

Agilent Technologies Z5623A Option H48

Multiport Test Set User's and Service Guide



Agilent Technologies

Manufacturing Part Number: Z5623-90016

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Safety Notes

The following safety notes are used throughout this document. Familiarize yourself with each of these notes and its meaning before performing any of the procedures in this document.

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.**

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

Statement of Compliance

This instrument has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The 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.

Definitions

- Specifications describe the performance of parameters covered by the product warranty (temperature -0 to 55 °C, unless otherwise noted.)
- *Typical* describes additional product performance information that is not covered by the product warranty. It is performance beyond specification that 80% of the units exhibit with a 95% confidence level over the temperature range 20 to 30 °C. Typical performance does not include measurement uncertainty.
- *Nominal* values indicate expected performance or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

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- [Overview](#)
- [Specifications](#)
- [Electrical Requirements](#)
- [Environmental Requirements](#)
- [General Characteristics](#)
- [Available Options](#)
- [Cleaning and Shipping Instructions](#)

Overview

The Agilent Z5623A Option H48 Multiport Test Set is designed for use with 50 Ω Network Analyzers such as the Agilent PNA Series (Models E8356A, E8357A, and E8358A). [Figure 1-1](#) shows a typical equipment setup.

The test set reduces the time required to test multiport devices having up to eight ports (distribution amplifiers, taps, switches, couplers, etc.). It does this by reducing the number of device reconnects the operator must perform. The test set can connect each of its test ports to any of the following:

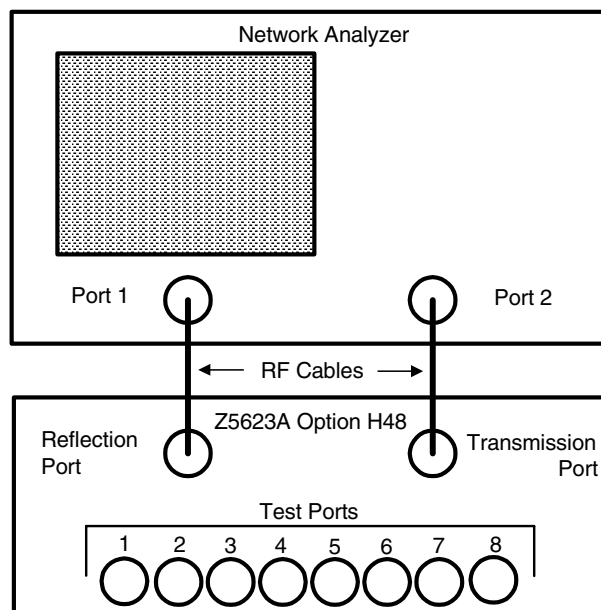
- Reflection Port
- Transmission Port
- 50 Ω termination internal to the test set.

Switching is performed with mechanical switches.

The test set is controlled by means of its GPIB interface. The control can be performed either by a PNA Series network analyzer or by an external computer.

NOTE This User's and Service Guide documents the use of the test set with an Agilent E8358A network analyzer.

Figure 1-1 Typical Equipment Setup



Specifications

Agilent provides two different types of specifications for the test set:

- Guaranteed performance specs
- Typical performance specs

Typical performance specs have been benchmarked during product development, but are not tested by the factory and are not guaranteed.

Guaranteed Performance

Table 1-1

Agilent Z5623A Option H48 Guaranteed Performance Specs

Parameter	Specification
Frequency Range	300 kHz to 9.0 GHz
Crosstalk ^a	1) -110 dB ^b 2) -105 dB ^c 3) -95 dB ^d 4) -90 dB ^e
Return Loss (port active) ^f	1) 24 dB ^b 2) 18 dB ^c 3) 14 dB ^d 4) 9 dB ^e
Return Loss (port off) ^g	1) 26 dB ^b 2) 20 dB ^c 3) 16 dB ^d 4) 14 dB ^e
Insertion Loss ^h	1) 1.5 dB ^b 2) 2.0 dB ^c 3) 2.5 dB ^d 4) 3.5 dB ^e
Switch Lifetime	5 million cycles
Maximum Input Power	1 Watt (RF + DC) ⁱ

a. Between any two non-connected signal paths

b. Band 1 (300 kHz to 1.3 GHz)

c. Band 2 (1.3 GHz to 3.0 GHz)

d. Band 3 (3.0 GHz to 6.0 GHz)

e. Band 4 (6.0 GHz to 9.0 GHz)

f. When using an external termination on the Reflection or Transmission port

g. When using one of the 50 Ω internal terminations

h. From any test set port to the Reflection or Transmission port

i. Set by the power handling capability of the 50 Ω internal terminations

Typical Performance

Table 1-2

Agilent Z5623A Option H48 Typical Performance Specs

Parameter	Typical Performance
Source Power (max) ^a	1) -8.0 dBm ^b 2) -8.0 dBm ^c 3) -7.0 dBm ^d 4) -1.0 dBm ^e
Dynamic Range (max) ^f	1) 110 dB ^b 2) 105 dB ^c 3) 95 dB ^d 4) 90 dB ^e
Cycle Time (minimum; IF BW = 35 kHz) ^g	1) 430 mS (Dynamic Range = 86 dB) ^b 2) 430 mS (Dynamic Range = 89 dB) ^c 3) 430 mS (Dynamic Range = 78 dB) ^d 4) 430 mS (Dynamic Range = 71 dB) ^e
Cycle Time (@ 100 dB Dynamic Range; IF BW = 3 kHz) ^g	2) 900 mS ^c 3) 900 mS ^d
Switching Time	11 mS

- a. Power measured at test ports 1-8 on Z5623A Option H48 when connected to the E8358A using the 8120-4782 RF Jumper cables supplied.
- b. Band 1 (300 kHz to 1.3 GHz)
- c. Band 2 (1.3 GHz to 3.0 GHz)
- d. Band 3 (3.0 GHz to 6.0 GHz)
- e. Band 4 (6.0 GHz to 9.0 GHz)
- f. IF Bandwidth set to 10 Hz
- g. Conditions: 2 Windows, 4 Channels, 8 Traces, 2-port cal, no band crossings, 201points.

Electrical Requirements

The alternating-current (AC) power that is supplied to the test set must meet the following requirements:

Voltage: 90 to 250 Vac

Frequency: 48 to 66 Hz

Available power: 40 watts minimum

If the available AC line voltage is outside the 90 to 250 Vac range, an autotransformer that provides third wire continuity to earth ground may be used.

Environmental Requirements

Operating Environment

Indoor use only

Operating temperature: 0 to 55 °C

Maximum relative humidity: 80 percent for temperatures up to 31 °C decreasing linearly to 50 percent relative humidity at 40 °C

Altitude: up to 15,000 feet (4,572 meters)

Enclosure protection: IP 20, according to IEC 529

CAUTION

This product is designed for use in INSTALLATION CATEGORY II, and POLLUTION DEGREE 2, per IEC 101 and 664 respectively.

Non-Operating Storage Conditions

Temperature: -40 °C to +70 °C

Humidity: 0 to 90 percent relative at +65 °C (non-condensing)

Altitude: 0 to 15,240 meters (50,000 feet)

General Characteristics

Weight

Net: Approximately 9 kg

Shipping: Approximately 20 kg

Cabinet Dimensions

These dimensions exclude front and rear panel protrusions.

89 mm H by 425 mm W by 500 mm D (3.5 in by 16.75 in by 19.7 in)

Miscellaneous Characteristics

RF connectors: Type N female

Switch type: Mechanical

I/O Control: GPIB

Available Options

UK6

Option UK6 provides a commercial calibration certificate including actual test data. Data includes test results including reflection, transmission, and crosstalk for all test ports.

Rack Ear Mounts

Option 908, part number 5062-3974, provides rack mounts that make it quick and easy to install or remove the test set from a mainframe.

For further information on these options, please contact Agilent Technologies. Refer to [Chapter 10](#), “[Contacting Agilent.](#)”

Cleaning and Shipping Instructions

Cleaning

Clean the instrument cabinet using a damp cloth only.

Shipping

Always transport or ship the instrument using the original packaging if possible. If not, comparable packaging must be used.

This chapter contains the following sections:

- [Checking the Shipment](#)
- [Recommended Additional Equipment](#)
- [Familiarization with Safety Requirements](#)
- [Electrical Preparations](#)
- [Environmental Preparations](#)
- [Test Set Familiarization](#)
- [Setting the GPIB Address of the Test Set](#)
- [Connecting and Turning on the Test Set](#)

Checking the Shipment

After the test set has been unpacked, keep the original packaging materials so they can be used if you need to transport the instrument.

Check the items received against [Table 2-1](#) to make sure you have received everything.

Inspect the test set and all accessories for any signs of damage that may have occurred during shipment. If your test set or any accessories appear to be damaged or missing, call Agilent Technologies. Refer to [Chapter 10](#), “[Contacting Agilent](#).”

Table 2-1

Accessories Supplied with Z5623A Option H48

Description	Agilent Part Number	Quantity
Power Cord	See Figure 2-2 on page 2-6	1
Front Handle Kit	5063-9226	1
Rack Mount Kit	5063-9232	1
RF Cable	8120-4782	2
GPIB Cable .5M	HP 10833D	1
User's and Service Guide	Z5623-90016	1

Recommended Additional Equipment

The equipment listed in [Table 2-2](#) is not shipped with the test set, but is recommended for use with it. The remainder of this User's and Service Guide assumes that the user has the listed equipment (or its equivalent) available.

Table 2-2 Recommended Equipment Not Supplied With Test Set

Description	Model Or Part Number	Quantity
PNA Series Network Analyzer	Agilent Model No. E8356A, E8357A, or E8358A	1
Electronic Calibration Module	Agilent Part No. 85072-60007	1
Keyboard with USB cable	Hewlett-Packard Model No. SK-2502U ^a	1
Mouse with USB cable	Hewlett-Packard Model No. M-UB48 ^a	1
USB Quad Hub	Peracom Model No. UH4000A ^{a,b}	1
USB Cable	Peracom Model No. CA2000A ^{a,b}	1
RF Cable (24")	Agilent Part No. 8120-4781 ^a	3
9/16" Wrench	Agilent Part No. 8710-1770	1
3/4" Torque Wrench	Agilent Part No. 8710-1766	1
Type N 50 Ohm Male Short	Agilent Part No. 85032-60016	2
Type N 50 Ohm Female Short	Agilent Part No. 85032-60015	2
Type N 50 Ohm Female Termination	Agilent Part No. 85032-60018	2
Type N 50 Ohm Female-Female Adapter	Agilent Part No. 85032-60021	1

a. Or equivalent

b. Available from Peracom Networks, Inc., Cary, North Carolina (www.peracom.com).

Familiarization with Safety Requirements

This document contains two types of safety notices: Warnings and Cautions.

A Warning denotes a hazard that may endanger the operator.

A Caution denotes a hazard that may endanger the instrument.

Before proceeding to the Electrical Preparations described in the next section, turn to [Chapter 9, “Safety and Regulatory Information,”](#) and review the Warnings, Cautions, and safety markings that apply to this instrument.

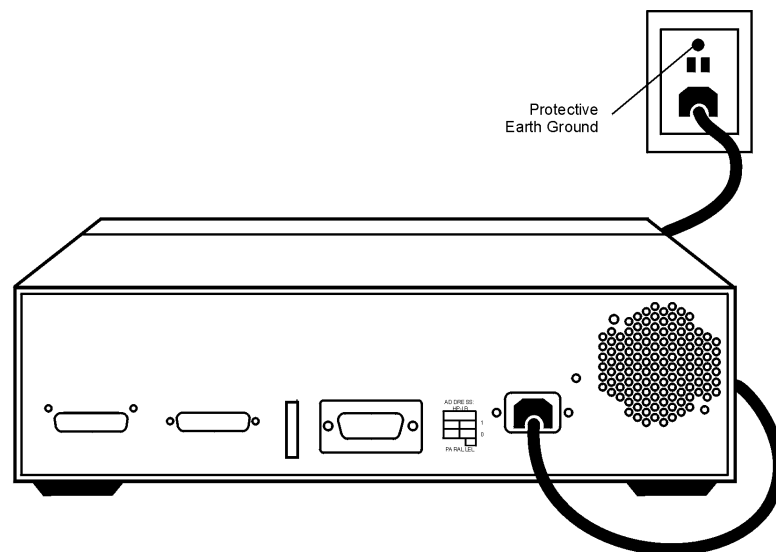
Electrical Preparations

1. Ensure that the [“Electrical Requirements”](#) on page 1-6 are met.
2. Verify that the power cable is not damaged and that the power source outlet provides a protective earth ground contact. Note that [Figure 2-1 on page 2-5](#) depicts only one type of power source outlet. Refer to [Figure 2-2 on page 2-6](#) to see the different types of power cord plugs that can be used with your test set.

Cables are available in different lengths. For descriptions and part numbers of cables other than those described in [Figure 2-2](#), call Agilent Technologies. Refer to [Chapter 10 , “Contacting Agilent.”](#)

3. If this product is to be powered by autotransformer, make sure the common terminal is connected to the neutral (grounded) side of the ac power supply.

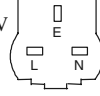


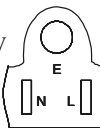

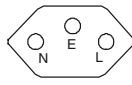

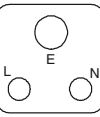

Figure 2-1 **Protective Earth Ground**



WARNING

This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted into 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 of the protective conductor is prohibited.

Figure 2-2 Power Cables

Plug Type ^a	Cable Part Number	Plug ^b Description	Length cm (in.)	Cable Color	For Use in Country
250V 	8120-8705	Straight BS 1363A	229 (90)	Mint Gray	Option 900 United Kingdom, Hong Kong, Cyprus, Nigeria, Singapore, Zimbabwe
	8120-8709	90°	229 (90)	Mint Gray	
250V 	8120-1369	Straight AS 3112	210 (79)	Gray	Option 901 Argentina, Australia, New Zealand, Mainland China
	8120-0696	90°	200 (78)	Gray	
125V 	8120-1378	Straight NEMA 5-15P	203 (80)	Jade Gray	Option 903 United States, Canada, Brazil, Colombia, Mexico, Philippines, Saudi Arabia, Taiwan
	8120-1521	90°	203 (80)	Jade Gray	
125V 	8120-4753	Straight NEMA 5-15P	229 (90)	Gray	Option 918 Japan
	8120-4754	90°	229 (90)	Gray	
250V 	8120-1689	Straight CEE 7/VII	200 (78)	Mint Gray	Option 902 Continental Europe, Central African Republic, United Arab Republic
	8120-1692	90°	200 (78)	Mint Gray	
230V 	8120-2104	Straight SEV Type 12	200 (78)	Gray	Option 906 Switzerland
	8120-2296	90°	200 (78)	Gray	
220V 	8120-2956	Straight SR 107-2-D	200 (78)	Gray	Option 912 Denmark
	8120-2957	90°	200 (78)	Gray	
250V 	8120-4211	Straight IEC 83-B1	200 (78)	Mint Gray	Option 917 South Africa, India
	8120-4600	90°	200 (78)	Mint Gray	
250V 	8120-5182	Straight SI 32	200 (78)	Jade Gray	Option 919 Israel
	8120-5181	90°	200 (78)	Jade Gray	

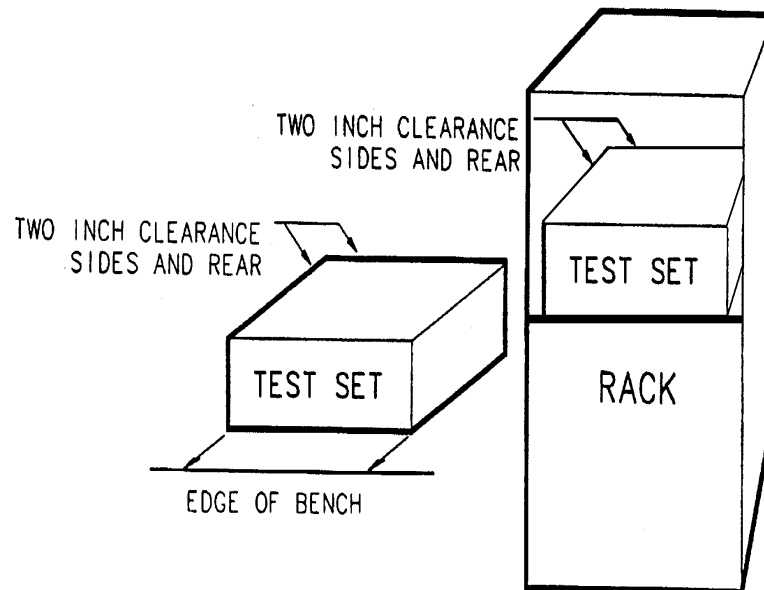
a. E =earth ground, L = line, and N = neutral.

b. Plug identifier numbers describe the plug only. The Agilent Technologies part number is for the complete cable assembly.

Environmental Preparations

1. Ensure that the “[Environmental Requirements](#)” on page 1-6 are met.
2. If you are installing the test set into a cabinet, ensure there are at least two inches of clearance around the sides and back of the test set and the system cabinet. See [Figure 2-3](#). The convection into and out of the test set must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the test set by 4 °C for every 100 watts dissipated in the cabinet.

Figure 2-3 Ventilation Clearance Requirements

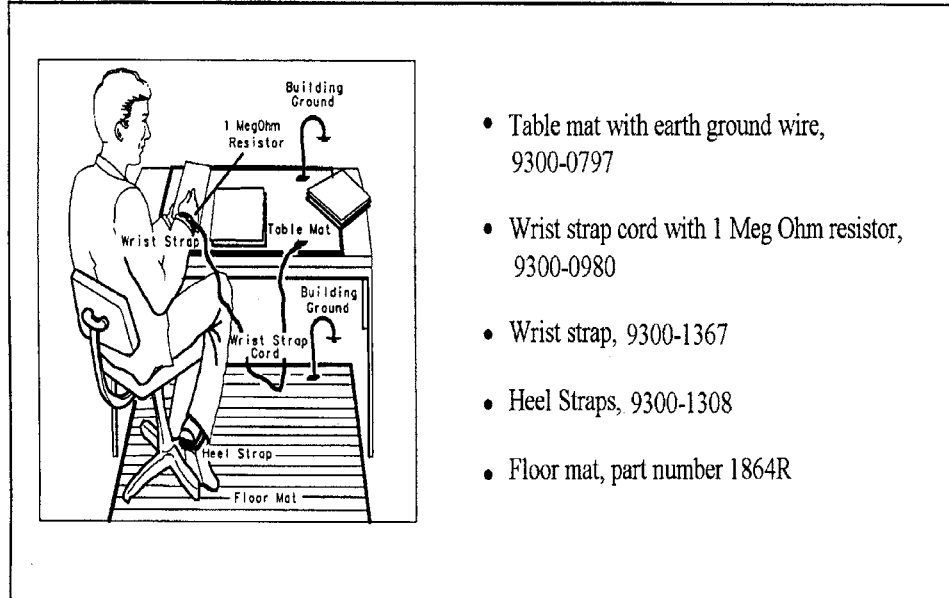


CAUTION

If the total power dissipated in the cabinet is greater than 800 watts, forced convection must be used.

3. Set up a static safe workstation such as the one shown in [Figure 2-4](#). Electrostatic discharge (ESD) can damage or destroy electronic components.

Figure 2-4 Example of an Antistatic Workstation

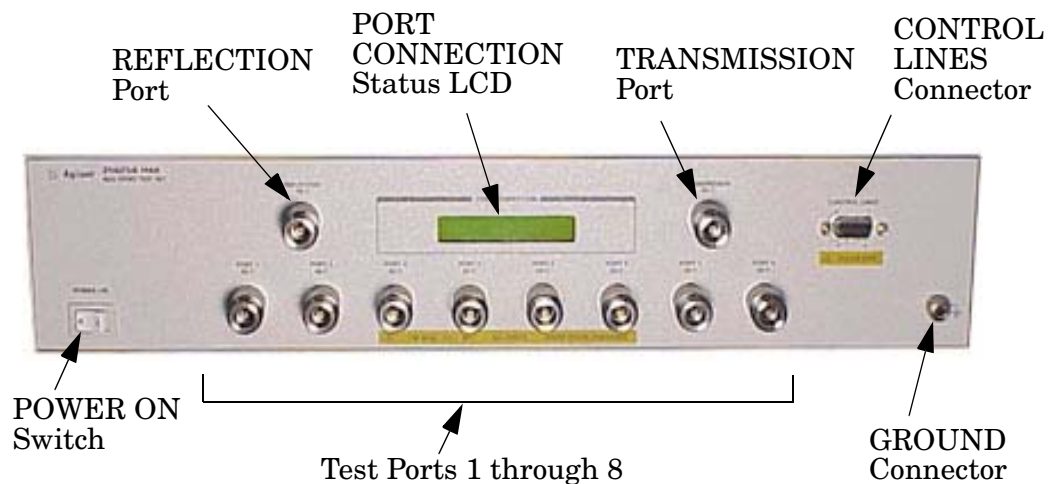


Test Set Familiarization

This section familiarizes the user with various front and rear panel features of the test set.

Front Panel

Figure 2-5 Front Panel Features



POWER ON Switch

The POWER ON Switch turns the AC power to the test set on and off. The switch is located at the bottom left corner of the front panel. See [Figure 2-5](#).

The switch disconnects the mains circuits from the mains supply after the EMC filters and before other parts of the instrument.

REFLECTION Port, TRANSMISSION Port, and Test Ports 1–8

The REFLECTION Port, the TRANSMISSION Port, and Test Ports 1 through 8 are 50 Ω connectors that are used to connect to the device under test.

CAUTION

Do not input more than 1 Watt maximum RF+DC to these ports or damage to the internal RF switches or the analyzer may occur.

The GROUND Connector

The GROUND Connector provides a convenient front panel ground connection for a standard banana plug.

The PORT CONNECTION Status LCD

The PORT CONNECTION Status LCD displays the following:

- Which test port is connected to the REFLECTION port
- Which test port is connected to the TRANSMISSION port
- The status (O = “Open”, L = “Low”) of each of the five control lines (C5 through C1)

All test ports not displayed on the Status LCD are internally terminated in 50 Ω

The CONTROL LINES Connector

The 9-pin CONTROL LINES Connector provides the user with a way of controlling either the Device Under Test (DUT) or other equipment. The test set cannot source any current from this connector. Therefore, the user must provide an external power supply and some additional circuitry if he wishes to use the connector. Refer to [“Using the Control Lines Connector” on page 7-6](#) for further details.

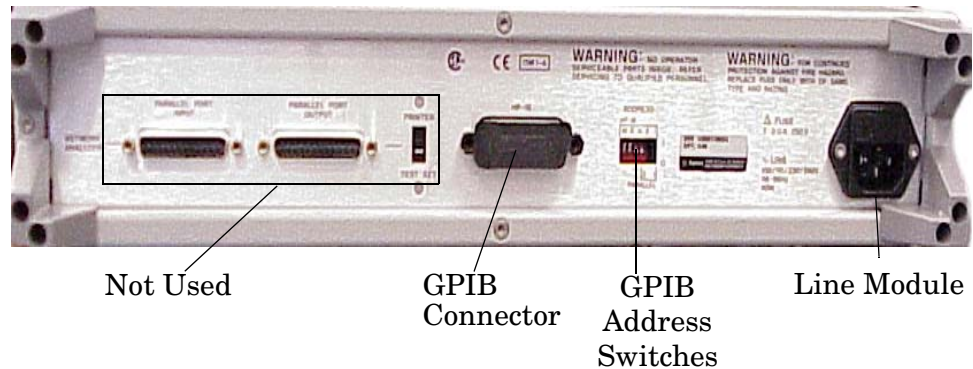
CAUTION Do not apply more than +22 Vdc to pins 1 through 5 of the CONTROL LINES Connector.

CAUTION Do not employ external circuitry that forces the test set to sink more than 250 mA on any control line (pins 1 through 5 of the CONTROL LINES Connector) when that line is commanded to the “Low” state (+0.63 Vdc).

Rear Panel

Figure 2-6

Rear Panel Features



GPIB Connector

This connector allows the test set to be controlled either by the network analyzer or by an external controller.

GPIB Address Switches

The GPIB Address Switches set the GPIB address of the test set. See [“Setting the GPIB Address of the Test Set” on page 2-13](#) for information.

Line Module

The line module contains the power cable receptacle and the line fuse.

Power Cables

The line power cable is supplied in one of several configurations, depending on the destination of the original shipment.

Each instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument chassis. The type of power cable shipped with each instrument depends on the country of destination. See [Figure 2-2, “Power Cables,” on page 2-6](#) for the part numbers of these power cables.

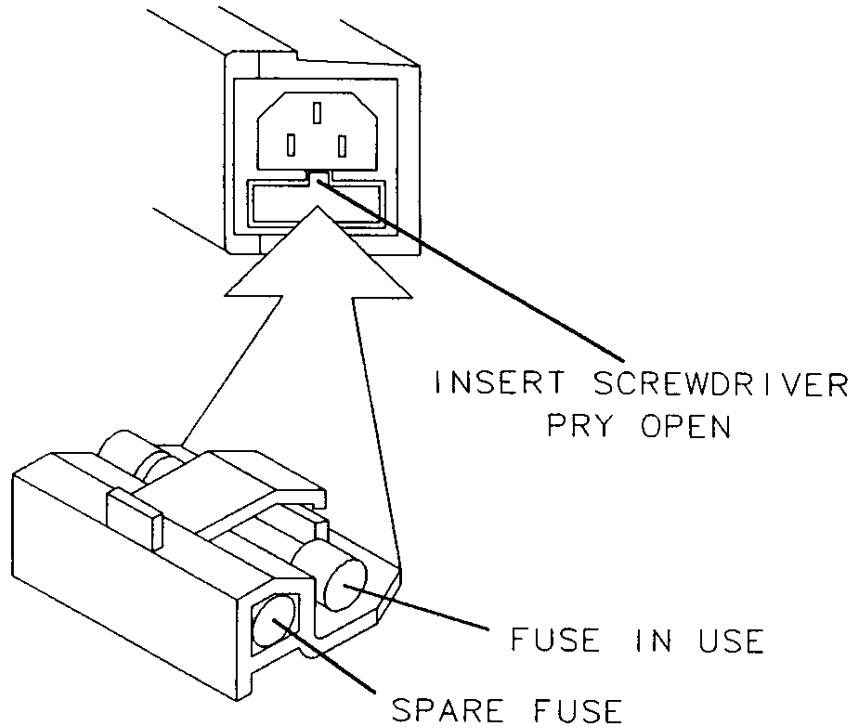
WARNING

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

The Line Fuse

The line fuse (F 3 A/250 V, part number 2110-0780) and a spare reside within the line module. [Figure 2-7](#) illustrates where the fuses are and how to access them.

Figure 2-7 Location of Line Fuses

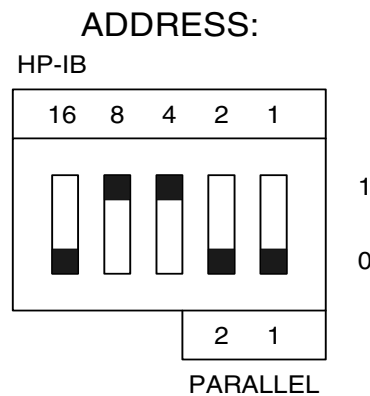


Setting the GPIB Address of the Test Set

A bank of five switches is used to set the GPIB address of the test set. The switch bank is located on the rear panel of the test set and is shown in [Figure 2-6 on page 2-11](#). A diagram of the switch bank is presented in [Figure 2-8](#).

The switch bank sets the GPIB address in binary (base 2) format. Each switch controls one bit of the address. To set a bit to 1, move the corresponding switch to the up position. To set a bit to 0, move the corresponding switch to the down position. The binary address shown in [Figure 2-8](#) is 01100.

Figure 2-8 GPIB Address Switches



To convert the binary address to decimal (base 10) format, just multiply each bit by the decimal value of that bit, then add the results. The decimal value of each bit is shown above the corresponding switch. Applying this conversion method to [Figure 2-8](#) we obtain

Equation 2-1

$$\begin{array}{r}
 0 \times 16 = 0 \\
 1 \times 8 = 8 \\
 1 \times 4 = 4 \\
 0 \times 2 = 0 \\
 0 \times 1 = 0 \\
 \hline
 \text{Sum} = 12
 \end{array}$$

Therefore, the binary GPIB address (01100) shown in [Figure 2-8](#) is equal to 12 in decimal (base 10) format.

If all bits are set to 1, the GPIB address is 11111 in binary format, or 31 in decimal format. (16 + 8 + 4 + 2 + 1 = 31.) Therefore, the GPIB address can have any value from 0 to 31 inclusive.

NOTE The test set is shipped from the factory with the GPIB address set to 12.

Connecting and Turning on the Test Set

Make the connections shown in [Figure 2-9, “Detailed Equipment Connection Diagram.”](#) The figure shows two RF cables connecting the network analyzer to the test set. If you intend to verify the performance of the test set, use the long RF cables listed in [Table 2-3](#). Otherwise, use the short ones.

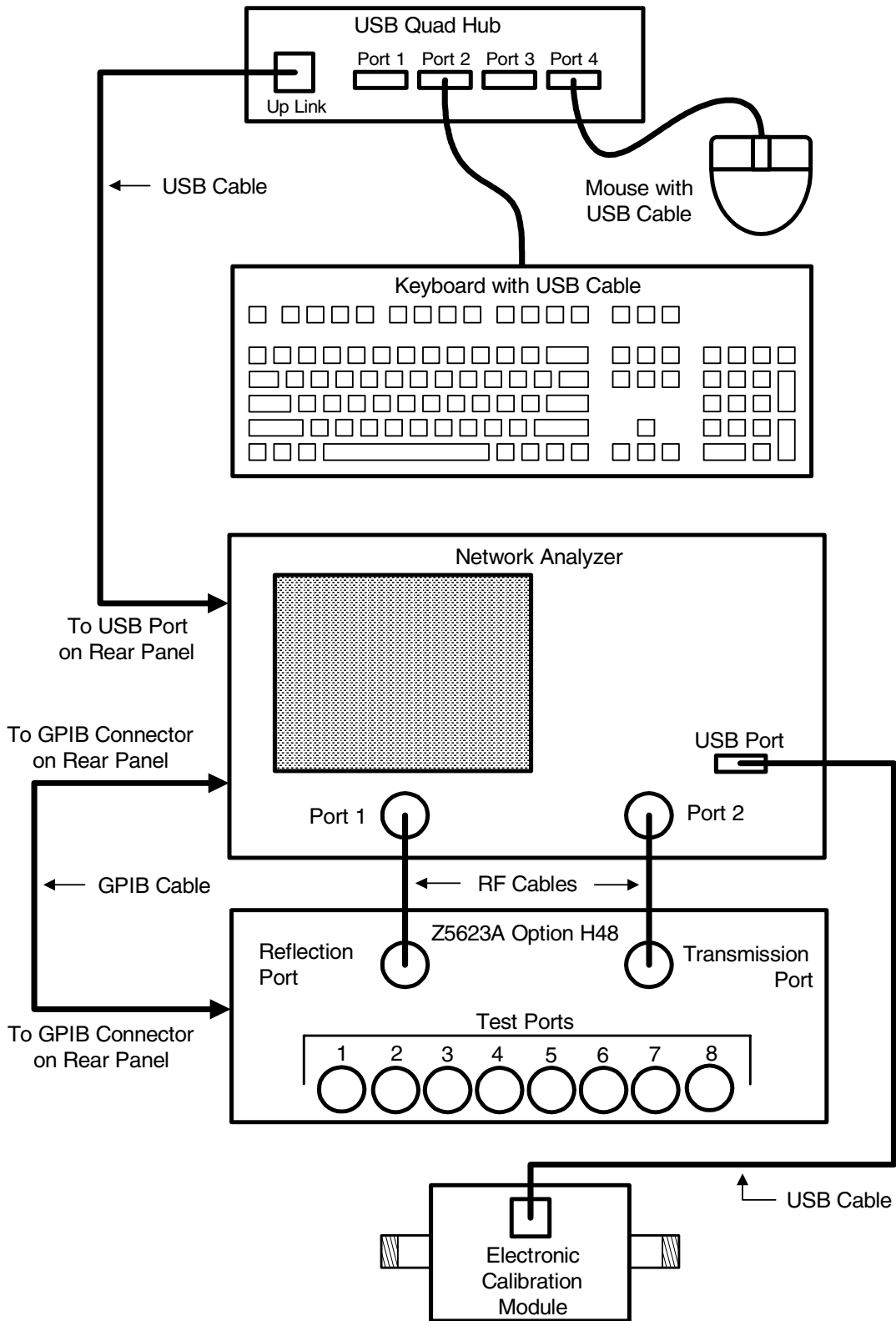
Table 2-3 RF Cables Connecting Network Analyzer to Test Set

Length	Part No.	Purpose
Long	8120-4781	Verification of test set performance
Short	8120-4782	Measurement of multipoint devices

Plug power cords into the test set. Turn both instruments on.

NOTE Allow the test set to warm up for at least 2 hours. For the most stable and accurate measurements, leave the test set turned on at all times.

Figure 2-9 Detailed Equipment Connection Diagram



Installation
Connecting and Turning on the Test Set

Using the Network Analyzer to Control the Test Set

This chapter assumes the following:

- The instructions in [Chapter 2](#) , “[Installation](#),” have been performed.
- The test set and associated equipment are connected as shown in [Figure 2-9](#) on [page 2-15](#).

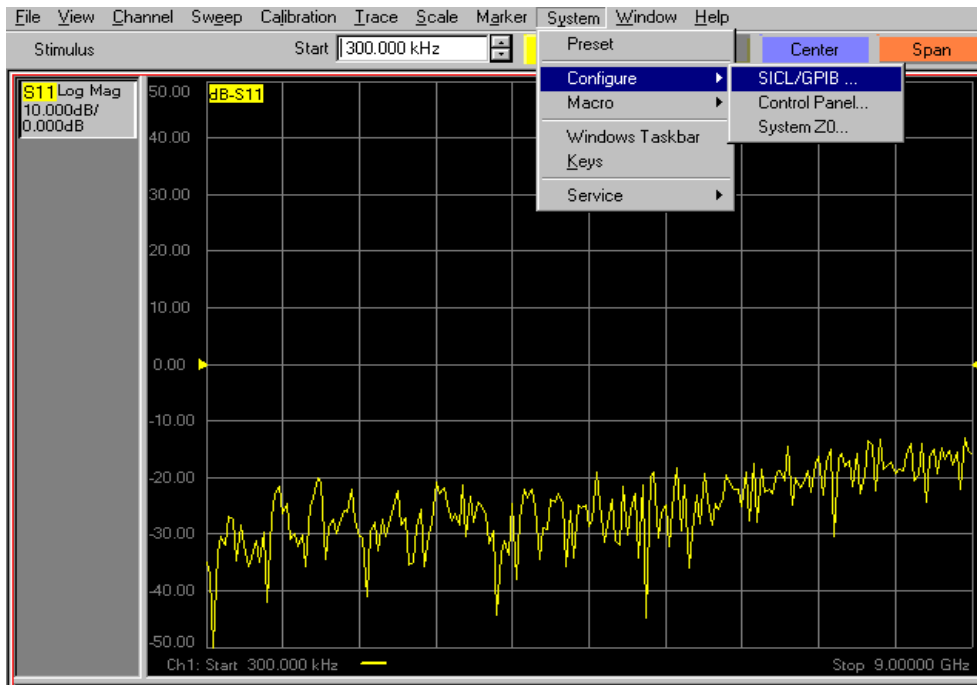
This chapter shows you how the network analyzer can be used to manually control the test set. The method presented here is considered a manual one because the user manually enters individual commands on a keyboard connected to the network analyzer. The chapter includes the following sections:

- [Preparing the Analyzer to Control the Test Set](#)
- [How to Send a Manual Command](#)
- [Common Errors in Manual Commands](#)
- [A List of GPIB Commands](#)
- [Restoring the Analyzer to its Normal Configuration](#)
- [Disaster Recovery](#)

Preparing the Analyzer to Control the Test Set

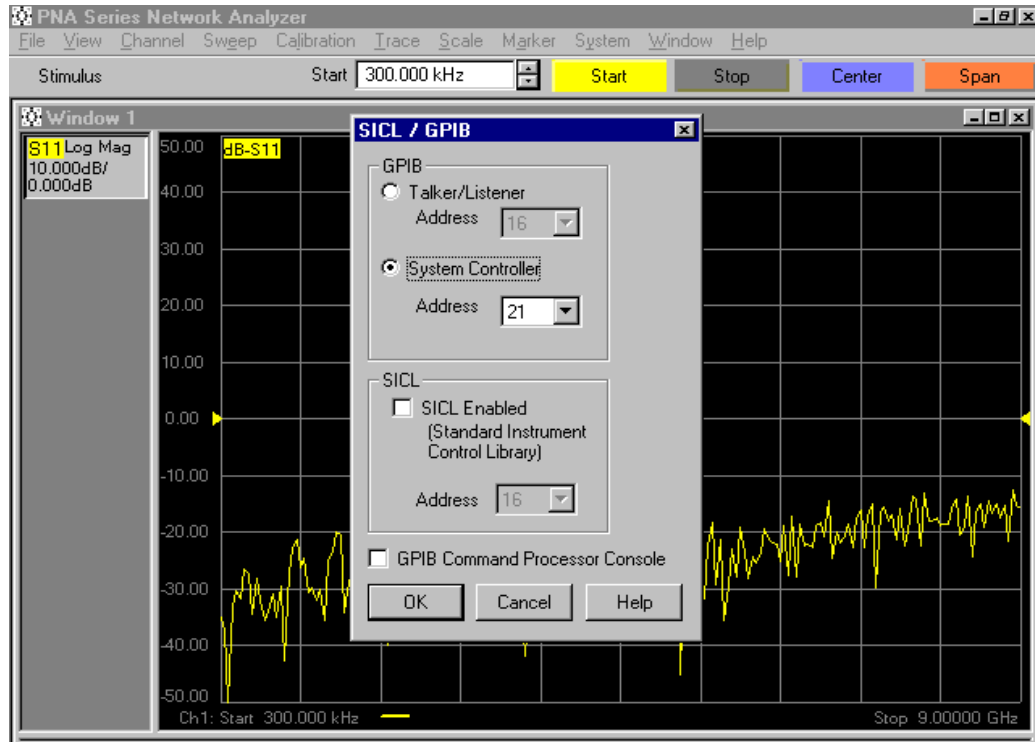
- Step 1.** Make sure that all connections shown in [Figure 2-9](#) on [page 2-15](#) have been made.
- Step 2.** Make sure that both the PNA Series analyzer and the test set are turned on.
- Step 3.** On the network analyzer, click the **System** menu, scroll down to **Configure**, and click **SICL/GPIB**. See [Figure 3-1](#), “System Menu.”

Figure 3-1 System Menu



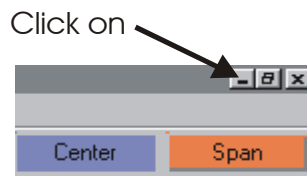
Step 4. In the SICL/GPIB window, click **System Controller** and then **OK**. See [Figure 3-2, “SICL/GPIB Window.”](#)

Figure 3-2 SICL/GPIB Window



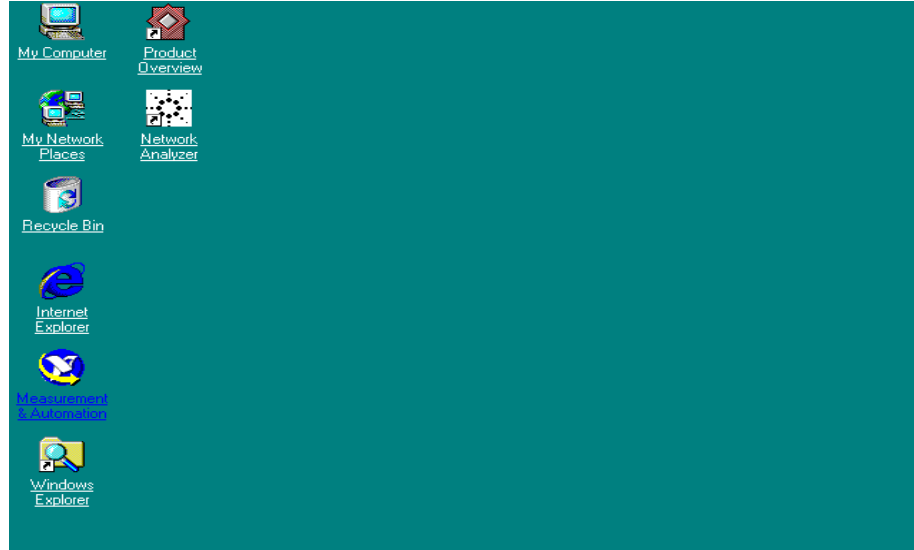
Step 5. Locate the Minimize button (“_”) in the top right corner of the window. See the upper right-hand corner of [Figure 3-2](#). See also the magnified view shown in [Figure 3-3, “Minimize Window.”](#) If the button is not visible, click on the View menu, then scroll down to Title Bars and click on it. When the Minimize button is visible, minimize the analyzer window by clicking on the button.

Figure 3-3 Minimize Window



- Step 6.** On the desktop, double-click the **Measurement & Automation** icon. See Figure 3-4, “PNA DeskTop.”

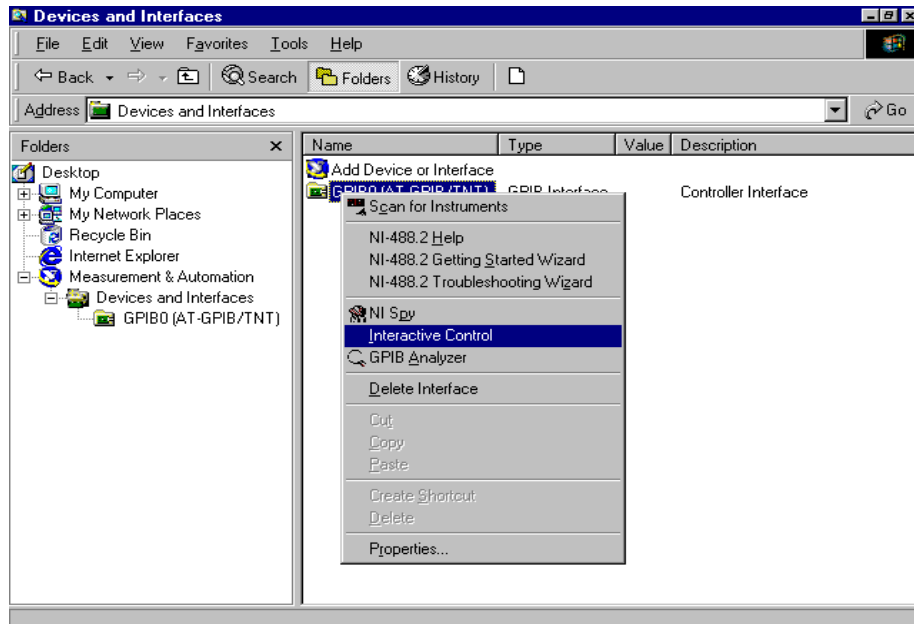
Figure 3-4 PNA DeskTop



- Step 7.** From the Measurement & Automation window, click on the **Devices and Interfaces** folder to expand the directory.

- Step 8.** *Right-click* **GPIBO (AT-GPIB/TNT)**, then click **Interactive Control**. See Figure 3-5, “Interactive Control window.”

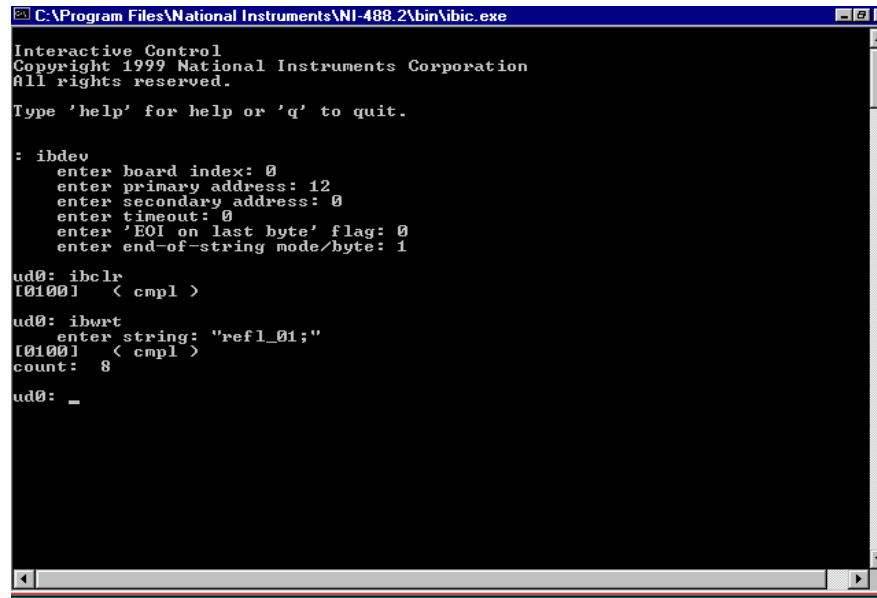
Figure 3-5 Interactive Control window



Step 9. When the C:\Program Files\National Instruments\ NI-488.2\bin\ibic.exe window appears, type `ibdev`. See Figure 3-6, “User Controller Window.”. Then you will be prompted to:

```
Enter board index: "0"  
Enter primary address: "12"  
Enter secondary address: "0"  
Enter timeout: "0"  
Enter 'EOI on last byte' flag: "0"  
Enter end-of-string byte/mode: "1"
```

Figure 3-6 User Controller Window



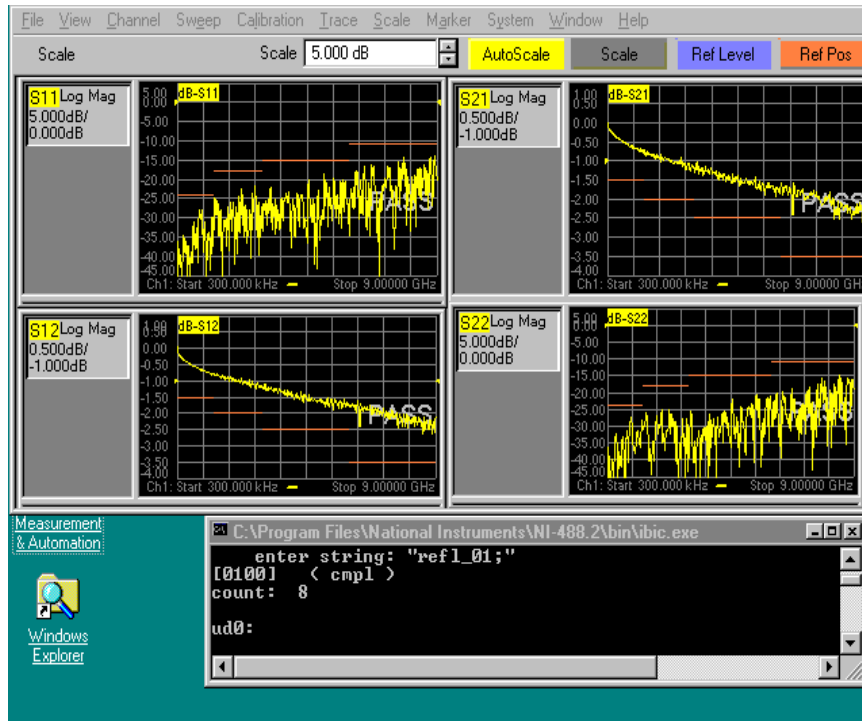
```
C:\Program Files\National Instruments\NI-488.2\bin\ibic.exe  
Interactive Control  
Copyright 1999 National Instruments Corporation  
All rights reserved.  
Type 'help' for help or 'q' to quit.  
  
: ibdev  
  enter board index: 0  
  enter primary address: 12  
  enter secondary address: 0  
  enter timeout: 0  
  enter 'EOI on last byte' flag: 0  
  enter end-of-string mode/byte: 1  
  
ud0: ibclr  
[0100] < cml >  
  
ud0: ibwrt  
  enter string: "refl_01;"  
[0100] < cml >  
count: 8  
  
ud0: _
```

Step 10. If you make a mistake, close the window and repeat steps 7, 8, and 9.

Step 11. When the prompt `ud0:` appears in the window, enter `ibclr`. This command clears the internal bus. When the `ud0:` prompt is returned after the `ibclr` command has been issued, you are ready to issue commands to the test set from this window.

Step 12. Use the mouse to size and position the PNA Series Network Analyzer window and the command window (C:\Program Files\National Instruments\NI-488.2\bin\ibic.exe) so that both windows are visible on the network analyzer screen. See [Figure 3-7](#), “Manual Control Window.”

Figure 3-7 Manual Control Window



How to Send a Manual Command

This procedure assumes the following:

- The instructions in the previous section (“[Preparing the Analyzer to Control the Test Set](#)”) have been performed.
- The command window (C:\Program Files\National Instruments\NI-488.2\bin\ibic.exe) shown at the bottom of [Figure 3-7](#) is visible on the analyzer.

Step 1. Select a command from [Table 3-2](#) or [Table 3-3](#).

Step 2. Click in the command window once to ensure that it is active.

Step 3. Verify that the last line of text appearing in the window is the ud0: prompt with nothing after it.

Step 4. Type `ibwrt` and then press the <Enter> key.

Step 5. When the prompt enter string: appears, type *all* of the following in exactly the order listed here:

- a double quotation mark (“
- the command selected in Step 1
- a semicolon
- another double quotation mark (“
- the <Enter> key

For example, to connect the Reflection port of the network analyzer to Test Port #3, type “`refl_03;`”<Enter>. To connect the Transmission port of the network analyzer to Test Port #7, type “`tran_07;`”<Enter>. See [Figure 3-6](#), “[User Controller Window](#).”

Step 6. Look at the PORT CONNECTION display on the test set to verify that the command was received.

Step 7. If the message on the PORT CONNECTION display is, “ERR: Invalid Command”, type `ibclr`<Enter> to clear the bus. Next, repeat Steps 3 through 5.

NOTE Use the <Up Arrow> key to recall previous commands. This will decrease typing time and errors.

NOTE The test set waits until it receives a semicolon before executing any command. Once the semicolon is received, the test set combines into a single string all of the characters it has received since the previous semicolon. The test set then treats the string as a single command.

NOTE

It is possible to issue several commands in a single line. For example, the following string connects the Reflection port to Test Port #2, connects the Transmission port to Test Port #5, and sets the Control Lines to OLOOL: “refl_02;tran_05;00001001;”<Enter>.

Common Errors in Manual Commands

This section explains several common errors.

Table 3-1 Common Errors in Manual Commands

Command(s) Issued	Explanation of Error	Solution
“refl_01”	Missing semicolon.	Send a semicolon: “,”
“refl_01” “tran_08;”	Missing semicolon in first command causes both commands to be interpreted as a single invalid command: “refl_01tran_08;”	Resend both commands with a semicolon in each: “refl_01;” “tran_08;”
“10101;”	Three leading zeroes are missing. (This is a binary Control Line command. It needs three leading zeroes.) (Decimal Control Line commands don't need leading zeroes.)	Resend the command with leading zeroes included: “00010101;”

A List of GPIB Commands

Table 3-2 Test Port Commands

Connection Path	GPIB Command
Reflection to Port 1	refl_01
Reflection to Port 2	refl_02
Reflection to Port 3	refl_03
Reflection to Port 4	refl_04
Reflection to Port 5	refl_05
Reflection to Port 6	refl_06
Reflection to Port 7	refl_07
Reflection to Port 8	refl_08
Transmission to Port 1	tran_01
Transmission to Port 2	tran_02
Transmission to Port 3	tran_03
Transmission to Port 4	tran_04
Transmission to Port 5	tran_05
Transmission to Port 6	tran_06
Transmission to Port 7	tran_07
Transmission to Port 8	tran_08
Reset	*rst
Reflection Termination	*r_term
Transmission Termination	*t_term
All Termination	*all_term

NOTE Every Test Port is connected to one and only one of the following at any instant:

- Reflection port of the test set.
- Transmission port of the test set.
- 50 Ω termination inside the test set.

Table 3-3

Control Line Commands

GPIB Command			Resulting Control Line States ^a (C5, C4, C3, C2, C1)
Mnemonic	Decimal	Binary	
c1_on			xxxxL
c1_off			xxxxO
c2_on			xxxLx
c2_off			xxxOx
c3_on			xxLxx
c3_off			xxOxx
c4_on			xLxxx
c4_off			xOxxx
c5_on			Lxxxx
c5_off			Oxxxx
	0	00000000	O0000
	1	00000001	O000L
	2	00000010	O00LO
	3	00000011	O00LL
	4	00000100	O0LOO
	5	00000101	O0LOL
	6	00000110	O0LLO
	7	00000111	O0LLL
	8	00001000	OLOOO
	9	00001001	OLOOL
	10	00001010	OLOLO
	11	00001011	OLOLL
	12	00001100	OLLOO
	13	00001101	OLLOL
	14	00001110	OLLLO
	15	00001111	OLLLL
	16	00010000	LOOOO

Table 3-3 Control Line Commands

GPIB Command			Resulting Control Line States ^a (C5, C4, C3, C2, C1)
Mnemonic	Decimal	Binary	
	17	00010001	LOOOL
	18	00010010	LOOLO
	19	00010011	LOOLL
	20	00010100	LOLOO
	21	00010101	LOLOL
	22	00010110	LOLLO
	23	00010111	LOLLL
	24	00011000	LLOOO
	25	00011001	LLOOL
	26	00011010	LLOLO
	27	00011011	LLOLL
	28	00011100	LLLOO
	29	00011101	LLLOL
	30	00011110	LLLLO
	31	00011111	LLLLL

a. L = "Low"; O = "Open"; x = "Unchanged"

To connect all test ports to their internal 50 Ω loads, send the following command:

```
OUTPUT 712; "*all_term"
```

Restoring the Analyzer to its Normal Configuration

It is a good idea to restore the analyzer to its normal configuration once you are finished using the analyzer to control the test set. To accomplish this, use the following procedure:

- Step 1.** Type **q** in the command window, then press the <Enter> key. This terminates the interactive control session on the analyzer.
- Step 2.** In the analyzer window, click **System** on the menu bar, then scroll down to **Configure**, then click **SICL/GPIB**.
- Step 3.** In the SICL/GPIB window, click **Talker/Listener** and then **OK**. This allows other devices to control the analyzer.

Disaster Recovery

This section provides recovery procedures for the following problems:

- [Malfunctioning Command Window](#)
- [Malfunctioning Network Analyzer](#)

Malfunctioning Command Window

Symptoms

Any of the following symptoms indicates a malfunctioning command window.

- No ud0: prompt is returned when the ibclr command is executed.
- An error message is returned when the ibdev command is properly executed.
- Upon turning on the network analyzer, the following message appears: “The device at ‘AT-GPIB/TNT’ cannot be stopped because a program is still accessing it.”
- When the Recovery Procedure described below is performed, the “AT-GPIB/TNT” icon observed in Step 6 has a red slash through it (indicating that the device is presently disabled). However, when Step 7 is performed, the pop-up menu has “Disable” as a menu item (indicating that the device is presently enabled!).

Recovery Procedure

- Step 1.** Close every application that is running.
 - a.** If an application’s window is open, click on the X in the upper right-hand corner of the window.
 - b.** If an application’s window has been minimized, locate its icon on the task bar at the bottom of the network analyzer screen. See [Figure 3-8](#). Click on the icon. This will open the application’s window. Next, click on the X in the upper right-hand corner of the window to close the application.
 - c.** When all applications are closed, the task bar will look like the one in [Figure 3-9](#).

Figure 3-8 Network Analyzer Screen With Four Applications Running

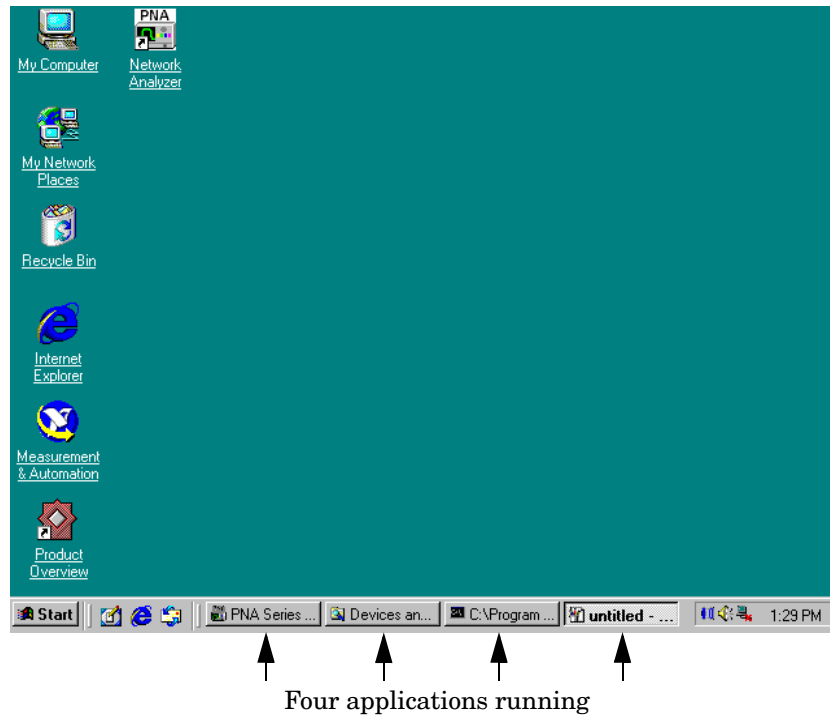
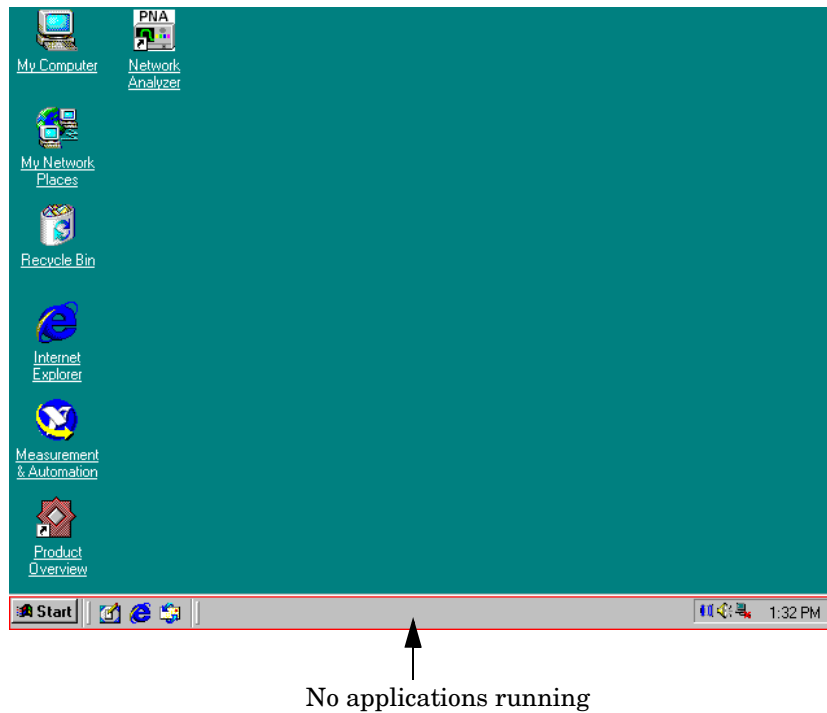
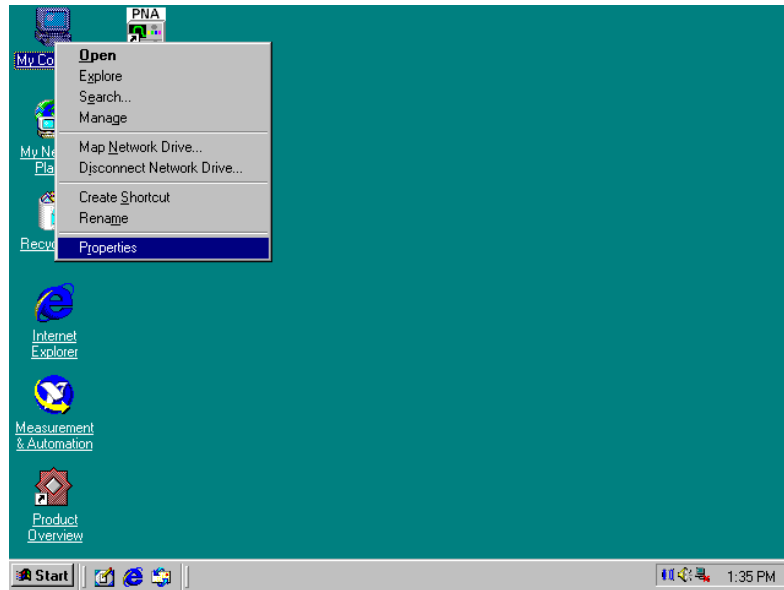


Figure 3-9 Network Analyzer Screen With No Applications Running



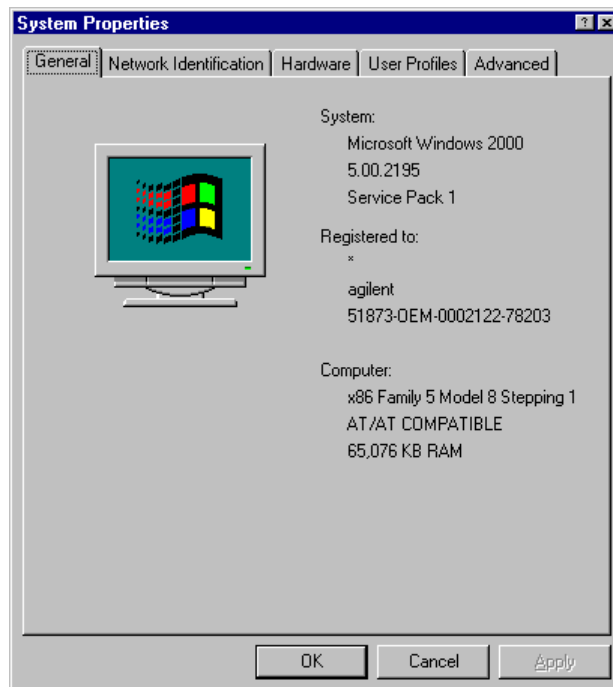
Step 2. *Right*-click on the “My Computer” icon on the network analyzer screen. A drop-down menu will appear as shown in [Figure 3-10](#).

Figure 3-10 Analyzer Screen After Right-Click On “My Computer” Icon



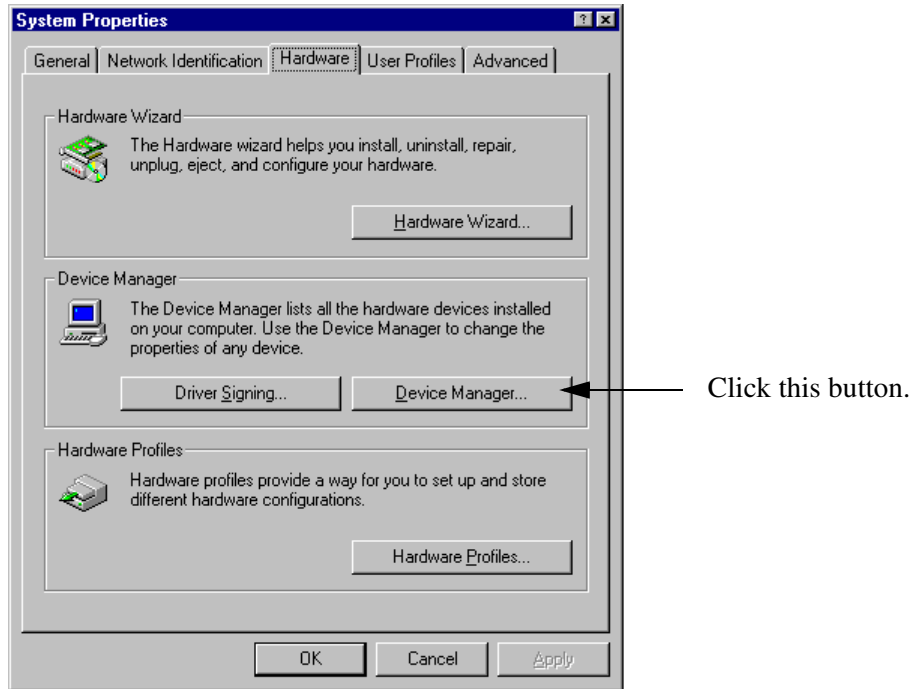
Step 3. Click **Properties** in the drop-down menu. A “System Properties” window will appear as shown in [Figure 3-11](#).

Figure 3-11 “System Properties” Window



- Step 4.** Click the **Hardware** tab shown in [Figure 3-11](#). The result is shown in [Figure 3-12](#).

Figure 3-12 “Hardware” Tab In “System Properties” Window



- Step 5.** Click the **Device Manager** button. After you do so, there will be a 10-second delay before the “Device Manager” window appears. This window is shown in [Figure 3-13](#) and [Figure 3-14](#).
- Step 6.** Check to see if the “AT-GPIB/TNT” icon is visible as shown in [Figure 3-14](#). If it is not, click on the “National Instruments GPIB Interfaces” icon as in [Figure 3-13](#).

Figure 3-13 Device Manager Window

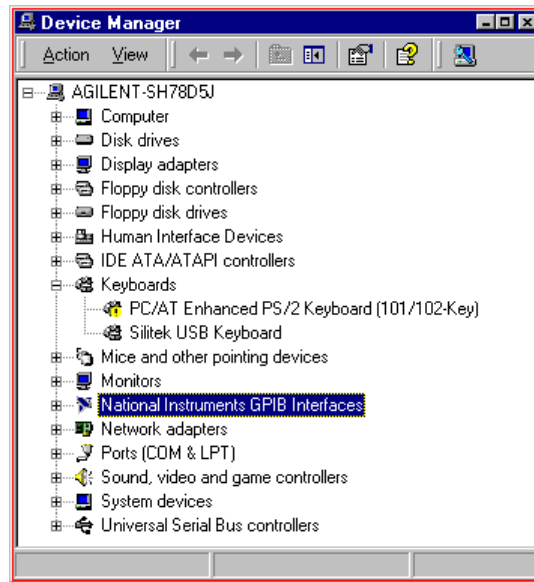
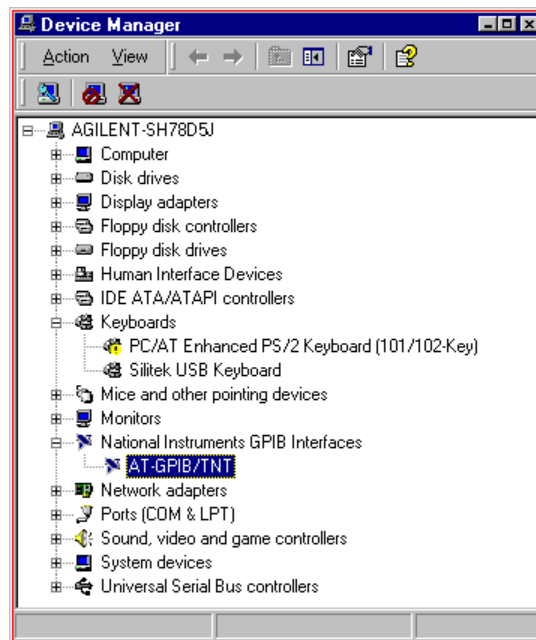


Figure 3-14 Device Manager Window With “AT-GPIB/TNT” Icon Visible

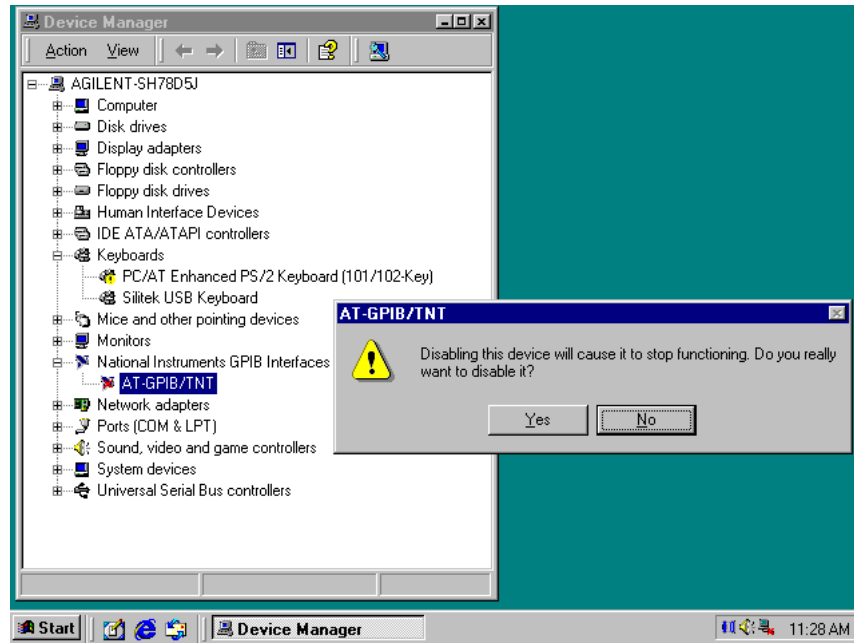


Step 7. *Right*-click on the “AT-GPIB/TNT” icon. A menu will pop up.

Step 8. Click **Disable** on the menu.

Step 9. The following message will pop up: “Disabling this device will cause it to stop functioning. Do you really want to disable it?” Click “Yes.” See [Figure 3-15](#).

Figure 3-15 GPIB Device Disabling Message



Step 10. *Right*-click on the “AT-GPIB/TNT” icon once again. A menu will pop up.

Step 11. Click **Enable** on the menu.

Step 12. Close the Device Manager window by clicking on the X in the upper right-hand corner of the window.

Step 13. Close the System Properties window by clicking on the X in the upper right-hand corner of the window.

The recovery procedure is now complete. To resume control of the test set, perform the procedure described in “[Preparing the Analyzer to Control the Test Set](#)” on page 3-2.

Malfunctioning Network Analyzer

Symptoms

Any abnormality in the network analyzer’s behavior indicates a malfunction of the analyzer. An example would be the failure of icons to appear on the screen of the analyzer.

Recovery Procedure

Perform a Hard Reset on the PNA Series network analyzer as follows: First, make sure the power is on (indicated by the power switch being green). Next, hold the power switch in for about 20 seconds, or until the color of the switch changes from green to orange. Release the switch, then press it again and release it immediately.

Calibrating the Network Analyzer

This chapter shows you how to calibrate the network analyzer so that it can be used to verify the performance of the test set.

The calibration technique presented in this chapter uses an Electronic Calibration (ECal) Module and is by far the easiest of all 2-port calibration techniques. Consult the Help facility built into the PNA Series Network Analyzer for a comprehensive tutorial on this calibration method and on many others.

This chapter contains the following sections:

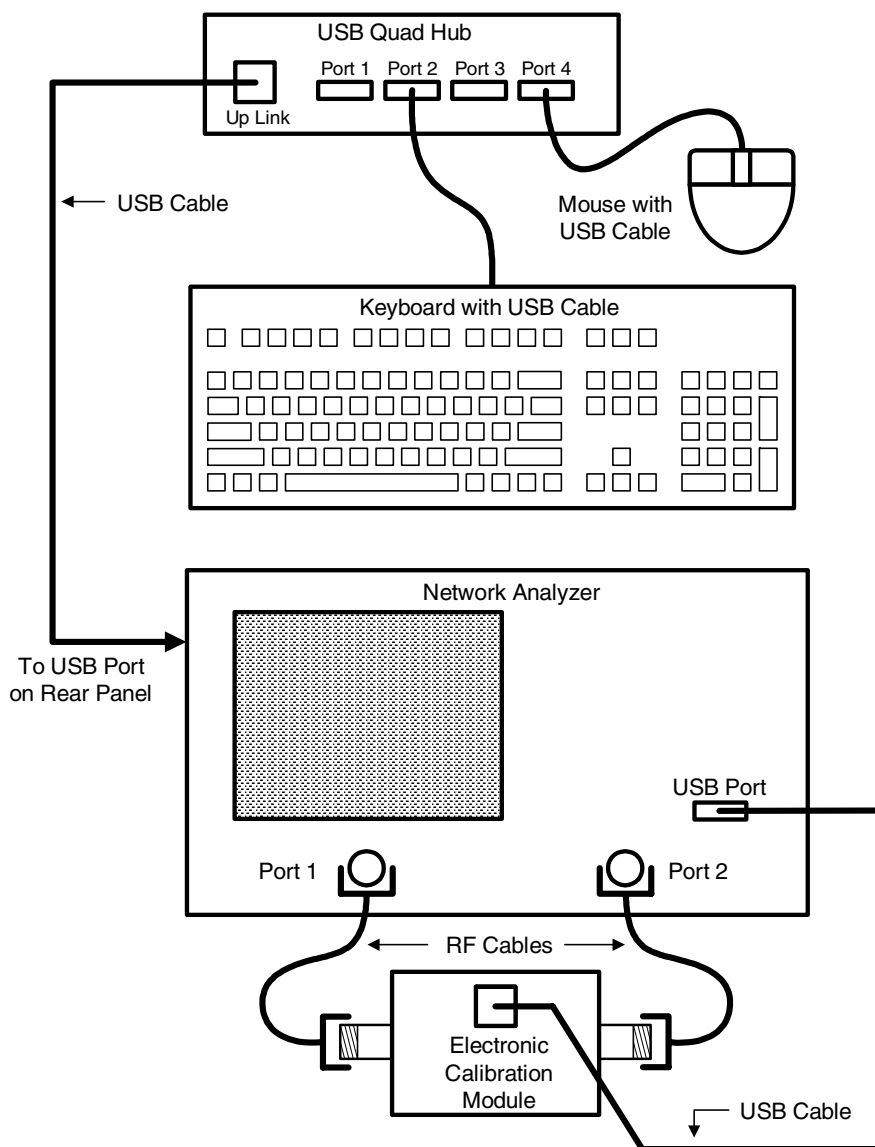
- [Performing the Calibration](#)
- [Renaming the Calibration File](#)
- [Recalling and Examining Calibrations](#)

Performing the Calibration

Step 1. Make the connections shown in [Figure 4-1](#).

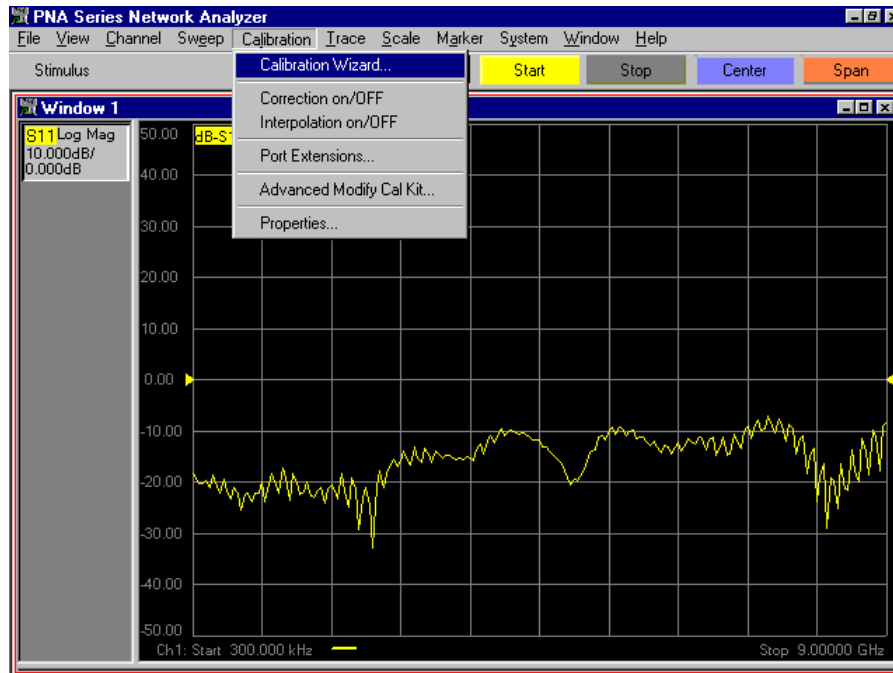
The figure shows two RF cables connecting the two ports of the network analyzer to the two ports of the ECal Module. The 24" RF cables (Agilent Part No. 8120-4781 or equivalent) listed in [Table 2-2](#) on [page 2-3](#) should be used. Make sure the connectors are snugly tightened but not overtorqued. A torque wrench set to 12 inch-pounds (Agilent Part No. 8710-1766 or equivalent) is recommended.

Figure 4-1 Calibrating the Network Analyzer



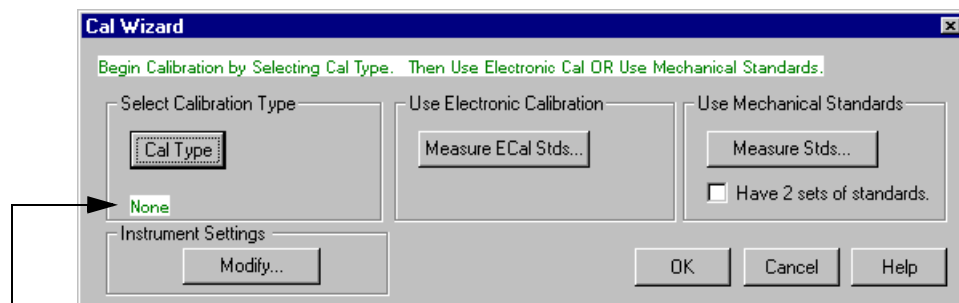
- Step 2.** Press the Preset button on the Network Analyzer.
- Step 3.** Verify that the Ready light on the ECal Module is green.
- Step 4.** On the network analyzer, click **Calibration** on the menu bar, then click the **Calibration Wizard** button. See [Figure 4-2](#).

Figure 4-2 Calibration Menu on Network Analyzer



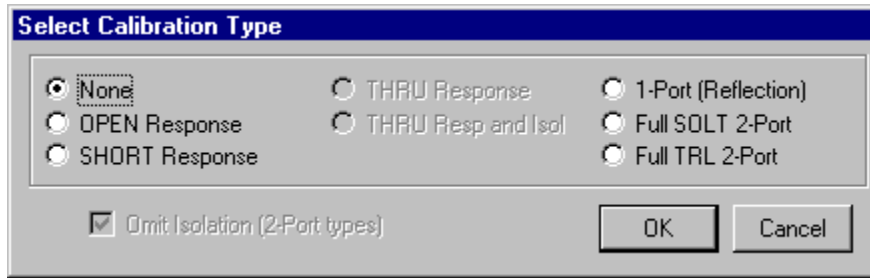
- Step 5.** When the window shown in [Figure 4-3](#) comes up, click the **Cal Type** button. The Cal Type window shown in [Figure 4-4](#) will then pop up.

Figure 4-3 Cal Wizard Window



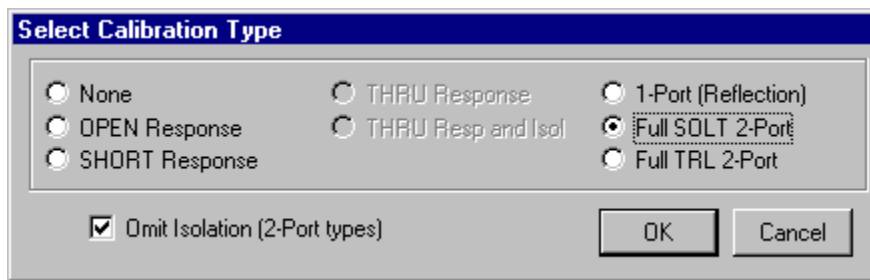
The currently selected calibration type is “None”.

Figure 4-4 Cal Type Window When It Is First Opened



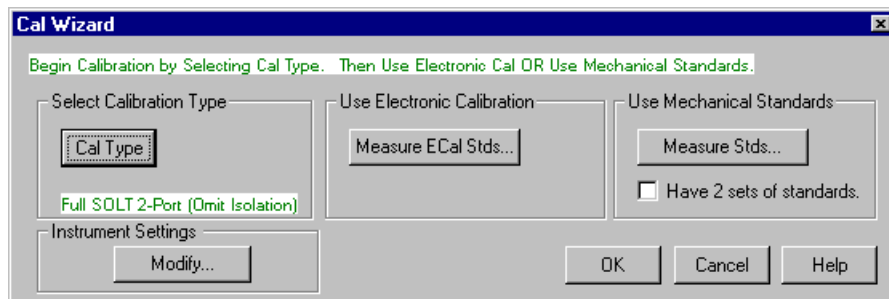
Step 6. Click the **Full SOLT 2-Port** button. The result is shown in [Figure 4-5](#).

Figure 4-5 Cal Type Window After Selecting “Full SOLT 2-Port”



Step 7. Click the **OK** button. The Cal Type window will then close and the Cal Wizard window will pop back up as shown in [Figure 4-6](#).

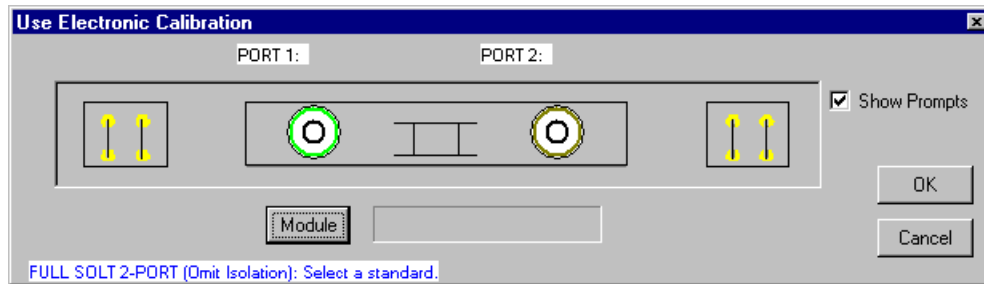
Figure 4-6 Cal Wizard Menu After Selection Of Cal Type Is Complete



Step 8. Verify that the currently selected calibration type shown in the Cal Wizard window is “Full SOLT 2-Port (Omit Isolation)” as shown in [Figure 4-6](#).

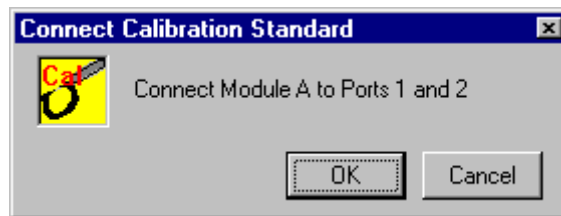
Step 9. Click the **Measure ECal Stds** button in the Cal Wizard window. The window shown in [Figure 4-7](#) will then pop up.

Figure 4-7 Electronic Calibration Window



Step 10. Click the **Module** button. The window shown in [Figure 4-8](#) will then pop up.

Figure 4-8 Module Connection Message

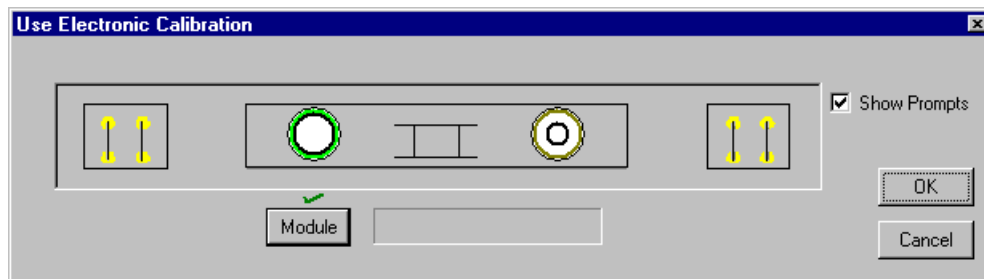


Step 11. Click the **OK** button. (The connections requested in [Figure 4-8](#) were made in [Step 1](#) of “Performing the Calibration” on [page 4-2](#).) This window will close, the window shown in [Figure 4-7](#) will pop back up, and the calibration will begin.

The network analyzer will complete the calibration with no further operator actions required. The calibration will take about 5 seconds.

Step 12. Verify that the calibration has been completed. This is shown by a check mark over the **Module** button as shown in [Figure 4-9](#).

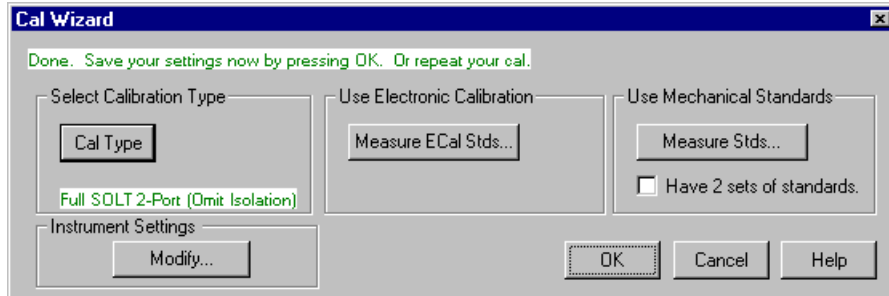
Figure 4-9 Electronic Calibration Window After Cal Is Complete



Step 13. Click the **OK** button shown in [Figure 4-9](#). The window will close; the Cal Wizard window will pop back up with the following message as shown in [Figure 4-10](#): “Done. Save your settings now by pressing OK”.

Or repeat your cal.”

Figure 4-10 Cal Wizard Window After Cal Is Complete



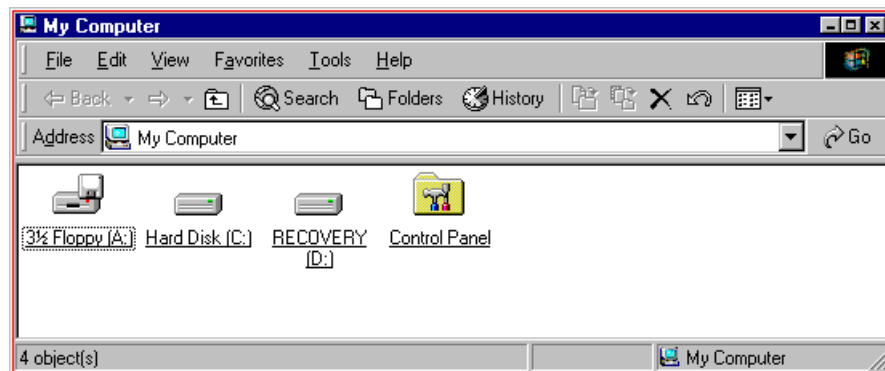
- Step 14.** Get a pen or pencil and a piece of paper. [Step 16](#) will ask you to write down a filename.
- Step 15.** Click the **OK** button. The calibration will now be saved to disk in the following directory: C:\Program Files\Agilent\Network Analyzer\Documents. The file will have a “.cst” suffix.
- Step 16.** Copy down the name of the file into which the calibration is saved. The name will appear on the screen for about 10 seconds. Copy the filename, not the path. (The path is listed in [Step 15](#) above.) A typical filename would be, “at006.cst”. Record also the date and time that the calibration was performed. (The date and time can be used to locate the file in case the filename you write down is incorrect or incomplete.)

Renaming the Calibration File

In this section you will rename the calibration file to make it easier to identify and retrieve.

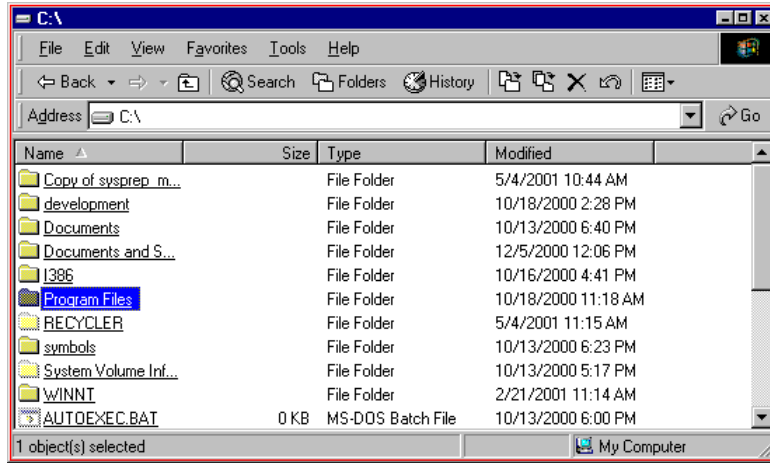
- Step 1.** Minimize the network analyzer window. (If you are not sure how to do this, refer to [Step 5](#) of “Preparing the Analyzer to Control the Test Set” on page 3-2.)
- Step 2.** Double-click the “My Computer” icon on the network analyzer display. This icon can be seen in the upper left-hand corner of Figure 3-8 on page 3-14.
- Step 3.** The window shown in [Figure 4-11](#) will pop up. Click the Hard Disk (C:) icon in that window.

Figure 4-11 “My Computer” Window



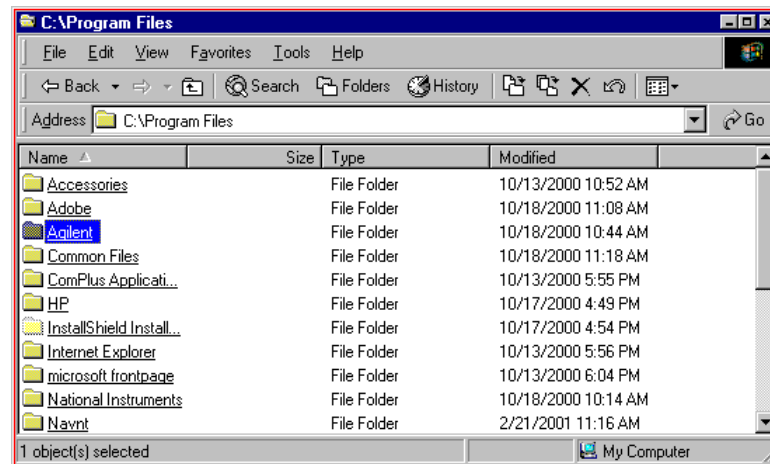
Step 4. The window shown in [Figure 4-12](#) will pop up. Click the “Program Files” icon.

Figure 4-12 **Root Directory of the C: Drive**



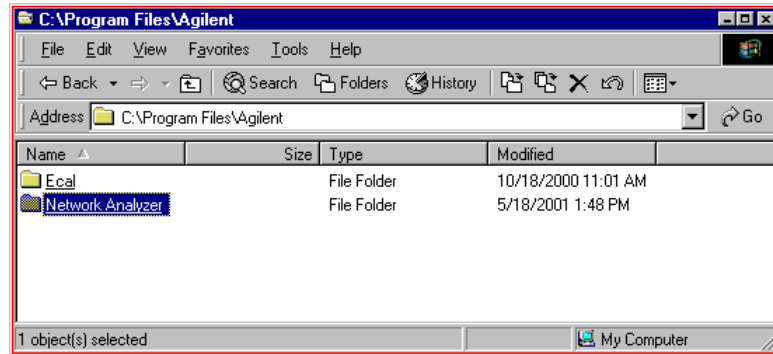
Step 5. The window shown in [Figure 4-13](#) will pop up. Click the “Agilent” icon.

Figure 4-13 **“C:\Program Files” Directory**



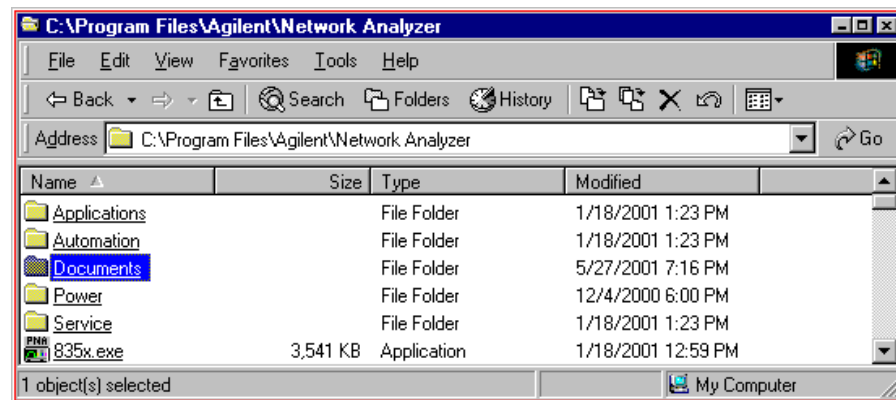
Step 6. The window shown in [Figure 4-14](#) will pop up. Click the “Network Analyzer” icon.

Figure 4-14 “C:\Program Files\Agilent” Directory



Step 7. The window shown in [Figure 4-15](#) will pop up. Click the “Documents” icon.

Figure 4-15 “C:\Program Files\Agilent\Network Analyzer” Directory



Step 8. The window shown in [Figure 4-16](#) will pop up. It contains all of the calibration files. Click the **Type** button above the files so that they will be listed by file type. The result is shown in [Figure 4-17](#).

Figure 4-16 Directory Containing Cal Files

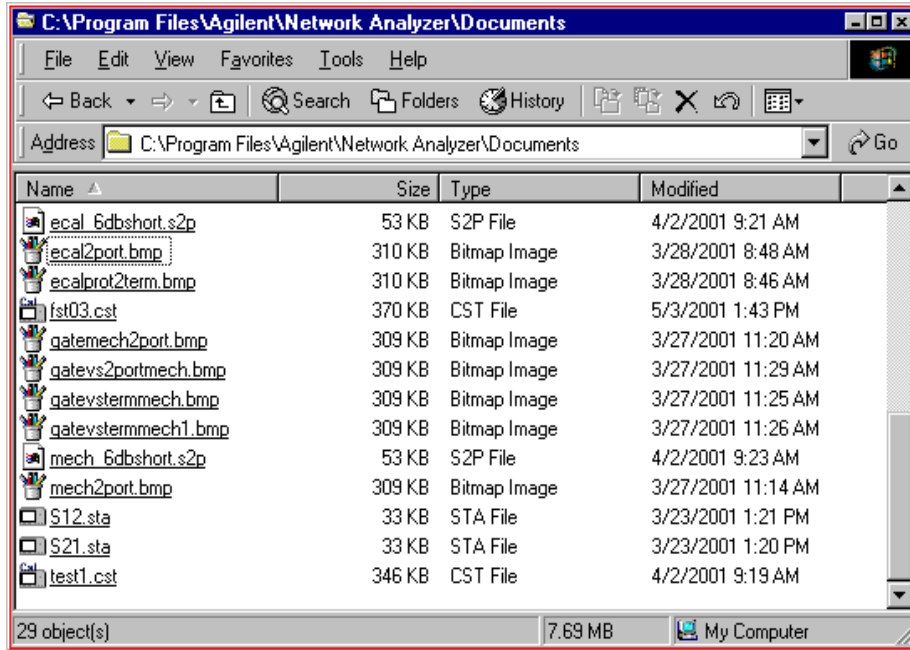
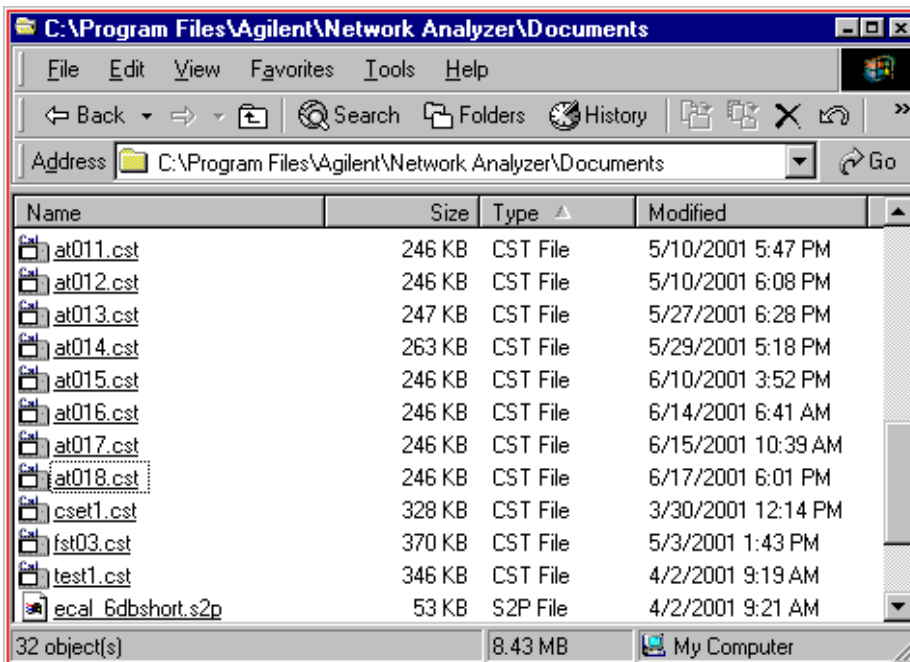
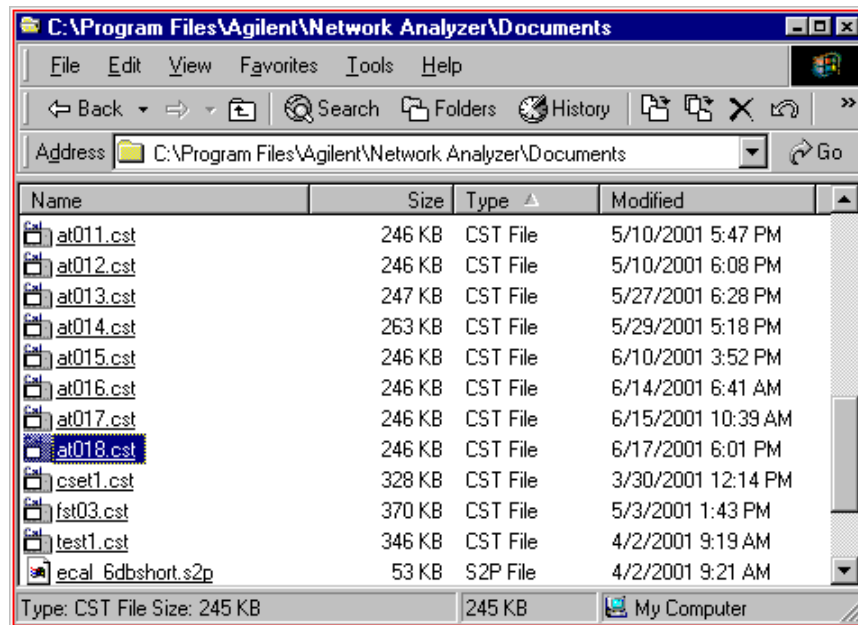


Figure 4-17 Directory Containing Cal Files After Clicking “Type” Button



Step 9. Move the cursor over the filename that was copied down in [Step 16](#) of “[Performing the Calibration](#)” on [page 4-6](#). (If you were not able to copy down the filename, select the “.cst” file whose date and time correspond to when you completed the calibration.) Do *not* click the filename you have selected. Just keep the cursor positioned over the filename for about two seconds (until it is highlighted as shown in [Figure 4-18](#)).

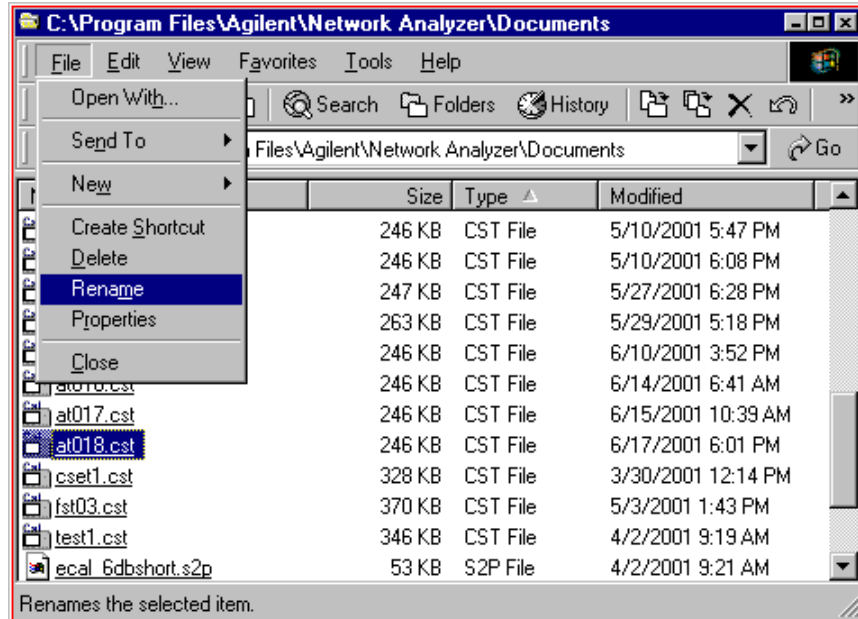
Figure 4-18 Cal File Highlighted



Step 10. Move the cursor off the selected filename (either to the left or to the right). The selected filename will remain highlighted.

Step 11. Click **File** on the menu bar, then scroll down and click the **Rename** button as shown in [Figure 4-19](#).

Figure 4-19 Preparing to Rename the Cal File

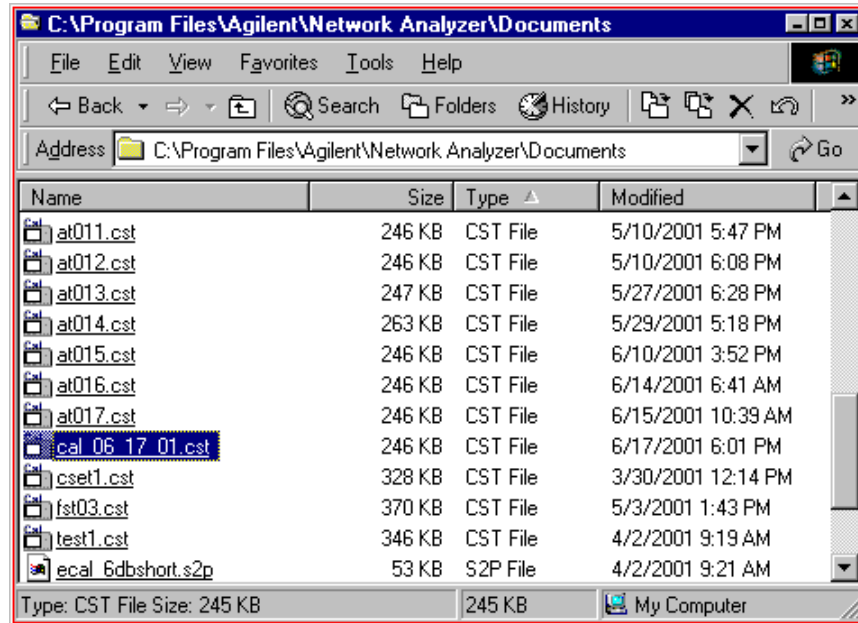


Step 12. Give the file a new name that includes the following:

- The date the cal was performed
- The suffix “.cst”

For example, if the calibration was performed on 6/17/01, a filename of “cal_06_17_01.cst” would be appropriate. See [Figure 4-20](#).

Figure 4-20 The Cal File After It Has Been Renamed



Step 13. Record the new name of the calibration file in [Table 4-1](#). The file must have a suffix of “.cst”.

Table 4-1 Name of Calibration File

<input type="text"/>	.cst
----------------------	------

Recalling and Examining Calibrations

This section contains the following subsections:

- [How to Recall a Calibration](#)
- [How to Turn a Calibration On and Off](#)
- [How to Examine the Properties of a Calibration](#)

How to Recall a Calibration

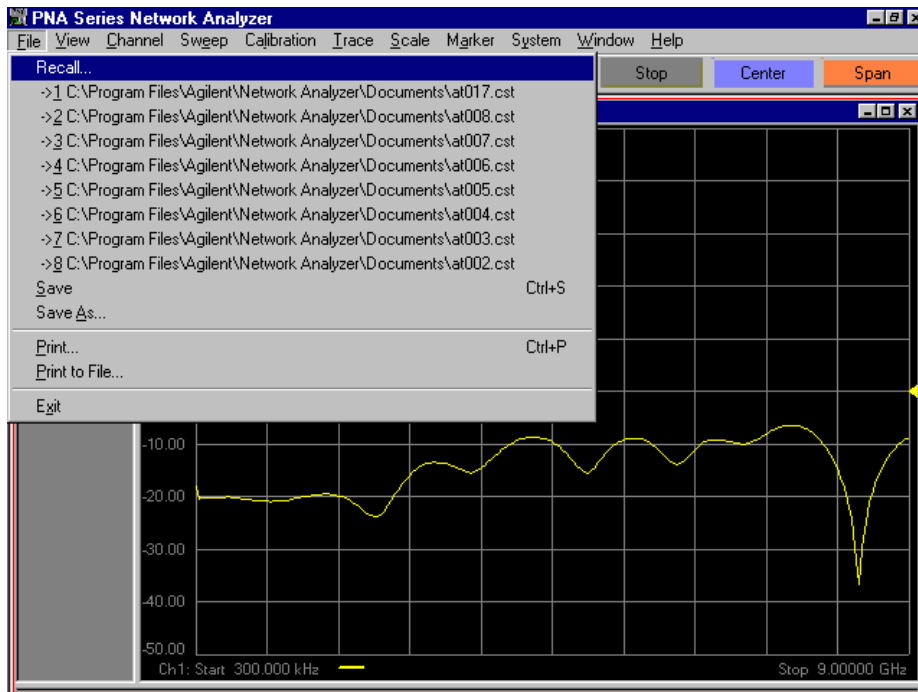
There are two methods of recalling a calibration. The first and more general method is used when the calibration file is not on the “quick recall” list that appears whenever **File** is clicked on the menu bar. The second method is used when the calibration file is on the “quick recall” list. (This list displays the last eight files that were recalled.)

The examples shown here assume that the desired calibration file is named, “cal_06_17_01.cst”.

Method 1. Calibration File Is Not On “Quick Recall” List

- Step 1.** In the network analyzer window, click **File** on the menu bar, then scroll down and click the **Recall** button. See [Figure 4-21](#).

Figure 4-21 File Recall Button



Step 2. The Recall window shown in Figure 4-22 will pop up. Move the horizontal scroll box until the desired calibration file is visible, then click on it. The window will momentarily appear as shown in Figure 4-23. The file will then be recalled and the window will close.

Figure 4-22 File Recall Window

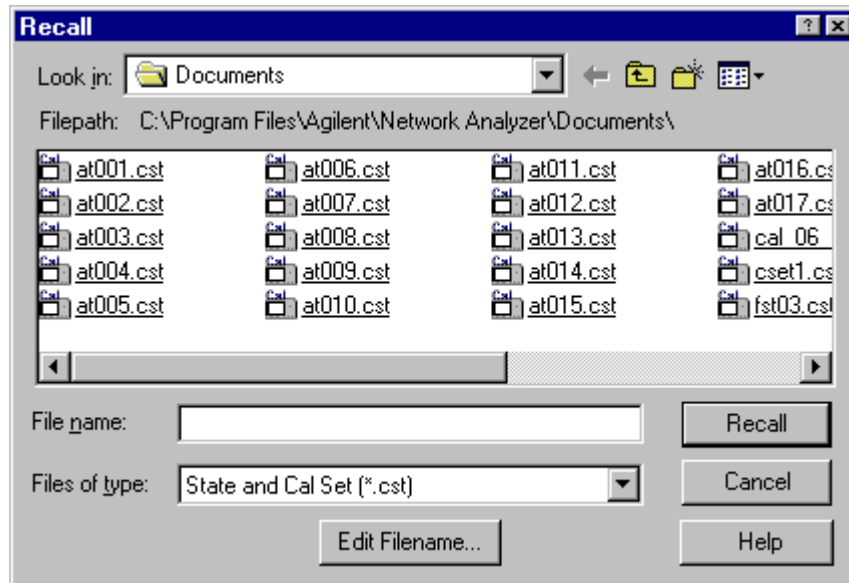
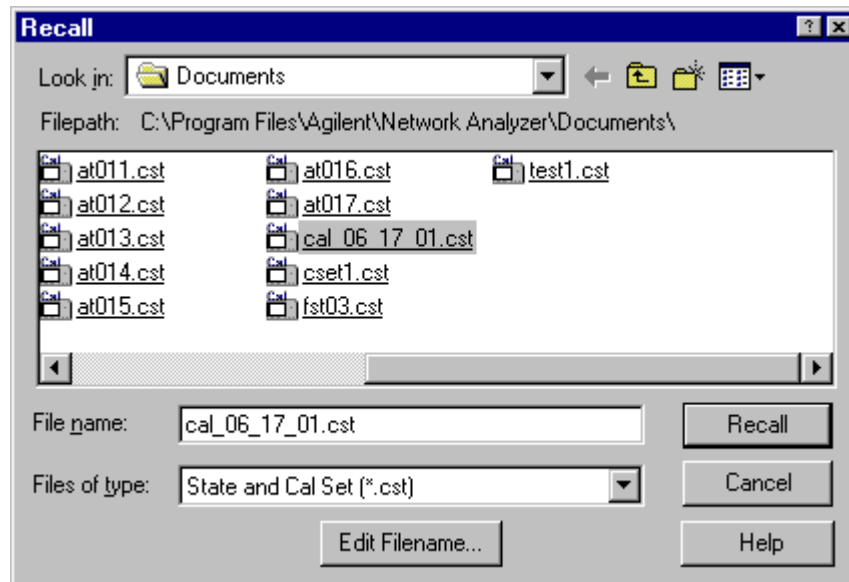


Figure 4-23 File Recall Window After Clicking the Desired Calibration File

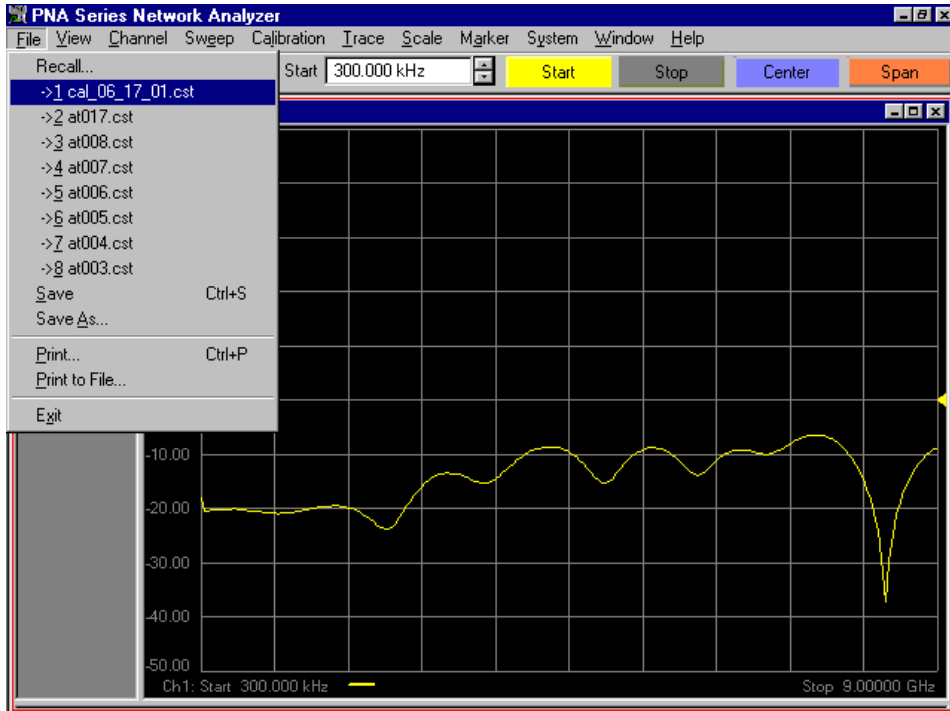


Method 2. Calibration File Is On “Quick Recall” List

Click **File** on the menu bar, then scroll down to the desired calibration file and click it. See [Figure 4-24](#). The file will immediately be recalled.

Figure 4-24

Recalling a Calibration File That Is On the “Quick Recall” List



How to Turn a Calibration On and Off

Click **Calibration** on the menu bar, then scroll down to the **Correction On/Off** button.

- If the calibration is turned on, the button will have a check mark in front of it and the text will read, “Correction ON/off” as in [Figure 4-25](#).
- If the calibration is turned off, the button will have *no* check mark in front of it and the text will read, “Correction on/OFF” as in [Figure 4-26](#).

To change from one state to the other, just click the button. Try it! The trace will change instantaneously. (Compare the trace in [Figure 4-25](#) with the trace in [Figure 4-26](#).)

Figure 4-25 Calibration Turned On

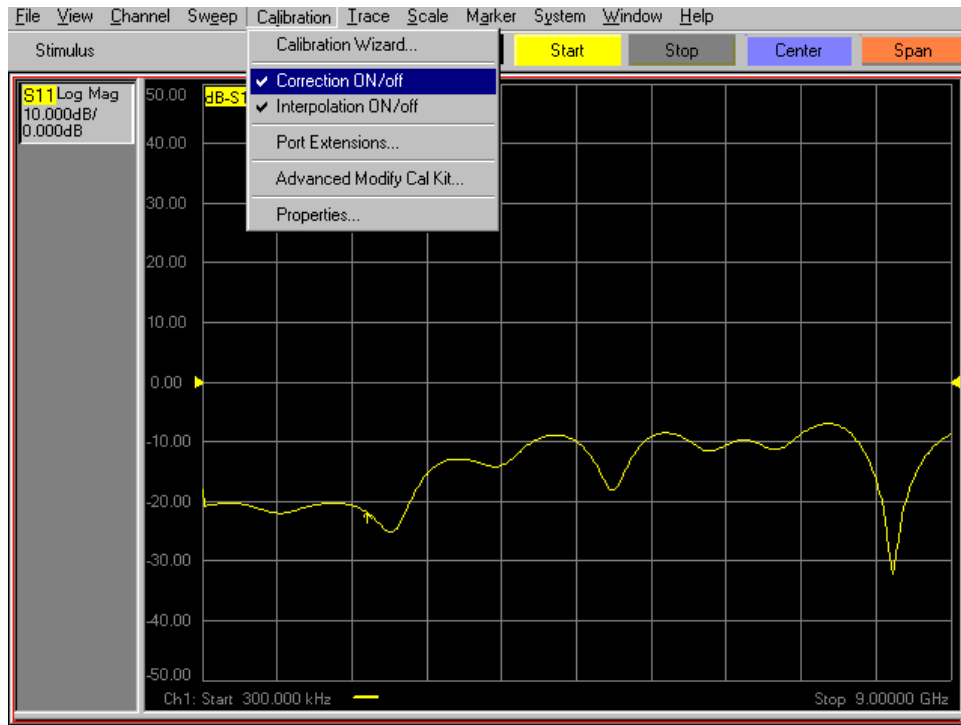
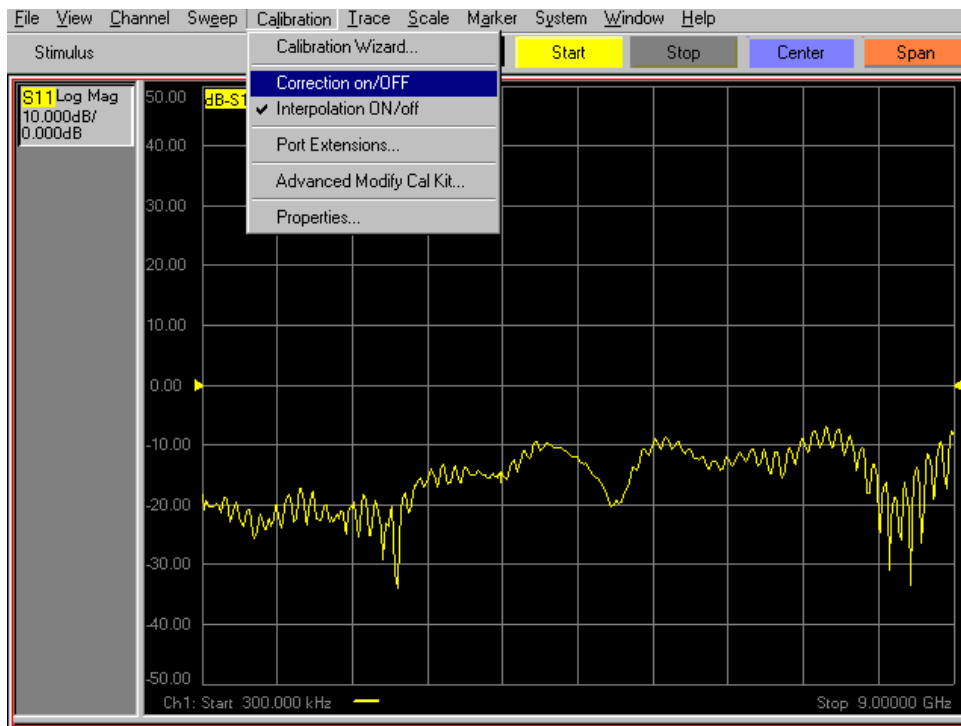


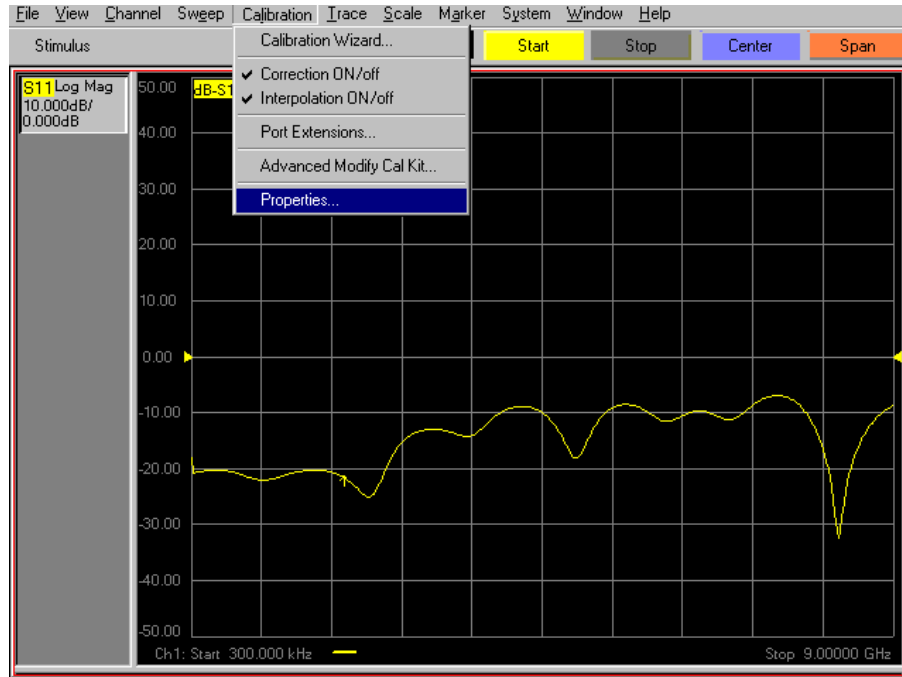
Figure 4-26 Calibration Turned Off



How to Examine the Properties of a Calibration

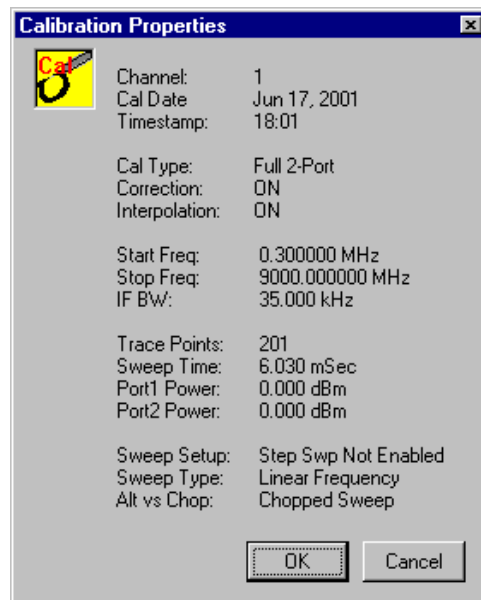
Step 1. Click **Calibration** on the menu bar, then scroll down to the **Properties** button and click it. See [Figure 4-27](#).

Figure 4-27 Calibration Properties Button



Step 2. The window shown in [Figure 4-28](#) will pop up. Examine it carefully.

Figure 4-28 Calibration Properties Window



This chapter contains the following sections:

- [Setting Test Limits](#)
- [Test Strategy](#)
 - [Insertion Loss](#)
 - [Return Loss](#)
 - [Crosstalk](#)
- [Setting Up Limit Testing](#)
 - [Limit Testing for Insertion Loss](#)
 - [Limit Testing for Return Loss \(Port Active\)](#)
 - [Limit Testing for Return Loss \(Port Off\)](#)
 - [Limit Testing for Crosstalk](#)
- [Verifying Return Loss and Insertion Loss Specifications](#)
- [Verifying Crosstalk Specs](#)

Setting Test Limits

A test limit is the pass/fail criterion for a measurement. A test limit can be either a maximum limit or a minimum limit. With a maximum limit, the measurement must not go above the limit in order for the Device Under Test (DUT) to pass. With a minimum limit, the measurement must not go below the limit in order for the DUT to pass.

Test limits are derived from the specifications of the DUT, but are usually different from them because every measurement has some uncertainty associated with it. In order to ensure that a performance specification is met, a “guard band” must be added to account for the uncertainty in the measurement. This can be done by applying [Equation 5-1](#).

Equation 5-1 How to Set Test Limits

$$\text{Test Limit} = \text{Specification} \pm \text{Measurement Uncertainty}$$

In [Equation 5-1](#), the plus sign is selected if the limit is a minimum limit, and the minus sign is selected if the limit is a maximum limit. For example, if a specification is 20 dB *minimum* and the measurement uncertainty is 2 dB, then the test limit should be set to 22 dB. In other words, the *measured* value in this example must be 22 dB or greater to insure that the *actual* value is 20 dB or greater. Similarly, if a specification is 20 dB *maximum* and the measurement uncertainty is 2 dB, then the test limit should be set to 18 dB. In other words, the *measured* value in this example must be 18 dB or less to insure that the *actual* value is 20 dB or less.

The measurement uncertainties listed in [Table 5-1](#) apply to the performance tests described in this document. The uncertainties are derived from the equipment used and the specific measurements performed.

Table 5-1 Measurement Uncertainties for Performance Verification Tests

Measurement (dB)	Band 1 (300 kHz - 1.3 GHz)	Band 2 (1.3 - 3 GHz)	Band 3 (3 - 6 GHz)	Band 4 (6 - 9 GHz)
Crosstalk	5	5	5	7
Return Loss (port active)	1.5	1.0	0.5	0.5
Return Loss (port off)	1.5	1.5	1.0	0.5
Insertion Loss	0.3	0.3	0.3	0.3

Applying Equation 5-1 to the uncertainties listed in Table 5-1 and to the guaranteed specifications listed in Table 1-1 on page 1-4, we obtain the test limits in Table 5-2:

Table 5-2 Derivation of Test Limits for Performance Verification of Test Set

Parameter	Specification	Measurement Uncertainty	Test Limit
Crosstalk ^{a,b}	1) -110 dB ^c 2) -105 dB ^d 3) -95 dB ^e 4) -90 dB ^f	1) 5 dB ^c 2) 5 dB ^d 3) 5 dB ^e 4) 7 dB ^f	1) -115 dB ^c 2) -110 dB ^d 3) -100 dB ^e 4) -97 dB ^f
Return Loss (port active) ^g	1) 24 dB ^c 2) 18 dB ^d 3) 14 dB ^e 4) 9 dB ^f	1) 1.5 dB ^c 2) 1.0 dB ^d 3) 0.5 dB ^e 4) 0.5 dB ^f	1) 25.5 dB ^c 2) 19 dB ^d 3) 14.5 dB ^e 4) 9.5 dB ^f
Return Loss (port off) ^h	1) 26 dB ^c 2) 20 dB ^d 3) 16 dB ^e 4) 14 dB ^f	1) 1.5 dB ^c 2) 1.5 dB ^d 3) 1.0 dB ^e 4) 0.5 dB ^f	1) 27.5 dB ^c 2) 21.5 dB ^d 3) 17 dB ^e 4) 14.5 dB ^f
Insertion Loss ⁱ	1) 1.5 dB ^c 2) 2.0 dB ^d 3) 2.5 dB ^e 4) 3.5 dB ^f	0.3 dB (all bands)	1) 1.8 dB ^c 2) 2.3 dB ^d 3) 2.8 dB ^e 4) 3.8 dB ^f

- a. Between any two non-connected signal paths
- b. Conditions: IF Bandwidth = 100 Hertz, Averaging = 10
- c. Band 1 (300 kHz to 1.3 GHz)
- d. Band 2 (1.3 GHz to 3.0 GHz)
- e. Band 3 (3.0 GHz to 6.0 GHz)
- f. Band 4 (6.0 GHz to 9.0 GHz)
- g. When using an external termination on the Reflection or Transmission port
- h. When using one of the 50 Ω internal terminations
- i. From any test set port to the Reflection or Transmission port

Test Strategy

The overall test strategy of this chapter is to verify each guaranteed specification by means of a limit test that is stored and recalled on the network analyzer. This strategy minimizes the number of cable connections and the amount of time required to complete the performance verification. It also minimizes the likelihood of operator error.

Whenever one of the limit test files is recalled, it will do the following to the network analyzer:

- Select the correct S-parameter measurement
- Activate the proper calibration
- Put a title on the screen
- Scale the axes
- Load a limit table
- Display limit lines
- Turn on limit testing

Limit testing tells the user immediately whether the Device Under Test passes or fails the test. The pass / fail limits are set by the limit table. In a manner to be described later in this section, the limit table for each test will be derived from the test limits presented in [Table 5-2](#).

Once the limit test file has been created for a test, the user will run the test as follows:

- Make the necessary cable connections.
- Issue any needed commands to the test set.
- Recall the limit test file.

Test results will be immediately displayed on the screen of the network analyzer.

The specifications that are to be verified fall into three general categories:

- Insertion Loss
- Return Loss
- Crosstalk

The remainder of this section describes, for each category, the S-parameter measurement that will be used to verify the specifications. The test limits of [Table 5-2](#) will be converted to S-parameter test limits for each category.

Insertion Loss

For this measurement, Port 1 of the network analyzer will be connected to one of the test ports of the test set, and Port 2 of the network analyzer will be connected either to the Reflection port or to the Transmission port of the test set. By definition,

$$\text{Insertion Loss} = -S_{21}$$

where Insertion Loss and S_{21} are both in units of dB.

The network analyzer will be configured to measure S_{21} . Limit lines will be set up in such a way that each limit equals the negative of the corresponding insertion loss test limit shown in [Table 5-2](#). For example, if an insertion loss test limit happens to be 1.0 dB, the corresponding S_{21} limit will be -1.0 dB.

Insertion loss is a maximum spec. Therefore, each S_{21} limit will be set up as a minimum limit. For example, if an insertion loss test limit happens to be 1.0 dB, the limit table will be set up so that S_{21} must be above -1.0 dB in order for the instrument to pass. (S_{21} will always be zero or negative because the test set provides no amplification. In units of dB, S_{21} can range from zero to minus infinity.)

Return Loss

For this measurement, Port 1 of the network analyzer will be connected to one of the test ports of the test set, and Port 2 of the network analyzer will be connected to the Reflection port of the test set. By definition,

$$\text{Return Loss} = -S_{11}$$

where Return Loss and S_{11} are both in units of dB.

The network analyzer will be configured to measure S_{11} . Limit lines will be set up in such a way that each limit equals the negative of the corresponding return loss test limit shown in [Table 5-2](#). For example, if a return loss test limit happens to be 20 dB, the corresponding S_{11} limit will be -20 dB.

Return loss is a minimum spec. Therefore, each S_{11} limit will be set up as a maximum limit. For example, if a return loss test limit happens to be 20 dB, the limit table will be set up so that S_{11} must be below -20 dB in order for the instrument to pass. (S_{11} will always be zero or negative because the test set provides no amplification. In units of dB, S_{11} can range from zero to minus infinity.)

Return loss is specified for two different conditions:

- Test port active (this means that the test port is internally connected either to the Reflection port or to the Transmission port)
- Test port off (this means that the test port is internally connected to a 50-ohm termination)

Return loss is specified for the test ports, but not for the Reflection and Transmission ports.

Crosstalk

This measurement will be performed between each of the test set's pairs of adjacent test ports (1 and 2, 2 and 3, 3 and 4, etc.). The test set will be commanded to connect its Reflection port to one of the test ports in the pair, and to connect its Transmission port to the other test port in the pair. An RF cable will connect Port 1 of the network analyzer to the Reflection port of the test set. Another RF cable will connect Port 2 of the network analyzer to the Transmission port of the test set. Network analyzer calibration will be turned off for this measurement. (The reason is that the isolation calibration achievable with the Electronic Calibration module is not good enough.) A Type N 50-ohm male short will be mounted on each test port in the pair.

The network analyzer will be configured to measure S_{21} . By definition,

$$\text{Crosstalk} = S_{21}$$

for the setup described above. Limit lines will be set up in such a way that each S_{21} limit equals the corresponding crosstalk test limit shown in [Table 5-2](#).

Crosstalk is a maximum spec. Therefore, each S_{21} limit will be set up as a maximum limit. For example, if a crosstalk test limit happens to be -100 dB, the corresponding S_{21} limit will be set up so that S_{21} must be below -100 dB in order for the instrument to pass.

Setting Up Limit Testing

In this section, you will create the limit test files described in “[Test Strategy](#)” on [page 5-4](#). As you work through this section, record the names of the files you create in [Table 5-3](#).

Table 5-3

Limit Test Files

Test Name	File Name
Insertion Loss	
Return Loss (Port Active)	
Return Loss (Port Off)	
Crosstalk	

This section contains the following subsections:

- [Limit Testing for Insertion Loss](#)
- [Limit Testing for Return Loss \(Port Active\)](#)
- [Limit Testing for Return Loss \(Port Off\)](#)
- [Limit Testing for Crosstalk](#)

Limit Testing for Insertion Loss

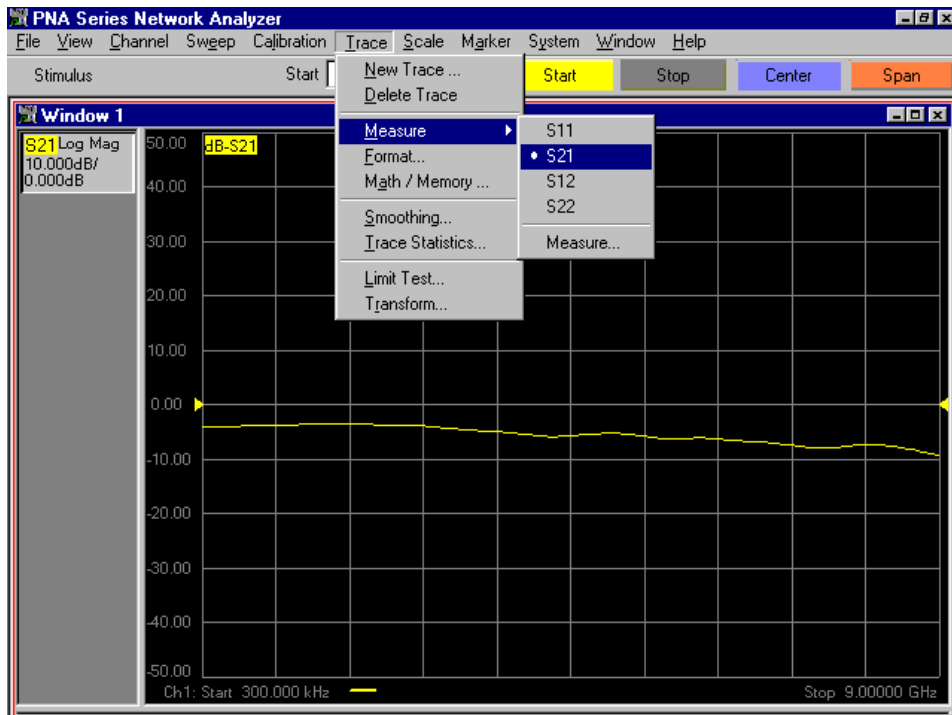
Recalling the Calibration

Recall the calibration file listed in [Table 4-1 on page 4-13](#). (Consult “[How to Recall a Calibration](#)” on [page 4-14](#).)

Specifying Measurement Type, Title, and Scaling

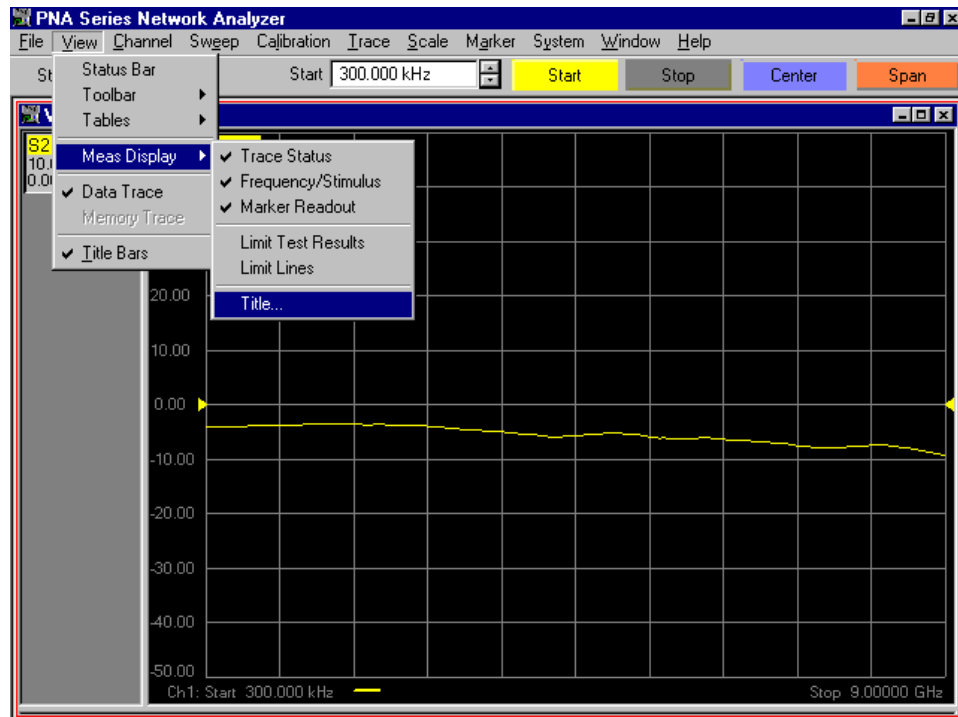
- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Measure** button and pause momentarily. When the Measure menu appears, scroll down to the **S21** button and click it. See [Figure 5-1](#).

Figure 5-1 Specifying an S₂₁ Measurement



Step 2. Click **View** on the menu bar. When the View menu appears, scroll down to the **Meas Display** button and pause momentarily. When the Meas Display menu appears, scroll down to the **Title...** button and click it. See [Figure 5-2](#).

Figure 5-2 The “Title...” Button



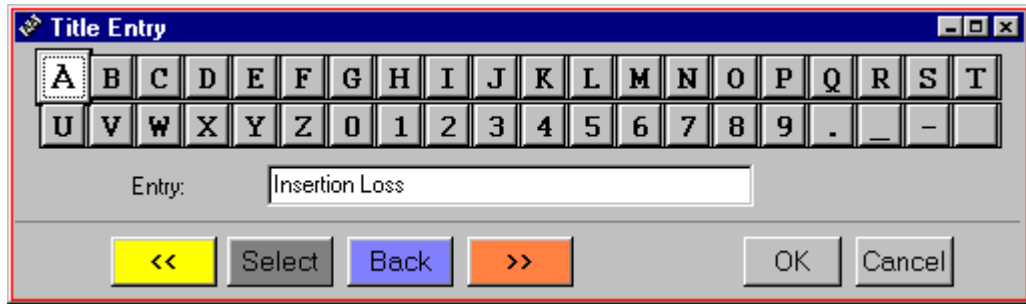
Step 3. The Title Entry window is shown in [Figure 5-3](#). When this window pops up, use the mouse to click anywhere in the white rectangle to the right of the word, “Entry:”. (The white rectangle is referred to as the Entry field.) A text entry cursor (a vertical line) will then appear in the white rectangle.

Figure 5-3 Title Entry Window



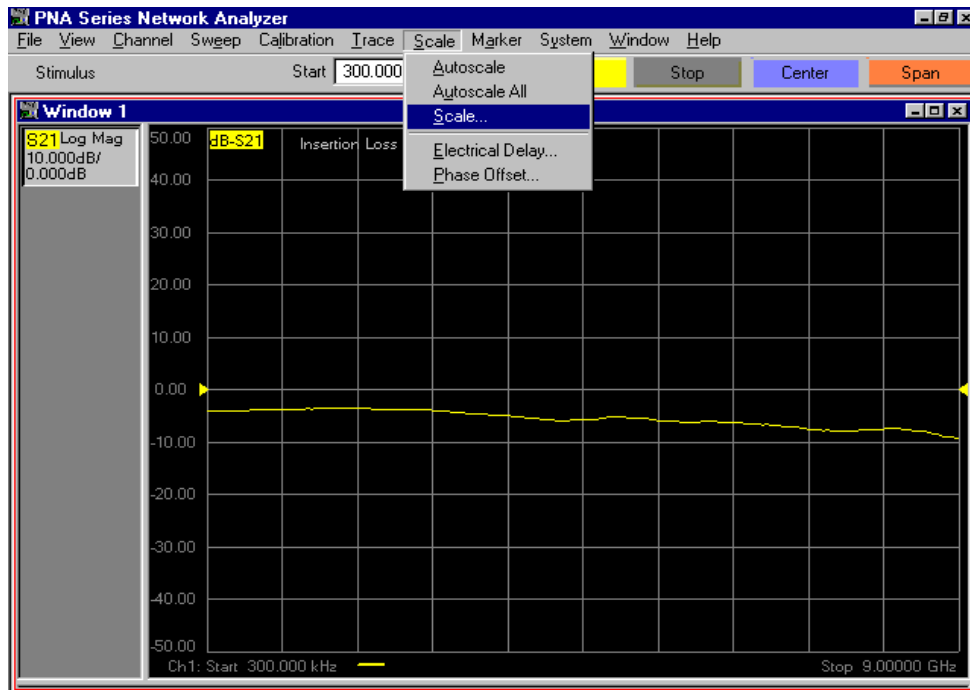
- Step 4.** Type “Insertion Loss” in the Entry field as shown in [Figure 5-4](#). You can do this with the keyboard shown in the Title Entry window if you want, but an easier way is to use the USB keyboard shown in [Figure 2-9](#) on [page 2-15](#). After typing “Insertion Loss”, press the Enter key on the USB keyboard (or the **OK** button in the Title Entry window) to close the window and display the new title.

Figure 5-4 Title Entry Window With “Insertion Loss” Entered



- Step 5.** Click **Scale** on the menu bar. When the Scale menu appears, scroll down to the **Scale...** button and click it. See [Figure 5-5](#).

Figure 5-5 The “Scale...” Button



Step 6. The Scale window shown in [Figure 5-6](#) will pop up. When it does, set the following values:

- Scale Per Division = 1 dB
- Reference Level = 0 dB
- Reference Position = 9 Divisions

When these values have been entered, the Scale window will look like [Figure 5-7](#). Click the **OK** button.

Figure 5-6 The Scale Window With Default Values

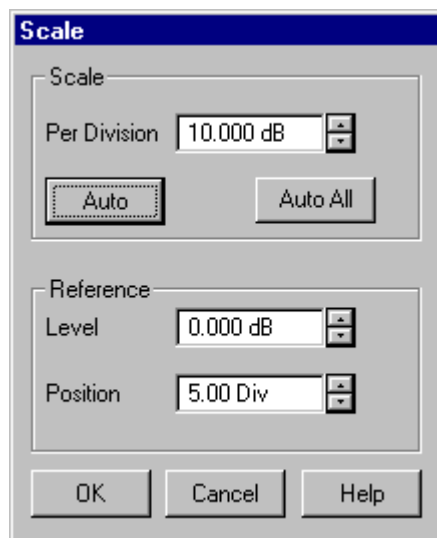
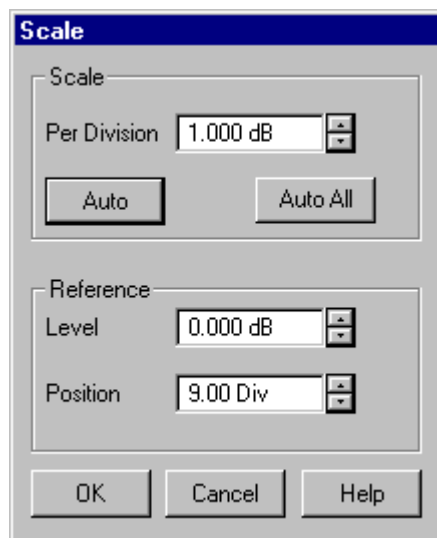


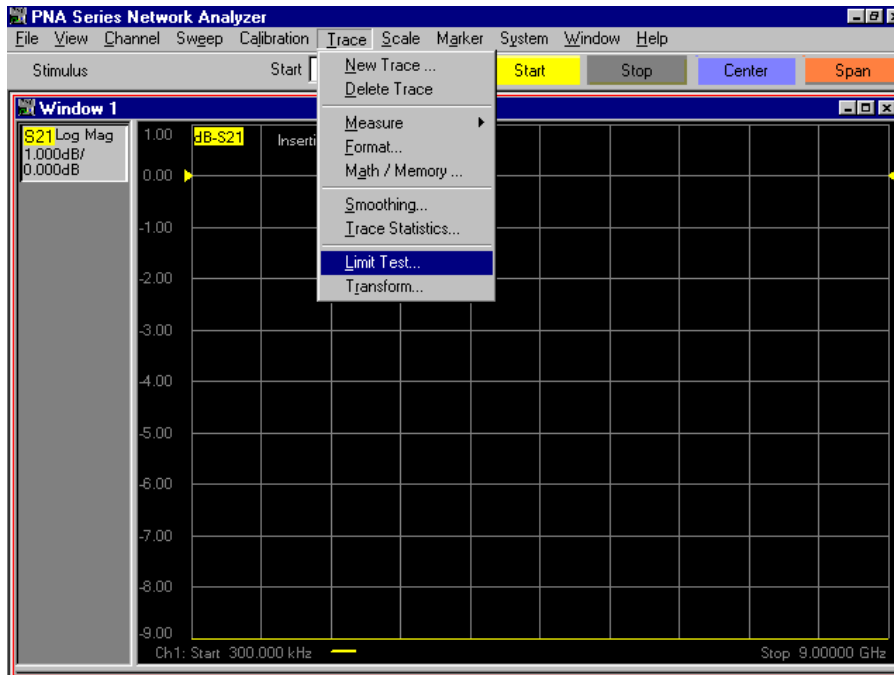
Figure 5-7 The Scale Window With Desired Values For Insertion Loss



Setting Up the Limit Table

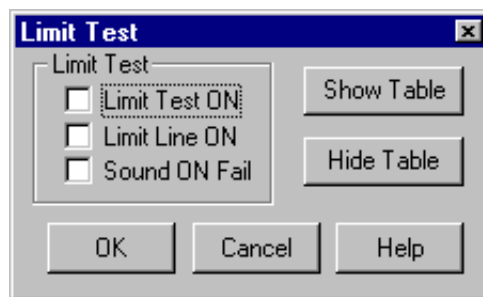
- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it. See [Figure 5-8](#).

Figure 5-8 The “Limit Test...” Button



- Step 2.** When the Limit Test window pops up as shown in [Figure 5-9](#), click the **Show Table** button, then click the **OK** button.

Figure 5-9 The “Limit Test” Window



- Step 3.** When the Limit Table pops up as shown in [Figure 5-10](#), transfer entries from [Table 5-4](#) to the Limit Table on the network analyzer. The result is shown in [Figure 5-11](#).

Shortcuts:

- a. To specify a Segment Type, click the Segment Type box in the desired row, then use the drop-down menu.
- b. To specify a Beginning Stimulus or an Ending Stimulus, click the respective box in the desired row, then enter the desired value followed by “k” if the value is in kilohertz, or by “g” if the value is in gigahertz. For example, to specify a Beginning Stimulus of 300 kHz, type, “300k” (without the quotation marks). To specify an Ending Stimulus of 1.3 GHz, type, “1.3g” (without the quotation marks).
- c. To specify a Beginning Response or an Ending Response, click the respective box in the desired row, then enter the desired value in dB, then hit the space bar. For example, to specify a Beginning Response of -1.8 dB, type, “-1.8<space>”.
- d. Use the tab key to advance from left to right across a row. Use <shift><tab> to advance from right to left across a row. (When moving from right to left, the cursor will not move until you release the shift key.)

Figure 5-10

Empty Limit Table

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	OFF ▾	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

Table 5-4

Limit Table Entries for Insertion Loss

Segment Number	Limit Type	Beginning Stimulus	Ending Stimulus	Beginning Response	Ending Response
1	Min	300 KHz	1.3 GHz	-1.8 dB	-1.8 dB
2	Min	1.3 GHz	3 GHz	-2.3 dB	-2.3 dB
3	Min	3 GHz	6 GHz	-2.8 dB	-2.8 dB
4	Min	6 GHz	9 GHz	-3.8 dB	-3.8 dB

Figure 5-11

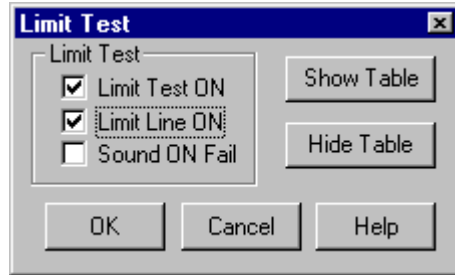
Completed Limit Table for Insertion Loss

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MIN	300.000000 KHz	1.300000 GHz	-1.800000 dB	-1.800000 dB
2	MIN	1.300000 GHz	3.000000 GHz	-2.300000 dB	-2.300000 dB
3	MIN	3.000000 GHz	6.000000 GHz	-2.800000 dB	-2.800000 dB
4	MIN	6.000000 GHz	9.000000 GHz	-3.800000 dB	-3.800000 dB
5	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

Turning On Limit Lines and Limit Testing

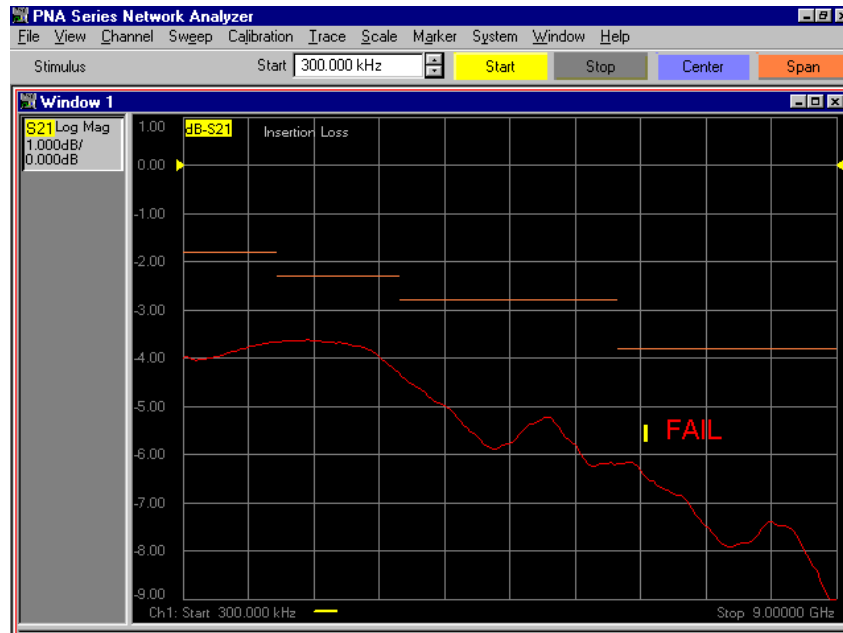
- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it as shown in [Figure 5-8](#). The Limit Test window shown in [Figure 5-9](#) will pop up.
- Step 2.** Click the **Limit Test ON** and **Limit Line ON** boxes. The result is shown in [Figure 5-12](#).

Figure 5-12 Turning On Limit Testing and Limit Line Display



- Step 3.** Click the **Hide Table** button, then click the **OK** button. The result is shown in [Figure 5-13](#). The trace shown in the figure is an S_{21} measurement of the Electronic Calibration (ECal) module. Notice that the ECal module does not meet the insertion loss specifications of the test set.

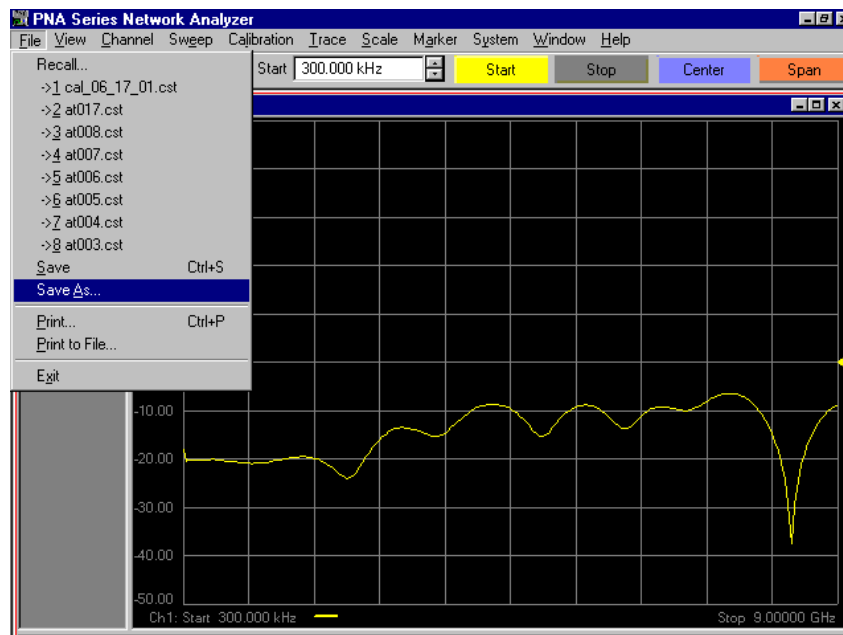
Figure 5-13 Insertion Loss Limit Test Being Run On ECal Module



Saving the Limit Test File

- Step 1.** Click **File** on the menu bar. When the File menu appears, scroll down to the **Save As...** button and click it. See [Figure 5-14](#).

Figure 5-14 “Save As...” Button



Step 2. When the Save As window comes up as shown in [Figure 5-15](#), type a file name that includes the words, “insertion loss,” and the date of the calibration listed in [Table 4-1](#) on [page 4-13](#). For example, if the calibration file is named, “cal_06_17_01”, an appropriate file name for this step would be, “insertion_loss_with_06_17_01_cal”. See [Figure 5-16](#). After entering the file name, record it in [Table 5-3](#) on [page 5-7](#). Next, click the **Save** button.

Figure 5-15 “Save As...” Window

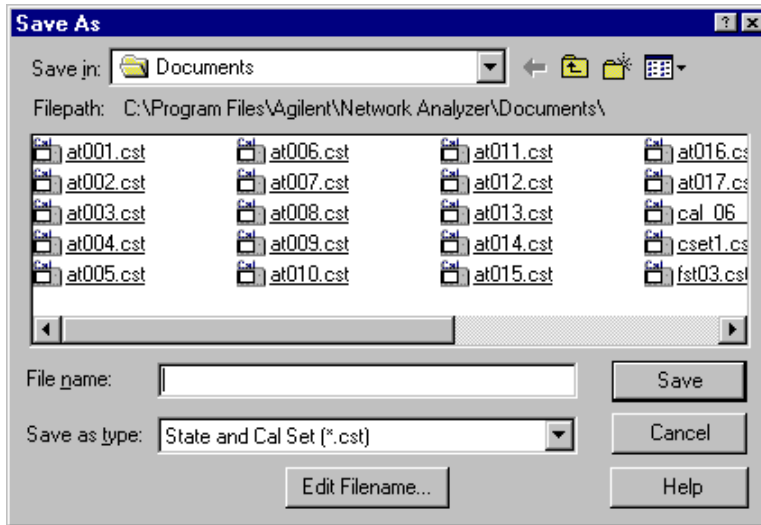
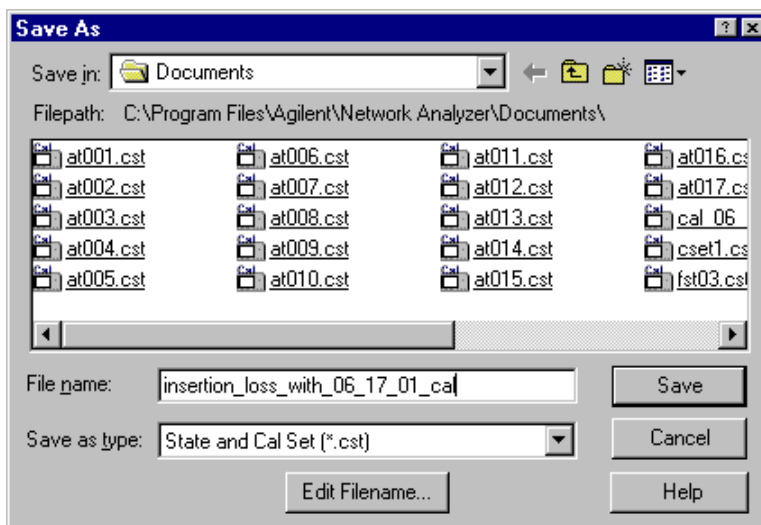


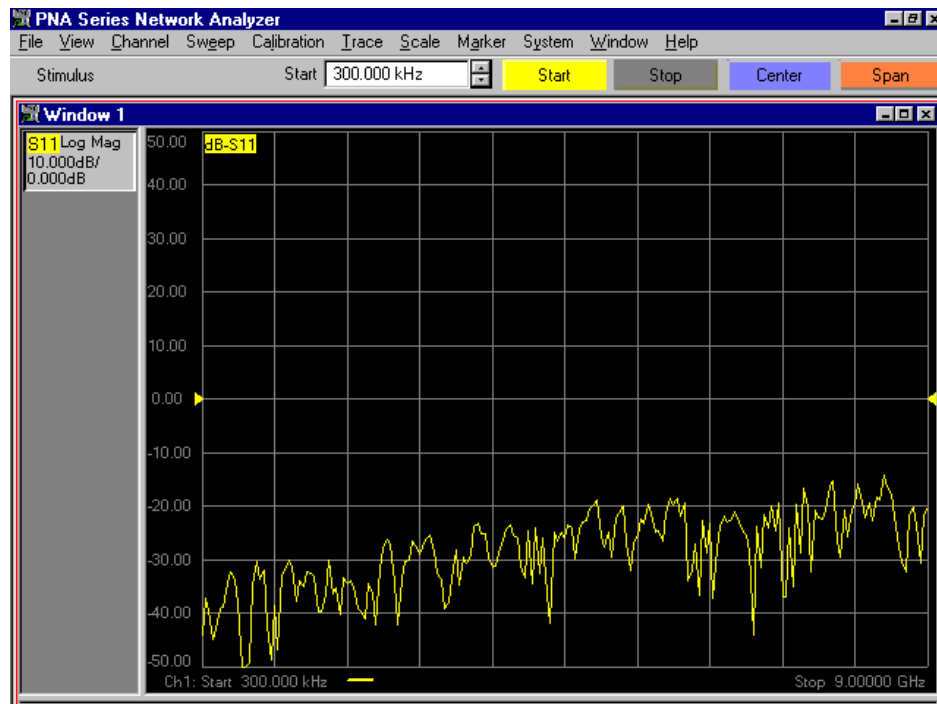
Figure 5-16 Specifying The Name Of The Limit Test File For Insertion Loss



Checking the Limit Test File

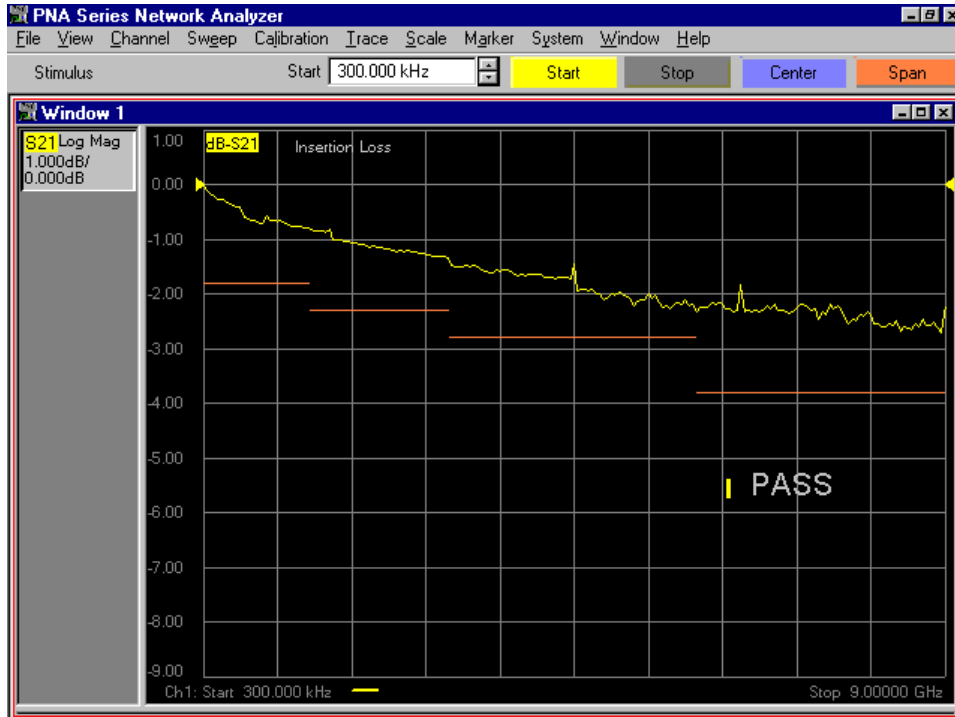
- Step 1.** Connect an RF cable from Port 1 of the network analyzer to Test Port 1 of the test set. Connect an RF cable from Port 2 of the network analyzer to the Reflection Port of the test set.
- Step 2.** If the test set is turned off, turn it on. If the test set is already turned on, turn it off, then back on again. This causes the test set to execute the “*rst;” command, which is equivalent to the “refl_01;” command combined with the “tran_08;” command.
- Step 3.** Recall the calibration file listed in [Table 4-1](#) on [page 4-13](#). (Consult [“How to Recall a Calibration”](#) on [page 4-14](#).) The resulting display should look something like [Figure 5-17](#).

Figure 5-17 Insertion Loss Test Setup, Cal File Recalled



- Step 4.** Recall the limit line file for insertion loss. The file name should be listed in [Table 5-3](#) on [page 5-7](#). The resulting display should look something like [Figure 5-18](#).

Figure 5-18 Insertion Loss Test Setup, Limit Test File Recalled



Limit Testing for Return Loss (Port Active)

Recalling the Calibration

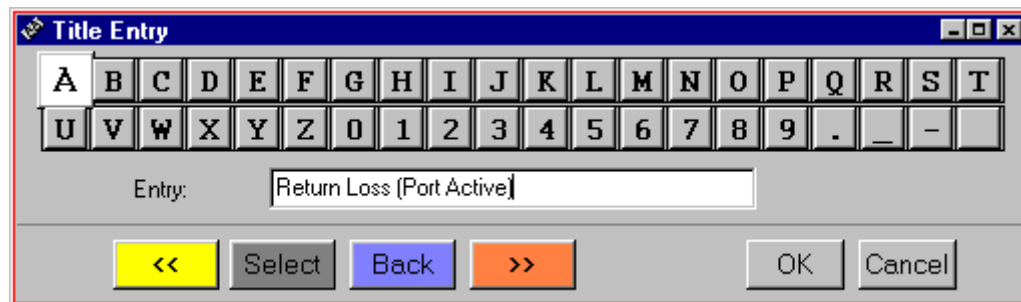
Recall the calibration file listed in [Table 4-1 on page 4-13](#). (Consult “[How to Recall a Calibration](#)” on [page 4-14](#).)

Specifying Measurement Type, Title, and Scaling

The desired measurement type for the Return Loss test is S_{11} . The network analyzer is already configured to measure S_{11} .

- Step 1.** Click **View** on the menu bar. When the View menu appears, scroll down to the **Meas Display** button and pause momentarily. When the Meas Display menu appears, scroll down to the **Title...** button and click it. See [Figure 5-2](#).
- Step 2.** The Title Entry window is shown in [Figure 5-3](#). When this window pops up, use the mouse to click anywhere in the white rectangle to the right of the word, “Entry:”. (The white rectangle is referred to as the Entry field.) A text entry cursor (a vertical line) will then appear in the white rectangle.
- Step 3.** Type “Return Loss (Port Active)” in the Entry field as shown in [Figure 5-19](#). You can do this with the keyboard shown in the Title Entry window if you want, but an easier way is to use the USB keyboard shown in [Figure 2-9 on page 2-15](#). After typing “Return Loss (Port Active)”, press the Enter key on the USB keyboard (or the **OK** button in the Title Entry window) to close the window and display the new title.

Figure 5-19 Title Entry Window With “Return Loss (Port Active)” Entered



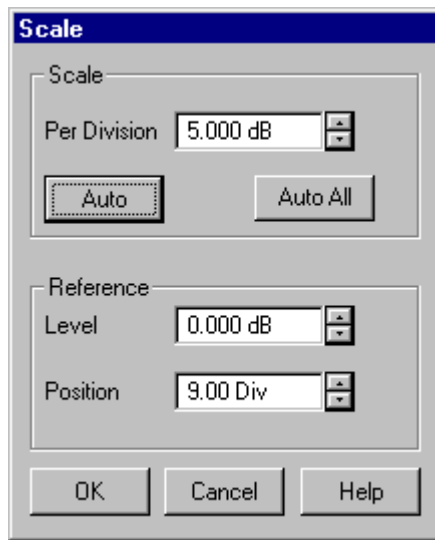
- Step 4.** Click **Scale** on the menu bar. When the Scale menu appears, scroll down to the **Scale...** button and click it. See [Figure 5-5](#).

Step 5. The Scale window shown in [Figure 5-6](#) will pop up. When it does, set the following values:

- Scale Per Division = 5 dB
- Reference Level = 0 dB
- Reference Position = 9 Divisions

When these values have been entered, the Scale window will look like [Figure 5-20](#). Click the **OK** button.

Figure 5-20 The Scale Window With Desired Values For Return Loss



Setting Up the Limit Table

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it. See [Figure 5-8](#).
- Step 2.** When the Limit Test window pops up as shown in [Figure 5-9](#), click the **Show Table** button, then click the **OK** button.
- Step 3.** When the Limit Table pops up as shown in [Figure 5-10](#), transfer entries from [Table 5-5](#) to the Limit Table on the network analyzer. (Consult the shortcuts listed on [page 5-13](#).) The result is shown in [Figure 5-21](#).

Table 5-5 Limit Table Entries for Return Loss (Port Active)

Segment Number	Segment Type	Beginning Stimulus	Ending Stimulus	Beginning Response	Ending Response
1	Max	300 kHz	1.3 GHz	-25.5 dB	-25.5 dB
2	Max	1.3 GHz	3 GHz	-19 dB	-19 dB
3	Max	3 GHz	6 GHz	-14.5 dB	-14.5 dB
4	Max	6 GHz	9 GHz	-9.5 dB	-9.5 dB

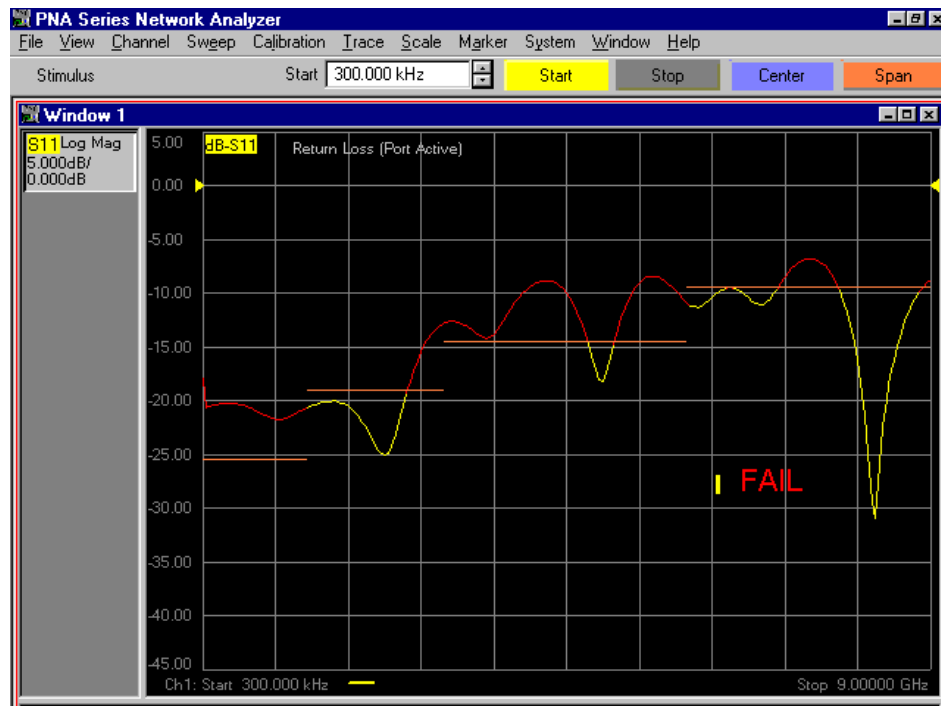
Figure 5-21 Completed Limit Table for Return Loss (Port Active)

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MAX	300.000000 KHz	1.300000 GHz	-25.500000 dB	-25.500000 dB
2	MAX	1.300000 GHz	3.000000 GHz	-19.000000 dB	-19.000000 dB
3	MAX	3.000000 GHz	6.000000 GHz	-14.500000 dB	-14.500000 dB
4	MAX	6.000000 GHz	9.000000 GHz	-9.500000 dB	-9.500000 dB
5	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

Turning On Limit Lines and Limit Testing

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it as shown in Figure 5-8. The Limit Test window shown in Figure 5-9 will pop up.
- Step 2.** Click the **Limit Test ON** and **Limit Line ON** boxes. The result is shown in Figure 5-12.
- Step 3.** Click the **Hide Table** button, then click the **OK** button. The result is shown in Figure 5-22. The trace shown in the figure is an S_{11} measurement of the Electronic Calibration (ECal) module. Notice that the ECal module does not meet the return loss specifications of the test set.

Figure 5-22 Return Loss (Port Active) Limit Test On ECal Module



Saving the Limit Test File

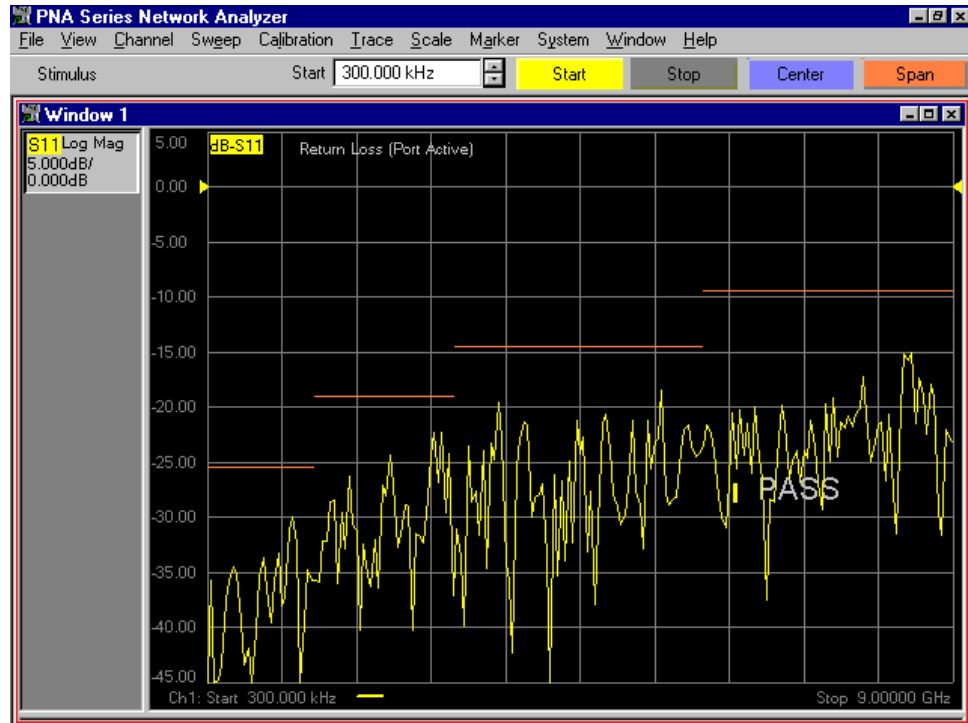
- Step 1.** Click **File** on the menu bar. When the File menu appears, scroll down to the **Save As..** button and click it. See [Figure 5-14](#).
- Step 2.** When the Save As window comes up as shown in [Figure 5-15](#), type a file name that includes the words, “return loss,” the words, “port active”, and the date of the calibration listed in [Table 4-1 on page 4-13](#). For example, if the calibration file is named, “cal_06_17_01”, an appropriate file name for this step would be, “return_loss_port_active_with_06_17_01_cal”. See [Figure 5-16](#). After entering the file name, record it in [Table 5-3 on page 5-7](#). Next, click the **Save** button.

Checking the Limit Test File

- Step 1.** Connect an RF cable from Port 1 of the network analyzer to Test Port 1 of the test set. Connect an RF cable from Port 2 of the network analyzer to the Reflection Port of the test set.
- Step 2.** If the test set is turned off, turn it on. If the test set is already turned on, turn it off, then back on again. This causes the test set to execute the “*rst;” command, which is equivalent to the “refl_01;” command combined with the “tran_08;” command.
- Step 3.** Recall the calibration file listed in [Table 4-1 on page 4-13](#). (Consult [“How to Recall a Calibration” on page 4-14](#).) The resulting display should look something like [Figure 5-17](#).

- Step 4.** Recall the limit line file for return loss (port active). The file name should be listed in [Table 5-3 on page 5-7](#). The resulting display should look something like [Figure 5-23](#).

Figure 5-23 Return Loss (Port Active) Test Setup, Limit Test File Recalled



Limit Testing for Return Loss (Port Off)

The limit test for return loss (port off) is identical to the limit test for return loss (port active) with the following exceptions:

- The title
- The limit table

Recalling the “Port Active” Limit Test File

Recall the limit test file for return loss (port active). It should be recorded in [Table 5-3 on page 5-7](#).

Specifying the Title

- Step 1.** Click **View** on the menu bar. When the View menu appears, scroll down to the **Meas Display** button and pause momentarily. When the Meas Display menu appears, scroll down to the **Title...** button and click it. See [Figure 5-2](#).
- Step 2.** The Title Entry window is shown in [Figure 5-3](#). When this window pops up, click in the Entry field.
- Step 3.** Type “Return Loss (Port Off)” in the Entry field, then press the Enter key on the USB keyboard (or the **OK** button in the Title Entry window) to close the window and display the new title.

Setting Up the Limit Table

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it. See [Figure 5-8](#).
- Step 2.** When the Limit Test window pops up as shown in [Figure 5-9](#), click the **Show Table** button, then click the **OK** button.
- Step 3.** When the Limit Table pops up, transfer entries from [Table 5-6](#) to the Limit Table on the network analyzer. (Consult the shortcuts listed on [page 5-13](#).) The result is shown in [Figure 5-24](#).

Table 5-6

Limit Table Entries for Return Loss (Port Off)

Segment Number	Segment Type	Begin Stimulus	End Stimulus	Begin Response	End Response
1	Max	300 kHz	1.3 GHz	-27.5 dB	-27.5 dB
2	Max	1.3 GHz	3 GHz	-21.5 dB	-21.5 dB
3	Max	3 GHz	6 GHz	-17 dB	-17 dB
4	Max	6 GHz	9 GHz	-14.5 dB	-14.5 dB

Figure 5-24 Completed Limit Table for Return Loss (Port Off)

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MAX	300.000000 KHz	1.300000 GHz	-27.500000 dB	-27.500000 dB
2	MAX	1.300000 GHz	3.000000 GHz	-21.500000 dB	-21.500000 dB
3	MAX	3.000000 GHz	6.000000 GHz	-17.000000 dB	-17.000000 dB
4	MAX	6.000000 GHz	9.000000 GHz	-14.500000 dB	-14.500000 dB
5	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

Step 4. Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it as shown in [Figure 5-8](#). The Limit Test window shown in [Figure 5-9](#) will pop up.

Step 5. Click the **Hide Table** button, then click the **OK** button.

Saving the Limit Test File

Step 1. Click **File** on the menu bar. When the File menu appears, scroll down to the **Save As...** button and click it. See [Figure 5-14](#).

Step 2. When the Save As window comes up as shown in [Figure 5-15](#), type a file name that includes the words, “return loss,” the words, “port off”, and the date of the calibration listed in Table 4-1 on page 4-13. For example, if the calibration file is named, “cal_06_17_01”, an appropriate file name for this step would be, “return_loss_port_off_with_06_17_01_cal”. See [Figure 5-16](#). After entering the file name, record it in [Table 5-3 on page 5-7](#). Next, click the **Save** button.

Recalling the Limit Test File

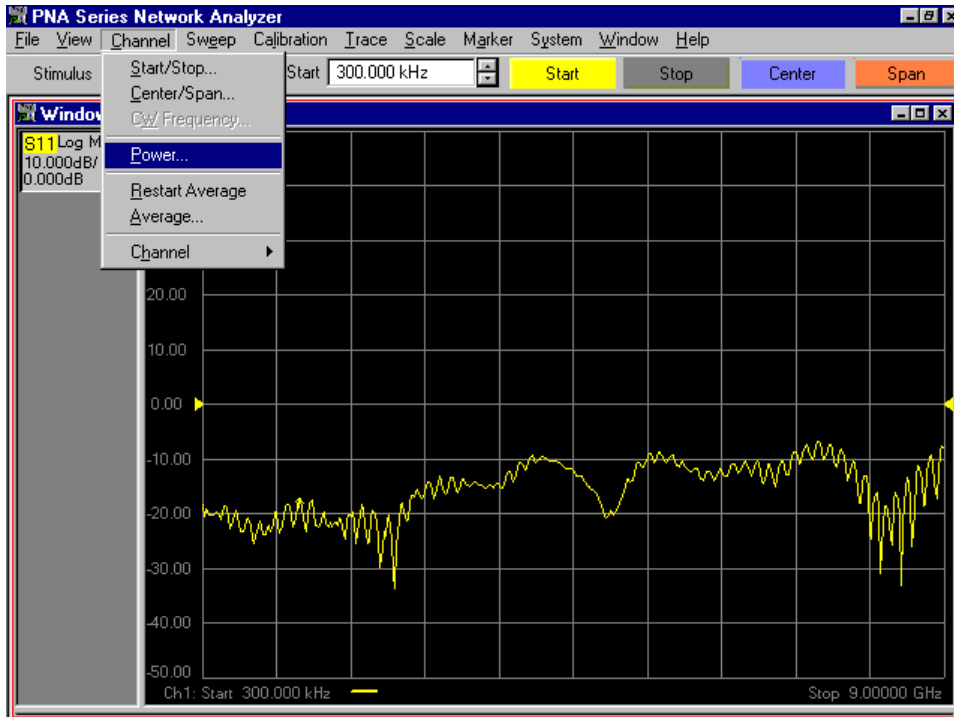
Recall the limit test file that you have just saved. (Consult “[How to Recall a Calibration](#)” on [page 4-14](#).) This will put it on the “Quick Recall” list.

Limit Testing for Crosstalk

Specifying Output Power

- Step 1.** Press the **Preset** button.
- Step 2.** Click Channel on the menu bar. When the Channel menu appears, scroll down to the Power... button and click it. See [Figure 5-25](#).

Figure 5-25 The “Power...” Button



Step 3. The Power window shown in Figure 5-26 will pop up. Set the Test Port Power to +10 dBm as shown in Figure 5-27. Click the **OK** button in the Power window.

Figure 5-26 Power Window with Default Values

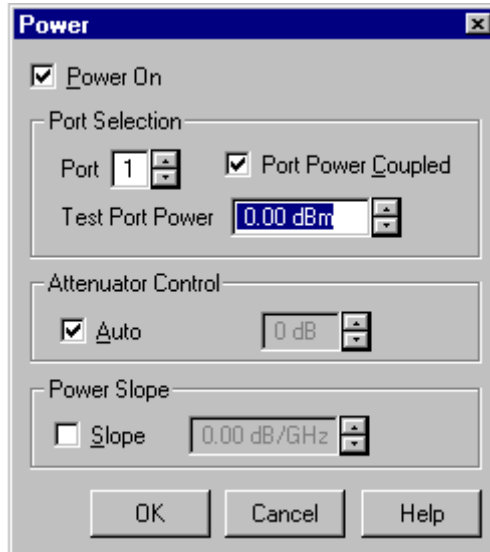
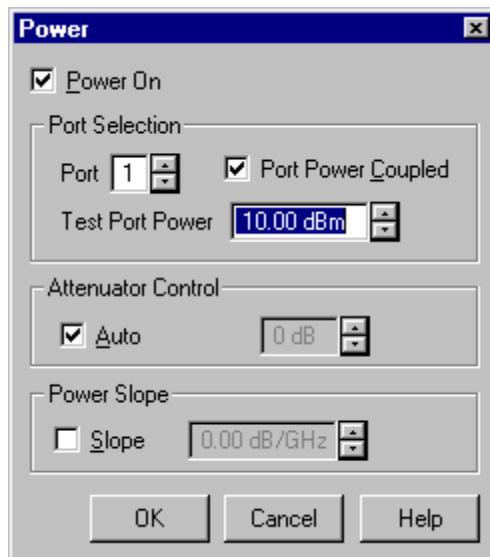


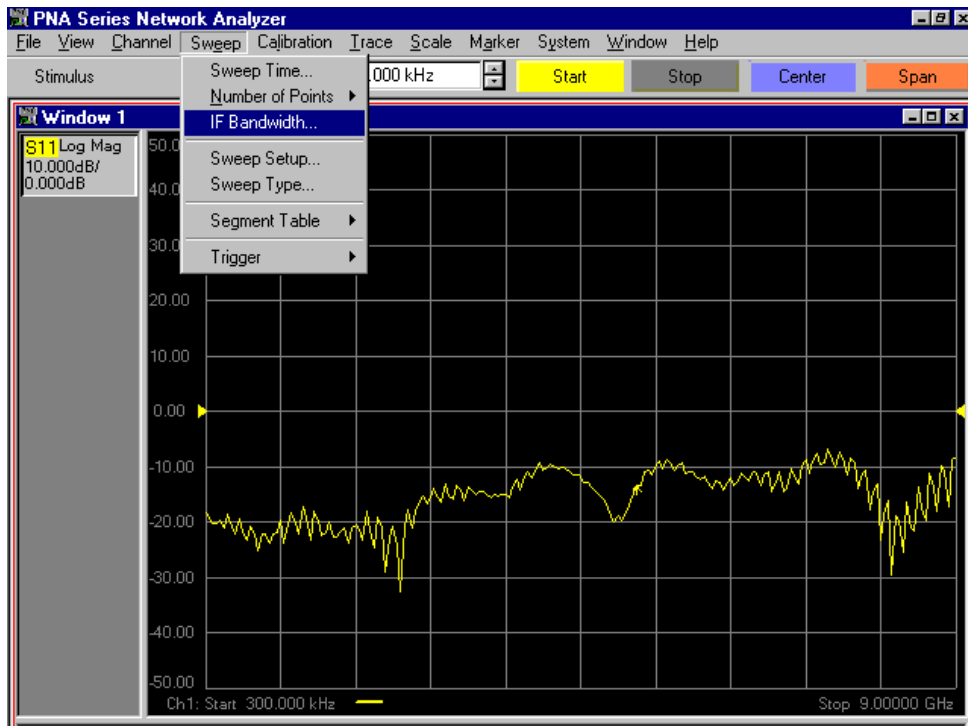
Figure 5-27 Power Window with Values Desired for Crosstalk



Specifying IF Bandwidth and Averaging

- Step 1.** Click **Sweep** on the menu bar. When the Sweep menu appears, scroll down to the **IF Bandwidth...** button and click it. See [Figure 5-28](#).

Figure 5-28 The “IF Bandwidth...” Button



- Step 2.** When the IF Bandwidth window pops up as shown in [Figure 5-29](#), change the IF Bandwidth to 100Hz. (Type, “100<space>”, without the quotation marks.) The result is shown in [Figure 5-30](#). Click the **OK** button.

Figure 5-29 IF Bandwidth Window with Default Value

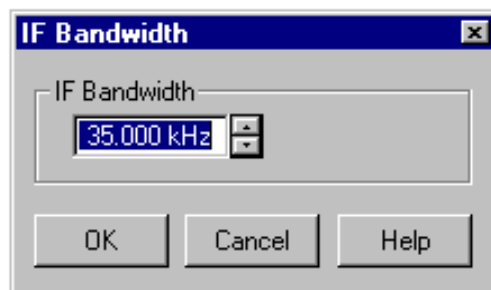
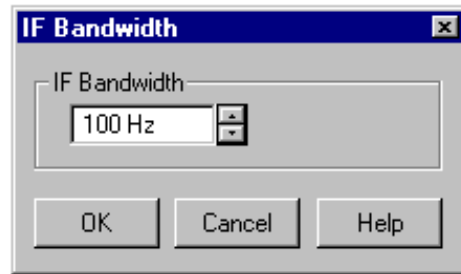
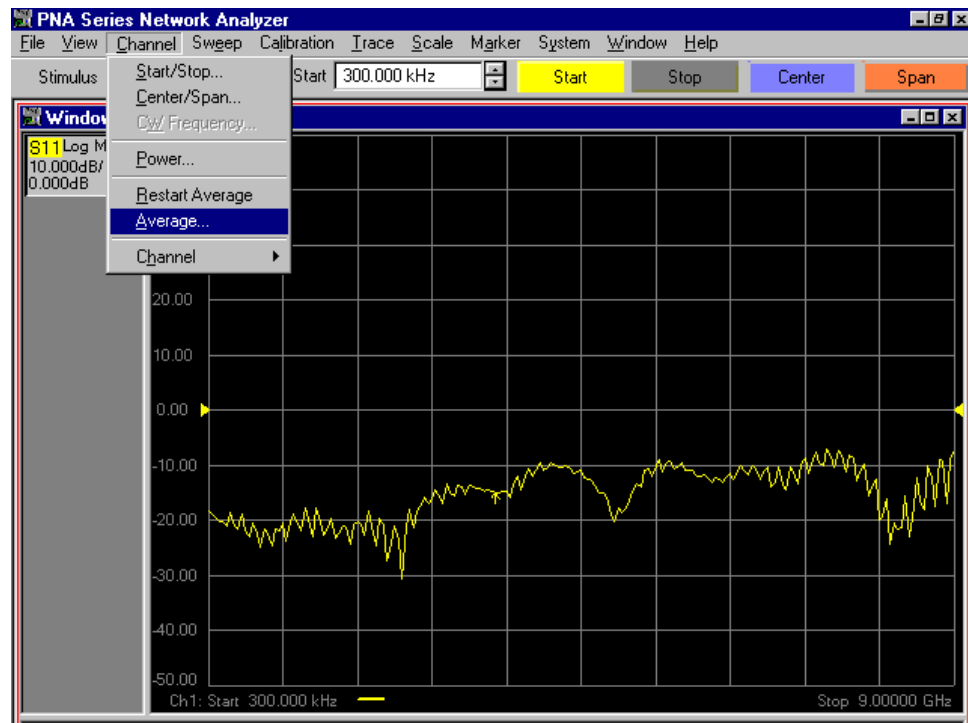


Figure 5-30 IF Bandwidth Window with Value Desired for Crosstalk



Step 3. Click **Channel** on the menu bar. When the Channel menu appears, scroll down to the **Average...** button and click on it. See [Figure 5-31](#).

Figure 5-31 The "Average..." Button



- Step 4.** When the Average window shown in [Figure 5-32](#) appears, click the **Average ON** box. Next, change the Average Factor to 10. (It is best to change the Average Factor by using the up arrow.) The results are shown in [Figure 5-33](#). Click the **OK** button.

Figure 5-32 Average Window with Default Settings

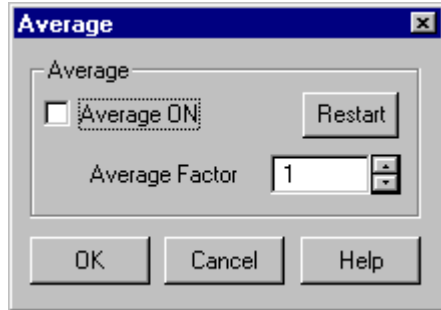
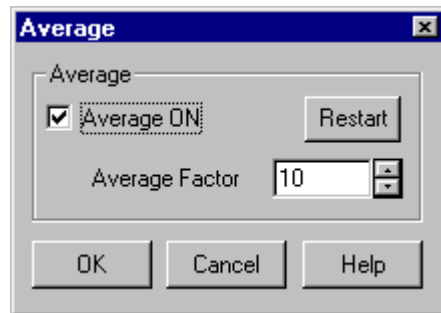


Figure 5-33 Average Window with Settings Desired for Crosstalk



Step 5. Click **View** on the menu bar. When the View menu appears, scroll down to the **Status Bar** button and click it as shown in [Figure 5-34](#). The status bar will appear at the bottom of the screen as shown in [Figure 5-35](#).

Figure 5-34 The “Status Bar” Button

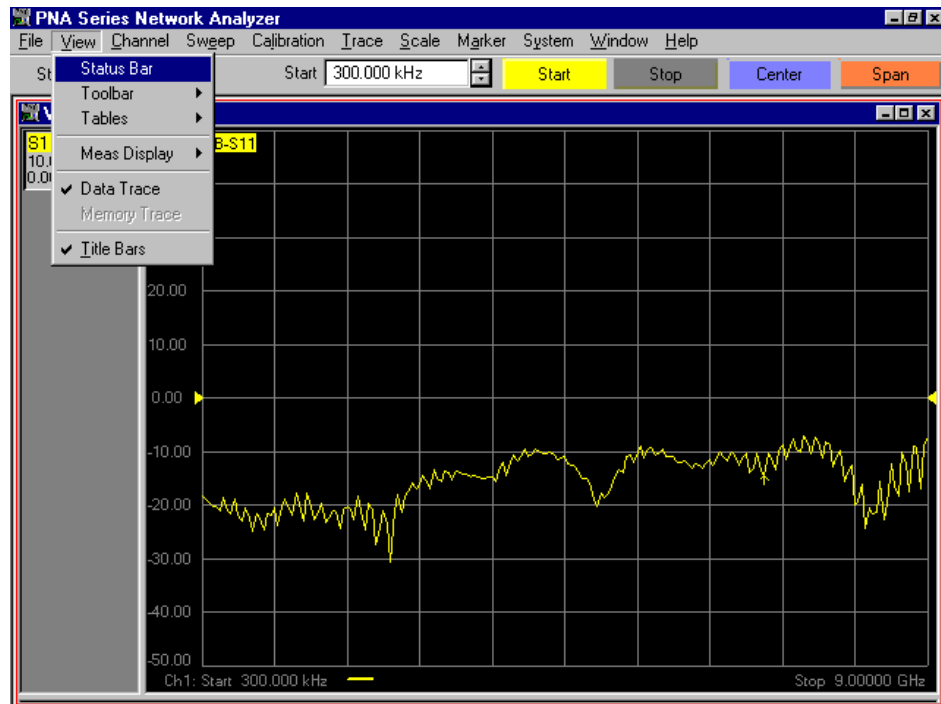
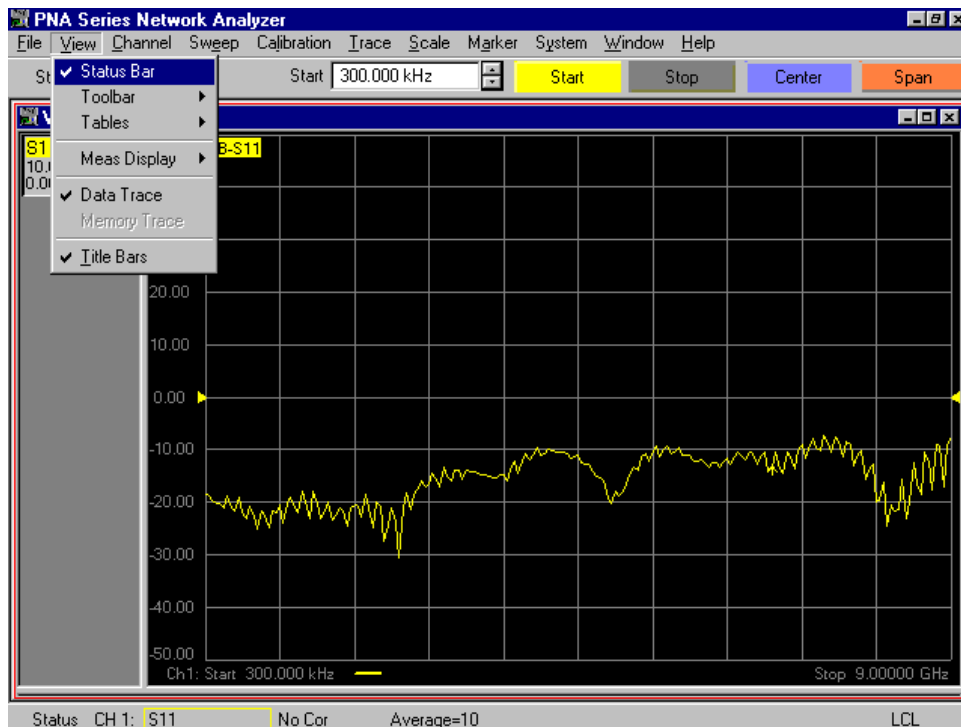


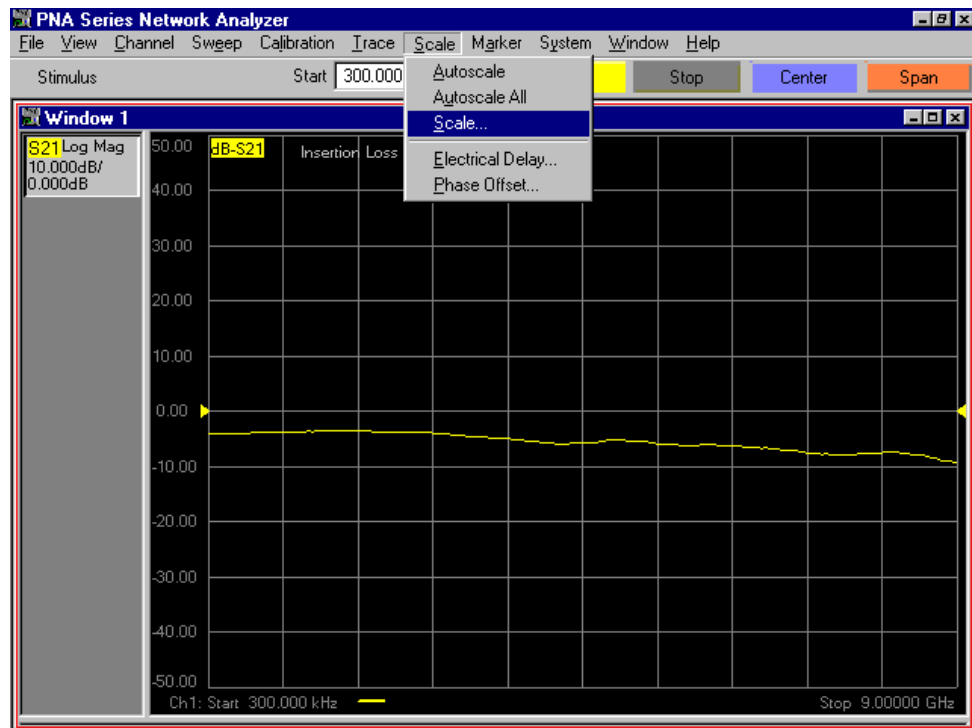
Figure 5-35 The Status Bar Displayed at Bottom of Screen



Specifying Measurement Type, Title, and Scaling

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Measure** button and pause momentarily. When the Measure menu appears, scroll down to the **S21** button and click it. See [Figure 5-1](#).
- Step 2.** Click **View** on the menu bar. When the View menu appears, scroll down to the **Meas Display** button and pause momentarily. When the Meas Display menu appears, scroll down to the **Title...** button and click it. See [Figure 5-2](#).
- Step 3.** The Title Entry window is shown in [Figure 5-3](#). When this window pops up, click in the Entry field.
- Step 4.** Type “Crosstalk” in the Entry field, then press the Enter key on the USB keyboard (or the **OK** button in the Title Entry window) to close the window and display the new title.
- Step 5.** Click **Scale** on the menu bar. When the Scale menu appears, scroll down to the **Scale...** button and click it. See [Figure 5-5](#).

Figure 5-36 The “Scale...” Button

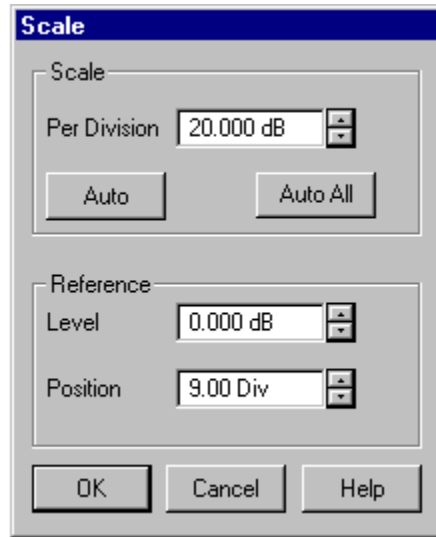


Step 6. The Scale window shown in [Figure 5-6](#) will pop up. When it does, set the following values:

- Scale Per Division = 20 dB
- Reference Level = 0 dB
- Reference Position = 9 Divisions

When these values have been entered, the Scale window will look like [Figure 5-37](#). Click the **OK** button.

Figure 5-37 The Scale Window With Desired Values For Crosstalk



Setting Up the Limit Table

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it. See [Figure 5-8](#).
- Step 2.** When the Limit Test window pops up as shown in [Figure 5-9](#), click the **Show Table** button, then click the **OK** button.
- Step 3.** When the Limit Table pops up as shown in [Figure 5-10](#), transfer entries from [Table 5-7](#) to the Limit Table on the network analyzer. (Consult the shortcuts listed on [page 5-13](#).) The result is shown in [Figure 5-38](#).

Table 5-7 Limit Table Entries for Crosstalk

Segment Number	Segment Type	Beginning Stimulus	Ending Stimulus	Beginning Response	Ending Response
1	Max	300 kHz	1.3 GHz	-115 dB	-115 dB
2	Max	1.3 GHz	3 GHz	-110 dB	-110 dB
3	Max	3 GHz	6 GHz	-100 dB	-100 dB
4	Max	6 GHz	9 GHz	-97 dB	-97 dB

Figure 5-38 Completed Limit Table for Crosstalk

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MAX	30.000000 KHz	1.300000 GHz	-115.000000 dB	-115.000000 dB
2	MAX	1.300000 GHz	3.000000 GHz	-110.000000 dB	-110.000000 dB
3	MAX	3.000000 GHz	6.000000 GHz	-100.000000 dB	-100.000000 dB
4	MAX	6.000000 GHz	9.000000 GHz	-97.000000 dB	-97.000000 dB
5	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

Turning On Limit Lines and Limit Testing

- Step 1.** Click **Trace** on the menu bar. When the Trace menu appears, scroll down to the **Limit Test...** button and click it as shown in [Figure 5-8](#). The Limit Test window shown in [Figure 5-9](#) will pop up.
- Step 2.** Click the **Limit Test ON** and **Limit Line ON** boxes. The result is shown in [Figure 5-12](#).
- Step 3.** Click the **Hide Table** button, then click the **OK** button.

Saving the Limit Test File

- Step 1.** Click **File** on the menu bar. When the File menu appears, scroll down to the **Save As...** button and click it. See [Figure 5-14](#).
- Step 2.** When the Save As window comes up as shown in [Figure 5-15](#), enter a file name. An appropriate file name for this step would be, “crosstalk_with_no_cal”. After entering the file name, record it in [Table 5-3 on page 5-7](#). Next, click the **Save** button in the Save As window.

Recalling the Limit Test File

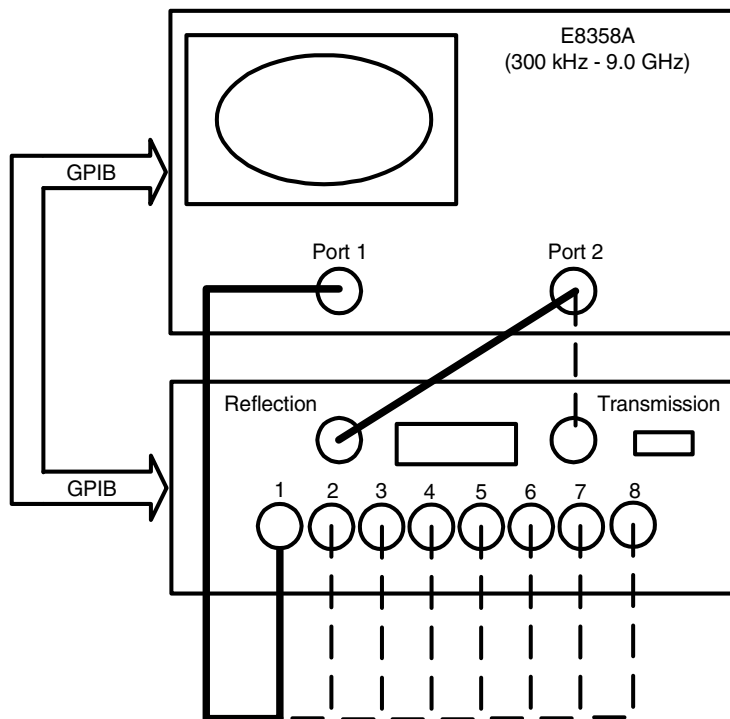
Recall the limit test file that you have just saved. (Consult “[How to Recall a Calibration](#)” on [page 4-14](#).) This will put it on the “Quick Recall” list.

Verifying Return Loss and Insertion Loss Specifications

Measurements Using The Reflection Port

- Step 1.** Connect an RF cable from Port 1 of the network analyzer to Test Port 1 of the test set. Connect another RF cable from Port 2 of the network analyzer to the Reflection Port of the test set. See [Figure 5-39](#).

Figure 5-39 Setup for Measuring Insertion Loss and Return Loss of Test Set



- Step 2.** Command the test set to connect the test port to the Reflection Port. Consult [Table 3-2 on page 3-9](#) for a list of commands.
- Step 3.** Recall the limit test file for insertion loss. It is listed in [Table 5-3 on page 5-7](#).
- Step 4.** Read the results of the insertion loss test on the screen of the network analyzer. Record the results in [Table 5-8](#).
- Step 5.** Recall the limit test file for return loss (port active). It is listed in [Table 5-3 on page 5-7](#).
- Step 6.** Read the results of the return loss (port active) test on the screen of the network analyzer. Record the results in [Table 5-8](#).

- Step 7.** Command the test set to terminate all of its test ports.
- Step 8.** Recall the limit test file for return loss (port off). It is listed in [Table 5-3 on page 5-7](#).
- Step 9.** Read the results of the return loss (port off) test on the screen of the network analyzer. Record the results in [Table 5-8](#).
- Step 10.** Move the RF cable to the next test port. Repeat [Step 2](#) through [Step 9](#).
- Step 11.** Repeat [Step 10](#) until all eight test ports have been measured.

Measurements Using The Transmission Port

- Step 1.** Move the RF cable from the Reflection Port to the Transmission Port. Move the test port cable back to Test Port 1.
- Step 2.** Command the test set to connect the test port to the Transmission Port. Consult [Table 3-2 on page 3-9](#) for a list of commands.
- Step 3.** Recall the limit test file for insertion loss. It is listed in [Table 5-3 on page 5-7](#).
- Step 4.** Read the results of the insertion loss test on the screen of the network analyzer. Record the results in [Table 5-8](#).
- Step 5.** Recall the limit test file for return loss (port active). It is listed in [Table 5-3 on page 5-7](#).
- Step 6.** Read the results of the return loss (port active) test on the screen of the network analyzer. Record the results in [Table 5-8](#).
- Step 7.** Move the RF cable to the next test port. Repeat [Step 2](#) through [Step 6](#).
- Step 8.** Repeat [Step 7](#) until all eight test ports have been measured.

Table 5-8 Pass/Fail Test Results For Insertion Loss And Return Loss

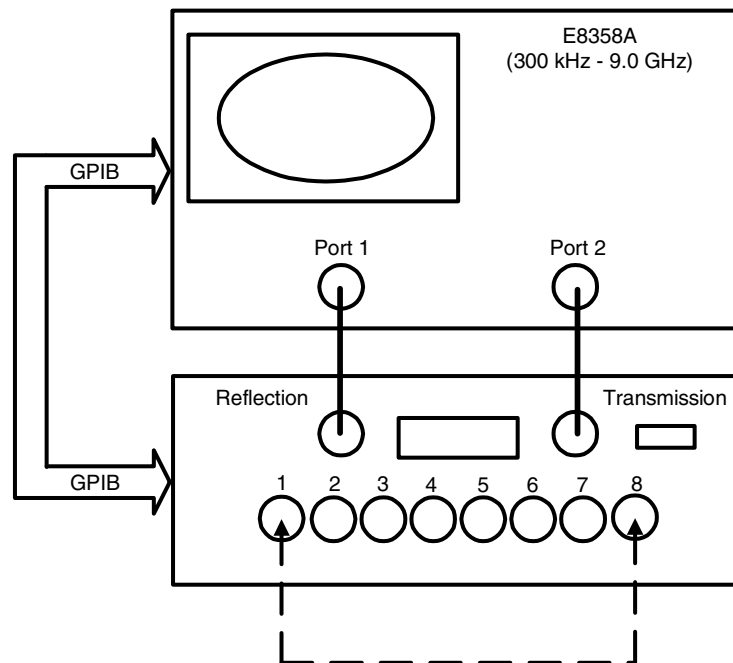
Test Port	Connected To Reflection Port		Internally Terminated	Connected To Transmission Port	
	Insertion Loss	Return Loss (Port Active)	Return Loss (Port Off)	Insertion Loss	Return Loss (Port Active)
1					
2					
3					
4					
5					
6					
7					
8					

Verifying Crosstalk Specs

Crosstalk need only be measured on adjacent ports. Two 50 Ω shorts are required for this test.

- Step 1.** Connect an RF cable from Port 1 of the network analyzer to the Reflection Port of the test set. Connect another RF cable from Port 2 of the network analyzer to the Transmission Port of the test set. Connect a third RF cable from Test Port 1 to Test Port 8. See [Figure 5-40](#).

Figure 5-40 Setup for Measuring Crosstalk of Test Set



- Step 2.** Issue the “*rst;” command to the test set.
- Step 3.** Recall the limit test file for crosstalk. It is listed in [Table 5-3](#) on [page 5-7](#).
- Step 4.** Normalize the S21 and S12 through response.
- Step 5.** Remove the RF cable between Test Ports 1 and 8.
- Step 6.** Put shorts on Test Ports 1 and 2.
- Step 7.** Command the test set to connect the Reflection Port to the first of the test ports having a short. Command the test set to connect the Transmission Port to the other test port having a short.
- Step 8.** Read the results of the crosstalk test on the screen of the network analyzer. Record the results in [Table 5-9](#).

- Step 9.** Move the shorts to the next pair of test ports. (Only one short actually needs to be moved.) Repeat [Step 7](#) and [Step 8](#).
- Step 10.** Repeat [Step 9](#) until all seven adjacent pairs of test ports have been measured.

Table 5-9 Pass/Fail Test Results for Crosstalk

Test Ports	Result
1 and 2	
2 and 3	
3 and 4	
4 and 5	
5 and 6	
6 and 7	
7 and 8	

Calibrating the Test System

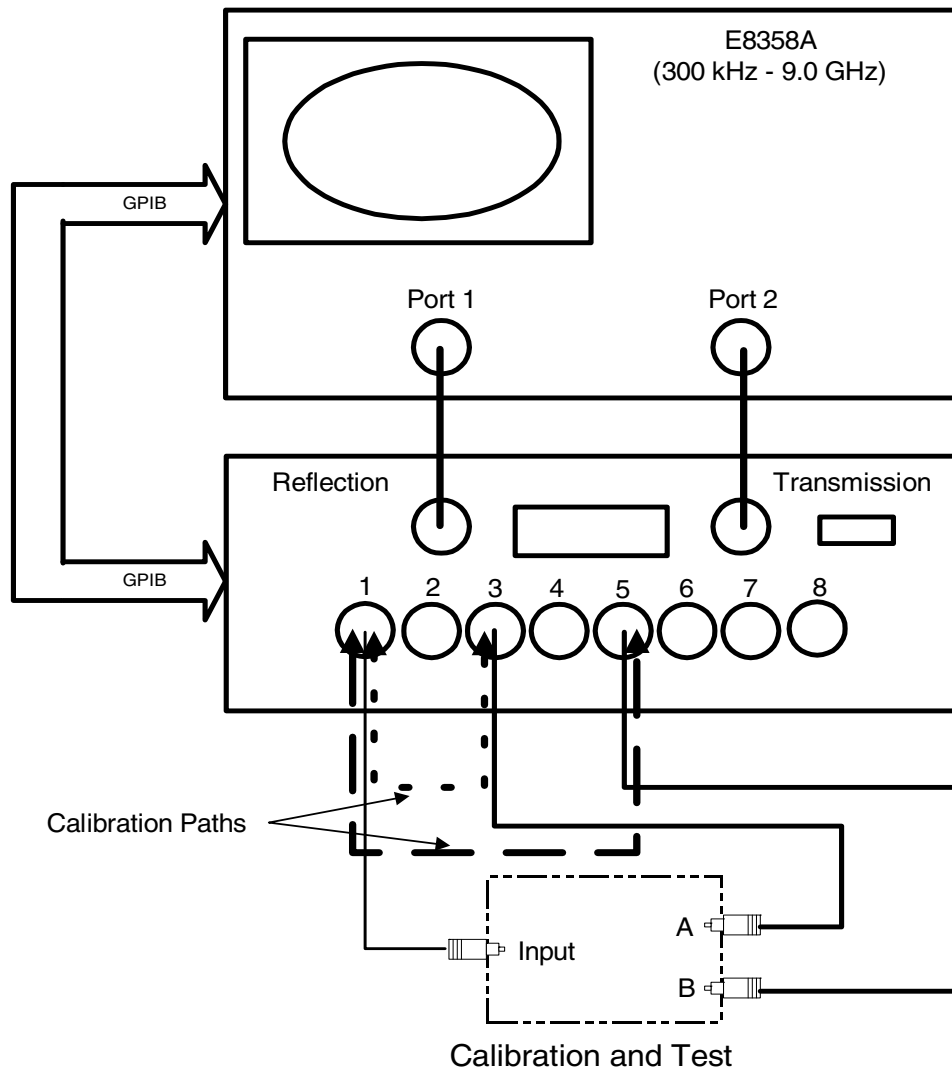
After the test set has warmed up for at least two hours, you must calibrate the instrument before making any measurements. To determine the type of calibration appropriate for the measurements you will be making, refer to the *PNA Series Network Analyzers User Guide*, part number E8356-90001.

You will need to calibrate each measurement path separately and store the calibration as an instrument state in the network analyzer. For information on how to calibrate and store instrument states, refer to the *PNA Series Network Analyzers User Guide*, part number E8356-90001.

In the example setup shown in [Figure 6-1](#), the following tests will be made:

- Return loss on the DUT's input and 2 output ports (A and B)
- Insertion loss (or gain) between the DUT's input and port A
- Insertion loss (or gain) between the DUT's input and port B

Figure 6-1 Calibrating the Test System



For the best accuracy, you should perform a full two-port calibration between ports 1 and 3 on the test set, and again between ports 1 and 5. As mentioned before, you need to save the calibrations as instrument states. For information on how to calibrate and store instrument states, refer to the *PNA Series Network Analyzers User Guide*, part number E8356-90001.

CAUTION

Do not use the test set to change the RF signal path direction when you are using a full two-port calibration. Doing so will render the calibration invalid. Instead, use the internal transfer switch in the analyzer.

This chapter contains the following sections:

- Using an External Computer to Control the Test Set
- Using the Control Lines Connector

Using an External Computer to Control the Test Set

Chapters 3 through 6 assume that the network analyzer is being used to control the test set. If desired, an external computer can be used instead. In order to do this, a GPIB cable needs to be connected between the computer and the network analyzer. There is no need to connect a GPIB cable between the test set and the network analyzer in this case.

The following advantages result from using an external computer:

- The control can be performed by a computer program running on the computer.
- GPIB queries (not available under manual control) can be sent to the test set.

GPIB Queries

When an external computer is used to control the test set, the computer can use all of the commands listed in [Table 3-2](#) and in [Table 3-3](#). In addition, the computer can use GPIB queries that are not available when the network analyzer is used to control the test set. These are listed in [Table 7-1](#).

Table 7-1 GPIB Queries

Query	What the test set sends in response
id?	Test Set ID
sw10?	Number of times Switch #10 has operated
sw11?	Number of times Switch #11 has operated
sw12?	Number of times Switch #12 has operated
sw13?	Number of times Switch #13 has operated
sw14?	Number of times Switch #14 has operated
sw15?	Number of times Switch #15 has operated
sw50?	Number of times Switch #50 has operated
sw51?	Number of times Switch #51 has operated

Box Identification

To read the Box Identification, first query the test set for its ID, then read back the ID from the test set. For example, if the GPIB address of the test set is 12, send the following commands:

```
OUTPUT 712;"id?"
```

```
ENTER 712;Box_id$
```

Switch Count

The Switch Count is the number of times a switch has been operated. To read the Switch Count for a particular switch, first query the switch and then read back the count. For example, if the test set has an address of 12, the following two commands will read the Switch Count for switch #10:

```
OUTPUT 712;"sw10?"
```

```
ENTER 712;Count$
```

Languages

Using Rocky Mountain Basic (RMB)

To address the Z5623A Option H48 test set directly over GPIB, use a controller to write directly to the test set's GPIB port. The following example assumes that the address of the test set is 12. (Note the semi- colon “;” .)

Write Commands:

```
OUTPUT 712;"STRING$;" ! Output Command
```

Read Commands:

```
OUTPUT 712;"STRING$;" ! Output Command
```

```
ENTER 712;String$ ! Enter Command
```

Using Quick Basic or Visual Basic

If you are using Quick Basic or Visual Basic, be sure to disable EOI and EOL before sending commands to the test set. Including the semicolon in program commands will not ensure that these commands are disabled as would be the case in HP Basic/RMB. When using the 82335 GPIB Interface and Visual Basic, use the following commands to disable EOI and EOL, send the necessary data to the test set, and re-enable EOI and EOL.

NOTE

Be sure to re-enable EOI and EOL before sending data to another instrument.

Write Commands:

```

info$="refl_01" `command for reflection to port 1
length%=len(info$) `length of command
HpibEoi(hHpib;7,0) `disable EOI
HpibEol(hHpib;7,"",0) `disable EOL
HpibOutputs (hHpib;712,info$,length%) `send command to test set
HpibEol(hHpib;7,chr$(13)+chr$(10),2) `re-enable EOL and set to
chr$(13)+chr$(10)
HpibEoi(hHpib;7,1,) `re-enable EOI hHpib specifies the handle
returned byHpibOpen.

```

Read Commands:

```

info$="id?" `command for test set identification.
length%=len(info$) `length of command
max.len% = 10 `max length data from id? or swxx? function.
infi$ = space$(max.len%)
HpibEoi(hHpib;7,0) `disable EOI.
HpibEol(hHpib;7,"",0) `disable EOL
HpibOutputs (hHpib;712,info$,length%) `send command to test set.
HpibEnters(hHpib%,712,infi$,max.len%) `get data from test set.
HpibEol(hHpib;7,chr$(13)+chr$(10),2) `re-enable EOL and set to
chr$(13)+chr$(10).
HpibEoi(hHpib;7,1,) `re-enable EOI hHpib specifies the handle
returned byHpibOpen.

```

NOTE

For more information on the EOI and EOL commands, refer to the programming library manual supplied with the 82335 interface.

Using HPVEE

If you are using HPVEE, be sure to set the Direct I/O in the Advance Device Configuration so the Read Terminator and Write EOL Sequence is set to "\n". In the I/O Transaction make sure the EOL is ON.

Using National Instruments VISA

If you are using National Instruments VISA, be sure to set the following variables as follows:

`VI_ATTR_SEND_END = VI_FALSE` ` This specifies whether to assert END during the transfer of the last byte of the buffer

`VI_ATTR_TERMCHAR = 0x0A` ` This is the termination character. When the termination character is read and `VI_ATTR_TERMCHAR_EN` is enabled during a read operation, the read operation terminates.

`VI_ATTR_TERMCHAR_EN = VI_TRUE` ` This is a flag that determines whether the read operation should terminate when a termination character is received.

`VI_ATTR_SUPPRESS_END_EN = VI_FALSE` ` Specifies whether to suppress the END bit termination. If this attribute is set to `VI_TRUE`, the END bit does not terminate read operations. If this attribute is set to `VI_FALSE`, the END bit terminates read operations.

Write Commands:

Append all commands with “\n,” for example, `*rst\n`.

Read Commands:

The Z5623A Option H48 returns data terminated by `\r\n`.

Using the Control Lines Connector

The Control Lines connector allows the test set to control other equipment. See [Figure 7-1, “Control Lines,” on page 7-7](#) for a diagram of the connector. The diagram identifies the ground pin and the pin that is associated with each of the five control lines (C1 through C5). (Notice that the connector has three unused pins.)

The connector is driven by open-collector output drivers within the test set. The drivers cannot source any current. Therefore, the user must provide an external power supply and some additional circuitry in order to use the connector. The next paragraph describes the absolute maximum limits associated with the connector. The remainder of the section describes possible ways of implementing the additional circuitry needed in order to use the connector.

Each control line on the test set can be independently set to either the “Open” state or the “Low” state. In the “Open” state, the voltage on the line will be set by the external power supply. This voltage must not exceed +22 Vdc. In the “Low” state, the voltage on the line will be about +0.63 Vdc. In the “Low” state, the drive circuitry can sink a maximum of 250 mA per control line.

Control Line Commands for 9-Pin Connector:

[Figure 7-1 on page 7-7](#) presents a diagram of the 9-pin connector and identifies the control lines (C1 through C5). To set the control lines, send the test set a number (either binary or decimal) specifying the state of all five lines. The binary number has the following format:

```
0 0 0 C5 C4 C3 C2 C1
```

Note that three leading zeroes are required. Note, also, that a 1 for a given control line specifies a low (+0.63 V) and a 0 specifies an open. For example, if the test set has an address of 12, the following command will set C3 and C1 low, and C5, C4, and C2 high:

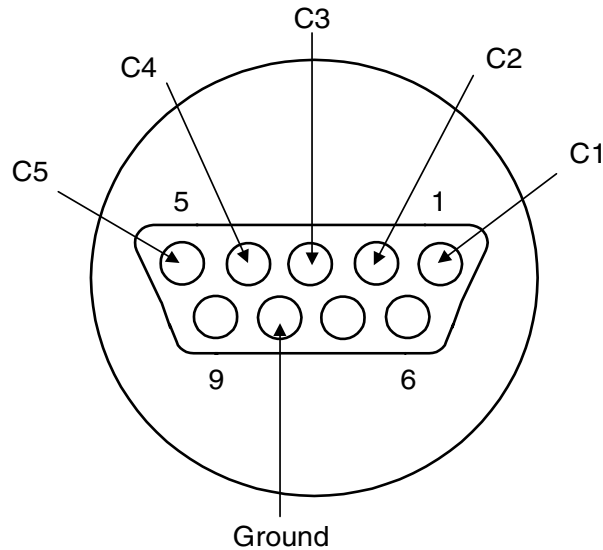
```
OUTPUT 712;"00000101;" ! sets C5-C1 to OOLOL
```

The decimal equivalent of the binary number can also be used:

```
OUTPUT 712;"5;" ! sets C5-C1 to OOLOL
```

[Table 3-3 on page 3-10](#) lists all possible combinations of control line states. For each combination, the table lists the binary and decimal numbers required to command that combination.

Figure 7-1 Control Lines

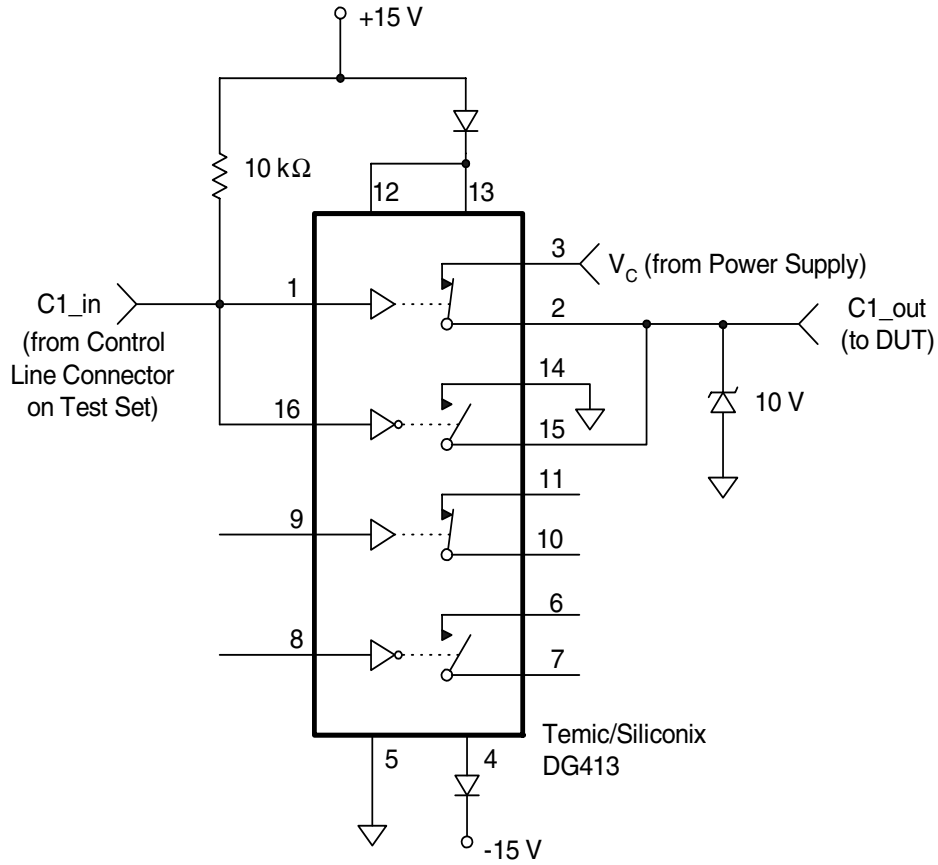


Suggested External Circuitry

Figure 7-2 shows one possible set of external circuitry for use with the Control Lines connector. The integrated circuit (IC) shown in the figure is a quad single-pole-single-throw (SPST) CMOS analog switch (Temic/Siliconix Part No. DG413). The IC contains two normally open and two normally closed switches.

Notice that, when “C1_in” is in the “Open” state, there will be no current through the 10 k Ω resistor and, consequently, no voltage drop across it. This means that +15 V will be applied to the control line when it is in the “Open” state. (The maximum allowable is +22 V.) When “C1_in” is in the “Low” state, it will sink $(15\text{ V} - 0.63\text{ V}) / 10\text{ k}\Omega = 1.44\text{ mA}$ of current. (The maximum allowable is 250 mA per control line.) The values computed in this paragraph do not depend on V_C , the voltage used to control the DUT. (V_C is applied to pin 3 in Figure 7-2.)

Figure 7-2 **Switch Driver Circuit For Use With Control Lines Connector**



The DUT may require a control voltage that is different from any of the existing power supply voltages. Rather than adding another power supply, a circuit such as the one shown in [Figure 7-3](#) can be used to derive the needed voltage from one of the existing power supply outputs. The IC shown in the figure is a 3-Terminal Adjustable Voltage Regulator (National Semiconductor Part No. LM317). It can supply a maximum output current of 1.5 A provided that $(V_{IN} - V_{OUT}) \leq 15 \text{ V}$.

The equations governing the circuit shown in [Figure 4-13](#) are

$$3 \text{ V} \leq (V_{IN} - V_{OUT}) \leq 40 \text{ V}$$

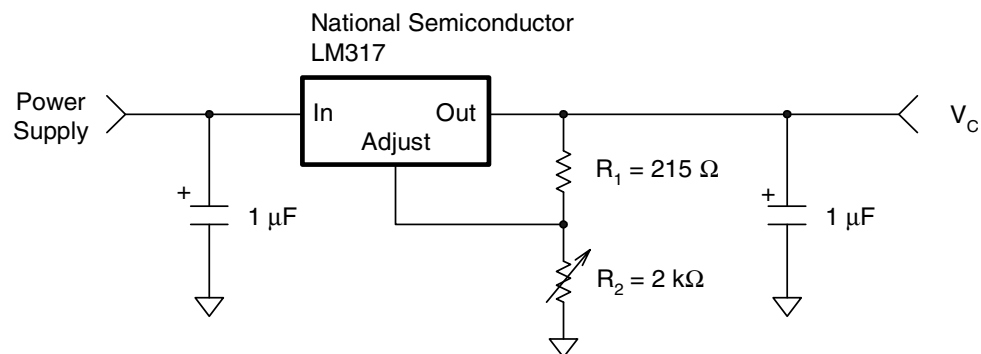
$$1.2 \text{ V} \leq V_{OUT}$$

$$V_C = (1.25 \text{ V})(1 + R_2 / R_1) + I_{ADJ} (R_2)$$

$$I_{ADJ} = 50 \mu\text{A (typical)}$$

The equations show that the circuit can be adjusted for any output voltage (V_C) from 1.2 V to 12.0 V provided that (a) a power supply voltage of 15 V is used and (b) the values of R_1 and R_2 shown in [Figure 7-3](#) are used.

Figure 7-3 Adjustable Voltage Regulator Circuit



V_C can be adjusted from +1.2 to +12.0 V if Power Supply = +15 V

Advanced Topics
Using the Control Lines Connector

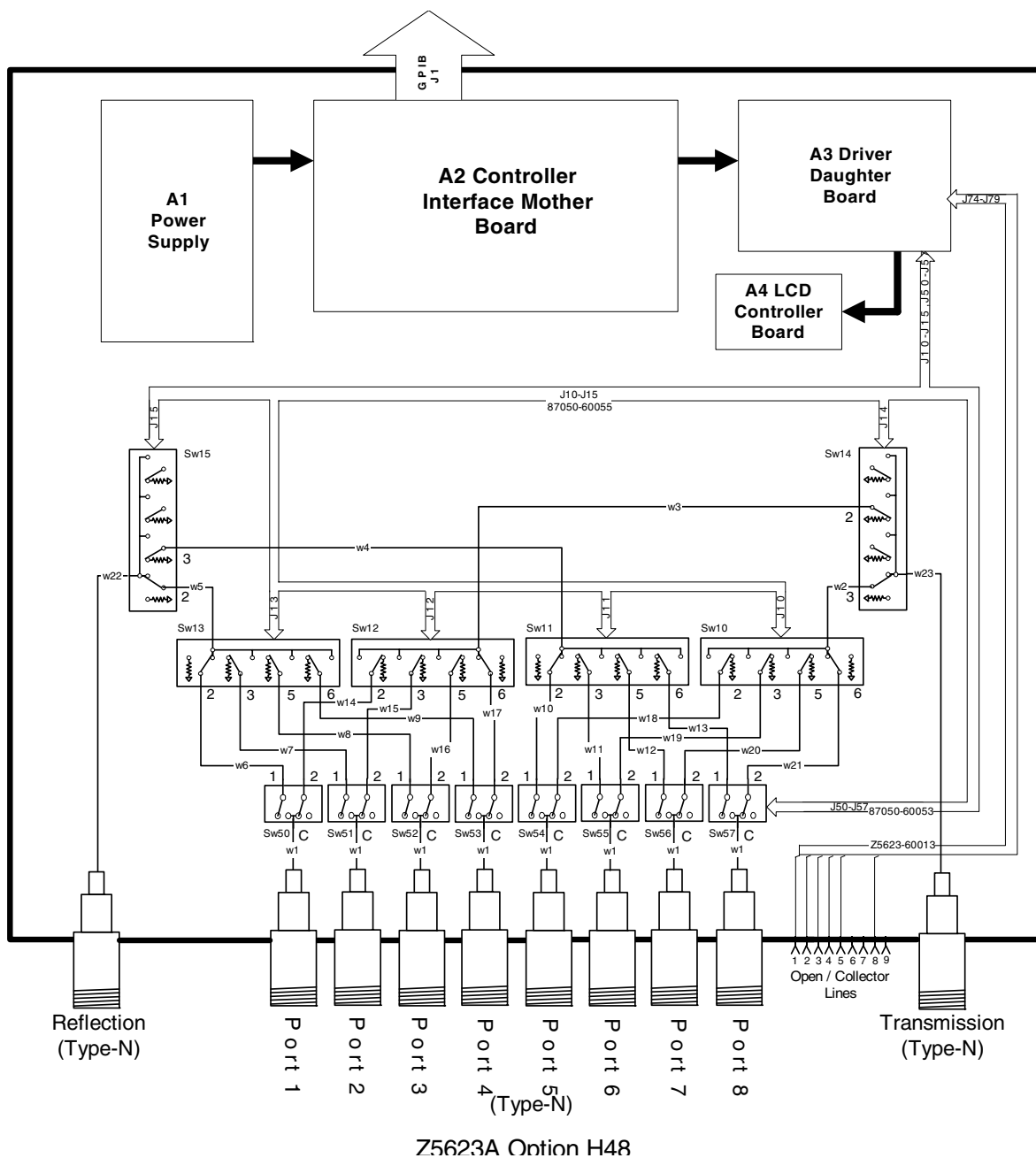
This chapter contains the following sections:

- [Adjustments](#)
- [Theory of Operation](#)
- [Troubleshooting](#)
- [List of Replaceable Parts](#)

Adjustments

There are no adjustments for the test set.

Figure 8-1 Z5623A Option H48 Block Diagram



Theory of Operation

The theory of operation begins with a general description of the test set. This is followed by more detailed operating theory. The operation of each group is described briefly, to the assembly level only. Detailed component-level circuit theory is not provided.

System Theory

Refer to [Figure 8-1 on page 8-2](#). The test set consists of three main components: a power supply, front panel display, and main switch board. The purpose of the power supply is to supply power to both the front panel display and the main switch board. The front panel display serves to indicate the switching paths to the user. Finally, the main switch board does the actual switching between the different ports.

A1 Power Supply Theory

The switching power supply provides regulated dc voltages to power all assemblies in the test set. A dc cable provides power to the main switch board. A connector from the main switch board to the front panel display provides dc power and control signals to the front panel. The power supply provides the following supplies: +24 V, +12 V, +5 V.

The power LED on the front panel indicates that the instrument is on and that the power supply is providing power.

A2 Controller and A3 Switch Driver Board Theory

The mother and daughter boards provide the bias for the switching paths for the various ports to the Reflection or Transmission ports. The front panel display contains an LCD that indicates the switched ports. A particular test port (1 through 8) can be in one of three states. The three states are:

- Switched to the forward path
- Switched to the reverse path
- Terminated in 50 Ω

When a port is not connected, it is automatically terminated in 50 Ω . Only one test port can be connected to any one reflection port and only one test port can be connected to any transmission port at any given time.

The test set consists of eight 1x2 switches and six 1x4 switches. The 1x2 switches divide each of the input ports (1 through 8) into two separate paths.

All switches are electromechanical and are biased according to the necessary switching path. A user interface through the GPIB and parallel ports converts the necessary input signals from the user to the necessary control signals to control the switching paths.

A4 Front Panel Display Theory

The front panel display consists of an LCD. The LCD is divided into two lines of text. The first line indicates which of the twelve ports are connected to the forward path. The second line indicates which of the twelve ports are connected to the reverse path. Control signals and DC power are provided by a cable connected to the main switch board.

Connector Replacement

The 50 Ω Type-N connectors are available separately. It is possible to replace them in the field.

Troubleshooting

This section contains procedures for troubleshooting the test set to assembly level only. These procedures should enable you to determine whether the power supply, front panel, or main switch board needs replacing. Refer to the system block diagram ([Figure 8-1 on page 8-2](#)) as an aid in troubleshooting.

General Troubleshooting Notes

WARNING	Always turn the instrument power off before removing or installing an assembly.
WARNING	Some parts in the instrument have sharp edges. Work carefully to avoid injury.
CAUTION	If you need to disassemble the instrument, be sure to work at an antistatic workstation and use a grounded wrist strap. This will protect the instrument from electrostatic discharges (ESD) that could damage the instrument.
CAUTION	After identifying a defective assembly or board, inspect it for obvious, easy-to-fix defects such as bent pins on ICs or cold solder joints. Repair of these defects by qualified personnel will restore the instrument to normal operation much more rapidly than ordering a replacement assembly or board.

Troubleshooting Power Supply Problems

Turn the instrument on. Check the condition of the LCD on the front panel:

- If it is off, there is still a possibility that the power supply is not supplying the necessary +24V, +12V, and +5V to the main board.
- If the LCD is off, check the main fuse located in the power supply filter at the rear of the instrument.
- If the LCD is still off, check the cable between the main board and front panel board.
- Finally, disconnect the DC power cable from the power supply to the main switch board and measure the voltages. They should be +15V, +12V, and +5V. If not, replace the power supply.

Troubleshooting the Front Panel Board

Turn the instrument power on and check the following:

- Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the transmission or reflection path. Ensure that the LCD indicates the appropriate path.
- If the LCD indicates a wrong path, the problem can lie with either the front panel board or the main switch board. Measure the RF path to determine where the problem is.
- Ensure that the front panel washers between the board and front panel assembly are present. Missing washers can cause erratic LCD behavior.
- If the LCD does not display the proper path, check to see if the RF path has indeed been switched. If the problem lies with the front panel board, replace it.

Troubleshooting the Controller and Switch Driver Boards

Turn the instrument power on. Check the condition of each of the switching paths by issuing commands to switch each of the paths to either the Reflection or Transmission path. Check each of the RF paths for connection. If an RF path is not connected to the necessary port or terminated in 50 Ω , replace the controller and switch driver board.

List of Replaceable Parts

The following table contains the list of replaceable parts for the test set. If any of these parts or assemblies is replaced, you must perform all performance tests to verify conformance to specifications.

Table 8-1 **Replaceable Parts for Z5623A Option H48**

Reference Designator	Description	Part Number	Quantity
A1	24 Volt Power Supply	0950-2252	1
A4	2x16 LCD	2090-0370	1
Sw50-Sw57	1P2T Switch 26.5 GHz	33314C	8
W5	RF Cable	87050-20017	1
W9	RF Cable	87050-20024	1
	J50-J57 CA AY	87050-60053	1
	J10-J15 CA AY	87050-60055	6
A3	Driver PCB	87050-60324	1
Sw10-Sw15	1P4T Switch 26.5 GHz	87104C	6
	Connector Type-N (F)	86290-60005	10
W1	RF Cable	Z5623-20027	8
W2	RF Cable	Z5623-20028	1
W3	RF Cable	Z5623-20029	1
W4	RF Cable	Z5623-20030	1
W6	RF Cable	Z5623-20031	1
W7	RF Cable	Z5623-20032	1
W8	RF Cable	Z5623-20033	1
W10	RF Cable	Z5623-20034	1
W11	RF Cable	Z5623-20035	1
W12	RF Cable	Z5623-20036	1
W13	RF Cable	Z5623-20037	1
W14	RF Cable	Z5623-20038	1

Table 8-1 **Replaceable Parts for Z5623A Option H48**

Reference Designator	Description	Part Number	Quantity
W15	RF Cable	Z5623-20039	1
W16	RF Cable	Z5623-20040	1
W17	RF Cable	Z5623-20041	1
W18	RF Cable	Z5623-20042	1
W19	RF Cable	Z5623-20043	1
W20	RF Cable	Z5623-20044	1
W21	RF Cable	Z5623-20045	1
W22	RF Cable	Z5623-20046	1
W23	RF Cable	Z5623-20047	1
A2	Control Mother PCB	Z5623-60016	1
	Front Panel AY	Z5623-60015	1

NOTE The above parts are unique to this special option. To order replacement parts, please contact the Component Test / Product Generation Unit (CT / PGU) Support Group at (707) 577-6802 with the part number, module/model number, and option number. If ordering parts through your local Agilent Technologies Sales and Service Office, specify that they are ordered through the Component Test PGU Support Group.

NOTE Special options are built to order. Long lead times may be encountered when ordering replacement parts.

Safety Information

This document contains two types of safety notices: Warnings and Cautions.

A Warning denotes a hazard that may endanger the operator. A Warning calls attention to a procedure, practice, or the like, which if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a Warning until the indicated conditions are fully understood and met.

A Caution denotes a hazard that may endanger the instrument. A Caution calls attention to an operating procedure, practice, or the like, which if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a Caution until the indicated conditions are fully understood and met.

Warnings

Warnings applicable to this instrument are:

WARNING	No operator serviceable parts inside. Refer servicing to qualified personnel. To prevent electrical shock, do not remove covers.
WARNING	If this instrument is not used as specified, the protection provided by the equipment could be impaired. This instrument must be used in a normal condition (in which all means for protection are intact) only.
WARNING	For continued protection against fire hazard replace line fuse only with same type and rating: <ul style="list-style-type: none">• United States—F 3A/250V, Part Number 2110-0780• Europe—F 3.15A/250V, Part Number 2110-0655 The use of other fuses or material is prohibited.
WARNING	This is a Safety Class I product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall be inserted only into a socket outlet provided with a protective earth contact. Any interruption of the protective conductor, inside or outside the instrument, is likely to make the instrument dangerous. Intentional interruption is prohibited.
WARNING	The power cord is connected to internal capacitors that may retain dangerous electrical charges for 5 seconds after disconnecting the plug from its power supply.

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

Cautions













Cautions applicable to this instrument are:

CAUTION Always use the three-prong ac power cord supplied with this instrument. Failure to ensure adequate earth grounding (by not using this cord) can cause instrument damage.

CAUTION This instrument has autoranging line voltage input; be sure the supply voltage is within the specified range.

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

Instrument Markings

	When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
	This symbol indicates that the instrument requires alternating current (ac) input.
	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
	This symbol indicates the product meets the Australian Standards.
	This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive, 2002/96/EC).
	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4).
	This symbol indicates that the power line switch is ON.
	This symbol indicates that the power line switch is OFF or in STANDBY position.
	Safety Earth Ground. This is a Safety Class I product (provided with a protective earthing terminal). An uninterruptible safety earth ground must be provided from the main power source to the product input wiring terminals, power cord, or supplied power cord set. Whenever it is likely that the protection has been impaired, the product must be made inoperative and secured against any unintended operation.

Regulatory Information

Statement of Compliance with IEC 1010

This instrument has been designed and tested in accordance with IEC Publication 1010, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The 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.

Declaration of Compliance with German Noise Requirements

This is to declare that this instrument conforms to the German Regulation on Machine Noise (Maschinenlaermverordnung -3.GSGV Deutschland).

Laermangabe (Noise Declaration)
Geraeuschemission (Acoustic Noise Emission)
LpA < 70 dB
am Arbeitsplatz normaler Betrieb (at Operator Position during Normal Operation)
nach DIN 45635 t.19 (per ISO 7779)

Contacting Agilent

By internet, phone, or fax, get assistance with all your test and measurement needs.

This information supersedes all prior HP contact information.			
Online assistance: www.agilent.com/find/assist			
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Brazil <i>(tel)</i> (+55) 11 3351 7012 <i>(fax)</i> (+55) 11 3351 7024	Canada <i>(tel)</i> +1 877 894 4414 <i>(fax)</i> +1 303 662 3369	Mexico <i>(tel)</i> 1 800 254 2440 <i>(fax)</i> 1 800 254 4222	United States <i>(tel)</i> 800 829 4444 <i>(alt)</i> (+1) 303 662 3998 <i>(fax)</i> 800 829 4433
Asia Pacific and Japan			
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Japan (Bench) <i>(tel)</i> 0120 32 0119 <i>(alt)</i> (+81) 426 56 7799 <i>(fax)</i> 0120 01 2144	Japan (On-Site) <i>(tel)</i> 0120 802 363 <i>(alt)</i> (+81) 426 56 7498 <i>(fax)</i> (+81) 426 60 8953	Singapore <i>(tel)</i> 1 800 275 0880 <i>(fax)</i> (+65) 6755 1235 <i>(fax)</i> (+65) 6755 1214	South Korea <i>(tel)</i> 080 778 0011 <i>(fax)</i> 080 778 0013
Taiwan <i>(tel)</i> 0800 047 669 <i>(fax)</i> 0800 047 667 <i>(fax)</i> 886 3492 0779	Thailand <i>(tel)</i> 1 800 2758 5822 <i>(alt)</i> (+66) 2267 5913 <i>(fax)</i> 1 800 656 336	Malaysia <i>(tel)</i> 1800 880 399 <i>(fax)</i> 1800 801 054	
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