT softkey label in the correction menu and the MODIFY label in the select cal kit menu. It will be saved with calibration sets.

This menu is accessed with the LABEL KIT softkey in the modify cal kit menu, and is identical to the label class menu and the label standard menu described above. It allows definition of a label up to eight characters long.

Verify performance

Once a measurement calibration has been generated with a user-defined calibration kit, its performance should be checked before making device measurements. To check the accuracy that can be obtained using the new calibration kit, a device with a well-defined frequency response (preferably unlike any of the standards used) should be measured. The verification device must not be one of the calibration standards: measurement of one of these standards is merely a measure of repeatability.

To achieve more complete verification of a particular measurement calibration, accurately known verification standards with a diverse magnitude and phase response should be used. NIST traceable or HP standards are recommended to achieve verifiable measurement accuracy.

Note The published specifications for the HP 8752C network analyzer system include accuracy enhancement with compatible calibration kits. Measurement calibrations made with user-defined or modified calibration kits are not subject to the HP 8752C specifications, although a procedure similar to the system verification procedure may be used.

Using the front panel to examine or modify calibration constants

Calibration constants can be loaded into the analyzer's user-defined kit via front panel entry. Follow the procedure below to enter, modify, or examine standard definitions on the HP 8752C network analyzer.

1. Press (CAL) CAL KIT [ ].
2. Select the softkey that corresponds to the kit you want to modify or examine.
3. Press MORE MODIFY.
4. Press DEFINE STANDARD and use the front panel entry keys to enter the number of the standard you want to examine or modify. For example, to select a short press (1) (x1).
5. Press the underlined softkey. If you selected a short in the previous step, SHORT should be the underlined softkey.
6. This step applies only to the *open*. Go to the next step if you selected any other standard.

   Press C0. Observe the value on the analyzer screen. To change the value, use the entry keys on the front panel. Repeat this step for C1, C2, and C3.
7. This step applies only to the *load*. Go to the next step if you selected any other standard.

   Ensure that the correct load type is underlined: FIXED or SLIDING.
8. Press SPECIFY OFFSET.
9. Press OFFSET DELAY and observe the value on the analyzer screen. To change the value, use the entry keys on the front panel. Repeat this step for the softkeys listed below:
   - OFFSET LOSS
   - OFFSET Z0
   - MINIMUM FREQUENCY
   - MAXIMUM FREQUENCY
10. Ensure that the correct transmission line is underlined: COAX or WAVEGUIDE.
11. Press STD OFFSET DONE STD DONE (DEFINED).
12. Repeat steps 4 through 11 for the remaining standards.

Saving the modified calibration constants

If you made modifications to any of the standard definitions, follow the remaining steps in this procedure to assign a kit label and store them in the non-volatile memory. The new set of standard definitions will be available under USER KIT until they are over-written by another kit or become modified and saved.

13. LABEL KIT ERASE TITLE. Use the RPG knob to move the pointer to a character and press SELECT LETTER.
14. DONE KIT DONE (DEFINED).
15. To save the standard definitions in the user-defined kit, press SAVE USER KIT.

Calibrating for non-insertable devices

A test device having the same sex connector on both the input and output cannot be connected directly into a transmission test configuration. Therefore, the device is considered to be *non-insertable*, and the following calibration method must be performed.

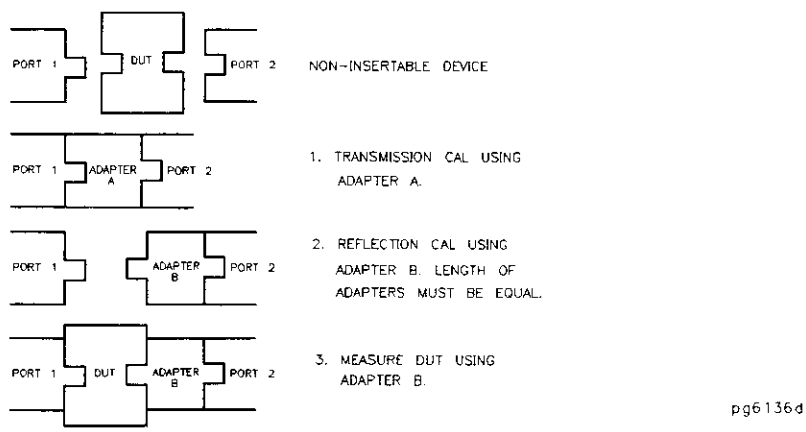


Figure 5-41. Calibrating for Non-Insertable Devices

With this method, you use two precision matched adapters which are "equal." To be equal, the adapters must have the same match, Z_0, insertion loss, and electrical delay.

To use this method, refer to Figure 5-41 and perform the following steps:

1. Perform a transmission calibration using the first adapter.
2. Remove adapter A, and place adapter B on the transmission port (port 2). Adapter B becomes the effective test port.
3. Perform a reflection cal.
4. Measure the test device with adapter B in place.

The errors remaining after calibration with this method are equal to the differences between the two adapters that are used.

Using Markers

The (MKR) key displays a movable active marker on the screen and provides access to a series of menus to control up to four display markers for each channel. Markers are used to obtain numerical readings of measured values. They also provide capabilities for reducing measurement time by changing stimulus parameters, searching the trace for specific values, or statistically analyzing part or all of the trace. Figure 5-42 illustrates the displayed trace with all markers on and marker 1 the active marker.

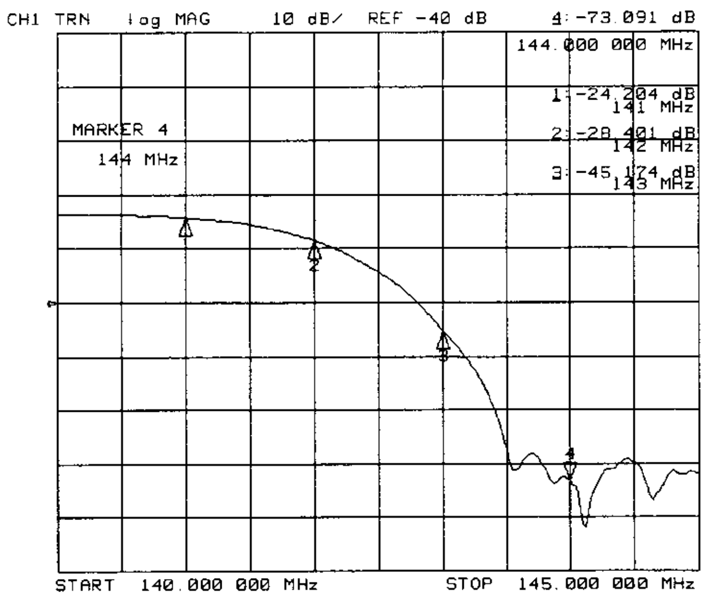


Figure 5-42. Markers on Trace

Markers have a stimulus value (the x-axis value in a Cartesian format) and a response value (the y-axis value in a Cartesian format). In a polar or Smith chart format, the second part of a complex data pair is also provided as an auxiliary response value. When a marker is activated and no other function is active, its stimulus value is displayed in the active entry area and can be controlled with the knob, the step keys, or the numeric keypad. The active marker can be moved to any point on the trace, and its response and stimulus values are displayed at the top right corner of the graticule for each displayed channel, in units appropriate to the display format. The displayed marker response values are valid even when the measured data is above or below the range displayed on the graticule.

Marker values are normally continuous: that is, they are interpolated between measured points. Or, they can be set to read only discrete measured points. The markers for the two channels normally have the same stimulus values, or they can be uncoupled so that each channel has independent markers, regardless of whether stimulus values are coupled or dual channel display is on.

If both data and memory are displayed, the marker values apply to the data trace. If only memory is displayed, the marker values apply to the memory trace. In a memory math display (data/memory or data−memory), the marker values apply to the trace resulting from the memory math function.

With the use of a reference marker, a delta marker mode is available that displays both the stimulus and response values of the active marker relative to the reference. Any of the four markers or a fixed point can be designated as the delta reference marker. If the delta reference is one of the four markers, its stimulus value can be controlled by the user and its response value is the value of the trace at that stimulus value. If the delta reference is a fixed marker, both its stimulus value and its response value can be set arbitrarily anywhere in the display area (not necessarily on the trace).

Markers can be used to search for the trace maximum or minimum point or any other point on the trace. The four markers can be used together to search for specified bandwidth cutoff points and calculate the bandwidth and Q values. Statistical analysis uses markers to provide a readout of the mean, standard deviation, and peak-to-peak values of all or part of the trace.

Basic marker operations are available in the menus accessed from the (MKR) key. The marker search and statistical functions, together with the capability for quickly changing stimulus parameters with markers, are provided in the menus accessed from the (MRK FCTN) key.

Marker menu

The marker menu is used to turn the display markers on or off, to designate the active marker, and to gain access to the marker delta mode and other marker modes and formats.

Delta marker mode

The delta reference is shown on the display as a small triangle Δ, smaller than the inactive marker triangles. If one of the markers is the reference, the triangle appears next to the marker number on the trace.

The marker values displayed in this mode are the stimulus and response values of the active marker minus the reference marker. If the active marker is also designated as the reference marker, the marker values are zero.

Fixed marker menu

This menu is used to set the position of a fixed reference marker, indicated on the display by a small triangle Δ. Both the stimulus value and the response value of the fixed marker can be set arbitrarily anywhere in the display area, and need not be on the trace. The units are determined by the display format, the sweep type, and the marker type.

There are two ways to turn on the fixed marker. One way is with the ΔREF = Δ FIXED MKR softkey in the delta marker menu. The other is with the MKR ZERO function in the marker menu, which puts a fixed reference marker at the present active marker position and makes the marker stimulus and response values at that position equal to zero.

The softkeys in this menu make the values of the fixed marker the active function. The marker readings in the top right corner of the graticule are the stimulus and response values of the active marker minus the fixed reference marker. Also displayed in the top right corner is the notation ΔREF=Δ.

The stimulus value, response value, and auxiliary response value (the second part of a complex data pair) can be individually examined and changed. This allows active marker readings that are relative in amplitude yet absolute in frequency, or any combination of relative/absolute readouts. Following a MKR ZERO operation, this menu can be used to reset any of the fixed marker values to absolute zero for absolute readings of the subsequent active marker values.

If the format is changed while a fixed marker is on, the fixed marker values become invalid. For example, if the value offset is set to 10 dB with a log magnitude format, and the format is then changed to phase, the value offset becomes 10 degrees. However, in polar and Smith chart formats, the specified values remain consistent between different marker types for those formats. Thus an R+jX marker set on a Smith chart format will retain the equivalent values if it is changed to any of the other Smith chart markers.

Marker mode menu

This menu provides different marker modes and makes available two additional menus of special markers for use with Smith chart or polar formats.

Polar marker menu

This menu is used only with a polar display format, selectable using the (FORMAT) key. In a polar format, the magnitude at the center of the circle is zero and the outer circle is the full scale value set in the scale reference menu. Phase is measured as the angle counterclockwise from 0° at the positive x-axis. The analyzer automatically calculates different mathematical forms of the marker magnitude and phase values, selected using the softkeys in this menu. Marker frequency is displayed in addition to other values regardless of the selection of marker type.

Smith marker menu

This menu is used only with a Smith chart format, selected from the format menu. The analyzer automatically calculates different mathematical forms of the marker magnitude and phase values, selected using the softkeys in this menu. Marker frequency is displayed in addition to other values for all marker types.

Marker function menu

This menu provides softkeys that use markers to quickly modify certain measurement parameters without going through the usual key sequence. In addition, it provides access to two additional menus used for searching the trace and for statistical analysis.

The MARKER → functions change certain stimulus and response parameters to make them equal to the current active marker value. Use the knob or the numeric keypad to move the marker to the desired position on the trace, and press the appropriate softkey to set the specified parameter to that trace value. When the values have been changed, the marker can again be moved within the range of the new parameters.

Marker search menu

This menu is used to search the trace for a specific amplitude-related point, and place the marker on that point. The capability of searching for a specified bandwidth is also provided. Tracking is available for a continuous sweep-to-sweep search. If there is no occurrence of a specified value or bandwidth, the message TARGET VALUE NOT FOUND is displayed.

Target menu

The target menu lets you place the marker at a specified target response value on the trace, and provides search right and search left options. If there is no occurrence of the specified value, the message TARGET VALUE NOT FOUND is displayed.

Using the Instrument State Functions

The instrument state function block keys provide control of channel-independent system functions. This section contains information on the following topics:

- local key
- HP-IB controller modes
- instrument addresses
- limit lines and limit testing

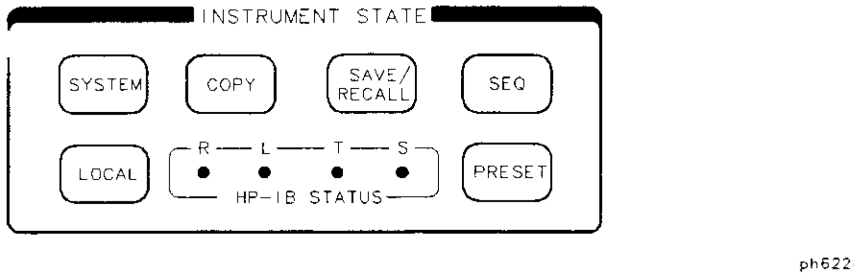


Figure 5-43. Instrument State Function Block

Information on other topics pertaining to the instrument state function block can be found in the following chapters:

Topic	Where to Look
time domain	in this chapter under "Time and Frequency Domain Concepts"
sequencing	in this chapter under "Test Sequence Function"
instrument preset	Chapter 11, "Preset State and Memory Allocation"
printing/plotting	Chapter 3, "Printing, Plotting, or Saving Measurement Results"
saving instrument states	Chapter 3, "Printing, Plotting, or Saving Measurement Results"

(LOCAL) key

This key is used to return the analyzer to local (front panel) operation from remote (computer controlled) operation. This key will also abort a test sequence or hardcopy print/plot. In this local mode, with a controller still connected on HP-IB, the analyzer can be operated manually (locally) from the front panel. This is the only front panel key that is not disabled when the analyzer is remotely controlled over HP-IB by a computer. The exception to this is when local lockout is in effect: this is a remote command that disables the (LOCAL) key, making it difficult to interfere with the analyzer while it is under computer control.

In addition, this key gives you access to the HP-IB menu, where you can set the controller mode, and to the address menu, where you can enter the HP-IB addresses of peripheral devices and select plotter/printer ports.

HP-IB menu

The analyzer is factory-equipped with a remote programming interface using the Hewlett-Packard Interface Bus (HP-IB). This enables communication between the analyzer and a controlling computer as well as other peripheral devices. This menu indicates the present HP-IB controller mode of the analyzer. Three HP-IB modes are possible: system controller, talker/listener, and pass control.

Talker/listener mode

Talker/listener is the mode of operation most often used. In this mode, a computer controller communicates with the analyzer and other compatible peripherals over the bus. The computer sends commands or instructions to and receives data from the analyzer. All of the capabilities available from the analyzer front panel can be used in this remote operation mode, except for control of the power line switch and some internal tests.

System controller mode

In the system controller mode, the analyzer itself can use HP-IB to control compatible peripherals, without the use of an external computer. It can output measurement results directly to a compatible printer or plotter, store instrument states using a compatible disk drive.

Pass control mode

A third mode of HP-IB operation is the pass control mode. In an automated system with a computer controller, the controller can pass control of the bus to the analyzer on request from the analyzer. The analyzer is then the controller of the peripherals, and can direct them to plot, print, or store without going through the computer. When the peripheral operation is complete, control is passed back to the computer. Only one controller can be active at a time. The computer remains the system controller, and can regain control at any time.

Preset does not affect the selected controller mode, but cycling the power returns the analyzer to talker/listener mode.

Information on compatible peripherals is provided in Chapter 10, "Compatible Peripherals."

HP-IB STATUS indicators

When the analyzer is connected to other instruments over HP-IB, the HP-IB STATUS indicators in the instrument state function block light up to display the current status of the analyzer.

R = remote operation

L = listen mode

T = talk mode

S = service request (SRQ) asserted by the analyzer

Address menu

In communications through the Hewlett-Packard Interface Bus (HP-IB), each instrument on the bus is identified by an HP-IB address. This decimal-based address code must be different for each instrument on the bus.

This menu lets you set the HP-IB address of the analyzer, and enter the addresses of peripheral devices so that the analyzer can communicate with them.

Most of the HP-IB addresses are set at the factory and need not be modified for normal system operation. The standard factory-set addresses for instruments that may be part of the system are as follows:

Instrument	HP-IB Address (decimal)
Analyzer	16
Plotter	05
Printer	01
External Disk Drive	00
Controller	21
Power Meter	13

The address displayed in this menu for each peripheral device must match the address set on the device itself. The analyzer does not have an HP-IB switch: its address is set only from the front panel.

These addresses are stored in non-volatile memory and are not affected by preset or by cycling the power.

Limit lines and limit testing

You can have limit lines drawn on the display to represent upper and lower limits or device specifications with which to compare the test device. Limits are defined in segments, where each segment is a portion of the stimulus span. Each limit segment has an upper and a lower starting limit value. Three types of segments are available: flat line, sloping line, and single point.

Limits can be defined independently for the two channels, up to 18 segments for each channel. These can be in any combination of the three limit types.

Limit testing compares the measured data with the defined limits, and provides pass or fail information for each measured data point. An out-of-limit test condition is indicated in five ways: with a `FAIL` message on the screen, with a beep, by blanking of portions of the trace, with an asterisk in tabular listings of data, and with a bit in the HP-IB event status register B.

The limit test bit is output to the I/O test set interconnect on the rear panel of the instrument (see Figure 5-44). The I/O control adapter (HP part number 08752-60020) gives you access to this line via a female SMB connector (see Figure 5-45).

Limit lines and limit testing can be used simultaneously or independently. If limit lines are on and limit testing is off, the limit lines are shown on the display for visual comparison and adjustment of the measurement trace. However, no pass/fail information is provided. If limit testing is on and limit lines are off, the specified limits are still valid and the pass/fail status is indicated even though the limit lines are not shown on the display.

Limits are entered in tabular form. Limit lines and limit testing can be either on or off while limits are defined. As new limits are entered, the tabular columns on the display are updated, and the limit lines (if on) are modified to the new definitions. The complete limit set can be offset in either stimulus or amplitude value.

Limits are checked only at the actual measured data points. It is possible for a device to be out of specification without a limit test failure indication if the point density is insufficient. Be sure to specify a high enough number of measurement points in the stimulus menu.

Limit lines are displayed only on Cartesian formats. In polar and Smith chart formats, limit testing of one value is available: the value tested depends on the marker mode and is the magnitude or the first value in a complex pair. The message `NO LIMIT LINES DISPLAYED` is shown on the display in polar and Smith chart formats.

The list values feature in the copy menu provides tabular listings to the display or a printer for every measured stimulus value. These include limit line or limit test information if these functions are activated. If limit testing is on, an asterisk is listed next to any measured value that is out of limits. If limit lines are on, and other listed data allows sufficient space, the upper limit and lower limit are listed, together with the margin by which the device data passes or fails the nearest limit.

If limit lines are on, they are plotted with the data on a plot. If limit testing is on, the PASS or FAIL message is plotted, and the failing portions of the trace that are blanked on the display are also blanked on the plot. If limits are specified, they are saved in memory with an instrument state.

The series of menus for defining limits is accessed from the (SYSTEM) key.

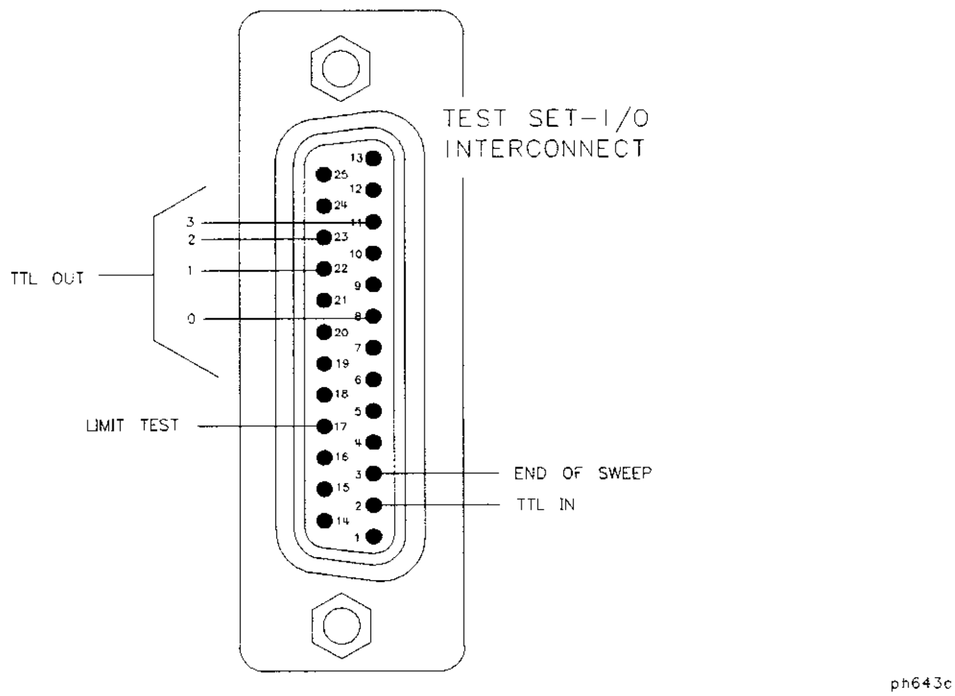


Figure 5-44. Pin Locations on IO Interconnect

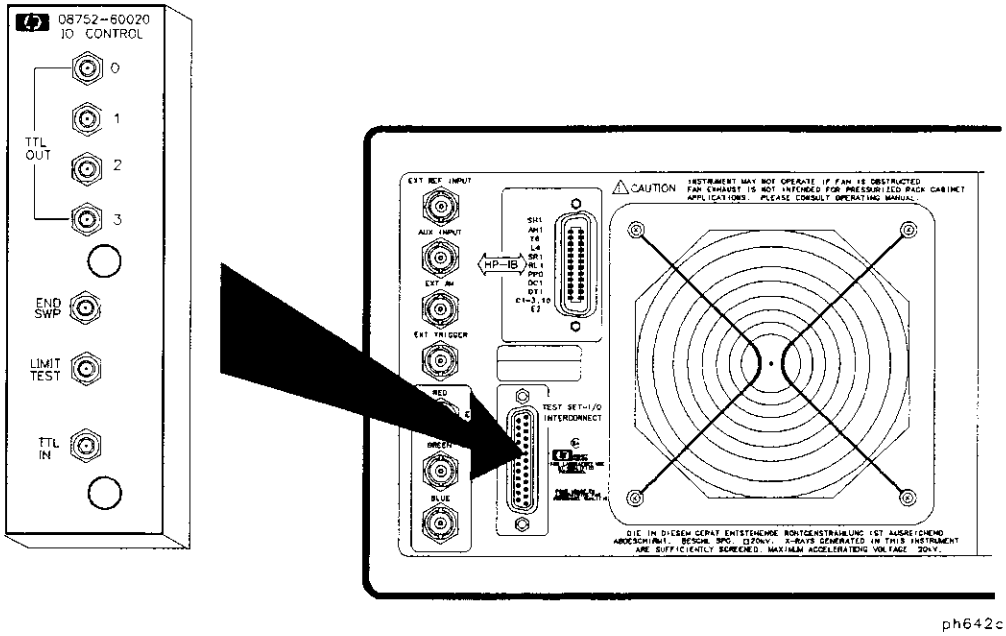


Figure 5-45. IO Control Adapter

Edit limits menu

This menu is used to specify limits for limit lines or limit testing, and presents a table of limit values on the display. Limits are defined in segments. Each segment is a portion of the stimulus span. Up to 18 limit segments can be specified for each channel. The limit segments do not have to be entered in any particular order: the analyzer automatically sorts them and lists them on the display in increasing order of start stimulus value.

For each segment, the table lists the segment number, the starting stimulus value, upper limit, lower limit, and limit type. The ending stimulus value is the start value of the next segment, or a segment can be terminated with a single point segment. Limit values are entered as upper and lower limits or delta limits and middle value. As new limit segments are defined the tabular listing is updated, and if limit lines are switched on they are plotted on the display.

If no limits have been defined, the table of limit values shows the notation EMPTY. Limit segments are added to the table using the ADD softkey or edited with the EDIT softkey, as previously described. The last segment on the list is followed by the notation END.

Edit segment menu

This menu sets the values of the individual limit segments. The segment to be modified, or a default segment, is selected in the edit limits menu. The stimulus value can be set with the controls in the entry block or with a marker (the marker is activated automatically when this menu is presented). The limit values can be defined as upper and lower limits, or delta limits and middle value. Both an upper limit and a lower limit (or delta limits) must be defined: if only one limit is required for a particular measurement, force the other out of range (for example +500 dB or −500 dB).

As new values are entered, the tabular listing of limit values is updated.

Segments do not have to be listed in any particular order: the analyzer sorts them automatically in increasing order of start stimulus value when the DONE key in the edit limits menu is pressed. However, the easiest way to enter a set of limits is to start with the lowest stimulus value and define the segments from left to right of the display, with limit lines turned on as a visual check.

Phase limit values can be specified between +500° and −500°. Limit values above +180° and below −180° are mapped into the range of −180° to +180° to correspond with the range of phase data values.

Offset limits menu

This menu allows the complete limit set to be offset in either stimulus value or amplitude value. This is useful for changing the limits to correspond with a change in the test setup, or for device specifications that differ in stimulus or amplitude. It can also be used to move the limit lines away from the data trace temporarily for visual examination of trace detail.

Understanding and Using Time Domain (option 010)

With option 010, the analyzer can transform frequency domain data to the time domain or time domain data to the frequency domain.

In normal operation, the analyzer measures the characteristics of a test device as a function of frequency. Using a mathematical technique (the inverse Fourier transform), the analyzer transforms frequency domain information into the time domain, with time as the horizontal display axis. Response values (measured on the vertical axis) now appear separated in time or distance, providing valuable insight into the behavior of the test device beyond simple frequency characteristics.

Note An HP 8752C can be ordered with option 010, or the option can be added at a later date using the HP 85019C time domain retrofit kit.

The transform used by the analyzer resembles time domain reflectometry (TDR) measurements. TDR measurements, however, are made by launching an impulse or step into the test device and observing the response in time with a receiver similar to an oscilloscope. In contrast, the analyzer makes swept frequency response measurements, and mathematically transforms the data into a TDR-like display.

The analyzer has three frequency-to-time transform modes:

Time domain bandpass mode is designed to measure band-limited devices and is the easiest mode to use. This mode simulates the time domain response to an impulse input.

Time domain low pass step mode simulates the time domain response to a step input. As in a traditional TDR measurement, the distance to the discontinuity in the test device, and the type of discontinuity (resistive, capacitive, inductive) can be determined.

Time domain low pass impulse mode simulates the time domain response to an impulse input (like the bandpass mode). Both low pass modes yield better time domain resolution for a given frequency span than does the bandpass mode. In addition, using the low pass modes you can determine the type of discontinuity. However, these modes have certain limitations that are defined in "Time domain low pass" of this section.

The analyzer has one time-to-frequency transform mode:

Forward transform mode transforms CW signals measured over time into the frequency domain, to measure the spectral content of a signal. This mode is known as the CW time mode.

In addition to these transform modes, this section discusses special transform concepts such as masking, windowing, and gating.

General theory

The relationship between the frequency domain response and the time domain response of the analyzer is defined by the Fourier transform. Because of this transform, it is possible to measure, in the frequency domain, the response of a linear test device and mathematically calculate the inverse Fourier transform of the data to find the time domain response. The analyzer's internal computer makes this calculation using the chirp-Z Fourier transform technique. The resulting measurement is the fully error-corrected time domain reflection or transmission response of the test device, displayed in near real-time.

Figure 5-46 illustrates the frequency and time domain reflection responses of a test device. The frequency domain reflection measurement is the composite of all the signals reflected by the discontinuities present in the test device over the measured frequency range.

Note In this section, all points of reflection are referred to as discontinuities.

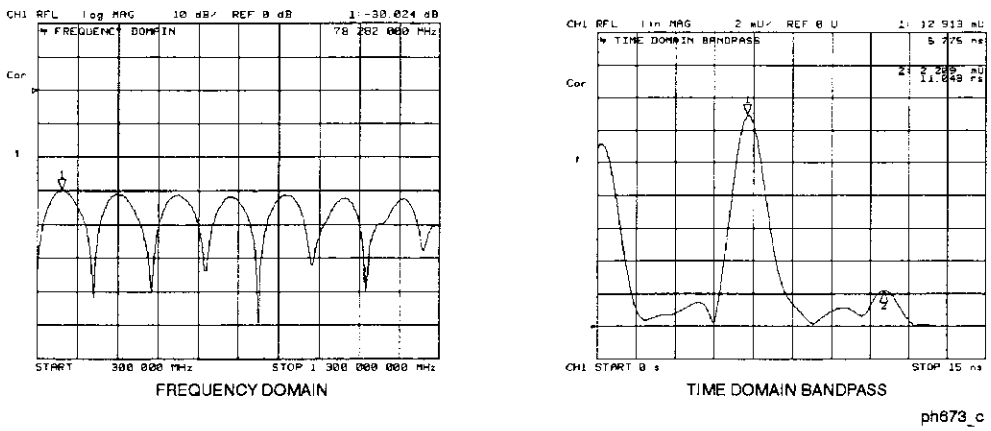


Figure 5-46. Device Frequency Domain and Time Domain Reflection Responses

The time domain measurement shows the effect of each discontinuity as a function of time (or distance), and shows that the test device response consists of three separate impedance changes. The second discontinuity has a reflection coefficient magnitude of 0.035 (i.e. 3.5% of the incident signal is reflected). Marker 1 on the time domain trace shows the elapsed time to the discontinuity and back to the reference plane (where the calibration standards are connected): 18.2 nanoseconds. The distance shown (5.45 meters) is based on the assumption that the signal travels at the speed of light. The signal travels slower than the speed of light in most media (e.g. coax cables). This slower velocity (relative to light) can be compensated for by adjusting the analyzer relative velocity factor. This procedure is described later in this section under "Time domain bandpass".

Time domain bandpass

This mode is called bandpass because it works with band-limited devices. Traditional TDR requires that the test device be able to operate down to dc. Using bandpass mode, there are no restrictions on the measurement frequency range. Bandpass mode characterizes the test device impulse response.

Adjusting the relative velocity factor

A marker provides both the time (x2) and the electrical length (x2) to a discontinuity. To determine the physical length, rather than the electrical length, change the velocity factor to that of the medium under test:

1. Press (CAL) MORE VELOCITY FACTOR.
2. Enter a velocity factor between 0 and 1.0 (1.0 corresponds to the speed of light in a vacuum). Most cables have a velocity factor of 0.66 (polyethylene dielectrics) or 0.70 (teflon dielectrics).

Note To cause the markers to read the actual one-way distance to a discontinuity, rather than the two-way distance, enter one-half the actual velocity factor.

Reflection measurements using bandpass mode

The bandpass mode can transform reflection measurements to the time domain. Figure 5-47a shows a typical frequency response reflection measurement of two sections of cable. Figure 5-47b shows the same two sections of cable in the time domain using the bandpass mode.

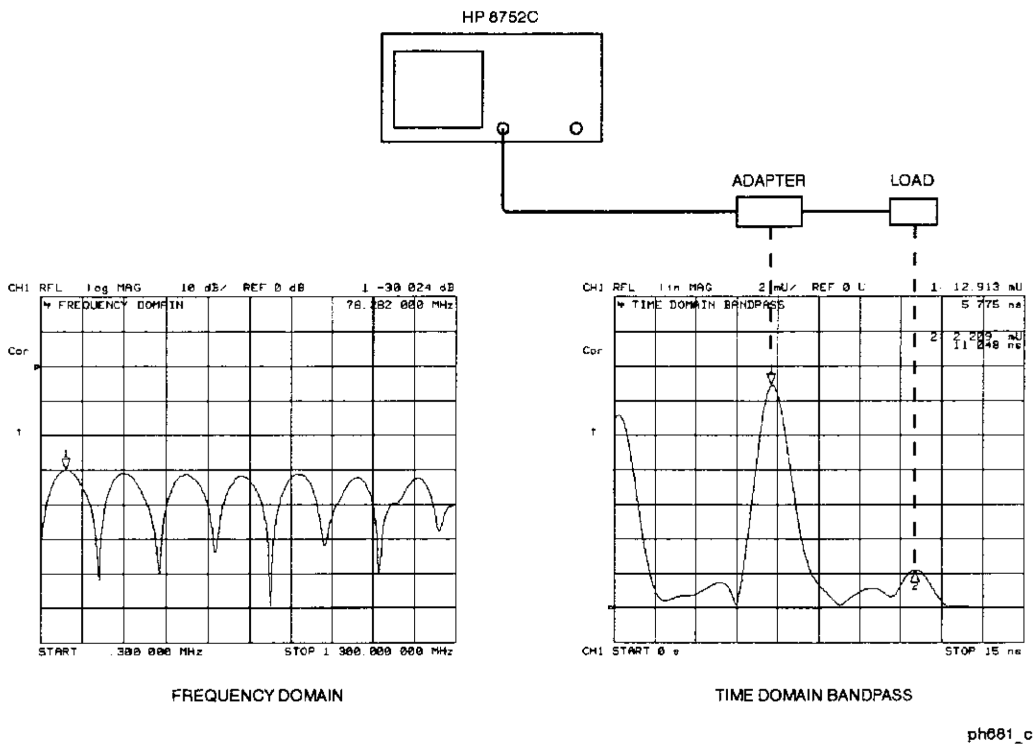


Figure 5-47. A Reflection Measurement of Two Cables

The ripples in reflection coefficient versus frequency in the frequency domain measurement are caused by the reflections at each connector "beating" against each other.

One at a time, loosen the connectors at each end of the cable and observe the response in both the frequency domain and the time domain. The frequency domain ripples increase as each connector is loosened, corresponding to a larger reflection adding in and out of phase with the other reflections. The time domain responses increase as you loosen the connector that corresponds to each response.

Interpreting the bandpass reflection response horizontal axis. In bandpass reflection measurements, the horizontal axis represents the time it takes for an impulse launched at the test port to reach a discontinuity and return to the test port (the two-way travel time). In Figure 5-46, each connector is a discontinuity.

Interpreting the bandpass reflection response vertical axis. The quantity displayed on the vertical axis depends on the selected format. The common formats are listed in Table 5-5. The default format is LOG MAG (logarithmic magnitude), which displays the return loss in decibels (dB). LIN MAG (linear magnitude) is a format that displays the response as reflection coefficient (ρ). This can be thought of as an average reflection coefficient of the discontinuity over the frequency range of the measurement. Use the REAL format only in low pass mode.

Table 5-5. Time Domain Reflection Formats

Format	Parameter
LIN MAG	Reflection Coefficient (unitless) (0 <ρ<1)
REAL	Reflection Coefficient (unitless) (−1 <ρ<1)
LOG MAG	Return Loss (dB)
SWR	Standing Wave Ratio (unitless)

Transmission measurements using bandpass mode

The bandpass mode can also transform transmission measurements to the time domain. For example, this mode can provide information about a surface acoustic wave (SAW) filter that is not apparent in the frequency domain. Figure 5-48illustrates a time domain bandpass measurement of a 321 MHz SAW filter.

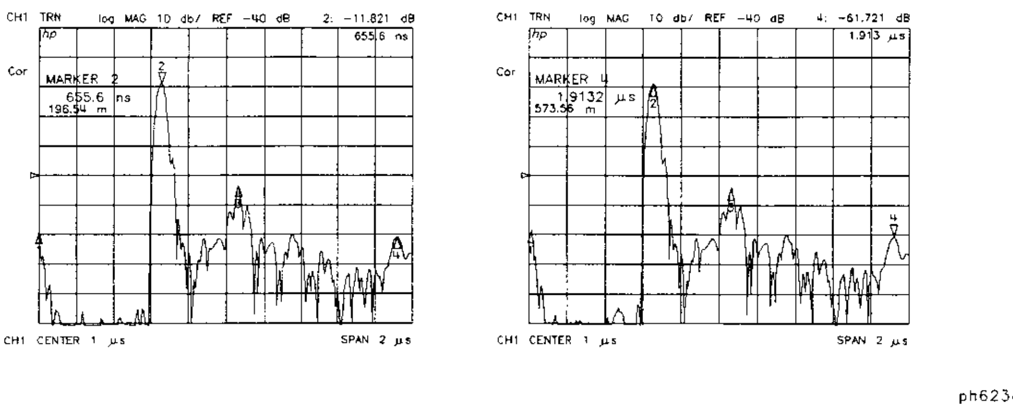


Figure 5-48. Transmission Measurement in Time Domain Bandpass Mode

Interpreting the bandpass transmission response horizontal axis. In time domain transmission measurements, the horizontal axis is displayed in units of time. The time axis indicates the propagation delay through the device. Note that in time domain transmission measurements, the value displayed is the actual delay (not x2). The marker provides the propagation delay in both time and distance.

Marker 2 in Figure 5-48a indicates the main path response through the test device, which has a propagation delay of 655.6 ns, or about 196.5 meters in electrical length. Marker 4 in Figure 5-48b indicates the triple-travel path response at 1.91 μs, or about 573.5 meters. The response at marker 1 (at 0 seconds) is an RF feedthru leakage path. In addition to the triple travel path response, there are several other multi-path responses through the test device, which are inherent in the design of a SAW filter.

Interpreting the bandpass transmission response vertical axis. In the log magnitude format, the vertical axis displays the transmission loss or gain in dB; in the linear magnitude format it displays the transmission coefficient (τ). Think of this as an average of the transmission response over the measurement frequency range.

Time domain low pass

This mode is used to simulate a traditional time domain reflectometry (TDR) measurement. It provides information to determine the type of discontinuity (resistive, capacitive, or inductive) that is present. Low pass provides the best resolution for a given bandwidth in the frequency domain. It may be used to give either the step or impulse response of the test device.

The low pass mode is less general-purpose than the bandpass mode because it places strict limitations on the measurement frequency range. The low pass mode requires that the frequency domain data points are harmonically related from dc to the stop frequency. That is, stop = n x start, where n = number of points. For example, with a start frequency of 300 kHz and 101 points, the stop frequency would be 30.3 MHz. Since the analyzer frequency range starts at 300 kHz, the dc frequency response is extrapolated from the lower frequency data. The requirement to pass dc is the same limitation that exists for traditional TDR.

Setting frequency range for time domain low pass

Before a low pass measurement is made, the measurement frequency range must meet the (stop = n x start) requirement described above. The SET FREQ LOW PASS softkey performs this function automatically: the stop frequency is set close to the entered stop frequency, and the start frequency is set equal to stop/n.

If the low end of the measurement frequency range is critical, it is best to calculate approximate values for the start and stop frequencies before pressing SET FREQ LOW PASS and calibrating. This avoids distortion of the measurement results. To see an example, select the preset values of 201 points and a 300 kHz to 1.3 GHz frequency range. Now press SET FREQ LOW PASS and observe the change in frequency values. The stop frequency changes to 1.299 GHz, and the start frequency changes to 6.467 MHz. This would cause a distortion of measurement results for frequencies from 300 kHz to 6.467 MHz.

Note If the start and stop frequencies do not conform to the low pass requirement before a low pass mode (step or impulse) is selected and transform is turned on, the analyzer resets the start and stop frequencies. If error correction is on when the frequency range is changed, this turns it off.

Table 5-6. Minimum Frequency Ranges for Time Domain Low Pass

Number of Points	Minimum Frequency Range
3	300 kHz to 0.90 MHz
11	300 kHz to 3.30 MHz
26	300 kHz to 7.80 MHz
51	300 kHz to 15.3 MHz
101	300 kHz to 30.3 MHz
201	300 kHz to 60.3 MHz
401	300 kHz to 120.3 MHz
801	300 kHz to 240.3 MHz
1601	300 kHz to 480.3 MHz

Minimum allowable stop frequencies. The lowest analyzer measurement frequency is 300 kHz, therefore for each value of n there is a minimum allowable stop frequency that can be used. That is, the minimum stop frequency = n × 300 kHz. Table 5-6 lists the minimum frequency range that can be used for each value of n for low pass time domain measurements.

Reflection measurements in time domain low pass

Figure 5-49 shows the time domain response of an unterminated cable in both the low-pass step and low-pass impulse modes.

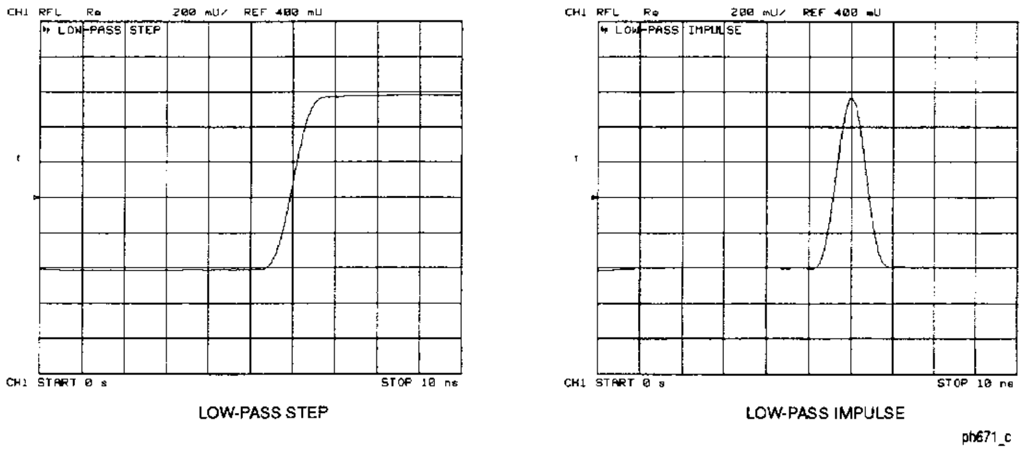


Figure 5-49.
Time Domain Low Pass Measurements of an Unterminated Cable

Interpreting the low pass response horizontal axis. The low pass measurement horizontal axis is the two-way travel time to the discontinuity (as in the bandpass mode). The marker displays both the two-way time and the electrical length along the trace. To determine the actual physical length, enter the appropriate velocity factor as described earlier in this section under "Time domain bandpass".

Interpreting the low pass response vertical axis. The vertical axis depends on the chosen format. In the low pass mode, the frequency domain data is taken at harmonically related frequencies and extrapolated to dc. Because this results in the inverse Fourier transform having only a real part (the imaginary part is zero), the most useful low pass step mode format in this application is the real format. It displays the response in reflection coefficient units. This mode is similar to the traditional TDR response, which displays the reflected signal in a real format (volts) versus time (or distance) on the horizontal axis.

The real format can also be used in the low pass impulse mode, but for the best dynamic range for simultaneously viewing large and small discontinuities, use the log magnitude format.

Fault location measurements using low pass

As described, the low pass mode can simulate the TDR response of the test device. This response contains information useful in determining the type of discontinuity present.

Figure 5-50 illustrates the low pass responses of known discontinuities. Each circuit element was simulated to show the corresponding low pass time domain reflection response waveform. The low pass mode gives the test device response either to a step or to an impulse stimulus. Mathematically, the low pass impulse stimulus is the derivative of the step stimulus.

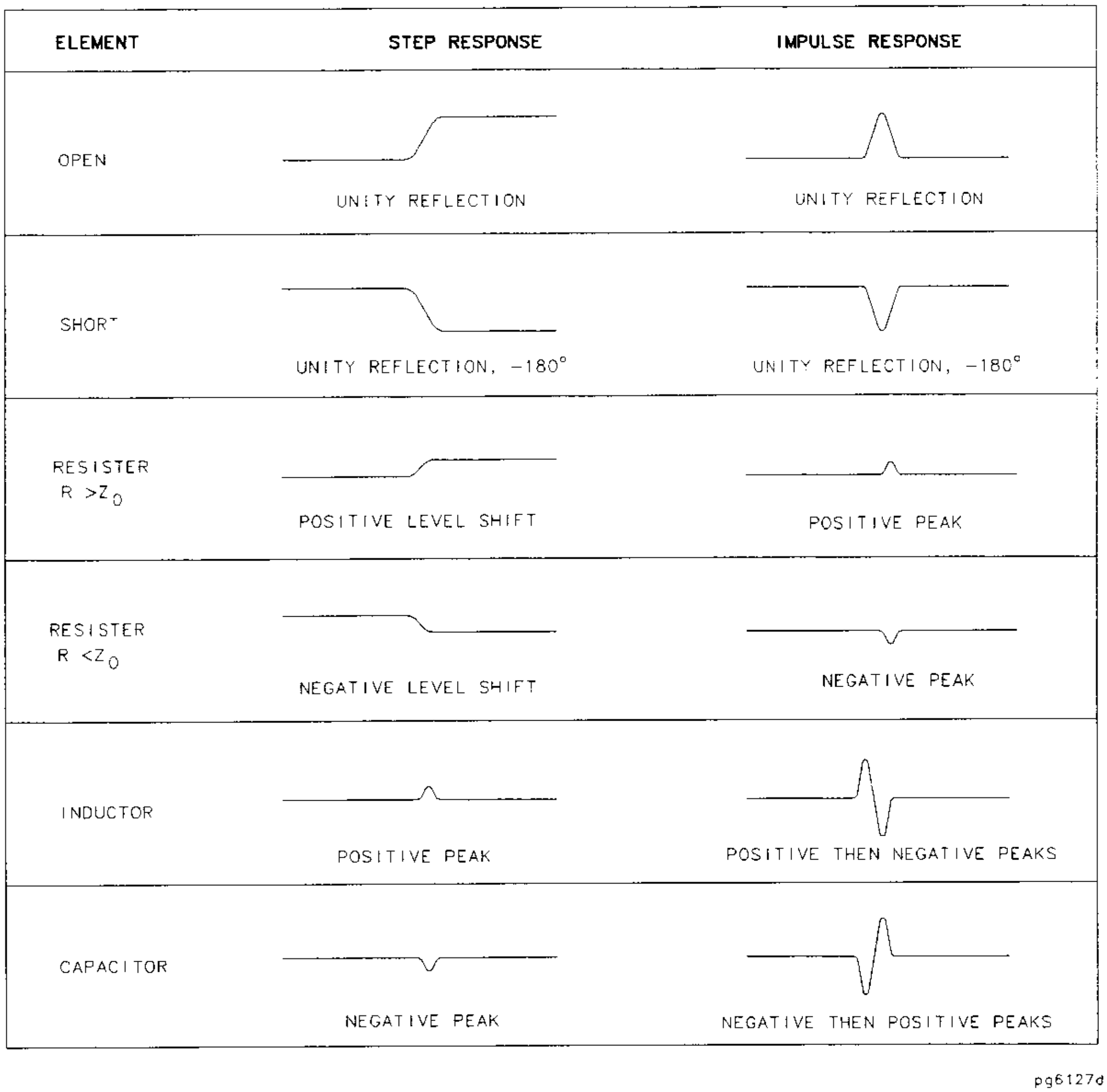


Figure 5-50. Simulated Low Pass Step and Impulse Response Waveforms (Real Format)

Figure 5-51 shows example cables with discontinuities (faults) using the low pass step mode with the real format.

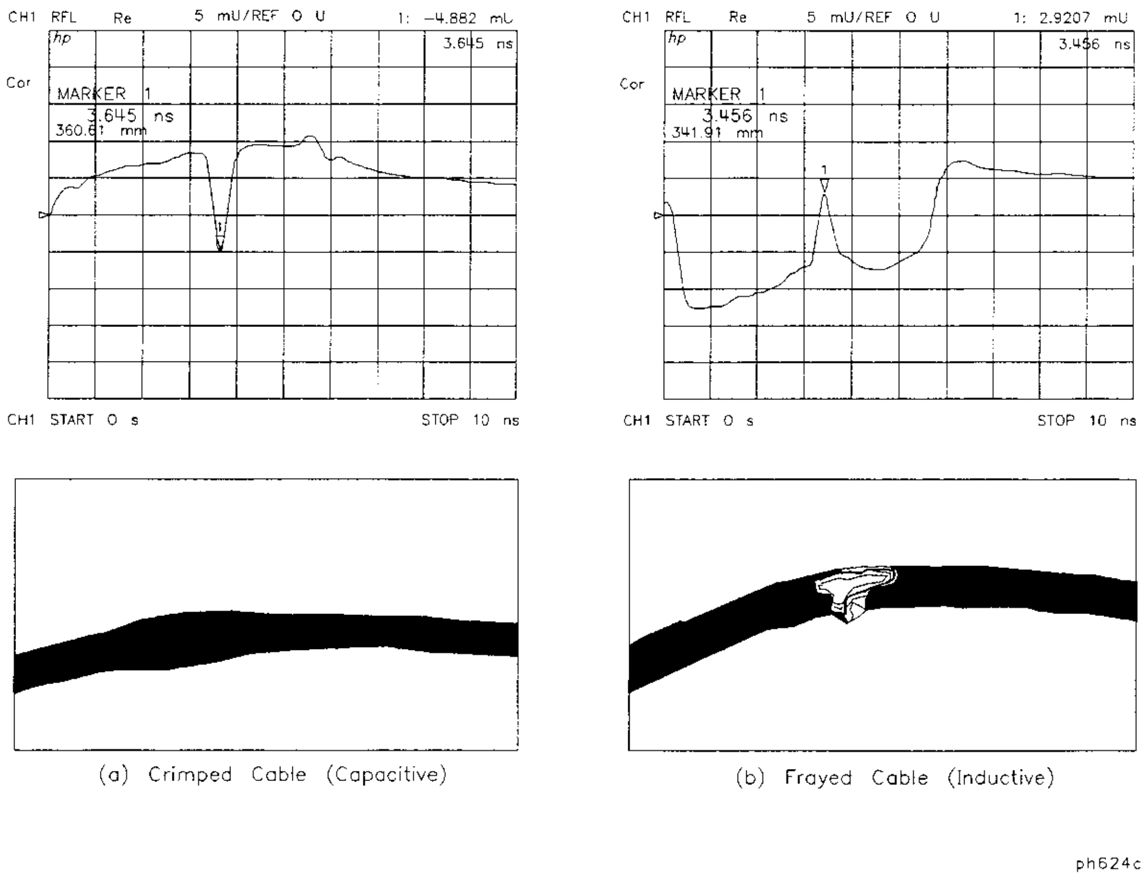


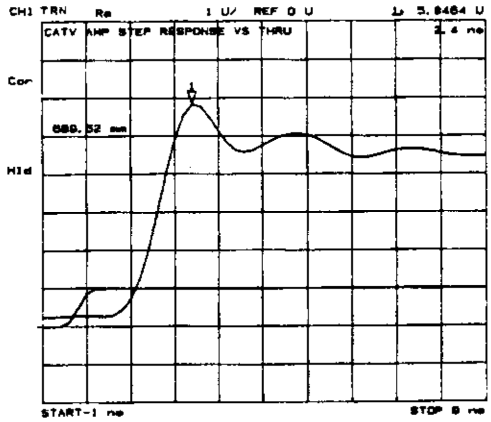
Figure 5-51. Low Pass Step Measurements of Common Cable Faults (Real Format)

Transmission measurements in time domain low pass

Measuring small signal transient response using low pass step. Use the low pass mode to analyze the test device's small signal transient response. The transmission response of a device to a step input is often measured at lower frequencies, using a function generator (to provide the step to the test device) and a sampling oscilloscope (to analyze the test device output response). The low pass step mode extends the frequency range of this type of measurement to 3 GHz (6 GHz with an analyzer option 006).

The step input shown in Figure 5-52 is the inverse Fourier transform of the frequency domain response of a thru measured at calibration. The step rise time is proportional to the highest frequency in the frequency domain sweep; the higher the frequency, the faster the rise time. The frequency sweep in Figure 5-52 is from 10 MHz to 1 GHz.

Figure 5-52 also illustrates the time domain low pass response of an amplifier under test. The average group delay over the measurement frequency range is the difference in time between the step and the amplifier response. This time domain response simulates an oscilloscope measurement of the amplifier's small signal transient response. Note the ringing in the amplifier response that indicates an under-damped design.



ph670

Figure 5-52.
Time Domain Low Pass Measurement of an Amplifier Small Signal Transient Response

Interpreting the low pass step transmission response horizontal. axis

The low pass transmission measurement horizontal axis displays the average transit time through the test device over the frequency range used in the measurement. The response of the thru connection used in the calibration is a step that reaches 50% unit height at approximately time = 0. The rise time is determined by the highest frequency used in the frequency domain measurement. The step is a unit high step, which indicates no loss for the thru calibration. When a device is inserted, the time axis indicates the propagation delay or electrical length of the device. The markers read the electrical delay in both time and distance. The distance can be scaled by an appropriate velocity factor as described earlier in this section under "Time domain bandpass".

Interpreting the low pass step transmission response vertical. axis

In the real format, the vertical axis displays the transmission response in real units (e.g. volts). For the amplifier example in Figure 5-52, if the amplifier input is a step of 1 volt, the output, 2.4 nanoseconds after the step (indicated by marker 1), is 5.84 volts.

In the log magnitude format, the amplifier gain is the steady state value displayed after the initial transients die out.

Measuring separate transmission paths through the test device. using low pass impulse mode

The low pass impulse mode can be used to identify different transmission paths through a test device that has a response at frequencies down to dc (or at least has a predictable response, above the noise floor, below 300 kHz). For example, use the low pass impulse mode to measure the relative transmission times through a multi-path device such as a power divider. Another example is to measure the pulse dispersion through a broadband transmission line, such as a fiber optic cable. Both examples are illustrated in Figure 5-53. The horizontal and vertical axes can be interpreted as already described in this section under "Time domain bandpass".

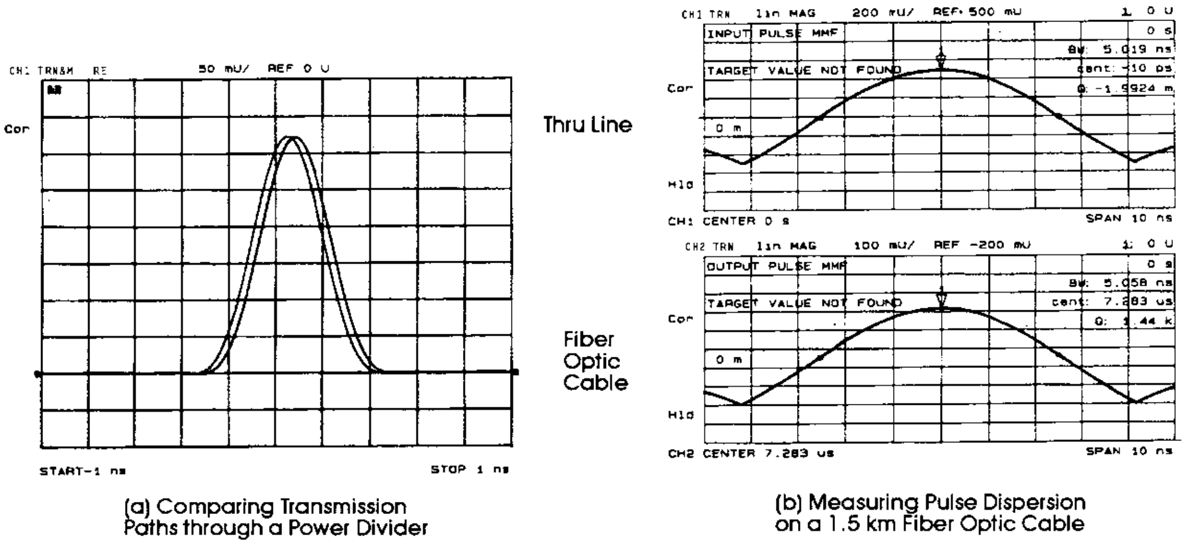


Figure 5-53. Transmission Measurements Using Low Pass Impulse Mode

Time domain concepts

Masking

Masking occurs when a discontinuity (fault) closest to the reference plane affects the response of each subsequent discontinuity. This happens because the energy reflected from the first discontinuity never reaches subsequent discontinuities. For example, if a transmission line has two discontinuities that each reflect 50% of the incident voltage, the time domain response (real format) shows the correct reflection coefficient for the first discontinuity (ρ=0.50). However, the second discontinuity appears as a 25% reflection (ρ=0.25) because only half the incident voltage reached the second discontinuity.

Note This example assumes a loss-less transmission line. Real transmission lines, with non-zero loss, attenuate signals as a function of the distance from the reference plane.

As an example of masking due to line loss, consider the time domain response of a 3 dB attenuator and a short circuit. The impulse response (log magnitude format) of the short circuit alone is a return loss of 0 dB, as shown in Figure 5-54a. When the short circuit is placed at the end of the 3 dB attenuator, the return loss is −6 dB, as shown in Figure 5-54b. This value actually represents the forward and return path loss through the attenuator, and illustrates how a lossy network can affect the responses that follow it.

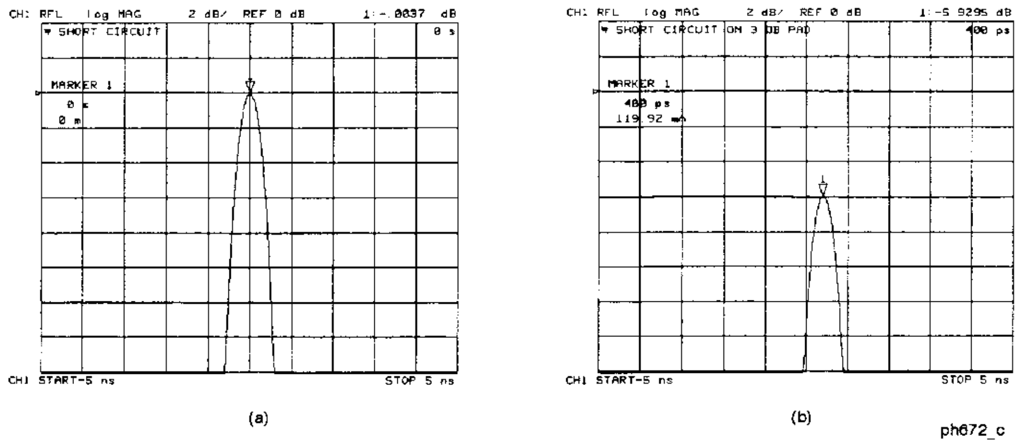


Figure 5-54. Masking Example

Windowing

The analyzer provides a windowing feature that makes time domain measurements more useful for isolating and identifying individual responses. Windowing is needed because of the abrupt transitions in a frequency domain measurement at the start and stop frequencies. The band limiting of a frequency domain response causes overshoot and ringing in the time domain response, and causes a non-windowed impulse stimulus to have a sin(kt)/kt shape, where

$k = \pi$/frequency span

and

t = time (see Figure 5-55).

This has two effects that limit the usefulness of the time domain measurement:

- **Finite impulse width (or rise time).** Finite impulse width limits the ability to resolve between two closely spaced responses. The effects of the finite impulse width cannot be improved without increasing the frequency span of the measurement (see Table 5-7).

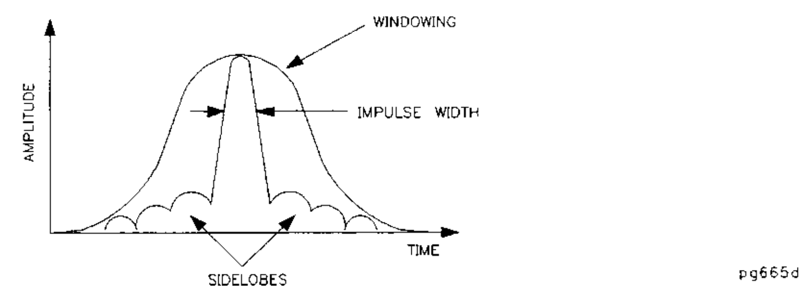


Figure 5-55. Impulse Width, Sidelobes, and Windowing

- **Sidelobes.** The impulse sidelobes limit the dynamic range of the time domain measurement by hiding low-level responses within the sidelobes of higher level responses. The effects of sidelobes can be improved by windowing (see Table 5-7).

Windowing improves the dynamic range of a time domain measurement by filtering the frequency domain data prior to converting it to the time domain, producing an impulse stimulus that has lower sidelobes. This makes it much easier to see time domain responses that are very different in magnitude. The sidelobe reduction is achieved, however, at the expense of increased impulse width. The effect of windowing on the step stimulus (low pass mode only) is a reduction of overshoot and ringing at the expense of increased rise time.

To select a window, press (SYSTEM) TRANSFORM MENU WINDOW. A menu is presented that allows the selection of three window types (see Table 5-7).

Table 5-7. Impulse Width, Sidelobe Level, and Windowing Values

Window Type	Impulse Sidelobe Level	Low Pass Impulse Width (50%)	Step Sidelobe Level	Step Rise Time (10 - 90%)
Minimum	−13 dB	0.60/Freq Span	−21 dB	0.45/Freq Span
Normal	−44 dB	0.98/Freq Span	−60 dB	0.99/Freq Span
Maximum	−75 dB	1.39/Freq Span	−70 dB	1.48/Freq Span
NOTE: The bandpass mode simulates an impulse stimulus. Bandpass impulse width is twice that of low pass impulse width. The bandpass impulse sidelobe levels are the same as low pass impulse sidelobe levels.				

Choose one of the three window shapes listed in Table 5-7. Or you can use the knob to select any windowing pulse width (or rise time for a step stimulus) between the softkey values. The time domain stimulus sidelobe levels depend only on the window selected.

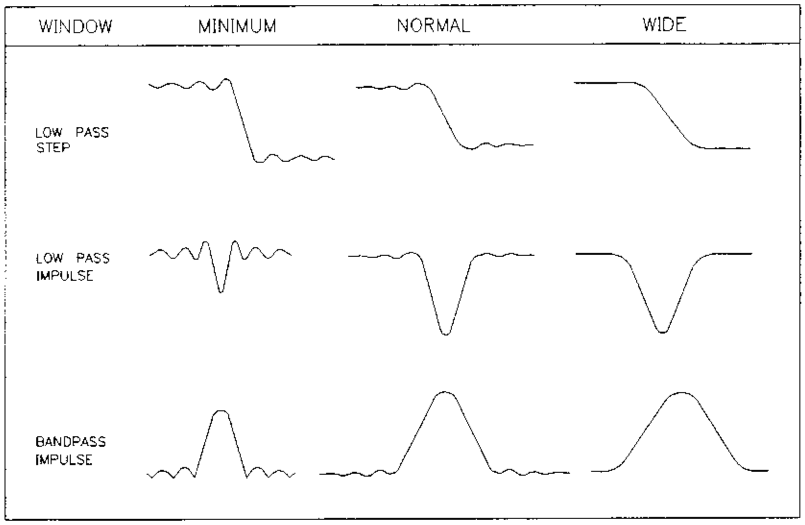
MINIMUM is essentially no window. Consequently, it gives the highest sidelobes.

NORMAL (the preset mode) gives reduced sidelobes and is the mode most often used.

MAXIMUM window gives the minimum sidelobes, providing the greatest dynamic range.

USE MEMORY on OFF remembers a user-specified window pulse width (or step rise time) different from the standard window values.

A window is activated only for viewing a time domain response, and does not affect a displayed frequency domain response. Figure 5-56 shows the typical effects of windowing on the time domain response of a short circuit reflection measurement.



pg666d

Figure 5-56. The Effects of Windowing on the Time Domain Responses of a Short Circuit

Range

In the time domain, range is defined as the length in time that a measurement can be made without encountering a repetition of the response, called aliasing. A time domain response repeats at regular intervals because the frequency domain data is taken at discrete frequency points, rather than continuously over the frequency band.

Measurement range is equal to $1/\Delta F$ (ΔF is the spacing between frequency data points).

Measurement range = (number of points − 1)/frequency span (Hz).

```
Example:

Measurement = 201 points

              1 MHz to 2.001 GHz

      Range = 1/ΔF or (number of points - 1)/frequency
span

            = 1/(10 x 106) or (201 - 1)/(2 x 109)

            = 100 x 10^-9 seconds

Electrical length = range x the speed of light (3 x 10^8 m/s)

                  = (100 x 10^-9 s) x (3 x 10^8 m/s)

                  = 30 meters
```

In this example, the range is 100 ns, or 30 meters electrical length. To prevent the time domain responses from overlapping, the test device must be 30 meters or less in electrical length for a transmission measurement (15 meters for a reflection measurement). The analyzer limits the stop time to prevent the display of aliased responses.

To increase the time domain measurement range, first increase the number of points, but remember that as the number of points increases, the sweep speed decreases. Decreasing the frequency span also increases range, but reduces resolution.

Resolution

Two different resolution terms are used in the time domain:

- Response Resolution.
- Range Resolution.

Response resolution. Time domain response resolution is defined as the ability to resolve two closely-spaced responses, or a measure of how close two responses can be to each other and still be distinguished from each other. For responses of equal amplitude, the response resolution is equal to the 50% (−6 dB) impulse width. It is inversely proportional to the measurement frequency span, and is also a function of the window used in the transform. The approximate formulas for calculating the 50% impulse width are given in Table 5-7. For example, using the formula for the bandpass mode with a normal windowing function for a 1 MHz to 3.001 GHz measurement (3 GHz span):

```
50% calculated impulse width = 0.98 x (1/3 GHz) x 2

                             = 0.65 nanoseconds
```

Electrical length (in air) = $(0.65 \times 10^{-9}$ s$) \times (30 \times 10^{9}$ cm/s$)$

= 19.6 centimeters

With this measurement, two equal responses can be distinguished when they are separated by at least 19.6 centimeters. In a 6 GHz measurement with an option 006 analyzer, two equal responses can be distinguished when they are separated by at least 9.8 cm. Using the low pass mode (the low pass frequencies are slightly different) with a minimum windowing function, you can distinguish two equal responses that are about 5 centimeters or more apart.

For reflection measurements, which measure the two-way time to the response, divide the response resolution by 2. Using the example above, you can distinguish two faults of equal magnitude provided they are 2.5 centimeters (electrical length) or more apart.

Note Remember, to determine the physical length, enter the relative velocity factor of the transmission medium under test.

For example, a cable with a teflon dielectric (0.7 relative velocity factor), measured under the conditions stated above, has a fault location measurement response resolution of 1.7 cm. This is the maximum fault location response resolution. Factors such as reduced frequency span, greater frequency domain data windowing, and a large discontinuity shadowing the response of a smaller discontinuity, all act to degrade the effective response resolution.

Figure 5-57 illustrates the effects of response resolution. The solid line shows the actual reflection measurement of two approximately equal discontinuities (the input and output of an SMA barrel). The dashed line shows the approximate effect of each discontinuity, if they could be measured separately.

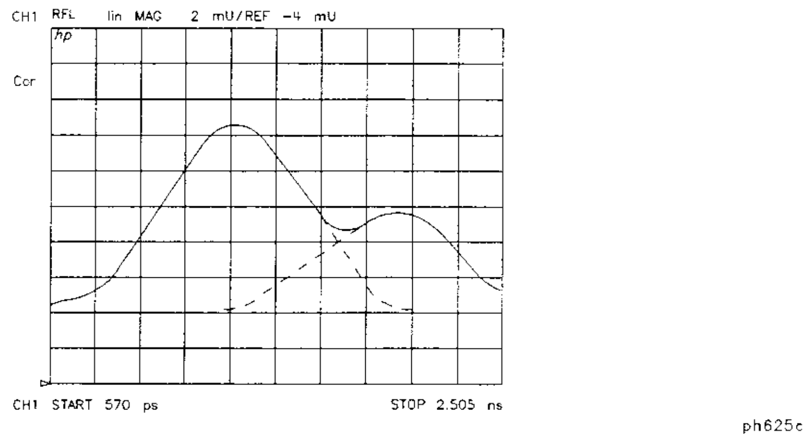


Figure 5-57. Response Resolution

While increasing the frequency span increases the response resolution, keep the following points in mind:

- The time domain response noise floor is directly related to the frequency domain data noise floor. Because of this, if the frequency domain data points are taken at or below the measurement noise floor, the time domain measurement noise floor is degraded.
- The time domain measurement is an average of the response over the frequency range of the measurement. If the frequency domain data is measured out-of-band, the time domain measurement is also the out-of-band response.

You may (with these limitations in mind) choose to use a frequency span that is wider than the test device bandwidth to achieve better resolution.

Range resolution. Time domain range resolution is defined as the ability to locate a single response in time. If only one response is present, range resolution is a measure of how closely you can pinpoint the peak of that response. The range resolution is equal to the digital resolution of the display, which is the time domain span divided by the number of points on the display. To get the maximum range resolution, center the response on the display and reduce the time domain span. The range resolution is always much finer than the response resolution (see Figure 5-58).

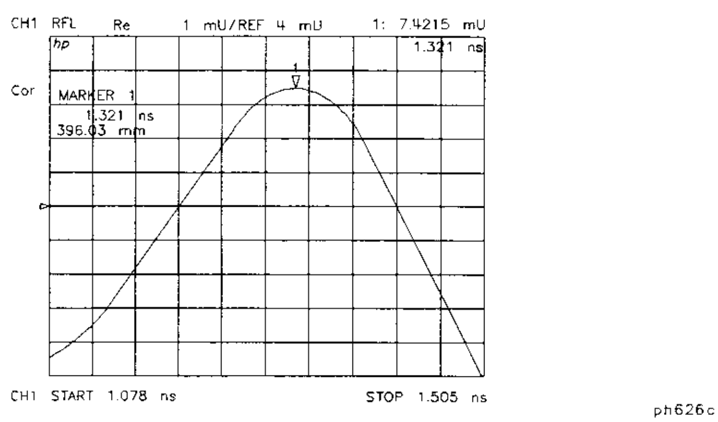


Figure 5-58. Range Resolution of a Single Discontinuity

Gating

Gating provides the flexibility of selectively removing time domain responses. The remaining time domain responses can then be transformed back to the frequency domain. For reflection (or fault location) measurements, use this feature to remove the effects of unwanted discontinuities in the time domain. You can then view the frequency response of the remaining discontinuities. In a transmission measurement, you can remove the effects of multiple transmission paths.

Figure 5-59a shows the frequency response of an electrical airline and termination. Figure 5-59b shows the response in the time domain.

The discontinuity on the left is due to the input connector. The discontinuity on the right is due to the termination. We want to remove the effect of the connector so that we can see the frequency response of just the airline and termination. Figure 5-59c shows the gate applied to the connector discontinuity. Figure 5-59d shows the frequency response of the airline and termination, with the connector "gated out."

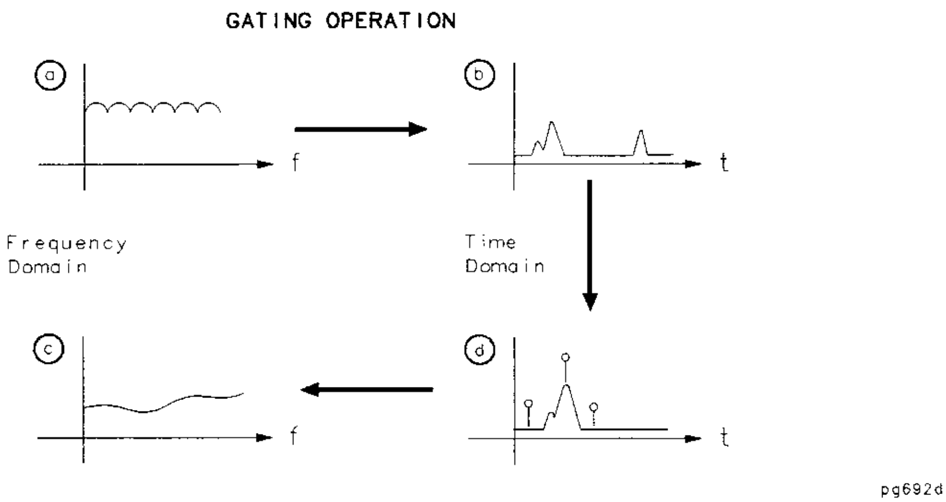


Figure 5-59. Sequence of Steps in Gating Operation

Setting the gate. Think of a gate as a bandpass filter in the time domain (see Figure 5-60). When the gate is on, responses outside the gate are mathematically removed from the time domain trace. Enter the gate position as a start and stop time (not frequency) or as a center and span time. The start and stop times are the bandpass filter −6 dB cutoff times. Gates can have a negative span, in which case the responses inside the gate are mathematically removed. The gate's start and stop flags define the region where gating is *on*.

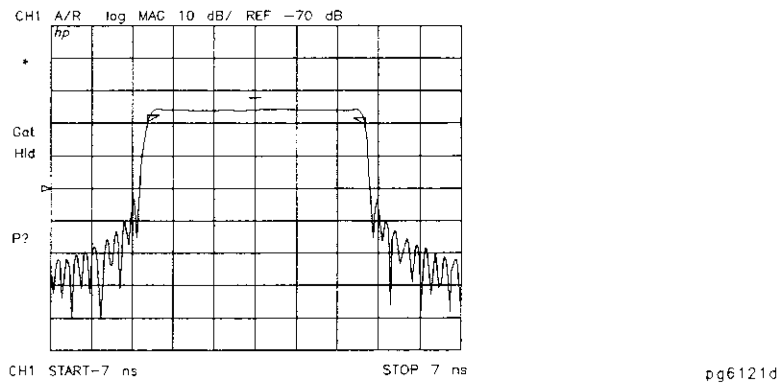


Figure 5-60. Gate Shape

Selecting gate shape. The four gate shapes available are listed in Table 5-8. Each gate has a different passband flatness, cutoff rate, and sidelobe levels.

Table 5-8. Gate Characteristics

Gate Shape	Passband Ripple	Sidelobe Levels	Cutoff Time	Minimum Gate Span
Gate Span Minimum	±0.10 dB	−48 dB	1.4/Freq Span	2.8/Freq Span
Normal	±0.01 dB	−68 dB	2.8/Freq Span	5.6/Freq Span
Wide	±0.01 dB	−57 dB	4.4/Freq Span	8.8/Freq Span
Maximum	±0.01 dB	−70 dB	12.7/Freq Span	25.4/Freq Span

Note With 1601 frequency points, gating is available only in the passband mode.

The passband ripple and sidelobe levels are descriptive of the gate shape. The cutoff time is the time between the stop time (−6 dB on the filter skirt) and the peak of the first sidelobe, and is equal on the left and right side skirts of the filter. Because the minimum gate span has no passband, it is just twice the cutoff time. Always choose a gate span wider than the minimum. For most applications, do not be concerned about the minimum gate span, simply use the knob to position the gate markers around the desired portion of the time domain trace.

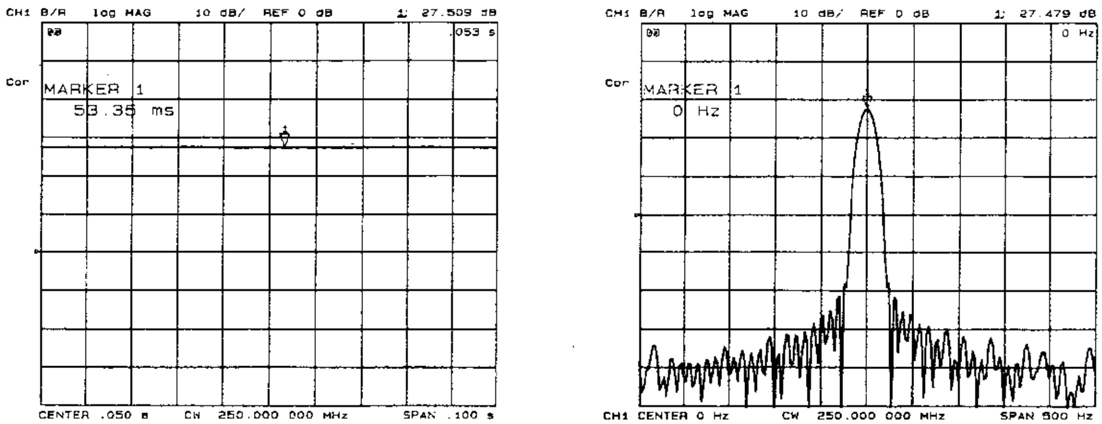
Transforming CW time measurements into the frequency domain

The analyzer can display the amplitude and phase of CW signals versus time. For example, use this mode for measurements such as amplifier gain as a function of warm-up time (i.e. drift). The analyzer can display the measured parameter (e.g. amplifier gain) for periods of up to 24 hours and then output the data to a digital plotter for hardcopy results.

These "strip chart" plots are actually measurements as a function of time (time is the independent variable), and the horizontal display axis is scaled in time units. Transforms of these measurements result in frequency domain data. Such transforms are called forward transforms because the transform from time to frequency is a forward Fourier transform, and can be used to measure the spectral content of a CW signal. For example, when transformed into the frequency domain, a pure CW signal measured over time appears as a single frequency spike. The transform into the frequency domain yields a display that looks similar to a spectrum analyzer display of signal amplitude versus frequency.

Forward transform measurements

This is an example of a measurement using the Fourier transform in the forward direction, from the time domain to the frequency domain (see Figure 5-61):



(a) CW Time

(b) Transform to Frequency Domain

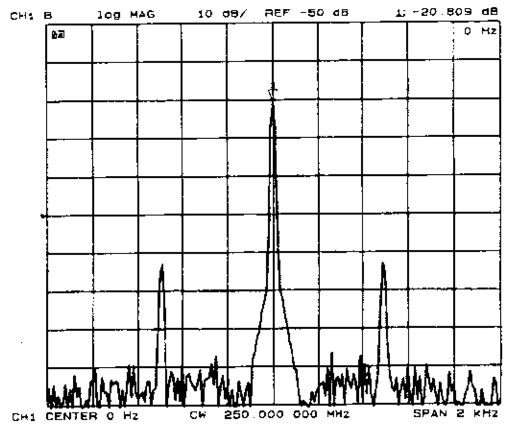
pg6189_c

Figure 5-61. Amplifier Gain Measurement

Interpreting the forward transform vertical axis. With the log magnitude format selected, the vertical axis displays dB. This format simulates a spectrum analyzer display of power versus frequency.

Interpreting the forward transform horizontal axis. In a frequency domain transform of a CW time measurement, the horizontal axis is measured in units of frequency. The center frequency is the offset of the CW frequency. For example, with a center frequency of 0 Hz, the CW frequency (250 MHz in the example) is in the center of the display. If the center frequency entered is a positive value, the CW frequency shifts to the right half of the display; a negative value shifts it to the left half of the display. The span value entered with the transform on is the total frequency span shown on the display. (Alternatively, the frequency display values can be entered as start and stop.)

Demodulating the results of the forward transform. The forward transform can separate the effects of the CW frequency modulation amplitude and phase components. For example, if a test device modulates the transmission response (S_{21}) with a 500 Hz AM signal, you can see the effects of that modulation as shown in Figure 5-62. To simulate this effect, apply a 500 Hz sine wave to the analyzer rear panel EXT AM input.



pg6187_c

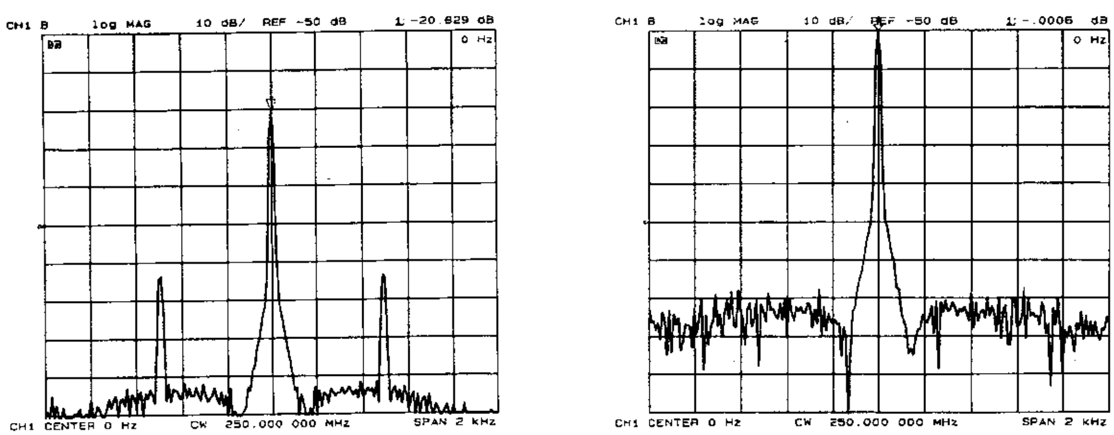
Figure 5-62. Combined Effects of Amplitude and Phase Modulation

Using the demodulation capabilities of the analyzer, it is possible to view the amplitude or the phase component of the modulation separately. The window menu includes the following softkeys to control the demodulation feature:

DEMOD: OFF — This is the normal preset state, in which both the amplitude and phase components of any test device modulation appear on the display.

AMPLITUDE — displays only the amplitude modulation, as illustrated in Figure 5-63a.

PHASE — displays only the phase modulation, as shown in Figure 5-63b.



(a) Amplitude Modulation Component *(b) Phase Modulation Component*

pg6188_c

Figure 5-63.
Separating the Amplitude and Phase Components of Test-Device-Induced Modulation

Forward transform range. In the forward transform (from CW time to the frequency domain), range is defined as the frequency span that can be displayed before aliasing occurs, and is similar to range as defined for time domain measurements. In the range formula, substitute time span for frequency span.

`Example:`

```
Range = (Number of points - 1)/time span

        = (201 - 1)/(200 x 10^-3)

        = 1000 Hertz
```

For the example given above, a 201 point CW time measurement made over a 200 ms time span, choose a span of 1 kHz or less on either side of the center frequency (see Figure 5-64). That is, choose a total span of 2 kHz or less.

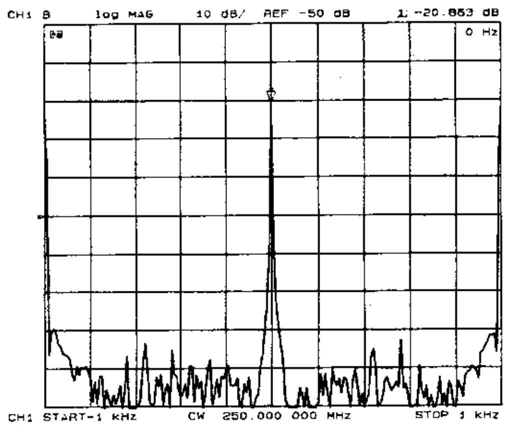


Figure 5-64. Range of a Forward Transform Measurement

To increase the frequency domain measurement range, increase the span. The maximum range is inversely proportional to the sweep time, therefore it may be necessary to increase the number of points or decrease the sweep time. Because increasing the number of points increases the auto sweep time, the maximum range is 2 kHz on either side of the selected CW time measurement center frequency (4 kHz total span). To display a total frequency span of 4 kHz, enter the span as 4000 Hz.

What is Test Sequencing?

Test sequencing is an analyzer function that allows you to automate repetitive tasks. You can create a sequence as you are making a measurement. Then when you want to make that same measurement again, you can recall the sequence and the analyzer will repeat the previous keystrokes.

The following is list of some of the key test sequencing features on the HP 8752C network analyzer:

- Limited decision-making functions increase the versatility of the test sequences you create by allowing you to jump from one sequence to another.
- A GOSUB SEQUENCE function that allows you to call other sequences as sub-routines.
- You can create, title, save, and execute up to six sequences.
- You can save your sequences to a disk using an external disk drive.
- You can use the I/O interconnect to read a TTL input bit in a decision making function, and send four TTL output bits to control a peripheral.

Note Product note 8753-3 "RF Component Measurements - Applications of the Test Sequence Function" provides practical applications examples for test sequencing. This note was written for the HP 8753B but also applies to the HP 8752C.

In-depth sequencing information

Features that operate differently when executed in a sequence

The analyzer does not allow you to use the following keys in a sequence:

- ⇧ ⇩ keys
- PRESET key
- ⇐ key

Commands that sequencing completes before the next sequence

command begins

The analyzer completes all operations related to the following commands before continuing with another sequence command:

- single sweep
- number of groups
- auto scale
- marker search
- marker function
- data → memory
- recall or save (internal or external)
- copy list values and operating parameters
- CH1, CH2, Wait 0*

*Wait 0 is the special sequencing function WAIT x with a zero entered for the delay value.

Commands that require a clean sweep

Many front panel commands disrupt the sweep in progress. For example, changing the channel or measurement type. When the analyzer does execute a disruptive command in a sequence, some instrument functions are inhibited until a complete sweep is taken. This applies to the following functions:

- autoscale
- data → memory

Forward stepping in edit mode

In the sequence modify mode, you can step through the selected sequence list, where the analyzer executes each step.

Titles

A title may contain non-printable or special ASCII characters if you download it from an external controller. A non-printable character is represented on the display as π.

Sequence size

A sequence may contain up to 2 kbytes of instructions. Typically, this is around 200 sequence command lines. To estimate a sequence's size (in kbytes), use the following guidelines.

Type of Command	Size in Bytes
Typical command	2
Title string character	1
Active entry command	1 per digit

Embedding the value of the loop counter in a title

You can append a sequentially increasing or decreasing numeric value to the title of stored data by placing a (DISPLAY) MORE TITLE MORE LOOP COUNTER command after the title string. (You must limit the title to three characters if you will use it as a disk file name. The three-character title and five-digit loop counter number reach the eight-character limit for disk file names.) This feature is useful in data logging applications.

Gosub sequence command

The "gosub sequence" feature allows you to call sub-routines in a test sequence. For example, you could perform an amplifier measurement in the following manner:

1. Create sequence 1 for the specific purpose of performing the gain measurement and printing the results. This sequence will act as a sub-routine.
2. Create sequence 2 to set up a series of different input power levels for the amplifier gain measurements. In-between each power level setting, call sequence 1 as a sub-routine by pressing GOSUB SEQUENCE SEQUENCE 1. Now, sequence 2 will print the measurement results for each input power level applied to the amplifier.

Using TTL I/O to interact with peripherals

The instrument's I/O interconnect can be connected to test fixtures and other peripheral equipment that the analyzer can interact with through test sequencing.

TTL output for controlling peripherals. Four TTL compatible output lines can be used for controlling equipment connected to the I/O interconnect. By pressing (SEQ) `TTL I/O` you will access the softkeys (listed below) that control the individual output bits. Refer to Figure 5-65 for output bus pin locations.

`TTL OUT ALL` lets you input a number (0 to 15) in base 10 and outputs it to the bus as binary.

`SET BIT` lets you set a single bit (0 - 3) to high on the output bus.

`CLEAR BIT` lets you set a single bit (0 - 3) to low on the output bus.

TTL input decision making. A TTL compatible input line can be used for decision making in test sequencing. For example, if a test fixture is connected to the I/O interconnect and has a micro switch that needs to be activated in order to proceed with a measurement, you can construct your test sequence so that it checks the TTL state of the input line corresponding to the switch. Depending on whether the line is high or low, you can jump to another sequence. To access these decision making functions, press (SEQ) `TTL I/O` . Refer to Figure 5-65 for the input line pin location.

`TTL IN IF BIT H` lets you jump to another sequence if the single input bit is in a high state.

`TTL IN IF BIT L` lets you jump to another sequence if the single input bit is in a low state.

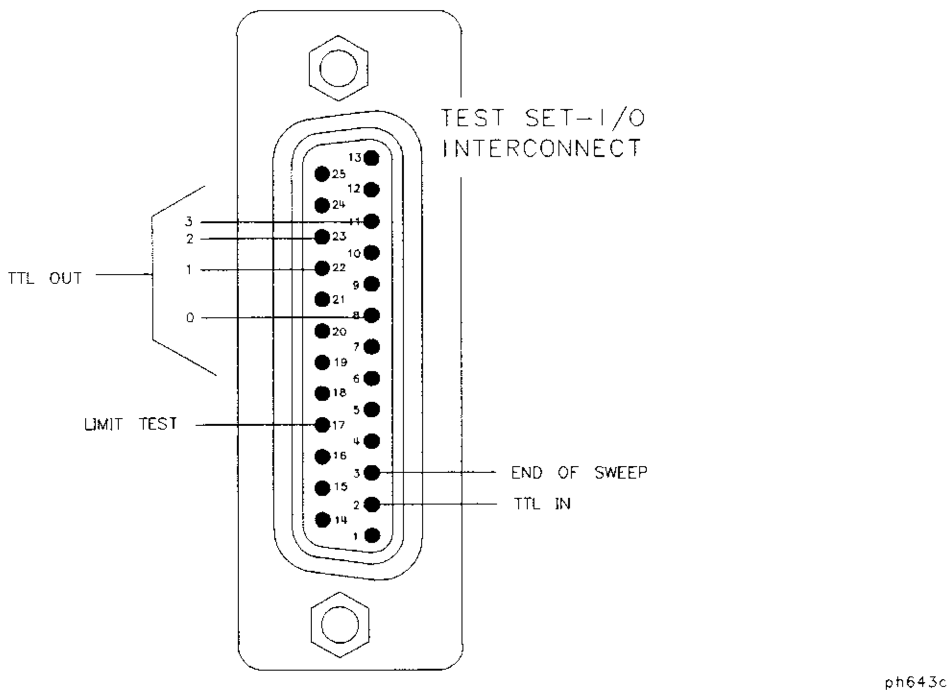


Figure 5-65. Pin Locations on IO Interconnect

The I/O control adapter shown in Figure 5-66 attaches to the I/O interconnect port and is used for connecting to peripherals. The HP part number for this adapter is 08752-60020.

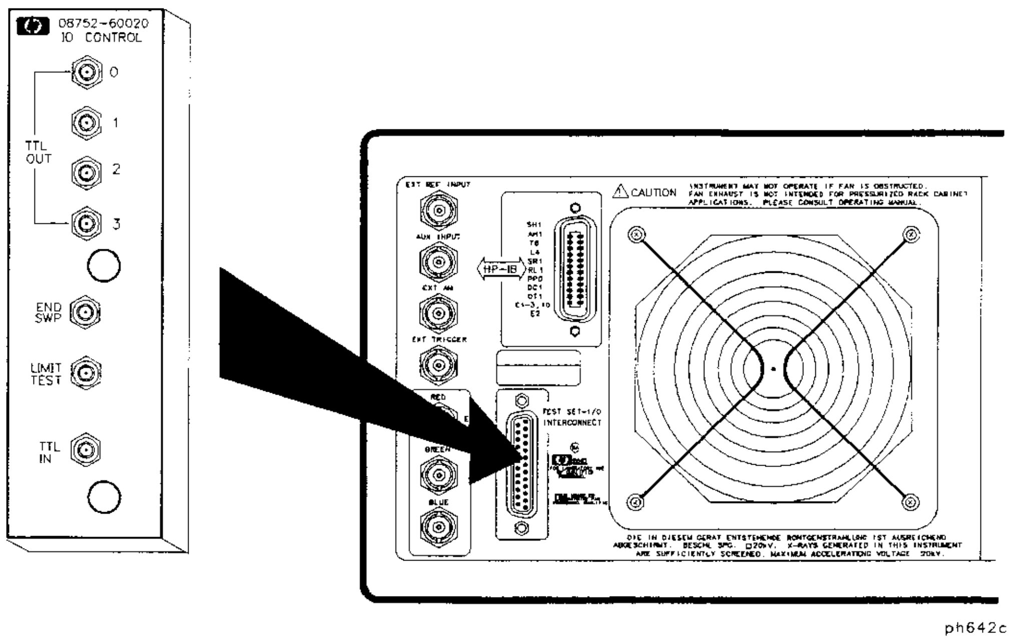


Figure 5-66. IO Control Adapter

Decision making functions

Decision making functions are explained in more detail below. These functions check a condition and jump to a specified sequence if the condition is true. The sequence called must be in memory. A sequence call is a one-way jump. A sequence can jump to itself, or to any of the other five sequences currently in memory. Use of these features is explained under the specific softkey descriptions.

Decision making functions jump to a softkey location, not to a. specific sequence title

Limit test, loop counter, and do sequence commands jump to any sequence residing in the specified sequence position (1 through 6). These commands do not jump to a specific sequence title. Whatever sequence is in the selected softkey position will run when these commands are executed.

Having a sequence jump to itself. A decision making command can jump to the sequence it is in. When this occurs, the sequence starts over and all commands in the sequence are repeated. This is used a great deal in conjunction with loop counter commands. See the loop counter description below.

TTL input decision making. TTL input from a peripheral connected to the I/O interconnect can be used in a decision making function. Refer to "Using TTL I/O to interact with peripherals" earlier in this section.

Limit test decision making. A sequence can jump to another sequence or start over depending on the result of a limit test. When entered into a sequence, the `IF LIMIT TEST PASS` and `IF LIMIT TEST FAIL` commands require you to enter the destination sequence.

Loop counter/loop counter decision making. The analyzer has a numeric register called a loop counter. The value of this register can be set by a sequence, and it can be incremented or decremented each time a sequence repeats itself. The decision making commands `IF LOOP COUNTER = 0` and `IF LOOP COUNTER <> 0` jump to another sequence if the stated condition is true. When entered into the sequence, these commands require you to enter the destination sequence. Either command can jump to another sequence, or restart the current sequence.

As explained later, the loop counter value can be appended to a title. This allows customized titles for data printouts or for data files saved to disk.

Autostarting sequences

You can define a sequence to run automatically when you apply power to the analyzer. To make an autostarting sequence, create a sequence in position six and title it "AUTO". To stop an autostarting sequence, press (LOCAL). To stop an autostarting sequence from engaging at power on, you must clear it from memory or rename it.

HP-GL considerations

Entering HP-GL commands

The analyzer allows you to use HP-GL (Hewlett-Packard Graphics Language) to customize messages or illustrations on the display of the analyzer. To use HP-GL, the instrument must be in system controller mode.

HP-GL commands should be entered into a title string using the (DISPLAY) MORE TITLE and character selection menu.

The TITLE TO PERIPHERAL sequencing command sends the HP-GL command string to the analyzers's HP-GL address. The address of the analyzer HP-GL graphics interface is always offset from the instrument's HP-IB address by 1:

- If the current instrument address is an even number:
  HP-GL address = instrument address +1.
- If the current instrument address is an odd number:
  HP-GL address = instrument address −1.

Special commands

Two HP-GL commands require special consideration when used in local operation or in sequencing. These are explained below:

Plot absolute (HP-GL command: PA)

The syntax for this command is PAx,y where x and y are screen location coordinates separated by a comma.

Label (HP-GL command: LB)

The syntax for this command is LB[text][etx]. The label command will print ASCII characters until the etx command is seen. The etx is the ASCII value 3 (not the ASCII character 3).

The analyzer title function does not have the ASCII value 3, so the instrument allows the LB command to be terminated with the END OF LABEL command (accessed by pressing (DISPLAY) MORE TITLE MORE END OF LABEL).

Entering sequences using HP-IB

You can create a sequence in a computer controller using HP-IB codes and enter it into the analyzer over HP-IB. This method replaces the keystrokes with HP-IB commands. The following is a procedure for entering a sequence over HP-IB:

1. Send the HP-IB command NEWSEQx where x is a number from 1 to 6.
2. Send the HP-IB commands for the measurement.
3. Terminate with the HP-IB command DONM (done modify).

Reading sequences using HP-IB

An external controller can read the commands in any sequence (in HP-IB command format). Send the following command to the analyzer:

OUTPSEQx where x is a number from 1 to 6.

Allocate an adequate amount of string variable space in the external controller and execute an ENTER statement.

Amplifier Testing

Amplifier parameters

The HP 8752C allows you to measure the transmission and reflection characteristics of many amplifiers and active devices. You can measure scalar parameters such as gain, gain flatness, gain compression, reverse isolation, return loss (SWR), and gain drift versus time. Additionally, you can measure vector parameters such as deviation from linear phase, group delay, complex impedance and AM-to-PM conversion.

Note For step-by-step instructions on performing the measurements mentioned above, refer to product note 8720-1. Although the product note is written for the HP 8720 family of network analyzers, it can be applied to the HP 8752C.

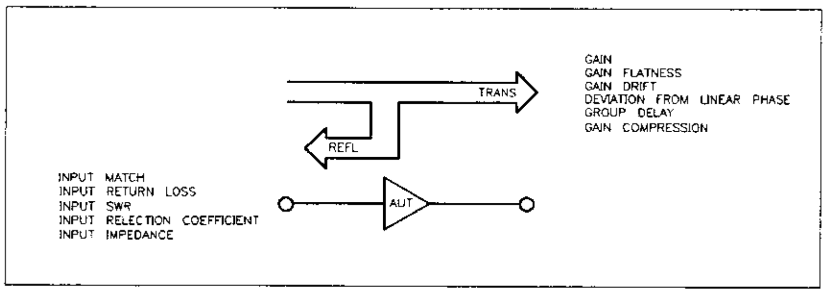


Figure 5-67. Amplifier Parameters

Gain compression

Vector network analyzers are commonly used to characterize amplifier gain compression versus frequency and power level. This is essentially linear characterization since only the relative level of the fundamental input to the fundamental output is measured. The narrowband receiver is tuned to a precise frequency and, as a result, is immune from harmonic distortion. You may want to quantify the harmonic distortion itself.

In a compression measurement it is necessary to know the RF input or output power at a certain level of gain compression. Therefore, both gain and absolute power level need to be accurately characterized. Uncertainty in a gain compression measurement is typically less than 0.05 dB. Also, each input channel of the analyzer is calibrated to display absolute power (typically within +0.5 dBm up to 3 GHz, and +1 dB up to 6 GHz). Refer to Chapter 2, "Making Measurements", for instructions on performing a gain compression measurement.

Connection Considerations

Adapters

To minimize the error introduced when you add an adapter to a measurement system, the adapter needs to have low SWR or mismatch, low loss, and high repeatability.

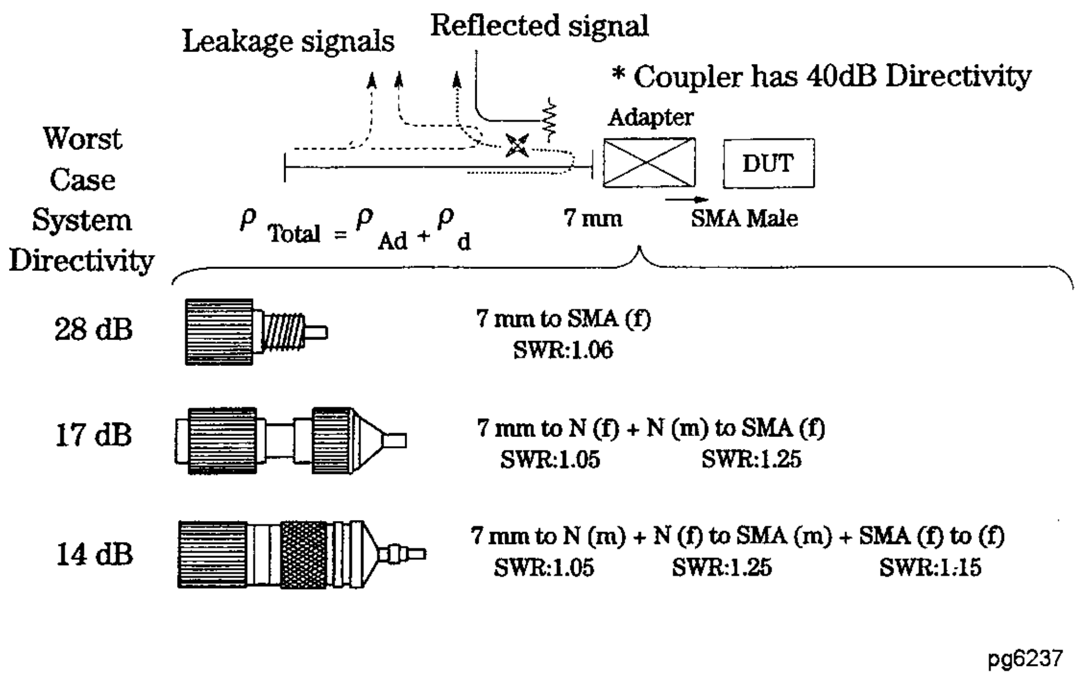


Figure 5-68. Adapter Considerations

In a reflection measurement, the directivity of a system is a measure of the error introduced by an imperfect signal separation device. It typically includes any signal that is detected at the coupled port which has not been reflected by the test device. This directivity error will add with the true reflected signal from the device, causing an error in the measured data. Overall directivity is the limit to which a device's return loss or reflection can be measured. Therefore, it is important to have good directivity to measure low reflection devices.

For example, a coupler has a 7 mm connector and 40 dB directivity, which is equivalent to a reflection coefficient of $\rho = 0.01$ (directivity in dB $= -20 \log \rho$). Suppose we want to connect to a device with an SMA male connector. We need to adapt from 7 mm to SMA.

If we choose a precision 7 mm to SMA adapter with a SWR of 1.06, which has $\rho = 0.03$, the overall directivity becomes $\rho = 0.04$ or 28 dB. However, if we use two adapters to do the same job, the reflection from each adapter adds up to degrade the directivity to 17 dB. The last example shown in Figure 5-68 uses three adapters that shows an even worse directivity of 14 dB. It is clear that a low SWR is desirable to avoid degrading the directivity of the system.

Fixtures

Fixtures are needed to interface non-coaxial devices to coaxial test instruments. It may also be necessary to transform the characteristic impedance from standard 50 or 75 ohm instruments to a non-standard impedance and to apply bias if an active device is being measured.

For accurate measurements, the fixture must introduce minimum change to the test signal, not destroy the test device, and provide a repeatable connection to the device.

Hewlett-Packard offers several fixtures for TO cans, stripline, and microstrip devices. Refer to Chapter 10, "Compatible Peripherals."

If you want to design your own fixture

Ideally, a fixture should provide a transparent connection between the test instrument and the test device. This means it should have no loss or electrical length and a flat frequency response, to prevent distortion of the actual signal. A perfect match to both the instrument and the test device eliminates reflected test signals. The signal should be effectively coupled into the test device, rather than leaking around the device and resulting in crosstalk from input to output. Repeatable connections are necessary to ensure consistent data.

Realistically, it is impossible to build an ideal fixture, especially at high frequencies. However, it is possible to optimize the performance of the test fixture relative to the performance of the test device. If the fixture's effects on the test signal are relatively small compared to the device's parameters, then the fixture's effects can be assumed to be negligible.

For example, if the fixture's loss is much less than the acceptable measurement uncertainty at the test frequency, then it can be ignored.

Reference Documents

Hewlett-Packard Company, “Simplify Your Amplifier and Mixer Testing” 5956-4363

Hewlett-Packard Company, “RF and Microwave Device Test for the ’90s - Seminar Papers” 5091-8804E

Hewlett-Packard Company “Testing Amplifiers and Active Devices with the HP 8720 Network Analyzer” Product Note 8720-1 5091-1942E

Blacka, Robert J., “TDR Gated Measurements of Stripline Terminations,” Reprint from “Microwave Product Digest,” HP publication no. 5952-0359, March/April 1989

Montgomery, David, “Borrowing RF Techniques for Digital Design,” Reprint from “Computer Design” HP publication number 5952-9335, May 1982

Rytting, Doug, “Advances in Microwave Error Correction Techniques,” Hewlett-Packard RF and Microwave Measurement Symposium paper HP publication number 5954-8378, June 1987

Rytting, Doug, “Improved RF Hardware and Calibration Methods for Network Analyzers,” Hewlett-Packard RF and Microwave Measurement Symposium paper, 1991

“Test Fixtures and Calibration Standards,” Inter-Continental Microwave Product Catalog HP publication number 5091-4254E

6

Specifications and Measurement Uncertainties

Dynamic Range

The specifications described in the table below apply to transmission measurements using 10 Hz IF BW and error-correction. Dynamic range is limited by the maximum test port power and the receiver's noise floor.

Table 6-1. HP 8752C Dynamic Range

Frequency Range	Dynamic Range
300 kHz to 1.3 GHz	110 dB*†
1.3 GHz to 3 GHz	110 dB†
3 GHz to 6 GHz	105 dB

* 100 dB, 300 kHz to 16 MHz, due to fixed spurs

† 105 dB, option 075

HP 8752C Network Analyzer Specifications

HP 8752C (50Ω) with Type-N Test Ports

The following specifications describe the system performance of the HP 8752C network analyzer. The system hardware includes the following:

Options: 006

Calibration kit: .... HP 85032B

Cables: .... HP part number 8120-4781 (included with HP 8752C)

Measurement Port Characteristics

The following tables describe the measurement port characteristics for both corrected and uncorrected HP 8752C network analyzers.

Table 6-2. Measurement Port Characteristics (Corrected)* for 50 Ohm Type-N Test Ports

	Frequency Range		
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**	**3 GHz to 6 GHz**
Directivity	50 dB	47 dB	40 dB
Source match (Reflection)	42 dB	36 dB	31 dB
Reflection tracking	±0.009 dB	±0.019 dB	±0.070 dB
Source match (Transmission)	23 dB	20 dB	16 dB
Load match	23 dB†	20 dB	20 dB
Transmission tracking	±0.043 dB‡	±0.086 dB	±0.172 dB

* These characteristics apply for an environmental temperature of 25 ± 5 °C, with less than 1 °C deviation from the calibration temperature.

† 14 dB, 300 kHz to 10 MHz, for option 006

‡ 0.13 dB, 300 kHz to 10 MHz, option 006

**Table 6-3.
Measurement Port Characteristics (Uncorrected)* for 50 Ohm Type-N Test Ports**

	Frequency Range		
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**	**3 GHz to 6 GHz**
Directivity	40 dB†	35 dB	30 dB
Source match (Reflection)	30 dB	25 dB	20 dB
Reflection tracking	±0.2 dB	±0.3 dB	±0.4 dB
Source match (Transmission)	23 dB	20 dB	16 dB
Load match	23 dB‡	20 dB	20 dB
Transmission tracking	±0.2 dB	±0.3 dB	±0.4 dB
Crosstalk	100 dB	100 dB	90 dB

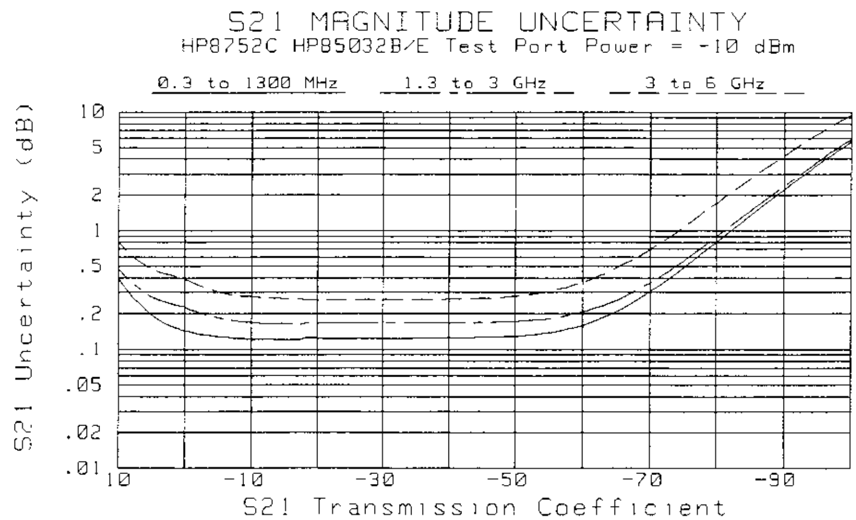
* Applies at 25 ±5 °C

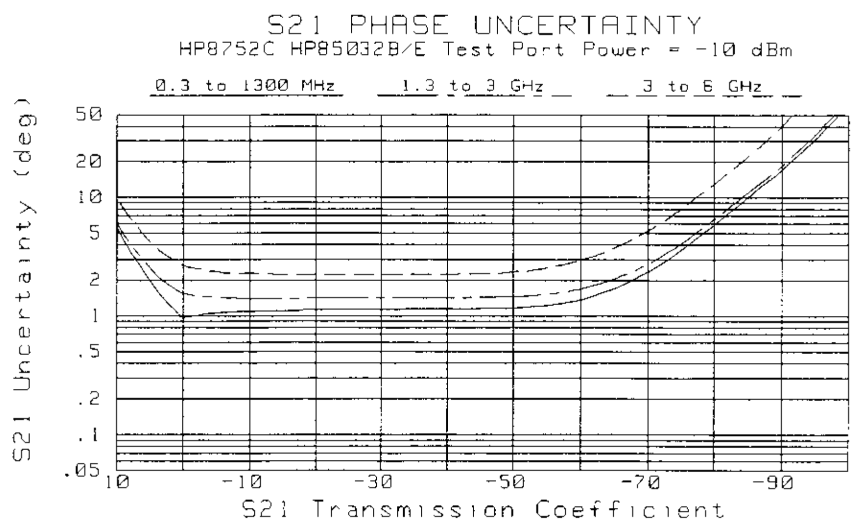
† 30 dB, 300 kHz to 10 MHz

‡ 14 dB, 300 kHz to 10 MHz, for option 006

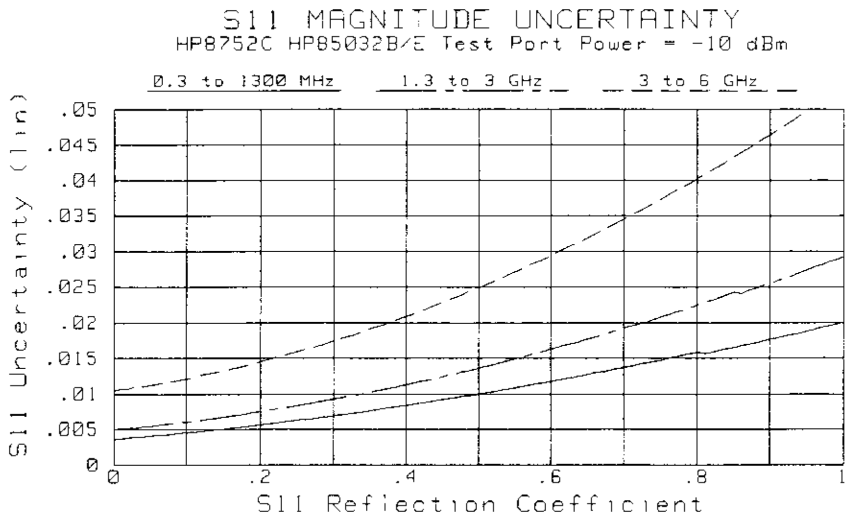
Transmission Measurement Uncertainties

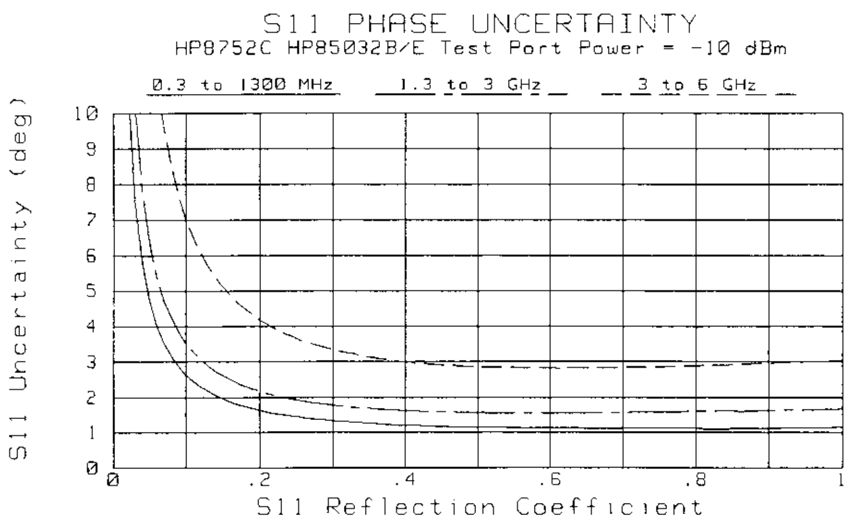
The graphs shown for transmission measurements assume a well-matched device ($S_{11} = S_{22} = 0$).





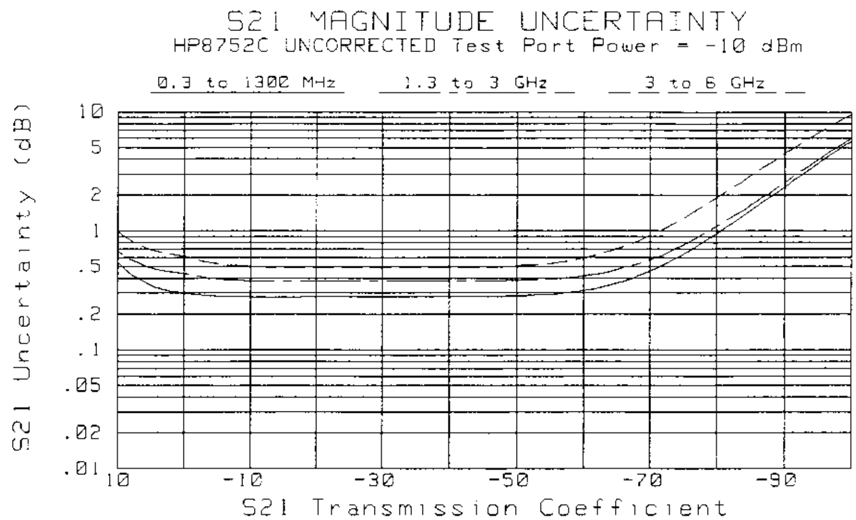
Reflection Measurement Uncertainties

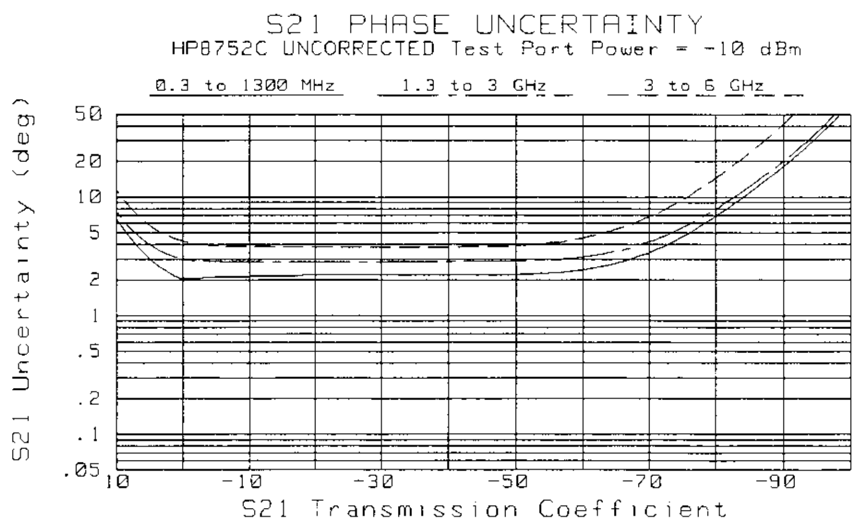




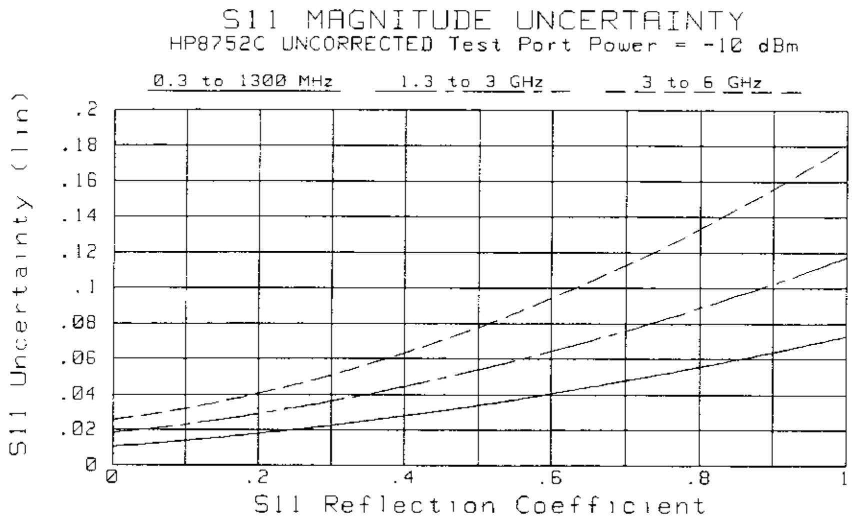
Transmission Measurement Uncertainties

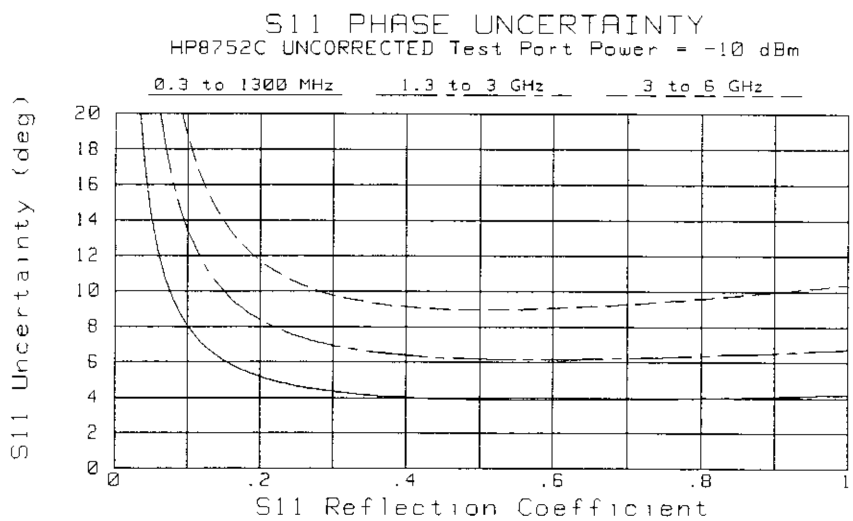
The graphs shown for transmission measurements assume a well-matched device ($S_{11} = S_{22} = 0$).





Reflection Measurement Uncertainties





HP 8752C (50Ω) with 3.5 mm Test Ports

The following specifications describe the system performance of the HP 8752C network analyzer. The system hardware includes the following:

Options: 006

Calibration kit: .... HP 85033D (Option 001)

Cables: .... HP part number 8120-4781

Measurement Port Characteristics

The following table describes the measurement port characteristics for corrected HP 8752C network analyzers.

Table 6-4. Measurement Port Characteristics (Corrected)* for 50 Ohm 3.5 mm Test Ports

	Frequency Range		
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**	**3 GHz to 6 GHz**
Directivity	46 dB	43 dB	37 dB
Source match (Reflection)	44 dB	41 dB	36 dB
Reflection tracking	±0.005 dB	±0.006 dB	±0.009 dB
Source match (Transmission)	22 dB	19 dB	15 dB
Load match	22 dB†	19 dB	19 dB
Transmission tracking	±0.043 dB‡	±0.086 dB	±0.172 dB

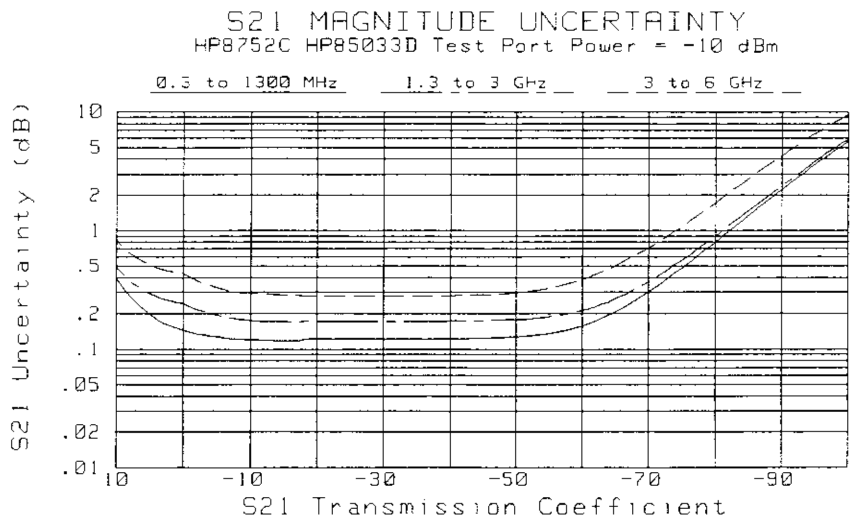
* Applies at 25 ±5 °C, with less that 1° deviation from the error-correction (calibration) temperature.

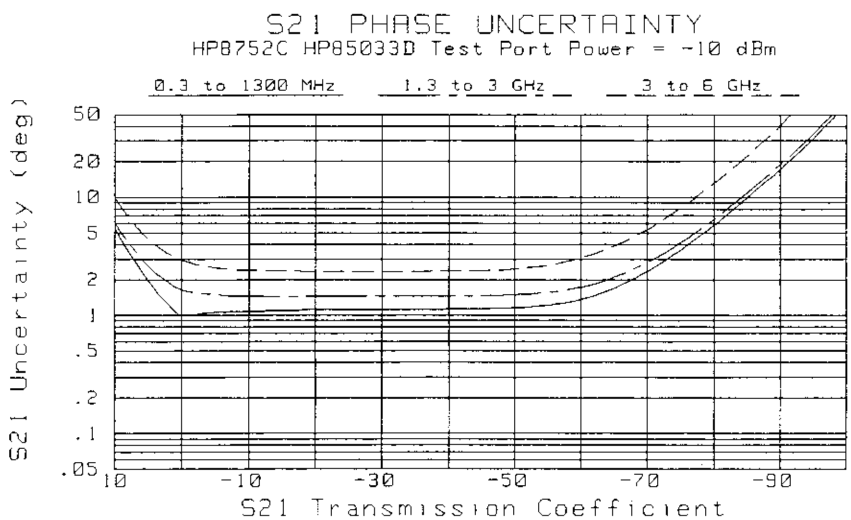
† 14 dB, 300 kHz to 10 MHz, option 006

‡ 0.13 dB, 300 kHz to 10 MHz, option 006

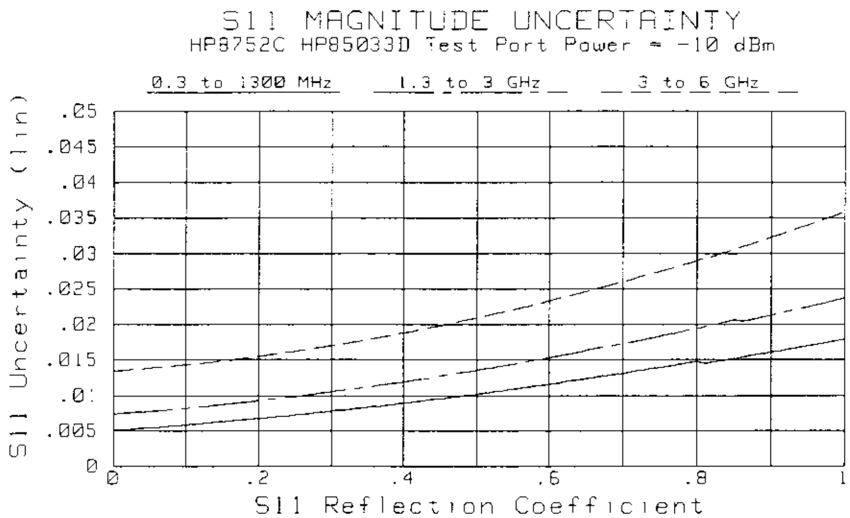
Transmission Measurement Uncertainties

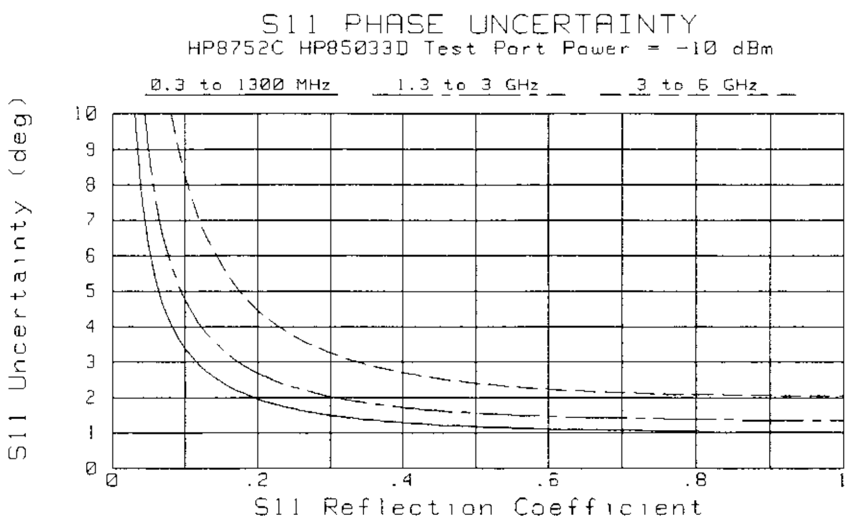
The graphs shown for transmission measurements assume a well-matched device ($S_{11} = S_{22} = 0$).





Reflection Measurement Uncertainties





HP 8752C (75Ω) with Type-N Test Ports

The following specifications describe the system performance of the HP 8752C network analyzer. The system hardware includes the following:

Options: 075

Calibration kit: .... HP 85036B

Cables: .... HP part number 8120-2408 (included with HP 8752C)

Measurement Port Characteristics

The following table describes the measurement port characteristics for corrected HP 8752C network analyzers.

**Table 6-5.
Measurement Port Characteristics (Corrected)* for 75 Ohm Type-N Test Ports**

	Frequency Range	
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**
Directivity	48 dB	43 dB
Source match (Reflection)	41 dB	35 dB
Reflection tracking	±0.010 dB	±0.019 dB
Source match (Transmission)†	23 dB	20 dB
Load match	23 dB	20 dB
Transmission tracking	±0.044 dB	±0.087 dB

* Applies at 25 ±5 °C, with less than 1°C deviation from the error-correction (calibration) temperature.

† Option 004 degrades source match by 2 dB, and transmission tracking by up to 0.05 dB.

**Table 6-6.
Measurement Port Characteristics (Uncorrected)* for 75 Ohm Type-N Test Ports**

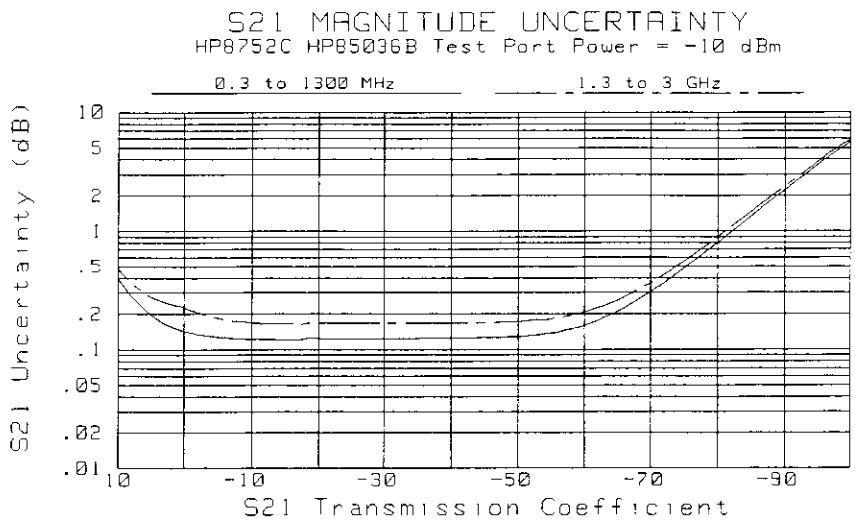
	Frequency Range	
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**
Directivity†	40 dB	35 dB
Source match (Reflection)	30 dB	25 dB
Reflection tracking	±0.2 dB	±0.3 dB
Source match (Transmission)	23 dB	20 dB
Load match	23 dB	20 dB
Transmission tracking	±0.2 dB	±0.3 dB
Crosstalk	100 dB	97 dB

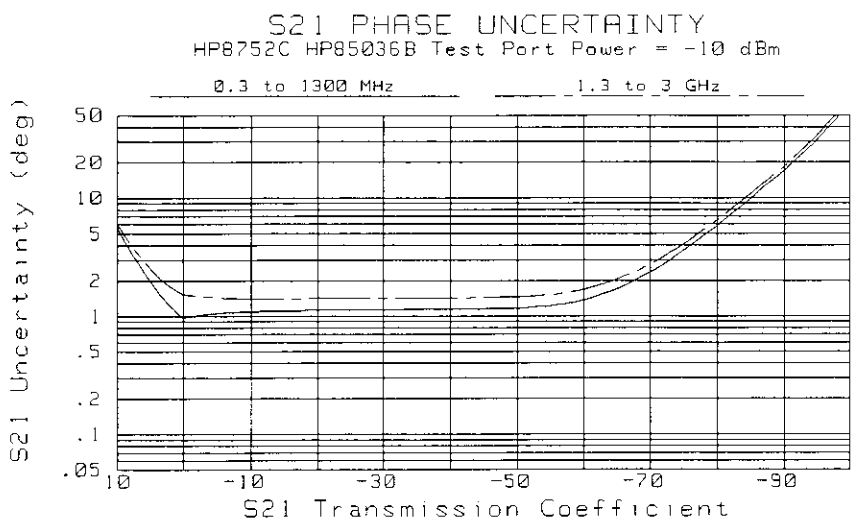
* Applies at 25±5°C

† 30 dB, 300 kHz to 10 MHz

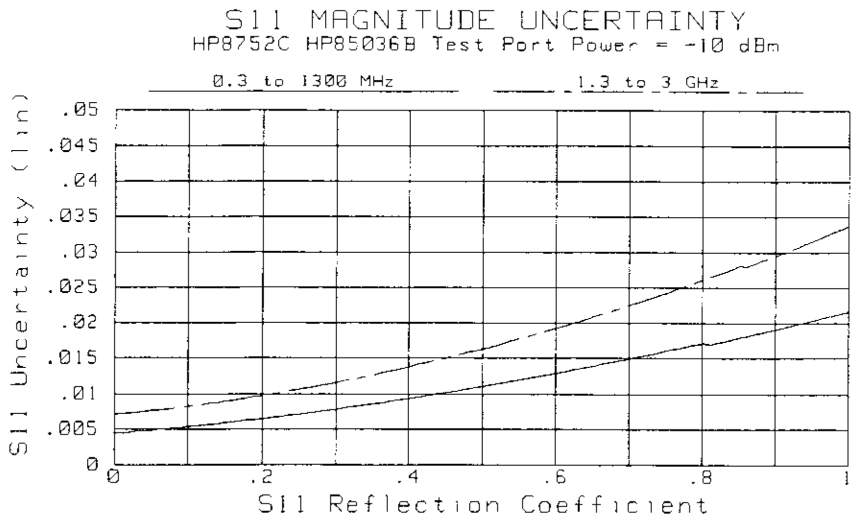
Transmission Measurement Uncertainties

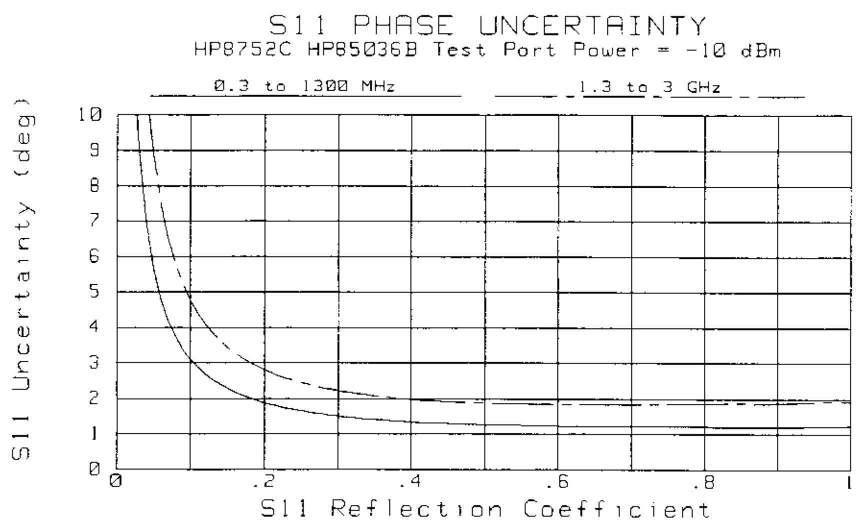
The graphs shown for transmission measurements assume a well-matched device ($S_{11} = S_{22} = 0$).





Reflection Measurement Uncertainties





HP 8752C (75Ω) with Type-F Test Ports

The following specifications describe the system performance of the HP 8752C network analyzer. The system hardware includes the following:

Options: 075

Calibration kit: .... HP 85039A

Cables: .... HP 11857B

Measurement Port Characteristics

The following table describes the measurement port characteristics for corrected HP 8752C network analyzers.

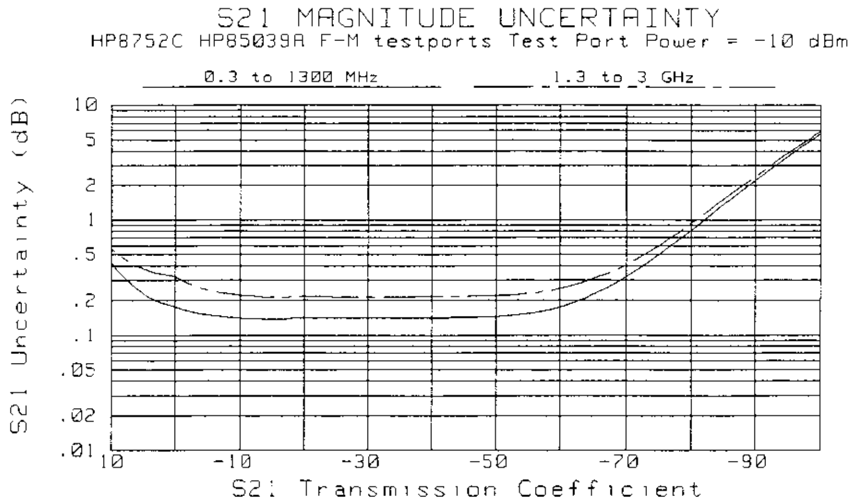
Table 6-7.
Measurement Port Characteristics (Corrected)* for HP 8752C (75Ω) using HP 85039A F-M Test Ports

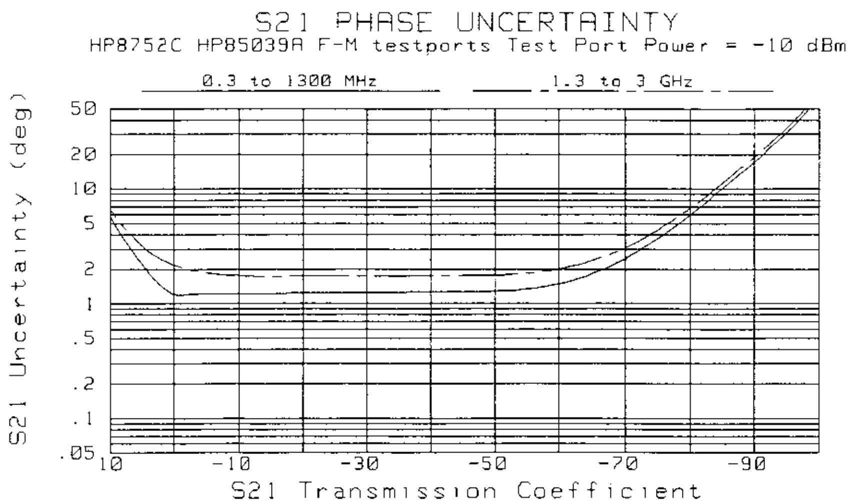
	Frequency Range	
	300 kHz to 1.3 GHz	1.3 GHz to 3 GHz
Directivity	38 dB	32 dB
Source match (reflection)	36 dB	30 dB
Source match (transmission)†	21 dB	18 dB
Load match	21 dB	18 dB
Reflection tracking	±0.008 dB	±0.032 dB
Transmission tracking	±0.060 dB	±0.135 dB

* Applies at 25 ±5 °C, with less that 1°C deviation from the calibration temperature.

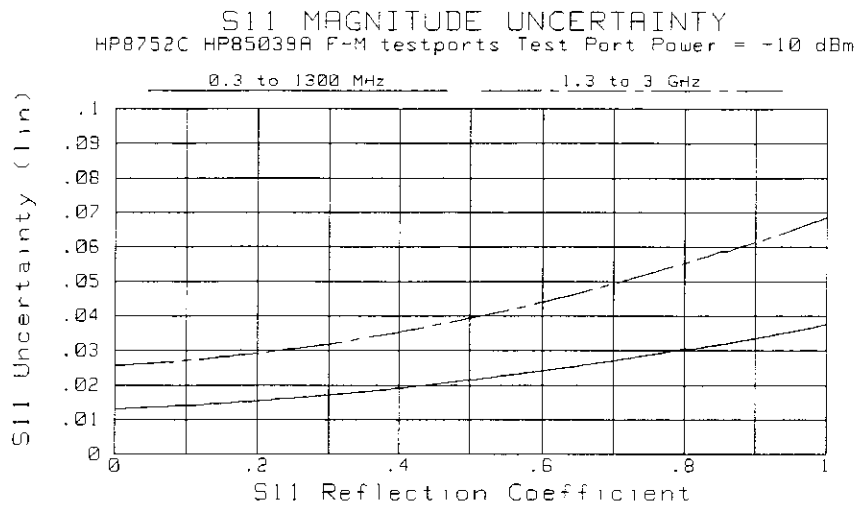
† Option 004 degrades source match by 2 dB, and transmission tracking by up to 0.05 dB.

Transmission Measurement Uncertainties





Reflection Measurement Uncertainties



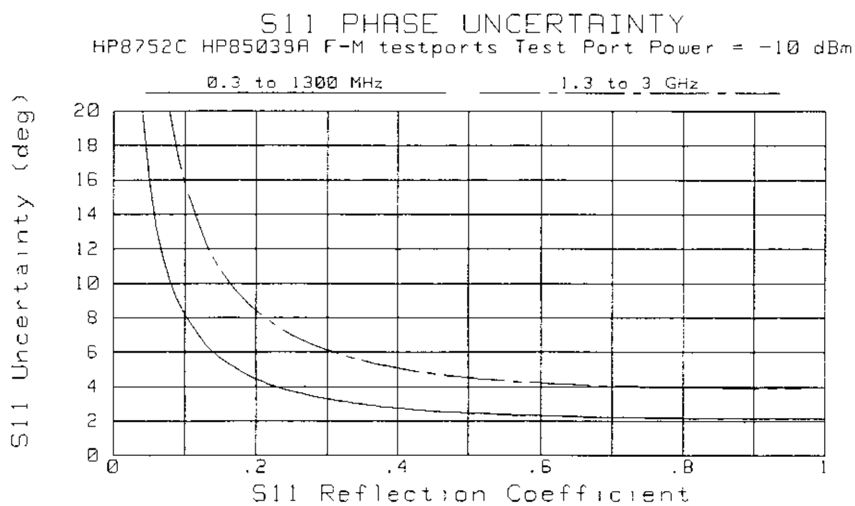


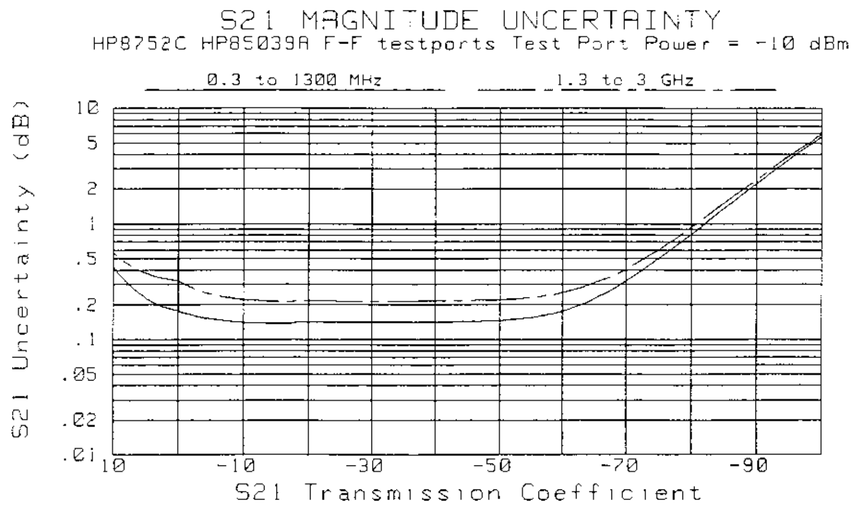
Table 6-8. Measurement Port Characteristics (Corrected)* for HP 8752C (75Ω) using HP 85039A F-F Testports

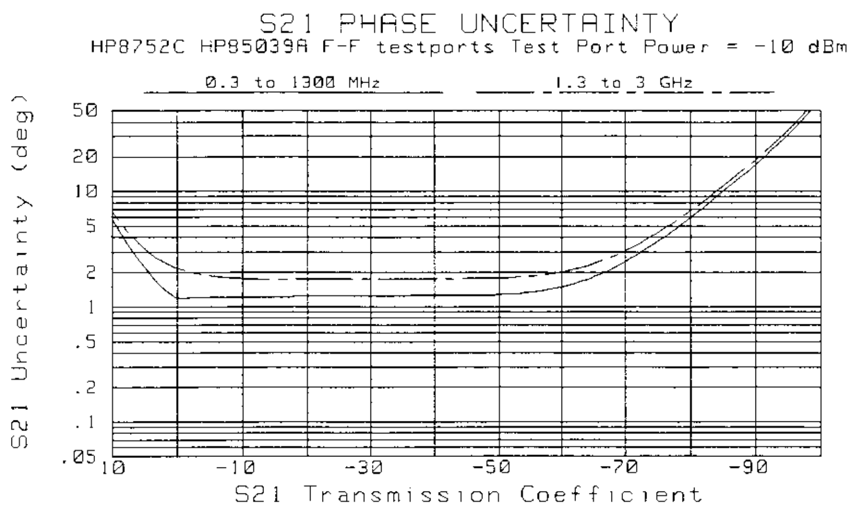
	Frequency Range	
	300 kHz to 1.3 GHz	1.3 GHz to 3 GHz
Directivity	38 dB	32 dB
Source match (reflection)	36 dB	30 dB
Source match (transmission)†	21 dB	18 dB
Load match	21 dB	18 dB
Reflection tracking	±0.008 dB	±0.032 dB
Transmission tracking	±0.060 dB	±0.135 dB

* Applies at 25 ±5 °C, with less than 1°C deviation from the error-correction (calibration) temperature.

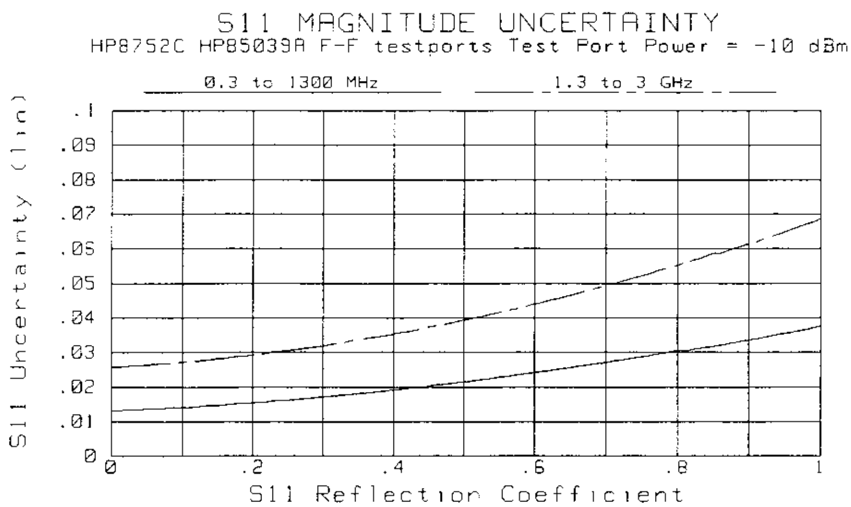
† Option 004 degrades source match by 2 dB, and transmission tracking by up to 0.05 dB.

Transmission Measurement Uncertainties





Reflection Measurement Uncertainties



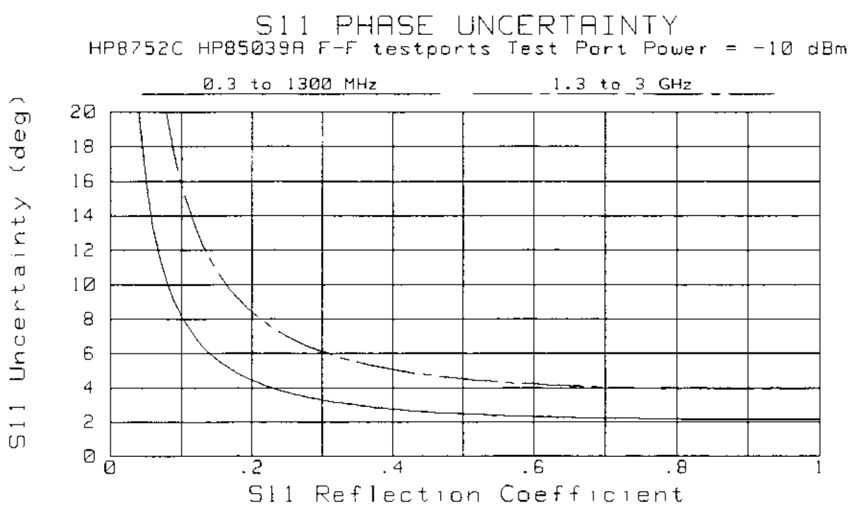


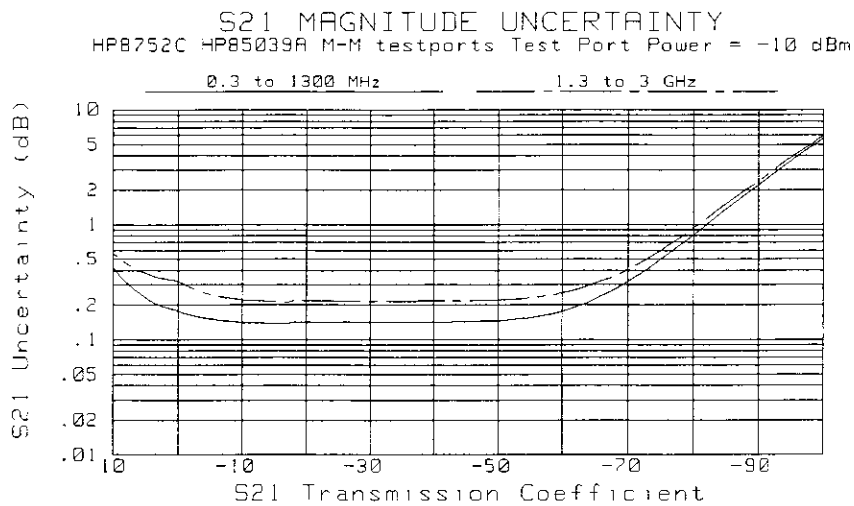
Table 6-9. Measurement Port Characteristics (Corrected)* for HP 8752C (75Ω) using HP 85039A M-M Testports

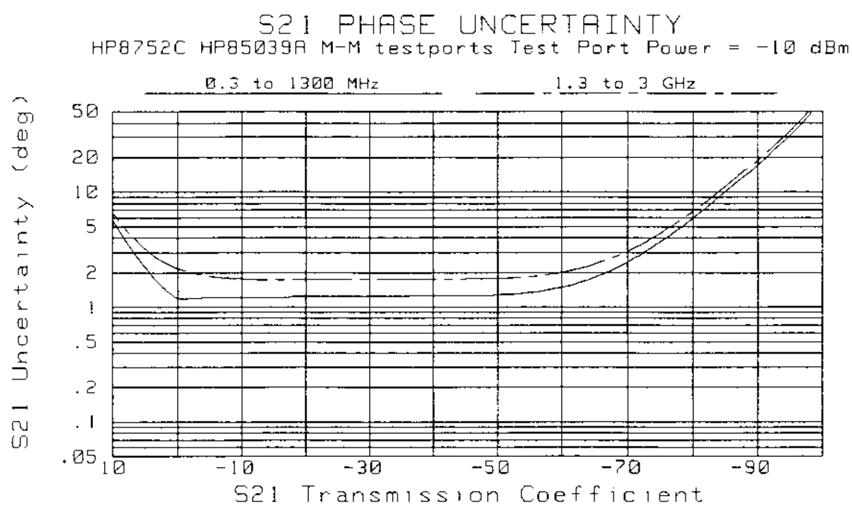
	Frequency Range	
	300 kHz to 1.3 GHz	1.3 GHz to 3 GHz
Directivity	32 dB	26 dB
Source match (reflection)	31 dB	25 dB
Source match (transmission)†	21 dB	18 dB
Load match	21 dB	18 dB
Reflection tracking	±0.025 dB	±0.073 dB
Transmission tracking	±0.060 dB	±0.135 dB

* Applies at 25 ±5 °C, with less than 1°C deviation from error-correction (calibration) temperature.

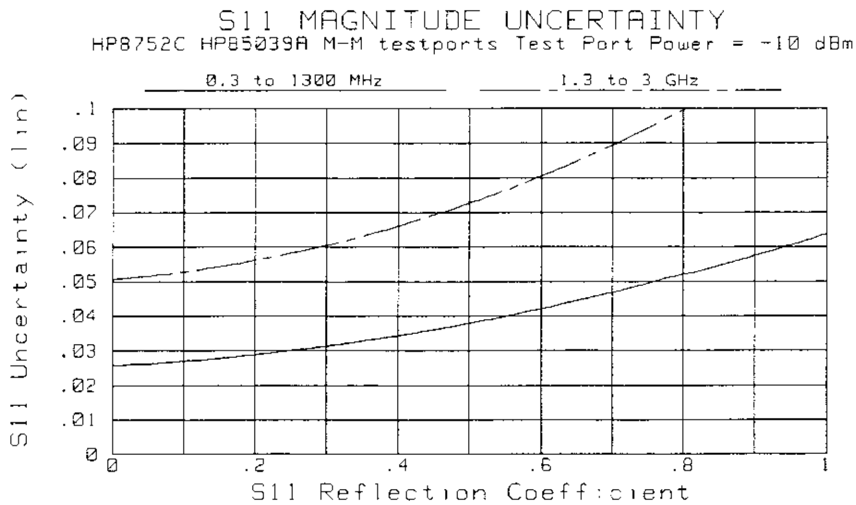
† Option 004 degrades source match by 2 dB, and transmission tracking by up to 0.05 dB.

Transmission Measurement Uncertainties





Reflection Measurement Uncertainties



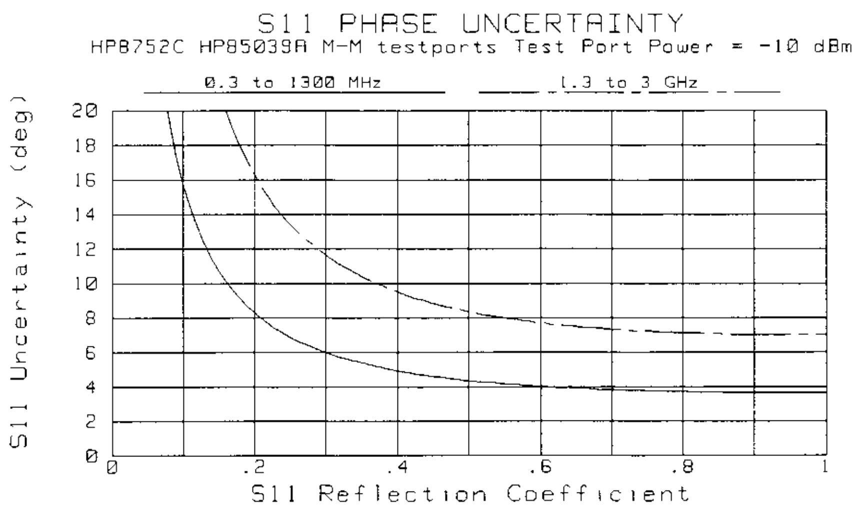


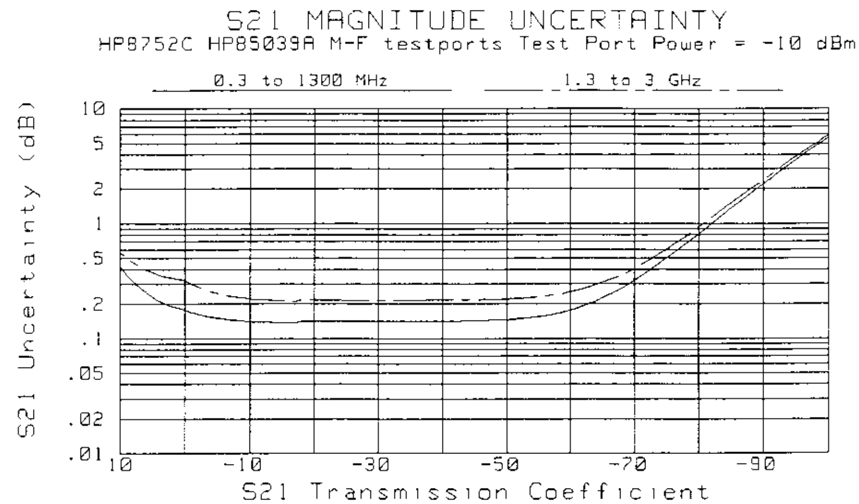
Table 6-10.
Measurement Port Characteristics (Corrected)* for HP 8752C (75Ω) using HP 85039A M-F Testports

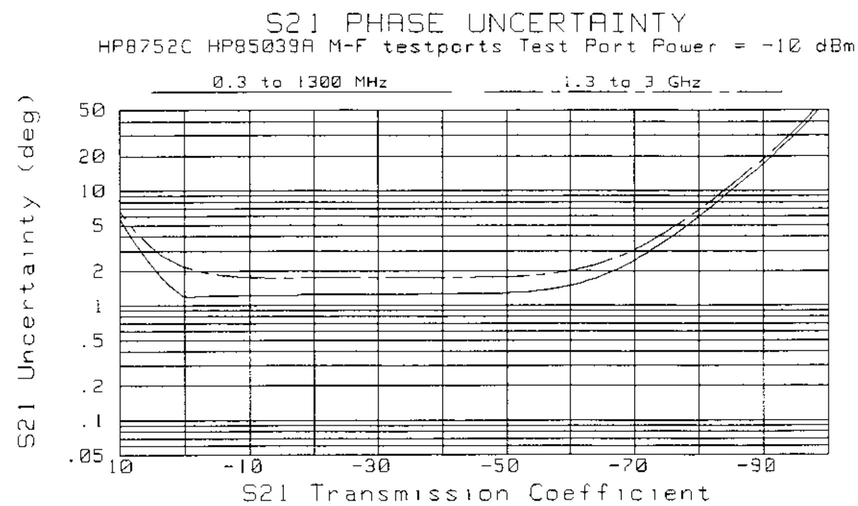
	Frequency Range	
	300 kHz to 1.3 GHz	**1.3 GHz to 3 GHz**
Directivity	32 dB	26 dB
Source match (reflection)	31 dB	25 dB
Source match (transmission)†	21 dB	18 dB
Load match	21 dB	18 dB
Reflection tracking	±0.025 dB	±0.073 dB
Transmission tracking	±0.060 dB	±0.135 dB

* Applies at 25 ±5 °C, with less than 1°C deviation from error-correction (calibration) temperature.

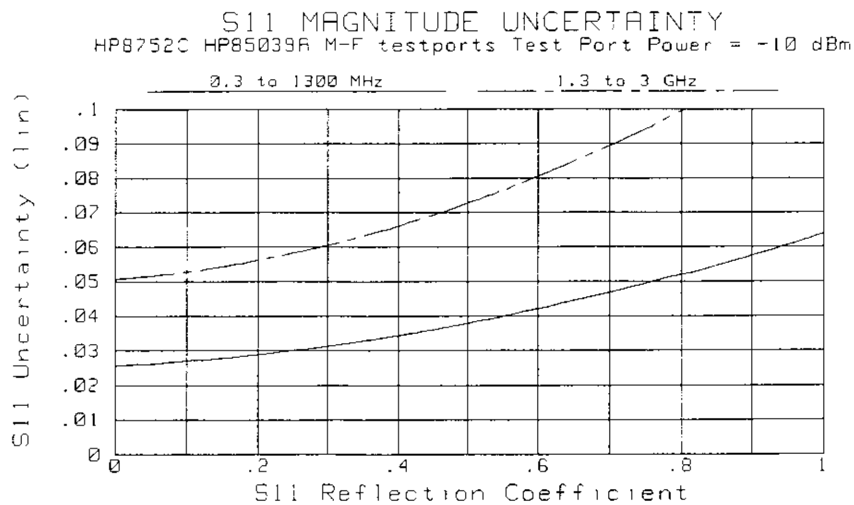
† Option 004 degrades source match by 2 dB, and transmission tracking by up to 0.05 dB.

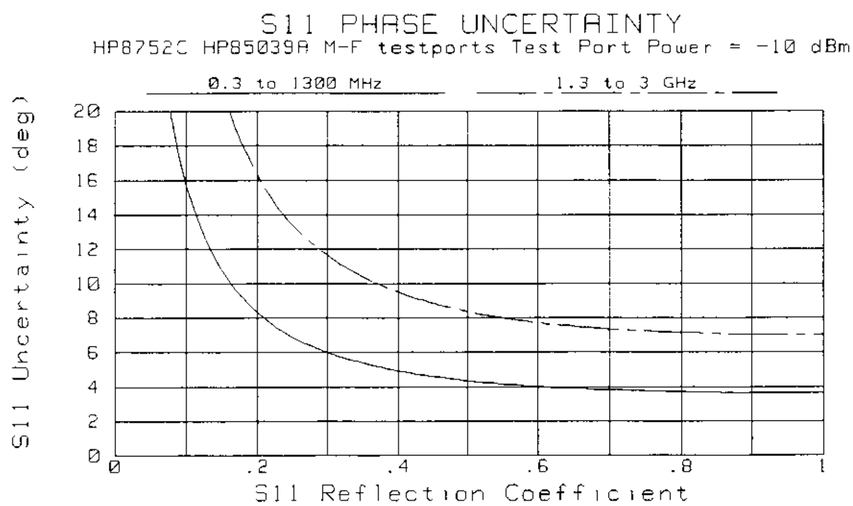
Transmission Measurement Uncertainties





Reflection Measurement Uncertainties





Instrument Specifications

The specifications listed in Table 1 range from those guaranteed by Hewlett-Packard to those typical of most HP 8752C instruments, but not guaranteed. Codes in the far right column of Table 1 reference a specification definition, listed below. These definitions are intended to clarify the extent to which Hewlett-Packard supports the specified performance of the HP 8752C.

S-1: This performance parameter is verifiable using performance tests documented in the service manual.

S-2: Due to limitations on available industry standards, the guaranteed performance of the instrument cannot be verified outside the factory. Field procedures can verify performance with a confidence prescribed by available standards.

S-3: These specifications are generally digital functions or are mathematically derived from tested specifications, and can therefore be verified by functional pass/fail testing.

T: Typical but non-warranted performance characteristics intended to provide information useful in applying the instrument. Typical characteristics are representative of most instruments, though not necessarily tested in each unit. Not field tested.

Table 1. HP 8752C Instrument Specifications (1 of 5)

TEST PORT OUTPUT		
Description	**Specification**	**Code**
FREQUENCY CHARACTERISTICS		
Range		
Standard	300 kHz to 1.3 GHz	S-1
Option 003	300 kHz to 3 GHz	S-1
Option 006	300 kHz to 6 GHz	S-1
Accuracy (at 25 °C ±5 °C)	±10 ppm	S-1
Stability		
0 ° to 55 °C	±7.5 ppm	T
per year	±3 ppm	T
Resolution	1 Hz	S-3
OUTPUT POWER CHARACTERISTICS		
Range		
Standard	−20 to +5 dBm	S-1
Option 004*	−85 to +10 dBm	S-1
Resolution	0.05 dB	S-3
Level Accuracy†	±1 dB	S-3
Linearity (at 25 °C ±5 °C)†		
−20 to −15 dBm	±0.5 dB (relative to −5 dBm output level)	S-1
−15 to 0 dBm	±0.2 dB (relative to −5 dBm output level)	S-1
0 to +5 dBm	±0.5 dB (relative to −5 dBm output level)	S-1
option 004		
−15 to +5 dBm	±0.2 dB (relative to −5 dBm output level)	S-1
+5 to +10 dBm‡	±0.5 dB (relative to −5 dBm output level)	S-1
Impedance	50 ohms, nominal	
	75 ohms, nominal (option 075)	

* −85 to +8 dBm, option 075

† typical from 2 to 3 GHz for options 003 with 075

‡ +5 to +8 dBm, option 075

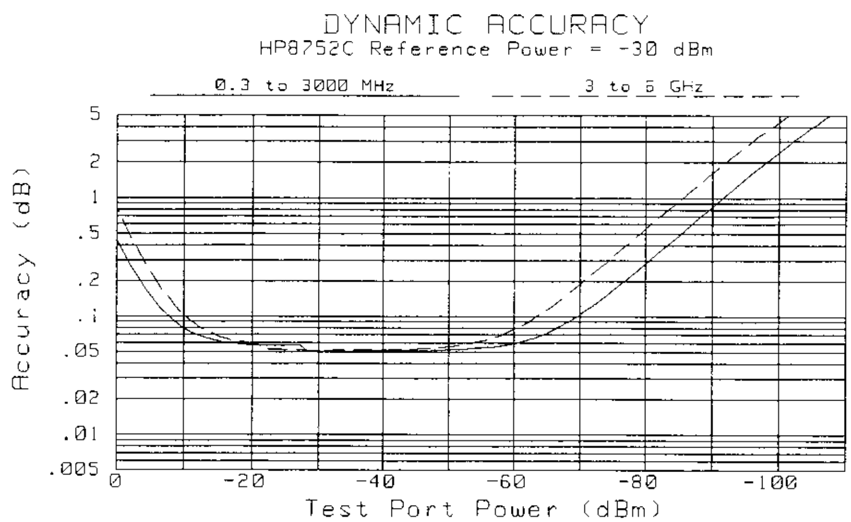
Table 1. HP 8752C Instrument Specifications (2 of 5)

TEST PORT INPUTS		
Description	**Specification**	**Code**
CHARACTERISTICS		
Frequency Range		
Standard	300 kHz to 1.3 GHz	S-1
Option 003	300 kHz to 3 GHz	S-1
Option 006	300 kHz to 6 GHz	S-1
Maximum Input Level		
	0 dBm at transmission port	S-1
	10 dBm at reflection port	S-1
Damage Level		
Standard	20 dBm or >25 VDC at both ports	T
Option 006	20 dBm or >10 VDC at transmission port	T
Average Noise Level		
Reflection		
3 kHz IF bandwidth	−75 dBm	T
10 Hz IF bandwidth	−85 dBm	T
Transmission		
300 kHz to 3 GHz		
3 kHz IF bandwidth	−90 dBm	S-1
10 Hz IF bandwidth	−110 dBm	S-1
3 GHz to 6 GHz (option 006)		
3 kHz IF bandwidth	−85 dBm	S-1
10 Hz IF bandwidth	−105 dBm	S-1
Crosstalk		
300 kHz to 1.3 GHz	100 dB	S-1
1.3 to 3 GHz	100 dB	S-1
3 GHz to 6 GHz	90 dB	S-1
Option 075		
300 kHz to 1.3 GHz	100 dB	S-1
1.3 GHz to 3 GHz	97 dB	S-1

* Explicitly tested as part of an on-site verification performed by Hewlett-Packard.

Table 1. HP 8752C Instrument Specifications (3 of 5)

INPUT GENERAL		
Description	**Specification**	**Code**
MAGNITUDE CHARACTERISTICS		
Display Resolution	0.001 dB/division	S-3
Marker* Resolution	0.0001 dB	S-3
Dynamic Accuracy (includes average noise level)		
(10 Hz BW, inputs Reflection and Transmission Port;)	(see graph)	S-1



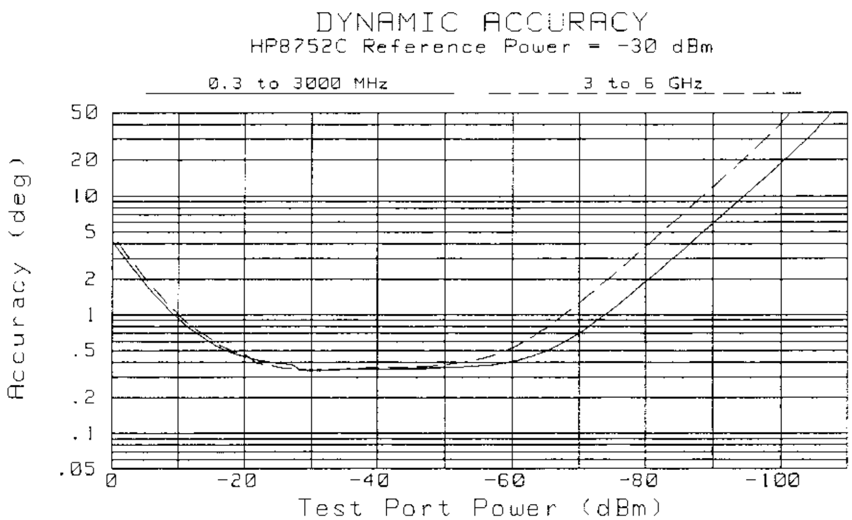
Dynamic Accuracy (Magnitude)

Trace Noise (0 dBm, 3 kHz BW)		
Reflection/Transmission		
300 kHz to 3 GHz	<0.006 dB rms	S-1
3 GHz to 6 GHz (option 006)	<0.010 dB rms	S-1
Reference Level		
Range	±500 dB	S-3
Resolution	0.001 dB	S-3
Stability	0.02 dB/°C	T
PHASE CHARACTERISTICS		
Range	±180 °	S-3
Display Resolution	0.01 °/division	S-3
Marker Resolution*	0.01 °	S-3

* Marker resolution for magnitude, phase, and delay is dependent upon the value measured; resolution is limited to 5 digits.

Table 1. HP 8752C Instrument Specifications (4 of 5)

INPUT GENERAL (cont.)		
Description	**Specification**	**Code**
PHASE CHARACTERISTICS (cont.)		
Dynamic Accuracy		
(10 Hz BW, inputs Reflection and Transmission Ports)	(see graph)	S-1

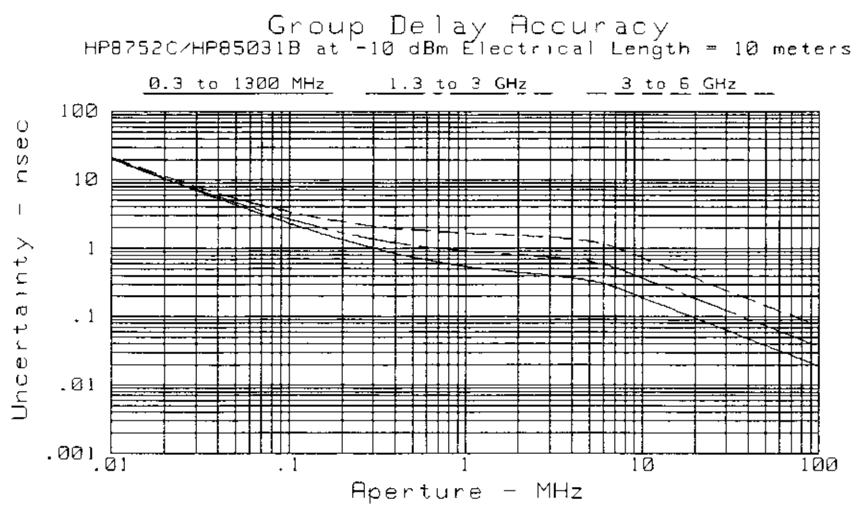


Dynamic Accuracy (Phase)

Trace Noise (+0 dBm, 3 kHz BW)		
Reflection/Transmission		
300 kHz to 3 GHz	0.038 °	S-1
3 GHz to 6 GHz (option 006)	0.070 °	S-1
Reference Level		
Range	±500 °	S-3
Resolution	0.001 °	S-3
Stability	0.10°/°C typically	T
POLAR CHARACTERISTICS (ratio measurement)		
Range	10 x 10^{-12} up to 1000 units full scale	S-3
Reference	range of ±500 units	S-3

Table 1. HP 8752C Instrument Specifications (5 of 5)

INPUT GENERAL (cont.)		
Description	**Specification**	**Code**
GROUP DELAY CHARACTERISTICS		
Group delay is computed by measuring the phase change within a specified frequency step (determined by the frequency span and the number of points per sweep).		
Minimum Aperture	(frequency span)/(number of points − 1)	S-3
Maximum Aperture	20% of frequency span	S-3
Range	1/2 x (1/minimum aperture)	S-3
(The maximum delay is limited to measuring no more than 180 ° of phase change within the minimum aperture.)		
Accuracy	(see graph)	S-3
The following graph shows group delay accuracy with type-N test ports and a 10 Hz IF bandwidth. Insertion loss is assumed to be <2 dB and electrical length to be ten meters.		



Group Delay Accuracy vs. Aperture

In general, the following formula can be used to determine the accuracy, in seconds, of specific group delay measurement:

±[0.003 x Phase Accuracy (deg)]/Aperture (Hz)

Depending on the aperture and device length, the phase accuracy used is either incremental phase accuracy or worst case phase accuracy.

HP 8752C Network Analyzer General Characteristics

Measurement Throughput Summary

The following table shows typical measurement times for the HP 8752C network analyzer in milliseconds.

Typical Time for Completion (ms)				
	Number of Points			
	51	201	401	1601
Measurement				
Uncorrected	125	200	300	900
1-port error-correction*	125	200	300	900
Time Domain Conversion†	80	350	740	1790
HP-IB Data Transfer‡				
Binary (Internal)	20	35	55	205
IEEE 754 floating point format				
32 bit	25	85	150	590
64 bit	40	115	220	840
ASCII	140	510	1000	3960

* S11 1-port calibration, with a 3 kHz IF bandwidth. Includes system retrace time, but does not include bandswitch time. Time domain gating is assumed off.

† Option 010 only, gating off.

‡ Measured with HP 9000 series 300 computer.

Remote Programming

Interface

HP-IB interface operates according to IEEE 488-1978 and IEC 625 standards and IEEE 728-1982 recommended practices.

Transfer Formats

Binary (internal 48-bit floating point complex format)

ASCII

32/64 bit IEEE 754 Floating Point Format

Interface Function Codes

SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C1, C2, C3, C10, E2

Front Panel Connectors

Connector Type .... type-N

Impedance .... 50 ohms (nominal)

.... 75 ohms (option 075)

Connector Center Pin Protrusion .... 0.204 to 0.207 in.

Probe Power

+15 V ±2% 400 mA

−12.6 V ±5.5% 300 mA

Rear Panel Connectors

External Reference Frequency Input (EXT REF INPUT)

Frequency .... 1, 2, 5, and 10 MHz (±200 Hz at 10 MHz)

Level .... −10 dBm to +20 dBm, typical

Impedance .... 50 ohms

External Auxiliary Input (AUX INPUT)

Input Voltage Limits .... −10 V to +10 V

External AM Input (EXT AM)

±1 volt into a 5 kΩ resistor, 1 kHz maximum, resulting in approximately 8 dB/volt amplitude modulation.

Test Set I/O Interconnect

With the use of an adapter (HP part number 08752-60020), you can use this connector for general purpose I/O control using the analyzer's test sequencing function.

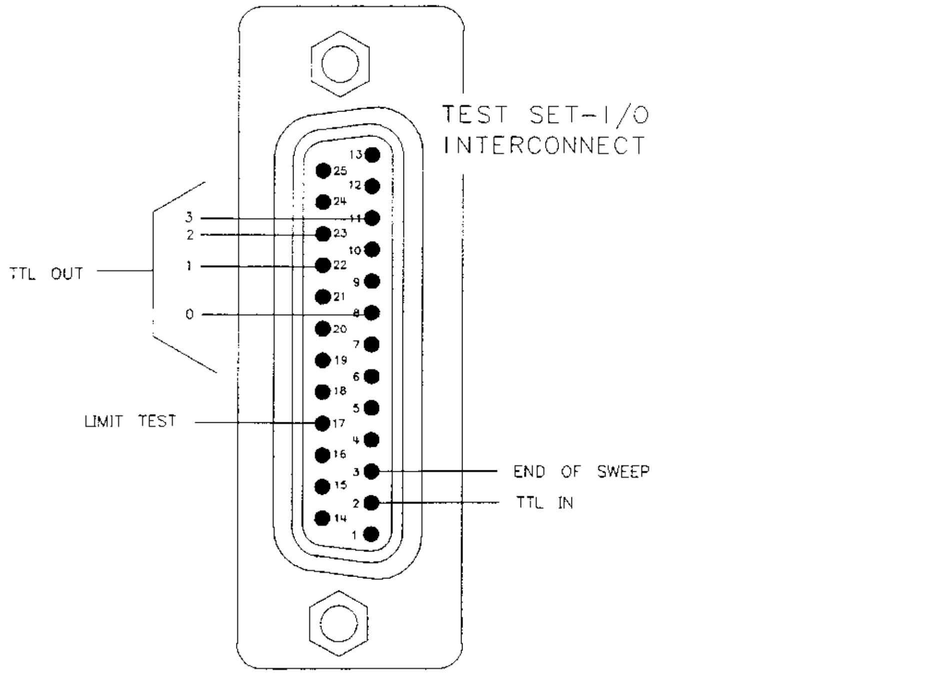


Figure 6-1. Test Set Interconnect Pin-out Diagram

External Trigger (EXT TRIGGER)

Triggers on a negative TTL transition or contact closure to ground.

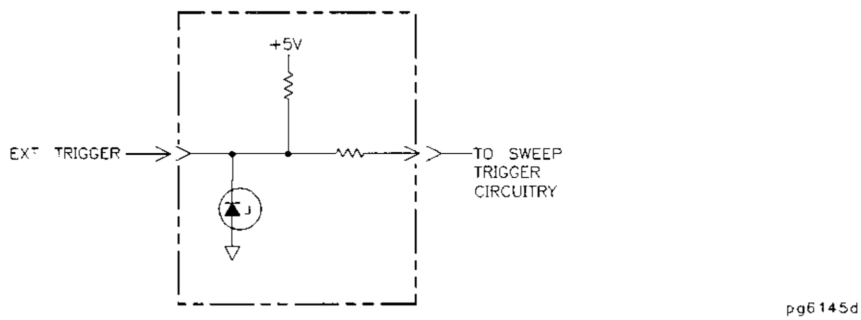


Figure 6-2. External Trigger Circuit

Video Output (EXT MON)

The RED, GREEN, and BLUE connectors drive external monitors with these characteristics:

RED, GREEN, BLUE with synch on green.

75 ohm impedance.

1 Vp-p (0.7 V = white; 0 V = black; −0.3 V = synch).

HP-IB

This connector allows communication with compatible devices including external controllers, printers, plotters, disk drives, and power meters.

Line Power

48 to 66 Hz

115 V nominal (90 V to 132 V) or 230 V nominal (198 V to 264 V). 280 VA max.

Environmental Characteristics

General Conditions

EMC characteristics: emissions, CISPR Publication 11; immunity, IEC 801-2/3/4, level 2.

ESD (electrostatic discharge): must be eliminated by use of static-safe work procedures and an anti-static bench mat (such as HP 92175T).

Dust: the environment should be as dust-free as possible.

Operating Conditions

Operating Temperature .... 0 ° to 55 °C

Error-Corrected Temperature Range .... ±1 °C of calibration temperature

Humidity .... 5% to 95% at 40 °C (non-condensing)

Altitude .... 0 to 4500 meters (15,000 feet)

Non-Operating Storage Conditions

Temperature .... −40 °C to +70 °C

Humidity .... 0 to 90% relative at +65 °C (non-condensing)

Altitude .... 0 to 15,240 meters (50,000 feet)

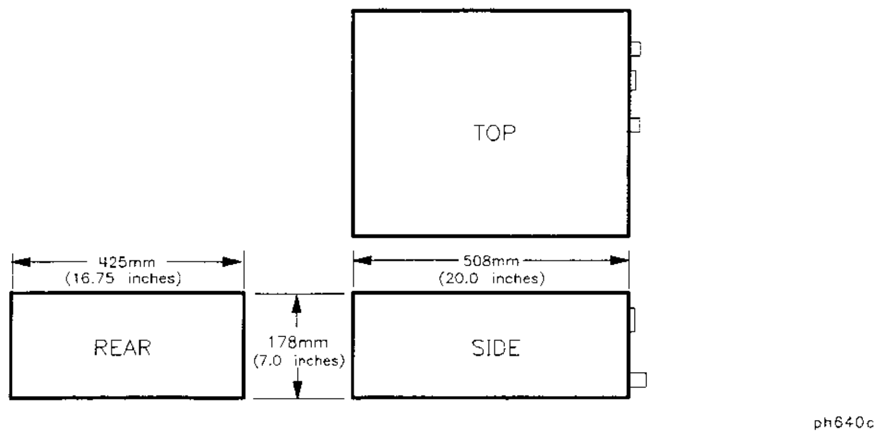
Weight

Net .... 34 kg (75 lb)

Shipping .... 37 kg (82 lb)

Cabinet Dimensions

178 mm H × 425 mm W × 508 mm D
(7.0 × 16.75 × 20.0 in)
(These dimensions exclude front and rear panel protrusions.)



Physical Dimensions

Internal Memory

Data Retention Time with 3 V, 1.2 Ah Battery

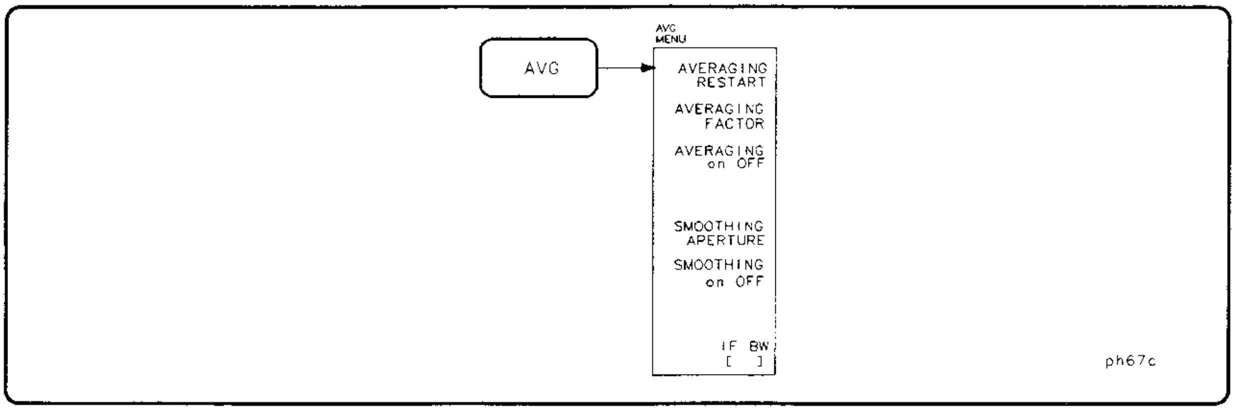
Temperature at 70 °C .... 208 days (0.57 year)
Temperature at 40 °C .... 1036 days (2.8 years)
Temperature at 25 °C .... 10 years typical

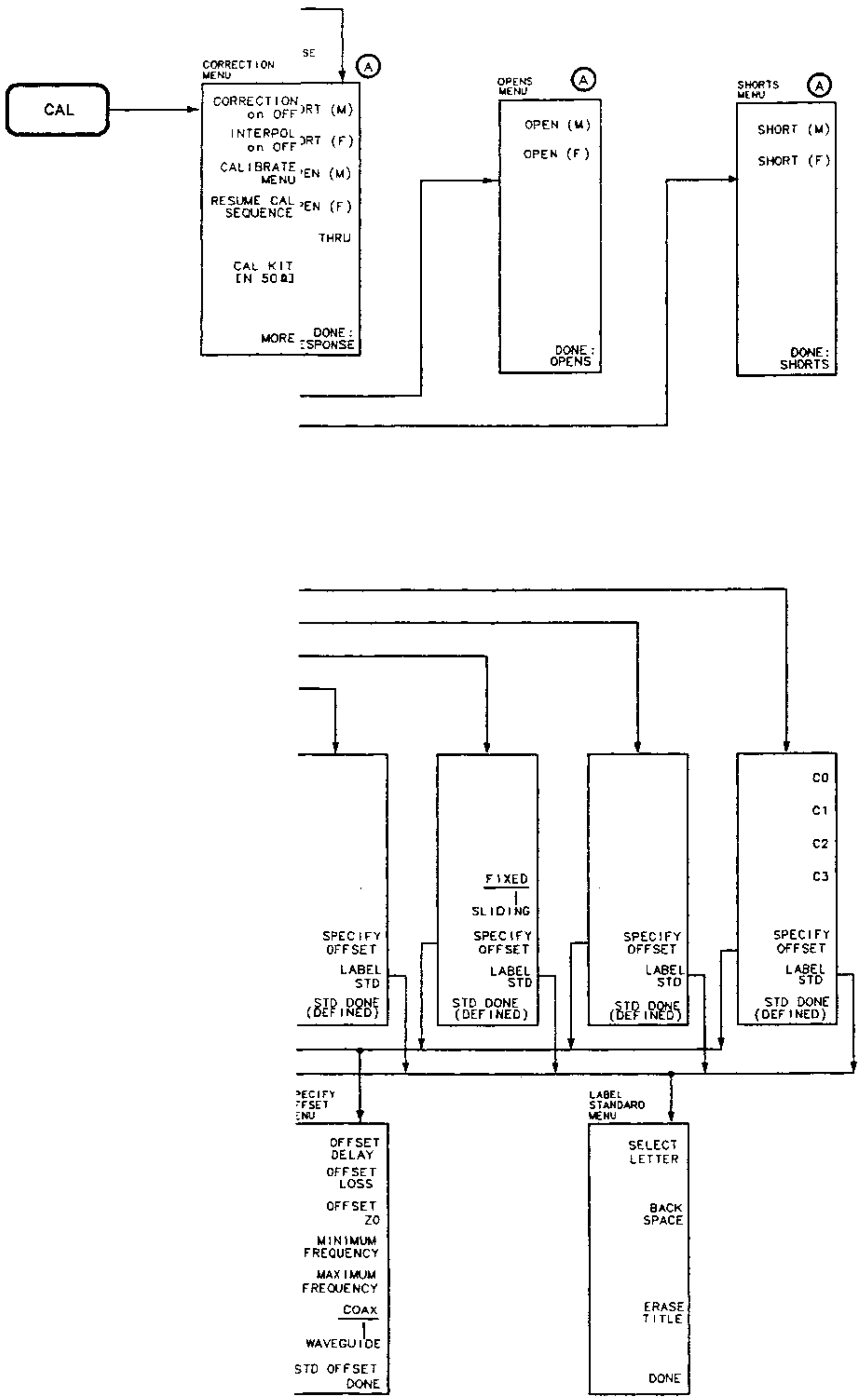
7

Menu Maps

This chapter contains menus maps arranged in the following order:

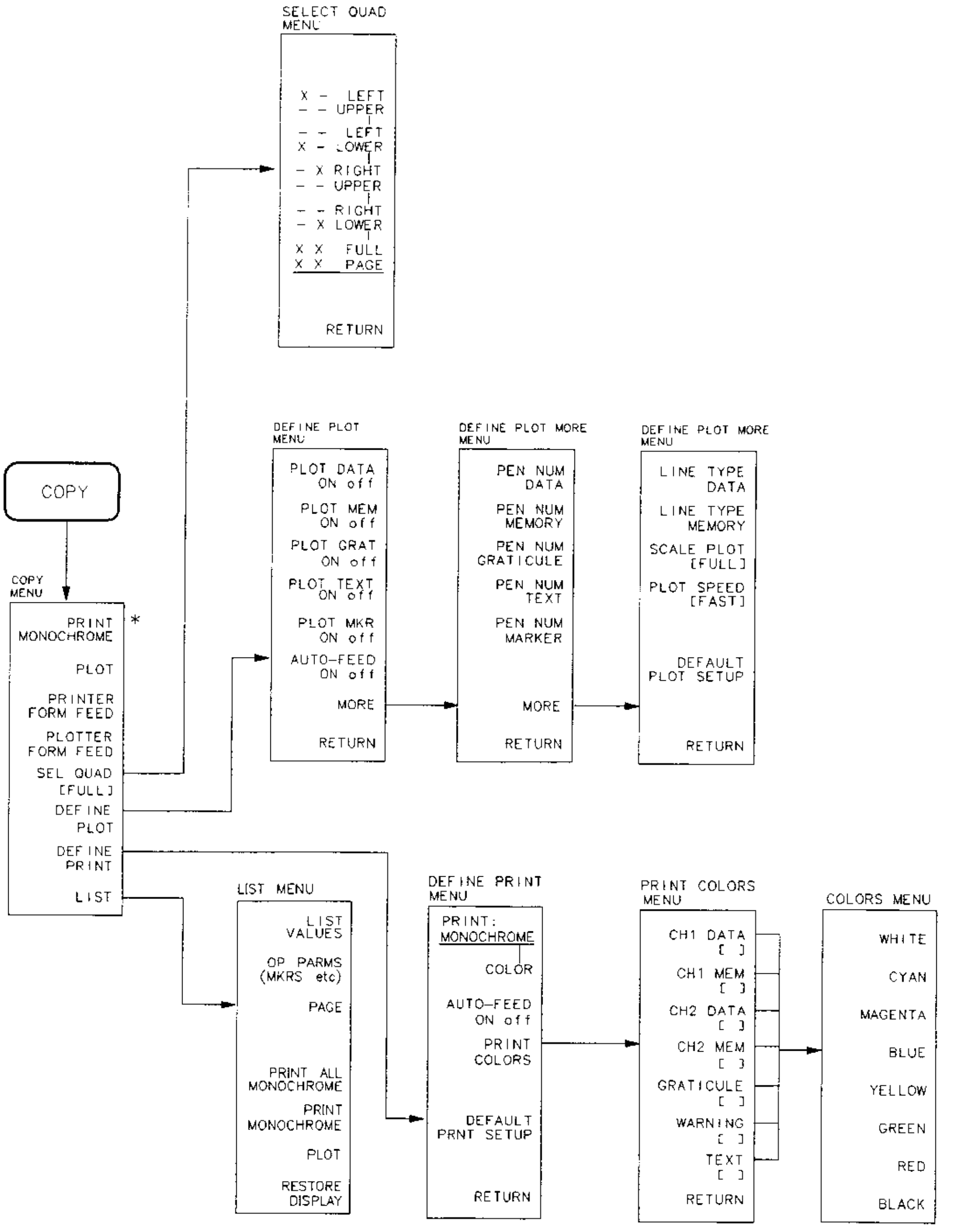
- (AVG)
- (CAL)
- (COPY)
- (DISPLAY)
- (FORMAT)
- (LOCAL)
- (MKR)
- (MKR FCTN)
- (MEAS)
- (MENU)
- (PRESET)
- (SAVE/RECALL)
- (SCALE REF)
- (SEQ)
- (SYSTEM)


AVG
AVG MENU
AVERAGING RESTART
AVERAGING FACTOR
AVERAGING on OFF
SMOOTHING APERTURE
SMOOTHING on OFF
IF BW [ ]
ph67c

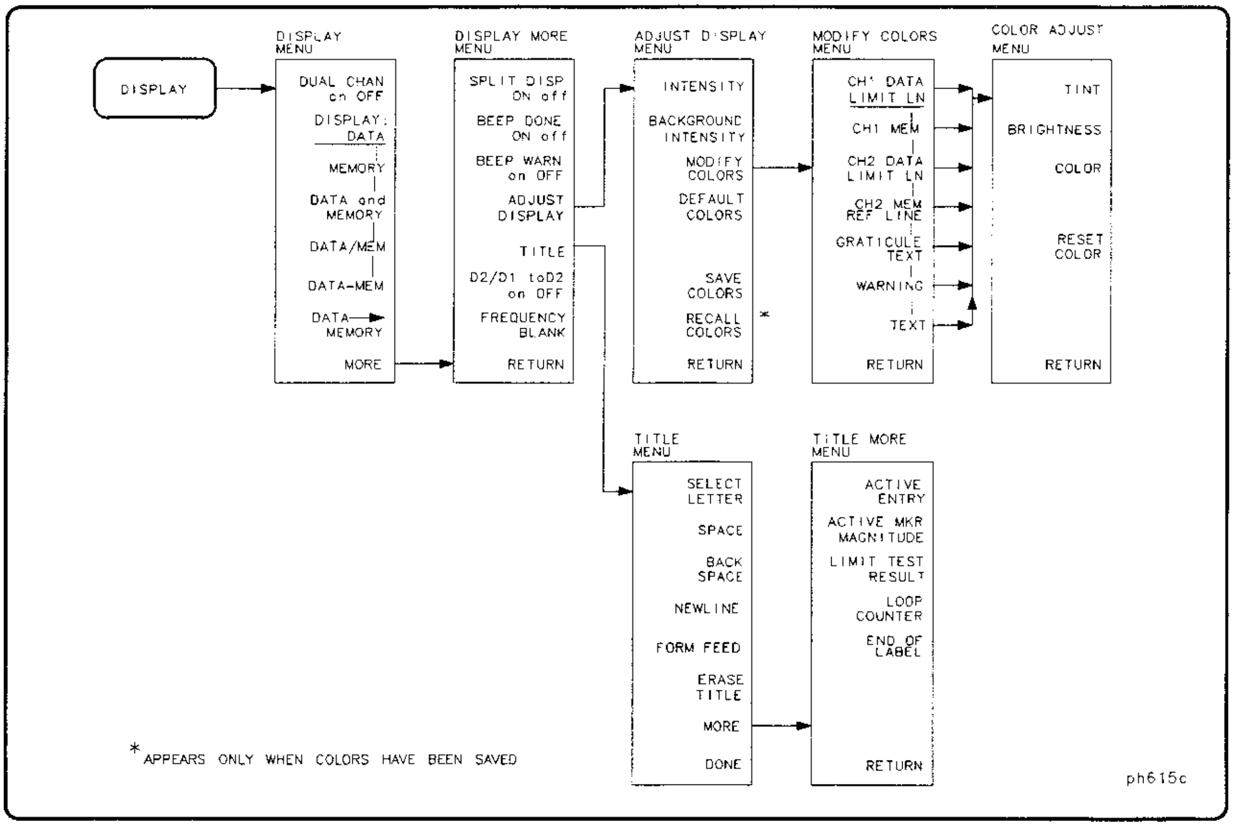


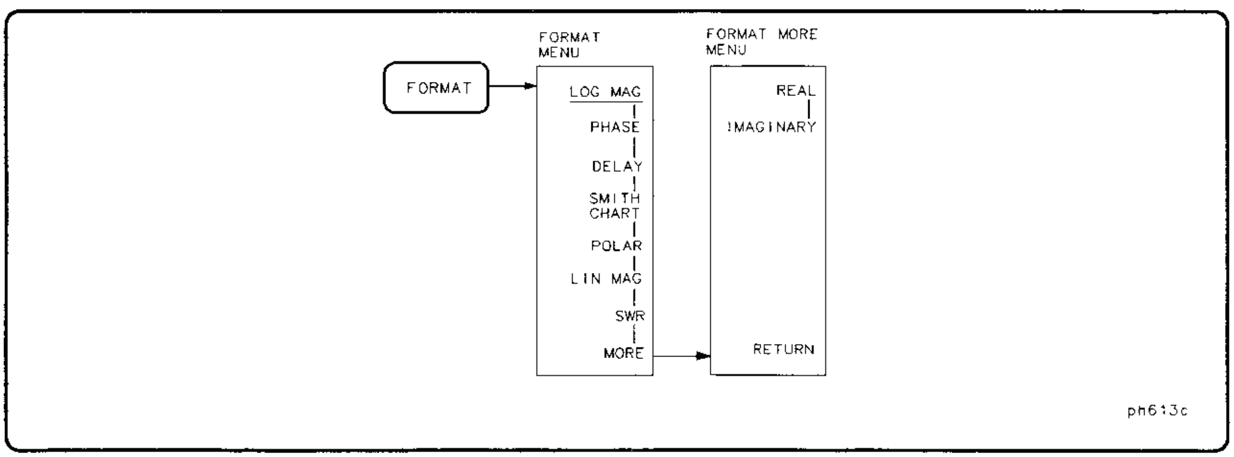
ND ON THE TYPE OF CAL KIT SELECTED
E CORECT FOR THE N 50Ω CAL KIT.

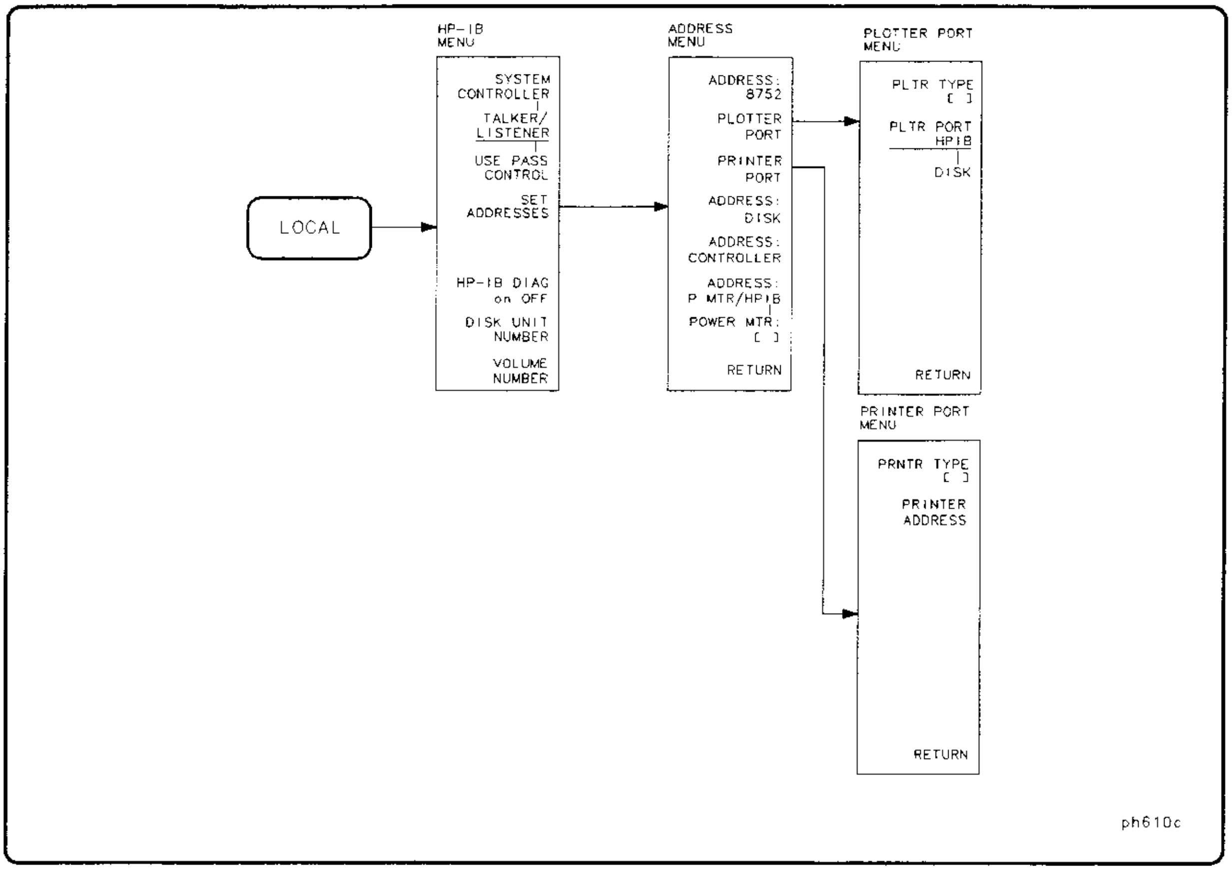
ph616c



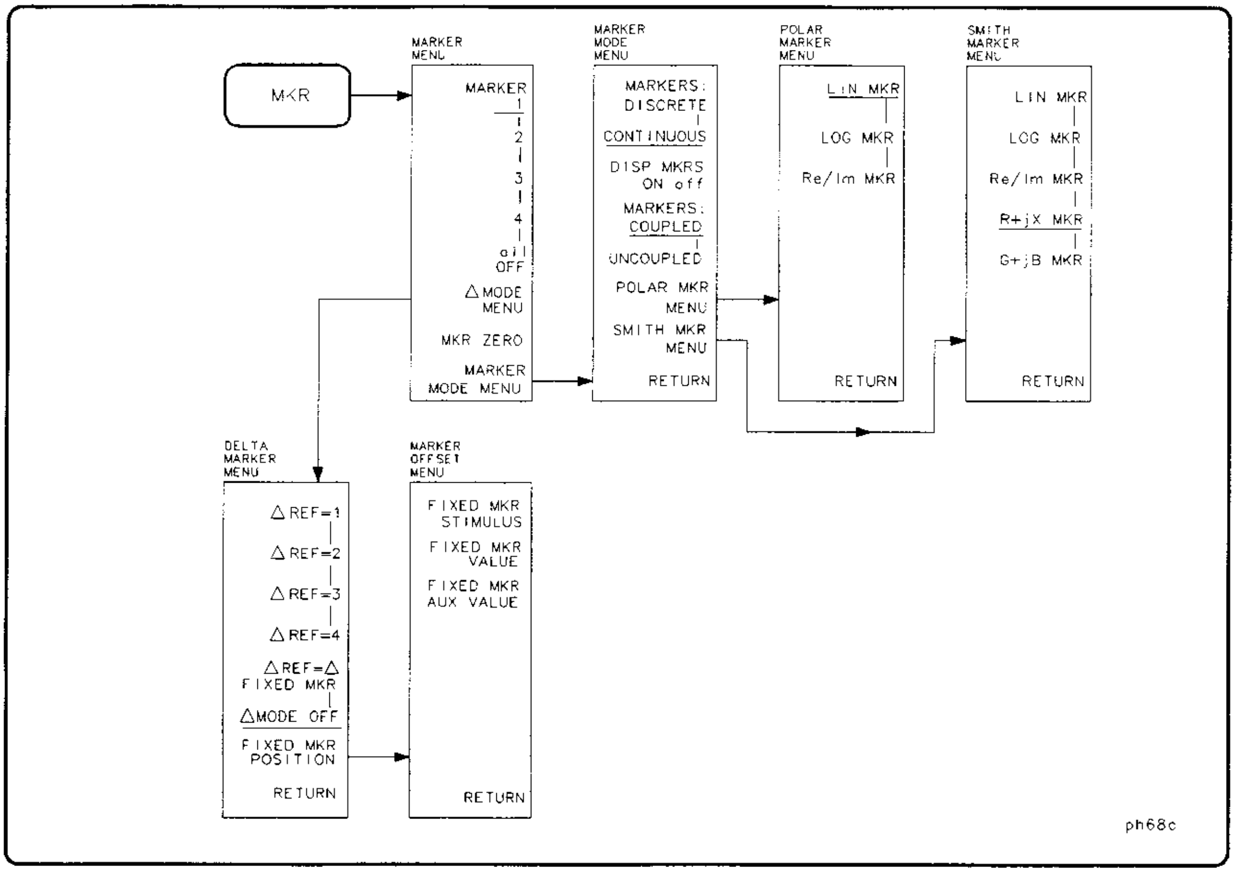
* THIS KEY LABEL CHANGES BETWEEN PRINT MONOCHROME AND PRINT COLOR, DEPENDING ON THE SETING OF THE PRINT: MONOCHROME/COLOR KEY SELECTION IN THE DEFINE PRINT MENU.

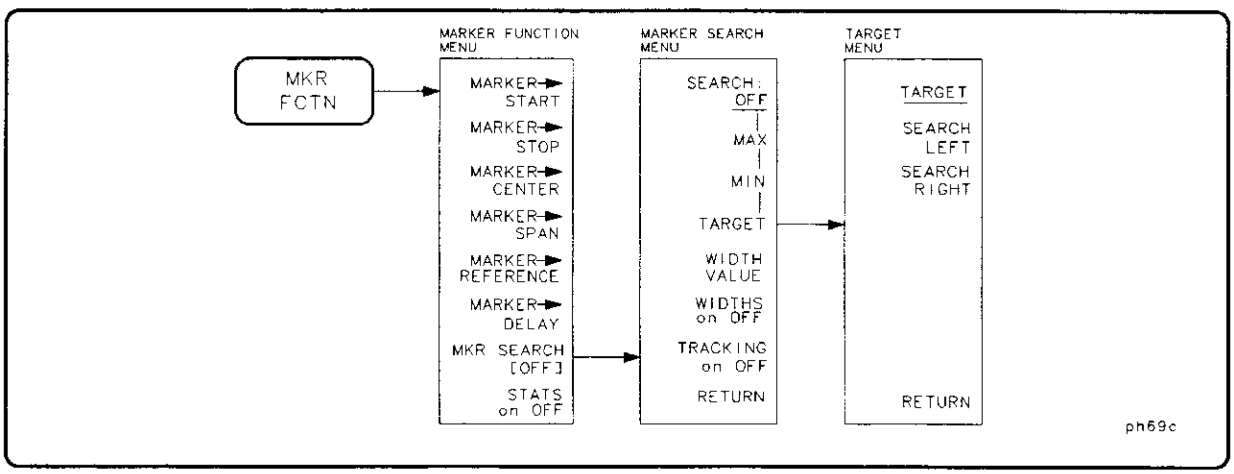

DISPLAY
DISPLAY MENU
DUAL CHAN on OFF
DISPLAY: DATA
MEMORY
DATA and MEMORY
DATA/MEM
DATA-MEM
DATA→MEMORY
MORE
DISPLAY MORE MENU
SPLIT DISP ON off
BEEP DONE ON off
BEEP WARN on OFF
ADJUST DISPLAY
TITLE
D2/D1 toD2 on OFF
FREQUENCY BLANK
RETURN
ADJUST DISPLAY MENU
INTENSITY
BACKGROUND INTENSITY
MODIFY COLORS
DEFAULT COLORS
SAVE COLORS
RECALL COLORS *
RETURN
MODIFY COLORS MENU
CH1 DATA LIMIT LN
CH1 MEM
CH2 DATA LIMIT LN
CH2 MEM REF LINE
GRATICULE TEXT
WARNING
TEXT
RETURN
COLOR ADJUST MENU
TINT
BRIGHTNESS
COLOR
RESET COLOR
RETURN
TITLE MENU
SELECT LETTER
SPACE
BACK SPACE
NEWLINE
FORM FEED
ERASE TITLE
MORE
DONE
TITLE MORE MENU
ACTIVE ENTRY
ACTIVE MKR MAGNITUDE
LIMIT TEST RESULT
LOOP COUNTER
END OF LABEL
RETURN
* APPEARS ONLY WHEN COLORS HAVE BEEN SAVED
ph615c

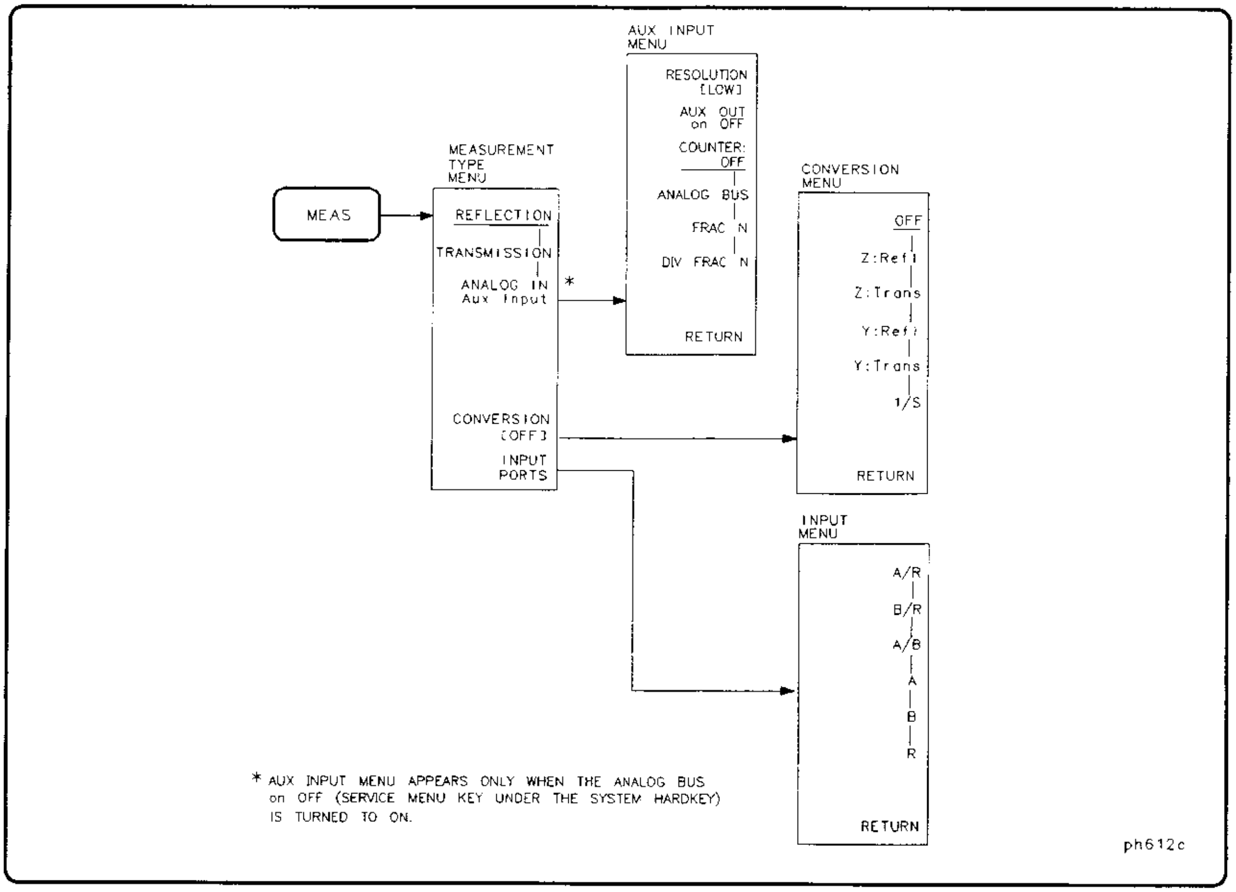

FORMAT
FORMAT MENU
LOG MAG
PHASE
DELAY
SMITH CHART
POLAR
LIN MAG
SWR
MORE
FORMAT MORE MENU
REAL
IMAGINARY
RETURN
ph613c

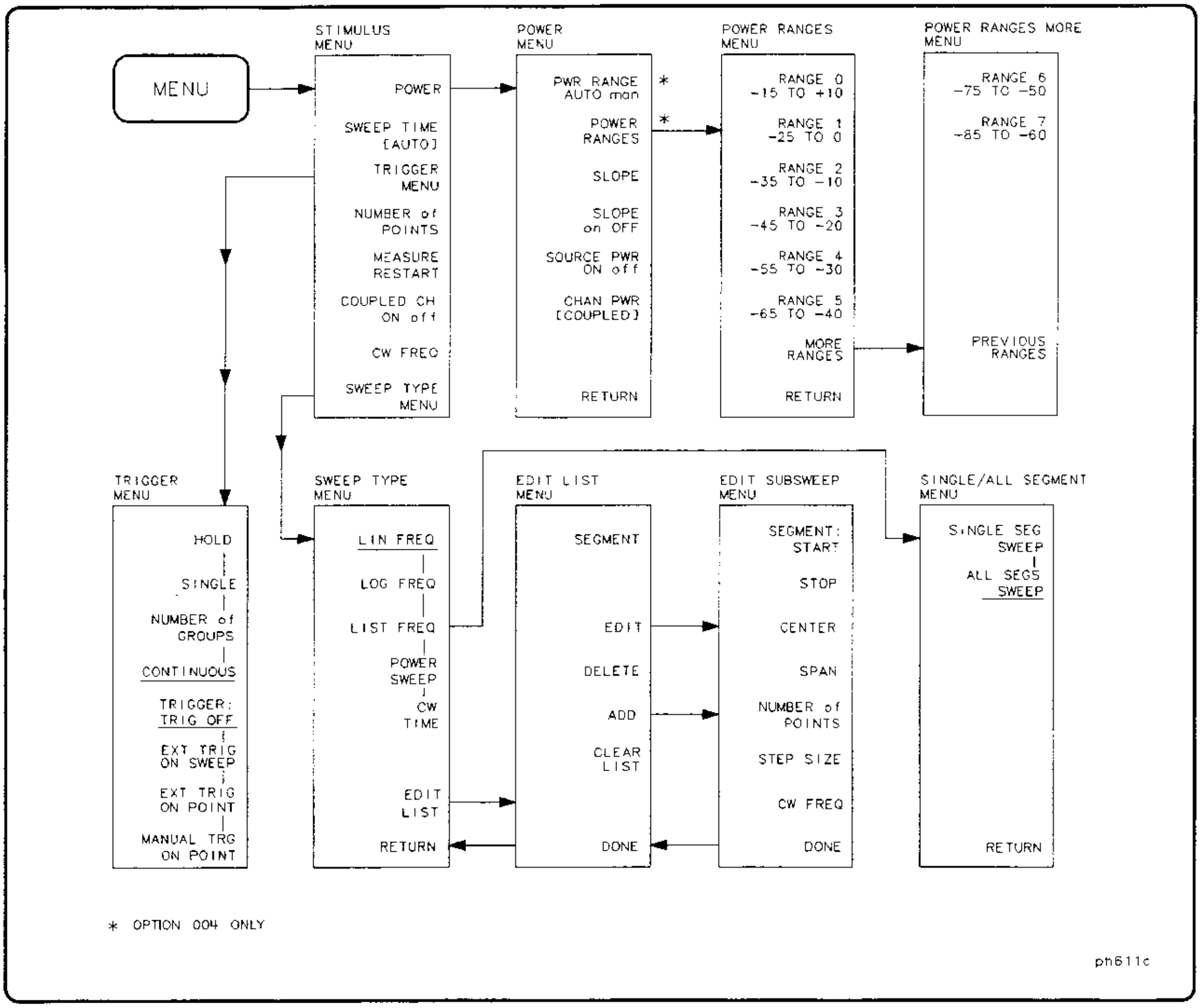


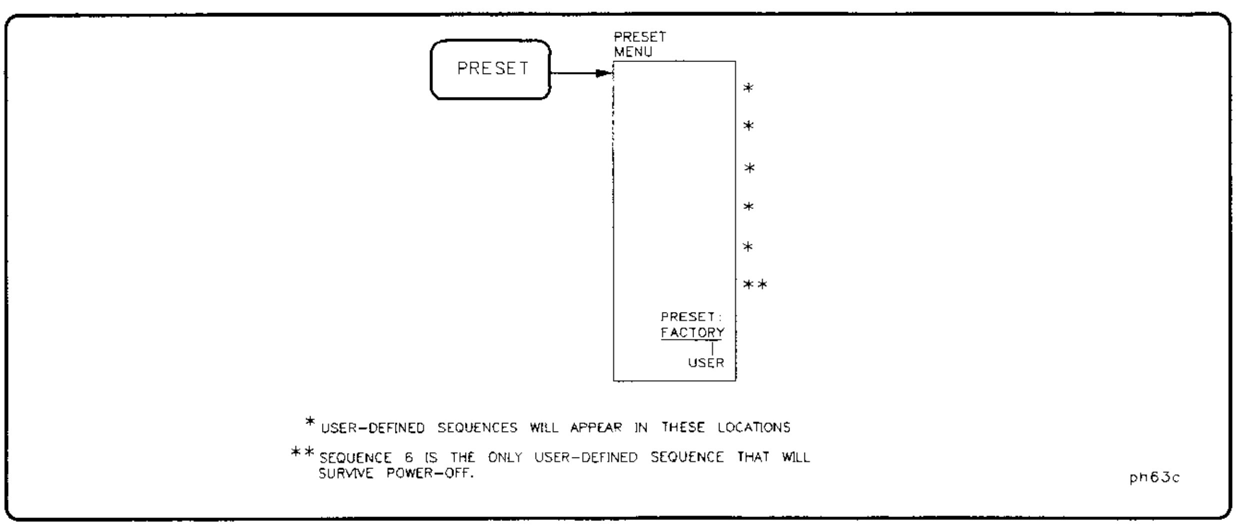
LOCAL
HP-IB MENU
SYSTEM CONTROLLER
TALKER/ LISTENER
USE PASS CONTROL
SET ADDRESSES
HP-IB DIAG on OFF
DISK UNIT NUMBER
VOLUME NUMBER
ADDRESS MENU
ADDRESS: 8752
PLOTTER PORT
PRINTER PORT
ADDRESS: DISK
ADDRESS: CONTROLLER
ADDRESS: P MTR/HPIB
POWER MTR: [ ]
RETURN
PLOTTER PORT MENU
PLTR TYPE [ ]
PLTR PORT HPIB
DISK
RETURN
PRINTER PORT MENU
PRNTR TYPE [ ]
PRINTER ADDRESS
RETURN
ph610c

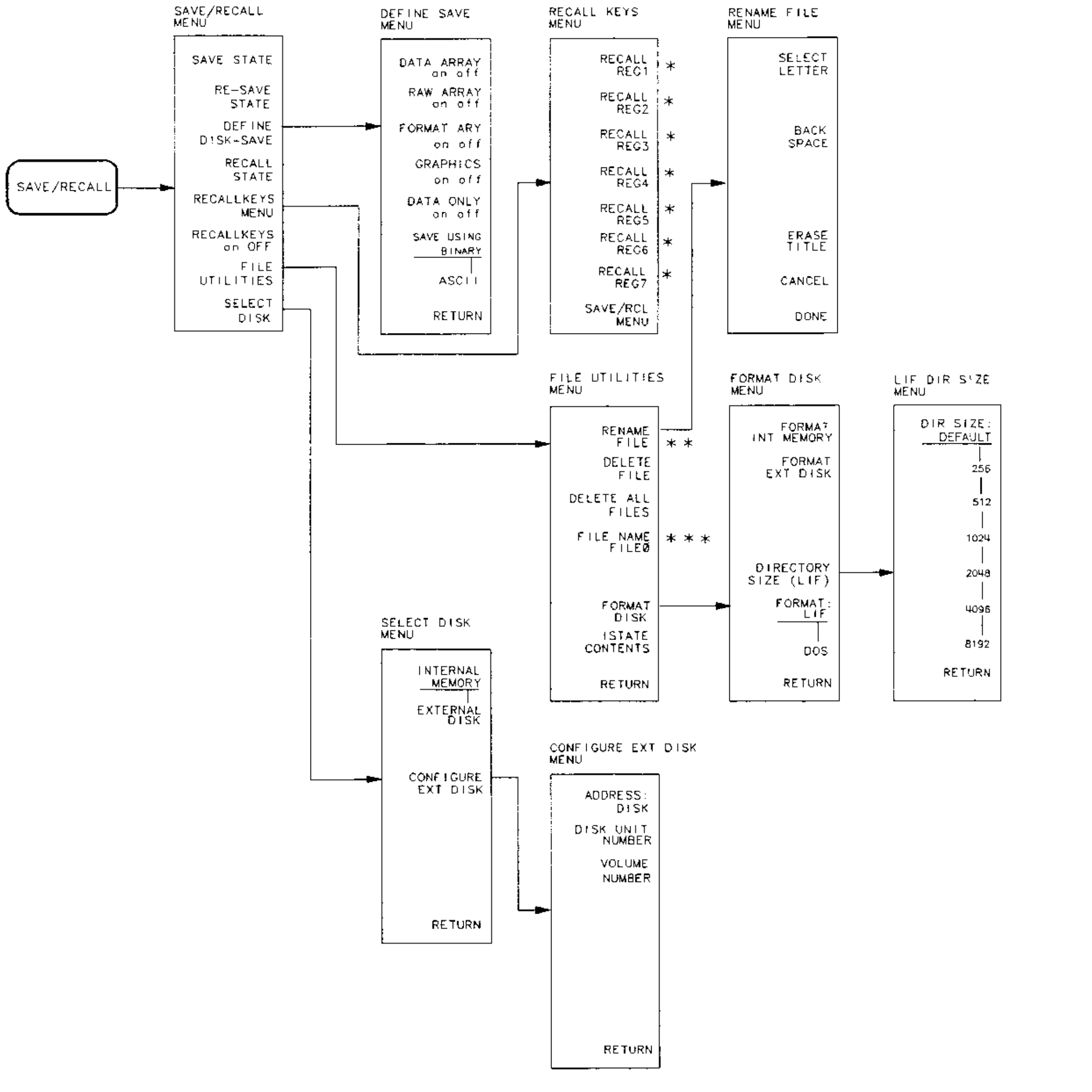

MKR
MARKER MENU
MARKER 1 2 3 4 all OFF
Δ MODE MENU
MKR ZERO
MARKER MODE MENU
MARKER MODE MENU
MARKERS: DISCRETE CONTINUOUS
DISP MKRS ON off
MARKERS: COUPLED UNCOUPLED
POLAR MKR MENU
SMITH MKR MENU
RETURN
POLAR MARKER MENU
LIN MKR
LOG MKR
Re/Im MKR
RETURN
SMITH MARKER MENU
LIN MKR
LOG MKR
Re/Im MKR
R+jX MKR
G+jB MKR
RETURN
DELTA MARKER MENU
ΔREF=1
ΔREF=2
ΔREF=3
ΔREF=4
ΔREF=Δ FIXED MKR
ΔMODE OFF
FIXED MKR POSITION
RETURN
MARKER OFFSET MENU
FIXED MKR STIMULUS
FIXED MKR VALUE
FIXED MKR AUX VALUE
RETURN
ph68c


MKR FCTN
MARKER FUNCTION MENU
MARKER→ START
MARKER→ STOP
MARKER→ CENTER
MARKER→ SPAN
MARKER→ REFERENCE
MARKER→ DELAY
MKR SEARCH [OFF]
STATS on OFF
MARKER SEARCH MENU
SEARCH: OFF
MAX
MIN
TARGET
WIDTH VALUE
WIDTHS on OFF
TRACKING on OFF
RETURN
TARGET MENU
TARGET
SEARCH LEFT
SEARCH RIGHT
RETURN
ph69c


AUX INPUT MENU
RESOLUTION [LOW]
AUX OUT on OFF
COUNTER: OFF
ANALOG BUS
FRAC N
DIV FRAC N
RETURN
MEASUREMENT TYPE MENU
MEAS
REFLECTION
TRANSMISSION
ANALOG IN Aux Input
CONVERSION [OFF]
INPUT PORTS
CONVERSION MENU
OFF
Z:Refl
Z:Trans
Y:Refl
Y:Trans
1/S
RETURN
INPUT MENU
A/R
B/R
A/B
A
B
R
RETURN
* AUX INPUT MENU APPEARS ONLY WHEN THE ANALOG BUS on OFF (SERVICE MENU KEY UNDER THE SYSTEM HARDKEY) IS TURNED TO ON.
ph612c


MENU
STIMULUS MENU
POWER
SWEEP TIME [AUTO]
TRIGGER MENU
NUMBER of POINTS
MEASURE RESTART
COUPLED CH ON off
CW FREQ
SWEEP TYPE MENU
POWER MENU
PWR RANGE AUTO man *
POWER RANGES *
SLOPE
SLOPE on OFF
SOURCE PWR ON off
CHAN PWR [COUPLED]
RETURN
POWER RANGES MENU
RANGE 0 -15 TO +10
RANGE 1 -25 TO 0
RANGE 2 -35 TO -10
RANGE 3 -45 TO -20
RANGE 4 -55 TO -30
RANGE 5 -65 TO -40
MORE RANGES
RETURN
POWER RANGES MORE MENU
RANGE 6 -75 TO -50
RANGE 7 -85 TO -60
PREVIOUS RANGES
TRIGGER MENU
HOLD
SINGLE
NUMBER of GROUPS
CONTINUOUS
TRIGGER: TRIG OFF
EXT TRIG ON SWEEP
EXT TRIG ON POINT
MANUAL TRG ON POINT
SWEEP TYPE MENU
LIN FREQ
LOG FREQ
LIST FREQ
POWER SWEEP
CW TIME
EDIT LIST
RETURN
EDIT LIST MENU
SEGMENT
EDIT
DELETE
ADD
CLEAR LIST
DONE
EDIT SUBSWEEP MENU
SEGMENT: START
STOP
CENTER
SPAN
NUMBER of POINTS
STEP SIZE
CW FREQ
DONE
SINGLE/ALL SEGMENT MENU
SINGLE SEG SWEEP
ALL SEGS SWEEP
RETURN
* OPTION 004 ONLY
ph611c


PRESET
PRESET MENU
*
*
*
*
*
**
PRESET: FACTORY
USER
* USER-DEFINED SEQUENCES WILL APPEAR IN THESE LOCATIONS
** SEQUENCE 6 IS THE ONLY USER-DEFINED SEQUENCE THAT WILL SURVIVE POWER-OFF.
ph63c

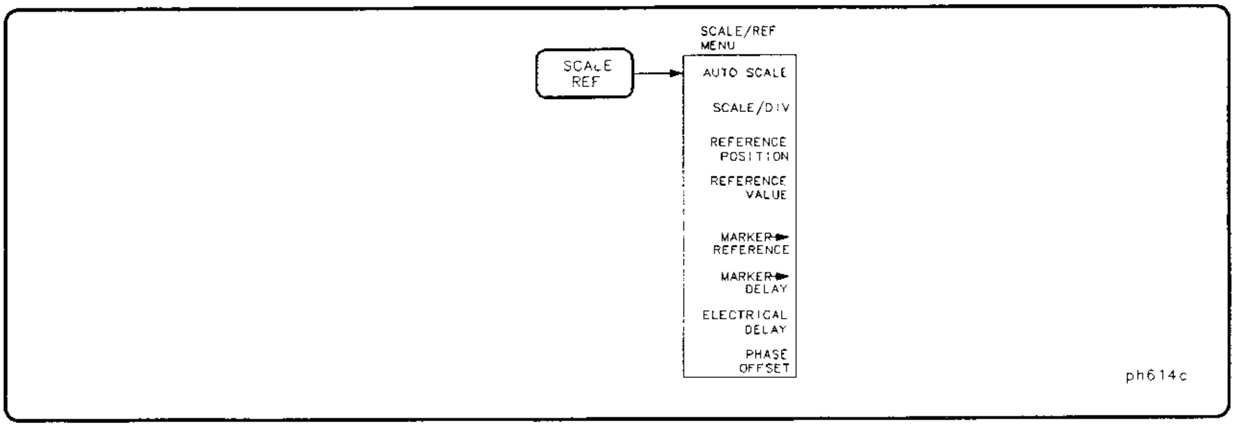


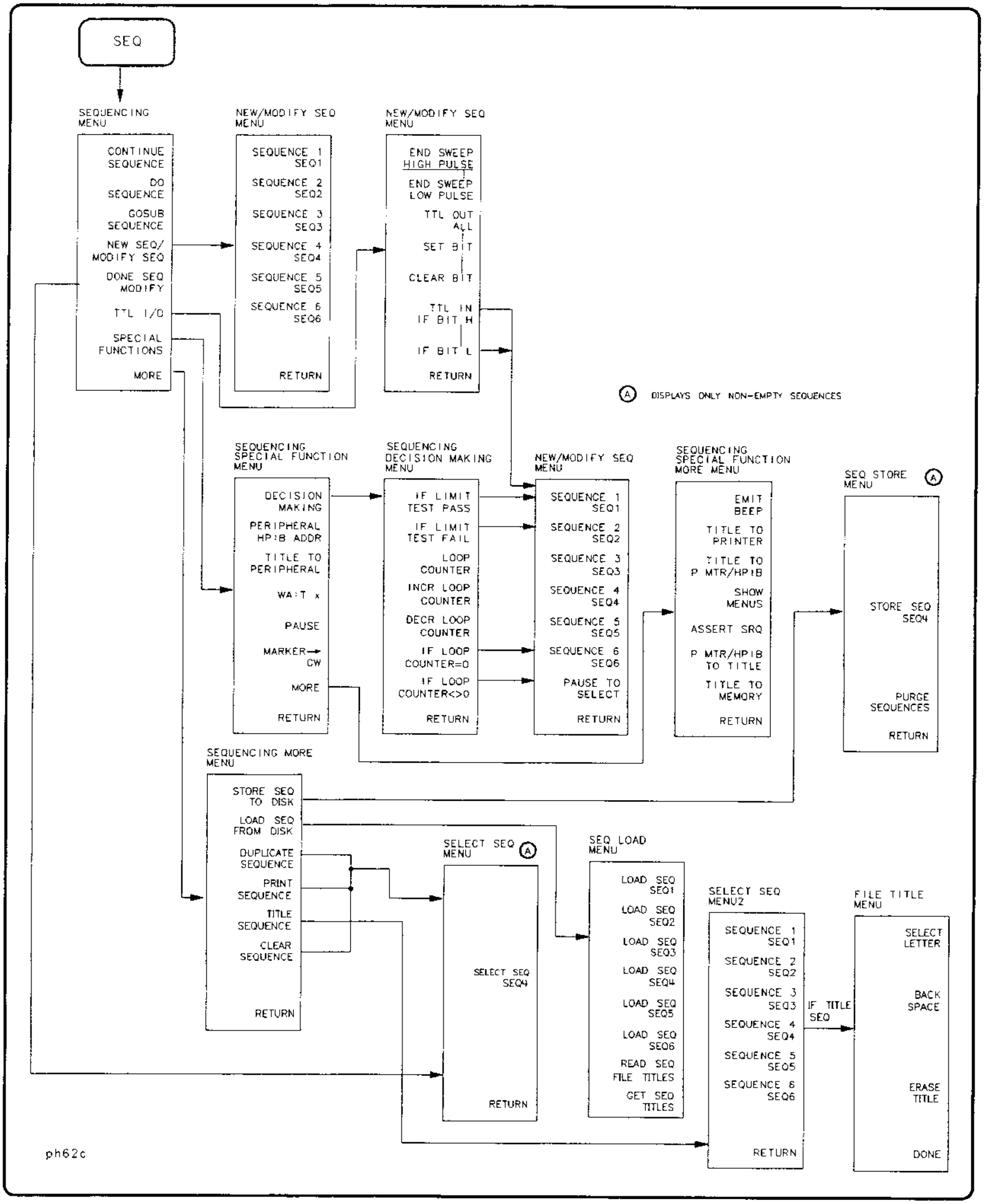
* THESE LABELS ONLY APPEAR IF THE PARTICULAR REGISTER HAS BEEN SAVED IN INTERNAL MEMORY.

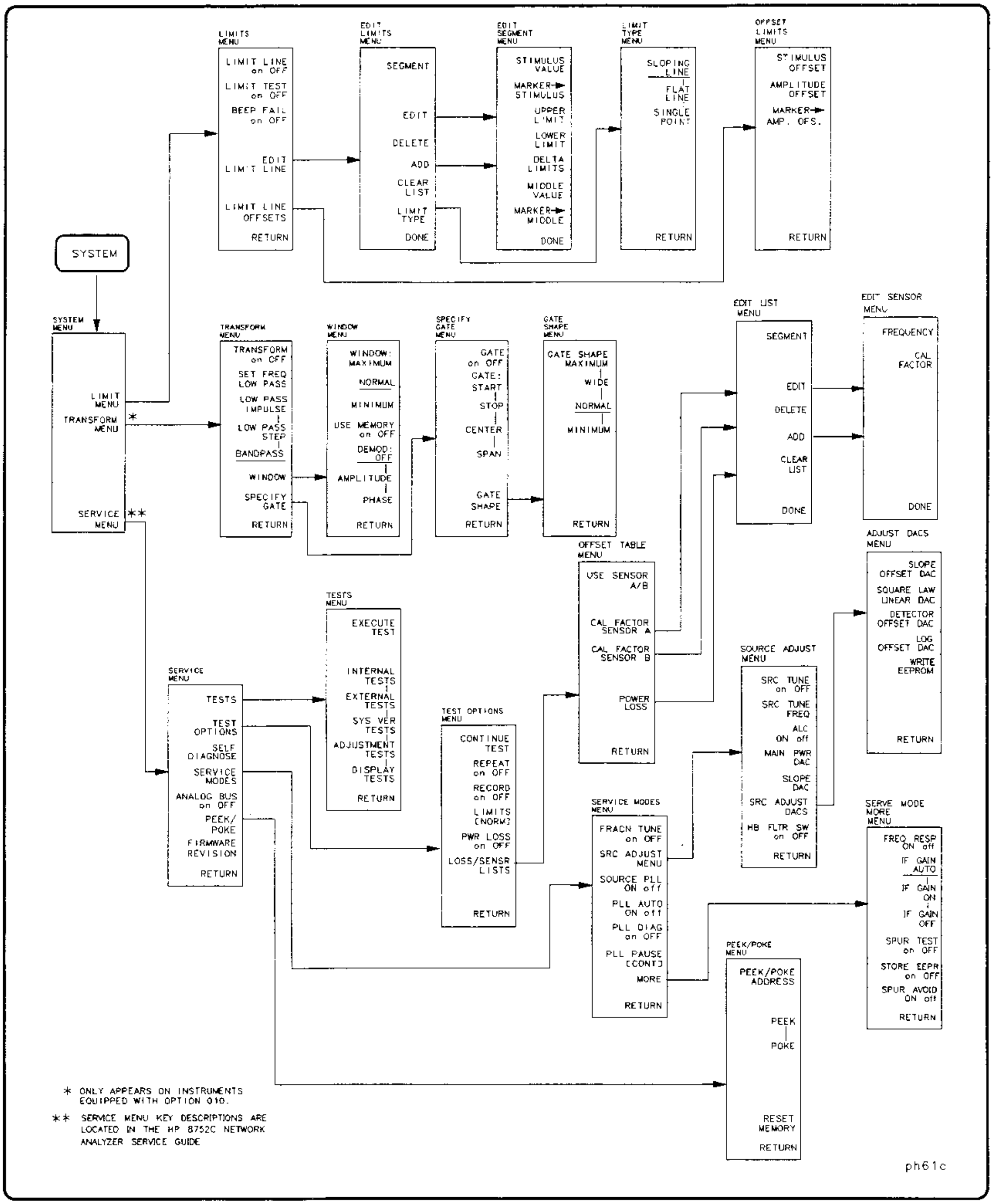
** DOES NOT APPEAR DURING SEQUENCE MODIFICATION.

*** ONLY APPEARS DURING SEQUENCE MODIFICATION WHEN EXTERNAL DISK IS SELECTED.

ph64c


SCALE/REF MENU
SCALE REF
AUTO SCALE
SCALE/DIV
REFERENCE POSITION
REFERENCE VALUE
MARKER→ REFERENCE
MARKER→ DELAY
ELECTRICAL DELAY
PHASE OFFSET
ph614c


SEQ
SEQUENCING MENU
CONTINUE SEQUENCE
DO SEQUENCE
GOSUB SEQUENCE
NEW SEQ/ MODIFY SEQ
DONE SEQ MODIFY
TTL I/O
SPECIAL FUNCTIONS
MORE
NEW/MODIFY SEQ MENU
SEQUENCE 1 SEQ1
SEQUENCE 2 SEQ2
SEQUENCE 3 SEQ3
SEQUENCE 4 SEQ4
SEQUENCE 5 SEQ5
SEQUENCE 6 SEQ6
RETURN
NEW/MODIFY SEQ MENU
END SWEEP HIGH PULSE
END SWEEP LOW PULSE
TTL OUT ALL
SET BIT
CLEAR BIT
TTL IN IF BIT H
IF BIT L
RETURN
A DISPLAYS ONLY NON-EMPTY SEQUENCES
SEQUENCING SPECIAL FUNCTION MENU
DECISION MAKING
PERIPHERAL HP-IB ADDR
TITLE TO PERIPHERAL
WAIT x
PAUSE
MARKER→ CW
MORE
RETURN
SEQUENCING DECISION MAKING MENU
IF LIMIT TEST PASS
IF LIMIT TEST FAIL
LOOP COUNTER
INCR LOOP COUNTER
DECR LOOP COUNTER
IF LOOP COUNTER=0
IF LOOP COUNTER<>0
RETURN
NEW/MODIFY SEQ MENU
SEQUENCE 1 SEQ1
SEQUENCE 2 SEQ2
SEQUENCE 3 SEQ3
SEQUENCE 4 SEQ4
SEQUENCE 5 SEQ5
SEQUENCE 6 SEQ6
PAUSE TO SELECT
RETURN
SEQUENCING SPECIAL FUNCTION MORE MENU
EMIT BEEP
TITLE TO PRINTER
TITLE TO P MTR/HPIB
SHOW MENUS
ASSERT SRQ
P MTR/HPIB TO TITLE
TITLE TO MEMORY
RETURN
SEQ STORE MENU A
STORE SEQ SEQ4
PURGE SEQUENCES
RETURN
SEQUENCING MORE MENU
STORE SEQ TO DISK
LOAD SEQ FROM DISK
DUPLICATE SEQUENCE
PRINT SEQUENCE
TITLE SEQUENCE
CLEAR SEQUENCE
RETURN
SELECT SEQ MENU A
SELECT SEQ SEQ4
RETURN
SEQ LOAD MENU
LOAD SEQ SEQ1
LOAD SEQ SEQ2
LOAD SEQ SEQ3
LOAD SEQ SEQ4
LOAD SEQ SEQ5
LOAD SEQ SEQ6
READ SEQ FILE TITLES
GET SEQ TITLES
SELECT SEQ MENU2
SEQUENCE 1 SEQ1
SEQUENCE 2 SEQ2
SEQUENCE 3 SEQ3
SEQUENCE 4 SEQ4
SEQUENCE 5 SEQ5
SEQUENCE 6 SEQ6
RETURN
IF TITLE SEQ
FILE TITLE MENU
SELECT LETTER
BACK SPACE
ERASE TITLE
DONE
ph62c


SYSTEM
SYSTEM MENU
LIMIT MENU
TRANSFORM MENU *
SERVICE MENU **
LIMITS MENU
LIMIT LINE on OFF
LIMIT TEST on OFF
BEEP FAIL on OFF
EDIT LIMIT LINE
LIMIT LINE OFFSETS
RETURN
EDIT LIMITS MENU
SEGMENT
EDIT
DELETE
ADD
CLEAR LIST
LIMIT TYPE
DONE
EDIT SEGMENT MENU
STIMULUS VALUE
MARKER→ STIMULUS
UPPER LIMIT
LOWER LIMIT
DELTA LIMITS
MIDDLE VALUE
MARKER→ MIDDLE
DONE
LIMIT TYPE MENU
SLOPING LINE
FLAT LINE
SINGLE POINT
RETURN
OFFSET LIMITS MENU
STIMULUS OFFSET
AMPLITUDE OFFSET
MARKER→ AMP. OFS.
RETURN
TRANSFORM MENU
TRANSFORM on OFF
SET FREQ LOW PASS
LOW PASS IMPULSE
LOW PASS STEP
BANDPASS
WINDOW
SPECIFY GATE
RETURN
WINDOW MENU
WINDOW: MAXIMUM
NORMAL
MINIMUM
USE MEMORY on OFF
DEMOD: OFF
AMPLITUDE
PHASE
RETURN
SPECIFY GATE MENU
GATE on OFF
GATE: START
STOP
CENTER
SPAN
GATE SHAPE
RETURN
GATE SHAPE MENU
GATE SHAPE MAXIMUM
WIDE
NORMAL
MINIMUM
RETURN
EDIT LIST MENU
SEGMENT
EDIT
DELETE
ADD
CLEAR LIST
DONE
EDIT SENSOR MENU
FREQUENCY
CAL FACTOR
DONE
OFFSET TABLE MENU
USE SENSOR A/B
CAL FACTOR SENSOR A
CAL FACTOR SENSOR B
POWER LOSS
RETURN
ADJUST DACS MENU
SLOPE OFFSET DAC
SQUARE LAW LINEAR DAC
DETECTOR OFFSET DAC
LOG OFFSET DAC
WRITE EEPROM
RETURN
TESTS MENU
EXECUTE TEST
INTERNAL TESTS
EXTERNAL TESTS
SYS VER TESTS
ADJUSTMENT TESTS
DISPLAY TESTS
RETURN
SERVICE MENU
TESTS
TEST OPTIONS
SELF DIAGNOSE
SERVICE MODES
ANALOG BUS on OFF
PEEK/ POKE
FIRMWARE REVISION
RETURN
TEST OPTIONS MENU
CONTINUE TEST
REPEAT on OFF
RECORD on OFF
LIMITS [NORM]
PWR LOSS on OFF
LOSS/SENSR LISTS
RETURN
SOURCE ADJUST MENU
SRC TUNE on OFF
SRC TUNE FREQ
ALC ON off
MAIN PWR DAC
SLOPE DAC
SRC ADJUST DACS
HB FLTR SW on OFF
RETURN
SERVICE MODES MENU
FRACN TUNE on OFF
SRC ADJUST MENU
SOURCE PLL ON off
PLL AUTO ON off
PLL DIAG on OFF
PLL PAUSE [CONT]
MORE
RETURN
SERVE MODE MORE MENU
FREQ RESP ON off
IF GAIN AUTO
IF GAIN ON
IF GAIN OFF
SPUR TEST on OFF
STORE EEPR on OFF
SPUR AVOID ON off
RETURN
PEEK/POKE MENU
PEEK/POKE ADDRESS
PEEK
POKE
RESET MEMORY
RETURN
* ONLY APPEARS ON INSTRUMENTS EQUIPPED WITH OPTION 010.
** SERVICE MENU KEY DESCRIPTIONS ARE LOCATED IN THE HP 8752C NETWORK ANALYZER SERVICE GUIDE
ph61c

8

Key Definitions

This chapter contains information on the following topics:

- Softkey and front-panel functions in alphabetical order (includes a brief description of each function)
- Cross reference of programming commands to key functions
- Cross reference of softkeys to front-panel access keys

Note The SERVICE MENU keys are not included in this chapter. Service information can be found in the *HP 8752C Network Analyzer Service Guide.*

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, or Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 4, "Optimizing Measurement Results," describes techniques and functions for achieving the best measurement results.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.

Guide Terms and Conventions

The eight keys along the right side of the analyzer display are called softkeys. Their labels are shown on the display. The softkeys appear in shaded boxes in this chapter. For example, TRANSMISSION. The labeled keys that are on the front panel of the analyzer are called front-panel keys. The front-panel keys appear in unshaded boxes in this chapter. For example, (SYSTEM).

Analyzer Functions

This section contains an alphabetical listing of softkey and front-panel functions, and a brief description of each function.

(.) is used to add a decimal point to the number you are entering.

(-) is used to add a minus sign to the number you are entering.

(▲) is used to step up the current value of the active function. The analyzer defines the step for different functions. No units terminator is required. For editing a test sequence, this key can be used to scroll through the displayed sequence.

(▼) is used to step down the current value of the active function. The analyzer defines the step for different functions. No units terminator is required. For editing a test sequence, this key can be used to scroll through the displayed sequence.

(←) is used to delete the last entry, or the last digit entered from the numeric keypad. This key can also be used in two ways for modifying a test sequence:

- deleting a single-key command that you may have pressed by mistake, (for example A/R)
- deleting the last digit in a series of entered digits, as long as you haven't yet pressed a terminator, (for example if you pressed (START) (1) (2) but did not press (G/n), etc)

Δ MODE MENU goes to the delta marker menu, which is used to read the difference in values between the active marker and a reference marker.

Δ MODE OFF turns off the delta marker mode, so that the values displayed for the active marker are absolute values.

Δ REF = 1 establishes marker 1 as a reference. The active marker stimulus and response values are then shown relative to this delta reference. Once marker 1 has been selected as the delta reference, the softkey label Δ REF = 1 is underlined in this menu, and the marker menu is returned to the screen. In the marker menu, the first key is now labeled MARKER Δ REF = 1. The notation "ΔREF=1" appears at the top right corner of the graticule.

Δ REF = 2 makes marker 2 the delta reference. Active marker stimulus and response values are then shown relative to this reference.

Δ REF = 3	makes marker 3 the delta reference.
Δ REF = 4	makes marker 4 the delta reference.
Δ REF = Δ FIXED MKR	sets a user-specified fixed reference marker. The stimulus and response values of the reference can be set arbitrarily, and can be anywhere in the display area. Unlike markers 1 to 4, the fixed marker need not be on the trace. The fixed marker is indicated by a small triangle Δ, and the active marker stimulus and response values are shown relative to this point. The notation "ΔREF=Δ" is displayed at the top right corner of the graticule. Pressing this softkey turns on the fixed marker. Its stimulus and response values can then be changed using the fixed marker menu, which is accessed with the FIXED MKR POSITION softkey described below. Alternatively, the fixed marker can be set to the current active marker position, using the MKR ZERO softkey in the marker menu.
1/S	expresses the data in inverse S-parameter values, for use in amplifier and oscillator design.
A	measures the absolute power amplitude at input A.
A/B	calculates and displays the complex ratio of input A to input B.
A/R	calculates and displays the complex ratio of the signal at input A to the reference signal at input R.
ACTIVE ENTRY	puts the name of the active entry in the display title.
ACTIVE MRK MAGNITUDE	puts the active marker magnitude in the display title.
ADD	displays the edit segment menu and adds a new segment to the end of the list. The new segment is initially a duplicate of the segment indicated by the pointer > and selected with the SEGMENT softkey.
ADDRESS: 8752	sets the HP-IB address of the analyzer, using the entry controls. There is no physical address switch to set in the analyzer.
ADDRESS: CONTROLLER	sets the HP-IB address the analyzer will use to communicate with the external controller.
ADDRESS: DISK	sets the HP-IB address the analyzer will use to communicate with an external HP-IB disk drive.
ADDRESS: P MTR/HPIB	sets the HP-IB address the analyzer will use to communicate with the power meter used in service routines.
ADJUST DISPLAY	presents a menu for adjusting display intensity, colors, and accessing save and recall functions for modified CRT display color sets.
ALL SEGS SWEEP	retrieves the full frequency list sweep.
ALTERNATE RFL/TRN	measures only one input per frequency sweep, in order to reduce spurious signals.
AMPLITUDE OFFSET	adds or subtracts an offset in amplitude value. This allows limits already defined to be used for testing at a different

response level. For example, if attenuation is added to or removed from a test setup, the limits can be offset an equal amount. Use the entry block controls to specify the offset.

ANALOG IN Aux Input displays a dc or low frequency ac auxiliary voltage on the vertical axis, using the real format. An external signal source such as a detector or function generator can be connected to the rear panel AUXILIARY INPUT connector.

ASCII selects ASCII format for data storage to disk.

ASSERT SRQ is used from sequences being executed over HP-IB. For SRQ to be asserted, the correct bits in the status register and the event status register must be enabled. HP-IB code "SRE 32" enables SRQ on a change in the event status register. HP-IB code "ESE 8" enables SEQ RQ bit (3) in the event status register. After sending these HP-IB codes, pressing the ASSERT SRQ key will cause the SRQ line to be asserted.

AUTO FEED ON off turns the plotter auto feed function on or off when in the define plot menu. It turns the printer auto feed on or off when in the define print menu.

AUTO SCALE brings the trace data in view on the CRT with one keystroke. Stimulus values are not affected, only scale and reference values. The analyzer determines the smallest possible scale factor that will put all displayed data onto 80% of the vertical graticule. The reference value is chosen to put the trace in center screen, then rounded to an integer multiple of the scale factor.

AUX OUT on OFF allows you to monitor the analog bus nodes (except nodes 1,2,3,4,9,10,12) with external equipment. To do this, connect the equipment to the AUX INPUT BNC connector on the rear panel.

AVERAGING FACTOR makes averaging factor the active function. Any value up to 999 can be used. The algorithm used for averaging is:

$$A(n) = S(n)/F + (1 - 1/F) \times A(n-1)$$

where

A(n) = current average

S(n) = current measurement

F = average factor

AVERAGING on OFF turns the averaging function on or off for the active channel. "Avg" is displayed in the status notations area at the left of the CRT, together with the sweep count for the averaging factor, when averaging is on. The sweep count for averaging is reset to 1 whenever an instrument state change affecting the measured data is made.

At the start of the averaging or following AVERAGING RESTART, averaging starts at 1 and averages each new sweep into the trace until it reaches the specified averaging factor. The sweep count is displayed in the status notations area below "Avg" and updated every sweep as it increments. When the specified averaging factor is reached, the trace data continues to be updated, weighted by that averaging factor.

AVERAGING RESTART	averaging starts at 1 and averages each new sweep into the trace until it reaches the specified averaging factor. The sweep count is displayed in the status notations area below "Avg" and updated every sweep as it increments.
(AVG)	is used to access three different noise reduction techniques: sweep-to-sweep averaging, display smoothing, and variable IF bandwidth. Any or all of these can be used simultaneously. Averaging and smoothing can be set independently for each channel, and the IF bandwidth can be set independently if the stimulus is uncoupled.
B	measures the absolute power amplitude at input B.
B/R	calculates and displays the complex ratio of input B to input R.
BACK SPACE	deletes the last character entered.
BACKGROUND INTENSITY	sets the background intensity of the CRT as a percent of white. The factory-set default value is stored in non-volatile memory.
BANDPASS	(Option 010 only) sets the time-domain bandpass mode.
BEEP DONE ON off	toggles an annunciator which sounds to indicate completion of certain operations such as calibration or instrument state save.
BEEP FAIL on OFF	turns the limit fail beeper on or off. When limit testing is on and the fail beeper is on, a beep is sounded each time a limit test is performed and a failure detected. The limit fail beeper is independent of the warning beeper and the operation complete beeper.
BEEP WARN on OFF	toggles the warning annunciator. When the annunciator is on it sounds a warning when a cautionary message is displayed.
BRIGHTNESS	adjusts the brightness of the color being modified. See Adjusting Color for an explanation of using this softkey for color modification of CRT display attributes.
C0	is used to enter the C0 term in the definition of an OPEN standard in a calibration kit, which is the constant term of the cubic polynomial and is scaled by 10^{-15}.
C1	is used to enter the C1 term, expressed in F/Hz (Farads/Hz) and scaled by 10^{-27}.
C2	is used to enter the C2 term, expressed in F/Hz^2 and scaled by 10^{-36}.
C3	is used to enter the C3 term, expressed in F/Hz^3 and scaled by 10^{-45}.
(CAL)	key leads to a series of menus to perform measurement calibrations for vector error correction (accuracy enhancement), and for specifying the calibration standards used. The CAL key also leads to softkeys which activate interpolated error correction and power meter calibration.

CAL KIT	leads to the select cal kit menu, which is used to select one of the default calibration kits available for different connector types. This, in turn, leads to additional menus used to define calibration standards other than those in the default kits (refer to Modifying Calibration Kits.) When a calibration kit has been specified, its connector type is displayed in brackets in the softkey label.
CAL KIT [ ]	selects the cal kit menu.
CAL KIT: 3.5mmC	selects the HP 85033C cal kit.
CAL KIT: 3.5mmD	selects the HP 85033D cal kit.
CAL KIT: 7mm	selects the HP 85031B cal kit.
CAL KIT: N 50Ω	selects the HP 85032B/E cal kit.
CAL KIT: N 75Ω	selects the HP 85036B/E cal kit.
CAL KIT: USER KIT	selects a kit that can be defined and installed by the user.
CALIBRATE MENU	leads to the calibration menu, which provides several accuracy enhancement procedures ranging from a simple frequency response calibration to a full two-port calibration. At the completion of a calibration procedure, this menu is returned to the screen, correction is automatically turned on, and the notation Cor or C2 is displayed at the left of the screen.
CALIBRATE: NONE	is underlined if no calibration has been performed or if the calibration data has been cleared. Unless a calibration is saved in memory, the calibration data is lost on instrument preset, power on, instrument state recall, or if stimulus values are changed.
(CENTER)	is used, along with the (SPAN) key, to define the frequency range of the stimulus. When the (CENTER) key is pressed, its function becomes the active function. The value is displayed in the active entry area, and can be changed with the knob, step keys, or numeric keypad.
(CH 1)	allows you to select channel 1 as the active channel. The active channel is indicated by an amber LED adjacent to the corresponding channel key. The front panel keys allow you to control the active channel, and all of the channel-specific functions you select apply to the active channel.
CH1 DATA [ ]	brings up the printer color selection menu. The channel 1 data trace default color is magenta for color prints.
CH1 DATA LIMIT LN	selects channel 1 data trace and limit line for display color modification.
CH1 MEM [ ]	brings up the printer color selection menu. The channel 1 memory trace default color is green for color prints.
CH1 MEM	selects channel 1 memory trace for display color modification.
(CH 2)	allows you to select channel 2 as the active channel. The active channel is indicated by an amber LED adjacent to the corresponding channel key. The front panel keys allow you

to control the active channel, and all of the channel-specific functions you select apply to the active channel.

CH2 DATA [ ] — brings up the printer color selection menu. The channel 2 data trace default color is blue for color prints.

CH2 DATA LIMIT LN — selects channel 2 data trace and limit line for display color modification.

CH2 MEM [ ] — brings up the printer color selection menu. The channel 2 memory trace default color is red for color prints.

CH2 MEM REF LINE — selects channel 2 memory and the reference line for display color modification.

CHAN PWR [COUPLED] — is used to apply the same power levels to each channel.

CHAN PWR [UNCOUPLED] — is used to apply different power levels to each channel.

CHOP RFL/TRN — measures RFL and TRN inputs simultaneously for faster measurements.

CLEAR BIT — must be entered through the keypad number keys, followed by the (x1) key. The bit is cleared when the (x1) key is pressed. Entering numbers larger than 3 will result in bit 3 being cleared, and entering numbers lower than 0 will result in bit 0 being cleared.

CLEAR LIST — deletes all segments in the list.

CLEAR SEQUENCE — clears a sequence from memory. The titles of cleared sequences will remain in load, store, and purge menus. This is done as a convenience for those who often reuse the same titles.

COAX — defines the standard (and the offset) as coaxial. This causes the analyzer to assume linear phase response in any offsets.

COLOR — adjusts the degree of whiteness of the color being modified. See Adjusting Color for an explanation of using this softkey for color modification of CRT display attributes.

CONFIGURE EXT DISK — brings up a menu for configuring the external disk HP-IB address and the disk volume and unit numbers.

CONTINUE SEQUENCE — resumes a paused sequence.

CONTINUOUS — located under the (MENU) key, is the standard sweep mode of the analyzer, in which the sweep is triggered automatically and continuously and the trace is updated with each sweep.

CONVERSION [ ] — brings up the conversion menu which converts the measured data to impedance (Z) or admittance (Y). When a conversion parameter has been defined, it is shown in brackets under the softkey label. If no conversion has been defined, the softkey label reads CONVERSION OFF.

(COPY) — provides access to the menus used for controlling external plotters and printers and defining the plot parameters.

CORRECTION on OFF — turns error correction on or off. The analyzer uses the most recent calibration data for the displayed parameter. If the stimulus state has been changed since calibration, the original state is recalled, and the message "SOURCE PARAMETERS CHANGED" is displayed.

COUNTER: ANALOG BUS — switches the counter to count the analog bus.

COUNTER: DIV FRAC N — switches the counter to count the A14 fractional-N VCO frequency after it has been divided down to 100 kHz for phase-locking the VCO.

COUNTER: FRAC N — switches the counter to count the A14 fractional-N VCO frequency at the node shown on the overall block diagram.

COUNTER: OFF — switches the internal counter off and removes the counter display from the CRT.

COUPLED CH on OFF — toggles the channel coupling of stimulus values. With COUPLED CH ON (the preset condition), both channels have the same stimulus values (the inactive channel takes on the stimulus values of the active channel).

CW FREQ — is used to set the frequency for power sweep and CW time sweep modes. If the instrument is not in either of these two modes, it is automatically switched into CW time mode.

CW TIME — turns on a sweep mode similar to an oscilloscope. The analyzer is set to a single frequency, and the data is displayed versus time. The frequency of the CW time sweep is set with [CW FREQ] in the stimulus menu.

D2/D1 to D2 on OFF — this math function ratios channels 1 and 2, and puts the results in the channel 2 data array. Both channels must be on and have the same number of points.

DATA and MEMORY — displays both the current data and memory traces.

DATA ARRAY on OFF — specifies whether or not to store the error-corrected data on disk with the instrument state.

DATA/MEM — divides the data by the memory, normalizing the data to the memory, and displays the result. This is useful for ratio comparison of two traces, for instance in measurements of gain or attenuation.

DATA - MEM — subtracts the memory from the data. The vector subtraction is performed on the complex data. This is appropriate for storing a measured vector error, for example directivity, and later subtracting it from the device measurement.

DATA -> MEMORY — stores the current active measurement data in the memory of the active channel. It then becomes the memory trace, for use in subsequent math manipulations or display. If a parameter has just been changed and the * status notation is displayed at the left of the CRT, the data is not stored in memory until a clean sweep has been executed. The gating and smoothing status of the trace are stored with the measurement data.

DATA ONLY on OFF — stores only the measurement data of the device under test to a disk file. The instrument state and calibration are not stored. This is faster than storing with the instrument state, and uses less disk space. It is intended for use in archiving data that will later be used with an external controller, and cannot be read back by the analyzer.

DECISION MAKING — presents the sequencing decision making menu.

DECR LOOP COUNTER — decrements the value of the sequencing loop counter by 1.

DEFAULT COLORS — returns all the display color settings back to the factory-set default values that are stored in non-volatile memory.

DEFAULT PLOT SETUP — resets the plotting parameters to their default values.

DEFAULT PRNT SETUP — resets the printing parameters to their default values.

DEFINE DISK-SAVE — leads to the define save menu. Use this menu to specify the data to be stored on disk in addition to the instrument state.

DEFINE PLOT — leads to a sequence of three menus. The first defines which elements are to be plotted and the auto feed state. The second defines which pen number is to be used with each of the elements (these are channel dependent.) The third defines the line types (these are channel dependent), plot scale, and plot speed.

DEFINE PRINT — leads to the define print menu. This menu defines the printer mode (monochrome or color) and the auto-feed state.

DEFINE STANDARD — makes the standard number the active function, and brings up the define standard menus. The standard number (1 to 8) is an arbitrary reference number used to reference standards while specifying a class.

DELAY — selects the group delay format, with marker values given in seconds.

DELETE — Deletes the segment indicated by the pointer.

DELETE ALL FILES — purges all files from the disk.

DELETE FILE — purges a selected file from the disk.

DELTA LIMITS — sets the limits an equal amount above and below a specified middle value, instead of setting upper and lower limits separately. This is used in conjunction with MIDDLE VALUE or MARKER -> MIDDLE, to set limits for testing a device that is specified at a particular value plus or minus an equal tolerance.

For example, a device may be specified at 0 dB ±3 dB. Enter the delta limits as 3 dB and the middle value as 0 dB.

DEMOD: AMPLITUDE — (Option 010 only) amplitude demodulation for CW TIME transform measurements.

DEMOD: OFF — (Option 010 only) turns time domain demodulation off.

DEMOD: PHASE — (Option 010 only) phase demodulation for CW time transform measurements.

DIRECTORY SIZE — lets you specify the number of directory files to be initialized on a disk. This is particularly useful with a hard disk, where you may want a directory larger than the default 256 files, or with a floppy disk you may want to reduce the directory to allow extra space for data files. The number of directory files must be a multiple of 8. The minimum number is 8, and there is no practical maximum limit. Set the directory size before initializing a disk.

DISK UNIT NUMBER — specifies the number of the disk unit in the disk drive that is to be accessed in an external disk store or load routine. This is used in conjunction with the HP-IB address of the disk drive, and the volume number, to gain access to a specific area on a disk. The access hierarchy is HP-IB address, disk unit number, disk volume number.

DISP MKRS ON off — displays response and stimulus values for all markers that are turned on. Available only if no marker functions are on.

(DISPLAY) — provides access to a series of menus for instrument and active channel display functions. The first menu defines the displayed active channel trace in terms of the mathematical relationship between data and trace memory. Other functions include dual channel display (overlaid or split), display intensity, color selection, active channel display title, and frequency blanking.

DISPLAY: DATA — displays the current measurement data for the active channel.

DISPLAY TESTS — leads to a series of service tests for the display.

DO SEQUENCE — has two functions:

- It shows the current sequences in memory. To run a sequence, press the softkey next to the desired sequence title.
- When entered into a sequence, this command performs a one-way jump to the sequence residing in the specified sequence position (SEQUENCE 1 through 6). DO SEQUENCE jumps to a softkey position, not to a specific sequence title. Whatever sequence is in the selected softkey position will run when the DO SEQUENCE command is executed. This command prompts the operator to select a destination sequence position.

DONE 1-PORT CAL — finishes one-port calibration (after all standards are measured) and turns error correction on.

DONE: OPENS — finishes the opens class during a calibration. This key only appears when there is more than one open to choose from.

DONE: RESPONSE — finishes response calibration (after all standards are measured) and turns error correction on.

DONE: SHORTS — finishes the shorts class during a calibration. This key only appears when there is more than one short to choose from.

DONE RESP ISOL'N CAL — finishes response and isolation calibration (after all standards are measured) and turns error correction on.

DONE SEQ MODIFY — terminates the sequencing edit mode.

DUAL CHAN on OFF — toggles between display of both measurement channels or the active channel only. This is used in conjunction with SPLIT DISP ON off in the display more menu to display both

	channels. With SPLIT DISP OFF the two traces are overlaid on a single graticule.
DUPLICATE SEQUENCE	duplicates a sequence currently in memory into a different softkey position. Follow the prompts on the analyzer screen. This command does not affect the original sequence.
EDIT LIMIT LINE	displays a table of limit segments on the CRT, superimposed on the trace. The edit limits menu is presented so that limits can be defined or changed. It is not necessary for limit lines or limit testing to be on while limits are defined.
EDIT LIST	presents the edit list menu. This is used in conjunction with the edit subsweep menu to define or modify the frequency sweep list. The list frequency sweep mode is selected with the LIST FREQ softkey described below.
ELECTRICAL DELAY	adjusts the electrical delay to balance the phase of the DUT. It simulates a variable length lossless transmission line, which can be added to or removed from a receiver input to compensate for interconnecting cables, etc. This function is similar to the mechanical or analog "line stretchers" of other network analyzers. Delay is annotated in units of time with secondary labeling in distance for the current velocity factor.
EMIT BEEP	causes the instrument to beep once.
END OF LABEL	terminates the HP-GL "LB" command.
END SWEEP HIGH PULSE	sets the TTL output on the test set interconnect to normally high with a 10 μs pulse high at the end of each sweep.
END SWEEP LOW PULSE	sets the TTL output on the test set interconnect to normally low with a 10 μs pulse low at the end of each sweep.
ERASE TITLE	deletes the entire title.
EXECUTE TEST	runs the selected service test.
EXT TRIG ON POINT	is similar to the trigger on sweep, but triggers each data point in a sweep.
EXT TRIG ON SWEEP	is used when the sweep is triggered on an externally generated signal connected to the rear panel EXT TRIGGER input. External trigger mode is allowed in every sweep mode.
EXTENSION INPUT A	Use this feature to add electrical delay (in seconds) to extend the reference plane at input A to the end of the cable. This is used for any input measurements including S-parameters.
EXTENSION INPUT B	adds electrical delay to the input B reference plane for any B input measurements including S-parameters.
EXTENSION REFL PORT	extends the reflection port reference plane.
EXTENSION TRANS PORT	extends the transmission port reference plane.
EXTENSIONS on OFF	toggles the reference plane extension mode. When this function is on, all extensions defined below are enabled; when off, none of the extensions are enabled.
EXTERNAL DISK	selects an (optional) external disk drive for SAVE/RECALL.

EXTERNAL TESTS leads to a series of service tests.

FILE NAME FILEO appears during sequence modification, when external disk is selected. FILEO is the default name. A new name can be entered when you save the state to disk.

FIXED defines the load in a calibration kit as a fixed (not sliding) load.

FIXED MKR AUX VALUE is used only with a polar or Smith format. It changes the auxiliary response value of the fixed marker. This is the second part of a complex data pair, and applies to a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker. Fixed marker auxiliary response values are always uncoupled in the two channels.

To read absolute active marker auxiliary values following a MKR ZERO operation, the auxiliary value can be reset to zero.

FIXED MKR POSITION leads to the fixed marker menu, where the stimulus and response values for a fixed reference marker can be set arbitrarily.

FIXED MKR STIMULUS changes the stimulus value of the fixed marker. Fixed marker stimulus values can be different for the two channels if the channel markers are uncoupled using the marker mode menu. To read absolute active marker stimulus values following a MKR ZERO operation, the stimulus value can be reset to zero.

FIXED MKR VALUE changes the response value of the fixed marker. In a Cartesian format this is the y-axis value. In a polar or Smith chart format with a magnitude/phase marker, a real/imaginary marker, an R+jX marker, or a G+jB marker, this applies to the first part of the complex data pair. Fixed marker response values are always uncoupled in the two channels.

To read absolute active marker response values following a MKR ZERO operation, the response value can be reset to zero.

FLAT LINE defines a flat limit line segment whose value is constant with frequency or other stimulus value. This line is continuous to the next stimulus value, but is not joined to a segment with a different limit value. If a flat line segment is the final segment it terminates at the stop stimulus. A flat line segment is indicated as FL on the table of limits.

FORM FEED puts a form feed command into the display title.

FORMAT presents a menu used to select the display format for the data. Various rectangular and polar formats are available for display of magnitude, phase, impedance, group delay, real data, and SWR.

FORMAT ARY on OFF specifies whether or not to store the formatted data on disk with the instrument state.

FORMAT DISK brings up a menu for formatting a disk.

FORMAT: DOS causes subsequent disk initialization to use the DOS disk format.

FORMAT: LIF	causes subsequent disk initialization to use the LIF disk format. FORMAT: LIF is the default setting.
FORMAT EXT DISK	initializes media in external drive, and formats the disk using the selected (DOS or LIF) format.
FORMAT INT MEMORY	clears all internal save registers and associated cal data and memory traces.
FREQUENCY BLANK	blanks the displayed frequency notation for security purposes. Frequency labels cannot be restored except by instrument preset or turning the power off and then on.
FULL PAGE	draws a full-size plot according to the scale defined with SCALE PLOT in the define plot menu.
FWD MATCH (Label Class)	is not used in the HP 8752C.
FWD MATCH (Specify Class)	is not used in the HP 8752C.
FWD TRANS (Label Class)	lets you enter a label for the forward transmission class. The label appears during a calibration that uses this class.
FWD TRANS (Specify Class)	specifies which standards are in the forward transmission class in the calibration kit.
G+jB MKR	displays the complex admittance values of the active marker in rectangular form. The active marker values are displayed in terms of conductance (in Siemens), susceptance, and equivalent capacitance or inductance. Siemens are the international units of admittance, and are equivalent to mhos (the inverse of ohms). The Smith chart graticule is changed to admittance form.
[G/n]	giga/nano (10^9 / 10^{-9})
GATE on OFF	(Option 010 only) turns gating on or off in time domain mode.
GATE: CENTER	(Option 010 only) allows you to specify the time at the center of the gate.
GATE: SPAN	(Option 010 only) allows you to specify the gate periods.
GATE: START	(Option 010 only) allows you to specify the starting time of the gate.
GATE: STOP	(Option 010 only)allows you to specify the stopping time of the gate.
GATE SHAPE	(Option 010 only)brings up the gate shape menu.
GATE SHAPE MAXIMUM	(Option 010 only) selects the widest time domain gate with the smallest passband ripple.
GATE SHAPE MINIMUM	(Option 010 only) selects the narrowest time domain gate with the largest passband ripple.
GATE SHAPE NORMAL	(Option 010 only) selects an intermediate time domain gate.
GATE SHAPE WIDE	(Option 010 only) selects an intermediate time domain gate.
GOSUB SEQUENCE	calls sub-routines in sequencing.

GRAPHICS on OFF — specifies whether or not to store display graphics on disk with the instrument state.

GRATICULE [ ] — brings up the color definition menu. The graticule trace default color is cyan.

GRATICULE TEXT — selects the graticule and a portion of softkey text (where there is a choice of a feature being on or off) for color modification. For example: FREQUENCY BLANK on OFF .

HOLD — freezes the data trace on the display, and the analyzer stops sweeping and taking data. The notation "Hld" is displayed at the left of the graticule. If the * indicator is on at the left side of the CRT, trigger a new sweep with (SINGLE).

HP-IB DIAG on off — toggles the HP-IB diagnostic feature (debug mode). This mode should only be used the first time a program is written: if a program has already been debugged, it is unnecessary.

When diagnostics are on, the analyzer scrolls a history of incoming HP-IB commands across the display in the title line. Nonprintable characters are represented as π. If a syntax error is received, the commands halt and a pointer $\wedge$ indicates the misunderstood character. To clear a syntax error, refer to the "HP-IB Programming Reference" and "HP-IB Programming Examples" chapters in the *HP 8752C Network Analyzer Programmer's Guide*.

IF BW [ ] — is used to select the bandwidth value for IF bandwidth reduction. Allowed values (in Hz) are 3000, 1000, 300, 100, 30, and 10. Any other value will default to the closest allowed value. A narrow bandwidth slows the sweep speed but provides better signal-to-noise ratio. The selected bandwidth value is shown in brackets in the softkey label.

IF LIMIT TEST FAIL — jumps to one of the six sequence positions (SEQUENCE 1 through 6) if the limit test fails. This command executes any sequence residing in the selected position. Sequences may jump to themselves as well as to any of the other sequences in memory. When this softkey is pressed, the analyzer presents a softkey menu showing the six sequence positions and the titles of the sequences located in them. Choose the destination sequence to be called if the limit test fails.

IF LIMIT TEST PASS — jumps to one of the six sequence positions (SEQUENCE 1 through 6) if the limit test passes. This command executes any sequence residing in the selected position. Sequences may jump to themselves as well as to any of the other sequences in memory. When this softkey is pressed, the analyzer presents a softkey menu showing the six sequence positions, and the titles of the sequences located in them. Choose the sequence to be called if the limit test passes (destination sequence).

IF LOOP COUNTER = 0 — prompts the user to select a destination sequence position (SEQUENCE 1 through 6). When the value of the loop counter reaches zero, the sequence in the specified position will run.

IF LOOP < > COUNTER 0 — prompts the user to select a destination sequence position (SEQUENCE 1 through 6). When the value of the loop counter is no longer zero, the sequence in the specified position will run.

IMAGINARY — displays only the imaginary (reactive) portion of the measured data on a Cartesian format. This format is similar to the real format except that reactance data is displayed on the trace instead of impedance data.

INCR LOOP COUNTER — increments the value of the sequencing loop counter by 1.

INPUT PORTS — brings up a menu that allows you to measure the R, A, and B channels and their ratios.

INTENSITY — sets the CRT intensity as a percent of the brightest setting. The factory-set default value is stored in non-volatile memory.

INTERNAL MEMORY — selects internal non-volatile memory as the storage medium for subsequent save and recall activity.

INTERNAL TESTS — leads to a series of service tests.

INTERPOL on OFF — turns interpolated error correction on or off. The interpolated error correction feature allows the operator to calibrate the system, then select a subset of the frequency range or a different number of points. Interpolated error correction functions in linear frequency, power sweep and CW time modes. When using the analyzer in linear sweep, it is recommended that the original calibration be performed with at least 67 points per 1 GHz of frequency span.

ISOL'N STD — measures the isolation of the device connected to the test port.

ISTATE CONTENTS — describes the selected instrument state file (disk only) translating the various filename prefixes into more descriptive detail.

[k/m] — kilo/milli (10^3 / 10^{-3})

KIT DONE (MODIFIED) — terminates the cal kit modification process, after all standards are defined and all classes are specified. Be sure to save the kit with the SAVE USER KIT softkey, if it is to be used later.

LABEL CLASS — leads to the label class menu, to give the class a meaningful label for future reference.

LABEL CLASS DONE — finishes the label class function and returns to the modify cal kit menu.

LABEL KIT — leads to a menu for constructing a label for the user-modified cal kit. If a label is supplied, it will appear as one of the five softkey choices in the select cal kit menu. The approach is similar to defining a display title, except that the kit label is limited to ten characters.

LABEL STD — The function is similar to defining a display title, except that the label is limited to ten characters.

LEFT LOWER — draws a quarter-page plot in the lower left quadrant of the page.

LEFT UPPER draws a quarter-page plot in the upper left quadrant of the page.

LIMIT LINE OFFSETS leads to the offset limits menu, which is used to offset the complete limit set in either stimulus or amplitude value.

LIMIT LINE on OFF turns limit lines on or off. To define limits, use the EDIT LIMIT LINE softkey described below. If limits have been defined and limit lines are turned on, the limit lines are displayed on the CRT for visual comparison of the measured data in all Cartesian formats.

If limit lines are on, they are plotted with the data on a plot, and saved in memory with an instrument state. In a listing of values from the copy menu with limit lines on, the upper limit and lower limit are listed together with the pass or fail margin, as long as other listed data allows sufficient space.

LIMIT MENU leads to a series of menus used to define limits or specifications with which to compare a test device. Refer to Limit Lines and Limit Testing.

LIMIT TEST on OFF turns limit testing on or off. When limit testing is on, the data is compared with the defined limits at each measured point. Limit tests occur at the end of each sweep, whenever the data is updated, when formatted data is changed, and when limit testing is first turned on.

Limit testing is available for both magnitude and phase values in Cartesian formats. In polar and Smith chart formats, the value tested depends on the marker mode and is the magnitude or the first value in a complex pair. The message "NO LIMIT LINES DISPLAYED" is displayed in polar and Smith chart formats if limit lines are turned on.

Five indications of pass or fail status are provided when limit testing is on. A PASS or FAIL message is displayed at the right of the CRT. The trace vector leading to any measured point that is out of limits is set to red at the end of every limit test, both on a CRT plot and a hard copy plot. The limit fail beeper sounds if it is turned on. In a listing of values using the copy menu, an asterisk * is shown next to any measured point that is out of limits. A bit is set in the HP-IB status byte.

LIMIT TEST RESULT puts the result of a limit test into the display title.

LIMIT TYPE leads to the limit type menu, where one of three segment types can be selected.

LIN FREQ activates a linear frequency sweep displayed on a standard graticule with ten equal horizontal divisions. This is the default preset sweep type.

LIN MAG displays the linear magnitude format. This is a Cartesian format used for unitless measurements such as reflection coefficient magnitude ρ or transmission coefficient magnitude τ, and for linear measurement units. It is used for display of conversion parameters and time domain transform data.

LIN MKR — displays a readout of the linear magnitude and the phase of the active marker. Marker magnitude values are expressed in units; phase is expressed in degrees.

LINE TYPE DATA — selects the line type for the data trace plot for the active channel. The default line type is 7, which is a solid unbroken line.

LINE TYPE MEMORY — selects the line type for the memory trace plot for the active channel. The default line type is 7.

LIST — brings up the list menu and displays list values.

LIST VALUES — provides a tabular listing of all the measured data points and their current values, together with limit information if it is turned on. At the same time, the screen menu is presented, to enable hard copy listings and access new pages of the table. 30 lines of data are listed on each page, and the number of pages is determined by the number of measurement points specified in the stimulus menu.

LIST FREQ — provides a user-definable arbitrary frequency list mode. This list is defined and modified using the edit list menu and the edit subsweep menu. Up to 30 frequency subsweeps (called "segments") of several different types can be specified, for a maximum total of 1632 points. One list is common to both channels. Once a frequency list has been defined and a measurement calibration performed on the full frequency list, one or all of the frequency segments can be measured and displayed without loss of calibration.

LOAD SEQ FROM DISK — presents the load sequence from disk menu. Select the desired sequence and the analyzer will load it from disk.

[LOCAL] — This key is used to return the analyzer to local (front panel) operation from remote (computer controlled) operation. This key will also abort a test sequence or hardcopy print/plot. In this local mode, with a controller still connected on HP-IB, the analyzer can be operated manually (locally) from the front panel. This is the only front panel key that is not disabled when the analyzer is remotely controlled over HP-IB by a computer. The exception to this is when local lockout is in effect: this is a remote command that disables the [LOCAL] key, making it difficult to interfere with the analyzer while it is under computer control.

LOG FREQ — activates a logarithmic frequency sweep mode. The source is stepped in logarithmic increments and the data is displayed on a logarithmic graticule. This is slower than a continuous sweep with the same number of points, and the entered sweep time may therefore be changed automatically. For frequency spans of less than two octaves, the sweep type automatically reverts to linear sweep.

LOG MAG — displays the log magnitude format. This is the standard Cartesian format used to display magnitude-only measurements of insertion loss, return loss, or absolute power in dB versus frequency.

LOG MKR displays the logarithmic magnitude value and the phase of the active marker in Polar or Smith chart format. Magnitude values are expressed in dB and phase in degrees. This is useful as a fast method of obtaining a reading of the log magnitude value without changing to log magnitude format.

LOOP COUNTER displays the current value of the loop counter and allows you to change the value of the loop counter. Enter any number from 0 to 32767 and terminate with the (x1) key. The default value of the counter is zero. This command should be placed in a sequence that is separate from the measurement sequence. For this reason: the measurement sequence containing a loop decision command must call itself in order to function. The LOOP COUNTER command must be in a separate sequence or the counter value would always be reset to the initial value.

LOWER LIMIT sets the lower limit value for the start of the segment in a limit line list. If an upper limit is specified, a lower limit must also be defined. If no lower limit is required for a particular measurement, force the lower limit value out of range (for example −500 dB).

LOW PASS IMPULSE (Option 010 only) sets the transform to low pass impulse mode, which simulates the time domain response to an impulse input.

LOW PASS STEP (Option 010 only) sets the transform to low pass step mode, which simulates the time domain response to a step input.

(M/μ) mega/micro (10^6 / 10^{-6})

MANUAL TRG ON POINT waits for a manual trigger for each point. Subsequent pressing of this softkey triggers each measurement. The annotation "man" will appear at the left side of the CRT when the instrument is waiting for the trigger to occur. This feature is useful in a test sequence when an external device or instrument requires changes at each point.

MARKER -> AMP. OFS. uses the active marker to set the amplitude offset for the limit lines. Move the marker to the desired middle value of the limits and press this softkey. The limits are then moved so that they are centered an equal amount above and below the marker at that stimulus value.

MARKER -> CENTER changes the stimulus center value to the stimulus value of the active marker, and centers the new span about that value.

MARKER -> CW sets the CW frequency of the analyzer to the frequency of the active marker. This feature is intended for use in automated compression measurements. Test sequences allow the instrument to automatically find a maximum or minimum point on a response trace. The MARKER -> CW command sets the instrument to the CW frequency of the active marker. When power sweep in engaged, the CW frequency will already be selected.

MARKER -> DELAY adjusts the electrical delay to balance the phase of the DUT. This is performed automatically, regardless of the format and the measurement being made. Enough line length is added to or subtracted from the receiver input to compensate for the phase slope at the active marker position. This effectively flattens the phase trace around the active marker, and can be used to measure electrical length or deviation from linear phase. Additional electrical delay adjustments are required on DUTs without constant group delay over the measured frequency span. Since this feature adds phase to a variation in phase versus frequency, it is applicable only for ratioed inputs.

`MARKER -> MIDDLE` sets the midpoint for `DELTA LIMITS` using the active marker to set the middle amplitude value of a limit segment. Move the marker to the desired value or device specification, and press this key to make that value the midpoint of the delta limits. The limits are automatically set an equal amount above and below the marker.

`MARKER -> REFERENCE` makes the reference value equal to the active marker's response value, without changing the reference position. In a polar or Smith chart format, the full scale value at the outer circle is changed to the active marker response value. This softkey also appears in the scale reference menu.

`MARKER -> SPAN` changes the start and stop values of the stimulus span to the values of the active marker and the delta reference marker. If there is no reference marker, the message "NO MARKER DELTA - SPAN NOT SET" is displayed.

`MARKER -> START` changes the stimulus start value to the stimulus value of the active marker.

`MARKER -> STIMULUS` sets the starting stimulus value of a limit line segment using the active marker. Move the marker to the desired starting stimulus value before pressing this key, and the marker stimulus value is entered as the segment start value.

`MARKER -> STOP` changes the stimulus stop value to the stimulus value of the active marker.

`MARKER 1` turns on marker 1 and makes it the active marker. The active marker appears on the CRT as ∇. The active marker stimulus value is displayed in the active entry area, together with the marker number. If there is a marker turned on, and no other function is active, the stimulus value of the active marker can be controlled with the knob, the step keys, or the numeric keypad. The marker response and stimulus values are displayed in the upper right-hand corner of the screen.

`MARKER 2` turns on marker 2 and makes it the active marker. If another marker is present, that marker becomes inactive and is represented on the CRT as Δ.

`MARKER 3` turns on marker 3 and makes it the active marker.

`MARKER 4` turns on marker 4 and makes it the active marker.

`MARKER all OFF` turns off all the markers and the delta reference marker, as well as the tracking and bandwidth functions that are accessed with the (MRK FCTN) key.

MARKER MODE MENU provides access to the marker mode menu, where several marker modes can be selected including special markers for polar and Smith chart formats.

MARKERS: CONTINUOUS
- located under the (MRK) key, interpolates between measured points to allow the markers to be placed at any point on the trace. Displayed marker values are also interpolated. This is the default marker mode.

MARKERS: COUPLED couples the marker stimulus values for the two display channels. Even if the stimulus is uncoupled and two sets of stimulus values are shown, the markers track the same stimulus values on each channel as long as they are within the displayed stimulus range.

MARKERS: DISCRETE places markers only on measured trace points determined by the stimulus settings.

MARKERS: UNCOUPLED allows the marker stimulus values to be controlled independently on each channel.

MAXIMUM FREQUENCY is used to define the highest frequency at which a calibration kit standard can be used during measurement calibration. In waveguide, this is normally the upper cutoff frequency of the standard.

(MEAS) key provides access to a series of softkey menus for selecting the parameters or inputs to be measured.

MEASURE RESTART aborts the sweep in progress, then restarts the measurement. This can be used to update a measurement following an adjustment of the device under test. When a full two-port calibration is in use, the MEASURE RESTART key will initiate another update of both forward and reverse S-parameter data. This softkey will also override the test set hold mode, which inhibits continuous switching of either the test port transfer switch or step attenuator. The measurement configurations which cause this are described in Test Set Attenuator, Test Port Transfer Switch, and Doubler Switch Protection, at the beginning of this section. This softkey will override the test set hold mode for one measurement.

If the analyzer is taking a number of groups (see Trigger Menu), the sweep counter is reset at 1. If averaging is on, MEASURE RESTART resets the sweep-to-sweep averaging. If the sweep trigger is in (HOLD) mode, MEASURE RESTART executes a single sweep.

MEMORY displays the trace memory for the active channel. This is the only memory display mode where the smoothing and gating of the memory trace can be changed. If no data has been stored in memory for this channel, a warning message is displayed.

(MENU) provides access to a series of menus which are used to define and control all stimulus functions other than start, stop, center, and span. When the (MENU) key is pressed, the stimulus menu is displayed.

MIDDLE VALUE — sets the midpoint for DELTA LIMITS. It uses the entry controls to set a specified amplitude value vertically centered between the limits.

MINIMUM FREQUENCY — is used to define the lowest frequency at which a calibration kit standard can be used during measurement calibration. In waveguide, this must be the lower cutoff frequency of the standard, so that the analyzer can calculate dispersive effects correctly (see OFFSET DELAY).

(MKR) — displays an active marker (-) on the screen and provides access to a series of menus to control from one to four display markers for each channel. Markers provide numerical readout of measured values at any point of the trace.

The menus accessed from the (MRK) key provide several basic marker operations. These include special marker modes for different display formats, and a marker delta mode that displays marker values relative to a specified value or another marker.

(MKR FCTN) — key activates a marker if one is not already active, and provides access to additional marker functions. These can be used to quickly change the measurement parameters, to search the trace for specified information, and to analyze the trace statistically.

MKR SEARCH [ ] — leads to the marker search menu, which is used to search the trace for a particular value or bandwidth.

MKR ZERO — puts a fixed reference marker at the present active marker position, and makes the fixed marker stimulus and response values at that position equal to zero. All subsequent stimulus and response values of the active marker are then read out relative to the fixed marker. The fixed marker is shown on the CRT as a small triangle Δ (delta), smaller than the inactive marker triangles. The softkey label changes from MKR ZERO to MKRZERO ΔREF = Δ and the notation "ΔREF = Δ" is displayed at the top right corner of the graticule. Marker zero is canceled by turning delta mode off in the delta marker menu or turning all the markers off with the ALL OFF softkey.

MODIFY [ ] — leads to the modify cal kit menu, where a default cal kit can be user-modified.

MODIFY COLORS — present a menu for color modification of CRT display elements. Refer to Adjusting Color for information on modifying CRT display elements.

NEW SEQ/MODIFY SEQ — activates the sequence edit mode and presents the new/modify sequence menu with a list of sequences that can be created or modified.

NEWLINE — puts a new line command into the display title.

NUMBER OF GROUPS — triggers a user-specified number of sweeps, and returns to the hold mode. This function can be used to override the test set hold mode, which protects the electro-mechanical transfer switch and attenuator against continuous switching. This is explained fully in the Test Set Attenuator description in the "Application and Operation Concepts" chapter, in this manual.

If averaging is on, the number of groups should be at least equal to the averaging factor selected to allow measurement of a fully averaged trace. Entering a number of groups resets the averaging counter to 1.

NUMBER OF POINTS is used to select the number of data points per sweep to be measured and displayed. Using fewer points allows a faster sweep time but the displayed trace shows less horizontal detail. Using more points gives greater data density and improved trace resolution, but slows the sweep and requires more memory for error correction or saving instrument states.

The possible values that can be entered for number of points are 3, 11, 26, 51, 101, 201, 401,801, and 1601. The number of points can be different for the two channels if the stimulus values are uncoupled.

In list frequency sweep, the number of points displayed is the total number of frequency points for the defined list (see Sweep Type Menu).

OFFSET DELAY is used to specify the one-way electrical delay from the measurement (reference) plane to the standard, in seconds (s). (In a transmission standard, offset delay is the delay from plane to plane.) Delay can be calculated from the precise physical length of the offset, the permittivity constant of the medium, and the speed of light.

OFFSET LOSS is used to specify energy loss, due to skin effect, along a one-way length of coax offset. The value of loss is entered as ohms/nanosecond (or Giga ohms/second) at 1 GHz. (Such losses are negligible in waveguide, so enter 0 as the loss offset.)

OFFSET Z0 is used to specify the characteristic impedance of the coax offset. (Note: This is not the impedance of the standard itself.) (For waveguide, the offset impedance is always assigned a value equal to the system Z0.)

OP PARMS (MKRS etc) provides a tabular listing on the CRT of the key parameters for both channels. The screen menu is presented to allow hard copy listings and access new pages of the table. Four pages of information are supplied. These pages list operating parameters, marker parameters, lists and system parameters that relate to control of peripheral devices rather than selection of measurement parameters.

OPEN (F) causes the analyzer to measure the open standard during a calibration with female test ports.

OPEN (M) causes the analyzer to measure the open standard during a calibration with male test ports.

P MTR/HPIB TO TITLE gets data from an HP-IB device set to the address at which the analyzer expects to find a power meter. The data is stored in a title string. The analyzer must be in system controller or pass control mode.

PAGE steps through a tabular list of data page-by-page.

PAUSE	pauses the sequence so the operator can perform a needed task, such as changing the DUT, changing the calibration standard, or other similar task. Press CONTINUE SEQUENCE when ready.
PAUSE TO SELECT	when editing a sequence, PAUSE TO SELECT appears when you press DO SEQUENCE. When placed in a sequence, it presents the menu of up to 6 available sequences (softkeys containing non-empty sequences). The message "CHOOSE ONE OF THESE SEQUENCES" is displayed and the present sequence is stopped. If the operator selects one of the sequences, that sequence is executed. Any other key can be used to exit this mode. This function is not executed if used during modify mode and does nothing when operated manually. This softkey is not visible on the display, and the function is not available, unless programmed into analyzer memory.
PEN NUM DATA	selects the number of the pen to plot the data trace. The default pen for channel 1 is pen number 2, and for channel 2 is pen number 3.
PEN NUM GRATICULE	selects the number of the pen to plot the graticule. The default pen for channel 1 is pen number 1, and for channel 2 is pen number 1.
PEN NUM MARKER	selects the number of the pen to plot both the markers and the marker values. The default pen for channel 1 is pen number 7, and for channel 2 is pen number 7.
PEN NUM MEMORY	selects the number of the pen to plot the memory trace. The default pen for channel 1 is pen number 5, and for channel 2 is pen number 6.
PEN NUM TEXT	selects the number of the pen to plot the text. The default pen for channel 1 is pen number 7, and for channel 2 is pen number 7.
PERIPHERAL HPIB ADDR	sets the HP-IB address the analyzer will use to communicate with a peripheral device, such as a programmable power supply.
PHASE	displays a Cartesian format of the phase portion of the data, measured in degrees. This format displays the phase shift versus frequency.
PHASE OFFSET	adds or subtracts a phase offset that is constant with frequency (rather than linear). This is independent of MARKER -> DELAY and ELECTRICAL DELAY.
PLOT	makes a hard copy plot of one page of the tabular listing on the CRT, using a compatible HP plotter connected to the analyzer through HP-IB. This method is appropriate when speed of output is not a critical factor.
PLOT DATA ON off	specifies whether the data trace is to be drawn (on) or not drawn (off) on the plot.
PLOT GRAT ON off	specifies whether the graticule and the reference line are to be drawn (on) or not drawn (off) on the plot. Turning PLOT GRAT ON and all other elements off is a convenient way to make preplotted grid forms. However, when data is to

be plotted on a preplotted form, PLOT GRAT OFF should be selected.

PLOT MEM ON off — specifies whether the memory trace is to be drawn (on) or not drawn (off) on the plot. Memory can only be plotted if it is displayed (refer to "Display Menu" in Chapter 6).

PLOT MKR ON off — specifies whether the markers and marker values are to be drawn (on) or not drawn (off) on the plot.

PLOT SPEED [ ] — toggles between fast and slow speeds.

PLOT TEXT ON off — selects plotting of all displayed text except the marker values, softkey labels, and CRT listings such as the frequency list table or limit table. (Softkey labels can be plotted under the control of an external controller. Refer to the Introductory Programming Guide.)

PLOTTER FORM FEED — sends a page eject command to the plotter.

PLOTTER PORT — brings up the plotter port menu.

PLTR PORT: DISK — directs plots to the external disk.

PLTR PORT: HPIB — directs plots to the HP-IB port and sets the HP-IB address the analyzer will use to communicate with the plotter.

PLTR TYPE [PLOTTER] — selects a pen plotter such as the HP 7440A, HP 7470A, HP 7475A, or HP 7550B, as the plotter type.

PLTR TYPE [HPGL PRT] — selects a PCL5 compatible printer, which supports HP-GL/2, such as the LaserJet III or LaserJet 4 for a monochrome plotter type, or the DeskJet 1200C for a color plotter type.

POLAR — displays a polar format. Each point on the polar format corresponds to a particular value of both magnitude and phase. Quantities are read vectorally: the magnitude at any point is determined by its displacement from the center (which has zero value), and the phase by the angle counterclockwise from the positive x-axis. Magnitude is scaled in a linear fashion, with the value of the outer circle usually set to a ratio value of 1. Since there is no frequency axis, frequency information is read from the markers.

POLAR MKR MENU — leads to a menu of special markers for use with a polar format.

PORT EXTENSIONS — goes to the reference plane menu, which is used to extend the apparent location of the measurement reference plane or input.

POWER — makes power level the active function and sets the RF output power level of the analyzer's internal source. The analyzer will detect an input power overload at any of the three receiver inputs, and automatically reduce the output power of the source to −85 dBm. This is indicated with the message "OVERLOAD ON INPUT (R, A, B)." In addition, the annotation "P↓" appears at the left side of the CRT. When this occurs, set the power to a lower level, and toggle SOURCE POWER on OFF.

POWER MTR: [ ] — toggles between (436A) or (438A/437). These power meters are HP-IB compatible with the analyzer. The model number in the softkey label must match the power meter to be used.

POWER RANGES	(Option 004 only) leads to the power ranges menu. There are 8 predetermined power ranges to choose from.
POWER SWEEP	turns on a power sweep mode that is used to characterize power-sensitive circuits. In this mode, power is swept at a single frequency, from a start power value to a stop power value, selected using the [START] and [STOP] keys and the entry block. This feature is convenient for such measurements as gain compression or AGC (automatic gain control) slope. To set the frequency of the power sweep, use [CW FREQ] in the stimulus menu. Refer to the User's Guide for an example of a gain compression measurement. Note that power range switching is not allowed in power sweep mode. In power sweep, the entered sweep time may be automatically changed if it is less than the minimum required for the current configuration (number of points, IF bandwidth, averaging, etc.).
[PRESET]	presents a menu to select a factory or user defined preset state.
PRESET: FACTORY	is used to select the preset conditions defined by the factory.
PRESET: USER	is used to select a preset condition defined by the user. This is done by saving a state in a register under [SAVE/RECALL] and naming the register UPRESET. When PRESET: USER is underlined, the [PRESET] key will bring up the state of the UPRESET register.
PRINT: COLOR	sets the print command to default to a color printer. The printer output is always in the analyzer default color values. This command does not work with a black and white printer.
PRINT: MONOCHROME	sets the print command to default to a black and white printer.
PRINT COLOR	prints the specified page of the listed values in color.
PRINT COLORS	is used to select the print colors menu.
PRINT MONOCHROME	prints the specified page of the listed values in black and white.
PRINT SEQUENCE	prints any sequence currently in memory to a compatible printer.
PRINTER ADDRESS	sets the HP-IB address the analyzer will use to communicate with the printer.
PRINTER FORM FEED	sends a conditional form feed to the printer.
PRINTER PORT	brings up the printer port menu.
PRNTR TYPE [DESKJET]	sets the printer type to the DeskJet series.
PRNTR TYPE [EPSON-P2]	sets the printer type to Epson compatible printers, which support the Epson ESC/P2 printer control language.
PRNTR TYPE [LASERJET]	sets the printer type to the LaserJet series.
PRNTR TYPE [PAINTJET]	sets the printer type to PaintJet.
PRNTR TYPE [THINKJET]	sets the printer type to ThinkJet or QuietJet.

PWR RANGE AUTO man — (Option 004 only) toggles the power range mode between auto and manual. Auto mode selects the power range based on the power selected. Manual mode limits power entry to within the selected range.

R — measures the absolute power amplitude at input R.

R+jX MKR — converts the active marker values into rectangular form. The complex impedance values of the active marker are displayed in terms of resistance, reactance, and equivalent capacitance or inductance. This is the default Smith chart marker.

RANGE 0 -15 TO +10 — (Option 004 only) selects power range 0 when in manual power range.

RANGE 1 -25 TO 0 — (Option 004 only) selects power range 1 when in manual power range.

RANGE 2 -35 TO -10 — (Option 004 only) selects power range 2 when in manual power range.

RANGE 3 -45 TO -20 — (Option 004 only) selects power range 3 when in manual power range.

RANGE 4 -55 TO -30 — (Option 004 only) selects power range 4 when in manual power range.

RANGE 5 -65 TO -40 — (Option 004 only) selects power range 5 when in manual power range.

RANGE 6 -75 TO -50 — (Option 004 only) selects power range 6 when in manual power range.

RANGE 7 -85 TO -60 — (Option 004 only) selects power range 7 when in manual power range.

RAW ARRAY on OFF — specifies whether or not to store the raw data (ratioed and averaged) on disk with the instrument state.

Re/Im MKR — when in the smith marker menu, Re/Im MKR displays the values of the active marker on a Smith chart as a real and imaginary pair. The complex data is separated into its real part and imaginary part. The first marker value given is the real part M cos θ, and the second value is the imaginary part M sin θ, where M = magnitude + 0 = phase.

When in the polar marker menu, Re/Im MKR displays the values of the active marker as a real and imaginary pair. The complex data is separated into its real part and imaginary part. The first marker value given is the real part M cos θ, and the second value is the imaginary part M sin θ, where M = magnitude + 0 = phase.

REAL — displays only the real (resistive) portion of the measured data on a Cartesian format. This is similar to the linear magnitude format, but can show both positive and negative values. It is primarily used for analyzing responses in the time domain, and also to display an auxiliary input voltage signal for service purposes.

RECALL COLORS — recalls the previously saved modified version of the color set. This key appears only when a color set has been saved.

RECALL KEYS on OFF — when this key is turned on, it allows you to jump directly to the recall keys menu when you press (SAVE/RECALL). This makes it easier to recall the contents of a register.

RECALL REG1 — recalls the instrument state saved in register 1.

RECALL REG2 — recalls the instrument state saved in register 2.

RECALL REG3 — recalls the instrument state saved in register 3.

RECALL REG4 — recalls the instrument state saved in register 4.

RECALL REG5 — recalls the instrument state saved in register 5.

RECALL REG6 — recalls the instrument state saved in register 6.

RECALL REG7 — recalls the instrument state saved in register 7.

RECALL STATE — is used in conjunction with sequencing, to return the instrument to the known preset state without turning off the sequencing function. This is not the same as pressing the (PRESET) key: no preset tests are run, and the HP-IB and sequencing activities are not changed.

REFERENCE POSITION — sets the position of the reference line on the graticule of a Cartesian display, with 0 the bottom line of the graticule and 10 the top line. It has no effect on a polar or Smith display. The reference position is indicated with a small triangle just outside the graticule, on the left side for channel 1 and the right side for channel 2.

REFERENCE VALUE — changes the value of the reference line, moving the measurement trace correspondingly. In polar and Smith chart formats, the reference value is the same as the scale, and is the value of the outer circle.

REFLECTION 1-PORT — leads to the menus used to perform a reflection 1-port calibration, for the most accurate measurement of reflection coefficient. This calibration effectively removes the directivity, source match, and frequency response of the analyzer's reflection test port.

RESET COLOR — resets the color being modified to the default color.

RESOLUTION [ ] — toggles between RESOLUTION [LOW] and RESOLUTION [HIGH].

RESPONSE

- When in the specify class more menu, RESPONSE is used to enter the standard numbers for a response calibration. This calibration corrects for frequency response in either reflection or transmission measurements, depending on the parameter being measured when a calibration is performed. (For default kits, the standard is either the open or short for reflection measurements, or the thru for transmission measurements.)
- When in the calibrate menu, RESPONSE leads to the frequency response calibration. This is the simplest and fastest accuracy enhancement procedure, but should be used when extreme accuracy is not required. It effectively

removes the frequency response errors of the test setup for reflection or transmission measurements.

RESPONSE & ISOL'N

- When in the specify class more menu, RESPONSE & ISOL'N is used to enter the standard numbers for a response and isolation calibration. This calibration corrects for frequency response and directivity in reflection measurements, or frequency.
- When in the calibrate menu, RESPONSE & ISOL'N leads to the menus used to perform a response and isolation measurement calibration, for measurement of devices with wide dynamic range. This procedure effectively removes the same frequency response errors as the response calibration. In addition, it effectively removes the isolation (crosstalk) error in transmission measurements or the directivity error in reflection measurements. As well as the devices required for a simple response calibration, an isolation standard is required. The standard normally used to correct for isolation is an impedance-matched load (usually 50 or 75 ohms). Response and directivity calibration procedures for reflection and transmission measurements are provided in the following pages.

RESTORE DISPLAY turns off the tabular listing and returns the measurement display to the screen.

RESUME CAL SEQUENCE eliminates the need to restart a calibration sequence that was interrupted to access some other menu. This softkey goes back to the point where the calibration sequence was interrupted.

REV MATCH (Label Class) is not used in the HP 8752C.

REV MATCH (Specify Class) is not used in the HP 8752C.

REV TRANS (Label Class) is not used in the HP 8752C.

REV TRANS (Specify Class) is not used in the HP 8752C.

RIGHT LOWER draws a quarter-page plot in the lower right quadrant of the page.

RIGHT UPPER draws a quarter-page plot in the upper right quadrant of the page.

S11A RE FW MTCH is used to enter the standard numbers for the first class required for a reflection calibration. (For default cal kits, this is the open.)

S11B LN FW MTCH is used to enter the standard numbers for the second class required for a reflection calibration. (For default cal kits, this is the short.)

S11C LN FW TRAN is used to enter the standard numbers for the third class required for a reflection calibration. (For default kits, this is the load.)

S22A RE RV MTCH is not used in the HP 8752C.

S22B LN RV TRAN is not used in the HP 8752C.

S22C LN RV TRAN is not used in the HP 8752C.

SAVE COLORS — saves the modified version of the color set.

(SAVE/RECALL) — provides access to all the menus used for saving and recalling instrument states in internal memory and for storing to, or loading from, external disk. This includes the menus used to define titles for internal registers and external disk files, to define the content of disk files, to initialize disks for storage, and to clear data from the registers or purge files from disk.

SAVE USER KIT — stores the user-modified or user-defined kit into memory, after it has been modified.

SAVE USING BINARY — selects binary format for data storage.

SCALE/DIV — changes the response value scale per division of the displayed trace. In polar and Smith chart formats, this refers to the full scale value at the outer circumference, and is identical to reference value.

SCALE PLOT [ ] — toggles between two selections for plot scale, FULL and GRAT.

SCALE PLOT [FULL] — the normal scale selection for plotting on blank paper, and includes space for all display annotations such as marker values, stimulus values, etc. The entire CRT display fits within the user-defined boundaries of P1 and P2 on the plotter, while maintaining the exact same aspect ratio as the CRT display.

SCALE PLOT [GRAT] — the horizontal and vertical scale are expanded or reduced so that the graticule lower left and upper right corners exactly correspond to the user-defined P1 and P2 scaling points on the plotter. This is convenient for plotting on preprinted rectangular or polar forms (for example, on a Smith chart).

(SCALE REF) — makes scale per division the active function. A menu is displayed that is used to modify the vertical axis scale and the reference line value and position. In addition this menu provides electrical delay offset capabilities for adding or subtracting linear phase to maintain phase linearity.

SEARCH LEFT — searches the trace for the next occurrence of the target value to the left.

SEARCH RIGHT — searches the trace for the next occurrence of the target value to the right.

SEARCH: MAX — moves the active marker to the maximum point on the trace.

SEARCH: MIN — moves the active marker to the minimum point on the trace.

SEARCH: OFF — turns off the marker search function.

SEGMENT — specifies which limit segment in the table is to be modified. A maximum of three sets of segment values are displayed at one time, and the list can be scrolled up or down to show other segment entries. Use the entry block controls to move the pointer > to the required segment number. The indicated segment can then be edited or deleted. If the table of limits is designated "EMPTY," new segments can be added using the ADD or EDIT softkey.

SEGMENT: CENTER	sets the center frequency of a subsweep in a list frequency sweep.
SEGMENT: SPAN	sets the frequency or power span of a subsweep about a specified center frequency.
SEGMENT: START	sets the start frequency of a subsweep.
SEGMENT: STOP	sets the stop frequency of a subsweep.
SEL QUAD [ ]	leads to the select quadrant menu, which provides the capability of drawing quarter-page plots. This is not used for printing.
SELECT LETTER	The active entry area displays the letters of the alphabet, digits 0 through 9, and mathematical symbols. To define a title, rotate the knob until the arrow ↑ points at the first letter, then press SELECT LETTER. Repeat this until the complete title is defined, for a maximum of 50 characters. As each character is selected, it is appended to the title at the top of the graticule.
(SEQ)	accesses a series of sequencing menus. These allow you to create, modify, and store up to 6 sequences which can be run automatically.
SEQUENCE 1 SEQ1	activates editing mode for the segment titled "SEQ1" (default title).
SEQUENCE 2 SEQ2	activates editing mode for the segment titled "SEQ2" (default title).
SEQUENCE 3 SEQ3	activates editing mode for the segment titled "SEQ3" (default title).
SEQUENCE 4 SEQ4	activates editing mode for the segment titled "SEQ4" (default title).
SEQUENCE 5 SEQ5	activates editing mode for the segment titled "SEQ5" (default title).
SEQUENCE 6 SEQ6	activates editing mode for the segment titled "SEQ6" (default title).
SET ADDRESSES	goes to the address menu, which is used to set the HP-IB address of the analyzer, and to display and modify the addresses of peripheral devices in the system.
SET BIT	must be entered through the keypad number keys, followed by the (x1) key. The bit is set when the (x1) key is pressed. Entering numbers larger than 3 will result in bit 3 being set, and entering numbers lower than 0 will result in bit 0 being set.
SET FREQ LOW PASS	(Option 010 only) changes the frequency sweep to harmonic intervals to accommodate time domain low-pass operation (option 010). If this mode is used, the frequencies must be set before calibration.
SET Z0	sets the characteristic impedance used by the analyzer in calculating measured impedance with Smith chart markers and conversion parameters. Characteristic impedance must be set correctly before calibration procedures are performed.

SHORT (F) — causes the analyzer to measure the short standard during a calibration with female test ports.

SHORT (M) — causes the analyzer to measure the short standard during a calibration with male test ports.

SHOW MENUS — used to display a specific menu prior to a pause statement.

SINGLE — takes one sweep of data and returns to the hold mode.

SINGLE POINT — sets the limits at a single stimulus point. If limit lines are on, the upper limit value of a single point limit is displayed as \9, and the lower limit is displayed as \8. A limit test at a single point not terminating a flat or sloped line tests the nearest actual measured data point. A single point limit can be used as a termination for a flat line or sloping line limit segment. When a single point terminates a sloping line or when it terminates a flat line and has the same limit values as the flat line, the single point is not displayed as \9 and \8. The indication for a sloping line segment in the displayed table of limits is SP.

SINGLE SEG SWEEP — enables a measurement of a single segment of the frequency list, without loss of calibration. The segment to be measured is selected using the entry block.

In single segment mode, selecting a measurement calibration will force the full list sweep before prompting for calibration standards. The calibration will then be valid for any single segment.

If an instrument state is saved in memory with a single-segment trace, a recall will re-display that segment while also recalling the entire list.

SLIDING — defines the load as a sliding load. When such a load is measured during calibration, the analyzer will prompt for several load positions, and calculate the ideal load value from it.

SLOPE — compensates for power loss versus the frequency sweep, by sloping the output power upwards proportionally to frequency. Use this softkey to enter the power slope in dB per GHz of sweep.

SLOPE on OFF — toggles the power slope function on or off. With slope on, the output power increases with frequency, starting at the selected power level.

SLOPING LINE — defines a sloping limit line segment that is linear with frequency or other stimulus value, and is continuous to the next stimulus value and limit. If a sloping line is the final segment it becomes a flat line terminated at the stop stimulus. A sloping line segment is indicated as SL on the displayed table of limits.

SMITH CHART — displays a Smith chart format. This is used in reflection measurements to provide a readout of the data in terms of impedance.

SMITH MKR MENU — leads to a menu of special markers for use with a Smith chart format.

SMOOTHING APERTURE	lets you change the value of the smoothing aperture as a percent of the span. When smoothing aperture is the active function, its value in stimulus units is displayed below its percent value in the active entry area. Smoothing aperture is also used to set the aperture for group delay measurements. Note that the displayed smoothing aperture is not the group delay aperture unless smoothing is on.
SMOOTHING on OFF	turns the smoothing function on or off for the active channel. When smoothing is on, the annotation "Smo" is displayed in the status notations area.
SOURCE POWER on OFF	turns the source power on or off. Use this key to restore power after a power trip has occurred. (See the POWER key description.)
SPACE	inserts a space in the title.
(SPAN)	is used, along with the (CENTER) key, to define the frequency range of the stimulus. When the (SPAN) key is pressed it becomes the active function. The value is displayed in the active entry area, and can be changed with the knob, step keys, or numeric keypad.
SPECIAL FUNCTIONS	presents the special function menu.
SPECIFY CLASS	leads to the specify class menu. After the standards are modified, use this key to specify a class to consist of certain standards.
SPECIFY CLASS DONE	finishes the specify class function and returns to the modify cal kit menu.
SPECIFY GATE	(Option 010 only) is used to specify the parameters of the gate.
SPECIFY OFFSET	allows additional specifications for a user-defined standard. Features specified in this menu are common to all five types of standards.
SPLIT DISP on OFF	toggles between a full-screen single graticule display of one or both channels, and a split display with two half-screen graticules one above the other. The split display can be used in conjunction with DUAL CHAN ON in the display menu to show the measured data of each channel simultaneously on separate graticules. In addition, the stimulus functions of the two channels can be controlled independently using COUPLED CH ON in the stimulus menu. The markers can also be controlled independently for each channel using MARKERS: UNCOUPLED in the marker mode menu.
(START)	is used to define the start frequency of a frequency range. When the (START) key is pressed it becomes the active function. The value is displayed in the active entry area, and can be changed with the knob, step keys, or numeric keypad.
STATS on OFF	calculates and displays the mean, standard deviation, and peak-to-peak values of the section of the displayed trace between the active marker and the delta reference marker. If there is no delta reference, the statistics are calculated for

the entire trace. A convenient use of this feature is to find the peak-to-peak value of passband ripple without searching separately for the maximum and minimum values.

The statistics are absolute values: the delta marker here serves to define the span. For polar and Smith chart formats the statistics are calculated using the first value of the complex pair (magnitude, real part, resistance, or conductance).

After each standard is defined, including offsets, press STD DONE (DEFINED) to terminate the standard definition.

STD DONE (DEFINED) returns to the define standard menu.

STD OFFSET DONE is used to end the specify offset sequence.

STD TYPE: is used to specify the type of calibration device being measured.

STD TYPE: ARBITRARY IMPEDANCE defines the standard type to be a load, but with an arbitrary impedance (different from system Z0).

STD TYPE: DELAY/THRU defines the standard type as a transmission line of specified length, for calibrating transmission measurements.

STD TYPE: LOAD defines the standard type as a load (termination). Loads are assigned a terminal impedance equal to the system characteristic impedance Z0, but delay and loss offsets may still be added. If the load impedance is not Z0, use the arbitrary impedance standard definition.

STD TYPE: OPEN defines the standard type as an open, used for calibrating reflection measurements. Opens are assigned a terminal impedance of infinite ohms, but delay and loss offsets may still be added. Pressing this key also brings up a menu for defining the open, including its capacitance.

STD TYPE: SHORT defines the standard type as a short, for calibrating reflection measurements. Shorts are assigned a terminal impedance of 0 ohms, but delay and loss offsets may still be added.

STEP SIZE is used to specify the subsweep in frequency steps instead of number of points. Changing the start frequency, stop frequency, span, or number of points may change the step size. Changing the step size may change the number of points and stop frequency in start/stop/step mode; or the frequency span in center/span/step mode. In each case, the frequency span becomes a multiple of the step size.

STIMULUS VALUE sets the starting stimulus value of a segment, using entry block controls. The ending stimulus value of the segment is defined by the start of the next line segment. No more than one segment can be defined over the same stimulus range.

STIMULUS OFFSET adds or subtracts an offset in stimulus value. This allows limits already defined to be used for testing in a different stimulus range. Use the entry block controls to specify the offset required.

[STOP] is used to define the stop frequency of a frequency range. When the [STOP] key is pressed it becomes the active function.

The value is displayed in the active entry area, and can be changed with the knob, step keys, or numeric keypad.

STORE SEQ TO DISK presents the store sequence to disk menu with a list of sequences that can be stored.

SWEEP is used to set the frequency of the LO source to sweep.

SWEEP TIME [ ] toggles between automatic and manual sweep time.

SWEEP TYPE MENU presents the sweep type menu, where one of the available types of stimulus sweep can be selected.

SWR reformats a reflection measurement into its equivalent SWR (standing wave ratio) value. SWR is equivalent to $(1+\rho)/(1-\rho)$, where ρ is the reflection coefficient. Note that the results are valid only for reflection measurements. If the SWR format is used for measurements of S21 or S12 the results are not valid.

(SYSTEM) presents the system menu.

SYSTEM CONTROLLER is the mode used when peripheral devices are to be used and there is no external controller. In this mode, the analyzer can directly control peripherals (plotter, printer, disk drive, or power meter). System controller mode must be set in order for the analyzer to access peripherals from the front panel to plot, print, store on disk, or perform power meter functions, if there is no other controller on the bus.

The system controller mode can be used without knowledge of HP-IB programming. However, the HP-IB address must be entered for each peripheral device.

This mode can only be selected manually from the analyzer's front panel, and can e used only if no active computer controller is connected to the system through HP-IB. If you try to set system controller mode when another controller is present, the message "CAUTION: CAN'T CHANGE - ANOTHER CONTROLLER ON BUS" is displayed. Do not attempt to use this mode for programming.

TALKER/LISTENER is the mode normally used for remote programming of the analyzer. In this mode, the analyzer and all peripheral devices are controlled from the external controller. The controller can command the analyzer to talk, and the plotter or other device to listen. The analyzer and peripheral devices cannot talk directly to each other unless the computer sets up a data path between them.

This mode allows the analyzer to be either a talker or a listener, as required by the controlling computer for the particular operation in progress.

A talker is a device capable of sending out data when it is addressed to talk. There can be only one talker at any given time. The analyzer is a talker when it sends information over the bus.

A listener is a device capable of receiving data when it is addressed to listen. There can be any number of listeners at any given time. The analyzer is a listener when it is controlled over the bus by a computer.

TARGET
makes target value the active function, and places the active marker at a specified target point on the trace. The default target value is −3 dB. The target menu is presented, providing search right and search left options to resolve multiple solutions.

For relative measurements, a search reference must be defined with a delta marker or a fixed marker before the search is activated.

TERMINAL IMPEDANCE
is used to specify the (arbitrary) impedance of the standard, in ohms.

TEXT
selects all the non-data text for color modification. For example: operating parameters.

TEXT [ ]
brings up the color definition menu. The default color for text is black.

THRU
a calibration standard type.

TINT
adjusts the continuum of hues on the color wheel of the chosen attribute. See Adjusting Color for an explanation of using this softkey for color modification of CRT display attributes.

TITLE
presents the title menu in the softkey labels area and the character set in the active entry area. These are used to label the active channel display. A title more menu allows up to four values to be included in the printed title; active entry, active marker amplitude, limit test results, and loop counter value.

TITLE SEQUENCE
allows the operator to rename any sequence with an eight character title. All titles entered from the front panel must begin with a letter, and may only contain letters and numbers. A procedure for changing the title of a sequence is provided at the beginning of this chapter.

TITLE TO MEMORY
moves the title string data obtained with the P MTR/HPIB TO TITLE command into a data array.

TITLE TO MEMORY strips off leading characters that are not numeric, reads the numeric value, and then discards everything else. The number is converted into analyzer internal format, and is placed into the real portion of the memory trace at:

Display point = total points - 1 - loop counter

If the value of the loop counter is zero, then the title number goes in the last point of memory. If the loop counter is greater than or equal to the current number of measurement points, the number is placed in the first point of memory. A data to memory command must be executed before using the title to memory command.

TITLE TO P MTR/HPIB
outputs a title string to any device with an HP-IB address that matches the address set with the analyzer (LOCAL) SET ADDRESSES ADDRESS: P MTR/HPIB commands. This softkey is generally used for two purposes:

- Sending a title to a printer when a CR-LF is not desired.
- Sending commands to an HP-IB device.

TITLE TO PERIPHERAL — outputs a title string to any device with an HP-IB address that matches the address set with the analyzer (SEQ) SPECIAL FUNCTIONS PERIPHERAL HPIB ADDR commands. This softkey is generally used for two purposes:

- Sending a title to a printer when a CR-LF is not desired.
- Sending commands to an HP-IB device.

TITLE TO PRINTER — outputs a title string to any device with an HP-IB address that matches the address set with the analyzer (LOCAL) SET ADDRESSES ADDRESS: PRINTER commands. This softkey is generally used for two purposes:

- Sending a title to a printer for data logging or documentation purposes.
- Sending commands to a printer or other HP-IB device.

TRACKING on OFF — is used in conjunction with other search features to track the search with each new sweep. Turning tracking on makes the analyzer search every new trace for the specified target value and put the active marker on that point. If bandwidth search is on, tracking searches every new trace for the specified bandwidth, and repositions the dedicated bandwidth markers.

When tracking is off, the target is found on the current sweep and remains at the same stimulus value regardless of changes in trace response value with subsequent sweeps.

A maximum and a minimum point can be tracked simultaneously using two channels and uncoupled markers.

TRANS DONE — goes back to the two-port cal menu when transmission measurements are finished.

TRANSFORM MENU — (Option 010 only) leads to a series of menus that transform the measured data from the frequency domain to the time domain.

TRANSFORM on OFF — (Option 010 only) switches between time domain transform on and off.

TRIGGER MENU — presents the trigger menu, which is used to select the type and number of the sweep trigger.

TRIGGER: TRIG OFF — turns off external trigger mode.

TTL I/O — brings up the new/modify seq menu.

TTL IN IF BIT H — while creating a sequence, this softkey inserts a command to jump to another sequence if the single input selected is in a high state.

TTL IN IF BIT L — while creating a sequence, this softkey inserts a command to jump to another sequence if the single input selected is in a low state.

TTL OUT ALL
: is generally used in a sequence to set the four output bits to a number (0 to 15) in base 10 and output it as binary. To affect the state of individual bits, refer to CLEAR BIT and SET BIT.

UNCOUPLED
: allows the marker stimulus values to be controlled independently on each channel.

UPPER LIMIT
: sets the upper limit value for the start of the segment. If a lower limit is specified, an upper limit must also be defined. If no upper limit is required for a particular measurement, force the upper limit value out of range (for example +500 dB).

When UPPER LIMIT or LOWER LIMIT is pressed, all the segments in the table are displayed in terms of upper and lower limits, even if they were defined as delta limits and middle value.

If you attempt to set an upper limit that is lower than the lower limit, or vice versa, both limits will be automatically set to the same value.

USE MEMORY ON off
: (Option 010 only) remembers a specified window pulse width (or step rese time) different from the standard window values. A window is activated only for viewing a time domain response, and does not affect a displayed frequency domain response.

USE PASS CONTROL
: lets you control the analyzer with the computer over HP-IB as with the talker/listener mode, and also allows the analyzer to become a controller in order to plot, print, or directly access an external disk. During this peripheral operation, the host computer is free to perform other internal tasks that do not require use of the bus (the bus is tied up by the network analyzer during this time).

The pass control mode requires that the external controller is programmed to respond to a request for control and to issue a take control command. When the peripheral operation is complete, the analyzer passes control back to the computer. Refer to the "HP-IB Programming Reference" and "HP-IB Programming Examples" chapters in the *HP 8752C Network Analyzer Programmer's Guide* for more information.

In general, use the talker/listener mode for programming the analyzer unless direct peripheral access is required.

VELOCITY FACTOR
: Enters the velocity factor used by the analyzer to calculate equivalent electrical length in distance-to-fault measurements using the time domain option. Values entered should be less than 1.

VOLUME NUMBER
: specifies the number of the disk volume to be accessed. In general, all 3.5 inch floppy disks are considered one volume (volume 0). For hard disk drives, such as the HP 9153A (Winchester), a switch in the disk drive must be set to define the number of volumes on the disk. For more information, refer to the manual for the individual hard disk drive.

WAIT x
: pauses the execution of subsequent sequence commands for x number of seconds. Terminate this command with [x1].

Entering a 0 in wait x causes the instrument to wait for prior sequence command activities to finish before allowing the next command to begin. The wait 0 command only affects the command immediately following it, and does not affect commands later in the sequence.

WARNING — selects the warning annotation for color modification.

WARNING [ ] — brings up the color definition menu. The warning annotation default color is black.

WAVEGUIDE — defines the standard (and the offset) as rectangular waveguide. This causes the analyzer to assume a dispersive delay (see OFFSET DELAY above).

WIDTH VALUE — is used to set the amplitude parameter (for example 3 dB) that defines the start and stop points for a bandwidth search. The bandwidth search feature analyzes a bandpass or band reject trace and calculates the center point, bandwidth, and Q (quality factor) for the specified bandwidth. Bandwidth units are the units of the current format.

WIDTHS on OFF — turns on the bandwidth search feature and calculates the center stimulus value, bandwidth, and Q of a bandpass or band reject shape on the trace. The amplitude value that defines the passband or rejectband is set using the WIDTH VALUE softkey.

All four markers are turned on, and each has a dedicated use. Marker 1 is a starting point from which the search is begun. Marker 2 goes to the bandwidth center point. Marker 3 goes to the bandwidth cutoff point on the left, and marker 4 to the cutoff point on the right.

If a delta marker or fixed marker is on, it is used as the reference point from which the bandwidth amplitude is measured. For example, if marker 1 is the delta marker and is set at the passband maximum, and the width value is set to –3 dB, the bandwidth search finds the bandwidth cutoff points 3 dB below the maximum and calculates the 3 dB bandwidth and Q.

If marker 2 (the dedicated bandwidth center point marker) is the delta reference marker, the search finds the points 3 dB down from the center.

If no delta reference marker is set, the bandwidth values are absolute values.

WINDOW — (Option 010 only) is used to specify the parameters of the window in the transform menu.

WINDOW: MAXIMUM — (Option 010 only) sets the pulse width to the widest value allowed. This minimizes the sidelobes and provides the greatest dynamic range.

WINDOW: MINIMUM — (Option 010 only) is used to set the window of a time domain measurement to the minimum value. Provides essentially no window.

WINDOW: NORMAL	(Option 010 only) is used to set the window of a time domain measurement to the normal value. Usually the most useful because it reduces the sidelobes of the measurement somewhat.
(x1)	is used to terminate basic units: dB, dBm, Hz, dB/GHz, degrees, or seconds. It may also be used to terminate unitless entries such as averaging factor.
Y: Refl	converts reflection data to its equivalent admittance values.
Y: Trans	converts transmission data to its equivalent admittance values.
Z: Refl	converts reflection data to its equivalent impedance values.
Z: Trans	converts transmission data to its equivalent impedance values.

Cross Reference of Key Function to Programming Command

The following table lists the front-panel keys and softkeys alphabetically. The "Command" column identifies the command that is similar to the front-panel or softkey function. Softkeys that do not have corresponding programming commands are not included in this section.

Table 8-1. Cross Reference of Key Function to Programming Command

Key	Name	Command
▲	Step Up	UP
▼	Step Down	DOWN
Δ MODE OFF	Delta Marker Mode Off	DELO
Δ REF = 1	Delta Reference = Marker 1	DELR1
Δ REF = 2	Delta Reference = Marker 2	DELR2
Δ REF = 3	Delta Reference = Marker 3	DELR3
Δ REF = 4	Delta Reference = Marker 4	DELR4
Δ REF = Δ FIXED MKR	Delta Reference = Delta Fixed Marker	DELRFIXM
1/S	Inverted S-Parameters	CONVIDS
A	Measure Channel A	MEASA
A/B	Ratio of A to B	AB
A/R	Ratio of A to R	AR
ADD	Add	SADD
ADDRESS: CONTROLLER	Address of Controller	ADDRCONT
ADDRESS: DISK	Address of Disk	ADDRDISC
ADDRESS: P MTR/HPIB	Address of Power Meter/HPIB	ADDRPOWM
ALL SEGS SWEEP	All Segments Sweep	ASEG
ALTERNATE RFL/TRN	Alternate RFL/TRN	ALTAB
AMPLITUDE OFFSET	Amplitude Offset	LIMIAMPO
ANALOG IN Aux Input	Analog In	ANAI
ARBITRARY IMPEDANCE	Arbitrary Impedance	STDTARBI
ASCII	Save ASCII Format	SAVUASCI
ASSERT SRQ	Service Request	ASSS
AUTO FEED ON off (Plotter)	Plotter Auto Feed On	PLTTRAUTFON
AUTO FEED on OFF (Plotter)	Plotter Auto Feed Off	PLTTRAUTFOFF
AUTO FEED ON off (Printer)	Printer Auto Feed On	PRNTRAUTFON
AUTO FEED on OFF (Printer)	Printer Auto Feed Off	PRNTRAUTOFF

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
AUTO SCALE	Auto Scale	AUTO
AVERAGING FACTOR	Averaging Factor	AVERFACT
AVERAGING ON off	Averaging On	AVERON
AVERAGING on OFF	Averaging Off	AVEROFF
AVERAGING RESTART	Averaging Restart	AVERREST
(AVG)	Average	MENUAVG
B	Measure Channel B	MEASB
B/R	Ratio of B to R	BR
BACKGROUND INTENSITY	Background Intensity	BACI
BANDPASS	Bandpass	BANDPASS
BEEP DONE ON off	Beep Done On	BEEPDONEON
BEEP DONE on OFF	Beep Done Off	BEEPDONEOFF
BEEP FAIL ON off	Beep Fail On	BEEPFAILON
BEEP FAIL on OFF	Beep Fail Off	BEEPFAILOFF
BEEP WARN ON off	Beep Warn On	BEEPWARNON
BEEP WARN on OFF	Beep Warn Off	BEEPWARNOFF
BRIGHTNESS	Brightness	CBRI
C0	C0 Term	C0
C1	C1 Term	C1
C2	C2 Term	C2
C3	C3 Term	C3
(CAL)	Calibrate	MENUCAL
CAL KIT: 3.5mmC	3.5mmC Calibration Kit	CALK35MM
CAL KIT: 3.5mmD	3.5mmD Calibration Kit	CALK35MD
CAL KIT: 7mm	7mm Calibration Kit	CALK7MM
CAL KIT: N 50Ω	Type-N 50Ω Calibration Kit	CALKN50
CAL KIT: N 75Ω	Type-N 75Ω Calibration Kit	CALKN75
CAL KIT: USER KIT	User Calibration Kit	CALKUSED
CALIBRATE: NONE	Calibrate None	CALN
CENTER	Center, list freq subsweep	CENT
(CH 1)	Channel 1 Active	CHAN1
CH1 DATA [ ] (Printer)	Channel 1 Data (Print Color)	PCOLDATA1
CH1 DATA LIMIT LN (Display)	Channel 1 Data/Limit Line (Display Color)	COLOCH1D

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
CH1 MEM (Display)	Channel 1 Memory (Display Color)	COLOCH1M
CH1 MEM [ ] (Printer)	Channel 1 Memory (Printer Color)	PCOLMEMO1
(CH 2)	Channel 2 Active	CHAN2
CH2 DATA [ ] (Printer)	Channel 2 Data (Printer Color)	PCOLDATA2
CH2 DATA LIMIT LN (Display)	Channel 2 Data/Limit Line (Display Color)	COLOCH2D
CH2 MEM [ ] (Printer)	Channel 2 Memory (Printer Color)	PCOLMEMO2
CH2 MEM REF LINE (Display)	Channel 2 Memory Reference Line (Display Color)	COLOCH2M
CHAN PWR [COUPLED]	Channel Power Coupled	CHANPCPLD
CHAN PWR [UNCOUPLED]	Channel Power Uncoupled	CHANPUNCPLD
CHOP RFL/TRN	Chop RFL/TRN	CHOPAB
CLASS DONE	Class Done	CLAD
CLEAR BIT	Clear Bit	CLEABIT
CLEAR LIST	Clear List	CLEAL
CLEAR SEQUENCE	Clear Sequence	CLEASEQn
COAX	Coax	COAX
COLOR	Color	COLOR
CONTINUE SEQUENCE	Continue Sequence	CONS
CONTINUOUS	Continuous	CONT
CONVERSION [OFF]	Conversion Off	CONVOFF
(COPY)	Copy	MENUCOPY
CORRECTION ON off	Correction On	CORRON
CORRECTION on OFF	Correction Off	CORROFF
COUPLED CH ON off	Coupled Channel On	COUCON
COUPLED CH on OFF	Coupled Channel Off	COUCOFF
CW FREQ	CW Frequency	CWFREQ
CW TIME	CW Time	CWTIME
D2/D1 to D2 ON off	Ratio D2 to D1 On	D1DIVD2ON
D2/D1 to D2 on OFF	Ratio D2 to D1 Off	D1DIVD2OFF
DATA and MEMORY	Data and Memory	DISPDATM
DATA ARRAY ON off	Data Array On	EXTMDATAON
DATA ARRAY on OFF	Data Array Off	EXTMDATAOFF
DATA/MEM	Ratio Data to Memory	DISPDDM

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
DATA - MEM	Data Minus Memory	DISPDMM
DATA -> MEMORY	Data to Memory	DATI
DATA ONLY ON off	Data Only On	EXTMDATOON
DATA ONLY on OFF	Data Only Off	EXTMDATOOFF
DECR LOOP COUNTER	Decrement Loop Counter	DECRLOOC
DEFAULT COLORS	Default Colors	DEFC
DEFAULT PLOT SETUP	Default Plot Setup	DFLT
DEFAULT PRINT SETUP	Default Print Setup	DEFLPRINT
DEFINE STANDARD	Define Standard	DEFS
DELAY	Delay	DELA
DELETE	Delete Segment	SDEL
DELETE FILE	Delete File	PURG
DELTA LIMITS	Delta Limits	LIMD
DEMOD: AMPLITUDE	Demodulation Amplitude	DEMOAMPL
DEMOD: OFF	Demodulation Off	DEMOOFF
DEMOD: PHASE	Demodulation Phase	DEMOPHAS
DIRECTORY SIZE (LIF)	Directory Size	DIRS
DISK UNIT NUMBER	Disk Unit Number	DISCUNIT
DISP MKRS ON off	Display Markers On	DISM
DISP MKRS on OFF	Display Markers Off	DISM
DISPLAY	Display	MENUDISP
DISPLAY: DATA	Display Data	DISPDATA
DO SEQUENCE	Do Sequence	DOSEQn
DONE	Done	EDITDONE
DONE 1-PORT CAL	Done 1-Port Cal	SAV1
DONE: OPENS	Done: Opens	DONE
DONE: RESPONSE	Done: Response	RESPDONE
DONE: SHORTS	Done: Shorts	DONE
DONE RESP ISOL'N CAL	Done Response Isolation Cal	RAID
DONE SEQ MODIFY	Done Sequence Modify	DONM
DUAL CHAN ON off	Dual Channel On	DUACON
DUAL CHAN on OFF	Dual Channel Off	DUACOFF
DUPLICATE SEQUENCE	Duplicate Sequence	DUPLSEQxSEQy
EDIT	Edit	SEDI

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
EDIT LIMIT LINE	Edit Limit Line	EDITLIML
EDIT LIST	Edit List	EDITLIST
ELECTRICAL DELAY	Electrical Delay	ELED
EMIT BEEP	Emit Beep	EMIB
END SWEEP HIGH PULSE	End Sweep High Pulse	TTLHPULS
END SWEEP LOW PULSE	End Sweep Low Pulse	TTLLPULS
ENTRY OFF	Entry Off	ENTO
EXT TRIG ON POINT	External Trigger on Point	EXTTPOIN
EXT TRIG ON SWEEP	External Trigger on Sweep	EXTTON
EXTENSION INPUT A	Extension Input A	PORTA
EXTENSION INPUT B	Extension Input B	PORTB
EXTENSION REFL PORT	Extension Reflection Port	PORTR
EXTENSION TRANS PORT	Extension Transmission Port	PORTT
EXTENSIONS ON off	Extensions On	POREON
EXTENSIONS on OFF	Extensions Off	POREOFF
EXTERNAL DISK	Select External Disk Drive	EXTD
FILE NAME FILEO	File Name File 0	TITF0
FIXED	Fixed Load	FIXE
FIXED MKR AUX VALUE	Fixed Marker Auxiliary Value	MARKFAUV
FIXED MKR POSITION	Fixed Marker Position	DELRFIXM
FIXED MKR STIMULUS	Fixed Marker Stimulus	MARKFSTI
FIXED MKR VALUE	Fixed Marker Value	MARKFVAL
FLAT LINE	Flat Line	LIMTFL
FORMAT	Format	MENUFORM
FORMAT ARY ON off	Format Array On	EXTMFORMON
FORMAT ARY on OFF	Format Array Off	EXTMFORMOFF
FORMAT: DOS	Format DOS	FORMATDOS
FORMAT: LIF	Format LIF	FORMATLIF
FORMAT EXT DISK	Format External Disk	INIE
FORMAT INT MEMORY	Format Internal Memory	INTM
FREQUENCY BLANK	Frequency Blank	FREO
FULL PAGE	Full Page	FULP
FWD MATCH (Label Class)	Label Forward Match	LABEFWDM LABETTFM

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
FWD MATCH (Specify Class)	Specify Forward Match	SPECFWDM SPECTTFM
FWD TRANS (Label Class)	Label Forward Transmission	LABEFWDT LABETTFT
FWD TRANS (Specify Class)	Specify Forward Transmission	SPECFWDT SPECTTFT
G+jB MKR	G+jB Marker Readout	SMIMGB
GATE: CENTER	Gate Center	GATECENT
GATE: SPAN	Gate Span	GATESPAN
GATE: START	Gate Start	GATESTAR
GATE: STOP	Gate Stop	GATESTOP
GATE ON off	Gate On	GATEOON
GATE on OFF	Gate Off	GATEOOFF
GATE SHAPE MAXIMUM	Gate Shape Maximum	GATSMAXI
GATE SHAPE MINIMUM	Gate Shape Minimum	GATSMINI
GATE SHAPE NORMAL	Gate Shape Normal	GATSNORM
GATE SHAPE WIDE	Gate Shape Wide	GATSWIDE
GOSUB SEQUENCE	GOSUB Sequence	GOSUBSEQ
GRAPHICS ON off	Graphics On	EXTMGRAPON
GRAPHICS on OFF	Graphics Off	EXTMGRAPOFF
GRATICULE [ ] (Printer)	Graticule (Printer Color)	PCOLGRAT
GRATICULE TEXT (Display)	Modify Graticule Display Color	COLOGRAT
HOLD	Hold	HOLD
HP-IB DIAG ON off	HP-IB Diagnostics On	DEBUON
HP-IB DIAG on OFF	HP-IB Diagnostics Off	DEBUOFF
IF BW [ ]	IF Bandwidth	IFBW
IF LIMIT TEST FAIL	If Limit Test Fail	IFLTFAIL
IF LIMIT TEST PASS	If Limit Test Pass	IFLTPASS
IF LOOP COUNTER = 0	IF Loop Counter = 0	IFLCEQZE
IF LOOP < > COUNTER 0	IF Loop < > Counter 0	IFLCNEZE
IMAGINARY	Imaginary	IMAG
INCR LOOP COUNTER	Increment Loop Counter	INCRLOOC
INTENSITY	Intensity	INTE
INTERNAL MEMORY	Select Internal Memory	INTM

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
INTERPOL ON off	Interpolation On	CORION
INTERPOL on OFF	Interpolation Off	CORIOFF
ISOL'N STD	Isolation Standard	RAIISOL
KIT DONE (MODIFIED)	Kit Done	KITD
LABEL KIT	Label Kit	LABK
LABEL STD	Label Standard	LABS
LEFT LOWER	Select Left lower Display Quadrant	LEFL
LEFT UPPER	Select Left Upper Display Quadrant	LEFU
LIMIT LINE ON off	Limit Line On	LIMILINEON
LIMIT LINE on OFF	Limit Line Off	LIMILINEOFF
LIMIT TEST ON off	Limit Test On	LIMITESTON
LIMIT TEST on OFF	Limit Test Off	LIMITESTOFF
LIN FREQ	Linear Frequency	LINFREQ
LIN MAG	Linear Magnitude	LINM
LIN MKR	Linear Marker	POLMLIN
LINE TYPE DATA	Line Type Data	LINTDATA
LINE TYPE MEMORY	Line Type Memory	LINTMEMO
LIST FREQ	List Frequency	LISTFREQ
LIST VALUES	Display Tabular Listing of Measured Data	LISV
LOAD SEQ FROM DISK	Load Sequence From Disk	LOADSEQn
LOG FREQ	Logarithmic Frequency	LOGFREQ
LOG MAG	Logarithmic Magnitude	LOGM
LOG MKR	Logarithmic Marker	SMIMLOG
LOOP COUNTER	Loop Counter	LOOC
LOWER LIMIT	Lower Limit	LIML
LOW PASS IMPULSE	Low Pass Impulse	LOWPIMPU
LOW PASS STEP	Low Pass Step	LOWPSTEP
MANUAL TRG ON POINT	Manual Trigger On Point	MANTRIG
MARKER -> AMP. OFS.	Marker -> Amplitude Offset	LIMIMAOF
MARKER -> CENTER	Marker to Center	MARKCENT
MARKER -> CW	Marker to CW	MARKCW

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
MARKER -> DELAY	Marker to Delay	MARKDELA
MARKER -> MIDDLE	Marker to Middle	MARKMIDD
MARKER -> REFERENCE	Marker to Reference	MARKREF
MARKER -> SPAN	Marker to Span	MARKSPAN
MARKER -> START	Marker to Start	MARKSTAR
MARKER -> STIMULUS	Marker to Stimulus	MARKSTIM
MARKER -> STOP	Marker to Stop	MARKSTOP
MARKER 1	Marker 1	MARK1
MARKER 2	Marker 2	MARK2
MARKER 3	Marker 3	MARK3
MARKER 4	Marker 4	MARK4
MARKER all OFF	All Markers Off	MARKOFF
MARKERS: CONTINUOUS	Markers Continuous	MARKCONT
MARKERS: COUPLED	Markers Coupled	MARKCOUP
MARKERS: DISCRETE	Markers Discrete	MARKDISC
MARKERS: UNCOUPLED	Markers Uncoupled	MARKUNCO
MAXIMUM FREQUENCY	Maximum Frequency	MAXF
(MEAS)	Measure	MENUMEAS
MEASURE RESTART	Measure Restart	REST
MEMORY	Memory	DISPMEMO
MIDDLE VALUE	Middle Value	LIMM
MINIMUM FREQUENCY	Minimum Frequency	MINF
(MKR)	Marker	MENUMARK
(MKR FCTN)	Marker Function	MENUMRKF
MKR SEARCH [OFF]	Marker Search Off	SEAOFF
MKR ZERO	Marker Zero	MARKZERO
MODIFY [ ]	Modify Kit	MODI1
NEW SEQ/MODIFY SEQ	New Sequence/Modify Sequence	NEWSEQn
NUMBER OF GROUPS	Number of Groups	NUMG
NUMBER OF POINTS	Number of Points	POIN
OFFSET DELAY	Offset Delay	OFSD
OFFSET LOSS	Offset Loss	OFSL
OFFSET ZO	Offset Impedance	OFSZ
OP PARMS (MKRS etc)	Tabular Listing of Operating Parameters	OPEP

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
OPEN (F) (Response)	Open (Female)	STAND
OPEN (F) (Response & Isol'n)	Open (Female)	STAND
OPEN (F) (Reflection 1-Port)	Open (Female)	STANB
OPEN (M) (Response)	Open (Male)	STANC
OPEN (M) (Response & Isol'n)	Open (Male)	STANC
OPEN (M) (Reflection 1-Port)	Open (Male)	STANA
P MTR/HPIB TO TITLE	Power Meter HPIB to Title	PMTRTTIT
PAGE	Display Next Page of Tabular Listing	NEXP
PAUSE	Pause	PAUS
PAUSE TO SELECT	Pause to Select	PTOS
PEN NUM DATA	Pen Number Data	PENNDATA
PEN NUM GRATICULE	Pen Number Graticule	PENNGRAT
PEN NUM MARKER	Pen Number Marker	PENNMARK
PEN NUM MEMORY	Pen Number Memory	PENNMEMO
PEN NUM TEXT	Pen Number Text	PENNTEXT
PERIPHERAL HPIB ADDR	Peripheral HPIB Address	ADDRPERI
PHASE	Phase	PHAS
PHASE OFFSET	Phase Offset	PHAO
PLOT	Plot	PLOT
PLOT DATA ON off	Plot Data On	PDATAON
PLOT DATA on OFF	Plot Data Off	PDATAOFF
PLOT GRAT ON off	Plot Graticule On	PGRATON
PLOT GRAT on OFF	Plot Graticule Off	PGRATOFF
PLOT MEM ON off	Plot Memory On	PMEMON
PLOT MEM on OFF	Plot Memory Off	PMEMOFF
PLOT MKR ON off	Plot Marker ON	PMKRON
PLOT MKR on OFF	Plot Marker Off	PMKROFF
PLOT SPEED [FAST]	Plot Speed Fast	PLOSFAST
PLOT SPEED [SLOW]	Plot Speed Slow	PLOSSLOW

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
PLOT TEXT ON off	Plot Text On	PTEXTON
PLOT TEXT on OFF	Plot Text Off	PTEXTOFF
PLOTTER FORM FEED	Plotter Form Feed	PLTTRFORF
PLTR PORT: DISK	Plotter Port Disk	PLTPRTDISK
PLTR PORT: HPIB	Sets the Port	PLTPRTHPIB
PLTR PORT: HPIB	Sets the HP-IB Address	ADDRPLOT
PLTR TYPE [PLOTTER]	Plot to a Plotter	PLTTYPPLTR
PLTR TYPE [HPGL PRT]	Plot to a HP-GL/2 Compatible Printer	PLTTYPHPGL
POLAR	Polar	POLA
POWER	Power	POWE
POWER MTR: [436A]	Power Meter 436A	POWMON
POWER MTR: [437B/438A]	Power Meter 437B/438A	POWMOFF
POWER RANGES	Power Ranges	PWRR
POWER SWEEP	Power Sweep	POWS
PRESET	Factory Preset	RST PRES
PRESET: FACTORY	Factory Preset	RST PRES
PRINT: COLOR	Print Color	PRIC
PRINT: MONOCHROME	Print Monochrome	PRIS
PRINT SEQUENCE	Print Sequence	PRINSEQn
PRINTER ADDRESS	Printer Address	PRNPRTHPIB
PRINTER FORM FEED	Printer Form Feed	PRNTRFORF
PRNTR TYPE [DESKJET]	DeskJet Printer	PRNTYPDJ
PRNTR TYPE [EPSON-P2]	EPSON ESC/P2 Printer Central Language	PRNTYPEP
PRNTR TYPE [LASERJET]	LaserJet Printer	PRNTYPLJ
PRNTR TYPE [PAINTJET]	PaintJet Printer	PRNTYPPJ
PRNTR TYPE [THINKJET]	ThinkJet Printer	PRNTYPTJ
PWR RANGE AUTO man	Power Range Auto	PWRRPAUTO
PWR RANGE auto MAN	Power Range Man	PWRRPMAN
R	Measure Channel R	MEASR
R+jX MKR	R+jX Marker Readout	SMIMRX

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
RANGE 0 -15 TO +10	Power Range 0	PRAN0
RANGE 1 -25 TO 0	Power Range 1	PRAN1
RANGE 2 -35 TO -10	Power Range 2	PRAN2
RANGE 3 -45 TO -20	Power Range 3	PRAN3
RANGE 4 -55 TO -30	Power Range 4	PRAN4
RANGE 5 -65 TO -40	Power Range 5	PRAN5
RANGE 6 -75 TO -50	Power Range 6	PRAN6
RANGE 7 -85 TO -60	Power Range 7	PRAN7
RAW ARRAY ON oFF	Raw Array On	EXTMRAWON
RAW ARRAY on OFF	Raw Array Off	EXTMRAWOFF
Re/Im MKR	Real/Imaginary Markers	POLMRI
READ FILE TITLES	Read File Titles	REFT
REAL	Real	REAL
RECALL COLORS	Recall Colors	RECO
RECALL REG1	Recall Register 1	RECA1
RECALL REG2	Recall Register 2	RECA2
RECALL REG3	Recall Register 3	RECA3
RECALL REG4	Recall Register 4	RECA4
RECALL REG5	Recall Register 5	RECA5
RECALL REG6	Recall Register 6	RECA6
RECALL REG7	Recall Register 7	RECA7
REFERENCE POSITION	Reference Position	REFP
REFERENCE VALUE	Reference Value	REFV
REFLECTION 1-PORT	Reflection 1-Port	CALIS111
RESET COLOR	Reset Display Color	RSCO
RESPONSE (Calibrate)	Response	CALIRESP
RESPONSE (Label Class)	Response	LABERESP
RESPONSE (Specify Class)	Response	SPECRESP
RESPONSE & ISOL'N (Calibrate)	Response and Isolation	CALIRAI
RESPONSE & ISOL'N (Label Class)	Response and Isolation	LABERESI
RESPONSE & ISOL'N (Specify Class)	Response and Isolation	SPECRESI

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
PLOT TEXT ON off	Plot Text On	PTEXTON
PLOT TEXT on OFF	Plot Text Off	PTEXTOFF
PLOTTER FORM FEED	Plotter Form Feed	PLTTRFORF
PLTR PORT: DISK	Plotter Port Disk	PLTPRTDISK
PLTR PORT: HPIB	Sets the Port	PLTPRTHPIB
PLTR PORT: HPIB	Sets the HP-IB Address	ADDRPLOT
PLTR TYPE [PLOTTER]	Plot to a Plotter	PLTTYPPLTR
PLTR TYPE [HPGL PRT]	Plot to a HP-GL/2 Compatible Printer	PLTTYPHPGL
POLAR	Polar	POLA
POWER	Power	POWE
POWER MTR: [436A]	Power Meter 436A	POWMON
POWER MTR: [437B/438A]	Power Meter 437B/438A	POWMOFF
POWER RANGES	Power Ranges	PWRR
POWER SWEEP	Power Sweep	POWS
(PRESET)	Factory Preset	RST PRES
PRESET: FACTORY	Factory Preset	RST PRES
PRINT: COLOR	Print Color	PRIC
PRINT: MONOCHROME	Print Monochrome	PRIS
PRINT SEQUENCE	Print Sequence	PRINSEQn
PRINTER ADDRESS	Printer Address	PRNPRTHPIB
PRINTER FORM FEED	Printer Form Feed	PRNTRFORF
PRNTR TYPE [DESKJET]	DeskJet Printer	PRNTYPDJ
PRNTR TYPE [EPSON-P2]	EPSON ESC/P2 Printer Central Language	PRNTYPEP
PRNTR TYPE [LASERJET]	LaserJet Printer	PRNTYPLJ
PRNTR TYPE [PAINTJET]	PaintJet Printer	PRNTYPPJ
PRNTR TYPE [THINKJET]	ThinkJet Printer	PRNTYPTJ
PWR RANGE AUTO man	Power Range Auto	PWRRPAUTO
PWR RANGE auto MAN	Power Range Man	PWRRPMAN
R	Measure Channel R	MEASR
R+jX MKR	R+jX Marker Readout	SMIMRX

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
S22C LN RV TRAN (Label Class)	S_{22}C Line Reverse Transmission	LABES22C LABETLRT
S22C LN RV TRAN (Specify Class)	S_{22}C Line Reverse Transmission	SPECS22C SPECTLRT
SAVE COLORS	Save Display Color Set	SVCO
SAVE USER KIT	Save User Kit	SAVEUSEK
SAVE USING BINARY	Save Using Binary	SAVUBINA
SCALE/DIV	Scale/Division	SCAL
SCALE PLOT [FULL]	Scale Plot Full	SCAPFULL
SCALE PLOT [GRAT]	Scale Plot Graticule	SCAPGRAT
(SCALE REF)	Scale Reference	MENUSCAL
SEARCH LEFT	Search Left	SEAL
SEARCH RIGHT	Search Right	SEAR
SEARCH: MAX	Search Maximum	SEAMAX
SEARCH: MIN	Search Minimum	SEAMIN
SEARCH: OFF	Search Off	SEAOFF
SEGMENT: CENTER	Segment: Center	CENT
SEGMENT: SPAN	Segment: Span	SPAN
SEGMENT: START	Segment: Start	STAR
SEGMENT: STOP	Segment: Stop	STOP
SEQUENCE 1 SEQ1	Select Sequence 1	SEQ1
SEQUENCE 2 SEQ2	Select Sequence 2	SEQ2
SEQUENCE 3 SEQ3	Select Sequence 3	SEQ3
SEQUENCE 4 SEQ4	Select Sequence 4	SEQ4
SEQUENCE 5 SEQ5	Select Sequence 5	SEQ5
SEQUENCE 6 SEQ6	Select Sequence 6	SEQ6
SET BIT	Set Bit	SETBIT
SET FREQ LOW PASS	Set Frequency Low Pass	SETF
SET ZO	Set Impedance	SETZ
SHORT (F) (Response)	Short (Female)	STANB
SHORT (F) (Response & Isol'n)	Short (Female)	STANB
SHORT (F) (Reflection 1-Port)	Short (Female)	STANB

Table 8-1.
Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
SHORT (M) (Response)	Short (Male)	STANA
SHORT (M) (Response & Isol'n)	Short (Male)	STANA
SHORT (M) (Reflection 1-Port)	Short (Male)	STANA
SHOW MENUS	Show Menus	SHOM
SINGLE	Single Sweep	SING
SINGLE POINT	Single Point	LIMTSP
SINGLE SEG SWEEP	Single Segment Sweep	SSEG
SLIDING	Sliding	SLIL
SLOPE	Power Slope	SLOPE
SLOPE ON off	Power Slope On	SLOPON
SLOPE on OFF	Power Slope Off	SLOPOFF
SLOPING LINE	Sloping Line	LIMTSL
SMITH CHART	Smith Chart	SMIC
SMOOTHING APERTURE	Smoothing Aperture	SMOOAPER
SMOOTHING ON off	Smoothing On	SMOOON
SMOOTHING on OFF	Smoothing Off	SMOOOFF
SOURCE PWR ON off	Source Power On	SOUPON
SOURCE PWR on OFF	Source Power Off	SOUPOFF
SPECIFY GATE	Specify Gate	SPEG
SPLIT DISP ON off	Split Display On	SPLDON
SPLIT DISP on OFF	Split Display Off	SPLDOFF
(START)	Start	LOFSTAR
STATS ON off	Statistics On	MEASTATON
STATS on OFF	Statistics Off	MEASTATOFF
STD DONE (DEFINED)	Standard Done	STDD
STD TYPE: ARBITRARY IMPEDANCE	Standard Type: Arbitrary Impedance	STDTARBI
STD TYPE: DELAY/THRU	Standard Type: Delay/Thru	STDTDELA
STD TYPE: LOAD	Standard Type: Load	STDTLOAD
STD TYPE: OPEN	Standard Type: Open	STDTOPEN
STD TYPE: SHORT	Standard Type: Short	STDTSHOR
STEP SIZE	Step Size	STPSIZE

Table 8-1. Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
STIMULUS VALUE	Stimulus Value	LIMS
STIMULUS OFFSET	Stimulus Offset	LIMISTIO
(STOP)	Stop	LOFSTOP
STOP	Stop	STOP
STORE SEQ TO DISK	Store Sequence to Disk	STORSEQn
SWEEP	Sweep Mode	LOFSWE
SWEEP TIME [ ]	Sweep Time	SWET
SWR	SWR	SWR
(SYSTEM)	System	MENUSYST
TALKER/LISTENER	Talker/Listener	TALKLIST
TARGET	Target	SEATARG
TERMINAL IMPEDANCE	Terminal Impedance	TERI
TEXT (Display)	Text Display Color	COLOTEX
TEXT [ ] (Printer)	Text Printer Color	PCOLTEX
TINT	Tint	TINT
TITLE	Title	TITL
TITLE SEQUENCE	Title Sequence	TITSEQn
TITLE TO MEMORY	Title to Memory	TITTMEM
TITLE TO P MTR/HPIB	Title to Power Meter/HPIB	TITTPMTR
TITLE TO PERIPHERAL	Title to HP-IB Peripheral	TITTPERI
TITLE TO PRINTER	Title to Printer	TITTPRIN
TRACKING ON off	Tracking On	TRACKON
TRACKING on OFF	Tracking Off	TRACKOFF
TRANSFORM ON off	Transform On	TIMDTRANON
TRANSFORM on OFF	Transform Off	TIMDTRANOFF
TRIGGER: TRIG OFF	External Trigger Off	EXTTOFF
TTL IN IF BIT H	TTL in if Bit High	IFBIHIGH
TTL IN IF BIT L	TTL in if Bit Low	IFBILOW
TTL OUT ALL	TTL Out All	TTLOA
UPPER LIMIT	Upper Limit	LIMU
USE MEMORY ON off	Use Memory On	WINDUSEMON
USE MEMORY on OFF	Use Memory Off	WINDUSEMOFF
USE PASS CONTROL	Use Pass Control	USEPASC
VELOCITY FACTOR	Velocity Factor	VELOFACT

Table 8-1. Cross Reference of Key Function to Programming Command (continued)

Key	Name	Command
VOLUME NUMBER	Volume Number	DISCVOLU
WAIT x	Wait X Seconds	SEQWAIT
WARNING (Display)	Warning Display Color	COLOWARN
WARNING [ ] (Printer)	Warning Printer Color	PCOLWARN
WAVEGUIDE	Waveguide	WAVE
WIDTH VALUE	Width Value	WIDV
WIDTHS ON off	Widths On	WIDTON
WIDTHS on OFF	Widths Off	WIDTOFF
WINDOW	Window	WINDOW
WINDOW: MAXIMUM	Window Maximum	WINDMAXI
WINDOW: MINIMUM	Window Minimum	WINDMINI
WINDOW: NORMAL	Window Normal	WINDNORM
Y: Refl	Y: Reflection	CONVYREF
Y: Trans	Y: Transmission	CONVYTRA
Z: Refl	Z: Reflection	CONVZREF
Z: Trans	Z: Transmission	CONVZTRA

Softkey Locations

The following table lists the softkey functions alphabetically, and the corresponding front-panel access key.

Table 8-2. Softkey Locations

Softkey	Front-Panel Access Key
Δ MODE MENU	MRK
Δ MODE OFF	MRK
Δ REF = 1	MRK
Δ REF = 2	MRK
Δ REF = 3	MRK
Δ REF = 4	MRK
Δ REF = Δ FIXED MKR	MRK
1/S	MEAS
A	MEAS
A/B	MEAS
A/R	MEAS
ACTIVE ENTRY	DISPLAY
ACTIVE MRK MAGNITUDE	DISPLAY
ADD	MENU
ADDRESS: 8752	LOCAL
ADDRESS: CONTROLLER	LOCAL
ADDRESS: DISK	LOCAL
ADDRESS: DISK	SAVE/RECALL
ADDRESS: P MTR/HPIB	LOCAL
ADJUST DISPLAY	DISPLAY
ALL SEGS SWEEP	MENU
ALTERNATE RFL/TRN	CAL
AMPLITUDE OFFSET	SYSTEM
ANALOG IN Aux Input	MEAS
ASCII	SAVE RECALL
ASSERT SRQ	SEQ
AUTO FEED on OFF	COPY
AUTO SCALE	SCALE REF

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
AUX OUT on OFF	(MEAS)
AVERAGING FACTOR	(AVG)
AVERAGING on OFF	(AVG)
AVERAGING RESTART	(AVG)
B	(MEAS)
B/R	(MEAS)
BACKGROUND INTENSITY	(DISPLAY)
BANDPASS	(SYSTEM)
BEEP DONE ON off	(DISPLAY)
BEEP FAIL on OFF	(SYSTEM)
BEEP WARN on OFF	(DISPLAY)
BRIGHTNESS	(DISPLAY)
C0	(CAL)
C1	(CAL)
C2	(CAL)
C3	(CAL)
CAL KIT [ ]	(CAL)
CAL KIT: 3.5mmC	(CAL)
CAL KIT: 3.5mmD	(CAL)
CAL KIT: 7mm	(CAL)
CAL KIT: N 50Ω	(CAL)
CAL KIT: N 75Ω	(CAL)
CAL KIT: USER KIT	(CAL)
CALIBRATE MENU	(CAL)
CALIBRATE: NONE	(CAL)
CENTER	(MENU)
CENTER	(SYSTEM)
CH1 DATA [ ]	(COPY)
CH1 DATA LIMIT LN	(DISPLAY)
CH1 MEM	(DISPLAY)
CH1 MEM [ ]	(COPY)
CH2 DATA [ ]	(COPY)
CH2 DATA LIMIT LN	(DISPLAY)

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
CH2 MEM [ ]	COPY
CH2 MEM REF LINE	DISPLAY
CHAN PWR [COUPLED]	MENU
CHAN PWR [UNCOUPLED]	MENU
CHOP RFL/TRN	CAL
CLEAR BIT	SEQ
CLEAR LIST	MENU
CLEAR SEQUENCE	SEQ
COAX	CAL
COLOR	DISPLAY
CONFIGURE EXT DISK	SAVE/RECALL
CONTINUE SEQUENCE	SEQ
CONTINUOUS	MENU
CONVERSION [ ]	MEAS
CORRECTION on OFF	CAL
COUNTER: ANALOG BUS	MEAS
COUNTER: DIV FRAC N	MEAS
COUNTER: FRAC N	MEAS
COUNTER: OFF	MEAS
COUPLED CH on OFF	MENU
CW FREQ	MENU
CW TIME	MENU
D2/D1 to D2 on OFF	DISPLAY
DATA and MEMORY	DISPLAY
DATA ARRAY on OFF	SAVE RECALL
DATA/MEM	DISPLAY
DATA - MEM	DISPLAY
DATA -> MEMORY	DISPLAY
DATA ONLY on OFF	SAVE RECALL
DECISION MAKING	SEQ
DECR LOOP COUNTER	SEQ
DEFAULT COLORS	DISPLAY
DEFAULT PLOT SETUP	COPY
DEFAULT PRINT SETUP	COPY

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
DEFINE DISK-SAVE	SAVE RECALL
DEFINE PLOT	COPY
DEFINE PRINT	COPY
DEFINE STANDARD	CAL
DELAY	FORMAT
DELETE FILE	SAVE/RECALL
DELTA LIMITS	SYSTEM
DEMOD: AMPLITUDE	SYSTEM
DEMOD: OFF	SYSTEM
DEMOD: PHASE	SYSTEM
DIRECTORY SIZE (LIF)	SAVE RECALL
DISK UNIT NUMBER	LOCAL
DISK UNIT NUMBER	SAVE/RECALL
DISP MKRS ON off	MRK
DISPLAY: DATA	DISPLAY
DO SEQUENCE	SEQ
DONE 1-PORT CAL	CAL
DONE: OPENS	CAL
DONE: RESPONSE	CAL
DONE: SHORTS	CAL
DONE RESP ISOL'N CAL	CAL
DONE SEQ MODIFY	SEQ
DUAL CHAN on OFF	DISPLAY
DUPLICATE SEQUENCE	SEQ
EDIT LIMIT LINE	SYSTEM
EDIT LIST	MENU
ELECTRICAL DELAY	SCALE REF
EMIT BEEP	SEQ
END OF LABEL	DISPLAY
END SWEEP HIGH PULSE	SEQ
END SWEEP LOW PULSE	SEQ
ERASE TITLE	CAL
ERASE TITLE	DISPLAY
ERASE TITLE	SAVE RECALL

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
EXT TRIG ON POINT	MENU
EXT TRIG ON SWEEP	MENU
EXTENSION INPUT A	CAL
EXTENSION INPUT B	CAL
EXTENSION REFL PORT	CAL
EXTENSION TRANS PORT	CAL
EXTENSIONS on OFF	CAL
EXTERNAL DISK	SAVE/RECALL
FILE NAME FILE0	SAVE/RECALL
FIXED	CAL
FIXED MKR AUX VALUE	MRK
FIXED MKR POSITION	MRK
FIXED MKR STIMULUS	MRK
FIXED MKR VALUE	MRK
FLAT LINE	SYSTEM
FORM FEED	DISPLAY
FORMAT ARY on OFF	SAVE/RECALL
FORMAT DISK	SAVE/RECALL
FORMAT: DOS	SAVE/RECALL
FORMAT: LIF	SAVE/RECALL
FORMAT EXT DISK	SAVE/RECALL
FORMAT INT MEMORY	SAVE/RECALL
FORWARD: LOAD	CAL
FORWARD: OPENS	CAL
FORWARD: SHORTS	CAL
FREQUENCY	CAL
FREQUENCY BLANK	DISPLAY
FULL PAGE	COPY
FWD MATCH	CAL
FWD TRANS	CAL
G+jB MKR	MRK
GATE: CENTER	SYSTEM
GATE: SPAN	SYSTEM
GATE: START	SYSTEM

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
GATE: STOP	SYSTEM
GATE on OFF	SYSTEM
GATE SHAPE	SYSTEM
GATE SHAPE MAXIMUM	SYSTEM
GATE SHAPE MINIMUM	SYSTEM
GATE SHAPE NORMAL	SYSTEM
GATE SHAPE WIDE	SYSTEM
GOSUB SEQUENCE	SEQ
GRAPHICS on OFF	SAVE RECALL
GRATICULE [ ]	COPY
GRATICULE TEXT	DISPLAY
HOLD	MENU
HP-IB DIAG on off	LOCAL
IF BW [ ]	AVG
IF LIMIT TEST FAIL	SEQ
IF LIMIT TEST PASS	SEQ
IF LOOP COUNTER = 0	SEQ
IF LOOP < > COUNTER 0	SEQ
IMAGINARY	FORMAT
INCR LOOP COUNTER	SEQ
INPUT PORTS	MEAS
INTENSITY	DISPLAY
INTERNAL MEMORY	SAVE/RECALL
INTERPOL on OFF	CAL
ISOL'N STD	CAL
ISTATE CONTENTS	SAVE/RECALL
KIT DONE (MODIFIED)	CAL
LABEL CLASS	CAL
LABEL CLASS DONE	CAL
LABEL KIT	CAL
LABEL STD	CAL
LEFT LOWER	COPY
LEFT UPPER	COPY
LIMIT LINE OFFSETS	SYSTEM

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
LIMIT LINE on OFF	SYSTEM
LIMIT MENU	SYSTEM
LIMIT TEST on OFF	SYSTEM
LIMIT TEST RESULT	DISPLAY
LIMIT TYPE	SYSTEM
LIN FREQ	MENU
LIN MAG	FORMAT
LIN MKR	MRK
LINE TYPE DATA	COPY
LINE TYPE MEMORY	COPY
LIST	COPY
LIST FREQ	MENU
LOAD SEQ FROM DISK	SEQ
LOG FREQ	MENU
LOG MAG	FORMAT
LOG MKR	MRK
LOOP COUNTER	SEQ
LOOP COUNTER	DISPLAY
LOWER LIMIT	SYSTEM
LOW PASS IMPULSE	SYSTEM
LOW PASS STEP	SYSTEM
MANUAL TRG ON POINT	MENU
MARKER -> AMP. OFS.	SYSTEM
MARKER -> CENTER	MRK FCTN
MARKER -> CW	SEQ
MARKER -> DELAY	MRK FCTN
MARKER -> DELAY	SCALE REF
MARKER -> MIDDLE	SYSTEM
MARKER -> REFERENCE	MRK FCTN
MARKER -> REFERENCE	SCALE REF
MARKER -> SPAN	MRK FCTN
MARKER -> START	MRK FCTN
MARKER -> STIMULUS	SYSTEM
MARKER -> STOP	MRK FCTN

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
MARKER 1	MRK
MARKER 2	MRK
MARKER 3	MRK
MARKER 4	MRK
MARKER all OFF	MRK
MARKER MODE MENU	MRK
MARKERS: CONTINUOUS	MRK
MARKERS: COUPLED	MRK
MARKERS: DISCRETE	MRK
MARKERS: UNCOUPLED	MRK
MAXIMUM FREQUENCY	CAL
MEASURE RESTART	MENU
MEMORY	DISPLAY
MIDDLE VALUE	SYSTEM
MINIMUM FREQUENCY	CAL
MKR SEARCH [ ]	MRK FCTN
MKR ZERO	MRK
MODIFY [ ]	CAL
MODIFY COLORS	DISPLAY
NEW SEQ/MODIFY SEQ	SEQ
NEWLINE	DISPLAY
NORMAL	SYSTEM
NUMBER OF GROUPS	MENU
NUMBER OF POINTS	MENU
OFFSET DELAY	CAL
OFFSET LOSS	CAL
OFFSET Z0	CAL
OP PARMS (MKRS etc)	COPY
OPEN (F)	CAL
OPEN (M)	CAL
P MTR/HPIB TO TITLE	SEQ
PAUSE TO SELECT	SEQ
PEN NUM DATA	COPY
PEN NUM GRATICULE	COPY

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
PEN NUM MARKER	COPY
PEN NUM MEMORY	COPY
PEN NUM TEXT	COPY
PERIPHERAL HPIB ADDR	SEQ
PHASE	FORMAT
PHASE OFFSET	SCALE REF
PLOT	COPY
PLOT DATA ON off	COPY
PLOT GRAT ON off	COPY
PLOT MEM ON off	COPY
PLOT MKR ON off	COPY
PLOT SPEED [ ]	COPY
PLOT TEXT ON off	COPY
PLOTTER FORM FEED	COPY
PLOTTER PORT	LOCAL
PLTR PORT: DISK	LOCAL
PLTR PORT: HPIB	LOCAL
PLTR TYPE [PLOTTER]	LOCAL
PLTR TYPE [HPGL PRT]	LOCAL
POLAR	FORMAT
POLAR MKR MENU	MRK
PORT EXTENSIONS	CAL
POWER	MENU
POWER MTR [436A]	LOCAL
POWER MTR [437B/438A]	LOCAL
POWER RANGES	MENU
POWER SWEEP	MENU
PRESET: FACTORY	PRESET
PRESET: USER	PRESET
PRINT: COLOR	COPY
PRINT: MONOCHROME	COPY
PRINT COLORS	COPY
PRINT MONOCHROME	COPY
PRINT SEQUENCE	SEQ

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
PRINTER ADDRESS	LOCAL
PRINTER FORM FEED	COPY
PRINTER PORT	LOCAL
PRNTR TYPE [ ]	LOCAL
PWR RANGE AUTO man	MENU
R	MEAS
R+jX MKR	MRK
RANGE 0 -15 TO +10	MENU
RANGE 1 -25 TO 0	MENU
RANGE 2 -35 TO -10	MENU
RANGE 3 -45 TO -20	MENU
RANGE 4 -55 TO -30	MENU
RANGE 5 -65 TO -40	MENU
RANGE 6 -75 TO -50	MENU
RANGE 7 -85 TO -60	MENU
RAW ARRAY on OFF	SAVE/RECALL
Re/Im MKR	MRK
REAL	FORMAT
RECALL KEYS on OFF	SAVE/RECALL
RECALL COLORS	DISPLAY
RECALL REG1	SAVE/RECALL
RECALL REG2	SAVE/RECALL
RECALL REG3	SAVE/RECALL
RECALL REG4	SAVE/RECALL
RECALL REG5	SAVE/RECALL
RECALL REG6	SAVE/RECALL
RECALL REG7	SAVE/RECALL
RECALL STATE	SAVE/RECALL
REFERENCE POSITION	SCALE REF
REFERENCE VALUE	SCALE REF
REFLECTION 1-PORT	CAL
RE-SAVE STATE	SAVE/RECALL
RESET COLOR	DISPLAY
RESOLUTION [ ]	MEAS

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
RESPONSE	CAL
RESPONSE & ISOL'N	CAL
RESTORE DISPLAY	COPY
RESUME CAL SEQUENCE	CAL
REV MATCH	CAL
REV TRANS	CAL
RIGHT LOWER	COPY
RIGHT UPPER	COPY
S11A RE FW MTCH	CAL
S11B LN FW MTCH	CAL
S11C LN FW TRAN	CAL
S22A RE RV MTCH	CAL
S22B LN RV MTCH	CAL
S22C LN RV TRAN	CAL
SAVE COLORS	DISPLAY
SAVE USER KIT	CAL
SAVE USING BINARY	SAVE/RECALL
SCALE/DIV	SCALE REF
SCALE PLOT [FULL]	COPY
SCALE PLOT [GRAT]	COPY
SEARCH LEFT	MRK FCTN
SEARCH RIGHT	MRK FCTN
SEARCH: MAX	MRK FCTN
SEARCH: MIN	MRK FCTN
SEARCH: OFF	MRK FCTN
SEGMENT	CAL
SEGMENT	SYSTEM
SEGMENT: CENTER	MENU
SEGMENT: SPAN	MENU
SEGMENT: START	MENU
SEGMENT: STOP	MENU
SEL QUAD [ ]	COPY
SELECT LETTER	DISPLAY
SEQUENCE 1 SEQ1	SEQ

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
SEQUENCE 2 SEQ2	SEQ
SEQUENCE 3 SEQ3	SEQ
SEQUENCE 4 SEQ4	SEQ
SEQUENCE 5 SEQ5	SEQ
SEQUENCE 6 SEQ6	SEQ
SET ADDRESSES	LOCAL
SET BIT	SEQ
SET FREQ LOW PASS	SYSTEM
SET ZO	CAL
SHORT (F)	CAL
SHORT (M)	CAL
SINGLE	MENU
SINGLE POINT	SYSTEM
SINGLE SEG SWEEP	MENU
SLIDING	CAL
SLOPE	MENU
SLOPE on OFF	MENU
SLOPING LINE	SYSTEM
SMITH CHART	FORMAT
SMITH MKR MENU	MRK
SMOOTHING APERTURE	AVG
SMOOTHING on OFF	AVG
SOURCE PWR ON off	MENU
SPECIAL FUNCTIONS	SEQ
SPECIFY CLASS	CAL
SPECIFY GATE	SYSTEM
SPECIFY OFFSET	CAL
SPLIT DISP on OFF	DISPLAY
STATS on OFF	MRK FCTN
STD DONE (MODIFIED)	CAL
STD OFFSET DONE	CAL
STD TYPE: ARBITRARY IMPEDANCE	CAL
STD TYPE: DELAY/THRU	CAL
STD TYPE: LOAD	CAL

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
STD TYPE: OPEN	CAL
STD TYPE: SHORT	CAL
STEP SIZE	MENU
STIMULUS VALUE	SYSTEM
STIMULUS OFFSET	SYSTEM
STORE SEQ TO DISK	SEQ
SWEEP	SYSTEM
SWEEP TIME [ ]	MENU
SWEEP TYPE MENU	MENU
SWR	FORMAT
SYSTEM CONTROLLER	LOCAL
TALKER/LISTENER	LOCAL
TARGET	MRK FCTN
TERMINAL IMPEDANCE	CAL
TEXT	DISPLAY
TEXT [ ]	COPY
THRU	CAL
TINT	DISPLAY
TITLE	DISPLAY
TITLE SEQUENCE	SEQ
TITLE TO MEMORY	SEQ
TITLE TO P MTR/HPIB	SEQ
TITLE TO PERIPHERAL	SEQ
TITLE TO PRINTER	SEQ
TRACKING on OFF	MRK FCTN
TRANSFORM MENU	SYSTEM
TRANSFORM on OFF	SYSTEM
TRIGGER MENU	MENU
TRIGGER: TRIG OFF	MENU
TTL I/O	SEQ
TTL IN IF BIT H	SEQ
TTL IN IF BIT L	SEQ
TTL OUT ALL	SEQ
UPPER LIMIT	SYSTEM

Table 8-2. Softkey Locations (continued)

Softkey	Front-Panel Access Key
USE MEMORY on OFF	SYSTEM
USE PASS CONTROL	LOCAL
VELOCITY FACTOR	CAL
VOLUME NUMBER	LOCAL
VOLUME NUMBER	SAVE/RECALL
WAIT x	SEQ
WARNING	DISPLAY
WARNING [ ]	COPY
WAVEGUIDE	CAL
WIDTH VALUE	MRK FCTN
WIDTHS on OFF	MRK FCTN
WINDOW	SYSTEM
WINDOW: MAXIMUM	SYSTEM
WINDOW: MINIMUM	SYSTEM
WINDOW: NORMAL	SYSTEM
Y: Refl	MEAS
Y: Trans	MEAS
Z: Refl	MEAS
Z: Trans	MEAS

9

Error Messages

This chapter contains the following information to help you interpret any error messages that may be displayed on the analyzer CRT or transmitted by the instrument over HP-IB:

- An alphabetical listing of all error messages, including:
  - an explanation of the message
  - suggestions to help solve the problem
- a numerical listing of all error messages

Note Some messages described in this chapter are for information only and do not indicate an error condition. These messages are not numbered and so they will not appear in the numerical listing.

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, and Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.
- Chapter 8, "Key Definitions," describes all the front panel keys, softkeys, and their corresponding HP-IB commands.
- Chapter 11, "Preset State and Memory Allocation," contains a discussion of memory allocation, memory storage, instrument state definitions, and preset conditions.

Error Messages in Alphabetical Order

ABORTING COPY OUTPUT

Information Message	This message is displayed briefly if you have pressed (LOCAL) to abort a copy operation. If the message is not subsequently replaced by error message number 25, PRINT ABORTED, the copy device may be hung. Press (LOCAL) once more to exit the abort process and verify the status of the copy device. At this point, the copy device will probably have an error condition which must be fixed. (For example: out of paper or paper jam.)

ADDITIONAL STANDARDS NEEDED

Error Number 68	Error correction for the selected calibration class cannot be computed until you have measured all the necessary standards.

ADDRESSED TO TALK WITH NOTHING TO SAY

Error Number 31	You have sent a read command to the analyzer (such as ENTER 716) without first requesting data with an appropriate output command (such as OUTPDATA). The analyzer has no data in the output queue to satisfy the request.

ALL REGISTERS HAVE BEEN USED

Error Number 200	You have used all of the available registers; you can store no more instrument states even though you may still have sufficient memory. There are 31 registers available plus the present instrument state.

ASCII: MISSING 'BEGIN' STATEMENT

Error Number 193	The citifile you just downloaded over the HP-IB or via disk was not properly organized. The analyzer is unable to read the "BEGIN" statement.

ASCII: MISSING 'CITIFILE' STATEMENT

Error Number 194	The citifile you just downloaded over the HP-IB or via disk was not properly organized. The analyzer is unable to read the "CITIFILE" statement.

ASCII: MISSING 'DATA' STATEMENT

Error Number 195 — The citifile you just downloaded over the HP-IB or via disk was not properly organized. The analyzer is unable to read the "DATA" statement.

ASCII: MISSING 'VAR' STATEMENT

Error Number 196 — The citifile you just downloaded over the HP-IB or via disk was not properly organized. The analyzer is unable to read the "VAR" statement.

AVERAGING INVALID ON NON-RATIO MEASURE

Error Number 13 — You cannot use sweep-to-sweep averaging in single-input measurements. Sweep-sweep averaging is valid only for ratioed measurements (A/R, B/R, A/B, and reflection and transmission). You can use other noise reduction techniques for single input measurements.

BATTERY FAILED. STATE MEMORY CLEARED

Error Number 183 — The battery protection of the non-volatile CMOS memory has failed. The CMOS memory has been cleared. Refer to the *HP 8752C Network Analyzer Service Guide* for battery replacement instructions. See Chapter 11, "Preset State and Memory Allocation," for more information about the CMOS memory.

BATTERY LOW! STORE SAVE REGS TO DISK

Error Number 184 — The battery protection of the non-volatile CMOS memory is in danger of failing. If this occurs, all of the instrument state registers stored in CMOS memory will be lost. Save these states to a disk and refer to the *HP 8752C Network Analyzer Service Guide* for battery replacement instructions. See Chapter 11, "Preset State and Memory Allocation," for more information about the CMOS memory.

BLOCK INPUT ERROR

Error Number 34 — The analyzer did not receive a complete data transmission. This is usually caused by an interruption of the bus transaction. Clear by pressing the [LOCAL] key or aborting the I/O process at the controller.

BLOCK INPUT LENGTH ERROR

Error Number 35 — The length header received by the analyzer did not agree with the size of the internal array block. Refer to the *HP 8752C Network Analyzer Programmer's Guide* for instructions on using analyzer input commands.

CALIBRATION ABORTED

Error Number 74 — You have changed the active channel during a calibration so the calibration in progress was terminated. Make sure the appropriate channel is active and restart the calibration.

CALIBRATION REQUIRED

Error Number 63 — A calibration set could not be found that matched the current stimulus state or measurement parameter. You will have to perform a new calibration.

CANNOT FORMAT DOS DISKS ON THIS DRIVE

Error Number 185 — You have attempted to initialize a floppy disk to DOS format on an external disk drive that does not support writing to all 80 tracks of the double density (gray) and high density disks (usually black). The older single-sided disks (blue) had only 66 tracks and some disk drives were limited to accessing that number of tracks. To format the disk, choose another disk drive.

CANNOT MODIFY FACTORY PRESET

Error Number 199 — You have attempted to rename, delete, or otherwise alter the factory preset state. The factory preset state is permanently stored in CMOS memory and cannot be altered. If your intent was to create a user preset state, you must create a new instrument state, save it, and then rename it to "UPRESET". Refer to Chapter 11, "Preset State and Memory Allocation," for more detailed instructions.

CAN'T CHANGE-ANOTHER CONTROLLER ON BUS

Error Number 37 — You must remove the active controller from the bus or the controller must relinquish the bus before the analyzer can assume the system controller mode.

CAN'T STORE/LOAD SEQUENCE, INSUFFICIENT MEMORY

Error Number 127	Your sequence transfer to or from an external disk could not be completed due to insufficient memory.

CH1 (CH2) TARGET VALUE NOT FOUND

Error Number 159	Your target value for the marker search function does not exist on the current data trace.

CONTINUOUS SWITCHING NOT ALLOWED

Error Number 10	Your current measurement requires the power range to switch between channel 1 and channel 2. To protect the attenuator from undue mechanical wear, it will not be switched continuously. The "tsH" (test set hold) indicator in the left margin of the display indicates that the inactive channel has been put in the sweep hold mode. This error only occurs in instruments with option 004.

COPY: device not responding; copy aborted

Error Number 170	The printer or plotter is not accepting data. Verify the cable connections, HP-IB addresses, and otherwise ensure that the copy device is ready.

COPY OUTPUT COMPLETED

Information Message	The analyzer has completed outputting data to the printer or plotter. The analyzer can now accept another copy command.

CORRECTION AND DOMAIN RESET

Error Number 65	When you change the frequency range, sweep type, or number of points, error correction is turned off and the time domain transform is recalculated without error correction. You can either correct the frequency range, sweep type, or number of points to match the calibration, or perform a new calibration. Then perform a new time domain transform.

CORRECTION CONSTANTS NOT STORED

Error Number 3	A store operation to the EEPROM was not successful. You must change the position of the jumper on the A9 CPU assembly. Refer to the "A9 CC Jumper Position Procedure" in the "Adjustments and Correction Constants" chapter of the *HP 8752C Network Analyzer Service Guide*.

CORRECTION TURNED OFF

Error Number 66 — Critical parameters in your current instrument state do not match the parameters for the calibration set, therefore correction has been turned off. The critical instrument state parameters are sweep type, start frequency, frequency span, and number of points.

CURRENT PARAMETER NOT IN CAL SET

Error Number 64 — Correction is not valid for your selected measurement parameter. Either change the measurement parameters or perform a new calibration.

D2/D1 INVALID WITH SINGLE CHANNEL

Error Number 130 — You can only make a D2/D1 measurement if both channels are on.

D2/D1 INVALID. CH1 CH2 NUM PTS DIFFERENT

Error Number 152 — You can only make a D2/D1 measurement if both channels have the same number of points.

DEADLOCK

Error Number 111 — A fatal firmware error occurred before instrument preset completed. Call your local Hewlett-Packard sales and service office.

DEMODULATION NOT VALID

Error Number 17 — Demodulation is only valid for the CW time mode.

DEVICE: not on, not connect, wrong addrs

Error Number 119 — The device at the selected address cannot be accessed by the analyzer. Verify that the power meter is on, and check the HP-IB connection between the analyzer and the device. Ensure that the device address recognized by the analyzer matches the HP-IB address set on the device itself.

DIRECTORY FULL

Error Number 188 — There is no room left in the directory to add files. Either delete files or get a new disk.

DISK HARDWARE PROBLEM

Error Number 39 — The disk drive is not responding correctly. Refer to the disk drive operating manual.

DISK IS WRITE PROTECTED

Error Number 48 — The store operation cannot write to a write-protected disk. Slide the write-protect tab over the write-protect opening in order to write data on the disk.

DISK MEDIUM NOT INITIALIZED

Error Number 40 — You must initialize the disk before it can be used.

DISK MESSAGE LENGTH ERROR

Error Number 190 — The analyzer and the disk drive aren't communicating properly. Check the HP-IB connection and then try substituting another disk drive to isolate the problem instrument.

DISK: not on, not connected, wrong addrs

Error Number 38 — The disk cannot be accessed by the analyzer. Verify power to the disk drive, and check the HP-IB connection between the analyzer and the disk drive. Ensure that the disk drive address recognized by the analyzer matches the HP-IB address set on the disk drive itself.

DISK READ/WRITE ERROR

Error Number 189 — There may be a problem with your disk. Try a new floppy disk. If a new floppy disk does not eliminate the error, suspect hardware problems.

DISK WEAR - REPLACE DISK SOON

Error Number 49
Cumulative use of the disk is approaching the maximum. Copy files as necessary using an external controller. If no controller is available, load instrument states from the old disk and store them to a newly initialized disk using the save/recall features of the analyzer. Discard the old disk.

DOMAIN RESET

Error Number 67
Time domain has been turned off due to a change in the frequency range, sweep type, or number of points. Perform a new time domain transform on the new state.

DOS NAME LIMITED TO 8 CHARS + 3 CHAR EXTENSION

Error Number 180
A DOS file name must meet the following criteria:

- minimum of 1 character
- first character must be alpha; the remainder must be alphanumeric or underscore
- format is

  `filename.ext`

  - maximum of 8 characters in the filename
  - maximum of 3 characters in the extension field
  - a dot separates the filename from the extension field (the dot is not part of the name on the disk)

DUPLICATING TO THIS SEQUENCE NOT ALLOWED

Error Number 125
A sequence cannot be duplicated to itself.

EXCEEDED 7 STANDARDS PER CLASS

Error Number 72
When modifying calibration kits, you can define a maximum of seven standards for any class.

FILE NOT FOUND

Error Number 202 — You have sent a remote command to the instrument that is only valid for an HP 8753. The HP 8752C accepts these commands (no syntax error is generated) but they have no effect.

FILE NOT FOUND

Error Number 192 — The requested file was not found on the current disk medium.

FILE NOT FOUND OR WRONG TYPE

Error Number 197 — During a resave operation, either the file was not found or the type of file was not an instrument state file.

FIRST CHARACTER MUST BE A LETTER

Error Number 42 — The first character of a disk file title or an internal save register title must be an alpha character.

FORMAT NOT VALID FOR MEASUREMENT

Error Number 75 — Conversion measurements (Z or Y reflection and transmission) are not valid with smith chart and SWR formats.

FORMATTING DATA

Information Message — The list information is being processed for a list data output to a copy device and stored in the copy spool buffer. During this time, the analyzer's resources are dedicated to this task (which takes less than a few seconds.)

FUNCTION NOT VALID

Error Number 14 — The function you requested is incompatible with the current instrument state.

FUNCTION NOT VALID DURING MOD SEQUENCE

Error Number 131 — You cannot perform sequencing operations while a sequence is being modified.

FUNCTION NOT VALID FOR INTERNAL MEMORY

Error Number 201 — The function you selected only works with disk files.

FUNCTION ONLY VALID DURING MOD SEQUENCE

Error Number 164 — You can only use the GOSUB SEQUENCE capability when you are building a sequence. Attempting to use this softkey at any other time returns an error message and no action is taken.

HPIB COPY IN PROGRESS, ABORT WITH LOCAL

Error Number 169 — An HP-IB copy was already in progress when you requested the HP-IB for another function. To abort the first copy, press (LOCAL), otherwise the HP-IB is unavailable until the first copy is completed.

ILLEGAL UNIT OR VOLUME NUMBER

Error Number 46 — The disk unit or volume number set in the analyzer is not valid. Refer to the disk drive operating manual.

INIT DISK removes all data from disk

Information Message — Continuing with the initialize operation will *destroy* any data currently on the disk.

INITIALIZATION FAILED

Error Number 47 — The disk initialization failed, probably because the disk is damaged.

INSTRUMENT STATE MEMORY CLEARED

Error Number 56 — All instrument state registers have been cleared from memory along with any saved calibration data, memory traces, and calibration kit definitions. In addition, all user-settable selections (such as HP-IB addresses) have been set to their defaults.

INSUFFICIENT MEMORY

Error Number 51	Your last front panel or HP-IB request could not be implemented due to insufficient memory space. In some cases, this is a fatal error from which you can escape only by presetting the instrument.

INSUFFICIENT MEMORY FOR PRINT/PLOT

Error Number 168	There is not enough memory available for the print or plot function. Increase the available memory by changing or eliminating a memory-intensive operation such as reducing the number of points in the sweep.

INVALID KEY

Error Number 2	You pressed an undefined softkey.

LIST TABLE EMPTY

Error Number 9	The frequency list is empty. To implement list frequency mode, add segments to the list table.

LOG SWEEP REQUIRES 2 OCTAVE MINIMUM SPAN

Error Number 150	A logarithmic sweep is only valid if the stop frequency is greater than four times the start frequency. For frequency spans of less than two octaves, the sweep type automatically reverts to linear sweep.

LOW PASS: FREQ LIMITS CHANGED

Information Message	The frequency domain data points must be harmonically related from dc to the stop frequency. That is, stop = n × start, where n = number of points. If this condition is not true when a low pass mode (step or impulse) is selected and transform is turned on, the analyzer resets the start and stop frequencies. The stop frequency is set close to the entered stop frequency, and the start frequency is set equal to stop/n.

LOW PASS MODE NOT ALLOWED

Error Number 18	You must set the number of points to 801 or less when you are in low pass time domain mode.

MEMORY FOR CURRENT SEQUENCE IS FULL

Error Number 132 — All the memory in the sequence you are modifying is filled with instrument commands.

MORE SLIDES NEEDED

Error Number 71 — When you use a sliding load (in a user-defined calibration kit), you must set at least three slide positions to complete the calibration.

NO CALIBRATION CURRENTLY IN PROGRESS

Error Number 69 — The RESUME CAL SEQUENCE softkey is not valid unless a calibration is already in progress. Start a new calibration.

NO DISK MEDIUM IN DRIVE

Error Number 41 — You have no disk in the current disk unit. Insert a disk, or check the disk unit number stored in the analyzer.

NO FAIL FOUND

Service Error Number 114 — The self-diagnose function of the instrument operates on an internal test failure. At this time, no failure has been detected.

NO FILE(S) FOUND ON DISK

Error Number 45 — No files of the type created by an analyzer store operation were found on the disk. If you requested a specific file title, that file was not found on the disk.

NO IF FOUND: CHECK R INPUT LEVEL

Error Number 5 — The first IF signal was not detected during pretune. Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting.

NO LIMIT LINES DISPLAYED

Error Number 144 — You can turn limit lines on but they cannot be displayed on polar or Smith chart display formats.

NO MARKER DELTA -SPAN NOT SET

Error Number 15 — You must turn the delta marker mode on, with at least two markers displayed, in order to use the MARKER -> SPAN softkey function.

NO MEMORY AVAILABLE FOR INTERPOLATION

Error Number 123 — You cannot perform interpolated error correction due to insufficient memory.

NO MEMORY AVAILABLE FOR SEQUENCING

Error Number 126 — You cannot modify the sequence due to insufficient memory.

NO PHASE LOCK: CHECK R INPUT LEVEL

Error Number 7 — The first IF signal was detected at pretune, but phase lock could not be acquired. Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting.

NO SPACE FOR NEW CAL. CLEAR REGISTERS

Error Number 70 — You cannot store a calibration set due to insufficient memory. You can free more memory by clearing a saved instrument state from an internal register (which may also delete an associated calibration set if all the instrument states using the calibration set have been deleted.) You can store the saved instrument state and calibration set to a disk before clearing them. After deleting the instrument states, press (PRESET) to run the memory packer.

NOT ENOUGH SPACE ON DISK FOR STORE

Error Number 44 — The store operation will overflow the available disk space. Insert a new disk or purge the files appearing last in the directory, to create free disk space.

NO VALID MEMORY TRACE

Error Number 54 — If you are going to display or otherwise use a memory trace, you must first store a data trace to memory.

NO VALID STATE IN REGISTER

Error Number 55 — You have requested the analyzer, over HP-IB or by sequencing, to load an instrument state from an *empty* internal register.

ONLY LETTERS AND NUMBERS ARE ALLOWED

Error Number 43 — You can only use alpha-numeric characters (and underscores) in disk file titles or internal save register titles. Other symbols are not allowed.

OPTIONAL FUNCTION; NOT INSTALLED

Error Number 1 — The function you requested requires a capability provided by an option to the standard analyzer. That option is not currently installed. (Options are 003, 3 GHz operation, 004, step attenuator, 006, 6 GHz operation, 010, time domain transform, and 075, 75 ohm impedance.)

OVERLOAD ON INPUT R, POWER REDUCED

Error Number 57 — Source power exceeds +17 dBm. The RF output power level is automatically reduced to −20 dBm. The annotation P⇓ appears in the left margin of the display to indicate that the power trip function has been activated. When this occurs, reset the power to a lower level, then toggle the SOURCE PWR on OFF softkey to turn the power back on.

OVERLOAD ON REFL PORT, POWER REDUCED

Error Number 58 — You have exceeded approximately +20 dBm at the reflection port. The RF output power is automatically reduced to −20 dBm. The annotation P⇓ appears in the left margin of the display to indicate that the power trip function has been activated. When this occurs, reset the power to a lower level, then toggle the SOURCE PWR on OFF softkey to turn the power back on.

OVERLOAD ON TRANS PORT, POWER REDUCED

Error Number 59 — You have exceeded approximately +4 dBm at the transmission port. The RF output power level is automatically reduced to −20 dBm. The annotation P⇓ appears in the left margin of the display to indicate that the power trip function has been activated. When this occurs, reset the power to a lower level, then toggle the SOURCE PWR on OFF softkey to turn the power back on.

PHASE LOCK CAL FAILED

Error Number 4

An internal phase lock calibration routine is automatically executed at power-on, preset, and any time a loss of phase lock is detected. This message indicates that phase lock calibration was initiated and the first IF detected, but a problem prevented the calibration from completing successfully. Refer to the *HP 8752C Network Analyzer Service Guide* and execute pretune correction test 48.

PHASE LOCK LOST

Error Number 8

Phase lock was acquired but then lost. Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting information.

PLOT ABORTED

Error Number 27

When you press the (LOCAL) key, the analyzer aborts the plot in progress.

PLOTTER: not on, not connect, wrong addrs

Error Number 26

The plotter does not respond to control. Verify power to the plotter, and check the HP-IB connection between the analyzer and the plotter. Ensure that the plotter address recognized by the analyzer matches the HP-IB address set on the plotter itself.

PLOTTER NOT READY-PINCH WHEELS UP

Error Number 28

The plotter pinch wheels clamp the paper in place. If you raise the pinch wheels, the plotter indicates a "not ready" status on the bus.

POSSIBLE FALSE LOCK

Error Number 6

Phase lock has been achieved, but the source may be phase locked to the wrong harmonic of the synthesizer. Perform the source pretune correction routine documented in the "Adjustments and Correction Constants" chapter in the *HP 8752C Network Analyzer Service Guide.*

POWER UNLEVELED

Error Number 179 — There is either a hardware failure in the source or you have attempted to set the power level too high. Check to see if the power level you set is within specifications. If it is, refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting. You will only receive this message over the HP-IB. On the analyzer, P? is displayed.

POW MET INVALID

Error Number 116 — The power meter indicates an out-of-range condition. Check the test setup.

POW MET NOT SETTLED

Error Number 118 — Sequential power meter readings are not consistent. Verify that the equipment is set up correctly. If so, preset the instrument and restart the operation.

POW MET: not on, not connected, wrong addrs

Error Number 117 — The power meter cannot be accessed by the analyzer. Verify that the power meter address and model number set in the analyzer match the address and model number of the actual power meter.

POWER SUPPLY HOT!

Error Number 21 — The temperature sensors on the A8 post-regulator assembly have detected an over-temperature condition. The power supplies regulated on the post-regulator have been shut down.

POWER SUPPLY SHUT DOWN!

Error Number 22 — One or more supplies on the A8 post-regulator assembly have been shut down due to an over-current, over-voltage, or under-voltage condition.

PRINT ABORTED

Error Number 25 — When you press the (LOCAL) key, the analyzer aborts output to the printer.

`print color not supported with EPSON`

Error Number 178 — Color print is not supported with the EPSON printer. The print will abort.

`PRINTER: not on, not connected, wrong addrs`

Error Number 24 — The printer does not respond to control. Verify power to the printer, and check the HP-IB connection between the analyzer and the printer. Ensure that the printer address recognized by the analyzer matches the HP-IB address set on the printer itself.

`PRINT/PLOT IN PROGRESS, ABORT WITH LOCAL`

Error Number 166 — If a print or plot is in progress and you attempt a second print or plot, this message is displayed and the second attempt is ignored. To abort a print or plot in progress, press [LOCAL].

`PROBE POWER SHUT DOWN!`

Error Number 23 — The analyzer biasing supplies to the HP 85024A external probe are shut down due to excessive current. Troubleshoot the probe, and refer to the power supply troubleshooting section of the *HP 8752C Network Analyzer Service Guide.*

`PROCESSING DISPLAY LIST`

Information Message — The display information is being processed for a screen print to a copy device and stored in the copy spool buffer. During this time, the analyzer's resources are dedicated to this task (which takes less than a few seconds.)

`REQUESTED DATA NOT CURRENTLY AVAILABLE`

Error Number 30 — The analyzer does not currently contain the data you have requested. For example, this condition occurs when you request error term arrays and no calibration is active.

SAVE FAILED. INSUFFICIENT MEMORY

Error Number 151 — You cannot store an instrument state in an internal register due to insufficient memory. Increase the available memory by clearing one or more save/recall registers and pressing (PRESET) to run the memory packer, or by storing files to an external disk.

SELECTED SEQUENCE IS EMPTY

Error Number 124 — The sequence you attempted to run does not contain instrument commands.

SELF TEST #n FAILED

Service Error Number 112 — Internal test #n has failed. Several internal test routines are executed at instrument preset. The analyzer reports the first failure detected. Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting information on internal tests and the self-diagnose feature.

SEQUENCE ABORTED

Error Number 157 — The sequence running was stopped prematurely when you pressed the (LOCAL) key.

SEQUENCE MAY HAVE CHANGED, CAN'T CONTINUE

Error Number 153 — When you pause a sequence, you cannot continue it if you have modified it. You must start the sequence again.

SLIDES ABORTED (MEMORY REALLOCATION)

Error Number 73 — You cannot perform sliding load measurements due to insufficient memory. Reduce memory usage by clearing save/recall registers, then repeat the sliding load measurements.

SOURCE PARAMETERS CHANGED

Error Number 61 — Some of the stimulus parameters of the instrument state have been changed, because you have turned correction on. A calibration set for the current measurement parameter was found and activated. The instrument state was updated to match the stimulus parameters of the calibration state.

SOURCE POWER TRIPPED, RESET UNDER POWER MENU

Information Message — You have exceeded the maximum power level at one of the inputs and power has been automatically reduced. The annotation P⇓ indicates that power trip has been activated. When this occurs, reset the power and then toggle the SOURCE PWR on OFF softkey to turn the power back on. This message follows error numbers 57, 58, and 59.

STARTING COPY SPOOLER

Information Message — The analyzer is beginning to output data from the spool buffer to the copy device. The analyzer resumes normal operation; the data is being output to the copy device in the background.

SWEEP TIME INCREASED

Error Number 11 — You have made instrument changes that cause the analyzer sweep time to be automatically increased. Some parameter changes that cause an increase in sweep time are narrower IF bandwidth, an increase in the number of points, and a change in sweep type.

SWEEP TIME TOO FAST

Error Number 12 — The fractional-N and digital IF circuits have lost synchronization. Refer to the *HP 8752C Network Analyzer Service Guide* for troubleshooting information.

SWEEP TRIGGER SET TO HOLD

Information Message — The instrument is in a hold state and is no longer sweeping.

SYNTAX ERROR

Error Number 33 — You have improperly formatted an HP-IB command. Refer to the *HP 8752C Network Analyzer Programmer's Guide* for proper command syntax.

SYST CTRL OR PASS CTRL IN LOCAL MENU

Error Number 36 — The analyzer is in talker/listener mode. In this mode, the analyzer cannot control a peripheral device on the bus. Use the local menu to change to system controller or pass control mode.

SYSTEM IS NOT IN REMOTE

Error Number 52 — The analyzer is in local mode. In this mode, the analyzer will not respond to HP-IB commands with front panel key equivalents. It will, however, respond to commands that have no such equivalents, such as status requests.

TEST ABORTED

Error Number 113 — You have prematurely stopped a service test.

THIS LIST FREQ INVALID IN HARM/3 GHZ RNG

Error Number 133 — You have set frequencies in the list that are greater than 3 GHz on instruments without option 006. Reduce the frequency range of the list.

TOO MANY NESTED SEQUENCES. SEQ ABORTED

Error Number 164 — You can only nest sequences to a maximum level of six. The sequence will abort if you nest more than six.

TOO MANY SEGMENTS OR POINTS

Error Number 50 — You can have a maximum of 30 segments or 1632 points in frequency list mode.

TRANSFORM, GATE NOT ALLOWED

Error Number 16 — You can perform a time domain transformation only in linear and CW sweep types.

TROUBLE! CHECK SETUP AND START OVER

Service Error Number 115 — Your equipment setup for the adjustment procedure in progress is not correct. Check the setup diagram and instructions *HP 8752C Network Analyzer Service Guide*. Start the procedure again.

WAITING FOR CLEAN SWEEP

Information Message — In single sweep mode, the instrument ensures that all changes to the instrument state, if any, have been implemented before taking the sweep. The command that you have initiated is being processed and will not be complete until the new sweep is completed. An asterisk * is displayed in the left margin of the CRT until a complete fresh sweep has been taken.

WAITING FOR DISK

Information Message — This message is displayed between the start and finish of a read or write operation to a disk.

WAITING FOR HP-IB CONTROL

Information Message — You have instructed the analyzer to use pass control (USEPASC). When you send the analyzer an instruction that requires active controller mode, the analyzer requests control of the bus and simultaneously displays this message. If the message remains, the system controller is not relinquishing the bus.

WRITE ATTEMPTED WITHOUT SELECTING INPUT TYPE

Error Number 32 — You have sent the data header "#A" to the analyzer with no preceding input command (such as INPUDATA). The instrument recognized the header but did not know what type of data to receive. Refer to the *HP 8752C Network Analyzer Programmer's Guide* for command syntax information.

WRONG DISK FORMAT, INITIALIZE DISK

Error Number 77 — You have attempted to store, load, or read file titles, but your disk format does not conform to the Logical Interchange Format (LIF). You must initialize the disk before reading or writing to it.

Error Messages in Numerical Order

Refer to the alphabetical listing for explanations and suggestions for solving the problems.

Error Number	Error
1	OPTIONAL FUNCTION; NOT INSTALLED
2	INVALID KEY
3	CORRECTION CONSTANTS NOT STORED
4	PHASE LOCK CAL FAILED
5	NO IF FOUND: CHECK R INPUT LEVEL
6	POSSIBLE FALSE LOCK
7	NO PHASE LOCK: CHECK R INPUT LEVEL
8	PHASE LOCK LOST
9	LIST TABLE EMPTY
10	CONTINUOUS SWITCHING NOT ALLOWED
11	SWEEP TIME INCREASED
12	SWEEP TIME TOO FAST
13	AVERAGING INVALID ON NON-RATIO MEASURE
14	FUNCTION NOT VALID
15	NO MARKER DELTA - SPAN NOT SET
16	TRANSFORM, GATE NOT ALLOWED
17	DEMODULATION NOT VALID
18	LOW PASS MODE NOT ALLOWED
21	POWER SUPPLY HOT!
22	POWER SUPPLY SHUT DOWN!
23	PROBE POWER SHUT DOWN!
24	PRINTER: not on, not connect, wrong addrs
25	PRINT ABORTED
26	PLOTTER: not on, not connect, wrong addrs
27	PLOT ABORTED
28	PLOTTER NOT READY-PINCH WHEELS UP
30	REQUESTED DATA NOT CURRENTLY AVAILABLE
31	ADDRESSED TO TALK WITH NOTHING TO SAY

Error Number	Error
32	WRITE ATTEMPTED WITHOUT SELECTING INPUT TYPE
33	SYNTAX ERROR
34	BLOCK INPUT ERROR
35	BLOCK INPUT LENGTH ERROR
36	SYST CTRL OR PASS CTRL IN LOCAL MENU
37	CAN'T CHANGE-ANOTHER CONTROLLER ON BUS
38	DISK: not on, not connected, wrong addrs
39	DISK HARDWARE PROBLEM
40	DISK MEDIUM NOT INITIALIZED
41	NO DISK MEDIUM IN DRIVE
42	FIRST CHARACTER MUST BE A LETTER
43	ONLY LETTERS AND NUMBERS ARE ALLOWED
44	NOT ENOUGH SPACE ON DISK FOR STORE
45	NO FILE(S) FOUND ON DISK
46	ILLEGAL UNIT OR VOLUME NUMBER
47	INITIALIZATION FAILED
48	DISK IS WRITE PROTECTED
49	DISK WEAR-REPLACE DISK SOON
50	TOO MANY SEGMENTS OR POINTS
51	INSUFFICIENT MEMORY
52	SYSTEM IS NOT IN REMOTE
54	NO VALID MEMORY TRACE
55	NO VALID STATE IN REGISTER
56	INSTRUMENT STATE MEMORY CLEARED
57	OVERLOAD ON INPUT R, POWER REDUCED
58	OVERLOAD ON REFL PORT, POWER REDUCED
59	OVERLOAD ON TRANS PORT, POWER REDUCED
61	SOURCE PARAMETERS CHANGED
63	CALIBRATION REQUIRED
64	CURRENT PARAMETER NOT IN CAL SET
65	CORRECTION AND DOMAIN RESET

Error Number	Error
66	CORRECTION TURNED OFF
67	DOMAIN RESET
68	ADDITIONAL STANDARDS NEEDED
69	NO CALIBRATION CURRENTLY IN PROGRESS
70	NO SPACE FOR NEW CAL \ CLEAR REGISTERS
71	MORE SLIDES NEEDED
72	EXCEEDED 7 STANDARDS PER CLASS
73	SLIDES ABORTED (MEMORY REALLOCATION)
74	CALIBRATION ABORTED
75	FORMAT NOT VALID FOR MEASUREMENT
77	WRONG DISK FORMAT, INITIALIZE DISK
111	DEADLOCK
112	SELF TEST #n FAILED
113	TEST ABORTED
114	NO FAIL FOUND
115	TROUBLE! CHECK SETUP AND START OVER
116	POW MET INVALID
117	POW MET: not on, not connected, wrong addrs
118	POW MET NOT SETTLED
119	DEVICE: not on, not connect, wrong addrs
123	NO MEMORY AVAILABLE FOR INTERPOLATION
124	SELECTED SEQUENCE IS EMPTY
125	DUPLICATING TO THIS SEQUENCE NOT ALLOWED
126	NO MEMORY AVAILABLE FOR SEQUENCING
127	CAN'T STORE/LOAD SEQUENCE, INSUFFICIENT MEMORY
130	D2/D1 INVALID WITH SINGLE CHANNEL
131	FUNCTION NOT VALID DURING MOD SEQUENCE
132	MEMORY FOR CURRENT SEQUENCE IS FULL
133	THIS LIST FREQ INVALID IN HARM/3 GHZ RNG
144	NO LIMIT LINES DISPLAYED

Error Number	Error
150	LOG SWEEP REQUIRES 2 OCTAVE MINIMUM SPAN
151	SAVE FAILED \ INSUFFICIENT MEMORY
152	D2/D1 INVALID \ CH1 CH2 NUM PTS DIFFERENT
153	SEQUENCE MAY HAVE CHANGED, CAN'T CONTINUE
157	SEQUENCE ABORTED
159	CH1 (CH2) TARGET VALUE NOT FOUND
163	FUNCTION ONLY VALID DURING MOD SEQUENCE
164	TOO MANY NESTED SEQUENCES
166	PRINT/PLOT IN PROGRESS, ABORT WITH LOCAL
168	INSUFFICIENT MEMORY FOR PRINT/PLOT
169	HPIB COPY IN PROGRESS, ABORT WITH LOCAL
170	COPY:device not responding; copy aborted
178	print color not supported with EPSON
179	POWER UNLEVELED
180	DOS NAME LIMITED TO 8 CHARS + 3 CHAR EXTENSION
183	BATTERY FAILED. STATE MEMORY CLEARED
184	BATTERY LOW! STORE SAVE REGS TO DISK
185	CANNOT FORMAT DOS DISKS ON THIS DRIVE
188	DIRECTORY FULL
189	DISK READ/WRITE ERROR
190	DISK MESSAGE LENGTH ERROR
192	FILE NOT FOUND
193	ASCII: MISSING 'BEGIN' statement
194	ASCII: MISSING 'CITIFILE' statement
195	ASCII: MISSING 'DATA' statement
196	ASCII: MISSING 'VAR' statement
197	FILE NOT FOUND OR WRONG TYPE
199	CANNOT MODIFY FACTORY PRESET
200	ALL REGISTERS HAVE BEEN USED
201	FUNCTION NOT VALID FOR INTERNAL MEMORY
202	FEATURE NOT AVAILABLE

10

Compatible Peripherals

This chapter contains the following information:

- measurement accessories available
- system accessories available
- HP-IB programming overview

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 5, "Application and Operation Concepts," contains explanatory-style information about many applications and analyzer operation.

Measurement Accessories Available

Calibration Kits

The following calibration kits contain precision standards and required adapters of the indicated connector type. The standards (known devices) facilitate measurement calibration, also called vector error correction. Refer to the data sheet and ordering guide for additional information. Parts numbers for the standards are in their manuals.

- HP 85032B 50 Ohm Type-N Calibration Kit
- HP 85033D 3.5 mm Calibration Kit
- HP 85033C 3.5 mm Calibration Kit
- HP 85036B 75 Ohm Type-N Calibration Kit
- HP 85039A 75 Ohm Type-F Calibration Kit

Note The HP 85033D is the recommended 3.5 mm calibration kit as it provides greater measurement accuracy than the HP 85033C and it is easier to use due to one-piece opens.

Verification Devices

You can verify accurate operation of the analyzer system by measuring a set of calibration devices and comparing the residual error data to the specification limits drawn on the analyzer display. Refer to the *System Verification and Test Guide* for verification procedures.

Test Port Return Cables

The following RF cables are used to connect a device between the test ports. These cables provide shielding for high dynamic range measurements.

- HP Part Number 8120-4781 50 Ohm Type-N
- HP Part Number 8120-2408 75 Ohm Type-N (includes 2 male connectors)
- HP Part Number 8120-2409 75 Ohm Type-N (includes 1 male and 1 female connector)

Adapter Kits

HP 11852B 50 to 75 Ohm Minimum Loss Pad.

This device converts impedance from 50 ohms to 75 ohms or from 75 ohms to 50 ohms. It is used to provide a low SWR impedance match between a 75 ohm device under test and the HP 8752C network analyzer (without option 075.)

These adapter kits contain the connection hardware required for making measurements on devices of the indicated connector type.

- HP 11853A 50 Ohm Type-N Adapter Kit
- HP 11854A 50 Ohm Type-N to 50 Ohm BNC Adapter Kit
- HP 11855A 75 Ohm Type-N Adapter Kit
- HP 11856A 75 Ohm Type-N to 75 Ohm BNC Adapter Kit
- HP 11878A 50 Ohm Type-N to 3.5 mm Adapter Kit

System Accessories Available

System Cabinet

The HP 85043D system cabinet is designed to rack mount the analyzer in a system configuration. The 132 cm (52 in) system cabinet includes a bookcase, a drawer, and a convenient work surface.

Plotters and Printers

The analyzer is capable of plotting or printing displayed measurement results directly (without the use of an external computer) to a compatible peripheral. The analyzer supports HP-IB, and parallel peripherals (with the appropriate adapter). Most Hewlett-Packard desktop printers and plotters are compatible with the analyzer. Some common compatible peripherals are listed here (some are no longer available for purchase but are listed here for your reference):

These plotters are compatible:

- HP 7440A ColorPro Eight-Pen Color Graphics Plotter
- HP 7470A Two-Pen Graphics Plotter
- HP 7475A Six-Pen Graphics Plotter
- HP 7550A/B High-Speed Eight-Pen Graphics Plotter

These printers are compatible:

- Deskjet 1200C (can also be used to plot)
- DeskJet 500
- HP C2170A, DeskJet 520
- DeskJet 500C
- DeskJet 550C
- HP C2168A, DeskJet 560C
- All LaserJets (LaserJet III and IV can also be used to plot)
- HP C2621A, DeskJet 310 Portable InkJet
- HP 3630A, PaintJet Color Graphics Printer

Epson printers which are compatible with the Epson ESC/P2 printer control language, such as the LQ570, are also supported by the analyzer. Older Epson printers, however, such as the FX-80, will not work with the analyzer.

Printer Interface Adapter

The analyzer can support parallel peripherals by using one of the listed adapters. The adapters convert HP-IB to Centronics parallel interface for connecting to printers.

- HP ITEL-45CHVU (U.S. and Canada version)
- HP ITEL-45CHVE (International version)

Switches 1 through 4 should be set to the correct HP-IB address to match the printer or plotter address in the analyzer. Switches 5 through 8 should be set to 0 (default).

I/O Control Adapter

The I/O control adapter (HP part number 08752-60020) is helpful for connecting to peripherals. The adapter fits into the analyzer's test set connector and makes the following connections available through SMA connectors:

- four TTL output lines
- one TTL input line
- end-of-sweep output
- limit test pass/fail output

Mass Storage

The analyzer has the capability of storing instrument states directly to its internal memory, or to an external disk. The analyzer can initialize a floppy disk in both LIF and DOS formats and is capable of reading and writing data in both formats. Most external disks using CS80 protocol are compatible.

Note The LIF HFS (hierarchical file system) is not supported.

HP-IB Cables

An HP-IB cable is required for interfacing the analyzer with a plotter, printer, external disk drive, or computer. Some cables available are:

- HP 10833A HP-IB Cable, 1.0 m (3.3 ft.)
- HP 10833B HP-IB Cable, 2.0 m (6.6 ft.)
- HP 10833D HP-IB Cable, 0.5 m (1.6 ft.)

Interface Cables

- HP C2912B Centronics (Parallel) Interface Cable, 3.0 m (9.9 ft.)
- HP C2913A RS-232C Interface Cable, 1.2 m (3.9 ft.)
- HP C2914A Serial Interface Cable, 1.2 m (3.9 ft.)
- HP 24542G Serial Interface Cable, 3 m (9.9 ft.)
- HP 24542D Parallel Interface Cable, 2 m (6 ft.)
- HP 92284A Parallel Interface Cable, 2 m (6 ft.)

Computer

An external controller is not required for measurement calibration or time domain capability. However, the system can be automated with the addition of an HP 9000 series 200/300 computer. In addition, some performance test procedures are semi-automated and require the use of an external controller. (The system verification procedure does not require an external controller.) For more information about compatible computers, call your Hewlett-Packard customer engineer. A Vectra or other PC-compatible computer with an HP-IB interface card will also work.

Sample Software

A set of sample measurement programs is provided with the *HP 8752C Programmer's Guide* on a 3.5 inch disk. The program includes typical measurements to be used as an introductory example for programming the analyzer over HP-IB. It is designed to be easily modified for use in developing programs for specific needs. The program is compatible with HP BASIC versions 2.0 and later and will run on an HP 9000 series 200/300 computer, using any HP 8752C-compatible printer or plotter.

System Furniture

A table may be required for the system controller and the plotter or printer. The recommended work station table is HP 92170G, which is 720 mm (28 in) high by 930 mm (36 in) wide by 712 mm (28 in) deep and is mounted on casters.

External Monitors

The analyzer can drive both its internal display monitor and an external monitor simultaneously. One recommended color monitor is the HP 35741A/B.

Hewlett-Packard Interface Bus (HP-IB)

The analyzer is factory-equipped with a remote programming digital interface using the Hewlett-Packard Interface Bus (HP-IB). HP-IB is Hewlett-Packard's hardware, software, documentation, and support for IEEE 488.1 and IEC-625, worldwide standards for interfacing instruments. The HP-IB lets you control the analyzer with an external computer that sends commands or instructions to and receives data from the analyzer. This provides a remote operator with the same control of the instrument available to the local operator, except for control of the power line switch and some internal tests.

In addition, without the use of an external computer, the analyzer can use HP-IB to output measurement results directly to a compatible printer or plotter and store data to an external disk drive.

- For more complete information on programming the analyzer remotely over HP-IB, refer to the *HP 8752C Programmer's Guide.*
- For a complete general description of the HP-IB, refer to the *Tutorial Description of the Hewlett-Packard Interface Bus*, HP publication 5952-0156 and to *Condensed Description of the Hewlett-Packard Interface Bus* (HP part number 59401-90030).
- For more information on the IEEE-488.1 standard, refer to *IEEE Standard Digital Interface for Programmable Instrumentation*, published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

How HP-IB Works

The HP-IB uses a party-line bus structure in which up to 15 devices can be connected on one contiguous bus. The interface consists of 16 signal lines and 8 ground lines in a shielded cable. With this cabling system you can connect many different types of devices in parallel including instruments, computers, plotters, printers, and disk drives.

Every HP-IB device must be capable of performing one or more of the following interface functions:

Talker

A talker is a device capable of sending device-dependent data when addressed to talk. You can have only one talker at any given time. Examples of this type of device are voltmeters, counters, and tape readers. The analyzer is a talker when it sends trace data or marker information over the bus.

Listener

A listener is a device capable of receiving device-dependent data when addressed to listen. You can have any number of listeners at any given time. Examples of this type of device are printers, power supplies, and signal generators. The analyzer is a listener when it is controlled over the bus by a computer.

Controller

A controller is a device capable of managing the operation of the bus and addressing talkers and listeners. You can have only one active controller at any time. Examples of controllers include desktop computers and minicomputers. In a multiple-controller system, you can pass active control between controllers, but you can only have one system controller. The system controller acts as the master and can regain active control at any time. The analyzer is an active controller when it plots, prints, or stores to an external disk drive in the pass control mode. The analyzer is a system controller when it is in the system controller mode. These modes are discussed in more detail in Chapter 8, "Key Definitions."

HP-IB Bus Structure

Data Bus

The data bus consists of eight bi-directional lines that are used to transfer data from one device to another. Programming commands and data are typically encoded on these lines in ASCII, although you can use binary encoding to speed up the transfer of large arrays. Both ASCII and binary data formats are available to the analyzer. In addition, every byte transferred over HP-IB undergoes a handshake to ensure valid data.

Handshake Lines

A three-line handshake scheme coordinates the transfer of data between talkers and listeners. This technique forces data transfers to occur at the speed of the slowest device, and ensures data integrity in multiple listener transfers. With most computing controllers and instruments, the handshake is performed automatically, which makes it transparent to the programmer.

Control Lines

The data bus also has five control lines that the controller uses both to send bus commands and to address devices:

IFC - Interface Clear

Only the system controller uses this line. When this line is true (low), all devices (addressed or not) will un-address and go to an idle state.

ATN - Attention

The active controller uses this line to define whether the information on the data bus is a command or is data. When this line is true (low), the bus is in the command mode and the data lines carry bus commands. When this line is false (high), the bus is in the data mode and the data lines carry device-dependent instructions or data.

SRQ - Service Request

This line is set true (low) when a device requests service: the active controller services the requesting device. The analyzer can be enabled to pull the SRQ line for a variety of reasons.

REN - Remote Enable

Only the system controller uses this line. When this line is set true (low), the bus is in the remote mode, and devices are addressed either to listen or to talk. When the bus is in remote and a device is addressed, it receives instructions from HP-IB rather than from its front panel (the [LOCAL] key returns the device to front panel operation). When this line is set false (high), the bus and all devices return to local operation.

EOI - End or Identify

This line is used by a talker to indicate the last data byte in a multiple byte transmission, or by an active controller to initiate a parallel poll sequence. The analyzer recognizes the EOI line as a terminator, and it pulls the EOI line with the last byte of a message output (data, markers, plots, prints, error messages). The analyzer does not respond to parallel poll.

Figure 10-1 illustrates the structure of the HP-IB bus lines.

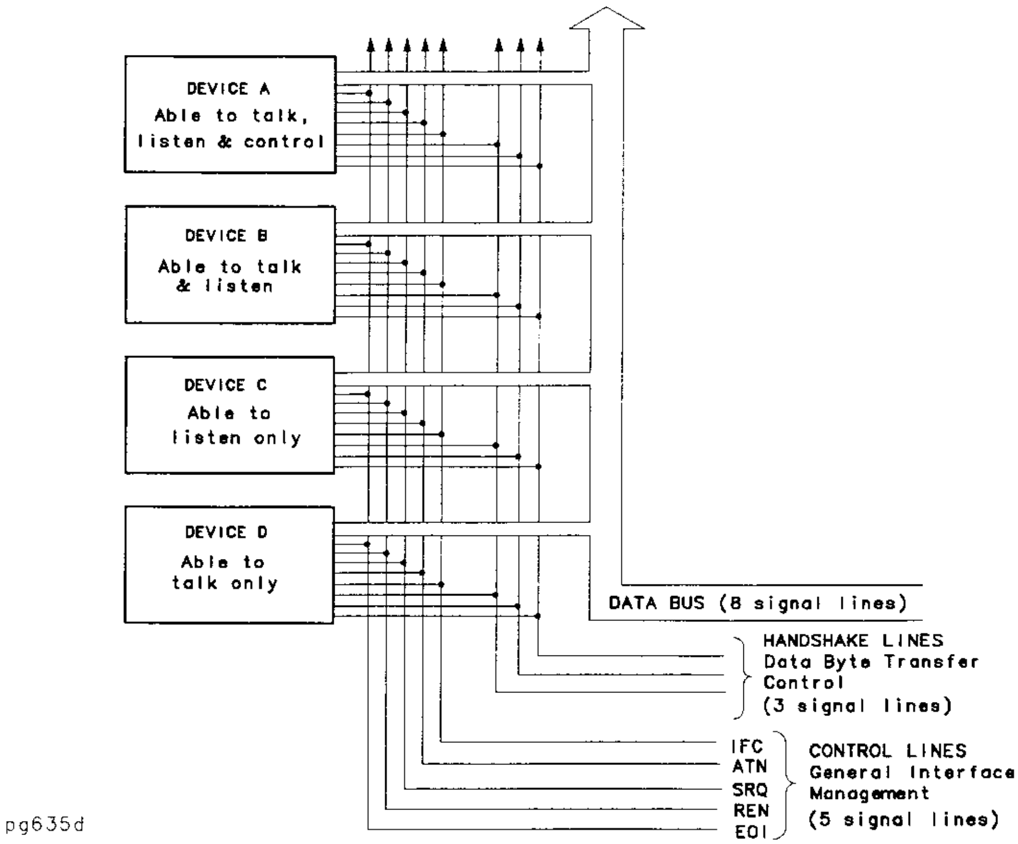


Figure 10-1. HP-IB Structure

HP-IB Requirements

Number of Interconnected Devices:	15 maximum.
Interconnection Path/Maximum Cable Length:	20 meters maximum or 2 meters per device whichever is less.
Message Transfer Scheme:	Byte serial/bit parallel asynchronous data transfer using a 3-line handshake system.
Data Rate:	Maximum of 1 megabyte per second over limited distances with tri-state drivers. Actual data rate depends on the transfer rate of the slowest device involved.
Address Capability:	Primary addresses: 31 talk, 31 listen. A maximum of 1 talker and 14 listeners at one time.
Multiple Controller Capability:	In systems with more than one controller (like the analyzer system), only one can be active at a time. The active controller can pass control to another controller, but only the system controller can assume unconditional control. Only one system controller is allowed. The system controller is hard-wired to assume bus control after a power failure.

Analyzer HP-IB Capabilities

As defined by the IEEE 488.1 standard, the analyzer has the following capabilities:

SH1	Full source handshake capability.
AH1	Full acceptor handshake capability.
T6	Can be a basic talker, answers serial poll, unaddresses if MLA is issued.
TE0	No extended talker capabilities.
L4	Acts as a basic listener and unaddresses if MTA is issued.
SR1	Can issue service requests.
RL1	Will do remote, local, and local lockout.
PP0	Does not respond to parallel poll.
DC1	Device clear capability.
DT1	Will respond to device trigger in hold mode.
C1, C2, C3	No controller capabilities in talker/listener mode. System controller mode can be selected under the LOCAL menu.
C10	Pass control capability in pass control mode.
E2	Tri-state drivers.

Bus Mode

The analyzer uses a single-bus architecture. The single bus allows both the analyzer and the host controller to have complete access to the peripherals in the system.

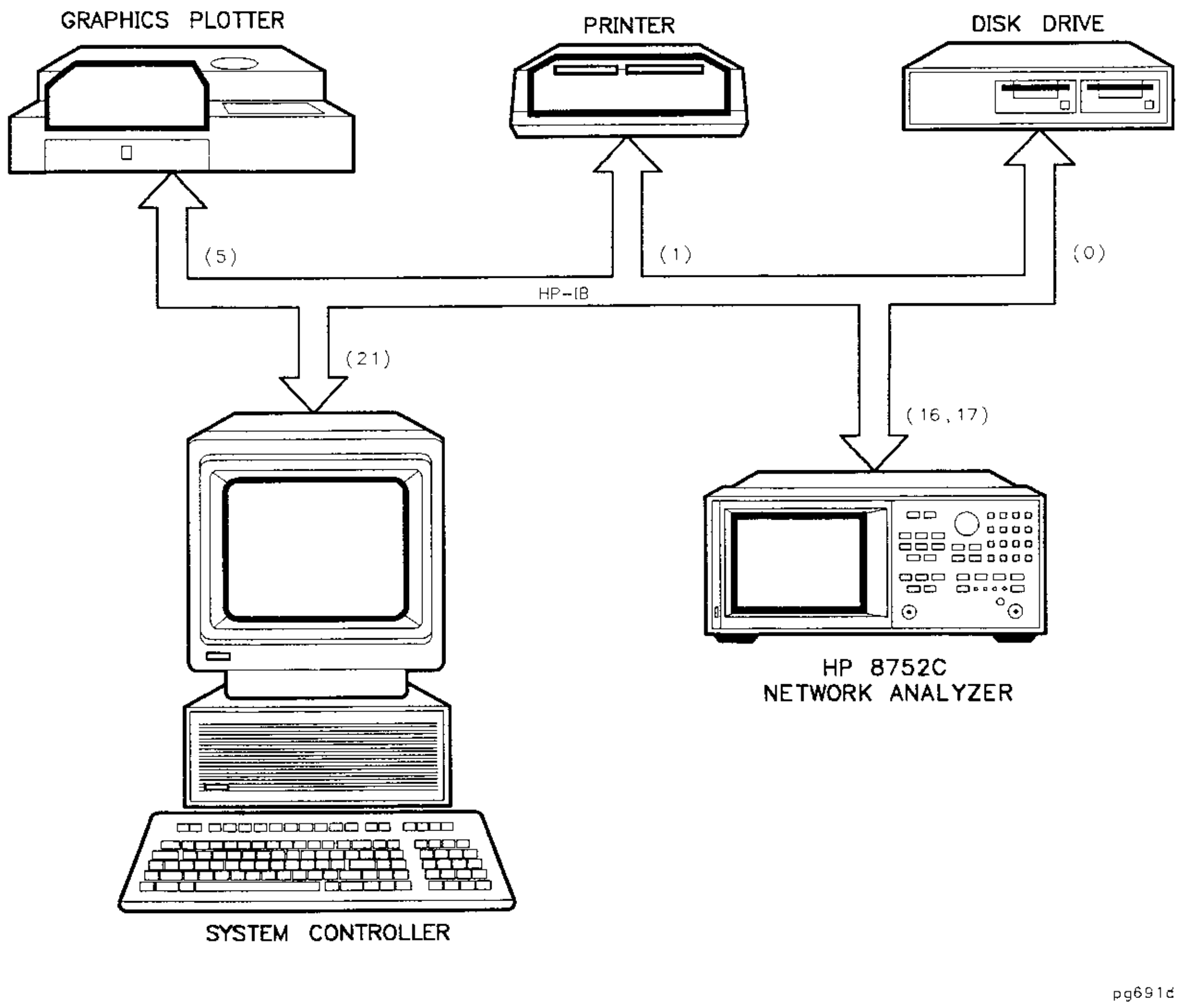


Figure 10-2. Analyzer Single Bus Concept

The analyzer has three bus modes: system controller, talker/listener, and pass control.

System Controller

This mode allows the analyzer to control peripherals directly in a stand-alone environment (without an external controller). You can only select this mode manually from the analyzer front panel. Use this mode for operation when no computer is connected to the analyzer. Do not use this mode for programming.

Talker/Listener

This is the traditional programming mode, in which the computer controls all HP-IB operations. Plotting and printing is possible by addressing the analyzer to talk, addressing the peripheral to listen, placing the HP-IB data bus in the data mode, and issuing one of the following commands: OUTPPRW, OUTPPLOT, OUTPPRNALL. Data can only be sent to the peripheral, therefore, plotter error conditions on P1/P2 locations can not be queried.

Pass Control

This mode allows you to control the analyzer over HP-IB as with the talker/listener mode, and also allows the analyzer to take or pass control in order to plot, print, and access a disk. During the peripheral operation, the host computer is free to perform other internal tasks such as data or display manipulation (the bus is tied up by the analyzer during this time). After a task is completed, the host controller accepts control again when the analyzer returns it.

In general, use the talker/listener mode for programming the analyzer unless you desire direct peripheral access. Preset does not affect the selected bus mode, but the bus mode returns to talker/listener if power is cycled.

Refer to the "Command Reference" and the "HP-IB Programming Reference" in the *HP 8752C Programmer's Guide* for additional programming information about the three different bus modes.

Setting Addresses

In communications through HP-IB, each instrument on the bus is identified by an HP-IB address. This address code must be different for each instrument on the bus. See "Configuring the Interface Port" located earlier in this chapter for information on default addresses, and on setting and changing addresses. These addresses are stored in non-volatile memory and are not affected when you press (PRESET) or cycle the power (although the (PRESET) key must be pressed to implement a change to the analyzer address).

Valid Characters

The analyzer accepts ASCII letters, numbers, decimal points, +/−, semicolons, quotation marks ("), carriage returns (CR), and linefeeds (LF). Both upper and lower case are acceptable. Leading zeros, spaces, carriage returns, and unnecessary terminators are ignored, except those within a command or appendage. Carriage returns are ignored. An invalid character causes a syntax error. See the "Command Reference" in the *HP 8752C Programmer's Guide* for more information about proper syntax and syntax errors.

Code Naming Convention

The analyzer HP-IB commands are derived from their front panel key titles (where possible), according to the following naming convention.

Table 10-1. Code Naming Convention

Convention	Key Title	For HP-IB Code Use	Example
One Word	Power Start	First Four Letters	POWE STAR
Two Words	Electrical Delay Search Right	First Three Letters of First Word First Letter of Second Word	ELED SEAR
Two Words in a Group	Marker →Center Gate →Span	Four Letters of Both	MARKCENT GATESPAN
Three Words	Cal Kit N 50Ω Pen Num Data	First Three Letters of First Word First Letter of Second Word First Four Letters of Third Word	CALKN50 PENNDATA

Some codes require appendages such as on or off, or 1 or 2. Codes that have no front panel equivalent are HP-IB only commands, and use a similar convention based on the common name of the function. Where possible, analyzer codes are compatible with HP 8510A/B codes.

For a summary of the front panel equivalent codes and the HP-IB only codes, see the "Command Reference" in the *HP 8752C Programmer's Guide*.

Units and Terminators

The analyzer outputs data in basic units and assumes these basic units when it receives an input, unless you otherwise qualify the input. The basic units and allowable expressions follow; either upper or lower case is acceptable.

Basic Units	Allowable Expressions
Seconds	S
Milliseconds	MS
Microseconds	US
Nanoseconds	NS
Picoseconds	PS
Femtoseconds	FS
Hertz	HZ
Kilohertz	KHZ
Megahertz	MHZ
Gigahertz	GHZ
dB or dBm	DB
Volts	V

Use terminators to indicate the end of a command. Terminators allow the analyzer to recover to the next command in the event of a syntax error. The semicolon is the recommended command terminator. You can also use the line feed (LF) character and the HP-IB EOI line as terminators. The analyzer ignores the carriage return (CR) character.

HP-IB Debug Mode

An HP-IB diagnostic feature (debug mode) is available in the HP-IB menu. Activating the debug mode causes the analyzer to scroll incoming HP-IB commands across the display. Nonprintable characters are represented with a π. Any time the analyzer receives a syntax error, the commands halt, and a pointer indicates the misunderstood character. See the *HP 8752C Programmer's Guide* for information on correct programming syntax.

Display Graphics

You can use the analyzer screen as a graphics display for displaying connection diagrams or custom instructions to an operator. The display accepts a subset of Hewlett-Packard Graphics Language (HP-GL) commands.

Note The analyzer display occupies an additional address on the HP-IB. Determine the analyzer bus address by adding 1 to the analyzer address if the analyzer address is an even number, or subtracting 1 if it is an odd number. Therefore, the factory default display address for graphics is 17.

11

Preset State and Memory Allocation

The analyzer is capable of saving complete instrument states for later retrieval. It can store these instrument states into internal memory or to an external disk. This chapter describes these capabilities in the following sections:

- instrument state definition
- memory allocation
- internal and external data storage
- description of analyzer state after preset

Where to Look for More Information

Additional information about many of the topics discussed in this chapter is located in the following areas:

- Chapter 2, "Making Measurements," contains step-by-step procedures for making measurements or using particular functions.
- Chapter 3, "Printing, Plotting, and Saving Measurement Results," contains instructions for saving to disk or the analyzer internal memory, and printing and plotting displayed measurements.

Types of Memory and Data Storage

The analyzer utilizes two types of memory and can also be connected to an external disk drive:

Volatile Memory

This is dynamic read/write memory, of approximately 2 Mbytes, that contains all of the parameters that make up the *current* instrument state. An instrument state consists of all the stimulus and response parameters that set up the analyzer to make a specific measurement.

Some data that you may think is part of the instrument state (such as calibration data and memory traces) are actually stored in non-volatile memory. See "Non-Volatile Memory" to read more about the differences.

Volatile memory is cleared upon a power cycle of the instrument and, except as noted, upon instrument preset.

Non-Volatile Memory

This is CMOS read/write memory that is protected by a battery to provide storage of data when line power to the instrument is turned off. With this battery protection, data can be retained in memory for ≈208 days at 70° C and for ≈10 years at 25° C (typically.)

Non-volatile memory consists of a block of user-allocated memory and a block of fixed memory.

The user-allocated memory is available for you to save the following data:

- instrument states
- measurement calibration data
- user calibration kit definitions
- memory traces
- user preset

Note Even though calibration data is stored in non-volatile memory, if the associated instrument state is not saved, you will not be able to retrieve the calibration data after a power cycle.

The fixed memory is used to store the following data (you cannot change where this data is stored and it does not affect your memory availability for storing user-allocated data):

- HP-IB addresses
- copy configuration (printer and plotter type)
- power meter type (HP 436/438)
- display colors
- sequence titles
- sixth sequence
- power sensor calibration factors and loss tables
- user-defined calibration kits
- system Z0
- factory preset
- HP-IB configuration
- CRT intensity default

The maximum number of instrument states, calibrations, and memory traces that can reside in non-volatile memory at any one time is limited to 31 instrument states, 128 calibrations (4 per instrument state including the present instrument state), and 64 memory traces (2 per instrument state including the present instrument state).

In addition, the number of instrument states and associated calibrations and memory traces are limited by the available memory. To display the amount of unused memory on the analyzer, press (SAVE RECALL). (Be sure you have selected INTERNAL MEMORY as your disk type.) In the upper righthand portion of the display, the value displayed as `Bytes free:` is the unused non-volatile memory. When you save to the internal memory, you will see the number of bytes free decrease. When you delete files, the number of bytes free increases. There is a maximum of 512 kbytes available.

If you have deleted registers since the last time the instrument was preset, the bytes available for you to use may be less than the actual "bytes free" that is displayed. Deleting registers to increase the available memory will work in cases where the registers being deleted and the registers needing to be added are of the same standard size (such as instrument states not having calibrations associated with them). In certain other cases, however, you may have to press (PRESET) after deleting registers so that the "bytes free" value equals the available memory value. During a preset, the analyzer runs a memory packer that de-fragments the free memory into one contiguous block.

Table 11-1 shows the memory requirements of calibration arrays and memory trace arrays to help you approximate memory requirements. For example, add the following memory requirements:

- a reflection 1-port calibration with 801 points (14 k)
- the memory trace array (4.9 k)
- the instrument state (3 k)

The total memory requirement is 21.9 kbytes. There is sufficient memory to store 23 calibrations of this type. However, the same calibration performed with 1601 points and 2 channels uncoupled would require 80 kbytes:

- a reflection 1-port calibration with 1601 points, two channels, uncoupled (58 k)
- the memory trace array (19 k)
- the instrument state (3 k)

Only 6 of these calibrations could reside in memory before the available memory would be depleted.

Table 11-1.
Memory Requirements of Calibration and Memory Trace Arrays

Variable	Data Length (Bytes)	Approximate Totals (Bytes)			
		401 pts	801 pts	1601 pts	
		1 chan		1 chan	2 chans
Calibration Arrays					
Response	N x 6 + 52	2.5 k	5 k	10 k	19 k
Response and Isolation	N x 6 x 2 + 52	5 k	10 k	19 k	38 k
Reflection 1-Port	N x 6 x 3 + 52	7 k	14 k	29 k	58 k
Interpolated Cal	Same as above in addition to regular cal				
Measurement Data					
Memory Trace Array*	N x 6 + 52	2.5 k	4.9 k	9.7 k	19 k
Instrument State#		3 k	3 k	3 k	3 k

N = number of points
* This variable is allocated once per active channel.
\# This value may change with different firmware revisions.

The analyzer attempts to allocate memory at the start of a calibration. If insufficient memory is available, an error message is displayed. It is possible that the CMOS memory might be fragmented due to the sequence of saving and deleting states of various sizes. So another alternative would be to store the current state to disk and then press (PRESET). The analyzer runs a memory packer which might regain some previously inaccessible memory. If memory is still inadequate, delete an instrument state and restart the calibration.

External Disk

You can use an external disk for storage of instrument states, calibration data, measurement data, and plot files. (Refer to Chapter 3, "Printing, Plotting, and Saving Measurement Results", for more information on saving measurement data and plot files.)

The analyzer displays one file name per stored instrument state when you list the disk directory. In reality, several files are actually stored to the disk when you store the instrument state. Thus, when the disk directory is accessed from a remote system controller, the directory will show several files associated with a particular saved state. The maximum number of files that you can store on a disk depends on the directory size. You can define the directory size when you format a disk. See Table 11-3 for the default directory size for floppy disks and hard disks.

The maximum number of instrument states and calibrations that can reside on a disk is limited by the available disk space. To see the available disk space displayed on the analyzer, press (SAVE RECALL). (Be sure you have selected EXTERNAL DISK as your disk type.) In the upper righthand portion of the display, the value displayed as `Bytes free:` is the available disk space. If your disk is formatted in LIF, this value is the largest contiguous block of disk space. Since the analyzer is reporting the largest contiguous block of disk space, you may or may not see the bytes free number change when you delete files. If your disk is formatted in DOS, the number reported as bytes free is the total available disk space. That number is updated whenever you save to or delete files from the disk.

A disk file created by the analyzer appends a suffix to the file name. (This is on the analyzer's directory and is not visible. The suffix consists of one or two characters: the first character is the file type and the second is a data index. (Refer to Table 11-2 for the definitions of each suffix character.)

Table 11-2. Suffix Character Definitions

Char 1	Definition	Char 2	Definition
I	Instrument State		
G	Graphics	1	Display Graphics
		0	Graphics Index
D	Error Corrected Data	1	Channel 1
		2	Channel 2
R	Raw Data	1 to 4	Channel 1, raw arrays 1 to 4
		5 to 8	Channel 2, raw arrays 5 to 8
F	Formatted Data	1	Channel 1
		2	Channel 2
C	Cal	K	Cal Kit
1	Cal Data, Channel 1	0	Stimulus State
		1 to 9	Coefficients 1 to 9
		A	Coefficient 10
		B	Coefficient 11
		C	Coefficient 12
2	Cal Data, Channel 2	0 to C	same as Channel 1
M	Memory Trace Data	1	Channel 1
		2	Channel 2

If correction is on at the time of an external store, the calibration set is stored to disk. (Note that inactive calibrations are not stored to disk.) When an instrument state is loaded into the analyzer from disk, the stimulus and response parameters are restored first. If correction is on for the loaded state, the analyzer will load a calibration set from disk that carries the same title as the one stored for the instrument state.

Conserving Memory

If you are concerned about conserving memory, either internal memory or external disk space, some of the most memory-intensive operations include:

- reflection 1-port error correction
- interpolated error correction
- 1601 measurement points
- using time domain
- saving data arrays and graphics with the instrument state

Using Saved Calibration Sets

When you are saving to internal memory (CMOS, non-volatile memory), calibration sets are linked to the instrument state and measurement parameter for which the calibration was done. Therefore a saved calibration can be used for multiple instrument states as long as the measurement parameter, frequency range, and number of points are the same. A reflection 1-port calibration is valid for any reflection measurement with the same frequency range and number of points. When an instrument state is deleted from memory, the associated calibration set is also deleted if it is unused by any other state.

The following hints will help you avoid potential problems:

- If a measurement is saved with calibration and interpolated calibration on, it will be restored with interpolated calibration on.
- A calibration stored from one instrument and recalled by a different one will be invalid. To ensure maximum accuracy, always recalibrate in these circumstances.
- No record is kept in memory of the temperature when a calibration set was stored. Instrument characteristics change as a function of temperature, and a calibration stored at one temperature may be inaccurate if recalled and used at a different temperature. See chapter 7, "Specifications and Measurement Uncertainties," for allowable temperature ranges for individual specifications.
- The HP 8752C can read disk files created by the HP 8752A/B and the HP 8752A/B can read files created by the HP 8752C.

Preset State

When the (PRESET) key is pressed, the analyzer reverts to a known state called the factory preset state. This state is defined in Table 11-3. There are subtle differences between the preset state and the power-up state. These differences are documented in Table 11-4. If power to non-volatile memory is lost, the analyzer will have certain parameters set to default settings. Table 11-5 shows the affected parameters.

When line power is cycled, or the (PRESET) key pressed, the analyzer performs a self-test routine. Upon successful completion of that routine, the instrument state is set to the conditions shown in Table 11-3. The same conditions are true following a "PRES;" or "RST;" command over HP-IB, although the self-test routines are not executed.

You also can configure an instrument state and define it as your user preset state:

1. Set the instrument state to your desired preset conditions.
2. Save the state (save/recall menu).
3. Rename that register to "UPRESET".
4. Press (PRESET).

The (PRESET) key is now toggled to the USER selection and your defined instrument state will be recalled each time you press (PRESET) and when you turn power on. You can toggle back to the factory preset instrument state by pressing (PRESET) and selecting FACTORY.

Note When you send a preset over HP-IB, you will always get the factory preset. You can, however, activate the user-defined preset over HP-IB by recalling the register in which it is stored.

Table 11-3. Preset Conditions (1 of 4)

Preset Conditions	Preset Value	Preset Conditions	Preset Value
Stimulus Conditions		Display	Data
Sweep Type	Linear Frequency	Color Selections	Same as before (PRESET)
Display Mode	Start/Stop	Dual Channel	Off
Trigger Type	Continuous	Active Channel	Channel 1
External Trigger	Off	Frequency Blank	Disabled
Sweep Time	100 ms, Auto Mode	Split Display	On
Sweep Time (Option 006)	175 ms, Auto Mode	Intensity	If set to $\geq$ 15%, (PRESET)
Start Frequency	300 kHz		has no effect. If set to
Stop Frequency	1300 MHz		< 15% (PRESET) increases
Stop Frequency (Option 003)	3 GHz		intensity to 15%.
Stop Frequency (Option 006)	6 GHz	Beeper: Done	On
Start Time	0	Beeper: Warning	Off
Time Span	100 ms	D2/D1 to D2	Off
CW Frequency	1000 MHz	Title	Channel 1 = [hp]
Test Port Power	−10 dBm		Channel 2 = Empty
Power Slope	0 dB/GHz; Off	IF Bandwidth	3000 Hz
Start Power	−20 dBm	IF Averaging Factor	16; Off
Start Power (Option 004)	−15 dBm	Smoothing Aperture	1% SPAN; Off
Power Span	25 dB	Phase Offset	0 Degrees
Coupled Power	On	Electrical Delay	0 s
Source Power	On	Scale/Division	10 dB/Division
Coupled Channels	On		
Power Range (Option 004)	Auto; Range 1	**Calibration**	
Number of Points	201	Correction	Off
		Calibration Type	None
Frequency List		Calibration Kit	Type-N 50Ω
Frequency List	Empty	Calibration Kit (Option 075)	Type-N 75Ω
Edit Mode	Start/Stop, Number of Pts.	Alternate RFL & TRN	Off
Response Conditions		System Z0	50 Ohms
Parameter	Channel 1: Reflection	System Z0 (Option 075)	75 Ohms
	Channel 2: Transmission	Chop RFL & TRN	On
Conversion	Off	Interpolated Error Cor.	Off
Format	Log Magnitude (all inputs)		

Table 11-2. Preset Conditions (2 of 4)

Preset Conditions	Preset Value	Preset Conditions	Preset Value
Markers (coupled)		**Time Domain**	
Markers 1, 2, 3, 4	1 GHz; All Markers Off	Transform	Off
Last Active Marker	1	Transform Type	Bandpass
Reference Marker	None	Start Transform	−20 nanoseconds
Marker Mode	Continuous	Transform Span	40 nanoseconds
Display Markers	On	Gating	Off
Delta Marker Mode	Off	Gate Shape	Normal
Coupling	On	Gate Start	−10 nanoseconds
Marker Search	Off	Gate Span	20 nanoseconds
Marker Target Value	−3 dB	Demodulation	Off
Marker Width Value	−3 dB; Off	Window	Normal
Marker Tracking	Off	Use Memory	Off
Marker Stimulus Offset	0 Hz	**System Parameters**	
Marker Value Offset	0 dB	HP-IB Addresses	Last Active State
Marker Aux Offset (Phase)	0 Degrees	HP-IB Mode	Last Active State
Marker Statistics	Off	Intensity	Last Active State
Polar Marker	Lin Mkr	Preset: Factory/User	Last Selected State
Smith Marker	R+jX Mkr		
		Disk Save Configuration (Define Store)	
Limit Lines		Corrected Data Array	Off
Limit Lines	Off	Raw Data Array	Off
Limit Testing	Off	Formatted Data Array	Off
Limit List	Empty	Graphics	Off
Edit Mode	Upper/Lower Limits	Data Only	Off
Stimulus Offset	0 Hz	Directory Size	Default[1]
Amplitude Offset	0 dB	Save Using	Binary
Limit Type	Sloping Line	Select Disk	Internal Memory
Beep Fail	Off	Disk Format	LIF

1 The directory size is calculated as 0.013% of the floppy disk size (which is ≈256) or 0.005% of the hard disk size.

Table 11-2. Preset Conditions (3 of 4)

Preset Conditions	Preset Value
Sequencing[1]	
Loop Counter	0
End Sweep	High Pulse
TTL Out All	Last Active State
Service Modes	
HP-IB Diagnostic	Off
Source Phase Lock	Loop On
Sampler Correction	On
Spur Avoidance	On
Aux Input Resolution	Low
Analog Bus Node	11 (Aux Input)
Plot	
Plot Data	On
Plot Memory	On
Plot Graticule	On
Plot Text	On
Plot Marker	On
Plot Quadrant	Full Page
Scale Plot	Full
Plot Speed	Fast
Pen Number:	
Ch1 Data	2
Ch2 Data	3
Ch1 Memory	5

Preset Conditions	Preset Value
Ch2 Memory	6
Ch1 Graticule	1
Ch2 Graticule	1
Ch1 Text	7
Ch2 Text	7
Ch1 Marker	7
Ch2 Marker	7
Line Type:	
Ch1 Data	7
Ch2 Data	7
Ch1 Memory	7
Ch2 Memory	7
Auto-feed	On
Print	
Print Type	Last Active State
Auto-feed	On
Print Colors:	
Ch1 Data	Magenta
Ch2 Data	Green
Ch1 Memory	Blue
Ch2 Memory	Red
Graticule	Cyan
Warning	Black
Text	Black

1 Pressing preset turns off sequencing modify (edit) mode and stops any running sequence.

Table 11-2. Preset Conditions (4 of 4)

Format Table	Scale	Reference	
		Position	Value
Log Magnitude (dB)	10.0	5.0	0.0
Phase (degree)	90.0	5.0	0.0
Group Delay (ns)	10.0	5.0	0.0
Smith Chart	1.00	–	1.0
Polar	1.00	–	1.0
Linear Magnitude	0.1	0.0	0.0
Real	0.2	5.0	0.0
Imaginary	0.2	5.0	0.0
SWR	1.00	0.0	1.0

Table 11-4. Power-on Conditions (versus Preset)

HP-IB MODE	Talker/listener.
SAVE REGISTERS	Calibration data not associated with an instrument state are cleared.
COLOR DISPLAY	Default color values
INTENSITY	Factory stored values. The factory values can be changed by running the appropriate service routine. Refer to the "Adjustments and Correction Constants" chapter in the *HP 8752C Service Guide*.
SEQUENCES	Sequence 1 through 5 are erased.
DISK DIRECTORY	Cleared.

Table 11-5. Results of Power Loss to Non-Volatile Memory

HP-IB ADDRESSES are set to the following defaults:

HP 8752C	16
USER DISPLAY	17
PLOTTER	5
PRINTER	1
POWER METER	13
DISK	0
DISK UNIT NUMBER	0
DISK VOLUME NUMBER	0

POWER METER TYPE is set to HP 438A/437

INTERNAL REGISTER TITLES are set to defaults: REG1 through REG32.

EXTERNAL REGISTER TITLES (store files) are set to defaults: FILE1 through FILE 5.

PRINT TYPE is set to default: MONOCHROME.

Index

D

E

I

M

N

O

P

Q

R

S

U

V

W