User's Guide

Agilent Technologies
Multiport Test System

Using the Agilent Technologies
N4413A, N4414A, N4415A, N4416A, N4417A,
N4418A, N4419A, and N4421A Multiport Test Sets
with N4425A Balanced Measurement Software

Agilent Technologies

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Software Compatibility

This user's guide is compatible with N4425A Balanced Measurement Software revisions 1.24 and above.

Document Conventions

This document uses a few conventions to make reading easier.

- Menu and dialog box items are shown in bold face type. When described in text, menus and sub-menus are separated by right arrows, as in **File > Open > Data...**
- Dialog box names are shown in *italic* font.
- Keyboard entries are shown in `mono-spaced` typeface.
- Network analyzer keys are displayed in **condensed**, **bold** font.

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1 About the Multiport Test System

Introduction

The Agilent Multiport Test System makes quick and accurate S-parameter measurements of both active and passive devices with up to four ports.

The multiport test system consists of an Agilent network analyzer, an Agilent multiport test set, a system controller (PC) running the balanced measurement software, and interconnect cabling.

Combining a unique multiport hardware architecture with a fast multiple-term calibration algorithm, the multiport test system provides true multiport vector error-correction while preserving the accuracy of the underlying network analyzer.

Model Numbers at a Glance

The frequency range and network analyzer requirements for the various multiport test system configurations are shown below in “Multiport Test System Configurations.” Descriptions of analyzer options are shown in “Agilent Network Analyzer Option Reference Table” on page 4.

Multiport Test System Configurations

Multiport Test Set Model Number	System Frequency Range	Supported Network Analyzer			
		Model Number	Options[a]		
			Required	Compatible	Incompatible
N4413A[b]	50 MHz to 6.0 GHz	8753C[c]/D/E/ES	006[d], 011	1D5, 002, 010	075
N4414A[b]	300 kHz to 6.0 GHz				
N4415A[b]	30 kHz to 6.0 GHz	8753ES	006[d], 014	1D5, 002, 010	075, H16
N4416A[b]	300 kHz to 6.0 GHz	E8356A[e]/7A[e]/8A	015	010	
N4417A[f]	300 kHz to 9.0 GHz	E8356A[e]/7A[e]/8A	015	010	
		E8801A[e]/2A[e]/3A	014	010, 1E1, 1E5	
N4418A[b]	50 MHz to 20 GHz	8719D/ES[e] 8720D/ES	H32 or H42	010, 012, 400	007, 085, 089
		8722D/ES[g]	H32 or H44	010, 012, 400	007, 085, 089
N4419A	45 MHz to 20 GHz	E8362A/B	014	010, 022, 711, UNL	
N4421A	45 MHz to 50 GHz	E8364A/B	014	010, 022, 711, UNL	

a. This table lists only the most specifically relevant options. For compatibility with options not listed here, contact the factory.
b. This test set may also be labeled with an ATN model number. N4413: previously ATN-4111A; N4414A: previously ATN-4111B; N4415A: previously ATN-4111C; N4416A: previously ATN-4111D; and N4418A: previously ATN-4112A
c. 8753C requires firmware revision 4.13 or above.
d. Option 006 required only for operation above 3 GHz.
e. When the Multiport Test Set is used with this network analyzer model, the maximum system frequency is limited by the maximum operating frequency of the analyzer: 3 GHz for E8356A/E8801A, 6 GHz for E8357/E8802A, and 13.5 GHz for 8719D/ES.
f. E8356A/57A/58A requires N4417A Option 103; E8801A/02A/03A requires N4417A Option 104.
g. When an 8722D/ES is used with an N4418A, the N4418A requires Option 302. The system’s maximum operating frequency is limited to 20.0 GHz.

"Agilent Network Analyzer Option Reference Table" (located below) lists common options for supported network analyzers. Refer to "Multiport Test System Configurations" on page 3 for compatibility of these options with the multiport test system.

Agilent Network Analyzer Option Reference Table

Option Numbers and Descriptions			
8753C/D/E/ES Options			
002	Harmonic-Measurement Upgrade	004	Step Attenuator Upgrade
006	6 GHz Upgrade for Standard Units	010	Time Domain Capability
011	Receiver Configuration	014	Configurable Test Set
075	75 ohm impedance	1D5	High Stability Frequency Reference
8719D/ES, 8720D/ES, and 8722D/ES Options			
007	Mechanical Transfer Switch	010	Time Domain Capability
012	Direct Sampler Access	085	High-Power Test Set
089	Frequency Offset Mode	1D5	High Stability Frequency Reference
400	Four-Sampler Test Set	H32	Front panel access to A and B samplers and Port 1 and Port 2 switch and coupler
H42	8719/8720 only: Front panel access to all samplers and Port 1 and Port 2 switch and coupler (installs options 400 and 012)	H44	8722 only: Front panel access to R1, R2, A, and B samplers, and Port 1 and Port 2 switch and coupler ports (installs options 400 and 012)
E8356A, E8357A, and E8358A Options			
010	Time Domain Capability	015	Configurable Test Set
E8801A, E8802A, and E8803A Options			
010	Time Domain Capability	014	Configurable Test Set
1E1	Add Source Attenuator	1E5	High Stability Time Base
E8362A/B and E8364A/B Options			
010	Time Domain Capability	014	Configurable Test Set
016[a]	Add Receiver Attenuators	022	Extended Memory
080[a]	Frequency Offset	081[a]	External Reference Switch
083[a]	Frequency Converter Measurement Application	711	Standard Power Range
UNL	Extended Power Range with Bias Tees		

a. This option has not been tested and is not specified with the Multiport Test System.

Basic System Components

Each multiport test system has configuration options. Your packing list provides details of the hardware and software provided for your system configuration.

As a minimum, the following will be provided with each standard system:

- Agilent two- or four-port multiport test set
- Balanced measurement software on CD-ROM
- User's guide
- Interconnect cabling

Supported Equipment

Refer to the following lists for information about equipment used with the multiport test system.

Network Analyzer:

- Refer to "Multiport Test System Configurations" on page 3.

System Controller:

- Pentium[1] PC compatible computer (or better)
- Windows 95/98[2], Windows NT[3], or Windows 2000 (Windows 2000 recommended). Windows should be run with the latest service pack available.
- At least 64 megabytes of RAM (>128 MB RAM recommended)
- CD-ROM Drive
- Supported GPIB card
  — Agilent 82340, 82341, or 82350 - or - National Instruments (any)
- 1024 x 768 video in at least 256 colors with small fonts.

S/O/L/T Calibration Kits:

- Agilent N4430A Electronic Multiport Calibration Module (6 GHz)
- Agilent N4430B Electronic Multiport Calibration Module (9 GHz)
- Agilent 85032B/E (Type-N) (dc – 6 GHz)
- Agilent 85033D (3.5 mm) (dc – 6 GHz)
- Agilent 85050B/C (7 mm) (dc – 18 GHz)
- Agilent 85052D (3.5 mm) (dc – 26.5 GHz)
- Agilent 85056A (2.4 mm) (dc – 50 GHz)

Additional calibration kits, including on-wafer standards, may be added by the user. Refer to "How to Add a Calibration Kit Definition" on page 78.

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Available Options and Accessories

The following is a list of options and accessories that are available with the multiport test system.

Options

Option 103	Front Panel Cable Configuration for E8356A/57A/58A (N4417A Only)
Option 104	Front Panel Cable Configuration for E8801A/02A/03A (N4417A Only)
Option 302	Adds interface adapters for connectivity to the Agilent 8722D/ES with Option H32 or Option H44; includes precision 3.5 mm to 2.4 mm adapters and custom RF interface cables. (N4418A only)
Option 1CP	Rack Mount Flange Kit
Option 1E1	Source step attenuator (N4414A only)
Option B20	Set of 4 test port cables
Option UNL	(1) Integrated 70 dB (x 10 dB) step attenuator (4) Integrated 0.5 Amp bias tees (N4413A only)

Accessories

N4430A	Electronic Multiport Calibration Module (300 kHz to 6.0 GHz)
N4430B	Electronic Multiport Calibration Module (300 kHz to 9.0 GHz)

NOTE The N4431A 4-port RF Electronic Calibration Module is not compatible with the Multiport Test System.

2 User Interface

The Main Screen

The opening screen of the N4425A Balanced Measurement Software is shown on page 11.

Initially, the system displays a thumbnail-sized single-ended (unbalanced) four-port S-parameter matrix. A mixed-mode (balanced) four-port S-parameter matrix can also be displayed (select **Data > Transforms > 2 Balanced Ports** or **Data > Transforms > 2 Single-Ended, 1 Balanced Port**).

User-defined displays, combining measured data with math functions, can be easily created. See "How to Set Up User-Defined Displays" on page 49.

The number of thumbnail S-parameters displayed is dependent on the port selection that you make in the Setup menu.

- For the 4-port measurement selection, 16 S-parameter thumbnails are displayed.
- For the 3-port measurement selection, 9 S-parameter thumbnails are displayed.
- For the 2-port measurement selections, 4 S-parameter thumbnails are displayed.

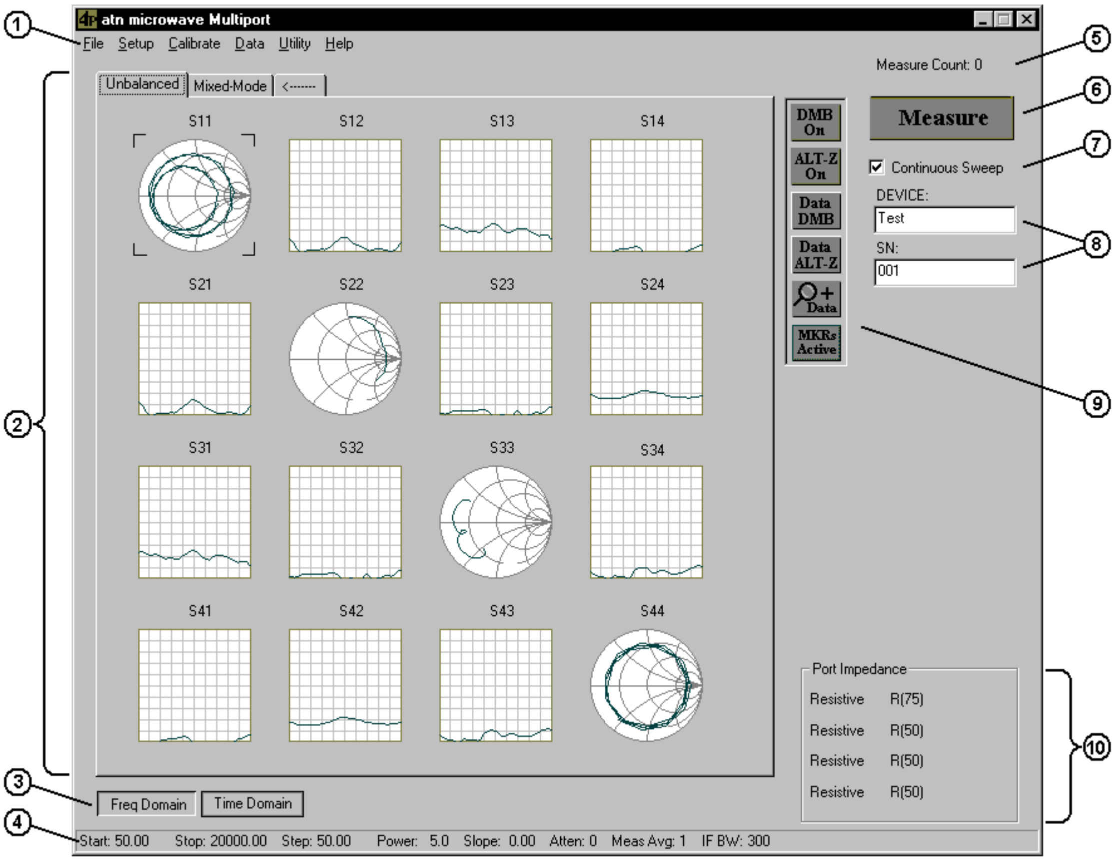
For each display, the plot or chart type, scaling, and other parameters can be assigned individually. See "Individual Measurement Screens" on page 14.

Display parameters can also be easily copied from one display to another.

- To copy the display parameters, simply move the cursor over the display with the desired formatting, and left-click the mouse while holding the Shift key.
- To paste the display parameters into a different measurement display, put the cursor in that display and left-click the mouse while holding the Ctrl key.

Printing the main screen can easily be performed. To open the Print Annotation dialog box, double left-click any shaded part of the measurement display area. See "File > Print…" on page 107.

Figure 1 The Main Screen



1 Use the **Main Menu** to access additional functions.

2 Available parameters are shown in the **Measurement Display** area. By default, the single-ended thumbnail display is selected (as shown above). See "Individual Measurement Screens" on page 14.

To display an individual measurement screen:

For 2-port Displays:	Hold the Alt key down and double left-click the measurement thumbnail plot that you want to display.
For 3- and 4-port Displays:	Double left-click the measurement thumbnail plot that you want to display.

3 Parameter Set Selection. Choose **Frequency Domain**, **Time Domain**, or **User-Defined**.

4 The system displays messages at the bottom of the screen in the **Message Window**.

5 If **Measure Count** is enabled, it shows the number of measurements made. See "Utility > Measurement Counter Visible" on page 151.

6 **Measure** starts the measurement sequence. See "How to Make Measurements" on page 47.

7 **Continuous Sweep** performs the next measurement with continuous sweeps. Click the **STOP** button to stop continuous measurements.

NOTE: If **Continuous Sweep** is enabled, **Measure Count** does not increment.

8 Use the **DEVICE:** and **SN:** boxes to the right to enter information about the device under test. This information is saved with the DUT data set and appears in printouts and exported data files.

9 The **Indicator Bar** shows the measurement settings. See "The Indicator Bar" on page 12.

10 **Port Impedance**, as defined through the setup, is shown in this area unless all ports are set to 50Ω.

The Indicator Bar

The Indicator Bar buttons show measurements settings.

- Green buttons show settings that will affect future measurements.
- Blue buttons show settings applied to the current data.

De-embedding Indicators

De-embedding or reference plane rotation has been activated in Setup.

The data has been modified by de-embedding or reference plane rotation.

See "Setup > Modify Rotations…" on page 119.

Reference Impedance Indicators

An arbitrary reference impedance (non-50Ω) has been selected in Setup on at least one port.

The data has been modified for a non-50Ω reference impedance on at least one port.

See “Setup > Test Port Impedance…” on page 120.

NOTE If the default reference impedance value (50Ω) has been modified on at least one port, the Port Impedance box shows the reference impedance values on all 4 ports.

Frequency Zooming Indicators

Frequency zooming or point skipping has been applied and a subsequent measurement has been made, creating a new set of calibration data.

Frequency zooming or point skipping has been selected, but a subsequent measurement has not been made.

See “How to Use Frequency Zoom” on page 54.

Marker Indicators

Markers are turned on in the active state.

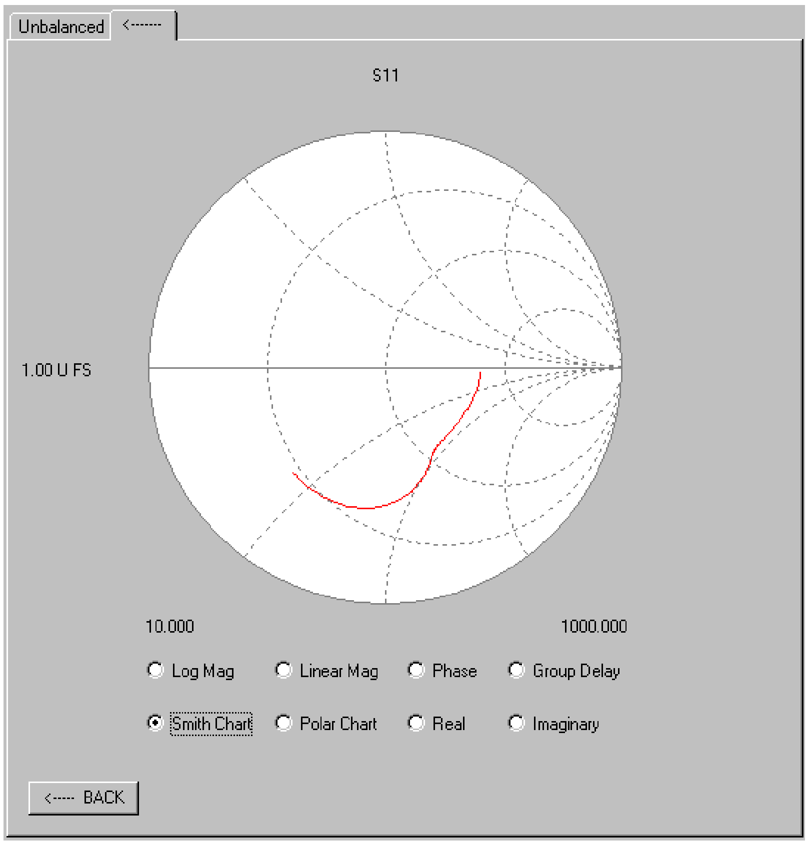
Markers are turned on in the fixed state.

See “How to Use Markers” on page 50.

Individual Measurement Screens

Click a button to select the display type from **Log Mag**, **Linear Mag**, **Phase**, **Smith Chart**, **Polar Chart**, **Group Delay**, **Real**, and **Imaginary**.

Figure 2 Individual Measurement Screen



Click ← BACK to return to the previous display.

Right-click the shaded area of the display to open the display properties box. See "How to Use Markers" on page 50 and "How to Use Frequency Zoom" on page 54 for information on how to use the property box options.

Double left-click the shaded area to open the Print Annotation dialog box. See "File > Print…" on page 107.

Scaling

The system supports changes to scale parameters for individual measurement displays. Methods for changing the scale parameters of both rectangular display formats and Smith Chart/Polar display formats are described in this section.

Changing the Scale Parameters of Rectangular Displays

Scale parameters of individual measurement displays of rectangular plots (Log Mag, Linear Mag, Phase, Group Delay, Real, Imaginary) may be changed using one of two methods. Rectangular plot scale parameters may be changed:

- Using mouse shortcut strokes (not available when markers are active)
- Entering the scale parameters directly

To Use Mouse Shortcut Strokes

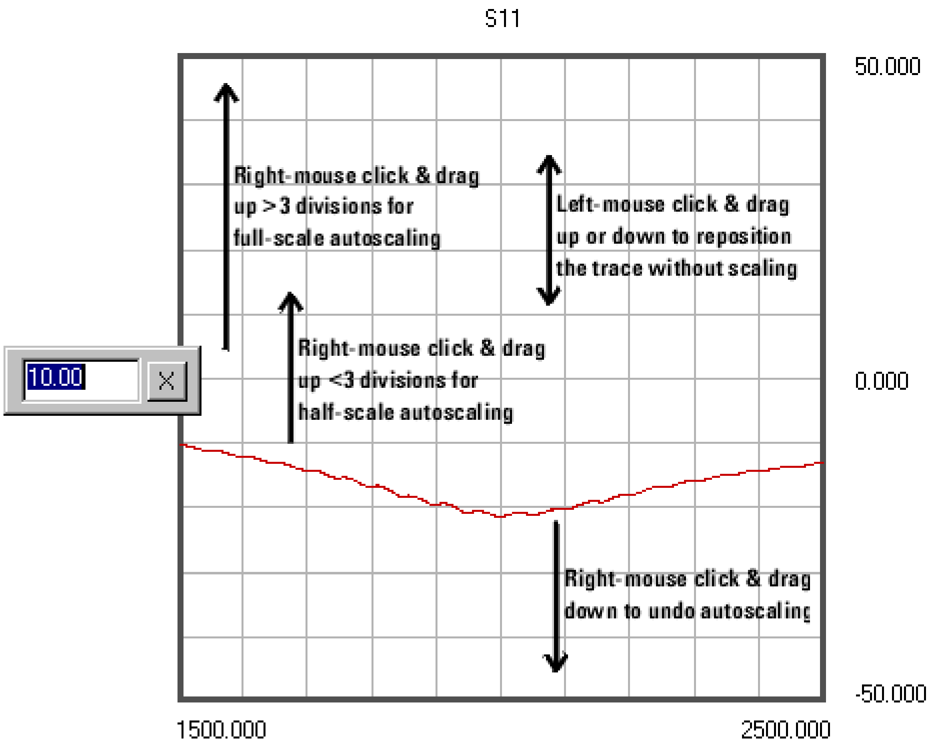
When you first open an individual display or select a plot type (Log Mag, Phase, etc.), the system establishes a display baseline for that display. If you undo auto-scaling via any of the methods described below, the display returns to this configuration.

- Double left-click the display area to *zoom in* on the data in the vertical axis.
- Double right-click the display area to *zoom out* on the data in the vertical axis.

Zooming in this fashion occurs concentrically around the cursor position. If you want to zoom relative to another reference line, for instance, move the cursor there first.

- Left-button drag up or down to reposition the trace on the plot without changing the scale (units/division). The cursor does not need to be on the trace to reposition. The number of vertical graticules traversed determines the position change.
- Right-button drag upward more than three graticules to select full-scale auto-scaling. Full-scale auto-scaling makes the data fit in the full vertical screen axis.
- Right-button drag upward less than three graticules to select half-scale autoscaling. Half-scale auto-scaling makes the data fit in half of the vertical screen axis.
- Right-button drag downward to undo all auto-scaling and return the display to the baseline configuration.

Figure 3 Mouse Shortcut Strokes for Scaling



To Edit the Scale Directly

Scale parameters in rectangular displays may be edited directly. When a scale parameter is changed, other scale parameters may change to adjust to the new parameter that was entered. For example, if the decibels per division value is changed, the upper and lower scale values will change.

To edit a scale parameter directly, double left-click on the parameter to open a dialog box at the parameter's location as shown on the left side of Figure 3, enter the new value, and press the Enter key. Select the close button (×) to cancel.

Changing the Scale Parameters of Smith/Polar Chart Displays

When you first open an individual display or select a plot type (Smith Chart or Polar Chart) the system establishes a display baseline for that display.

- Double left-click the display area to *zoom in* on the data.
- Double right-click the display area to *zoom out* on the data.

3 Using the Multiport Test System

How to Set Up the Multiport Test System Hardware

You set up the Agilent multiport test system as you would any other test set for the supported vector network analyzer. The normal physical location of the test set is beneath the network analyzer in either a tabletop or rack configuration. The test set is supplied with notches in the top of the case to accept the feet of the analyzer for a secure tabletop installation.

Perform the following procedure to set up the multiport test system.

1. Make sure the host computer, the network analyzer, and the test set are powered off.
2. Situate the network analyzer with the test set for operation.
3. Make connections between the system components as needed:
    - Connections between test set and the network analyzer. See "To Connect the RF Cables between the Multiport Test Set and the Network Analyzer" on page 23 for the interconnect diagram applicable to your test set.
    - GPIB connections between the host computer, the test set, and the network analyzer. See "To Set the GPIB Addresses" on page 38.
    - Test-cable connections to the test set. Use phase-stabilized RF cables, such as the optional cable set available with Option B20.
    - If you will be using an Agilent Electronic Multiport Calibration (ECal) Module, connect the control cable from the test set auxiliary port to the module.
    - If your test set is equipped with optional bias tees, make connections to the bias supplies.

NOTE The bias connections are coaxial. The center conductor is hot and the outer conductor is at case ground.

4. Power on all the equipment.

NOTE If the multiport test set does not power up, check the rear panel to ensure the line fuse is installed.

5. If your network analyzer is an N8362A/B or N8364A/B PNA, you will need to perform the Phase-Lock IF Gain Adjustment on the analyzer after it has been connected to the test set as a system. This routine adjusts the R Channel receivers ALC gain to ensure phase lock over the entire frequency range. Refer to **Phase-Lock IF Gain Adjustment** in the network analyzer's online help system for details. Use the following steps to perform this adjustment:

    a. On the network analyzer, from the **System** menu, click **Service**, then **Adjustments**, then **IF Gain Adjustment**.

       If you are unable to find these selections on your N8362A/N8364A PNA, your analyzer firmware is a revision prior to 3.0. Follow the instructions in "IF Gain Adjustment" on page 212 to complete this adjustment.

    b. Select the test set options installed.

    c. No connections to the test ports are required.

    d. Click **Begin Adj**. The adjustment takes about a minute to complete.

       The advanced screen is for factory personnel only.

NOTE This adjustment must be performed before using the network analyzer each time the system is assembled or disassembled.

6. If it hasn't already been done, install and configure the software. See "How to Install and Start the Balanced Measurement Software" on page 39.

Attach the Network Analyzer to the Multiport Test Set

The normal physical location of the test set is beneath the network analyzer in either a tabletop or rack configuration.

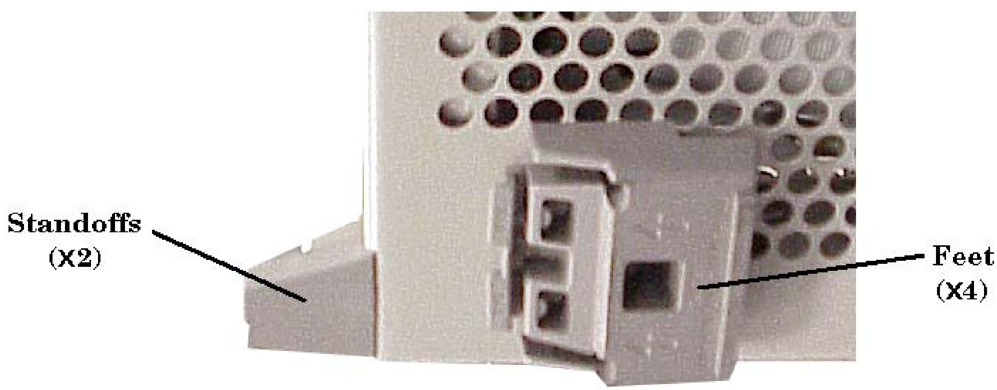
For all test sets except the N4421A, the test set is supplied with notches in the top of the case to accept the feet of the network analyzer for a secure tabletop installation. Then return to "How to Set Up the Multiport Test System Hardware" on page 18 to complete the installation.

Attaching the E8364A/B Network Analyzer to the N4421A Test Set

The E8364A/B network analyzer is attached with the N4421A test set using lock links at the front and locking feet at the rear. This hardware is supplied with the N4421A test set.

Preparing the Network Analyzer

1. Remove the four feet from the bottom of the network analyzer.



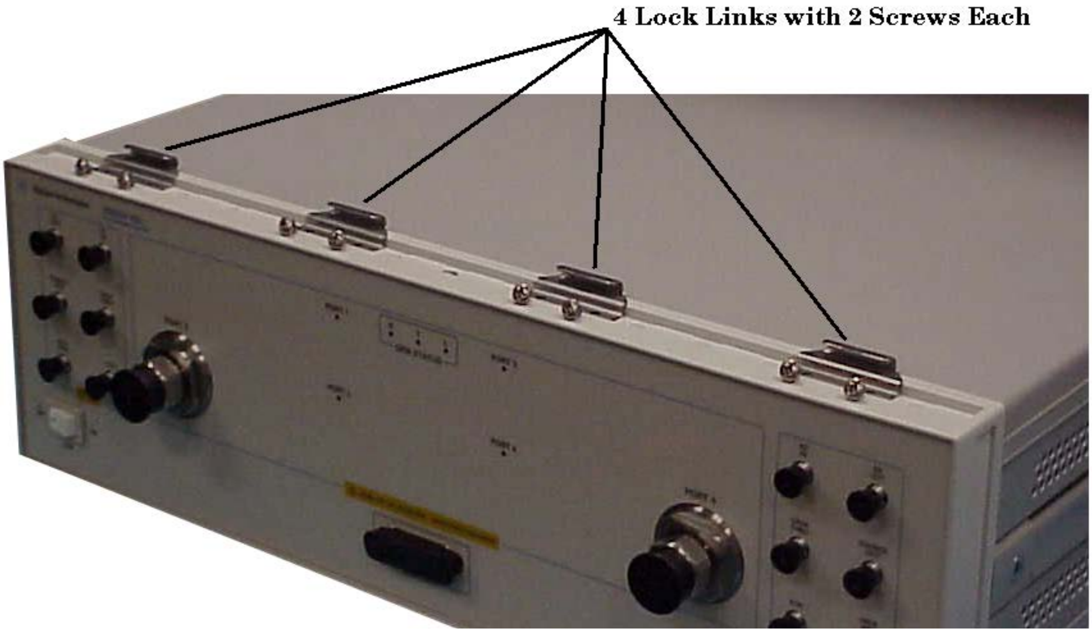
2. Remove the screws from the two lower rear panel standoffs.
3. Install the two rear locking feet where the standoffs were removed. Use part number Z5823-20239 on the left side of the analyzer and part number Z5823-20240 on the right side. Use the two longer screws to secure the feet to the analyzer.

Preparing the Test Set

4. Remove the trim strip from the top of the front frame.

5. Install the four lock links to the top of the front frame using eight screws.

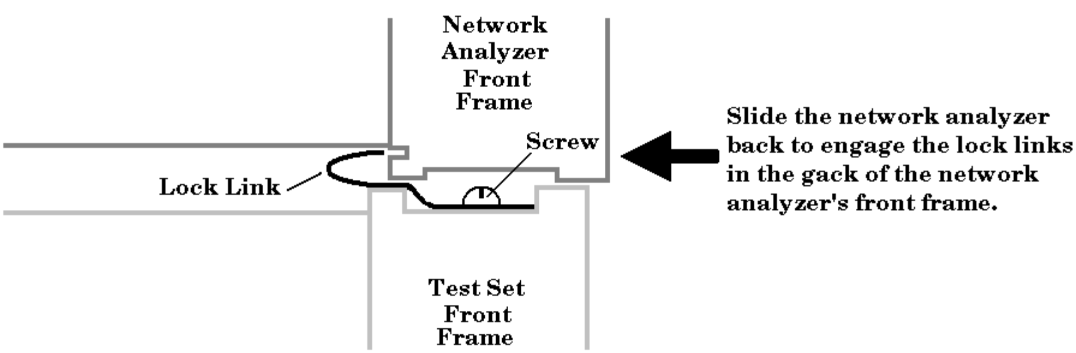
Lock Link Installation



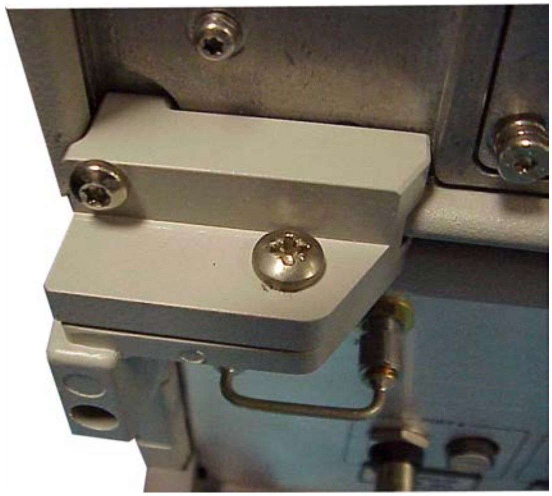
Attaching the Network Analyzer to the Test Set

6. Place the network analyzer on top of the test set ensuring that the front frame of the network analyzer is positioned slightly forward of the lock links that are attached to the the test set. Then slide the network analyzer back so the lock links engage the front frame of the analyzer.

Making the Lock Link Connection



7. Secure the network analyzer's lower locking feet to the test set's upper locking feet by inserting the shorter two screws between the two pairs of locking feet, one on each side of the instrument as shown below.



If the screw holes between the network analyzer's lower locking feet are not aligned with the screw holes in the test set's upper locking feet, loosen the screws securing the feet to the instruments slightly to align.

8. Tighten all screws.

9. Return to "How to Set Up the Multiport Test System Hardware" on page 18 to complete the installation.

To Connect the RF Cables between the Multiport Test Set and the Network Analyzer

An illustration showing each multiport test system and its interconnections is provided in this section. Each illustration has a corresponding table that lists the sequence of each interconnection, the interconnect cable part number, and the connector label for the network analyzer and the S-parameter test set.

Connect the RF cables between the front panel of the test set and the front panel of the network analyzer using the interconnect information provided in this section.

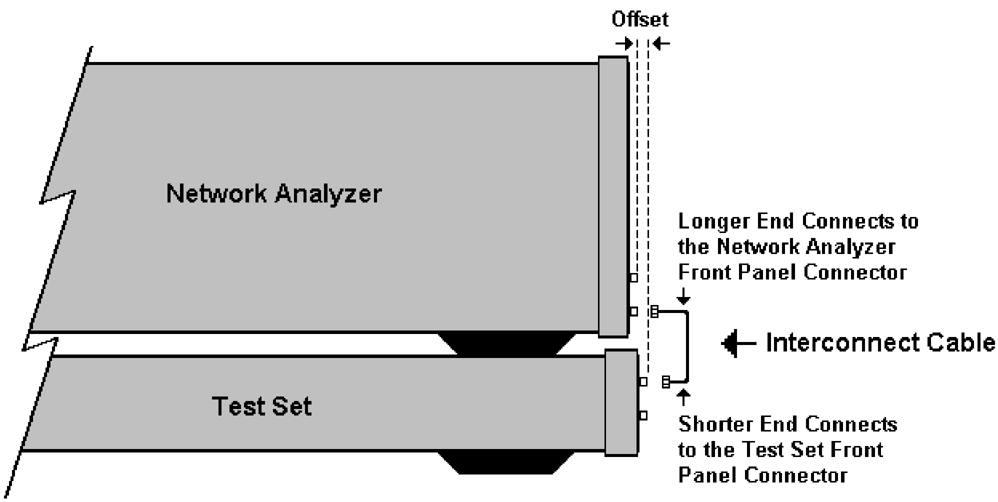
Refer to the specific interconnect information for your test set model number.

- For the N4413A, refer to “Interconnections for the N4413A/N4414A Test Set” on page 25.
- For the N4414A, refer to “Interconnections for the N4413A/N4414A Test Set” on page 25.
- For the N4415A, refer to “Interconnections for the N4415A Test Set” on page 26.
- For the N4416A, refer to “Interconnections for the N4416A Test Set” on page 28.
- For the N4417A, refer to “Interconnections for the N4417A Test Set” on page 30.
- For the N4418A, refer to “Interconnections for the N4418A Test Set” on page 32.
- For the N4419A, refer to “Interconnections for the N4419A Test Set” on page 34.
- For the N4421A, refer to “Interconnections for the N4421A Test Set” on page 36.

Refer to "Multiport Test System Configurations,” on page 3 and "Agilent Network Analyzer Option Reference Table,” on page 4 for additional information about test set and network analyzer model and option requirements.

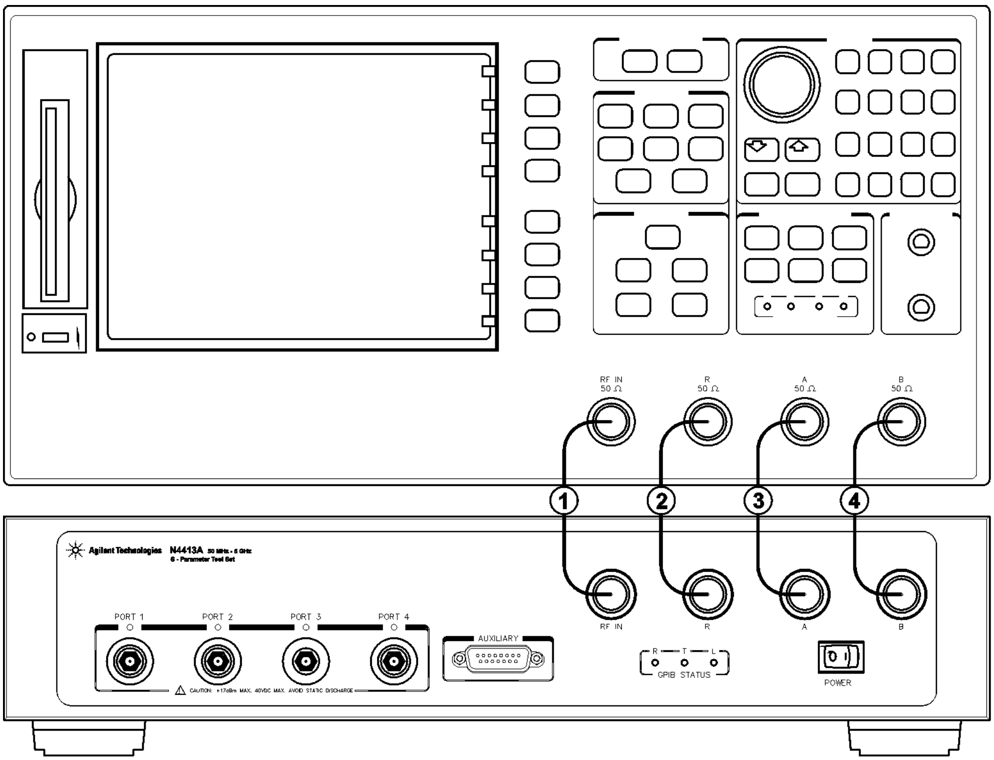
CAUTION When connecting the interconnect cables described in the remaining pages of this section, be careful to install the interconnect cables correctly. The longer end of the interconnect cable connects to the network analyzer front panel connector. Refer to Figure 3-1 for the correct orientation.

Figure 3-1 Interconnect Cable Orientation



Damage to the interconnect cable can result from improper connection of the cable.

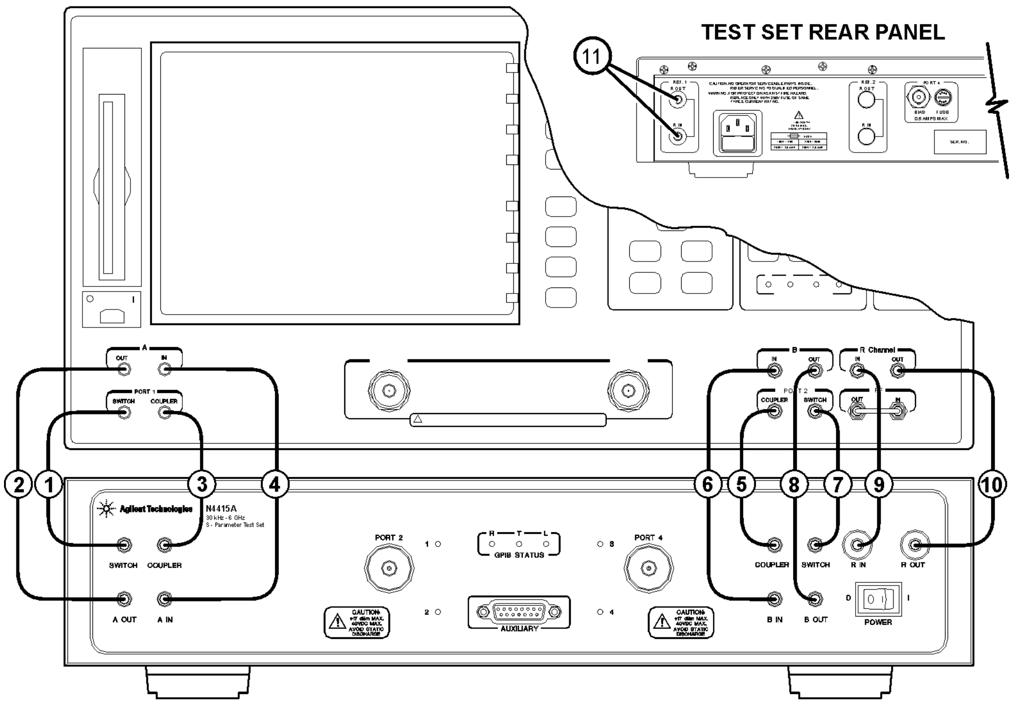
Interconnections for the N4413A/N4414A Test Set



pc901a

Installation Sequence	Cable Part Number	From 8753	To N4413A/N4414A
1	RF00329	RF IN	RF IN
2	RF00329	R	R
3	RF00329	A	A
4	RF00329	B	B

Interconnections for the N4415A Test Set

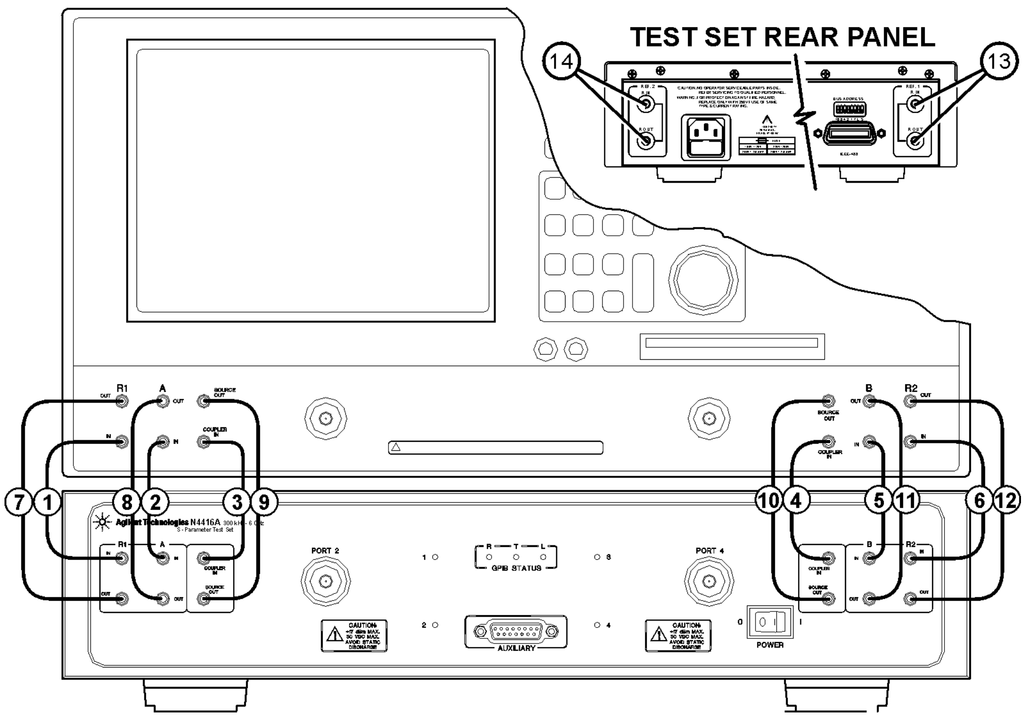


4415_frtpnl_connections

CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Installation Sequence	Cable Part Number	From 8753ES	To N4415A
1	AD00632-2	Port 1 Switch	Switch
2	AD00632-1	A OUT	A OUT
3	AD00632-2	Port 1 Coupler	Coupler
4	AD00632-1	A IN	A IN
5	AD00632-2	Port 2 Coupler	Coupler
6	AD00632-1	B IN	B IN
7	AD00632-2	Port 2 Switch	Switch
8	AD00632-1	B OUT	B OUT
9	AD00632-3	R Channel In	R IN
10	AD00632-3	R Channel Out	R OUT
11	AD00632-4	REF 1 on rear panel of the test set	

Interconnections for the N4416A Test Set

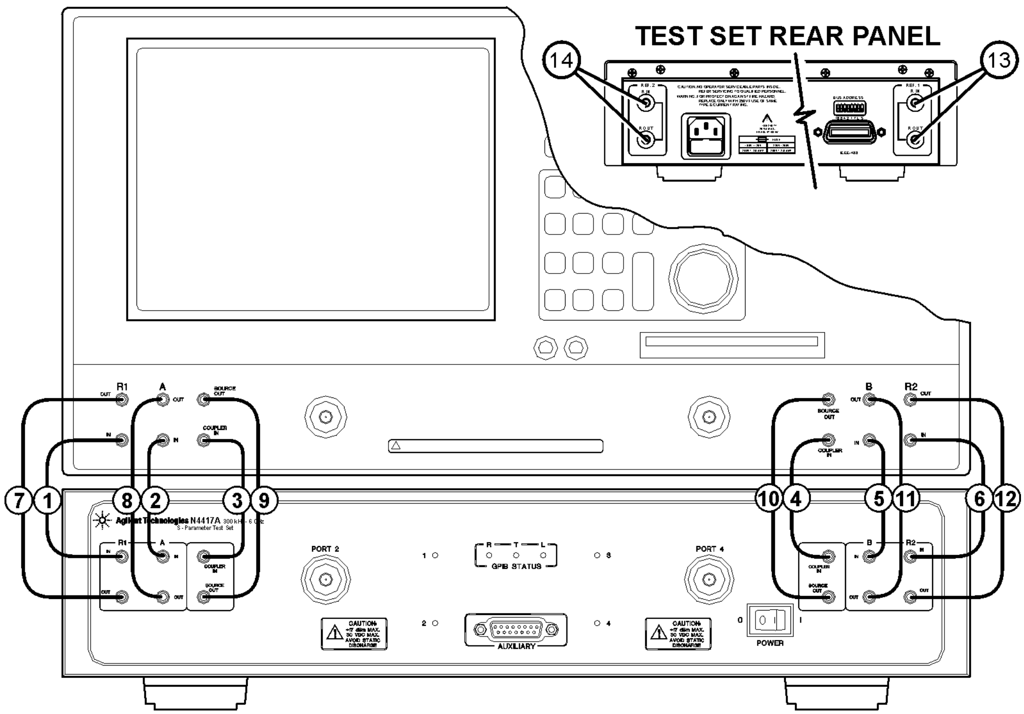


441617_frtpnl_connections

CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Installation Sequence	Cable Part Number	From E8356/E8357/E8358	To N4416A
1	AD00653-2	R1 IN	R1 IN
2	AD00653-2	A IN	A IN
3	AD00653-2	COUPLER IN	COUPLER IN
4	AD00653-2	COUPLER IN	COUPLER IN
5	AD00653-2	B IN	B IN
6	AD00653-2	R2 IN	R2 IN
7	AD00653-1	R1 OUT	R1 OUT
8	AD00653-1	A OUT	A OUT
9	AD00653-1	SOURCE OUT	SOURCE OUT
10	AD00653-1	SOURCE OUT	SOURCE OUT
11	AD00653-1	B OUT	B OUT
12	AD00653-1	R2 OUT	R2 OUT
13	AD00653-3	REF 1 on rear panel of the test set	
14	AD00653-3	REF 2 on rear panel of the test set	

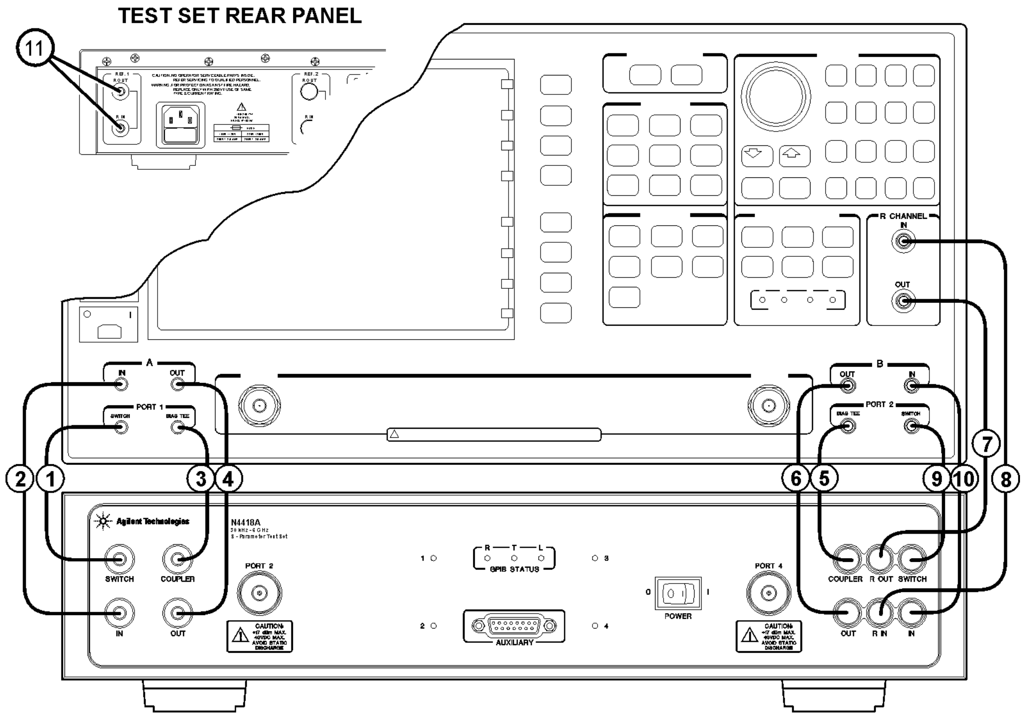
Interconnections for the N4417A Test Set



CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Installation Sequence	Cable Part Number	From E8356/E8357/E8358	To N4417A
1	AD00747-1-2	R1 IN	R1 IN
2	AD00747-1-2	A IN	A IN
3	AD00747-1-2	COUPLER IN	COUPLER IN
4	AD00747-1-2	COUPLER IN	COUPLER IN
5	AD00747-1-2	B IN	B IN
6	AD00747-1-2	R2 IN	R2 IN
7	AD00747-1-1	R1 OUT	R1 OUT
8	AD00747-1-1	A OUT	A OUT
9	AD00747-1-1	SOURCE OUT	SOURCE OUT
10	AD00747-1-1	SOURCE OUT	SOURCE OUT
11	AD00747-1-1	B OUT	B OUT
12	AD00747-1-1	R2 OUT	R2 OUT
13	AD00747-1-3	REF 1 on rear panel of the test set	
14	AD00747-1-3	REF 2 on rear panel of the test set	

Interconnections for the N4418A Test Set

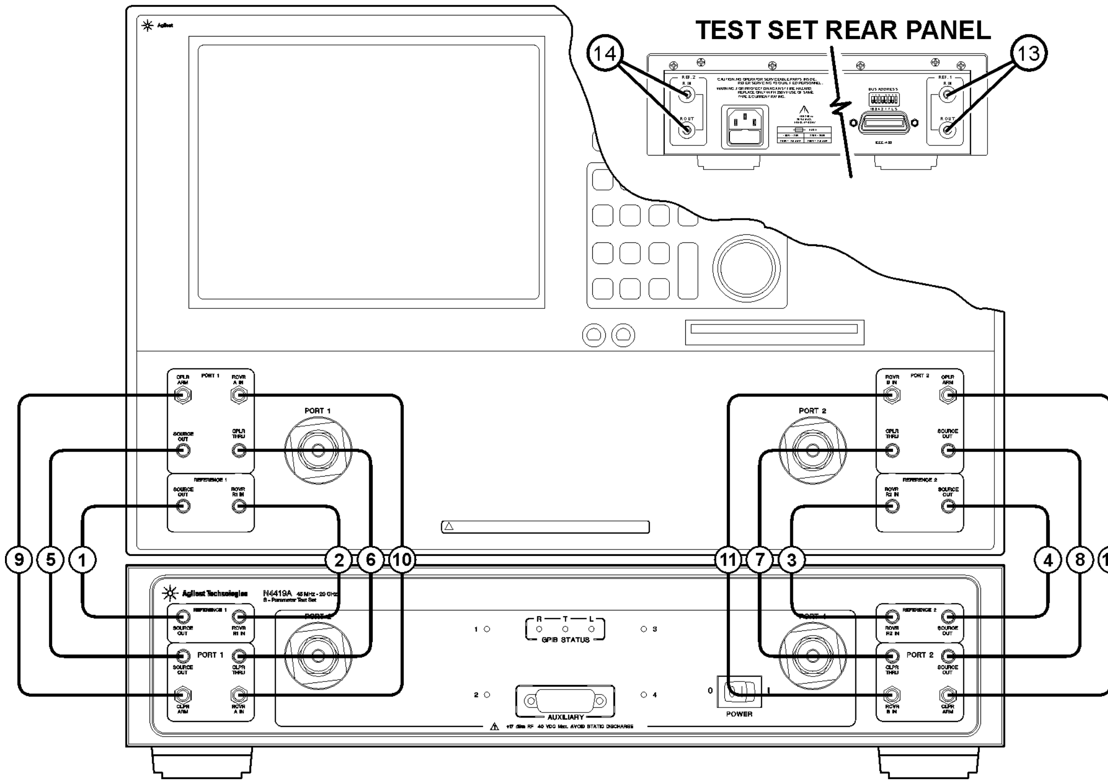


4418_frtpnl_connections

CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Call Out Sequence	Cable Part Number	From 8720ES/8722ES	To N4418A
1	AD00599-2	PORT 1 SWITCH	PORT 1 SWITCH
2	AD00599-1	A IN	A IN
3	AD00599-2	PORT 1 BIAS TEE	PORT 1 COUPLER
4	AD00599-1	A OUT	A OUT
5	AD00599-2	PORT 2 BIAS TEE	PORT 2 COUPLER
6	AD00599-1	B OUT	B OUT
7	AD00599-4	R CHANNEL OUT	R OUT
8	AD00599-3	R CHANNEL IN	R IN
9	AD00599-2	PORT 2 SWITCH	PORT 2 SWITCH
10	AD00599-1	B IN	B IN
11	AD00599-5	REF 1 on rear panel of the test set	

Interconnections for the N4419A Test Set

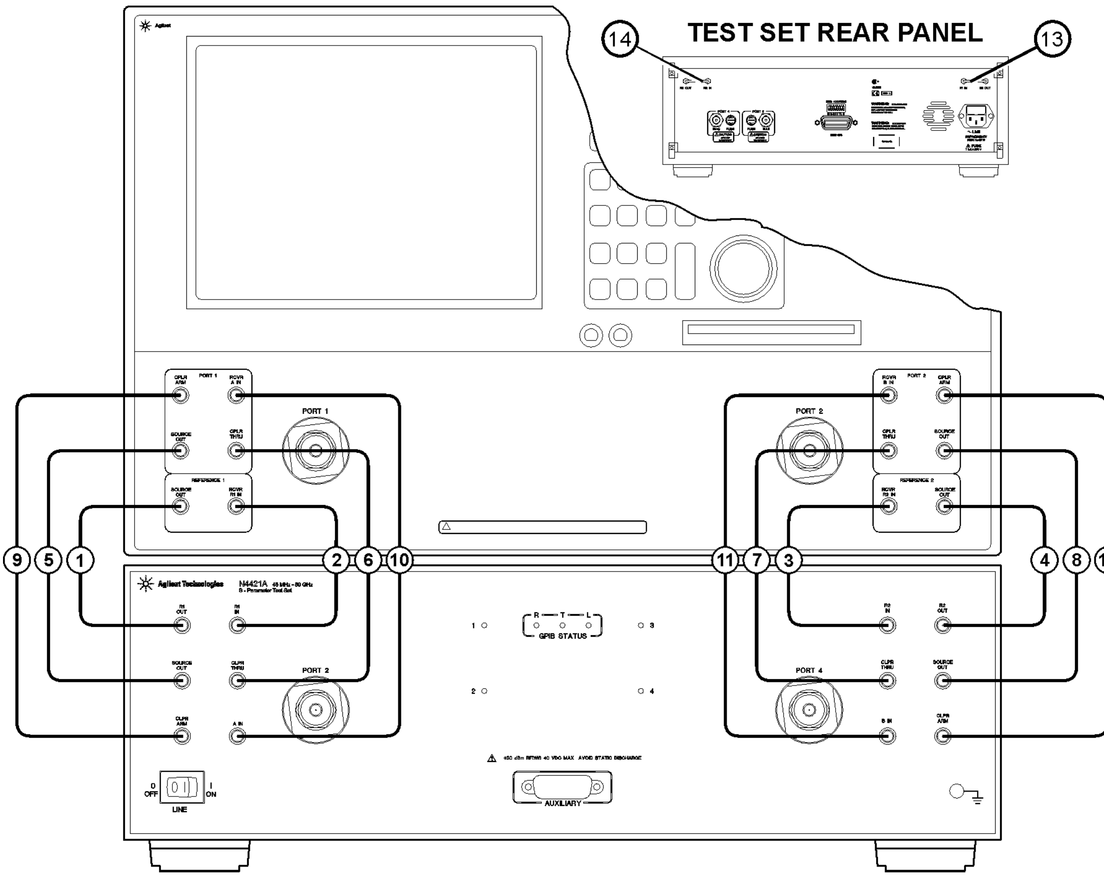


4419_connections

CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Call Out Sequence	Cable Part Number	From E8362A/B	To N4418A
1	AD00756-1	REF 1 SOURCE OUT	REF 1 SOURCE OUT
2	AD00756-1	REF 1 RCVR R1 IN	REF 1 RCVR R1 IN
3	AD00756-1	REF 2 RCVR R2 IN	REF 2 RCVR R2 IN
4	AD00756-1	REF 2 SOURCE OUT	REF 2 SOURCE OUT
5	AD00756-2	PORT 1 SOURCE OUT	PORT 1 SOURCE OUT
6	AD00756-2	PORT 1 CPLR THRU	PORT 1 CPLR THRU
7	AD00756-2	PORT 2 CPLR THRU	PORT 2 CPLR THRU
8	AD00756-2	PORT 2 SOURCE OUT	PORT 2 SOURCE OUT
9	AD00756-3	PORT 1 CPLR ARM	PORT 1 CPLR ARM
10	AD00756-3	PORT 1 RCVR A IN	PORT 1 RCVR A IN
11	AD00756-3	PORT 2 RCVR B IN	PORT 2 RCVR B IN
12	AD00756-3	PORT 2 CPLR ARM	PORT 2 CPLR ARM
13	AD00756-4	REF 1 on rear panel of the test set	
14	AD00756-4	REF 2 on rear panel of the test set	

Interconnections for the N4421A Test Set



4421_connections

CAUTION Damage to the interconnect cable can result from improper orientation of the cable. Refer to page 24 for detailed information regarding the correct cable orientation.

Call Out Sequence	Cable Part Number	From E8364A/B	To N4421A
1	Z5623-20215	REF 1 SOURCE OUT	REF 1 R1 OUT
2	Z5623-20215	REF 1 RCVR R1 IN	REF 1 RCVR R1 IN
3	Z5623-20215	REF 2 RCVR R2 IN	REF 2 RCVR R2 IN
4	Z5623-20215	REF 2 SOURCE OUT	REF 2 R2 OUT
5	Z5623-20216	PORT 1 SOURCE OUT	PORT 1 SOURCE OUT
6	Z5623-20216	PORT 1 CPLR THRU	PORT 1 CPLR THRU
7	Z5623-20216	PORT 2 CPLR THRU	PORT 2 CPLR THRU
8	Z5623-20216	PORT 2 SOURCE OUT	PORT 2 SOURCE OUT
9	Z5623-20217	PORT 1 CPLR ARM	PORT 1 CPLR ARM
10	Z5623-20217	PORT 1 RCVR A IN	PORT 1 RCVR A IN
11	Z5623-20217	PORT 2 RCVR B IN	PORT 2 RCVR B IN
12	Z5623-20217	PORT 2 CPLR ARM	PORT 2 CPLR ARM
13	E8364-20059	REF 1 on rear panel of the test set	
14	E8364-20059	REF 2 on rear panel of the test set	

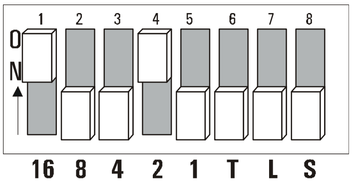
To Set the GPIB Addresses

The test set uses GPIB to communicate with system components. The GPIB address switch is on the back panel of the test set; it is set to “18” at the factory. While this will work in most situations, the address can be changed if required to avoid address conflicts with other equipment on the same bus. If you change the address on the test set, make sure you also change it in the software. (See “Setup > Hardware…” on page 124.)

GPIB addresses are five-bit binary numbers set with the switches labeled “16” through “1”, with “1” being the least significant digit.

“T”, “L”, and “S” correspond to Talk, Listen, and Status. Set them as shown (off).

The example below shows the default setting, “18”, set by turning on switches “16” and “2”.



NOTE After changing a GPIB address setting, on any of the system equipment, turn the test set AC power off and back on establish the new GPIB address.

Pull down **Setup > Hardware…** to set the test set GPIB address in the software. See “Setup > Hardware…” on page 124.

How to Install and Start the Balanced Measurement Software

1. Insert the system CD-ROM in your PC.
2. In Windows, select **Start > Run...** to open the *Run* dialog box.
3. Enter `x:\setup.exe` in the *Open* box, where *x* is the letter of the drive with the media.
4. Click **OK** and follow the onscreen instructions.
5. After the installation is complete, run the program by selecting **Start > Programs > Agilent** (or **ATN**) **Multiport x.xx > Multiport**, where x.xx is the software revision number.

To configure your system hardware options, see "Setup > Hardware…" on page 124.

How to Calibrate

Calibration is required for accurate measurements. Even though calibration does take a few minutes to complete, it saves time and money compared to costs associated with erroneous measurement data. Even mechanical (non-electronic) calibration is reasonably quick once you become familiar with the process.

TIP **Understanding How Changes Affect Measurements**

No two measurements and environmental conditions are exactly the same. The best way to understand your conditions is to experiment and see how your test equipment behaves over a period of time. A good way of doing this is to measure the same device (i.e., a known standard) hourly throughout the day. Save or print the measurement results of each measurement. Compare these results to gain an understanding of how the ambient environment and drift affect the measurements. Watch for trends with regard to the device meeting specifications or measuring within guard band limits.

Triggers to Calibrate

We recommend that you perform a calibration on your multiport test system when the following conditions occur:

- When connectors are cleaned, repaired, or replaced.
- If test cables have any changes, such as:
  - When a test cable is replaced.
  - When any connection is changed except the connections to the DUT.
  - When test cables are flexed excessively (kinked or unkinked).
- If the frequency range is changed beyond the limits of the previous calibration.
- If the number of measurement points is increased to more than the number of points of the previous calibration.
- When ambient temperature changes more than ±3 °C.
- Any other ambient environmental changes of significance.
- Regularly by time because of drift, if none of the previous conditions apply.
  - Check the calibration at least daily (twice daily is recommended). Refer to “A Method of Checking Calibration” on page 41.
  - Recalibrate weekly.

A Method of Checking Calibration

A good method of checking calibration is to establish a Golden Device, which is a device that meets all specifications and is saved for comparison of the measured results in the future.

Establishing a Golden Device

Follow these steps to establish a golden device:

1. Calibrate the system.
2. Perform the complete set of measurements on the golden device.
3. Save and print all of the test results from these initial measurements.

Now you can measure the Golden Device when you suspect that your system may need to be calibrated. Compare the results of these measurements against the results that you saved and printed from the initial measurements.

Starting a Calibration

1. Complete the hardware and software setup. See "How to Set Up the Multiport Test System Hardware" on page 18 and "How to Install and Start the Balanced Measurement Software" on page 39.
2. Define a test plan to include desired measurement types, and the use and placement of any adapters.
3. Characterize the adapters. See "How to Characterize Adapters" on page 44.
4. For test sets with the optional step attenuator, determine the attenuation needs. Once you calibrate at an attenuation setting, any changes to the setting will invalidate the accuracy of the calibration. Even if the attenuator is moved from the calibrated position and reset prior to measurement, measurement accuracy will be reduced. It is strongly recommended that you recalibrate if you have changed the attenuator setting.
5. When all of these prerequisite steps have been completed, select **Calibrate > Standard Calibration...** or **Calibrate > Electronic Calibration...** to begin. You are guided through this process step-by-step.

NOTE **Creating a Calibration Subset**
If you do not want to use all frequency points for your measurement, you can create a calibration subset and use it for the active calibration instead of the full calibration set. See "Calibrate > Create Cal Subset..." on page 133.

How to Perform Electronic Calibration

You can perform a 4-port electronic calibration using the Agilent N4430A/B Four-Port Electronic Calibration (ECal) Module (formerly the ATN-4801 Multiport Calibration Module). Note that the N4431A 4-port RF Electronic Calibration Module is ***not*** compatible with the Multiport Test System.

With a one-time connection, the ECal procedure cycles through all of the impedance states required for a full, four-port, vector error-corrected calibration, and can transfer factory-calibration accuracy to the network analyzer system. The balanced measurement software controls the electronic calibration.

CAUTION ECal module damage will occur if connected to incompatible multiport test sets. Do not connect an ECal module to the following test sets:
- Model ATN-4111A, serial number A433652 or below
- Model ATN-4111B, serial number A433901 or below

NOTE For maximum accuracy and repeatability, the system (network analyzer, test set, and ECal module) should be stabilized at room temperature for a minimum of 24 hours before calibration.

Using standard alignment precautions, the multiport test set may have the ECal module connected and disconnected in any power state. After calibration, the ECal module may remain connected to the test set or may be disconnected from the test set with no effect on the calibration.

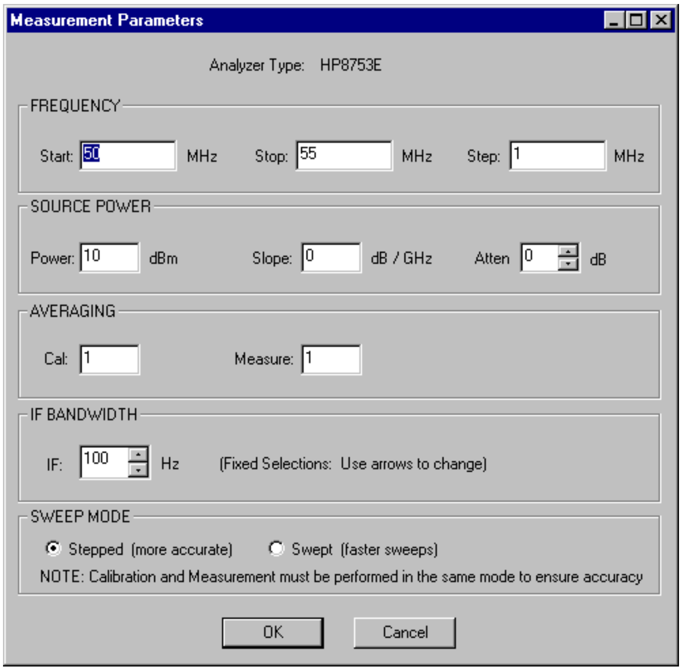
To perform the ECal with the multiport test system:

1. Connect the ECal module to the multiport test system as follows:

ECal Module Connector	Test Set Connector	Cable Type	Specified Torque
CONTROL	AUXILIARY	DB-15	N/A
PORT 1 (3.5 mm F)	PORT 1 (3.5 mm M)	Coax	8 in/lb
PORT 2 (3.5 mm F)	PORT 2 (3.5 mm M)	Coax	8 in/lb
PORT 3 (3.5 mm F)	PORT 3 (3.5 mm M)	Coax	8 in/lb
PORT 4 (3.5 mm F)	PORT 4 (3.5 mm M)	Coax	8 in/lb

2. In the software, select **Calibrate > Electronic Calibration...**

3. Modify any parameters in the *Measurement Parameters* dialog box as required and click **OK**.



4. When prompted, select the module characterization file for your ECal module. This file is located on the floppy disk provided with the module. Each module characterization file is unique, so verify that the module serial number matches the file's serial number.
5. A progress meter is displayed during the calibration. When complete, assign the calibration a file name and save the calibration data.

NOTE **Creating a Calibration Subset**
If you do not want to use all frequency points for your measurement, you can create a calibration subset and use it for the active calibration instead of the full calibration set. See "Calibrate > Create Cal Subset…" on page 133.

How to Characterize Adapters

To allow their effects to be removed, adapters which will be used for making through connections during the calibration must first be characterized.

First, a short/open/load calibration is performed at the instruments front panel. Then the adapter is inserted and the s/o/l calibration is repeated. The resulting adapter S-parameters are saved in Citifile format.

For adapters that will be used for broadband measurements, characterize the adapter over the entire frequency range of the instrument with as many points as possible. This allows for interpolation of adapter data if the frequency points used in a later DUT measurement are not exactly the same as the adapter frequency points.

There are two adapter characterization methods available, based on the adapter type(s) to be used.

- **"In-Series, Same-Sex"** uses a single port (Port 1) and applies only to adapters having the same type and gender on both ends (3.5 mm male-to-male, for example). Select the calibration kit to be used on Port 1 from the pull-down menu. Refer to the illustration titled "One-Port Adapter Characterization" on page 45.
- **"All Others"** uses two ports (Ports 1 and 4) and allows the adapter types to be specified independently. Select the calibration kits to be used on Port 1 and on Port 4 from the pull-down menu. Refer to the illustration titled "Two-Port Adapter Characterization" on page 45.

Adapter characterization is performed directly at the instruments front panel (either Port 1 or Ports 1 and 4). If an additional adapter is needed between the front panel and the adapter to be characterized (for type or gender change), install the additional adapter first (metrology grade recommended), and perform all calibrations with it installed.

For purposes of characterization, your adapters must have an orientation. Mark the connectors on the adapter as ports 1 and 2, and treat them as such during the characterization procedure. Forward orientation has the lower-numbered adapter port connected to the test-set port.

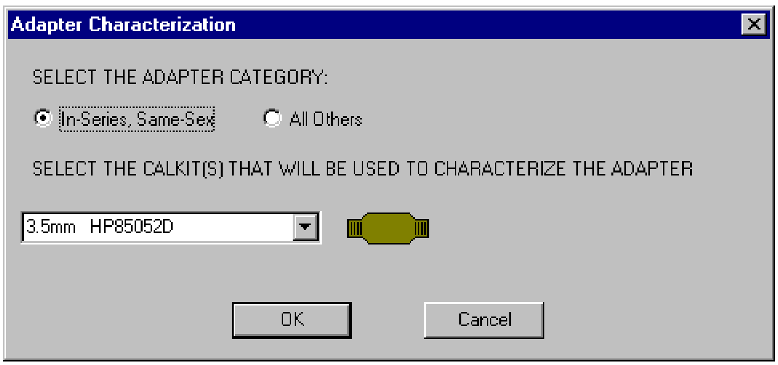
Follow these steps to characterize your adapters:

1. Select **Setup > Meas Parameters...** to setup or confirm requirements for frequency, power, etc...
2. Select **Utility > Characterize Adapter...**

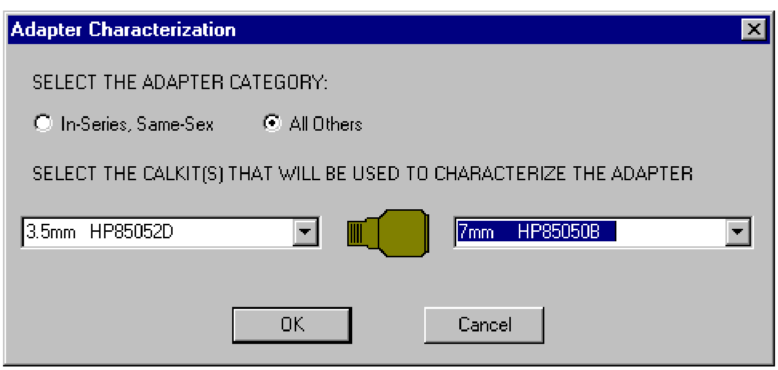
3. Select the appropriate adapter characterization category (**"In-Series, Same-Sex"** or **"All Others"**) and calibration kit(s).
4. Follow the program prompts to perform the characterization.

When the characterization is complete, save the adapter file using the default `.TXS` file extension. Since the characterization file is in Citifile format, you can import the data and make a visual check of the quality of the characterization. Select **File > Import > Citifile >** and open and inspect the adapter characterization file.

One-Port Adapter Characterization



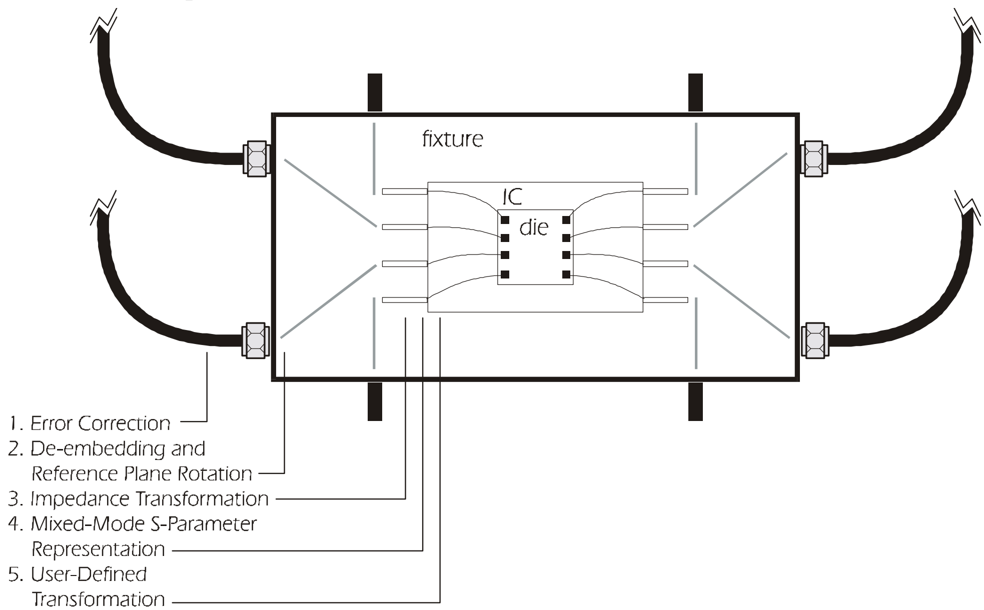
Two-Port Adapter Characterization



See "Setup > De-Embedding…" on page 115 and "Setup > Modify Rotations…" on page 119 for more information on characterization and de-embedding.

How to Interpret Multiport Test System Data

The multiport test system supports several types of post-measurement data processing. Proper interpretation of the manipulated data requires understanding the sequence of mathematical operations.



1. The single-ended S-parameter data is error-corrected to provide accurate measurements at the calibration reference plane.
2. De-embedding and reference plane rotation is performed to move the measurement reference planes as needed.
3. Reference impedance is changed if specified.
4. Mixed-mode S-parameters are calculated.
5. User-defined parameters are calculated.

As shown in the preceding illustration, this sequence allows the system to work sequentially toward the device being characterized.

Because of the order of this sequence, the system assumes a 50Ω trace in the fixture when performing a reference plane rotation. Once a new measurement reference plane is established, all data (single-ended, mixed-mode, and user-defined) is at that reference plane and in the reference impedance that has been specified.

How to De-Embed Measurement Data

To use test fixtures or adapters with the multiport test system and establish different calibration and measurement reference planes, the system allows the effect of the fixture or adapter to be removed by de-embedding.

You select de-embedding options during setup of a measurement. The characterization file contains the S-parameters in Citifile format, but with additional header information.

You must first characterize any adapters, fixtures, or probes to use the de-embedding function. See "How to Characterize Adapters" on page 44 for more information.

How to Make Measurements

The multiport test system measurements require the completion of four prerequisite steps:

- Setup of the software and hardware (see "How to Set Up the Multiport Test System Hardware" on page 18 and "How to Install and Start the Balanced Measurement Software" on page 39.)
- Determination of your test requirements
- Characterization of any needed adapters (see "How to Characterize Adapters" on page 44)
- System calibration (see "How to Calibrate" on page 40)

On completion of these steps, simply connect the device under test (DUT) to the system and click the **Measure** button on the main screen.

Attenuation

Set the attenuator to allow sufficient measurement dynamic range while considering DUT compression and avoiding over-driving the receiver in the network analyzer. Too much attenuation limits calibration accuracy. Calibration accuracy can be improved at the expense of measurement time with a narrower calibration IF bandwidth. This selection is only available on the N4413A (ATN-4111A) and N4414A (ATN-4111B) systems.

How to Remove Fixture Delay

A simple method of removing the delay of a fixture is to rotate the reference plane. This is also referred to as port extension.

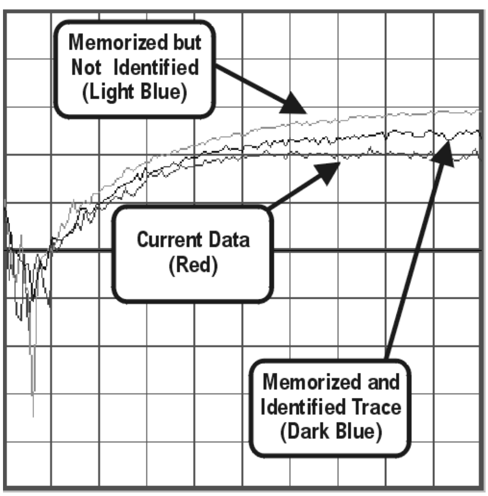
This approach works well for removing the effect of lines that have little insertion loss and a very good impedance match. The system assumes the fixture to have 50Ω feed lines, even if the reference impedance of the DUT is not 50Ω.

See "Setup > Modify Rotations..." on page 119 for more information.

How to Use Trace Memory

Trace memory provides a convenient means of comparing two or more sets of measured data, either from measurements made during this session, or from data previously saved to files. The *Trace Memory* dialog box can be opened by selecting **Data > Memory...**

The software assigns colors to traces based on their status.



- The red data set (or trace) is considered current data, either from the most recent measurement, the last file load, or from data management within the trace memory function (**Identified MEM** → **Data**). The system supports one current data set. When you use the math functions of the *Trace Memory* dialog box, like Data / Memory, the red (current) trace is the "Data" part of the function.

- The system allows you to assign a trace to a memory location using the **DATA** → **MEM** function. Memorized traces turn dark blue. If you click **Identify MEM**, the identified trace turns dark blue while the other traces turn light blue-green. You can load or measure and memorize as many traces as your memory will support, but there can only be one current (red) trace. Memorized traces are assigned identification numbers in the order in which they are memorized.
- Traces that are the result of trace math appear violet.

For more information, see “Data > Memory…” on page 136.

How to Set Up User-Defined Displays

User-defined displays provide a convenient way to set up new display types based on formulas you specify. You can use conventional S-parameters and mixed-mode S-parameters in expressions with operators and constants to analyze data.

NOTE User-defined displays are saved and can be loaded with display configurations.

See “Data > User-Defined Display > Add Page…” on page 139 for more information.

How to Use Markers

If you are familiar with using markers on Agilent network analyzers, read the following section. Otherwise, skip to the following section, "Defining Multiport Test System Markers."

Multiport Test System Markers Versus Network Analyzer Markers

The multiport test system marker function is similar to the marker function implementation in your network analyzer, with most of the differences owing to either enhanced functions or the difference between the interfaces (mouse versus softkey). This section highlights the important differences in marker implementation between the multiport test system and the network analyzer for those familiar with the marker function of the analyzer.

In the multiport test system, marker values are always discrete. The software does not interpolate marker values between measured points.

In the multiport test system, the delta reference marker is always the active (current) marker. The fixed marker concept is somewhat different in the multiport test system. When you fix the markers in the multiport test system (as described in the remainder of this section), they become inactive, but they are still visible.

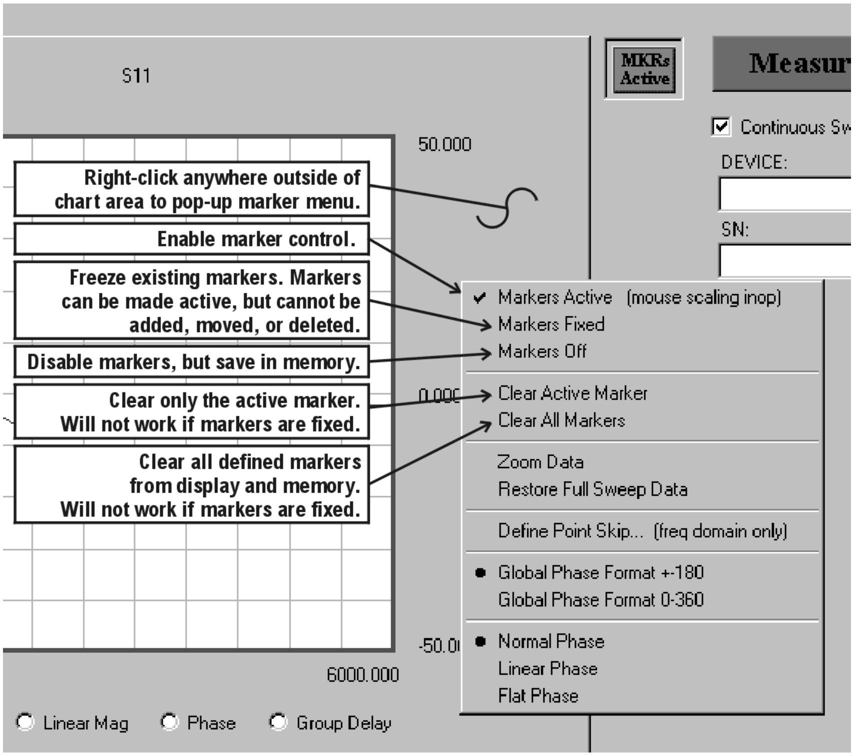
The multiport test system does not yet support the network analyzer Marker →, marker search, or target markers keys.

The multiport test system supports marker use in both scalar and polar type displays. You can select and move markers on both scalar and polar charts using **Ctrl** key combinations. On scalar charts, you can also use the mouse to select and move markers.

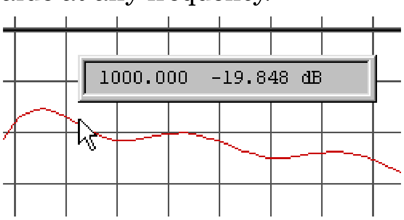
Defining Multiport Test System Markers

Markers are initially defined in single plot displays. Once set, markers on frequency-domain displays can be viewed and manipulated in thumbnail displays as well as in single plot displays.

Right-click the area just outside of a single plot to open the display properties menu.

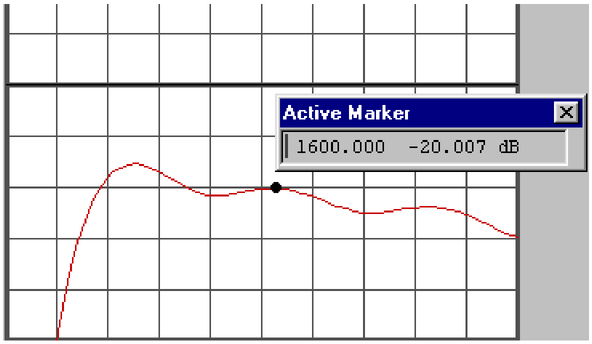


Select **Markers Active** to turn markers on. Inside the plot area, point at the trace with cursor and click the left mouse button. While holding the left mouse button down, move the mouse to select the desired frequency. The instant readout marker function shows the marker value at any frequency.



The frequency display is in MHz to the left, with the data value to the right. In displays with a large number of data points, hold down the shift key while moving the mouse for greater placement accuracy.

To place a marker, hold the left mouse button while clicking the right button. Note that you do not have to place the mouse pointer on or even near the trace; the frequency (horizontal) position of the pointer is used to position the marker.



The active marker is a black indicator (either a dot or an arrow) on the trace. The value of the marker is shown in the *Active Marker* box. You can move the *Active Marker* box by dragging the title area.

You can place up to 20 markers on the plot. The latest marker's indicator appears in black, the previous markers' indicators turn to gray. As soon as you add a new marker, its value is added to the *Active Marker* box.

NOTE The *Markers Active* option of the display properties menu must be selected to place or move markers. You cannot use the mouse to scale the display with markers active.

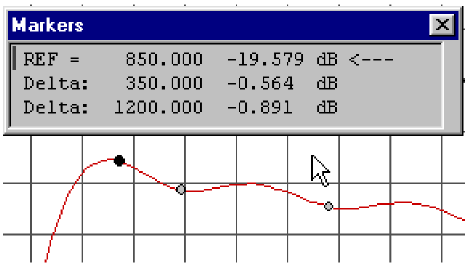
Moving Markers

Scalar displays allow full mouse and keyboard control of setting, selecting, and moving markers as described below. Smith and polar displays allow only keyboard selection and movement of markers. Impedance and conductance formats are valid for S-parameter reflection terms and for user-defined parameters that are specifically defined in the `ImpedanceDef.txt` file. See "Defining the Reference Impedance in User-Defined Equations" on page 66 for more information.

Use the left and right arrow keys to move the active marker in single steps.
Use SHIFT+arrow key to move the active marker in large (10X) increments.
Use CTRL+arrow key to select a new active marker.

Setting Up Delta Displays

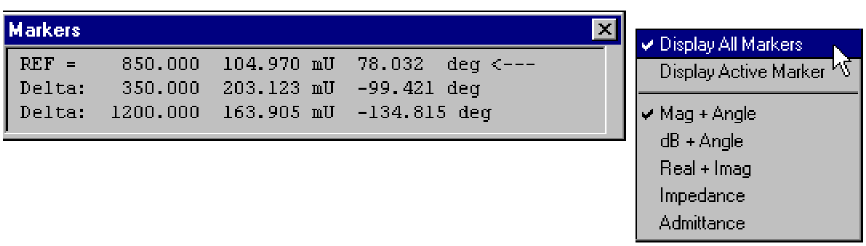
Right-click any marker to make it the reference marker and to set up delta displays. Other defined markers turn gray and show the values relative to the reference marker.



You can also right-drag on the display to show the value under the pointer as a delta value from the reference (active) marker.

Setting Marker Properties

Right click the right edge of the *Markers* window to open the markers properties box on Polar or Smith Charts.

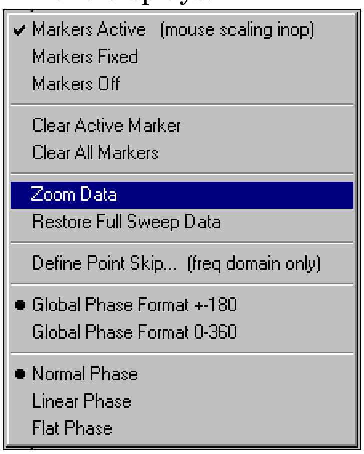


SELECT:	TO:
Display All Markers	Show all set markers on display.
Display Active Marker	Restrict marker display to the active marker.
Mag + Angle	Show the magnitude and angle of the reflection coefficient.
dB + Angle	Show the log magnitude and angle of the reflection coefficient.
Real + Imag	Show the real and imaginary parts of the reflection coefficient.
Impedance	Show the real and imaginary parts of the impedance.
Admittance	Show the real and imaginary parts of the admittance.

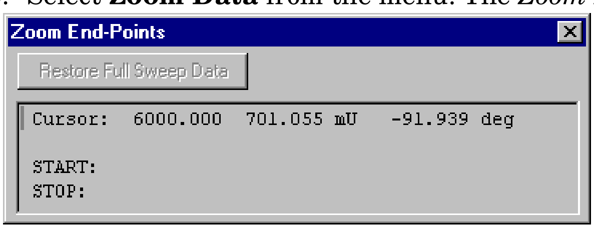
How to Use Frequency Zoom

To examine a narrower range of data, you can scale the frequency axis. To scale the frequency axis, follow these steps:

1. Open a page that displays a frequency domain single graph.
2. Right click the mouse in the gray area outside of the plot region. The display properties menu displays:



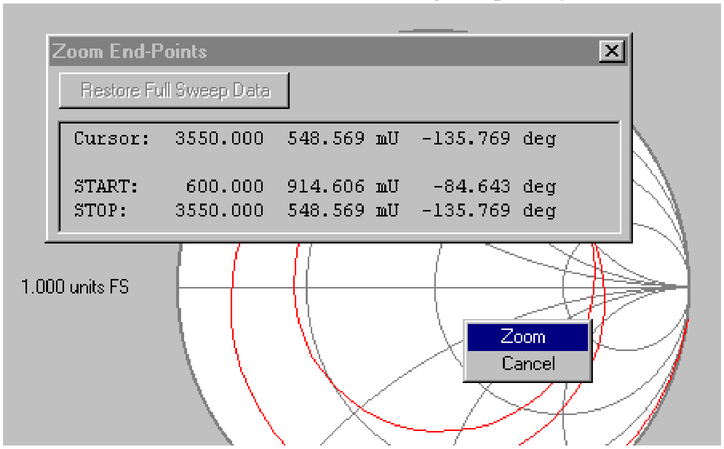
3. Select **Zoom Data** from the menu. The *Zoom End-Points* box displays:



   The **Cursor:** line shows the frequency corresponding to the cursor position in the plot area.

4. Move the cursor to the desired start frequency or use the arrow keys to change.
5. Left click on the trace or press the **Enter** key to anchor the start point. The **START:** line shows the selected frequency.
6. Move the cursor to the ending frequency and left click or use the arrow keys to change the stop frequency and press the **Enter** key.

The **STOP**: line shows the ending frequency and a two-line confirmation menu displays:



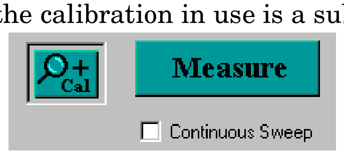
7. Click on **Zoom** to confirm selected settings. The part of the trace between the start and stop points is zoomed.

8. To restore the original measurement range, right click in the gray area outside of the plot to display the display properties menu and select **Restore Full Sweep Data** from the menu.

If frequency zooming has been applied to the data, the **+Data** button appears in the indicator bar:

If a measurement is made after the frequency axis is zoomed, only the points within the zoom range are measured. This creates a new set of calibration data adjusted to the new frequency range.

As soon as the measurement starts, the **+Cal** button appears in the indicator bar to show that the calibration in use is a subset of the full calibration available:



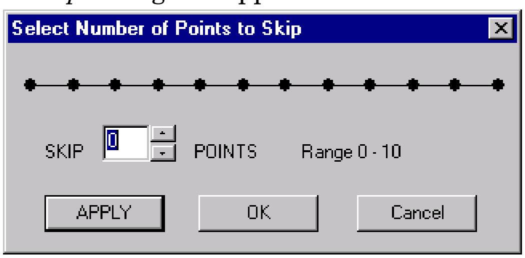
At the end of the measurement, the **+Data** button disappears because all available measurement points have been displaced.

Increasing Frequency Step

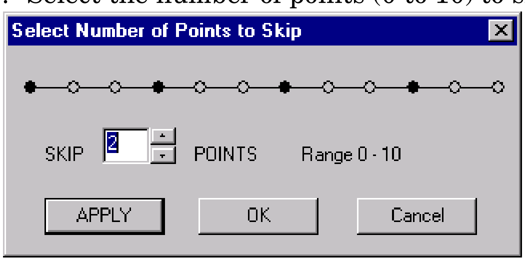
The multiport test system allows measurements to be made at frequency step sizes larger than the step size used in the calibration. This is accomplished by skipping points.

To skip points, follow these steps:

1. Right click in the gray area outside the plot to open the display properties menu.
2. In the display properties menu, select **Define Point Skip**. The *Select Number of Points to Skip* dialog box appears:



3. Select the number of points (0 to 10) to skip between two measured points.



4. Select one of the buttons at the bottom of the dialog to finish the selection.

APPLY	Applies the new settings without closing the dialog box.
OK	Applies the new settings and closes the dialog box.
Cancel	Closes the dialog box without making any changes.

5. To restore the original measurement condition, right click in the gray area outside of the plot, and select **Restore Full Sweep Data** from the menu.

If the frequency step has been increased, the **+Data** button appears in the indicator bar.

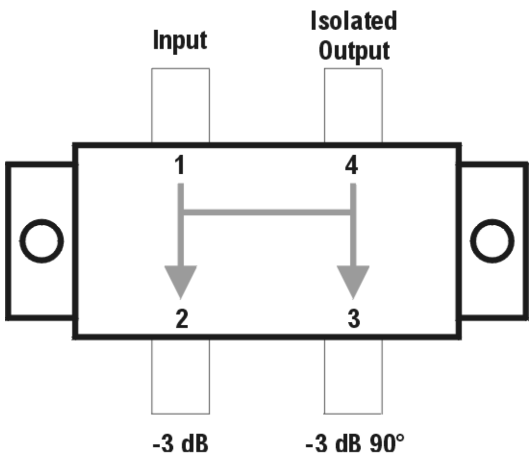
If a measurement is made after increasing the frequency step, fewer points are measured. This creates a new set of calibration data adjusted to the new frequency step.

As soon as the measurement starts, the **+Cal** button appears in the indicator bar to show that the calibration in use is a subset of the full calibration available.

At the end of the measurement, the **+Data** button disappears because all available measurement point have been displaced.

How to Characterize Passive Devices

This section describes characterization of a quadrature hybrid passive device as shown.



1. Install the system hardware and software, if needed. See “How to Set Up the Multiport Test System Hardware” on page 18 and “How to Install and Start the Balanced Measurement Software” on page 39.
2. Determine what network analyzer power, frequencies, and data points will be needed for characterization of the DUT.
3. Calibrate the system using these settings. See “How to Calibrate” on page 40.
4. Connect the DUT.
5. Click the **Measure** button to measure the DUT.

How to Characterize Active Devices

Set the input power level using the source power and/or attenuator settings (N4413A and N4414A only) to compensate for the expected gain of the DUT. Keep in mind the saturation level of the DUT and the input power limits and damage level of the test set and analyzer.

Some system models have a provision for biasing the DUT through the test ports. In this case, bias voltages are applied to the bias inputs on the rear of the test set.

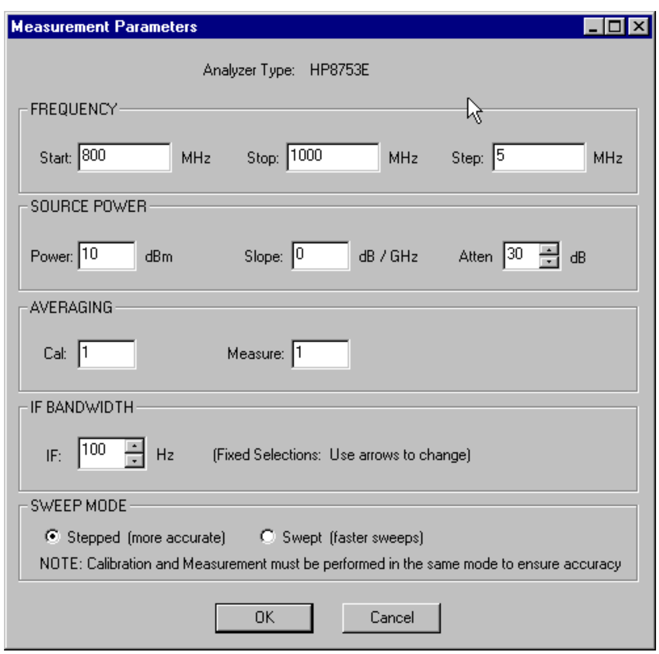
Active Device Measurement Example

This example shows the characterization of a 27 dB gain amplifier with a +10 dBm compression point. Measurements were made to show gain, isolation, and match.

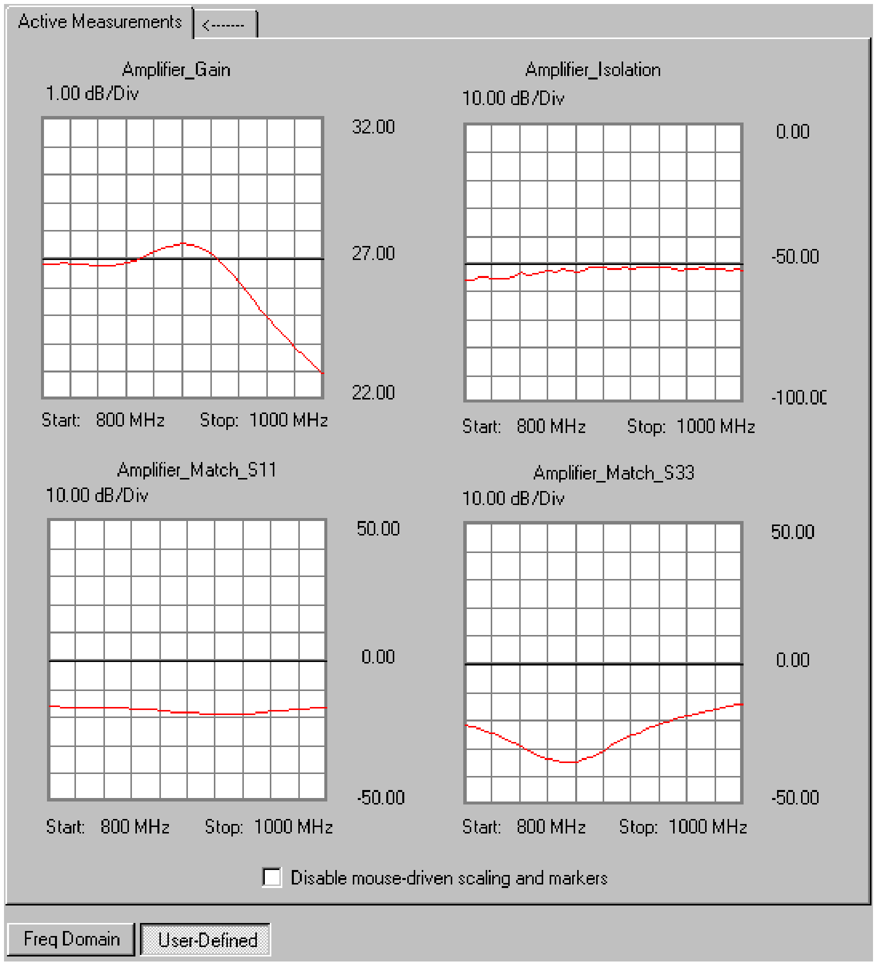
The system was calibrated with the following Measurement Parameters (as shown below):

- –30 dBm output level (10 dBm source power, 10 dB of test set path loss, and 30 dB of attenuation)
- Frequencies from 800 MHz to 1000 MHz with 5 MHz steps

The bias was set for 6 V_{DC} directly on the power supply.



The device performance is shown below. Note that the display has been user-defined to show specific areas of interest. See “How to Set Up User-Defined Displays” on page 49 and “How to Use User-Defined Displays” on page 65 for more information.



How to Interpret Mixed-Mode S-Parameters

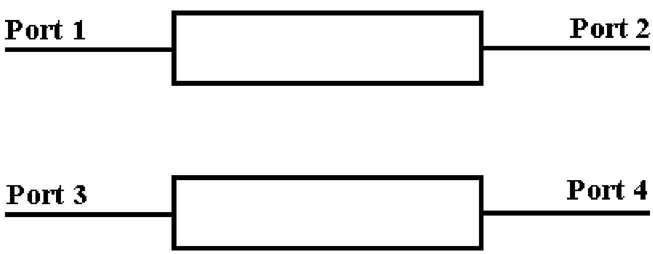
S-parameters are commonly used to describe the performance of microwave and RF devices. These parameters describe the behavior of the device when it is stimulated on a single port at a time. By expanding the definition of S-parameters, the multiport test system extends this ability to describe performance to devices with balanced ports.

See Agilent Application Note 1373-2 for more information.

How to Characterize Balanced Devices

Using the **Data > Transforms** functions, the multiport test system provides mixed-mode S-parameter measurement. This section provides a sample characterization of a differential device using the system to determine standard and mixed-mode S-parameters. The DUT is a balanced transmission line. The device has been measured as a four-port single-ended device with the following port definitions:

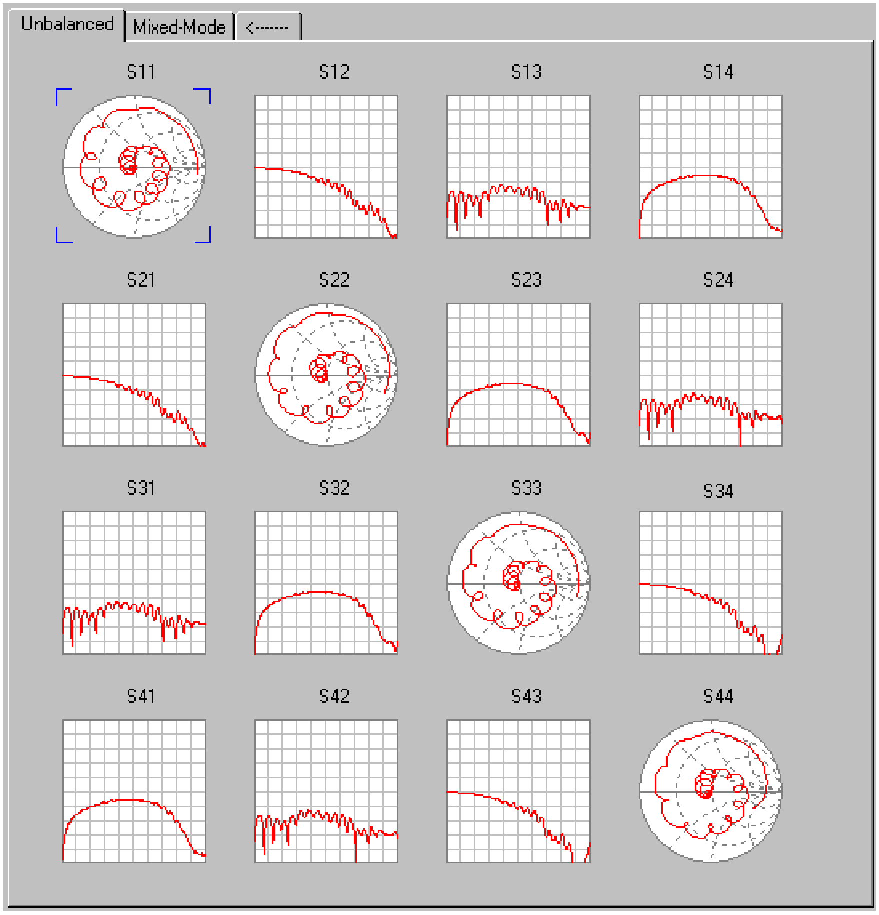
Balanced Transmission Line



NOTE These port definitions have changed from previous versions of the software. To make data taken with older versions of the software compatible with this version, the Port Exchange utility has been provided. See "How to Use the Port Exchange Utility" on page 76.

Single-Ended Performance

The device has the following single-ended S-parameters:



The parameters along a diagonal (from the upper-left corner to the lower-right corner) on the display are the single-ended matches on each terminal.

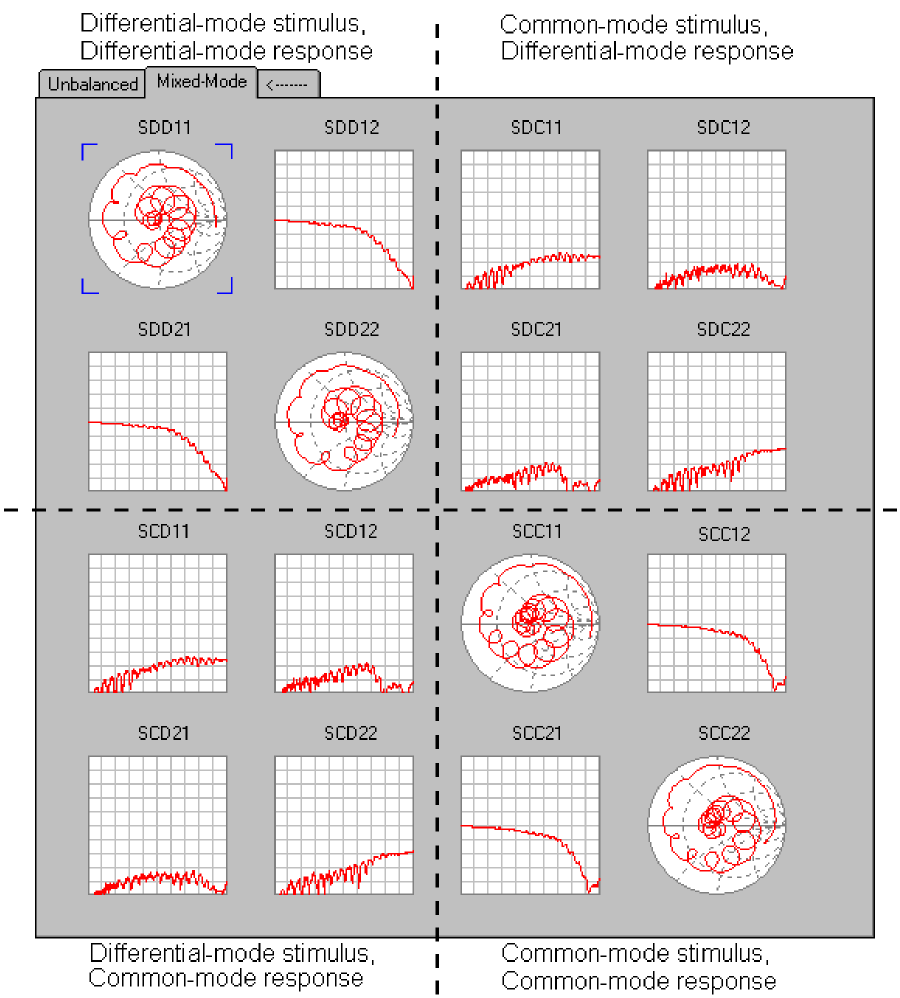
- The six forward-transmission path plots are displayed below the diagonal.
- The six reverse-transmission path plots are displayed above the diagonal.

At low frequencies, the through connection between port 1 and port 2 can be seen from S21 and between port 3 and port 4 from S43. Coupling between the pairs is evident from S41 and S32 increasing with frequency at the low end of the band while S21 and S43 are decreasing. Near-end coupling between the input ports (S31) and the output ports (S42) is very low.

Mixed-Mode Performance

The single-ended (unbalanced) data is not representative of the balanced performance because of the coupling between the two sides of the balanced pair. For balanced performance, mixed-mode S-parameters are used. For a device with two balanced ports, each of the four quadrants represents a different mode of operation. Each quadrant includes input- and output-reflection parameters, and forward- and reverse-transmission parameters.

For example, SDD11 represents the differential mode match on balanced port 1. SDD21 is the differential-mode forward transmission parameter from port 1 to port 2. Note the similarities between SDD21 and S21.



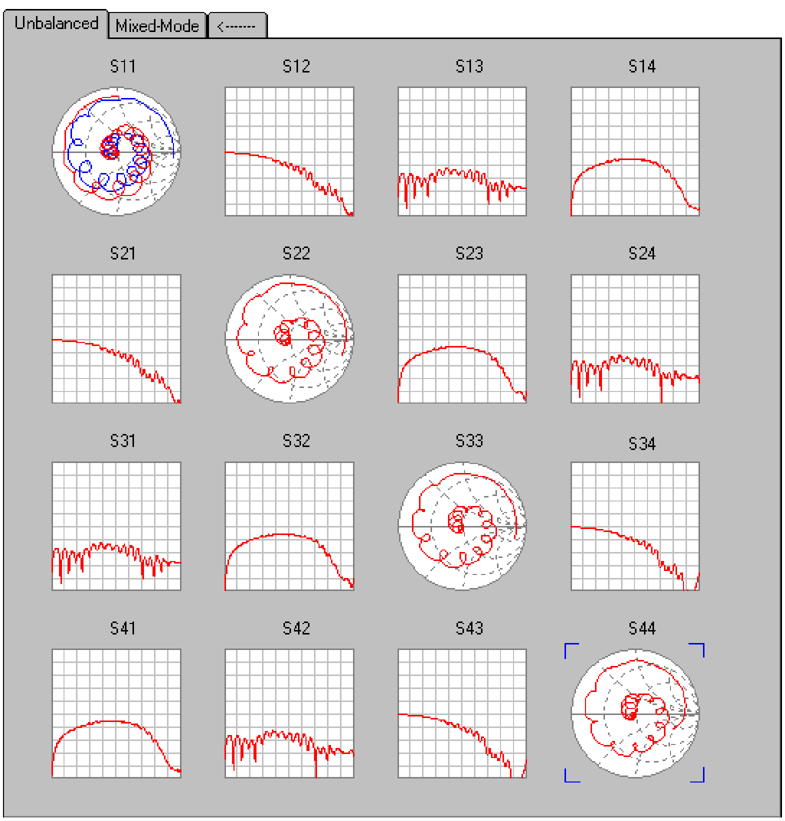
Mode Conversion

The degree of circuit symmetry is important for differential applications since symmetry is the fundamental assumption needed to realize such benefits as electromagnetic interference immunity, power supply noise immunity, even-order harmonic suppression, and so on. A perfectly symmetrical circuit has no mode conversion. This means, for example, that a differential stimulus will elicit a response with a differential-mode component, but no common-mode component, or vice versa. Therefore, the mode conversion terms in the mixed-mode S-parameter matrix provide a direct measurement of the degree of symmetry of the device.

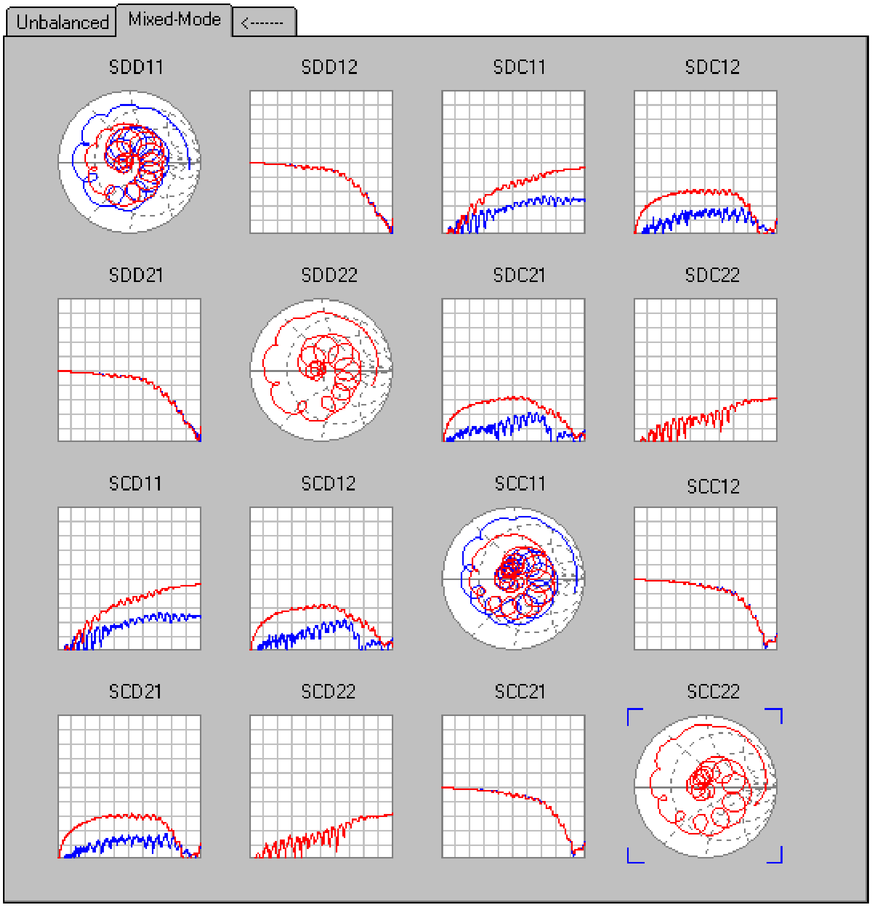
The Effect of Asymmetry on Mode Conversion Parameters

If there is a phase skew in the DUT introduced through a reference plane extension, the magnitude of single-ended transmission parameters is unaffected.

If a short reference plane rotation is introduced on port 1, the resulting S-parameters are:



The mixed-mode S-parameters of the asymmetrical device are shown below:



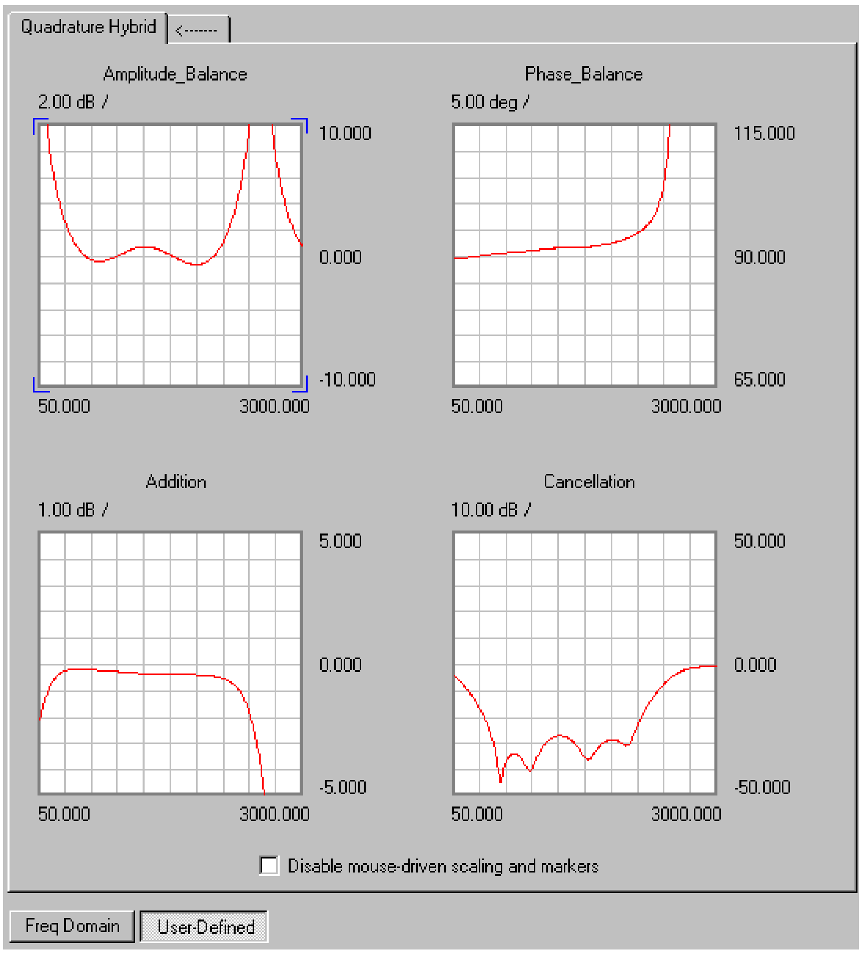
The phase skew can have a significant effect on the performance of a balanced device as shown in the mixed-mode S-parameter. The most noticeable change is in the mode conversion parameters, designated by the SDC*nn* and SCD*nn* terms. In a perfectly symmetrical device, these terms are equal to zero. Even a slight asymmetry is more noticeable in these terms than in the pure-mode terms (SDD*nn* or SCC*nn*).

How to Use User-Defined Displays

Use user-defined displays to help interpret the corrected data. For this device, you might consider making the following user-defined displays.

S21/S31 with a log magnitude display to show amplitude imbalance.

S21/S31 with a phase display centered on 90° to show phase imbalance.



This quadrature hybrid can be further characterized by employing other user-defined calculations. For instance, you could characterize loss with the equation:

```
(S21+(-1)^0.5*S31)/2^0.5
```

which translates to:

$$\frac{1}{\sqrt{2}}(S21 + jS31)$$

You could also characterize cancellation with the equation:

```
(S21-(-1)^0.5*S31)/2^0.5
```

which translates to:

$$\frac{1}{\sqrt{2}}(S21 - jS31)$$

These are the mathematical equivalents of connecting an ideal 90° hybrid to the DUT in such a way that the outputs either add constructively or cancel each other.

Defining the Reference Impedance in User-Defined Equations

When you define a user-defined parameter, the system does not know the correct reference impedance for displaying impedance and conductance markers.

You can define your port impedance values by editing the **impedanceDef.txt** file. The default location of this file is **..\Program Files\Agilent\system**, the actual location may be different.

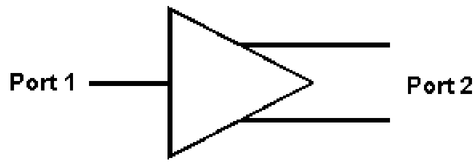
Instructions for editing impedance definitions are included in the file. Make sure you edit and save the file in ASCII text only format.

The section title in the **impedanceDef.txt** file must match the variable name created in the *User Defined Display* dialog box. Impedance equations defined here will only be loaded if the data tag (the variable name) is in use.

NOTE Maintain a copy of your unmodified (original) **impedanceDef.txt** file in a safe location.

How to Calculate the VSWR of a Test Port

The user-defined display can be used to calculate the VSWR of a device port from the reflection parameters. Consider a DUT with one single-ended port and one balanced port.



In general, the VSWR equation is in the form:

$$VSWR = \frac{1 + |S|}{1 - |S|}$$

where S is the reflection parameter corresponding to the port and mode of interest. For this device, the table summarizes the correct variable for S:

Port	Mode	S
1	N/A	`S11`
2	Differential	`SDD22`
3	Common	`SCC22`

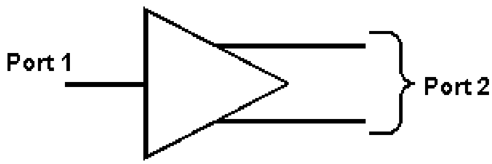
Therefore, the VSWR of each port can be calculated in the user-defined display as follows:

Port	Mode	VSWR
1	N/A	`(1+MAG(S11))/(1-MAG(S11))`
2	Differential	`(1+MAG(SDD22))/(1-MAG(SDD22))`
3	Common	`(1+MAG(SCC22))/(1-MAG(SCC22))`

For information regarding user-defined displays, refer to "Data > User-Defined Display > Add Page..." on page 139.

How to Calculate Impedance Looking into a Device Port

The user-defined display can be used to convert reflection parameters to impedance. Consider a device with one single-ended port and one balanced port.



In general, the equation is in the form:

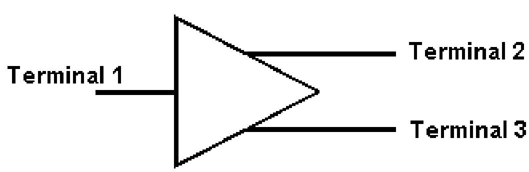
$$Z = Z_R \times \frac{(1 + S)}{(1 - S)}$$

where Z_R is a reference impedance and S is a reflection parameter.

For determining S, it is necessary to know the port and mode of interest. For this device, the following table summarizes the correct variable for S.

Port	Mode	S
1	N/A	S11
2	Differential	SDD22
2	Common	SCC22

For determining Z_R, it is helpful to think of the device as having “terminals” rather than “ports.”



In the multiport test system, the variable name Z_n is the reference impedance of terminal “n”. The following table summarized the correct expression for Z_R:

Port	Mode	Reference Impedance (Z_R)
1	N/A	`Z1`
2	Differential	`(Z2+Z3)`
2	Common	`(Z2*Z3)/(Z2+Z3)`

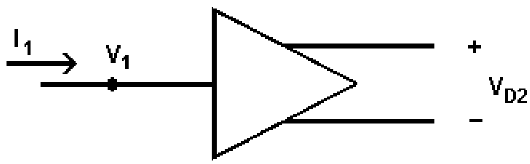
Therefore, the impedance on each port can be calculated in the user-defined display as follows:

Port	Mode	Port Impedance
1	N/A	`Z1*(1+S11)/(1-S11)`
2	Differential	`(Z2+Z3)*(1+SDD11)/(1-SDD11)`
2	Common	`(Z2*Z3)/(Z2+Z3)*(1+SCC11)/(1-SCC11)`

For information regarding user-defined displays, refer to “How to Set Up User-Defined Displays” on page 49 and “How to Use User-Defined Displays” on page 65.

How to Calculate the Gain of a Transimpedance Amplifier

The user-defined display capability can be used to determine the gain of a transimpedance amplifier. Assume the DUT has an unbalanced input and a differential output.



The transimpedance gain of this is defined as:

$$T_Z = \frac{V_{D2}}{I_1} = \frac{V_{D2}}{V_1} \cdot \frac{V_1}{I_1}$$

VD2 is the differential voltage across the balanced pairs.
Therefore,

$$T_Z = S_{DS21} \cdot Z_{in}$$

$$T_Z = S_{DS21} \cdot Z_{R1} \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

where Z_{R1} is the reference impedance at port 1.

1. Open the *User-Defined Display* dialog box. See "Data > User-Defined Display > Add Page…" on page 139.
2. Enter names in the **Tab Title**, **Graph Name**, and **Variable Nam**e boxes.
3. Enter the following equation in the **Equation** box:

```
SDS21*Z1*(1+S11)/(1-S11)
```

4. Click **OK**.

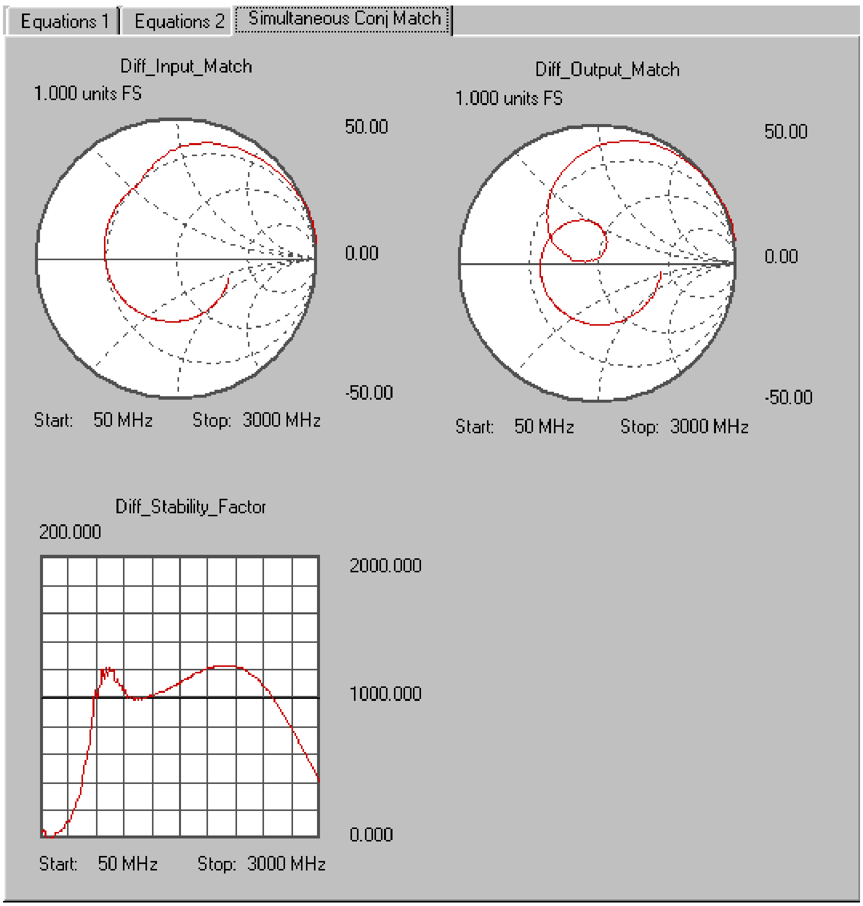
When viewed in LogMag scale, the data is displayed in dBΩ.

How to Measure Simultaneous Conjugate Match of a Differential 2-Port Device

The software includes a set of predefined display configurations, complete with the necessary formulas, to help in measuring the simultaneous conjugate match of a differential two-port device. To use these configurations:

1. Either load previously saved data (see "File > Open > Data…" on page 101), or make a new measurement on a differential device.
2. Open the *Display Configuration* dialog box. See "Setup > Display Configuration…" on page 121. Click **LOAD ALL** to open the simultaneous conjugate match display configuration file, called Mixed Mode Parameters.mpc. This file is normally copied to Multiport/User Config on installation.
3. Click **Set Display** for the Mixed Mode Parameters **Config Identifier**.
4. Click the **User-Defined** button on the main screen.

The Equations 1 and Equations 2 tabs on the user-defined display contain component equations used in the Simultaneous Conj Match display.



Pull down **Data > User-Defined Display > View Equations...** to open the *Defined Equations* dialog box. Notice the listed formula for the differential stability factor display:

```
DSF=(1-ABS(SDD11)^2-ABS(SDD22)^2+ABS(D)^2)/(2*ABS(SDD12)*ABS(SDD21))
```

This translates to:

$$K = \frac{1 - |S_{DD11}|^2 - |S_{DD22}|^2 + |D|^2}{2 \cdot |S_{DD12}| \cdot |S_{DD21}|}$$

where:

$$D = S_{DD11} \cdot S_{DD22} - (S_{DD12} \cdot S_{DD21})$$

Note the formula for differential input match:

```
DIM = (CONJ(C1)/ABS(C1))*(B1/(2*ABS(C1))-((B1^2/(ABS(2*C1))^2)-1)^0.5)
```

This translates to:

$$\Gamma_{GM} = \frac{C_1}{|C_1|}\left[\frac{B_1}{2|C_1|} - \sqrt{\frac{B_1^2}{|2C_1|^2} - 1}\right]$$

where:

$$C_1 = S_{DD11} - S_{DD22}$$

and where:

$$B_1 = 1 - |S_{DD22}|^2 + |S_{DD11}|^2 - |D|^2$$

Note the formula for differential output match:

```
DOM = (CONJ(C2)/ABS(C2))*(B2/(2*ABS(C2))-((B2^2/(ABS(2*C2))^2)-1)^0.5)
```

This translates to:

$$\Gamma_{GM} = \frac{C_2}{|C_2|}\left[\frac{B_2}{2|C_2|} - \sqrt{\frac{B_2^2}{|2C_2|^2} - 1}\right]$$

where:

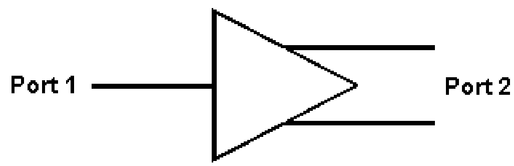
$$C_2 = S_{DD22} - S_{DD11}$$

and where:

$$B_2 = 1 - |S_{DD11}|^2 + |S_{DD22}|^2 - |D|^2$$

How to Measure Simultaneous Conjugate Match of a Device with One Single-Ended and One Differential Port

Calculating the simultaneous conjugate match of a device with one single-ended port is done in a very similar manner as a device with a simple parameter substitution. For example, if the DUT is configured as follows:



then, compared to a device with two differential ports, substitute S_{11} for S_{DD11}, S_{DS21} for S_{DD21}, and S_{SD12} for S_{DD12}. Therefore,

$$K = \frac{1 - |S_{11}|^2 - |S_{DD22}|^2 + |D|^2}{2 \cdot |S_{DD12}| \cdot |S_{DD21}|}$$

$$D = S_{11} \cdot S_{DD22} - S_{DS21} \cdot S_{SD12}$$

$$C_1 = S_{11} - S_{DD22}$$

$$B_1 = 1 - |S_{DD22}|^2 + |S_{11}|^2 - |D|^2$$

$$C_2 = S_{DD22} - S_{11}$$

$$B_2 = 1 - |S_{11}|^2 + |S_{DD22}|^2 - |D|^2$$

$$\Gamma_{GMn} = \frac{C_n}{|C_n|} \cdot \left[\frac{B_n}{2|C_n|} - \sqrt{\frac{(B_n)^2}{|2C_n|^2} - 1}\right]$$

where n=1 for port 1 and n=2 for port 2.

How to Check Test Cable Repeatability

The characteristics of the test cables used with the system should not change significantly when they are moved. To check test cable repeatability, use the following procedure:

1. Connect the short-circuit standard from your calibration kit to the cable.
2. Straighten the cable and remove as much mechanical strain as possible.
3. Pull down **Utility > Manual Test-Set Control...** to open the *Manual Test Set* dialog box. Set the test set for reflection on the port that the cable is connected to:

   S_{11} for port 1

   S_{22} for port 2

   S_{33} for port 3

   S_{44} for port 4
4. Use the network analyzer memory controls to memorize a base-line trace by selecting “memory minus.”
5. While observing the one-inch bend radius limit of the test cables, manipulate the cable through a 90 degree bend and hold it there.
6. Compare the base-line trace to the current data by observing the network analyzer screen.

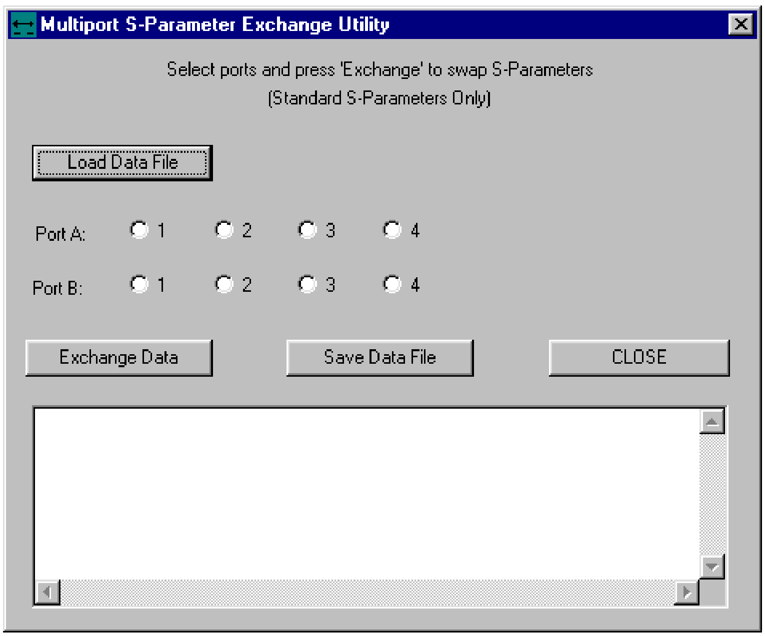
The multiport test system test cables should show better than –30 dB repeatability or a linear difference of less than 0.03.

How to Use the Port Exchange Utility

The Port Exchange utility, PortExchange.exe, is provided to make data taken with older versions of the software compatible with the current version.

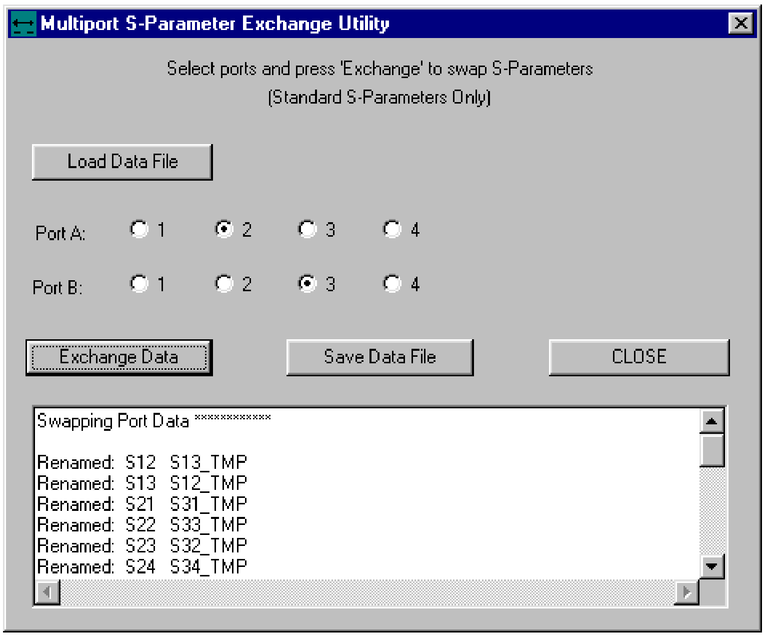
To use the Port Exchange Utility, follow these steps:

1. Run PortExchange.exe, which is located in the same directory with Multiport.exe. The *Multiport S-Parameter Exchange Utility* window opens.



2. Click **Load Data File**. The *Open* dialog box displays.
3. Select a file to load and click **OK**. The name of the loaded file appears in the window.
4. Select ports to exchange. For example, to exchange ports 2 and 3, choose **2** on Port A and choose **3** on Port B.

5. Click **Exchange Data**. The Port Exchange utility shows how the data has been exchanged.



6. Click **Save Data File**.
7. In the *Save As* dialog box, enter the name of the new data file and click **Save**.
8. Click **CLOSE** to close the utility.

How to Check Test Set Ports

You can test the multiport test system test set hardware for damage to the signal channels with the following procedure:

1. Connect the test cable of the signal channel in question to any other channel of the test set. For example, if you suspect channel three, connect it to channel one, two, or four.
2. Pull down **Utility > Manual Test-Set Control...** to open the *Manual Test Set* dialog box. Set the test set for a transmission path on the suspect channel.
3. If the test set has an attenuator, select the *Attenuator* tab and set the attenuator to 0.
4. Observe the thru on the network analyzer. Look for a smooth, monotonic trace, without ripple or bumps, at or near the zero reference line on the network analyzer. Loss should be less than 10 dB.
5. Switch through the attenuator settings. The trace should drop by approximately 10 dB and the shape should remain nearly the same. High attenuator settings will result in a noisy trace.
6. If the test set fails in any respect, return it to Agilent Technologies for repair.

How to Add a Calibration Kit Definition

The multiport test system comes with a number of predefined calibration kits. You can also add your own calibration kits by editing the **calkits.txt** file. The default location of this file is **..\Program Files\Agilent\system**, the actual location may be different.

Editing instructions are included in the file. Make sure you edit and save the file in ASCII text only format.

NOTE Maintain a copy of your unmodified (original) **calkits.txt** file in a safe location.

4 Performing Time Domain Measurements

General Theory

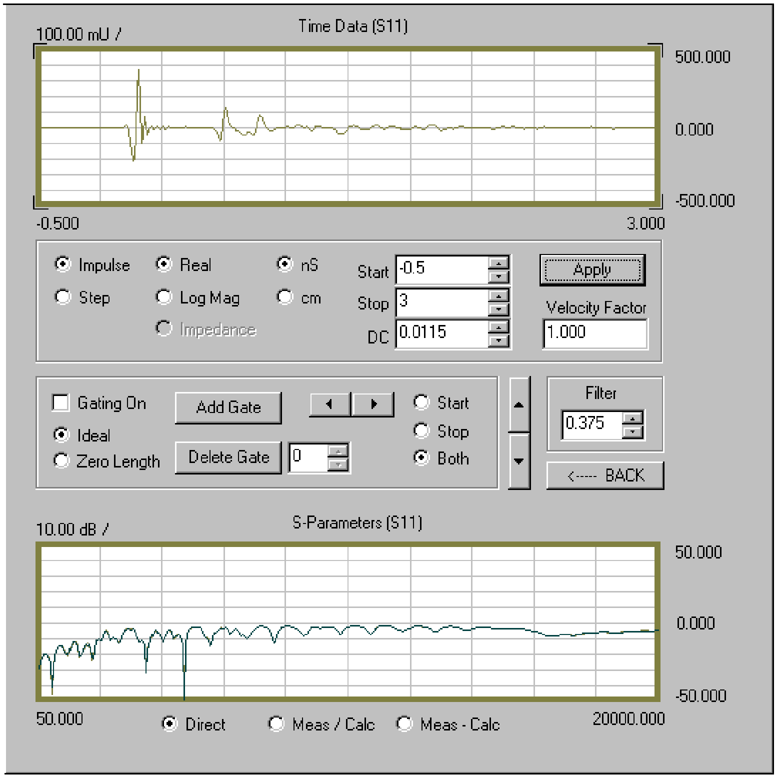
The Agilent multiport test system combined with Agilent's vector network analyzers and their companion multiport test sets perform measurements in the frequency domain by sweeping an RF signal and measuring the RF responses of a device under test (DUT). The software can also mathematically transform these frequency domain data S parameters into their time domain counterparts and display them in either their step, impedance or their impulse/response modes.

In a linear network, the Fourier Transform describes the relationship between a frequency domain measurement and its corresponding time domain response in detail. Therefore, given the measured frequency domain response of a DUT, it is possible to determine its time domain response mathematically by performing an inverse Fourier Transform. And the software accomplishes it's frequency domain transformation to time domain by utilizing this inverse chirp Z Fourier transform[1].

As shown in the following illustration, the type of information that can be observed in time domain mode is quite different than the information that can be observed in frequency domain mode. If the network is thought of in terms of its equivalent circuit model, then the frequency domain response describes the composite behavior of all of the circuit elements at any given operating frequency.

By contrast, the time-domain response shows the contribution of each individual circuit element. Since there is a direct relationship between time and distance, this mode allows each element to be separated spatially. With an understanding of the unique signature characteristics of different circuit elements, this view of the DUT can provide considerable insight into the device.

1. The advantage of the chirp z-transform is that it enables calculation of the sample of the z-transform equally spaced over an arc or a spiral contour with an arbitrary starting point and arbitrary frequency range. In contrast, the frequency range of the discrete Fourier Transform is strictly related to the sampling frequency.



An alternative method of obtaining time-domain characterization of a device is to make the measurement directly in the time domain by synthesizing a step waveform, applying it to the device, and observing the response on an oscilloscope. The advantages of using the measurement approach for TDR data are listed below.

While the traditional TDR measurement technique provides fast measurement speed, the measurement technique used by the multiport test system provides:

- Superior accuracy
- Significantly better dynamic range (important for crosstalk and mode-conversion terms)
- Ability to de-embed fixtures and signal launchers
- Access to both frequency and time domain information (as vector quantities)
- Single setup for forward and reverse transmission and reflection, single-ended, differential-, and common-mode, and mode-conversion terms
- No need for DUT to have DC return path
- No large voltage steps applied to DUT

Response Types

Agilent multiport test systems are able to display the response of a device as if it were stimulated with either a step or an impulse waveform. The algorithm that is used is robust enough that it can determine either type of response, even for band-limited devices. Furthermore, it is not necessary for the device to be able to operate at DC. Both Time Domain Transmission (TDT) and Time Domain Reflection (TDR) parameters can be displayed on the horizontal axis either as a time or a distance. It is also possible to enter a velocity factor so that the electrical length corresponds with the physical length of the DUT.

The time scale of transmission parameters shows the propagation delay through the device. The time scale of the reflection parameters shows the characteristics of the DUT at a certain time delay into the device. Therefore, the reflection parameter shows the one-way travel time into the device, not the round-trip propagation delay that other instruments may show.

On the vertical axis, the impulse response is a reflection or transmission coefficient displayed on either a linear or a logarithmic scale. This parameter can be displayed as an absolute number, or relative to a minimum or maximum value of the response.

Likewise, the step response can be displayed on either a linear or a logarithmic scale. Alternatively, a reflection parameter can be displayed as impedance versus time rather than as a reflection coefficient. Any of the single-ended or mixed-mode S-parameters can be displayed in the time-domain. The table below shows the relationship between frequency domain parameters to their time domain equivalents.

Relationship of Frequency Domain Parameters to Time Domain Equivalents

Mode	Direction	Type	Parameter
UNBALANCED	N/A	TDR	S11
UNBALANCED	REVERSE	TDT	S12
UNBALANCED	REVERSE	TDT	S13
UNBALANCED	REVERSE	TDT	S14
UNBALANCED	FORWARD	TDT	S21
UNBALANCED	N/A	TDR	S22
UNBALANCED	REVERSE	TDT	S23
UNBALANCED	REVERSE	TDT	S24

Relationship of Frequency Domain Parameters to Time Domain Equivalents

Mode	Direction	Type	Parameter
UNBALANCED	FORWARD	TDT	S31
UNBALANCED	FORWARD	TDT	S32
UNBALANCED	N/A	TDR	S33
UNBALANCED	REVERSE	TDT	S34
UNBALANCED	FORWARD	TDT	S41
UNBALANCED	FORWARD	TDT	S42
UNBALANCED	FORWARD	TDT	S43
UNBALANCED	N/A	TDR	S44
DIFFERENTIAL	FORWARD	TDR	SDD11
DIFFERENTIAL	REVERSE	TDT	SDD12
DIFFERENTIAL	FORWARD	TDT	SDD21
DIFFERENTIAL	REVERSE	TDR	SDD22
COMMON	FORWARD	TDR	SCC11
COMMON	REVERSE	TDT	SCC12
COMMON	FORWARD	TDT	SCC21
COMMON	REVERSE	TDR	SCC22
DIFFERENTIAL-TO-COMMON	FORWARD	TDR	SCD11
DIFFERENTIAL-TO-COMMON	REVERSE	TDT	SCD12
DIFFERENTIAL-TO-COMMON	FORWARD	TDT	SCD21
DIFFERENTIAL-TO-COMMON	REVERSE	TDR	SCD22
COMMON-TO-DIFFERENTIAL	FORWARD	TDR	SDC11
COMMON-TO-DIFFERENTIAL	REVERSE	TDT	SDC12
COMMON-TO-DIFFERENTIAL	FORWARD	TDT	SDC21

Relationship of Frequency Domain Parameters to Time Domain Equivalents

Mode	Direction	Type	Parameter
COMMON-TO-DIFFERENTIAL	REVERSE	TDR	SDC22
DIFF-TO-UNBALANCED	REVERSE	TDT	SSD12
DIFF-TO-UNBALANCED	REVERSE	TDT	SSD13
UNBALANCED-TO-DIFF	FORWARD	TDT	SDS21
UNBALANCED-TO-DIFF	FORWARD	TDT	SDS31
COMMON-TO-UNBALANCED	REVERSE	TDT	SSC12
COMMON-TO-UNBALANCED	REVERSE	TDT	SSC13
UNBALANCED-TO-COMMON	FORWARD	TDT	SCS21
UNBALANCED-TO-COMMON	FORWARD	TDT	SCS31

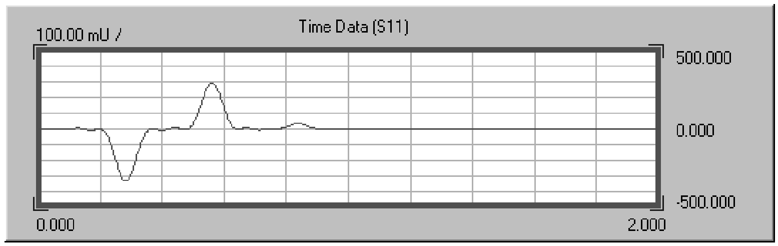
Analyzing Time-Domain Signatures

The time-domain response of a device, its signature, provides specific circuit detail. The shape of the response indicates the element type and configuration (series or shunt). Its value and location can be determined from the size of the reflection and its time delay. In general, a wider measurement bandwidth will provide finer response resolution. The following table, "Time Domain Signatures," shows various circuit elements and associated time-domain signatures.

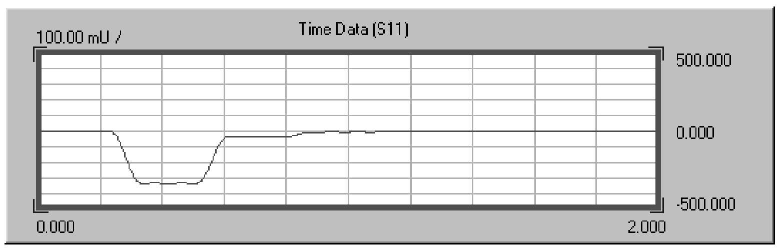
Time Domain Signatures

Transmission Line: ZC < Z0

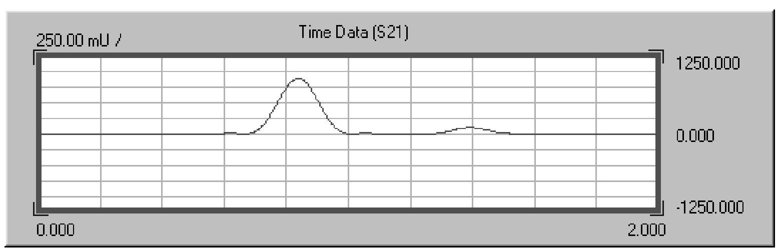
Impulse
Reflection



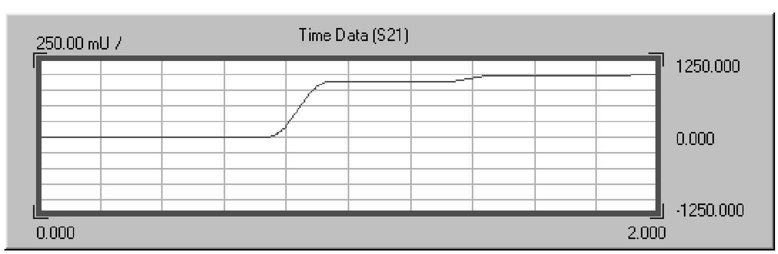
Step
Reflection

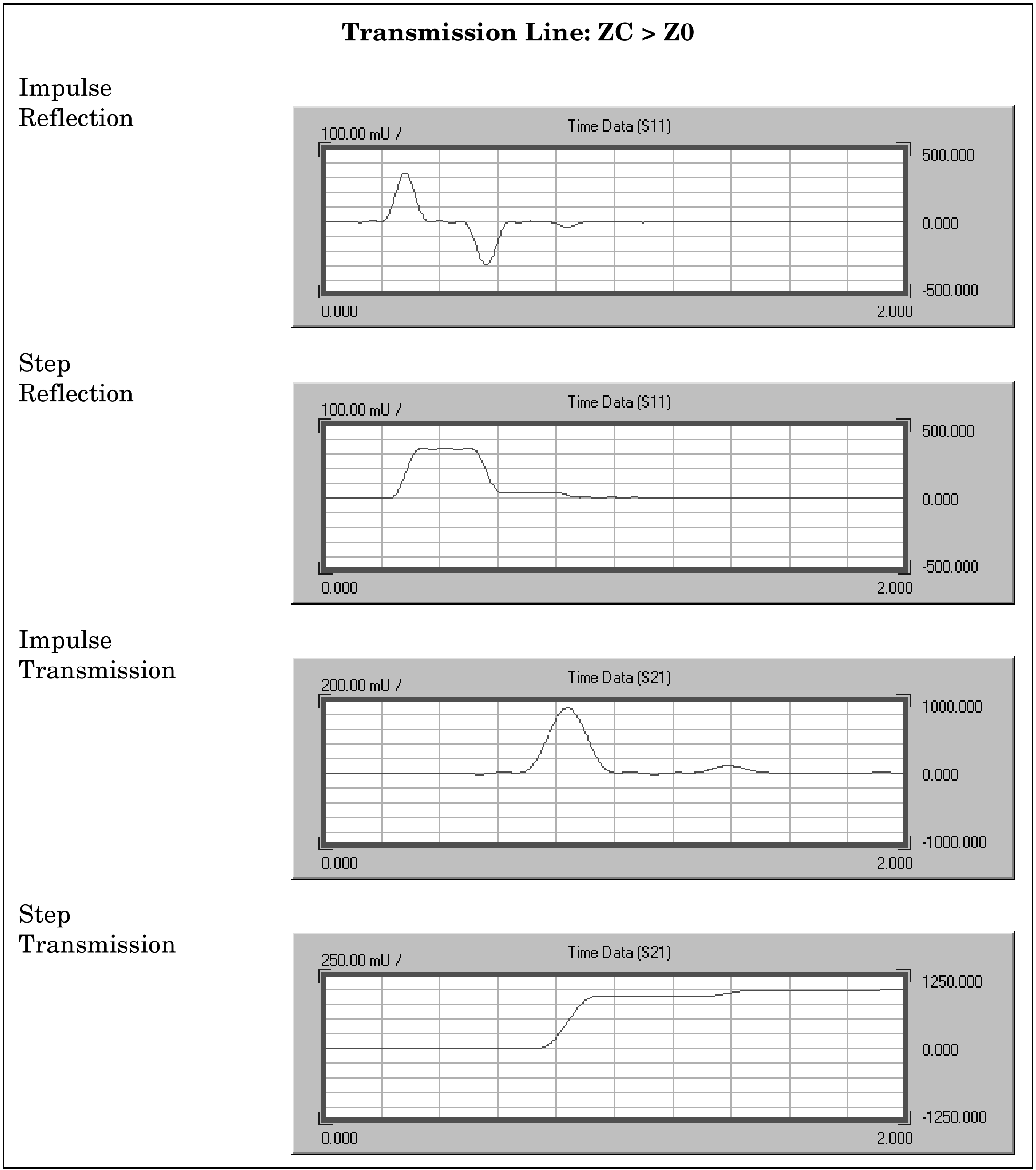


Impulse
Transmission



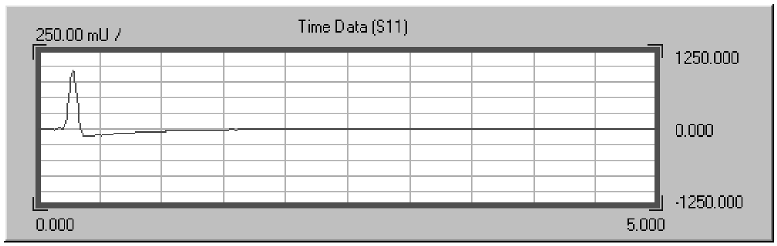
Step
Transmission



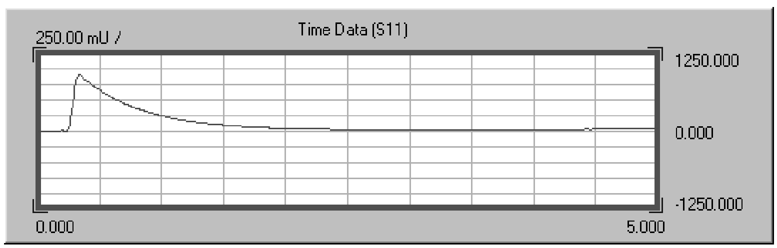

Transmission Line: ZC > Z0
Impulse Reflection
100.00 mU /
Time Data (S11)
500.000
0.000
-500.000
0.000
2.000
Step Reflection
100.00 mU /
Time Data (S11)
500.000
0.000
-500.000
0.000
2.000
Impulse Transmission
200.00 mU /
Time Data (S21)
1000.000
0.000
-1000.000
0.000
2.000
Step Transmission
250.00 mU /
Time Data (S21)
1250.000
0.000
-1250.000
0.000
2.000

Series Inductor

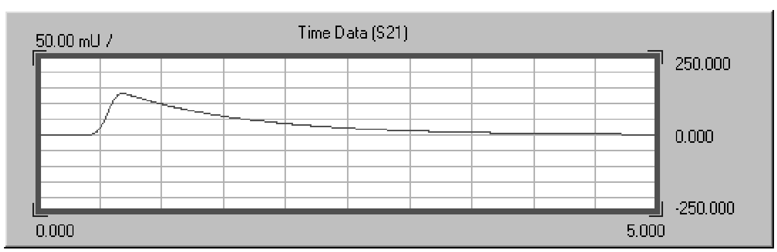
Impulse Reflection



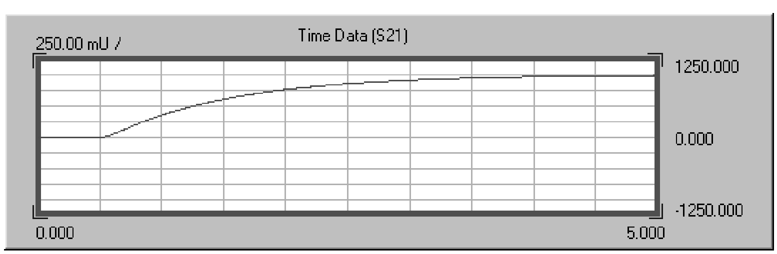
Step Reflection

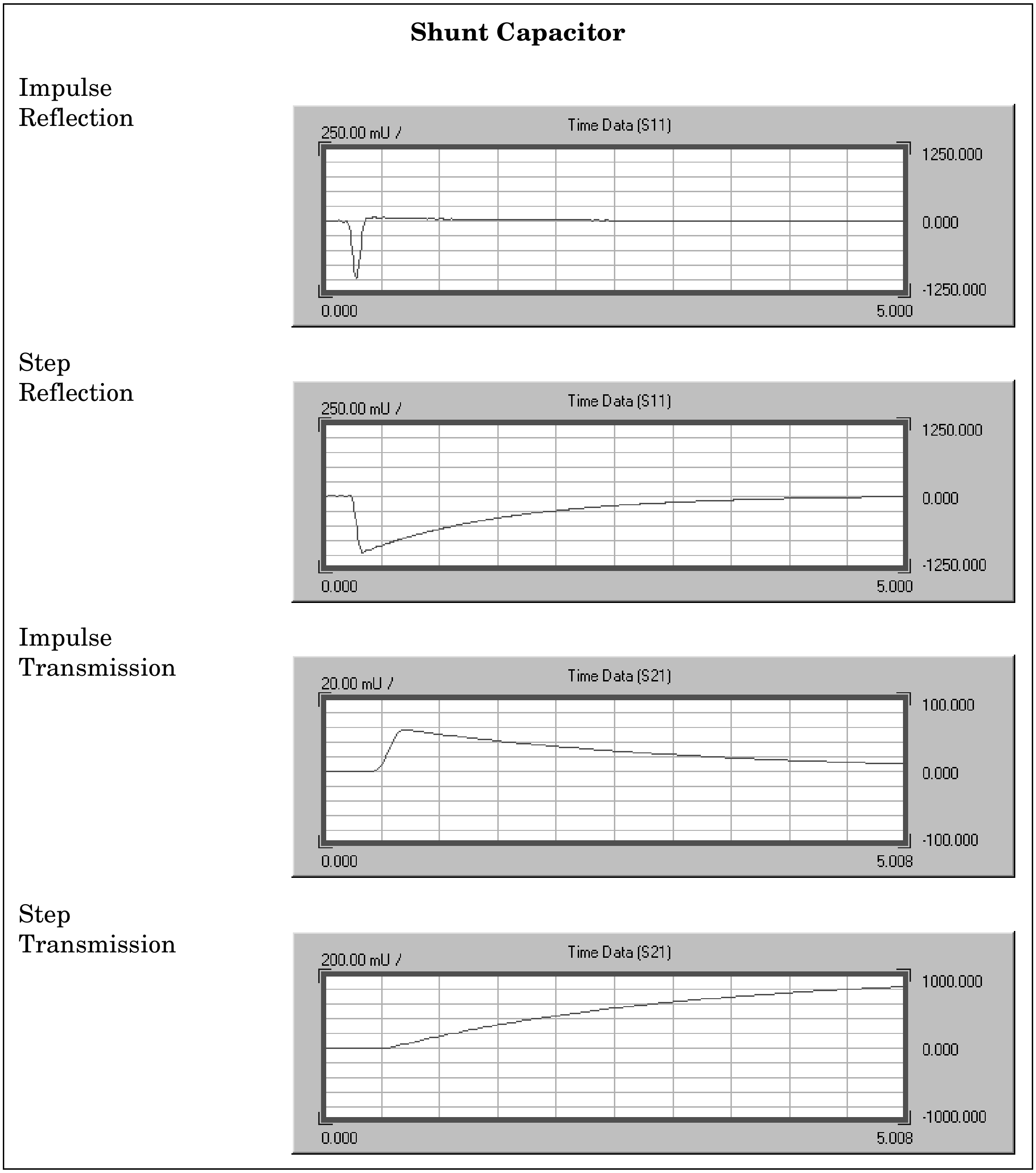


Impulse Transmission



Step Transmission



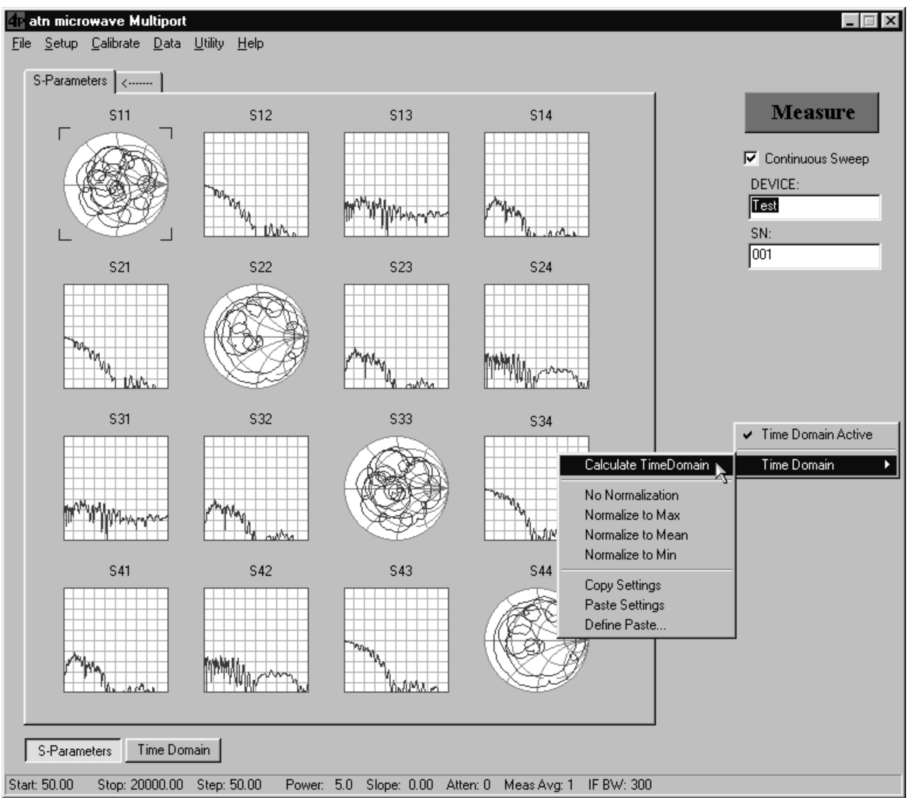

Shunt Capacitor
Impulse Reflection
250.00 mU /
Time Data (S11)
1250.000
0.000
-1250.000
0.000
5.000
Step Reflection
250.00 mU /
Time Data (S11)
1250.000
0.000
-1250.000
0.000
5.000
Impulse Transmission
20.00 mU /
Time Data (S21)
100.000
0.000
-100.000
0.000
5.008
Step Transmission
200.00 mU /
Time Data (S21)
1000.000
0.000
-1000.000
0.000
5.008

Using the Multiport Test System for Time-Domain Measurement and Analysis

This section shows you how to use the multiport test system's time-domain measurement and analysis function. It discusses enabling the time domain function, scaling and formatting the display, and selecting time-domain, gating, and frequency-domain controls.

Enabling the Time Domain Functions[1]

1. Measure a device, load a previously saved data file (*.dut), or import data from another source (*.cit or *.SnP). This will display the standard S-parameter matrix in thumbnail view as shown below.



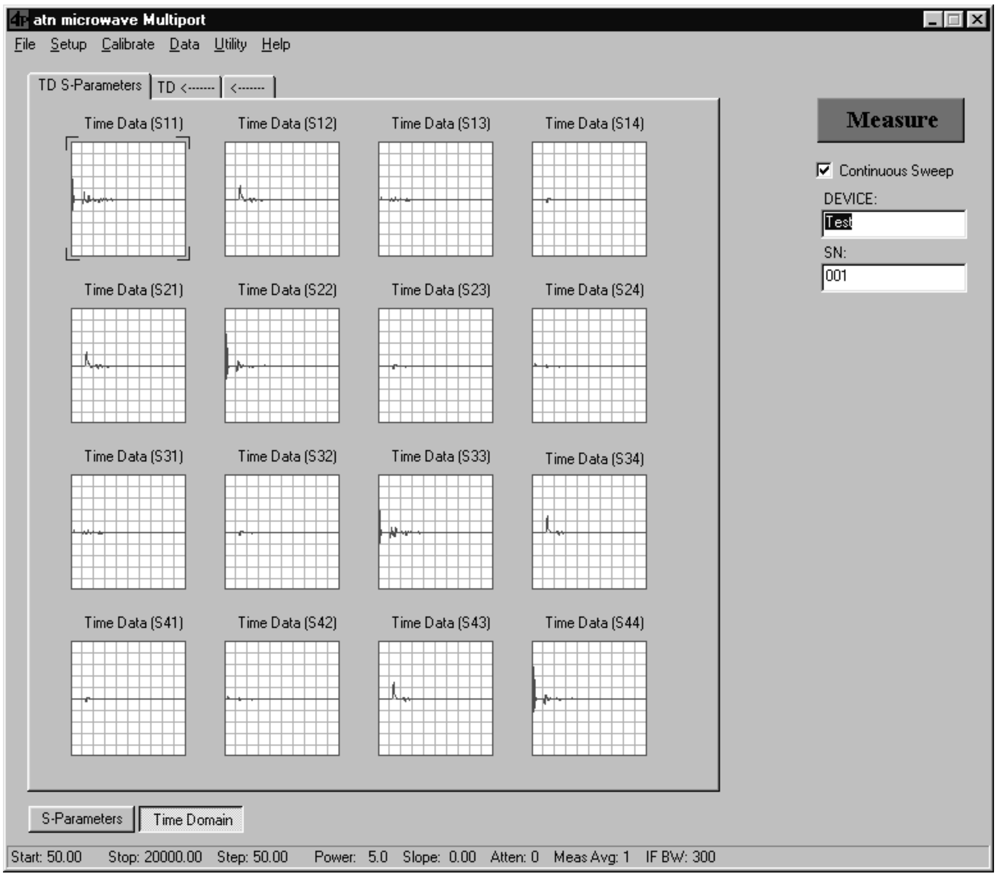
1. The optional time domain module must be installed.

2. Move the cursor outside of the thumbnail view and right mouse-click to display the sub-menu. Left mouse-click on **Time Domain Active**.

3. With time domain activated, select **Calculate Time Domain** from the sub-menu.

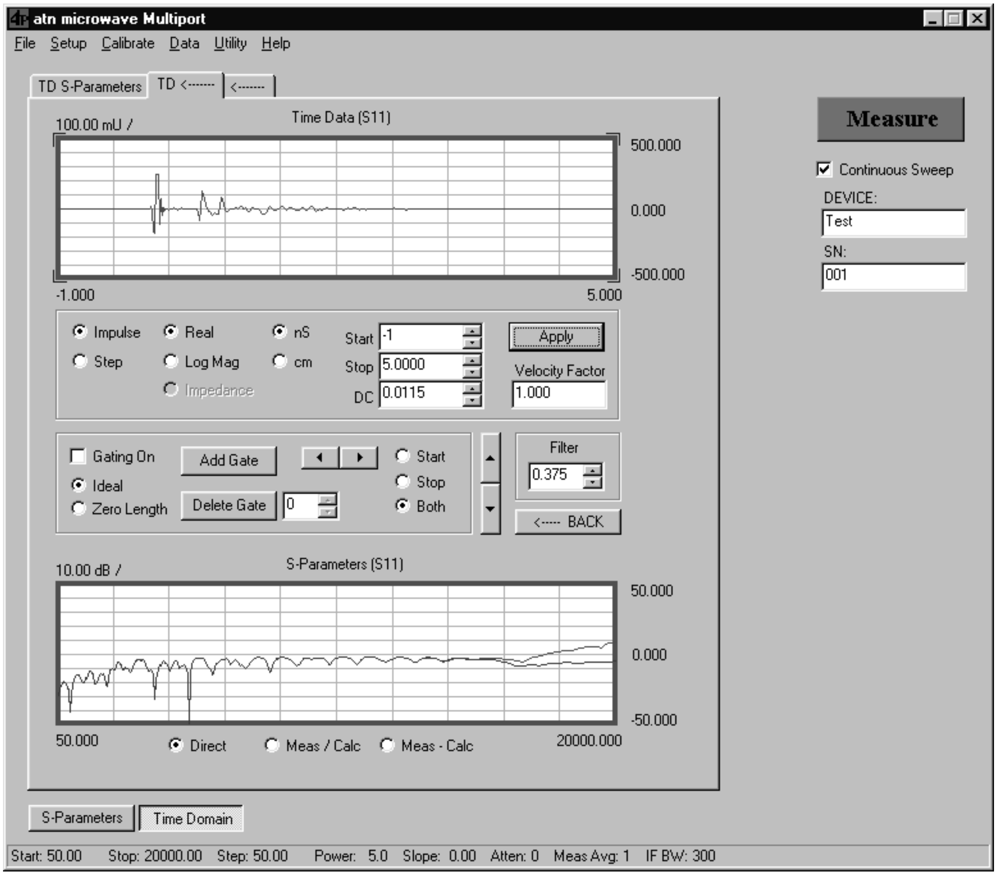
4. To toggle between S-parameter and time domain data, simply select the appropriate button just under the thumbnail display.

A four-terminal device will have 16 S-parameters in the frequency domain. These include transmission and reflection terms, and forward and reverse measurements. The time-domain function will translate these parameters and display them in a similar 4-by-4 matrix as shown below.



Scaling and Formatting

The scaling and formatting of the displays can be easily changed. Double-click on any of the thumbnails to enlarge the display and view a single parameter in both time (upper view) and frequency (lower view) domains.



Mouse scaling can be used in the same way as it is used with S-parameters, refer to "Changing the Scale Parameters of Rectangular Displays" on page 15 for details. Reference levels, offset, and scaling can be changed by simply double-clicking on the current value, entering a new value, and pressing the return key.

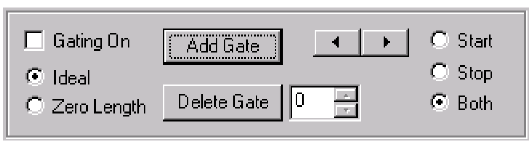
Time Domain Controls

Radio buttons allow selection of impulse or step response. When step response is chosen on a reflection parameter, the data can also be displayed as impedance rather than a reflection coefficient. Linear (Real) or logarithmic (Log Mag) scales can also be selected.

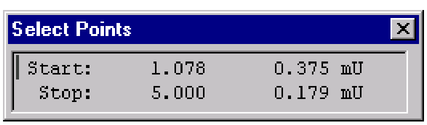
Fill-in forms allow the time window to be further customized. The units for the start- and stop-points are specified in either time (nS) or distance (cm), depending on the setting of the radio button. With distance selected, you may also specify a velocity factor.

Gating Controls

The controls for gating the time domain response provide the ability to remove the effect of a particular circuit element mathematically. To add a gate, first choose the gate type. An 'Ideal' gate replaces the gated section with an ideal transmission line having the same electrical delay as the section that is removed. A 'Zero Length' gate removes the gated section and effectively shortens the structure. Then select **Add Gate**.



When **Add Gate** is selected, a dialog box appears to allow the start- and stop-points of the gate to be defined.



Up to 10 gates can be added. When using multiple gates, 'Ideal' and 'Zero Length' gates are highlighted differently for easy identification. The gates are numbered sequentially from left to right. For example, to delete the left-most gate, set the **Delete Gate** box to 1 and click on the **Delete Gate** button. The next gate then becomes gate number 1.

Once a gate has been defined, its position can be adjusted. The start-point can be moved with the end-point fixed, the end-point can be moved with the start-point fixed, or the segment can be shifted along the trace. This is accomplished by selecting the gate (by its number), and clicking on the right or left soft arrow keys (not the keyboard).

By observing the original frequency domain response and the transformed frequency domain response, the effect of the gating operation on the S-parameter data can be seen.

Frequency Domain Controls

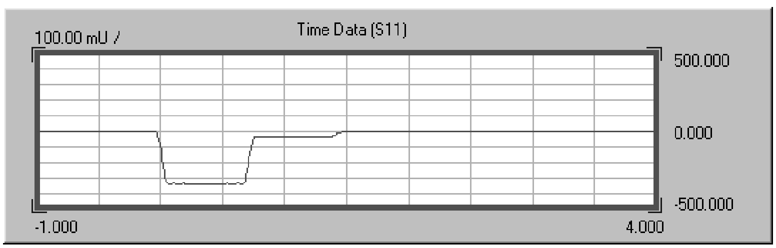
In addition to the S-parameters themselves, it is alternatively possible to display the difference (Meas-Calc) or the ratio (Meas/Calc) between the original data and the response once it is transformed to the time domain, and then transformed back to the frequency domain. This provides a method of determining the validity of the data.

Practical Considerations

In general, the more accurately the frequency domain data can be measured, the more accurate the time domain data will be. Using the step mode rather than the sweep mode provides additional frequency stability of the source that can greatly improve the time domain data. The following are several other important considerations.

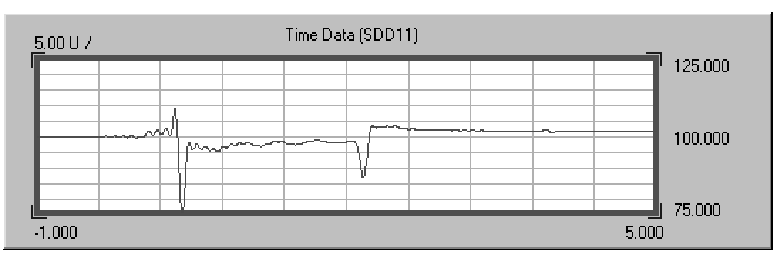
1. Masking

Masking occurs when the effect of one discontinuity affects the behavior of another discontinuity located further from the source. For example, the step response of a perfectly matched 25Ω lossless transmission line is shown below.

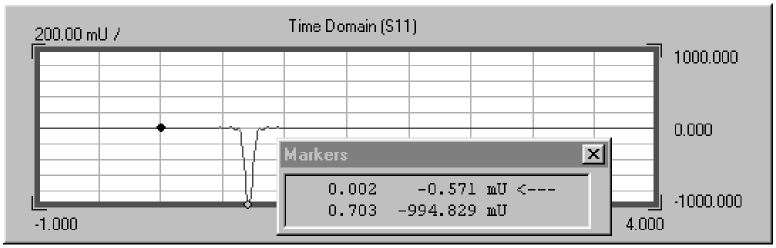


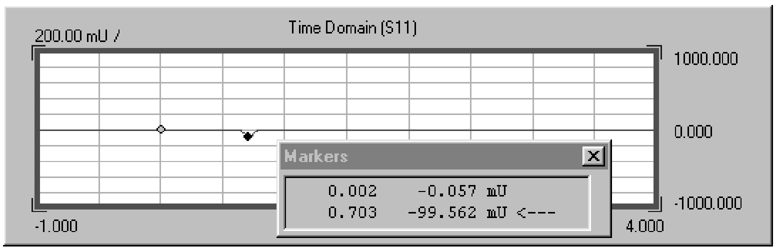
Notice that the response starts at a reflection of 0, steps down to –0.33 (corresponding to 25Ω), and then steps back up to a value slightly less than 0. If the time domain response truly showed impedance versus distance, the response should return to zero. It does not because some of the energy is lost due to the reflections at the discontinuities.

A lossy transmission line will also affect the response. Consider the lossy 100Ω lossy transmission line below. Notice that the region of the DUT has a slope in the step response, and again the end-point is not at zero reflection.



Finally, consider the example of a short circuit at the end of an ideal transmission line. The figure below shows the response as clearly having a reflection coefficient of –1 in the proper location. If there is a matched attenuator in the line, the short shows up as having a smaller reflection coefficient.





2. Filtering

When a measurement is made in the frequency domain, it is inherently band-limited because it is only measured up to a certain frequency. Therefore, in calculating the time-domain response, this is equivalent to measuring a device with a sharp frequency cutoff. For example, consider an ideal, lossless transmission line capable of passing an infinite bandwidth. The impulse response of this device would be an impulse function.

However, if we measured this ideal transmission line to only 10 GHz, it would be like measuring an ideal 10 GHz low-pass filter. When the resulting rectangular frequency domain response is transformed to the time domain, it has a sin(x)/x response. Compared to the case of the infinite frequency range, the width of the impulse response has become broader, and the level of the side lobes has increased, limiting the effective system dynamic range.

The width of the impulse response is directly related to the measurement frequency range. The level of the side lobes depends primarily on the bandwidth of the measurement; but can be greatly improved by filtering of the frequency domain response. This is accomplished at the expense of a further degradation in the width of the impulse response (or step response rise time).

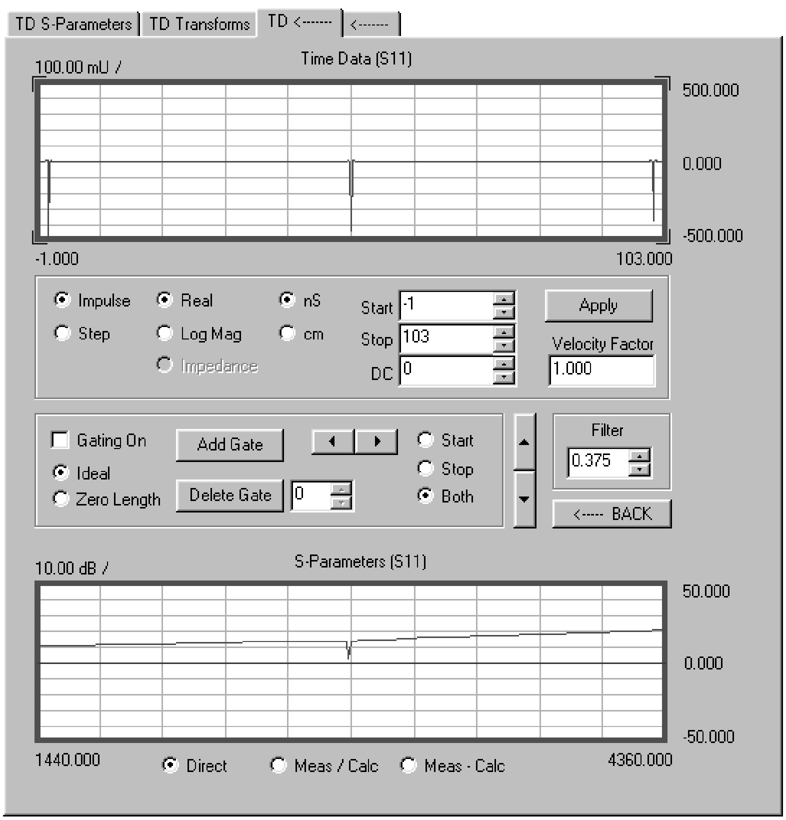
The multiport test system uses a default filter value of 0.375, and provides equivalent rise times of T=0.7/F (where T is the effective step rise time or impulse width in picoseconds, and F is the frequency span in gigahertz). For example, a 20 GHz measurement on the N4418A provides an equivalent time of 36 pS and a dynamic range of 110 dB.

By increasing or decreasing the filter value above or below the default, a tradeoff can be made between pulse width (rise time) and side-lobe level (dynamic range). The key is to pay attention to the calculated frequency-domain response vs. the original data when changing the value of the filter.

3. Aliasing

When data is first measured, a saved data file is first loaded, or the measurement frequencies are changed, the time domain start- and stop-points are calculated to give the best fit possible without aliasing. The start/stop window may be varied along the time base, but should not be widened or aliasing will occur. This is because the Fourier transforms are taken at discrete points, and the data is only valid over a finite range in the time domain.

For example, as shown in the figure below, the frequency step size has been increased, and the aliasing that occurs with the larger step size is clearly visible in the time-domain response. In general, the time window in which no aliasing will occur is equal to T=1/frequency step.



This has implications when selecting the measurement parameters for a DUT, namely that the time window must be larger than the delay through the device to have valid time-domain data. Therefore, the absolute maximum frequency step for the measurement must be Fstep max = 1/Tgd. For example, if the DUT is a SAW filter with a group delay of 2000 nS, the maximum step size is 500 kHz.

Also interesting to note is the frequency domain (S-Parameters (S11)) plot at the bottom of the figure above. Aliasing has caused the data that has been transformed into time domain and back (upper trace) to differ significantly from the original data.

Adjusting the start- and stop-points in the time domain can improve the agreement between the two frequency domain responses (before and after), eliminate the induced aliasing, and thereby validate the calculated time domain response.

4. Response Resolution

The response resolution describes how close in time two responses can be distinguished. This depends on the width of the impulse response, which is inversely related to the measurement bandwidth. The relationship between the three is approximately R=T=1.25/BW; where R is the response resolution in picoseconds, T is the effective impulse width in picoseconds, and BW is the frequency span in GHz.

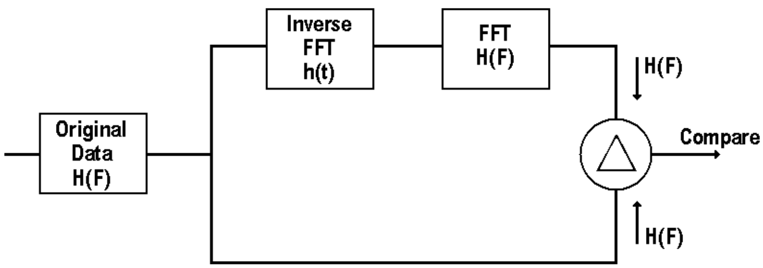
5. Range Resolution

As described previously in "Analyzing Time-Domain Signatures" on page 84, the TDR signature provides specific circuit detail. Range resolution (TD span/# of points, or Stop-Start/# of points) will define how accurately the signature of a response can be identified. In general, a wider measurement bandwidth will provide finer spatial resolution.

To improve range resolution, zoom in on the section of interest and adjust the start- and stop-points to be as narrow as possible without compromising the agreement in the frequency domain.

Checking the Validity of a Time-Domain Calculation

There are a number of practical considerations in examining time domain data, as described previously. Therefore, it is very important to have a method of validating the data. This can be accomplished by comparing the original frequency domain data to the data after it is inverse Fourier transformed into the time domain, and then Fourier transformed back into the frequency domain, as shown in the following illustration. Ideally, these data should be identical. Changing the time domain start- and stop-points, the filter value, and the value of the DC parameter may improve the agreement.



See “3. Aliasing” on page 96 and its figure for an example.

5 Menu Reference

Introduction

The N4425A Balanced Measurement Software menus are described in this chapter. This chapter is divided by each Main Menu selection. Refer to the following sections for each Main Menu selection.

- "File Menu" on page 101
- "Setup Menu" on page 110
- "Calibrate Menu" on page 133
- "Data Menu" on page 136
- "Utility Menu" on page 147
- "Help Menu" on page 152

File Menu

The following is a list of the File menu selections and their locations:

- “File > Open > Data…” on page 101
- “File > Open > Cal…” on page 101
- “File > Save > Data…” on page 101
- “File > Save > Cal…” on page 102
- “File > Import > Citifile…” on page 102
- “File > Import > Import S4P…” on page 102
- “File > Import > Import S3P…” on page 102
- “File > Import > Import S2P…” on page 102
- “File > Export > Citifile…” on page 103
- “File > Export > MMICAD >” on page 103
- “File > Export > Libra… >” on page 105
- “File > Export > Ansoft… >” on page 106
- “File > Export > Tab-Delimited Text…” on page 107
- “File > Print…” on page 107
- “File > Exit” on page 109

File > Open > Data...

Load a previously saved data file (in *.dut format). Note that data files can be used for comparison with other data files using the trace memory (see “Data > Memory…” on page 136) and math functions.

File > Open > Cal...

Load a previously saved calibration (in *.cal format).

File > Save > Data...

Save the current data. Note that this can be either newly measured data or imported data.

File > Save > Cal...

Save the current calibration. Note that this can be either a new calibration or an imported calibration.

File > Import > Citifile...

Import data previously saved in CitiFile (*.cit) format.

CitiFiles imported in this fashion can be used for comparison with other data sets using trace memory (see "Data > Memory..." on page 136) and math functions.

File > Import > Import S4P...

Import data previously saved in S4P (*.S4P) format.

Use **File > Import > Import S4P** to open the *Open* dialog box and import data into the software that was previously saved in S4P format.

The S4P file must contain a valid header line with the frequency unit and data format specified. For example:

MHZSMAR50.00

MHZSDBR50.00

MHZSRIR50.00

File > Import > Import S3P...

Import data previously saved in S3P (*.S3P) format.

Use **File > Import > Import S3P...** to open the *Open* dialog box and import data into the software that was previously saved in S3P format. Refer to "File > Import > Import S4P..." for information regarding the file header line.

File > Import > Import S2P...

Import data previously saved in S2P (*.S2P) format.

Use **File > Import > Import S2P...** to open the *Open* dialog box and import data into the software that was previously saved in S4P format. Refer to "File > Import > Import S4P..." for information regarding the file header line.

File > Export > Citifile...

Export current measurement data in memory to CitiFile S4P format.

In the *Save As* dialog box, enter the file name and click **Save** to save the file.

If transforms are on, user-defined equations are in use, or markers have been defined, the *Export* dialog box appears. Select which types of data to export by checking the appropriate boxes and click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

See "File > Export > MMICAD >" on page 103 for more details on dialog boxes.

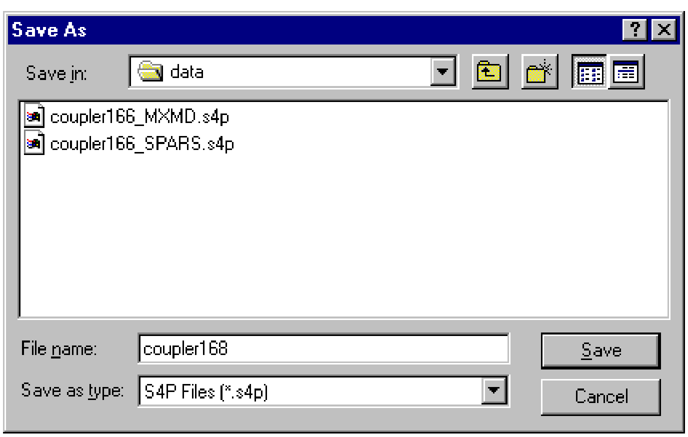
File > Export > MMICAD >

Pull down **File > Export > MMICAD >** to open the *Save As* dialog box and export current measurement data to one of the MMICAD formats. The MMICAD formats available are:

- **S4P**
- **S3P**
- **S2P**
- **S2P Mixed-Mode By Quadrant** (see "S2P Mixed-Mode By Quadrant Format" on page 104)

The S4P, S3P, and S2P selections each have the following additional data format choices in which the data may be saved:

- **mag, angle... (magnitude, angle...)**
- **dB, angle...**
- **real, imag... (real, imaginary...)**



Enter the file name and click **Save** to save the file.

NOTE Exporting to an invalid format may cause data loss. For example, exporting 3-port data in S4P format would create an empty data file (filename.S4P).

If transforms are on, user-defined equations are in use, or markers have been defined, the *Export* dialog box appears.

For all formats but the S2P Mixed-Mode By Quadrant format, the *Export* dialog box looks like this:

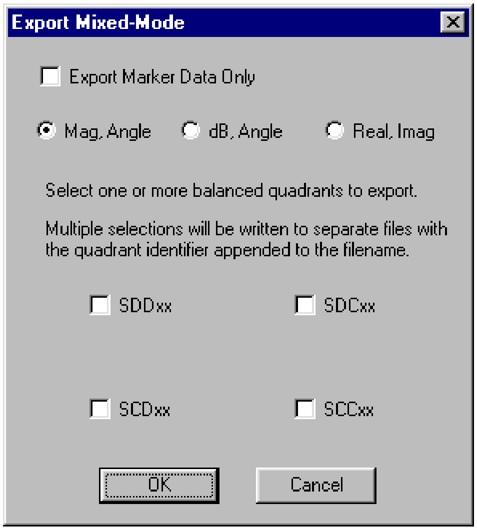
Select which types of data to export by checking the appropriate boxes. For example, if you want to export only marker data, check **Export Marker Data Only** and uncheck the rest of the boxes. If some types of data are not available in the current data set, the corresponding boxes are grayed out.

Click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

S2P Mixed-Mode By Quadrant Format

Each quadrant of the mixed-mode s-matrix of a balanced two-port can be considered as a 2×2 s-matrix for a given mode of operation. Each quadrant can be exported so that it can be read into a circuit simulator. The display must be in 4-port mode with transforms for 2 balanced ports turned on.

For the S2P Mixed-Mode By Quadrant format only, the *Export* dialog box looks like this:



Select the format of the data and the desired quadrants (one or more). One 2-port S-parameter file is generated for each selected mixed-mode quadrant. The file name contains a suffix identifying the quadrant. Click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

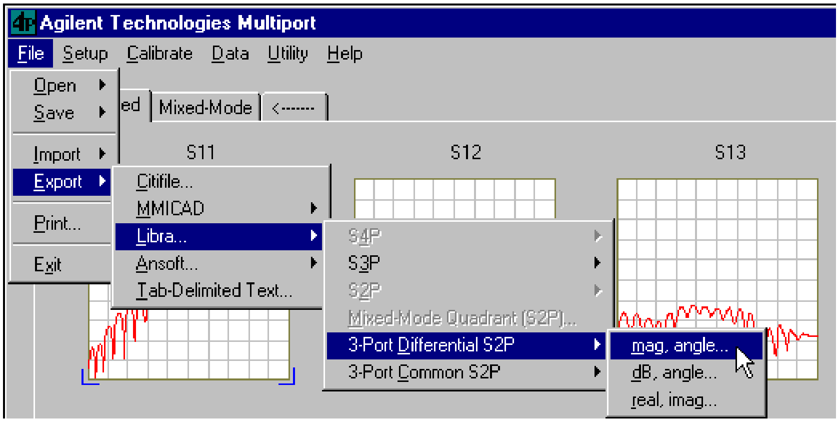
File > Export > Libra... >

Pull down **File > Export > Libra... >** to open the *Save As* dialog box and export current measurement data to one of the Libra formats. The Libra formats available are:

- **S4P**
- **S3P**
- **S2P**
- **3-Port Differential S2P**
- **3-Port Common S2P**
- **S2P Mixed-Mode By Quadrant** (see "S2P Mixed-Mode By Quadrant Format" on page 104)

The S4P, S3P, and S2P selections each have the following additional data format choices in which the data may be saved:

- **mag, angle... (magnitude, angle...)**
- **dB, angle...**
- **real, imag... (real, imaginary...)**



In the *Save As* dialog box, enter the file name and click **Save** to save the file.

If transforms are on, user-defined equations are in use, or markers have been defined, the *Export* dialog box appears. Select which types of data to export by checking the appropriate boxes and click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

See "File > Export > MMICAD >" on page 103 for more details on dialog boxes.

File > Export > Ansoft... >

Pull down **File > Export > Ansoft...>** to open the *Save As* dialog box and export current measurement data to one of the Ansoft formats. The Ansoft formats available are:

- **S4P**
- **S3P**
- **S2P**
- **3-Port Differential S2P**
- **3-Port Common S2P**
- **S2P Mixed-Mode By Quadrant** (see "S2P Mixed-Mode By Quadrant Format" on page 104)

The S4P, S3P, and S2P selections each have the following additional data format choices in which the data may be saved:

- **mag, angle... (magnitude, angle...)**
- **dB, angle...**
- **real, imag... (real, imaginary...)**

In the *Save As* dialog box, enter the file name and click **Save** to save the file.

If transforms are on, user-defined equations are in use, or markers have been defined, the *Export* dialog box appears. Select which types of data to export by checking the appropriate boxes and click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

See "File > Export > MMICAD >" on page 103 for more details on dialog boxes.

File > Export > Tab-Delimited Text...

Pull down **File > Export > Tab-Delimited Text...** to save current measurement data in tab-delimited data format. You can import tab-delimited data into many applications that accept delimited data, like spreadsheet programs.

In the *Save As* dialog box, enter the file name and click **Save** to save the file.

If transforms are on, user-defined equations are in use, or markers have been defined, the *Export* dialog box appears. Select which types of data to export by checking the appropriate boxes and click **OK** to export the file. Click **Cancel** to return to the main screen without exporting the file.

See "File > Export > MMICAD >" on page 103 for more details on dialog boxes.

The .txt default file extension denotes that the data will be saved as ASCII text only in the tab-delimited output.

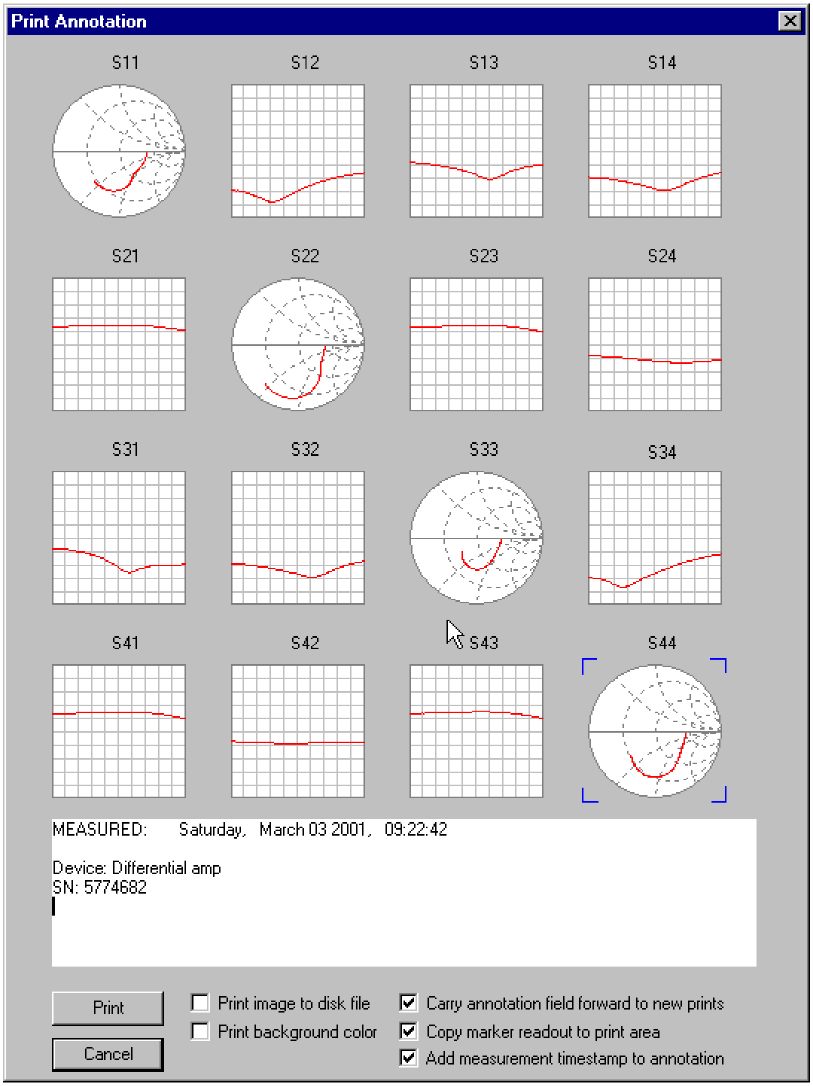
Tab-delimited text files may be loaded into spread sheet applications. The default import options of 'Delimited', 'Tab', and 'General' data format work with these files.

File > Print...

Pull down **File > Print...** to open the *Print Annotation* dialog box and print the data display.

You can edit the annotation by clicking in the box and typing. If you want to keep your entry and have it carry over to subsequent prints, click **Carry annotation field forward to new prints**. Note that with this selection, changes to the device information boxes on the main screen will not alter existing annotations.

You can force the software to clear the annotation field whenever a new measurement is made by clearing the appropriate box.



Click **Print image to disk file** to save the data displays as a graphic file. Select a drive and directory and enter a file name in the *Save As* dialog box. Graphic file options are Windows Bitmap (BMP), JPEG Bitmap (JPG), Targa Bitmap (TGA), and PaintBrush (PCX).

Click **Print background color** to have the colored fill surrounding the data displays print. Turn this off if the output will be faxed or copied.

Click **Copy marker readout to print area** to display the *Markers* dialog box to the printed data displays. This box can be moved to the location you prefer on the data displays.

Click **Add measurement timestamp to annotation** to add the time and date to the annotation area. The time stamp is displayed in the format shown in the previous illustration.

Click **Print** to open the standard *Windows Print* dialog box and print the data.

Click **Cancel** to close the dialog box and return.

File > Exit

Pull down **File > Exit** to quit the software.

Setup Menu

The following is a list of the Setup menu selections and their locations:

- “Setup > All…” on page 110
- “Setup > Meas Parameters…” on page 110
- “Setup > Cal Kit Selection…” on page 112
- “Setup > Adapter Usage…” on page 113
- “Setup > De-Embedding…” on page 115
- “Setup > Modify Rotations…” on page 119
- “Setup > Test Port Impedance…” on page 120
- “Setup > Display Configuration…” on page 121
- “Setup > Hardware…” on page 124
- “Setup > Preferences…” on page 125
- “Setup > 4-Port” on page 128
- “Setup > 3-Port (Ports 1, 2, and 4)” on page 129
- “Setup > 2-Port (Ports 1 and 3) / (Ports 2 and 4)” on page 131

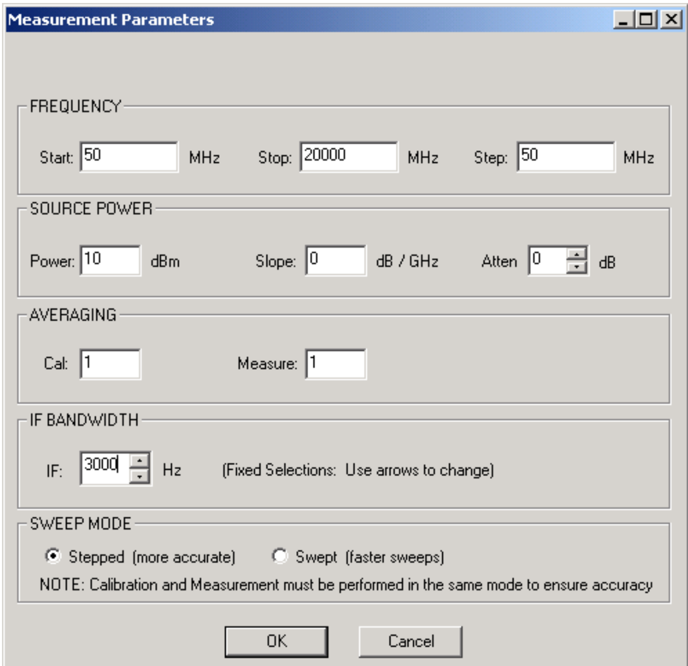
Setup > All...

Pull down **Setup > All...** to set up all operating parameters. These include:

- Measurement Parameters. See “Setup > Meas Parameters…” on page 110
- Calibration Kit Selection. See “Setup > Cal Kit Selection…” on page 112
- Thru Adapter Usage. “Setup > Adapter Usage…” on page 113

Setup > Meas Parameters...

Pull down **Setup > Meas Parameters...** to open the *Measurement Parameters* dialog box and set up measurements.



Enter settings for **Frequency**, **Source Power**, **Averaging**, and **IF Bandwidth** that are consistent with the capabilities of the equipment, the needs of the test, and the operating parameters of the DUT. See the passive and active device characterization examples in "How to Characterize Passive Devices" on page 57 and "How to Characterize Active Devices" on page 58.

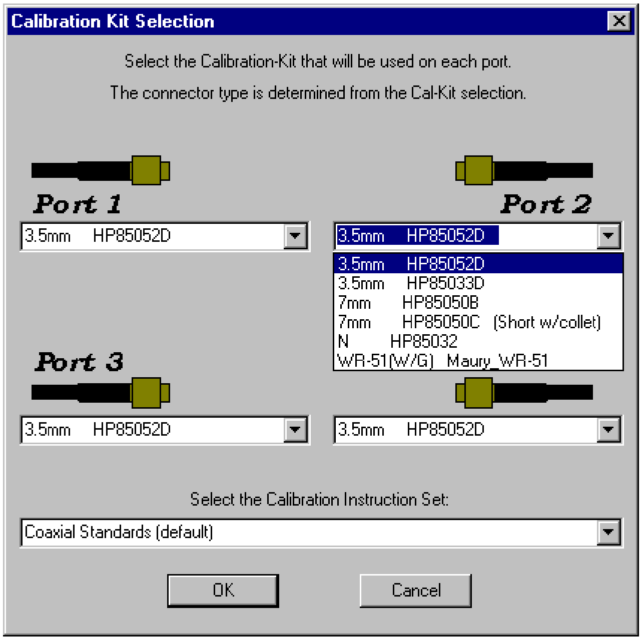
IF bandwidth selections can only be changed by clicking on the arrows next to the box. While the **Atten** box allows direct entry, only increments from 0 to 70 dB are supported. All other boxes allow direct entry. The attenuator box is only displayed on systems using the N4413A and N4414A test sets. In systems using other test sets, the attenuator is coupled to the source power setting.

NOTE Changing the attenuator setting after calibration will result in an invalid calibration. If the attenuator setting is changed and then reset to the calibrated value, measurement accuracy will be degraded. The attenuator is optional. The Atten control will have no effect if you do not have the attenuator installed.

Sweep mode sets the VNA to step mode or swept mode. Criteria for choosing the sweep mode is described in the VNA documentation.

Setup > Cal Kit Selection...

Pull down **Setup > Cal Kit Selection...** to open the *Select Calibration Kit* dialog box and select the calibration kits to use with the system.



The system supports assignment of calibration kits per port. Select a calibration kit from each of the drop-down lists.

Click **OK** to confirm the selection.

Click **Cancel** to quit the dialog box without changing the calibration kit selection.

The multiport test system comes with a number of predefined calibration kits. You can also add your own calibration kits by editing the **calkits.txt** file. The default location of this file is **..\Program Files\Agilent\system**, the actual location may be different.

Editing instructions are included in the file. Make sure you edit and save the file in ASCII text only format.

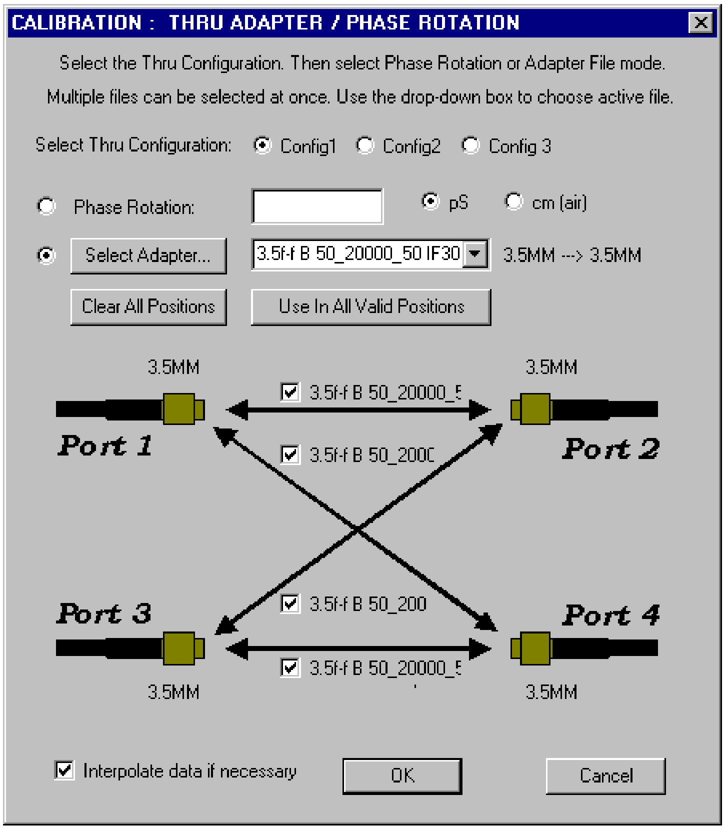
NOTE Maintain a copy of your unmodified (original) calkits.txt file in a safe location.

The selections you make in this dialog box are used in other parts of the software, such as de-embedding and thru adapter usage selections, to determine the connector types of the cables. Make calibration kit selections before making these other settings.

Select the Calibration Instruction Set allows tailoring of the sequence for presenting calibration standards to the system for the best match with the measurement environment.

Setup > Adapter Usage...

Pull down **Setup > Adapter Usage...** to open the *THRU ADAPTER USAGE* dialog box and setup adapters for use in calibrating the system.



Click the **Select Thru Configuration** choice that best minimizes the amount of cable bending during the calibration and the measurement. The choices are:

- **Config 1** - uses four paths (1-2, 3-4, 1-4, 3-2)
- **Config 2** - uses four paths (1-2, 3-4, 1-3, 2-4)
- **Config 3** - uses all six paths (1-2, 3-4, 1-3, 2-4, 1-4, 3-2)

The errors in the unmeasured paths of Config 1 and Config 2 are calculated. Config 3 measures all paths to ensure maximum accuracy when needed.

When a low-loss Thru adapter with a known delay is being used, select **Phase Rotation**, enter the delay value, and select the units in picoseconds, **pS**, or centimeters-in-air, **cm (air)**.

Click **Select Adapter...** to add adapter (`.txs`) files to the drop-down selection box. To select more than one adapter file, hold down the **CTRL** key while clicking each file. This allows multiple selections in the drop-down box.

Click **Clear All Positions** to remove the adapters files from all transmission paths.

Click **Use In All Valid Positions** to apply the adapter file in all valid positions. The software calculates this from the connector from the calibration kits selected in Setup > Cal Kit Selection… (see page 112).

Click the check boxes near the connector depictions to apply or remove an adapter characterization file to a transmission path.

If you try to apply an adapter file to a position where it cannot be used. The system will warn you:

Remember that cable connectors are defined by the calibration kit assigned to them.

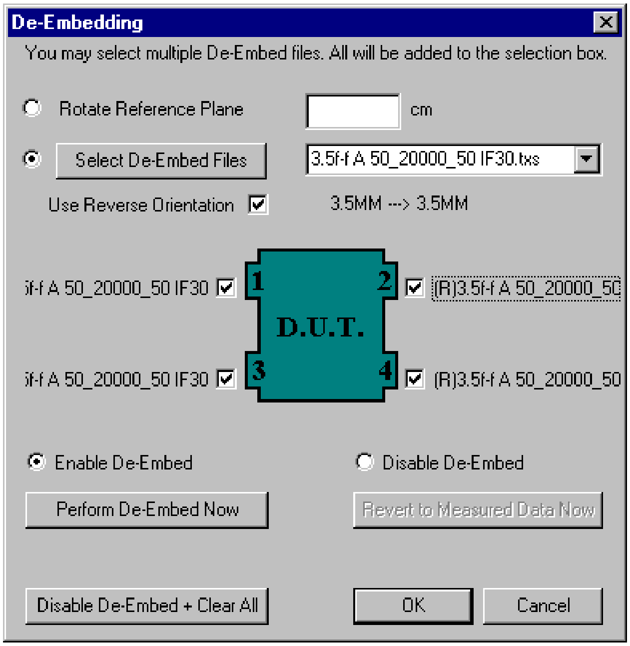
Click **Interpolate data** if necessary to have the software interpolate the adapter characterization file, if needed, relative to any measurement frequency settings. (This setting is recommended.)

Click **OK** to accept the adapter settings.

Click **Cancel** to exit the dialog box without making any changes.

Setup > De-Embedding...

Pull down **Setup > De-Embedding...** to open the *De-Embedding* dialog box and configure DUT reference planes by de-embedding probes, fixtures, or adapters from the measured data.



The software supports reference plane rotation and S-parameter de-embedding of fixtures.

Select the reference plane rotation using one of two methods:

- Click **Rotate Reference Plane** and enter a reference plane rotation value in centimeters-in-air.
- Click **Select De-Embed Files** to add de-embedding (`.txs`) files to the drop-down selection box to use S-parameter de-embedding. You can select more than one fixture (or adapter characterization) file at once to allow multiple selections in the drop-down box.

Select an S-parameter de-embedding file from the list then click the boxes near the DUT diagram to apply the de-embed file to the DUT port.

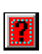
De-embedding files contain information about the ports on the fixture that you are de-embedding, and match the connectors during de-embed setup. If you try to specify a fixture connection that cannot be made, the software warns you:

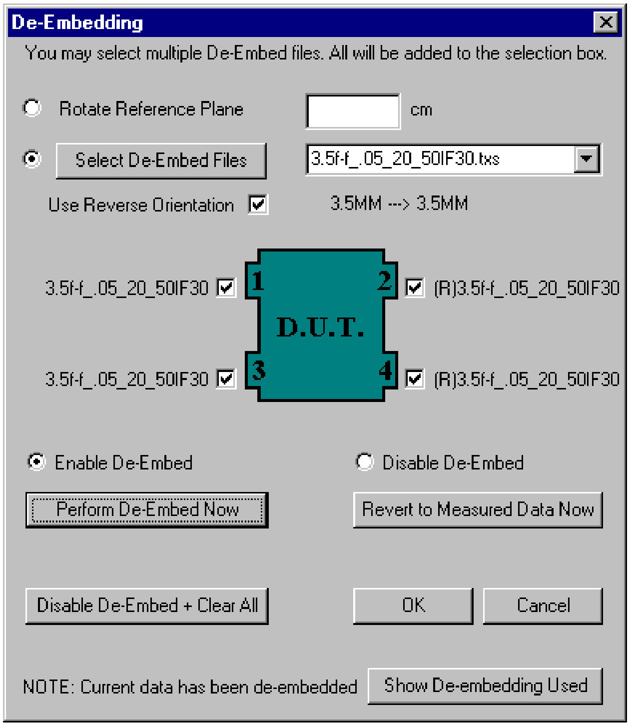
NOTE Port connectors are defined by the cal kits assigned to them in the *Calibration Kit Selection* window (see "Setup > Cal Kit Selection…" on page 112).

Click the **Use in Reverse Orientation** box to change the orientation of the adapter, probe, or fixture relative to the DUT port. This option does not work when **Rotate Reference Plane** is selected. It only works with selected de-embed files.

In the screen below, the fixture has been applied in forward orientation on the left-side ports of the DUT, and reverse orientation on the right-side ports of the DUT. Reverse application is noted by the (R) indicator.

NOTE If you open de-embedding files that conflict with the current de-embedding, the software warns you:

Click the  button to check the de-embedding status. Click each DUT port to add the rotation to that port. Click **Perform De-embed Now** to apply the rotation values to the current data set. Click **OK** to accept the settings and close the *De-embedding* window.



Click **Enable De-Embed** to turn de-embedding on.

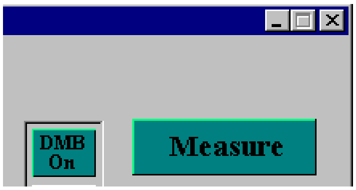
Click **Perform De-Embed Now** to perform de-embedding on the current data set. **Perform De-Embed Now** is only available when de-embedding has been turned on with **Enable De-Embed** (see above).

Click **Disable De-Embed** to turn de-embedding off.

Click **Revert to Measured Data Now** to remove any previously applied de-embedding from the current data set. **Revert to Measured Data Now** is only available when de-embedding has been turned off with **Disable De-Embed**.

Click **Disable De-Embed + Clear All** to turn off de-embedding and clear all the applications of probe, fixture, or adapter files.

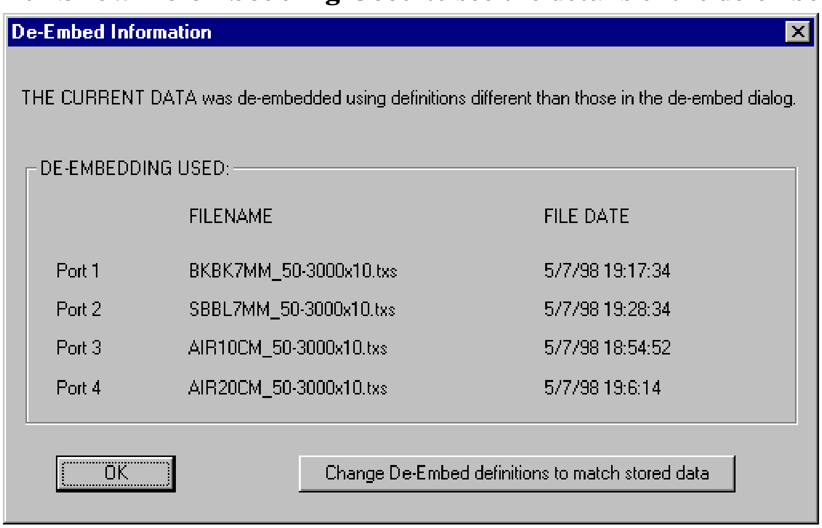
When de-embedding is enabled, the **DMB On** indicator is displayed in the upper right part of the main screen.



De-Embedding Status

Data files saved after de-embedding has been applied to the data are saved with the de-embedding in place. The software makes note of the de-embedding status when you subsequently load the data file. If the current data has had de-embedding applied (the current data can be either measured or loaded data), the following section is added to the *De-Embedding* dialog box.

Click **Show De-embedding Used** to see the details of the de-embedding.



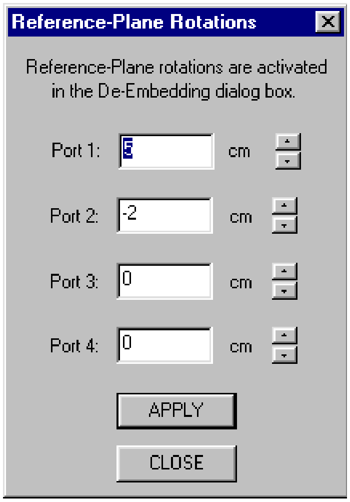
Click **OK** to return to the *De-Embedding* dialog box.

Click **Change De-Embed definitions to match stored data** to apply the de-embedding definitions from a stored file to the DUT for further measurements.

The software will look for the files that were used for de-embedding. The full path name and time stamp must match exactly. If they do not match, you will be warned and must re-define de-embedding as described above.

Setup > Modify Rotations...

Pull down **Setup > Modify Rotations...** to open the *Reference-Plane Rotations* dialog box and modify the reference plane rotation settings quickly while using the software.

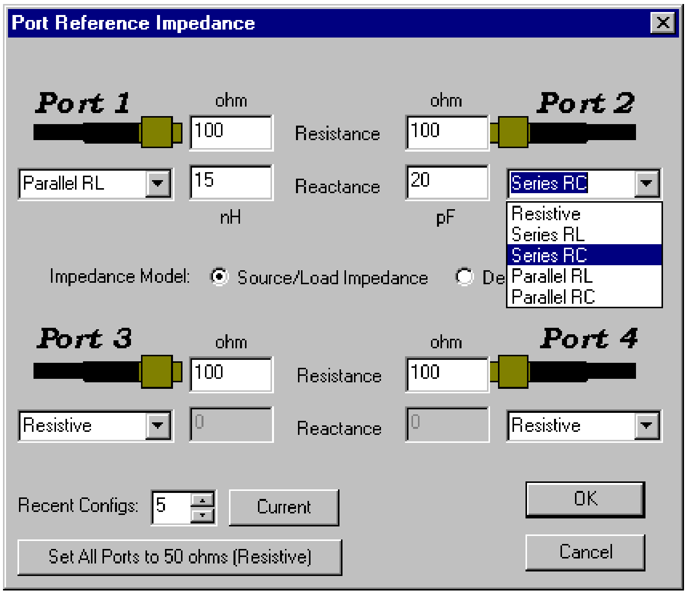


Enter the new rotation values for the desired ports. Using the arrows to change a value applies the change automatically. Direct entries are processed when you press the **Enter** key or click **APPLY**. Click **CLOSE** to return.

A positive value rotates the phase towards the DUT (effectively, removing a length of 50Ω line) and a negative value rotates the phase away from the DUT (effectively, adding a length of 50Ω line).

Setup > Test Port Impedance...

Pull down **Setup > Test Port Impedance...** to open the *Port Impedance* dialog box and set reference impedances.



By default all four ports are set to 50Ω impedance. Enter new reference impedances in the port boxes as desired.

This feature does not affect the impedance presented to the DUT by the system hardware. Rather, it mathematically transforms the measured data to show how the performance of a linear device would change in a non-50Ω measurement system. Impedance transforms can be specified either before or after measurement. Only the current data set is affected.

The reference impedance can be specified as resistive, or as an RL or RC circuit. The impedance model is used to specify whether the selected impedance is the effective source/load impedance, or whether it is an estimate of the DUT port impedance. One is the complex conjugate of the other.

Scroll through the **Recent Configs** box to select a configuration from one of the last ten reference impedance configurations.

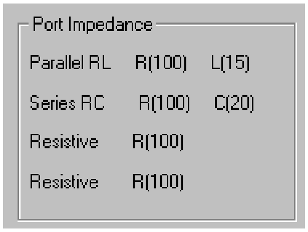
Click **Set All Ports to 50 ohms** to return to the default configuration.

Click **OK** to accept the configuration and exit the dialog box.

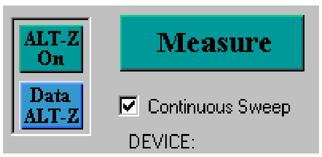
Click **Cancel** to ignore any changes and exit the dialog box.

If the default test port impedance has been changed on at least one of the ports:

- The new configuration is displayed on the main screen:



- Two indicator bar buttons are displayed on the main screen:



The **ALT-Z On** button means that an arbitrary reference impedance (non-50Ω) has been selected in Setup.

The **Data ALT-Z** button means that the current data has been modified for a non-50Ω reference impedance for at least one port.

Differential reference impedances are additive. For example, specifying a reference impedance of 125Ω on port 1 and 125Ω on port 3 corresponds to a differential-mode reference impedance of 250Ω on balanced port one. Likewise, the common-mode reference impedances are the parallel equivalent impedance.

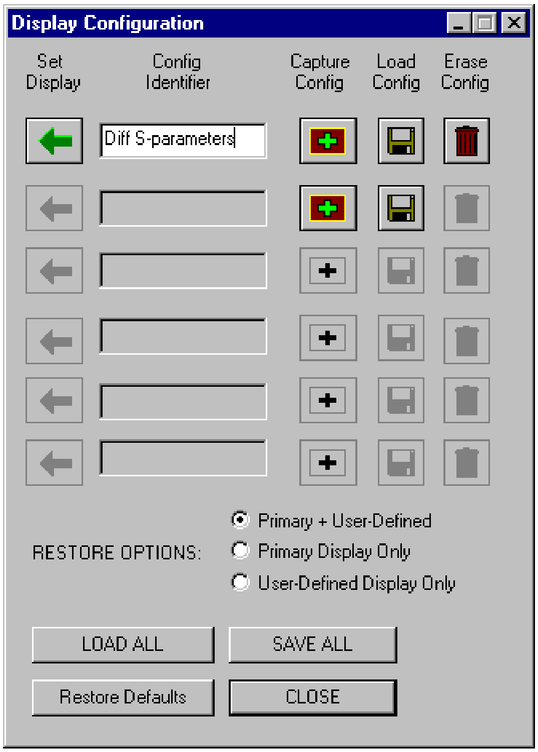
Setup > Display Configuration...

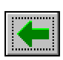
The software supports saving and loading display configuration information so that you can restore a previously configured display. The saved display configuration information includes:

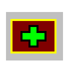
- all properties associated with the frequency domain displays, including scaling and display type settings (Smith Chart, Phase, etc.)
- all user-defined displays

Pull down **Setup > Display Configuration...** to open the *Display Configuration* dialog box.

Each display configuration file can hold up to six display settings. You can load all the display configurations in a file as a group, or you can select individual display settings from different configuration files.



Click **Set Display**  to apply the associated display configuration.

Click **Capture Config**  to capture the current display configuration. Enter a configuration identification in the **Config Identifier** box. The configuration identification must be unique to that configuration file.

Click **Erase Config**  to remove that configuration from the system. **Erase Config** removes the configuration immediately, so make sure you have saved the configuration(s) before using **Erase Config** if you want to keep the configuration information for later use.

Use the **RESTORE OPTIONS** selections to select which parts of a display configuration will be used. Select from **All Displays**, **Primary Display Only**, and **User-Defined Display Only**. **All Displays** includes both the primary and any user-defined displays. The primary display is the S-parameter or mixed-mode S-parameter display.

Click **LOAD ALL** to load all the display configurations associated with a configuration file without selecting individual display configurations.

Click **SAVE ALL** to save all the currently loaded display configurations.

Click **Restore Defaults** to undo any changes that have been made since the beginning of the session to primary and user-defined displays.

Click **CLOSE** to close the *Display Configuration* dialog box.

The normal sequence of events in using display configuration is:

1. Define a display configuration through using the system.
2. Pull down **Setup > Display Configuration...** and click **Capture Config**.
3. Identify the configuration by entering a name under **Config Identifier**.
4. Define and capture up to six display configurations per configuration file.
5. In the *Display Configuration* dialog box, click **SAVE ALL** to save the configurations.
6. In subsequent sessions click **LOAD ALL** to load an entire configuration file or click **Load Config** to load an individual configuration into a slot in the *Display Configuration* dialog box.

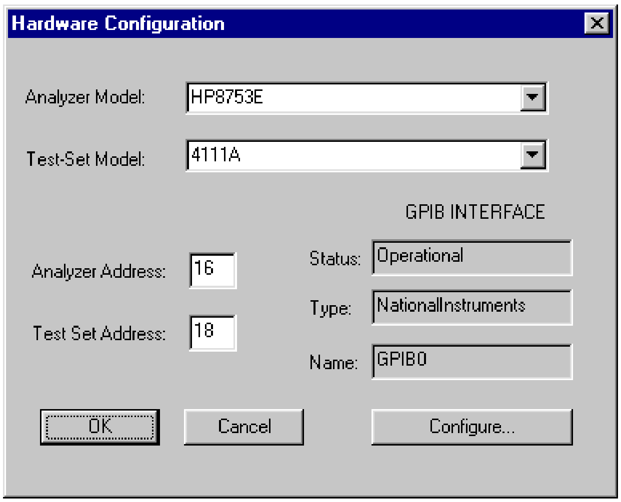
NOTE The format of the .mpc file has changed from older versions of the software. However, you can load configuration files generated by older versions into the current version of the software.

To recall a display configuration generated by a previous version of the software, follow these steps:

1. Click the **LOAD ALL** button.
2. In the *Open* dialog box, select an old configuration file and click **Open**.
3. Click **Set Display**. The system displays an Error message. Follow the instructions in the message.

Setup > Hardware...

Pull down **Setup > Hardware...** to open the *Hardware Configuration* dialog box to configure the system.



Select the **Analyzer Model** and the **Test-Set Model** from the drop-down lists.

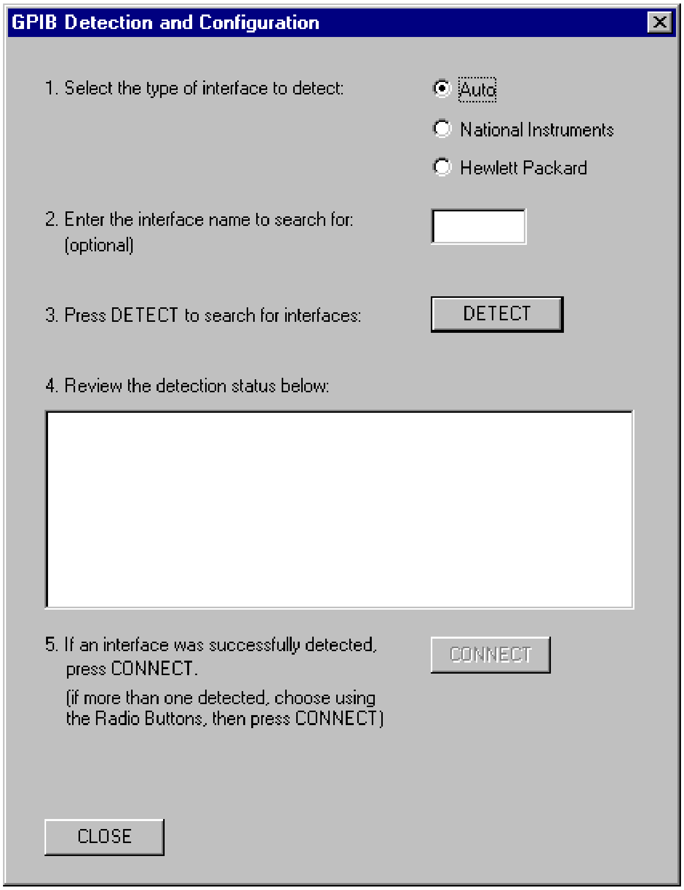
Enter the **Analyzer Address** and the **Test-Set Address** (GPIB addresses).

The **GPIB INTERFACE** area shows the current status of the interface.

Click **OK** to accept any changes and exit the dialog box.

Click **Cancel** to ignore any changes and exit the dialog box.

Click **Configure...** to open the *GPIB Detection and Configuration* dialog box and automatically configure GPIB communication on your host computer.

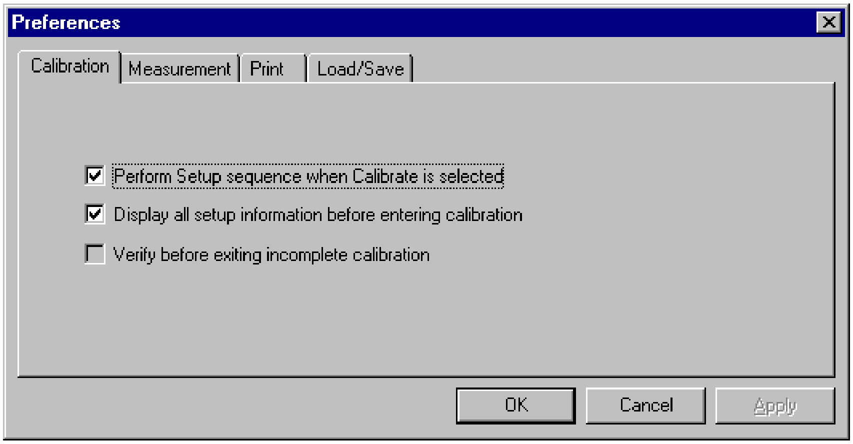


Follow the five step configuration process as shown in the *GPIB Detection and Configuration* dialog box. The name in step 2 is optional. If desired, use the name of the interface card supplied by the manufacturer.

Setup > Preferences...

Pull down **Setup > Preferences...** to open the *Preferences* dialog box.

The **Calibration** tab shows calibration preference options.

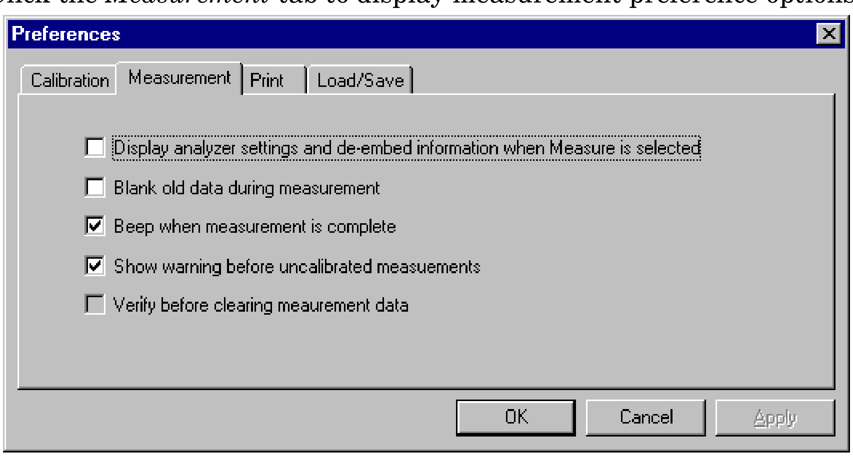


Select **Perform Setup sequence when Calibrate is selected** to force complete calibration configuration each time you select **Calibrate > Perform Calibration >** from the main menu. With **Perform Setup sequence when Calibrate is selected** enabled, the *Measurement Parameters*, *Calibration Kit Selection*, and *CALIBRATION: THRU ADAPTER / PHASE ROTATION* dialog boxes are displayed for edits or confirmation. With this option off, the system begins calibrating immediately with the current calibration settings.

Select **Display all setup information before entering calibration** to have the system show you the current calibration settings before starting the calibration. This allows you to confirm that the calibration settings are correct before starting.

Verify before exiting incomplete calibration is not implemented.

Click the *Measurement* tab to display measurement preference options.



Select **Display analyzer settings and de-embed information when Measure is selected** to have the system show this information prior to a measurement. This allows you to confirm that the measurement settings are correct before beginning a measurement.

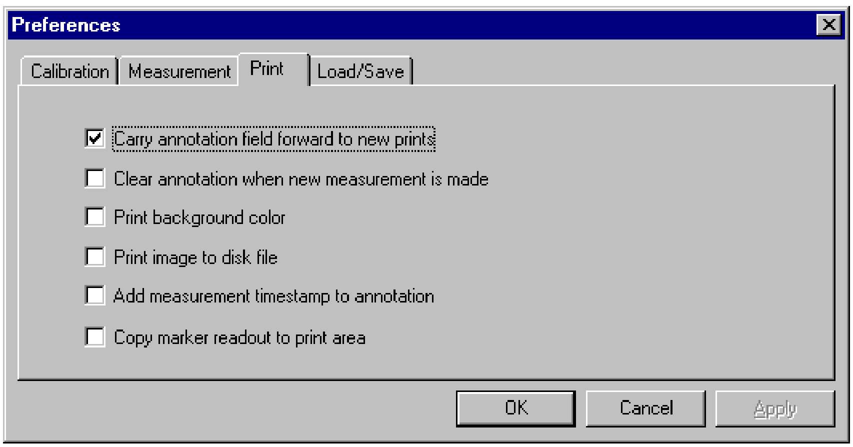
Select **Blank old data during measurement** to have the system stop showing any old measurements on display while a new measurement is being made.

Select **Beep when measurement is complete** to have the system give you an audible prompt on completion of a measurement.

Select **Show warning before uncalibrated measurements** to display a warning if the system has not been calibrated when a measurement is attempted.

Verify before clearing measurement data is not implemented.

Click the **Print** tab to display the print preference options.



Select Carry forward last print annotation field to new prints to have the system remember any notes you entered in the *Print Annotation* dialog box from one measurement to the next. These notes can be changed at any time prior to printing.

Select **Clear annotation when new measurement is made** to have the system clear the note field in the *Print Annotation* dialog box for each new measurement.

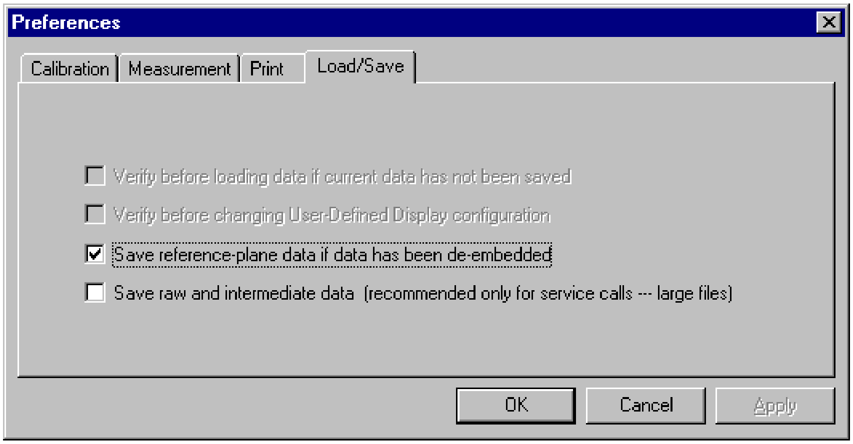
Select **Print background color** to use the gray background around the measurement displays. You may want to make prints without the gray background if the print will be faxed, since the background can slow down faxing.

Click **Print image to disk file** to have the system default to save the images, rather than printing them.

Click **Add measurement timestamp to annotation** to have the system include the date and time of the measurement to the printed copies.

Click **Copy marker readout to print area** to have the system default to include marker information in the annotation area of the printed copy.

Click the **Load/Save** tab to display the Load/Save preference options.



Performing a measurement creates a large amount of data in addition to the displayed data. This includes raw uncorrected data and data generated during intermediate stages of the correction process.

If de-embedding or alternate port impedance is active, more intermediate data is created.

When you save data using **File > Save > Data**, the raw data and most of the intermediate data is removed to reduce the size of the disk file. As a result, certain operations cannot be reversed if the file is loaded back into the application.

Click **Save reference-plane data if data has been de-embedded** to allow the removal of de-embedding information from a data file loaded to a disk. (This is the default setting.)

If **Save reference-plane data if data has been de-embedded** is not checked, the plots with the de-embedding information are saved and the raw data used to create the loaded data file can no longer be viewed. However, information about the de-embedding used on the raw data is still available for review.

Click **Save raw and intermediate data** to save all the data. This is only recommended when you need data for a service call to Agilent. For normal operation this selection is not recommended because it results in large disk files.

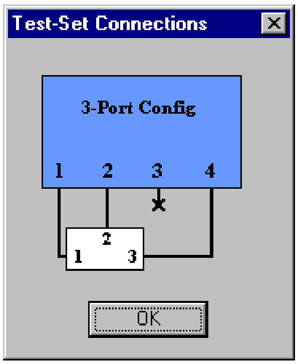
Setup > 4-Port

Select **Setup > 4-Port** to change the measurement configuration from 3-port or 2-port to the default 4-port configuration.

Setup > 3-Port (Ports 1, 2, and 4)

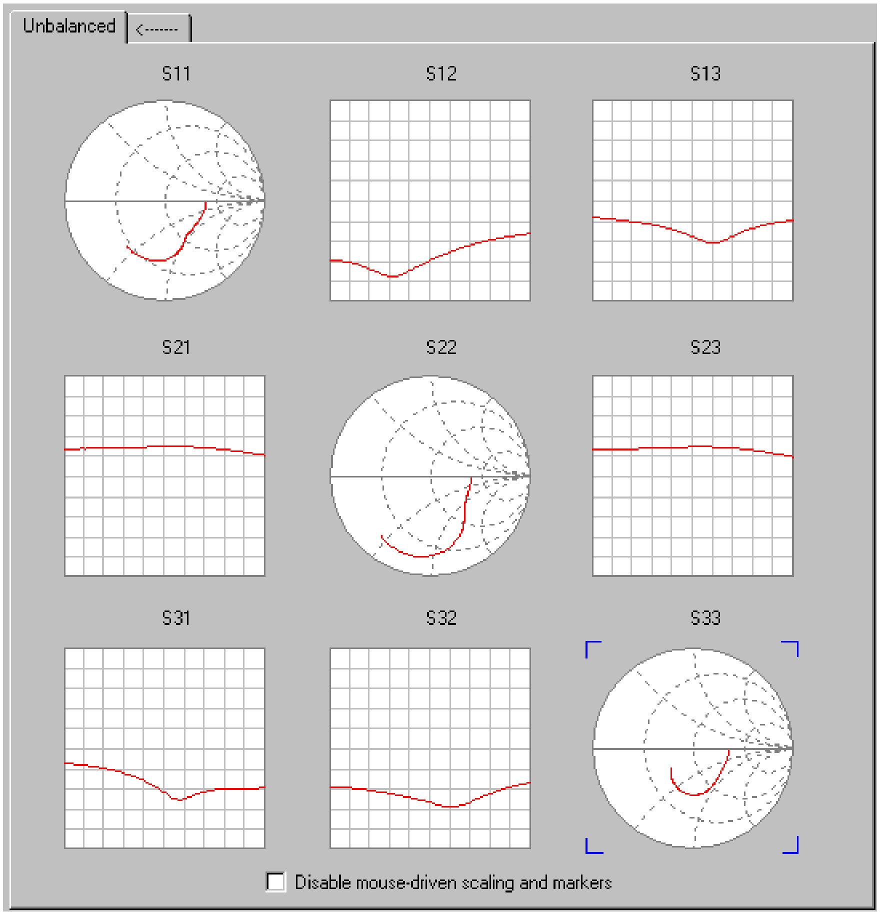
With a 4-port calibration, it is possible to make 3-port measurements. This reduces the number of sweeps from 8 (for a 4-port device) to 6. Test ports 1, 2, and 4 are used. Test port 3 is not used.

Select **Setup > 3-Port (Ports 1, 2, and 4)** to change the configuration from 4-Port to 3-Port. The *Test-Set Connections* box opens to show the proper connections:



This connection diagram shows the test-set to DUT connections for single-ended measurements. Click **OK** to close the *Test Set Connections* box.

The S-Parameter screen changes from 16 plots to 9 plots. Transforms are disabled whenever the port configuration is changed.



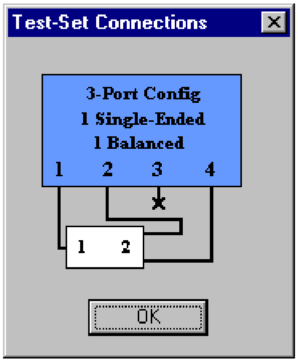
You can proceed with making a new 3-port measurement.

NOTE If you change the configuration from 4-port to 3-port for an existing measurement, and then change it back to 4-port by selecting **Setup > 4-Port**, the missing plots are displayed and the data from those plots is restored.

1 Single-Ended, 1 Balanced Port Transform

In 3-port mode, you can transform from “2 single-ended and 1 balanced port” to “1 single-ended and 1 balanced port”.

Pull down **Data > Transforms > 1 Single-Ended, 1 Balanced** from the menu. The new *Test Set Connections* box opens to show the proper connections:



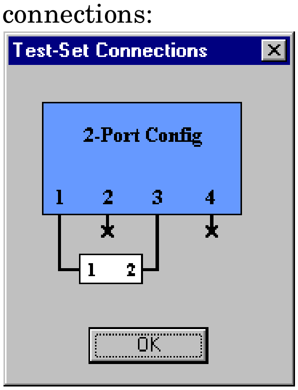
Click **OK** to close the *Test Set Connections* box.

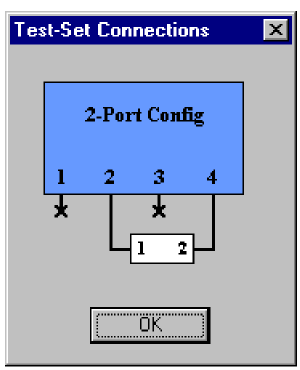
Setup > 2-Port (Ports 1 and 3) / (Ports 2 and 4)

With a 4-port calibration, it is possible to make 2-port measurements. This reduces the number of sweeps from 8 (for a 4-port device) to 2. Test ports 1 and 3, or test ports 2 and 4 are used in a 2-port measurement. 1-port reflection measurements can be made on balanced devices in the port 2 and 4 configuration only.

Select **Setup > 2-Port (Ports 1 and 3)** or **Setup > 2-Port (Ports 2 and 4)** to change the configuration from 4-Port to 2-Port.

The *Test-Set Connections* box for ports 1 and 3, or ports 2 and 4 opens to show the proper connections:





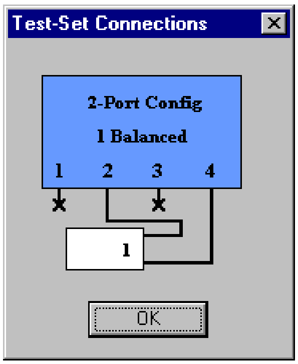
Click **OK** to close the *Test Set Connections* box.

You can proceed with making a 2-port measurement.

1 Balanced Port Transform

In 2-port (Ports 2 and 4) configuration (not Ports 1 and 3), a transform to 1 balanced port is available.

Pull down **Data > Transforms > 1 Balanced Port** from the menu. The new *Test-Set Connections* box opens to show the proper connections.



Click **OK** to close the box.

Calibrate Menu

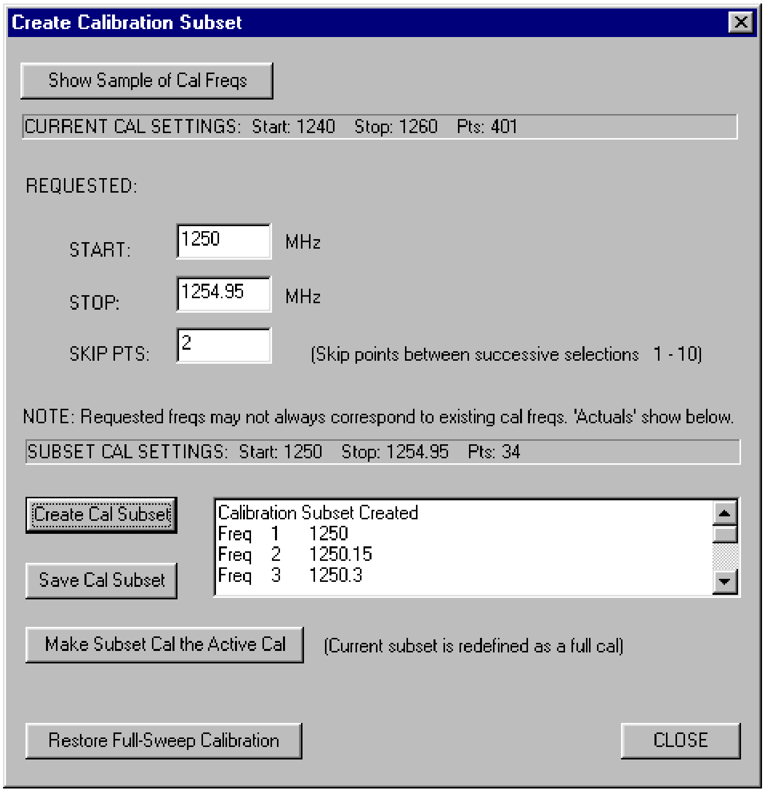
The following is a list of the Calibrate menu selections and their locations:

- "Calibrate > Create Cal Subset…" on page 133
- "Calibrate > Remove Cal Subset" on page 135
- "Calibrate > Standard Calibration…" on page 135
- "Calibrate > Electronic Calibration…" on page 135
- "Calibrate > Delete Current Cal" on page 135

Calibrate > Create Cal Subset...

Pull down **Calibrate > Create Cal Subset...** to create a subset of an existing calibration data set. Using a calibration subset can speed up measurement sweeps when you only need to measure a small span within the span of calibration. Creating the calibration subset allows you to change the frequency range while retaining the complete calibration settings.

If a calibration has not been performed or an existing calibration file is not opened, this menu selection is unavailable. The *Create Calibration Subset* screen is displayed when this menu item is selected.



Click **Show Sample of Cal Freqs** to display a sample of calibration frequencies from the current full-sweep calibration.

The **CURRENT CAL SETTINGS** line shows the Start and Stop frequencies and the number of points in the current full-sweep calibration.

In the **START:** and **STOP:** fields, enter the start and stop frequencies for the new calibration subset. Changing these fields allow you to sweep a narrower span while the calibration subset option is active.

In the **SKIP PTS:** field, enter the number of points to skip in the full calibration to create the new calibration subset.

The **SUBSET CAL SETTINGS** line shows the Start and Stop frequencies and the number of points in the new calibration subset.

Click **Create Cal Subset** to create the new subset of the current full-sweep calibration set.

Click **Save Cal Subset** to save the new calibration subset. In the *Save As* dialog box, enter the file name and click **Save**.

Click **Make Subset Cal the Active Cal** to redefine the current subset as full calibration.

Click **Restore Full-Sweep Calibration** to restore the full-sweep calibration set.

At any time click **CLOSE** to close the dialog box.

Calibrate > Remove Cal Subset

Pull down **Calibrate > Remove Cal Subset** to delete the current subset of the existing calibration data set.

Calibrate > Standard Calibration...

Pull down **Calibrate > Standard Calibration...** to create a calibration data set manually. This leads you through a complete calibration based on the selections that you made in the **Setup** menu (for example, calibration instruction set, thru adapter configuration, calibration preferences, and port selection).

Calibrate > Electronic Calibration...

Pull down **Calibrate > Electronic Calibration...** to create a calibration data set using the ECal standard. This leads you through a complete calibration based on the selections that you made in the **Setup** menu (for example, calibration instruction set, thru adapter configuration, calibration preferences, and port selection).

Calibrate > Delete Current Cal

Pull down **Calibrate > Delete Current Cal** to delete the existing calibration data set.

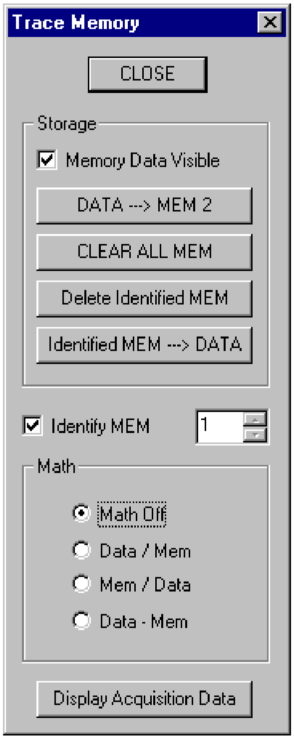
Data Menu

The following is a list of the Data menu selections and their locations:

- "Data > Memory…" on page 136
- "Data > User-Defined Display > Add Page…" on page 139
- "Data > User-Defined Display > Modify Page…" on page 142
- "Data > User-Defined Display > Delete Page…" on page 143
- "Data > User-Defined Display > View Equations…" on page 144
- "Data > Transforms > Disable Transforms" on page 144
- "Data > Transforms > 2 Balanced Ports" on page 144
- "Data > Transforms > 2 Single-Ended, 1Balanced Port" on page 145
- "Data > Transforms > 1 Single-Ended, 1 Balanced Port" on page 145
- "Data > Transforms > 1 Balanced Port" on page 145
- "Data > Display Visible" on page 145
- "Data > Reset Display to Default Config" on page 145
- "Data > Display Acquisition Info" on page 146
- "Data > Clear All Data" on page 146

Data > Memory…

Pull down **Data > Memory…** to open the *Trace Memory* dialog box. The *Trace Memory* dialog box may be used to compare two sets of measurements. Once the *Trace Memory* dialog box is opened, it can be to the side of the main menu for quick access while working between the two boxes.



Click **Close** to close the *Trace Memory* dialog box.

Use the **Storage** functions to manage data memory. The system identifies the various trace types on display through color. **Current** data displays a red trace. **Memorized** data displays in blue. Each memorized data set is also assigned an identification number.

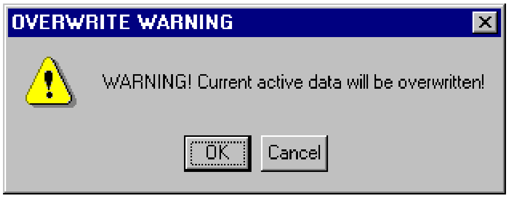
Select **Memory Data Visible** to see memorized data as well as the current data.

Click **DATA** → **MEM** to memorize a data set. As this is selected, the current data is stored in the memory location displayed and the memory location number is incremented. The system supports trace memories up to the memory limitations of the computer. This should allow for more than 10 sets of data to be stored in memory.

Click **CLEAR ALL MEM** to clear all stored traces.

Click **Delete Identified MEM** to remove the identified trace from memory. This selection is only available when **Identify MEM** is selected (see below).

Click Identified **MEM** → **DATA** to make the identified trace the current data. This selection is only available when **Identify MEM** is selected (see below). Since this will replace the current data, the system warns you:



Click **OK** to make the change, or click **Cancel** to return to the *Trace Memory* dialog box without making the change.

Notice how the trace color of the identified trace changes to red, signifying that it is now the current data.

All memorized data sets are assigned a number when memorized. Use the **Identify MEM** function to select from among memorized data sets. Select **Identify MEM**, then select the desired data set using the control box to the right. The identified trace displays in dark blue, other memorized traces display light blue.

Use the **Math** functions to compare the current data set to memorized data. **Math** functions are available when you select **Identify MEM** (see above).

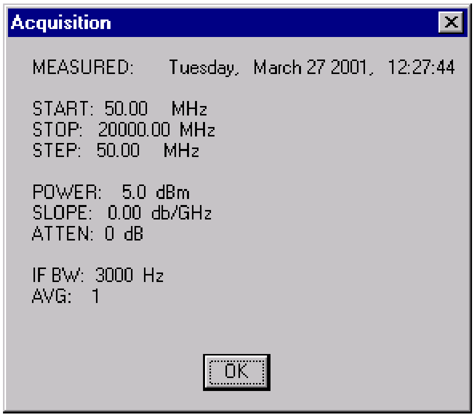
Select **Math Off** to display the current and memorized data sets without mathematical comparison.

Data / Memory provides vector normalization of the current data set to the identified data set. The calculated data set displays in violet.

Memory / Data provides vector normalization of the identified data set to the current data set. The calculated data set displays in violet.

Data – Memory provides vector subtraction of the identified data set from the current data set. The calculated data set displays in violet.

Click **Display Acquisition Data** to see the test conditions and acquisition settings when the measurement was performed. The system displays this acquisition information in an information box as shown in the following illustration.

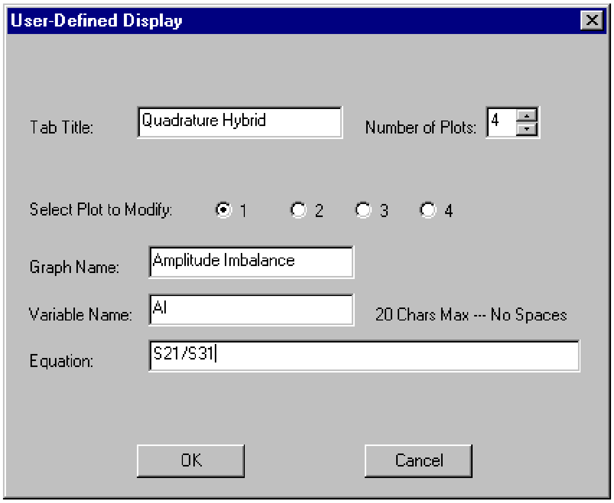


See "How to Use Trace Memory" on page 48 for more information.

Data > User-Defined Display > Add Page...

Pull down **Data > User Defined Display > Add Page...** to open the *User-Defined Display* dialog box. The *User-Defined Display* dialog box enables you to add a user-defined display or a series of user-defined displays to the system. This feature allows you to perform a mathematical operation on data and print the results.

NOTE This section uses the characterization of a quadrature hybrid for illustration purposes.



Enter a **Tab Title** for the tab associated with this display. In this case, **Quadrature Hybrid** was entered. See the tab on the illustration on page 142.

Select the **Number of Plots** to use in this display, up to four. You can enter the number directly or use the arrows. This display has four defined plots.

NOTE You must complete the definition of all the plots you add to the display.

Click a radio button to **Select Plot to Modify**. There will be as many buttons (one to four) as there are defined plots.

Each user-defined plot requires a **Graph Name**. The graph name appears above the plot. In this quadrature hybrid characterization, the graph name **Amplitude Imbalance** is used to describe the plot.

Enter a **Variable Name** for the plot. You use variable names to identify equations defined in the equation box. **AI** is defined in the equation as $\mathbf{S_{21}/S_{31}}$. Once defined, **AI** can be used as an operand in an equation on another plot. For instance, AI–S_{11} would evaluate as $(S_{21}/S_{31})–S_{11}$. Variable names can be up to 20 characters long and cannot contain spaces.

Enter an **Equation** for the plot. In general, all of the expressions operate on complex numbers. Operands in equations can be any defined variable name (see above), S-parameters, mixed-mode S-parameters, and constants. Constants are any valid floating point number and Pi (entered as PI).

Variables are:

- PI 3.1415926…
- Z1 Port 1 Reference Impedance
- Z2 Port 2 Reference Impedance
- Z3 Port 3 Reference Impedance
- Z4 Port 4 Reference Impedance

Operators include:

- addition (+)
- subtraction (–)
- multiplication (*)
- division (/)
- exponentiation (^)

Functions include:

$$ABS(X) = \sqrt{A^2 + B^2}$$

$$CONJ(X) = A - JB$$

$$REAL(X) = A$$

$$IMAG(X) = B$$

$$ARG(X) = TAN^{-1}\left(\frac{B}{A}\right) \ (returns\ radians)$$

where X is a complex number, A = Re(X), and B=Im(X).

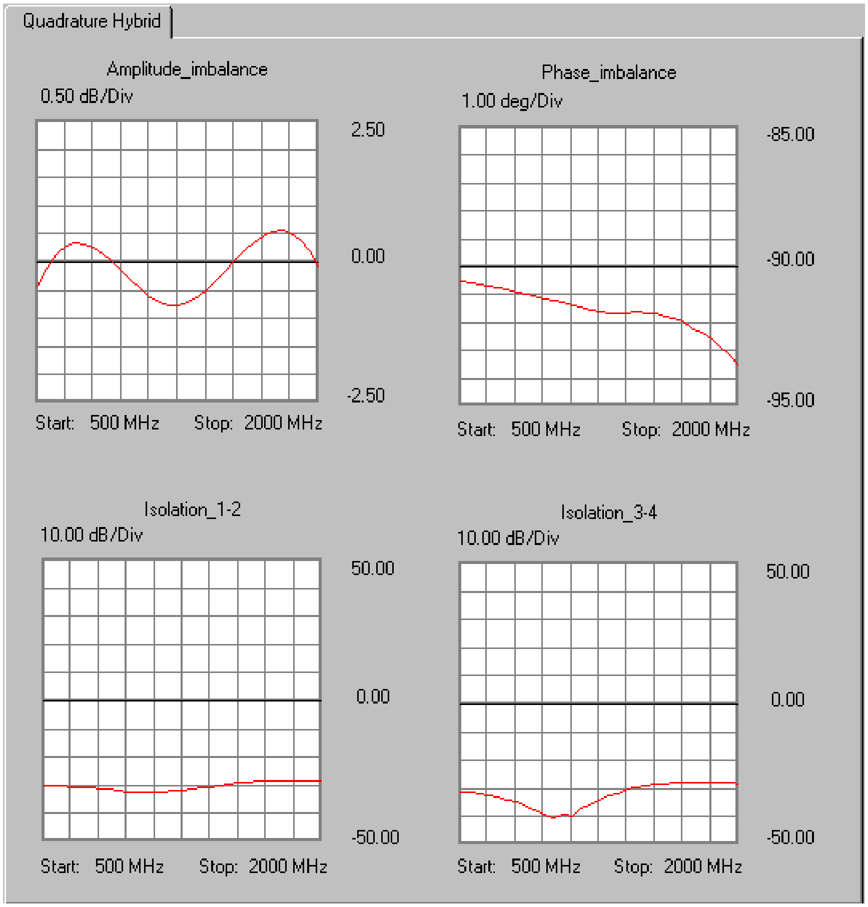
Expressions can be prioritized by using parentheses. Operator precedence follows the order parentheses ( ), functions (ABS, CONJ, REAL, IMAG, ARG), exponentiation, multiplication and division, addition and subtraction. There must be one more operand than operators.

Important: Negative constants must be enclosed in parentheses, even when the negative constants are inside function parentheses.

To offset the phase of an operand by 180º, multiply by (–1). To offset the phase by 90º, multiply by (–1)^0.5.

Click **OK** to accept the user-defined display definition. Remember to define all specified plots before clicking **OK**.

Click **Cancel** to abandon any changes and return to the main screen.

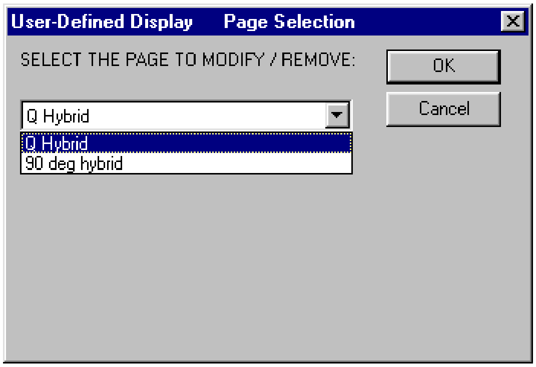


Click the **User-Defined** button near the bottom of the main screen to display your user-defined plots.

Your user-defined page will be saved with your display configuration, but is not saved automatically.

Data > User-Defined Display > Modify Page...

Pull down **Data > User-Defined Display > Modify Page...** to select a user display definition to modify using the *User-Defined Display* dialog box.



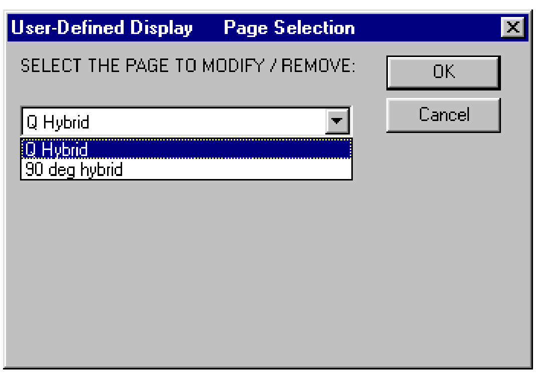
Select the page to modify from the drop-down list and click **OK** to modify the display definition.

Click **Cancel** to return to the main screen.

See "Data > User-Defined Display > Add Page..." on page 139 for more information.

Data > User-Defined Display > Delete Page...

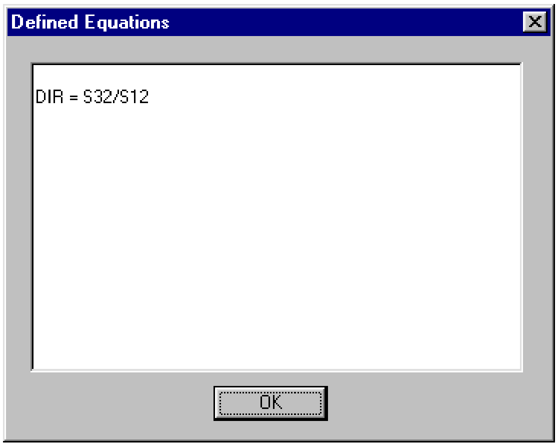
Pull down **Data > User-Defined Display > Delete Page...** to open the *User-Defined Display Page Selection* dialog box to select a defined display to remove from the system.



Select a page and click **OK** to delete. Click **Cancel** to return without deleting a user-defined display.

Data > User-Defined Display > View Equations...

Pull down **Data > User-Defined Display > View Equations...** to open the *Defined Equations* dialog box and view the equations that have been defined in the user-defined pages.



Click **OK** to close the dialog box.

Data > Transforms > Disable Transforms

Pull down **Data > Transforms > Disable Transforms** to disable transforms.

Data > Transforms > 2 Balanced Ports

Pull down **Data > Transforms > 2 Balanced Ports** to perform mixed-mode mathematical transformations on the data. Test-set ports 1 and 3, and ports 2 and 4 are assumed to be balanced pairs. See "How to Interpret Mixed-Mode S-Parameters" on page 60 for more information.

NOTE This transform is only available when measuring in the 4-port configuration.

Data > Transforms > 2 Single-Ended, 1Balanced Port

Pull down **Data > Transforms > 2 Single-Ended, 1 Balanced Port** to perform mixed-mode mathematical transformations on the data. Test-set ports 1 and 3 are assumed to be single-ended ports, and ports 2 and 4 are assumed to be a balanced pair. See "How to Interpret Mixed-Mode S-Parameters" on page 60 for more information.

NOTE This transform is only available when measuring in the 4-port configuration.

Data > Transforms > 1 Single-Ended, 1 Balanced Port

Pull down **Data > Transforms > 1 Single-Ended, 1 Balanced Port** to perform mixed mode mathematical transformations on the data. This transform is only available when measuring in the 3-port configuration. Test-set port 1 is assumed to be single-ended, and ports 2 and 4 are assumed to be a balanced pair. See "How to Interpret Mixed-Mode S-Parameters" on page 60 for more information.

Data > Transforms > 1 Balanced Port

Pull down **Data > Transforms > 1 Balanced Port** to perform mixed mode mathematical transformation on the data. This transform is only available when measuring in 2-port, ports 2 and 4 configuration (not ports 1 and 3). Ports 2 and 4 are assumed to be a balanced pair.

Data > Display Visible

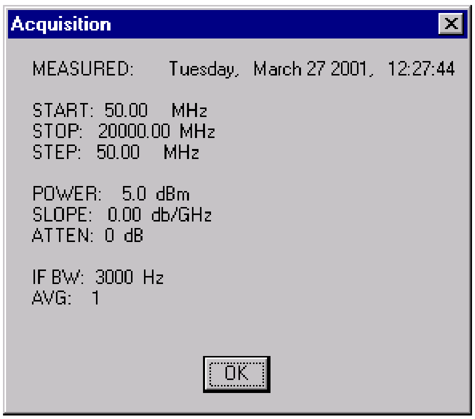
Pull down **Data > Display Visible** to toggle the data display on or off. Use this function when program operations have turned the data display off and you need to restore it.

Data > Reset Display to Default Config

Pull down **Data > Reset Display to Default Config** to restore the stored display. This will remove any changes you have made to the display configuration.

Data > Display Acquisition Info

Pull down **Data > Display Acquisition Info** to see the test conditions and acquisition settings. The system displays this acquisition information in an information box as shown in the following illustration.



Data > Clear All Data

Pull down **Data > Clear All Data** to clear all data in memory. This includes the current data set and any memorized data sets.

Utility Menu

The following is a list of the Utility menu selections and their locations:

- "Utility > Manual Test-Set Control..." on page 147
- "Utility > Characterize Adapter..." on page 150
- "Utility > Measurement Counter Visible" on page 151
- "Utility > Reset Measurement Counter" on page 151
- "Utility > Diagnostics" on page 151

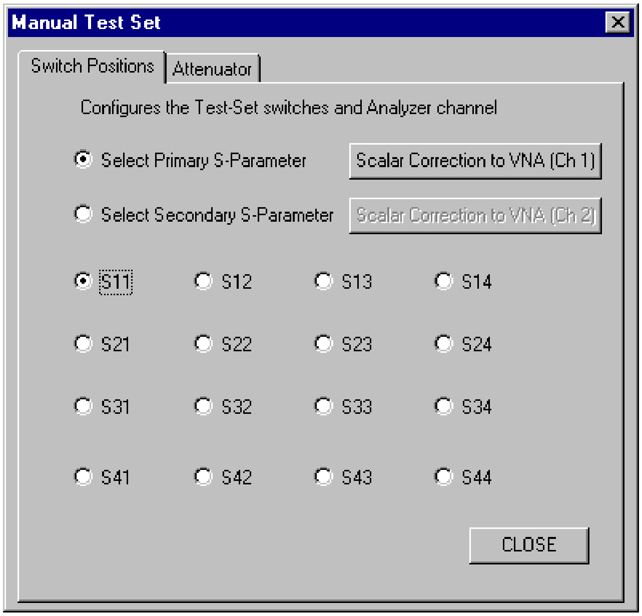
Utility > Manual Test-Set Control...

Pull down **Utility > Manual Test-Set Control...** to open the *Manual Test Set* dialog box. The two dialog box tabs, *Switch Positions* and *Attenuator*, are helpful when troubleshooting a problem with your setup. Use this dialog box to configure the test set and vector network analyzer (VNA) for the desired stimulus/response setting:

- Stimulus can be directed to a test-port so that the incident power level that will be presented to the DUT can be measured.
- System checks can be performed on the various RF paths in the test-set.
- Scalar corrections can be implemented in the VNA using trace memory to aid the tuning of a DUT.

Switch Positions Tab

The *Switch Positions* tab is used to select the stimulus/response settings.

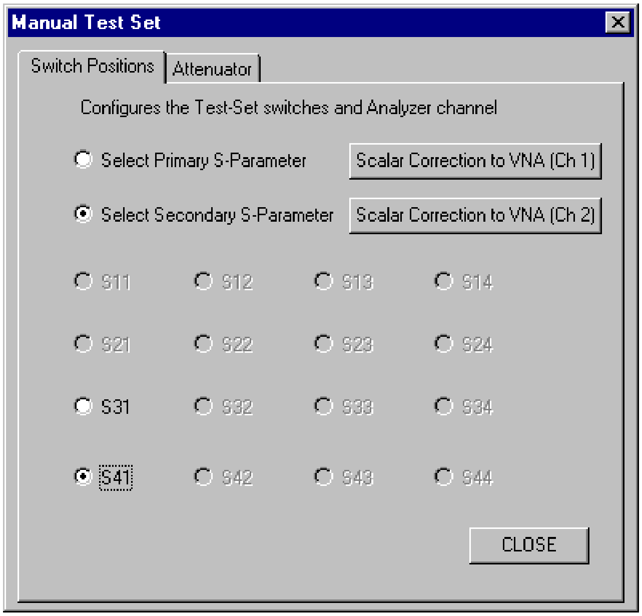


You can configure the system for two S-parameters at a time. The switch configuration allows only certain combinations of S-parameters.

The primary S-parameter can be one of the 16 available S-parameters. Selecting a primary S-parameter sets the switches on the test-set and sets the proper measurement, A/R or B/R, on channel one of the analyzer.

The secondary S-parameter is optional. It can be useful when tuning a device to monitor two parameters such as gain and return-loss.

Once the primary S-parameter has been selected, clicking **Select Secondary S-Parameter** limits the choice to the 2 S-parameters that are compatible with the primary S-parameter:



The analyzer is only capable of displaying uncorrected data and will not accurately display the S-parameter of the DUT on-screen in **Display-Data** mode.

To assist in the tuning process, analyzer trace-memory is used to make the analyzer screen emulate the corrected data as a baseline for tuning using **Data/Mem** mode.

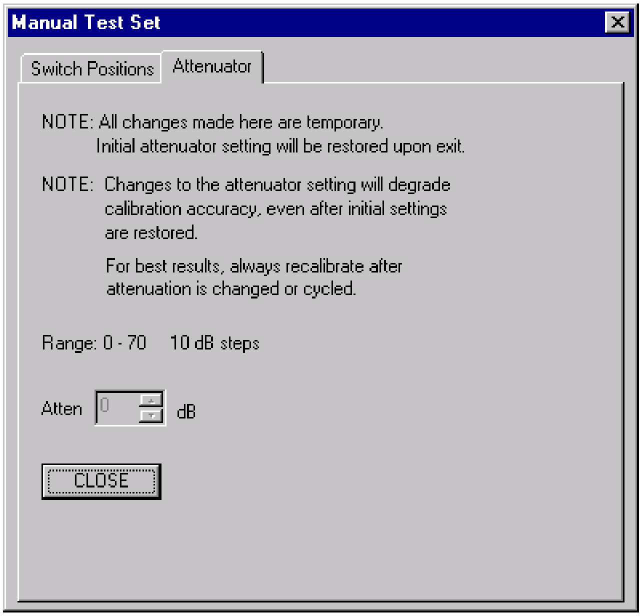
To prepare for tuning follow these steps:

1. Select a compatible pair (if using 2 S-parameters) and connect the DUT accordingly.
2. Make a measurement of the DUT. The difference between the corrected and uncorrected data will be used in the analyzer's trace memory.
3. Select the primary and (optional) secondary S-parameter.
4. Use the *Scalar Correction to VNA* buttons to load the analyzer's trace memory so that the on-screen display will emulate the corrected data.

NOTE This is only a scalar correction and should be used only as a baseline for tuning. Once significant change is made to the device's response, the DUT should be re-measured and the emulation repeated.

Attenuator Tab

The *Attenuator* tab is used to manually control the attenuator that is built into the test set.



Use the *Attenuator* tab when evaluating power levels at the test-set ports and during system checks.

Changes to the attenuator setting made here are temporary. The attenuator is reset to its prior value when the dialog box is closed.

NOTE Changes to the attenuator setting will degrade calibration accuracy, even after initial settings are restored. For best results, always recalibrate after the attenuation is changed or recycled.

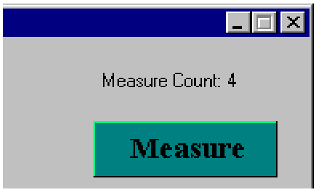
Utility > Characterize Adapter…

Pull down **Utility > Characterize Adapter…** to start the adapter S-parameter characterization procedure. After this procedure is complete, you can create a file to save the characterization for future measurements.

See "How to Characterize Adapters" on page 44 for more information.

Utility > Measurement Counter Visible

Select **Utility > Measurement Counter Visible** to turn on/off the **Measure Count**, which increments every time the **Measure** button is depressed for a measurement. This feature is not supported during calibration.



To reset the counter to 0, select **Utility > Reset Measurement Counter**.

NOTE The counter does not increment if the **Continuous Sweep** is tuned on or the counter is not visible.

Utility > Reset Measurement Counter

Select **Utility > Reset Measurement Counter** to reset the measurement counter (which increments every time the **Measure** button is depressed) to 0.

Utility > Diagnostics

This selection is for internal Agilent Technologies use only.

Help Menu

The following is a list of the Help menu selections and their locations:

- "Help > Contents..." on page 152
- "Help > About Multiport..." on page 152

Help > Contents...

Pull down **Help > Contents...** to open the help system.

Help > About Multiport...

Pull down **Help > About Multiport...** to see revision and copyright information about the software. You will need this information to receive technical support.

6 Maintenance and Troubleshooting

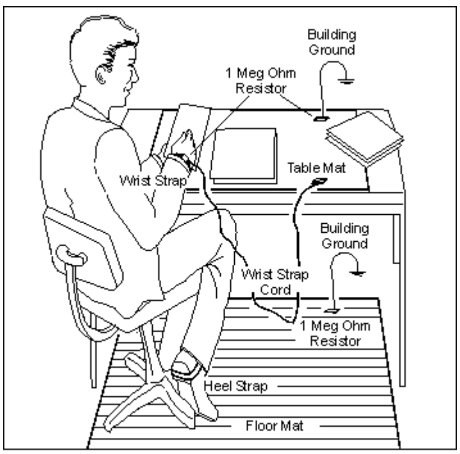
Electrostatic Discharge

Although protected internally, Agilent multiport test systems are sensitive to electrostatic discharge (ESD). Static discharges too small to feel can damage or degrade the test equipment or your devices.

Use standard precautions to protect against ESD before using the system for calibration or measurement.

Use the following illustration and list of equipment to set up a static-safe workstation.

Static-Safe Workstation



- static-control table mat and earth ground wire: part number 9300-0797
- wrist-strap cord: part number 9300-0980
- wrist-strap: part number 9300-1367
- heel-straps: part number 9300-1308
- floor mat: not available through Agilent Technologies

Care of Test Cable Assemblies

Proper use and care of your test cable assemblies will yield positive results including:

- longer life
- higher performance
- better repeatability

Performing the routine inspection and cleaning of the test cable assemblies, especially the connectors, is very important to making the best possible measurements.

Connector Mating

Alignment of the center lines of the connectors of the test cables with the test set and DUT connectors before mating is important. It is possible to start the threads on the connector nuts without good alignment, but this will result in bent pins and damaged inserts. Resistance encountered while turning the connector nut may be due to one of the following:

- The pins are not aligned.
- The coupling nut is cross-threaded.
- The connector (or its mate) has been damaged by excessive torque.

Stop and determine the reason. To proceed without doing so risks the destruction of the assembly and the mating connector.

Holding a connector nut stationary while screwing the socket into the connector will wear away the connector plating and score the connector parts. If the pins lock up, serious damage can be caused.

Connector Torque

Make sure to grasp the body of the connector before applying final torque. If the connector body is allowed to rotate with the nut, the connector plating, outer interface rim, or pin assembly may be damaged. Excess torque applied to the connector will be transferred to the cable assembly. Refer to "Connector Care for RF & Microwave Coaxial Connectors" on page 157 (also included in the multiport test system online Help) for more information.

Depending on the connector, over-torque can cause damage to connectors in a variety of ways:

- mushroomed outer interface shells
- mushroomed pin shoulders
- recessed or protruding pins
- recessed or protruding dielectrics
- bent pins
- chipped plating
- coupling nut retaining ring damage
- damage to coupling threads

Cable Handling

The test cables have a 1 inch minimum bend radius. Exceeding this radius can result in poor measurements and poor repeatability. Be alert to tight bends where they are not necessarily obvious — like at the end of connector strain relief tubing.

Swept 90° adapters may be used (typically, at the test set front panel) to minimize cable bending. However, if the adapters are used, they must be in place during the calibration.

Cables are often stored in a coiled configuration. Coiled cable “set” (the tendency to stay coiled) can occur if the cables are left coiled. Use large coil diameters (one or two feet) to minimize cable set. Unroll coiled cables prior to use — never just pull out the loops.

Avoid pinching, crushing, or dropping objects on cable assemblies. Dragging a cable over a sharp edge will tend to flatten one side, and it is highly likely that the minimum bend radius will be exceeded.

Connector Care for RF & Microwave Coaxial Connectors

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.

See "Connector Care Quick Reference" on page 158 for quick reference tips about connector care.

Connector Care Quick Reference

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

Troubleshooting

Use the following table to help troubleshoot your multiport test system.

Troubleshooting the Test System

Symptom	Cause	Cure
One or more biases not applied.	Bias fuse blown.	Check bias fuses. Replace if needed with fuse of the same type and rating.
Control computer can not communicate with the test set.	Accidental change to GPIB switch settings.	Set the GPIB address as needed. Restart the system. See "To Set the GPIB Addresses" on page 38.
The test set does not come on the first time you use it.	Line fuse not installed, or incorrect line fuse installed.	Install the line fuse. Refer to "How to Set Up the Multiport Test System Hardware" on page 18.
Excessive ripple in data.	Load termination damaged by excessive RF power.	Contact Agilent Technologies. See "Contacting Agilent" on page 160 for more information.
	Loose connections between VNA and test set and/or between test set and DUT.	Check and torque the connectors.
	Poor test cable repeatability. See "How to Check Test Cable Repeatability" on page 75.	Replace test cables as needed. You can replace a single cable, without replacing the entire set.
High loss on one path with poor raw data match (as seen during analyzer sweep) or inability to make a good calibration.	Possible signal channel damage. See "How to Check Test Cable Repeatability" on page 75.	Contact Agilent Technologies. See "Contacting Agilent" on page 160 for more information.

Contacting Agilent

You may use the following table to contact Agilent Technologies for assistance with any Agilent product.

Contacting Agilent

`Online assistance: www.agilent.com/find/assist`

United States *(tel)* 1 800 452 4844	**Latin America** *(tel)* (305) 269 7500 *(fax)* (305) 269 7599
New Zealand *(tel)* 0 800 738 378 *(fax)* (+64) 4 495 8950	**Japan** *(tel)* (+81) 426 56 7832 *(fax)* (+81) 426 56 7840
Malaysia *(tel)* 1 800 828 848 *(fax)* 1 800 801 664	**India** *(tel)* 1-600-11-2929 *(fax)* 000-800-650-1101
Taiwan *(tel)* 0800-047-866 *(fax)* (886) 2 25456723	**Hong Kong** *(tel)* 800 930 871 *(fax)* (852) 2506 9233
Canada *(tel)* 1 877 894 4414 *(fax)* (905) 282-6495	**Europe** *(tel)* (+31) 20 547 2323 *(fax)* (+31) 20 547 2390
Australia *(tel)* 1 800 629 485 *(fax)* (+61) 3 9210 5947	**Singapore** *(tel)* 1 800 375 8100 *(fax)* (65) 836 0252
Thailand *(tel) outside Bangkok:* (088) 226 008 *(tel) within Bangkok:* (662) 661 3999 *(fax)* (66) 1 661 3714	**People's Republic of China** *(tel) (preferred):* 800-810-0189 *(tel) (alternate):* 10800-650-0021 *(fax)* 10800-650-0121
Philippines *(tel)* (632) 8426802 *(tel) (PLDT subscriber only):* 1 800 16510170	 *(fax)* (632) 8426809 *(fax) (PLDT subscriber only):* 1 800 16510288

Make sure the following information is readily available when you call:

- the serial number of the test set
- a list of any options or accessories installed in or in use with the test set
- the type of GPIB board in your computer
- any information you can supply about the DUT
- the nature of the problem
- the version number of software

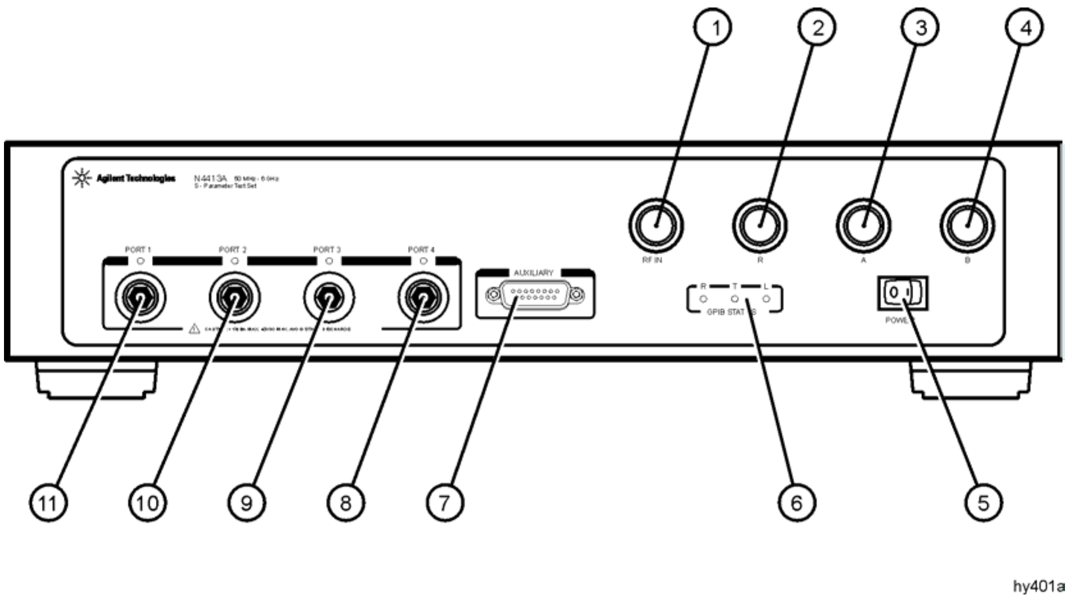
7 Instrument Information

Front and Rear Panels

The front and rear panel of each Agilent multiport test set model is illustrated and described in this section.

N4413A Front and Rear Panel

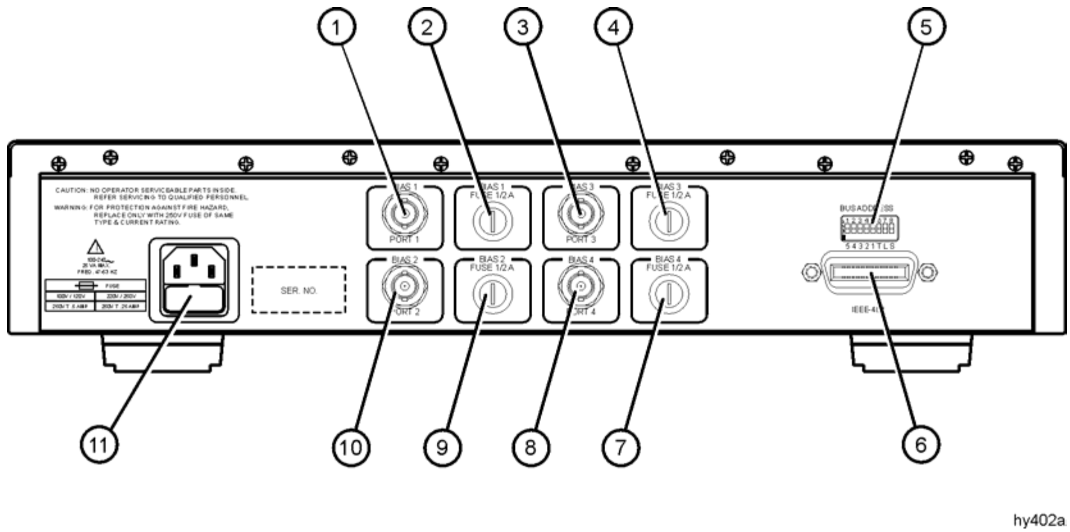
N4413A Front Panel



ID Number	Front Panel Feature	Feature Description
1	RF IN	Type-N (f) 50Ω connector that is connected to the network analyzer RF IN port.
2	R	Type-N (f) 50Ω connector that is connected to the network analyzer R port.
3	A	Type-N (f) 50Ω connector that is connected to the network analyzer A port.

ID Number	Front Panel Feature	Feature Description
4	B	Type-N (f) 50Ω connector that is connected to the network analyzer B port.
5	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.
6	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
7	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
8	PORT 4	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
9	PORT 3	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
10	PORT 2	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
11	PORT 1	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)

N4413A Rear Panel

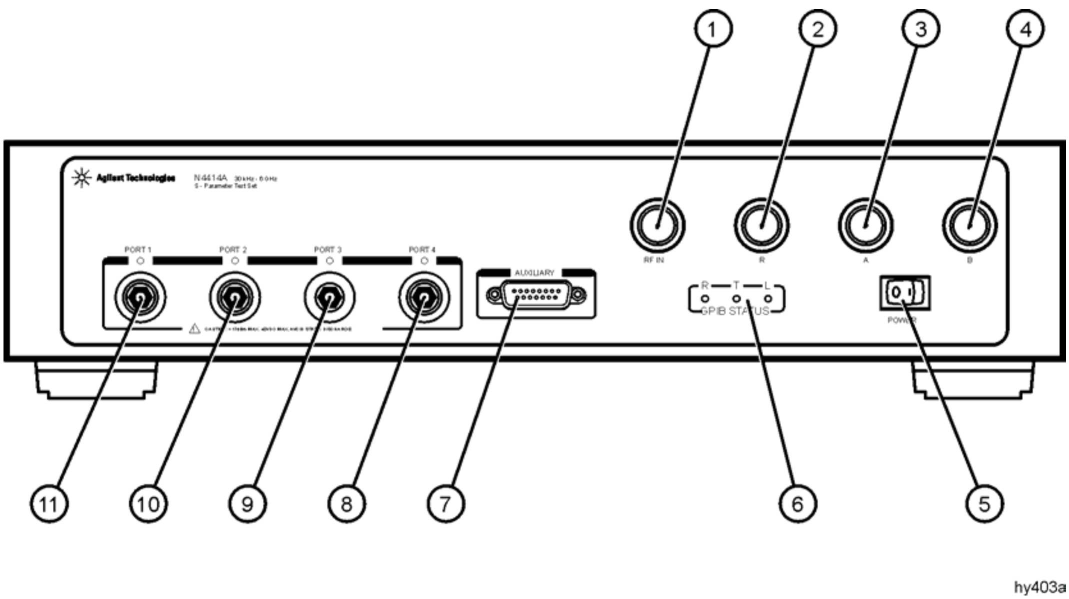


ID Number	Rear Panel Feature	Feature Description
1	BIAS 1 PORT 1	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
2	BIAS 1 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
3	BIAS 3 PORT 3	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
4	BIAS 3 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
6	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.
7	BIAS 4 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)

ID Number	Rear Panel Feature	Feature Description
8	BIAS 4 PORT 4	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
9	BIAS 2 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
10	BIAS 2 PORT 2	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
11	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)

N4414A Front and Rear Panel

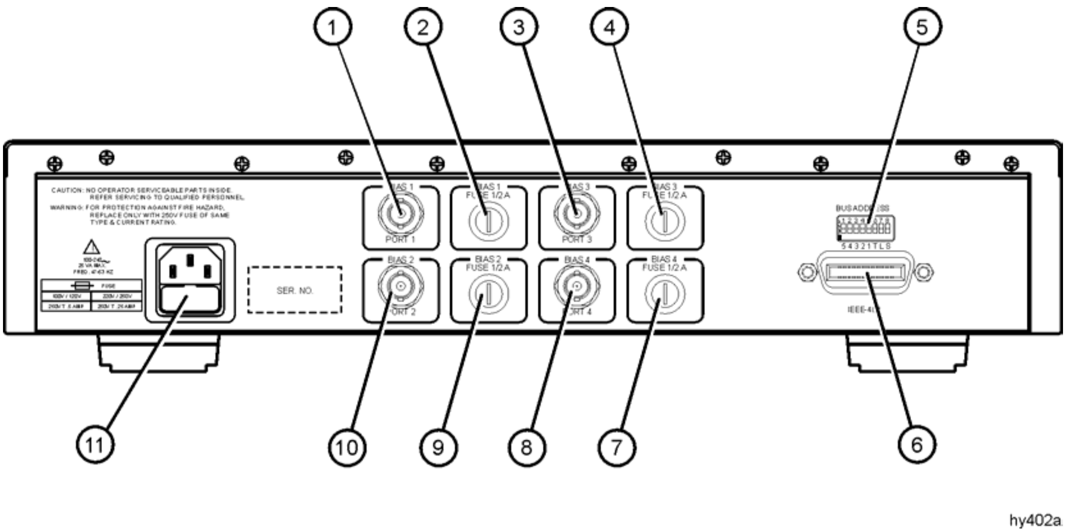
N4414A Front Panel



ID Number	Front Panel Feature	Feature Description
1	RF IN	Type-N (f) 50Ω connector that is connected to the network analyzer RF IN port.
2	R	Type-N (f) 50Ω connector that is connected to the network analyzer R port.
3	A	Type-N (f) 50Ω connector that is connected to the network analyzer A port.
4	B	Type-N (f) 50Ω connector that is connected to the network analyzer B port.
5	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.

ID Number	Front Panel Feature	Feature Description
6	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
7	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
8	PORT 4	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
9	PORT 3	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
10	PORT 2	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
11	PORT 1	APC-3.5 (f) connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)

N4414A Rear Panel

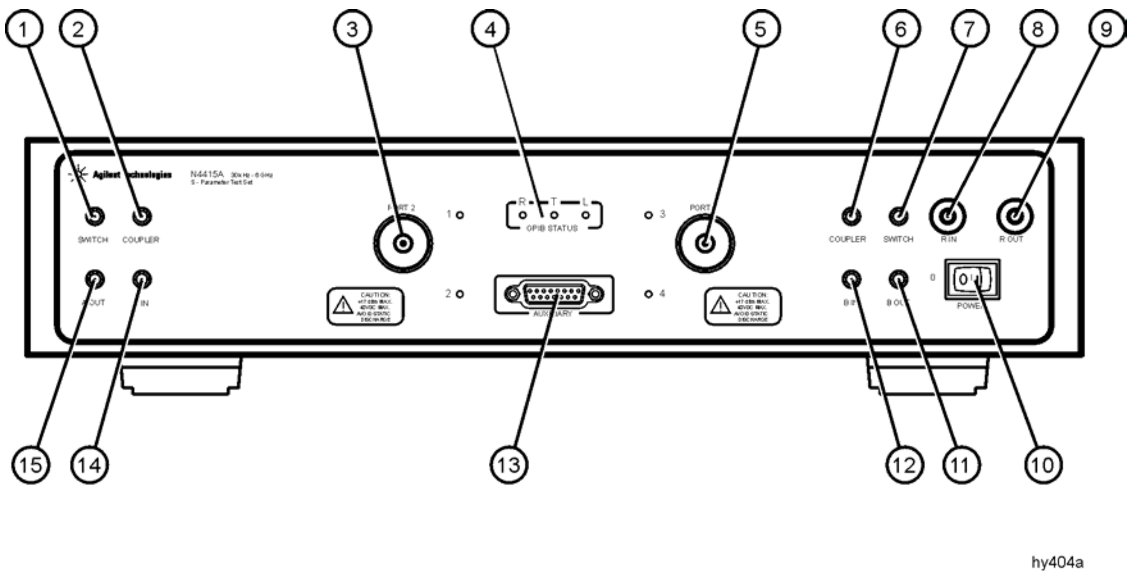


ID Number	Rear Panel Feature	Feature Description
1	BIAS 1 PORT 1	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
2	BIAS 1 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
3	BIAS 3 PORT 3	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
4	BIAS 3 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
6	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.
7	BIAS 4 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)

ID Number	Rear Panel Feature	Feature Description
8	BIAS 4 PORT 4	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
9	BIAS 2 FUSE 1/2A	Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
10	BIAS 2 PORT 2	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
11	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)

N4415A Front and Rear Panel

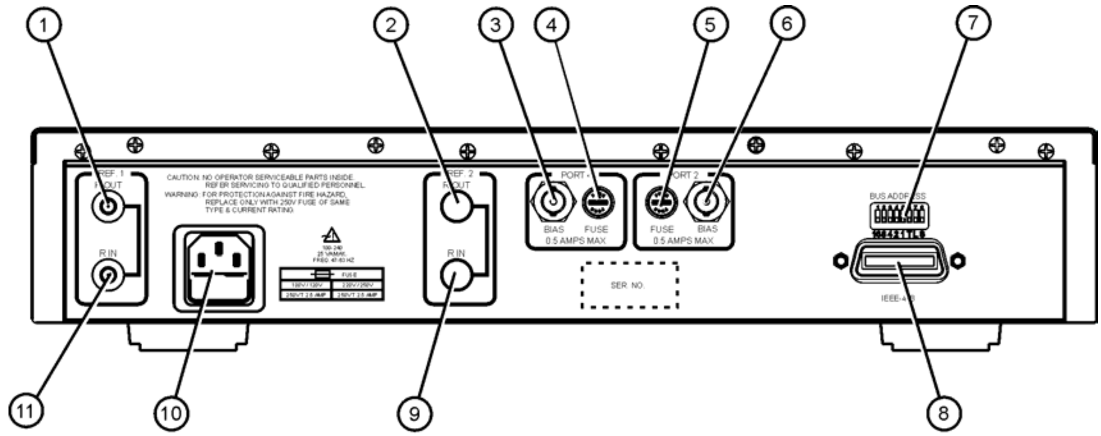
N4415A Front Panel



ID Number	Front Panel Feature	Feature Description
1	SWITCH	SMA (f) connector that is connected to the network analyzer PORT 1 SWITCH connector using a semirigid cable.
2	COUPLER	SMA (f) connector that is connected to the network analyzer PORT 1 COUPLER connector using a semirigid cable.
3	PORT 2	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
4	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
5	PORT 4	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
6	COUPLER	SMA (f) connector that is connected to the network analyzer PORT 2 COUPLER connector using a semirigid cable.

ID Number	Front Panel Feature	Feature Description
7	SWITCH	SMA (f) connector that is connected to the network analyzer PORT 2 SWITCH connector using a semirigid cable.
8	R IN	SMA (f) connector that is connected to the network analyzer R Channel IN connector using a semirigid cable.
9	R OUT	SMA (f) connector that is connected to the network analyzer R Channel OUT connector using a semirigid cable.
10	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.
11	B OUT	SMA (f) connector that is connected to the network analyzer B OUT connector using a semirigid cable.
12	B IN	SMA (f) connector that is connected to the network analyzer B IN connector using a semirigid cable.
13	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
14	A IN	SMA (f) connector that is connected to the network analyzer A IN connector using a semirigid cable.
15	A OUT	SMA (f) connector that is connected to the network analyzer A OUT connector using a semirigid cable.

N4415A Rear Panel



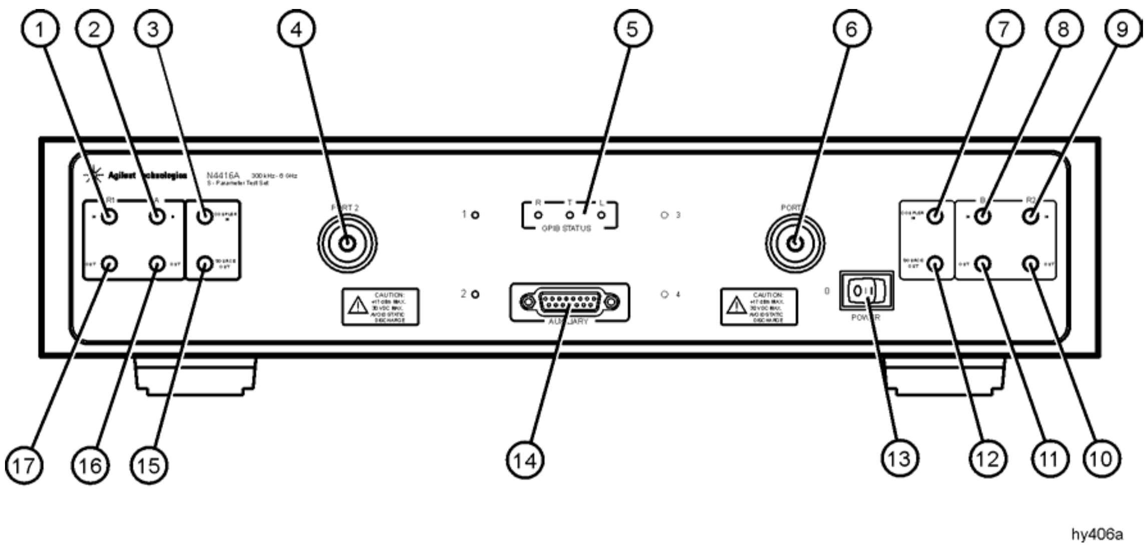
hy405a

ID Number	Rear Panel Feature	Feature Description
1	REF 1 R OUT	SMA (f) connector, used as an output reference signal
2	REF 2 R OUT	Not Used
3	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
4	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
6	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
7	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
8	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.
9	REF 2 R IN	Not Used

ID Number	Rear Panel Feature	Feature Description
10	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
11	REF 1 R IN	SMA (f) connector, used as an input reference signal

N4416A Front and Rear Panel

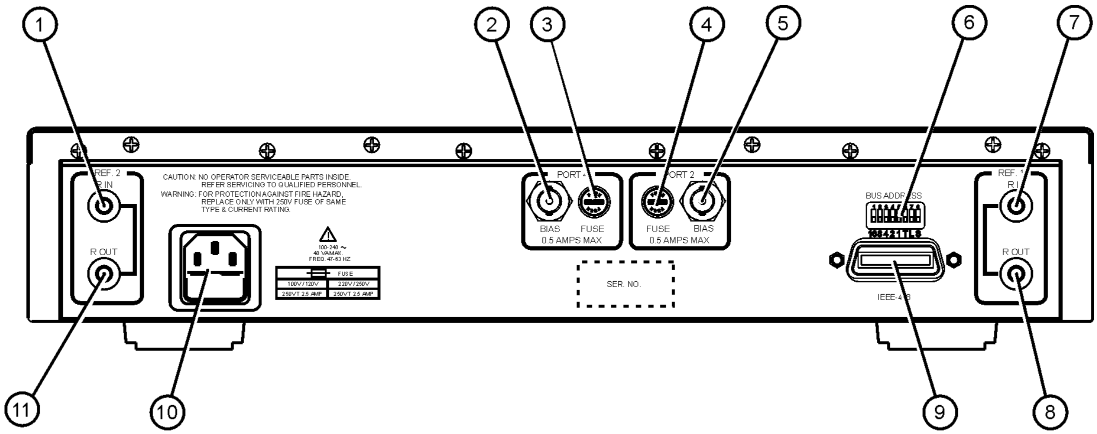
N4416A Front Panel



ID Number	Front Panel Feature	Feature Description
1	R1 IN	SMA (f) connector that is connected to the network analyzer R1 IN connector using a semirigid cable.
2	A IN	SMA (f) connector that is connected to the network analyzer A IN connector using a semirigid cable.
3	COUPLER IN	SMA (f) connector that is connected to the network analyzer COUPLER IN connector using a semirigid cable.
4	PORT 2	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
5	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
6	PORT 4	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)

ID Number	Front Panel Feature	Feature Description
7	COUPLER IN	SMA (f) connector that is connected to the network analyzer COUPLER IN connector using a semirigid cable.
8	B IN	SMA (f) connector that is connected to the network analyzer B IN connector using a semirigid cable.
9	R2 IN	SMA (f) connector that is connected to the network analyzer R2 IN connector using a semirigid cable.
10	R2 OUT	SMA (f) connector that is connected to the network analyzer R2 OUT connector using a semirigid cable.
11	B OUT	SMA (f) connector that is connected to the network analyzer B OUT connector using a semirigid cable.
12	SOURCE OUT	SMA (f) connector that is connected to the network analyzer SOURCE OUT connector using a semirigid cable.
13	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.
14	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
15	SOURCE OUT	SMA (f) connector that is connected to the network analyzer SOURCE OUT connector using a semirigid cable.
16	A OUT	SMA (f) connector that is connected to the network analyzer A OUT connector using a semirigid cable.
17	R1 OUT	SMA (f) connector that is connected to the network analyzer R1 OUT connector using a semirigid cable.

N4416A Rear Panel



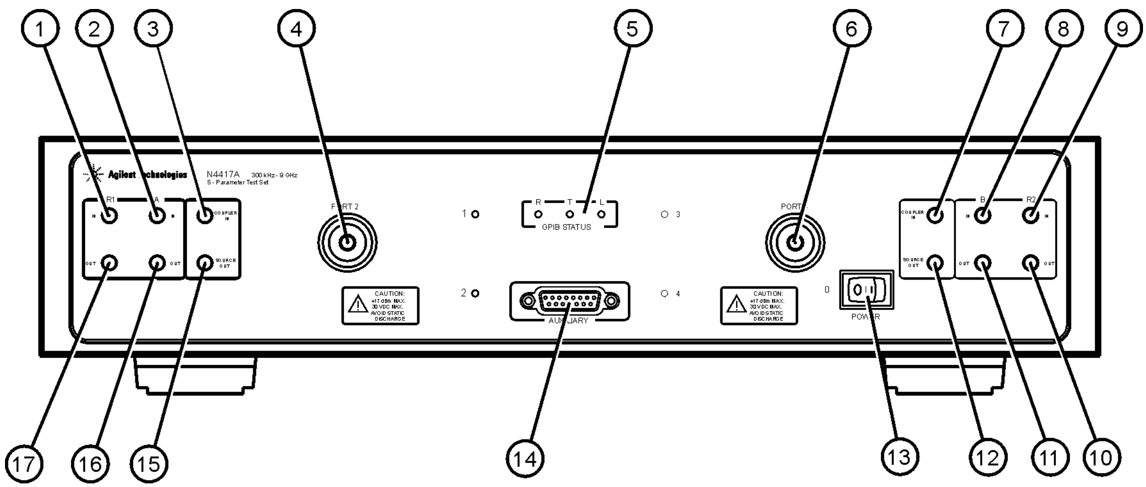
hy407a

ID Number	Rear Panel Feature	Feature Description
1	REF 2 R IN	SMA (f) connector, used as an input reference signal
2	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
3	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
4	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
6	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
7	REF 1 R IN	SMA (f) connector, used as an input reference signal
8	REF 1 R OUT	SMA (f) connector, used as an output reference signal
9	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.

ID Number	Rear Panel Feature	Feature Description
10	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
11	REF 2 R OUT	SMA (f) connector, used as an output reference signal

N4417A Front and Rear Panel

N4417A Front Panel

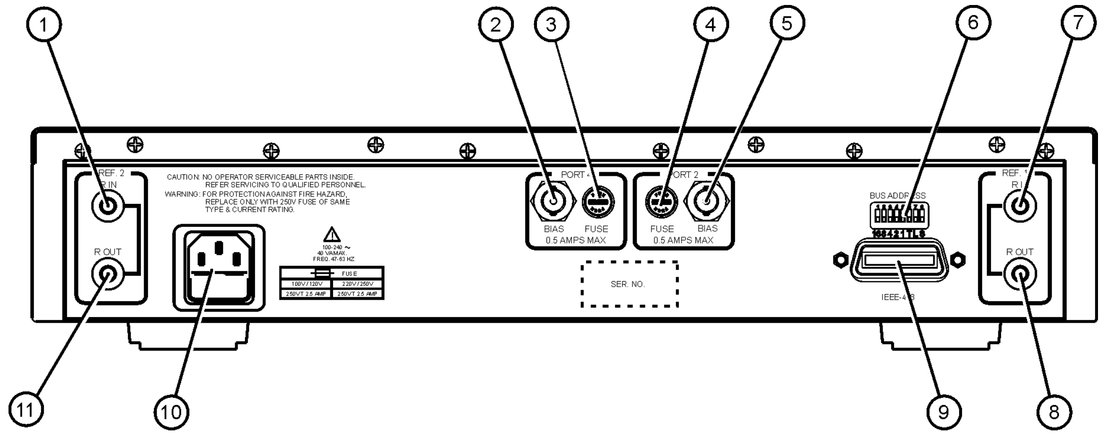


4417_frtpnl

ID Number	Front Panel Feature	Feature Description
1	R1 IN	SMA (f) connector that is connected to the network analyzer R1 IN connector using a semirigid cable.
2	A IN	SMA (f) connector that is connected to the network analyzer A IN connector using a semirigid cable.
3	COUPLER IN	SMA (f) connector that is connected to the network analyzer COUPLER IN connector using a semirigid cable.
4	PORT 2	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)
5	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
6	PORT 4	APC-7 connector that is connected to the DUT or fixture. (+17 dBm maximum operating level)

ID Number	Front Panel Feature	Feature Description
7	COUPLER IN	SMA (f) connector that is connected to the network analyzer COUPLER IN connector using a semirigid cable.
8	B IN	SMA (f) connector that is connected to the network analyzer B IN connector using a semirigid cable.
9	R2 IN	SMA (f) connector that is connected to the network analyzer R2 IN connector using a semirigid cable. This connector is installed on Option 103 only. It is not installed on Option 104.
10	R2 OUT	SMA (f) connector that is connected to the network analyzer R2 OUT connector using a semirigid cable. This connector is installed on Option 103 only. It is not installed on Option 104.
11	B OUT	SMA (f) connector that is connected to the network analyzer B OUT connector using a semirigid cable.
12	SOURCE OUT	SMA (f) connector that is connected to the network analyzer SOURCE OUT connector using a semirigid cable.
13	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.
14	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
15	SOURCE OUT	SMA (f) connector that is connected to the network analyzer SOURCE OUT connector using a semirigid cable.
16	A OUT	SMA (f) connector that is connected to the network analyzer A OUT connector using a semirigid cable.
17	R1 OUT	SMA (f) connector that is connected to the network analyzer R1 OUT connector using a semirigid cable.

N4417A Rear Panel



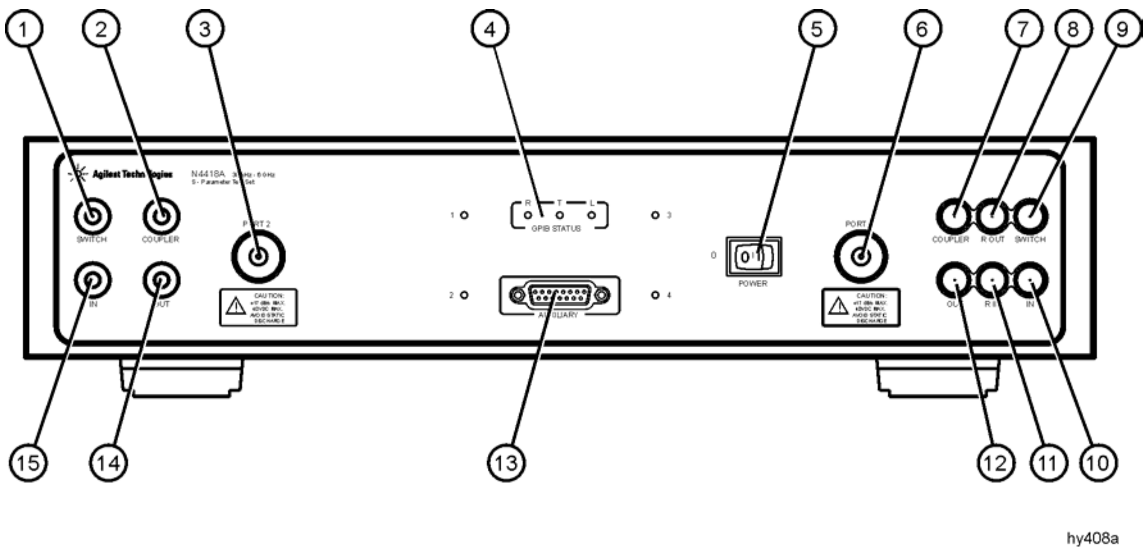
hy407a

ID Number	Rear Panel Feature	Feature Description
1	REF 2 R IN	SMA (f) connector, used as an input reference signal
2	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
3	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
4	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
6	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
7	REF 1 R IN	SMA (f) connector, used as an input reference signal
8	REF 1 R OUT	SMA (f) connector, used as an output reference signal
9	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.

ID Number	Rear Panel Feature	Feature Description
10	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
11	REF 2 R OUT	SMA (f) connector, used as an output reference signal

N4418A Front and Rear Panel

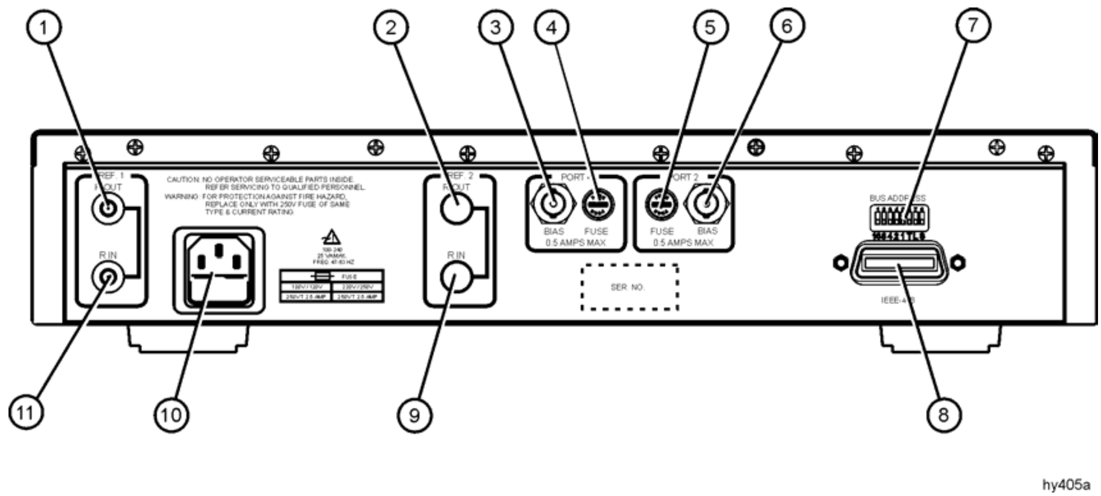
N4418A Front Panel



ID Number	Front Panel Feature	Feature Description
1	SWITCH	SMA (f) connector that is connected to the network analyzer PORT 1 SWITCH connector using a semirigid cable.
2	COUPLER	SMA (f) connector that is connected to the network analyzer PORT 1 BIAS TEE connector using a semirigid cable.
3	PORT 2	APC-3.5 (m) connector with 20 mm nut that is connected to the DUT or fixture. (+17 dBm maximum operating level)
4	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
5	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.

ID Number	Front Panel Feature	Feature Description
6	PORT 4	APC-3.5 (m) connector with 20 mm nut that is connected to the DUT or fixture. (+17 dBm maximum operating level)
7	COUPLER	SMA (f) connector that is connected to the network analyzer PORT 2 BIAS TEE connector using a semirigid cable.
8	R OUT	SMA (f) connector that is connected to the network analyzer R CHANNEL OUT connector using a semirigid cable.
9	SWITCH	SMA (f) connector that is connected to the network analyzer PORT 2 SWITCH connector using a semirigid cable.
10	IN	SMA (f) connector that is connected to the network analyzer B IN connector using a semirigid cable.
11	R IN	SMA (f) connector that is connected to the network analyzer R CHANNEL IN connector using a semirigid cable.
12	OUT	SMA (f) connector that is connected to the network analyzer B OUT connector using a semirigid cable.
13	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
14	OUT	SMA (f) connector that is connected to the network analyzer A OUT connector using a semirigid cable.
15	IN	SMA (f) connector that is connected to the network analyzer A IN connector using a semirigid cable.

N4418A Rear Panel

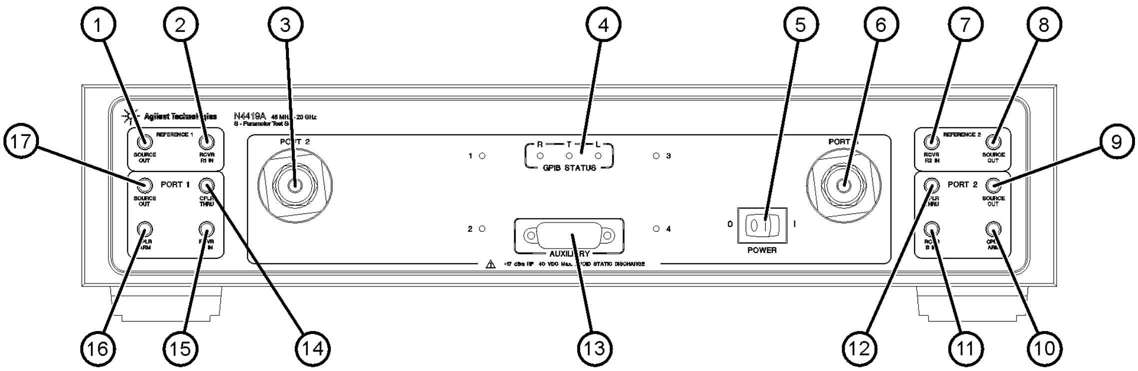


ID Number	Rear Panel Feature	Feature Description
1	REF 1 R OUT	SMA (f) connector, used as an output reference signal
2	REF 2 R OUT	SMA (f) connector, used as an output reference signal
3	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
4	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
6	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
7	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
8	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.
9	REF 2 R IN	SMA (f) connector, used as an input reference signal.

ID Number	Rear Panel Feature	Feature Description
10	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
11	REF 1 R IN	SMA (f) connector, used as an input reference signal

N4419A Front and Rear Panel

N4419A Front Panels

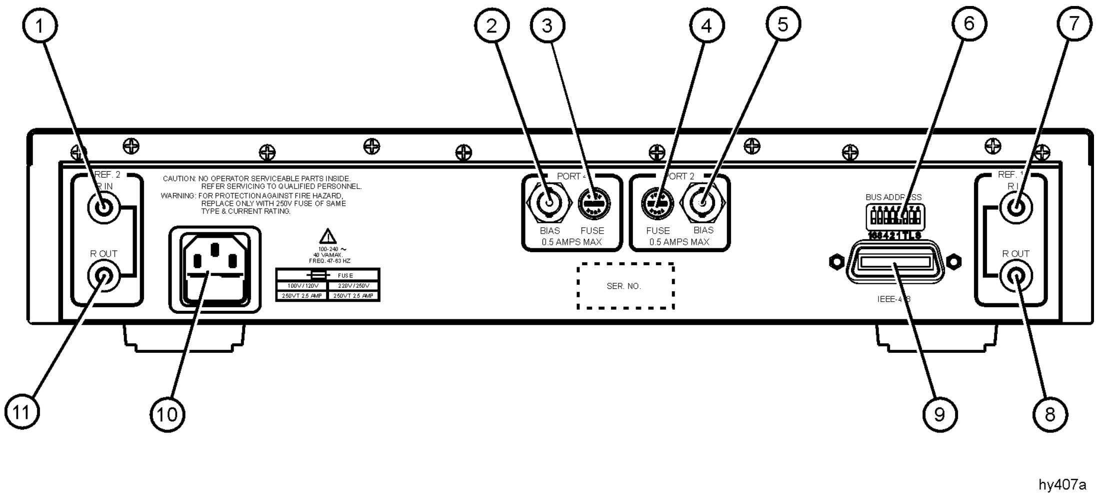


4419frnpnl

ID Number	Front Panel Feature	Feature Description
1	REFERENCE 1 SOURCE OUT	SMA (f) connector that is connected to the network analyzer REFERENCE 1 SOURCE OUT connector using a semirigid cable.
2	REFERENCE 1 RCVR R1 IN	SMA (f) connector that is connected to the network analyzer REFERENCE 1 RCVR R1 IN connector using a semirigid cable.
3	PORT 2	PORT 2 - APC-3.5 (m) connector with 20 mm nut that is connected to the DUT or fixture. (+17 dBm maximum operating level)
4	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
5	POWER	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.

ID Number	Front Panel Feature	Feature Description
6	PORT 4	PORT 4 - APC-3.5 (m) connector with 20 mm nut that is connected to the DUT or fixture. (+17 dBm maximum operating level)
7	REFERENCE 2 RCVR R2 IN	SMA (f) connector that is connected to the network analyzer REFERENCE 2 RCVR R2 IN connector using a semirigid cable.
8	REFERENCE 2 SOURCE OUT	SMA (f) connector that is connected to the network analyzer REFERENCE 2 SOURCE OUT connector using a semirigid cable.
9	PORT 2 SOURCE OUT	SMA (f) connector that is connected to the network analyzer PORT 2 SOURCE OUT connector using a semirigid cable.
10	PORT 2 CPLR ARM	SMA (f) connector that is connected to the network analyzer PORT 2 CPLR ARM connector using a semirigid cable.
11	PORT 2 RCVR B IN	SMA (f) connector that is connected to the network analyzer PORT 2 RCVR B IN connector using a semirigid cable.
12	PORT 2 CPLR THRU	SMA (f) connector that is connected to the network analyzer PORT 2 CPLR THRU connector using a semirigid cable.
13	AUXILIARY	15-pin ribbon (f) connector that may be connected to the Agilent N4430A/B ECal module to provide ECal capability.
14	PORT 1 CPLR THRU	SMA (f) connector that is connected to the network analyzer PORT 1 CPLR THRU connector using a semirigid cable.
15	PORT 1 RCVR A IN	SMA (f) connector that is connected to the network analyzer PORT 1 RCVR A IN connector using a semirigid cable.
16	PORT 1 CPLR ARM	SMA (f) connector that is connected to the network analyzer PORT 1 CPLR ARM connector using a semirigid cable.
17	PORT 1 SOURCE OUT	SMA (f) connector that is connected to the network analyzer PORT 1 SOURCE OUT connector using a semirigid cable.

N4419A Rear Panel

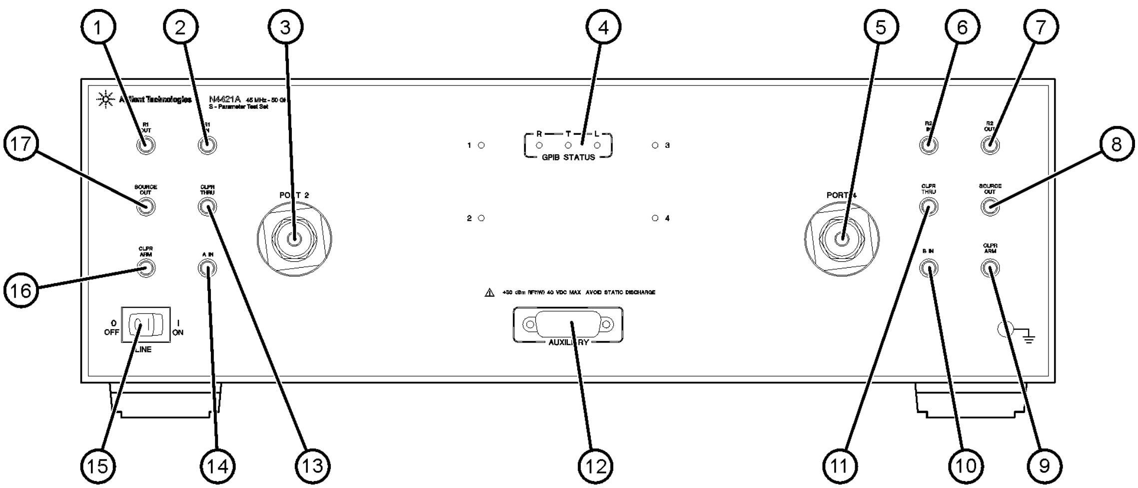


ID Number	Rear Panel Feature	Feature Description
1	REF 2 R IN	SMA (f) connector, used as an input reference signal
2	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
3	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
4	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
5	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
6	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
7	REF 1 R IN	SMA (f) connector, used as an input reference signal
8	REF 1 R OUT	SMA (f) connector, used as an output reference signal
9	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.

ID Number	Rear Panel Feature	Feature Description
10	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
11	REF 2 R OUT	SMA (f) connector, used as an output reference signal

N4421A Front and Rear Panel

N4421A Front Panel

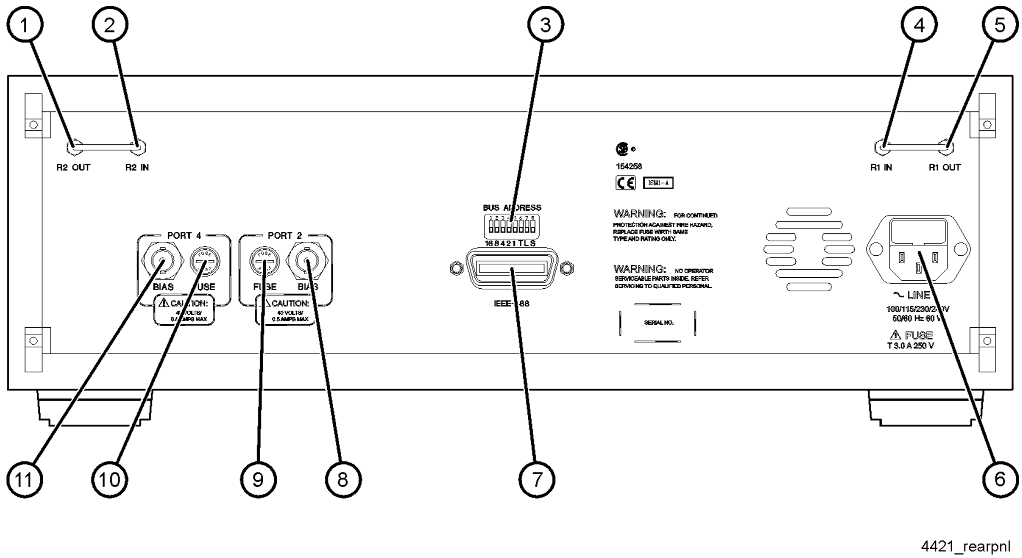


n4421_frtpnl

ID Number	Front Panel Feature	Feature Description
1	R1 OUT	2.4 mm (f) connector that connects to the network analyzer REFERENCE 1 OUT connector using a semirigid cable.
2	R1 IN	2.4 mm (f) connector that connects to the network analyzer REFERENCE 1 RCVR R1 connector using a semirigid cable.
3	PORT 2	2.4 mm bulkhead test port connector that is connect to the DUT or fixture. (+17 dBm maximum operating level)
4	GPIB STATUS	Three LEDs (R, T, and L) that display the GPIB status of the test set when it is communicating with the network analyzer. R = Remote Operation, T = Talk mode, L = Listen mode.
5	PORT 4	2.4 mm bulkhead test port connector that is connect to the DUT or fixture. (+17 dBm maximum operating level)
6	R2 IN	2.4 mm (f) connector that connects to the network analyzer REFERENCE 2 RCVR R2 connector using a semirigid cable.

ID Number	Front Panel Feature	Feature Description
7	R2 OUT	2.4 mm (f) connector that connects to the network analyzer REFERENCE 2 OUT connector using a semirigid cable.
8	SOURCE OUT	2.4 mm (f) connector that connects to the network analyzer PORT 2 SOURCE OUT connector using a semirigid cable.
9	CPLR ARM	2.4 mm (f) connector that connects to the network analyzer PORT 2 CPLR ARM connector using a semirigid cable.
10	B IN	2.4 mm (f) connector that connects to the network analyzer PORT 2 B IN connector using a semirigid cable.
11	CPLR THRU	2.4 mm (f) connector that connects to the network analyzer PORT 2 CPLR THRU connector using a semirigid cable.
12	AUXILIARY	15-pin ribbon (f) connector. Not currently used.
13	CPLR THRU	2.4 mm (f) connector that connects to the network analyzer PORT 1 CPLR THRU connector using a semirigid cable.
14	A IN	2.4 mm (f) connector that connects to the network analyzer PORT 1 A IN connector using a semirigid cable.
15	LINE	ON/OFF switch that disconnects the mains circuits from the mains supply before other parts of the test set. The front panel POWER switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.
16	CPLR ARM	2.4 mm (f) connector that connects to the network analyzer PORT 1 CPLR ARM connector using a semirigid cable.
17	SOURCE OUT	2.4 mm (f) connector that connects to the network analyzer PORT 1 SOURCE OUT connector using a semirigid cable.

N4421A Rear Panel



ID Number	Rear Panel Feature	Feature Description
1	REF 2 R OUT	2.4 mm (f) connector, used as an output reference signal
2	REF 2 R IN	2.4 mm (f) connector, used as an input reference signal.
3	BUS ADDRESS	Switch that is used to set the GPIB address. Refer to “To Set the GPIB Addresses” on page 38 for further information.
4	REF 1 R IN	2.4 mm (f) connector, used as an input reference signal
5	REF 1 R OUT	2.4 mm (f) connector, used as an output reference signal
6	Power Cord Connector	Connector, 100-120 Vac or 220-250Vac input and Fuse, T 2.5 A 250 V (Agilent part number 2110-0681)
7	IEEE-488	24-pin IEEE-488/PCB (f) connector. The GPIB is the communication bus with the PC and the network analyzer.
8	PORT 2 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.
9	PORT 2 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)

ID Number	Rear Panel Feature	Feature Description
10	PORT 4 FUSE	Bias Fuse, 0.5 A, 250 V (Agilent part number 2110-0012)
11	PORT 4 BIAS	BNC (f) connector. The bias port is used to supply a dc voltage to an active DUT, such as an amplifier or a transistor.

Specifications and Characteristics

The Agilent multiport test set power supply requirements, environmental operating conditions, and physical characteristics are displayed on the following pages.

Power Supply Requirements

The power supply requirements for the multiport test sets are listed below.

Input Voltage Range	100 to 120 Volts 220 to 250 Volts
Frequency Range	47 to 62 Hertz
Power	40 VA

Environmental Operating Conditions

The environmental operating conditions for the multiport test set are listed below.

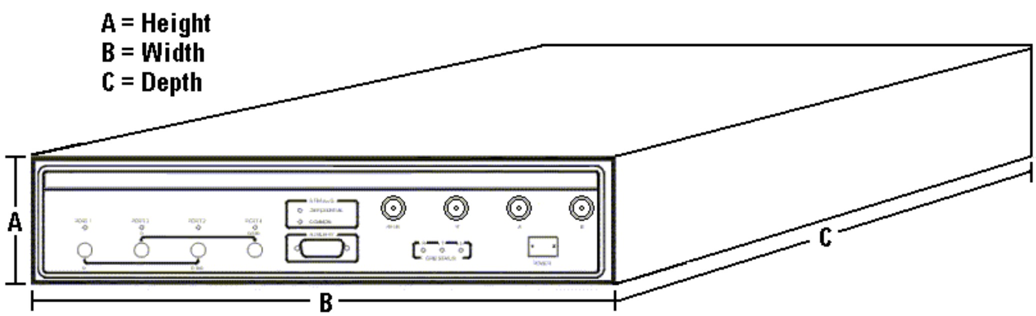
Operating Environment	Indoor use
Altitude	Operating:0 to 2.0 km (6,560 ft)
	Storage:0 to 15.24 km (50,000 ft)
Temperature	0 °C to 40 °C
Maximum Relative Humidity	80% for temperatures up to 31 °C decreasing linearly to 50% for a temperature of 40 °C

This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IED 61010-1 and 664, respectively.

Physical Characteristics

The weight and dimensions for each of the multiport test sets are listed below.

Weight and Dimensions



Model Number	Weight	Dimensions		
		Height (A)	Width (B)	Depth (C)
N4413A, N4414A, N4415A, N4416A, N4417A, N4418A, and N4419A	9.0 kilograms (19.9 pounds)	3.0 in (7.62 cm)	16.75 in (42.55 cm)	19.25 in (48.90 cm)
N4421A	9.0 kilograms (19.9 pounds)	5.5 in (13.97 cm)	16.75 in (42.55 cm)	16.75 in (42.55 cm)

8 Safety and Regulatory Information

General Information

Refer to the information in this section before cleaning your multiport test set or before returning your multiport test set to Agilent Technologies for service.

Cleaning

When cleaning the test set, using a dry or damp cloth only.

WARNING **To prevent electrical shock, disconnect the Agilent Technologies N441x series (N4413A, N4414A, N4415A, N4416A, N4417A, N4418A, N4419A, and N4421A) multiport test set from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

Positioning the System for Use

When setting up the multiport test system for use, position the equipment so that the front panel power switch is easy to reach.

Shipment for Service

Before shipping equipment for service, contact Agilent for instructions. See “Contacting Agilent” on page 160 for details.

Ship the test set using the original or comparable packaging materials.

Safety Information

Review to the safety information in this section before operating your Agilent Technologies multiport test system.

Safety Symbols

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

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

Familiarize yourself with each of the markings and its meaning before operating the multiport test system.

	The ON symbol. The ON symbol is used to mark the positions of the instrument line switch.
	The OFF symbol. The OFF symbol is used to mark the positions of the instrument line switch.
	The ON symbol. The ON symbol is used to mark the positions of the instrument line switch.
	The OFF symbol. The OFF symbol is used to mark the positions of the instrument line switch.
	The AC symbol. The AC symbol is used to indicate the required nature of the line module input power.
	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.
	The CE mark is a registered trademark of the European Community. (If accompanied by a year, it is when the design was proven.)
	The CSA mark is a registered trademark of the Canadian Standards Association.
ISM1-A	This is a symbol of an Industrial Scientific and Medical Group 1 Class A product.
ICES / NMB-001	This is a marking to indicate product compliance with the Canadian Interference-Causing Equipment Standard (ICES-001).
N10149	The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.

Safety Considerations

Familiarize yourself with each of the safety considerations before operating the multiport test system.

NOTE This instrument has been designed and tested in accordance with the standards listed on the Manufacturer's Declaration of Conformity and has been supplied in a safe condition. This instruction documentation contains information and warnings which must be followed by the user to ensure safe operation and to maintain the instrument in a safe condition.

Safety Earth Ground

WARNING **This is a Safety Class 1 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.**

CAUTION Always use the three-prong AC power cord supplied with this product. Failure to ensure adequate earth grounding by not using this cord may cause product damage.

Before Applying Power

CAUTION Install the instrument so that the ON/OFF switch is readily identifiable and is easily reached by the operator. The ON/OFF switch or the detachable power cord is the instrument disconnecting device. It disconnects the mains circuits from the mains supply before other parts of the instrument. Alternately, an externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.

CAUTION Before switching on this instrument, make sure that the correct fuse is installed and the supply voltage is in the specified range.

Servicing

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

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 5 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 (115V and 230V operation: T2.5A 250V). The use of other fuses or material is prohibited.**

General

WARNING **To prevent electrical shock, disconnect the Agilent Technologies N441x series (N4413A, N4414A, N4415A, N4416A, N4417A, N4418A, N4419A, and N4421A) multiport test set from mains before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

CAUTION This product is designed for use in Installation Category II and Pollution Degree 2 per IEC 1010 and 664 respectively.

CAUTION VENTILATION REQUIREMENTS: When installing the product in a cabinet, the convection into and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the product by 4° C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater that 800 watts, then forced convection must be used.

Regulatory Information

The Agilent Technologies multiport test system complies with the regulatory requirements listed in this section.

Compliance with Canadian EMC Requirements

This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme a la norme NMB du Canada.

Compliance with German Noise Requirements

This is to declare that this instrument is in conformance with the German Regulation on Noise Declaration for Machines (Laermangabe nach der Maschinenlaermrerordung –3. GSGV Deutschland).

Acoustic Noise Emission/Geraeuschemission	
LpA <70 dB	LpA <70 dB
Operator position	am Arbeitsplatz
Normal position	normaler Betrieb
per ISO 7779	nach DIN 45635 t. 19

Declaration of Conformity

DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name: Agilent Technologies, Inc.

Manufacturer's Address: 40 Shatttuck Road
Andover, MA 01810
USA

Declares that the products

Product Name: Multiport Test Sets & Calibration Modules

Model Number: N4413A, N4414A, N4415A, N4416A, N4417A, N4418A, N4419A, N4421A, N4425A, N4430A, N4430B

Product Options: This declaration covers all options of the above products.

Conform to the following product standards:

EMC: EN 61326:1998

Standard	Limit
EN 55011/A-1999	Group 1, Class A
EN 61000-4-2:1995	4 kV CD, 8 kV AD
EN 61000-4-3:1998+AMD1	3 V/m, 80 - 1000 MHz
EN 61000-4-4:1995	0.5 kV sig., 1 kV power
EN 61000-4-5:1995	0.5 kV L-L, 1 kV L-G
EN 61000-4-6:1996	3 V, 0.15 – 80 MHz
EN 61000-4-11:1994	1 cycle, 100%

Safety: EN 61010-1:1993 +A2:1995

Supplementary Information:
The products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carry the CE-marking accordingly.

Andover, MA, USA [10/21/02]

Peter Rienzo/Order Fulfillment Manager

For further information, please contact your local Agilent Technologies sales office, agent or distributor.

Rev. A

A Other Technical Procedures

This appendix contains a procedure that may be helpful to you, using the balanced measurement software. Refer to the following procedure:

- "Waveguide Characterization Procedure" on page 211
- "IF Gain Adjustment" on page 212

Waveguide Characterization Procedure

Use this procedure to characterize a waveguide measurement.

1. Calibrate the Agilent microwave network analyzer.
2. Measure the DUT.
3. Save the measured data in S2P format on the network analyzer by pressing the **Save/Recall** key and then pressing the **DEFINE DISK-SAVE**, **SAVE USING ASCII**, and **FORMAT ARY ON** off softkeys.
4. Import this measured data into the balanced measurement software by clicking **Import** and **Import S2P** on the **File** menu.
5. Export the data as a citifile by selecting **Export...** and **Citifile** on the **File** menu.
6. Open the Citifile in a text editor. The first three lines of the file are shown below.

```
CITIFILE A.01.00
NAME S-Parameters
VAR FREQ MAG 400
.
.
.
```

7. Insert the following two lines between the first and second lines of the Citifile.

```
#TXS TYPE=THRU
#TXS PORT1=WR-51 (W/G)   PORT2=WR-51 (W/G)
```

8. Save this file and use it in the adapter section of the calibration.

IF Gain Adjustment

This procedure is for N8362A and N8364A PNA network analyzers that have firmware revisions less than Revision 3.0.

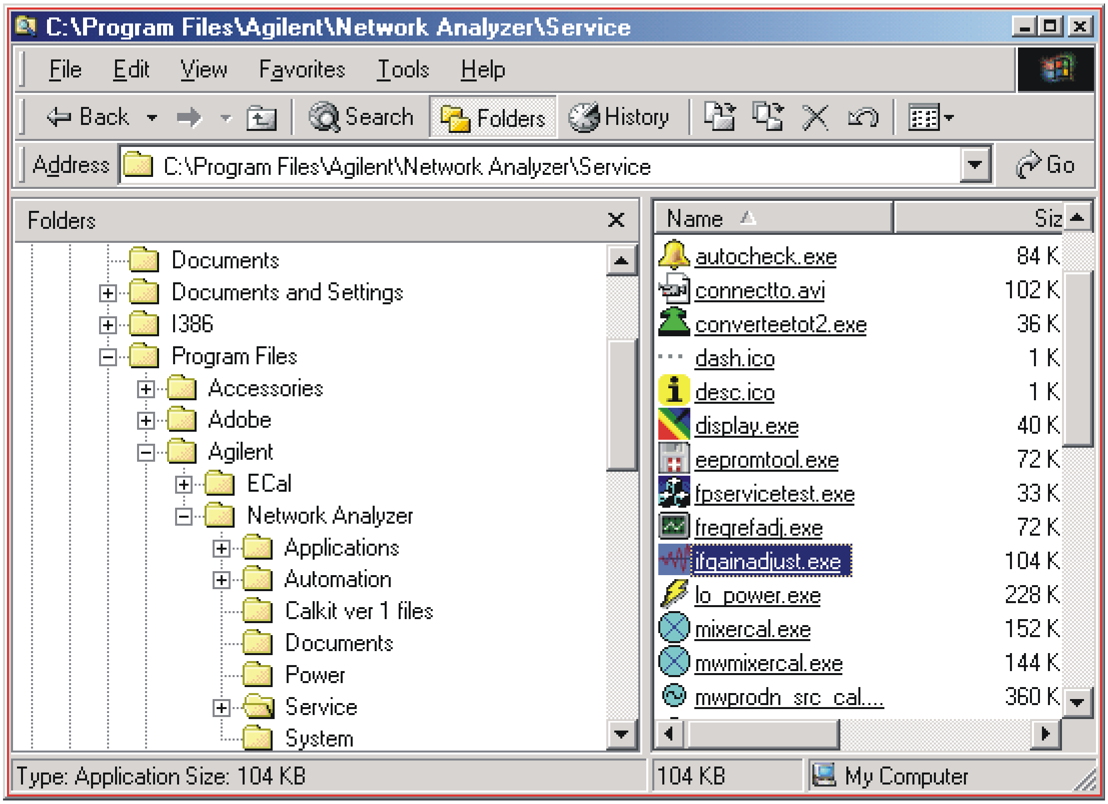
It is recommended that the Service IF Gain Adjustment test be run *before* using the test set. This routine adjusts the R Channel receivers ALC gain to ensure phase lock over the entire frequency range of the PNA Series Network Analyzer. Connect the test set to the analyzer before adjusting the IF gain.

NOTE When the analyzer is removed from the test set for service, or for other applications that do not require the test set, the IF gain adjustment must be run again to return the R Channel receiver ALC gain back to normal.

Adjustment Test

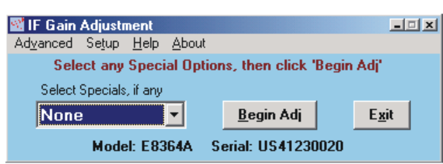
1. Close the PNA Series Network Analyzer window.
2. Open “My Computer”, located on the desk top, double click on “Hard Disk (c:).” (You may also use Windows Explorer). Refer to Figure A-1.
3. Open the following folder path: Programs Files/Agilent/Network Analyzer/Service

Figure A-1 File Path on PNA Network Analyzer Window



4. Double click “ifgainadjust.exe.”
5. Minimize the PNA Network Analyzer window when it appears. You should see the IF Gain Adjust window.

Figure A-2 IF Gain Adjustment Window



6. Select the test set in the “Select Specials, if any” pull down menu and click on “Begin Adj.”

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