User's Information
(Printed Version of Help)

Agilent Technologies
PNA Series Network Analyzers

Agilent Technologies

What's New in 2.6

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- Arbitrary Impedance calibration standard selections

- Many improvements to printed Help documentation including Programming Command Finder.

To check your PNA code version, click **Help**, then **About Network Analyzer**

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What's New in 2.5

- ECAL - Basic support for 4-port module

- ECAL User-Characterize - Use adapters with your ECAL module and store the characterization results in the module.

- Log Frequency Sweep - Logarithmic sweep and display.

- TRL Calibration - Added impedance and reference plane options

- Calibration Wizard - Improved error reporting messages

- Auto-Check - Automatically checks the Internet for new releases of the PNA

- Cal Kit Manager - Manage your Version 1 Cal Kits

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What's New in 2.0

The following are new and modified features in PNA code version A.02 (from A.01.5)

New Features

- 3 port Measurements - includes selection of all 9 S-parameters, selection of receiver "C" and associated ratios, and power level control on port 3.

- Calibration Sets - concept similar to that developed for the 8510 Network Analyzer but with more capability and flexibility.

- User Defined PRESET - you can customize the front panel PRESET functionality.

- AUXILIARY I/O, EXTERNAL TEST SET I/O, and MATERIAL HANDLER I/O - New Rear Panel Connectors

- ECAL Confidence Check - ensure confidence in your Electronic Calibration

- Manage Files... under File menu provides a File Manager functionality within the PNA.

- Source Power Cal and Receiver Power Cal - Power level flatness correction using for accurate absolute power measurements.

- S3P ASCII - file format for data files.

- .jpg format for screen dumps - includes white background on direct draw surface.

- Custom PNA Measurements - User-defined measurements

- Minimize - View menu selection allows you to minimize the PNA application.

Modified Features

- Calibration Wizard - supports guided and unguided calibrations. Guided calibrations provide additional features of "adapter removal", "unknown thru" and "full 3 port cal type". Both guided and unguided cals support "sliding load" calibration standards and more than one standard for a given frequency span.

- Limit Lines -can now be viewed on multiple traces in a single window. Also Limit lines are now updated for non active traces.

- 16 independent channels - Increased from 4

- Added several Marker Improvements:
  Coupled Markers
  Marker Readout
  Memory traces can now support markers

- SYSTem:PRESet - this SCPI command will no longer restore the display if it is disabled due to DISP:ENAB OFF. The display is restored by either front panel Preset or *RST.

- **PNA Product Overview** - includes the new additions to the PNA Series analyzers. Launch from the PNA desktop.

Administrative Tasks

Set Up Administrator Password

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By default, your analyzer does not require you to enter a password when started. Do this procedure if, for security reasons, you want to require a password.

1. In the PNA application, Press **Ctrl - Alt - Delete**

2. Click **Change Password**

3. Click in **New Password** text field

4. Type in your new password

Note: DO NOT FORGET YOUR NEW PASSWORD. You will not be able to start your analyzer without it.

Set Up Analyzer Users

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When the analyzer power is switched on, it automatically logs into Windows 2000 using the default Administrator user name and password. Anyone can have full access to the analyzer.

If the analyzer is in an environment as described below, then you may not need to specify analyzer users.

- Located in a secure environment

- Is not controlled using COM over the LAN

- Does not have users making network connections to the instrument disk drives or printers using their own user name and password

If the analyzer is in an environment that requires different levels of users, you can designate yourself as the administrator and then set the analyzer to allow others to use it with reduced permissions. That is, other people can be signed on to use the analyzer but they will not have the ability to perform all of the administrative functions that you can as the administrator.

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To set up analyzer users:

1. In the analyzer **System** menu, point to **Configure**, and click **Control Panel**.

2. In the **Control Panel** window, scroll down and select the **Users and Passwords** application.

3. On the **Users** tab, if the **Add** button appears dimmed, select the **Users must enter a user name and password to use this computer** check box near the top of the window.
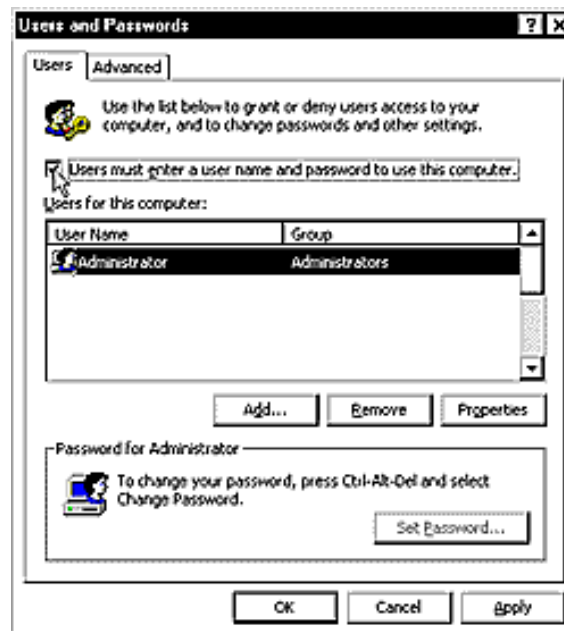
4. Click **Add** to enter the information for yourself or for another user.

5.   In the **User name** box, enter a user name for the user. In the **Full name** box, enter the full name of the user.

6.   In the **Description** box, enter a description for the user. Then, click **Next**.
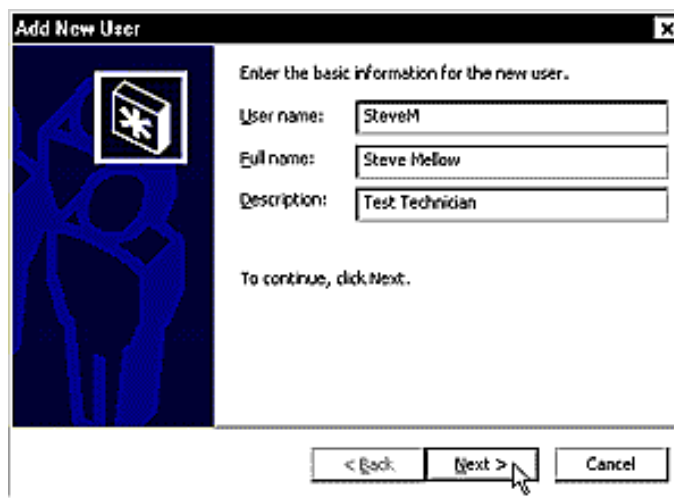
7.   In the **Password** box, have the user type a password. Have the user retype the password in the **Confirm password** box. Then, click **Next**.

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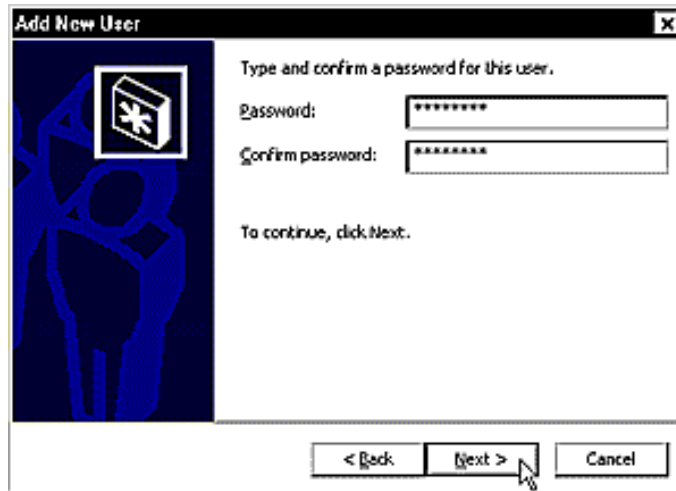
8. Select the level of access that you wish to grant this user

Note: Standard users and restricted users are unable to switch GPIB modes and install firmware.

There are several other levels of security that you may grant in the **Other** list. A description of each of these other levels is displayed beneath the **Other** box when it is selected. Then, click **Finish**.
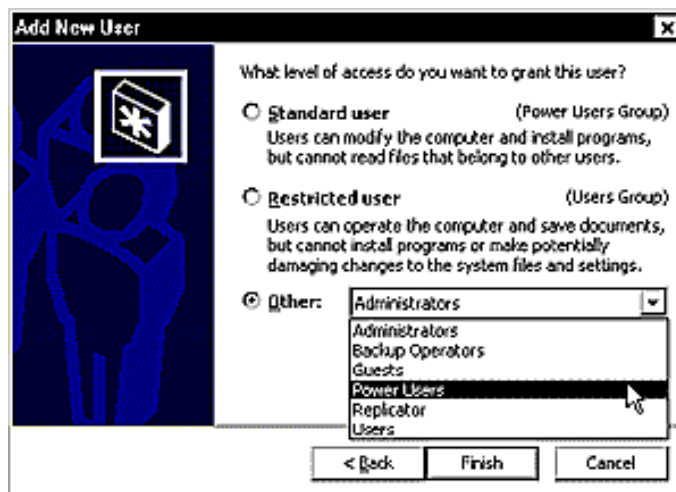
9. In the **Users for this computer** box, validate the user name and security level group of the user.

10. If you want this user to be able to use the network analyzer without entering their password each use, clear the **Users must enter a user name and password to use this computer** check box. Click **OK**.
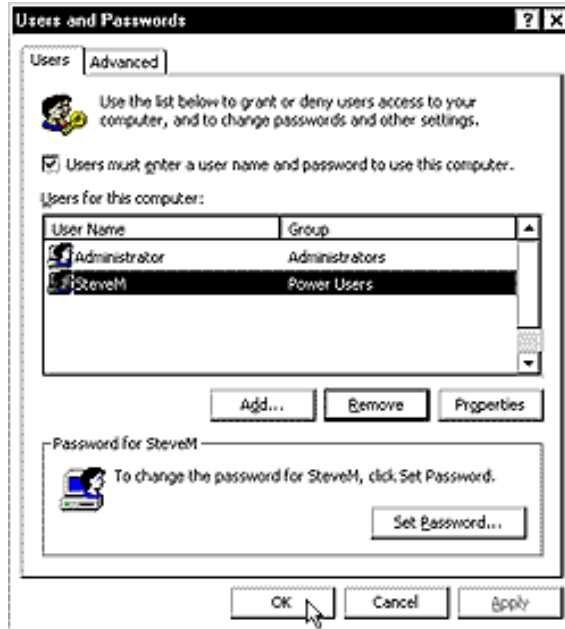
11. When the **Automatically Log On** window is displayed, have the new user type their password in the **Password** box and have them retype the password in the **Confirm Password** box.
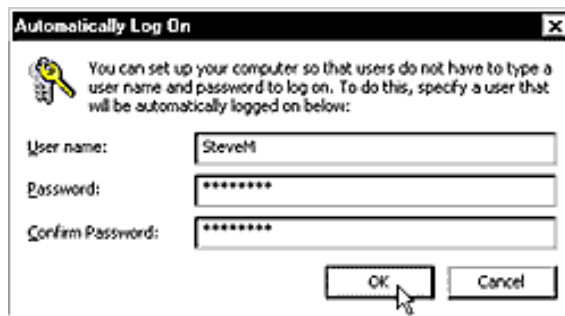
12. Click **OK** to complete this user addition.

13. In the **File** menu, click **Close** to close the Control Panel.

Change Computer Name

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Your PNA has a unique computer name that identifies it on a network. To view or change the computer name, you must first minimize the PNA application.

1. From the **View** menu click **Minimize Application**

To change the Computer Name:

1. On the desktop, right-click **My computer** Icon

2. Click **Properties**

3. Click the **Network Identification** tab at the top of the dialog box

4. Click **Properties**

5. Change **Computer Name** to your preference

Note: To add your computer to a domain, or to set up the networking configuration, contact your company's I.T. department. This setup is custom for each company.

To restore the PNA application, click on the PNA Analyzer taskbar button at the bottom of the screen

Set Time and Date

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To set the time and date on your PNA, you must first minimize the PNA application.

1. From the **View** menu click **Minimize Application**

To set the Time and Date:

1. Move the cursor to the lower corner of the screen

2. When the taskbar appears, double-click on the displayed time. This opens the **Date/Time Properties** dialog box.

3. Change the date, time, and time zone as appropriate.

To maximize the PNA application, click on the PNA Analyzer taskbar button at the bottom of the screen

Operating System Recovery

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This procedure will completely restore the operating system of the PNA back to the original factory condition. It will not work if the hard drive is damaged. Perform this procedure for the following types of situations:

- If recovering from a corrupted operating system.

- If you have security concerns where all previous usage remnants need to be eliminated.

- If the PNA must be in a known configuration such as rental companies.

Note: If you have made an emergency repair disk, you may be able to recover from some Windows operating system problems without losing any user information or settings. Windows 2000 has several other methods to help recover from situations where the system will not properly start up. The scope of these tools is too extensive to cover in this document. Refer to the Windows 2000 Help system or contact your systems administrator.

Overview

The hard drive in the PNA Series analyzer has two partitions (or drives):

1. **C: drive -** contains the Windows 2000 operating system (NTFS format), all programs, and other needed files.

2. **D: drive -** the Disaster Recovery Partition. It contains a compressed image of the C: drive as it existed when shipped from the factory, plus its support files. It may also contain

other items such as drivers or firmware. Do NOT use this drive for day-to-day use.

Important note: This procedure will erase the entire C: drive and the following information will be lost:
 - All changes and additions made to the analyzer since purchase (except options)
 - All user accounts and passwords
 - All added programs
 - All saved instrument states
 - All user configurations and Windows settings

You can save this information to a floppy drive or to a folder on the D:drive. The D:drive will not be affected by this restoration process. In addition, factory instrument calibration will not be affected if no changes have been made since the original factory calibration. If changes have been made through the service routines, copy all files that start with "mxcalfile_" in the C:\Program Files\Agilent\Network Analyzer directory, and save them to the D:\Calfiles directory. Any permanent instrument options should not be lost.

Operating System Restoration Procedure

Normally you can boot from the D: drive (which will allow you to erase and restore the C: drive) as a selection during the normal boot-up process. However, if this boot-up selection process is not functioning due to a damaged operating system, see If you CANNOT Boot from the Hard Drive.

To boot from the disaster recovery partition:

1. Click **Start, Shutdown, Restart**

2. After the Agilent logo displays on the screen, you have several seconds to select an alternative operating system from the normal default of Windows 2000. Select the **Recovery** partition. A brief "splash screen" will appear indicating that you are booting from the recovery partition.

3. The analyzer will display a warning about proceeding and give you two chances to abort. After the second warning, the restoration process will begin immediately.

Restoration will take from 30 to 60 minutes. There is no user interaction required. Near the end of the process, the PNA will reboot several times. The PNA application may start before the process is complete. Do not attempt to use the analyzer until the PNA application is running and all activity has stopped for at least one minute.

Once the operating system is completely recovered, you can restore any files you may have saved back to their original locations. The mxcalfiles that were stored in D:\Calfiles will be restored automatically. Other files must be copied or moved manually.

If PNA application updates had previously been downloaded through AgileUpdate, they can now be re-installed. Update files are stored on the D: drive and are unaffected by a system restoration. To access these, click **System**, then point to **Service**, then click **AgileUpdate**. Click **Install from File** then click **Browse.** Navigate to **D:\Updates**. Click **OK.**

If you CANNOT boot from the Hard Drive

If the PNA is unable to boot, then you must make a DOS boot disk. To make this disk, you will need a floppy disk and a computer that is currently running DOS or Windows 95/98/ME/XP.

Note: Windows NT or 2000 cannot be used!

Generally, the way to create this disk is to right-click on the **A:** drive, select **Format,** then select **Make System Disk** (or copy system files).

To boot from this disk:

1. Insert the created system disk into the PNA and restart the operating system. The PNA should detect this disk and boot from it. See if the System does not attempt to Boot from

the Floppy.

2. At the DOS prompt (A:\>)type **CD C:** and press **Enter**. You are really changing to the D: drive because a DOS operating system does not recognize the NTFS format and assumes the first valid drive is C:.

3. Type **Autoexec.bat** and press **Enter**.

4. Continue with Operating System Restoration Procedure (above).

If the Operating System does not attempt to Boot from the Floppy

You may have to change the PNA Bios settings to have it scan the floppy disk before booting from the hard drive. Due to bios revisions, the exact procedure may vary slightly from the following.

To enter the Bios menu:

1. Attach a keyboard to the analyzer. Restart the PNA.

2. When the Agilent logo appears, press **F2** (function key) on the keyboard a few times. The Bios menu will appear several seconds later.

3. Select **Boot** using the keyboard arrows. Depending on the Bios of your PNA, use the keyboard to select booting from the floppy drive before attempting to boot from the hard drive.

4. Select **Save** then **Exit**.

Once the analyzer is functioning properly, remove the floppy disk and use this procedure to change back to booting from the hard drive. Failure to do this will result in error messages when a floppy disk is inserted while powering up.

Emergency Repair Disk

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In the event that the analyzer hard disk becomes damaged, you may be able to recover the hard disk contents if you have created an emergency recovery disk. You should create this disk after you first setup the instrument.

Important Note: A different procedure can be used to restore the Operating System as it was shipped from the factory. However, you may lose some files or PNA settings. For more information see Operating System Recovery.

You will need a blank 1.44 MB floppy disk to create the emergency repair disk.

Note: The repair process relies on information that is saved in the systemroot\repair folder. Do not change or delete this folder.

Optional: for additional information on the repair process, use the following procedure to view the Windows 2000 Professional Getting Started online book.

Minimize the PNA application:

1. From the **View** menu click **Minimize Application**

View the online book:

1. On the desktop, click the **My Computer** icon.

2. Click **Help**.

3. Click **Help Topics**.

4. Click the **Index** tab.

5. Type keywords: **repair folder**.

6. Click **Display**.

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To Create an Emergency Repair Disk

1. From the analyzer **System** menu, click **Windows Taskbar**.

2. Point to **Programs**, **Accessories**, **System Tools**, and then click **Backup**.

3. In the **Tools** menu, click **Emergency Repair Disk**.

4. Click the checkbox for **Also back up the registry to the repair directory...**.

5. Follow the instructions that appear on the screen.

Windows 2000 Considerations

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This topic highlights a few notable changes to the operating environment with Windows 2000. For more detailed information on these and other topics, see the Windows 2000 Help system.

IMPORTANT: The PNA operates on a Intel processor-based personal computer (PC) platform with the Microsoft Windows 2000 operating system. This operating system has been modified and optimized by Agilent to improve the performance of the PNA. Any modifications or reconfigurations of the operating system or Agilent's software should NOT be attempted. For example:
1. Do not reinstall a standard version of the Windows 2000 operating system on the PNA.
2. Do not add or delete any hard disk drive partitions on the PNA.
3. Do not delete the "Agilent" user profile.
4. Do not modify any of the Agilent software registry entries.
 Attempting any of these modifications will result in the need to replace the hard disk drive at the owner's expense. Correcting problems caused by these actions will *not* be covered under warranty. Before taking any action that might be similar to those items listed above, contact Agilent for advice.

Using USB

The PNA has two USB ports for connecting devices: one on the front panel and one on the read panel. The main advantages of USB are "hot" connects and disconnects and fast data transfer speeds. Electronic Calibration modules are also now available with USB connections.

The first time you plug a device into a USB port there is some wait time. Windows 2000 reports it is identifying the hardware, then searching for the correct driver, then installing the driver (if it was found).

Connecting that same device back into that same port later is quick and easy, but if you move the device to a different USB port, you will have to wait through the hardware ID and driver search again.

Plug & Play Stability and Security

Plug & Play capabilities is similar to Win 95 and 98. It provides both a stable and secure operating environment. You may notice also that it greatly reduces the number of required reboots.

LAN Connections

Windows 2000 supports DHCP and fixed IP addressing. Also, "Hot" connect and disconnect of the LAN cable, as well as a visual indicator of LAN status in system tray area, makes LAN connections more intuitive. In addition, the Hardware Wizard helps users with system hardware configuration.

Single and Double Click option.

By default, Windows 2000 allows a single-click method of launching icons. To revert to double-clicking, go to Start -> Settings -> Control Panel and click on Mouse. In the Mouse Properties dialog, select Double-click to open an item. Then click OK.

Quick Start
Powering the PNA ON and OFF

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There are three PNA operating modes:

- Hibernate
- ON
- Shut down

As an alternative to using the green power button, you can perform these and other functions using a mouse:

1. On the PNA **System** menu, click **Windows Taskbar**
2. On the Windows Taskbar, click **Shutdown**
3. In the **What do you want the computer to do?** list, choose an action.
   Log off
   Shut down
   Restart
   Hibernate

   A description of your choice appears below the list box
4. Click **OK** to perform the action

Hibernate Mode

In Hibernate mode the current analyzer state is automatically saved to the hard disk before the analyzer is powered OFF. When the analyzer is powered ON, this analyzer state is loaded, thus saving time over a full system boot-up. A password is *not* required to resume analyzer operation after Hibernate mode.

The hibernation state is the normal OFF state. A small amount of standby power is supplied to the analyzer when it is in the hibernation mode. This standby power only supplies the power

switch circuits and the 10 MHz reference oscillator; no other CPU-related circuits are powered during hibernation. To guarantee that your measurements meet the analyzer's specified performance, allow the analyzer to **warm-up for 90 minutes** after the power button light has changed from yellow back to green.

To Hibernate the analyzer, press the power button briefly.

Within several seconds, the **Ready to Hibernate** banner will appear.

Shortly, the **Preparing to Hibernate** banner will appear.

The power button will change to yellow when in Hibernate mode.

ON Mode

To turn the analyzer ON, press the power button.

The power button will change to green when ON.

Shut Down Mode

In shut down mode the current analyzer state is *not* automatically saved before the analyzer is powered OFF. When the analyzer is powered ON, a full system boot-up is performed and the analyzer application powers-up in the preset settings. To guarantee that your measurements meet the analyzer's specified performance, allow the analyzer to **warm-up for 90 minutes** after the power button light has changed from yellow back to green.

A password is required to resume analyzer operation after shutdown mode. The analyzer should only be shut down for service or to provide security via password protection.

To shut down the analyzer:

1. Click **System** then click **Windows Taskbar.**
2. Click the Windows **Start** button, then **Shutdown**
3. In the **What do you want the computer to do?** box, click **Shutdown,** then click **OK**

The power button will change to yellow when OFF.

Note: If the analyzer is locked and you cannot operate the mouse or keypad, shut down the analyzer by pressing the power button for at least 4 seconds. This should be avoided as the file system can become corrupt - no different than with any other PC. Most of the time Windows is able to recover without loss of data. That does not indicate that the practice is safe.

Unplugging the PNA

Remove the power cord from the analyzer ONLY when the power button is yellow. The button will remain yellow for several seconds after the power cord has been removed.

If the power cord is removed while the power button is green (PNA ON), damage to the hard drive is **likely**.

Front Panel Interface

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There are three ways to use the front panel keys:

- **Active Entry Toolbar** (quickest)
- **Launch Dialog Boxes**
- **Navigate Menus** (most comprehensive)

Other Quick Start topics

Active Entry Toolbar

Not all settings can be made this way. For making ALL settings use Menus.

You can make settings quickly using this four step procedure.

(1) Press a key

(2) View active entry

(3) Select a function

(4) Enter a value (if necessary)
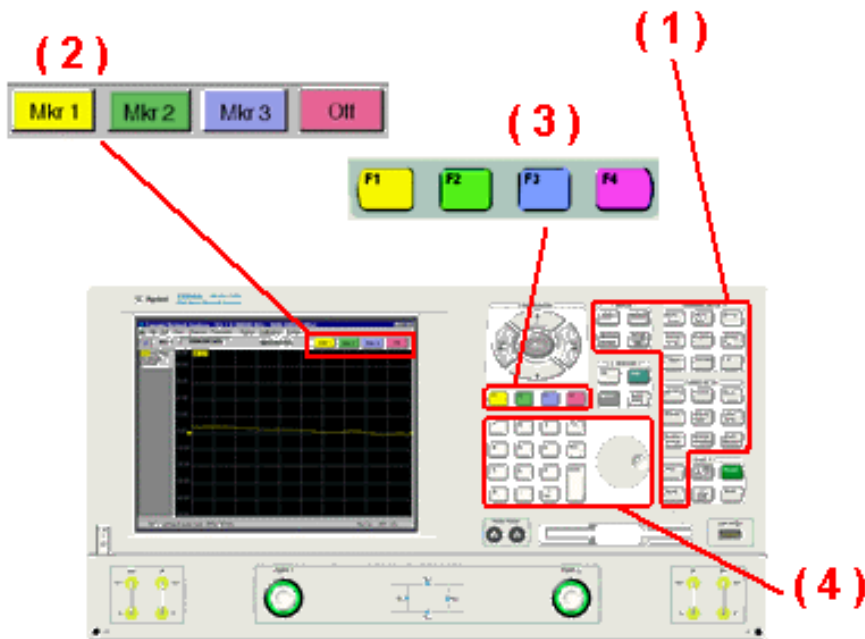
Launch Dialog Boxes,

To quickly launch MOST dialog boxes:

(1) Press the Menu/Dialog Key

(2) Select a function key
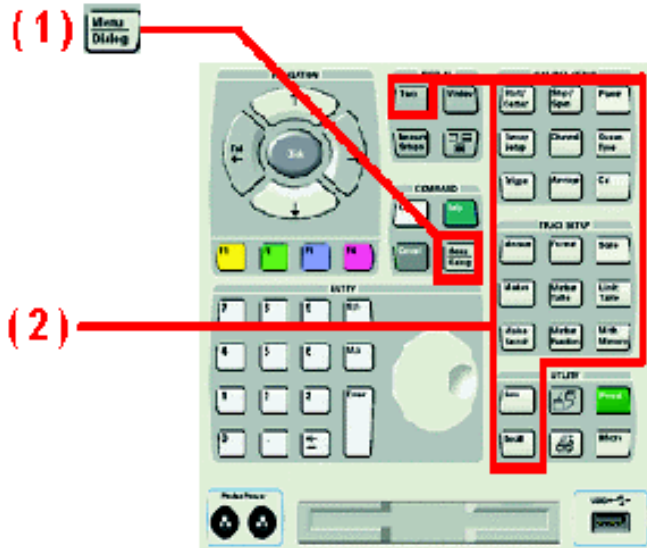
Navigate Menus

You can access ALL PNA functions using Menus:

(1) Press the Menu/Dialog Key

(2) Use the direction keys to navigate through the Menus. Use the "Click" key to make a selection.

(3) Other Command keys are available for cancelling or seeking Help (if necessary)
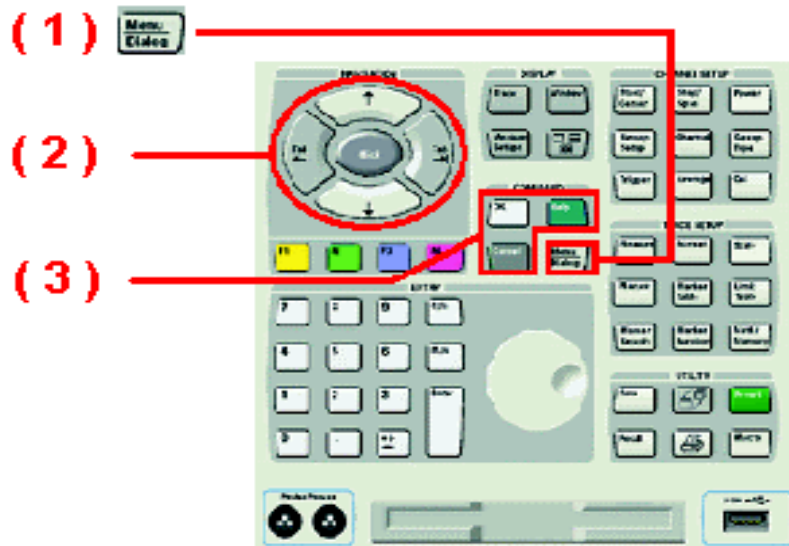
Traces, Channels, and Windows on the PNA
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It is critical to understand the meaning of the following terms as they are used on the PNA.

- Traces
- Channels
- Windows

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    Other Quick Start topics
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Traces are a series of data points seen on the PNA screen. The PNA can have up to **16 measurement traces** and 16 memory traces at one time.

Trace settings affect the mathematical operations and presentation of the measured data. The following are Trace settings. (A trace must be active to modify its settings.)

- Parameter
- Format
- Scale
- Calibration ON / OFF
- Trace Math
- Markers
- Electrical Delay
- Phase Offset
- Smoothing
- Transform

Channels contain traces. The PNA can have up to **16 independent channels.** All 16 (possible) traces can be assigned to one channel or each trace can be assigned to a different channel.

Channel settings determine **how** the trace data is measured . All traces that are assigned to a channel share the same channel settings. The following are channel settings (A channel must be active to modify its settings.)

- Frequency span
- Power
- Calibration data
- IF Bandwidth
- Number of Points
- Sweep Settings
- Average
- Trigger (some settings)

Windows are used for viewing traces. Windows are completely independent of channels. The PNA can show up to **4 windows** on the screen. Each window can contain up to **4 traces**.

Most Window settings are made from the **View** menu. See Customize the PNA screen for details.
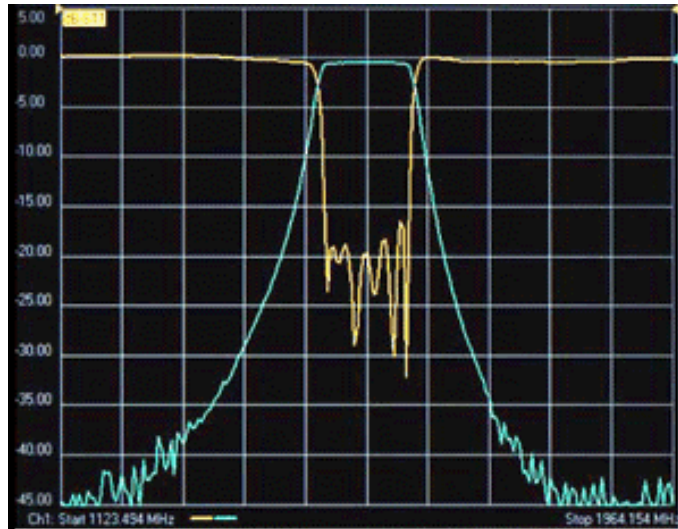
Basic Measurement Sequence
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The following process can be used to setup all PNA measurements:

Step 1. Set Up Measurements
 Reset the analyzer, create a measurement state, and adjust the display.

Step 2. Optimize Measurements
 Improve measurement accuracy and throughput using techniques and functions.

Step 3. Perform a Measurement Calibration
 Reduce the measurement errors by performing a calibration.

Step 4. Analyze Data
 Analyze the measurement results using markers, math operations, and limit tests.

Step 5. Print, Save or Recall Data
 Save or print the measurement data.

Using Help
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Help contains User and Programming documentation. This topic discusses the following:

- Printing Help

- Copying Help to your PC

- Launching Help

- Navigating Help

- Help Languages

- Glossary
- Dialog Boxes
- About Network Analyzer
- Documentation Warranty
- Suggestions Please

Other Quick Start Topics

Printing Help

You can print a hardcopy of all, or part, of the PNA Help system. If your PNA is connected to the web, click the links below to launch pdf files of Help. Or you can copy the URL to your PC. The pdfs are also on the CDROM that was shipped with your PNA.

- Users Information -http://www.tm.agilent.com/classes/MasterServlet?view=manual&man-ItemID=1000002733&language=eng&locale=US

- Programming Information - http://www.tm.agilent.com/classes/MasterServlet?view=manual&man-ItemID=1000002732&language=eng&locale=US

Copying Help to your PC

With the Help system on your PC, you can read about the PNA while away from it. You can also Copy and Paste programming code from this Help system directly into your programming environment.

The Help file is located on your PNA hard-drive at **C:\ Winnt\ Help\ PNAHelp.chm**. If both the PNA and PC are connected to LAN, you can map a drive and copy the file directly. The Help system is also on the CDROM that shipped with the PNA.

Launching Help

The Help system can be launched in three ways:

1. From the front panel Help button.
2. From the **Help** drop-down menu
3. From Dialog Box Help

Navigating Help

The Help Window contains 3 panes (regions):

1. Toolbar Pane
2. Topic Pane
3. Navigation Pane
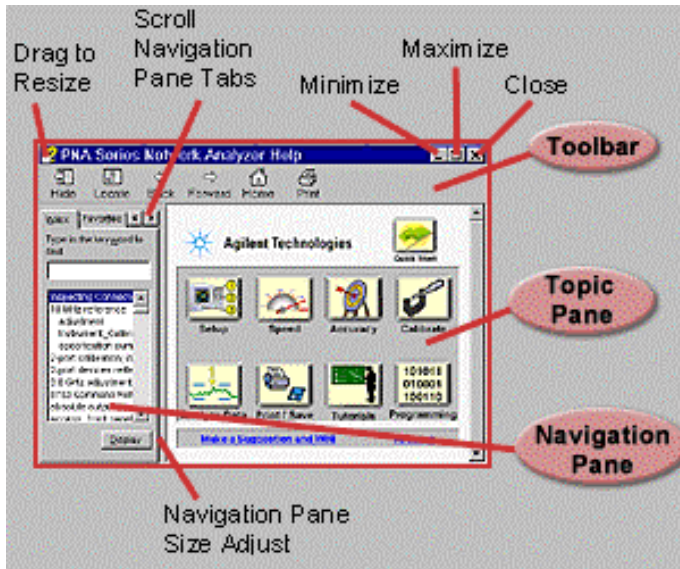
Toolbar Pane

The Toolbar is at the top of all Help windows. It allows you to resize the window, browse and print the selected topic.
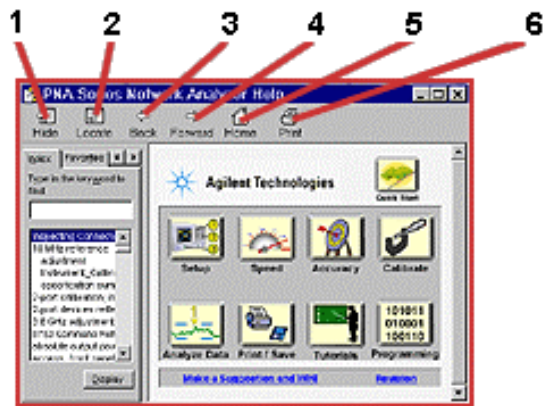
1. Click to hide or show the navigation pane
2. Click to locate the topic in the table of contents
3. Click to return to previous topic, if present.
4. Click to proceed to the next topic, if present.
5. Click to go to the Home page.
6. Click to print the topic pane.

Navigation Pane

Click the following tabs in the Navigation Pane to access information in the Help system:

Table of Contents Tab

Index Tab

Search Tab

Favorites Tab

(Table of)Contents Tab

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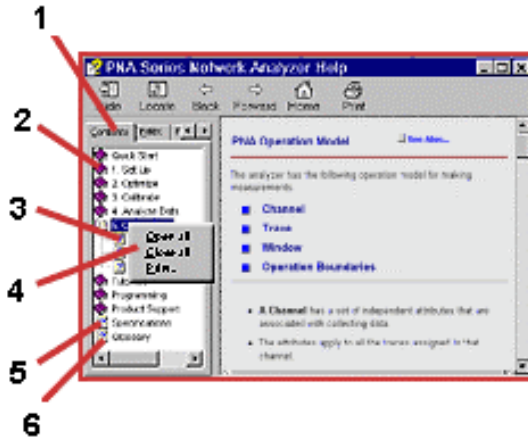
1. Click tab to select Table of Contents.
2. Click a book to access related topics.
3. Click to display a topic.
4. Right click to access menu.
5. Click to display specifications
6. Click to display glossary

Index Tab

The index tab allows you to type a keyword and go to only the most applicable topics.
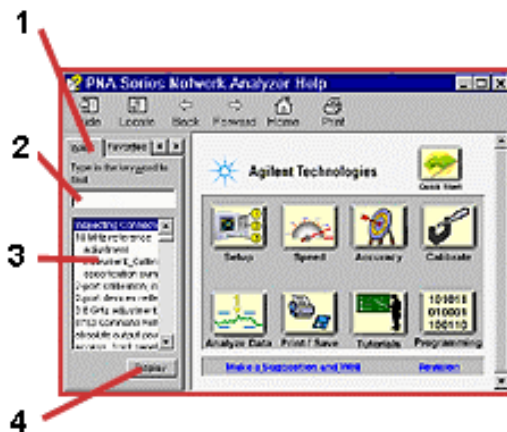
1. Click tab to select index.
2. Type keyword to find topics of interest.
3. View suggested topics. (Double-click to display topic.)
4. Click to display topic.

Search Tab

The following rules apply for using full-text search:

- Searches are not case-sensitive.
- You can search for any combination of letters (a-z) and numbers (0-9).
- Punctuation marks (period, colon, semicolon, comma, and hyphen) are ignored during a search.

- You can group the words of your search using double quotes or parentheses. Examples: "response calibration" or (response calibration). This requirement makes it impossible to search for quotation marks.

- Use Wildcard expressions:
   * To search for one undefined character use a question mark (?). For example, searching for **cal?** will find **calc** and **calf.**
   * To search for more than one undefined character use an asterisk (*). Searching for **Cal*** will find **calibration** and **calculate**

- Use Boolean operators to define a relationship between two or more search words.

Search for	Example	Results will show topics containing:
Two words in the same topic	response AND calibration	Both the words "response" and "calibration"
Either of two words in a topic	response OR calibration	Either the word "response" or the word "calibration" or both
The first word without the second word in a topic	response NOT calibration	The word "response" but not the word "calibration"
Both words in the same topic, close together.	response NEAR calibration	The word "response" within eight words of the word "callibration"

Favorites Tab

The favorites tab allows you to store (bookmark) the topics you refer to most often so that they can be recalled easily.
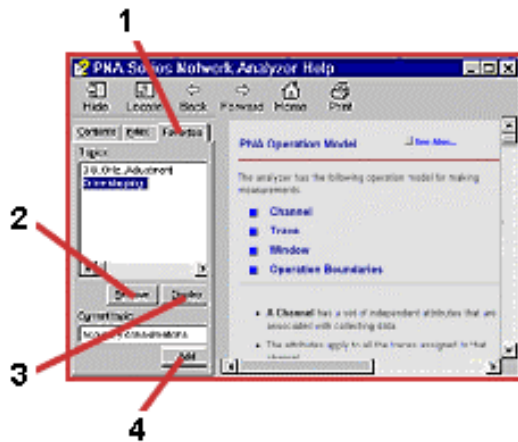
1. Click tab to view stored topics in Favorites.
2. Remove selected topic.
3. Display selected topic.
4. Add (store) current topic.

Topic Pane

The Topic pane allows you to view the contents of the selected topic.
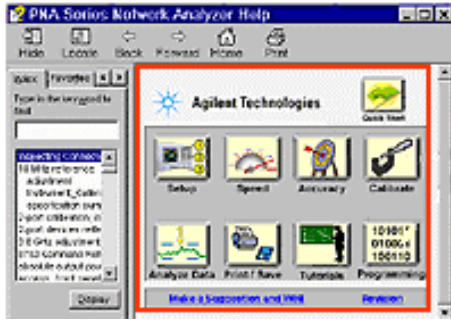
Help Languages

The Help system is available in five languages:

- English
- French
- German
- Japanese
- Spanish.

To select a different help language:

On the **Help** menu, point to **Help Language**. Then click the language.

Note: The Programming section is only available in English. Also, the most recent version of Help will be English.

Viewing Help in Japanese

Japanese uses a different character font set than the other languages. Most all of the Japanese Help system looks normal except pop-up windows. To view the pop-up windows in the Japanese version of Help, you must change the following settings:

1. From the PNA, click **View**
2. Click **Title Bars** (if not already checked)
3. Minimize the PNA screen
4. From the desktop of the PNA. click **Start / Settings / Control Panel / Regional Options**.
5. Under **Language settings for the system**, scroll to and check **Japanese**
6. Under **Your locale (location)** select **Japanese**
7. Click **Set default...**
8. Under **Select the appropriate locale**, select **Japanese**

These changes may cause the Windows 2000 fonts to become small. To change them back to larger fonts, change the following settings:

1. From the PNA desktop click **Start / Settings / Control Panel**
2. Click **Display / Appearance**
3. Under **Scheme** select **Windows Standard**

To restart the PNA application, click **PNA Analyzer** taskbar button at the bottom of the screen

Glossary

The Glossary holds definitions of words, in alphabetical order.

Click to Access
Terms that Start
With the Letter

View Term
Definitions
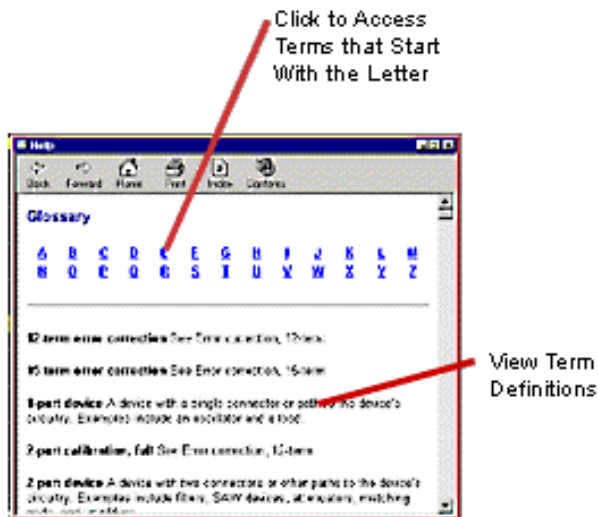
Note: Click on a word in green text to see the glossary definition.

Dialog Boxes

Click to Access
Information on This
Dialog Box

Help Topic That
Appears

Click to See
More Information
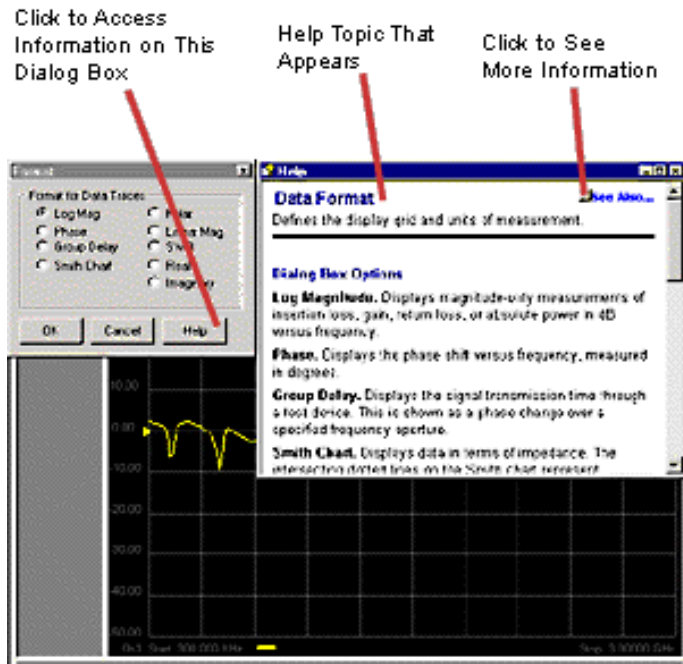
About Network Analyzer

To learn the following about your analyzer, click **Help**, then **About Network Analyzer:**

- Model number
- Frequency range

- Options installed on the analyzer
- Serial number of the analyzer
- Version of the installed analyzer software
- Version of hard drive in the analyzer

Documentation Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, AGILENT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. AGILENT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD AGILENT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

Suggestions Please!

Please let us know about your experience using the help system. Send your comments to: pna_help@am.exch.agilent.com. Comment about any aspect of the help system. Here are a few areas that you might consider:

- Does anything appear to be broken?
- Did you find what you were looking for?
- Was the information you found helpful?
- Any suggestions as to how we can improve the help system?

Your comments go directly to the help system authors. For help with technical questions, please refer to Technical Support.

1. Set Up a Measurement
Preset the PNA

_____

When you Preset the PNA, it is set to known, or preset conditions. You can use the factory default preset conditions, or define your own User Preset conditions.
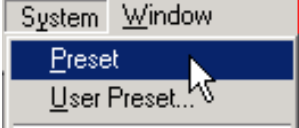
- Preset (Default) Conditions
- User Preset Conditions

See other 'Setup Measurements' topics

Preset Default Conditions

How to Preset the PNA
Use one of the following methods: •   •   Learn more about using the front panel interface

Click to view the **factory preset conditions**.

- Frequency Settings
- Power Settings
- Sweep Settings
- Segment Sweep Settings
- Trigger Settings
- Display Settings
- Response Settings
- Calibration Settings
- Marker Settings
- Limit Test Settings
- Time Domain Settings (Option 010)
- Global Display Settings

Frequency Settings:

Measurement Parameter	S11
Start Frequency	Minimum frequency of the PNA
Stop Frequency	Maximum frequency of the PNA
CW Frequency	1 GHz

See the technical specifications for the minimum and maximum frequency of your PNA

Power Settings:

Test Port Power	0 dBm for E8356/7/8A
	0 dBm for E8801/2/3A
	0 dBm for N3381/2/3A
	-12 dBm for E8362/3/4A standard
	-17 dBm for E8362/3/4A (Option UNL or 014)
Port Power Coupled	On
Auto Attenuation	On
Attenuator Value	0 dB
Power Slope	Off
Slope Value	0 dB/GHz

Sweep Settings:

Type	Linear Frequency
Mode	Continuous
Generation	Analog
Auto Sweep Time	On

Number of Points	201

Segment Sweep Settings:

Active Segments	1
Start Frequency	300 kHz for E8356/7/8A
	300 kHz for E8801/2/3A
	300 kHz for N3381/2/3A
	300 MHz for E8362/3/4A
Stop Frequency	1 MHz for E8356/7/8A
	1 MHz for E8801/2/3A
	1 MHz for N3381/2/3A
	1 GHz for E8362/3/4A
Number of Points	21
Power	0 dBm for E8356/7/8A
	0 dBm for E8801/2/3A
	0 dBm for N3381/2/3A
	-12 dBm for E8362/3/4A
	-17 dBm for E8362/3/4A with option UNL or 014
IF Bandwidth	35 kHz
Dwell Time	630.00 usecs

Trigger Settings

Source	Internal
Mode	Sweep

Display Settings:

Format	Log Mag

These settings apply for formats when selected:

FORMAT	SCALE	REFERENCE POSITION	REFERENCE VALUE
Log Mag	10 dB/	5	0 dB
Phase	45 degrees/	5	0 degrees
Group Delay	10 nsec/	5	0 s
Linear Mag	100 munits/	0	0 units
SWR	1 unit/	0	1 unit
Real	2 units/	5	0 units
Imaginary	2 units/	5	0 units
Polar	1 unit/	n/a	1 unit
Smith Chart	1 unit/	n/a	1 unit

Response Settings:

Channel Number	1
IF Bandwidth	35 kHz
Averaging	Off
Averaging Factor	1
Smoothing	Off
Smoothing Factor	1% of span
Electrical Delay	0 s
Velocity Factor	1.0
Phase Offset	0 degrees
Math/Memory Trace View	Data

Calibration Settings:

Correction State	Off

Interpolation State	On
Calibration Type	None
Cal Kit Number	1
System Z0	50 ohms
Port Extensions State	Off
Port Ext. Values	0
Input A, B	
Port 1, 2	

Marker Settings:

Initial Frequency	Current Center Frequency
Reference	None
Interpolation	On
Format	Trace Default
Type	Normal
Function	Max Value
Domain	Full Span
Table	Empty
Coupling	Always uncoupled

Limit Test Settings:

Limit Testing	Off
Line Display	ON
Sound on Fail	Off

Limit List Settings:

Type (OFF, MAX, MIN)	OFF
Begin Stimulus	0
End Stimulus	0
Begin Response	0
End Response	0

Time Domain Settings:

Transform State	Off
Transform Mode	Band Pass
Transform Start	-10 ns
Transform Stop	10 ns
Window	6.0 (Kaiser-Bessel factor)
Gating State	Off
Gating Start	-10 ns
Gating Stop	10 ns
Gate Type	Band Pass
Gate Shape	Normal

Global Display Settings:

Trace Status	On
Frequency/ Stimulus	Off
Marker Readout	On (when a marker is activated)
Toolbars Shown	Active Entry
Status Bar State	Off

User Preset Conditions

The analyzer can be **preset** to either **default** conditions or **User Preset** conditions.

How to set User Preset

Learn more about using the front panel interface
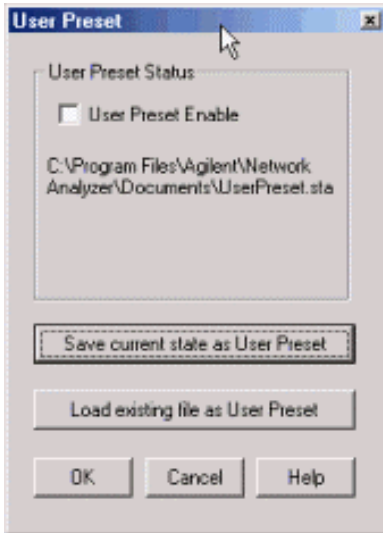
User Preset dialog box help
Allows the selection of User Preset conditions and the storing and recovery of those conditions.
User Preset Enable   Check - The PNA is preset to **User Preset** conditions when the Preset button is pressed.   Clear - The PNA is preset to **Default** conditions when the Preset button is pressed.
Save current state as User Preset Click to store the current instrument state as the User Preset conditions. File is stored as C:\ Program Files\ Agilent\ Network Analyzer\ Documents\ UserPreset.sta.
Load existing file as User Preset Click to retrieve an instrument state to be used as the User Preset conditions.

Measurement Parameters

_____

This topic contains the following information:

- S-Parameters (fixed ratios)
- Arbitrary Ratio (choose your own ratio)
- Unratioed Power (absolute power)
- How to Select a Measurement Parameter

See other 'Setup Measurements' topics

S-Parameters

S-parameters (scattering parameters) are used to describe the way a device modifies a signal. For a two port device, there are **four S-Parameters.** (If you have a 3-port PNA model, see the topic, 3-port Measurements.) The syntax for each parameter is described by the following:

S_{out-in}

out =   port number where the signal output is measured (receiver)
in =   port number where the signal is applied (source)

Move the mouse over each S-parameter to see the signal flow:

$$S_{11}$$
Reflection/ Incident

$$S_{21}$$

DUT

Port 1   Port 2

$$S_{12}$$ $$S_{22}$$
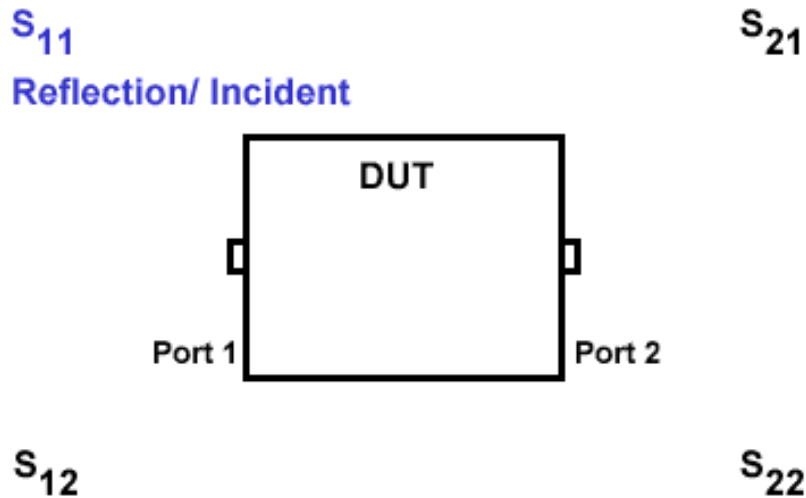
For two-port devices:

- When the source goes into port 1, the measurement is said to be in the **forward** direction.

- When the source goes into port 2, the measurement is said to be in the **reverse** direction.

- The analyzer automatically switches the source and receiver to make a forward or reverse measurement. Therefore, the analyzer can measure all four S-parameters for a two-port device with a single connection.

For PNAs with 3 measurement ports, see 3 port measurements

Common Measurements with S-Parameters

Reflection Measurements (S11 and S22)

- Return loss
- Standing wave ratio (SWR)
- Reflection coefficient
- Impedance

S_{11}, S_{22}

Transmission Measurements (S21 and S12)

- Insertion loss
- Transmission coefficient
- Gain/Loss
- Group delay
- Deviation from linear phase
- Electrical delay

S_{21}, S_{12}

Arbitrary Ratio

Arbitrary ratio allows you to choose your own ratio of input and reference signals using the A, B, R1 and R2 receivers. The following are common uses of arbitrary ratio:

- Comparing the phase between two paths of a device. An example could be something simple like a power splitter or more complicated like a dual-channel receiver.

- Measurements that require a higher dynamic range than the analyzer provides with S-parameters.

Your PNA **MAY** have front-panel jumper cables that go directly to the A, B, R1 and R2 receivers. Learn about the front-panel jumpers on your PNA.

Unratioed Power

The unratioed power parameter allows you to look at the absolute power of a device going into any of the receivers.
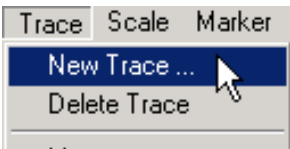
Note: Unratioed parameters cannot be used for phase or group delay measurements, or any measurement that has averaging activated.
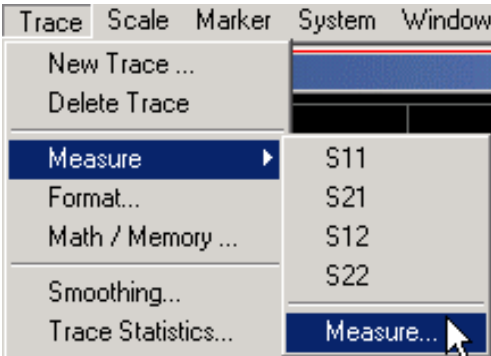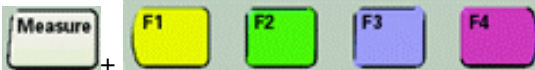
How to select a Measurement Parameter
Use either of the following methods to create a new trace: Use either of the following methods to **change** the **Active** trace: Learn more about using the front panel interface
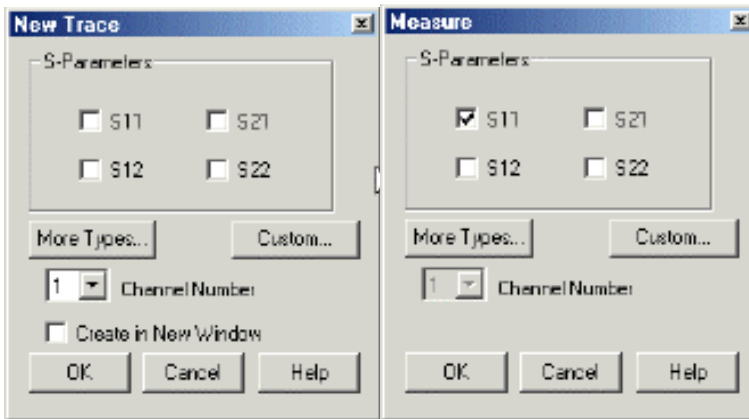
New Trace and Measure dialog box help
The following applies to both the **New Trace** and **Measure** dialog boxes
S-Parameters Check ONE to create or change the active measurement.
More Types... Press to open the More Types Dialog Box (for **Unratioed** or **Arbitrary Ratio** measurements)
Custom... Press to list the custom measurements installed on the analyzer (see <u>Custom Measurements)</u>
Channel Number (New Trace only) Select the channel to add the new trace to.
Create in New Window (New Trace only) Check to create the trace in a new window Clear to create the trace in the active window
About Measurement Parameters (top of page)
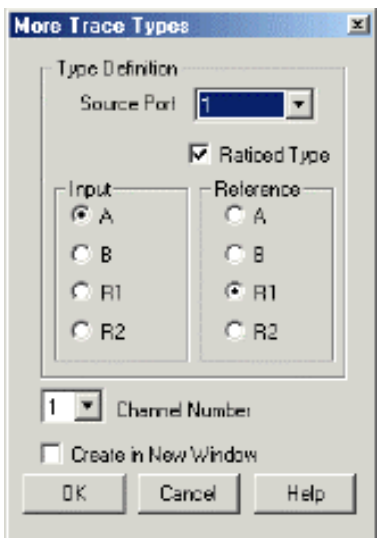
More Types dialog box help
Source Port Select the PNA port that will emit the source power
Ratioed Type Check to create a ratioed measurement (then select both Input and Reference receivers)

Clear to create an unratioed measurement (then select Input receiver only)

Input Select the PNA receiver to measure your DUT response. You can directly access the receivers ports by removing the <u>front-panel jumper cables</u>.

Reference Select the PNA reference receiver to ratio with the Input receiver (ratio measurement only). The reference level must be between 0 dBm and –35 dBm

Channel Number (New Trace only) Select the channel to add the new trace to.

Create in New Window (New Trace only) Check to create the trace in a new window. Clear to create the trace in the active window

About Measurement Parameters (top of page)

Frequency Range

_____

Frequency range is the span of frequencies you specify for making a device measurement.

- Frequency Range
- How to Set Frequency Range
- CW Frequencies
- Frequency Resolution
- Phase Lock Lost Indicator
- Frequency Band Crossings

See other 'Setup Measurements' topics

Frequency Ranges for PNA Series Analyzers:

PNA Model	Frequency Range
E8356A, E8801A, N3381A	300 kHz to 3 GHz
E8357A, E8802A, N3382A	300 kHz to 6 GHz
E8358A, E8803A, N3383A	300 kHz to 9 GHz
E8362A	45 MHz to 20 GHz
E8363A	45 MHz to 40 GHz
E8364A	45 MHz to 50 GHz

How to set Frequency Range

There are two ways to set the frequency range:
 	
     A. Specify the Start and Stop frequencies of the range.
 	
     B. Specify the Center frequency and desired span of the range.
 	
The following will accomplish both methods:
 	
•

The following settings will open dialog boxes:

-
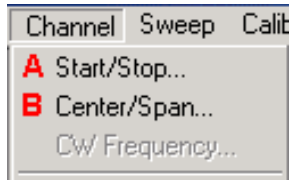
Learn more about using the front panel interface
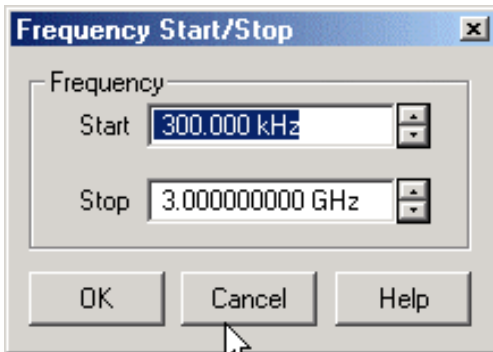
Frequency Start/Stop dialog box help
Start Specifies the beginning frequency of the swept measurement range.
Stop Specifies the end frequency of the swept measurement range.
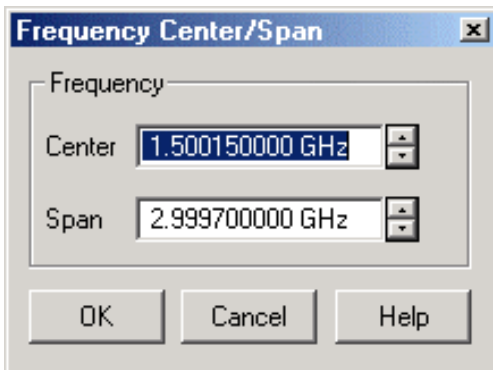
Frequency Center/Span dialog box help
Center Specifies the value at the center of the frequency sweep. This value can be anywhere in the analyzer range.
Span Specifies the span of frequency values measured to either side of the center frequency.

CW Frequencies

Measurements with a CW Time sweep or Power sweep as stimulus are made at a single frequency rather than over a range of frequencies.

How to set CW Frequency
First specify CW Sweep Type
You can set CW frequency from within the Sweep Type dialog box **or**
After specifying CW from the Sweep type dialog box, change CW frequency by selecting the following::
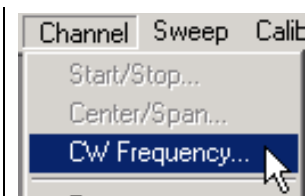
Learn more about using the front panel interface
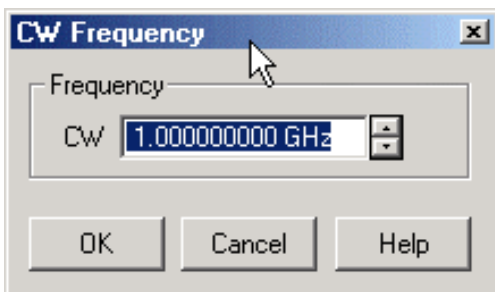
CW Frequency dialog box help

> **CW** Type a value and the first letter of the suffix (k,m,or g) or use the up and down arrows to select any value within the range of the PNA.

Frequency Resolution

The resolution for setting frequency is 1 Hz.

Phase Lock Lost Indicator

Under normal operating conditions the analyzer stimulus frequency will be phase locked and within specifications (see frequency specs). If the analyzer is unable to create the stimulus frequency to specifications, a **Phase Lock Lost** message will appear on the screen (see Troubleshoot the PNA).

Frequency Band Crossings

The frequency range of the PNA covers several internal frequency bands. The higher the frequency range of the PNA, the larger the number of bands. The source power to your DUT turns off as the stimulus frequency is swept through these band crossings. To learn more, see Power ON and OFF during Sweep and Retrace and Stimulus-Sweep Recommendation for a DUT with an AGC Loop

These band-crossings occur at the following frequencies for **3 GHz, 6 GHz, and 9 GHz PNA models:**

Band	Frequency
1	10 MHz
2	748 MHz
3	1500 MHz
4	3000 MHz
5	4500 MHz
6	6500 MHz

For all other PNA models

Band	Freq (GHz)	Band	Freq (GHz)	Band	Freq (GHz)

1	0.748	**9**	7.60	**17**	25.60
2	1.500	**10**	10.00	**18**	30.00
3	3.00	**11**	12.00	**19**	32.00
4	3.80	**12**	12.8	**20**	36.00
5	4.50	**13**	15.20	**21**	38.40
6	4.80	**14**	16.00	**22**	40.00
7	6.00	**15**	20.00	**23**	45.60
8	6.40	**16**	22.80	**24**	48.00

Power Level

_____

Power level is the power of the analyzer source signal at the test port. The following items describe details about power levels.

- Power Settings
- Unleveled Indicator
- Power Coupling Between Ports
- Source Attenuation
- Attenuation with Uncoupled Ports
- Receiver Attenuation
- Power Slope
- Power ON and OFF during Sweep and Retrace

See other 'Setup Measurements' topics

Power Settings

The test port output power is specified over frequency (See the Power Range and Frequency Range for your PNA)

How to make Power settings
Use one of the following methods:
Note: If Power Sweep is selected, (from Sweep Type dialog box) clicking **Channel, Power** will invoke a Power (Sweep) dialog box.
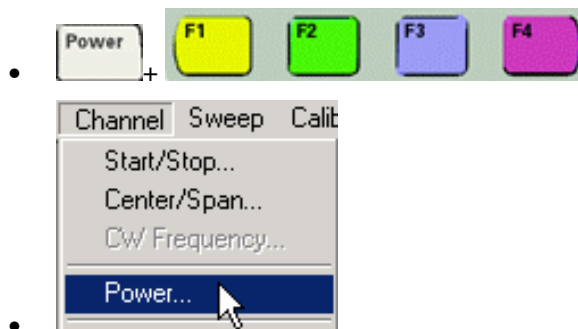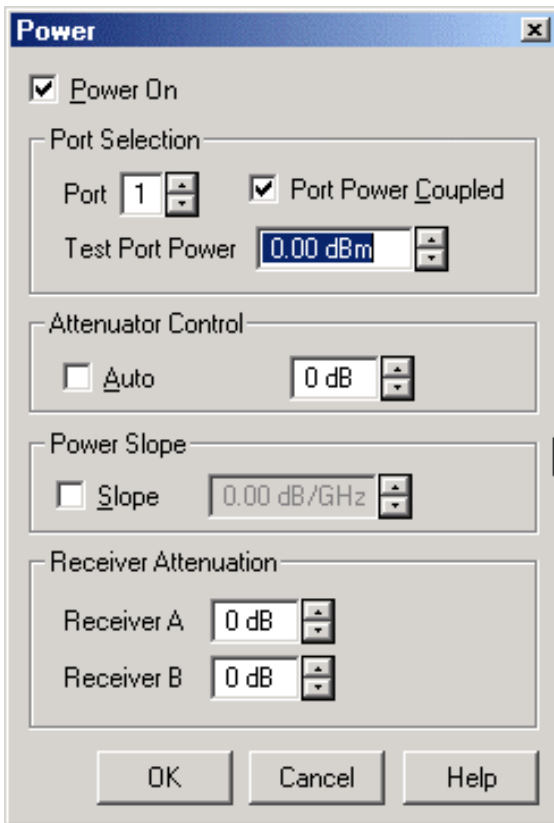
Power dialog box help

Defines and controls the analyzer source power.

Power On Toggles the source power ON and OFF.

Port Selection

Port Specifies the port which the values apply.

Port Power Coupled Toggles between coupled and uncoupled test port power. With the ports coupled, the power levels are the same at each test port. With the ports uncoupled, you can set different power levels for each test port. Learn more about coupled ports.

Test Port Power Sets the value of the power at the output of the test port.

Attenuator Control

Unavailable if there is no Attenuator option installed. If installed, the value of attenuation placed in the source path can be chosen automatically or manually. See PNA Options to view the availability and range of source attenuation on your PNA.

Auto Select to allow automatic attenuator control. The attenuation value select box will be unavailable. Clear to manually set the attenuator. Type or select the attenuation value in the adjacent text box.

Learn more about Source Attenuation.

Power Slope

Compensates for a device's power loss over a frequency sweep by increasing the PNA output power over frequency.

Slope Select to set the power slope. Clear to set power slope OFF.

Learn more about Power Slope.

Receiver Attenuation

Available with PNA models E8356A/ 57A/ 58A option 015 (35 dB range.)

Receiver A and **Receiver B** Type or select attenuation values independently in 5 dB increments.

Learn more about Receiver Attenuation.

Unleveled Indicator

The letters **LVL** appear on the status bar when the analyzer source is unleveled.
 To see the status bar, click **View**, then **Status Bar**.

LVL appears when the source power is **greater** than the maximum specified power. Resolve this by lowering the power level to return to a leveled condition (See your analyzer's Power Range).

If LVL continues to appear after lowering the source power, see Troubleshoot the PNA to determine the cause of the unleveled condition.

Power Coupling Between Ports

By default, the power level at each Port is **coupled to Port 1.** This means each Port will have the same output power level as Port 1. Some measurement applications require different power levels between ports. The analyzer allows you to **uncouple** the port powers so that you can set the power levels independently for each port.

For example, if you want to measure the gain and reverse-isolation of a high-gain amplifier, you must set the power for each port separately. This is because the power required for the input port of the amplifier is much lower than the power required for the output port. See Attenuation With Uncoupled Ports.

CAUTION! You can damage the analyzer receivers if the input power levels exceed the maximum values. See your analyzer's Technical Specifications for the maximum input power to a receiver.

Source Attenuation

The PNA uses a programmable step source attenuator to cover the full power range. The attenuator adjusts the power level of the test signal into the test device without changing the level of the incident power in the reference path. This provides:

- Better signal source accuracy and performance
- A more accurate source match

Source attenuation is available in various ranges either standard or as an option on all PNAs. If the attenuator option is not installed, the attenuator control is unavailable in the Power dialog box and not shown in the Active Entry Toolbar. See PNA Options to see the availability and range of source attenuation on your PNA.

The value of source attenuation can be set automatically or manually through the Power dialog box or front panel Power key.

Automatic Attenuation

With the attenuator control set to **Auto** (default), the analyzer:

- Allows you to select **any power level** within the total operating range of the instrument
- Automatically selects the attenuator position and source power so that the **optimum**

range of the total attenuator range is used.

Manual Attenuation

There are some measurement applications where you need to set the source power and attenuator manually. These include:

- **Testing Reflection Amplifiers** (oscillators or conditionally unstable amplifiers) . This requires a very good impedance match with the source (20dB return loss) over a wide frequency range. Choose **Auto Off**, with an attenuation level of 10 or 20 dB (or more) to ensure the best source match.

- **Power Sweeps** The attenuator is not allowed to switch attenuator settings during a power sweep to avoid premature wear from continuous switching. The Auto setting may not allow full coverage of the desired power sweep range. Choose **Auto Off** and a combination of source power range and attenuator position to provide the full desired power sweep range required for the measurement.

Attenuation Ranges and Values

The attenuator has eight different positions, allowing power levels in eight different power ranges.

- Each range has a total specified span (25 dBm in the following Attenuation Values graphic).

- The optimum range of each power range is the middle of the range. This range provides the best accuracy and performance of the source leveling system. The optimum ranges are the blue regions in the following graphic.

- An attenuator setting can be selected manually or automatically. If automatic is selected, the blue optimum ranges (shown in the following graphic) are used.

(Attenuator ranges vary, this particular range is 70 dB)
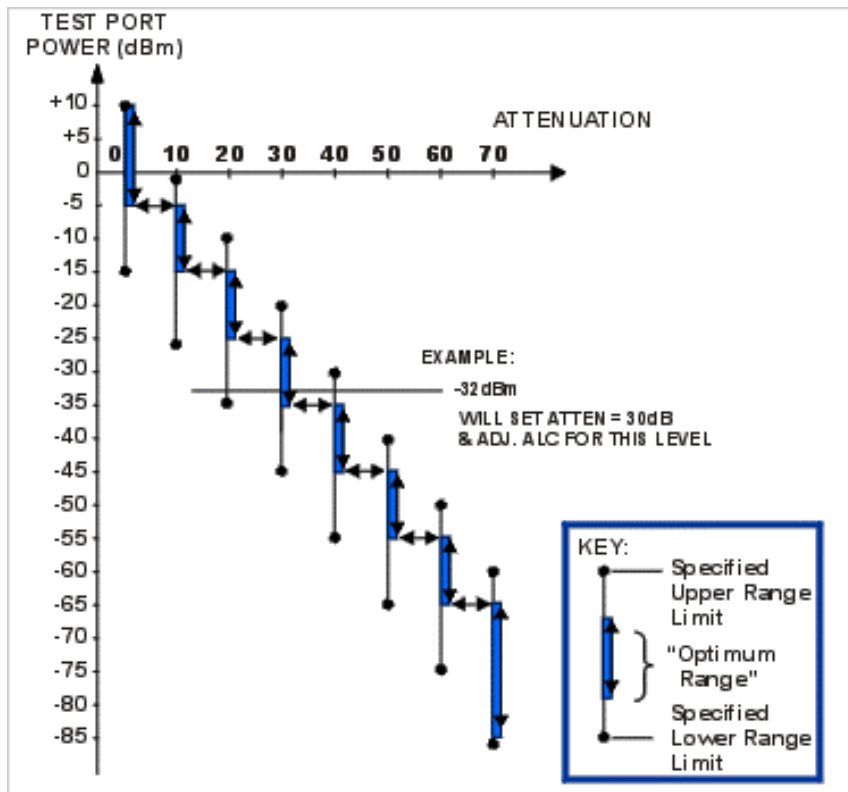
Note: Error correction is fully accurate only for the power level at which a measurement

calibration was performed. However, when changing power within the same attenuator range at which the measurement calibration was performed, ratioed measurements can be made with nearly full accuracy (non-ratioed measurements with less accuracy).

Source Attenuation in Power Sweep

To set source attenuation in power sweep mode, first select Power Sweep type, then click **Channel, Power**
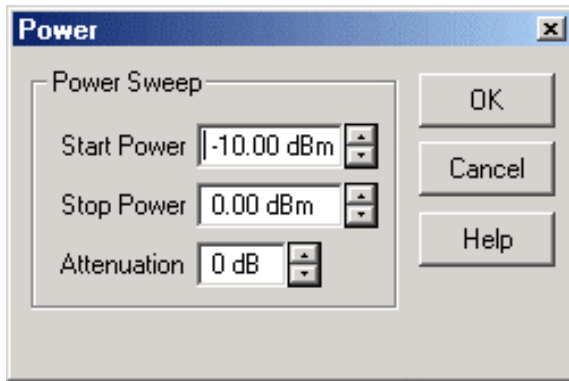
Power (Sweep) dialog box help
Start Power Sets the beginning value of the power sweep.
Stop Power Sets the end value of the power sweep.
Attenuation Sets the value of the source attenuator for both source ports.
Learn more about Source Attenuation.
Learn more about Power Sweep.

Attenuation with Uncoupled Ports

The E8356A / 57A / 58A and E8364A (option UNL) have a source attenuator with each port. The Test Port power levels can be set independently.

The E8801A / 02A / 03A and N3381A / 82A / 83A (option 1E1) analyzers have a single source attenuator, which is switched, between Test Ports. If the ports are uncoupled, the Test Port power levels can be set differently. If the power levels are far apart, the single source attenuator will have to change position when switching between ports. To avoid premature wear of the mechanical step attenuator, the PNA does the following:

- **Prevents continuous switching** between power ranges
- Automatically **engages hold mode** after measuring each channel one time

If averaging is on, the hold mode does not engage until the specified number of sweeps is completed for each channel.

Receiver Attenuation

To avoid damaging the PNA receivers, you may need to attenuate the output signal from the device under test.

The E8356A / 57A / 58A PNA has an **Option 015** which provides internal attenuators and direct access to both port receivers. The Option 015 Receiver Attenuator characteristics are:

- Range: 0 to 35 dB
- Resolution: 5 dB

Power Slope

Power slope helps compensate for cable and test fixture power losses at increased frequency.

- With the power slope feature enabled, the port output power increases (or decreases) as the sweep frequency increases.

- The units of power slope are dB/GHz.

- Power slope can only be set to values of 0.5, 1, 1.5, or 2 (positive or negative).

Power ON and OFF during Sweep and Retrace

The frequency range of the PNA covers several internal frequency bands. The higher the frequency range of the PNA, the larger the number of bands. For example, a 9 GHz PNA has 6 frequency bands, a 50 GHz PNA has 25 frequency bands. See the frequency band crossings.

Power to the DUT is set to minimum during band changes to avoid causing power spikes to the DUT. Minimum power is determined by the attenuator setting.

Retrace occurs when the source gets to the end of your selected frequency span and moves back to the start frequency. Power to the DUT is again set to minimum when retracing across frequency bands.

Therefore, the following occurs for various stimulus settings:

1. **Single band sweep** - The power to the DUT is always ON, even during retrace.

2. **Multi-band sweep** - The power to the DUT will go to minimum while sweeping across a band crossing. It will go to minimum again during retrace.

3. **Power sweep** - Because power sweep is always done at a single frequency, the frequency is always in a single band and the source power is always ON. At the end of a power sweep, power is immediately changed back to the start power. This helps prevent the DUT from overheating.

4. **Single sweep** - There are two methods of single sweep:

   - Manual trigger mode - At the end of a sweep the setup for the next sweep completes and the PNA waits for a trigger. During the setup of a multi-band sweep, the band swap completes and power to the DUT is turned back ON.

   - Hold mode - At the end of a sweep, power stays at minimum until the sweep is started.

Caution: Avoid expensive repairs to your PNA. Read Electrostatic Discharge Protection.

Sweep Settings

_____

A sweep is a series of consecutive data point measurements taken over a specified sequence of stimulus values. You can make the following sweep settings:

- Sweep Type
- Sweep Time
- Sweep Setup

See other 'Setup Measurements' topics

Sweep Type

There are five sweep types in the PNA:

- **Linear Frequency** - Sets a linear frequency sweep that is displayed on a standard grid with ten equal horizontal divisions. This is the default sweep type.

- **Log Frequency -** Sets the source to step in logarithmic increments and the data is displayed on a logarithmic x-axis.

- **Power Sweep** - Activates a power sweep at a single frequency that you specify. You can set any power range < 25 dB. (Default -10 dBm to 0 dBm.) Power sweep is used to characterize power-sensitive circuits, with measurements such as gain compression or AGC (automatic gain control) slope. Learn more about power sweep

- **CW Time -** Sets the PNA to a single frequency, and the data is displayed versus time.

- **Segment Sweep -** Sets the PNA to sweep through up to 30 user-defined sweep segments. Learn more about Segment sweep

How to set Sweep Type
Use one of the following methods: •   •   Learn more about using the front panel interface
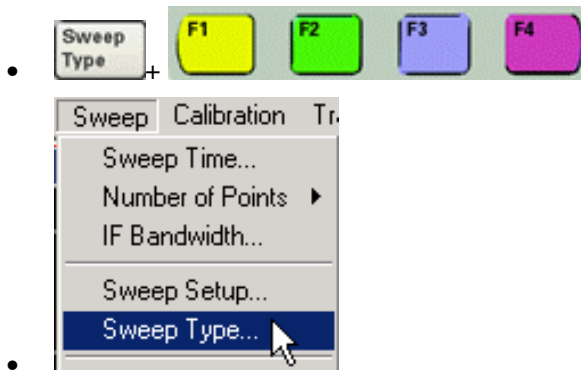
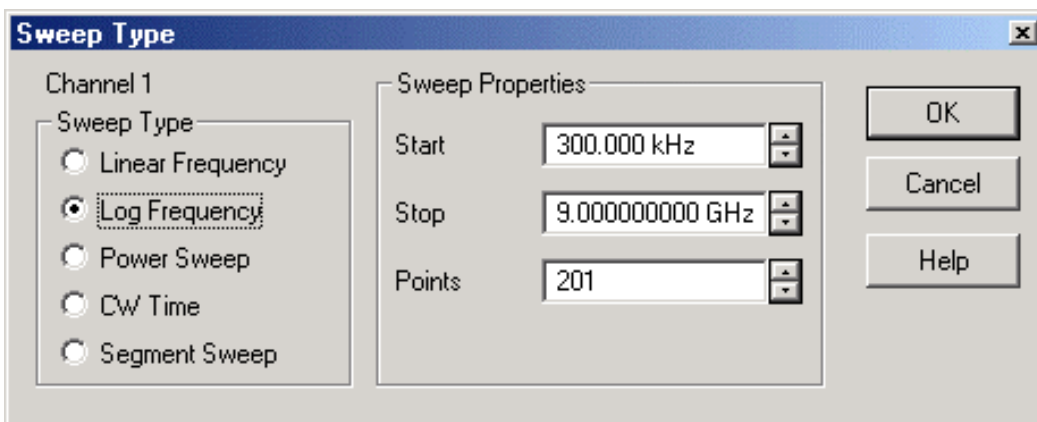| **Sweep Type** dialog box help |
|---|
| **Channel** The active channel when Sweep Type was selected. Sweep settings will be applied to this channel.

 Sweep Type

 Linear Frequency Sets a linear frequency sweep that is displayed on a standard grid with ten equal horizontal divisions. |

- **Start** Sets the beginning value of the frequency sweep.

- **Stop** Sets the end value of the frequency sweep.

- **Points** Sets the number of data points that the PNA measures during a sweep. Range: 2 to 1601.(Default is 201).

Log Frequency The source is stepped in logarithmic increments and the data is displayed on a logarithmic x-axis. This is usually slower than a continuous sweep with the same number of points.

- **Start** Sets the beginning value of the frequency sweep.

- **Stop** Sets the end value of the frequency sweep.

- **Points** Sets the number of data points that the PNA measures during a sweep. Range: 2 to 401.(Default is 201).

Power Sweep Activates a power sweep at a single frequency that you specify. Learn about power sweep

- **Start** Sets the beginning value of the power sweep.

- **Stop** Sets the end value of the power sweep.

- **CW Frequency** Sets the single frequency where the PNA remains during the measurement sweep.

CW Time Sets the PNA to a single frequency, and the data is displayed versus time.

- **CW Frequency** Sets the frequency where the PNA remains during the measurement.

- **Sweep Time** Sets the duration of the measurement, which is displayed on the X-axis.

- **Points** Sets the number of data points that the PNA measures during a sweep. Range: 2 to 1601.(Default is 201).

Segment Sweep Sets the PNA to sweep through user-defined sweep segments. Learn more about Segment sweep

- **Independent Power Levels** When checked, allows you to set the source power level for each segment.

- **Independent IF Bandwidth.** When checked, allows you to set the IF bandwidth for each segment.

- **Independent Sweep Time**. When checked, allows you to set the duration of the measurement for each segment.

   Show Table Shows the table that allows you to create and edit segments.

   Hide Table Hides the segment table from the screen.

Power Sweep

Activates a power sweep at a single frequency that you specify. You can set any power range < 25 dB. (Default -10 dBm to 0 dBm.) Power sweep is used to characterize power-sensitive circuits, with measurements such as gain compression or AGC (automatic gain control) slope.

- Power is stepped from a start value to a stop value at a single frequency.

  - The source amplitude increases in discrete power steps at each data point across the power sweep range.

  - The number of data points and power range determine the size of these steps.

- Choose a combination of source power range and manual attenuator position (if the PNA has source attenuators) to obtain the power sweep range required for the measurement.

Note:To set the attenuation in power sweep, click **Channel, Power** after selecting Power Sweep.

In Power Sweep mode, the following power settings apply:

- Port Power Coupled setting (ON/ OFF) is ignored. Both test ports use the same Power Sweep settings.

- Test Port Power setting is ignored. The code uses the Start Power and Stop Power to determine the power levels present at the test ports.

- Attenuator Control is set to Manual

- Power Slope (dB/GHz) is ignored. The output frequency is CW.

Learn more about Power Settings.

Segment Sweep

Segment Sweep activates a sweep which is comprised by frequency sub-sweeps, called segments. You can define up to **201 segments**. For each segment you can define independent power levels, IF Bandwidth, and Sweep time.

Once a measurement calibration is performed on the entire sweep or across all segments, you can make calibrated measurements for one or more segments.

In segment sweep type, the analyzer does the following:

- Sorts all the defined segments in order of increasing frequency

- Measures each point

- Displays a single trace that is a composite of all data taken

Restrictions for segment sweep:

- The frequency range of a segment is not allowed to overlap the frequency range of any other segment.

- The combined number of data points for all segments in a sweep cannot exceed 1601.

- All segments must have power levels within the same attenuator range to avoid premature wear of the mechanical step attenuator. See Power Level.

How to Insert, Delete, and Modify Segments
Insert and Delete Segments
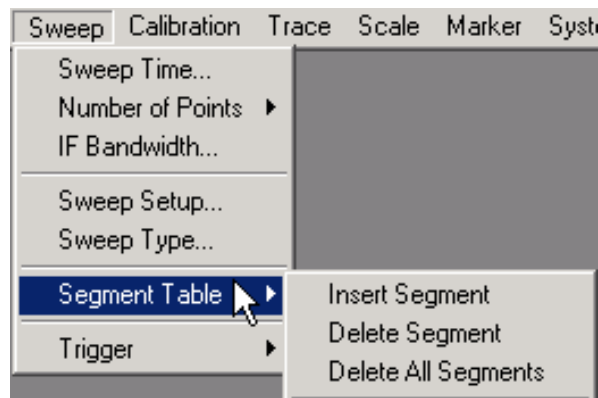
Insert Segment - adds a sweep segment before the selected segment.

Note- You can also click the "down" arrow on your keyboard to quickly add many segments.

Delete Segment - removes the selected segment

Delete All Segments - removes all segments

To Modify an Existing Segment

To make the following menu settings available, you must first show the segment table. Click **View**, point to **Tables**, then click **Segment Table.**

	STATE	START	STOP	POINTS	IFBW	POWER	TIME
		Ch1: Start 300.000 kHz	—				
1	ON	300.000000 kHz	1.000000 MHz	21	35.0 kHz	0.00 dBm	630.000 µsec
2	ON	1.000000 MHz	1.000000 GHz	101	20.0 kHz	1.00 dBm	4.848 msec

STATE Click the box on the segment to be modified. Then use the up / down arrow to turn the segment ON or OFF.

START Sets start frequency for the segment. Click the box and type a value and the first letter of a suffix (**K**Hz, **M**hz, **G**Hz). Or double-click the box to select a value.

STOP Sets stop frequency for the segment. Click the box and type a value and the first letter of a suffix (**K**Hz, **M**hz, **G**Hz). Or double-click the box to select a value.

POINTS Sets number of data points for this segment. Type a value or double-click the box to select a value.

To make the following settings available on the Segment table:

On the **Sweep** menu, click **Sweep Type**, then **Segment Sweep**.
 Check the appropriate **Sweep Properties** boxes

Then click the box and type a value or double-click the box and select a value.

IFBW Sets the IF Bandwidth for the segment.

POWER Sets the power level for the segment.

TIME Sets the Sweep time for the segment.

Learn more about using the front panel interface

Sweep Time

The PNA automatically maintains the fastest sweep time possible with the selected measurement settings. However, you can also set a specific sweep time if it is within the capability of the PNA.

How to set Sweep Time

Use one of the following methods:

-

-
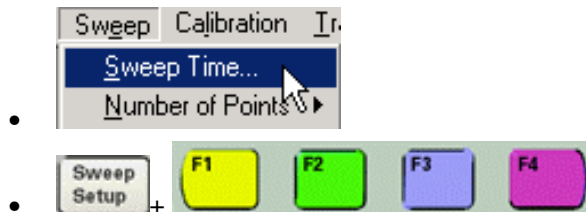
Learn more about using the front panel interface
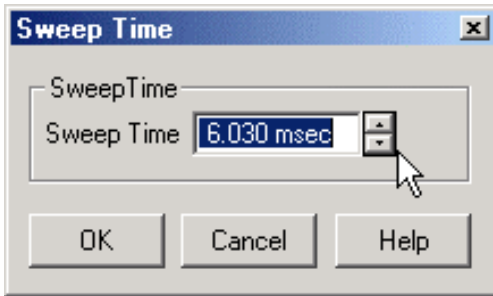
Sweep Time dialog box help

Specifies the time duration of a measurement sweep.

The PNA automatically maintains the fastest sweep time possible with the selected measurement settings. However, you can also select another sweep time that is in the capability of the instrument.

Set the desired sweep speed. Enter **0** seconds to return the analyzer to **automatic sweep time**.

Note: If the Sweep Time is 0.3 seconds or greater, a sweep indicator will appear on the screen and follow the measurement sweep from point to point. The sweep indicator is a small arrow pointing upward to the point on the data trace that was most-recently computed.

Sweep Setup

How to make Sweep Setup settings

Use one of the following methods:

-

-
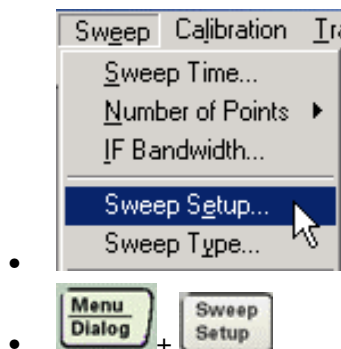
Learn more about using the front panel interface
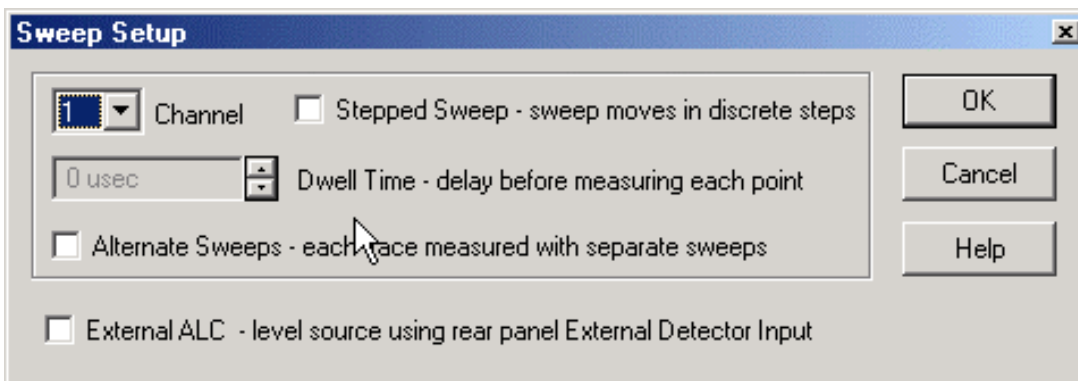
Sweep Setup dialog box help

Channel Specifies the channel that the settings apply to.

Stepped Sweep When checked, Stepped Sweep, the PNA source is tuned, then waits the specified Dwell time, then takes response data, then tunes the source to the next frequency point. This is

slower than Analog Sweep, but is more accurate when testing electrically-long devices.

When cleared, Analog Sweep, the PNA takes response data AS the source is sweeping. The sweep time is faster than Stepped, but could cause measurement errors when testing electrically-long devices.

When the dialog checkbox is cleared, the PNA could be in either Analog or Step mode depending on the sweep time or IF bandwidth. The PNA automatically uses Step Sweep when the IF Bandwidth is at, or below, 100Hz or when the Sweep time is at, or above, 8msec.

Dwell Time Specifies the time the source stays at each measurement point before the analyzer takes the data. Only applies to stepped sweep. See also Electrically Long Devices.

Alternate Sweeps When checked, the PNA measures only one receiver per sweep.
 When cleared, the PNA measures both the A and B receivers (if used) each sweep. See also Crosstalk.

External ALC When checked, the analyzer is enabled to receive an external signal that you provide for leveling the source output. The external ALC signal input connector is the External Detector Input on the rear panel. Available ONLY on 3 GHz, 6 GHz, and 9 GHz PNA models. Use this when using a booster amplifier in your test setup.

Trigger

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A trigger is a signal that causes the PNA to make a measurement sweep. The PNA offers great flexibility in configuring the trigger function.

View the Trigger Model Animation to see how triggering works in the PNA.

- How to Set Trigger
- Source
- Scope
- Channel Settings
- Restart

See other 'Setup Measurements' topics

How to Set Trigger
Use one of the following methods:

Note: The settings Continuous, Single, Hold apply only to the active channel. These settings are available from the Sweep Trigger menu (shown above) and Active Entry keys.

Trigger dialog box help

Trigger Source

These settings determine **where** the trigger signals originate for all existing channels. A valid trigger signal can be generated only when the PNA is not sweeping.

Internal Continuous trigger signals are sent by the PNA as soon as the previous measurement is complete.

Manual One trigger signal is sent when invoked by: the Trigger button, active toolbar, a programming command.

External Trigger signals are sent through the Aux I/O connector (pin19) on the rear panel. The trigger is level sensitive and can be either active TTL high or active TTL low.

Trigger Scope

These settings determine **what** is triggered.

Global All 'triggerable' channels (not in Hold) receive the trigger signal [Default setting]

Channel Only the next 'triggerable' channel receives the trigger signal. (Only allowed with Trigger Source:MANUAL.)

Channel Trigger State

These settings determine **How Many** trigger signals the channel will accept.

> **Note**: When a trigger signal is received, ALL measurements in the channel are made; first the forward measurements (S11, S21) are made simultaneously - then reverse measurements (S12, S22). There are two exceptions to this:
> 1. When Alternate sweep is selected.
> 2. When Point trigger is selected.

Continuous The channel accepts an infinite number of trigger signals.

Groups The channel accepts only the number of trigger signals that is specified in the **Number of Groups** textbox, then goes into Hold.

Single The channel accepts ONE trigger signal, then goes into Hold.

Hold The channel accepts NO trigger signals.

Point When triggered, the channel measures the next data point in the sweep. Subsequent trigger signals go to the same channel until all of its measurements are complete. Then the next triggerable channel is triggered. (Only allowed with Trigger Source:MANUAL and Trigger Scope:CHANNEL).

Trigger! - Manually sends one trigger signal to the PNA.

External Trigger - Invokes the External Trigger dialog box.

Restart - The analyzer stops sweeping. Each trace on the screen should update at least once. The analyzer then resumes normal operation. The individual channel (trigger) settings are affected as follows:

- Channels in Point sweep are taken out of Point sweep.

- Channels in Hold will be set to single trigger (the channel accepts a single trigger signal).

- All other settings are unaffected by Restart, including decrementing trigger counts.

View the Trigger Model Animation to see how triggering works in the PNA.
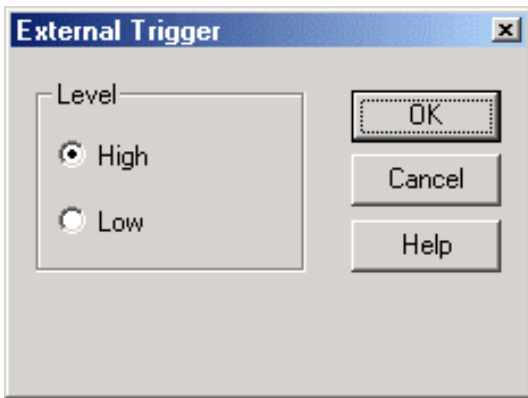
External Trigger dialog box help
High - Sets the PNA to trigger when the TTL signal from the rear panel Aux I/O connector (pin19) changes from 0 (Low) to 1 (High).
Low - Sets the PNA to trigger when the TTL signal from the rear panel Aux I/O connector (pin19) changes from 1 (High) to 0 (Low).

Data Format and Scale

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A data format is the way the analyzer presents measurement data graphically. You should pick a data format appropriate to the information you want to learn about the test device.

- Rectangular (Cartesian) Display Formats
- Polar
- Smith Chart
- How to Change Format
- Scale, Reference Level and Position

See other 'Setup Measurements' topics

Rectangular Display Formats

Seven of the nine available data formats use a rectangular display to present your measurement data. This display is also known as Cartesian, X/Y, or rectilinear. The rectangular display is especially useful for clearly displaying frequency response information of your test device.

- Stimulus data (frequency, power, or time) appears on the X-axis, scaled linearly
- Measured data appears on the Y-Axis.

Log Mag (Logarithmic Magnitude) Format

- Displays Magnitude (no phase)

- Y-axis: dB
- Typical measurements:
  - Return Loss
  - Insertion Loss or Gain

Phase Format

- Displays Phase (no magnitude)
- Y-axis: Phase (degrees)
- Typical Measurements:
  - Deviation from Linear Phase

Group Delay Format

- Displays signal transmission (propagation) time through a device
- Y-axis: Time (seconds)
- Typical Measurements:
  - Group Delay

Linear Magnitude Format

- Displays positive values only
- Y-axis: Unitless (**U**) for ratioed measurements
  Watts (**W**) for unratioed measurements.
- Typical Measurements:
  - reflection and transmission coefficients (magnitude)
  - time domain transfer

SWR Format

- Displays reflection measurement data calculated from the formula $(1+\rho)/(1\rho)$ where ρ is reflection coefficient.
- Valid only for reflection measurements.
- Y axis: Unitless
- Typical Measurements:
  - SWR

Real Format

- Displays only the real (resistive) portion of the measured complex data.
- Can show both positive and negative values.
- Y axis: Unitless
- Typical Measurements:
  - time domain
  - auxiliary input voltage signal for service purposes

Imaginary Format

- Displays only the imaginary (reactive) portion of the measured data.
- Y - axis: Unitless

- Typical Measurements:
  - impedance for designing matching network

Polar Format

Polar format is used to view the magnitude and phase of the reflection coefficient (Γ) from your S_{11} or S_{22} measurement.

You can use Markers to display the following:

- Linear magnitude (in units) or log magnitude (in dB)
- Phase (in degrees)
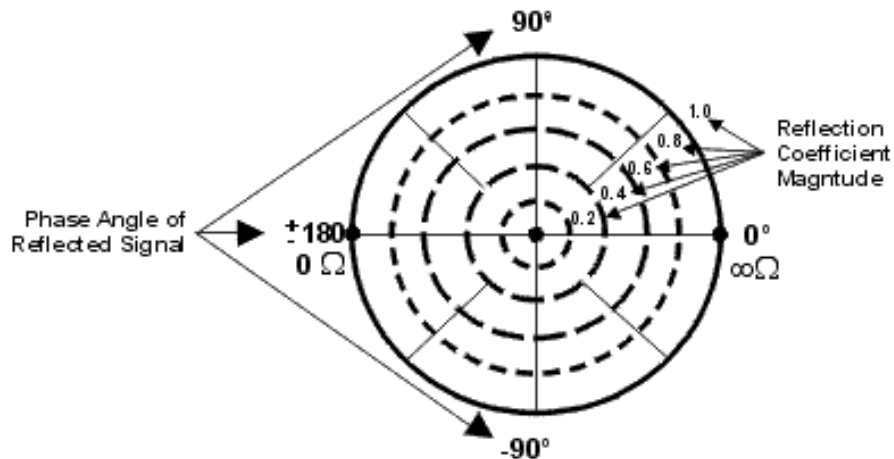
- The dashed circles represent reflection coefficient. The outermost circle represents a reflection coefficient (Γ) of 1, or total reflected signal. The center of the circle represents a reflection coefficient (Γ) of 0, or no reflected signal.
- The radial lines show the phase angle of reflected signal. The right-most position corresponds to zero phase angle, (that is, the reflected signal is at the same phase as the incident signal). Phase differences of 90°, ±180°, and -90° correspond to the top, left-most, and bottom positions on the polar display, respectively.

Smith Chart Format

The Smith chart is a tool that maps the complex reflection coefficient (Γ) to the test device's impedance.

In a Smith chart, the rectilinear impedance plane is reshaped to form a circular grid, from which the series resistance and reactance can be read (R + jX).

You can use Markers to display the following:

- Resistance (in units of ohms)
- Reactance as an equivalent capacitance (in units of farads) or inductance (in units of henrys)

Rectilinear Impedance Plane

+jX

0

+R∞ →

-jX

Smith Chart

$Z_L = Z_0$
$\Gamma = 0$

Constant X

Constant R

$Z_L = 0$ (short)
$\Gamma = 1 \angle \pm 180°$

$Z_L = \infty$ (open)
$\Gamma = 1 \angle 0°$
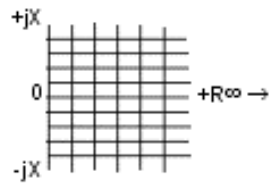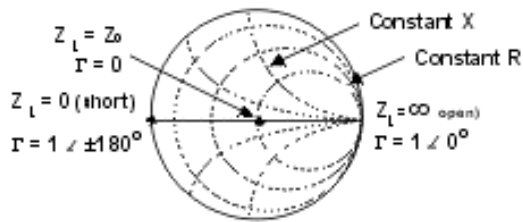
Interpreting the Smith Chart

Constant
Reactance

Constant
Resistance

j50

j25   j100

j10   j250   Inductive

Ω 0 10 25 50 100 250 ∞

Capacitive

-j10   -j250

-j25   -j100

-j50   System
Impedance
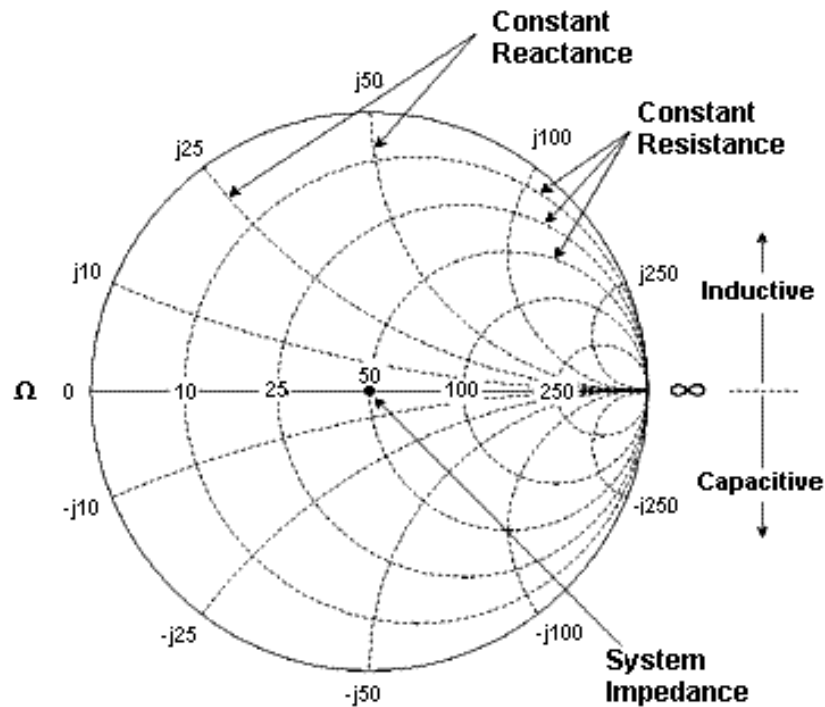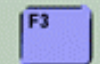
- Every point on the Smith Chart represents a complex impedance made up of a real resistance (r) and an imaginary reactance (r+-jX)

- The horizontal axis (the solid line) is the real portion of the impedance - the resistance. The center of the horizontal axis always represents the system impedance. To the far right, the value is infinite ohms (open). To the far left, the value is zero ohms (short)

- The dashed circles that intersect the horizontal axis represent constant resistance.

- The dashed arcs that are tangent to the horizontal axis represent constant reactance.

- The upper half of the Smith chart is the area where the reactive component is positive and therefore inductive.

- The lower half is the area where the reactive component is negative and therefore capacitive.

How to set the Format
Use one of the following methods: Trace Scale Marker New Trace ... Delete Trace Measure ▶ Format... Math / Memory ... -   Format F1 F2 F3 F4 - + Menu Dialog Format - + Learn more about using the front panel interface
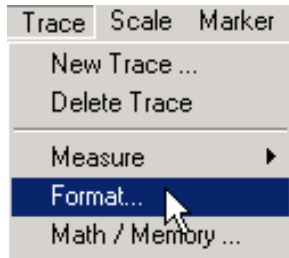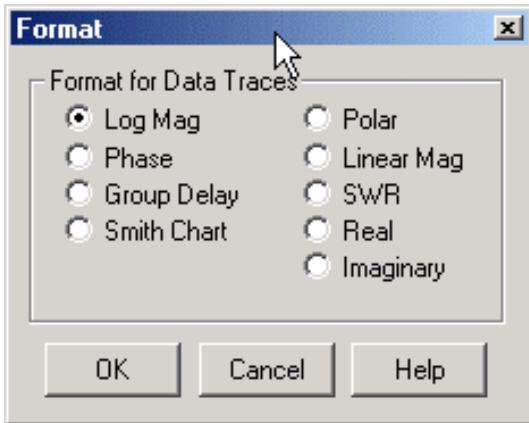
Format dialog box help
Log Mag
Phase
Group Delay
Smith Chart
Polar
Linear Mag
SWR
Real
Imaginary

Scale, Reference Level and Position

The Scale, Reference Level and Reference Position settings (along with format) determine how the data trace appears on the PNA screen.

How to set Scale, Reference Level, and Position
Use any of the following methods:
•
•
Learn more about using the front panel interface
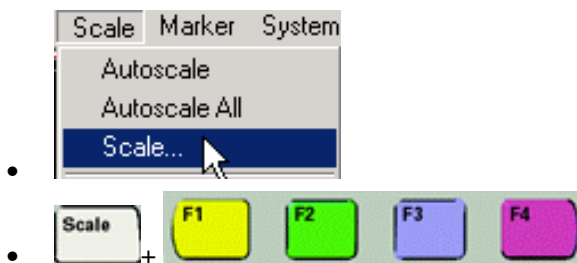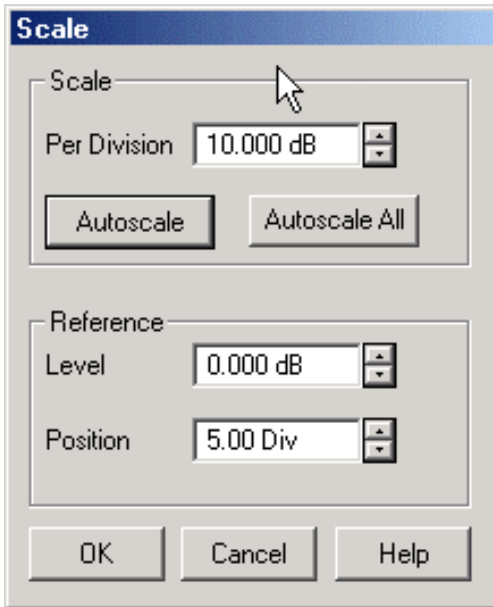
Scale dialog box help

Scale

Per Division Sets the value of the vertical divisions of a rectangular display format. In Polar and Smith Chart formats, scale sets the value of the outer circumference. Range: 0.001dB/div to 500 dB/div

Autoscale - Automatically sets value of the vertical divisions and reference value to fit the ACTIVE data trace within the grid area of the screen. The stimulus values and reference position are not affected.

The analyzer determines the smallest possible scale factor that will allow all the displayed data to fit onto 80 percent of the vertical grid.

The reference value is chosen to center the trace on the screen.

Autoscale All Automatically scales ALL data traces in the ACTIVE WINDOW to fit vertically within the grid area of the screen.

Reference

Level In rectangular formats, sets the value of the reference line, denoted by on the PNA screen. Range: -500 dB to 500 dB.

In Polar and Smith chart formats, reference level is not applicable.

Position In rectangular formats, sets the position of the reference line. Zero is the bottom line of the screen and ten is the top line. Default position is five (middle).

In Polar and Smith chart formats, reference position is not applicable.

Pre-configured Measurement Setups

_____

- Pre-configured setups for NEW measurements

- Pre-configured arrangements for EXISTING measurements

Before reading this topic, it is critical to understand Traces, Channels, and Windows in the PNA.

See other 'Setup Measurements' topics
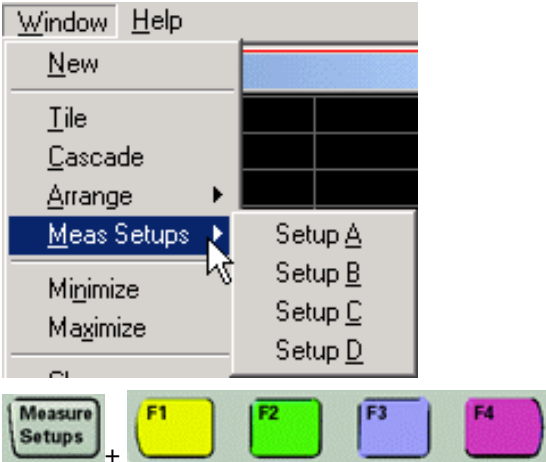
Pre-configured Setups for NEW Measurements

Each of the following setups **creates new traces**. Existing traces and their settings will be lost, unless you first save them.

How to select a pre-configured measurement setup
Use one of the following methods: •   •   Learn more about using the front panel interface

The following are the four pre-configured measurement setups:
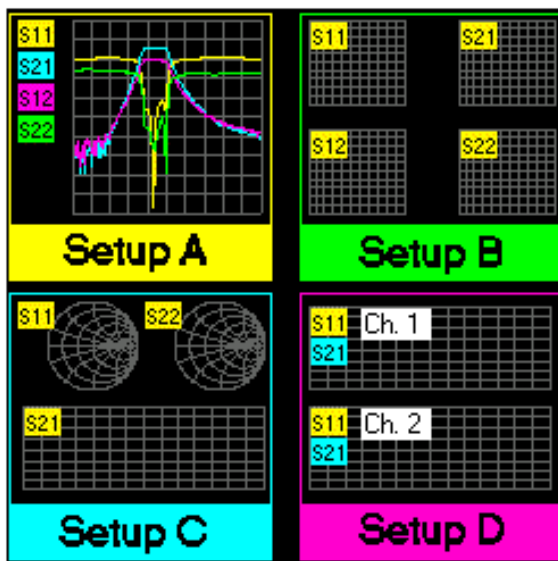
Arranging Existing Measurements

The following arrangements place EXISTING measurements into pre-configured Window arrangements using a sort algorithm.

How to select an Existing measurement arrangement
Use one of the following methods:
Learn more about using the front panel interface
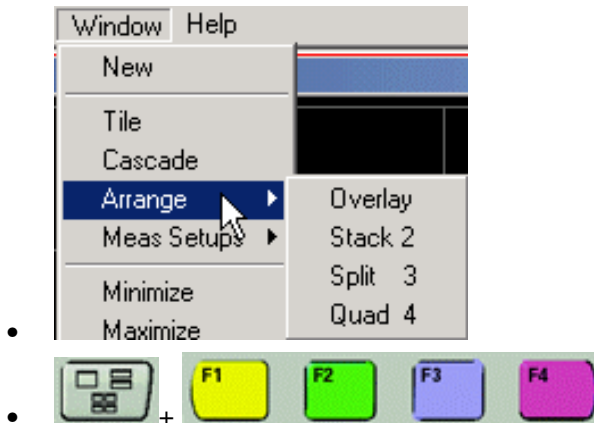
Overlay Arrangement

This configuration places all existing traces in a single window, all overlaid on each other.
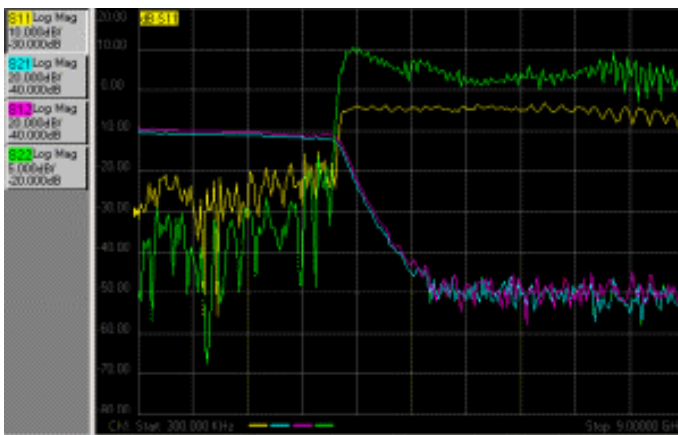
Stack 2 Arrangement

This configuration places all existing traces in two "stacked" windows.
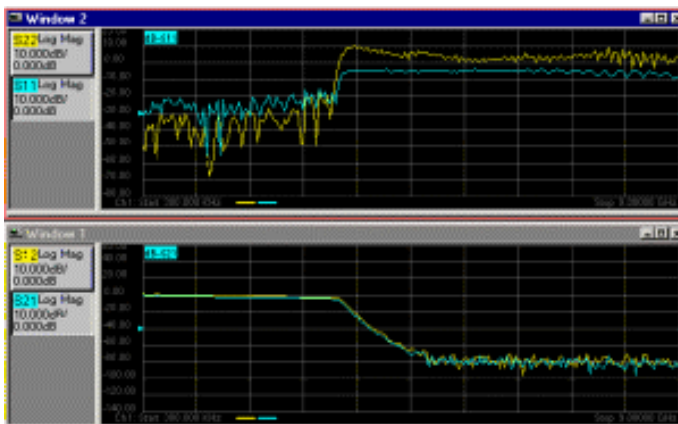
Split 3 Arrangement

This configuration places all existing traces in three windows, two on top and one below.
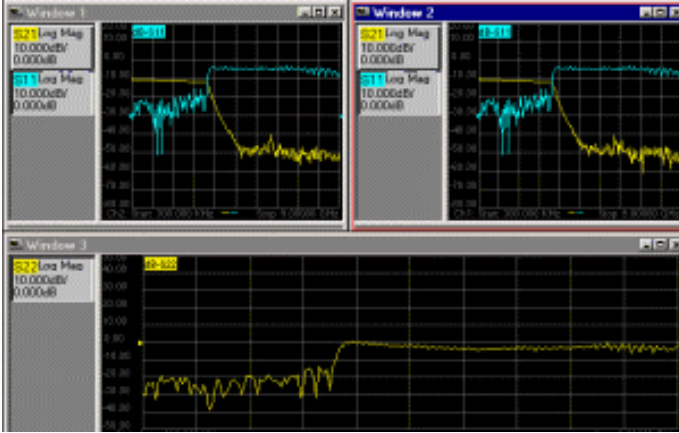
Quad 4 Arrangement

This configuration places all existing traces in four windows, one window in each screen quadrant.
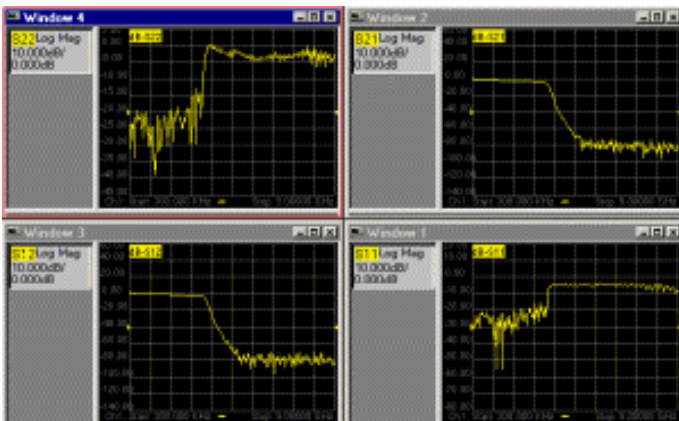
Sort Algorithm

The sort algorithm for the Arrange Windows feature is designed to:

- Divide traces among windows based on their properties
- Group traces with common properties

The algorithm sorting is based on the following trace properties, in order of priority:

1. Format: circular (polar or Smith) versus rectilinear (log mag, lin mag, group delay, etc.)
2. Channel number
3. Transmission versus reflection

Note: The analyzer limitation of four traces per window overrides this algorithm. An error occurs if the arrange selection cannot be completed with the current number of traces on the screen.

Customize the PNA Screen

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You can customize your PNA screen by showing or hiding the following display elements. All of these selections are made from the PNA **View** menu.

- Status Bar
- Toolbars
- Tables
- Measurement Display
- Data and Memory Trace
- Title Bars
- Minimize Application

Learn about using pre-configured measurements and windows arrangements

Learn about Traces, Channels, and Windows on the PNA

See other 'Setup Measurements' topics

Status Bar

Status CH 1: S11   No Cor

The status bar is displayed along the bottom of the screen. It shows the:

- Active channel
- Measurement parameter for the active trace
- Error correction status for the active trace
- Averaging status for the active channel (On or Off)
- GPIB status (local or remote)
- Smoothing Information
- Transform On/Off
- Trace Math

How to display the Status bar

View Channel Sweep
Status Bar
Toolbar   ►
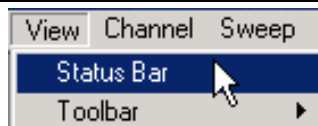
Learn more about using the front panel interface

Toolbars

You can display up to five different toolbars to allow you to easily set up and modify measurements.

How to display toolbars
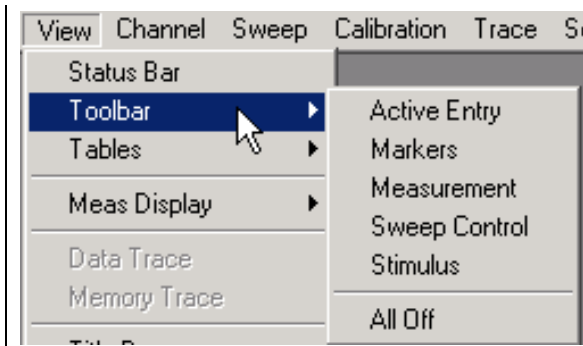
Learn more about using the front panel interface

Learn about each toolbar:

- Active Entry
- Markers
- Measurement
- Sweep Control
- Stimulus
- All Off

Note: There is also a CalSet toolbar available for Monitoring Error Terms.

Active Entry Toolbar

The active entry toolbar is displayed at the top of the screen, below the menu bar. It allows you to make selections from the active function using the mouse or by pressing the front panel key with the corresponding color.

Learn more about using the front panel interface

Markers Toolbar

The markers toolbar allows you to set up and modify markers. It shows:

- Marker number
- Stimulation value
- Marker functions
  - Delta
  - Start/Stop
  - Center/Span

Tip: To use the Front Panel Knob to change marker position, first click the **Stimulus** field of the marker toolbar. Then turn the knob.

Learn more about Markers

Measurement Toolbar
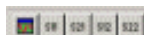
The measurement toolbar allows you to **create a new trace** for a desired S-parameter

measurement in a current window or new window.

Sweep Control Toolbar

In left to right order, the buttons on this toolbar set the active channel to:

- **Hold** mode
- **Single** sweep, then Hold mode
- **Continuous** sweep

Learn more about Channel Trigger State.

Stimulus Toolbar

The stimulus toolbar allows you to view, set up, and modify the sweep stimulus. It shows the:

- **Start** value
- **Stop** value
- Number of **points**

All Off

This allows you to **hide all toolbars** with a single selection.

Tables

Tables are displayed at the bottom of the selected window. Only one table may be displayed at a time for a window.

How to display Tables
Learn more about using the front panel interface

You can display tables for the following:

- Marker Table
- Limit Line Table
- Segment Table

Marker Table

You can display a table of marker settings. These settings include the:

- Marker number
- Marker reference (for delta measurements)
- Frequency
- Response

Limit Line Table

You can display, set up, and modify a table of limit test settings. These include:

- Type (MIN, MAX, or OFF)
- Beginning and ending stimulus values
- Beginning and ending response values

Learn more about Limit Lines

Segment Sweep Table

You can display, set up, and modify a table of segment sweep settings. These include:

- State (On/Off)
- Start and Stop frequencies
- Number of Points
- IF Bandwidth (if independent levels)
- Power Level (if independent levels)
- Sweep Time (if independent levels)

Learn more about Segment sweep

Measurement Display

How to display measurement information
Learn more about using the front panel interface

- Trace Status
- Frequency Stimulus
- Marker Readout
- Limit Test Results
- Limit Lines
- Title

Trace Status
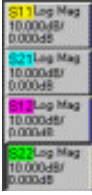
Trace status is displayed to the left of each window on the screen. It shows the:

- Measurement parameter
- Format
- Scaling factor
- Reference level

Click a trace status button to make that measurement active.

Frequency/Stimulus

Frequency/stimulus information is displayed at the bottom of each window on the screen. It shows:

- Channel number
- Start value
- Stop value

Marker Readout

- Checked - Shows the following Marker information in the top right corner of each window.
  - Marker number
  - Stimulus value
  - Response value in marker's selected format
- Cleared - Shows **no** Marker Readout display.

One Readout Per Trace

- Checked - Shows the Readout of the single **active marker** per trace.
- Cleared - Shows up to 4 markers on the **active trace**.

Large Marker Readout

- Checked - Shows the Marker Readout in **large font size for easy reading**.
- Cleared - Shows the Marker Readout in **normal font size**.

Limit Line Test Results

Limit line test results, **Pass** or **Fail,** are displayed on the right side of the designated window.

Limit Lines

Limit lines are displayed for the active trace in the designated window. Their position depends on:

- Limit levels

- Format

- Scaling

- Reference level

Learn more about Limit Lines

Title

You can create and display a title for each measurement window using the keyboard. You can also use the following Title Entry dialog box.

The title that is entered is displayed in the upper-left corner of the designated window.
To clear a title, delete the title from the dialog box entry area and click OK.

Data Trace and Memory Trace

You can view or hide the active data or memory trace.

- Make a trace active by clicking the trace status button

- To view a memory trace you must first store a trace in memory. Click **Trace**, then **Math / Memory**, then **Data => Memory.**

Learn more about Math operations

Title Bars

When checked, the title bars for all PNA windows are shown. The Title bar shows the window number and Minimize / Maximize icons. Clear Title Bars to hide the title bars of all the windows on the screen. This allows more room to display measurement results.

Minimize Application

Click to minimize the PNA application to the Windows taskbar.

To restore the PNA application either click the PNA application on the Windows taskbar or press

 on the front panel.

2. Optimize
Dynamic Range

_____

Dynamic range is the difference between the analyzer receiver's maximum input power and the

minimum measurable power (noise floor). For a measurement to be valid, input signals must be within these boundaries.

Increasing dynamic range is important if you need to measure very large variations in signal amplitude, such as filter bandpass and rejection. The dynamic range is shown below for an example measurement.
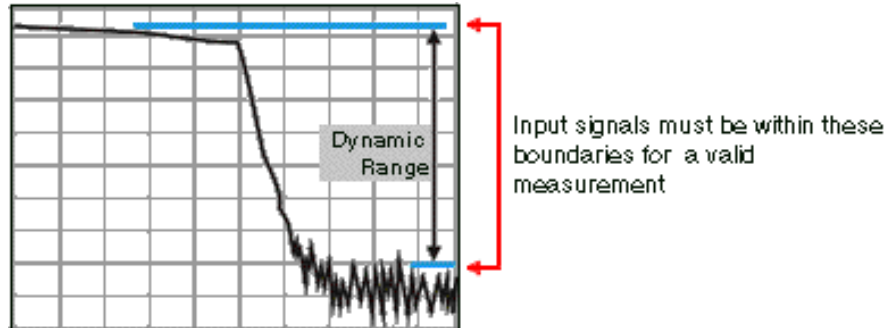
To help reduce measurement uncertainty, the analyzer dynamic range should be greater than the response that the DUT exhibits. For example, measurement accuracy is increased when the DUT response is at least 10 dB above the noise floor. The following methods can help you increase the dynamic range.

- Increase the Device Input Power
- Reduce the Receiver Noise Floor
- Use the Front-Panel Jumpers (if your analyzer has them)

Other topics about Optimizing Measurements

Increase Device Input Power

Increase the DUT input power so that the analyzer can more accurately detect and measure the DUT output power. However, use caution - too much power can damage the analyzer receiver or cause compression distortion.

Caution! Receiver input damage level: +15 dBm.

To increase input power to the device:

1. In the **Channel** menu, click **Power**
2. Select the **Power On** check box.
3. Under **Port Selection**, select the port that you are using as the source output.
4. In the **Test Port Power** box, type the value or press the arrow button to select the value you want.
5. Click **OK**.

Tip: You can further increase dynamic range by using an external booster amplifier to increase the input power to the DUT. See High Power Amplifier Measurements.

Reduce the Receiver Noise Floor

You can use the following techniques to lower the noise floor and increase the analyzer's dynamic range.

- Reduce **crosstalk** between the PNA receivers when measuring signals close to the noise floor. See Receiver Crosstalk.)

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- Use **Sweep Averaging** - learn more about Sweep Average

- Reduce the **IF Bandwidth** - learn more about IF Bandwidth.

- In Segment sweep mode each segment can have its own IF bandwidth. For example, when measuring a filter:

  - In the passband, the IF bandwidth can be set wider for a fast sweep rate, as long as high-level trace noise is kept sufficiently small.

  - In the reject band, where noise floor contributes significantly to measurement error, the IF bandwidth can be set low enough to achieve the desired reduction in average noise level.

Use the Front-Panel Jumpers (if your PNA has them)

If your PNA has FOUR front-panel jumpers, you can bypass the test-port couplers and apply signals directly into the receivers. See <u>Dynamic Range - 4 Jumpers</u>. Using this configuration, you can achieve up to 143 dB dynamic range with **Response Calibration** using segment sweep mode.

If your PNA has MORE THAN FOUR front-panel jumpers (Configurable Test Set Option 014 or 015), you can use the front-panel jumpers to reverse a test-port coupler. See <u>Dynamic Range - Configurable Test Set Option</u>. Using this configuration, you can achieve up to 143 dB dynamic range with **Full 2-port Calibration** using segment sweep mode.

Note: Bypassing a port's directional coupler increases the port mismatch by approximately 15 dB (the coupling factor of the directional coupler).

- For information about upgrading your PNA to include front-panel jumpers, see PNA Options.

- Discover the measurement possibilities using front-panel jumpers.

Improving Dynamic Range with FOUR front-panel jumpers

To improve dynamic range you can bypass the test-port coupler and apply the signal directly into the receiver. As shown in the following graphic, the signal is applied to the front-panel connector for the B In or Rcvr B In front-panel jumper rather than Port 2. Using this configuration, you can achieve up to 143 dB dynamic range with response calibration using segment sweep mode.

Explore the graphic with your mouse.

Note: Your PNA may not be equipped with front-panel jumpers or all of the components shown in this block diagram.
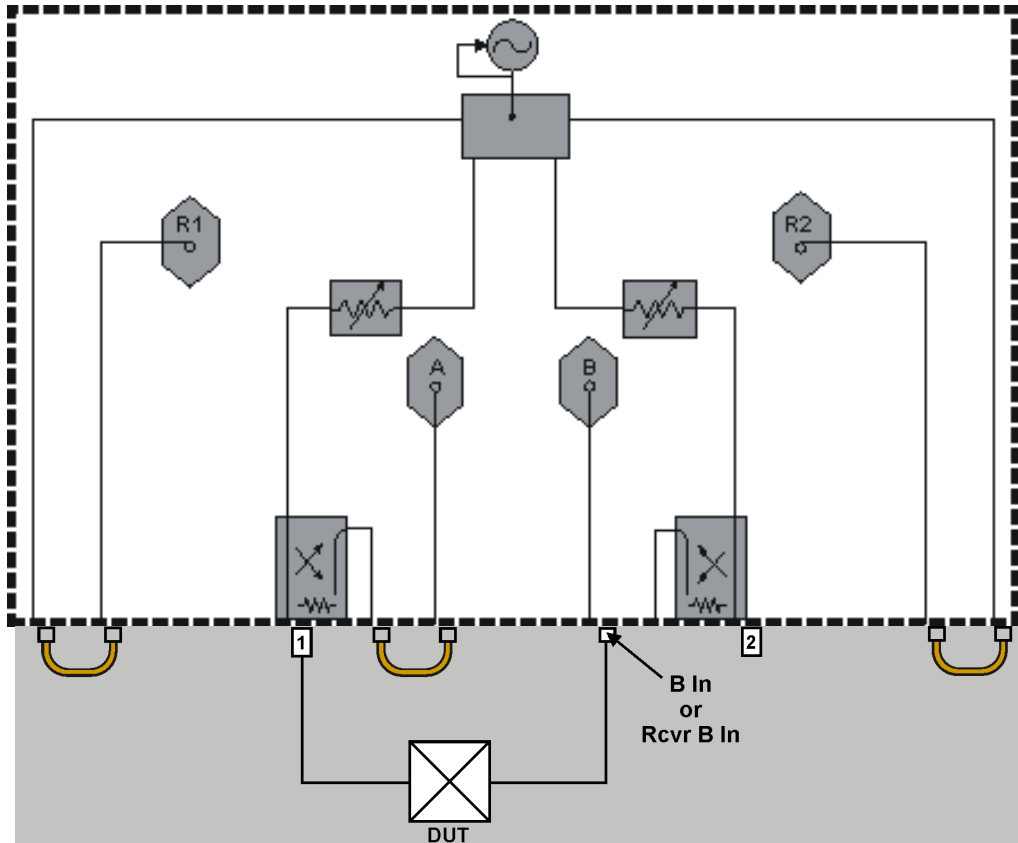
Improving Dynamic Range with Configurable Test Set Option

To improve dynamic range you can reverse the signal path in the test-port coupler and bypass the loss typically associated with the coupled arm. As shown in the following graphic, the signal is applied to Port 2. The signal bypasses the coupled arm via the jumper cable connected to the Coupler Thru (or Coupler In) and the Receiver B In (or B In) ports. Using this configuration, you can increase the forward measurement dynamic range up to 143 dB with full 2-port calibration using segment sweep mode. When making full 2-port error corrected measurements, the reverse measurement is degraded by 15 dB, with up to 113 dB of dynamic range available.

Explore the graphic with your mouse.

Note: Your analyzer's block diagram may contain different components than shown below.

B In
or
Rcvr B In   B Out
or
Cplr Arm
(Port 2)

Coupler In
or
Coupler Thru

Source
Out

DUT
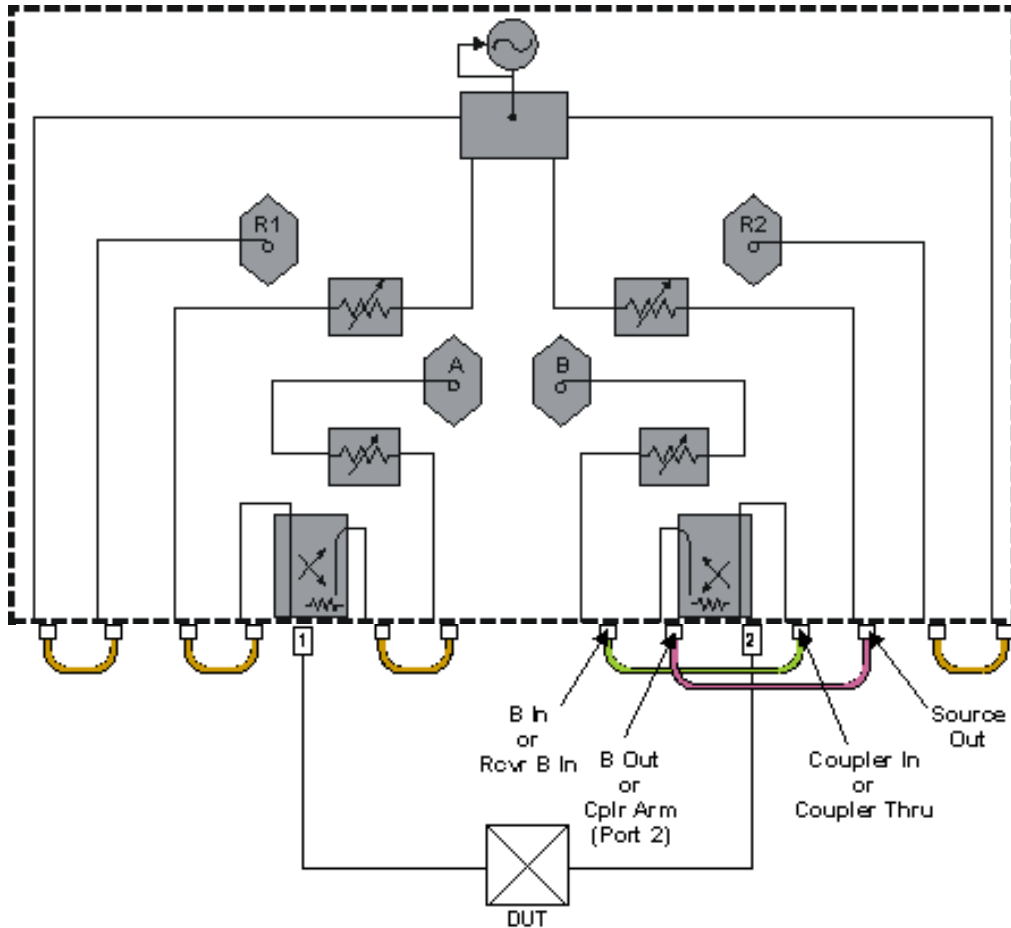
Number of Points

A data point or "point" is a sample of data representing a measurement at a single stimulus value. You can specify the number of points that the analyzer measures across a sweep. (A "sweep" is a series of consecutive data point measurements, taken over a sequence of stimulus values.)

The PNA sweep time changes proportionally with the number of points. However, the overall measurement cycle time does not. See Technical Specifications for more information on how the number of points, and other settings, affect the sweep time.

The default value is 201 points per sweep.

Other topics about Optimizing Measurements

Tips:

- To achieve the greatest trace resolution, use the maximum number of data points.

- For faster throughput use the smallest number of data points that will give you acceptable accuracy.

- To find an optimized number of points, look for a value where there is not a significant difference in the measurement when you increase the number of points.

- To ensure an accurate measurement calibration, perform the calibration with the same number of points that will be used for the measurement.

How to change the number of data points

Use one of the following methods:

Select a number or click Custom to invoke a dialog box

-

-
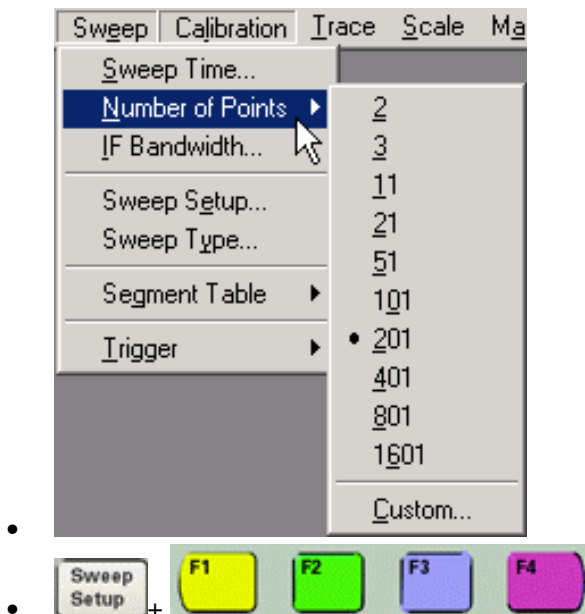
Learn more about using the front panel interface
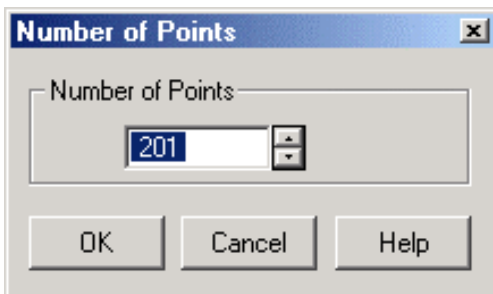
Number of Points dialog box help

Specifies the number of data points that the analyzer gathers during a measurement sweep.

You can specify any number from 2 to 1601.

The default value is 201.

Phase Measurement Accuracy

You can increase the accuracy of phase measurements by using the following PNA features.

- Electrical Delay
- Port Extensions

- Phase Offset
- Spacing Between Frequency Points (Aliasing)

Learn more about Phase measurements

Electrical Delay

Electrical delay is a mathematical function that simulates a variable length of lossless transmission line.

Use the electrical delay feature to compensate for the linear phase shift through a device. This feature allows you to look at only the deviation from linear phase of the device.

You can set the electrical delay independently for each measurement trace.

How to set Electrical Delay
Learn more about using the front panel interface
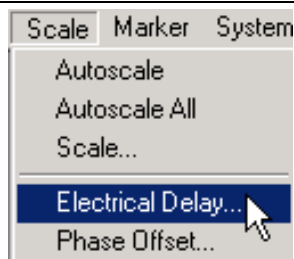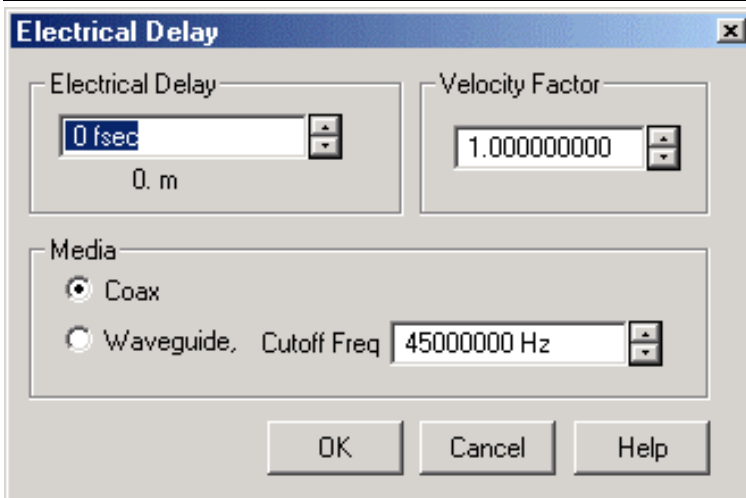
Electrical Delay dialog box help
Electrical Delay Specifies the value of delay added or removed, in units of time. This compensates for the linear phase shift through a device. You can set the electrical delay independently for each measurement trace.
Velocity Factor Specifies the relative velocity of the medium of the device inserted. The value for a polyethylene dielectric cable is 0.66 and 0.7 for Teflon dielectric.
Media
Coax select if the added length is coax. Also specify the velocity factor of the coax.
Waveguide Select if the added length is waveguide. Also specify the low frequency cutoff of the waveguide.
Cutoff Freq Low frequency cutoff of the waveguide.

Learn about Electrical Delay (scroll up)

Port Extensions

Use port extensions to electrically move the measurement reference plane after you have performed a calibration. This allows you to **avoid** performing another calibration. The following two scenarios show how port extensions can be useful.

1. You have already performed a calibration, and then decide that you need to add a length of cable in the measurement configuration. Use port extensions to "tell" the analyzer you have added the cable length to a specific port.

2. You are unable to perform a calibration directly at your device because it is in a test fixture. Use port extensions to compensate for the time delay (phase shift) caused by the fixture.

- Port extensions automatically apply electrical delay to **all** measurements associated with a particular port.

- You can add electrical length to the A and B receivers if you are using the receiver's direct access connectors on the front panel.

- Port extensions do NOT compensate for loss and mismatch errors of the cables, adapters, and fixtures; only the added electrical length.

Tip: To know when you have added enough delay:

1. Connect a short in place of the device.

2. Adjust the port extension until the phase response is flat.

Note: Most short-circuit calibration standards have a non-zero delay. Therefore, adjusting delay with this method results in a delay error equal to two times the short delay. Determine the offset delay of the calibration short by examining the standard definition.

How to set Port Extensions

Calibration   Trace   Scale
  Calibration Wizard...
 	
  Correction on/OFF
  ✔ Interpolation ON/off
 	
  Cal Set...
  Cal Type...
 	
  Port Extensions...

Learn more about using the front panel interface

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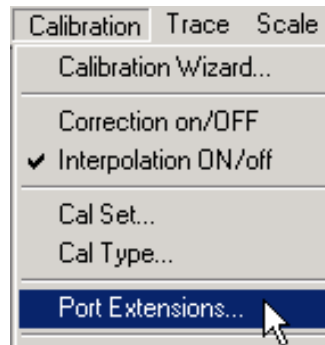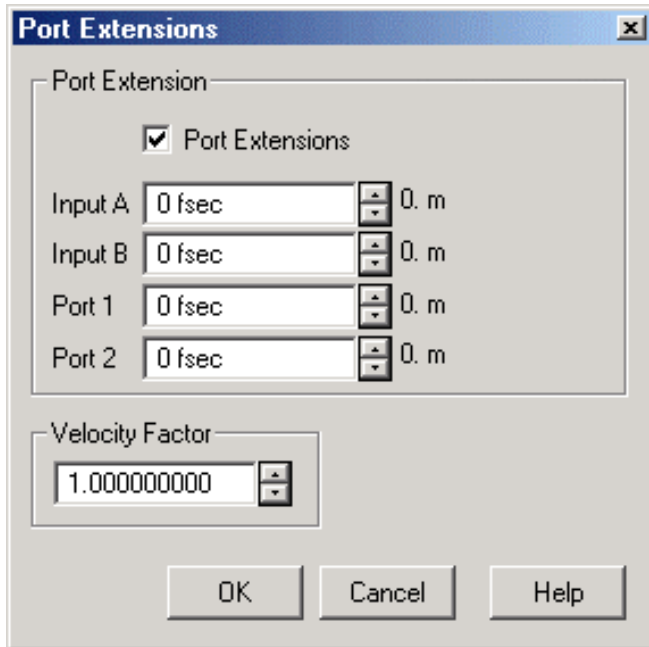
Port Extensions dialog box help
Port Extensions When checked, applies the port extension function to the specified port or ports.
Input A Specifies the distance that the reference plane is extended for Input A.
Input B Specifies the distance that the reference plane is extended for Input B.
Port 1 Specifies the distance that the reference plane is extended for Port 1.
Port 2 Specifies the distance that the reference plane is extended for Port 2.
Velocity Factor Specifies the velocity factor that applies to the medium of the device that was inserted after the measurement calibration. The value for a polyethylene dielectric cable is 0.66 and 0.7 for Teflon dielectric. 1.0 corresponds to the speed of light in a vacuum.
Learn about Port Extensions (scroll up)

Phase Offset

Phase offset mathematically adjusts the phase measurement by a specified amount, up to 360°. Use this feature in the following ways:

- **Improve the display of a phase measurement.** This is similar to the way you would change the reference level in an amplitude measurement. Change the phase response to center or align the response on the screen.

- **Emulate a projected phase shift in your measurement.** For example, if you know that you need to add a cable and that the length of that cable will add a certain phase shift to your measurement, you can use phase offset to add that amount and simulate the complete device measurement.

How to set Phase Offset
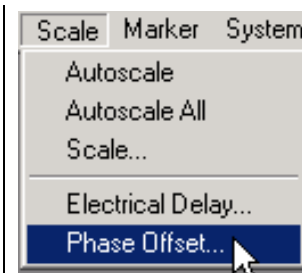
Learn more about using the front panel interface
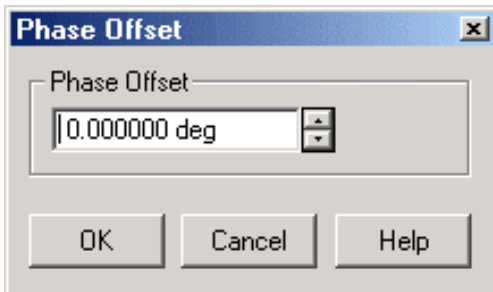
Phase Offset dialog box help

Phase Offset Type a value or use the up and down arrows to select any value up to 360 degrees.

Learn about Phase Offset (scroll up)

Spacing Between Frequency Points (Aliasing)

The analyzer samples data at discrete frequency points, then connects the points, creating a trace on the screen.

If the phase shift through a device is >180° between adjacent frequency points, the display can look like the phase slope is reversed. This is because the data is undersampled and aliasing is occurring.

If you are measuring group delay and the slope of the phase is reversed, then the group delay will change sign. For example, the following graphic shows a measurement of a SAW bandpass filter.

- The left measurement has 51 points and indicates the group delay is negative, which is a physical impossibility. That is, the response is below 0 seconds reference line.

- The right measurement shows an increase to 201 points which indicates the group delay is positive. That is, the response is above the 0 seconds reference line.
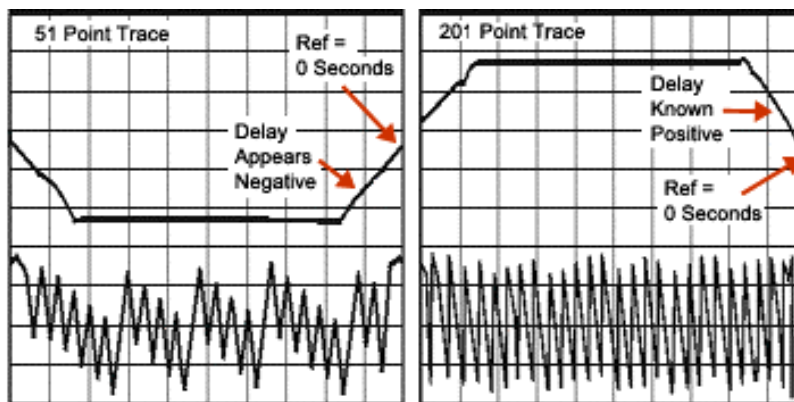
Tip: To check if aliasing might be occurring in a measurement, either increase the number of points or reduce the frequency span.

Electrically-Long Device Measurements

A signal coming out of a device under test may not be exactly the same frequency as the signal going in to a device at a given instant in time. This can sometimes lead to inaccurate measurement results. You can choose between two techniques to eliminate this situation and increase measurement accuracy.

- Why Device Delay May Create Inaccurate Results
- Solutions to Increase Measurement Accuracy
    - Slow the Sweep Speed
    - Add Electrical Length to the R Channel

Other topics about Optimizing Measurements

Why Device Delay May Create Inaccurate Results

The following graphic shows an example of this situation:

- In the network analyzer, the source and receiver are phase locked together and sweep simultaneously through a span of frequencies.

- The signal flow through the Device Under Test (DUT) is shown as different colors for different frequencies.

- You can see as a stimulus frequency travels through the DUT, the analyzer tunes to a new frequency **just before** the signal arrives at the receiver. This causes inaccurate measurement results.

.
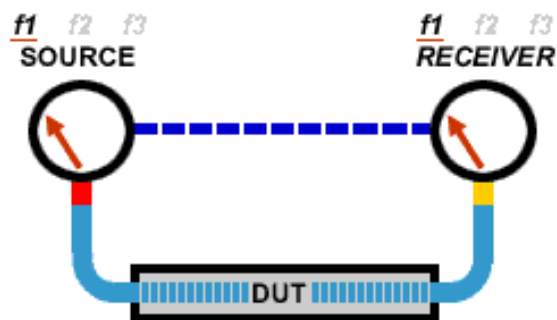
If the analyzer is measuring a long cable, the signal frequency at the end of the cable will lag behind the network analyzer source frequency. If the frequency shift is appreciable compared to the network analyzer's IF detection bandwidth (typically a few kHz), then the measured result will be in error by the rolloff of the IF filter.

Note: There is no fixed electrical length of a device where this becomes an issue. This is because

there are many variables that lead to measurement speed. When high measurement accuracy is critical, lower the sweep speed until measurement results no longer change.

Solutions to Increase Measurement Accuracy

Choose from the following methods to compensate for the time delay of an electrically long device.

- Slow the Sweep Speed
- Add Electrical Length to the R Channel

Slow the Sweep Speed

The following methods will slow the sweep speed.

- Increase the Sweep Time
- Increase the Number of Points
- Use Stepped Sweep
- Set Dwell Time

Add Electrical Length to the R Channel

Note: This method applies to PNA models with front panel loops.

Instead of slowing the sweep, you can compensate for the electrical length of a cable or fixture.

a. Remove the R-channel jumper on the front panel of the analyzer.

b. Replace the jumper with a cable of about the same length as the device under test.
    1. Add the cable on the R1 channel for S_{11} and S_{21} measurements.
    2. Add the cable on the R2 channels for S_{22} and S_{12} measurements.

c. Set the analyzer for a fast sweep.

Configuration for S_{22} and S_{12} Measurements
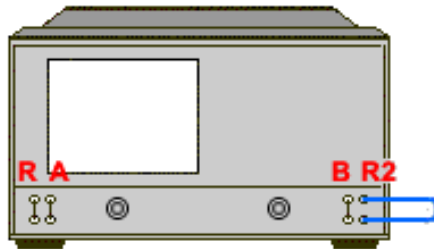
This method balances the delays in the reference and test paths, so that the network analyzer's ratioed transmission measurement does not have a frequency-shift error.

Note: This method works well if the delay is in a cable or fixture. For devices with long delays, this method is only suitable for uncalibrated measurements.

Reflection Accuracy on Low-Loss 2-Port Devices
_____

To make accurate reflection measurements that have a 1-port calibration, you should terminate

the unmeasured port.

- Why Terminate the Unmeasured Port
- How to Terminate the Unmeasured Port
- Resulting Measurement Uncertainty

Other topics about Optimizing Measurements

Why Terminate the Unmeasured Port

A 2-port calibration corrects for all 12 twelve error terms. A 1-port calibration corrects for directivity, source match and frequency response, but not load match. Therefore, for highest accuracy, you must make the load match error as small as possible. This especially applies for low-loss, bi-directional devices such as filter passbands and cables. You do not need to be concerned with load match when you are measuring a device with high reverse isolation, such as an amplifier.

How to Terminate the Unmeasured Port

Use one of the following methods:

- Connect a high-quality termination load (from a calibration kit, for example) to the unmeasured port of your device. This technique yields measurement accuracy close to that of a Full SOLT 2-port calibration.

- Connect the unmeasured port of your device directly to the analyzer, inserting a 10 dB precision attenuator between the device output and the analyzer. This improves the effective load match of the analyzer by approximately twice the value of the attenuator, or 20 dB.
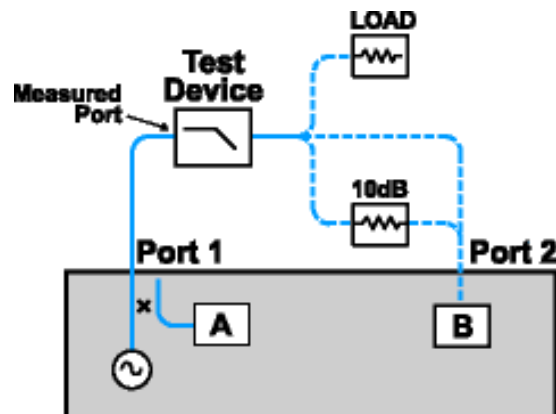
Resulting Measurement Uncertainty

The following graph illustrates the measurement uncertainty that results from terminating **with** and **without** a precision 10 dB attenuator on the output of the test device.

━━━━━━━━━━━━━━━━━━━━━━━━━ 0

- - - - - - - - - - - - - - - - - - -11.4 dB
- - - - - - - - - - - - - - - - - - -14.1 dB
━━━━━━━━━━━━━━━━━━━━━━━━━ -16   dB
- - - - - - - - - - - - - - - - - - -18.5 dB

- - - - - - - - - - - - - - - - - - -26.4 dB

Legend

_____	Filter Reflection
--------------	Uncertainty **with** attenuator
....	Uncertainty **without** attenuator

The calculations below show how adding a high-quality 10 dB attenuator improves the load match of the analyzer.

Note: The corresponding linear value is shown in parentheses.

Network Analyzer:
Load match (NA_{LM}) = 18 dB (.126)
Directivity (NA_D) = 40 db (.010)
Filter:
Insertion loss (F_{IL}) = 1dB (.891)
Return loss (F_{RL}) = 16 dB (.158)
Attenuator:
Insertion loss (A_{IL}) = 10 dB (.316)
SWR (A_{SWR}) = 1.05 (.024)
32.26 dB Return Loss

Calculations:

	Without Attenuator	**With Attenuator**
ρ_{NA}	$= (F_{IL})*(NA_{LM})*(F_{IL})$ $= (.891)*(.126)*(.891)$ $=.100$	$= (F_{IL})*(A_{IL})*(NA_{LM})*(A_{IL})*(F_{IL})$ $=$ $(.891)*(.316)*(.126)*(.316)*(.891)$ $= .010$
ρ**Attenuator**	NA	$= (F_{IL})*(A_{SWR})*(F_{IL})$ $= (.891)*(.126)*(.891)$ $= .019$

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Worst Case Error (E$_{WC}$)	$= \rho_{NA}$	$= \rho_{NA} + \rho$Attn.
	$=.1$	$=.01+.019$
		$=.029$

Uncertainty Adds	$= -20\log(F_{RL})+(E_{WC})+(NA_D)$	$= -20\log(F_{RL})+(E_{WC})+(NA_D)$
	$= -20\log(.158)+(.100)+(.010)$	$= -20\log(.158)+(.029)+(.010)$
	$= \textbf{11.4 dB}$	$= \textbf{14.1 dB}$

Uncertainty Subtracts	$= -20\log(F_{RL})-(E_{WC})-(NA_D)$	$= -20\log(F_{RL})-(E_{WC})-(NA_D)$
	$= -20\log(.158)-(.100)-(.010)$	$= -20\log(.158)-(.029)-(.010)$
	$= \textbf{26.4 dB}$	$= \textbf{18.5 dB}$

Measurement Stability

There are several situations that can cause unstable measurements. To ensure that you are making repeatable measurements, you can use various methods to create a stable measurement environment.

- Frequency Drift
- Temperature Drift
- Inaccurate Measurement Calibrations
- Device Connections

Other topics about Optimizing Measurements

Frequency Drift

The analyzer frequency accuracy is based on an internal 10 MHz frequency oscillator. See Technical Specifications for stability and aging specifications.

If your measurement application requires better frequency accuracy and stability, you can override the internal frequency standard and provide your own high-stability external frequency source through the 10 MHz Reference Input connector on the rear panel.

1. Input the external frequency reference signal to the rear panel connector as shown.

2. This external reference signal will be detected and used instead of the internal reference signal.

    - Input frequency: 10 MHz (±10ppm or better)

    - Input level: –15 to +20 dBm

    - Input impedance: 200 ohms

10MHz Reference Input
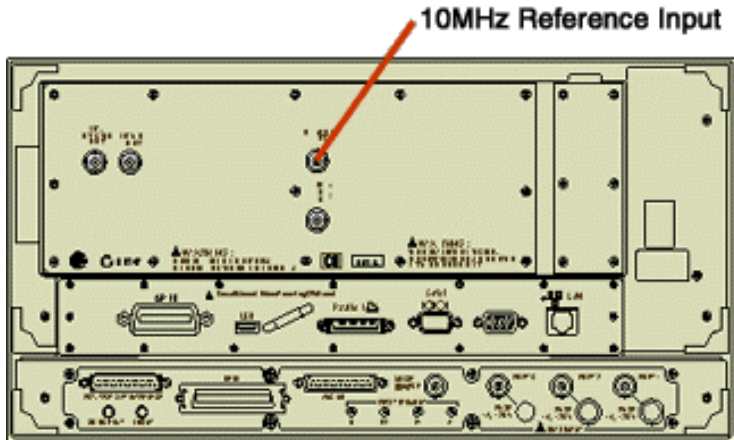
Temperature Drift

Thermal expansion and contraction changes the electrical characteristics of the following components:

- Devices within the analyzer
- Calibration kit standards
- Test devices
- Cables
- Adapters

To reduce the effects of temperature drift on your measurements, do the following.

- Switch on the analyzer 1/2 hour before performing a measurement calibration or making a device measurement.
- One hour before you perform a measurement calibration, open the case of the calibration kit and take the standards out of the protective foam.
- Use a temperature-controlled environment. All specifications and characteristics apply over a 25 °C ±5 °C range (unless otherwise stated).
- Ensure the temperature stability of the calibration kit devices.
- Avoid handling the calibration kit devices unnecessarily during the calibration procedure.
- Ensure the ambient temperature is ±1°C of the measurement calibration temperature.

Inaccurate Measurement Calibrations

If a measurement calibration is inaccurate, you will not measure the true response of a device under test. To ensure that your calibration is accurate, you should consider the following practices:

- Perform a measurement calibration at the points where you connect the device under test, that is, the reference plane.
- If you insert any additional accessory (cable, adapter, attenuator) to the test setup after you have performed a measurement calibration, use the port extensions function to compensate for the added electrical length and delay.
- Use calibration standards that match the definitions used in the calibration process.
- Inspect, clean, and gage connectors. See Connector Care.

See Accurate Measurement Calibrations for more detailed information.

Device Connections

Good connections are necessary for repeatable measurements. To help make good connections, do the following:

- Inspect and clean the connectors for all of the components in the measurement setup.

- Use proper connection techniques.

- Avoid moving the cables during a measurement.

Noise Reduction Techniques

Random electrical noise which shows up in the analyzer receiver chain can reduce measurement accuracy. The following PNA functions help reduce trace noise and the noise floor which can lead to better dynamic range and more accurate measurements.

- Sweep Average
- IF Bandwidth
- Trace Smoothing

See Increase Dynamic Range to learn more about improving this critical parameter.

Other topics about Optimizing Measurements

Sweep Average

Sweep average is a feature that reduces the effects of random noise on a measurement. The PNA computes each data point based on the average of the same data point over several consecutive sweeps. You determine the number of consecutive sweeps by setting the Average factor. The higher the average factor, the greater the amount of noise reduction.

- When Averaging is ON, an **Average Counter** appears on the screen displaying the number of sweeps that has been averaged. The effect on the signal trace can be viewed as the Average Factor increases. This can assist in the selection of the optimum number of sweep averages.

- Averaging is applied to all measurements in a channel. The Average counter is displayed for each channel.

- Although you can average unratioed (single receiver) measurements, you may get unexpected results:

  - Phase results may tend toward 0. This is because phase measurements are relative by nature. Measuring absolute phase with a single receiver appears random. Averaging random positive and negative numbers will tend toward 0.

  - The noise floor does not drop when averaging unratioed measurements as on ratioed measurements.

- Use Average and IF bandwidth for the same benefit of general noise reduction. For minimizing very low noise, using Average is more effective than reducing system

bandwidth. Generally, Averaging takes slightly longer than IF Bandwidth reduction to lower noise, especially if many averages are required.

Effects of Sweep Average
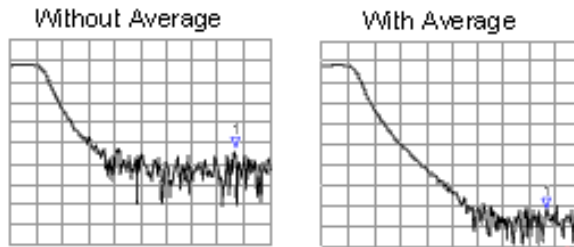
How to Set Averaging
Use one of the following methods: ●   ● Learn more about using the front panel interface
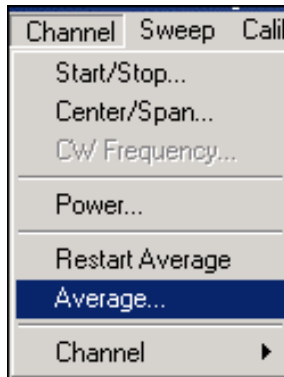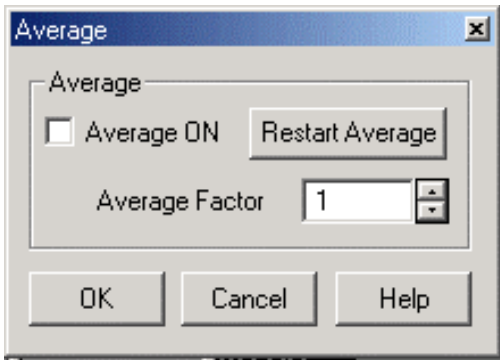
Average dialog box help
Average ON Checked - Averaging is applied Cleared - Averaging is NOT applied
Average Factor   Specifies the number of sweeps that is averaged. Range of 1 to 1024.
Restart Begins a new set of measurements that are used for the average. This set of measurements is equal to the average factor.
Learn about Averaging (scroll up)

IF Bandwidth

The PNA converts the received signal from its source to a lower intermediate frequency (IF) of 41.67 kHz. The bandwidth of the IF bandpass filter is adjustable from 40 kHz down to a minimum of 1 Hz.

Reducing the IF receiver bandwidth reduces the effect of random noise on a measurement. Each tenfold reduction in IF bandwidth lowers the noise floor by 10 dB. However, narrower IF bandwidths cause longer sweep times.

You can set the IF bandwidth independently for each channel or each segment of segment sweep.

Effect of Reducing IF Bandwidth
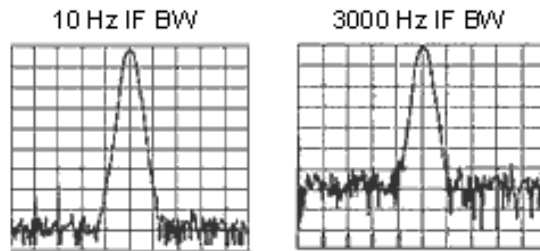
How to set IF Bandwidth
Learn more about using the front panel interface
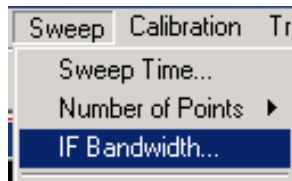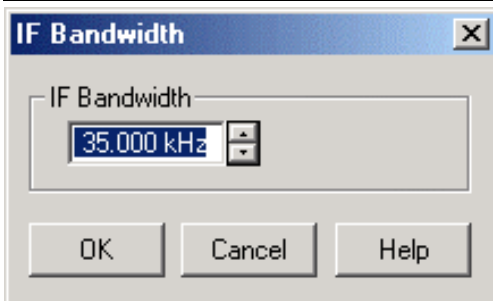
IF Bandwidth dialog box help
IF bandwidth Specifies the IF (receiver) bandwidth between 1 Hz to 40 kHz. The value of IF bandwidth is selected by scrolling through the values available in the IF bandwidth text box.
OK Selects the value of IF bandwidth shown in the text box.
Learn about IF Bandwidth (scroll up)

Trace Smoothing

Trace smoothing averages a number of adjacent data points to smooth the displayed trace. The number of adjacent data points that get averaged together is also known as the smoothing

aperture. You can specify aperture as either the number of data points or the percentage of the x-axis span.

Trace Smoothing reduces the peak-to-peak noise values on broadband measured data. It smooths trace noise and does not increase measurement time significantly.
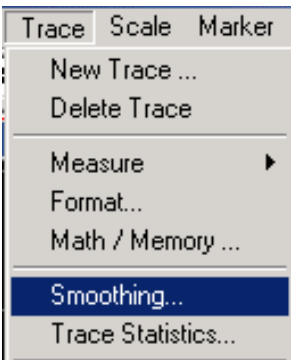
Tips:

- Start with a high number of display points and reduce until you are confident that the trace is not giving misleading results.

- Do not use smoothing for high-resonance devices, or devices with wide trace variations. It may introduce measurement errors.

- You can set the smoothing function independently for each trace.
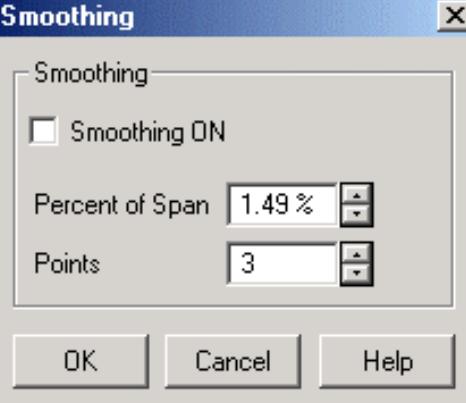
Effects of Smoothing on a Trace
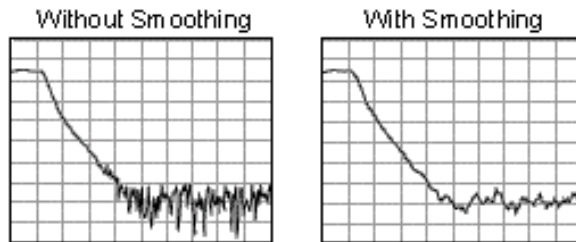
How to set Trace Smoothing
  Learn more about using the front panel interface

Smoothing dialog box help
Smoothing ON When checked, applies the smoothing function that averages data over a portion of the displayed trace.

Percent of Span Specifies the smoothing aperture as a percent of the swept stimulus span. For example, with a 401 points specified, the percent span is between 0.19% and 25%.

Points Specifies the smoothing aperture as a percent of the total number of measurement points in the swept stimulus span.

Learn about Trace Smoothing (scroll up)

Crosstalk

Crosstalk is energy leakage between analyzer signal paths. This can be a problem with high-loss transmission measurements. However, you can reduce the effects of crosstalk by doing the following:

- Set the Sweep to Alternate
- Perform an Isolation Calibration

Other topics about Optimizing Measurements

Set the Sweep to Alternate

Alternate sweep measures only one receiver per sweep. When one receiver is measured, the analyzer switches off the other receiver. This helps reduce receiver crosstalk.

Note: Alternate sweep mode can be set independently for each measurement channel. If multiple measurement channels are in use, you may want to set Alternate sweep for each channel.

1. In the **Sweep** menu, click **Sweep Setup.**
2. Check **Alternate Sweeps.**
3. Click **OK**.

Tips:

- The analyzer measures reflection (Receiver A) and transmission (Receiver B) on separate sweeps. Therefore, when the analyzer is making both reflection and transmission measurements, alternate sweep doubles the sweep cycle time.

- For transmission only or reflection only measurements, you can use alternate sweep to minimize the effects of crosstalk without affecting the sweep cycle time.

- The noise floor has to be lowered substantially before crosstalk is visible. You may need to use the average function or narrow the IF bandwidth.

Perform an Isolation Calibration

For transmission measurements, a response and isolation measurement calibration helps reduce crosstalk because the analyzer measures and then subtracts the leakage signal during the measurement calibration. The calibration improves isolation so that it is limited only by the noise floor.

See Isolation error to learn how crosstalk can be reduced in the calibration process.

Generally, the isolation error falls below the noise floor. So when you are performing an isolation calibration you should use a noise reduction technique such as sweep averages or reducing the IF bandwidth.

Effects of Accessories
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Accessories in a configuration may affect the results of a device measurement. You can choose between two analyzer features that reduce the effects of accessories.

- Power Slope to Compensate for Cable Loss
- Gating to Selectively Remove Responses

Other topics about Optimizing Measurements

Power Slope to Compensate for Cable Loss

If you have a long cable or other accessory in a measurement configuration where a power loss occurs over frequency, apply the power slope function. This function increases the analyzer source power by a rate that you define (dB/GHz).

1. In the **Channel** menu, click **Power**.
2. If the slope function is not already switched on, click the **Slope** check box.
3. In the **dB/GHz** box, enter the rate that you want the source power to increase over the frequency sweep. Click **OK**.

Gating to Selectively Remove Responses

Gating is a feature in the time domain (option 010) that allows the analyzer to mathematically remove responses. You can set the gate for either a reflection or transmission response, but you will see different results.

- **Gating a reflection response** isolates a desired response (such as a filter's return loss), from unwanted responses (such as adapter reflections or connector mismatches).

- **Gating a transmission response** isolates a specific path in a multipath device that has long electrical lengths.

After you apply gating to the time domain mode, you can switch off the transform and study the frequency response of the device with the gate still active. The time filter gate can have the following shapes and behaviors:

- **Bandpass shaped** that removes responses outside the passband region
- **Notch shaped** that removes responses inside the rejection region.

1. In the **Trace** menu, click **Transform**.
2. Click the **Transform** check box to switch on the transform mode.
3. Under **Transform Mode**, click the mode you want.

   - Low Pass Impulse

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- Low Pass Step
- Band Pass

4. If you selected Low Pass, click **Set Freq. Low Pass**.

5. In the **Category** box, click the down arrow to select **Gating**.

6. In the **Gate Type** box, click the down arrow to select the gate operation.

- Bandpass
- Notch

7. Set the gating boundaries by either using the **Start** and **Stop** or **Center** and **Span** settings.

8. Click the **Gating** check box to switch on the gating function. Click **OK**.

9. In the **Trace** menu, click **Transform**.

10. In the **Category** box, click the down arrow to select **Transform**. Click the **Transform** check box and **OK**.

See Gate Filter for more information.

Fast Sweep Speed

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Maintaining the fastest measurement sweep is one aspect of achieving the best measurement throughput. You can make the analyzer have the fastest sweep for your measurement application by adjusting the following:

- Sweep Settings
- Noise Reduction Settings
- Measurement Calibration Choice
- Unnecessary Functions

Other topics about Optimizing Measurements

Sweep Settings

Consider changing each of the following settings as suggested.

Frequency Span - Measure only the frequencies that are necessary for your device.

Segment Sweep - Use segments to focus test data only where you need it.

Switch Off Stepped Sweep - Use linear swept mode to minimize sweep time when possible.

Auto Sweep Time - Use this default to sweep as quickly as possible for the current settings.

Number of Points - Use the minimum number of points required for the measurement.

For more information on how number of points and other settings affect sweep cycle time, see Technical Specifications.

Noise Reduction Settings

Using a combination of these settings, you can decrease the sweep time while still achieving an acceptable measurement.

IF Bandwidth. Use the widest IF bandwidth that will produce acceptable trace noise and dynamic range.

Average. Reduce the average factor, or switch Average off.

Measurement Calibration Choice

Choose the fastest type of calibration for the required level of accuracy.

- Sweep speed is about the same for uncorrected measurements and measurements done using a response calibration, or one-port calibration.

- A full two-port calibration requires both forward and reverse sweeps to update all four S-parameters for error correction, even when only a single S-parameter is displayed.

For more information see Select a Calibration.

Unnecessary Functions

The analyzer must update information for all active functions. To achieve an additional increase in sweep speed, switch off all of the analyzer functions that are not necessary for your measurement application.

Delete Unwanted Traces

1. Click on the Trace Status bar to make an unnecessary trace active.
2. In the **Trace** menu, click **Delete Trace**.

Switch Off Unwanted Markers

1. In the **Marker** menu, click **Select Marker**, and click an unwanted marker on the list.
    - If you want to switch off all of the markers, click **All Off**.
2. Display the Marker toolbar: from the **View** menu, click **Toolbars**, and then click **Marker**.
3. Clear the **On** checkbox to switch off the marker.

Switch Off Smoothing

1. In the **Trace** menu, click **Smoothing**.
2. Click the **Smoothing On** box to clear the checkbox, switching off the smoothing function. Click **OK**.

Switch Off Limit Testing

1. In the **Trace** menu, click **Limit Test**.
2. Click the **Limit Test ON** box to clear the checkbox, switching off the limit function. Click **OK**.

Switch Off Math Functions

- In the **Trace** menu, point to the **Data Math** list and click **Data** to view only the current measurement trace.

Analyzer sweep speed is dependent on various measurement settings. Experiment with the settings to get the fastest sweep and the measurement results that you need.

Switch Between Multiple Measurements

If you need to make multiple measurements to characterize a device, you can use various methods to increase throughput. Experiment with these methods to find what is best for your measurement application needs.

- Set Up Measurements for Increased Throughput
    - Arrange Measurements in Sets
    - Use Segment Sweep
    - Trigger Measurements Selectively
- Automate Changes Between Measurements
- Recall Measurements Quickly

Other topics about Optimizing Measurements

Set Up Measurements for Increased Throughput

To achieve optimum throughput of devices that require multiple measurements, it is helpful to know the operation of the analyzer. This knowledge allows you to set up the measurement scenarios that are best for your applications. You can arrange measurements in any combination, using the following building blocks.

- 1 to 16 independent measurement channels
- 1 to 4 traces per window
- 1 to 4 windows per screen
- 1 to 16 measurement traces per screen
- 1 to 16 memory traces per screen

Learn more about Traces, Channels, and Windows on the PNA

Arrange Measurements in Sets

If you arrange measurements to keep the complete set of device measurements in one instrument state, you can save them so that you can later recall a number of measurements with one recall function.

See Pre-configured Measurement Setups for more information.

Use Segment Sweep

Segment sweep is helpful if you need to change the following settings to characterize a device under test.

- Frequency Range
- Power Level
- IF Bandwidth
- Number of Points

The segment sweep allows you to define a set of frequency ranges that have independent attributes. This allows you to use one measurement sweep to measure a device that has varying characteristics.

See Segment Sweep for more information.

Trigger Measurements Selectively

You can use the measurement trigger to make measurements as follows:

- Continuously update only the measurements that have rapidly changing data.
- Occasionally update measurements that have infrequently changing data.

For example, if you had four channels set up as follows:

- Two channels measuring the data that is used to tune a filter
- Two channels measuring the data for the out-of-band responses of the filter

You would want to constantly monitor only the measurement data that you use for tuning the filter. If you continuously update all of the channels, this could slow the response of the analyzer so that you would not be able to tune the filter as effectively.

Note: You must either trigger the infrequent measurement manually or with remote interface commands.

To trigger measurements selectively:

This procedure shows you how to set up two different measurements with the following behavior:

- Channel 1 measurement will continuously update the data.
- Channel 2 measurement will occasionally update the data.

1. In the **Windows** menu, click **Meas Setups**, **Setup D**.

Set Up a Measurement Trigger for Continuous Updates

2. In the **Sweep** menu, click **Trigger**, **Trigger...**.
3. Under **Trigger Source**, click **Internal**.
4. Under **Channel Trigger State**, select **Channel 1**, and click **Continuous**.

Set Up a Measurement Trigger for Occasional Updates

5. Under **Channel Trigger State**, select **Channel 2**, and click **Single**, **OK**.

   - If you want the analyzer to trigger more than a single sweep, click the **Enable Groups** check box and enter the number of sweeps.

6. In the **System** menu, click **Keys, Trigger**.

Update the Measurement

7. Click on the lower window to make Channel 2 the active channel.
8. On the active entry toolbar, click the type of trigger you set up.

   - Click **Single** if you set up the analyzer for a single sweep per trigger.
   - Click **Groups** if you set up the multiple sweeps per trigger.

Note: A trace must be active for you to initiate a trigger for that measurement.

Automate Changes Between Measurements

If there are slight differences between the various measurements that you need to characterize a device, you may find that it is faster to change the measurement settings using programming. .

Recall Measurements Quickly

The most efficient way to recall measurements is to recall them as a set of measurements (instrument state).

- It only takes a short time longer to recall an instrument state that includes multiple measurements, than it does to recall an instrument state with only one measurement.

- Each recall function has time associated with it. You can eliminate that time by setting up the measurements as a set so you can recall them as a set.

See Save and Recall Files for more information.

Data Transfer Speed

The fastest data transfer helps you achieve the best measurement throughput. Try these methods for improving data transfer speed.

- **Use single sweep mode** to ensure that a measurement is complete before starting a data transfer.

1. In the **Sweep** menu, click **Trigger**, **Trigger...**.

2. Under **Trigger Source**, click **Manual**.

3. Under **Channel Trigger State**, select the channel for the measurement that you want to transfer, and click **Continuous**, **OK**.

4. Update the Measurement

    1. In the **System** menu, click **Keys, Trigger**

    2. In the active entry toolbar, click **Single**

- **Transfer the minimum amount of data** needed. For example, a trace with a few points, using segment sweep rather than a full trace with many linearly spaced points. Also, use markers instead of trace transfers.

- **Choose the REAL data format** to provide the fastest transfer speed when using SCPI programs for automated applications.

- **Use SCPI over LAN** for applications that are automated with SCPI programs.

- **Use COM programs** to provide the fastest transfer speed when using an automated application. See Data Transfer Time.

Data Transfer Speed Comparison
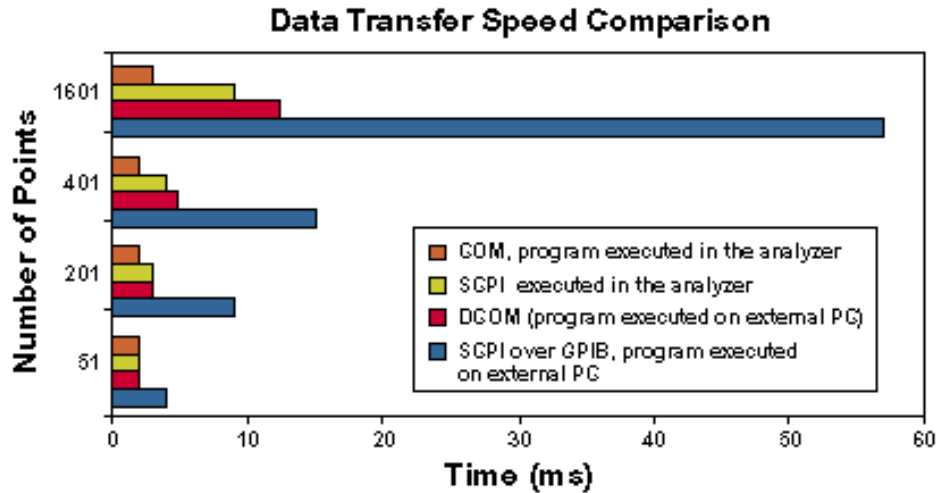
Other topics about Optimizing Measurements

3. Calibrate

Calibration Overview

The following is discussed in this topic:

- What Is Measurement Calibration?
- Why Is Calibration Necessary?
- Conditions Where Calibration Is Suggested
- What Is ECal?

See other Calibration Topics

What Is Measurement Calibration?

Calibration removes one or more of the systematic errors using an equation called an error model. Measurement of high quality standards (for example, a short, open, load, and thru) allows the analyzer to solve for the error terms in the error model. See Measurement Errors.

You can choose from different calibration types, depending on the measurement you are making and the level of accuracy you need for the measurement. See Select a Calibration Type.

The accuracy of the calibrated measurements is dependent on the quality of the standards in the calibration kit and how accurately the standards are modeled (defined) in the calibration kit definition file. The calibration-kit definition file is stored in the analyzer. In order to make accurate measurements, the calibration-kit definition must match the actual calibration kit used. To learn more, see Accurate Calibrations.

Calibration Wizard provides the different calibration methods used in the PNA. See Calibration Wizard.

There are quick checks you can do to ensure your measurement calibration is accurate. To learn more see Validity of a Measurement Calibration

If you make your own custom-built calibration standards (for example, during in-fixture measurements), then you must characterize the calibration standards and enter the definitions into a user modified calibration-kit file. For more information on modifying calibration kit files, see Calibration Standards.

Note: Instrument Calibration is ensuring the analyzer hardware is performing as specified. This is not the same as measurement calibration.

Why Is Calibration Necessary?

It is impossible to make perfect hardware that would not need any form of error correction. Even making the hardware good enough to eliminate the need for error correction for most devices would be extremely expensive.

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

The best balance is to make the hardware as good as practically possible, balancing performance and cost. Calibration is then a very useful tool to improve measurement accuracy.

Conditions Where Calibration Is Suggested

Generally, you should calibrate for making a measurement under the following circumstances:

- You want the best accuracy possible.
- You are adapting to a different connector type or impedance.
- You are connecting a cable between the test device and an analyzer test port.
- You are measuring across a wide frequency span or an electrically long device.
- You are connecting an attenuator or other such device on the input or output of the test device.

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

- Amplitude at device input
- Frequency response accuracy
- Directivity
- Crosstalk (isolation)
- Source match
- Load match

What Is ECAL

ECal is a complete solid-state calibration solution. It makes one port (Reflection), full two and three-port calibrations fast and easy. See Using ECal.

- It is less prone to operator error.
- The various standards (located inside the calibration module) never wear out because they are switched with PIN-diode or FET switches.
- The calibration modules are characterized using a TRL-calibrated network analyzer.

- ECal is not as accurate as a good TRL calibration.

For information about ordering ECal modules, see Analyzer Accessories or contact your Agilent Support Representative

Select a Calibration Type

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This section provides information about the calibration types available in the PNA.

Calibration Types	
OPEN Response	1-PORT Reflection
SHORT Response	Full SOLT 2-port
THRU Response	Full TRL 2-port
THRU Resp + Isol	Full SOLT 3-port

See other Calibration Topics

Type: **Open and Short Response**
Calibration Method: Unguided Calibration
General Accuracy: Low to Medium
Parameters: S11 or S22 (S33 on a 3-port PNA)
Standards Required: OPEN or SHORT
Systematic Errors Corrected:
• Frequency response reflection tracking
Application:
• Reflection measurements on any one port.

Type: **Thru Response**
Calibration Method: Unguided Calibration
General Accuracy: Medium
Parameters: S12 or S21 (S23, S32, S31, S13 on a 3-port PNA)
Standards Required: THRU
Systematic Errors Corrected:
• Frequency response transmission tracking
Application:
• Transmission measurements in any one direction.

Note: The THRU definition for a predefined calibration kit assumes zero-length and zero-loss. If you use an adapter as a THRU, characterize the adapter in the calibration kit file for better accuracy. See Accurate Calibrations

Type: **Thru Response and Isolation**
Calibration Method: Unguided Calibration
General Accuracy: Medium
Parameters: S11 or S22 (S23, S32, S31, S13 on a 3-port PNA)
Standards Required: THRU, LOAD
Systematic Errors Corrected:
• Frequency response transmission tracking

- Crosstalk

Application:
- Use only for transmission measurements in any one direction.
- Isolation portion of calibration improves high dynamic range measurements.

Type: **1-Port (Reflection)**
Calibration Method: Unguided Calibration, Guided Calibration, ECal
General Accuracy: High
Parameters: S11 or S22 (S33 on a 3-port PNA)
Standards Required: (SHORT, OPEN, LOAD) or ECal module
Systematic Errors Corrected: • Directivity   • Source match   • Frequency response reflection tracking
Application: • Reflection measurements on any one port.
PNA Models: All

Type: **Full SOLT 2-Port**
General Accuracy: High
Calibration Method: Unguided Calibration, Guided Calibration, ECal
Parameters: All
Standards Required: (SHORT, OPEN, LOAD, THRU) or ECal module
Systematic Errors Corrected: • Directivity   • Source match   • Isolation   • Load match   • Frequency response transmission tracking   • Frequency response reflection tracking
Application: • Use for all S-parameter measurements.   • 12-term error-correction

Type: **Full TRL 2-Port**
Only on PNA Models E8356A, E8357A, E8358A, E8362A, E8363A, E8364A
Calibration Method: Unguided Calibration
General Accuracy: Very High
Parameters: All
Standards Required: THRU, REFLECT, LINE
Systematic Errors Corrected: • Directivity   • Source match   • Isolation   • Load match   • Frequency response transmission tracking   • Frequency response reflection tracking
Application: • Use for all S-parameter measurements.   • 12-term error-correction

- Highest accuracy of all calibrations

For more information, see TRL Cal

To perform a TRL calibration with a connector type other than 3.5 mm or 7 mm, you must first modify or create TRL standards and definitions. For more information on modifying standards, see Calibration Standards.

Type: **Full SOLT 3-Port**	
Only on PNA Models N3381A, N3382A, N3383A	
General Accuracy: High	
Calibration Method: Guided, ECal	
Parameters: All	
Standards Required: (SHORT, OPEN, LOAD, THRU) or ECal module	
Systematic Errors Corrected: • Directivity • Source match • Isolation • Load match • Frequency response transmission tracking • Frequency response reflection tracking	
Application: • Use for all S-parameter measurements. • 27-term error-correction	

Calibration Wizard

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The Calibration Wizard allows you to choose a Calibration method.

- Starting Calibration Wizard
- Guided Calibration: Mechanical Standards
- Guided Calibration: ECal
- Unguided Calibration
- Saving a Calibration

Other Cal Topics...

How to start Calibration Wizard
Use one of the following methods: •   •

-
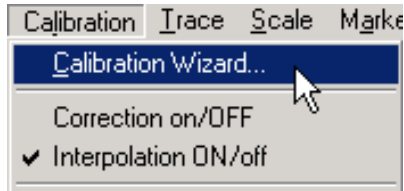
Learn more about using the front panel interface

Notes:

- Calibration Wizard uses Cal Sets to store stimulus settings and calibration data. After a calibration is performed, you can copy the Cal Set to other channels. See Using Cal Sets.

- The quality of the calibration depends on the quality of the standards and connections. See Connector Care.

- Avoid expensive repairs to your PNA and devices. Read Electrostatic Discharge Protection.
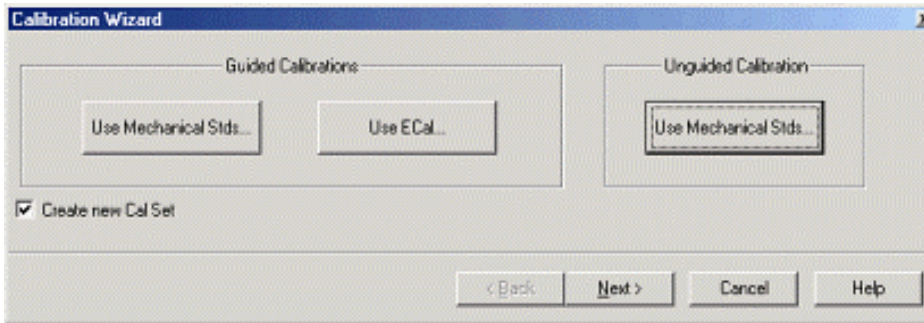
Calibration Wizard dialog box help
Allows you to select the calibration method:

Guided Calibrations

Use Mechanical Stds. This method provides:

- 1-port Refl., Full 2-port and 3-port calibrations
- Highest accuracy
- Step-by-step "wizard" interface
- Automatic adapter removal calibration
- Use of multiple calibration kits

Note: To perform a Full 1-Port cal, select 'Not Used' for the unused DUT connector.

See Guided Calibration-Mechanical Standards

Use ECal This method provides:

- Fast calibrations
- 1-port Refl., Full 2-port and 3-port calibration
- Software controlled operation

See Using ECal

Unguided Calibrations

Use Mechanical Stds. This method provides:

- All calibration types (except Full 3-port)
- TRL Cal (available with E835xA and E836xA series network analyzers).
- Familiar calibration interface

See Unguided Calibration

Create new Cal Set

Check to create a new Cal Set for the calibration to be performed.
 Clear to write the new calibration data over an existing Cal Set. Click **Next** to invoke the **Select Cal Set** dialog box
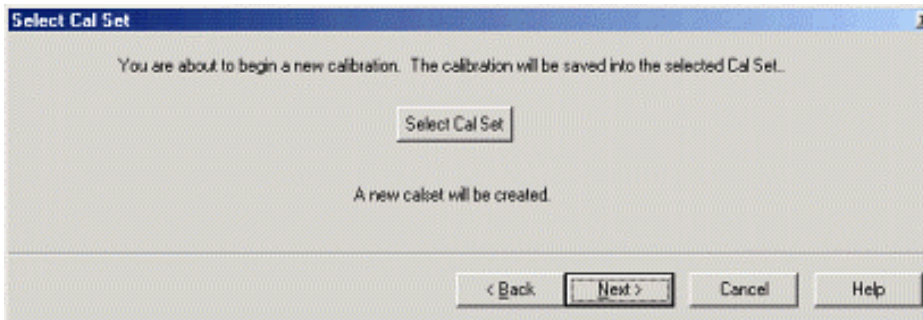
Select Cal Set dialog box help
Allows you to select a stored Cal Set to overwrite.
Select Cal Set   Click to select a Cal Set to overwrite. Invokes the **Select A Cal Set** dialog box.
Note: If you do NOT click **Select a Cal Set**, the current active Cal Set (which is displayed below the button) will be overwritten. If there is no active Cal Set, a new calset will be created (also displayed).

Guided Calibration   Mechanical Standards

Guided calibration offers 1-PORT Reflection, FULL 2-PORT and 3-PORT calibration types. The "wizard" interface, depending on the DUT type, automatically determines the calibration type and calibration kit required.

Note: To perform a Full 1-Port cal, select 'Not Used' for the unused DUT connector.

The PNA displays the following dialog boxes when performing a Guided calibration:

- Selecting DUT Connectors
- Select Version 2 Cal Kit
- View/Modify Calibration Standard Selection
- Guided Calibration Steps
- Using ECal
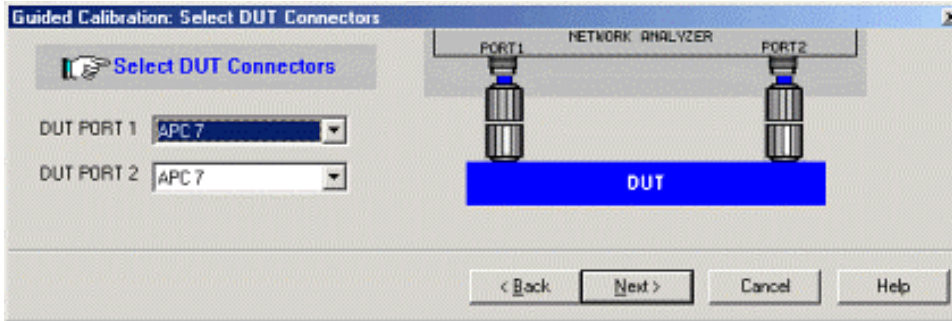
Select DUT Connectors dialog box help
Allows you to select the connector type of each port on the device under test (DUT).
DUT PORT 1 Identifies the DUT connector type connected to port 1.
DUT PORT 2 Identifies the DUT connector type connected to port 2.
DUT PORT 3 Identifies the DUT connector type connected to port 3 (on a three-port PNA).
Next The Select Version 2 Cal Kits dialog box opens.
Notes:
To perform a Full 1-Port cal, select 'Not Used' for the unused DUT connector.

If your DUT connectors are:
 	
   • **Waveguide** change the system impedance to 1 ohm before performing a calibration. See Setting System Impedance.
 	
   • **Not listed** (male and female) select **Type A** as the connector type. Type A requires a calibration kit file containing the electrical properties of the standards used for calibration (see Version 2 Calibration kits).
 	
   • **Unspecified** (like a packaged device) select **Type B** as the connector type. Type B requires a calibration kit file containing the electrical properties of the standards used for calibration (see Version 2 Calibration kits).
Non-insertable Guided Cal will automatically perform an Adapter Removal calibration. This requires that you have an adapter that has the same connectors as the DUT.
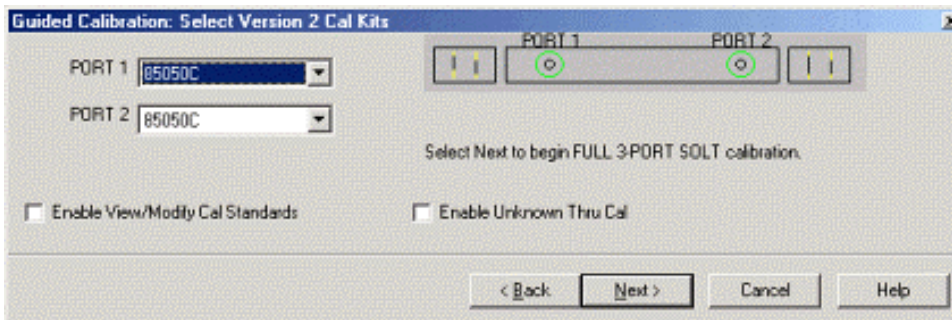
Select Version 2 Cal Kits dialog box help
Allows you to select the calibration kit used with each measurement port. The list for each PORT displays kits having the same connector type as the DUT.
PORT 1 Lists the calibration kits available with port 1.
PORT 2 Lists the calibration kits available with port 2.

PORT 3 Lists the calibration kits available with port 3 (on a three-port PNA).

Enable View/Modify Cal Standards Allows you to choose a THRU standard from a calibration kit file containing multiple THRU standards. Check to choose the THRU standard required for the calibration.

Enable Unknown Thru Cal. When measuring a DUT having connectors, you need to use a thru standard instead of a zero-length thru. This results in degraded transmission tracking error terms. The Unknown thru setting requires an additional step, the measurement of the thru standard, but improves the transmission tracking error term.

Check to enable Unknown thru Cal

- There must be fewer than four windows open when selecting **Unknown Thru**. The fourth Window is used by the calibration process.

The Unknown Thru Cal setting is available with E835xA and E836xA series network analyzers.
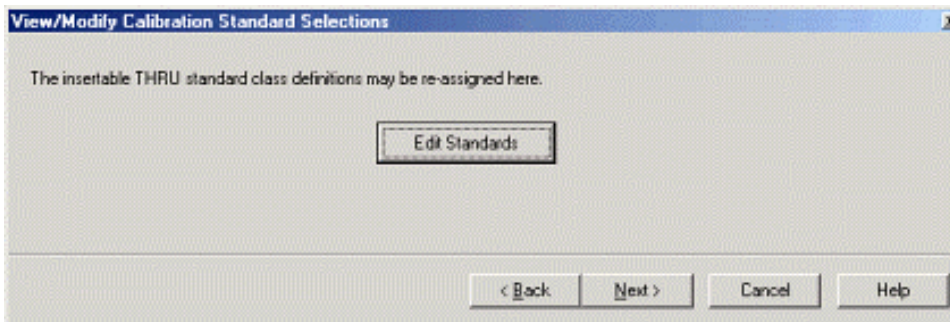
View/Modify Calibration Standard Selection dialog box help

When the setting is selected, you choose a THRU standard from a calibration kit file containing multiple THRU standards. (The setting is available with E835xA and E836xA series network analyzers.)

   Edit Standards Click to open the **Modify Calibration Class Assignments** dialog box. Select the desired standard for the THRU connection.
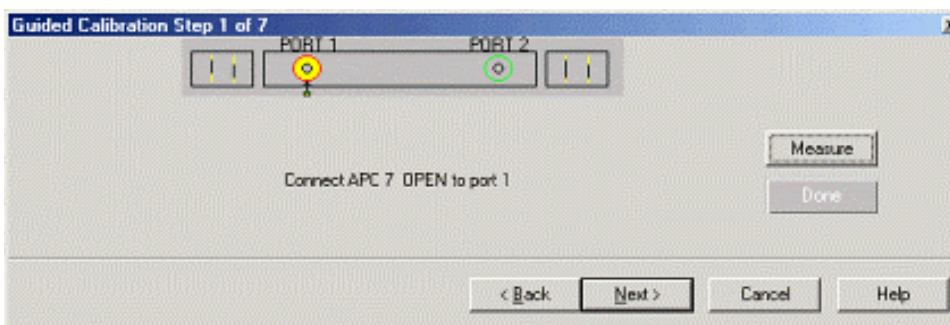
Guided Calibration Steps dialog box help

Provides instructions for the connections and measurements required for calibration.

   Measure Click to measure the standard.

   Done Click **after** a standard is re-measured and all measurements for the calibration are complete.

> **Next** Click to continue to the next calibration step. Does **NOT** measure the standard.

Unguided Calibration

Unguided calibration offers all calibration types (except Full 3-Port and ECal). The types available depend on the parameter selected for the active channel and the PNA model.

The PNA displays the following dialog boxes when performing an Unguided calibration:

- Select Calibration Type for Mechanical Standards
- Measure Mechanical Standards
- Select Version 1 Cal Kit
- Multiple Standards
- Sliding Load Measurement
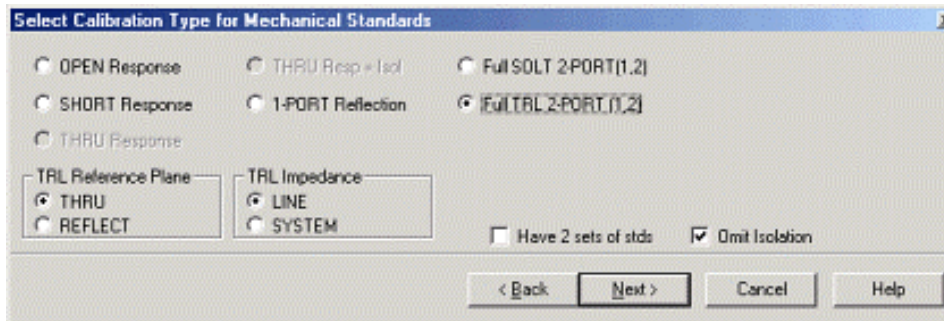
> **Select Calibration Type for Mechanical Standards** dialog box help
>
> Allows you to select the calibration type and settings. **Response** calibration types require a reflection or transmission parameter selected for the active channel (as indicated).
>
> **OPEN Response** (reflection)
>
> **SHORT Response** (reflection)
>
> **THRU Response** (transmission)
>
> **THRU Resp + Isol** (transmission)
>
> **Full SOLT 2-PORT (1,2)** The numbers in parenthesis represent the port pair used in the calibration.
>
> **Full TRL 2-PORT (1,2)** TRL calibration is available with E835xA and E836xA series network analyzers.
>
> **TRL Reference Plane (when TRL is selected)**
>
> **THRU** The THRU standard is used to establish the position of the measurement reference plane. Select if the THRU standard is zero-length or very short.
>
> **REFLECT** The REFLECT standard is used to establish the position of the measurement reference plane. Select if the THRU standard is not appropriate AND the delay of the REFLECT standard is well defined.
>
> **TRL Impedance (when TRL is selected)**
>
> **LINE** The impedance of the line standard is used as the reference impedance, or center of the Smith Chart. Any reflection from the line standard is assumed to be part of the directivity error.

SYSTEM The system impedance is used as the reference impedance. Choose when the desired test port impedance differs from the impedance of the LINE standard.

Have 2 sets of standards Check to use two sets of calibration standards, reducing the number of measurements. Clear to use one set of standards.

Omit Isolation Check to NOT correct for crosstalk (isolation). Use when your measurement does not require high dynamic range. Clear to calibrate and correct for isloation . Use when your measurement requires maximum dynamic range (> 90 dB).

See also Isolation Portion of 2-Port Calibration.

Next Click to continue to Measure Mechanical Standards dialog box.

Notes:

- If the DUT connector type is waveguide or an impedance other than 50 ohms, then change the system impedance before performing a calibration. See Setting System Impedance.

Full SOLT 3-PORT calibration type links to Guided calibration (on a three-port PNA).
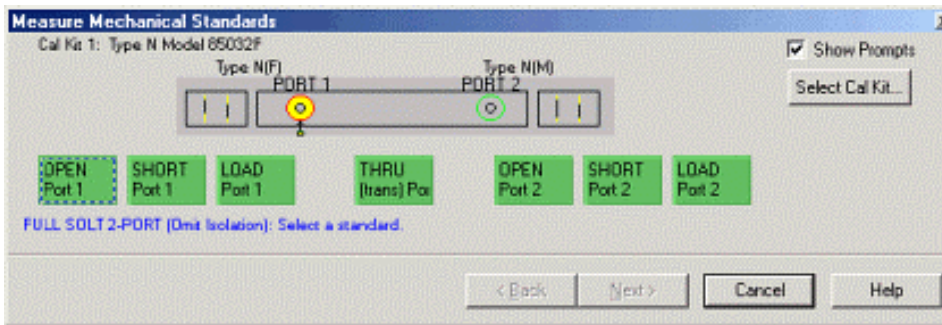
Measure Mechanical Standards dialog box help

Displays the calibration kit file and standards required for the calibration.

- Connect the standard to the measurement port and click the green button associated with it. A check mark indicates the standard has been measured. (Standards may be connected and measured in any order.)

- If a standard type contains multiple standards, a dialog box opens to display the multiple standards included in the calibration kit file.

- If a sliding load is included in the calibration kit file, a dialog box opens to perform the measurement with the standard.

Show Prompts Check to provide a reminder for the required connection when you click on the standard.

Select Cal Kit Click to select from a list of ten calibration kit files (Version 1).
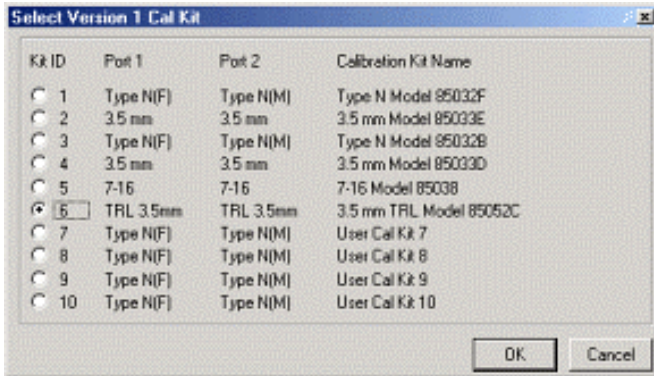
Select Version 1 Cal Kit dialog box help

Displays the calibration kit files available for Unguided calibration.

- Select the desired calibration kit file and click **OK**.

To substitute other calibration kits not included in Kit ID 1-10, see Cal Kit Manager.
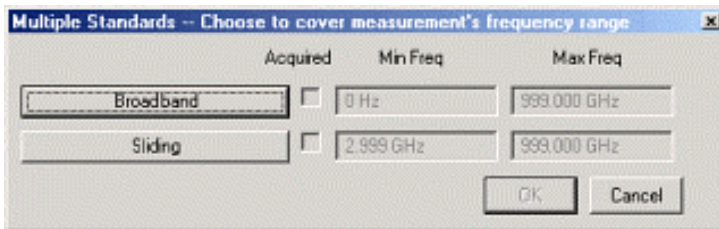
Multiple Standards dialog box help

Displays the multiple standards available to measure.

- Connect the standard to the measurement port and click the button associated with it. A check mark in the **Acquired** box indicates the standard has been measured.

- Carefully arrange the order in which the standards are measured. The last standard measured will override the others in respect to the frequency range of the standard definition.

Example: In the case of measuring both a broadband load and a sliding load, you would measure the sliding load last (in order to include its measurement with the calibration). This is because the frequency range of the sliding load is a subset of the broadband load.

To modify the class assignments for Version 1 calibration kits, see Calibration Standards.
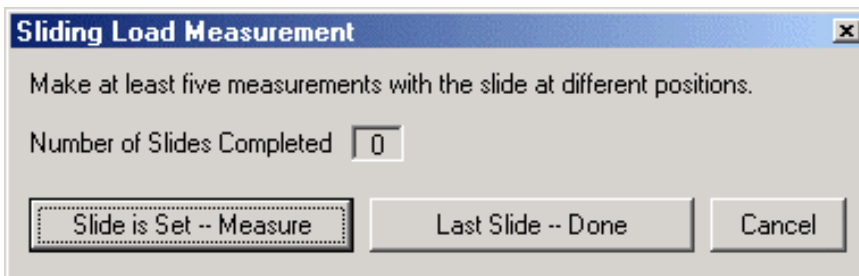
Sliding Load Measurement dialog box help

Allows you to measure the sliding load standard.

To Measure a Sliding Load:

1. Click **Sliding** from the list of standards.

2. Connect sliding load to the measurement port.

3. Position the sliding element, then click **Slide is Set -- Measure**. Do not move the sliding element until measurement is complete.

4. Measure the sliding load for at least five positions. Eight or more positions will provide better accuracy.

Note: The positions of the sliding element should be unequally spaced to reduce the possibility of overlapping data points.

5. **Click Last Slide -- Done** for final measurement.

6. Remove sliding load from the measurement port.

Measure remaining standards.

Saving a Calibration

The PNA displays the following dialog boxes at the completion of a calibration. You can save the Cal Set data only or the Cal Set data and all instrument settings for the active channel.

- Standards Measured
- Calibration Completed
- Save Instrument State
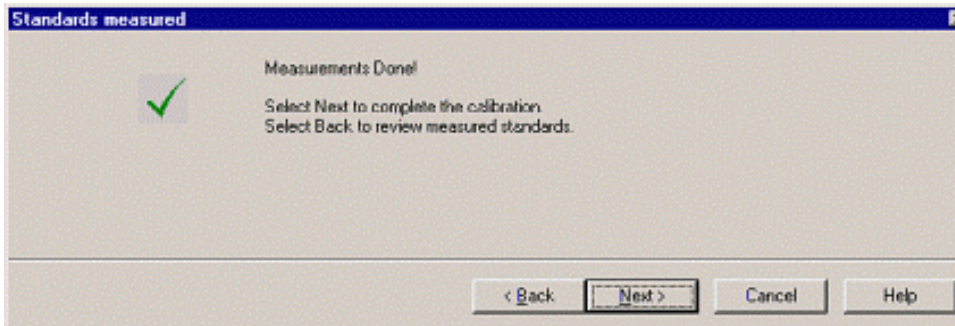
Standards Measured dialog box help

All standards required for Guided calibration have been measured.

Back Click to re-measure a calibration standard.

Cancel Exits Calibration Wizard.

Next Click to continue.
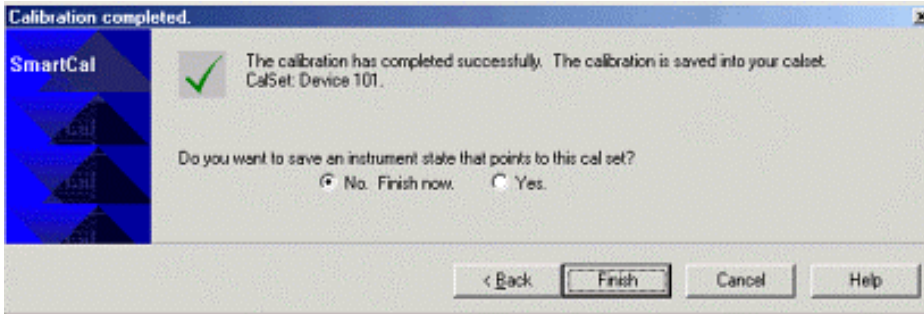
Calibration Completed dialog box help
Allows you to finish the calibration or continue to **Save** options.
No. Finish now. Completes calibration.
Yes Allows selection of Save options.
Finish Performs the following:
• Saves Cal Set to memory
• Turns correction **ON**
• Exits Calibration Wizard
Note: You can apply Cal Set data to other channels. See Using Cal Sets.
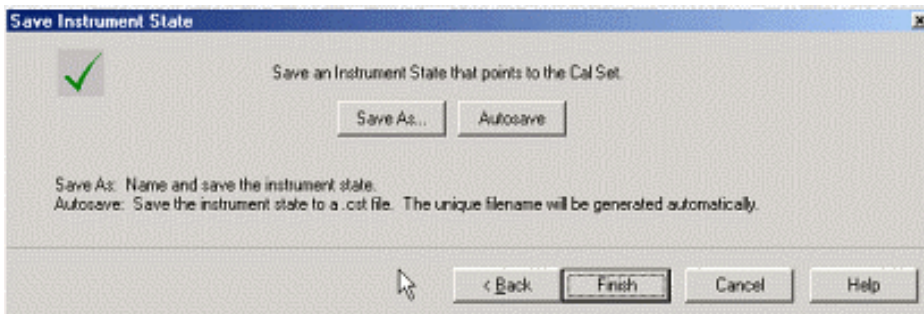
Save Instrument State dialog box help
Allows you to save calibration data and instrument state settings to the following locations:
• Internal Hard Disk
• Floppy Disk
• External CD-RW Drive, PC or Server-Using a Mapped Network Drive
Save As Saves calibration and instrument settings (using **.cst** file type). You determine the name of the file and location to store it.
Autosave Automatically saves instrument settings and Cal Set to the current location and assigns a new file name in the **.cst** file type. A message temporarily appears on the display showing the path and new filename. The error terms are automatically stored as Cal Sets in the analyzer's memory.
Back Click to view previous dialog box.
Cancel Exits Calibration Wizard.
Notes:

- You can recall the instrument settings and calibration data from memory or recall just the Cal Set. See Using Cal Sets.

For more information about saving and recalling data, see Save and Recall.

Using Calibration Sets

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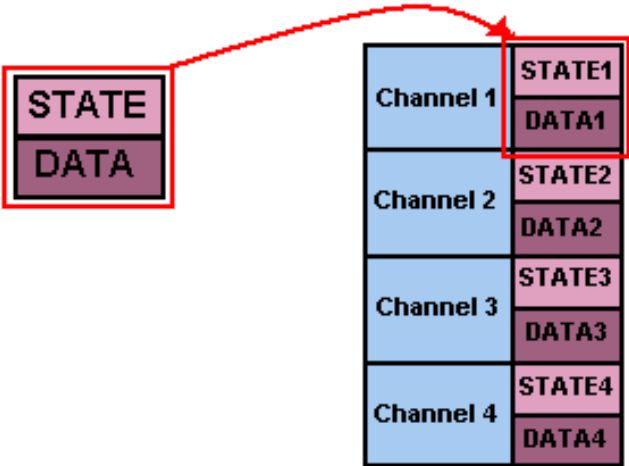
Calibration Sets (Cal Sets) enable you to use a single calibration on multiple channels.

- PNA Calibration Data, past and present
- Creating a Cal Set
- Managing Cal sets
- Applying Cal Sets
- Examples of Cal Set Usage
- Archiving Cal Sets using .cal files

See other Calibration Topics

PNA Calibration Data, past and present

Past

One .cst File	Analyzer set up
- Instrument **State** and Cal **Data** were stored and recalled in **.sta** and **.cal** files (**.cst** files are both). - Cal data was tied to the channel it came from - Cal data could not be shared between Channels. Limited ability to apply different **calibration types** on the same channel.	

Present with Cal Sets

One Cal Set	Cal Set file
STATE CAL TYPE / PORT / DATA	CalSet 1 CalSet 2 CalSet3 CalSet 4 . . CalSet 99 CalSet 100

- Cal Data and Instrument Data are separated in two files, .cst for State and PNACalSets.dat for data.
- Cal Data has been expanded to allow storage of multiple Cal Types.

Cal data is available for use by any channel.
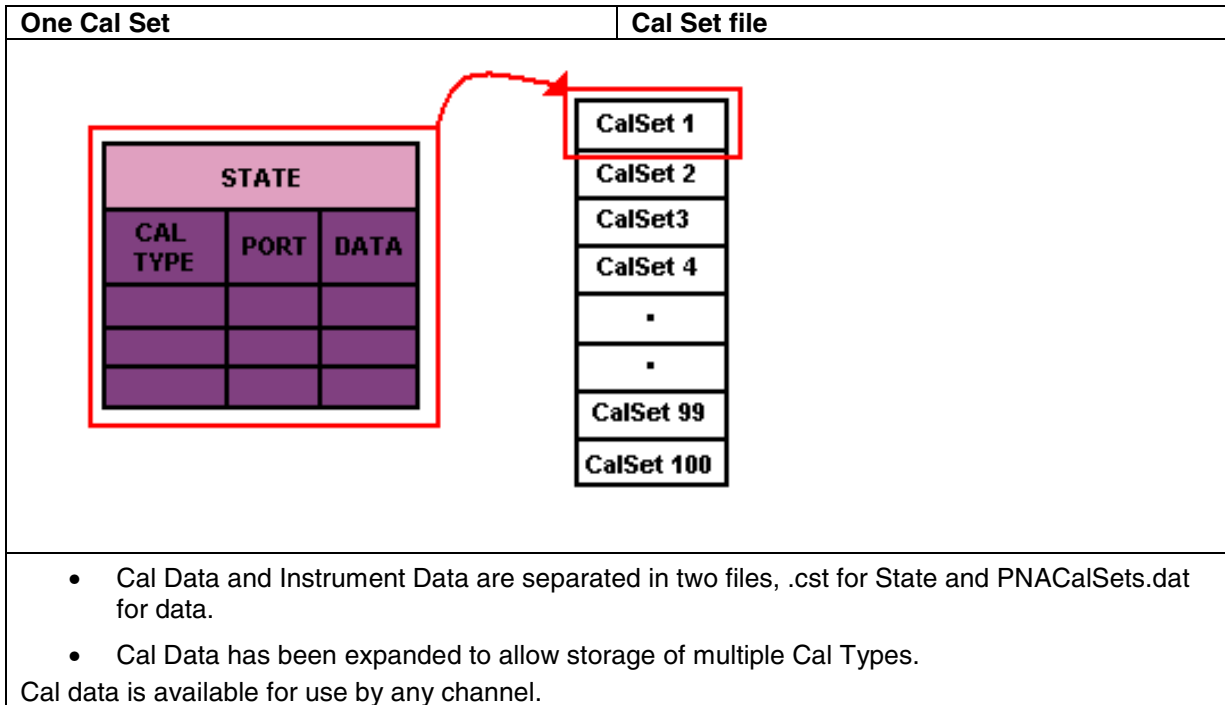
Each Cal Set contains the following items:

1. GUID Global Unique IDentifier
2. Cal Set description
3. Cal Set Attributes
4. Standards data
5. Error term data
6. Interpolated Error term data

Creating a Cal Set

Create Cal Sets in the following ways:

1. From the Calibration Wizard for both guided and non-guided methods.
2. From COM programming using the Calibrator::SetCalInfo method.
3. From COM programming using the CalManager::CreateCalSet method.
4. From SCPI programming using the SYST:CORR:WIZARD to start the Cal Wizard.

Once the Cal Set has been created, it can be applied to a measurement and then managed.

Managing Cal Sets

Cal Sets are managed through the Select A Cal Set dialog box.

Access the dialog box by Clicking **Calibration** then click **Cal Set...**
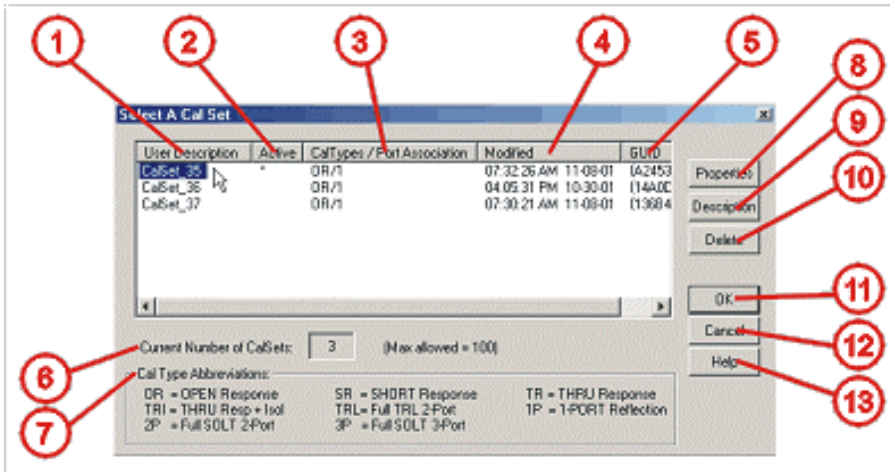
Select a Cal Set dialog box help

Lists available Cal Sets, their properties, and associated Cal Types.

1. **User Description** User name to identify the Cal Set. This can be edited by clicking the **Description** button. Click heading to view Cal Sets that have a similar name.

2. **Active** Status of the Cal Set: * indicates Active or "in use". Click heading to know which Cal Sets will be archived in .cal file.

3. **CalTypes / Port Association** Type of Cal and port number of the Cal Set. Click heading to know which Cal Sets have the Cal Types for your Measurement.

4. **Modified** Date and time the Cal Set was last modified. Click heading to view the oldest and latest modified Cal Sets.

5. **GUID** Unique identifier for each Cal Set. Click heading to sort the Cal Sets in numerical order.

6. **Current Number of CalSets** Number of listed Cal Sets. If the number reaches 100, the oldest Cal Set will be written over by the newest Cal Set.

7. **Cal Type Abbreviations** Description of the Calibration Type.

8. **Properties** Invokes the Calibration Properties window.

9. **Description** Edit the Cal Set User Description.

10. **Delete** Permanently deletes the Cal Set after choosing Yes to a "Are you sure?" prompt.

11. **OK** Select and apply a Cal Set to the Active measurement.

12. **Cancel** Exit the dialog box without selecting a Cal Set.

Help Invokes this section of Help

Applying Cal Sets:

The following procedure shows how to apply a Cal Set to a single measurement. To apply a Cal Set to multiple measurements, repeat this same procedure for all of the measurements.

Note: The measurement(s) can be on any channel.

1. Create the measurement: (for a detailed understanding, see Set Up Measurements)

2. Select a Cal Set

a. Click **Calibration** then click **Cal Set...**

b. Select the Cal Set to apply to the measurement.

c. Click **OK**.

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d. The analyzer compares the selected Cal Set with the Measurement. If their Attributes are the same, the Cal Set is selected. If the Cal Set and Measurement Attributes are different, a choice must be made.

3. Select a Cal Type

   1. Click **Calibration** then click **Cal Type...**

   2. Select the Cal Type

   3. Click **OK**.

Error term correction is now applied to the measurement as shown in the status bar.

Differences between Cal Set and Measurement Attributes

The Cal Set is created during a calibration and it is associated with at least one Cal Type. The Cal Set contains attributes recorded at the time of the calibration. These attributes will probably be different than those of the measurement to which the Cal Set is being applied. If there is a difference, the Measurement Attributes may have to be changed for the Cal Set to be applied.

If the frequency span of the **Cal Set is equal to or greater than the measurement.**

Frequency Range
Cal Set |---------------|
Measurement |--------|
Then choose
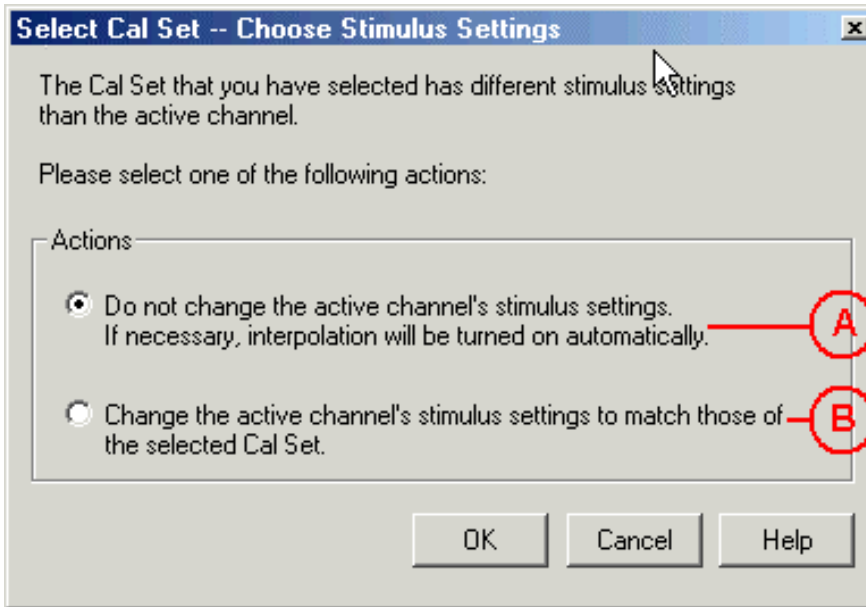
either:

A The calibration will be interpolated

B The measurement will change to equal the Cal Set

For Cal Sets to be applied correctly, Interpolation must be turned on
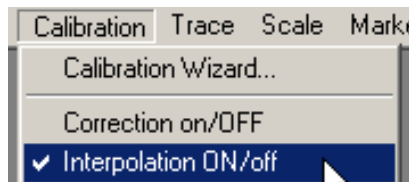
If the frequency span of the **Cal Set is less than the measurement.**

Frequency Range

Cal Set |--------|
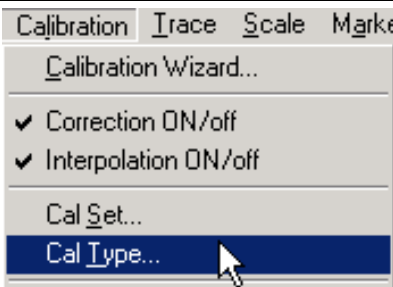
Measurement |-------------

Then choose either:
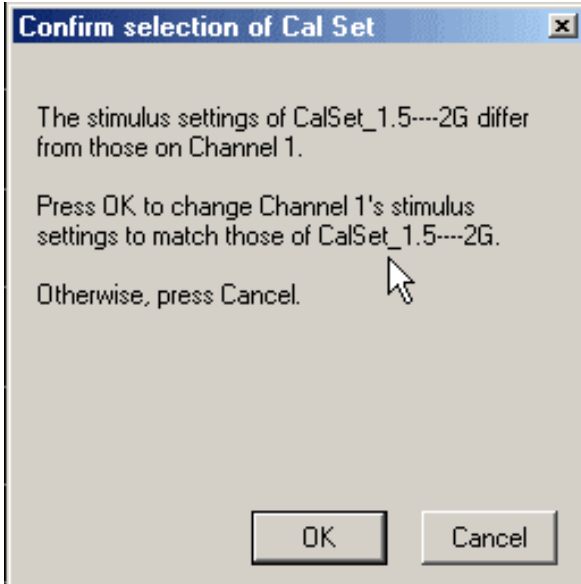
OK Reduce the measurement frequency span

Cancel Cal Set will NOT be applied

How to Select a Calibration Type
Learn more about using the front panel interface

The Select Calibration Type dialog box opens.
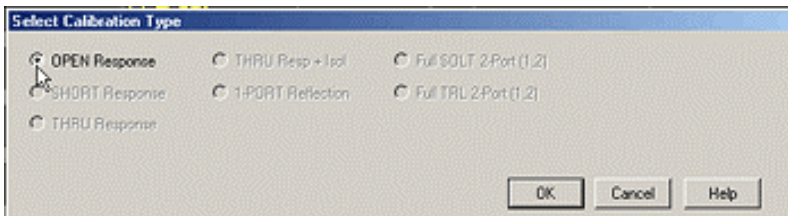
Select Calibration Type dialog box help
Lists the available calibration types associated with the Cal Set.

1. Click an available Cal Type.

Click **OK** to select or **Cancel** to close the dialog box.

Examples of Cal Set Usage

The following examples show how Cal Sets increase flexibility and speed in making analyzer measurements.

- Using one Cal Set with many Measurements
- Using one Measurement with many Cal Sets

Using one Cal Set with many Measurements

It is common to do one calibration, then to use it to set up several Measurements, all using the same calibration data.

An example:

During a manufacturing process, you may have many calibrated S-parameter Measurements. You may wish to continuously cycle through the Measurements and examine them individually. Occasionally, you may wish to refresh the calibration without having to recreate all the Measurement state files.

Here is how: First do some planning. After examining the stimulus settings for the group of S-parameter Measurements, the Cal Set stimulus range is designed to be a super-set of the whole group. Each measurement can then use the same Cal Set.

Note: Make sure that interpolation is turned on. The individual S-parameter Measurements will have stimulus settings that will be a sub set of the Cal Set. Interpolation Error Corrected values will be calculated for these measurements.

Notice in the following image, Cal Set 78 is used on more than one Channel, in this case Channels 5 and 16 .
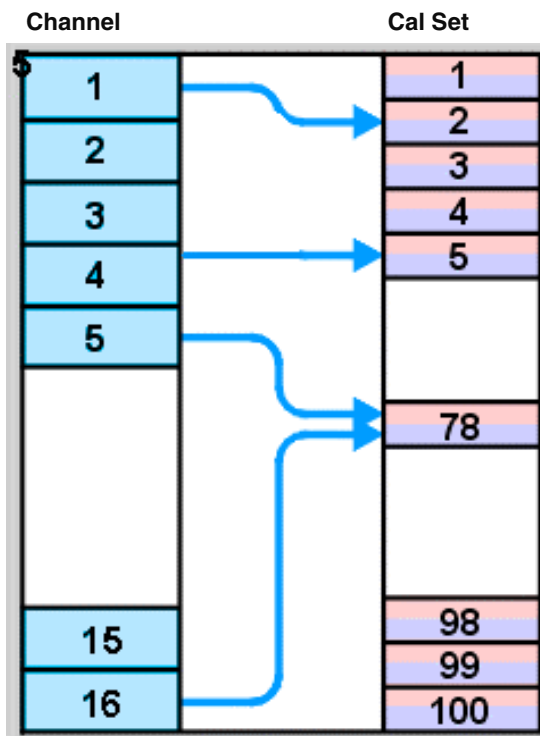
Using one Measurement with many Cal Sets

The drawback with having one very large Cal Set associated with many instrument states could be a loss of measurement speed. In such cases, consider using one Measurement with many Cal Sets. The stimulus conditions can then be changed for a measurement by applying different Cal Sets. Other settings (window setups, measurement definitions, scaling, limits, markers) will not change. This may result in faster state changes than if you saved and recalled *.cst files for each set of stimulus conditions

Example #1: An amplifier needs to be measured at several input power levels. Calibrate at several power levels and save each calibration in a separate Cal Set. Then, apply the Cal Sets to the single measurement consecutively.

Example #2: Making an S21 Measurement, you need to measure both wide span and narrow span characteristics of the device. One Cal Set covers the wide span setup, another the narrow span setup.

Example #3, Multi-port measurements: A 6-port device is being measured. It has one input port and 5 output ports. Measure S21 from the input to each output under identical measurement conditions (stimulus, markers, limits, etc). Create a Cal Set for each Port selection and recall them one at a time.

Archiving Cal Sets using .cal files in addition to Cal Sets

This feature provides some calibration data **security**, especially for people who must **share instruments**.

Example:

One person performs a calibration, names and saves it as a Cal Set. This Cal Set is available for any other person to use. A second user could accidentally delete or modify the Cal Set requiring the originator to repeat the calibration.

Security can be provided for calibration data by saving the Cal Set to a **.cal** file. At a later time, the .cal file could be recalled and the original calibration restored.

The .cal file

In the past the .cal file only saved calibration data.

Now, the .cal file saves Cal Sets, one or more Cal Set can be saved in a single .cal file (see saving a .cal file). The .cal file acts as an archive for Cal Sets. The Cal Sets that get saved are the ones that are currently in use by the active channels on the analyzer.

Using ECal

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This topic discusses all aspects of ECAL:

- ECal Overview
- Connect ECal Module to the PNA
- Perform a Calibration
- Validate a Calibration With ECal Module
- Use Advanced Settings
- Characterize an ECal Module

ECal Overview

Each ECal module contains electronic standards that are automatically switched into position during a PNA measurement calibration. These electronic standards have been measured at the factory and the data stored within the memory of the ECal module. The PNA uses this stored data, along with the PNA-measured data, to calculate the error terms for a measurement calibration.

ECal modules are available in 2-port and 4-port models and a variety of connector types, covering many frequency ranges. See Analyzer Accessories for more about available ECal modules and ordering information.

You can perform the following calibrations with ECal:

- 1-Port Reflection

- Full 2-Port

- Full 3-Port

Care and Handling of ECal Modules

You can improve accuracy, repeatability, and avoid costly repair of equipment in the following ways.

- Practice proper connector care. See Connector Care.

- Protect equipment against ESD damage. Read Electrostatic Discharge Protection.

- Do not apply excess power to ports. Refer to specifications in the literature provided with your ECal module.

Connect ECal Module USB to PNA USB

ECal modules are controlled and powered through a USB connection to the analyzer. When you connect the module, the PNA automatically recognizes the type of module, frequency range, and connector type.

ECal modules connect to the USB port on the front or rear panel of the PNA with the USB cable supplied with the module.

1. Wear a grounded wrist strap when making connections.

2. Connect the USB cable **Type B** connector to the ECal module and the USB cable **Type A** connector to the front or rear panel USB connector of the analyzer, as shown in the following graphics.

   ECal Module USB Port   **Analyzer Front Panel USB Port**

USB Type B

USB Type A
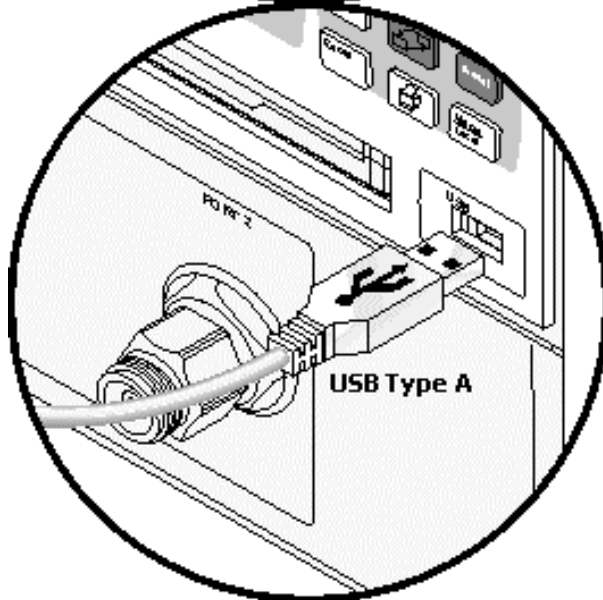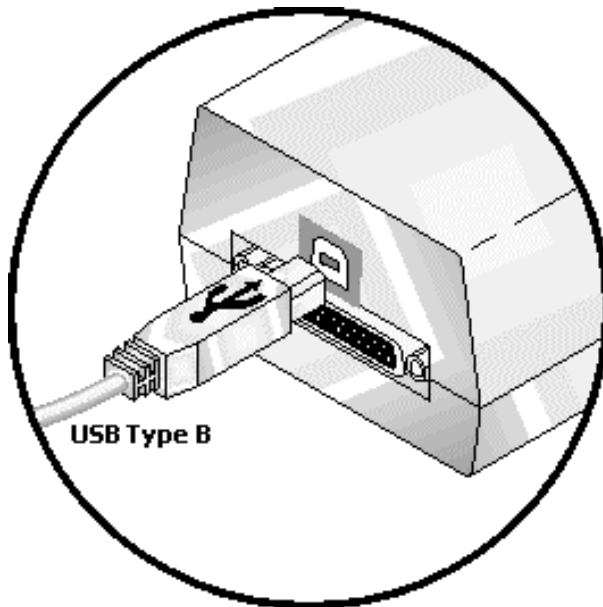
Notes:

- Unused ECal modules that have completed a calibration may remain connected to the USB port.

- You can connect and disconnect the ECal module while the analyzer is operating. However, DO NOT connect or disconnect the module while data transfer is in progress. This can result in damage or at least corrupted data.

- A USB hub may be used to connect more than one USB device to the analyzer. See Analyzer Accessories for more information about USB peripheral equipment.

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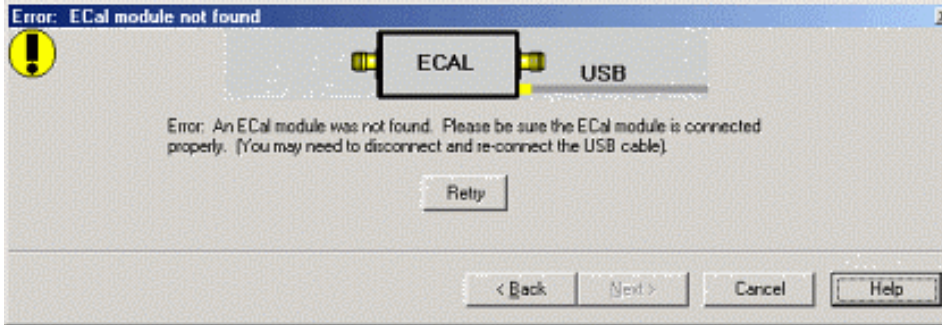
ECal module not found dialog box help
Displays an error message indicating the ECal module is not connected or has not been recognized by the network analyzer. **Retry** Check the USB connections and click to continue. **Notes:** When the ECal module is connected to the network analyzer for the first time, it may take approximately 30 seconds for the analyzer to recognize the module and make it available for calibration. For best accuracy, allow the ECal module to warm-up completely before use. See Connect ECal Module USB to PNA USB.

Perform a Calibration Using ECal

The following graphics show the typical connections for 1-port, 2-port, and 3-port calibrations and measurements.

Select an ECal module that has connectors of the same type and gender as the DUT. If such an ECal module is not available, a module with connectors different from the DUT can be used by using Advanced Settings or User Characterization.

3-Port
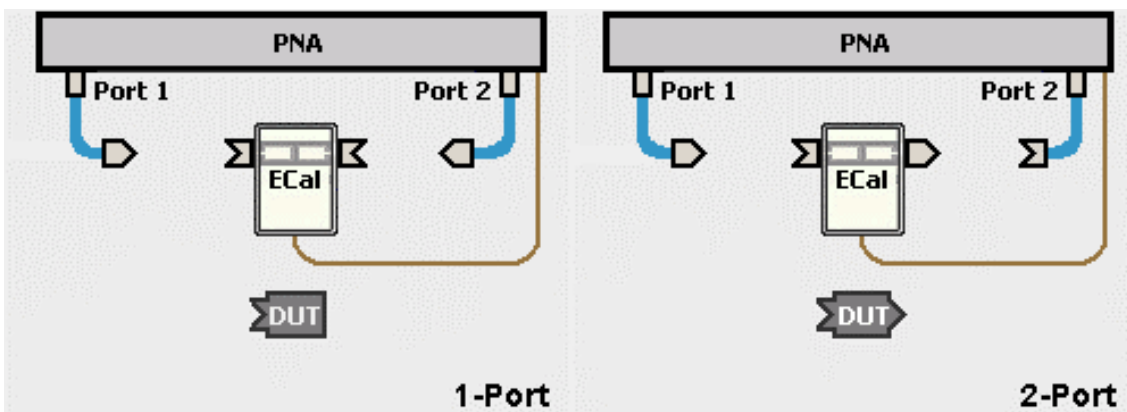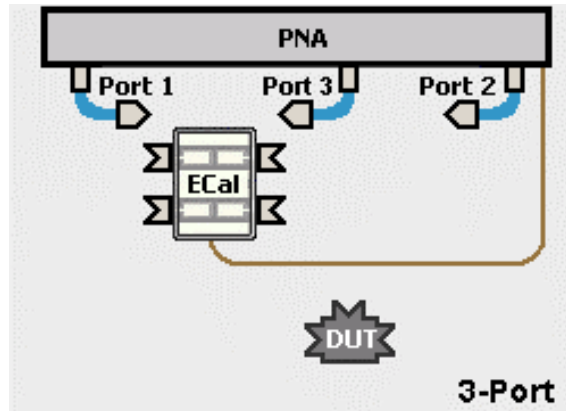
How to Perform a Calibration Using ECal:

1. Connect the ECal module USB cable to the analyzer USB. See Connect ECal Module USB to PNA USB.

2. Allow the module to warm up until it indicates **READY**.

3. Enter the analyzer settings. See Set Up Measurements.

4. Start the Calibration Wizard as follows:
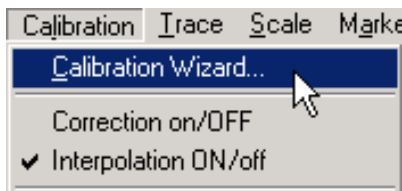
5. In the **Calibration Wizard** dialog box, click **Use ECal**.
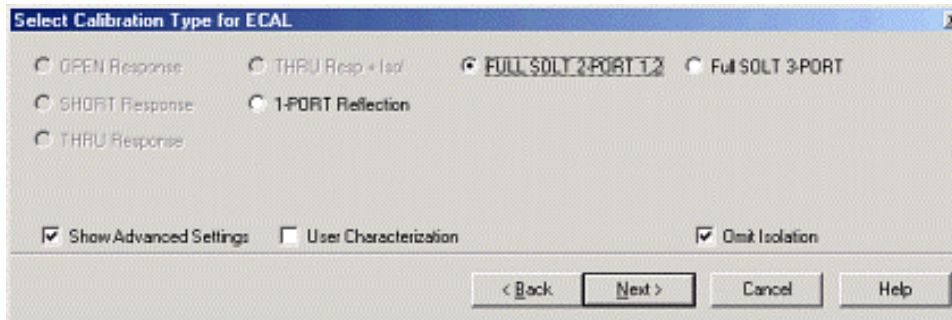
Select Calibration Type for ECal dialog box help
Allows you to select calibration type and settings.
1-PORT Reflection Click to select a 1-Port reflection calibration. Advanced Settings and Isolation are not available with 1-Port Reflection.
Full SOLT 2-PORT Click to select a Full 2-Port calibration.
Full SOLT 3-PORT Click to select a Full 3-Port calibration.
Show Advanced Settings Check to display the Advanced Settings for the calibration type selected.
User Characterization Check to select the User Characterization data instead of the factory characterization data (available when a user characterization is stored in the ECal module).
Omit Isolation Check to omit the isolation measurement when performing a Full 2-port or Full 3-port

calibration. Clear to perform isolation measurement.

Note: If the frequency range of the active channel is greater than that of the ECal module, the analyzer will display an error message.

- Change the frequency range of the active channel.

- Re-characterize the module with the frequency range desired.

Use the factory-characterization for the ECal module.
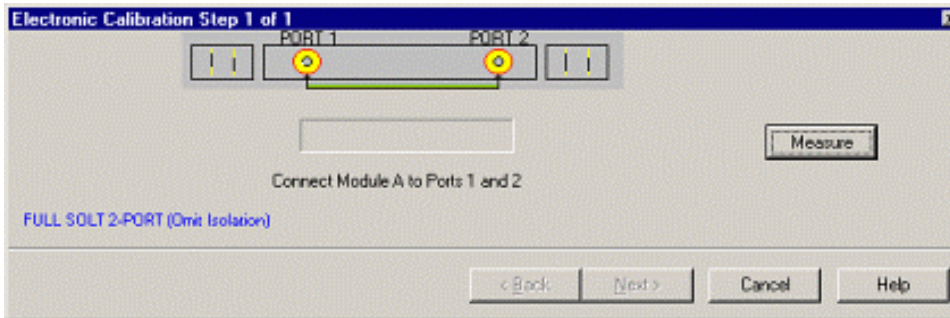
Electronic Calibration Steps dialog box help
Displays the instructions for each measurement required for calibration.
Measure Measures the ECal standards.
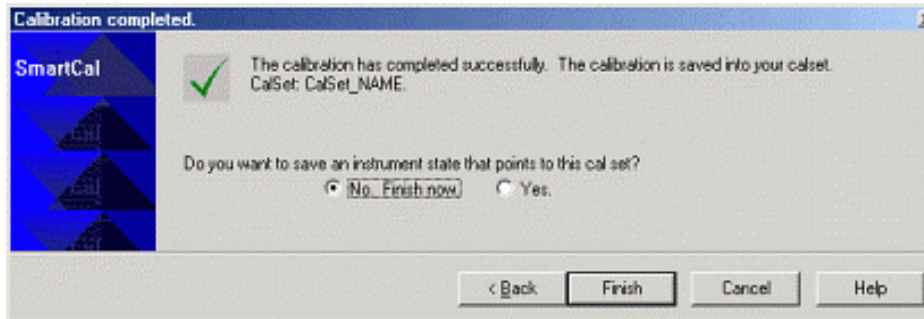
Calibration Completed dialog box help
Allows you to finish the calibration or continue to **Save** options.
No. Finish now. Completes calibration.
Yes Allows selection of Save options.
Finish Performs the following:
• Saves Cal Set to memory
• Turns correction **ON**
Exits Calibration Wizard
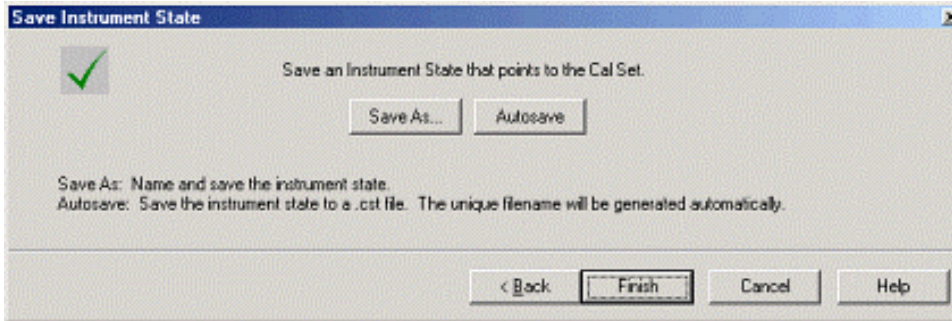
Save Instrument State dialog box help
Save As Saves calibration and instrument settings (using **.cst** file type). You determine the name of the file and location to store it.
Autosave Saves instrument settings and Cal Set data to the current location and automatically assigns a new file name of the .cst file type. A message temporarily appears on the display showing the path and new filename.
• Learn more about Using Cal Sets.
Learn more about saving and recalling files.
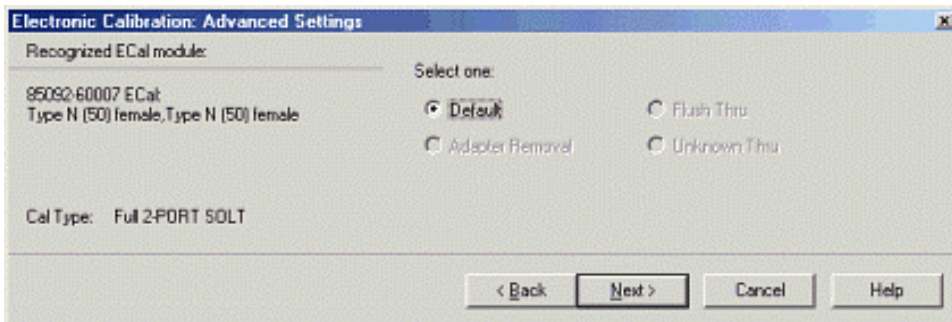
Advanced Settings dialog box help
Advanced Settings are enhancements that may be applied to a Full 2-Port or Full 3-Port calibration. Some settings are limited by the PNA model or ECal module connectors.
Recognized ECal module Displays the model number and connector type of the modules connected to the PNA.
Default Does not apply Advanced Settings to the calibration type selected.
Adapter Removal Use adapter removal setting with a Full 2-Port or Full 3-Port calibration to perform a calibration for a non-insertable device, using an insertable module and adapter. This setting characterizes and removes the effects of the adapter connected to the module. The adapter must be reversible, and for best accuracy should be instrument grade or better. This setting requires an ECal module having insertable connectors.
Flush Thru The THRU state of the ECal module has more loss than a zero-length thru, resulting in degraded transmission tracking error terms. This setting requires an ECal module having insertable connectors.
The Flush Thru setting adds the following additional step to the ECal process:
• The ECal module is removed and the two reference planes are connected directly together (zero-length thru).
Unknown Thru The Unknown Thru setting serves the same purpose as the Flush Thru setting

except for ECal modules having connectors.

The Unknown Thru setting adds the following additional step to the ECal process:

- The ECal module is removed and a thru adapter is connected between the measurement ports. The characteristics of this "unknown thru" are measured and its effects mathematically removed, to improve transmission tracking performance.

The Unknown Thru setting is available only on E835xA and E836xA series network analyzers.
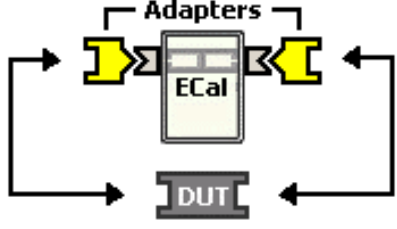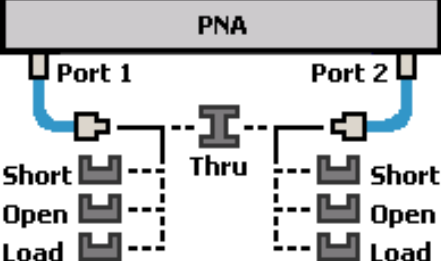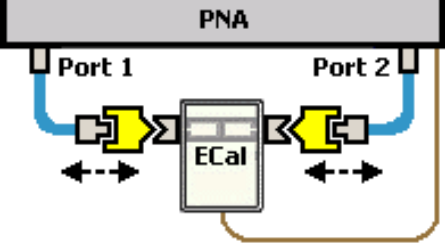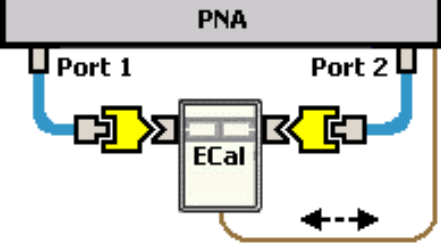
User Characterization

A user characterized ECal allows you to add adapters to the ECal module, re-measure the ECal standards INCLUDING the adapters, then add that data to ECal memory. This extends the reference plane from the module's test ports to the adapters. This makes it unnecessary to do the added steps of an adapter removal cal when performing an ECal.

User Characterization does not delete the factory characterization data. The factory data is saved in the ECal module in addition to the user characterization data; either may be selected when performing a calibration.

User characterization may be performed with either a 2-port or a 4-port ECal module.

The following graphics describe the general steps needed to perform a User Characterization. The Calibration Wizard guides you through each of the steps:

1. Select adapters for the module to match the connector configuration of the DUT.	2. Perform a Guided calibration using mechanical standards or recall a Cal Set.
3. Measure the ECal module and adapters as though it were a DUT.	4. Store User Characterization data into the module. Factory characterization data is not changed.

How to Perform a User Characterization:

1. Connect ECal module to the network analyzer with the USB cable. See Connect ECal Module USB to PNA USB.

2. Allow the module to warm up until it indicates **READY**.

3. **Preset** the analyzer.

4. Set up the measurement.

Note: For best accuracy, the **IF bandwidth** should be set to **1 kHz** or less.

5. Start characterization:
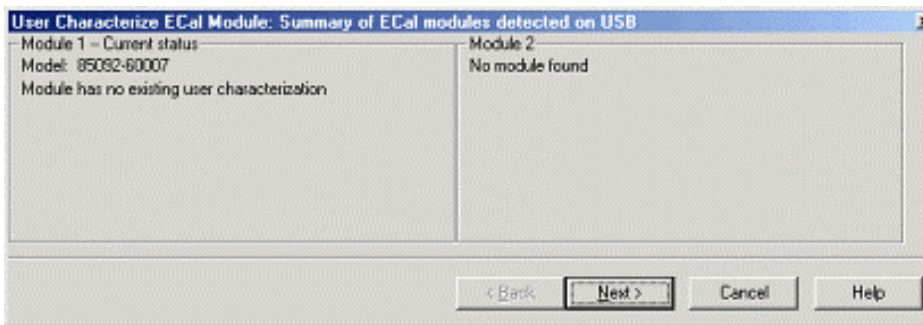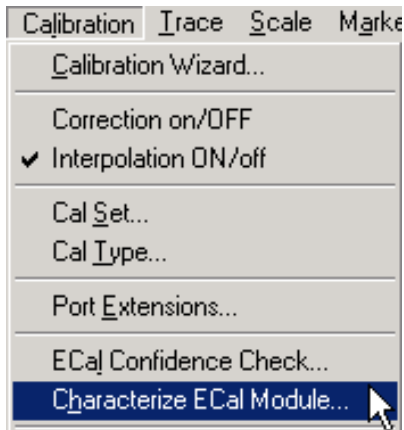
Summary of ECal modules detected on USB dialog box help

Verify the status of ECal modules connected to the PNA.
 	
   Module 1, Module 2 Displays the following information:
 	
•   ECal module model number
 	
•   summary from previous user characterization (if performed)
 	
   Next Click to continue to the Select Connectors for the Characterization dialog box.
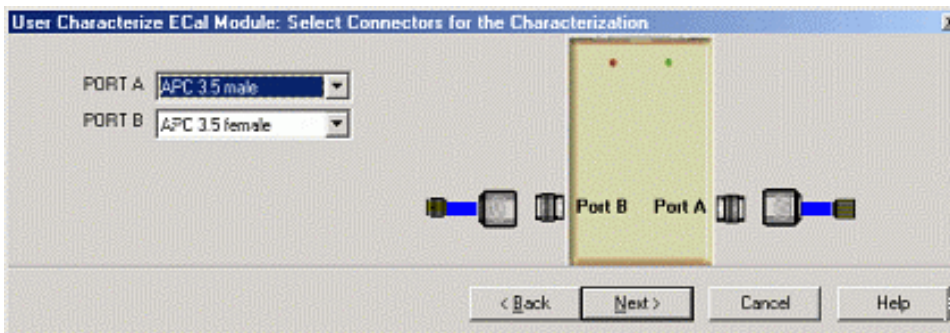
Select Connectors for the Characterization dialog box help
Allows you to select the adapters for the ECal module test ports. Select **NONE** if no adapter is used

on a port.

    PORT A Lists the connector types available for Port A.

    PORT B Lists the connector types available for Port B.

    PORT C Lists the connector types available for Port C (available with a 4-port ECal module).

    PORT D Lists the connector types available for Port D (available with a 4-port ECal module).

Next Click to continue to the Calibrations to perform or recall dialog box.
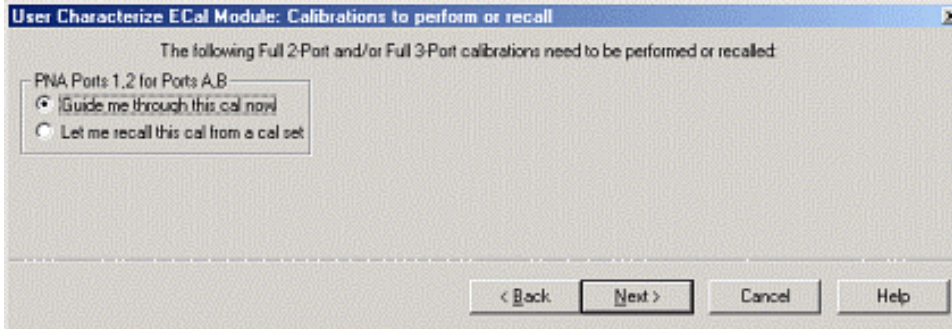
Calibrations to perform or recall dialog box help

Displays the number and types of mechanical calibrations required for the characterization.

    Guide me through this cal now Click to perform a Guided calibration for the connector types selected. A calibration kit is required for each connector type.

    Let me recall this cal from a cal set Click to select a Cal Set from a previous calibration for the connector types Learn more about Using Cal Sets.

    Next Click to continue to either the Select Version 2 Cal Kits or the Select Cal Set dialog box.

Select Version 2 Cal Kits dialog box help

Provides a list of calibration kits to perform the calibration. Select the cal kit you will use for each port.

    Enable Unknown Thru for characterizing the module Check to enable. This reduces the number of steps required to characterize the THRU standard. (Use this setting when performing a calibration for non-insertable devices.)

Note: This setting is available with E835xA and E836xA series network analyzers.

    Next Click to continue to the Select Cal Set dialog box.
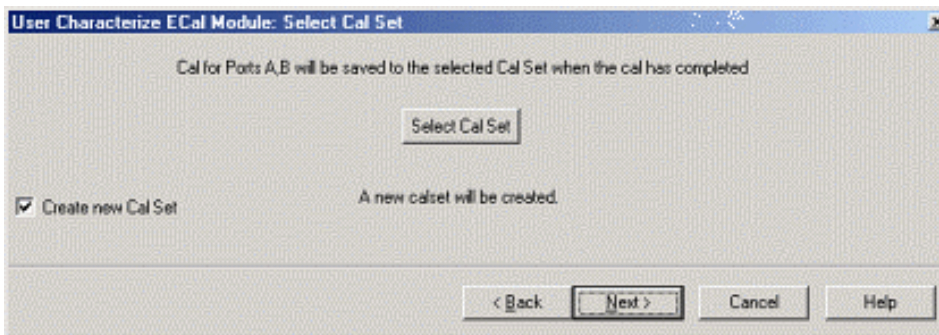
Select Cal Set dialog box help

Allows you to select a stored Cal Set to perform a calibration for the connector type selected.

Select Cal Set Click to open the **Select A Cal Set** dialog box.

Create new Cal Set Check to create a new Cal Set for the calibration. Clear to select a stored Cal Set from a previous calibration.

Next Click to continue to the Guided Calibration Steps dialog box.

Note: A Guided calibration may require many steps to perform. Make a note of the Cal Set file name for future reference.
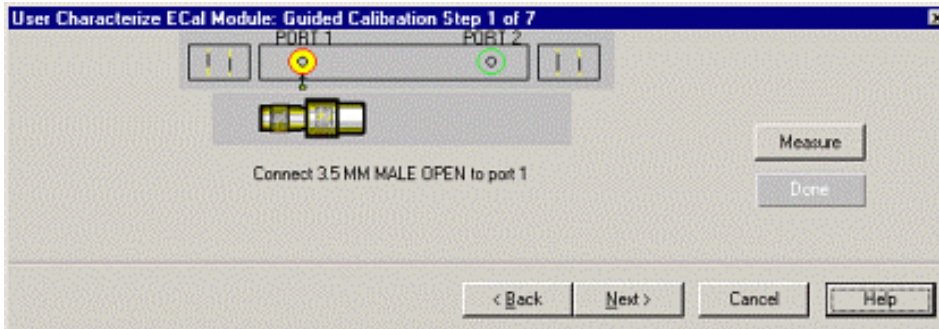
Guided Calibration Steps dialog box help

Instructs you to connect each calibration standard to the measurement port.

Measure Click to measure the standard.

Back Click to repeat one or more calibration steps.

Done Click **after** a standard is re-measured and all measurements for the calibration are complete.

Next Click to continue to the next calibration step. (Does **not** measure the standard.)

Cancel Exits Calibration Wizard.

The Standards measured dialog box opens when the steps are completed.
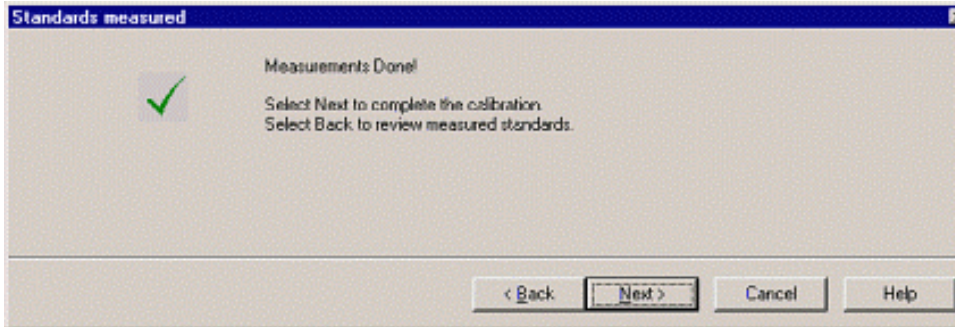
Standards measured dialog box help
Indicates that all standards required for the calibration have been measured.

   Back Click to re-measure a calibration standard.

   Next Click to continue to either the Specify nominal delay or the Guided Calibration Completed dialog box.
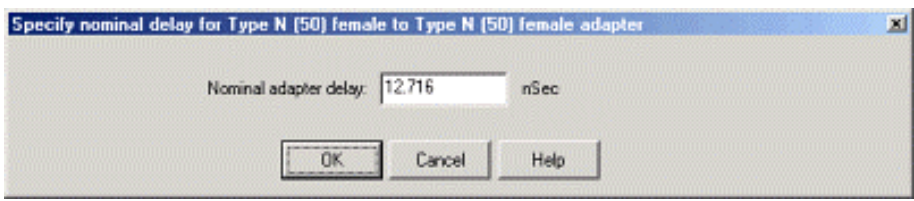
Specify nominal delay dialog box help
An estimate of the nominal delay is required.

OK Click to accept adapter delay.

For CW sweep or frequency sweeps with large frequency steps, overwrite the estimate and then click OK.

Compute delay by calculating the physical length of the adapter divided by the propagation velocity.

Delay = Length / Propagation Velocity
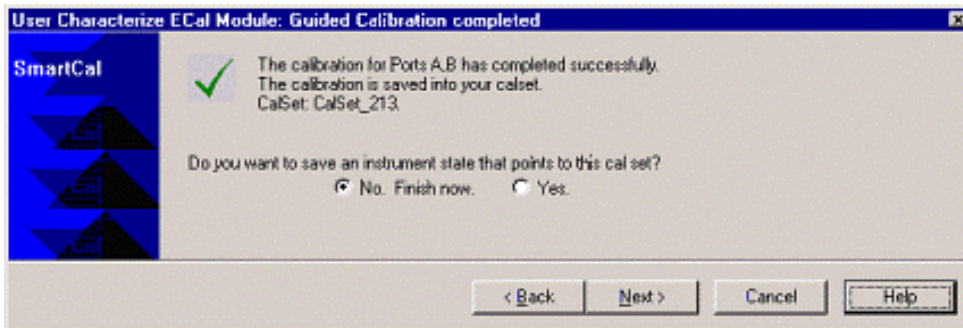
Guided Calibration completed dialog box help
Allows you to finish the calibration and continue to the next characterization steps.

No. Finish now Select to save Cal Set data.

Yes Allows selection of Save options.

Next Click to continue to the Exit to Inspect Quality of Calibration dialog box.
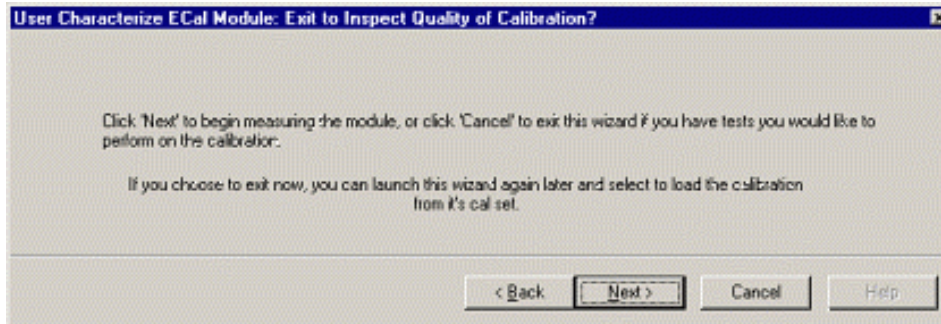
Exit to Inspect Quality of Calibration dialog box help
Allows you to exit User Characterization to validate the calibration before proceeding with the characterization.
Back Allows you to repeat calibration.
Next Click to continue to the Characterization Steps dialog box.
Note: If you click Cancel to verify the calibration, you will exit User Characterization. To return to the current step:
1.   Start User Characterization.
2.   In the **Summary** dialog box, click **Next**.
3.   In the **Select Connectors for Characterization** dialog box, click **Next**. (Previous entry is stored in memory.)
In the **Calibrations to perform or recall** dialog box, select the Cal Set from the calibration just performed.
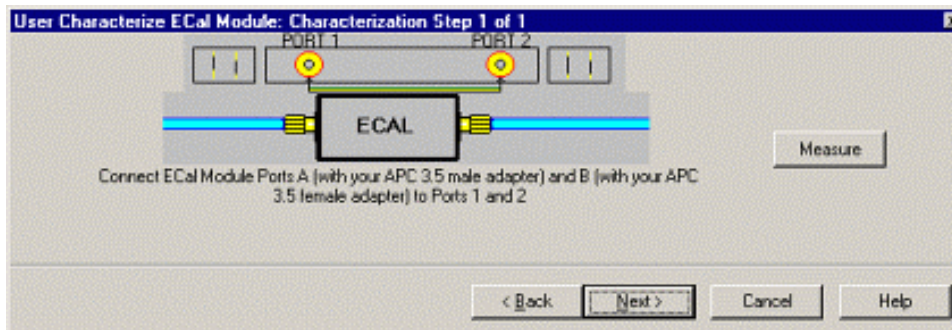
Characterization Steps dialog box help
Describes the instructions for each measurement required for characterization.
Measure Measures the ECal module.
Next Click to continue to the Information for the New Characterization dialog box when

measurements are complete.

Information for the New Characterization dialog box help
Allows you to describe the properties of the User Characterization.
The following table lists the maximum number of characters allowed in each field.
Description of Field
Your name or company name:
Description of this network analyzer (to be stored in module):
Description of Port A extension (adapter, cable, fixture, etc.):
Description of Port B extension (adapter, cable, fixture, etc.):
Next Click to continue to the Write Characterized Data to the ECal module dialog box.

To minimize the number of characters, use the following 3-character codes to describe the connectors listed.

Connector Type	3-Character Code
2.4 mm female	24F
2.4 mm male	24M
3.5 mm female	35F
3.5 mm male	35M
7-16 female	16F
7-16 male	16M
Type F female	F7F
Type F male	F7M
N50 female	NF5F
N50 male	N5M
N75 female	N7F
N75 male	N7M
APC 7	7MM
K-band waveguide	KBW
P-band waveguide	PBW
Q-band waveguide	QBW
R-band waveguide	RBW
U-band waveguide	UBW
V-band waveguide	VBW
W-band waveguide	WBW
X-band waveguide	XBW
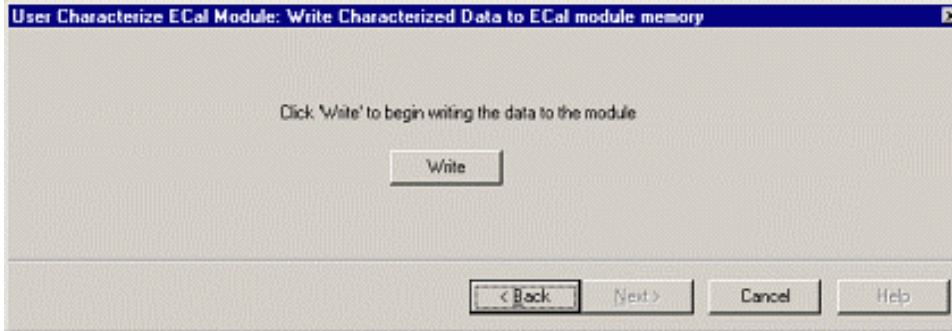
| **Write Characterized Data to the ECal module memory** dialog box help |
|---|
| The PNA writes User Characterization data to the ECal module memory. |
| **Write** Click to write data into the ECal module. |
| The Updated Summary of ECal modules detected on USB dialog box opens after data is saved to module. |
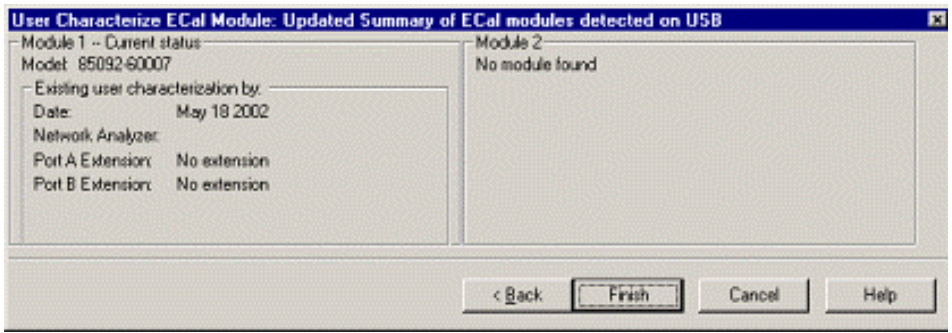
Updated Summary of ECal modules detected on USB dialog box help
Verify the status of ECal modules connected to the PNA.
Module 1, Module 2 Displays the following:
•   ECal module model number
•   summary from user characterization
Cancel Click to exit (characterization complete).
Finish Click to exit (characterization complete).

Accurate Measurement Calibrations

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Calibration accuracy is affected by the type of calibration, quality of the calibration standards, and the care with which the calibration is performed. This section provides additional information about how to make accurate calibrations.

- Measurement Reference Plane
- Effects of Using Wrong Calibration Standards

- Accuracy Level of Interpolated Measurement
- Effects of Power Level
- Setting System Impedance
- Using Port Extensions
- Measuring Non-insertable Devices
- Swap-Equal-Adapters Method
- Adapter Removal Calibration
- Isolation Portion of 2-Port Calibration

See other Calibration Topics

Measurement Reference Plane

Most measurement setups will NOT allow you to connect a device under test directly to the analyzer's front panel test ports. More likely, you would connect your device to test fixtures or cables that are connected to the analyzer.

For the highest measurement accuracy, you should calibrate at the points where you connect your device. This is called the measurement reference plane (see graphic). If you calibrate at these points, the errors associated with the test setup (cables, test fixtures, and adapters used between the analyzer ports and the reference plane) are measured and removed in the calibration process.
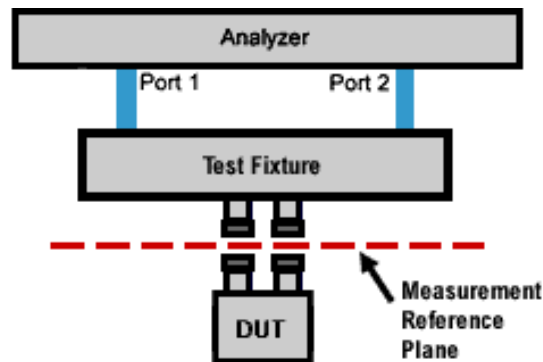
Effects of Using Wrong Calibration Standards

Normally, a calibration is performed using a calibration kit that contains standards with connectors of the same type and sex as your device under test.

However, your calibration kit may not have the same connector type as your device. For example, your device has 3.5mm connectors and you have a Type-N calibration kit. So, you use an adapter to connect the Type-N standards to the 3.5mm test port.

Because the adapter is part of the calibration and NOT part of the test setup, this will result in significant errors in your reflection measurements.

Inaccuracies can also result if you use calibration standards other than those specified during the calibration process. The amount of inaccuracy depends on how much the standard you use differs from the one specified.

Accuracy Level of Interpolated Measurement

Because the current instrument settings do not exactly match those under which the calibration was performed, the accuracy of the measurements cannot be predicted. The measurement accuracy may be affected significantly or not at all. Identifying measurement errors in these cases must be determined on a case-by-case basis.

You can determine how accurate your interpolated measurement is by validating the calibration. See Validating a Calibration.
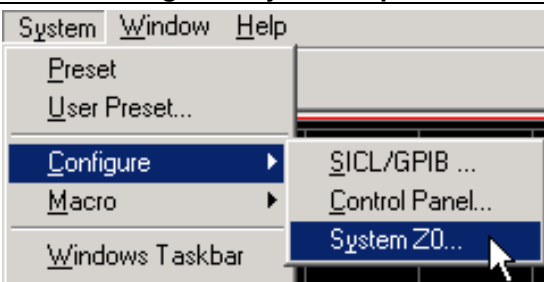
Effects of Power Level

Most accurate error correction applies only for the power level at which a measurement calibration was performed. However, when changing power within the same attenuator range at which the measurement calibration was performed, S-parameter measurements can be made with only a small degradation of accuracy. If a different attenuator range is selected, the accuracy of error correction is further degraded.

To check the accuracy of a calibration, see Validity of a Calibration.

Setting System Impedance

The system impedance can be changed for making waveguide measurements or devices with an impedance other than 50 ohms.

How to change the System Impedance
Learn more about using the front panel interface
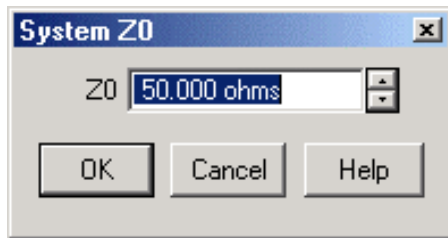
System Z0 dialog box help
Allows you to change the system impedance (default setting is 50 ohms). **Z0** Displays the current system impedance. **For 75 ohm devices:** 1. Change the system Z0 to 75 ohms. 2. Connect minimum loss pads (75 ohm impedance) between the analyzer and the DUT. 3. Perform a calibration with 75 ohm calibration standards. **For waveguide devices:**

1. Change the system Z0 to 1 ohm.

Perform a calibration with the appropriate waveguide standards.

Using Port Extensions

Use the port extensions feature after calibration to compensate for phase shift of an extended measurement reference plane due to additions such as cables, adapters, or fixtures.

Port extensions is the simplest method to compensate for phase shift between the calibration reference plane and the DUT. Applying port extensions does not, however, compensate for the mismatch and loss of the path between the reference plane and the DUT. For this reason, you should minimize the loss and mismatch caused by a test fixture to achieve best measurement accuracy.

To learn how to apply port extensions, see Port Extensions.

To learn about characterizing a test fixture, see Fixturing Macro.

Measuring Non-insertable Devices

A "non-insertable" device means that the measurement ports cannot be connected together to establish the Thru connection during calibration. The following section provides information about the following:

- Non-insertable Device Calibration
- Uncharacterized Thru Adapter
- Characterized Thru Adapter

Note: Guided Calibration automatically applies an adapter removal calibration for non-insertable devices.

Non-insertable Device Calibration

An example of an **insertable** device is shown below. The device has two Type-N connectors, one port male and the other port female.
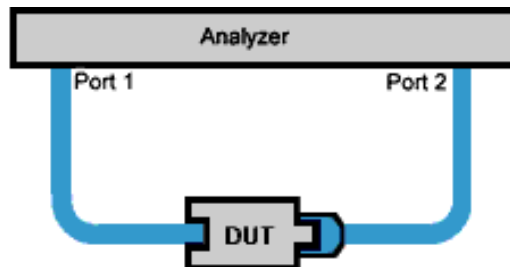
When calibrating for an insertable device, the test ports at your measurement reference plane connect directly together. This is called a zero-length thru. That means the definition, or electrical description the analyzer uses in the calibration process, has zero-length, no delay, no loss, no capacitance, and no inductance.

Your calibration kit may not have a thru standard because it is assumed you have an insertable device.

If your device is **non-insertable**, the test ports at your measurement reference plane cannot connect directly together, as shown in the graphic below. So, you must use an adapter for the thru connection. This adapter is not included in the measurement, and therefore reduces measurement accuracy.
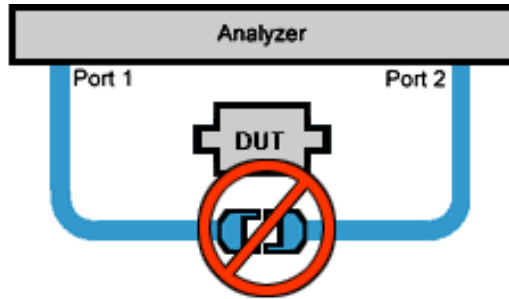
If you have a non-insertable device you must choose one of the following methods when making a thru connection during calibration. The methods are listed in order of ascending accuracy (least accurate first).

Uncharacterized Thru Adapter
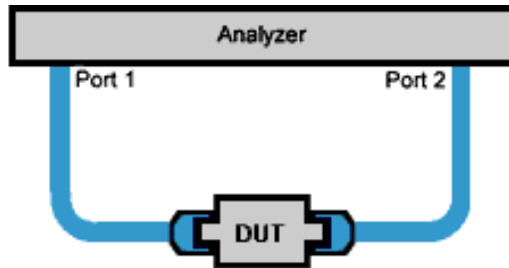
This is the easiest but least accurate method of calibrating for a non-insertable device. "Uncharacterized" means that the thru adapter's electrical delay and loss are not recorded in the analyzer.

Although the adapter is used to calibrate the through path, the loss and delay are not removed from subsequent measurements because they are unknown.

Characterized Thru Adapter

A characterized thru adapter means the electrical delay and loss of the thru adapter are specified in the calibration kit definition in the analyzer.

The manufacturer of the adapter may supply you with the electrical delay and loss of the male-male or female-female adapter. If not, you can measure the electrical delay and loss. However, you will need an accurate calibration to measure the thru adapter, which is itself a non-insertable device.

Note: An alternate calibration method which automatically characterizes the thru connector and removes its effect in the test system is available with Guided Calibration. See Adapter Removal Calibration.

To characterize a thru adapter:

1. Perform a Full SOLT 2-Port calibration using the Swap Equal Adapters method. This method is selected because the test device (thru adapter) is a non-insertable device.

2. Measure the delay of the thru adapter at approximately mid-span of your frequency range setting. Record the measurement value.

3. Measure the insertion loss of the thru adapter at approximately mid-span of your

frequency range setting. Record the measurement value.

4. Use these values to modify the calibration kit definition of the thru adapter. To do so, modify the standard definitions for the calibration kit in Advanced Modify Cal Kit. See Modify Calibration Kits.

5. Perform a calibration using the modified calibration kit, now containing the characterized thru adapter.

Note: You will only use the characterized thru adapter to perform the thru path calibration; not during the testing of your devices. This preserves the life of your characterized thru adapter. (As you will see in the Swap Equal Adapters method, one of the characterized adapters is used to test every device.)

Swap-Equal-Adapters Method

- The swap-equal-adapters calibration method is very useful for devices with the same connector type and sex (for example, female SMA on both ends.)

- It requires the use of two precision matched adapters that are equal in performance but have connectors of different sexes.

  - For example, for measuring a device with female SMA connectors on both ends using APC-7 mm test cables, the adapters could be 7-mm-to-male-3.5-mm and 7-mm-to-female-3.5-mm.

- To assure that the adapters are equal, many of Agilent's calibration kits include adapters that have the following identical characteristics:

  - Characteristic impedance
  - Insertion loss
  - Electrical delay
  - Match

Overview of the Swap-Equal-Adapters Calibration

1. The transmission portion of a two-port calibration is performed with the adapter needed to make the through connection.

2. This adapter is then removed and the second adapter is used in its place during the reflection portion of the calibration, which is performed on both test ports.

3. Swapping the adapters changes the sex of one of the test ports so that the test device can be inserted and measured (with the second adapter still in place) after the calibration procedure is finished.

4. The errors remaining after calibration are equal to the difference between the two adapters.

To perform the Swap Equal-Adapters Calibration:

1. In the Cal Wizard, select Unguided calibration method.

2. Select a Full SOLT 2-Port calibration.

3. In the **Measure Mechanical Standards** dialog box, do the following:

   a. Connect adapter A between Port 1 and Port 2, as shown in the graphic below.
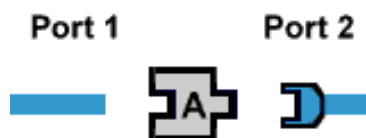
b. Select Thru in the Measure Mechanical Standards dialog box of the Cal Wizard.

c. Remove adapter A between Port 1 and Port 2.

d. Connect adapter B (the one with connectors of different sexes than your device) to the appropriate port (in this example, Port 1). This becomes part of your measurement setup. See the graphic below.

e. Select Open, Short, and Load in the Measure Mechanical Standards dialog box of the Cal Wizard.

f. Connect the selected standard for Port 1 to adapter B when prompted.

g. Connect the selected standard for Port 2 to the end of the cable connected to Port 2 when prompted.

h. Measure your device with adapter B in place, as shown in the graphic below.

Note: Adapter B used in the calibration is part of your measurement setup. That is, you connect test devices directly to it, causing wear on one of your precision matched adapters. As an alternative, use the Swap Equal Adapters method to characterize a thru adapter.

Adapter Removal Calibration

Adapter removal calibration provides the most accurate way to measure non-insertable devices. However, it requires additional calibration steps.

Adapter Removal is automatically performed with a Guided Calibration when the DUT is defined as a **non-insertable** device. You can override this by selecting the **Preview / Modify Settings** checkbox.

Performing an Adapter Removal Cal requires:

- an adapter with connectors that match those on the DUT.

- calibration standards for both DUT connector types.

Two Full 2-port calibrations are performed on each measurement port; one directly at the measurement port and one with the adapter connected to the measurement port.

The result of the two sets of calibrations is a single cal set that provides Full 2-port calibration and accurate characterization and removal of the mismatch caused by the adapter.

See Guided Calibration in Calibration Wizard.

Isolation Portion of 2-Port Calibration

When performing a 2-port calibration, you have the option of omitting the isolation portion of the calibration. The isolation portion of the calibration corrects for crosstalk, the signal leakage between test ports when no device is present.

Perform an isolation calibration when you are testing a device with high insertion loss. For example:

- Some filter stopbands.
- A switch in the open position.

The isolation calibration adds noise to the error model because the measurement is very close to the noise floor of the analyzer. To improve measurement accuracy:

- Perform the isolation calibration only when it is necessary.
- Use sweep averages to help reduce the noise.

The best way to perform an isolation calibration

Place the devices that will be measured on each test port of the analyzer, with terminations on the other two device ports. In this way, the analyzer is connected to the same impedance that it will be during subsequent device measurements.

If the previous method is impractical (in test fixtures, or if only one device is available), the next best method is to place a terminated device on the source port and a termination on the load port of the analyzer.

If no device is available or if the device will be tuned (which will change its port matches), place terminations on both ports of the analyzer.

Validity of a Calibration

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This section helps you determine if your calibration is valid and how the analyzer displays correction level information for your measurement.

- Viewing Correction Level
- Validating a Calibration
    - Quick Check
    - ECal Confidence Check
    - Verification Kit

See other Calibration Topics

Viewing Correction Level

The correction level provides information about the accuracy of the active measurement. Correction level notation is displayed on the status bar for different calibration types like response, full 2-port, TRL or power calibration.

To View Correction Levels:

In the **View** menu, click **Status Bar**. The status bar appears and displays the following items:
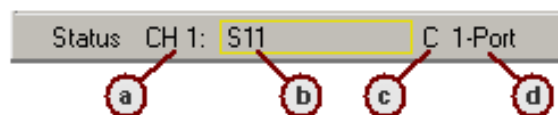
a. Active Channel

b. Measurement parameter

c. Correction Level (see description below)

d. Calibration type

Correction Level	Status Bar Notation	Accuracy
Full	C	Highest
Interpolated	C*	Uncertain
No Correction	No Cor	Lowest

Full Correction (C)

Full Correction level is displayed immediately after a calibration is performed or when a valid calibration is recalled from memory.

If you require optimum accuracy, avoid adjusting analyzer settings after calibration so your measurement remains at this level.

Interpolated Correction (C*)

An interpolated measurement is indicated by (C*) in the status bar. Interpolation occurs when you change any of the following settings:

- Sweep time

- Frequency (subset of Start/Stop)

- IF Bandwidth

- Port power

- Stepped sweep enabled/disabled

- Number of points

Note: Changing sweep type or frequency (outside of Start/Stop) will turn correction **OFF**.

No Correction

If the frequency span is increased outside the original start/stop frequency, or sweep type is changed, the current calibration becomes invalid and error correction is turned **OFF**.

The analyzer indicates a no-correction status with **No Cor** on the status bar.

Interpolation ON/OFF

Interpolation **ON** in the calibration menu makes interpolation **available** for the active measurement. The opposite is true for interpolation **OFF**.
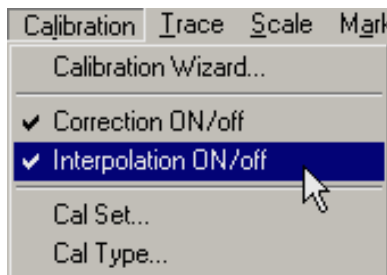
Validating a Calibration

At the completion of a calibration or selection of a stored Cal Set, validation can accomplish the following:

Improve Measurement Accuracy Once a measurement calibration has been performed, its performance should be checked before making device measurements. There are several sources of error that can invalidate a calibration: bad cables, dirty or worn calibration standards that no longer behave like the modeled standards, and operator error.

Verify Accuracy of Interpolation You should validate the calibration if you are testing a device and the measurements are uncertain because of interpolation**.**

Verify Accuracy of Cal Standards To check accuracy, a device with a known magnitude and phase response should be measured.

Quick Check

For this test, all you need are a few calibration standards. The device used should not be one of the calibration standards; a measurement of one of these standards is merely a measure of repeatability. The reflection and transmission tests can be applied to all test ports.

To verify reflection measurements, perform the following steps:

1. Connect either an OPEN or SHORT standard to port 1. The magnitude of S11 should be close to 0 dB (within a few tenths of a dB).

2. Connect a load calibration standard to port 1. The magnitude of S11 should be less than the specified calibrated directivity of the analyzer (typically less than -30 dB).

To verify transmission measurements:

1. Connect a THRU cable (or known device representative of your measurement) from port 1 to port 2. Verify the loss characteristics are equivalent to the known performance of the cable or device.

2. To verify S21 isolation, connect two loads: one on port 1 and one on port 2. Measure the magnitude of S21 and verity that it is less than the specified isolation (typically less than -80 dB).

Note: To get a more accurate range of expected values for these measurements, consult the analyzer's specifications.

ECal Confidence Check

ECal Confidence Check is a method to check the accuracy of a calibration performed with mechanical standards or an ECal module. The confidence check allows you to measure an impedance state in the ECal module (called the confidence state), and compare it with factory measured data stored in the module.

In order for this test to be valid, the test ports of the ECal module must connect directly to the calibration reference plane (without adapters).

To Perform ECal Confidence Check:

1. Connect ECal module to the analyzer with the USB cable. See Connect ECal Module to the PNA.

2. Allow the module to warm up for 15 minutes (20 minutes for a four-port module) or until the module indicates **READY**.

3. To start ECal Confidence Check, press **Menu/Dialog**, tab to the **Calibration** menu, and then click **ECal Confidence Check**.
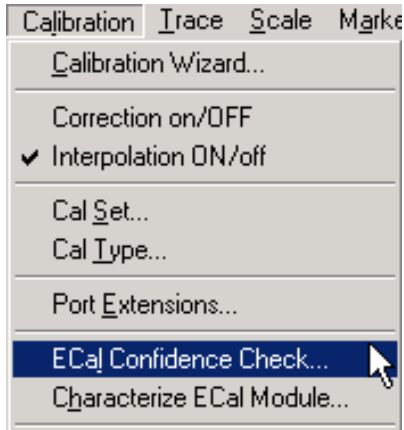
The ECal Confidence Check dialog box opens.

4. Click **Read Module Data**. The following occurs:
    - ECal module is set to "confidence state".
    - Analyzer reads and displays stored data.
    - Analyzer measures and displays "confidence state".

5. If you want to view a different parameter, select **Change Measurement** and select the check box for the desired parameter. (The default is the active channel parameter).

6. Select the viewing option in the Trace View Options block.

7. Compare the stored and measured data for each measurement parameter.

Notes:

- If the two traces show excessive difference, there may be a loose or dirty connection at the test ports or damage to the test cables. Carefully inspect the cables and connections. Then clean and gage each connector, and re-calibrate if needed.

- The User Characterization setting selects the user-characterization data instead of the factory characterization data (available when a User-Characterization is stored in the ECal module).
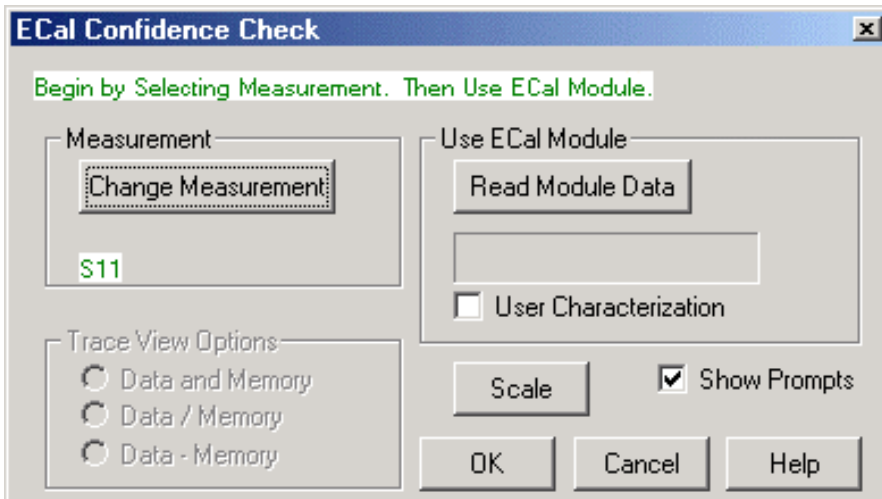
ECal Confidence Check dialog box help
Compares the accuracy of corrected (calibrated) data with stored data in the ECal module. For the check to be valid, the module test ports must connect directly to the calibration reference plane (without an adapter).

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Measurement

Change Measurement Opens the Measure dialog box.

Use ECal Module

Read Module Data

- Copies stored data from the ECal module to Memory.

- Changes state of ECal module to confidence state.

- Measures and displays confidence state and Memory trace.

User Characterization Selects the user-characterization data (stored in the module) instead of the factory characterization data (available when a User-Characterization is stored in the ECal module).

Scale Opens the Scale dialog box.

Show Prompts Check to show a reminder for the connection (default).

Trace View Options

Data and Memory Trace Displays current measurement data and Memory trace.

Data / Memory Performs an operation where the current measurement data is divided by the data in memory.

Data + Memory Performs an operation where the current measurement data is added to the data in memory.

Verification Kit

Measuring known devices, other than calibration standards, is a straightforward way of verifying that the network analyzer system is operating properly. Verification kits use accurately known verification standards with well-defined magnitude and phase response. These kits include precision airlines, mismatch airlines, and precision fixed attenuators. Traceable measurement data is shipped with each kit on disk and verification kits may be re-certified by Agilent.

See Analyzer Accessories for a list of Agilent verification kits.

Measurement Errors

You can improve accuracy by knowing how errors occur and how to correct for them. This topic discusses the sources of measurement error and how to monitor error terms.

- Drift Errors
- Random Errors
- Systematic Errors
- Monitoring Error Terms

See other Calibration Topics

Drift Errors

- Drift errors are due to the instrument or test-system performance changing after a calibration has been done.

- Drift errors are primarily caused by thermal expansion characteristics of interconnecting cables within the test set and conversion stability of the microwave frequency converter and can be removed by re-calibrating.

- The time frame over which a calibration remains accurate is dependent on the rate of drift that the test system undergoes in your test environment.

Providing a stable ambient temperature usually minimizes drift. For more information, see Measurement Stability.

Random Errors

Random errors are not predictable and cannot be removed through error correction. However, there are things that can be done to minimize their impact on measurement accuracy. The following explains the three main sources of random errors.

Instrument Noise Errors

Noise is unwanted electrical disturbances generated in the components of the analyzer. These disturbances include:

- Low level noise due to the broadband noise floor of the receiver.

- High level noise or jitter of the trace data due to the noise floor and the phase noise of the LO source inside the test set.

You can reduce noise errors by doing one or more of the following:

- Increase the source power to the device being measured.

- Narrow the IF bandwidth.

- Apply several measurement sweep averages.

Switch Repeatability Errors

- Mechanical RF switches are used in the analyzer to switch the source attenuator settings.

- Sometimes when mechanical RF switches are activated, the contacts close differently from when they were previously activated. When this occurs inside of the analyzer, it can adversely effect the accuracy of a measurement.

- You can reduce the effects of switch repeatability errors by avoiding switching attenuator settings during a critical measurement.

Connector Repeatability Errors

Connector wear causes changes in electrical performance. You can reduce connector repeatability errors by practicing good connector care methods. See Connector Care.

Systematic Errors

Systematic errors are caused by imperfections in the analyzer and test setup.

- They are repeatable (and therefore predictable), and are assumed to be time invariant.

- They can be characterized during the calibration process and mathematically reduced during measurements.

- They are never completely removed. There are always some residual errors due to

limitations in the calibration process. The residual (after measurement calibration) systematic errors result from:

- imperfections in the calibration standards
- connector interface
- interconnecting cables
- instrumentation

Reflection measurements generate the following three systematic errors:

- Directivity
- Source Match
- Frequency Response Reflection Tracking

Transmission measurements generate the following three systematic errors:

- Isolation
- Load Match
- Frequency Response Transmission Tracking

Note: The figures for the following six systematic errors show the relevant hardware configured for a forward measurement. For reverse measurements, internal switching in the analyzer makes Port 2 the source and Port 1 the receiver. Channel 'A' becomes the transmitted receiver, channel 'B' becomes the reflected receiver, and channel 'R2' becomes the reference receiver. These six systematic errors, times two directions, results in 12 systematic errors for a two port device.

Directivity Error

All network analyzers make reflection measurements using directional couplers or bridges.

With an ideal coupler, only the reflected signal from the DUT appears at channel 'A'. In reality, a small amount of incident signal leaks through the forward path of the coupler and into channel 'A'.

This measurement error is called directivity error. It can be measured and reduced by the analyzer.
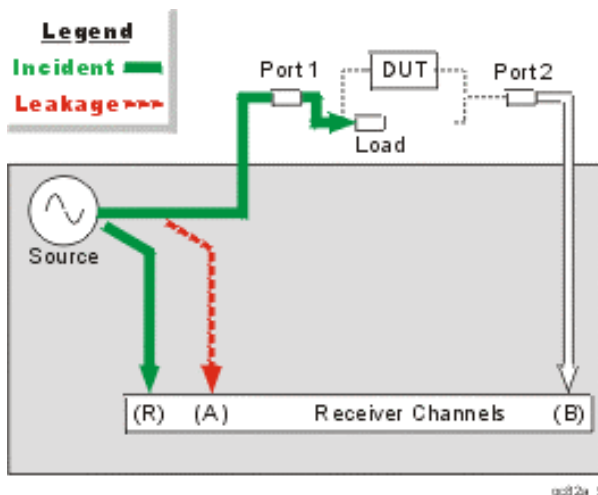
How the Analyzer Measures and Reduces Directivity Error.

1. During calibration, a load standard is connected to Port 1. We assume no reflections from the load.
2. The signal measured at channel 'A' results from the incident signal leakage through the coupler.

3. Directivity error is subtracted from subsequent reflection measurements.

Isolation Error

Ideally, only signal transmitted through the DUT is measured at channel 'B'.

In reality, a small amount of signal leaks into the channel 'B' receiver through various paths in the analyzer.

The signal leakage, also known as crosstalk, is isolation error which can be measured and reduced by the analyzer.
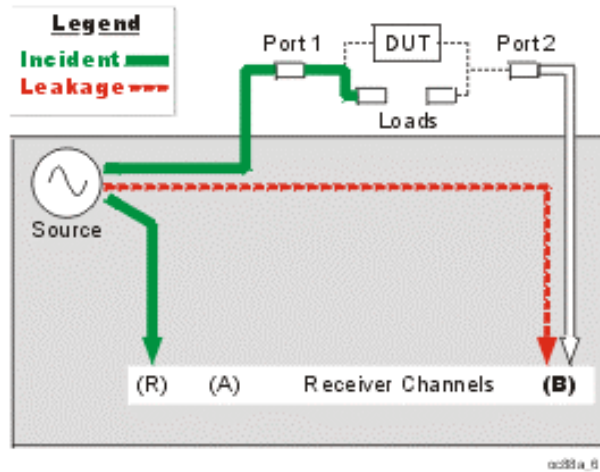
How the Analyzer Measures and Reduces Isolation Error

1. During calibration, load standards are connected to both Port 1 and Port 2.
2. The signal measured at channel 'B' is leakage through various paths in the analyzer.
3. This isolation error is subtracted from subsequent transmission measurements.

Source Match Error

Ideally in reflection measurements, all of the signal reflected off of the DUT is measured at channel 'A'.

In reality, some of the signal that is reflected off of the DUT is reflected again off of Port 1 and is not measured at channel 'A'.

This measurement error is called source match error which can be measured and reduced by the analyzer.
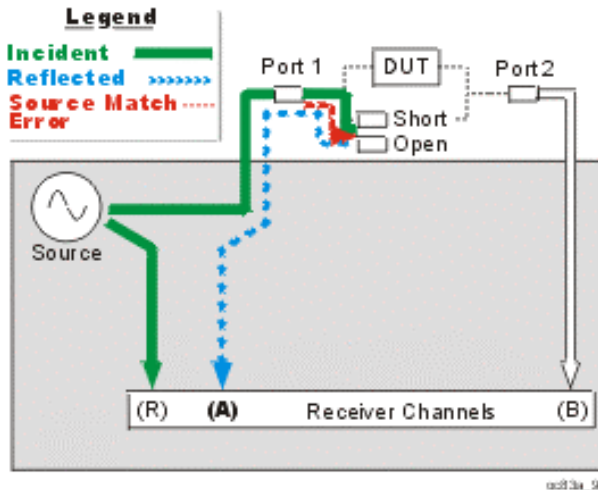
How the Analyzer Measures and Reduces Source Match Error

1. During calibration, a short standard is connected to Port 1. Known reflection from the short is measured at channel 'A' and stored in the analyzer.

2. An open standard is connected to Port 1. Known reflection from the open is measured at channel 'A' and stored in the analyzer.

3. The analyzer compares the two stored signals. The difference between the two signals is due to source match error.

4. Source match error is subtracted from subsequent reflection and transmission measurements.

Load Match Error

Ideally in transmission measurements, an incident signal is transmitted through the DUT and is measured at channel 'B'.

In reality, some of the signal is reflected off of Port 2 and is not measured at channel 'B'.

This measurement error is called load match error which can be measured and reduced by the analyzer.
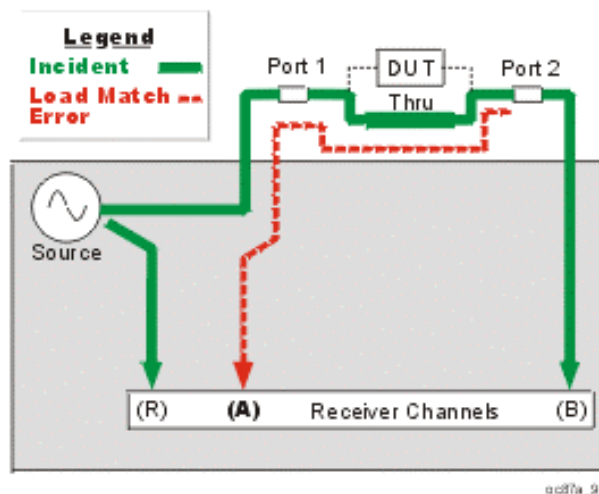
How the Analyzer Measures and Reduces Load Match Error

1. The Port 1 and Port 2 test connectors are mated together for a perfect zero-length thru

connection. (If this is not possible, a thru-line adapter is inserted.) This allows a known amount of incident signal at Port 2.

2. The signal measured at channel 'A' is reflection signal off of Port 2

3. The resulting load match error is subtracted from subsequent transmission and reflection measurements.

Frequency Response Reflection Tracking Error

Reflection measurements are made by comparing signal at channel 'A' (the reflection channel) to signal at channel 'R1' (the reference channel). This is called a ratio measurement or "A over R1" (A/R1).

For ideal reflection measurements, the frequency response of the channel 'A' and channel 'R1' receivers would be identical.

In reality, they are not, causing a frequency response reflection tracking error. This is the vector sum of all test variations in which magnitude and phase change as a function of frequency. This includes variations contributed by:

- signal-separation devices

- test cables

- adapters

- variations between the reference and test signal paths

Frequency response reflection tracking error can be measured and reduced by the analyzer.

How the Analyzer Measures and Reduces Frequency Response Reflection Tracking Error.

1. During calibration, a short standard is connected to Port 1. Known reflection from the short is measured at channel 'A' and stored in the analyzer.

2. An open standard is connected to Port 1. Known reflection from the open is measured at channel 'A' and stored in the analyzer.

3. The analyzer averages the two stored channel 'A' signals.

4. The average channel 'A' response is compared with the reference signal measured at 'R1'.

5. The result is the difference in frequency response of the channel 'A' and channel 'R1' receivers (see the following diagram). This frequency response reflection tracking error is subtracted from subsequent DUT measurements.
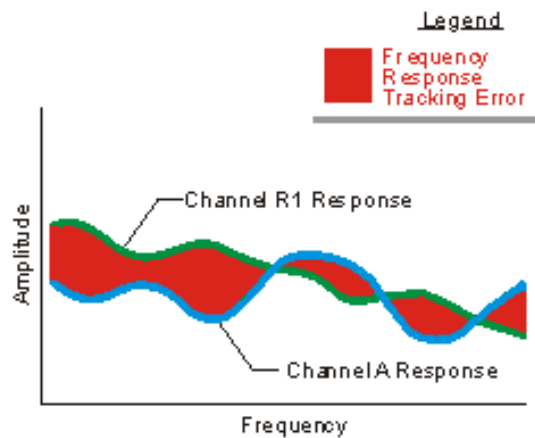
Note: In reflection response calibrations, only a single calibration standard is measured (open or short) and thus only its contribution to the error correction is used.

Frequency Response Transmission Tracking Error

Transmission measurements are made by comparing signal at channel 'B' (the transmission channel) to signal at channel 'R1' (the reference channel). This is called a ratio measurement or "B over R1" (B/R1).

For ideal transmission measurements, the frequency response of the channel 'B' and channel 'R1' receivers would be identical.

In reality, they are not, causing a frequency response transmission tracking error. This is the vector sum of all test variations in which magnitude and phase change as a function of frequency. This includes variations contributed by:

- signal-separation devices
- test cables
- adapters
- variations between the reference and test signal paths

Frequency response transmission tracking error can be measured and reduced by the analyzer.

How the Analyzer Measures and Reduces Frequency Response Transmission Tracking Error.

1. During calibration, the Port 1 and Port 2 test connectors are mated together for a perfect

zero-length thru connection. (If this is not possible, a thru-line adapter is inserted.) This allows a known amount of incident signal to reach Port 2.

2. Measurements are made at channel 'B' and channel 'R1' and stored.

3. The analyzer compares the channel 'R1' and channel 'B' signals.

4. The result is the difference in frequency response of the channel 'B' and channel 'R1' receivers (see the following diagram). This frequency response transmission tracking error is subtracted from subsequent device measurements.

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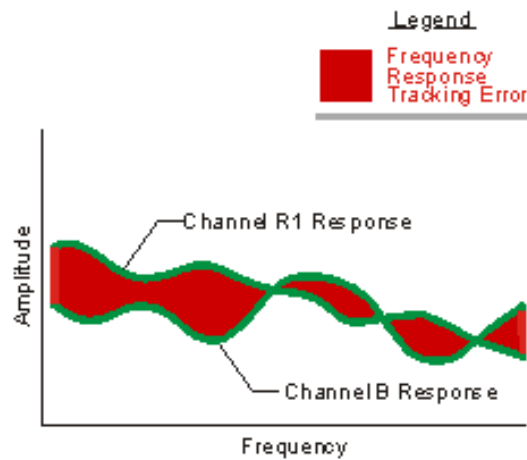
Monitoring Error Terms

The analyzer saves the measurement of systematic errors as error terms. By using **Cal Set Viewer**, you can monitor these error terms to determine the health of your analyzer and the accuracy of your measurements.

By printing or saving the error terms, you can periodically compare current error terms with the record of values generated previously with the same instrument and calibration kit. If previously generated values are not available, refer to typical values or typical error term measurement results found in Appendix A, "Error Terms", of the Service Guide.

Note: The service guide for your PNA is available at http://www.agilent.com/find/pna
It is also on the CDROM that was shipped with your PNA.

- A stable system should generate repeatable error terms over about six months.

- A sudden shift in error terms over the same frequency range, power, and receiver settings, may indicate the need for troubleshooting system components. For information on troubleshooting error terms, see Appendix A , "Error Terms", of the Service Guide.

- A subtle, long-term shift in error terms often reflects drift or connector and cable wear. The cure is often as simple as cleaning and gauging connectors or inspecting cables.

How to monitor Error Terms:

1. In the **System** menu, point to **Service**, point to **Utilities,** and then select **Cal Set Viewer.**

2. In the Cal Set Viewer Toolbar, select the desired Cal Set.

3. Click the **Standards/ETerms** button to toggle between viewing the raw measurement data of the Standard or the corrected Error Term data.

4. Select the Error Term or Standard to view.

5. Select the **Enable** check box.

Automated Retrieval of Error Terms

Refer to the Cal Tab of Command Finder to see the SCPI and COM commands that retrieve and store error terms.

Modify Calibration Kits

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You can create or modify Version 1 or 2 calibration kit files using Advanced Modify Cal Kits.

- What are Version 1 and 2 Kits?
- Modifying Calibration Kit Models
- Starting Advanced Modify Cal Kit
- Editing Version 1 Kits
- Editing Version 2 Kits

Note: You can modify cal standard definitions and manage Version 1 Cal Kits with Cal Kit Manager.

See other Calibration Topics

What are Version 1 and 2 Kits?

The analyzer uses two sets of calibration kit files: Version 1 and 2. Each set is stored in memory and is available for calibration using the Calibration Wizard.

Version 1 kits are used with **Unguided** calibration

- Files Available: 6 predefined, 4 user-defined.
- Number of definitions: 0 to 8
- Number of class assignments: 0 to 8
- Types of Calibration: Response, 1-port Refl., Full 2-port, TRL

Version 2 kits are used with **Guided** calibration

- Files Available: All supported Agilent calibration kits.
- Number of definitions: Unlimited
- Number of class assignments: Unlimited
- Types of Calibration: 1-port Refl., Full 2-port and 3-port

Modifying Calibration Kit Models

You can modify the Version 1 or Version 2 calibration kit files or create a custom one.

For most applications, the default calibration kit models provide sufficient accuracy for your calibration. However, several situations exist that may require a user-defined calibration kit:
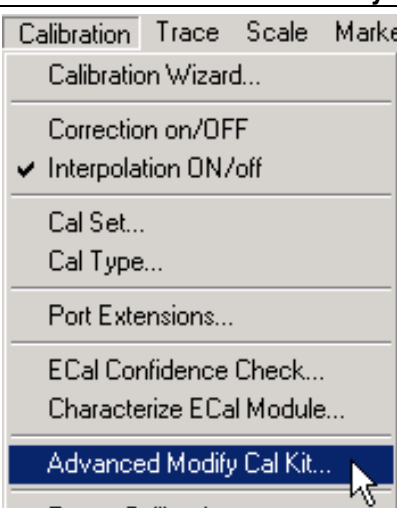
- Using a connector interface different from those used in the predefined calibration kit models.

- Using standards (or combinations of standards) that are different from the predefined calibration kits (For example, using three offset SHORTs instead of an OPEN, SHORT, and LOAD to perform a 1-port calibration).

- Improving the accuracy of the models for predefined kits. When the model describes the actual performance of the standard, the calibration is more accurate. (Example: A 7 mm LOAD is determined to be 50.4 instead of 50.0.)

- Modifying the THRU definition when performing a calibration for a non-insertable device.

- Performing a TRL calibration.
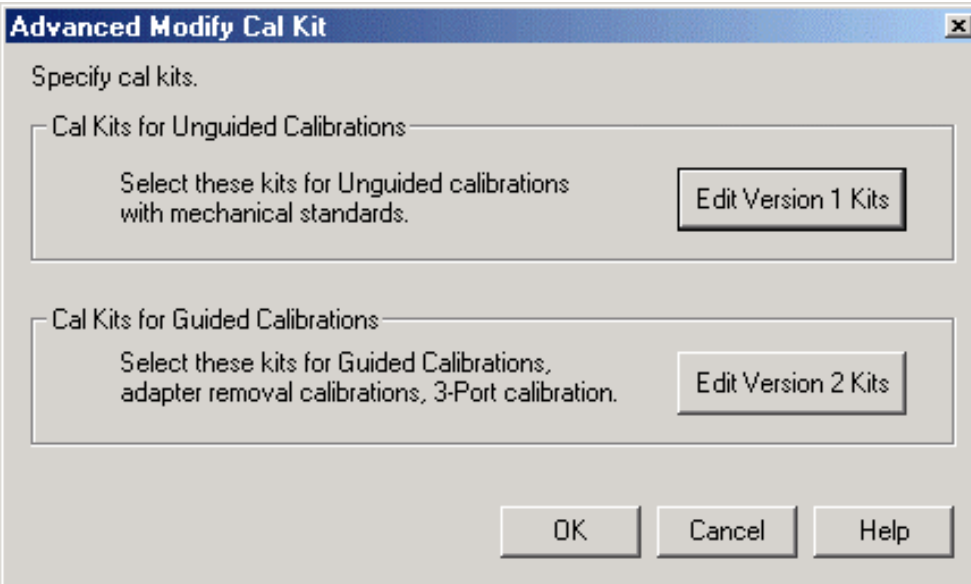
Starting Advanced Modify Cal Kit

Advanced Modify Cal Kit allows you to modify the standard definitions or class assignments contained in Version 1 and 2 calibration kit files.

How to start **Advanced Modify Cal Kit**
Learn more about using the front panel interface

Advanced Modify Cal Kit dialog box help

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Version 1 calibration kits are used to perform an **Unguided** calibration:

Version 2 calibration kits are used when performing a **Guided** calibration.
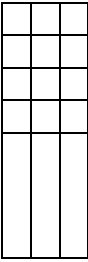
Editing Version 1 Cal Kits

Note: You can modify cal standard definitions and manage Version 1 Cal Kits with Cal Kit Manager.

In the **Advanced Modify Cal Kit** dialog box, click **Edit Version 1 Kits** to open the following dialog box:
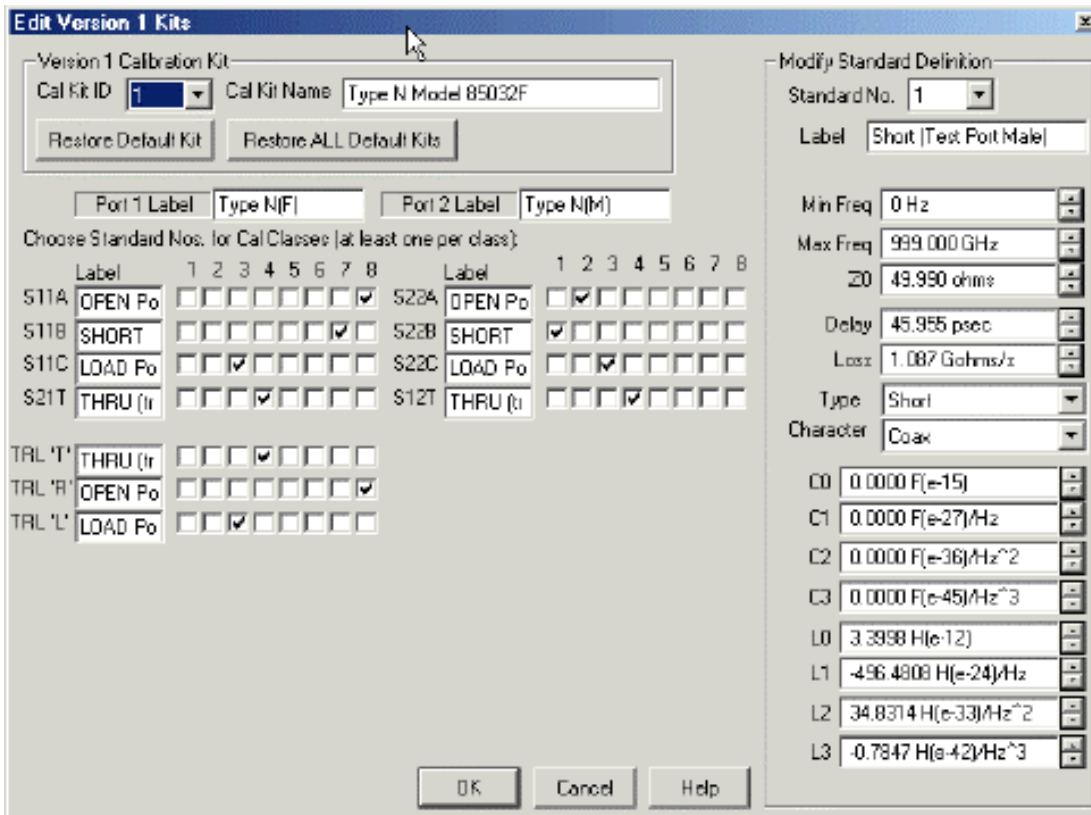
Edit Version 1 Kits dialog box help

Version 1 Calibration Kit

Cal Kit ID Specifies the calibration kit that you want to modify. Kits 1-6 are predefined calibration kit definitions. Kits 7-10 are user-defined calibration kit definitions.

Cal Kit Name Specifies the connector type and model number or name of the calibration kit that you want to modify.

Restore Default Kit Restores the currently selected calibration kit to its predefined values.

Restore All Default Kits Restores all calibration kits to their predefined values.

Choose Standard Nos. for Cal Classes:

Select the check box that corresponds to the standard number or numbers (1 to 8) and apply to the appropriate class label.

Port Label Specifies the port connector type.

S11A, S11B, S11C, S21T Classes for the Port 1 assignment of the standards: three reflection and one transmission.

S22A, S22B, S22C, S12T Classes for the Port 2 assignment of the standards: three reflection and one transmission.

S33A, S33B, S33C, S32T, S23T, S31T, S13T . Classes for the Port 3 assignment of the standards: three reflection and four transmission. (Available only on 3-port PNA models)

TRL 'T', 'R', 'L' Classes for the port assignments for through, reflect and line standards. The ports are assumed to be symmetrical, thus no corresponding port is necessary.

Class assignments 1-8 Allows assigning up to 8 standards to each class. See Class Assignments.

Modify Standard Definition

Standard No Specifies the calibration standard number for the following:

Label Specifies a description of the standard that you are modifying.

Min Freq Specifies the minimum frequency the standard is used for calibration.

Max Freq Specifies the maximum frequency the standard is used for calibration.

Z0 Specifies the system characteristic impedance.

Delay Specifies a uniform length of transmission line between the standard being defined and the actual measurement plane.

Loss Specifies energy loss, due to skin effect, along a one-way length of coaxial cable.

Type Specifies what type of calibration standard you are modifying.

When Arbitrary Z is selected, the following settings replace C0 and C1:

> **Trm Z.re** The real portion of the impedance value.

> **Trm Z.im** The imaginary portion of the impedance value.

> Arbitrary Impedance defines the standard type to be a load, but with an impedance value different from system Z0.

Character Specifies if the standard is either coax or waveguide.

C0, C1, C2, C3 Specifies the fringing capacitance for the open calibration standard.

L0, L1, L2, L3 Specifies the residual inductance for the short calibration standard. The effect of inductance is negligible for frequencies of 20 GHz or less.

OK Saves the new standard definitions, class assignments, and Cal Kit Name.

Editing Version 2 Kits

In the Advanced Modify Cal Kit dialog box, click **Edit Version 2 Kits** to open the following dialog box:

- Edit Version 2 Kits

- Edit Kit
- Add Connector
- Modify Calibration Class Assignments
- Add Standard
- Edit Standards
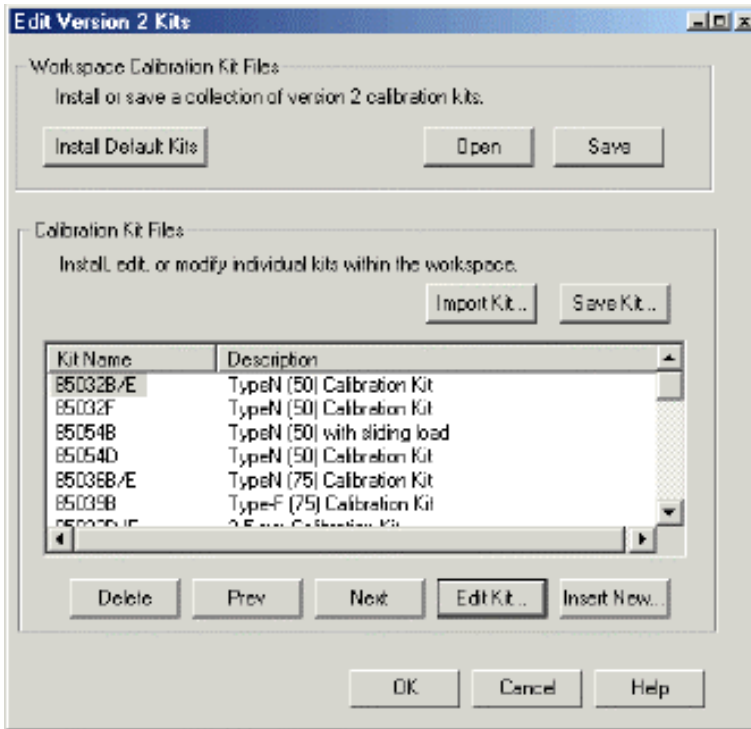
Edit Version 2 Kits dialog box help

Workspace Calibration Kit Files

    Install Default Kits Installs default list of calibration kits and displays each kit name and description.

    Open Allows you to select a user-defined list of calibration kits and displays each kit name and description.

    Save Saves user-defined list of calibration kits (using .wks file type).

Calibration Kit Files

    Import Kit Imports calibration kit definitions from hard disk or other drive that are saved in the **.cks** file format.

    Save Kit Saves modified calibration kit definitions (using **.ckt** file type).

    Delete Deletes selected calibration kit file.

    Prev Selects previous calibration kit in list.

    Next Selects next calibration kit in list.

    Edit Kit Invokes the Edit Kit dialog box to modify selected calibration kit definitions.

    Insert New Invokes a blank Edit Kit dialog box to create new calibration kit definitions.
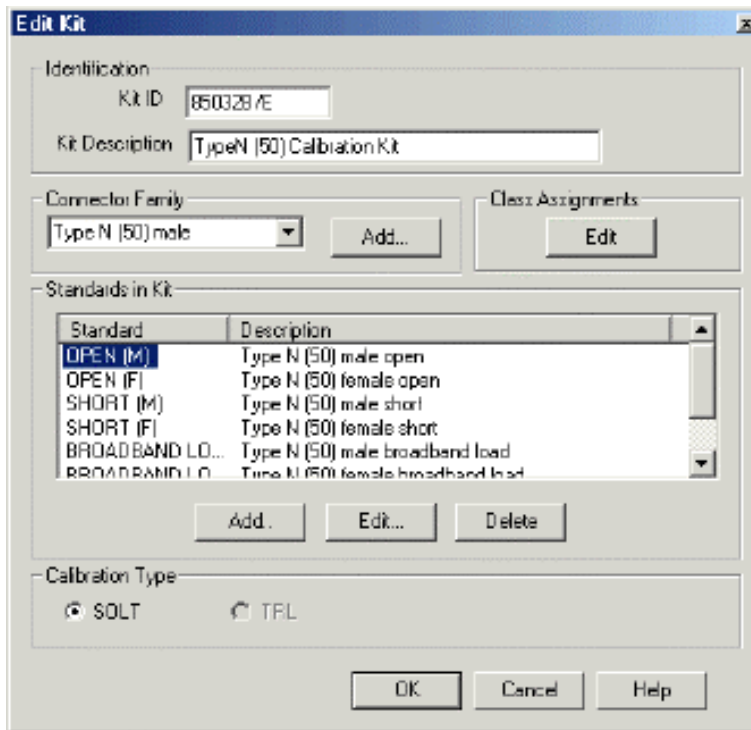
Edit Kit dialog box help

Identification

  Kit ID Displays model number of selected calibration kit.

  Kit Description Displays connector type of calibration kit.

Connector Family

  Click the down arrow to select a connector type to modify.

  Add Invokes the Add Connector dialog box which allows you to add new connector type to the calibration kit.

Class Assignments

  Edit Invokes the Modify Calibration Class Assignments dialog box.

Standards in Kit

  Add Invokes the Add Standard dialog box that allows you to add definitions for a standard.

  Edit Invokes the Edit dialog box that allows you to modify standard definitions for the selected standard: either Open, Short, Load, or Thru.

  Delete Deletes selected standard from calibration kit.

Calibration Type

  SOLT Applies standard definitions to SOLT (short, open, load, thru) standards.

  TRL Unavailable.
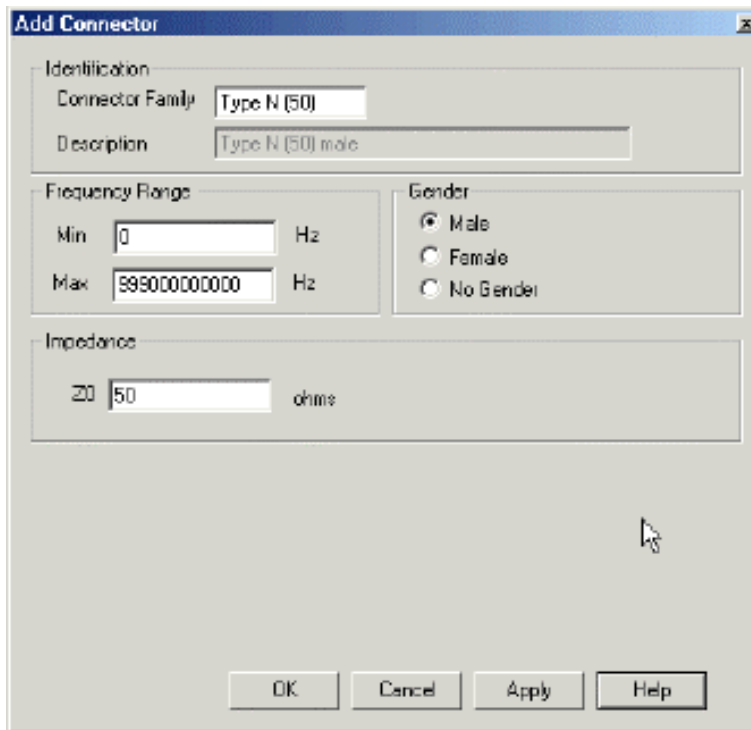
Add Connector dialog box help

Identification
 	
    Connector Family Allows you to define connector family.
 	
    Description Displays connector type and gender.
 	
Frequency Range
 	
    Min Allows you to define the lowest frequency at which the standard is used for calibration.
 	
    Max Allows you to define the highest frequency at which the standard is used for calibration.
 	
Gender
 	
    Allows you to define the connector gender.
 	
Impedance
 	
    Allows you to define the impedance of the offset between the standard and the calibration plane.
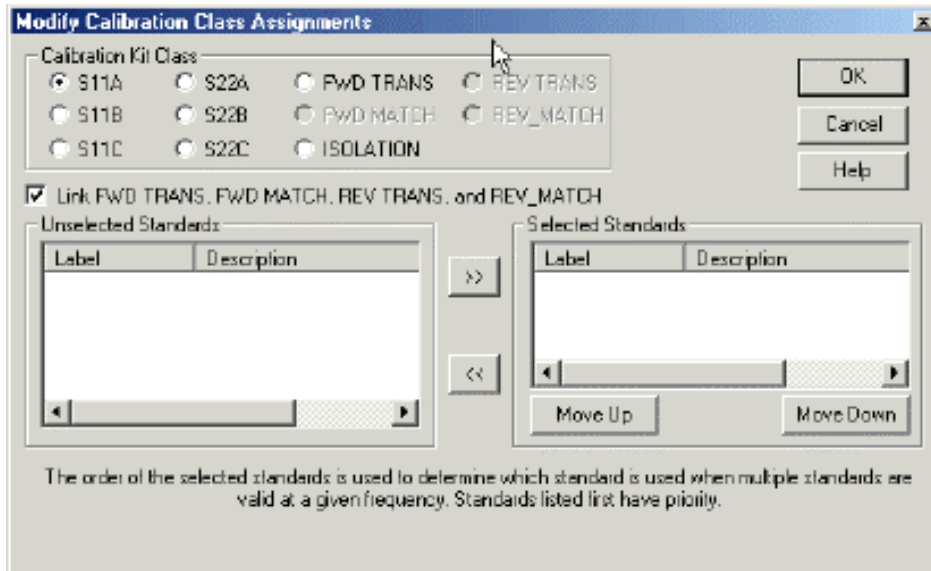
Modify Calibration Class Assignments dialog box help
Allows you to assign single or multiple standards to classes.
Calibration Kit Class
S11A, S11B, S11C Classes for Port 1 reflection standards.
S22A, S22B, S22C Classes for Port 2 reflection standards.
FWD/REV TRANS Classes for transmission standards.
FWD/REV MATCH Classes forward and reverse match.
ISOLATION Class for isolation standard.
Link FWD TRANS, FWD MATCH, REV TRANS, and REV MATCH Check to automatically assign the standard definition for FWD TRANS to FWD MATCH, REV MATCH and REV TRANS. Clear to separately assign FWD MATCH, REV MATCH and REV TRANS classes.
Unselected Standards
Displays the list of standards NOT USED in the current class assignment. Move standards to the Selected Standard field by selecting and clicking the right arrow.
Selected Standards
Displays the list of standards USED in the current class assignment. Move standards to the Unselected Standard field by selecting and clicking the right arrow.
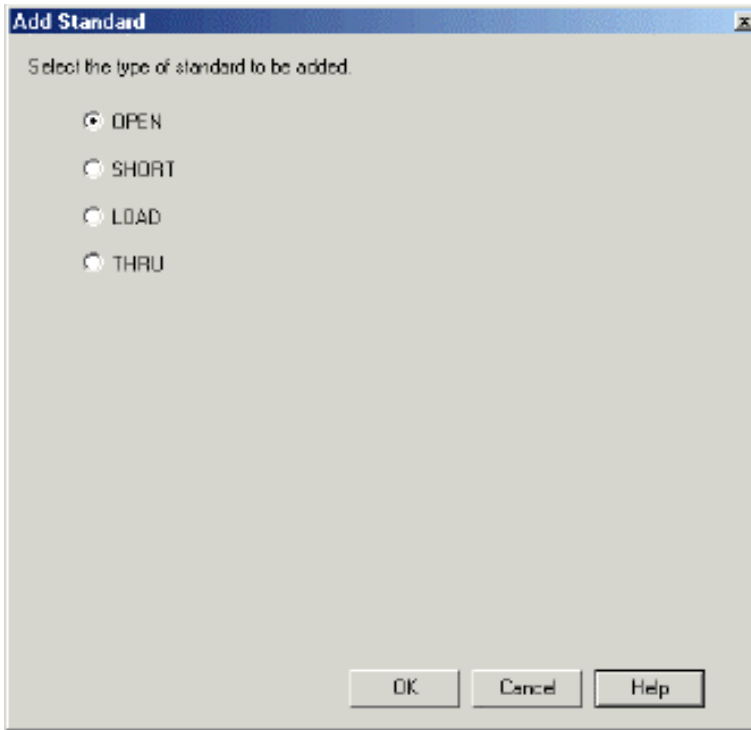
Add Standard dialog box help
Allows you to add standards to the calibration kit file.
OPEN Adds an open to the calibration kit file.
SHORT Adds a short to the calibration kit file.
LOAD Adds a load to the calibration kit file.
THRU Adds a thru to the calibration kit file.
OK Invokes the Open, Short, Load, or Thru dialog box, which is a blank Edit Standards dialog box

Edit / Add Standards (Open, Short, Load, or Thru)

Edit / Add Standards dialog box help

This dialog box changes depending on the type of standard selected. The following applies to all standards:

Identification

   Label Displays / specify type of standard.

   Description Displays / specify connector type and gender of standard.

Frequency Range

   Min Defines the lowest frequency at which the standard is used for calibration.

   Max Defines the highest frequency at which the standard is used for calibration.

Gender

   Indicates the gender of the standard: Male, Female, None

Delay Characteristics

   Delay Defines the one-way travel time from the calibration plane to the standard in seconds.

   Z0 Defines the impedance of the offset between the standard and the calibration plane.

   Loss Defines energy loss, due to skin effect, along a one-way length of coaxial cable.

   • The value of loss is entered as ohms/second at 1 GHz.

   • To compute the loss of the standard, measure the delay in seconds and the loss in dB at 1 GHz. Then use the following formula:

$$\text{Loss}\left(\frac{\Omega}{s}\right) = \frac{\text{loss (dB)} \times Z_0(\Omega)}{4.3429(\text{dB}) \times \text{delay}(s)}$$

The following describes the unique selections for standard types Open, Short, Load, and Thru

Open Standard

Open Characteristics			
C0 89.939	F(e-12)	C2 -264.9901	F(e-36)/Hz^2
C1 2536.7999	F(e-27)/Hz	C3 13.4	F(e-45)/Hz^3
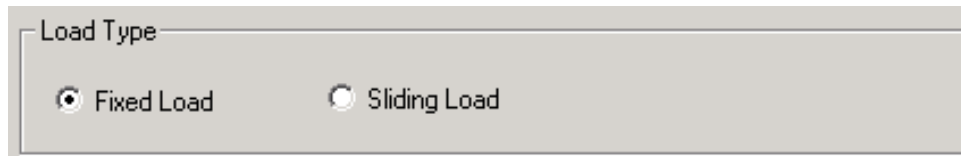
   C0, C1, C2, C3 Specifies the fringing capacitance.

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Short Standard

Short Characteristics			
L0 0.7563	H(e-12)	L2 -52.429	H(e-33)/Hz^2
L1 459.8799	H(e-24)/Hz	L3 1.5846	H(e-42)/Hz^3

   L0, L1, L2, L3 Specifies the residual inductance.

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Load Standard

Load Type

Allows you to select the type of load; fixed or sliding.

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Thru Standard

Connectors

Defines connector type at both ports.

3-Port Measurements

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PNA Series network analyzers, N3381A, N3382A, and N3383A, provide true vector error-corrected measurements for three port devices. This topic provides information about making 3-Port measurements.

- Overview
- 3-Port Calibrations
- Selecting Parameters

See other Calibration Topics

Overview

3-port PNA Series network analyzers offer complete characterization of three-port devices quickly, compared to two-port analyzers. You can measure devices like directional couplers, splitters, and antenna diplexers without setup changes. 3-port measurements allow viewing up to nine different S-parameters in a variety of format and scale settings.

3-Port Calibrations

To perform a Full 3-port calibration, use Guided calibration in the Calibration Wizard. In Guided Calibration, you can perform the calibration with either mechanical standards or an ECal module. When you use mechanical standards, Guided calibration automatically performs adapter removal calibrations for noninsertable devices. See Using Calibration Wizard.

Error Terms

The following flowgraph displays the error terms in the 3-port model:
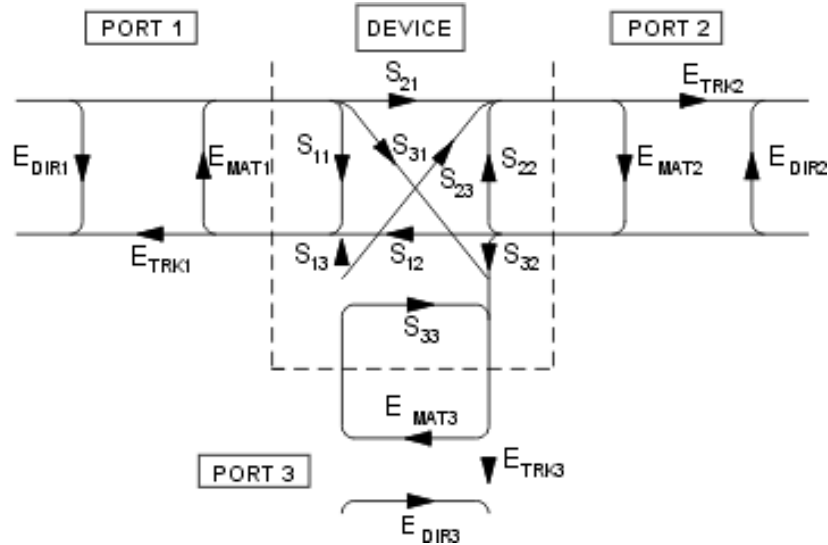
where:

E = error term

DIR = Directivity

MAT = Forward Source Match and Reverse Load Match

TRK = Forward Reflection Tracking and Reverse Transmission Tracking

Viewing Measurements

Because there are nine available parameters to view, it is useful to know how to configure the measurement in order to view data. You can configure multiple measurements in a variety of ways using up to four Windows and four traces per Window. Once your measurement is configured, you can resize and arrange the placement of Windows as well as print data.

Selecting Parameters

You can select from nine S-parameters; three reflection and six transmission. The reflection parameters are displayed with a numbered annotation that determines what port pair is available when performing a full 2-port calibration as shown in the following graphic:

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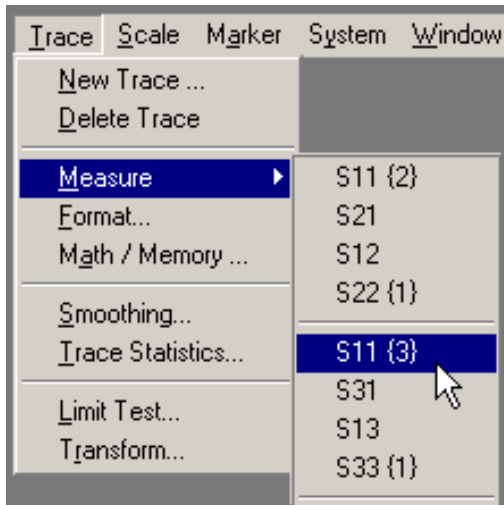
Select these and other parameters as you would on a 2-port PNA. See How to select a measurement

Power Calibration

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Source and Receiver Power Calibrations work together to provide very accurate power levels from the source and power measurements from the receiver.

- Source Power Calibration
- Receiver Power Calibration
- Saving Source and Receiver Cals

See other Calibration Topics

Source Power Calibration

Perform Source Power Calibration when you need accurate power levels at some point in the measurement path between the PNA test ports. For example, you need to characterize the gain of an amplifier across a frequency range at a specified input power. You would perform a source power cal at the input of the amplifier to ensure the **exact** power level into the amplifier across the frequency range.

Using a Source Power Cal, you can reasonably expect the power at the point of calibration to be within the range of the uncertainty of the power meter and sensor that is used.

Source Power Calibration:

- Is independent of measurement type. It corrects the PNA source regardless of which receivers are being used in a measurement. Therefore, it can be used with both ratio or non-ratio measurements.
- Applies to all measurements on the channel that is active when the calibration is

performed.

- ONLY applies to those measurements that use the test port that was specified as the Source for the calibration. For example, if you specify Port 1 as the source to be calibrated, only those measurements on the active channel that use port 1 as the source will be corrected.

- Can be used in conjunction with other measurement calibrations, such as a full 2-port calibration. For highest accuracy, perform the measurement calibration AFTER the source calibration.

- Can be used with Power Sweep type. Source Power Cal will correct the power at all power levels across the power sweep. When Power Sweep is selected, the Power Selection section of the Source Power Cal dialog box is ignored.

How it works:

Click to see the detailed procedure

1. Specify the measurement settings (frequency range, IFBW and so forth)

2. Start Source Power Calibration

3. Connect a power meter sensor to the point at which you want a known power level. This may be at the input or output of your device, or some other point between the test ports.

4. The program steps the PNA source through the specified frequency range, at the specified power level, and measures the power using a power meter.

5. The program calculates and stores the difference between the desired corrected power (Cal power) and what was measured by the power meter, at each data point.

6. The power meter is removed and the measurement path reconnected.

7. During subsequent sweeps, the source power is adjusted by the difference values to provide the corrected power level.

8. When complete, the source power calibration can be saved to disk as part of the instrument state.

Test Equipment Supported

Power Sensors

You can use up to two sensors to cover the frequency span of the measurement.

Agilent Model Number	Critical Specification
8482A	100 KHz to 4.2 GHz
E4412A	10 MHz to 18 GHz
E8487A	50 MHz to 50 GHz

Note: The Agilent E9300 family of average power sensors is not currently supported by Source Power Calibration.

Power Meters

Agilent Model Number	Critical Specification
E4416A	Single Channel
E4417A	Dual Channel
EPM-441A, E4418A/B	Single Channel
EPM442A, E4419A/B	Dual Channel
437B	Single Channel
438A	Dual Channel

See Create a Custom Power Meter Driver.

How to perform Source Power Calibration

1. Setup your measurement (sweep type, frequency range, IFBW, and so forth).

2. Connect coax cable, GPIB cable, and power sensor(s) to the PNA as shown in graphic below:
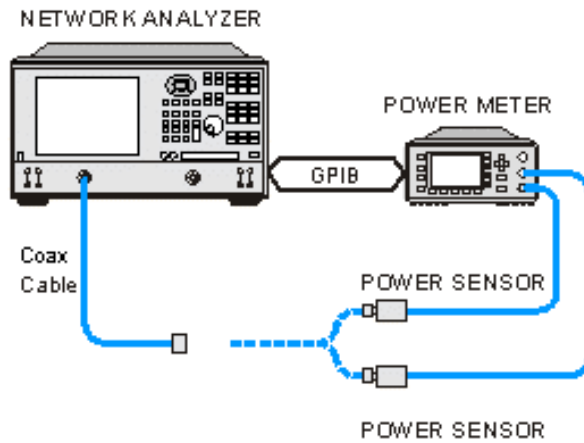
3. Apply power to the power meter and allow 30 minutes warm-up time before beginning calibration.

4. Select **Source Power Cal** as follows:
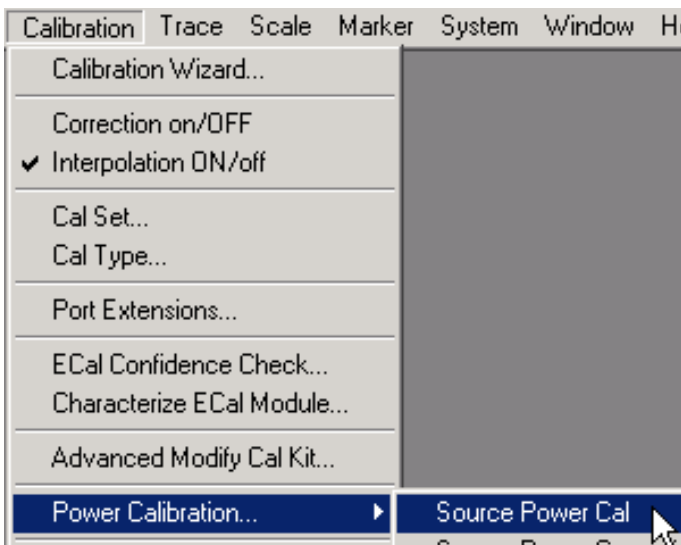
5. Complete the Source Power Cal dialog box (below), including Loss Compensation and Power Sensor Settings, as needed.

6. When complete, click **Take a Cal Sweep** in the Source Power Cal dialog box.

7. Follow the prompts to connect the sensors as required.

8. When calibration is finished, click **OK**.

9. Remove sensor.

- **Src Pwr Cal** is displayed in the status bar and correction data is applied to subsequent sweeps.

- To turn correction **OFF**, on the **Calibration** menu, point to **Power Calibration**, then set **Source Power Correction** to **OFF**.

Interpolation

If the original stimulus settings are changed, Interpolation or EXTRAPOLATION is applied and **Src Pwr Cal*** is displayed in the status bar. This is different from <u>measurement calibration interpolation</u>. If the frequency span is increased, the PNA will extrapolate new correction values rather than turn correction off. This is to protect your test device from being overpowered by the source.

If the original settings are restored, then source power calibration returns to full correction.
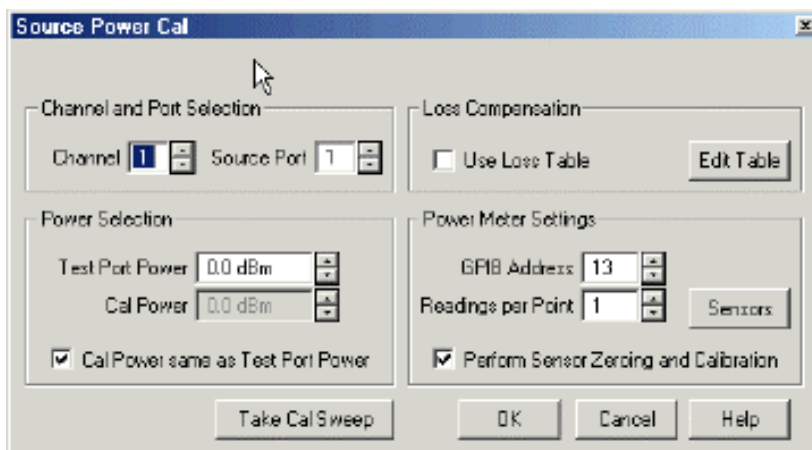
Source Power Cal dialog box help
Channel and Port Selection
Channel Specifies the channel on which to perform the calibration
Source Port Specifies the selected port. Default is port 1.
Loss Compensation
Use Loss Table Check to apply loss data to Source Power calibration correction (such as for an adapter on the power sensor).
Edit Table... Click to invoke the Power Loss Compensation dialog box.
Power Selection
Test Port Power Sets the power level at the specified source port (in dBm).
Cal Power Sets the desired corrected power (in dBm) at the calibration point.
Cal power same as Test Port Power Check if you are calibrating directly at the test port. Clear if you are calibrating at some point other than the test port.
Power Meter Settings
GPIB Address GPIB address for the power meter . Default is 13.
Readings per Point The number of readings the power sensor takes for each measurement point.
Sensors Click to invoke the power sensor settings dialog box.
Perform Sensor Zeroing and Calibration Check to zero and calibrate the power sensor before taking data.
Take Cal Sweep Begins source power calibration measurement.
OK Applies calibration.

Cancel Cancels calibration.

	FREQUENCY	LOSS
1		
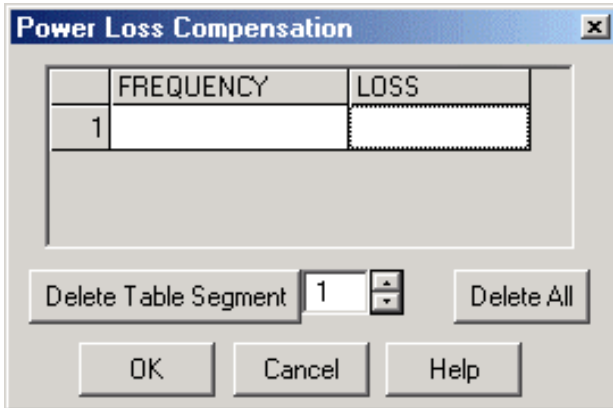
Power Loss Compensation dialog box help

Allows you to compensate for losses that occur when you use an adapter or coupler to connect the power sensor to the measurement port.

Delete Table Segment Deletes row indicated in the field.

Delete All Deletes all data in the table.

- If you enter a single frequency/loss segment, the analyzer applies that value to the entire frequency range.

You can enter up to 100 segments to achieve greater accuracy.

	FREQUENCY	CAL FACTOR
1	300.000000 KHz	97.3 %
2	1.000000 GHz	98.2 %
3	3.000000 GHz	99.3 %
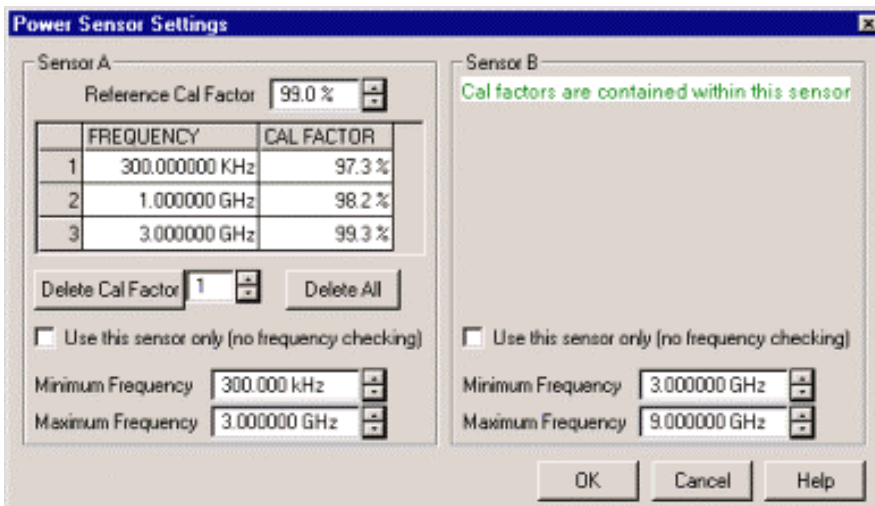
Power Sensor dialog box help

Sensor A (B). Displays one of the following messages depending on type of sensor.

- **Not connected** The PNA is not detecting a power sensor.

- **Cal factors are contained within this sensor** The PNA detects an Agilent E-Series power sensor. Reference Cal Factor and Cal Factor data are loaded automatically.

- **Sensor Data** Allows entry for power sensor data:

Reference Cal Factor Specifies the sensor's Reference Cal Factor.

Cal Factor Table Specifies the frequency and corresponding Cal Factor for the sensor.

Delete Cal Factor Deletes row indicated line in the field.

Delete All Deletes all data in the table.

Use this sensor only Check to use sensor over the entire frequency span of the measurement, even if two sensors are connected to power meter. Clear to allows entry of minimum and maximum frequency for the sensor.

Minimum Frequency Specifies the minimum frequency range for the sensor when using dual sensors.

Maximum Frequency Specifies the maximum frequency range for the sensor when using dual sensors.

Reducing Measurement Time

The time required to perform a Source Power Calibration depends on source power, number of points, and number of readings taken. You can reduce this measurement time with the following methods:

- **Reduce number of points before calibration.** You can reduce the number of points before the measurement, then return the number of points to its original value after calibration is complete and correction is ON. The analyzer will perform a linear interpolation, although with some loss in accuracy.

- **Use an Agilent E-Series sensor.** You can obtain 200+ readings per second over GPIB with this type of sensor.

- **Increase power to the sensor.** Lower power may have longer settling time with some sensors.

Receiver Power Calibration

Receiver power calibration mathematically removes frequency response errors in the specified PNA receiver, and adjusts readings to the same, or a value offset from, the source power calibration level. It is exactly the same as doing **Data / Memory.**

Use Receiver Power Calibration to make very accurate absolute power (amplitude) measurements

Receiver Power Calibration:

- Always requires that a source power calibration be performed first.

- Is ONLY allowed when making absolute power (unratioed) measurements.

- ONLY applies to the active measurement.

How to perform a Receiver Power Calibration

1. Perform a Source Power Calibration

2. Set the active measurement to unratioed. Learn How

3. Connect a coax cable from the source port to the receiver port as shown in graphic below.

NETWORK ANALYZER

Coax
Cable
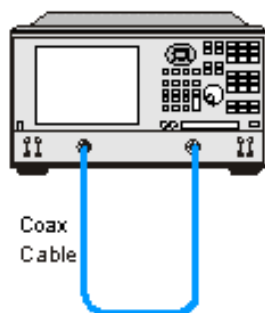
4. Ensure correction for Source Power Calibration is ON as indicated by **Src Pwr Cal** or **Src Pwr Cal*** in the status bar

5. Select **Receiver Power Cal** as follows:
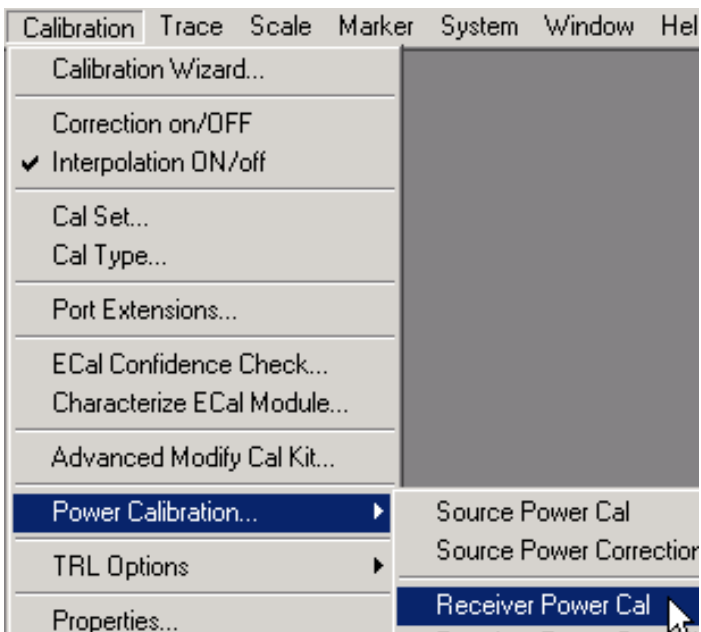
6. Complete the following Receiver Power Cal dialog box
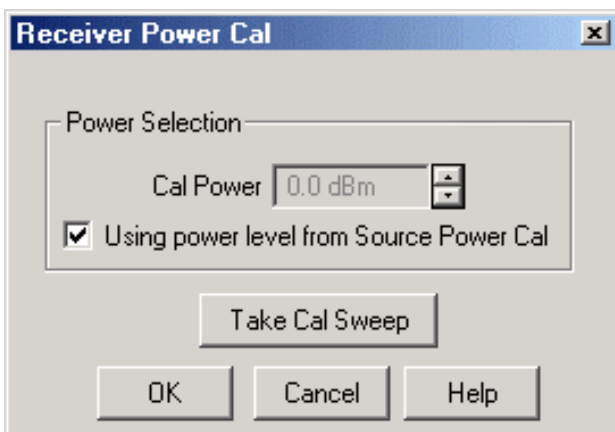
Receiver Power Cal dialog box help
Cal Power Specifies the power to be measured by the receiver.
Using power level from Source Power Cal. Check to use Cal Power from Source power Calibration as Cal Power for Source Power Calibration value. Clear to enter a different Cal Power value.
Take a Cal Sweep Click to trigger a Receiver Power Calibration sweep.
OK Click when Receiver Power Calibration sweep is complete.

- When Receiver Power Cal is finished, **C Rcvr Pwr** is displayed in the status bar and correction data is applied to subsequent sweeps.

- To turn correction **OFF**, click **Calibration,** point to **Power Calibration**, then set **Receiver Power Correction** to **OFF**.

Interpolation

Like a measurement calibration, if the original stimulus settings are narrowed, Interpolation is applied and **C* Rcvr Pwr** is displayed in the status bar. If the original stimulus settings are made wider, the PNA will turn Receiver Power Correction **OFF.**

If the original settings are restored, then receiver power calibration returns to full correction.

Saving Source and Receiver Power Calibration

Both Source and Receiver Cals are saved as part of the Instrument State; NOT as Calibration Data. Therefore, you can save them with either a .sta file, or a .cst file. If you would like to save measurement calibration data along with the Source or Receiver Cals, you must use a .cst file. Learn more about Saving PNA files types.

Calibration Standards

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This following section explains the general principles and terms regarding calibration kit files. To learn **how** to modify calibration kit files, See Modify Calibration Kits.

- About Calibration Kits
- Calibration Standards
- Standard Type
- Standard Definitions
- Class Assignments

See other Calibration Topics

About Calibration Kits

A calibration kit is a set of physical devices called standards. Each standard has a precisely known or predictable magnitude and phase response as a function of frequency.

In order for the analyzer to use the standards of a calibration kit, the response of each standard must be mathematically defined and then organized into standard classes that correspond to the error models used by the analyzer.

To be able to use a particular calibration kit, the known characteristics from each standard in the kit must be entered into analyzer memory or recalled from a default list of calibration kits stored in the analyzer.

Note: You can modify cal standard definitions and manage Version 1 Cal Kits with Cal Kit Manager.

For a list of standard calibration kits available, see Analyzer Accessories.

Calibration Standards

Calibration standards provide the reference for error-corrected measurements in the network analyzer. Each standard has a precisely known definition that includes electrical delay, impedance, and loss. The analyzer stores these definitions and uses them to calculate error correction terms.

During measurement calibration, the analyzer measures standards and mathematically compares the results with "ideal models" of those standards. The differences are separated into error terms that are later removed from device measurements during error correction.

Standard Type

A standard type is one of four basic types that define the form or structure of the model to be used with that standard. The four standard types are shown below:

Standard	Terminal Impedance
SHORT	zero ohms
OPEN	infinite ohms
LOAD	system impedance, Z0
THRU/LINE	no terminal impedance
ARBITRARY	user-defined

Standard Definitions

Standard definitions describe the electrical characteristics of the standards and the frequencies they will be used. Refer to the "standards definition table" included with the calibration kit. Standard definitions include:

- **Minimum Frequency** Specifies the minimum frequency the standard is used for calibration.

- **Maximum Frequency** Specifies the maximum frequency the standard is used for calibration.

- **Z0** Specifies the characteristic impedance of the standard (not the system characteristic impedance or the terminal impedance of the standard).

- **Delay** Specifies a uniform length of transmission line between the standard being defined and the actual calibration plane.

- **Type** Specifies type of standard (SHORT, OPEN, THRU/LINE, LOAD, ARBITRARY).

- **Loss** Specifies energy loss, due to skin effect, along a one-way length of coaxial cable.

Loss model equation:

- The value of loss is entered as ohms/second at 1 GHz.

- To compute the loss of the standard, measure the delay in seconds and the loss in dB at 1 GHz. Then use the following formula:

$$Loss\left(\frac{\Omega}{s}\right) = \frac{loss\ (dB) \times Z_0(\Omega)}{4.3429(dB) \times delay(s)}$$

Capacitance model equation:

C0, C1, C2, C3. Specifies the fringing capacitance for the open standard.

- $C = (C0) + (C1 \times F) + (C2 \times F^2) + (C3 \times F^3)$
- (F is the measurement frequency).
- The terms in the equation are defined when specifying the open as follows:
  - C0 term is the constant term of the third-order polynomial and is expressed in Farads.
  - C1 term is expressed in F/Hz (Farads/Hz).
  - C2 term is expressed in F/Hz^2.
  - C3 term is expressed in F/Hz^3.

Inductance model equation:

L0, L1, L2, L3. Specifies the residual inductance for the short standard.

- $L = (L0) + (L1 \times F) + (L2 \times F^2) + (L3 \times F^3)$
- (F is the measurement frequency).
- The terms in the equation are defined when specifying the short as follows:
  - L0 term is the constant term of the third-order polynomial and is expressed in Henries.
  - L1 term is expressed in H/Hz (Henries/Hz)
  - L2 term is expressed in H/Hz^2.
  - L3 term is expressed in H/Hz^3.

Class Assignments

Once a standard is characterized, it must be assigned to a standard "class". A standard class is a group of standards that are organized according to the calibration of the PNA error model.

The number of classes needed for a particular calibration type is equal to the number of error terms being corrected.

A class often consists of a single standard, but may be composed of multiple standards, such as loads or delay lines. Refer to the calibration kit "class assignment" table.

Example: A response calibration requires only one class, and the standards for that class may include an OPEN, or SHORT, or THRU. A 1-port calibration requires three classes. A full 2-port requires 10 classes, not including two for isolation.

The number of standards assigned to a given class may vary from none (class not used) to one (simplest class) to eight. Version 1 calibration kits allow up to eight standards assigned to a class, while Version 2 calibration kits allows as many standards assigned to a class as needed.

The different classes used in the PNA:

S11A, S11B, S11C

These are the three classes for port 1-reflection calibrations (three classes also for S22 and S33). They are used in the one-port calibrations and the full two-port calibration. They are required in calibrating the directivity, source match, and reflection tracking. Typically, these classes might consist of an open, a short and a load standard for each port.

Transmission and Match (forward and reverse)

These classes are used to perform a full two-port calibration. The transmission class relates

primarily to the transmission tracking, while the match class refers to load match. Transmission and match are explicitly defined for Version 2 calibration kits only. For both of these classes, the typical standard is a thru or delay.

Isolation

The isolation classes are used to perform a full two-port and the TRL two-port calibrations. They are explicitly defined for Version 2 calibration kits only. Version 1 calibration kits define these to contain a single standard, a load. The isolation classes apply to the forward and reverse crosstalk terms in the PNA error model.

TRL thru or line

These are used to perform a TRL two-port calibration. The TRL thru or line class should contain a thru standard or a short line. If it contains a non-zero length line standard, then the calibration type is called LRL or LRM.

TRL reflect

This class is used to perform a TRL two-port calibration. The TRL reflect class should contain a standard with a high reflection coefficient, typically an open or short. The actual reflection coefficient need not be known, but its phase angle should be specified approximately correctly (± 90 deg). The exact same reflection standard must be used on both ports in the TRL calibration process.

TRL line or match

These are used to perform a TRL two-port calibration. The TRL line or match class should contain line standards, load standards, or both. If a line standard is used, its phase shift must differ from that of the TRL thru/line standard by 20° to 160°. This limits the useable frequency range to about 8 to 1. Two or more line standards of different lengths may be specified to get broader frequency coverage. It is also common to include a load standard for covering low frequencies, where the line's length would be impractically long. When a load is used, the calibration type is called TRM or LRM.

Note: For more information, read application note 8510-5A, "*Specifying Calibration Standards for the Agilent 8510 Network Analyzer*". Although the application note is written for the Agilent 8510 series of network analyzers, it applies to the PNA as well. The part number for the publication is 5956-4352.

TRL Calibration

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TRL (Thru - Reflect - Line) represents a **family** of calibration techniques that measure two transmission standards and one reflection standard to determine the 2-port 12-term error coefficients. For example, TRM (Thru - Reflect - Match) is included in this family. The traditional SOLT calibration measures one transmission standard (T) and three reflection standards (SOL) to determine the same error coefficients.

- Why Perform a TRL Cal?
- TRL Cal Kits
- Cal Standards Used in TRL
- TRL Options
- TRL Calibration Process

Note: You can only perform a TRL cal on PNA models with 2 ports and 4 receivers. These include the following models: E8356A, E8357A, E8358A, E8362A, E8363A, and E8364A.

Why Perform a TRL Cal?

TRL Cal is performed when you require a high level of accuracy and do not have calibration standards in the same connector type as your DUT. This is usually the case when using test fixtures, or making on-wafer measurements with probes. Therefore, in some cases you must construct and characterize standards in the same media type as your DUT configuration. It is easier to manufacture and characterize three TRL standards than the four SOLT standards.

TRL calibration is extremely accurate, in some cases more accurate than an SOLT cal. Calibrating over a broad frequency range (for example 2GHz to 26 GHz) requires two LINE standards. A limitation for TRL cal with broad frequency coverage is the requirement for multiple LINE standards. For example, a span from 2 GHz to 26 GHz requires two line standards. Also, for lower frequencies, the LINE standard can be too long for practical use.

TRL Cal Kits

Agilent Technologies offers two cal kits that include the required standards to perform a TRL calibration: 85050C (APC 7mm) and 85052C (3.5mm). Both kits include the traditional Short, Open, and Load standards. (The Thru standard, not actually supplied, assumes a zero-length Thru). In addition, the kits include an airline which is used as the LINE standard. To use the airline, the kits include an airline body, center conductor, and insertion / extraction tools. The APC 7 kit includes an adapter to connect airline to the APC connector.

Cal Standards Used in TRL

THRU

- The THRU standard can be either a zero-length or non-zero length. However, a zero-length THRU is more accurate because it has zero loss and no characteristic impedance.
- The THRU standard can not be the same electrical length as the LINE standard.
- If the insertion phase and electrical length are well-defined, the THRU standard may be used to set the reference plane.

REFLECT

- The REFLECT standard can be anything with a high reflection, as long as it is the same when connected to both PNA ports.
- The actual magnitude of the reflection need not be known.
- The phase of the reflection standard must be known within 1/4 wavelength.
- If the magnitude and phase of the reflection standard is well-defined, the standard may be used to set the reference plane.

LINE

The LINE standard establishes the reference impedance for the measurement after the calibration is completed. TRL calibration is limited by the following restrictions of the LINE standard:

- Must be of the same impedance as the THRU standard
- The electrical length need only be specified within 1/4 wavelength.
- Cannot be the same length as the THRU standard.
- Must be an appropriate electrical length for the frequency range: at each frequency, the phase difference between the THRU and the LINE should be greater than 20 degrees

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and less than 160 degrees. This means in practice that a single LINE standard is only usable over an 8:1 frequency range (Frequency Span / Start Frequency). Therefore, for broad frequency coverage, multiple lines are required.

- At low frequencies, the LINE standard can become too long for practical use. The optimal length of the LINE standard is 1/4 wavelength at the geometric mean of the frequency span (square root of f1 x f2).

MATCH

If the LINE standard of appropriate length or loss cannot be fabricated, a MATCH standard may be used instead of the LINE.

- In the TRL computation, this standard is treated as a high-loss, infinite length transmission line.

- The MATCH standard is a low-reflection termination connected to both Port 1 and Port 2.

- The impedance of the MATCH standard becomes the reference impedance for the measurement.
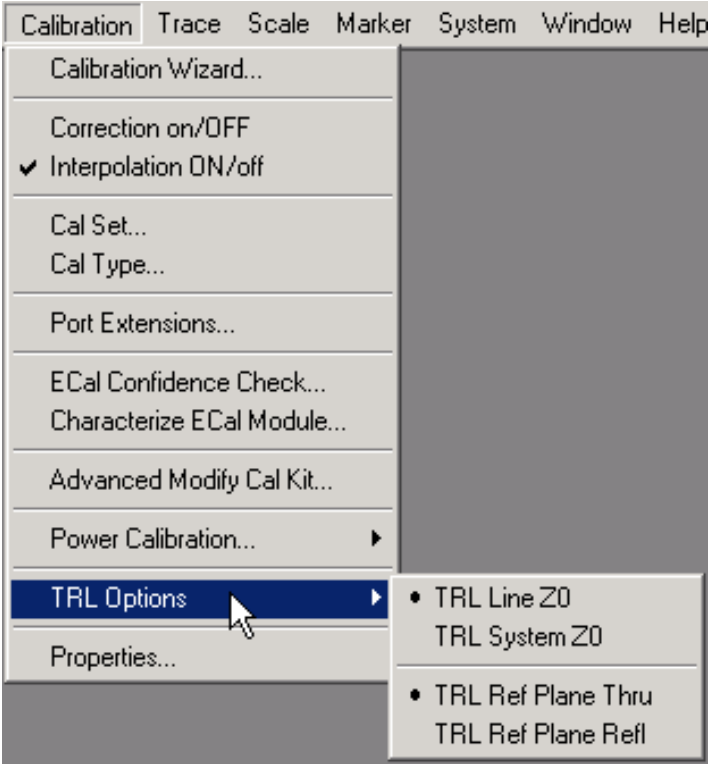
Note: Find more information about TRL standards at http://www.tm.agilent.com. Click "Technical Support". Use "Application Notes" to search for App Note 8510-5A (part number 5956-4352). Although the application note is written for the Agilent 8510 Series Network Analyzers, it also applies to the PNA.

Also see Calibration Standards for more information about creating and modifying Calibration kit definitions.

How to set TRL Options
Use one of the following methods:

- Click **Full TRL 2-PORT** from within the **Cal Wizard, Unguided Cal**

Learn more about using the front panel interface

Select Calibration Type dialog box help

TRL Reference Plane

Thru - The THRU standard is used to establish the position of the measurement reference plane. Select if the THRU standard is zero-length or very short.

Reflect - The REFLECT standard is used to establish the position of the measurement reference plane. Select if the THRU standard is not appropriate AND the delay of the REFLECT standard is well defined.

TRL Impedance

Line Z0 - The impedance of the line standard is used as the reference impedance, or center of the Smith Chart. Any reflection from the line standard s assumed to be part of the directivity error.

System Z0 - The system impedance is used as the reference impedance. Choose when the desired test port impedance differs from the impedance of the LINE standard.

TRL Cal Process

The following describes a typical process for a TRL calibration. This process assumes that you already have calibration standards defined and included in the PNA.

1. Preset the PNA
2. Connect the DUT to the PNA
3. Set up a S-parameter measurement and the desired stimulus settings.
4. Click **Calibration / Calibration Wizard...**.
5. Click **Unguided Cal / Use Mechanical Stds**
6. Click **Full TRL 2-Port Cal**. Select appropriate TRL Options**.**
7. Click **Select Cal Kit.** Select the cal kit that you will be using for the TRL cal.
8. Follow the prompts to complete the calibration.
9. Check the accuracy of the calibration

Fixturing Macro

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This macro allows you to compensate your PNA measurements for the effects of test fixtures or other external components. Using this macro you can do the following:

- Add Port Extensions with or without loss

- Modify the Reference Impedance of the measurement port

- Embed or De-embed a two-port device

The compensation which results from these operations is applied to specific ports and channels.

For example, you can measure a DUT in a 50 ohm, 75 ohm, and 100 ohm environment by creating three measurement channels, each channel at a different reference impedances. No physical connection changes are required.

How to start the Fixturing Macro
1. Press the Macro key repeatedly until Fixturing appears on the Active Entry screen area.
2. Press the corresponding Active Entry key.
Learn more about using the front panel interface
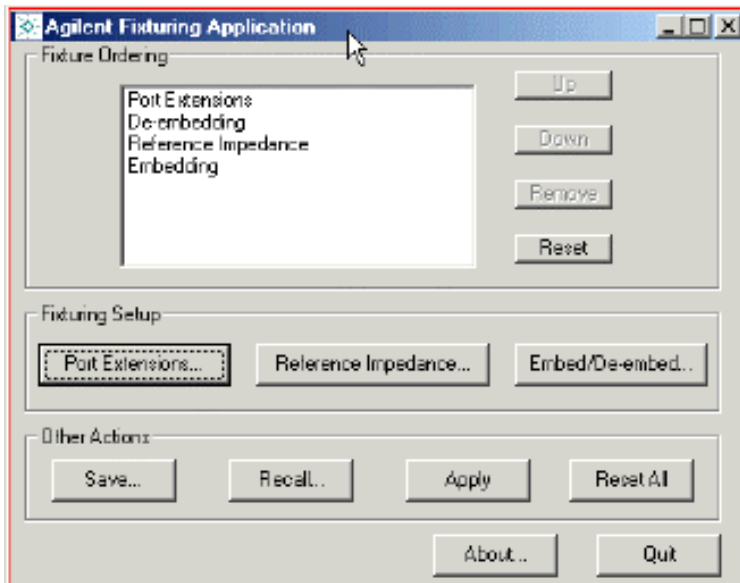
Agilent Fixturing Macro dialog box help
Fixture Ordering
Different results will occur depending on the order in which these operations are performed. For example, applying a port extension and then embedding a fixture will not give the same results as embedding followed by applying a port extension.
To reorder the operations:
1. Select one of the fixturing operations.
2. Use **Up** and **Down** buttons to reorder the operations as necessary

3. **Remove** any operation that will not be used.

Reset Restores all operations to the default order.

Fixturing Setup

Port Extension Invokes the Port Extensions dialog box.

Reference Impedance Invokes the Reference Impedance dialog box.

Embed/De-Embed Invokes the Embed/De-Embed dialog box.

Other Actions

Save Saves the fixturing information for later recall, eliminating the need to re-enter parameters.

Recall Recalls a previously saved fixturing file. Click Apply to apply the recalled fixturing information.

Apply Modifies the PNA error coefficients to include the fixturing information.

Note: Click **Apply** after a file is recalled to implement the compensation on the current measurements.

Reset All   Restores the default order of the fixturing operations.
 Clears the data entered on the individual operational dialogs.
 Restores the original calibration.
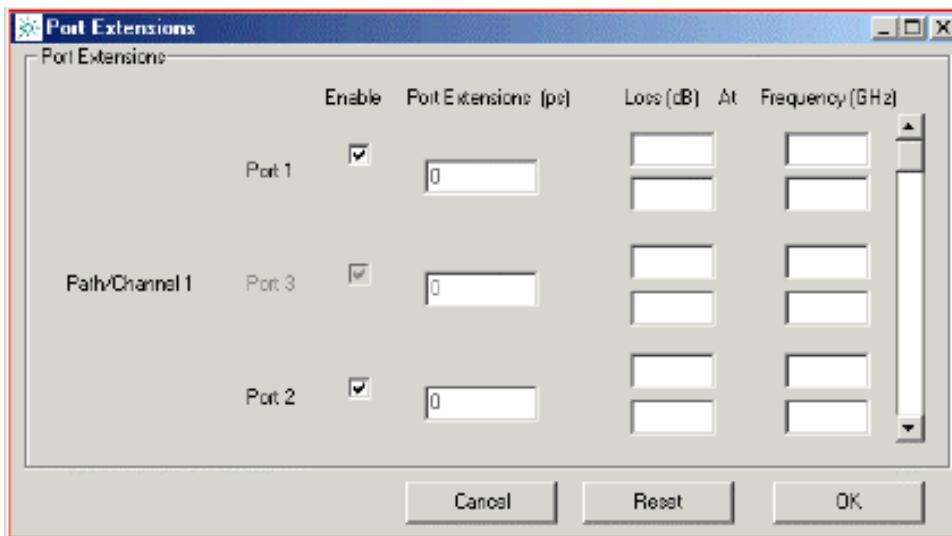
Port Extensions dialog box help
Note: Port Extensions apply to individual ports on EACH CHANNEL. Use the scroll bar (far right of dialog box) to scroll to the appropriate channel.
Enable Check to enable port extension on the associated PNA port.
Port Extensions (ps) The amount of extension entered in picoseconds. This value will be reflected in the corrected measurement as a corresponding phase rotation.
Loss(dB) At Frequency One or two loss values may be associated with a Port Extension value.
If one loss value is specified with no frequency value, that loss is taken as a constant across all frequencies. If loss is specified at one frequency, then the loss is extrapolated such that:

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L(f) = Loss (1 GHz) * f ^.5

Where:
  L(f) is the loss in dB at the frequency of measurement in GHz
  Loss(1 GHz) is the loss in dB at 1 GHz.

If loss is specified at two frequencies, then the loss is extrapolated for all frequencies such that:

  L(f) = L * f ^n
  n = (log (L1/L2)) / (log (f1/f2))
  L = L1 / f1^n

Where:
  L1 and L2 are the loss in dB at f1 and f2 (in GHz) respectively.

OK Saves the entries

Reset Restores the form back to default values

Cancel Exits without saving the entries.

Learn about Port Extensions

Reference Impedance dialog box help
The reference impedance algorithm corrects the measurement and displays the results as if the measurement had been made into a reference impedance of the specified value. The physical port termination is still approximately 50 ohms.
Note: Reference Impedance applies to individual ports on EACH CHANNEL. Use the scroll bar (far right of dialog box) to scroll to the appropriate channel.
R Resistance part of the desired reference impedance for the specified port and channel.
X Reactance part of the desired reference impedance for the specified port and channel.
Cancel Exits without saving the entries.
Reset Restores the form to default values
OK Saves the entries
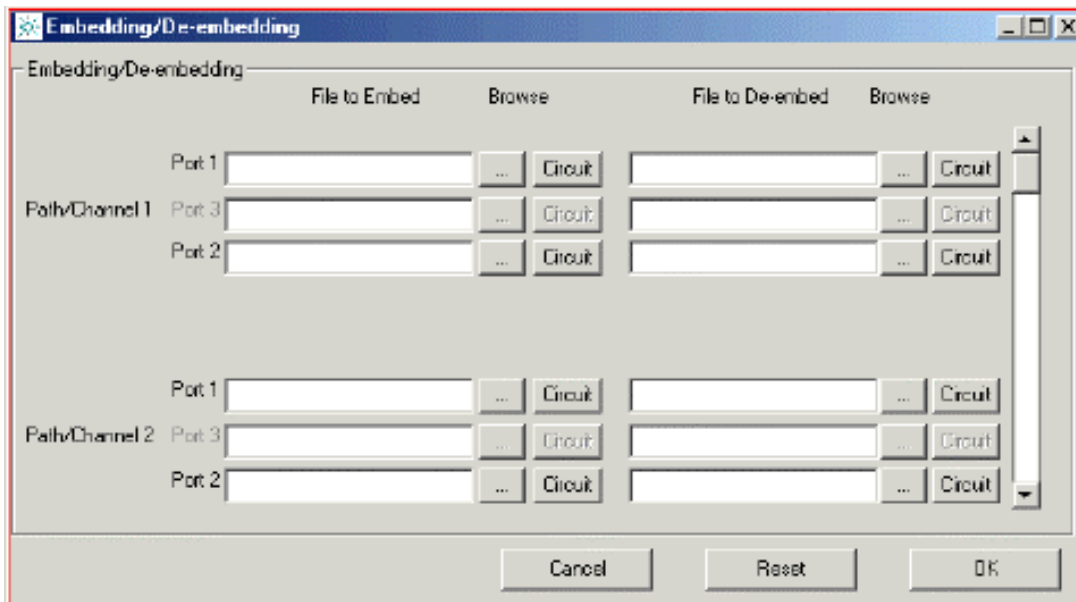
Embed/De-Embed dialog box help
Embedding is used to **add** the effect of a device to the measurement results. For example, you could add a reactive load that is not currently in place.
De-embedding is used to **remove** the unwanted effects of a device from the measurement results. For example, you could remove the effects of a test fixture.
The embedding/de-embedding operation creates and recalls an s2p file (Touchstone format) for a 2-port device. The file includes the electrical characteristics of a supplemental fixture or device. The file can be in any standard format (real-imaginary, magnitude-angle, dB-angle) and can represent any 2-port device.
Note: In all cases, Port 1 of the supplemental device is assumed to be connected to the PNA and Port 2 of the device is assumed to be connected to the DUT.
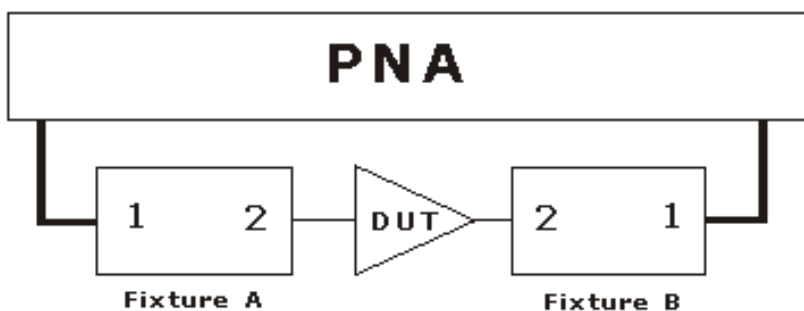
 |
| Do one of the following for each port on each channel:

Type the full path name of the file to be embedded or de-embedded in the appropriate box.

Browse Finds a file that already exists.

Circuit Creates a file by starting the Circuit Characteristics dialog box |
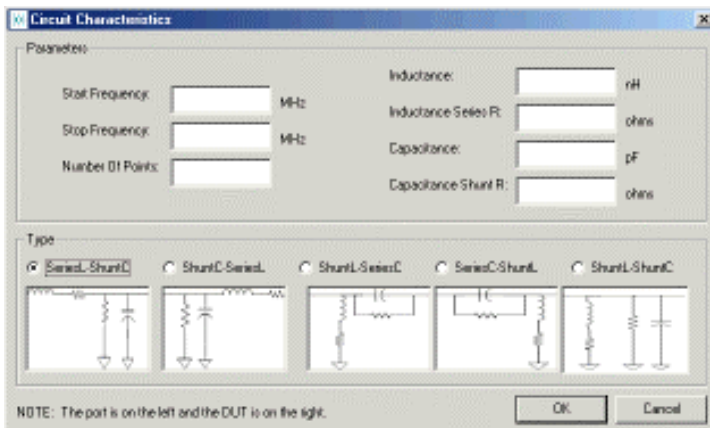
Circuit Characteristics dialog box help
Allows the design of one of several simple matching circuits. This circuit simulates the device that you are embedding or de-embedding.
Note: The PNA is always on the left and the DUT is always on the right of the circuit.

Parameters
 	
    Start Frequency Start frequency of the measurement that the compensation will be applied to.
 	
    Stop Frequency Stop frequency of the measurement that the compensation will be applied to.
 	
    Number of Points Number of data points of the measurement that the compensation will be applied to.
 	
    Inductance, Inductance Series R, Capacitance, Capacitance Shunt R Values for the specific components of the circuit type that models the supplemental device. Capacitance and Capacitance Shunt R are not allowed to be zero.

Type Type of circuit to be created that matches the fixture
OK Creates a Touchstone (.s2p) data file for the specified circuit. Provide a file name when prompted. The Circuit Characteristics dialog box then closes. **Cancel** Exits without saving the entries.

Cal Kit Manager

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This program allows you to choose any 10 Agilent Cal Kits for active use as Version 1 Cal Kits in the PNA.

- Modes of Operation
- Start Cal Kit Manager
- Version 1 Cal Kit Structure
- Using Cal Kit Manager
  - Replacing Active Cal Kits
  - Changing the Order of Active Cal Kits
  - Saving an Active Cal Kit to the Library
  - Deleting a Cal Kit from the Library
  - Saving Active Cal Kits as Defaults

- Viewing the Default Cal Kits
- Restoring Factory Defaults
- Editing Cal Kits
- Importing 8510 Cal Kits
- Example Usage

Modes of Operation

For full capability, this program should either be installed on a PNA, or a PC with a LAN connection to a PNA. To learn how to connect to a PNA from a PC, see Drive Mapping.

On a PC without a PNA connected, the program can ONLY be used in edit mode. In edit mode, cal kits can be created, modified, or imported. However, the resulting files will have to be transferred to the PNA using a floppy disk or other method.

Note: This program is fully functional only on PNA's using release code A.02.xx or later.

Start Cal Kit Manager

To start Cal Kit Manager on the PNA, on the **System** menu, click **Service** then click **Cal Kit Manager**.

To install and start Cal Kit Manager from a PC:

1. From the PNA, Map a drive to your PC.
2. Click **View** then click **Minimize Application**.
3. On the PNA desktop, click Windows Explorer.
4. Copy C:\Program Files\Agilent\Network Analyzer\CalKit Ver 1 Files\CalKitMngr_Install.exe to your PC. You can also transfer the file using a floppy disk.
5. Double-click on the file to install and start the program on your PC.

Version 1 Cal Kit Structure

To understand how this program works, you first must understand how the PNA uses Version 1 Cal Kits.

Although you can access and modify 10 Version 1 Cal Kits in the PNA, there are actually 30 Cal Kits stored in the PNA; 10 each in the following three groups:

1. Active There are ten active Cal Kits in the PNA. You can actively use these kits for calibration and modify the standards and definitions. As the PNA is shipped, Cal Kits 1 through 7 are popular Agilent Cal Kits. Kits 8 through 10 are identical to kit 1, but named User Cal Kit. These numbers vary with PNA models. The contents of all ten kits are contained in a single file on the PNA named **user calkitfiles**.

2. Default There are ten Default Cal Kits. As shipped, these are identical to the Active Cal Kits except that they are contained in ten separate files named **default calkitfile1** through **10**. The data in these files is copied to the Active Cal Kit file whenever selecting **Restore default kit** or **Restore All default kits.** You can replace Default Cal Kits within Cal Kit Manager, but not within the PNA application.

3. Factory Default There are 10 factory default Cal Kits. Factory default Cal Kits are stored in the PNA application. They cannot be modified. They are used to restore the default files if necessary.

Using Cal Kit Manager

Cal Kit Manager allows you to change the 10 Active Cal Kits, and the 10 Default Cal Kits, in the PNA. The Cal Kit Manager displays two lists of Cal Kits:

1. The left pane, **Available Cal Kits,** displays the names of all Cal Kits stored in the Cal Kit library directory (C:\...).

2. The right pane, **User-Defined Cal Kits,** displays the names of the 10 currently active Cal Kits in the PNA.

Cal Kit descriptions can contain up to 50 characters. You can view the description of a Cal Kit in the lower text box by selecting the kit. Cal Kits are displayed by Cal Kit descriptionnot by File Name.

Replacing Active Cal Kits

You can replace any Cal Kit in the Active list (right pane) with one of the library Cal Kits (left pane).

1. Select the library kit you want to add.

2. Select the Active Cal Kit you wish to replace.

3. Click **Replace**.

4. After all of your replacements are made, click **Make Changes** to save the changes on the PNA.

Changing the Order of Active Cal Kits

You can change the numerical order of the Active Cal Kits.

1. Select a kit in the left pane.

2. Click **Move Up** or **Move Down**.

3. Click **Make Changes** to save the order on the PNA.

Saving an Active Cal Kit to the Library

Active kits that have been modified in the PNA can be stored in the library using Cal Kit manager. This provides a backup for your modified Cal Kits.

1. Select the Active kit (left pane).

2. Click **Save As** Available Cal Kit.

Library Cal Kits that you have moved to the Active Cal Kit section cannot be immediately re-saved to the library.

Deleting a Cal Kit from the Library

You can delete a Cal Kit from the library

1. Select the Available Kit.

2. Click **Delete file**.

3. At the warning, click **OK** to delete the file. Read-only files (those supplied by Agilent) will result in another confirmation prompt.

To restore the file, you must reinstall Cal Kit Manager.

Saving Active Cal Kits as Defaults

You can save your Active Cal Kits as the Default Cal Kit.

1. Click **Make Changes**.

2. At the **Save Current Active Cal Kits as Defaults?** prompt, click **Yes** to overwrite the existing Default Cal Kits.

Viewing the Default Cal Kits

You can view the ten current PNA default Cal Kits.

Click **View Default Cal Kits**. No changes are made; this is informational only.

Restoring Factory Defaults

You can restore the Default Cal Kits to the original Factory Default Cal Kits.

1. Click **Restore Factory Defaults**. The changes are made immediately.

2. Restart the PNA application (not the entire instrument) to complete these changes.

Editing Cal Kits

You can edit the contents of any of the library cal kits.

Note: Edit Mode is not available when using Windows 95/98/ME operating systems.

1. In the left pane, select a Cal Kit to edit.

2. Click **Edit**. The edit screen that appears is similar to that of the Advanced/Modify cal kit selection on the PNA.

3. When editing is complete, either:

- Click **Save** to save the file using the same filename.

- Click **Save As** to save the file using a different filename.

4. Click **Create Text File** to create a text file with a summary of the entire cal kit. This is useful for archival and reference information.

Importing 8510 Cal Kits

8510 Cal Kits can be imported into the PNA if they are stored on a DOS formatted disk. LIF formatted disks are not supported.

PNA Version 1 Cal Kits end in a ".ck1" suffix.

Note: The 8510 allows 21 standards, while the PNA currently supports only 8 standards. Therefore, you may have to create 2 PNA cal kits from a single 8510 cal kit, with one being for SOLT calibrations and the other for TRL calibration.

From the main menu, click **Import**.

For more information, click **Help** on the Import screen.

Note: The default save location is your PC's C:\ drive. If you have mapped the PNA to this PC, and you wish to save the files to the mapped PNA, you must select the mapped drive letter. Failure to do this will result in the file being stored on the PC.

Example Usage

Assume you need 3 customized cal kits that you will use frequently on several analyzers. The three kits are identical except for the length of an offset short which is 3 cm, 4 cm, and 5 cm.

1. In the left pane, select a Cal Kit with properties similar to your requirements.

2. Click **Edit** and modify the properties to meet the requirements of the 3cm Cal Kit.

3. Click **Save As (Available Cal Kit)**.

4. Type a unique filename (**Special_3cm**) and click **Save**. All Version 1 cal kits must have a .ck1 file extension.

5. Repeat steps 2 through 5 to create Special_4cm and Special_5cm Cal Kits.

6. In the left pane, select **Special_3cm**.

7. In the right pane, select one of the User cal kits to be replaced. There can be only 10 Cal Kits in the User Cal Kit section.

8. Click **Replace** to make Special_3cm available in the PNA.

9. Repeat steps 6 through 8 for the Special_4cm and Special_5cm Cal Kits.

10. Click **Make Changes** to make the changes permanent.

4. Analyze Data

Markers

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The Markers function provides a numerical readout of measured data, a search capability for specific values, and can change stimulus settings. There are 9 regular markers and one Reference marker available per trace. This topic discusses all aspects of markers.

Note: Marker Readout can be turned ON / OFF and customized from the **View** menu. See Marker Readout

- Creating and Moving Markers
- Delta Markers
- Searching with Markers
- Marker Functions (Change Instrument Settings)
- Advanced Marker Settings
- Marker Table

Other Analyze Data topics

How to Create and Move Markers
Use one of the following methods:

- Active Entry toolbar

- Marker toolbar
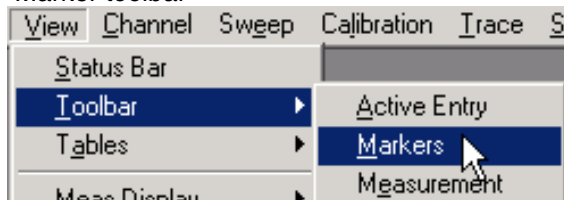
- Marker dialog box
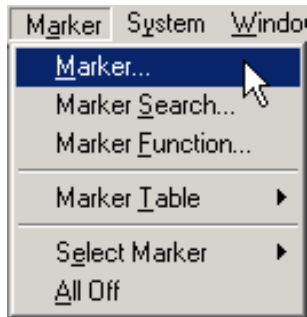
Learn more about using the front panel interface

Create a Marker

- From the Active Entry toolbar, press a marker number. To access markers 4 through 9,

  press [Marker] repeatedly.

- From the Marker Toolbar or Marker Dialog Box, select a marker number and click **ON**

Moving a Marker

To move a marker, make the marker active by selecting its number (in any of the previous 3 methods. Then change the stimulus value using any of the following methods:

- Type a value

- Scroll to a stimulus value using the up / down arrows

- Click the stimulus box, then use the front-panel knob.

Note: To change marker properties, the marker must be active. The **active marker** appears on the analyzer display as ∇. All of the other markers are inactive and are represented on the analyzer display as Δ.
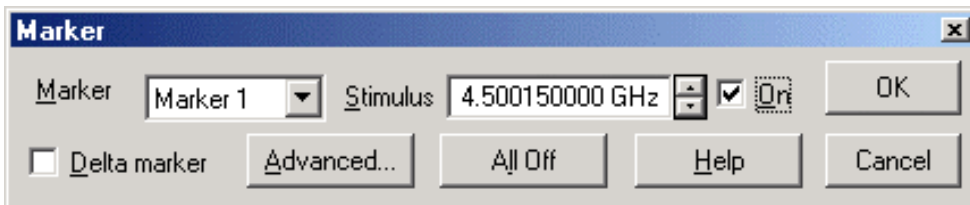
Marker dialog box help
Marker Specifies the marker number that you are defining.
Stimulus Specifies the X-axis value of the selected marker. To change stimulus value, type a value, use the up and down arrows, or click in the text box and use the front-panel knob.
On Check to display the marker and corresponding data on the screen.
Delta Marker Check to make the specified marker data relative to the reference marker. If not already on, the reference (R) marker will be displayed automatically. Learn more about Delta Markers
Advanced... Invokes the Advanced Markers dialog box.
All Off Switches OFF all markers on the active trace.

Delta Markers

Delta Markers allow you to view data that is relative to the **reference** marker.

A delta marker can be set from the Marker dialog box or the Marker Toolbar.

When a Delta marker is created, the reference marker will be activated automatically.
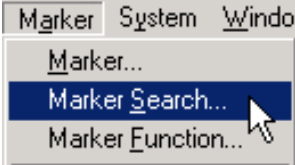
Searching with Markers

You can use markers to search measurement data for specific criteria.

If there is no valid data match for any of the search types, the marker will not move from its current position.

How to Search with Markers
Use one of the following methods: •   Only **Max, Min, Left Peak**, and **Right Peak** search types are available from Active Entry Keys   Learn more about using the front panel interface
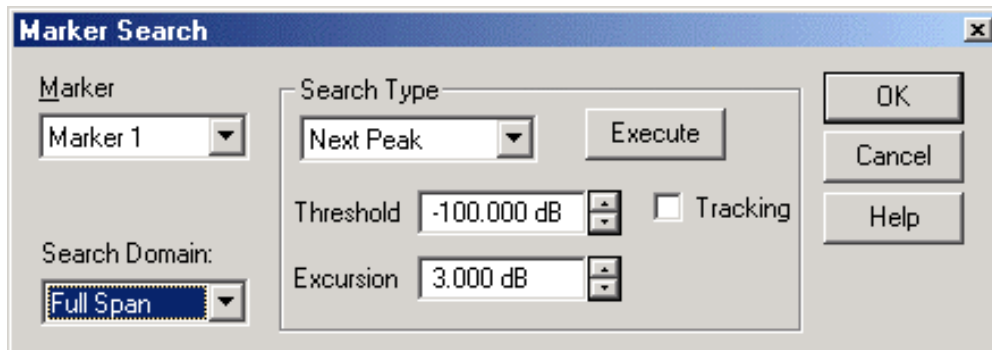
Marker Search dialog box help
Marker Specifies the marker that you are defining.
Search Domain Defines the area where the marker can move or search. For full span, the marker searches for specified values within the full measurement span. For user span, the marker searches for specified values within a measurement span that you define. Learn more about Search Domain.

Search Type
 	
     Maximum Marker locates the maximum (highest) data value.
 	
     Minimum Marker locates the minimum (lowest) data value.
 	
     Next Peak Marker locates the peak with the next lower amplitude value relative to its starting position. See What is a Peak.
 	
     Peak Right The marker locates the **next valid peak to the right** of its starting position on the X-axis .See What is a Peak.
 	
     Peak Left The marker locates the **next valid peak to the left** of its starting position on the X-

axis .See What is a Peak.

- **Threshold** - Minimum amplitude (dB). To be considered valid, the peak must be **above** the threshold level. The valley on either side can be below the threshold level.

- **Excursion** The vertical distance (dB) between the peak and the valleys on both sides. To be considered a peak, data values must "fall off" from the peak on both sides by the excursion value.

Target Enter the Target value. The marker moves to the first occurrence of the Target value **to the right of its current position**. Subsequent presses of the Execute button cause the marker to move to the next value to the right that meets the Target value. When the marker reaches the upper end of the stimulus range, it will "wrap around" and continue the search from the lower end of the stimulus range (left side of the window).

- If **Discrete Marker** is OFF, the marker locates the interpolated data point that equals the target value.

- If **Discrete Marker** is ON and there are two data points on either side of the target value, the marker locates the data point closest to the Target value

Bandwidth Marker1 locates the highest peak which falls off on both sides by the specified level. (When Bandwidth is selected, a Level box appears to specify the level in dB down from the peak where bandwidth is measured - default is -3dB.)

This search type always uses Markers 1-4.

- Marker 1: Peak

- Marker 2: Specified level down to the left of the peak

- Marker 3: Specified level down to the right of the peak

- Marker 4: Center frequency of the bandwidth

Display readout for Bandwidth Search:

- **BW**: (Marker 3 x-axis value) - (Marker 2 x-axis value) = width of the filter

- **Center** Mathematical midpoint between markers 2 and 3

- **Q** Ratio of Center Frequency to Bandwidth (Center Frequency / Bandwidth)

- **Loss** Y-axis value of Marker 4. This is the loss of the filter at its center frequency. The ideal filter has no loss (0 dB) in the passband.

Note: You must either press **Execute** or check **Tracking** to initiate all search types.

Execute Click to cause the marker to search for the specified criteria.

Tracking Check to cause the marker to search for the specified criteria with each new sweep. The searches begin with the first sweep after Tracking has been checked, based on the current search type and domain information. Therefore, make sure that the search criteria are in the desired state before using the data. You cannot manually change the stimulus setting for a marker if Tracking is selected for that marker.

What Is a "Peak"?

You define what the analyzer considers a "peak" by selecting the following two peak criteria settings:

- **Threshold** - Minimum amplitude (dB). To be considered valid, the peak must be **above** the threshold level. The valley on either side can be below the threshold level.

- **Excursion** - The vertical distance (dB) between the peak and the valleys on both sides. To be considered a peak, data values must "fall off" from the peak on both sides by the

excursion value.

Example:

Threshold Setting: -10dB
Excursion Setting: 1dB
Scale = 1 dB / Division
Mouse over the graphic to find a valid peak.
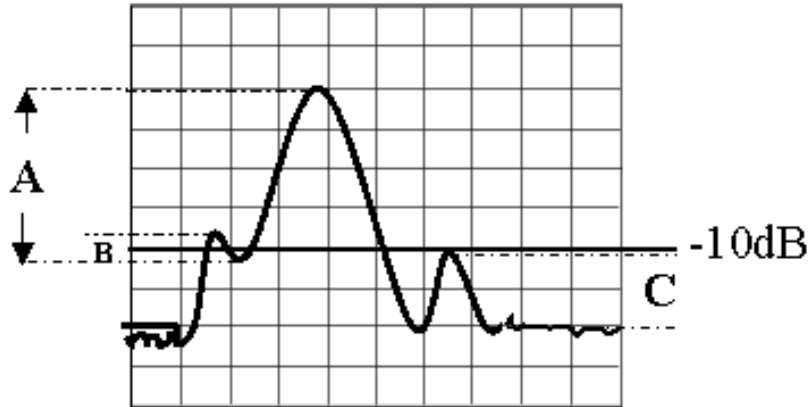
Peak A = Valid Peak (Above Threshold and Excursion Settings)
Peak B = Invalid Peak (Below Excursion Setting)
Peak C = Invalid Peak (Below Threshold Setting)

Search Domain

Search domain settings restrict the stimulus values (X-axis for rectangular format) to a specified span. Set the Start and Stop stimulus settings of these **User** spans. If Start is greater than Stop, the marker will not move.

- The default domain of each new marker is "full span".

- There are 9 user-defined domains for every channel.

- The user-defined domains can overlap.

- More than one marker can use a defined domain.

The graphic below shows examples of search domains.

User 1   User 3   User 2
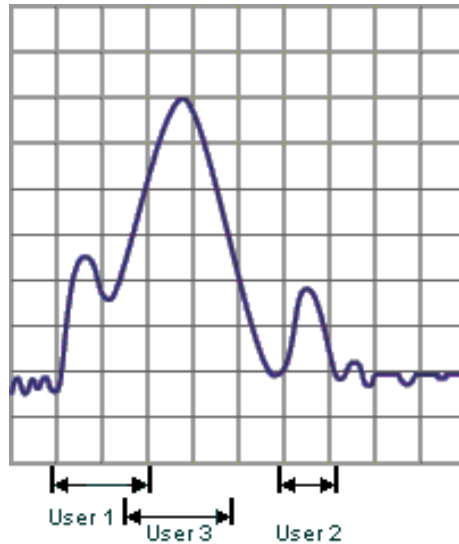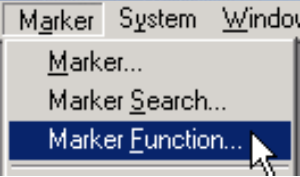
Marker Functions - Change Instrument Settings

The following settings change the relevant PNA settings to the position of the active maker.

How to change instrument setting using markers
Use one of the following methods:
Only **Center, Ref Level**, and **Delay** are available
• From the Marker Toolbar only Start, Stop Center and Span Frequencies are available.
Learn more about using the front panel interface
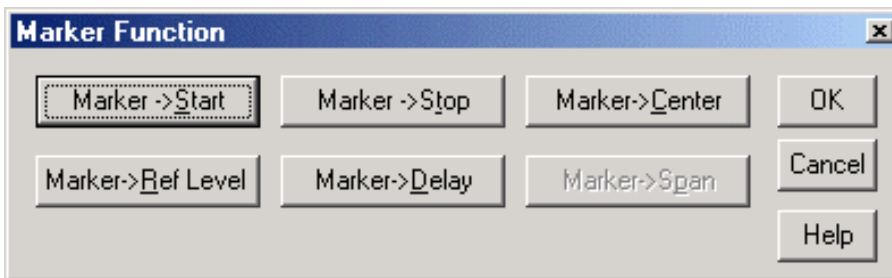
Marker Function dialog box help
Marker =>Start Sets the start sweep setting to the value of the active marker.
Marker =>Stop Sets the stop sweep setting to the value of the active marker.
Marker =>Center Sets the center of the sweep to the value of the active marker.
Marker =>Ref Level Sets the screen reference level to the value of the active marker.

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Marker =>Delay The phase slope at the **active marker** stimulus position is used to adjust the line length to the receiver input. This effectively flattens the phase trace around the active marker. (Additional Electrical Delay adjustments are required on devices without constant group delay over the measured frequency span.) You can use this to measure the electrical length or deviation from linear phase.

This feature adds phase delay to a variation in phase versus frequency; therefore, it is only applicable for ratioed measurements. (See Measurement Parameters.)

Marker =>Span Sets the sweep span to the span that is defined by the delta marker and the marker that it references. Unavailable if there is no delta marker.

How to select Advanced Marker settings
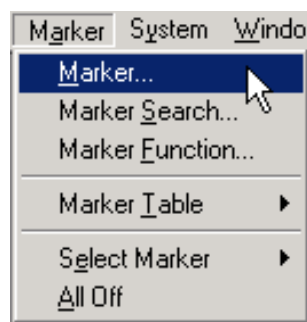
Then click **Advanced** on the Marker dialog box

Learn more about using the front panel interface
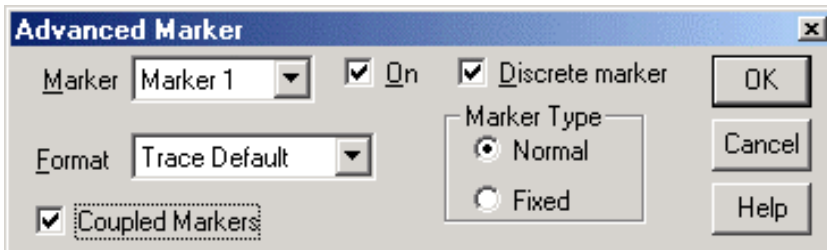
Advanced Marker dialog box help

Marker Specifies the marker number that you are defining.

On Check to display the marker and corresponding data on the screen.

Format Displays the marker data in a format that you choose. The marker format could be different from the grid format. In the default setting, the marker and grid formats are the same.

Discrete Marker Check to display values at only the discrete points where data is taken. Clear to display values that are interpolated from the data points.

Coupled Markers Check to couple markers by marker number, 1 to 1, 2 to 2 and so forth. The markers will remain coupled until this box in unchecked. Learn more about coupled markers.

Marker Type

  Normal Has a fixed stimulus position (X-axis) and responds to changes in data amplitude (Y-axis). It can be scrolled left and right on the X-axis by changing the marker stimulus value. Use this marker type with one of the marker search types to locate the desired data.

  Fixed Has a fixed X and Y-axis position based on its placement on the trace when it was set to

fixed. It does NOT move with trace data amplitude. It can be scrolled left and right on the X-axis by changing the marker stimulus value.

Use this marker type to quickly monitor "before and after" changes to your test device. For example, you could use fixed markers to record the difference of test results before and after tuning a filter.

Coupled Markers

The coupled markers feature causes markers on different traces to line up with the markers on the selected trace. Markers are coupled by marker number, 1 to 1, 2 to 2, 3 to 3, and so forth. If the x-axis domain is the same (such as frequency or time), coupling occurs across all channels, windows, and traces. Trace markers in a different x-axis domain will not be coupled. If a trace marker has no marker to couple with on the selected trace, the marker remains independent.

Coupled Markers Model

This model simulates the use of coupled markers in the PNA
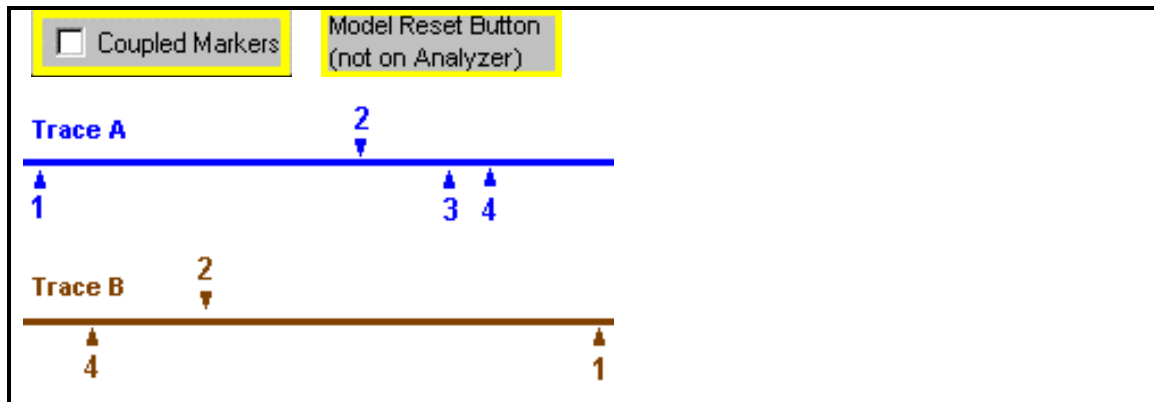
1. Click **Trace A** or **Trace B**

2. Click **Coupled Markers**

3. Notice the following:
    * Markers on the unselected trace move to the x-axis position of the selected trace.
    * If a marker number on the unselected trace has no corresponding marker on the selected trace, no movement occurs for that marker.

4. Click **Reset** to run the model again. (There is no Reset for coupled markers on the PNA.)

Set Coupled Markers from the Advanced Markers dialog box.

Marker Table

You can display a table that provides a summary of marker data for the active trace. The marker data is displayed in the specified format for each marker.

How to view the Marker Table
Use one of the following methods:

Learn more about using the front panel interface

Note: The Marker Table and Marker Readout can also be turned on from the **View** menu. (See Customize Your Analyzer Screen.)

Manipulate Data Using Math Operations

You can perform four types of math on the active trace and a memory trace. In addition three statistics (Mean, Standard Deviation and Peak to Peak) can be calculated and displayed for the active data trace.

- Trace Math
- Trace Statistics

Other Analyze Data topics

Trace Math

To perform any of the math operations, you must first store a trace to memory. You can display the memory trace using the View options.

Trace math is performed on the complex data before it is formatted for display.

Markers can be used while viewing the memory trace.

How to select Trace Math

Use either of the following methods:
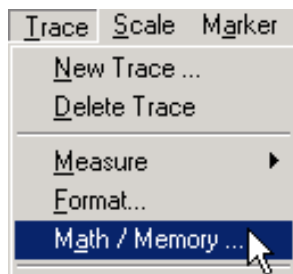
Only the following are available from Active Entry

- **Data>>Mem** (stores Data trace into Memory)

- **Data/Mem** (math operation: Data divided by memory)

- **Data Only** (display data trace only)

- **Data&Mem** (displays both data and memory traces)

Learn more about using the front panel interface
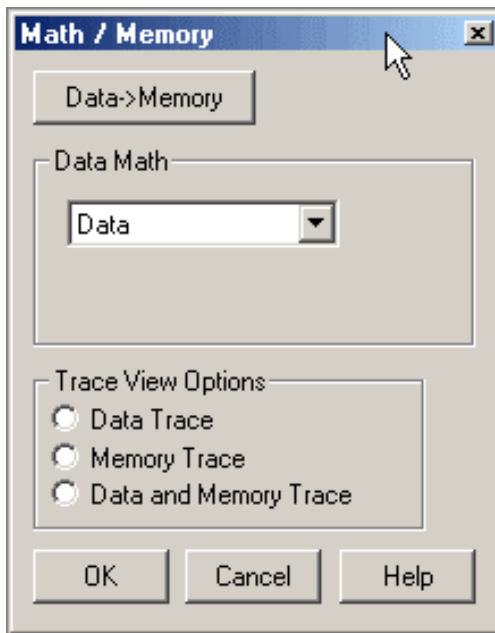
Math / Memory dialog box help

Data=>Memory Puts the active data trace into memory.

Data Math

   Data Does no mathematical operation.

   Data / Memory - Current measurement data is divided by the data in memory. Use for ratio comparison of two traces, such as measurements of gain or attenuation.

   Data – Memory - Data in memory is subtracted from the current measurement data using vector subtraction on complex measurement data. For example, you can use this feature for storing a measured vector error, then subtracting this error from the DUT measurement.

   Data + Memory - Current measurement data is added to the data in memory.

   Data * Memory - Current measurement data is multiplied by the data in memory.

Learn more about using the previous two features

Trace View Options

   Data Trace Displays the current measurement trace only.

   Memory Trace Displays the trace that was put in memory only.

> **Data and Memory Trace** Displays both the current measurement trace and the trace that was put in memory.
>
> Learn more about Trace Math (scroll up)

Data * Memory and Data + Memory

Use **Data * Memory and Data + Memory** to perform math on an active data trace using data from your own formulas or algorithms rather than data from a measurement. For example, if you want to simulate the gain of a theoretical amplifier placed in series before the DUT, you could:

1. Create an algorithm that would characterize the frequency response of the theoretical amplifier.

2. Enter complex data pairs that correspond to the number of data points for your data trace.

3. Load the data pairs into memory with SCPI or COM commands. The analyzer maps the complex pairs to correspond to the stimulus values at the actual measurement points.

4. Use the **data + memory** or **data * memory** function to add or multiply the frequency response data to the measured data from the active data trace.

Note: The data trace must be configured before you attempt to load the memory.

Trace Statistics

You can calculate and display statistics for the active data trace. These statistics are:

- Mean

- Standard deviation

- Peak-to-peak values

You can calculate statistics for the full stimulus span or for part of it with user ranges.

There are nine user ranges per channel. These user ranges are the same as the search domains specified for a marker search in that same channel; they use the same memory registers and thus share the same stimulus spans. If you specified search domains with marker search for a channel, you can recall these same spans by selecting the corresponding user ranges. The user ranges for a channel can overlap each other.

A convenient use for trace statistics is to find the peak-to-peak value of passband ripple without searching separately for the minimum and maximum values.

The trace statistics are calculated based on the format used to display the data.

- Rectangular data formats are calculated from the scalar data represented in the display

- Polar or Smith Chart formats are calculated from the data as it would be displayed in Log Mag format

How to activate Trace Statistics
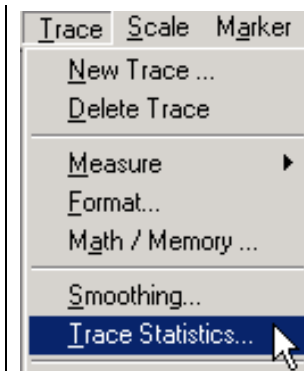
Learn more about using the front panel interface
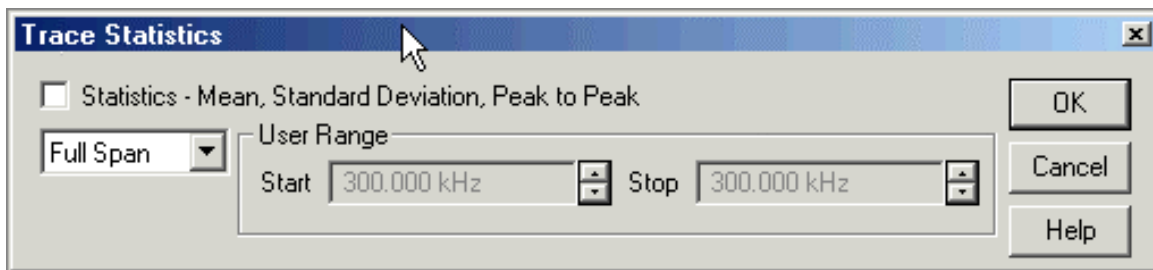
Trace Statistics dialog box help
Statistics Check to display mean, standard deviation, and peak to peak values for the active trace.
Span Specifies the span of the active trace where data is collected for a math operation. You can define up to 9 user spans per channel with Start and Stop. You can also define the user spans from the Marker Search dialog box.
Start Defines the start of a user span.
Stop Defines the stop of a user span.
Learn more about Trace Statistics (scroll up)

Use Limits to Test Devices

_____

Limit lines allow you to compare measurement data to performance constraints that you define.

- Overview
- Create and Edit Limit Lines
- Display and Test with Limit Lines
- Testing with Sufficient Data Points

Other Analyze Data topics

Overview

Limit lines are visual representations on the PNA screen of the specified limits for a measurement. You can use limit lines to do the following:

- Give the operator **visual guides** when tuning devices
- Provide **standard criteria** for meeting device specification
- Show the **comparison** of data versus specifications

Limit testing compares the measured data with defined limits, and provides optional **Pass or Fail** information for each measured data point.

You can have up to **100** discrete lines for each measurement allowing you to test all aspects of your DUT response.

Limit lines and limit testing are **NOT available with Smith Chart or Polar display format**. If limit lines are ON and you change to Smith Chart or Polar format, the analyzer will automatically disable the limit lines and limit testing.

Create and Edit Limit Lines

You can create limit lines for all measurement traces. The limit lines are the same color as the measurement trace.

Note: To ADD a limit line to the table, change the last limit line to either MAX or MIN
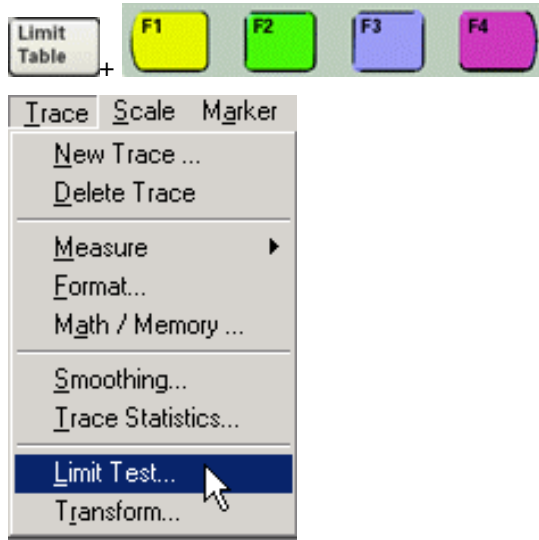
Limit lines are made up of discrete lines with four coordinates:

- BEGIN and END stimulus - X-axis values
- BEGIN and END response - Y-axis values.

How to create and edit Limit Lines
Limits are created, edited, and activated, with the limit table.

Use one of the following methods to show the limit table

-

-

Learn more about using the front panel interface

Limit Table

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MIN	1.930000 GHz	1.990000 GHz	-5.000000 dB	-5.000000 dB
2	MAX	1.000000 GHz	1.900000 GHz	-60.000000 dB	50.000000 dB
3	MAX	2.050000 GHz	3.000000 GHz	-50.000000 dB	-60.000000 dB
4	OFF	0 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

1. In the **Type** area of the Limit Table, select **MIN** or **MAX** for Limit Line 1.
   The MIN value will fail measurements BELOW this limit.
   The MAX value will fail measurements ABOVE this limit.

2. Click **BEGIN STIMULUS** for Limit Segment 1. Enter the desired value.

3. Click **END STIMULUS** for Limit Segment 1. Enter the desired value.

4. Click **BEGIN RESPONSE** for Limit Segment 1. Enter the desired value.

5. Click **END RESPONSE** for Limit Segment 1. Enter the desired value.

6. Repeat Steps 1-5 for each desired limit line.

Displaying and Testing with Limit Lines

After creating limit lines, you can then choose to **display** or **hide** them for each trace. The specified limits remain valid even if limit lines are not displayed.

Limit testing cannot be performed on memory traces.
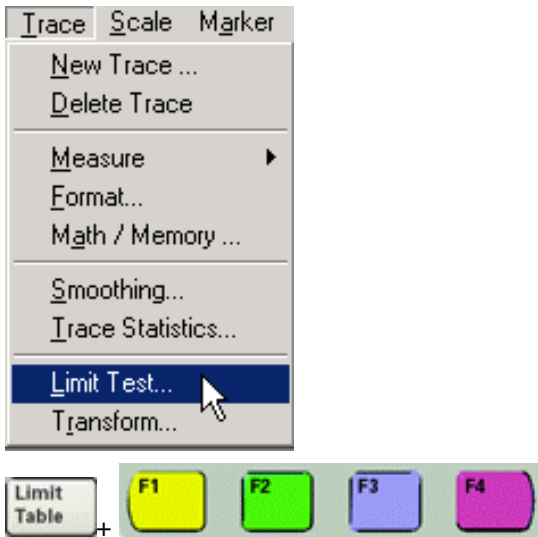
You can choose to provide a visual and / or audible PASS / FAIL indication.
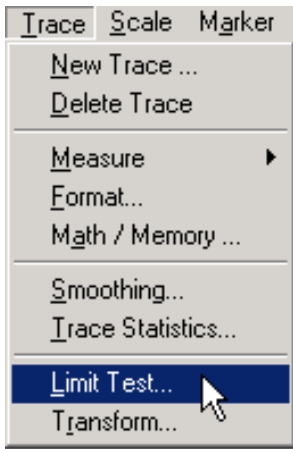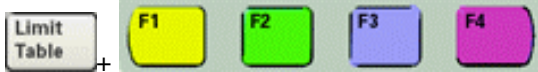
With limit testing turned ON:

- Any portion of the measurement trace that **fails** is **displayed in red**.
- Any portion of the measurement trace that does **NOT fail** remains unchanged and silent.

How to display and test with Limit Lines
Use one of the following methods
•
Sound ON Fail selection is not available from the Active Entry
Learn more about using the front panel interface

194
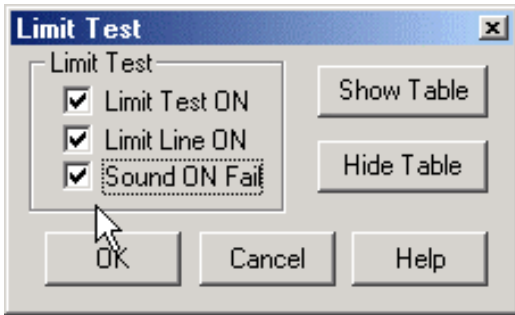
	Limit Test dialog box help
Limit Test ON Check to compare the data trace to the limits.
Limit Line ON Check to make the limits visible on the screen. Testing still occurs if the limits are not visible.
Sound ON Fail Check to make the PNA beep when a point on the data trace fails the limit test.
Show Table Shows the table that allows you to create and edit limits.
Hide Table Makes the limits table disappear from the screen.
Learn more about Displaying and testing with Limits (scroll up)

Testing with Sufficient Data Points

Limits are checked only at the actual measured data points. Therefore, It is possible for a device to be out of specification without a limit test failure indication if the data point density is insufficient.

The following image is a data trace of an actual filter using 11 data points (approximately one every vertical graticule). The filter is being tested with a minimum limit line (any data point under the limit line fails).

Although the data trace is clearly below the limit line on both sides of the filter skirts, there is a PASS indication because there is no data point being measured at these frequencies.

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE	
1	MIN ▼	135.000000 MHz	215.000000 MHz	-10.000000 dB	-10.000000 dB	
2	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB	
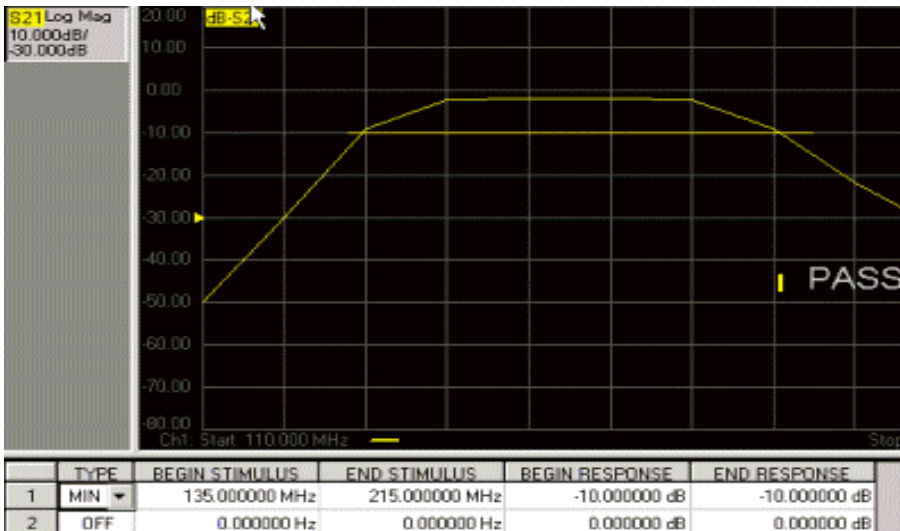
The following image shows the exact same conditions, except the number of data points is increased to 1601. The filter now fails the minimum limit test indicated by the red data trace.

	TYPE	BEGIN STIMULUS	END STIMULUS	BEGIN RESPONSE	END RESPONSE
1	MIN ▼	135.000000 MHz	215.000000 MHz	-10.000000 dB	-10.000000 dB
2	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB
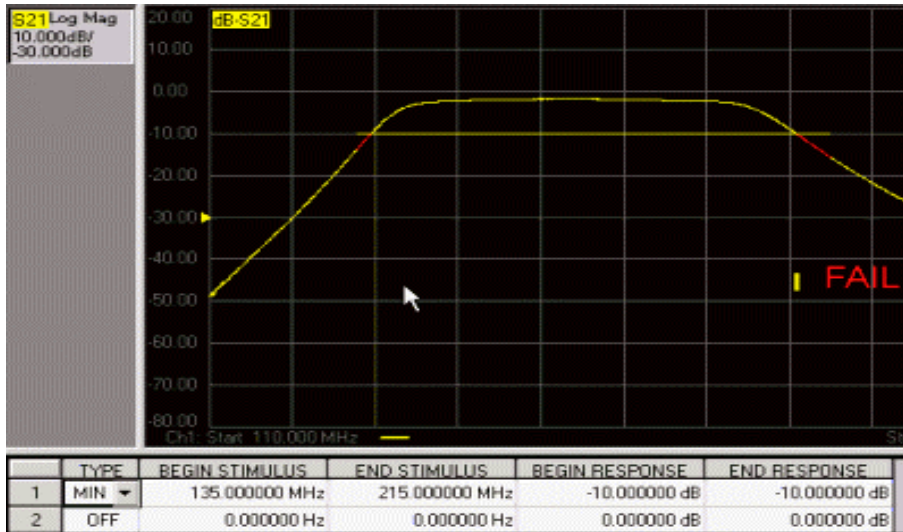
5. Output Data

Save and Recall a File

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The PNA allows you to save and recall files to and from an internal or external storage device in a variety of file formats.

- File Types
- Saving a File
- Recall a File
- Managing Files without a Mouse

Other Data Outputting topics

File Types

The PNA uses two file types:

- Binary File Types
- ASCII File Types

Binary File Types

Measurement data is saved and recalled in three binary file types: *__.sta,__ *__.cal,__ and *__.cst, .__

*__.sta__ files contain the following **Instrument State** data:

- Measurements that are set up on the analyzer, including limit lines and markers
- Arrangement of windows

*__.cal__ files contain **Calibration** data, but NOT as a Cal Set. Learn more about Cal Sets.

*.cst files contain **BOTH Calibration and Instrument State** data:

- Measurements that are set up on the analyzer, including limit lines and markers
- Arrangement of windows
- A reference to the correction data stored as a Cal Set.

Recalling a *.cst file saves the time of recalling both the instrument state and the calibration data for each measurement.

ASCII File Types

ASCII file types are **saved** by the PNA for use in a spreadsheet or CAE programs. Two ASCII file types are used by the analyzer.

- *.prn files
- MDIF or Touchstone formats

*.prn Files

- Read directly into rows and columns by spreadsheet software, such as Microsoft® Excel.
- Contains formatted and corrected stimulus and response data.
- Comma-separated list for the current active trace ONLY.
- Output only - it cannot be read by the analyzer.

Example:

"S$_{11}$ Log Mag"
"Frequency (Hz)",   "dB"
3.000000e+005   ,   **-3.528682e+001 ,**
4.529850e+007   ,   **-2.817913e+001 ,**
9.029700e+007   ,   **-3.216808e+001 ,**
1.352955e+008   ,   **-3.101017e+001 ,**
                               _____

MDIF or Touchstone Formats (*.s1p, *.s2p, *.s3p)

This file format is used by CAE programs such as Agilent's Microwave Design System (MDS) and Advanced Design System (ADS).

Note: The data in MDIF files do NOT include the results of Averaging or Trace Smoothing.

- Data includes the effects of electrical delay and port extensions.
- Output only - cannot be read by the analyzer.
- Cannot display a screen-capture image.
- Only REAL / IMAGINARY data pairs are saved regardless of the display format.
- The file type depends on the number of ports involved in your measurements:

File Type	# of Ports	# of Measurements saved
*.s1p	1	1 S-parameter (Reflection)
*.s2p	2	4 S-parameters
*.s3p	3	9 S-parameters

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Interpreting MDIF Data

The MDIF files contain a header, stimulus data, and a real / imaginary data pair for EACH S-parameter measurement. The data format for S1P, S2P, and S3P files differ only in the number of

S-parameters saved.

*.s1p Files

Each record contains 1 stimulus value and 1 S-parameter (total of 2 values)

Stim Real (Sxx) Imag(Sxx)

*.s2p Files

Each record contains 1 stimulus value and 4 S-parameters (total of 8 values)

Stim Real (S11) Imag(S11) Real(S21) Imag(S21) Real(S12) Imag(S12) Real(S22) Imag(S22)

*.s3p Files

Each record contains 1 stimulus value and 9 S-parameters (total of 18 values)

Stim   Real (S11) Imag(S11) Real(S12) Imag(S12) Real(S13) Imag(S13)

     Real (S21) Imag(S21) Real(S22) Imag(S22) Real(S23) Imag(S23)

     Real (S31) Imag(S31) Real(S32) Imag(S32) Real(S33) Imag(S33)

Note: *.s3p files require 3 lines per stimulus.

Actual MDIF Data

The following is an ***.s1p** file from an S11 measurement with two data points:

```
!Agilent N3383A: M.01.32
!S1P File: Measurement: S11:
#   Hz   S   RI   R 50.0
3.00E+05  9.34E-01  2.45E-01
4.53E+07  8.89E-01  3.20E-01
```

Header Key:

! - comments describing the file

Hz - frequency

S - S-parameters

RI - real and imaginary pair

R 50.0 - reference impedance

Validity of Data

If full Error correction is performed and turned on, the PNA makes all 4 S-parameter measurements even though they may not be displayed. Therefore, for all 3 file types, the data that is saved is only valid if full error correction has been performed and turned on.

For example, If you are making S11 and S21 measurements and:

- You HAVE performed a full 2-port calibration and error correction is ON.
   Then All FOUR S-parameters are saved and all data is valid

- You HAVE NOT performed a full 2-port calibration and error correction is OFF.
   Then ONLY the active trace data is valid, and it is uncorrected data. All other S-parameter data are zeroes

How to Save a File

Use one of the following methods:

-

-
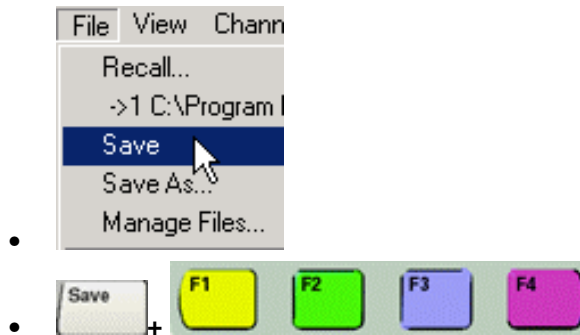
Learn more about using the front panel interface

Save Immediately saves the PNA state and calibration data to the current file. A message temporarily appears on the display showing you the path and filename used to save your file. This file will be overwritten the next time you Save unless you use one of the following methods.

Save As Invokes the following dialog box which saves binary or ASCII files to a location and file type that you specify.

Auto Save (Only available from the Active Entry keys) Saves state and calibration data to the internal hard disk automatically selecting a new .cst filename in C:\Program Files\Agilent\Network Analyzer\Documents. This is done so the previously saved file is not overwritten. A message temporarily appears on the display showing you the path and filename used to save your file.
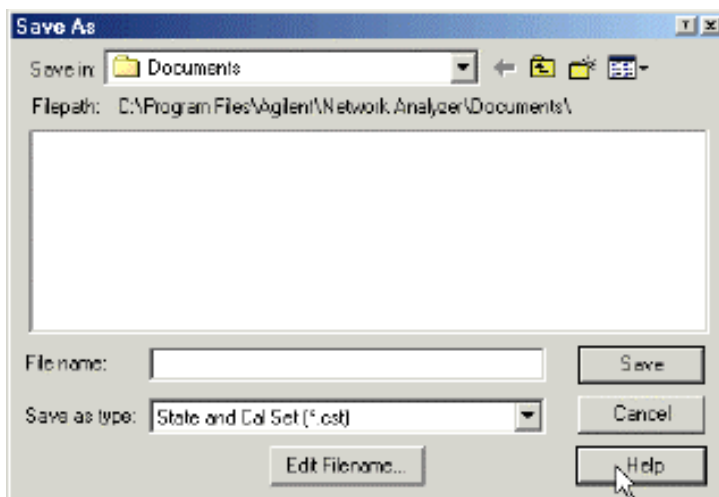
Save As dialog box help

Save in Allows you to navigate to the directory where you want to save the file.

File name Displays the filename that you either typed in or clicked on in the directory contents box.

Save as type

The following **binary file types** are available when clicking **File / Save As** to save measurement-related data. These file types are only recognized by Agilent PNA Series analyzers.

- *.cst: Use this file type to save calibration data (instrument state and Cal Set reference).

- *.sta: Use this file type to save instrument state only (**no** calibration data)

- *.cal: Use this file type to archive Cal Set data.

The following **ASCII file types** are available when clicking **File / Save As** to save measurement data for use in spreadsheet or CAE programs:

- *.prn
- *.s1p
- *.s2p
- *.s3p (only available on 3-port PNAs)

The following graphics file types are available when clicking **File / Print to File...** to save screen capture images. Learn more about Printing from the PNA

- *.bmp
- *.jpg
- *.png

Save Saves the file to the file name and directory that you selected.

Recall a File

Opens calibration and state (binary) files to be used on the PNA.

How to Recall a file
Use one of the following methods: • Press **Recall** repeatedly, then   Learn more about using the front panel interface
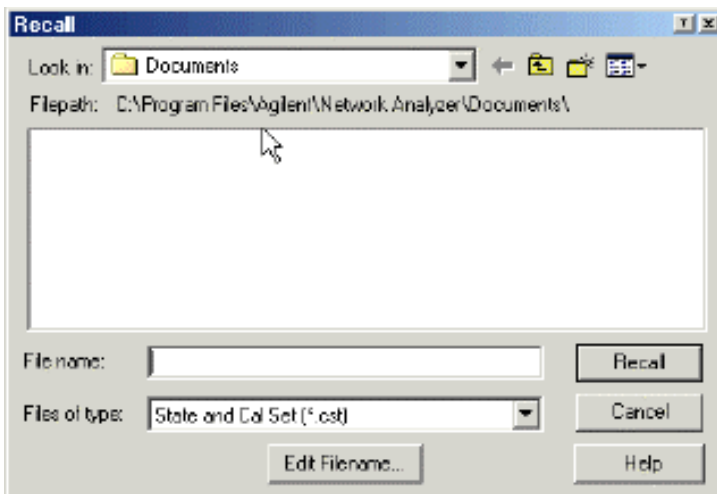
Recall dialog box help
Look in Allows you to select the directory that contains the file that you want to recall.
File name Displays the filename that you either typed in or clicked on in the directory contents box.
Files of type Allows you view and select files that are listed in categories of a file type.

> **Recall** Recalls the file displayed in the file name box.

Manage Files without a Mouse

The Manage Files dialog box is designed to be used from the front panel. It performs the same function as Windows Explorer, but can be used without the use of a mouse or keyboard.

Learn more about using the Front-panel interface.
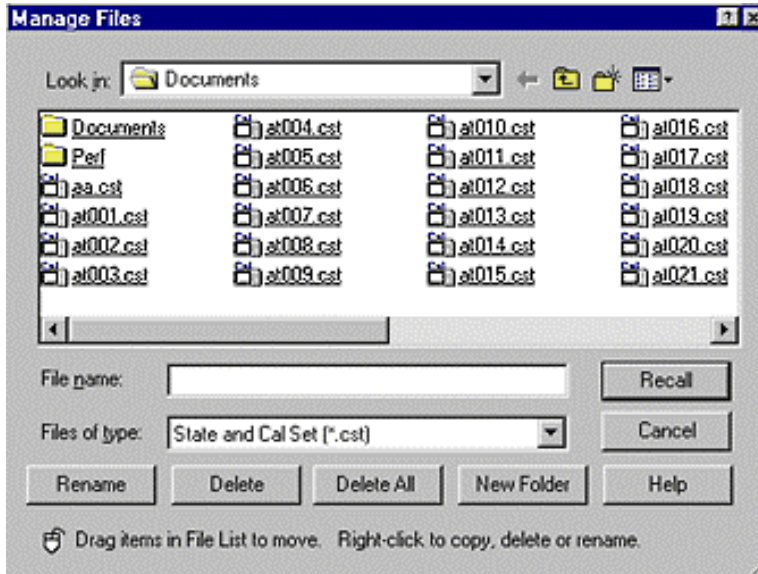
Manage Files dialog box help
Recall Opens a Network Analyzer State already stored in memory.
Rename Renames a file that is selected in the open folder.
Delete Removes a selected file from the open folder.
Delete All Removes all files of the file type selected that appear in the open folder.
New folder Create a new folder and give it a name
If using a mouse:
Files can be moved by dragging them in the file contents.
Right click in the topic page to carry out file management features.

Drive Mapping

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Drive mapping allows you to share disk drives between the PNA and an external computer. You can either map from the PNA, or from your PC, to the other.

- From the PNA, map to a drive on an External PC
- From an External PC, map to a drive on the PNA

To prepare for Drive Mapping:

1. Both the PC and PNA must be connected to a shared computer network

2. You must know the full computer name of the PC (or analyzer) you are mapping **TO**. Tell me how

   On the PC you are mapping TO

      a. Click **System**, **Windows Taskbar, Settings**, **Control Panel**, and the **System** icon.

      b. Select the **Network Identification** tab. If desired, record the computer name

3. Your logon and password on the analyzer must be the same as that on the external PC. You can add your PC logon to the analyzer. Tell me how

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Note: These procedures require a mouse and keyboard. Also, the external PC must have Windows NT 4.0 (or later).

From the Analyzer, map to a drive on the External PC

1. On the external computer desktop, go to **Windows Explorer**. In the listing of drives, right click on the drive you want to share. Click **Sharing**.

2. In the dialog box, select **Shared As**. In the **Share Name** box, use the arrow key or type in a share name for the drive. For example: **C$**. Click **OK**.

3. On the analyzer desktop, click **Windows Explorer**. From the **Tools** menu, click **Map Network Drive**. (To get to the analyzer desktop, click **View**, then click **Title Bars)**

4. If you would like to connect to your external PC using a different logon, click **Connect using a different Logon**. This logon must be registered on the analyzer and you must be currently logged on the external PC using this logon.

   1. In the **Connect as** box, type your logon name.
      The logon name and password must be exactly the same on both the external PC and the analyzer.

   2. In the **Password** box, type the logon password that you use on the external computer. Click **OK**. The logon name and password must be exactly the same on both the external PC and the analyzer.

5. In the **Folder** box, type \(full computer name of analyzer)\share name (from step 2). (For example: **\SLT1234\C$**)

6. Click **Finish**.

From an External PC, map to a drive on the Analyzer

1. On the analyzer desktop, click **Windows Explorer**. Right click on the drive you want to share. Click on **Sharing...**

2. In the dialog box, select **Shared this folder**. In the **Share Name** box, type in a share name for the drive. For example: **C$**. Click **OK**.

3. On the external PC desktop, click **Windows Explorer**. From the **Tools** menu, click **Map Network Drive**.

4. If the current logon on your PC is different from the current logon on the analyzer, click **Connect using a different Logon** to connect to using the current analyzer logon, .This logon must be registered on the external PC. To see the current logon on either the PC or analyzer, hold **Ctrl** - **Alt**, and press **Delete**.

   1. In the **Connect as** box, type the logon currently being used by the analyzer.

   2. In the **Password** box, type the logon password that you use on the external computer. Click **OK**

5. In the **Folder** box, type *computername (prep1)\share name* (from step 2). (For example: **\\SLT1234\C$**)

6. Click **Finish**.

Print a Displayed Measurement

The analyzer allows you to print a displayed measurement to a printer or to a file. The printer can be either a networked or local. Click on a button to learn how to connect to a printer or print a displayed measurement.

- Connecting a Printer
- Printing

Other Outputting Data topics

Connecting a Printer

You can connect your printer to the PNA using three different connector types:

- Parallel connector
- Serial connector
- USB

Note: Early PNAs have a Centronics connector for connecting a printer. An adapter (36-pin male - 1284-C - to 25-pin female) was shipped with those PNAs to allow connection with a standard parallel printer cable.

CAUTION: Do NOT use the 25-pin female port labeled **Ext. Test Set Interface** for connecting your printer. Voltage levels of signal lines may damage the printer's I/O.

To Install a Printer

This procedure requires a mouse and a keyboard.

1. From the PNA application, click **View** then click **Minimize Application**

2. On the Windows taskbar, click **Start**, point to **Settings**, then click **Printers**.

3. Double-click **Add Printer**.

4. Follow the instructions in the **Add Printer** Wizard.

For more information, refer to the Windows 2000 Help or your printer documentation.

Printing

- Print a Hardcopy
- Print Options
- Print to File

The measurement information on the screen can be printed to any local or networked printer that

is connected to the analyzer. The amount of measurement information printed is selected by the print options settings.

The graphic below shows an example of how a screen-capture image appears when printed. The print options settings allows you to customize the printed form of the measurement information.
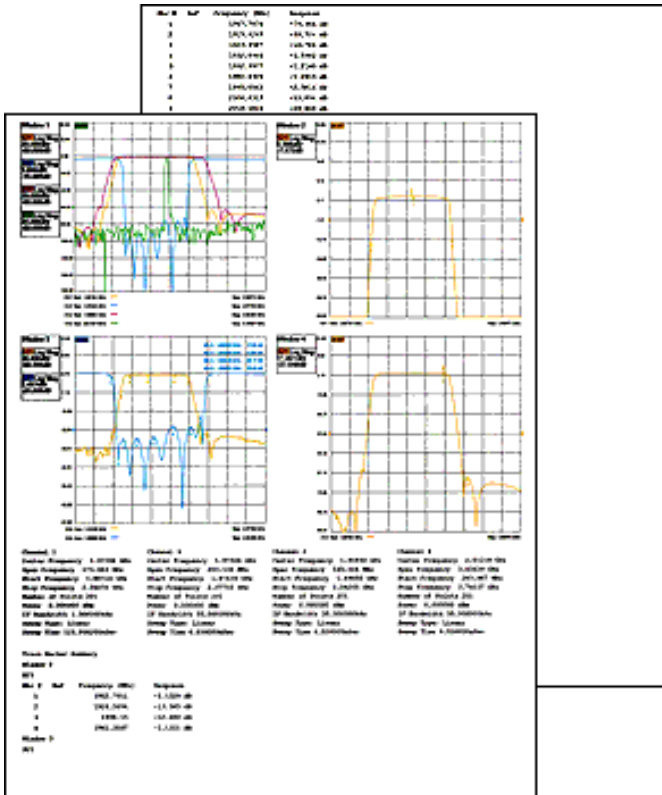
How to Print a Hardcopy
Use one of the following methods
Learn more about using the front panel interface
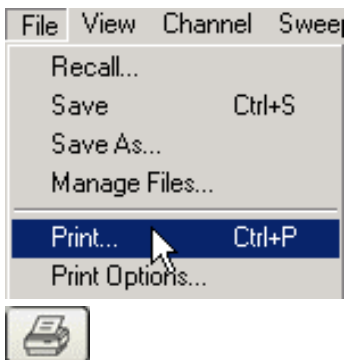
Note: For information on the choices in the Print dialog box, see Windows 2000 Help.

Print Options

The Print Options Dialog Box allows flexibility in the appearance that measurement data is printed. After selecting the options, click **Print...** to obtain a hard-copy.

How to select Print Options
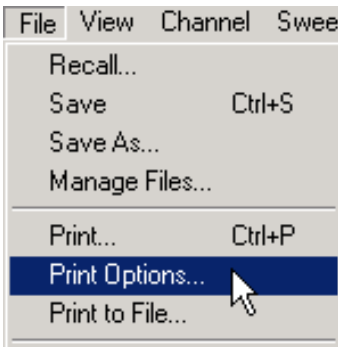
Learn more about using the front panel interface
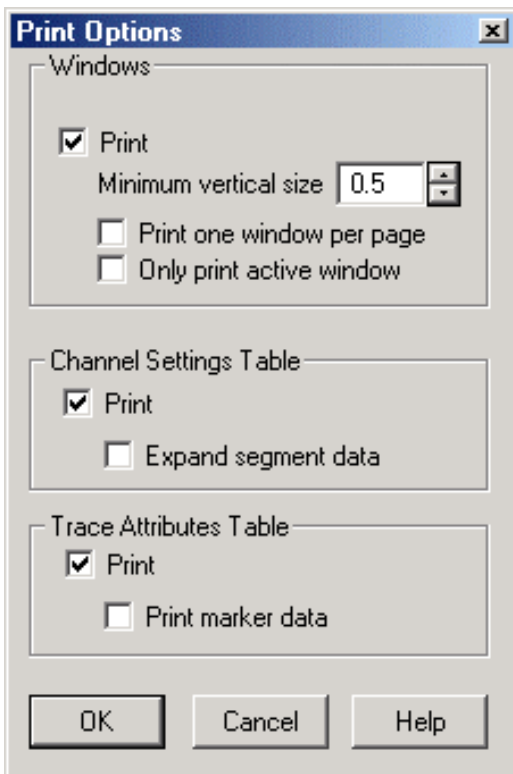
Print Options dialog box help

Windows

Print Check to print measurement windows.

Minimum vertical size Adjust to change the amount of a page that the measurement window fills. The adjustment range is from .4 to 1.0 of a page.

Print one window per page Check to print one window per page. Clear to print all selected windows without a forced page break.

Only print active window Check to print only the active window. Clear to print all windows.

Channel Settings Table

Print Check to print the channel settings table.

Expand segment data Check to print segment data. The amount of data depends on how much the sweep is segmented.

Trace Attributes Table

Print Check to print the Trace Attributes Table. The Trace Attributes are measurement type, correction factors ON or OFF, smoothing, options, and marker details. The Trace Attributes are listed by Trace ID# (1 to 4), for each window.

Each Trace ID# can have multiple entries depending on the number of markers associated with the trace. The marker details are marker number, position and response. If there are multiple markers on a trace, the trace attributes are only shown for the first marker. However, the trace attributes for the first marker apply to all other markers on that trace.

The options column can have one or more options. **D** for Delay, **M** for Marker, **G** for Gating. Multiple options selected would appear as follows: DMG.

Print marker data Check to print all marker data. The amount of data depends on how many markers are created.

Print to a File

The analyzer can save a screen-capture image in any of the following formats:

- **.bmp** (bitmap) format
- **.jpg** format
- **.png** format

The analyzer automatically saves the file to the current path. If not previously defined, the analyzer automatically selects the default path C:\Program Files\Agilent\Network Analyzer\Documents\

A .bmp file, like a .prn file, can be imported into software applications such as Microsoft Excel, Word, or Paint to display a screen-capture image.

How to Print to a File
Learn more about using the front panel interface
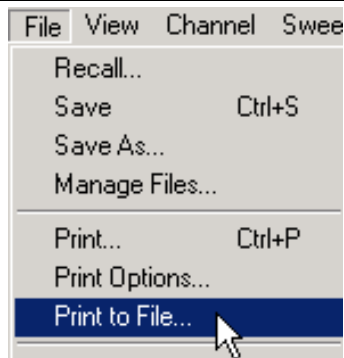
See Save and Recall files for more information.

Product Support

Troubleshoot the Analyzer

By running a few checks, you can identify if the analyzer is at fault. Before calling Agilent Technologies or returning the instrument for service, please make the following checks.

- Check the Basics
- Check Error Terms
- Check the Service Guide

Other Support Topics

Check the Basics

A problem can often be solved by repeating the procedure you were following when the problem occurred. Before calling Agilent Technologies or returning the instrument for service, please make the following checks:

1. Is there power at the power socket? Is the instrument plugged in?

2. Is the instrument turned on? Check to see if the front panel line switch and at least one of the LED rings around the test ports glows green. This indicates the power supply is on.

3. If other equipment, cables, and connectors are being used with the instrument, make sure they are connected properly and operating correctly.

4. Review the procedure for the measurement being performed when the problem appeared. Are all the settings correct?

5. If the instrument is not functioning as expected, return the unit to a known state by pressing the **Preset** key.

6. Is the measurement being performed, and the results that are expected, within the specifications and capabilities of the instrument?

7. If the problem is thought to be due to firmware, check to see if the instrument has the latest firmware before starting the troubleshooting procedure.

8. Check that the measurement calibration is valid. See Accurate Measurement Calibrations for more information.

9. If the necessary test equipment is available, perform the operator's check and system verification in Chapter 2 of the PNA Service Guide, "System Tests, Verifications, and Adjustments," included on the CD-ROM that was shipped with the analyzer.

Check Error Terms

If you print the error terms at set intervals (weekly, monthly, and so forth), you can compare current error terms to these records. A stable, repeatable system should generate repeatable error terms over long time intervals, for example, six months. If a subtle failure or mild performance problem is suspected, the magnitude of the error terms should be compared against values generated previously with the same instrument and calibration kit. See the procedure for monitoring error terms.

- A long-term trend often reflects drift, connector and cable wear, or gradual degradation, indicating the need for further investigation and preventative maintenance. Yet, the

system may still conform to specifications. The cure is often as simple as cleaning and gaging connectors or inspecting cables.

- A sudden shift in error terms reflects a sudden shift in systematic errors, and may indicate the need for further troubleshooting.

Consider the following while troubleshooting:

- All parts of the system, including cables and calibration devices, can contribute to systematic errors and impact the error terms.

- Connectors must be clean and gauged, and within specification for error term analysis to be meaningful. See the Chapter 2 in the PNA Service Guide for information on cleaning and gaging connectors.

  - Avoid unnecessary bending and flexing of the cables following measurement calibration, thus minimizing cable instability errors.

  - Use good connection techniques during the measurement calibration. The connector interface must be repeatable. See the PNA Service Guide for information on connection techniques.

- It is often worthwhile to perform the procedure twice (using two distinct measurement calibrations) to establish the degree of repeatability. If the results do not seem repeatable, check all connectors and cables.

- Use error-term analysis to troubleshoot minor, subtle performance problems. See Chapter 3, "Troubleshooting," in the PNA Service Guide if a blatant failure or gross measurement error is evident.

Check the Service Guide

Check the PNA Service Guide for specific troubleshooting procedures to help identify problems. It is included on the CD-ROM that was shipped with your analyzer. You can also get a copy of the Service Guide at our Web site at http://www.agilent.com/find/pna

PNA Error Messages

_____

- **511 - 641 Calibrate**
- **772 - 868 Hardware**
- **1025 - 1128 Measure**
- **1284 - 1535 Parser**
- **1536 - 1621 Display**
- **1792 - 1878 Channel**
- **2048 - 2167 General**
- **Standard SCPI Errors**

Note: The **EventID**'s listed below are provided for COM programmers. For more information on PNA error messages (see Error Messages).

_____

_____

Message: 512

"A secondary parameter (power, IFBW, sweeptime, step mode) of the calibrated state has changed."

Severity: Informational

Further explanation: The calibration is questionable when any of these secondary parameters change after the calibration is performed.

Suggestions: If you require an accurate measurement with the new settings, repeat the calibration.

EventID: 68020200 (hex)

_____

Message: 513

"Calibration cannot be completed until you have measured all the necessary standards for your selected Cal Type."

Severity: Informational

Further explanation: You probably received this message because you attempted to turn correction on without first measuring all of the calibration standards

Suggestions: Finish measuring the cal standards

EventID: 68020201 (hex)

_____

Message: 515

"Calibration is required before correction can be turned on. Channel number is <x>, Measurement is <x>."

Severity: Informational

Further explanation: There are no error correction terms to apply for the specified channel and measurement.

Suggestions:Perform or recall a calibration

EventID: 68020203 (hex)

_____

Message: 516

"Critical parameters in your current instrument state do not match the parameters for the calibration set, therefore correction has been turned off. The critical instrument state parameters are sweep type, start frequency, frequency span, and number of points."

Severity: Informational

Further explanation: None

Suggestions: You can either recalibrate using the new settings or change back to the original setting that was used when the calibration was performed.

EventID: 68020204 (hex)

_____

Message: 517

"Interpolation is turned off and you have changed the stimulus settings of the original calibration, so correction has been turned off."

Severity: Informational

Further explanation: The most accurate calibration is maintained only when the original stimulus settings are used.

Suggestions: If reduced accuracy is OK, set interpolation ON to allow stimulus setting changes.

EventID: 68020205 (hex)

_____

Message: 518

"Interpolation is turned off and you have selected correction ON. Correction has been restored with the previous stimulus settings."

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 68020206 (hex)

_____

Message: 519

"Stimulus settings for your current instrument state exceeded the parameters of the original calibration, so correction has been turned off."

Severity: Informational

Further explanation: Correction data outside the stimulus settings does not exist.

Suggestions: Perform a broadband calibration, with increased numbers of points with interpolation ON, to maintain calibration over the widest possible stimulus frequency settings.

EventID: 68020207(hex)

_____

Message: 520

"Cal Type is set to NONE for Channel <x>, Measurement <x>; please select Calibration menu or press Cal hard key."

Severity: Informational

Further explanation: A cal operation can not proceed until a calibration exists or the cal type is selected. This error can occur if the calibration can not be found. Also this error can happen if a calibration type is not specified before attempting to programmatically execute cal acquisitions.

Suggestions To find a calibration, select a Cal Set that contains the calibration needed for the current measurements. OR specify the cal type before beginning a calibration procedure.

EventID: 68020208 (hex)

_____

Message: 521

"The measurement you set up does not have a corresponding calibration type, so correction has been turned off or is not permitted."

Severity: Informational

Further explanation: The calibration for the channel may apply only to certain S-Parameters. For example, a 1-Port calibration for S11 can not be applied to a 1-Port calibration applied to S22.

Suggestions: Select a calibration type, such as full 2-Port cal, that can be applied to all the measurements to be selected.

EventID: 68020209 (hex)

Message: 526

"No user calibration found for this channel."

Severity: Informational

Further explanation: A cal operation can not proceed until a calibration exists.

Suggestions: To find a calibration, you can select a Cal Set that contains the calibration needed for the current measurement.

EventID: 6802020E (hex)

Message: 527

"You do not need to acquire this standard for this calibration type."

Severity: Informational

Further explanation: This error can happen as a result of PROGRAMMATICALLY requesting the measurement of an un-needed calibration standard during a calibration procedure.

Suggestions: Check the specified cal type or eliminate the request for the measurement of the standard.

EventID: 6802020F (hex)

Message: 528

"Could not configure the Electronic Calibration system. Check to see if the module is plugged into the proper connector."

Severity: Informational

Further explanation: During an ECal operation, communication could not be established with the ECal module. The calibration will not be initiated until the presence of the ECal module is verified.

Suggestions: Verify the USB cable is connected properly. Disconnect and re-connect the cable to ensure the analyzer recognizes the module.

EventID: 68020210 (hex)

Message: 529

"DATA OUT OF RANGE: Design Limits Exceeded"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020211(hex)

Message: 530

"EXECUTION ERROR: Array dimensions mismatched"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020212 (hex)

Message: 531

"EXECUTION ERROR: Array div by zero"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020213 (hex)

Message: 532

"EXECUTION ERROR: Array function invalid"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020214 (hex)

Message: 533

"EXECUTION ERROR: Array index error"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020215 (hex)

Message: 534

"EXECUTION ERROR: Array index out of range"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020216 (hex)

Message: 535

"EXECUTION ERROR: Arrays wrong rank"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020217 (hex)

Message: 536

"EXECUTION ERROR: CPU"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020218 (hex)

Message: 537

"EXECUTION ERROR: Cannot ERASE module"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020219 (hex)

Message: 538

"EXECUTION ERROR: Cannot WRITE module"

Severity: Error

Further explanation:

Suggestions:

EventID: E802021A (hex)

Message: 539

"EXECUTION ERROR: Entry Not Found"

Severity: Error

Further explanation:

Suggestions:

EventID: E802021B (hex)

Message: 540

"EXECUTION ERROR: Invalid command while system is busy"

Severity: Error

Further explanation:

Suggestions:

EventID: E802021C (hex)

Message: 541

"Electronic Cal: The Module is NOT in RF path. Please connect it to the port indicated."

Severity: Error

Further explanation: There is no RF connection to the ECal module during a calibration step. An ECal orientation measurement has been attempted but the signal was not found.

Suggestions: Connect the ECal module RF connections to ports specified for the calibration step. The ECal module typically requires at least -18dBm for measurements.

EventID: E802021D (hex)

Message: 542

"EXECUTION ERROR: NO SPACE for NEW CAL, DELETE A CAL"

Severity: Error

Further explanation:

Suggestions:

EventID: E802021E (hex)

Message: 543

"EXECUTION ERROR: No More Room"

Severity: Error

Further explanation:

Suggestions:

EventID: E802021F (hex)

Message: 544

"EXECUTION ERROR: Other array error"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020220 (hex)

Message: 545

"EXECUTION ERROR: Ranks not equal"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020221 (hex)

Message: 546

"EXECUTION ERROR: Too few CONSTANT ranks"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020222 (hex)

Message: 547

"EXECUTION ERROR: Too few VARYing ranks"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020223 (hex)

Message: 548

"EXECUTION ERROR: Unknown error"

Severity: Error

Further explanation:

Suggestions:

EventID: 68020224 (hex)

Message: 549

"EXECUTION ERROR: ecaldrvr.dll bug or invalid module #"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020225 (hex)

Message: 550

"EXECUTION ERROR: unexpected error code from ecal driver"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020226 (hex)

Message: 551

"EXECUTION ERROR: unexpected internal driver error"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020227 (hex)

Message: 552

"HARDWARE ERROR: Can't access ECal Interface Module"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020228 (hex)

Message: 553

"HARDWARE ERROR: Can't release LPT port, reboot"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020229 (hex)

Message: 554

"HARDWARE ERROR: VNA Error"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022A (hex)

Message: 555

"HARDWARE ERROR: not enough data read from ECal module"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022B (hex)

Message: 556

"OPERATION ABORTED BY HOST COMPUTER"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022C (hex)

Message: 557

"OPERATION ABORTED BY USER"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022D (hex)

Message: 558

"OUT OF MEMORY"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022E (hex)

Message: 559

"QUERY INTERRUPTED:Message(s Abandoned"

Severity: Error

Further explanation:

Suggestions:

EventID: E802022F (hex)

Message: 560

"QUERY UNTERMINATED: INCOMPLETE PROGRAM Message"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020230 (hex)

Message: 561

"QUERY UNTERMINATED: NOTHING TO SAY"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020231 (hex)

Message: 562

"QUEUE OVERFLOW"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020232 (hex)

Message: 563

"SETTINGS CONFLICT: ADDITIONAL STANDARDS ARE NEEDED"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020233 (hex)

Message: 564

"SETTINGS CONFLICT: Adapter Cal is NOT possible"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020234 (hex)

Message: 565

"SETTINGS CONFLICT: COMMAND OUT OF SEQUENCE"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020235 (hex)

Message: 566

"SETTINGS CONFLICT: Cal STOPPED - VNA SETUP CHANGED"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020236 (hex)

Message: 567

"SETTINGS CONFLICT: Calibration is NOT in progress"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020237 (hex)

Message: 568

"SETTINGS CONFLICT: Can't find specified GPIB board"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020238 (hex)

Message: 569

"SETTINGS CONFLICT: Can't find/load gpib32.dll"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020239 (hex)

Message: 570

"SETTINGS CONFLICT: Can't find/load sicl32.dll"

Severity: Error

Further explanation:

Suggestions:

EventID: E802023A (hex)

Message: 571

"SETTINGS CONFLICT: Can't initialize VNA (bad address?"

Severity: Error

Further explanation:

Suggestions:

EventID: E802023B (hex)

Message: 572

"SETTINGS CONFLICT: Can't load LPT port driver or USB driver DLL"

Severity: Error

Further explanation:

Suggestions:

EventID: E802023C (hex)

Message: 573

"SETTINGS CONFLICT: Invalid Calibration Sweep Mode."

Severity: Error

Further explanation:

Suggestions:

EventID: E802023D (hex)

Message: 574

"SETTINGS CONFLICT: Invalid Calibration Type"

Severity: Error

Further explanation:

Suggestions:

EventID: E802023E (hex)

Message: 575

"SETTINGS CONFLICT: Invalid Calibration"

Severity: Error

Further explanation:

Suggestions:

EventID: E802023F (hex)

Message: 576

"SETTINGS CONFLICT: Invalid GPIB board number specified"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020240 (hex)

Message: 577

"SETTINGS CONFLICT: Invalid GPIB board type specified"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020241 (hex)

Message: 578

"SETTINGS CONFLICT: Invalid Module Status"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020242 (hex)

Message: 579

"SETTINGS CONFLICT: Invalid States"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020243 (hex)

Message: 580

"SETTINGS CONFLICT: LPT port must be between 1 and 4"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020244 (hex)

Message: 581

"Could not configure the Electronic Calibration system. Check to see if the module is properly connected."

Severity: Error

Further explanation:

Suggestions:

EventID: E8020245 (hex)

Message: 582

"SETTINGS CONFLICT: Specified LPT port does not exist"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020246 (hex)

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Message: 583

"SETTINGS CONFLICT: Use frequency domain for cal"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020247 (hex)

———

Message: 584

"SETTINGS CONFLICT: Use step sweep type for cal."

Severity: Error

Further explanation:

Suggestions:

EventID: E8020248 (hex)

———

Message: 585

"SETTINGS CONFLICT: VNA address must be between 0 and 30"

Severity: Error

Further explanation:

Suggestions:

EventID: E8020249 (hex)

———

Message: 586

"SETTINGS CONFLICT: Wrong LPT port driver or USB driver DLL"

Severity: Error

Further explanation:

Suggestions:

EventID: E802024A (hex)

———

Message: 587

"SYNTAX ERROR: ECAL:DELAY command must have 2 numbers"

Severity: Error

Further explanation:

Suggestions:

EventID: E802024B (hex)

Message: 588

"SYNTAX ERROR: INCORRECT SYNTAX"

Severity: Error

Further explanation:

Suggestions:

EventID: E802024C (hex)

Message: 589

"SYNTAX ERROR: UNKNOWN COMMAND"

Severity: Error

Further explanation:

Suggestions:

EventID: E802024D (hex)

Message: 590

"Wrong port of module in RF path"

Severity: Error

Further explanation: None

Suggestions:None

EventID: E802024E (hex)

Message: 591

"User characterization not found in module"

Severity: Error

Further explanation: None

Suggestions:None

EventID: E802024F (hex)

Message: 592

Severity: Informational

"No source power calibration found for the channel and source port of the current measurement."

Further explanation: You tried to turn on source power cal but there is no source power cal data.

Suggestions: Perform a source power calibration

EventID: 68020250 (hex)

Message: 593

Severity: Informational

"A source power calibration sweep was not performed, so there is no correction for the channel and source port of the current measurement."

Further explanation: You tried to turn on source power cal but there is incomplete source cal data.

Suggestions:Perform a complete source power calibration

EventID: 68020251 (hex)

_____

Message: 594

Severity: Informational

"A new trace could not be added to the active window for viewing the source power cal sweep, because it would have exceeded the limit on number of traces/window. Please remove a trace from the window before proceeding with source power cal."

Further explanation: The source power cal attempts to add a data trace to the active window. The active window already contains four traces.

Suggestions:Make the active window contain less than four traces.

EventID: 68020252 (hex)

_____

Message: 595

Severity: Informational

"A new measurement could not be added for performing the source power cal sweep, because the limit on number of measurements has been reached. Please remove a measurement before proceeding with source power cal."

Further explanation: The source power cal attempts to add a measurement. The PNA already has the maximum number of measurements.

Suggestions: Delete a measurement.

EventID: 68020253 (hex)

_____

Message: 596

Severity: Informational

"The calibration power value associated with the source power calibration of Port %1 on Channel %2 was changed with the calibration on. The calibration was not turned off, but the power value might no longer represent the calibration."

Further explanation: The source power cal accuracy is questionable.

Suggestions: If high accuracy is required, perform another source power calibration.

EventID: 68020254 (hex)

_____

Message: 597

Severity: Informational

- Message that is passed from the power meter driver for a source power calibration. -

Further explanation: This error is generated by the power meter driver and passed through the PNA.

Suggestions:None

EventID: 68020255 (hex)

Message: 598

"During the acquisition of the sliding load standard, the slide was not properly moved to perform a circle fit. The standard's raw impedance was used to determine the directivity for one or more points."

Severity: Informational

Further Explanation: To accurately characterize the standard, the sliding load must be move sufficiently to ensure enough samples around the complex circle or Smith Chart. Under-sampling will cause an inaccurate result.

Suggestions: For best results when using a sliding load, be sure to use multiple slide positions that cover the full range of movement from front to back of the slot.

EventID: 68020256 (hex)

Message: 599

"This feature requires an unused channel, but could not find one. Please free up a channel and try again."

Severity: Informational

Further Explanation: You attempted to view an item within a calset. However, the calset viewer requires that the result be displayed in a channel that is not currently in use. All the channels are currently used. The view can not display the requested item.

Suggestions: You must delete at least one channel that is currently in use.

EventID: 68020257 (hex)

Message: 600

"Interpolation of the original calibration is not allowed since it was performed using Segment Sweep. Correction has been turned off."

Severity: Informational

EventID: 68020258 (hex)

Message: 608

"CalType not set."

Severity: Error

Further explanation: A cal operation can not proceed until a calibration exists or the proper cal type is selected.

Suggestions: This error can happen if the calibration can't be found.   To find a calibration, you can select a Cal Set that contains the calibration needed for the current measurements. This error can also happen if a calibration type is not specified before attempting to programmatically execute cal acquisitions. Specify the cal type before beginning a calibration procedure.

EventID: E8020260 (hex)

Message: 609

"The Calibration feature requested is not implemented."

Further explanation: The specified cal type can be one of many choices. For example, response calibrations require single standards, 1-Port calibrations require 3 standards, and 2-Port

calibrations require up to 12 standards.

Suggestions: Be sure to measure only the standards needed for the specified cal type.

EventID: E8020261 (hex)

Message: 610

"The Calibration Class Acquisition requested is not valid for the selected Calibration Type. Please select a different acquisition or a different Calibration Type."

Further explanation: None

Suggestions: None

EventID: E8020262 (hex)

Message: 611

"The Calibration Standard data required for the selected caltype was not found."

Severity: Error

Further explanation: An unsuccessful attempt was made to retrieve a specified standard from the raw measurement buffer. The buffer should contain the raw measurements of cal standards stored during a calibration procedure.

Suggestions: Be sure the requested standard is required for the current cal type. Not all standards are needed for all cal types.

EventID: E8020263 (hex)

Message: 612

" The Error Term data required for the selected caltype was not found."

Severity: Error

Further explanation: An unsuccessful attempt was made to retrieve a specified error term from the error correction buffer. The buffer should contain the error correction arrays for the current calibration.

Suggestions: Be sure the requested error term is required for the current cal type. Not all error terms are needed for all cal types.

EventID: E8020264 (hex)

Message: 613

The Calibration data set was not found.

Severity: Error

Further explanation: An unsuccessful attempt to access a cal set has been made. This may indicate a calset has been deleted or has been corrupted.

Suggestions: Try again or select another cal set. If the cal set appears in the cal set list, it may need to be deleted.

EventID: E8020265 (hex)

Message: 614

"The specified measurement does not have a calibration valid for Confidence Check. Please select a different measurement, or recall or perform a different Calibration Type."

Severity: Error

Further explanation: The measurement choice is prevented so that calibration will not be turned off. Not all cal types support all measurements. For example, an 1-Port cal on S11 can not be used to calibrate an S12 measurement. When a measurement is selected that does not have a calibration which can be applied, an informational message is displayed and calibration is turned off.

Suggestions: Use a full 2-Port calibration to be compatible with any S-Parameter.

EventID: E8020266 (hex)

Message: 615

" New calset created."

Severity: Error

Further explanation: The newly created cal set will be automatically named and time stamped. If this is the beginning of a calibration procedure, the cal set will not be stored to memory until the calibration has completed successfully. The new cal set will be deleted if the calibration is canceled or does not otherwise complete successfully.

Suggestions: Informational message.

EventID: E8020267 (hex)

Message: 617

The calset file: <x> appears to be corrupted and cannot be removed. Exit the application, remove the file, and restart.

Severity: Error

Further explanation:

Suggestions: The cal set file is stored in the application home directory C:\Program Files\Agilent\Network Analyzer\PNACalSets.dat. Remove this file, then restart the application.

EventID: E8020269 (hex)

Message: 634

"The calset file: <x> load failed."

Severity: Error

Further explanation: The calset file contains a collection of calsets. The file resides on the hard drive.

Suggestions: Try restarting the application. If the failure persists, you may have to delete the cal set data file and restart the application. The cal set file is stored in the application home directory. C:\Program Files\Agilent\Network Analyzer\PNACalSets.dat. Remove this file, then restart the application.

EventID: E802027A (hex)

Message: 635

"The calset file: <x> save failed."

Severity: Error

Further explanation: The file operation detected an error. The save operation was aborted.

Suggestions: Retry.

EventID: E802027B (hex)

_____

Message: 636

"A calset was deleted."

Severity: Informational

Further explanation: One of the calsets has been successfully deleted from the collection of calsets available. This can happen as the result of a user request or intentional operation.

Suggestions: None

EventID: 6802027C (hex)

_____

Message: 637

"The version of the calset file: <x> is not compatible with the current instrument."

Severity: Error

Further explanation: A versioning error can prevent a calset from being used. This can happen as a result of instrument firmware upgrades.

Suggestions: If the versioning error is the result of firmware upgrade, you will have to re-install the old version of firmware to re-use the calset file. Or you can re-create the calsets with the current version of firmware.

The cal set file is stored in the application home directory C:\Program Files\Agilent\Network Analyzer\PNACalSets.dat. Remove this file, then restart the application.

EventID: E802027D (hex)

_____

Message: 638

"Incompatible CalSets found: <x> of <y> stored calsets have been loaded."

Severity: Error

Further explanation: Errors were found on some of the calsets stored in the calset file. The errors may have been caused by versioning issues that may have corrupted the various calset keys.

Suggestions: Use the calset viewer to look at the contents of calset files. Delete the files that are corrupted.

EventID: 6802027E (hex)

_____

Message: 639

"The Calset file: <x> was not found. A new file has been created."

Severity: Informational

Further explanation: The calset file should be stored on the hard drive. When the application is started, a search is done and the file is loaded if it can be found. If the file is not found, the analyzer will create a new file and display this message.

Suggestions: None

EventID: 6802027F (hex)

_____

Message: 640

"The Calset specified is currently in use."

Severity: Error

Further explanation: This may indicate a conflict between multiple calset users attempting calibration tasks.

Suggestions: Save the instrument state. Preset the analyzer and recall the instrument state. This may abort any processes that may be in progress.

EventID: E8020280 (hex)

Message: 641

"The calset specified has not been opened."

Severity: Error

Further explanation: Multiple users may be attempting to access the calset.

Suggestions: Close multiple calset users so that only one user will access the calset.

EventID: E8020281 (hex)

Message: 642

"The maximum number of cal sets has been reached. Delete old or unused cal sets before attempting to create new ones."

Severity: Error

Further explanation: The analyzer will save up to 100 calsets.

Suggestions: You may also delete the calsets data file.

The cal set file is stored in the application home directory. C:\Program Files\Agilent\Network_Analyzer\PNACalSets.dat. Remove this file, then restart the application.

EventID: E8020282 (hex)

Message: 644

"A valid calibration is required before correction can be turned on."

Severity: Error

Further explanation: This usually indicates a calibration procedure has not run to completion or that the selected measurement does not have a valid calibration available from within the currently selected cal set.

Suggestions: To find a calibration, you can select a Cal Set that contains the calibration needed for the current measurements. This error can happen if a calibration type is not specified before attempting to programmatically execute cal acquisitions. Specify the cal type before beginning a calibration procedure.

EventID: E8020284 (hex)

Message: 645

The cal data for <x> is incompatible and was not restored. Please recalibrate."

Severity: Warning

Further explanation: None

Suggestions: None

EventID: A8020285 (hex)

Message: 646

"CalSet not loaded, version is too new."

Severity: Error

Further explanation: An old version of firmware is attempting to run with a new calset version. The version is incompatible.

Suggestions: The calset can be removed. You may also delete the calsets data file if you are migrating between various firmware revisions often and you would like to avoid this error. The cal set file is stored in the application home directory. C:\Program Files\Agilent\Network Analyzer\PNACalSets.dat. Remove this file, then restart the application.

EventID: E8020286 (hex)

Hardware Errors 772- 868

Message: 772

"The spampnp.sys driver is not working. Check system hardware. ! Data will be simulated. !"

Severity: Error

Further explanation: The Network Analyzer application cannot locate the DSP board. Hardware or a driver may be malfunctioning. This is also common when attempting to run the Network Analyzer on a workstation.

Suggestions:

EventID: E8030304 (hex)

Message: 773

"Instrument Serial Bus Not Working."

Severity: Error

Further explanation: The instrument EEPROM appears to contain either all ones or all zeros. A serial bus hardware failure prevents reading the EEPROM.

Suggestions:

EventID: E8030305 (hex)

Message: 848

"Phase lock lost"

Severity: Error

Further explanation: The instrument source was not able to lock properly. This can be the result of broken hardware, poor calibration, or bad EEPROM values.

Suggestions: Perform source calibration. Click System / Service / Adjustments / Source Calibration

EventID: E8030350 (hex)

Message: 850

"Unknown hardware error."

Severity: Error

Further explanation: Hardware malfunctioned prevents communication with the DSP.

Suggestions:

EventID: E8030352 (hex)

Message: 855

"Source unleveled."

Severity: Error

Further explanation: The source was unable to properly level at the requested power. The indicated power may not be accurate.

Suggestions: Try a different power level. Recalibrate source, if problem persists.

EventID: E8030357 (hex)

Message: 859

"Yig calibration failed."

Severity: Error

Further explanation: Internal self-calibration of YIG oscillator tuning failed.

Suggestions:

EventID: E803035B (hex)

Message: 861

"Analog ramp calibration failed."

Further explanation: Internal analog sweep ramp calibration has failed.

Suggestions:

EventID: E803035D (hex)

Message: 865

"EEPROM write failed."

Severity: Error

Further explanation: Attempt to store calibration data to EEPROM has failed. There is a possible hardware failure.

Suggestions:

EventID: E8030361 (hex)

Message: 867

Attempted I/O write while port set to read only.

Severity: Error

Further explanation: Attempt to write to an I/O data port while the port set to input/read only.

Suggestions: Set data port to write/output before attempting to write to port.

EventID: E8030363 (hex)

Message: 868

" Attempted I/O read from write only port.

Severity: Error

Further explanation: Attempt to read from an I/O data port while the port set to output/write only.

Suggestions: Set data port to read/input before attempting to read from port.

EventID: E8030364 (hex)

Measure Errors 1025 -1128

Message: 1025

"The measurement failed to shut down properly. The application is in a corrupt state and should be shut down and restarted."

Severity: Error

Further explanation: This message is displayed if the PNA application becomes corrupt. If you continue to get this error, please call customer service

Suggestions:

EventID: E8040401 (hex)

Message: 1027

"Group Delay format with CW Time or Power sweeps produces invalid data."

Severity: Warning

Further explanation: Group Delay format is incompatible with single-frequency sweeps. Invalid data is produced.

Suggestions: Ignore the data or choose a different format or sweep type.

EventID: A8040403 (hex)

Message: 1028

Severity: Informational

"MSG_LIMIT_FAILED"

Further explanation: Limit line test failed.

Suggestions:

EventID: 68040404 (hex)

Message: 1029

Severity: Informational

"MSG_LIMIT_PASSED"

Further explanation: Limit line test passed.

Suggestions:

EventID: 68040405 (hex)

Message: 1030

"Exceeded the maximum number of measurements allowed."

Severity: Warning

Further explanation: You can only create 16 measurements.

Suggestions: None

EventID: A8040406 (hex)

_____

Message: 1031

"Network Analyzer Internal Error. Unexpected error in AddNewMeasurement."

Severity: Warning

Further explanation: If you continue to get this message, contact product support.

EventID: A8040407 (hex)

_____

Message: 1032

"No measurement was found to perform the selected operation. Operation not completed."

Severity: Warning

Further explanation: None

Suggestions:Create a measurement before performing this operation.

EventID: A8040408 (hex)

_____

Message: 1034

"A memory trace has not been saved for the selected trace. Save a memory trace before attempting trace math operations."

Severity: Warning

Further explanation: Must have a memory trace when trying to do Trace Math,

Suggestions:

EventID: A804040A (hex)

_____

Message: 1035

"MSG_SET_AVERAGE_COMPLETE"

Severity: Informational

Further explanation: Informational for COM programming. Averaging factor has been reached.

Suggestions:

EventID: 6804040B (hex)

_____

Message: 1036

"MSG_CLEAR_AVERAGE_COMPLETE"

Further explanation: Informational for COM programming. Averaging factor has NOT been reached.

Suggestions:

EventID: 6804040C (hex)

_____

Message: 1037

"Time Domain transform requires at least 3 input points. The transform has been deactivated."

Severity: Informational

Further explanation: None

Suggestions: Increase the number of points.

EventID: 6804040D (hex)

_____

Message: 1104

"Exceeded limit on number of measurements."

Severity: Error

Further explanation: You can only create 16 measurements.

Suggestions:

EventID: E8040450 (hex)

_____

Message: 1105

"Parameter not valid."

Severity: Error

Further explanation: A measurement parameter that was entered programmatically is not valid.

Suggestions:

EventID: E8040451 (hex)

_____

Message: 1106

"Measurement not found."

Severity: Error

Further explanation: Any of these could be the cause:

Trying to calibrate but already have 16 measurements.
 Trying to do a confidence check but there is not a measurement.
 Trying to create, activate, or alter a measurement through COM that has been deleted through the front panel.
 Trying to use a trace name through programming that is not unique.

Suggestions:

EventID: E8040452 (hex)

_____

Message: 1107

"No valid memory trace."

Severity: Error

Further explanation: Must have a memory trace when trying to do Trace Math,

Suggestions: Store a memory trace.

EventID: E8040453 (hex)

Message: 1108

"The reference marker was not found."

Severity: Error

Further explanation: Attempted to create a delta marker without first creating a reference marker (COM only).

Suggestions:

EventID: E8040454 (hex)

Message: 1109

"Data and Memory traces are no longer compatible. Trace Math has been turned off."

Severity: Error

Further explanation: Warning - channel setting has changed while doing trace math.

Suggestions: Store another memory trace and turn trace math back on.

EventID: A8040455 (hex)

Message: 1110

"Data and Memory traces are not compatible. For valid trace math operations, memory and data traces must have similar measurement conditions."

Severity: Error

Further explanation: Tried to do trace math without compatible data and memory traces.

Suggestions: Store another memory trace.

EventID: E8040456 (hex)

Message: 1111

"Marker Bandwidth not found."

Severity: Error

Further explanation: Could not find a portion of trace that meets the specified bandwidth criteria.

Suggestions:

EventID: E8040457 (hex)

Message: 1112

"The peak was not found."

Severity: Error

Further explanation: Could not find portion of trace that meets peak criteria.

Suggestions: See Marker Peak criteria.

EventID: E8040458 (hex)

Message: 1113

"The target search value was not found."

Severity: Error

Further explanation: Could not find interpolated data point that meets search value.

Suggestions:

EventID: E8040459 (hex)

Message: 1114

"Reflection measurement, such as S11, must supply an auxiliary port to disambiguate 2-port measurements on multiport instruments."

Severity: Error

Further explanation:

Suggestions:

EventID: E804045A (hex)

Message: 1115

"The receiver power calibration has been turned off because the type of measurement or source port has changed, so the calibration is no longer valid."

Severity: Warning

Further explanation:

Suggestions:

EventID: A804045B (hex)

Message: 1116

"Receiver power cal requires the active measurement to be of unratioed power."

Severity: Warning

Further explanation:

Suggestions:

EventID: A804045C (hex)

Message: 1117

"There is currently no source power calibration associated with the channel and source port of the active measurement. A source power cal should be performed or recalled before performing a receiver power calibration."

Severity: Warning

Further explanation:

Suggestions:

EventID: A804045D (hex)

Message: 1118

"The attempted operation can only be performed on a standard measurement type."

Severity: Error

Further explanation:

Suggestions:

EventID: E804045E (hex)

Message: 1119

"The custom measurement cannot be loaded because it is not compatible with the Network Analyzer hardware."

Severity: Error

Further explanation:

Suggestions:

EventID: E804045F (hex)

Message: 1120

"The custom measurement cannot be loaded because it is not compatible with the Network Analyzer software."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040460 (hex)

Message: 1121

"The custom measurement load operation failed for an unspecified reason."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040461 (hex)

Message: 1122

"The custom measurement data processing has generated an unhandled exception, and will be terminated. The PNA software may be in an unstable state and it is recommended that the PNA software be shutdown and restarted."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040462 (hex)

Message: 1123

"The attempted operation can only be performed on a custom measurement type."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040463 (hex)

Message: 1124

"The requested custom measurement is not available."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040464 (hex)

Message: 1125

"The requested custom algorithm was not found."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040465 (hex)

Message: 1126

"Normalization cannot be turned on because the measurement does not have a valid divisor buffer."

Severity: Error

Further explanation:

Suggestions:

EventID: E8040466 (hex)

Message: 1127

"The Raw Data requested by the measurement could not be provided."

Severity: Warning

Further explanation:

Suggestions:

EventID: A8040467 (hex)

Message: 1128

"The selected Sweep Type does not allow Transform and Gating. Transform and Gating disabled. "

Severity: Informational

Further explanation:

Suggestions:

EventID: 68040468 (hex)

Parser Errors 1284 - 1535

Message: 1284

"The instrument status byte has changed."

Severity: Informational

Further explanation:

Suggestions:

EventID: 68050504 (hex)

Message: 1285

"The SCPI command received has caused error number <x>: "<x>"."

Severity: Informational

Further explanation:

Suggestions:

EventID: 68050505 (hex)

Message: 1360

"Execution of the SCPI command has failed"

Severity: Error

Further explanation:

Suggestions:

EventID: E8050550 (hex)

Message: 1535

"Parser got command: <x>"

Severity: Informational

Further explanation:

Suggestions:

EventID: 680505FF (hex)

Display Errors 1536 - 1621

Message: 1536

"Exceeded the maximum of 4 traces in each window. The trace for <x> will not be added to window <x>."

Severity: Warning

Further explanation: None

Suggestions: Create the trace in another window. See the PNA window limits.

EventID: A8060600 (hex)

Message: 1537

"Exceeded the maximum of 4 data windows. New window will not be created."

Severity: Warning

Further explanation: None

Suggestions: Create the trace in an existing window. See the PNA window limits.

EventID: A8060601 (hex)

Message: 1538

"No Data Windows are present. Unable to complete operation."

Severity: Warning

Further explanation: Your remote SCPI operation tried to create a new measurement while there were no windows present

Suggestions: Create a new window before creating the measurement. See example Create a measurement using SCPI

EventID: A8060602 (hex)

Message: 1539

"No data traces are present in the selected window. Operation not completed."

Severity: Warning

Further explanation: None

Suggestions: None

EventID: A8060603 (hex)

Message: 1540

"Cannot complete request to arrange existing measurements in <x> windows due to the limit of <x> traces per window."

Severity: Warning

Further explanation: The arrange window feature cannot put the existing traces into the number of windows you requested because only 4 traces per window are allowed. See Arranging Existing Measurements

Suggestions:Either create more windows or delete some traces.

EventID: A8060604 (hex)

Message: 1541

"Unable to establish a connection with the specified printer."

Severity: Warning

Further explanation: None

Suggestions: Refer to Printer Help

EventID: A8060605 (hex)

Message: 1542

"Printout canceled."

Severity: Informational

Further explanation: None

Suggestions: None

EventID: A8060606 (hex)

_____

Message: 1616

"Window not found."

Severity: Error

Further explanation: A window was specified in your program which does not exist.

Suggestions: Query the name of your window before specifying.

EventID: E8060650 (hex)

_____

Message: 1617

"Duplicate window ID specified."

Severity: Error

Further explanation: None

Suggestions:None

EventID: E8060651 (hex)

_____

Message: 1618

"Exceeded limit on number of windows."

Severity: Error

Further explanation: There is a limit of 4 windows per screen.

Suggestions: None

EventID: E8060652 (hex)

_____

Message: 1619

"Exceeded limit on number of traces/window."

Severity: Error

Further explanation: There is a limit of 4 traces per window. See the Traces, Channels, and Windows on the PNA.

Suggestions: Create the trace in another window

EventID: E8060653 (hex)

_____

Message: 1620

"Trace not found."

Severity: Error

Further explanation: Your program tried to communicate with a non-existing trace.

Suggestions:Query the trace ID before writing to it.

EventID: E8060654 (hex)

_____

Message: 1621

"The operating system does not recognize this printer."

Severity: Warning

Suggestions:

EventID: A8060655 (hex)

Channel Errors 1792 -1878

Message: 1792

"Sweep Complete."

Severity: Informational

Further explanation: None

Suggestions:None

EventID: 68070700 (hex)

Message: 1793

"All triggerable acquisitions have completed."

Severity: Informational

Further explanation:

Suggestions:

EventID: 68070701 (hex)

Message: 1794

"The last trigger produced an aborted sweep."

Severity: Informational

Further explanation:

Suggestions:

EventID: 68070702 (hex)

Message: 1795

"The segment list must be adjusted to have at least one active segment with more than 0 points to use segment sweep."

Severity: Informational

Further explanation: You attempted to change **Sweep type** to Segment sweep, but there is either no segments defined or no sweep points in the defined segments

Suggestions: Define at least one segment with at least one measurement point. See Segment sweep for more information

EventID: 68070703 (hex)

Message: 1796

"MSG_SET_CHANNEL_DIRTY"

Severity: Informational

Further explanation: This informational message occurs when a channel setting has changed but the channel still has data that was taken with the previous setting. The following CLEAR message occurs when new channel data is taken.

Suggestions: None

EventID: 68070704 (hex)

Message: 1797

"MSG_CLEAR_CHANNEL_DIRTY"

Severity: Informational

Further explanation: The previous SET message occurs when a channel setting has changed but the channel still has data that was taken with the previous setting. This CLEAR message occurs when new channel data is taken.

Suggestions: None

EventID: 68070705 (hex)

Message: 1872

"Channel not found."

Severity: Error

Further explanation: A non-existent channel is being referenced under program control.

Suggestions: Query the channel number, then refer to it by number.

EventID: E8070750 (hex)

Message: 1873

"The requested sweep segment was not found."

Severity: Error

Further explanation: A non-existent sweep segment is being referenced under program control.

Suggestions:

EventID: E8070751 (hex)

Message: 1874

"The sweep segment list is empty."

Severity: Error

Further explanation: Segment Sweep cannot be specified unless there is at least one defined segment. This error will only occur under remote control.

Suggestions:

EventID: E8070752 (hex)

Message: 1875

"The number of points in active sweep segment list segments is 0."

Severity: Error

Further explanation: Segment Sweep cannot be specified unless there is at least data point specified in a segment. This error will only occur under remote control.

Suggestions:

EventID: E8070753 (hex)

_____

Message: 1876

"The specified source attenuator is not valid."

Severity: Error

Further explanation: You tried to set the Attenuator property on the Channel object on a PNA that doesn't have a source attenuator.

Suggestions:

EventID: E8070754 (hex)

_____

Message: 1877

"Log Frequency sweep cannot be selected with the current Number of Points. Please reduce Number of Points."

Severity: Error

Further explanation: The maximum number of points that can be used for Log sweep is 401.

Suggestions:

EventID: E8070755 (hex)

_____

Message: 1878

"The requested Number of Points is greater than can be selected for Log Frequency sweep."

Severity: Error

Further explanation: The maximum number of points that can be used for Log sweep is 401.

Suggestions:

EventID: E8070756 (hex)

_____

Message: 1879

"Response frequencies exceeded instrument range so Frequency Offset has been turned off."

Severity: Error

Further explanation: This error is returned whenever the instrument detects that the stimulus sweep setup and Frequency Offset settings result in computed response frequencies that exceed instrument limits. When this occurs, the instrument automatically turns off Frequency Offset to avoid the out-of-range conditions.

Suggestions: When this condition has occurred, the user should change settings for either the stimulus frequencies or Frequency Offset so that the Response frequencies are within instrument bounds. Once this is done, Frequency Offset can once again be turned on.

EventID: E8070757 (hex)

_____

General Errors 2048- 2167

Message: 2048

"The function you requested requires a capability provided by an option to the standard analyzer. That option is not currently installed."

Severity: Error

Further explanation: None

Suggestions:To view the options on your analyzer, click **Help \ About Network Analyzer**. For more information see PNA Options

EventID: 68080800 (hex)

Message: 2049

"The feature you requested is not available on the current instrument."

Severity: Error

Further explanation: None

Suggestions: None

EventID: 68080801 (hex)

Message: 2050

"The feature you requested is incompatible with the current instrument state."

Severity: Error

Further explanation: None

Suggestions: None

EventID: 68080802 (hex)

Message: 2051

"File<x> has been saved."

Severity: Informational

Further explanation: None

Suggestions:None

EventID: 68080803 (hex)

Message: 2052

"Attempt to save <x> failed."

Severity: Error

Further explanation: None

Suggestions: If using a floppy disk, ensure it is inside the drive and the disk is not full. Check the filename for special characters.

EventID: E8080804 (hex)

Message: 2053

"Attempt to recall file failed because <x> was not found."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080805 (hex)

Message: 2054

"<x> has a bad header."

Severity: Error

Further explanation: None

Suggestions: Recopy the file and / or delete the file.

EventID: E8080806 (hex)

Message: 2056

"Request to enter hibernate state."

Further explanation: None

Suggestions: None

EventID: 68080808 (hex)

Message: 2057

"Power up from automatic hibernate state. Program received PBT_APMRESUMEAUTOMATIC Message."

Further explanation: None

Suggestions: None

EventID: 68080809 (hex)

Message: 2058

"Power up from suspend hibernate state. Program received PBT_APMRESUMESUSPEND Message."

Further explanation: None

Suggestions: None

EventID: 6808080A (hex)

Message: 2059

"Power up from suspend hibernate state. Program received PBT_APMRESUMECRITICAL Message."

Severity: Warning

Further explanation: None

Suggestions: None

EventID: A808080B (hex)

Message: 2060

"Power up from unknown hibernate state UI recovery called. Program received no PBT_Message within the time allotted and is attempting recovery."

Severity: Warning

Further explanation: None

Suggestions: None

EventID: A808080C (hex)

Message: 2061

"<x> already exists. File is being overwritten."

Further explanation: Used only for remote applications

Suggestions: None

EventID: 6808080D (hex)

Message: 2062

"File has not been saved."

Severity: Error

Further explanation: Used only for remote applications

Suggestions: None

EventID: E808080E (hex)

Message: 2063

"File <x> has been recalled."

Further explanation: Used only for remote applications

Suggestions: None

EventID: 6808080F (hex)

Message: 2064

"State version in <x> is considered obsolete by this version of this code."

Severity: Error

Further explanation: You attempted to recall a file that is no longer valid.

Suggestions: You must recreate the file manually.

EventID: E8080810 (hex)

Message: 2065

"State version in <x> is newer than the latest version supported by this code."

Severity: Error

Further explanation: You attempted to recall a file that was created by a later version of the PNA application.

Suggestions: You must recreate the file manually.

EventID: E8080811 (hex)

Message: 2066

"Error occurred while reading file <x>"

Severity: Error

Further explanation: The file may be corrupt.

Suggestions: Try to recreate the file.

EventID: E8080812 (hex)

Message: 2067

"Windows shell error: <x>"

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080813 (hex)

Message: 2068

Send message timed out returning: <x>.

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080814 (hex)

Message: 2069

"Changing GPIB mode to System Controller."

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 68080815 (hex)

Message: 2070

"Changing GPIB mode to Talker Listener."

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 68080816 (hex)

Message: 2071

"The Network Analyzer can not be put in GPIB System Controller mode until the GPIB status is Local. Stop any remote GPIB programs which may be using the Network analyzer, press the Macro/Local key and try again. "

Severity: Informational

Further explanation: See LCL and RMT Operation

Suggestions: Press the Macro/Local key and try again.

EventID: 68080817 (hex)

_____

Message: 2120

"This method can not be invoked through a late-bound COM call."

Severity: Error

Further explanation: None

Suggestions: Use the alternate method described in the COM programming documentation

EventID: E8080878 (hex)

_____

Message: 2128

"The specified format is invalid."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080850 (hex)

_____

Message: 2129

"WINNT exception caught by Automation layer."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080851 (hex)

_____

Message: 2130

"Bad port specification."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080852 (hex)

_____

Message: 2131

"Failed to find a printer."

Severity: Error

Further explanation: None

Suggestions: See Connecting to a Printer

EventID: E8080853 (hex)

_____

Message: 2132

"Manual trigger ignored."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080854 (hex)

Message: 2133

"Attempt to set trigger failed."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080855 (hex)

Message: 2134

"Macro execution failed."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080856 (hex)

Message: 2135

"Specified macro definition is incomplete."

Severity: Error

Further explanation:

Suggestions: None

EventID: E8080857 (hex)

Message: 2137

"Block data length error."

Severity: Error

Further explanation: See Getting Data from the Analyzer

Suggestions: None

EventID: E8080859 (hex)

Message: 2139

"Requested data not found."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E808085B (hex)

Message: 2142

"The parameter supplied was out of range, so was limited to a value in range before being applied to the instrument."

Severity: Success

Further explanation: None

Suggestions: View range limits before sending programming commands.

EventID: 2808085E (hex)

Message: 2144

"Request failed. The required license was not found."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080860 (hex)

Message: 2145

"A remote call to the front panel has returned hresult <x>"

Severity: Error

Further explanation: This may indicate a problem with the front panel

Suggestions: Contact Technical support

EventID: E8080861 (hex)

Message: 2146

The recall operation failed.

Severity: Error

Further explanation:

Suggestions:

EventID: E8080862 (hex)

Message: 2147

Attempt to save file failed.

Severity: Error

Further explanation:

Suggestions:

EventID: E8080863 (hex)

Message: 2148

Recall attempt failed because file was not found.

Severity: Error

Further explanation:

Suggestions:

EventID: E8080864 (hex)

Message: 2149

Recall file has a bad header.

Severity: Error

Further explanation:

Suggestions:

EventID: E8080865 (hex)

Message: 2150

Recall file version is obsolete and no longer compatible with this instrument.

Severity: Error

Further explanation:

Suggestions:

EventID: E8080866 (hex)

Message: 2151

The recall file contains an istate version newer than this instrument. A remote call to the front panel has returned hresult %1

Severity: Error

Further explanation:

Suggestions:

EventID: E8080867 (hex)

Message 2152

"Front Panel <x>

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080868 (hex)

Message 2153

"Front Panel message"

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 68080869 (hex)

Message 2154

"Power Service <x>

Severity: Error

Further explanation: There is more than 1 instance of powerservice running. There should only be one running. This might happen after running install shield - especially when upgrading the CPU board.

Suggestions: Try rebooting. If this persists, please call Customer Support.

EventID: E808086A (hex)

Message 2155

"Power Service <x>

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 6808086B (hex)

Message 2156

"The Agilent Technologies GPIB driver can not be loaded or unloaded."

Severity: Error

Further explanation: None

Suggestions: If the problem persists, from the PNA desktop, right-click on My Computer. Click Properties, Click Hardware Tab. Click Device Manager Button. Expand GPIB Devices. Right-click and click Uninstall all GPIB interfaces devices. Reboot the PNA.

EventID: E808086C (hex)

Message 2157

"The National Instruments GPIB driver can not be loaded or unloaded."

Severity: Error

Further explanation: None

Suggestions: If the problem persists, from the PNA desktop, right-click on My Computer. Click Properties, Click Hardware Tab. Click Device Manager Button. Expand GPIB Devices. Right-click and click Uninstall all GPIB interfaces devices. Reboot the PNA.

EventID: E808086D (hex)

Message 2158

"The Agilent GPIB driver is loaded but it can not start its parser."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E808086E (hex)

Message 2163

"The Network Analyzer executed a preset."

Severity:Informational

Further explanation: None

Suggestions: None

EventID: 68080873 (hex)

Message 2164

"Access to file denied."

Severity: Error

Further explanation: This means that the system can not open an output file for writing. Most likely because the file is write protected.

Suggestions: Pick another file name or file directory, check floppy disk hard disk write access.

EventID: E8080874 (hex)

Message 2165

"File type is structured storage."

Severity: Informational

Further explanation: None

Suggestions: None

EventID: 68080875 (hex)

Message 2166

"The trigger operation failed."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080876 (hex)

Message 2167

"Argument out of range error."

Severity: Error

Further explanation: None

Suggestions: None

EventID: E8080877 (hex)

About Error Messages

PNA errors and Operating System errors are displayed and logged in an error file. You can

choose how to display PNA errors, or choose to not display PNA errors at all.

- Error Preferences
- View Error Log
- List of PNA Errors
- SCPI Errors

Other Support topics

Error Preferences

By default, error messages appear on the PNA screen for a brief period. You can choose to have them stay on the screen until you click an OK button, or have them not appear at all. When they stay on the screen, a Help button is available to provide further assistance.

How to select Error Preferences
Marker System Window | Help
Network Analyzer Help Network Analyzer on the Web Help Language ▶ Error Preferences... Error Messages ▶ View Error Log About Network Analyzer
Learn more about using the front panel interface

Error Message Preferences ⊠
State ☑ Enable Messages Calibration Error Message Windows ⊙ Timed Popups ○ Confirmation Dialog boxes OK   Cancel   Help
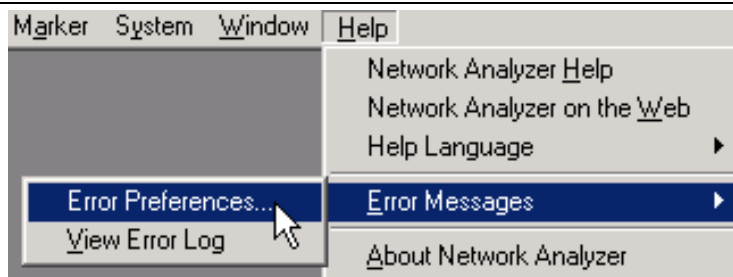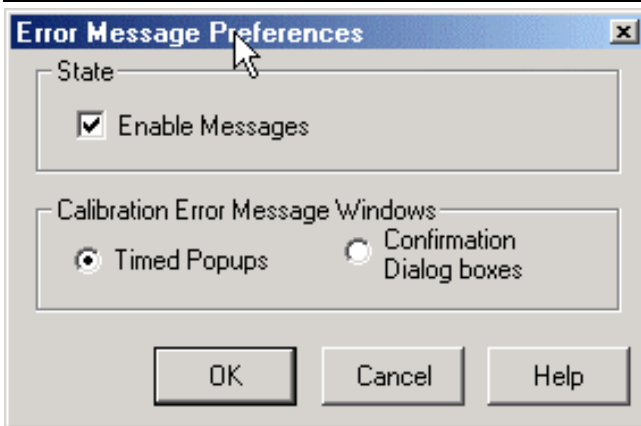
Error Preferences dialog box help
Enable Messages Check to display all PNA error messages as they occur. Clear to suppress the display of PNA error messages. You can still view them in the error log.
Calibration Error Message Windows
Timed Popups Displays error messages on the screen for a duration of time proportional to the length of the message. You can then view the message in the error log and get further assistance.
Confirmation Dialog boxes Displays error messages in a standard dialog box. You then choose OK or Cancel to close the dialog box, or press Help to get further information on the error message.

View Error Log

The PNA Error Log is a list of all events that have occurred. (Events are used in programming the PNA using COM.) PNA errors is a subset of PNA events. Only events with severity codes of

ERROR are displayed on the PNA screen as they occur. From the error log, you can access further help with an error by selecting the error and clicking Help.

How to view the Error Log
Learn more about using the front panel interface
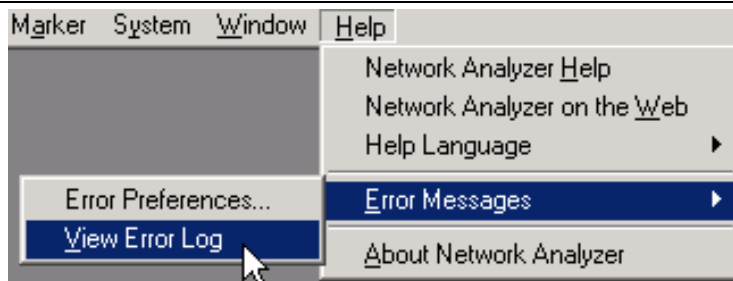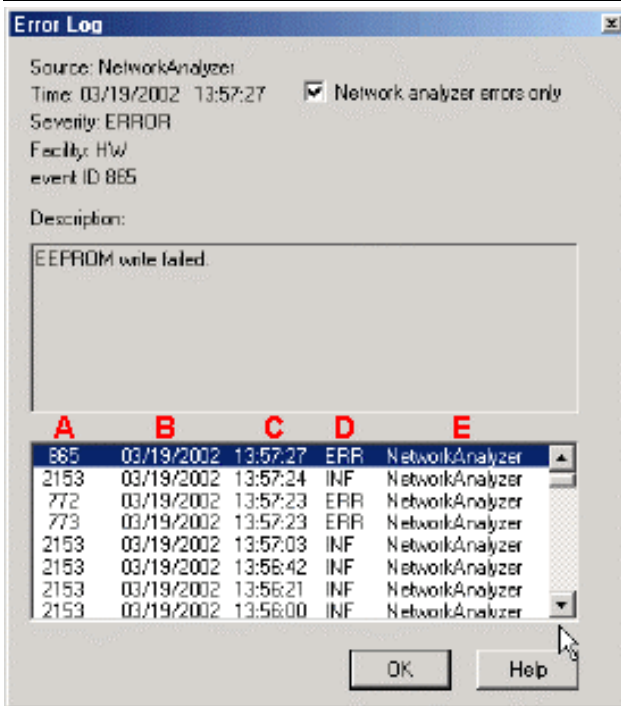
Error Log dialog box help
Network analyzer errors only Select to view only PNA errors. Clear to view all errors that occur on all applications of the computer.
Description Error message that appears on the PNA screen.
A - Event ID Error message number
B - Date the Error occurred
C - Time the Error occurred
D - Severity Code - All events have one of the following severity codes:
• SUCcess - the operation completed successfully
• INFormational - events that occur without impact on the measurement integrity
• WARning - events that occur with potential impact on measurement integrity
• ERRor - events that occur with serious impact on measurement integrity
E - Application in which the error occurred.

OK Closes the Dialog box

Help Provides further information on the selected Error message

To clear the Error Log:

1. From the **View** menu click **Minimize Application**
2. On the desktop, select **Start, Settings, Control Panel**
3. On the Control Panel, click **Administrative Tools**
4. On the Administrative Tools window, click **Event Viewer**
5. On the Event Viewer window, right-click **Application Log**
6. Select **Clear all Events**
7. If you want to save a file with the contents of the Event Log, click **Yes**. Otherwise, click **No**

To restore the PNA application, click on the PNA Analyzer taskbar button at the bottom of the screen

Analyzer Accessories

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- Coax Mechanical Calibration Kits
- Waveguide Mechanical Calibration Kits
- Electronic Calibration (ECal)
- Mechanical Verification Kits
- Adapter and Accessory Kits
- Test Port Cables
- USB Peripherals
- Connector Care and Cleaning Supplies
- ESD Protection

Other Support topics

For product and order information:

- Call 1-800-452-4844 (8am-8pm EST)
- Visit www.agilent.com/find/accessories
  Use the search function to locate information about a particular accessory or view the entire RF and Microwave Test Accessories Catalog.

Accessories are available in these connector types:

- 50 ohm Type-N
- 3.5 mm
- 7 mm (APC-7)

- 7-16

- 2.4 mm

Test port cables and a calibration kit are necessary for a complete measurement system. A verification kit is used to verify corrected system performance.

Coax Mechanical Calibration Kits

Model	Connector Type	Frequency Upper Limit
85032B	Type-N (50 Ohm)	6 GHz
85032F	Type-N (50 Ohm)	9 GHz
85054B	Type-N (50 Ohm)	18 GHz
85036E	Type-N (75 Ohm)	3 GHz
85050B	7 mm	18 GHz
85033D	3.5 mm	6 GHz
85033E	3.5 mm	9 GHz
85052B	3.5 mm	26.5 GHz
85052C	3.5 mm TRL	26.5 GHz
85056K	2.92 mm	50 GHz
85056A	2.4 mm	50 GHz
85038A	7-16	7.5 GHz

Waveguide Mechanical Calibration Kits

Model	Connector Type	Frequency Range
X11644A	WR-90	8.2-12.4 GHz
P11644A	WR-62	12.4-18 GHz
K11644A	WR-42	18-26.5 GHz
R11644A	WR-28	26.5-40 GHz
Q11644A	WR-22	33-50 GHz
U11644A	WR-19	40-60 GHz
V11644A	WR-15	50-75 GHz

Electronic Calibration (ECal)

Model	Connector Type	Frequency Range
85092C	Type-N (50 ohm)	300 kHz-9 GHz
85093C	3.5 mm	300 kHz-9 GHz
85091C	7 mm (APC-7)	300 kHz-9 GHz
85099C	Type-F	300 kHz-3 GHz
85062B	3.5 mm	1-26.5 GHz
85064B	Type-N (50 ohm)	1-18 GHz
N4431A Option 010	3.5mm (f) (four-port)	300 kHz-9 GHz
N4431A Option 020	Type-N (f) (four-port)	300 kHz-9 GHz

Verification Kits

Model	Connector Type	Frequency Range
85055A	Type-N (50 Ohm)	300 kHz-9 GHz
85053B	3.5 mm	300 kHz-26.5 GHz
85057B	2.4 mm	.045-50 GHz
R11645A	WR-28	26.5-40 GHz
Q11645A	WR-22	33-50 GHz

Adapters and Accessory Kits

Model	Description

11878A	Type-N to 3.5 mm Adapter Kit
11525A	Type-N (m) to 7 mm (APC-7)
11853A	Type-N Accessory Kit
11900B	2.4 mm (f) to 2.4 mm (f)
11900C	2.4 mm (f) to 2.4 mm (m)
85130G	Test Port Adapter Set, 2.4 mm (f) to 2.4 mm (m,f)
11901B	2.4 mm (f) to 3.5 mm (f)
11901D	2.4 mm (f) to 3.5 mm (m)
85130F	Test Port Adapter Set, 2.4 mm (f) to 3.5 mm (m,f)
11902B	2.4 mm (f) to 7 mm (APC-7)

Test Port Cables

Model	Description
N6315A	Type-N (m) to Type-N (f), 16 in. (single)
N6314A	Type-N (m) to Type-N (m), 24 in. (single)
85133D	2.4 mm (f) to 2.4 mm (m,f) semi-rigid (set)
85133F	2.4 mm (f) to 2.4 mm (m,f) flexible (set)
85134D	2.4 mm (f) to 3.5 mm (m,f) semi-rigid (set)
85134F	2.4 mm (f) to 3.5 mm (m,f) flexible (set)

USB Peripherals

Model	Description
N4688A	**CD RW drive -** with USB cable.
N4689A	**USB 4-port hub** - for connecting additional USB peripherals.

Connector Care and Cleaning Supplies

Part Number	Description
9301-1243	Lint-Free Swabs (small), 100 ct.
8500-5344	IPA 99.5% alcohol, 30 ml. bottle
8500-6659	Compressed Air, 235 ml. can
5021-7607	Type-N Contact Removal Tool
1401-0225	Standard End-Cap, Type-N (m)
1401-0248	ESD Safe End-Cap, Type-N (m)
1401-0225	Standard End-Cap, Type-N (f)
1401-0247	ESD Safe End-Cap, Type-N (f)

ESD Supplies

Part Number	Description
9300-1367	Adjustable antistatic wrist strap
9300-0980	Antistatic wrist strap grounding cord (5 foot)
9300-0797	Static control table mat (2 foot x 4 foot) with earth ground wire
9300-1126	ESD heel strap

Firmware Upgrade

The PNA firmware upgrade is a self-extracting Install Shield file that is available to you at no cost. The upgrade file includes the PNA application, Online help, and Service utilities.

The following three options are available for you to upgrade your PNA application:

- Auto-Check and AgileUpdate If your PNA is connected to the Internet, these utilities will automatically check for, download, and install, the new firmware and associated files when the PNA application is started.

- Website Access If your PNA is NOT connected to the Internet, but you have a PC that is, you can download the PNA firmware and associated files to a storage medium.

- CD-ROM If you do not have high speed Internet access, (the upgrade file is about 40 MB) firmware upgrades are also available on CD-ROM. To learn how to get a CD-ROM see PNA options.

Other Support Topics

Auto-Check

With Internet access to your PNA, Auto-Check automatically and regularly checks the Internet for new PNA firmware revisions. If a new revision is found, a notification message prompts you to run the AgileUpdate utility, which then performs the actual download.

Auto-Check is run only when the PNA application is started. Once the PNA application is running, it will not check for updates again until it is restarted.

When Auto-Check runs, it checks the following conditions:

- Is there an active connection to the Internet?

- Is the Auto-Check utility enabled?

- Is it time to check for new firmware?

- Does new firmware exist?

If all of these conditions are true, Auto-Check shows the following dialog box:
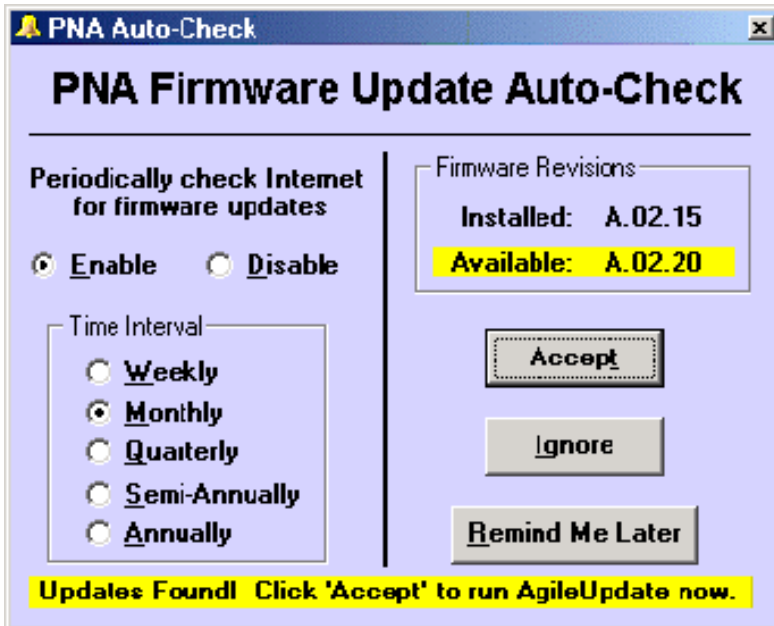
Note: To change these settings at any time, click **System** then **AgileUpdate**. From within AgileUpdate, click **AutoCheck**. These preferences are stored in the PNA registry; future firmware upgrades will not affect these settings.

PNA Auto-Check dialog box help
Enable When the PNA application is started, Auto-Check will search the PNA website for firmware

updates at the selected time interval.

Disable When the PNA application is started, Auto-Check will NOT search the PNA website for firmware updates.

Time Interval Select the time interval Auto-Check is to search for firmware updates.

Accept Prompts you to run AgileUpdate.

Ignore No further action is done until the selected time interval has elapsed.

Remind me Later This dialog box will be shown again in 1 to 20 days. (The number of days depends on the selected Time Interval.)

AgileUpdate

Note: You must have administrative privileges on the analyzer to run this utility. See Set Up Analyzer Users.

In most cases, the following steps are sufficient to download and install the newest version of PNA firmware:

1. Connect the PNA to the Internet. A LAN connection is recommended because a firmware download can take up to three hours using a modem.

2. In the **System** menu, click **Service**, then **AgileUpdate**.

3. Click **Check for Updates**.

4. If updates exist, click **Download & Install**.
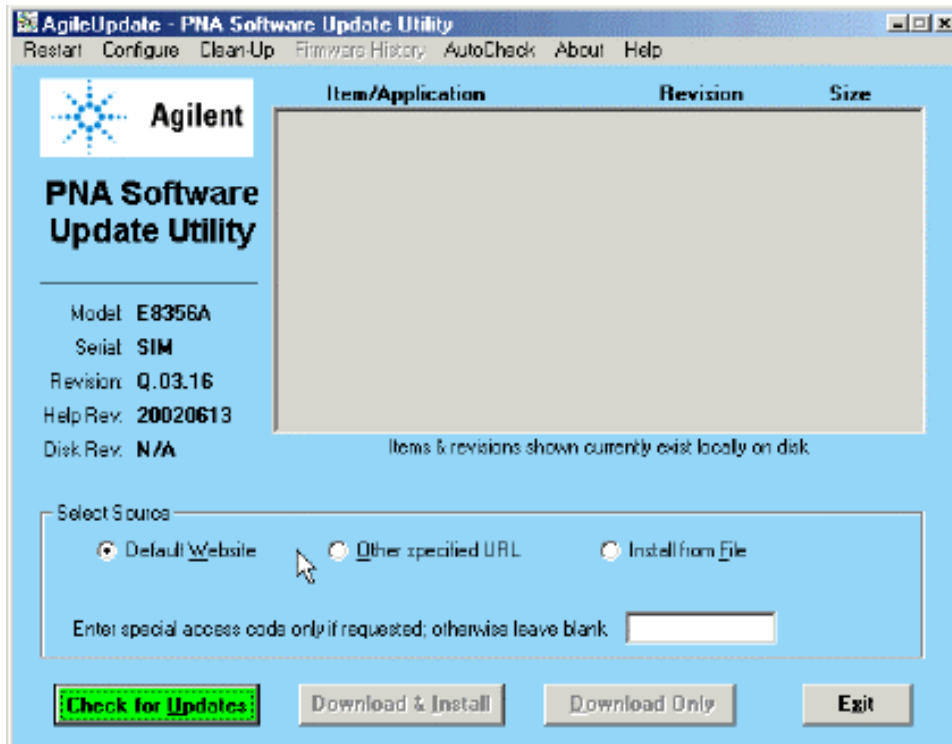
AgileUpdate dialog box help
Restart Click to make another connection
Configure Click to launch the Configure Dialog Box
Clean-up Click to delete all but the two most recent install shield packages from the PNA Hard

drive.

Firmware History Available after clicking Check for Updates. Click to read about changes in previous releases. Click the **ReadMe** menu selection if it is available, and review information that may include details regarding upgrade procedures, known problems and solutions.

Auto-Check Opens the Auto-Check utility so it can be reconfigured.

Item / Application Lists the items available for download at the firmware website. Click on items with **i** to read more information about the download.

Note: The firmware includes the help file. Therefore, only the firmware checkbox will be selected if a new version for both the firmware and the help file are available.

Select Source

  Default Website The Agilent site that contains upgrade FW.

  Other Specified URL Click if you were instructed to get firmware from a different website.

  Install from File Click if you have already downloaded the InstallShield package and want AgileUpdate to install it for you.

  Special Access Code Type in a code if you were given one from Agilent Technical Support

Check for Updates Click to look for firmware updates at the Agilent website. If there are newer versions of the files, the files will be listed (where) with the check boxes selected. If you do not want to update any of the files listed, click the check box to clear the selection.

Download and Install When updates are found, this selection becomes available. Check the items to download. Then click to download and install the update.

Download Only Click to download the files to the analyzer hard disk and install the files at a later time. Then click **Install from File.**
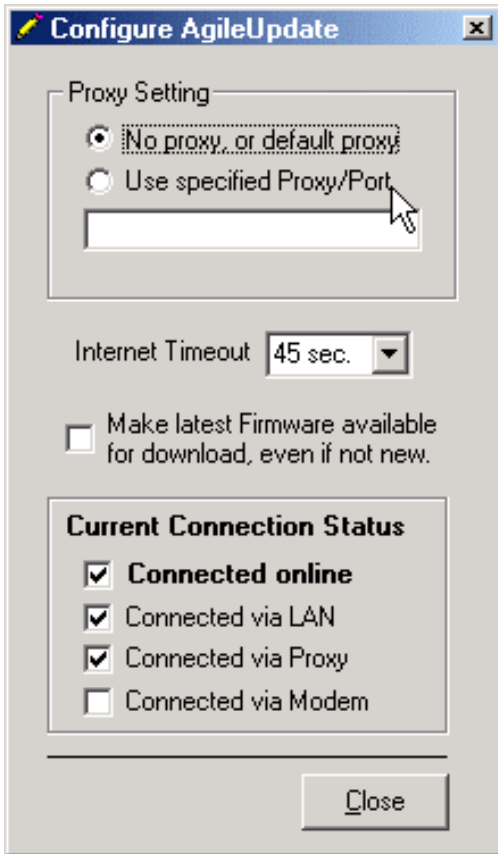
Configuration dialog box help
Proxy Setting
No Proxy or Default Proxy Click if you use a LAN connection. AgileUpdate will automatically use the proxy specified in Internet Explorer.
Use specified Proxy / Port Click to enter the proxy name and port. The format is: proxyName:portNumber. (The proxy port number is typically 8088.).
Internet timeout If you are using an automatic dial-up Internet connection you may need to increase the timeout.
Make latest firmware available, even if not new. Check to allow firmware from an earlier revision to be downloaded.
Current Connection Status Lists the current status of the PNA connection to the Internet.
Note: These settings are NOT saved; they must be re-entered each time AgileUpdate is run.

Agilent Website Access

If you cannot access the Internet directly with your analyzer, you can use an external PC with Internet access to download the file from the Agilent website. You can then transfer the file from your PC to your analyzer over a LAN or other means.

1. Connect to the PNA web page at http://www.agilent.com/find/PNA.
2. Follow the links, or search for the "PNA firmware" download page.
3. Click on the firmware to be downloaded.
4. Save the program to disk (hard drive of your PC).
5. Transfer the file from your PC to your PNA using LAN, CD, or USB Flash memory device.

6. Double-click the file on the PNA.

Warning: You can save the upgrade file to your PC, but do not attempt to install the PNA application on your PC. It will alter system settings and can result in system crashes.

PNA Options

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Included with each instrument is a mouse, keyboard, documentation CD-ROM, and a standard three-year return-to-Agilent service warranty. This topic presents the available options and upgrades.

- Options and Upgrade Kits

- Documentation and Localization

- Service and Support Options

Note: To view the options that are installed on your analyzer, on the **Help** menu, click **About Network Analyzer**

Other Support Topics

Options and Upgrade Kits

The following options are installed at the time of purchase, and some are also available after the initial purchase of a PNA. To order an upgrade, contact your Agilent representative.

Option	Supported Models	Description
006	E8356A E8801A N3381A	**Upgrade to 6 GHz frequency range.** Adds 6 GHz operation. Includes installation at an Agilent service center. Instrument calibration (required after frequency upgrade) is available for an additional fee.
009	E8356/7A E8801/2A N3381/2A	**Upgrade to 9 GHz frequency range.** Adds 9 GHz operation. Includes installation at an Agilent service center. Instrument calibration (required after frequency upgrade) is available for an additional fee.
010	All	**Time-domain** Adds time-domain capability to analyzer. The serial number of the analyzer must be specified when ordering this kit. Installation is not included.
014	E8801/2/3A N3381/2/3A E8362/3/4A	**Configurable test set** Adds front panel access to the source output and coupler input on test ports 1 and 2. Adds front panel access directly to all receivers, including the reference receiver. Includes installation at an Agilent service center. See the PNA block diagram.
015	E8356/7/8A	**Configurable test set** Adds front panel access to the source output and coupler input on

test ports 1 and 2. Adds 35 dB step attenuators between the couplers and receivers. Includes installation at an Agilent service center.

See the PNA block diagram

098	E8356/7/8A	**CPU board upgrade** Replaces the 266 MHz CPU board with a 500 MHz CPU board. Includes installation at an Agilent service center.

To check your PNA CPU speed:

1. On the PNA, click **View**, then **Minimize Application**.

2. On the desktop, right-click **My Computer**, then click **Manage**.

3. Open **System Tools** folder, then click **System Information.**

Click **System Summary**. After refreshing, read the **Processor** entry. The end of the line states the CPU speed.

099	All	**Firmware upgrade kit** Provides the latest revision of firmware for the PNA Series Analyzer on CD-ROM. Firmware is user-installable. Installation requires a USB CD-ROM drive or external computer connected through LAN. The latest firmware is also available by using the AgileUpdate utility in the PNA.
1E1	E8801/2/3A N3381/2/3A	**70 dB step attenuator** Adds a 70 dB step attenuator between the source and each output port to extend the output power to -85 dBm. Includes installation at an Agilent service center. This item is standard with PNA models E8356/7/8A.
1E5	E8801/2/3A N3381/2/3A	**High stability 10 MHz time base** Replaces 10 ppm time base with a 1 ppm time base. High stability time base is standard with PNA models E8356/7/8A and E8362/3/4A.
UNL	E8362/3/4A	**60 dB step attenuators and bias tees** Adds two step attenuators and two bias tees. A step attenuator and bias-tee set is inserted between the source and test port 1 and another set between the source and test port 2. Includes installation at an Agilent service center.

Documentation and Localization

Option	Description
AVK	Adds printed version of Help, which includes a User's Guide and Programmer's documentation.
0BW	Adds printed copy of assembly-level service manual.
ABD	Adds printed version of Help in German.
ABE	Adds printed version of Help in Spanish.
ABF	Adds printed version of Help in French.
ABJ	Adds printed version of Help in Japanese.

Service and Support Options

Option	Description
W01	Converts three-year return-to-Agilent service warranty to one-year on-site service (check with your local Agilent sales or service office for availability in your area). Not available for microwave PNA models E8362/3/4A. See Agilent Contacts.
W31	Converts three-year return-to-Agilent service warranty to three-year on-site service (check with your local Agilent sales or service office for availability in your area). Not

available for microwave PNA models E8362/3/4A. See Agilent Contacts.

W32	Adds three-year return-to-Agilent commercial calibration agreement.
W34	Adds three-year return-to-Agilent standards-compliant calibration agreement.
W50	Extends return-to-Agilent service warranty to five years.
W51	Converts three-year return-to-Agilent service warranty to five-year on-site service (check with your local Agilent sales or service office for availability in your area). Not available for microwave PNA models E8362/3/4A. See Agilent Contacts.
W52	Adds five-year return-to-Agilent commercial calibration agreement.
W54	Adds five-year return-to-Agilent standards-compliant calibration agreement.

Note: For on-line information about Agilent's service and support products visit: www.agilent.com/find/tm_services

Option Enable Utility
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The Option Enable utility allows you to perform the following activities.

- Add or remove software options and some hardware options.

- Recover option data if the hard drive or other data-containing assembly is replaced.

- Input or change a serial number.

- Keywords

- Running the Program

- Removing an Option

- Installing an Option

- Repairing and Recovering Option Data

- Installing or Changing the Serial Number

Keywords

To add certain options, you need a keyword that is provided by Agilent. There are two types of keywords:

- **Option Keywords** to add a software option.
- **Model Keywords** that may be required if you replace multiple assemblies.

Temporary and Permanent Options

Any software option can also be installed on a temporary basis for a specified amount of time. This allows you to evaluate a specific feature or capability at no cost.

If the license key provided by Agilent has an expiration date, you must select the "temporary" option and enter the expiration date exactly as stated in the license statement. If you decide to make this option permanent, Agilent will provide a new keyword that converts the option to permanent status.

For either permanent or temporary software options, a provided keyword must be entered.

Running the Program

1. In the analyzer **System** menu, point to **Service**, and click **Option Enable**.

2. The first screen will display the model number, serial number, and all installed options. To add or remove an option, select it from the drop-down list of available options.

   - If the desired option is not listed, select the last choice in the list, labeled **Enter Unlisted Option**.

If a software option was chosen, the following occurs.

- The "Remove" button will be enabled.

- The keyword entry area becomes visible.

- The permanent/temporary selection is enabled.

If a hardware option is selected, the following occurs.

- With the hardware option already installed, the Remove button is enabled.

- With the hardware option not installed, the Install button is enabled.

Removing an Option

1. To remove an option, click the **Remove** button.

2. After the option is removed, restart the network analyzer application for any changes to take effect.

Installing an Option

1. If the keyword entry area is visible, enter a keyword. (The keyword is not case sensitive.)

2. Click Install.

3. After the option is installed, restart the network analyzer application for any changes to take effect.

Repairing and Recovering Option Data

Use this part of the Option Enable Utility in the following situations:

- If the hard drive is replaced

- If the frequency reference assembly is replaced

This routine rebuilds the option information contained on the hard drive and frequency reference assembly (primary and backup).

1. Select **Repair** from the **Option Enable Utility** menu bar.

Note: If you are unsure if this routine needs to be done, run it; no harm will result.

2. The model and serial number are displayed, along with four check boxes.

3. Select the boxes that apply.

4. Click **Begin Repair**. The routine checks all data files and performs any needed repairs. You may be asked to verify certain information and processes.

5. If the routine finds that the model number is incorrect or invalid, you will be asked to select the correct model number.

   - Along with this model number, a model keyword will be required.

   - If this is not labeled on the analyzer, or is not otherwise known, contact Agilent.

   - After you have entered the requested data, click **Change Model**. This process takes about 30 seconds.

6. When done, select **Exit Repair**.

7. If you do not need to install any other options, click **Exit**.

Installing or Changing the Serial Number

It may be necessary to install or change a serial number if certain assemblies are replaced.

1. To change the serial number, select Change Serial from the Option Enable menu bar. The current serial number will be displayed. If no serial number has previously been entered, the word "NONE" will be displayed.

2. Type the new serial number into the space provided, and click Change Serial. (The serial number is not case sensitive.)

Note: Use extreme care when entering the serial number; only one entry chance is allowed!

3. To change an incorrect serial number a clear-code password will be required. Contact Agilent to obtain this clear code and have the existing serial number available.

4. To change the serial number, enter the clear code in the space provided, along with the new serial number, then click **Change Serial**.

Other Resources

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The following network analysis resources are also available.

▪ Document Resources

▪ Third Party Resources

Other Support Topics

Document Resources

Application Notes

You can access a number of the following application notes from the analyzer.

1. In the **Help** menu, click **Product Overview.**

2. The Product Overview starts with an introduction. To immediately move through this, click **Main Menu.**

3. In the main menu click **Literature**, and then any literature title to view the document.

You can also access all of the following application and product notes at this URL:

http://www.agilent.com/find/PNA

- Application Development with the Agilent PNA Series of Network Analyzers, (literature number 5980-2666ENUS).

- Understanding and Improving Network Analyzer Dynamic Range, Agilent Application Note 1363-1 (literature number 5980-2778EN).

- The "Need for Speed" in Component Manufacturing Test, (literature number 5980-2783EN).

- Generate Component Data Sheets with Agilent's BenchLinkXL, (literature number 5980-2781EN).

- Connectivity Advances in a LAN-enabled Instument, (literature number 5980-2782EN).

- De-embedding and Embedding S-Parameter Networks Using the PNA Series Network Analyzer, Agilent Application Note 1364-1 (literature number 5980-2784EN).

- Advanced Filter Tuning Using TIme Domain, Agilent Application Note 1287-10 (literature number 5980-2785EN).

- Understanding the Fundamental Principles of Vector Network Analysis, Agilent Application Note 1287-1 (literature number 5965-7707E).

- Exploring the Architectures of Network Analyzers, Agilent Application Note 1287-2 (literature number 5965-7708E).

- Applying Error Correction to Network Analyzer Measurements, Agilent Application Note 1287-3 (literature number 5965-7709E).

- Network Analyzer Measurements: Filter and Amplifier Examples, Agilent Application Note 1287-4 (Agilent literature number 5965-7710E).

- Improving Throughput in Network Analyzer Applications, Agilent Application Note 1287-5 (literature number 5966-3317E)

- Using a Network Analyzer to Characterize High-Power Components, Agilent Application Note 1287-6 (literature number 5966-3319E)

- Simplified Filter Tuning Using Time-Domain Analysis, Agilent Application Note 1287-8 (literature number 5968-5328E).

- In-Fixture Measurements Using Vector Network Analysis, Agilent Application Note 1287-9 (literature number 5968-5329E).

- 8 Hints for Making Better Network Analyzer Measurements, Agilent Application Note AN 1291-1 (literature number 5965-8166E)

- Specifying Calibration Standards for the Agilent 8510 Network Analyzer, Agilent Product Note 8510-5A, (literature number 5956-4352, or Agilent part number 08510-90352, February 1988).

- In-Fixture Microstrip Device Measurements Using TRL* Calibration, Agilent Product Note 8720-2, (literature number 5091-1943E, August 1991).

Third-Party Resources

For information about test fixtures and part handlers, contact:

Inter-Continental Microwave
1515 Wyatt Drive
Santa Clara, CA 95054-1524 USA
Telephone: (408) 727-1596
Fax: (408) 727-0105
Web site: www.icmicrowave.com
E-mail: icmfixture@aol.com

For information about probing equipment and accessories, contact:

Cascade Microtech, Inc.
2430 NW 206th Avenue
Beaverton, OR 97006 USA
Telephone: (503) 601-1000
Fax: (503) 601-1002
Web site: www.cascademicrotech.com
E-mail: sales@cmicro.com

SCPI Errors

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Standard SCPI Errors

-100 to -200 Command Errors

-200 to -299 Execution Errors

-300 to -399 SCPI Specified Device-Specific Errors

-400 to -800 Query and System Errors

PNA specific Errors

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Note: See also PNA Errors

-100 to -200 Command Errors

A command error indicates that the test set's GPIB parser has detected an IEEE 488.2 syntax error. When one of these errors is generated, the command error bit in the event status register is set.

-100	std_command	Command - This event bit (Bit 5) indicates a syntax error, or a semantic error, or a GET command was entered, see IEEE 488.2, 11.5.1.1.4.
-101	std_invalidChar	Invalid character - Indicates a syntactic elements contains a character which is invalid for that type.
-102	std_syntax	Syntax - Indicates that an unrecognized command or data type was encountered. For example, a string was received when the device does not accept strings.
-103	std_invalidSeparator	Invalid separator - The parser was expecting a separator and encountered an illegal character. For example, the semicolon was omitted after a program message unit.
-104	std_wrongParamType	Data type -The parser recognized a data element different than one allowed. For example, numeric or string data was expected but block data was encountered.
-105	std_GETNotAllowed	GET not allowed - Indicates a Group Execute Trigger was received within a program message. Correct the

		program so that the GET does not occur within the program code.
-108	std_tooManyParameters	Parameter not allowed - Indicates that more parameters were received than expected for the header. For example, *ESE common command only accepts one parameter, so *ESE 0,1 is not allowed.
-109	std_tooFewParameters	Missing parameter - Indicates that less parameters were received than required for the header. For example, *ESE requires one parameter, *ESE is not allowed.
-110	std_cmdHeader	Command header - Indicates an error was detected in the header. This error is used when the device cannot detect the more specific errors -111 through -119.
-111	std_headerSeparator	Header separator - Indicates that a character that is not a legal header separator was encountered while parsing the header.
-112	std_IDTooLong	Program mnemonic too long - Indicates that the header contains more that twelve characters, see IEEE 488.2, 7.6.1.4.1.
-113	std_undefinedHeader	Undefined header - Indicates the header is syntactically correct, but it is undefined for this specific device. For example, *XYZ is not defined for any device.
-114	std_suffixOutOfRange	Header suffix out of range - Indicates the value of a header suffix attached to a program mnemonic makes the header invalid.
-120	std_numericData	Numeric data - This error, as well as errors
-121	std_invalidCharInNumber	Invalid character in number - Indicates an invalid character for the data type being parsed was encountered. For example, an alpha in a decimal numeric or a "9" in octal data.
-123	std_exponentTooLarge	Exponent too large - Indicates the magnitude of an exponent

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		was greater than 32000, see IEEE 488.2, 7.7.2.4.1.
-124	std_decimalTooLong	Too many digits - Indicates the mantissa of a decimal numeric data element contained more than 255 digits excluding leading zeros, see IEEE 488.2, 7.7.2.4.1.
-128	std_numericNotAllowed	Numeric data not allowed - Indicates that a legal numeric data element was received, but the device does not accept one in this position for the header.
-130	std_suffix	Suffix - This error, as well as errors -131 through -139, are generated when parsing a suffix. This particular error message is used if the device cannot detect a more specific error.
-131	std_badSuffix	Invalid suffix - Indicates the suffix does not follow the syntax described in IEEE 488.2, 7.7.3.2, or the suffix is inappropriate for this device.
-134	std_suffixTooLong	Suffix too long - Indicates the suffix contain more than 12 characters, see IEEE 488.2, 7.7.3.4.
-138	std_suffixNotAllowed	Suffix not allowed - Indicates that a suffix was encountered after a numeric element that does not allow suffixes.
-140	std_charData	Character data - This error, as well as errors
-141	std_invalidCharData	Invalid character data - Indicates that the character data element contains an invalid character or the particular element received is not valid for the header.
-144	std_charDataTooLong	Character data too long - Indicates the character data element contains more than twelve characters, see IEEE 488.2, 7.7.1.4.
-148	std_charNotAllowed	Character data not allowed - Indicates a legal character data element was encountered where prohibited by the device.
-150	std_stringData	String data - This error, as well as errors

-151	std_stringInvalid	Invalid string data - Indicates that a string data element was expected, but was invalid, see IEEE 488.2, 7.7.5.2. For example, an END message was received before the terminal quote character.
-158	std_stringNotAllowed	String data not allowed - Indicates that a string data element was encountered but was not allowed by the device at this point in parsing.
-160	std_blockData	Block data - This error, as well as errors -161 through -169, are generated when parsing a block data element. This particular error message is used if the device cannot detect a more specific error.
-161	std_badBlock	Invalid block data - Indicates a block data element was expected, but was invalid, see IEEE 488.2, 7.7.6.2. For example, and END message was received before the end length was satisfied.
-168	std_blockNotAllowed	Block data not allowed - Indicates a legal block data element was encountered, but not allowed by the device at this point in parsing.
-170	std_expr	Expression - This error, as well as errors -171 through -179, are generated when parsing an expression data element. This particular error message is used if the device cannot detect a more specific error.
-171	std_invalidExpression	Invalid expression - Indicates the expression data element was invalid, see IEEE 488.2, 7.7.7.2. For example, unmatched parentheses or an illegal character.
-178	std_exprNotAllowed	Expression data not allowed - Indicates a legal expression data was encountered, but was not allowed by the device at this point in parsing.
-180	std_macro	Macro - This error, as well as error -181 through -189, are generated when defining a macro or execution a macro. This particular error message

		is used if the device cannot detect a more specific error.
-181	std_validOnlyInsideMacro	Invalid outside macro definition - Indicates that a macro parameter place holder was encountered outside of a macro definition.
-183	std_invalidWithinMacro	Invalid inside macro definition - Indicates that the program message unit sequence, sent with a *DDT or a *DMC command, is syntactically invalid, see IEEE 488.2, 10.7.6.3.
-184	std_macroParm	Macro parameter - Indicates that a command inside the macro definition had the wrong number or type of parameters.

-200 to -299 Execution Errors

These errors are generated when something occurs that is incorrect in the current state of the instrument. These errors may be generated by a user action from either the remote or the manual user interface

-200	std_execGen	Execution - This event bit (Bit 4) indicates a PROGRAM DATA element following a header was outside the legal input range or otherwise inconsistent with the device's capabilities, see IEEE 488.2, 11.5.1.1.5.
-201	std_invalidWhileInLocal	Invalid while in local
-202	std_settingsLost	Settings lost due to rtl
-203	std_commandProtected	Command protected - Indicates that a legal password-protected program command or query could not be executed because the command was disabled.
-210	std_trigger	Trigger
-211	std_triggerIgnored	Trigger ignored
-212	std_armIgnored	Arm ignored
-213	std_initIgnored	Init ignored
-214	std_triggerDeadlock	Trigger deadlock
-215	std_armDeadlock	Arm deadlock
-220	std_parm	Parameter - Indicates that a program data element related error occurred.
-221	std_settingsConflict	Settings conflict - Indicates that a legal program data element was parsed but could not be executed due to the current device state.
-222	std_dataOutOfRange	Data out of range - Indicates

		that a legal program data element was parsed but could not be executed because the interpreted value was outside the legal range defined by the devices
-223	std_tooMuchData	Too much data - Indicates that a legal program data element of block, expression, or string type was received that contained more data than the device could handle due to memory or related device-specific requirements.
-224	std_illegalParmValue	Illegal parameter value - Indicates that the value selected was not part of the list of values given.
-225	std_noMemoryForOp	Out of memory - The device has insufficient memory to perform the requested operation.
-226	std_listLength	Lists not same length - Attempted to use LIST structure having individual LIST's of unequal lengths.
-230	std_dataCorruptOrStale	Data corrupt or stale - Indicates invalid data, a new reading started but not completed since the last access.
-231	std_dataQuestionable	Data questionable - Indicates that measurement accuracy is suspect.
-232	std_invalidFormat	Invalid format
-233	std_invalidVersion	Invalid version - Indicates that a legal program data element was parsed but could not be executed because the version of the data is incorrect to the device. For example, a not supported file version, a not supported instrument version.
-240	std_hardware	Hardware - Indicates that a legal program command or query could not be executed because of a hardware problem in the device.
-241	std_hardwareMissing	Hardware missing - Indicates that a legal program command or query could not be executed because of missing device hardware. For example, an option was not installed.

-250	std_massStorage	Mass storage - Indicates that a mass storage error occurred. The device cannot detect the more specific errors described for errors -251 through -259.
-251	std_missingMassStorage	Missing mass storage - Indicates that a legal program command or query could not be executed because of missing mass storage.
-252	std_missingMedia	Missing media - Indicates that a legal program command or query could not be executed because of missing media. For example, no disk.
-253	std_corruptMedia	Corrupt media - Indicates that a legal program command or query could not be executed because of corrupt media. For example, bad disk or wrong format.
-254	std_mediaFull	Media full- Indicates that a legal program command or query could not be executed because the media is full. For example, there is no room left on the disk.
-255	std_directoryFull	Directory full - Indicates that a legal program command or query could not be executed because the media directory was full.
-256	std_fileNotFound	File name not found - Indicates that a legal program command or query could not be executed because the file name was not found on the media.
-257	std_fileName	File name - Indicates that a legal program command or query could not be executed because the file name on the device media was in error. For example, an attempt was made to read or copy a nonexistent file.
-258	std_mediaProtected	Media protected - Indicates that a legal program command or query could not be executed becuse the media was protected. For example, the write-protect switch on a memory card was set.

-260	std_expression	Expression
-261	std_math	Math in expression
-270	std_macroExecution	Macro - Indicates that a macro related execution error occurred.
-271	std_macroSyntax	Macro syntax - Indicates that a syntactically legal macro program data sequence, according to IEEE 488.2, 10.7.2, could not be executed due to a syntax error within the macro definition.
-272	std_macroExec	Macro execution - Indicates that a syntactically legal macro program data sequence could not be executed due to some error in the macro definition, see IEEE 488.2, 10.7.6.3.
-273	std_badMacroName	Illegal macro label - Indicates that the macro label was not accepted, it did not agree with the definition in IEEE 488.2, 10.7.3
-274	std_macroPlaceholder_Ma	cro parameter - Indicates that the macro definition improperly used a macro parameter placeholder, see IEEE 4882, 10.7.3.
-275	std_macroTooLong	Macro definition too long - Indicates that a syntactically legal macro program data sequence could not be executed because the string of block contents were too long for the device to handle, IEEE 488.2, 10.7.6.1.
-276	std_macroRecursion	Macro recursion - Indicates that a syntactically legal macro program data sequence count not be executed because it would be recursive, see IEEE 488.2, 10.7.6.6.
-277	std_cantRedefineMacro	Macro redefinition not allowed - Indicates that redefining an existing macro label, see IEEE 488.2, 10.7.6.4.
-278	std_macroNotFound	Macro header not found - Indicates that a legal macro label in the *GMS?, see IEEE 488.2, 10.13, could not be executed because the header was not previously defined.
-280	std_program	Program

-281	std_cantCreateProgram	Cannot create program
-282	std_illegalProgramName	Illegal program name
-283	std_illegalVarName	Illegal variable name
-284	std_programRunning	Program currently running
-285	std_programSyntax	Program syntax
-286	std_programRuntime	Program runtime
-290	std_memoryUse	Memory use
-291	std_execOutOfMemory	Out of memory
-292	std_nameNotFound	Referenced name does not exist
-293	std_nameAlreadyExists	Referenced name already exists
-294	std_incompatibleType	Incompatible type

-300 to -399 SCPI Specified Device-Specific Errors

A device-specific error indicates that the instrument has detected an error that occurred because some operations did not properly complete, possibly due to an abnormal hardware or firmware condition. For example, an attempt by the user to set an out of range value will generate a device specific error. When one of these errors is generated, the device specific error bit in the event status register is set.

-300	std_deviceSpecific	Device specific - This event bit (Bit 3) indicates that a device operation did not properly complete due to some condition, such as overrange see IEEE 488.2, 11.5.1.1.6.
-310	std_system	System
-311	std_memory	Memory - Indicates some physical fault in the devices memory, such as a parity error.
-312	std_PUDmemoryLost	PUD memory lost - Indicates protected user data saved by the *PUD command has been lost, see IEEE 488.2, 10.27.
-313	std_calMemoryLost	Calibration memory lost - Indicates that nonvolatile calibration data used by the *CAL? command has been lost, see IEEE 488.2, 10.2.
-314	std_savRclMemoryLost	Save/recall memory lost - Indicates that the nonvolatile data saved by the *SAV command has been lost, see IEEE 488.2, 10.33.
-315	std_configMemoryLost	Configuration memory lost - Indicates that nonvolatile configuration data saved by the device has been lost.
-320	std_storageFault	Storage fault - Indicates that the firmware detected a fault when using data storage. This is not an indication of

		physical damage or failure of any mass storage element.
-321	std_outOfMemory	Out of memory - An internal operation needed more memory than was available
-330	std_selfTestFailed	Self-test failed - Indicates a problem with the device that is not covered by a specific error message. The device may require service.
-340	std_calFailed	Calibration failed - Indicates a problem during calibration of the device that is not covered by a specific error.
-350	std_queueOverflow	Queue overflow - Indicates that there is no room in the queue and an error occurred but was not recorded. This code is entered into the queue in lieu of the code that caused the error.
-360	std_comm	Communication - This is the generic communication error for devices that cannot detect the more specific errors described for error -361 through -363.
-361	std_parity	Parity in program message - Parity bit not correct when data received for example, on a serial port.
-362	std_framing	Framing in program message - A stop bit was not detected when data was received for example, on a serial port (for example, a baud rate mismatch).
-363	std_inputBufferOverrun	Input buffer overrun - Software or hardware input buffer on serial port overflows with data caused by improper or nonexistent pacing.

-400 to -800 Query and System Errors

A Query error is generated either when data in the instrument's GPIB output queue has been lost, or when an attempt is being made to read data from the output queue when no output is present or pending.

-400	std_queryGen	Query - This event bit (Bit 2) indicates that an attempt to read data from the Output Queues when no output is present or pending, to data in the Output Queue has been lost see IEEE488.2, 11.5.1.1.7.

-410	std_interrupted	Query INTERRUPTED - Indicates the test set has been interrupted by a new program message before it finishes sending a RESPONSE MESSAGE see IEEE 488.2, 6.3.2.3.
-420	std_unterminated	Query UNTERMINATED - Indicates an incomplete Query in the program see IEEE 488.2, 6.3.2.2.
-430	std_deadlocked	Query DEADLOCKED - Indicates that the Input Buffer and Output Queue are full see IEEE 488.2, 6.3.1.7.
-440	std_responseNotAllowed	Query UNTERMINATED after indefinite response - Indicates that a query was received in the same program message after a query requesting an indefinite response was executed see IEEE 488.2, 6.5.7.5.
-500	std_powerOn	Power on
-600	std_userRequest	User request
-700	std_requestControl	Request control
-800	std_operationComplete	Operation complete

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PNA Specific SCPI Errors

100	dupWindNum	"Duplicate window number"
101	windNumNotFound	"Window number not found"
102	failedWindCreate	"Window creation failed"
103	noCalcParamSelection	"CALC measurement selection set to none"
104	dupMeasName	"Duplicate measurement name"
105	dataNotFound	"Requested data not available"
106	measNotFound	"Requested measurement not found"
107	traceNotFound	"Requested trace not found"
108	notImplemented	"Mnemonic not yet implemented"
109	noDocument	"No measurement container found"
110	dupTraceNum	"Duplicate trace number"
111	titleStrTooLong	"Title string exceeds 50 characters"
112	memoryNotFound	"Requested memory not found"
113	exceedMaxTraces	"Exceeded the maximum number of traces per window"
114	SerNumNotFound	"The serial number was not

		found. Please store the serial number."
115	LoadFailed	"The state was not loaded. Please check the file name."
116	StoreFailed	"The state was not stored. Please check the file and path names."
117	File	"An in the File operation occurred. Please check file and path names."
118	measChanConflict	"Measurement does not belong to specified channel."
119	exceedMaxWindows	"Exceeded the maximum number of data windows"
120	markerNotFound	"The specified marker was not found."
121	diagnostic	"Diagnostic ."
122	channelNotFound	"The specified channel was not found."
123	exceedMaxMeasurements	"Exceeded the maximum number of allowed mesurements."
124	parameterOutOfRange	"The specified value was out of range."
125	userRangeNotValid	"The currently selected user range is not valid."
126	referenceMarkerNotFound	"The reference marker is not active."
127	sweepSegmentNotFound	"The sweep segment was not found."
128	markerNotDelta	"The specified marker is not a delta marker."
129	printoutFailed	"Attempt to output to a printer failed."
130	memory_trace_not_compatible	"Memory not compatible. Trace Math not applied."
131	trace_math_reset	"Memory not compatible. Trace Math turned off."
132	hw_read_failed	"Hardware read failed."
133	hw_write_failed	"Hardware write failed."
134	dsp_active	"Failed because DSP was not halted."
135	secure_memory	"Attempt to access secure memory region."
136	snum_protected	"The serial number is protected."
137	snum_format_bad	"The serial number format is bad."
138	snum_already_set	"The serial number is already set."
139	hw_setting_failed	"Hardware setting failed."
140	cal_access_failed	"Calibration data access failed."
141	db_access_failed	"Database access failed."

142	memory_range_exceeded	"Command exceeds usable memory range."
143	lost_phase_lock	"Phase lock has been lost."
144	over_power	"Detected too much power at input."
145	ee_wrt_failed	"EEPROM write failed."
146	yig_cal_failed	"YTO calibration failed."
147	ramp_cal_failed	"Analog ramp calibration failed."
148	dspcom_bad	"DSP communication failed."
149	no_license_found	"Request failed. The required license was not found."
150	argLimited	"The argument was out of range
151	markerBWNotFound	"The Marker Bandwidth was not found."
153	peakNotFound	"The Peak was not found."
154	targetNotFound	"The Target search value was not found."
155	calNotImpl	"The Calibration feature requested is not implemented."
156	calClassNotValidForCalType	"SENS:CORR:CCH measurement selection set to none"
158	calNotValidForConfidenceChe e	"Selected measurement does not have a calibration valid for Confidence Check"
159	invalidPort	"Specified port is out of range"
160	invalidPortPath	"ROUT:PATH:DEF:PORT x, y does not match measurement; setting to defaults"
161	ioInvalidWrite	"Attempted I/O write while port set to read only."
162	ioInvalidRead	"Attempted I/O read from write only port."
163	calsetNotFound	"Requested Cal Set was not found in Cal Set Storage."
164	noCalSetSelected	"There is no Cal Set currently selected for the specified channel."
165	cantDeleteCalSetInUse	"Cannot delete a Cal Set while it is being used."
166	calsetStimChange	"Channel stimulus settings changed to match selected Cal Set."
167	exceedMaxCalSets	"Exceeded the maximum number of cal sets."
168	calCouldNotTurnOn	"A valid calibration is required before correction can be turned on."
169	standardMeasurementRequir	"The attempted operation

	ed	can only be performed on a standard measurement type."
170	noDivisorBuffer	"A valid divisor buffer is required before normalization can be turned on."
171	invalidReceiverPowerCalPara graph	"Receiver power cal requires the measurement to be of unratioed power."
172	ecalCouldNotConfigure	"Could not configure the Electronic Calibration system. Check to see if the module is plugged into the proper connector."
173	measHasNoMemoryAlg	"This measurement does not support memory operations"
174	measHasNoNormalizeAlg	"This measurement does not support normalize operations."
175	userCharacterizationNotFoun d	"User characterization was not found in the Electronic Calibration module."
176	measInvalidBufferSize	"The data provided has an invalid number of points. It could not be stored."

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Diagnostic Tools and Adjustments
3.8 GHz Frequency Adjustment

This routing adjusts the internal fixed-frequency YIG Oscillator to 3.8 GHz by changing a DAC value. This DAC value is stored in the analyzer's non-volatile memory.

Typically, the oscillator can be set to within 12 kHz of 3.8GHz; it is not necessary for it to be exactly 3.8GHz.

Spectrum Analyzers Compatibility

This routine is compatible with Agilent 856x and 859x spectrum analyzers.

If no compatible analyzer is available, select "NONE" for the spectrum analyzer. You can then adjust the DAC manually by viewing the 3.8 GHz signal on another analyzer.

Procedure (For Compatible Spectrum Analyzers Only)

Note: The viewable 3.8 GHz signal level will be low; typically be around -70dBm. Do not use any attenuators in the adjustment, other than the default 10 dB attenuation used in most spectrum analyzers.

1. Connect spectrum analyzer input to the network analyzer's PORT 1 output.

2. Connect GPIB cable from analyzer to spectrum analyzer. Make sure no other controllers are active on the same connection.
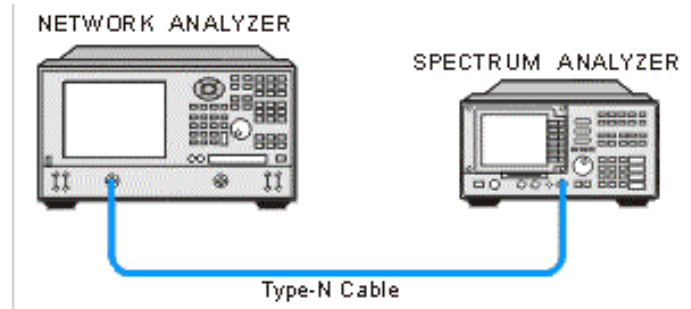
3. Set the spectrum analyzer GPIB address to 18.

4. In the analyzer **System** menu, point to **Service**, **Adjustments**, and click **3.8 GHz Freq. Adjust**.

5. Click **Begin Adj.** for the program to adjust the internal oscillator for minimal error and store the results. When the status area indicates the adjustment is complete, select **Exit**.

Procedure (For Non-Compatible Spectrum Analyzers Only)

Note: The viewable 3.8 GHz signal level will be low; typically be around -70dBm. Do not use any attenuators in the adjustment, other than the default 10 dB attenuation used in most spectrum analyzers.

1. Connect the spectrum analyzer input to the network analyzer's PORT 1 output.

2. Set the spectrum analyzer to the following settings:

   - Center frequency=3.8 GHz

   - Span= 100 MHz

   - Bandwidth= 10 kHz

   - Scaling where a signal of -70 dBm will be clearly visible

3. In the analyzer **System** menu, point to **Service**, **Adjustments**, and click **3.8 GHz Freq. Adjust**.

4. Under **Spectrum Analyzer**, select **NONE** option for spectrum analyzer.

5. Click **Begin Adj**.

6. The application presets the DAC to an initial value equal to the current value stored. View the spectrum analyzer to see if the signal is above or below 3.800 GHz.

   - If the signal frequency is above 3.8 GHz, move the slider to adjust the DAC to a lower value (left).

   - If the frequency is below 3.8 GHz, move the slider to adjust the DAC to a higher value (right).

Note: The valid DAC values are from 0 to 4095. The oscillator will shift about 23 kHz per DAC value.

7. Set the DAC value to reach a frequency very close to 3.8 GHz. If you made large changes in DAC values, allow several seconds for thermal effects to stablize.

8. Change the spectrum analyzer settings to better view the frequency signal:

    - Frequency span = 500 kHz

    - Bandwidth = 3 kHz

9. Change the DAC value to keep the signal centered at 3.8 GHz.

10. Once you have determined the correct DAC value, click **SAVE DAC** to permanently store that value into EEPROM. Click **Exit**.

Note: If large changes are made to the existing DAC value, then this test should be repeated again after 15-30 minutes. This allows the thermal effects to fully stablize.

10 MHz Reference Frequency Adjustment
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This routine adjusts the analyzer's internal time-base to exactly 10 MHz by changing a DAC value. This DAC value is stored in the analyzer's non-volatile memory. This routine should only be necessary in the following situations:

- The frequency reference assembly is replaced.

- The 10 MHz reference has drifted significantly from the factory adjusted value.

WARNING: The range of this adjustment is only about 20 Hz. It is highly recommended that a very accurate frequency standard be used to measure this 10 MHz signal.

Frequency Counter Compatibility

This procedure uses SCPI commands (over GPIB) to communicate with the frequency counter. It should work with the Agilent 5313xA, 5315xA, 53181A series of counters as well as the older 5350 series.

If no compatible counters are available, select the "Manual" mode of operation. If you do choose the manual mode, you must input the measured frequency manually.

Procedure for GPIB Counters Only

1. Connect the analyzer rear panel 10 MHz Reference output to the frequency counter .

2. Connect a GPIB cable from the analyzer to the counter. Make sure no other controllers are active on the same connection.

3. If applicable, connect the house frequency standard to the counter reference input.

4. Set the counter GPIB address to 03. Ensure that the counter is the only device at this address.

5. In the analyzer **System** menu, point to **Service**, **Adjustments**, and click **10 MHz Freq. Adjust**.

6. Click **Begin Adj**. The application adjusts the internal reference for minimal error and stores the results.

7. Click **Read Freq** to trigger another reading of the 10 MHz signal.

8. Click **Read DAC** to view the current DAC value stored in the analyzer's non-volatile memory (value = 0 - 4095).

9. When the status area indicates the adjustment is complete, click **Exit**.

Procedure for Non-GPIB Counters

1. Connect the counter input to the rear panel 10 MHz Reference Output.

2. Set the counter to at least 1 Hz resolution.

3. If applicable, connect the house-frequency standard to the counter reference input.

4. In the analyzer **System** menu, point to **Service**, **Adjustments** and click **10 MHz Freq. Adjust**.

5. Under **Frequency Counter**, select **Manual.**

6. Click **Begin Adj.**

7. The application presets the DAC to an initial value. Enter the measured frequency offset from 10 MHz. If the measured frequency is less than 10 MHz, use a minus (-) sign to indicate a negative error. For example:

   - If the counter reads 10000003.5 Hz, enter 3.5 (or +3.5) in the indicated window.

   - If the counter reads 9999997.8 Hz, enter -2.2 in the indicated window.

8. The adjustment loops at least 3 times unless the entered value is exactly zero.

   - Click **Read Freq** to trigger another reading of the 10 MHz signal.

   - Click **Read DAC** to view the current DAC value stored in the analyzer's non-volatile memory (value = 0 - 4095).

9. When the status area indicates the adjustment is complete, click **Exit**.

Note: If the counter is misreading the frequency, it may be necessary to attenuate the input, or set the input impedance to 50 ohms, or both.

LO Power Adjustment
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This procedure adjusts the receiver's LO input power to a specific level by changing DAC values. These DAC values are then stored in the analyzer's non-volatile memory. The procedure will vary depending upon the model number.

Power Meter Compatibility

This routine is only compatible with the Agilent EPM series of power meters. Different sensors may be used. For 9 GHz analyzers and below, an 8482 or E4412A sensor can be used. For the higher frequency units (20 GHz or above), a sensor must be able to measure a maximum of 20 GHz. At no time during this test will a frequency higher than 20 GHz be measured, even if the PNA has a maximum frequency of 50 GHz.

If the older HP 84xx series of sensors are used, the correct calibration data should be entered into the appropriate cal table of the EPM series power meter, although for this adjustment, high accuracy is not required. Inaccuracies in the order of several tenths of a dB are acceptable.

Procedure

1. Allow the analyzer and power meter to warm up for 30 minutes.

2. Manually zero and calibrate the power sensor. (This allows you to skip this step later)

3. Connect a GPIB cable from the analyzer to the power meter. Make sure no other controllers are active on the same connection.

4. Set the power meter GPIB address to 13. (others can also be used; 13 is the default)

5. Remove the outer cover on the analyzer.

6. In the PNA **System** menu point to **Service**, then **Adjustments**, and click **LO Power Adjust**.

7. Connect the power sensor to the LO output, using adapters if needed.. The LO output location varies with model number. Click on the LO Power Adjust **Setup** menu selection to see a diagram of the exact location.

8. **For 9 GHz units and below:**
   Click **Begin Adj** to start the LO power cal routine. The routine adjusts the power level for each band (1 through 3) to fall within certain bounds. If any changes are made, it automatically stores them.

   For 20GHz units and above:
   If using an 84xx power sensor, click **Configure** and select the proper sensor model number. Click **Close**. Click **Calibrate** to begin the adjustment. The entire calibration process takes about 5 minutes. Once completed, you can verify the current calibration accuracy by clicking **Verify Cal**.
   Note: Correction constants are defaulted at the beginning of calibration. Once the calibration process has started, it must be completed in order to regenerate proper data.

9. Click **Read DAC** to view the current DAC values (0-4095) stored in the PNA non-volatile memory for each band (0-7).

10. When the message/status area indicates the adjustment is complete, click **Exit**.

11. Reconnect the semi-rigid cable and replace the covers.

Operator's Check

_____

- Overview
- To Display the Operator's Check
- The Operator's Check Procedure

Overview

The Operator's Check should be performed when you first receive your analyzer, and any time you wish to have confidence that the analyzer is working properly. The Operator's Check does not verify performance to specifications, but should give you a high degree of confidence that the instrument is performing properly.

To verify PNA performance to specifications, run System Verification.

Use the Operator's Check to check for obvious failures in the following portions of the network analyzer hardware:

- Repeatability of the RF Switch in the Test Set
- Attenuation ranges of any Test Port Attenuators

How to display the Operator's Check
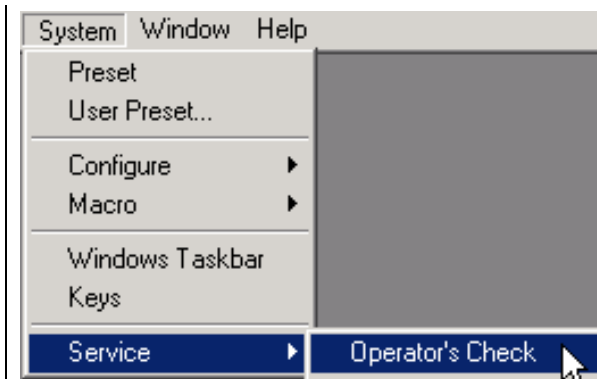
Learn more about using the front panel interface
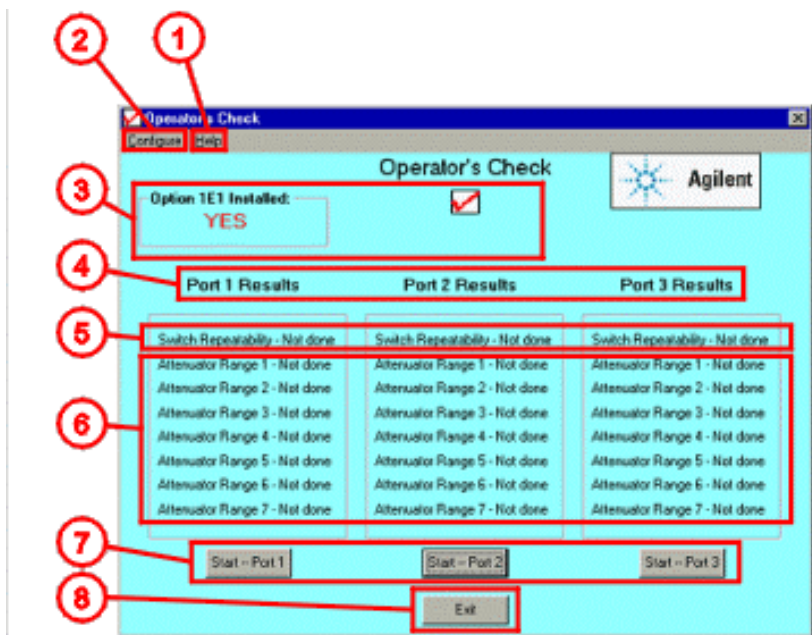
Operators Check dialog box help

Note: The display will look slightly different, depending on Model Number and Installed Options. This example has three ports and optional attenuators installed.

1. **Help:** Has two selections, one brings you here, the other gives Operator's Check program revision information.

2. **Configure:** Runs the program automatically or stops and prompts before each test.

3. **Option installed:** Indicates whether the Attenuator Option is installed.

4. **Test Ports:** Shows the number of ports available to be tested.

5. **Switch Repeatability:** Shows the status of the RF Switch Repeatability Test, either Not Done, Pass or Fail.

6. **Attenuator Range:** Shows the status of the Attenuator Range Test, either Not Done, Pass or Fail. If there are no attenuators installed these tests will not appear.

7. **Start - Port #:** Starts the Operator's Check on the Port.

8. **Exit:** Ends the program and closes the window.

The Operator's Check Procedure

1. Select Program Sequence.

On the pull down menu click **Configure**, select **Automatic** or **Prompted Sequencing**.

- **Automatic Sequencing** prepares the software to test switch repeatability and any of the installed attenuator ranges with an interval of 0.25 seconds in between each test.
- **Prompted Sequencing** prepares the software to place a prompt before the range test execution of each installed attenuator.

2. Start Test on Port 1

Click the **Start-Port 1** button. When prompted, connect a Short standard from a calibration kit to test port 1.

- The network analyzer shows a PASS or FAIL indication at the completion of each test. Notice the test limit lines, shown in red.
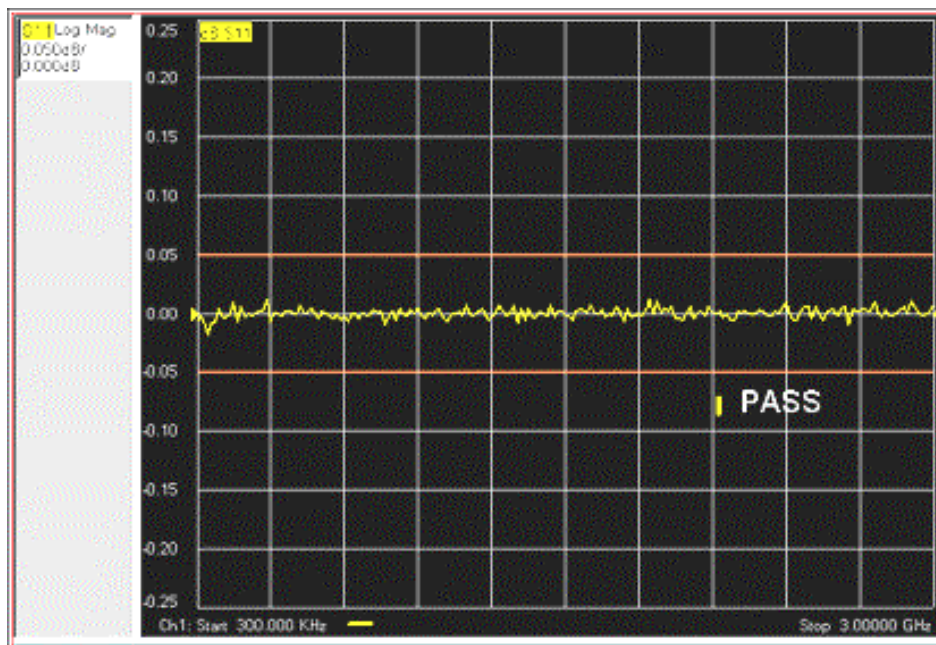
- When all tests are complete, the Operator's Check window reappears showing the summary of test results for that port. The graphic below shows all test passing on Port 1. If any tests do not pass, refer to the chapter 3 of the service guide.
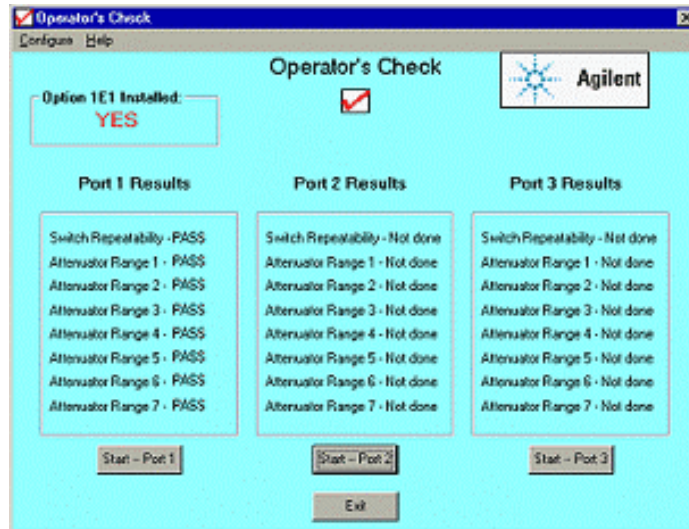
3. Start Test on next Port #.

Repeat Step 2 for each additional Port shown on the Operator's Check display.

System Verification

_____

The system verification utility verifies the PNA operation by automatically measuring the magnitude and phase for all four S-parameters for each verification device, and comparing the values against the following:

- Factory measured data from files on the verification disk
- Limit lines based on the measurement uncertainty

To perform a quicker, less rigorous test of the PNA performance, run the Operator's Check.

- Equipment Used in the System Verification
- Precautions for Handling Airlines
- Flow Diagram of Procedure
- Procedure for System Verification
- If the System Fails the Verification Test
- Interpreting the Verification Results

Note: Although the performance for all four S-parameters is measured, the S_{11} and S_{22} phase uncertainties are less important for verifying system performance, so they are not used and will not appear on printouts.

Equipment Used in the System Verification

For PNA models:

E8356A, E8357A, E8358A
N3381A, N3382A, N3383A
E8801A, E8802A, E8803A.

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Equipment Type	Model	Alternate Model
Calibration kit, Type-N	85032F	85033E (3.5mm)
or		
ECAL Module	85092B	85093B (3.5mm)
Verification kit, Type-N	85055A	85053B (3.55mm)
RF Cable, Type-N	N6314A	See Cable substitution

For E8362A

Equipment Type	Model	Alternate Model
Calibration kit, 3.5mm	85052B	85052D
Verification kit, 3.5mm	85053B	None
RF Cable, 3.5 mm (f) to 3.5 mm (f)	85131C	85131E

For E8363A, E8364A

Equipment Type	Model	Alternate Model
Calibration kit, 2.4mm	85056A	85056D
Verification kit, 2.4mm	85057B	None
RF cable, 2.4 mm (f) to 2.4 mm (f)	85133C	85133E

Cable Substitution

The test port cables specified for the PNA have been characterized for connector repeatability, magnitude and phase stability with flexing, return loss, insertion loss, and aging rate. Since test port cable performance is a significant contributor to the system performance, cables of lower performance will increase the uncertainty of your measurement. It is highly recommended that the test port cables be regularly tested.

If the system verification is performed with a non-Agilent cable, ensure that the cable meets or exceeds the operation of the specified cable. Refer to the cable User's Guide for specifications.

Calibration Kit Substitution

Non-Agilent calibration kits are not recommended or supported.

Precautions for Handling Airlines

When you are using the airlines in the verification kit, observe the following practices to ensure good measurement techniques.

- Be very careful not to drop the airline's center or outer conductor. Damage will result if these devices are dropped.

- Use proper Electro-Static Discharge (ESD) procedures.

- Clean your hands or wear gloves, skin oils will cause a change in electrical performance.

PNA Test Port 1   PNA Test Port 2

Protective
End Cap

Male End

Female End

Insert Airline Center
Conductor Tip Onto
Center Conductor
of Cable Conector

PNA Test Port 1   PNA Test Port 2

Torque Nut
on Airline

Hold Stationary with
Open-End Wrench

Torque Nut
on Cable
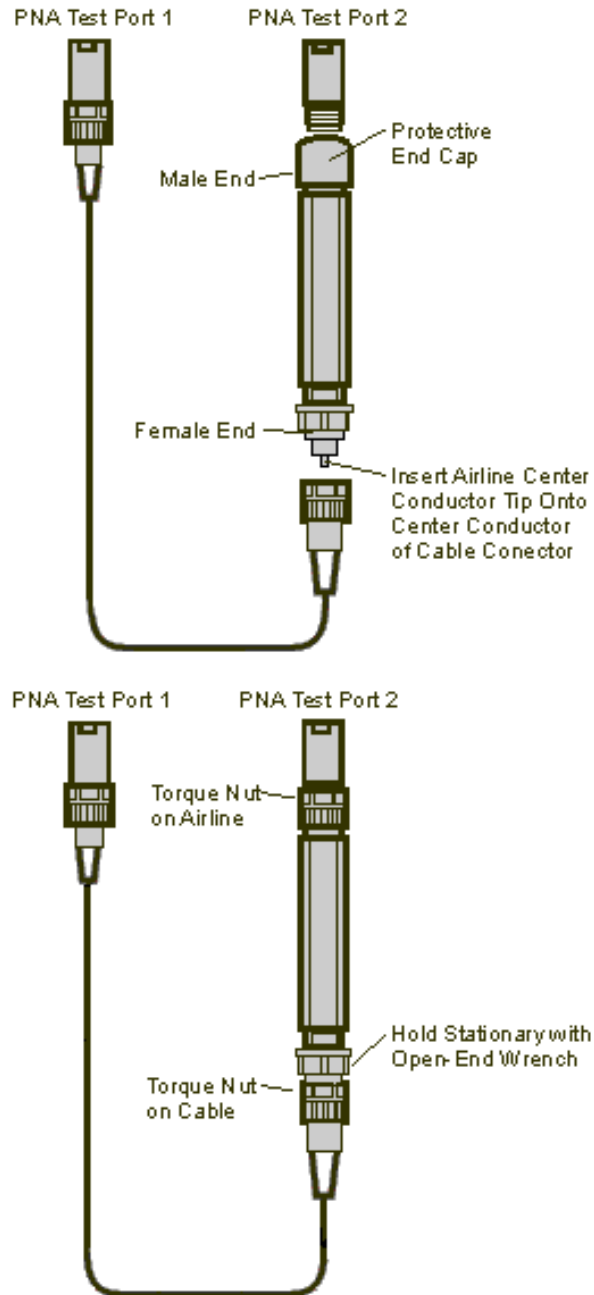
Flow Diagram of Procedure

The operational flow of the software is depicted by the flowchart shown below.
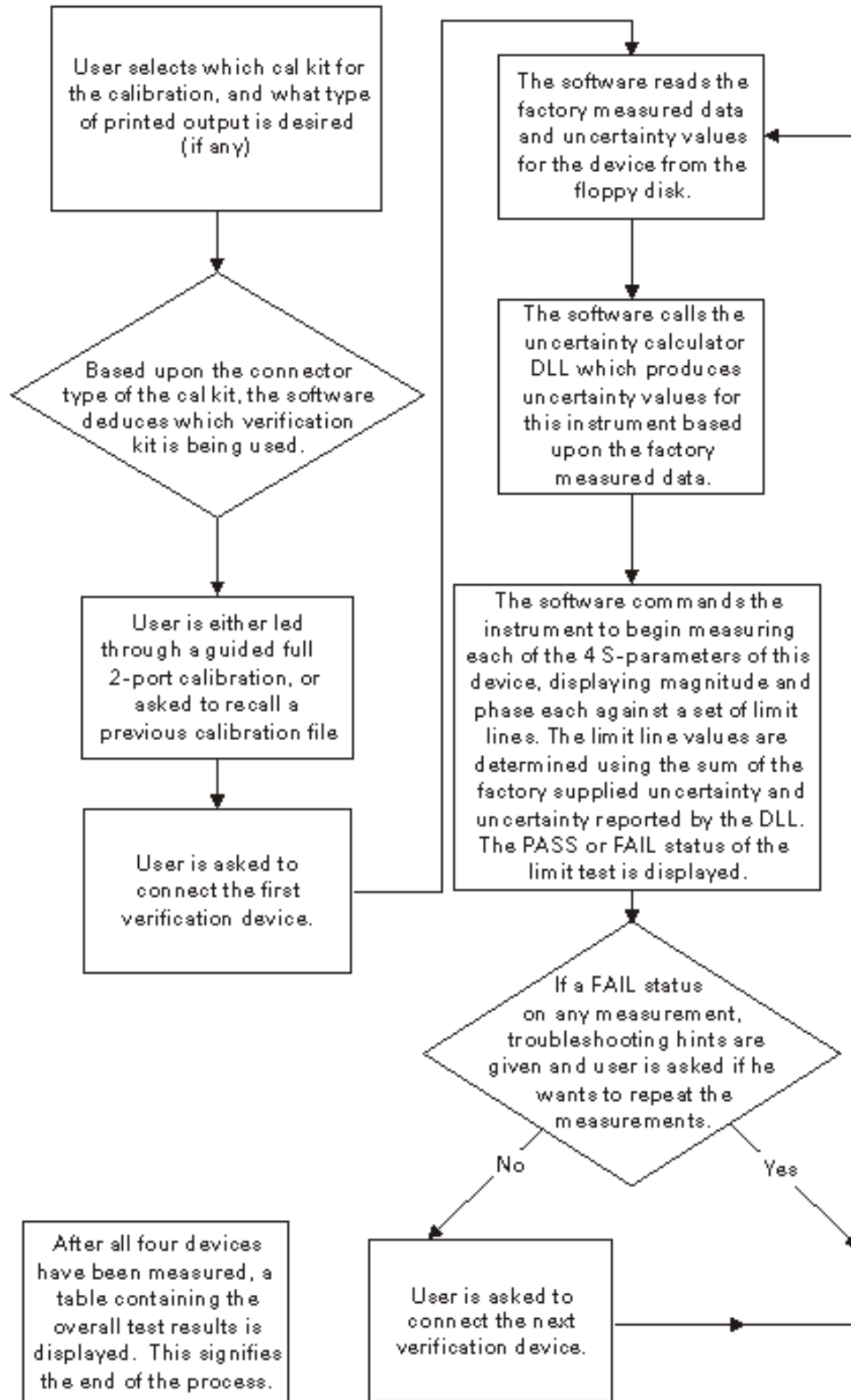
Procedure for System Verification

1. Connect a cable to Port 2 on the analyzer. If you want printed test outputs, connect a

printer to the analyzer. Let the analyzer warm up for at least 30 minutes.

System Verification Test Setup
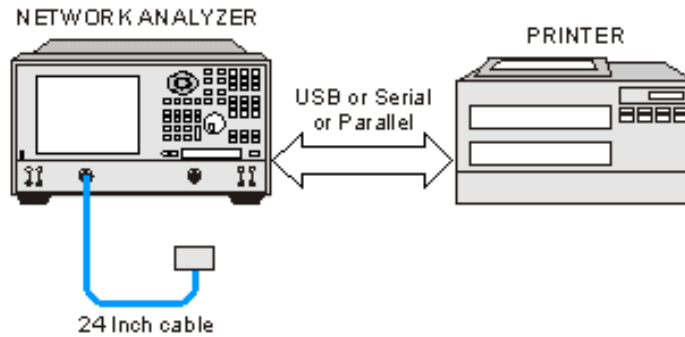
2. Insert the PNA verification kit floppy disk into the analyzer disk drive.

3. On the **System** menu, point to **Service**, and click **System Verification**. The System Verification window similar to this will be displayed.

System Verification window
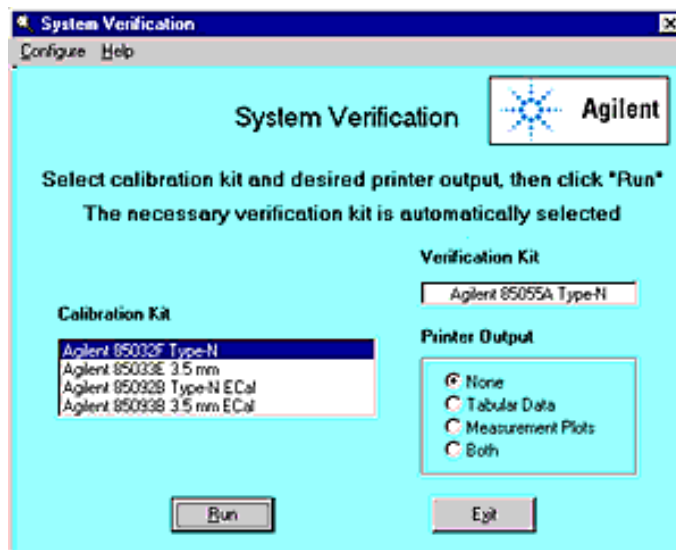
4. In the **Calibration Kit** box, select the calibration kit that is being used. The corresponding verification kit to use appears in the **Verification Kit** box.

5. Under **Printer Output** click one of the following options.

    - **None:** No printouts of results.

    - **Tabular Data:** Prints the verification data in tabular form which includes measured data and uncertainty limits. Refer to a tabular data example, later in this topic.

    - **Measurement Plots:** Prints the verification data in graphical form. The graphic form includes the measured data trace, factory supplied data trace and uncertainty limits. Refer to a plot data example, later in this topic.

    - **Both:** Prints the verification data in both forms.

Note: If you want printed output, it is assumed you have already installed the Windows 2000 driver for your particular printer, and have tested that you can print to the printer from the network analyzer. This software is designed to print to whichever printer is currently set as the Default printer (see Printers in the Windows Control Panel).

6. The **System Verification Configure** menu allows you to affect the system verification procedure in two ways:

- The **Calibration** submenu allows you to choose from two calibrations.

  - **Perform a calibration** (default), prepares the software to guide you through performing a 2-port calibration using the selected calibration kit.

  - **Load previous calibration** prepares the software to prompt you for a calibrated instrument state (*.cst) file which was saved earlier, using the system verification software.

- The **Devices to Measure** submenu allows you to select which devices will be measured during the system verification procedure. By default, all the devices from the kit are selected. For the system verification to be truly adequate, the software must measure all devices in the kit.

7. Click **Run**.

8. When prompted for devices during the system verification, insert the devices as shown.

Verification Device Connections

NETWORK ANALYZER

Verification Device
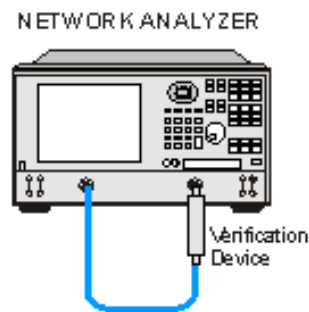
Note for 3 Port PNA:
The same System Verification Procedure is **repeated two more times**.
The System Verification Cable is connected next between **Ports 1 and 3**.
Finally the Cable is connected between **Ports 2 and 3**.

Step-by-Step Process Description

1. Depending upon the selected choice in the Calibration submenu of the Configure menu, the user is either prompted to recall a previous calibrated instrument state, or is guided through a full 2-port calibration using the selected calibration kit. For ECal, the ECal module is connected just once; a standby message is posted while the software is performing the calibration.

2. The user is prompted to connect the first verification device.

3. The software reads the factory measured data for that device and uncertainty values for that data (CITIfiles) from the floppy disk supplied with the verification kit.

4. The software sends the factory measured data, calibration kit and instrument state information to the uncertainty calculator DLL, which generates uncertainty values specific to the PNA.

5. The analyzer first sets up for magnitude measurements of all four S-parameters, each parameter in a separate window (lin mag for S_{11} and S_{22}, log mag for S_{21} and S_{12}). Each of the factory measured S-parameters are fed to the appropriate window as a memory trace. Limit line offsets are calculated as the sum of the factory measured data uncertainties and PNA uncertainties reported by the DLL. Upper and lower limits are displayed (factory measured data + uncertainty sum, factory measured data - uncertainty sum). The PNA takes a sweep, limit test is turned on and PASS/FAIL status is reported in

each of the four windows.

6. The user clicks a button when ready to view phase measurements. The four windows get updated for phase format, phase memory traces, phase limits and PASS/FAIL result.

7. If the limit test of any of the four S-parameters (magnitude or phase) indicates a FAIL status, the software suggests troubleshooting tips and asks if the user would like to repeat measurement of that device or proceed to the next device. If proceeding to the next device, the factory measured data and uncertainties for the next device are read from floppy, the uncertainty DLL gets called with this next set of factory measured data, and the four measurement windows get updated for magnitude measurement of the next device.

8. The software follows this same process until all selected devices have been measured, at which point a summary window is displayed containing the set of PASS/FAIL results for all four parameters of each device.

If the System Fails the Verification Test

IMPORTANT: Inspect all connections. Do not remove the cable from the analyzer test port. This will invalidate the calibration that you have done earlier.

1. Repeat this verification test. Make good connections with correct torque specifications for each verification device.

2. Disconnect, clean and reconnect the device that failed the verification test. Then measure the device again.

3. If the analyzer still fails the test, check the measurement calibration by viewing the error terms as described in "Front Panel Access to Error Terms" on page 4-7 of the Service Guide.

4. Refer to the graphic below, for additional troubleshooting steps.

Verification Fails Flowchart
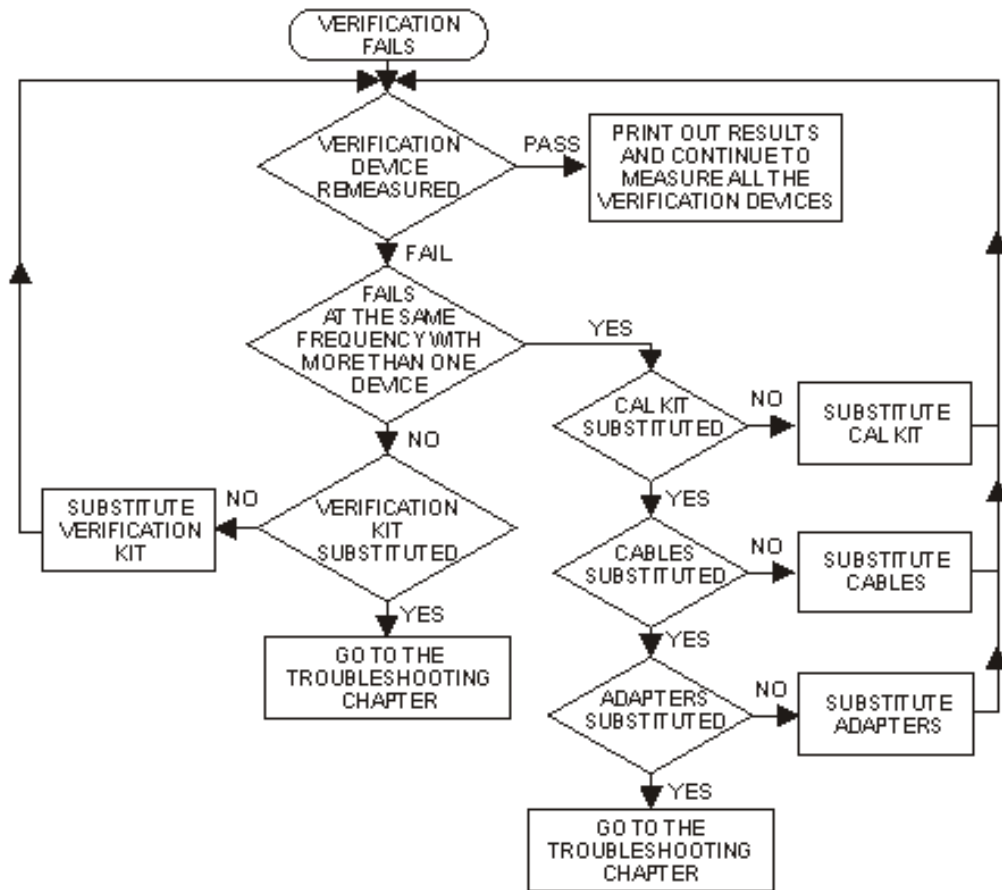
Interpreting the Verification Results

The graphic below shows an example of typical verification results with **Tabular Data** selected in the **Printer Output** area of the **System Verification** window. A graphic later in this topic shows an example of typical verification results with **Measurement Plots** selected in the **Printer Output** area of the **System Verification** windows. These printouts include a comparison of the data from your measurement results with the traceable data and corresponding uncertainty specifications. Use these printouts to determine whether your measured data falls within the total uncertainty limits at all frequencies.

The tabular data consists of:

- Frequency of the data points (in MHz).
- Lower limit line as defined by the total system uncertainty specification.
- Results of the measurement.
- Upper limit line as defined by the total system uncertainty specification.
- Test status (PASS or FAIL) of that measurement point.

Printout of Tabular Verification Results

The printed graphical results show:

- Upper limit points as defined by the total system uncertainty specifications.
- Lower limit points as defined by the total system uncertainty specifications.
- Data measured at the factory.
- Results of measurements.
- Measurement parameter names and formats (Lin Mag or Log Mag).
- Serial number of device (00810).
- Device being measured (Sys Ver 20 dB attenuator).

Printout of Graphical Verification Results
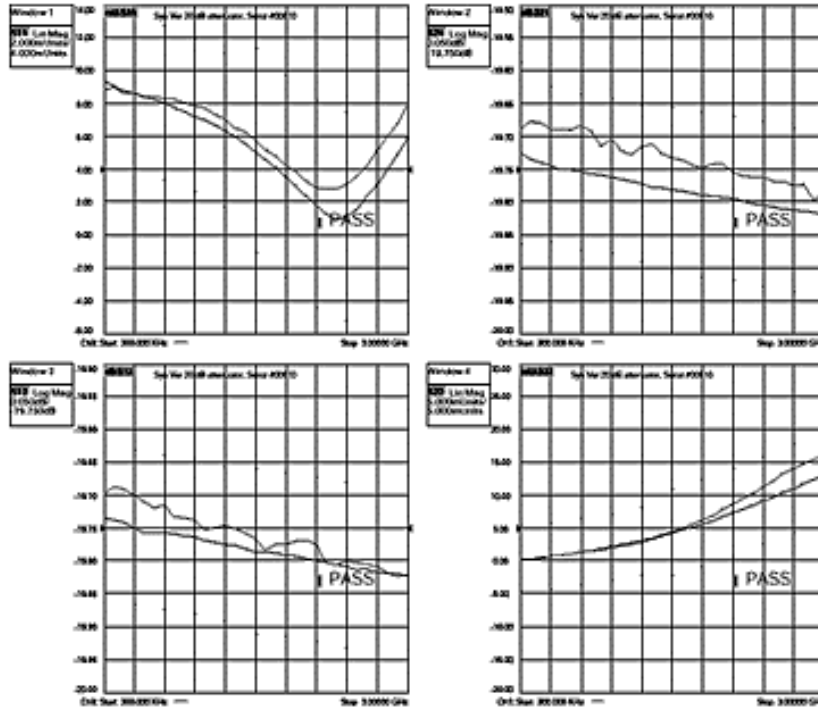
Source Calibration

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Source calibration adjusts the PNA source power for flatness across its full frequency range. This adjustment is for service only; not for measurement calibration.

Required Equipment

Preferred Power Meter: E4419B
 Alternate Power Meters: E4419A or EPM-442A

Note: The power sensor depends on the PNA frequency range. Depending on the PNA model, two power sensors may be required to test the full frequency range.
 The PNA front panel connector type will determine the cable used and if an adapter is required with the power sensor(s).

PNA Model	Power Sensor(s)	Cable
E8356A	8482A	N6314A
E8357A/E8358A	8482A and E4412A	N6314A
E8801A	8482A	N6314A
E8802A/E8803A	8482A and E4412A	N6314A
N3381A	8482A	N6314A
N3382A/N3383A	8482A and E4412A	N6314A
E8362A	E4413A	85131E
E8363A / E8364A	8487A (use with adapter 11900B)	85133E

See PNA Accessories

Procedure

1. Refer to your power meter documentation to ensure the proper calibration factors for the power sensor have been entered into the table on the power meter.

2. Connect a GPIB cable between the power meter and network analyzer.

3. Ensure the power sensor(s) are connected to the power meter.

4. In the analyzer **System** menu, point to **Service**, **Adjustments**, and click **Source Calibration**.

5. The software presents you with three choices:

   a. Click **Inspect Linearity** to observe how accurately the power steps from one power level to the next. When finished, Test Output Power Linearity should meet specification for your PNA Model.

   b. Click **Inspect Amplitude** to observe flatness of the source power versus frequency for three power levels: -5 dBm, 0 dBm and +5 dBm. When finished, Test Output Power Accuracy should meet specification for your PNA Model.

   c. Click **Calibrate** to begin the source calibration process. The software begins by identifying the power meter and sensor. Then you are prompted to connect the sensor(s) and cable as needed.

Connecting sensors to the PNA

NETWORK ANALYZER

POWER METER

GPIB

ADAPTER

POWER SENSOR
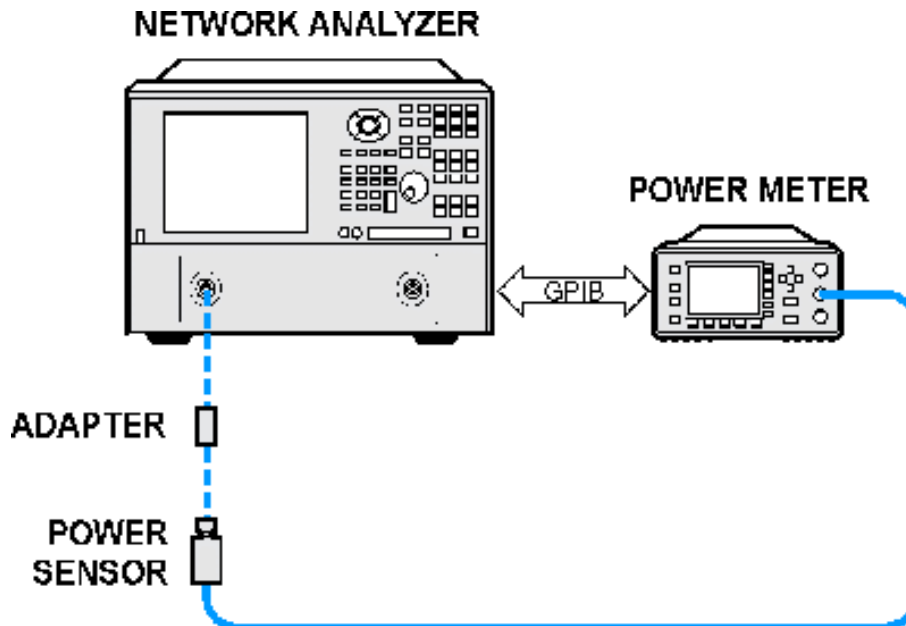
Additional Information

Calibration will proceed to determine the DAC settings. All ports are tested on 3 GHz, 6 GHz, and 9 GHz PNAs. Only port 1 is tested for all other PNAs. It is assumed the ports behave the same.

Source calibration takes approximately 20 to 60 minutes to complete depending on the frequency range of the PNA.

Troubleshooting

In the event there is a problem with Source Calibration, please refer to the "Troubleshooting" chapter in the PNA Service Guide.

Receiver Calibration

Receiver calibration adjusts the network analyzer receivers for a flat response across its full frequency range. This adjustment is for service only; not for measurement calibration.

Required Equipment

Preferred Power Meter: E4419B
 Alternate Power Meters: E4419A or EPM-442A

Note: The power sensor depends on the PNA frequency range. Depending on the PNA model, two power sensors may be required to test the full frequency range.
 The PNA front panel connector type will determine the cable used and if an adapter is required with the power sensor(s).

PNA Model	Power Sensor(s)	Cable
E8356A	8482A	N6314A
E8357A/E8358A	8482A and E4412A	N6314A
E8801A	8482A	N6314A
E8802A/E8803A	8482A and E4412A	N6314A
N3381A	8482A	N6314A
N3382A/N3383A	8482A and E4412A	N6314A
E8362A	E4413A	85131E
E8363A / E8364A	8487A (use with adapter 11900B)	85133E

See PNA Accessories

Procedure

1. Refer to your power meter documentation to ensure the proper calibration factors for the power sensor have been entered into a table on the power meter.

2. Connect a GPIB cable between the power meter and network analyzer.

3. Ensure the power sensor(s) are connected to the power meter.

4. In the analyzer **System** menu, point to **Service**, **Adjustments**,and click **Receiver Calibration**.

5. The software presents you with two choices:

   a. Click **Inspect Flatness** to observe flatness of receiver response versus frequency. Although there is no explicit specification for receiver flatness, Receiver Calibration should improve Transmission and Reflection Tracking error terms which are specified.

   b. Click **Calibrate** to begin the receiver calibration process. The software prompts you to connect the sensor(s), cable and adapter as needed (see the following graphics).

Connecting sensor(s) to the PNA

NETWORK ANALYZER

POWER METER

GPIB

ADAPTER

POWER
SENSOR
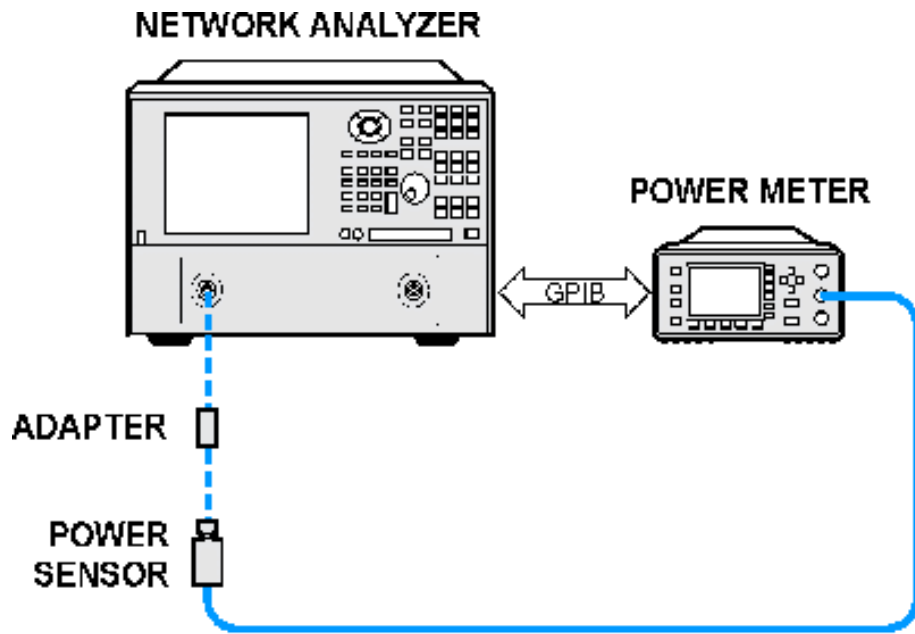
Connecting adapter and cable between sensor and PNA

NETWORK ANALYZER

POWER METER

GPIB

RF Cable

POWER SENSOR
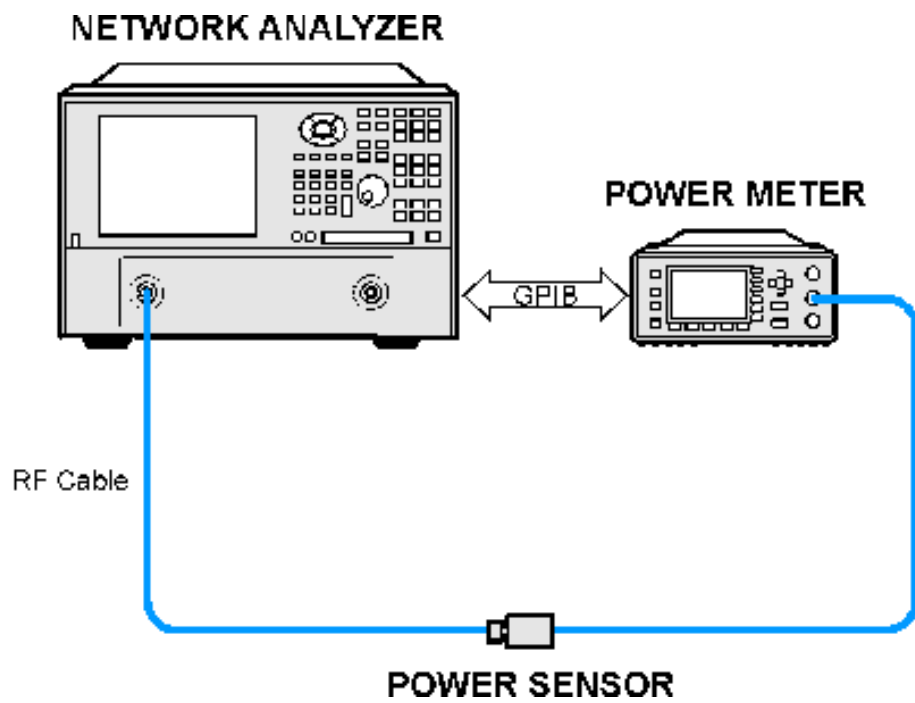
Through connection using the specified cable

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NETWORK ANALYZER

RF Cable
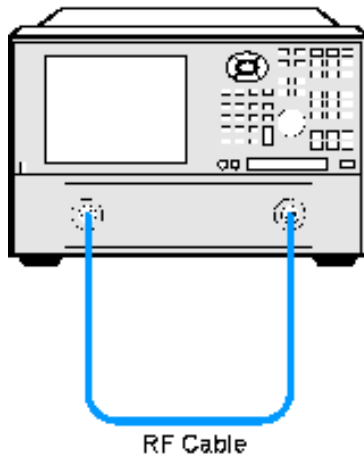
Additional Information

Receiver Calibration tests all PNA receivers, taking approximately 15 and 45 minutes. Length is dependent on frequency range and number of ports.

Troubleshooting

In the event there is a problem with Receiver Calibration, please refer to the "Troubleshooting" chapter in the Network Analyzer Service Guide.

Receiver Display

_____

- The Receiver Display as a Troubleshooting Tool
- How to start the Receiver Display

Other Support Topics

The Receiver Display as a Troubleshooting Tool

The Receiver Display is a Troubleshooting Tool. It enables the analyzer to isolate faulty functional groups within its own Measurement System. Traces for each Receiver are Displayed in individual windows. Identifying discrepancies of the traces in these windows can help isolate the faulty assembly.

For a thorough description of Receiver Display and the troubleshooting steps see Chapter 3 of the PNA Service Guide.

The PNA Service Guide is available in PDF format on the CD-ROM for viewing or printing from a personal computer (PC).

How to Start the Receiver Display
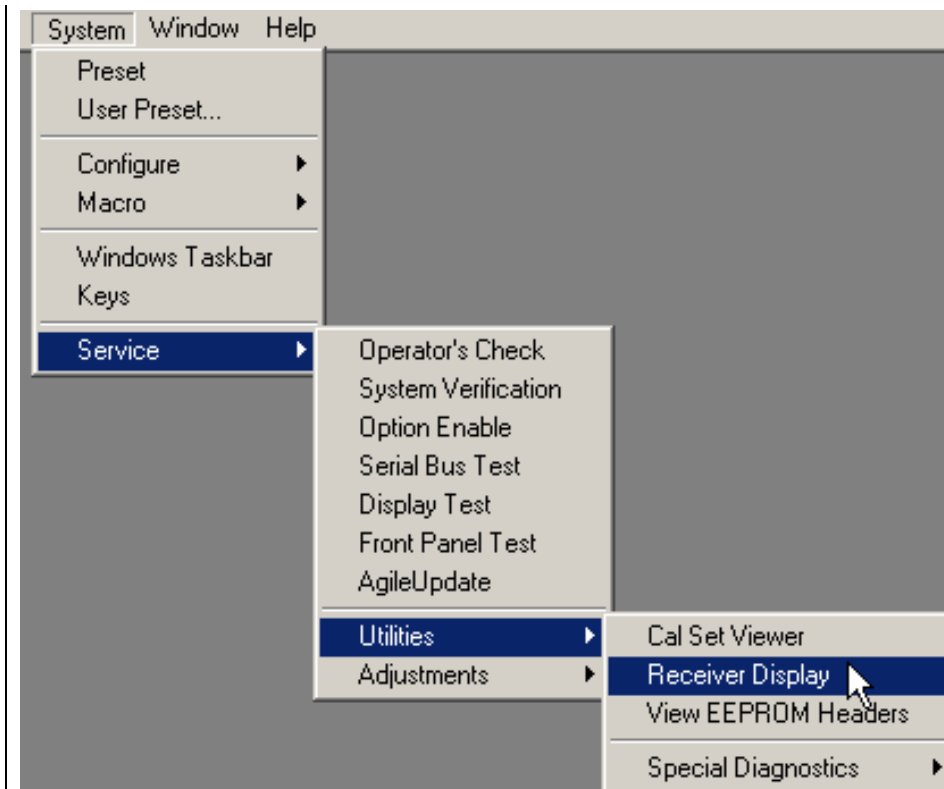
Learn more about using the front panel interface

Serial Bus Test

_____

This test is designed to work with the PNA Series Network Analyzer as it was originally manufactured. If any of the following assemblies have been replaced in the analyzer, this test may not show accurate pass/fail results.

- A8

- A10

- A11

- A12

This test sequentially tests all 32 nodes at 300 kHz, and then all nodes whose values change with frequency, at 11 other frequencies. All measured values are written to an ASCII text file in the service directory any measured values which exceeed their tolerances are highlighted in the application and the data file.

The assemblies tested and their associated node numbers are as follows:

Board Assembly	Node Numbers
A12 Source Assembly	111 to 118
A10 Frequency Reference	211 to 218
A11 Phase Lock	311 to 318
A8 Fractional-N Synthesizer	411 to 418

How to Start Serial Bus Test
System Window Help Preset User Preset... Configure ▶ Macro ▶ Windows Taskbar Keys Service ▶   Operator's Check System Verification Option Enable **Serial Bus Test** ▶ Display Test
Learn more about using the front panel interface
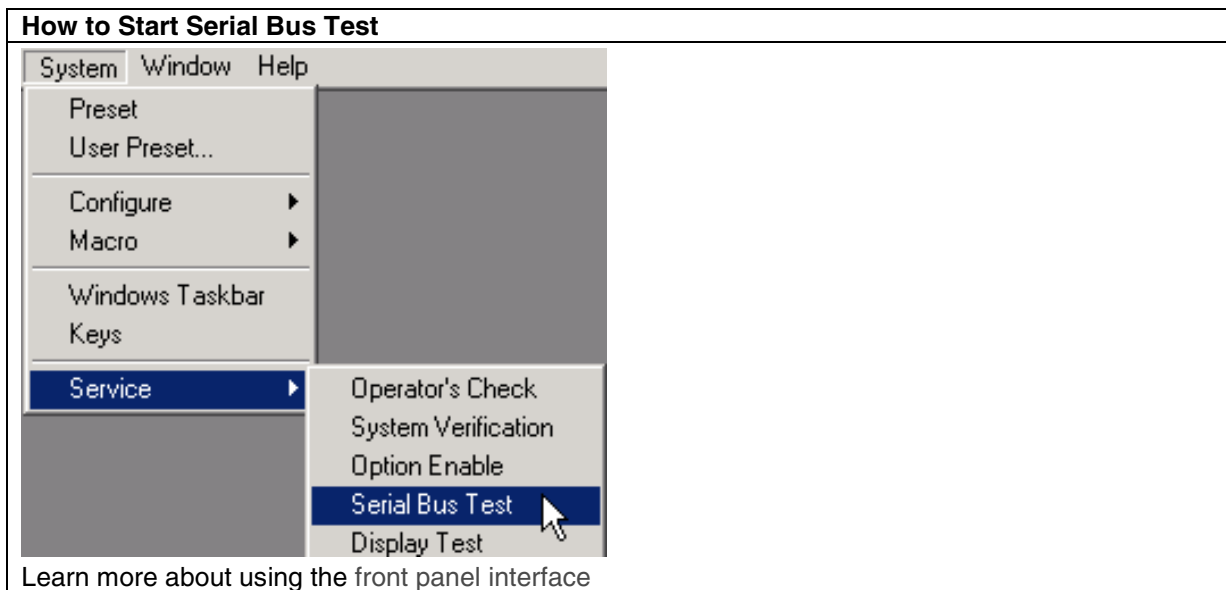
Note: If any errors are reported, refer to the service guide.

Instrument Calibration

An instrument calibration is a process where the analyzer performance is measured to ensure that the analyzer operates within specifications. If any performance parameter does not conform to the published specifications, adjustments are made to bring the performance into conformance.

Why Should I Get an Instrument Calibrated?

Over time, the active components in the analyzer age and the performance may degrade or drift. To ensure that the analyzer is performing to the published specifications, you must have an instrument calibration performed periodically.

How Often Should I Get an Instrument Calibrated?

The instrument specifications are set to consider the performance drift that may occur over a 12 month period. Therefore, getting the instrument calibrated at 12 month intervals ensures that the analyzer maintains performance within the operating specifications. If you need the analyzer to maintain more consistent operation parameters, you may want to have the instrument calibrated more often than the suggested 12-month interval.

How Do I Get an Instrument Calibrated?

To get the instrument calibrated, send it to one of the Agilent Technologies service centers. See Technical Support. If you want to perform the instrument calibration, you must have the following required items:

- Instrument Calibration Test Equipment
- Performance Test Software

What Are My Choices of Instrument Calibration?

The following types of instrument calibration are available from Agilent Technologies:

Standard	Includes a certificate of calibration, stating the instrument has been calibrated and is operating within the published specifications.
Option UK6	Includes the test data from the calibration and the standard certificate, stating the instrument has been calibrated and is operating within the published specifications.
Option M40 (Special)	Includes the test data from the calibration and a certificate, stating the instrument has been calibrated using a process in compliance with ANSI Z540 and is operating within the published specifications.

Other Support Topics

Tutorials

Connector Care

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Proper connector care is critical for accurate and repeatable measurements. The following information will help you preserve the precision and extend the life of your connectors - saving both time and money.

- Connector Care Quick Reference Guide

- Connector Cleaning Supplies

- Safety Reminders

- About Connectors

- Gaging Fundamentals

- Connector Care Procedures

Connector Care Quick Reference Guide

Handling and Storing Connectors

Do	**Do Not**
Keep connectors clean	Touch mating-plane surfaces
Protect connectors with plastic end caps	Set connectors contact-end down
Keep connector temperature same as analyzer	Store connectors loose in box or drawer

Visual Inspection

Do	**Do Not**
Inspect connectors with magnifying glass.	Use a connector with a bent or broken center conductor
Look for metal debris, deep scratches or dents	Use a connector with deformed threads

Cleaning Connectors

Do	**Do Not**
Clean surfaces first with clean, dry compressed air	Use high pressure air (>60 psi)
Use lint-free swab or brush	Use any abrasives
Use minimum amount of alcohol	Allow alcohol into connector support beads
Clean outer conductor mating surface and	Apply lateral force to center conductor

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threads

Gaging Connectors

Do	Do Not
Inspect and clean gage, gage master and device tested	Use an out of specification connector
	Hold connector gage by the dial
Use correct torque wrench	
zero gage before use	
Use multiple measurements and keep record of readings	

Making Connections

Do	Do Not
Align connectors first	Cross thread the connection
Rotate only the connector nut	Twist connector body to make connection
Use correct torque wrench	Mate different connector types

Connector Care and Cleaning Supplies

Listed below are products commonly used for connector cleaning. To order these and other connector care products, see Analyzer Accessories .

Description	Agilent P/N
Lint-Free Swabs, small 100 ct.	9301-1243
IPA 99.5% alcohol, 30 ml bottle	8500-5344
Compressed Air, 235 ml can	8500-6659

Safety Reminders

When cleaning connectors:

- Always use protective eyewear when using compressed air or nitrogen.
- Keep isopropyl alcohol away from heat, sparks and flame. Use with adequate ventilation. Avoid contact with eyes, skin and clothing.
- Avoid electrostatic discharge (ESD). Wear a grounded wrist strap (having a 1 MΩ series resistor) when cleaning device, cable or test port connectors.

About Connectors

- Connector Service Life
- Connector Grades and Performance
- Adapters as Connector Savers
- Connector Mating Plane Surfaces

Connector Service Life

Even though calibration standards, cables, and test set connectors are designed and manufactured to the highest standards, all connectors have a limited service life. This means that connectors can become defective due to wear during normal use. For best results, all connectors should be inspected and maintained to maximize their service life.

Visual Inspection should be performed each time a connection is made. Metal particles from connector threads often find their way onto the mating surface when a connection is made or disconnected. See Inspection procedure.

Cleaning the dirt and contamination from the connector mating plane surfaces and threads can extend the service life of the connector and improve the quality of your calibration and measurements. See Cleaning procedure.

Gaging connectors not only provides assurance of proper mechanical tolerances, and thus connector performance, but also indicate situations where the potential for damage to another connector may exist. See Gaging procedure.

Proper connector care and connection techniques yield:

- Longer Service Life
- Higher Performance
- Better Repeatability

Connector Grades and Performance

The three connector grades (levels of quality) for the popular connector families are listed below. Some specialized types may not have all three grades.

- **Production** grade connectors are the lowest grade and the least expensive. It is the connector grade most commonly used on the typical device under test (DUT). It has the lowest performance of all connectors due to its loose tolerances. This means that production grade connectors should always be carefully inspected before making a connection to the analyzer. Some production grade connectors are not intended to mate with metrology grade connectors.

- **Instrument** grade is the middle grade of connectors. It is mainly used in and with test instruments, most cables and adapters, and some calibration standards. It provides long life with good performance and tighter tolerances. It may have a dielectric supported interface and therefore may not exhibit the excellent match of a metrology grade connector.

- **Metrology** grade connectors have the highest performance and the highest cost of all connector grades. This grade is used on calibration standards, verification standards, and precision adapters. Because it is a high precision connector, it can withstand many connections and disconnections and, thus, has the longest life of all connector grades. This connector grade has the closest material and geometric specifications. Pin diameter and pin depth are very closely specified. Metrology grade uses an air dielectric interface and a slotless female contact which provide the highest performance and traceability.

Note: In general, Metrology grade connectors should not be mated with Production grade connectors.

Adapters as Connector Savers

Make sure to use a high quality (Instrument grade or better) adapter when adapting a different connector type to the analyzer test ports. It is a good idea to use an adapter even when the device under test is the same connector type as the analyzer test ports. In both cases, it will help extend service life, and protect the test ports from damage and costly repair.

The adapter must be fully inspected before connecting it to the analyzer test port and inspected and cleaned frequently thereafter. Because calibration standards are connected to the adapter, the adapter should be the highest quality to provide acceptable RF performance and minimize the effects of mismatch.

Connector Mating Plane Surfaces

An important concept in RF and microwave measurements is the reference plane. For a network analyzer, this is the surface that all measurements are referenced to. At calibration, the reference plane is defined as the plane where the mating plane surfaces of the measurement port and the calibration standards meet. Good connections (and calibrations) depend on perfectly flat contact between connectors at all points on the mating plane surfaces (as shown in the following graphic).

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Mating Plane Surfaces

Type-N (f)   Type-N (m)
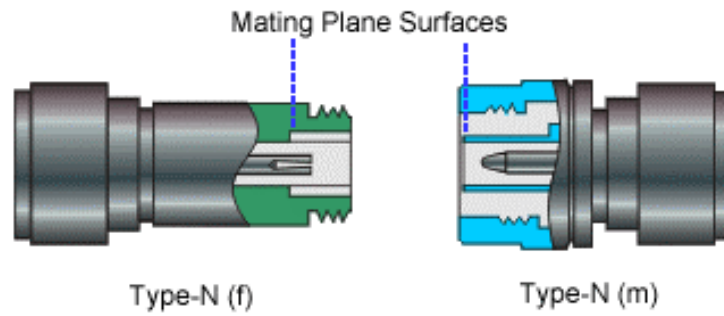
Gaging Fundamentals

Connector gages are important tools used to measure center conductor pin depth in connectors. Connector pin depth, measured in terms of recession or protrusion, is generally the distance between the mating plane and the end of the center conductor, or the shoulder of the center conductor for a stepped male pin.

Typical Connector Gage

RECESSION   **PROTRUSION**
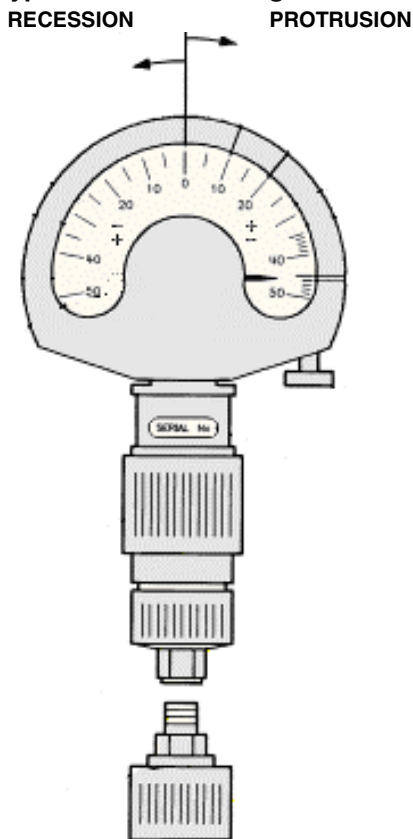
Recession and Protrusion

Pin depth is negative (recession) if the center conductor is recessed below the outer conductor mating plane, usually referred to as the "reference plane". Pin depth is positive (protrusion) if the center conductor projects forward from the connector reference plane.

Pin Depth
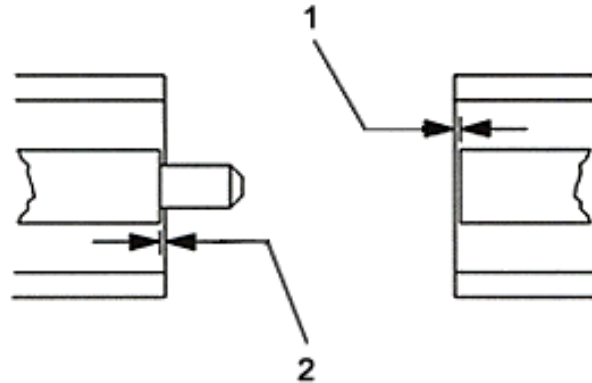
1. Recession of female contact
2. Recession of male pin shoulder

Difference with Type-N Connectors

Type-N connectors have the mating plane of the center conductors offset from the connector reference plane. In this case the zero setting "gage masters" generally offset the nominal distance between the center conductor mating plane and the connector reference plane.

When to Gage Connectors

- Before using a connector or adapter the first time.
- When visual inspection or electrical performance suggests the connector interface may be out of range.
- After every 100 connections, depending on use.

Connector Gage Accuracy

Connector gages (those included with calibration and verification kits), are capable of performing coarse measurements only. This is due to the repeatability uncertainties associated with the measurement. It is important to recognize that test port connectors and calibration standards have mechanical specifications that are extremely precise. Only special gaging processes and electrical testing (performed in a calibration lab) can accurately verify the mechanical characteristics of these devices. The pin depth specifications in the Agilent calibration kit manuals provide a compromise between the pin depth accuracy required, and the accuracy of the gages. The gages shipped with calibration and verification kits allow you to measure connector pin depth and avoid damage from out-of-specification connectors.

Note: Before gaging any connector, the mechanical specifications provided with that connector or device should be checked.

To Gage Connectors

1. Wear a grounded wrist strap (having a 1 MΩ series resistor).
2. Select proper gage for device under test (DUT).
3. Inspect and clean gage, gage master, and DUT.
4. Zero the connector gage.

    a. While holding gage by the barrel, carefully connect gage master to gage. Finger-tighten connector nut only.

    b. Use proper torque wrench to make final connection. If needed, use additional wrench

to prevent gage master (body) from turning. Gently tap the barrel to settle the gage.

    c. The gage pointer should line up exactly with the zero mark on gage. If not, adjust "zero set" knob until gage pointer reads zero. On gages having a dial lock screw and a movable dial, loosen the dial lock screw and move the dial until the gage pointer reads zero. Gages should be zeroed before each set of measurements to make sure zero setting has not changed.

    d. Remove gage master.

5. Gage the device under test.

    a. While holding gage by the barrel, carefully connect DUT to gage. Finger-tighten connector nut only.

    b. Use proper torque wrench to make final connection and, if needed, use additional wrench to prevent DUT (body) from turning. Gently tap the barrel to settle the gage.

    c. Read gage indicator dial for recession or protrusion and compare reading with device specifications.

Caution: If the gage indicates excessive protrusion or recession, the connector should be marked for disposal or sent out for repair.

6. For maximum accuracy, measure the device a minimum of three times and take an average of the readings. After each measurement, rotate the gage a quarter-turn to reduce measurement variations.

7. If there is doubt about measurement accuracy, be sure the temperatures of the parts have stabilized. Then perform the cleaning, zeroing, and measuring procedure again.

Connector Care Procedures

- Inspecting Connectors
- Cleaning Connectors
- Making Connections
- Using a Torque Wrench
- Handling and Storing Connectors

To Inspect Connectors

Wear a grounded wrist strap (having a 1 MΩ series resistor).

Use a magnifying glass ($\geq$10X) and inspect connector for the following:

- Badly worn plating or deep scratches
- Deformed threads
- Metal particles on threads and mating plane surfaces
- Bent, broken, or mis-aligned center conductors
- Poor connector nut rotation

Caution: A damaged or out-of-specification device can destroy a good connector attached to it even on the first connection. Any connector with an obvious defect should be marked for disposal or sent out for repair.

To Clean Connectors

1. Wear a grounded wrist strap (having a 1 MΩ series resistor).

2. Use clean, low-pressure air to remove loose particles from mating plane surfaces and threads. Inspect connector thoroughly. If additional cleaning is required, continue with the

following steps.
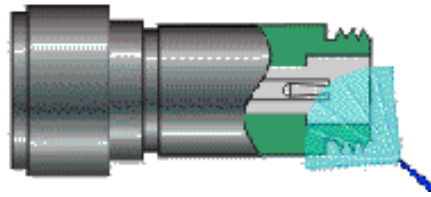
3. Moistendo not saturatea lint-free swab with isopropyl alcohol. See Cleaning Supplies for recommended type.

4. Clean contamination and debris from mating plane surfaces and threads. When cleaning interior surfaces, avoid exerting pressure on center conductor and keep swab fibers from getting trapped in the female center conductor.
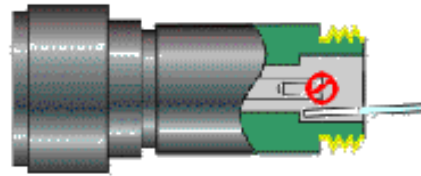
5. Let alcohol evaporatethen use compressed air to blow surfaces clean.

6. Inspect connector. Make sure no particles or residue remains.

7. If defects are still visible after cleaning, the connector itself may be damaged and should not be used. Determine the cause of damage before making further connections.

To Make Connections

1. Wear a grounded wrist strap (having a 1 MΩ series resistor).

2. Inspect, clean, and gage connectors. All connectors must be undamaged, clean, and within mechanical specification.

3. Carefully align center axis of both devices. The center conductor pinfrom the male connectormust slip concentrically into the contact finger of the female connector.
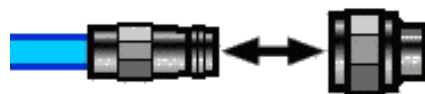
4. Carefully push the connectors straight together so they can engage smoothly. Rotate the connector nut (not the device itself) until finger-tight, being careful not to cross the threads.

HOLD
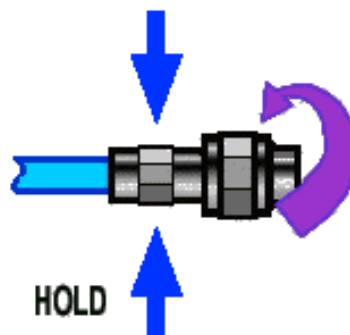
5. Use a torque wrench to make final connection. Tighten until the "break" point of the

torque wrench is reached. Do **not** push beyond initial break point. Use additional wrench, if needed, to prevent device body from turning.
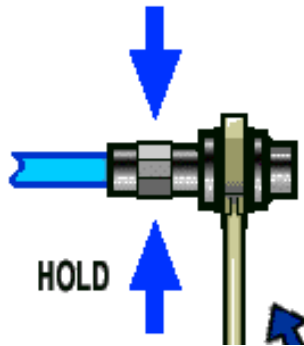
To Separate a Connection

1. Support the devices to avoid any twisting, rocking or bending force on either connector.
2. Use an open-end wrench to prevent the device body from turning.
3. Use another open-end wrench to loosen the connector nut.
4. Complete the disconnection by hand, turning only the connector nut.
5. Pull the connectors straight apart.

To Use a Torque Wrench

1. Make sure torque wrench is set to the correct torque setting.
2. Position torque wrench and a second wrench (to hold device or cable) within 90° of each other before applying force. Make sure to support the devices to avoid putting stress on the connectors.

HOLD		
CORRECT METHOD	INCORRECT METHOD	(TOO MUCH LIFT)
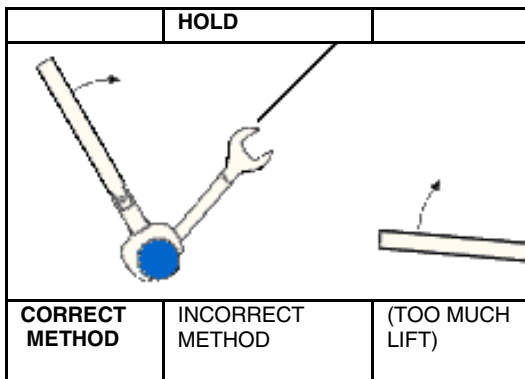
3. Hold torque wrench lightly at the end of handlethen apply force perpendicular to the torque wrench handle. Tighten until the "break" point of the torque wrench is reached. Do **not** push beyond initial break point.

TORQUING DIRECTION
STOP WHEN HANDLE BEGINS TO YIELD
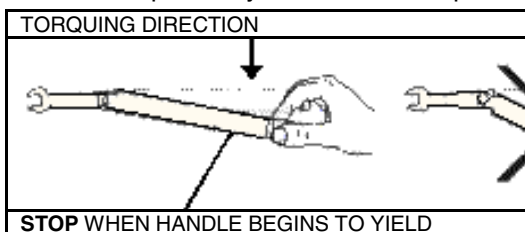
To Handle and Store Connectors

- Install protective end caps when connectors are not in use.

- Never store connectors, airlines, or calibration standards loose in a box. This is a common cause of connector damage.

- Keep connector temperature the same as analyzer. Holding the connector in your hand or cleaning connector with compressed air can significantly change the temperature. Wait for connector temperature to stabilize before using in calibration or measurements.

- Do not touch mating plane surfaces. Natural skin oils and microscopic particles of dirt are difficult to remove from these surfaces.

- Do not set connectors contact-end down on a hard surface. The plating and mating plane surfaces can be damaged if the interface comes in contact with any hard surface.

- Wear a grounded wrist strap and work on a grounded, conductive table mat. This helps protect the analyzer and devices from electrostatic discharge (ESD).

Electrostatic Discharge (ESD) Protection

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Protection against electrostatic discharge (ESD) is essential while removing or connecting cables to the network analyzer. Static electricity can build up on your body and can easily damage sensitive internal circuit elements when discharged. Static discharges too small to be felt can cause permanent damage. To prevent damage to the instrument:

- *Always* have a grounded, conductive table mat in front of your test equipment.

- *Aways* wear a grounded wrist strap, connected to a grounded conductive table mat, having a 1 M resistor in series with it, when making test setup connections.

- *Aways* wear a heel strap when working in an area with a conductive floor. If you are uncertain about the conductivity of your floor, wear a heel strap.

- *Aways* ground yourself before you clean, inspect, or make a connection to a static-sensitive device or test port. You can, for example, grasp the grounded outer shell of the test port or cable connector briefly.

- *Aways* ground the center conductor of a test cable before making a connection to the analyzer test port or other static-sensitive device. This can be done as follows:

  1. Connect a short (from your calibration kit) to one end of the cable to short the center conductor to the outer conductor.

  2. While wearing a grounded wrist strap, grasp the outer shell of the cable connector.

  3. Connect the other end of the cable to the test port and remove the short from the cable.

The following graphic shows a typical ESD protection setup using a grounded mat and wrist strap. Refer to Analyzer Accessories for part numbers.

Wrist Strap

Anti-Static Mat

1 MΩ

NOTE:

A 3-Wire line power cord with proper connection to ground must be used for ESD protection
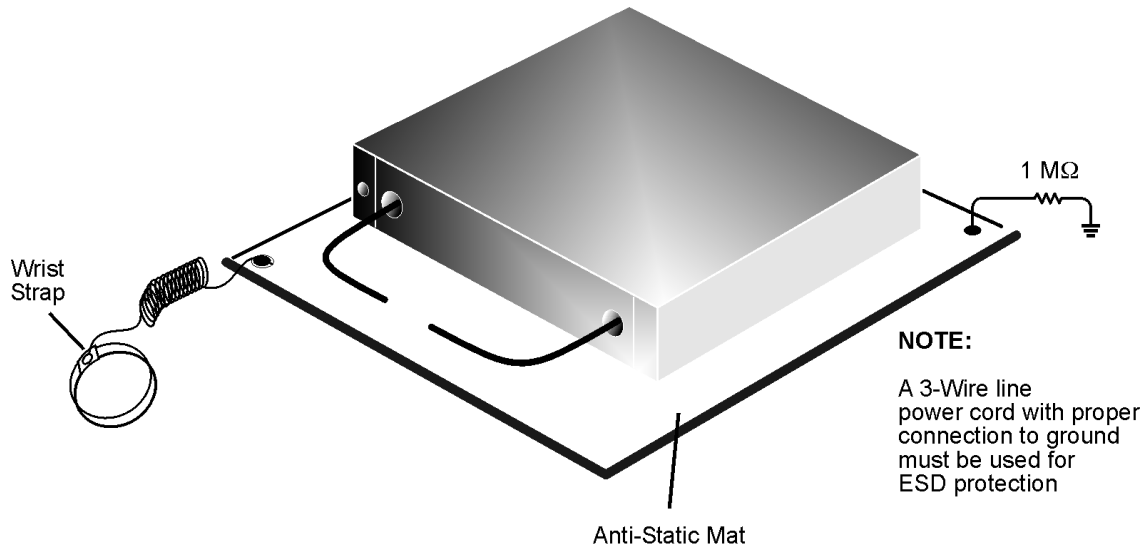
esd_setup

Reflection Measurements

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Reflection measurements are an important part of network analysis.

- What are Reflection Measurements?
- Why Make Reflection Measurements?
- Expressing Reflected Waves
  - Return Loss
  - VSWR
  - Reflection Coefficient
  - Impedance
  - Summary of Expressions

See other Tutorials

What are Reflection Measurements?

To understand reflection measurements, it is helpful to think of traveling waves along a transmission line in terms of a lightwave analogy. We can imagine incident light striking some optical component like a clear lens. Some of the light is reflected off the surface of the lens, but most of the light continues on through the lens. If the lens had mirrored surfaces, then most of the light would be reflected and little or none would be transmitted.
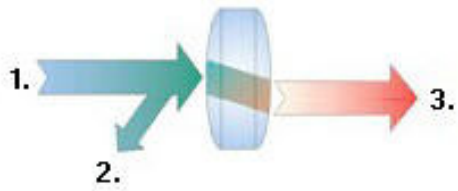
1. Incident   **2.** Reflected   **3.** Transmitted

With RF energy, reflections occur when the impedance of two mated devices are not the same. A

reflection measurement is the ratio of the reflected signal to the incident signal. Network analyzers measure the incident wave with the R (for reference) channel and the reflected wave with the A channel. Therefore, reflection is often shown as the ratio of A over R (A/R). We can completely quantify the reflection characteristics of our device under test (DUT) with the amplitude and phase information available at both the A and R channel. In S-parameter terminology, S11 is a reflection measurement of port1 of the device (the input port); S22 is a reflection measurement of the port 2 (the output port)

Why Make Reflection Measurements?

One reason we make reflection measurements to assure efficient transfer of RF power. We do this because:

1. RF energy is not cheap. When energy is reflected, that means less energy is transmitted to where it is intended to go.
2. If the reflected energy is large, it can damage components, like amplifiers.

For example, in the following graphic, the radio station on the left is not operating at peak efficiency. The amplifier impedance is not the same as the transmission line, and the transmission line impedance is not the same as the antenna. Both of these conditions cause high reflected power. This condition results in less transmitted power, and the high reflected power could damage the amplifier.
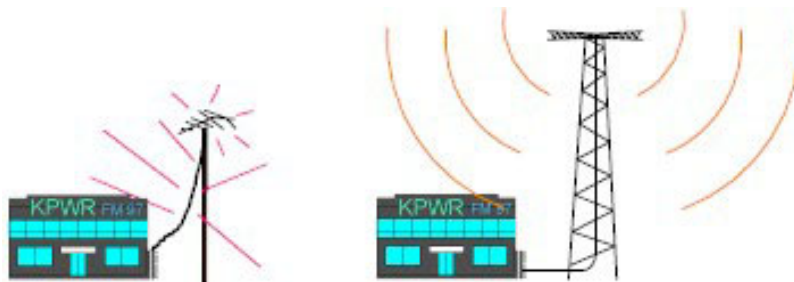
The radio station on the right installed properly "matched" transmission line and antenna. Very little of the transmitted signal is reflected, resulting in increased broadcast power, more listeners, more advertising revenue, and more profit. The amplifier, transmission, and antenna all need to be measured to ensure that reflected power is minimized.

Expressing Reflected Waves

After making a reflection measurement, the reflection data can be expressed in a number of ways, depending on what you are trying to learn. The various expressions are all calculated by the analyzer from the same reflection measurement data. Each method of expressing reflection data can be graphically displayed in one or more formats. For more information, see display formats.

Return Loss

The easiest way to convey reflection data is return loss. Return loss is expressed in dB, and is a scalar (amplitude only) quantity. Return loss can be thought of as the absolute value or dB that the reflected signal is below the incident signal. Return loss varies between infinity for a perfect impedance match and 0 dB for an open or short circuit, or a lossless reactance. For example, using the log magnitude format on the analyzer, the measured reflection value on the screen may be -18dB. The minus sign is ignored when expressing return loss, so the component is said to have 18dB of return loss.

VSWR

Two waves traveling in opposite directions on the same transmission line cause a "standing wave". This condition can be measured in terms of the voltage standing wave ratio (VSWR or

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SWR for short). VSWR is defined as the maximum reflected voltage over the minimum reflected voltage at a given frequency. VSWR is a scalar (amplitude only) quantity. VSWR varies between one for a perfect match, and infinity for an open or short circuit or lossless reactance.
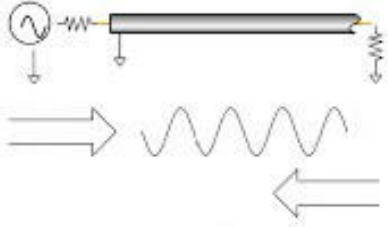
Reflection Coefficient

Another way of expressing reflection measurements is reflection coefficient gamma (Γ). Gamma includes both magnitude and phase.

The magnitude portion of gamma is called rho (ρ). Reflection coefficient is the ratio of the reflected signal voltage to the incident signal voltage. The range of possible values for ρ is between zero and one. A transmission line terminated in its characteristic impedance will have all energy transferred to the load; zero energy will be reflected and $\rho = 0$. When a transmission line terminated in a short or open circuit, all energy is reflected and $\rho = 1$. The value of rho is unitless.

Now for the phase information. At high frequencies, where the wavelength of the signal is smaller than the length of conductors, reflections are best thought of as waves moving in the opposite direction of the incident waves. The incident and reflected waves combine to produce a single "standing" wave with voltage that varies with position along the transmission line.

When a transmission line is terminated in its characteristic impedance (Zo) there is no reflected signal. All of the incident signal is transferred to the load, as shown in the following graphic. There is energy flowing in one direction along the transmission line.

Incident Voltage		Zo
		Reflected Voltage = 0
		(All the incident power is absorbed in the load)

When a transmission line is terminated in a short circuit termination, all of the energy is reflected back to the source. The reflected wave is equal in magnitude to the incident wave ($\rho = 1$). The voltage across any short circuit is zero volts. Therefore, the voltage of the reflected wave will be 180 degrees out of phase with the incident wave, canceling the voltage at the load.
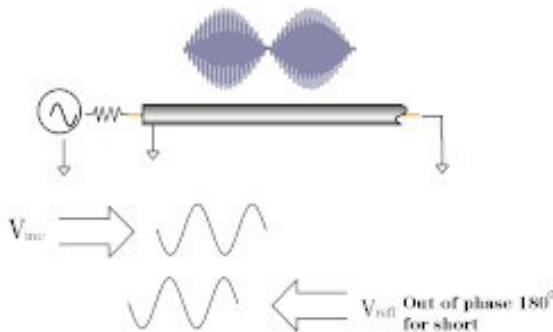
When a transmission line is terminated in an open circuit termination, all of the energy is reflected back to the source. The reflected wave is equal in magnitude to the incident wave ($\rho = 1$). However, no current can flow in an open circuit. Therefore, the voltage of the reflected wave will be in phase with the voltage of the incident wave.

V_{inc}

V_{refl} In phase for open
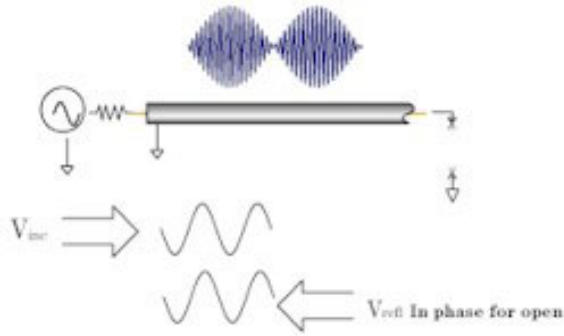
When a transmission line is terminated in a 25 ohm resistor, some but not all of the incident energy will be absorbed, and some will be reflected back towards the source. The reflected wave will have an amplitude 1/3 that of the incident wave and the voltage of the two waves will be out of phase by 180 degrees at the load. The phase relationship will change as a function of distance along the transmission line from the load. The valleys of the standing wave pattern will no longer go to zero, and the peaks will be less than that of the open / short circuit.

$Z_L = 25\ \Omega$

V_{inc}

V_{refl}
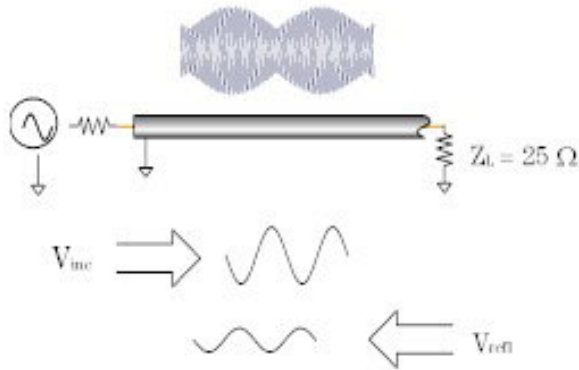
For more information, see Phase Measurements.

Impedance

Impedance is another way of expressing reflection data. For more information on Impedance, see Smith Charts.

Summary of the Expressions of Reflection Measurements:

No reflection
$(Z_L = Zo)$

Full reflection
$(Z_L = open, short)$

Return loss = $-20 \log(\rho), \rho = |\Gamma|$

∞ dB — RL — 0 dB

$$VSWR = \frac{E_{max}}{E_{min}} = \frac{1 + \rho}{1 - \rho}$$

Emax
Emin

1 — ∞

$$\text{Reflection Coefficient } \Gamma = \frac{V_{reflected}}{V_{incident}} = \rho \angle \phi = \frac{Z_L - Z_O}{Z_L + Z_O}$$

0 — ρ — 1
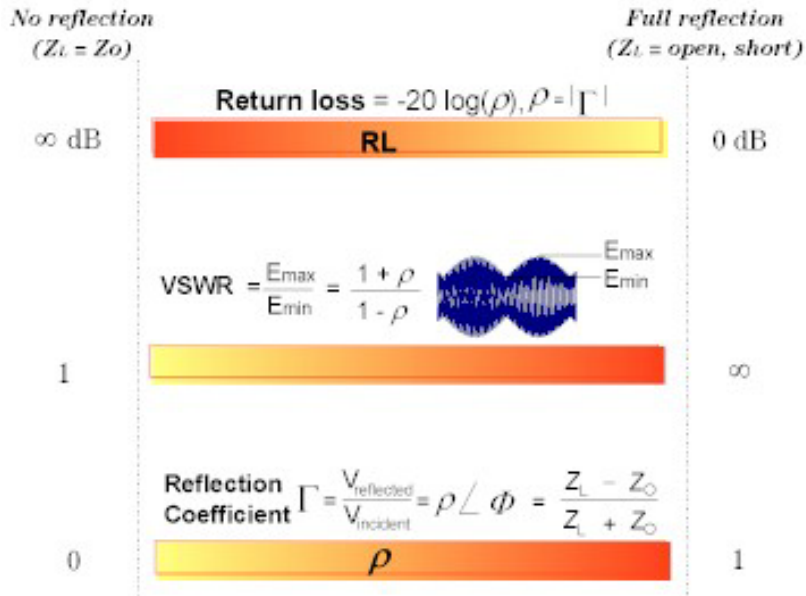
Phase Measurements

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Knowledge of both magnitude and phase characteristics is needed for successful higher-level component integration.

- What are Phase Measurements?
- Why Measure Phase?
- Using the Analyzer's Phase Format
- Types of Phase Measurements

See other Tutorials

What are Phase Measurements?

Phase measurements are made using S-parameters, just like amplitude measurements. A phase measurement is a relative (ratio) measurement and not an absolute measurement. Phase measurements compare the phase of the signal going into a device (the incident signal) to the phase of the device's response signal. The response signal can be either reflected or transmitted. Assuming an accurate calibration has been performed, the difference in phase between the two signals (known as phase shift) is a result of the electrical characteristics of the device under test.

The following graphic shows the phase shift (in time or degrees) between an incident signal and a transmitted signal (as might be seen on an oscilloscope display).
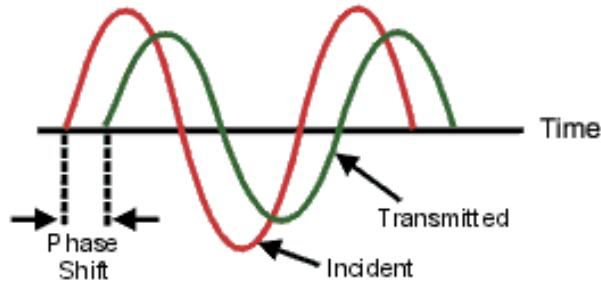
Why Measure Phase?

Measuring phase is a critical element of network analysis. The following graphic lists five reasons for measuring both magnitude and phase.
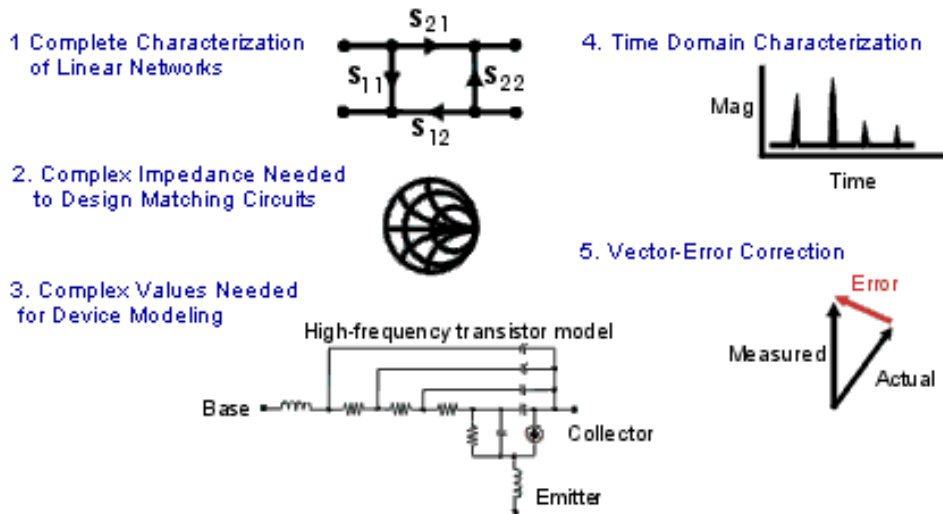
When used in communications systems to pass signals, components or circuits must not cause excessive signal distortion. This distortion can be:

- Linear, where flat magnitude and linear phase shift versus frequency is not maintained over the bandwidth of interest.

- Nonlinear, such as AM-to-PM conversion.

It is important to measure how reflective a component or circuit is, to ensure that it transmits or absorbs energy efficiently. Measuring the complex impedance of an antenna is a good example.

Using the Analyzer's Phase Format

The analyzer's phase format displays a phase-versus-frequency or phase-versus-power measurement. The analyzer does not display more than ±180 degrees phase difference between the reference and test signals. As the phase value varies between +180 degrees and -180 degrees, the analyzer display creates the sawtooth pattern as shown in the following graphic.

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Phase Format
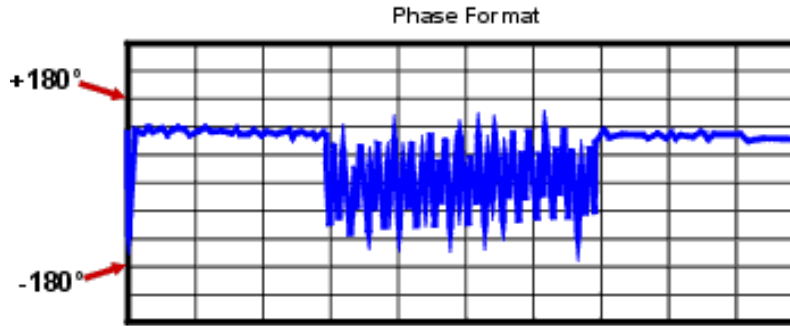
The sawtooth pattern does not always reach +180 degrees and -180 degrees. This is because the measurement is made at discrete frequencies, and the data point at +180 degrees and -180 degrees may not be measured for the selected sweep.

Types of Phase Measurements

Complex impedance data is information such as resistance, reactance, phase, and magnitude that can be determined from an S11 or S22 measurement. Complex impedance data can be viewed using either the Smith Chart format or the Polar format.

AM-to-PM conversion is a measure of the amount of undesired phase deviation (PM) that is caused by amplitude variations (AM) of the system. AM-to-PM conversion is usually defined as the change in output phase for a 1-dB increment in the input power to an amplifier (i.e. at the 1 dB gain compression point). This is expressed in degrees-per-dB (°/dB).

Deviation from linear phase is a measure of phase distortion caused by a device. Ideally, the phase shift through a device is a linear function of frequency. The amount of variation from this theoretical phase shift is known as its deviation from linear phase (also called phase linearity).

Group delay is another way to look at phase distortion caused by a device. Group delay is a measure of transit time through a device at a particular frequency. The analyzer computes group delay from the derivative of the measured phase response.

Deviation from Linear Phase Versus Group Delay

Although deviation from linear phase and group delay are similar measurements, they each have their purpose.

The following are the advantages of deviation from linear phase measurements:

- Less noisy than group delay.
- Able to characterize devices that pass phase modulated signals, and show units of phase rather than units of seconds.

The following are the advantages of group delay measurements:

- More easily interpreted indication of phase distortion than deviation from linear phase.
- Able to most accurately characterize a device under test. This is because in determining group delay, the analyzer calculates the slope of the phase ripple, which is dependent on the number of ripples which occur per unit of frequency. Comparing two phase responses with equal peak-to-peak phase ripple, the response with the larger phase slope results in:
  - More group delay variation.
  - More signal distortion.

Amplifier Parameters Reference

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- Gain
- Gain Flatness
- Reverse Isolation
- Gain Drift Versus Time
- Deviation from Linear Phase
- Group Delay
- Return Loss (SWR, ρ)
- Complex Impedance
- Gain Compression
- AM-to-PM Conversion

Gain

$$\tau = \frac{V_{trans}}{V_{inc}}$$

$$\text{Gain (dB)} = -20\log_{10}|\tau|$$

$$\text{Gain (dB)} = P_{out}\text{ (dBm)} - P_{in}\text{ (dBm)}$$

The ratio of the amplifier's output power (delivered to a Z_0 load) to the input power (delivered from a Z_0 source). Z_0 is the characteristic impedance, in this case, 50Ω.

For small signal levels, the output power of the amplifier is proportional to the input power. Small signal gain is the gain in this linear region.

As the input power level increases and the amplifier approaches saturation, the output power reaches a limit and the gain drops. Large signal gain is the gain in this nonlinear region. See Gain Compression.

Gain Flatness

The variation of the gain over the frequency range of the amplifier. See Small Signal Gain and Flatness.

Reverse Isolation

The measure of transmission from output to input. Similar to the gain measurement except the signal stimulus is applied to the output of the amplifier. See Reverse Isolation.

Gain Drift versus Time (temperature, bias)

The maximum variation of gain as a function of time, with all other parameters held constant. Gain drift is also observed with respect to other parameter changes such as temperature, humidity or bias voltage.

Deviation from Linear Phase

The amount of variation from a linear phase shift. Ideally, the phase shift through an amplifier is a linear function of frequency. See Deviation from Linear Phase.

Group Delay

$$\tau_g \, (\text{sec}) = -\frac{\Delta\theta}{\Delta\varpi}$$

$$= -\frac{1}{360} * \frac{\Delta\theta}{\Delta f}$$

The measure of the transit time through the amplifier as a function of frequency. A perfectly linear phase shift would have a constant rate of change with respect to frequency, yielding a constant group delay. See Group Delay.

Return Loss (SWR, ρ)

$$\Gamma = \frac{V_{refl}}{V_{inc}} = \rho\angle\theta$$

$$\text{Reflection coefficient} = \rho$$

$$\text{Return loss (dB)} = -20\log_{10}\rho$$

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

The measure of the reflection mismatch at the input or output of the amplifier relative to the system Z_0 characteristic impedance.

Complex Impedance

$$Z = \frac{1+\Gamma}{1-\Gamma} * Z_0$$

$$= -R + jX$$

Complex impedance (1+G). The amount of reflected energy from an amplifier is directly related to its impedance. Complex impedance consists of both a resistive and a reactive component. It is derived from the characteristic impedance of the system and the reflection coefficient. See Complex Impedance.

Gain Compression

An amplifier has a region of linear gain where the gain is independent of input power level (small signal gain). As the power is increased to a level that causes the amplifier to saturate, the gain decreases.

Gain compression is determined by measuring the amplifier's 1 dB gain compression point (P_{1dB}) which is the output power at which the gain drops 1 dB relative to the small signal gain. This is a common measure of an amplifier's power output capability. See Gain Compression.

AM-to-PM Conversion Coefficient

$$\text{AM/PM} = \frac{\Delta\theta}{\Delta P}$$

The amount of phase change generated in the output signal of an amplifier as a result of an amplitude change of the input signal.

The AM-to-PM conversion coefficient is expressed in units of degrees/dB at a given power level (usually P_{1dB}, which is the 1 dB gain compression point). See AM-PM Conversion.

AM-PM Conversion

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The AM-PM conversion of an amplifier is a measure of the amount of undesired phase deviation (PM) that is caused by amplitude variations (AM) inherent in the system.

- What Is AM-PM Conversion?
- Why Measure AM-PM Conversion
- Accuracy Considerations
- How to Measure AM-PM Conversion

Other Tutorials topics

What Is AM-PM Conversion?

AM-to-PM conversion measures the amount of undesired phase deviation (PM) that is caused by amplitude variations (AM) of the system. For example, unwanted phase deviation (PM) in a communications system can be caused by:

Unintentional amplitude variations (AM)

- Power supply ripple
- Thermal drift
- Multipath fading

Intentional modulation of signal amplitude

- QAM
- Burst modulation

AM-to-PM conversion is usually defined as the change in output phase for a 1-dB increment in the power-sweep applied to the amplifier's input (i.e. at the 1 dB gain compression point). It is expressed in degrees-per-dB (°/dB). An ideal amplifier would have no interaction between its phase response and the power level of the input signal.
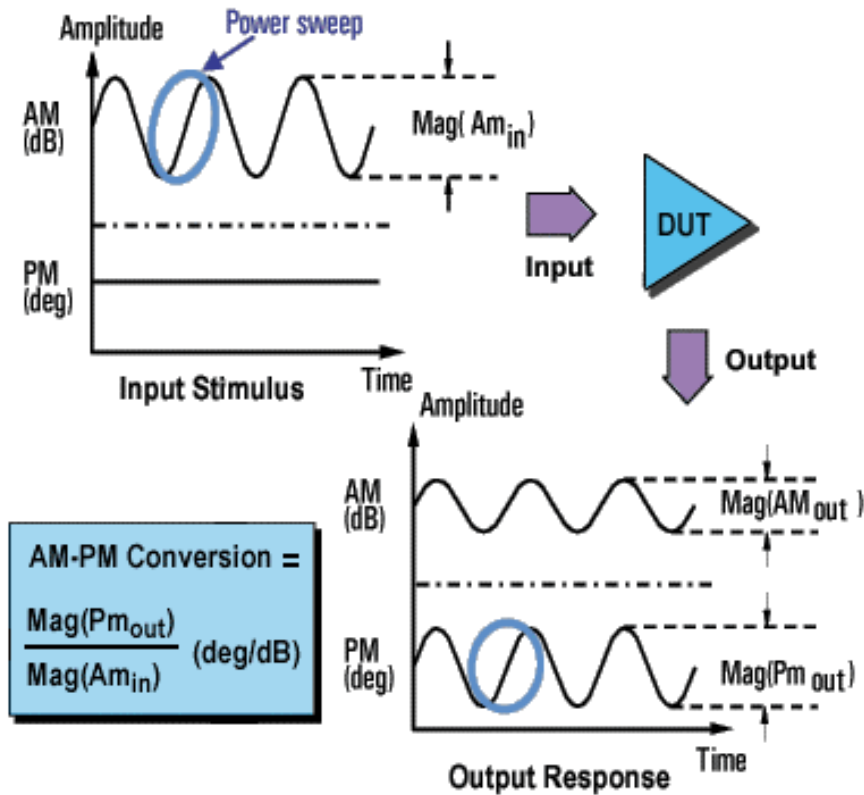
Why Measure AM-PM Conversion

AM-to-PM conversion is a critical parameter in systems where phase (angular) modulation is used, such as:

- FM
- QPSK
- 16QAM

It is a critical parameter because undesired phase deviation (PM) causes analog signal degradation, or increased bit-error rates (BER) in digital communication systems. While it is easy to measure the BER of a digital communication system, this measurement alone does not help you understand the underlying causes of bit errors. AM-to-PM conversion is one of the fundamental contributors to BER, and therefore it is important to quantify this parameter in communication systems.

Refer to the I/Q diagram below for the following discussion on how AM-to-PM conversion can cause bit errors.
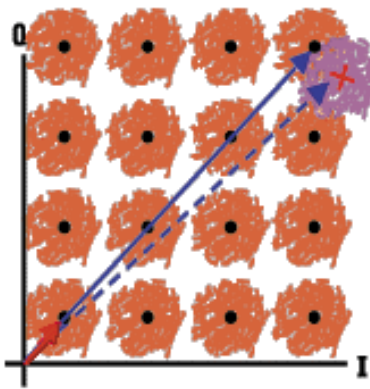
AM to PM conversion
can cause bit errors

- The desirable state change is from the small solid vector to the large solid vector.

- With AM-to-PM conversion, the large vector may actually end up as shown with the dotted line. This is due to phase shift that results from a change in the input power level.

- For a 64QAM signal as shown (only one quadrant is drawn), we see that the noise circles that surround each state would actually overlap, which means that statistically, some bit errors would occur.

Accuracy Considerations

With this method of measuring AM-to-PM conversion, the modulation frequency is approximately the inverse of the sweep time. Even with the fastest power sweep available on most network analyzers, the modulation frequency ends up being fairly low (typically less than 10 Hz). This could cause a slight temperature change as the sweep progresses, especially if the amplifier has low thermal mass, typical of an unpackaged device. Results using this method could differ slightly if the nonlinear behavior of an amplifier is extremely sensitive to thermal changes. (The PNA series analyzers can make power sweeps <1 ms.)

- The amplifier may respond very differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

- The output power of the amplifier should be sufficiently attenuated if necessary. Too much output power could:

  - damage the analyzer receiver

  - exceed the input compression level of the analyzer receiver, resulting in inaccurate measurements

- Attenuation of the amplifier's output power can be accomplished using:

  - Attenuators

  - Couplers

- The frequency-response effects of the attenuators and couplers must be accounted for during calibration since they are part of the test system. Proper error-correction techniques can reduce these effects.

- The frequency response is the dominant error in an AM-to-PM conversion measurement setup. Performing a thru-response measurement calibration significantly reduces this error. For greater accuracy, perform a 2-port measurement calibration.

How to Measure AM-PM Conversion

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1. Preset the analyzer.

2. Select an S21 measurement in the power-sweep mode.

3. Enter the start and stop power levels for the analyzer's power sweep. The start power level should be in the linear region of the amplifier's response (typically 10-dB below the 1-dB compression point). The stop power should be in the compression region of the amplifier's response.

4. Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port 2.

5. Connect the amplifier as shown in the following graphic, and provide the dc bias.
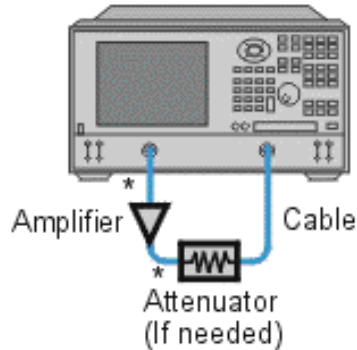
6. Select the analyzer settings for your amplifier under test in order to perform a swept-power gain compression measurement at a chosen frequency. See Gain Compression.

7. Remove the amplifier and perform a measurement calibration. Be sure to include the attenuator and cables in the calibration setup if they will be used when measuring the amplifier.

8. Save the instrument state to memory.

9. Reconnect the amplifier.

10. Use a reference marker to target the amplifier's input power at the 1-dB gain compression point. Select a second marker and adjust its stimulus value until its response is 1-dB below the reference marker.

11. Change the S_{21} measurement from a log magnitude format to a phase format (no new calibration is required).

12. Find the phase change between the markers. The value is the AM-to-PM conversion coefficient at the 1-dB gain compression point.

13. Print the data or save it to a disk.

Antenna Measurements

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This topic describes how to setup the PNA to make S21 measurements on an array of antennas. Measurements can be made on up to 100 antenna arrays (Ports) and up to 15 discrete

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frequencies

Measurement Sequence

1. The PNA is set to a start frequency.

2. As the antenna moves, the PNA responds to each external trigger signal by measuring an antenna port.

3. When all ports are measured, the PNA increments to the next frequency

4. Again the PNA measures all ports, and so forth until all ports are measured at all frequencies in the forward direction.

5. As the antenna begins moving in the opposite direction, the same sequence occurs, except the PNA decrements in frequency until all ports are measured at all frequencies and the PNA is set back to the original start frequency.

Once setup, only external trigger signals are sent to the PNA. After each trigger, measurement data is stored in internal PNA memory.

How to set up the PNA

See the Antenna Macro to learn how to do this automatically.

1. On the **System** menu click **Preset**

2. On the **Sweep** menu point to **Trigger** then click **Trigger**

3. In Trigger Source click **External**

4. In Trigger Scope click **Channel**

5. Click **OK**

Forward Sweep

1. On the **Trace** menu click **New Trace**

2. Click **S21** then Channel Number **1**

3. On the **Sweep** menu point to **Trigger** then click **Trigger**

4. In Channel Trigger State check **Point Sweep**

5. Click **OK**

6. On the Sweep menu click **Sweep Type**:then **Segment Sweep**

7. Click **OK**

8. On the **View** menu point to **Tables** then click **Segment Table**

9. Do this 15 times - Sweep menu point to **Segment Table** then **Insert Segment**

10. For each Segment in the Segment table:

    1. Click **State**:and select **ON**

    2. Double click both **START** and **STOP** Frequency: (each new segment ascends in frequency)

    3. Double click **Points**: type Number of Ports (elements)

Reverse sweep

Repeat the following steps for each frequency: (up to 15)

- Increment the channel number (**X**) Starting with Channel 2

- Decrement the frequency (**F**)

1. On the **Trace** menu click **New Trace...**

2. Click **S21** then Channel Number **X**

3. When a window contains four traces, check **Create in New Window**.

4. Click **OK**

5. On the **Sweep** menu point to **Trigger** then click **Trigger**

6. In Channel Trigger State check **Point Sweep**

7. Click **OK**

8. On the Sweep menu click **Sweep Type**:then **Segment Sweep**

9. Click **OK**

10. On the **View** menu point to **Tables** then click **Segment Table**

11. In the Segment table

    1. Click **State**:and select **ON**

    2. Double click both **START** and **STOP** Frequency **F**

    3. Double click **Points**: type Number of Ports (elements)

Antenna Test Macro

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This VB Script macro automates the setup of a PNA as documented in Antenna Measurements. This topic will show you how to copy this macro into a PNA and then run the macro.

For more information, see Using Macros.

Note: Print these instructions if viewing in the PNA. This topic will be covered by the Macro Setup dialog box.

1. Copy the following code into a Notepad file.

Notepad is a text editor that is installed on all PCs that use a Microsoft Operating system. To launch Notepad on the analyzer:

1. Click **View**, then click **Title Bars**

2. Click the **Start** button on the windows taskbar

3. Point to **Programs, Accessories**.

4. Click **Notepad**

```
'Start copying here
 Set rfna = CreateObject("AgilentPNA835x.Application")
 Set chans = rfna.Channels
numfreqs = 15
portz = 3
rfna.Preset
rfna.Reset
rfna.TriggerSignal=3 ' Manual trigger
rfna.TriggerType=1    ' ChannelTrigger
'setup forward sweep
win = 1
```

```
trce = 1
rfna.CreateMeasurement 1, "S21", 2, win
Set chan = rfna.ActiveChannel
chan.TriggerMode = 0 'TriggerModePoint
chan.SweepType = 4    'SegmentSweep


For i = 1 To 15
chan.Segments.Add (i)
chan.Segments(i).State = True
chan.Segments(i).NumberOfPoints = portz
Next


chan.Segments(1).StartFrequency = 30000
chan.Segments(1).StopFrequency = 30000
chan.Segments(2).StartFrequency = 1000000
chan.Segments(2).StopFrequency = 1000000
chan.Segments(3).StartFrequency = 500000
chan.Segments(3).StopFrequency = 500000
chan.Segments(4).StartFrequency = 10000000
chan.Segments(4).StopFrequency = 10000000
chan.Segments(5).StartFrequency = 100000000
chan.Segments(5).StopFrequency = 100000000
chan.Segments(6).StartFrequency = 500000000
chan.Segments(6).StopFrequency = 500000000
chan.Segments(7).StartFrequency = 1000000000
chan.Segments(7).StopFrequency = 1000000000
chan.Segments(8).StartFrequency = 2000000000
chan.Segments(8).StopFrequency = 2000000000
chan.Segments(9).StartFrequency = 3000000000
chan.Segments(9).StopFrequency = 3000000000
chan.Segments(10).StartFrequency = 4000000000
chan.Segments(10).StopFrequency = 4000000000
chan.Segments(11).StartFrequency = 5000000000
chan.Segments(11).StopFrequency = 5000000000
chan.Segments(12).StartFrequency = 6000000000
chan.Segments(12).StopFrequency = 6000000000
chan.Segments(13).StartFrequency = 7000000000
chan.Segments(13).StopFrequency = 7000000000
chan.Segments(14).StartFrequency = 8000000000
chan.Segments(14).StopFrequency = 8000000000
chan.Segments(15).StartFrequency = 9000000000
chan.Segments(15).StopFrequency = 9000000000


'setup reverse sweep
'setup the channel
'start with ch 2
For ch = 2 To numfreqs + 1


'put four traces per window
trce = trce + 1
If trce = 5 Then
win = win + 1
trce = 1
End If


rfna.CreateMeasurement ch, "S21", 2, win
```

```
Set chan = rfna.ActiveChannel
chan.TriggerMode = 0 'TriggerModePoint
chan.SweepType = 4    'SegmentSweep
Set segs = chan.Segments

Select Case ch
Case 2
segs(1).StartFrequency = 9000000000
segs(1).StopFrequency = 9000000000
Case 3
segs(1).StartFrequency = 8000000000
segs(1).StopFrequency = 8000000000
Case 4
segs(1).StartFrequency = 7000000000
segs(1).StopFrequency = 7000000000
Case 5
segs(1).StartFrequency = 6000000000
segs(1).StopFrequency = 6000000000
Case 6
segs(1).StartFrequency = 5000000000
segs(1).StopFrequency = 5000000000
Case 7
segs(1).StartFrequency = 4000000000
segs(1).StopFrequency = 4000000000
Case 8
segs(1).StartFrequency = 3000000000
segs(1).StopFrequency = 3000000000
Case 9
segs(1).StartFrequency = 2000000000
segs(1).StopFrequency = 2000000000
Case 10
segs(1).StartFrequency = 1000000000
segs(1).StopFrequency = 1000000000
Case 11
segs(1).StartFrequency = 500000000
segs(1).StopFrequency = 500000000
Case 12
segs(1).StartFrequency = 100000000
segs(1).StopFrequency = 100000000
Case 13
segs(1).StartFrequency = 10000000
segs(1).StopFrequency = 10000000
Case 14
segs(1).StartFrequency = 500000
segs(1).StopFrequency = 500000
Case 15
segs(1).StartFrequency = 100000
segs(1).StopFrequency = 100000
Case 16
segs(1).StartFrequency = 30000
segs(1).StopFrequency = 30000
End Select

segs(1).NumberOfPoints = portz
Next

'End copying here
```

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2. Save the file on the analyzer hard drive in the **C:\Documents** folder. Name the file **AntennaTest.vbs** . If viewing this on an external PC, you can transfer the file to the PNA with a floppy disk or by mapping a drive.

3. Close Notepad

Load the macro into the analyzer

1. In the analyzer application, click **System,** point to **Macro**, then click **Macro Setup**

2. Click on a blank line below the last entry. (There may be NO entry.)

3. Click **Edit**

4. In the **Macro Title** box**,** type **Antenna Test**

5. Click **Browse.**

6. Change **Files of Type** to **VBScript** Go to the **C:\Documents** folder.

7. Click **AntennaTest.vbs**

8. Click **OK**

9. Click **OK** on the Macro Setup dialog box.

To run the macro:

1. Press on the Front Panel **UTILITY** keys.

2. Click the Active Entry key labeled **Antenna Test**

Complex Impedance

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When making an S_{11} or S_{22} measurement of your device under test, you can view complex-impedance data such as series resistance and reactance as well as phase and magnitude information. Complex impedance data can be viewed using either the Smith Chart format or the Polar format.

- What Is Complex Impedance?
- Accuracy Considerations
- How to Measure Complex Impedance

What Is Complex Impedance?

Complex-impedance data is information that can be determined from an S_{11} or S_{22} measurement of your device under test, such as:

- Resistance
- Reactance
- Phase
- Magnitude

The amount of power reflected from a device is directly related to the impedances of both the device and the measuring system. For example, the value of the complex reflection coefficient (Γ) is equal to 0 only when the device impedance and the system impedance are exactly the same (i.e. maximum power is transferred from the source to the load). Every value for Γ corresponds uniquely to a complex device impedance (as a function of frequency), according to the equation:

$Z_L = [(1 + \Gamma) / (1 - \Gamma)] \times Z_0$

where Z_L is your test device impedance and Z_0 is the measuring system's characteristic impedance.

Complex Impedance is best viewed using either Polar or Smith Chart format.

Accuracy Considerations

- The Smith chart is most easily understood when used with a full scale value of 1.0.

- For greater accuracy when using markers in the Smith chart or polar formats, activate the discrete marker mode.

- The uncertainty of reflection measurements is affected by:
  - Directivity
  - Reflection tracking
  - Source match
  - Load match (with 2-port devices)

With a 2-port calibration, the effects of these factors are reduced. A 1-port calibration provides the same accuracy if the output of the device is well terminated. Refer to the graphic below for the following discussion.
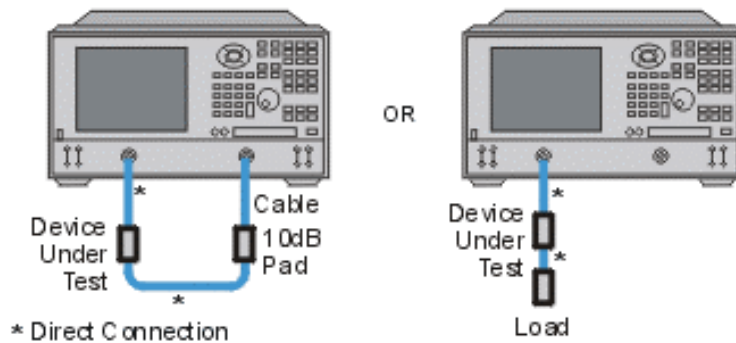
- If you connect the device between both analyzer ports, it is recommended that you use a 10 dB pad on the output of the device to improve measurement accuracy. This is not necessary if you use a 2-port calibration since it corrects for load match.

- If you connect a two-port device to only one analyzer port, it is recommended that you use a high-quality load (such as a calibration standard) on the output of the device.

How to Measure Complex Impedance

1. Connect the device as shown in the previous graphic.
2. Preset the analyzer.
3. Set up, calibrate, and perform an S11 or S22 measurement.
4. View impedance data:
   a. Select the Smith Chart format.
   b. Scale the displayed measurement for optimum viewing.
   c. Position the marker to read the resistive and reactive components of the complex impedance at any point along the trace.
   d. Print the data or save it to a disk.
5. View the magnitude and phase of the reflection coefficient:

a. Select the Smith chart format or the Polar format.

b. Select either Lin Marker or Log Marker formats.

c. Scale the displayed measurement for optimum viewing.

d. Position the marker to read the frequency, magnitude, and phase of the reflection coefficient (Γ) at any point along the trace.

e. Print the data or save it to a disk.

Deviation from Linear Phase

_____

Deviation from linear phase is a measure of phase distortion. The electrical delay feature of the analyzer is used to remove the linear portion of the phase shift from the measurement. This results in a high-resolution display of the non-linear portion of the phase shift (deviation from linear phase).

- What Is Linear Phase Shift?
- What Is Deviation from Linear Phase?
- Why Measure Deviation from Linear Phase?
- Using Electrical Delay
- Accuracy Considerations

See other Tutorials

What Is Linear Phase Shift?

Phase shift occurs because the wavelengths that occupy the electrical length of the device get shorter as the frequency of the incident signal increases. _Linear_ phase-shift occurs when the phase response of a device is linearly proportional to frequency. Displayed on the analyzer, the phase-versus-frequency measurement trace of this ideal linear phase shift is a straight line. The slope is proportional to the electrical length of the device. Linear phase shift is necessary (along with a flat magnitude response) for distortionless transmission of signals.

What Is Deviation from Linear Phase?

In actual practice, many electrical or electronic devices will delay some frequencies more than others, creating non-linear phase-shift (distortion in signals consisting of multiple-frequency components). Measuring deviation from linear phase is a way to quantify this non-linear phase shift.

Since it is only the deviation from linear phase which causes phase distortion, it is desirable to remove the linear portion of the phase response from the measurement. This can be accomplished by using the electrical delay feature of the analyzer to mathematically cancel the electrical length of the device under test. What remains is the deviation from linear phase, or phase distortion.

Why Measure Deviation from Linear Phase?

The deviation from linear phase measurement accomplishes the following:

- Presents data in units of phase rather than units of seconds (group delay). For devices that pass modulated signals, units of phase may be most practical.

- Provides a less noisy measurement than a group delay measurement.

Using Electrical Delay

The electrical delay feature is the electronic version of the mechanical "line stretcher" of earlier analyzers. This feature does the following:

- Simulates a variable-length lossless transmission line, which is effectively added to or removed from the reference signal path.

- Compensates for the electrical length of the device under test.

- Flattens the measurement trace on the analyzer's display. This allows the trace to be viewed at high resolution in order to see the details of the phase nonlinearity.

- Provides a convenient method to view the deviation from linear phase of the device under test. See the following graphic.
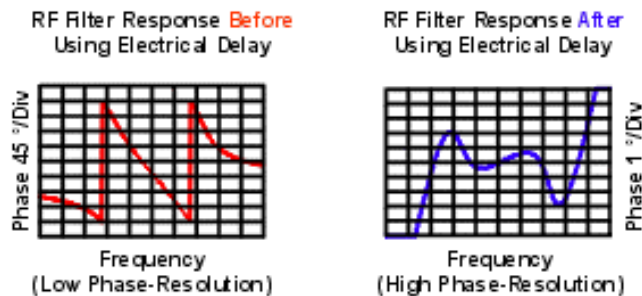
Accuracy Considerations

The frequency response of the test setup is the dominant error in a deviation from linear phase measurement. Performing a thru-response measurement calibration significantly reduces this error. For greater accuracy, perform a 2-port measurement calibration.

How to Measure Deviation from Linear Phase:

1. Preset the analyzer.

2. If your device under test is an amplifier, it may be necessary to adjust the analyzer's source power:

   - Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 10-dB below the 1-dB compression point).

   - Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port 2.

3. Connect the device under test as shown in the following graphic.

* Direct Connection
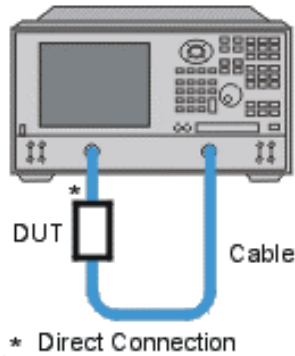
3. Select an S21 measurement.

4. Select the settings for your device under test, including the following:

   - Format: phase

   - Scale: autoscale

5. Remove the device and perform a calibration.

6. Reconnect the device.

7. Scale the displayed measurement for optimum viewing.

8. Activate the electrical delay function to automatically flatten the phase trace. If desired, manually fine-tune electrical delay to adjust the flatness of the phase trace.

9. Use the markers to measure the maximum peak-to-peak deviation from linear phase.

10. Print the data or save it to a disk.

Group Delay

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Group delay is a measure of phase distortion. Group delay is the actual transit time of a signal through a device under test as a function of frequency. When specifying group delay, it is important to specify the aperture used for the measurement.

- What is Group Delay?
- Group Delay versus Deviation from Linear Phase
- What Is Aperture?
- Accuracy Considerations
- How to Measure Group Delay

See other Amplifier Parameter topics

What Is Group Delay?

Group delay is:

- A measure of device phase distortion.

- The transit time of a signal through a device, versus frequency.
- The derivative of the device's phase characteristic with respect to frequency.

Refer to the graphic below for the following discussion:
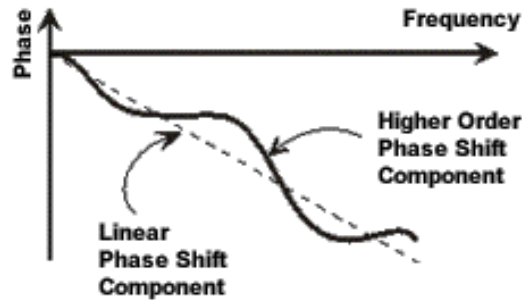
$$\text{Group Delay} = t_g = \frac{-d\,\varphi}{d\omega} \qquad \begin{array}{l}\varphi \text{ in Radians}\\ \omega \text{ in Radians/Sec}\end{array}$$

$$= \frac{-1}{360°} \cdot \frac{d\Theta}{df} \qquad \begin{array}{l}\Theta \text{ in Degrees}\\ f \text{ in Hz } (\omega = 2\,\pi\,f)\end{array}$$

The phase characteristic of a device typically consists of both linear and higher order (deviations from linear) phase-shift components.

Linear phase-shift component:	**Higher-order phase-shift component:**
Represents average signal transit time.	Represents variations in transit time for different frequencies.
Attributed to electrical length of test device.	Source of signal distortion.

Refer to the graphic below for the following discussion:
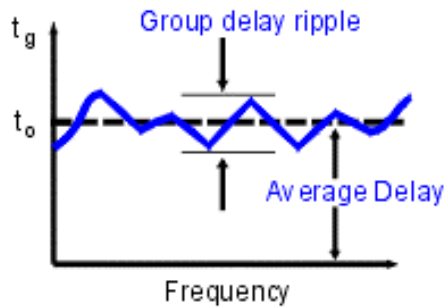
In a group delay measurement:

- The linear phase shift component is converted to a constant value (representing the average delay).

- The higher order phase shift component is transformed into deviations from constant group delay (or group delay ripple).

- The deviations in group delay cause signal distortion, just as deviations from linear phase cause distortion.

- The measurement trace depicts the amount of time it takes for each frequency to travel through the device under test.

Refer to the following equation for this discussion on how the analyzer computes group delay:

$$\text{Group Delay} = tg = \frac{-d\varphi}{d\omega}$$

$$= \frac{-1}{360°} \cdot \frac{d\Theta}{df}$$

φ in Radians
ω In Radians/Sec
Θ in Degrees
f in Hz (ω = 2 π f)

- Phase data is used to find the phase change (-dφ).

- A specified frequency aperture is used to find the frequency change (dω).

- Using the two values above, an approximation is calculated for the rate of change of phase with frequency.

- This approximation represents group delay in seconds (assuming linear phase change over the specified frequency aperture).

Group Delay versus Deviation from Linear Phase

Group delay is often a more accurate indication of phase distortion than Deviation from Linear Phase.

Deviation from linear phase results are shown in the upper region of the following graphic: Device 1 and device 2 have same value, despite different appearances.
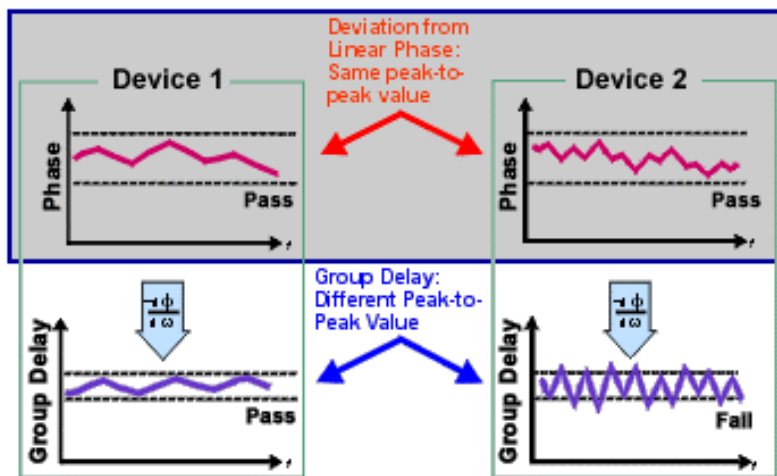
Group Delay results are shown in the lower region:
 Device 1 and device 2 have different values of group delay. This is because in determining group delay, the analyzer calculates slope of phase ripple, which is dependent on number of ripples which occur per unit of frequency.

What Is Aperture?

During a group delay measurement, the analyzer measures the phase at two closely spaced frequencies and then computes the phase slope. The frequency interval (frequency delta) between the two phase measurement points is called the aperture. Changing the aperture can result in different values of group delay. The computed slope (delta phase) varies as the aperture is increased. This is why when you are comparing group delay data, you must know the aperture that was used to make the measurements.

 Refer to the graphic below for the following discussion:

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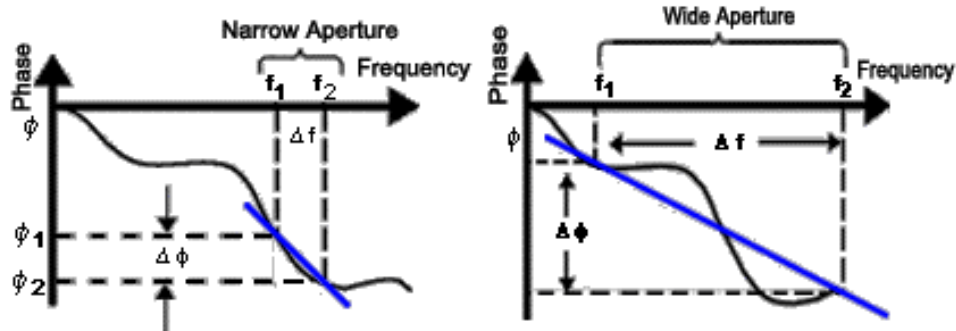
Narrow aperture:
Provides more fine detail in phase linearity.

Makes measurement susceptible to noise (smaller signal-to-noise ratio) and analyzer phase detector resolution.

Wide aperture:
Provides less fine detail in phase linearity because some phase response averaged-out or not measured.

Makes measurement less susceptible to noise (larger signal-to-noise ratio).

The analyzer's default setting for group delay aperture is the frequency span divided by the number of points across the display. There are two ways to set the aperture to a different value.

1. Adjust the number of measurement points or the frequency span.

- Increasing the number of points or reducing the frequency span narrows the aperture.

- Decreasing the number of points and/or increasing the frequency span widens the aperture.

Note: if the aperture is too wide (more than 180° of phase shift between adjacent frequency points), errors in group delay data will occur.

2. Use the analyzer's smoothing function.

- Performs a single-sweep, moving average of adjacent data-points over a specified percentage of the frequency span.

- Results in an action similar to changing the frequency interval between points.

- Allows a wider aperture because greater than 180º of phase shift can occur over the smoothing aperture.

Group delay measurements can be made on the following sweep types:

- Linear frequency
- List frequency sweep segment

The group delay aperture varies depending on the frequency spacing and point density, therefore the aperture is not constant in segment sweep. In segment sweep, extra frequency points can be defined to ensure the desired aperture.

Accuracy Considerations

It is important to keep the phase difference between two adjacent measurement points less than 180° (see the following graphic). Otherwise, incorrect phase and delay information may result. Undersampling may occur when measuring devices with long electrical length. You can verify that the phase difference measured between two adjacent points is less than 180° by adjusting the following settings until the measurement trace no longer changes:

- Increase the number of points
- Narrow the frequency span

Electrical delay may also be used to compensate for this effect.

Δφ = -90°   Δφ = -200°   Δφ = -170°

Actual Phase Response

Undersampled Region
(Incorrect Phase and Delay)
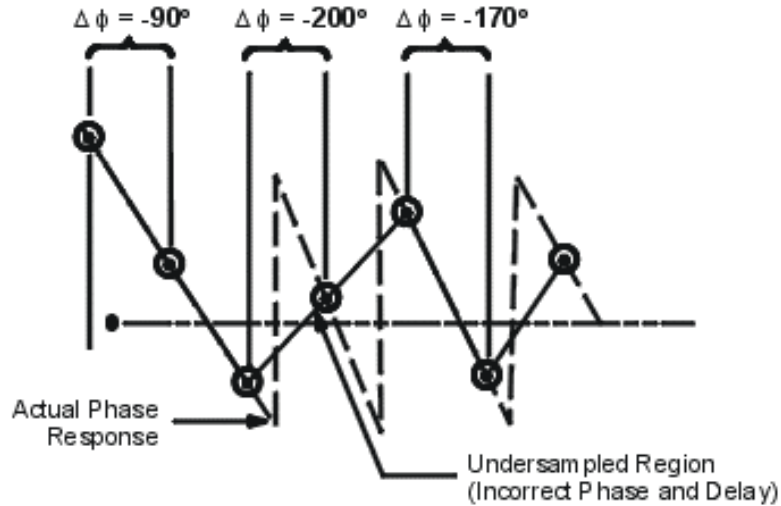
The frequency response is the dominant error in a group delay test setup. Performing a thru-response measurement calibration significantly reduces this error. For greater accuracy, perform a 2-port measurement calibration.

Particularly for an amplifier, the response may vary differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

How to Measure Group Delay

1. Preset the analyzer.

2. If your device under test is an amplifier, it may be necessary to adjust the analyzer's source power:

   - Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 10-dB below the 1-dB compression point).

   - Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port 2.

3. Connect the device under test as shown in the following graphic.

Amplifier   Cable

Attenuator
(If needed)
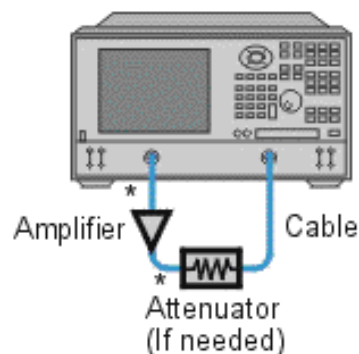
* Direct Connection

4. Select an S_{21} measurement.

5. Select the settings for your device under test, including the following:

   - number of measurement points: maximum

- format: delay
- scale: autoscale

6. Remove the device under test and perform a measurement calibration.

7. Reconnect the device under test.

8. Scale the displayed measurement for optimum viewing.

9. Use the analyzer's smoothing feature to increase the aperture, reducing noise on the trace while maintaining meaningful detail. To increase the aperture:

   - Switch on the analyzer's smoothing feature.
   - Vary the smoothing aperture (up to 25% of the span swept).

10. Use the markers to measure group delay (expressed in seconds) at a particular frequency of interest.

11. Print the data or save it to a disk.

Small Signal Gain and Flatness

_____

Small signal gain is the gain in the amplifier's linear region of operation. This is typically measured at a constant input power over a swept frequency. Gain flatness is the measure of the variation of gain over a specified frequency range.

- What Is Gain?
- What Is Flatness?
- Why Measure Gain and Flatness?
- Accuracy Considerations
- How to Measure Gain and Flatness

See other Amplifier Parameter topics

What Is Gain?

RF amplifier gain is defined as the difference in power between the amplifier output signal and the input signal. It is assumed that both input and output impedances of the amplifier are the same as the characteristic impedance of the system.

- Gain is called S_{21} using S-parameter terminology

- Gain is expressed in dB-a logarithmic ratio of the output power relative to the input power.

- Gain can be calculated by subtracting the input from the output levels when both are expressed in dBm, which is power relative to 1 milliwatt.

- Amplifier gain is most commonly specified as a minimum value over a specified frequency range. Some amplifiers specify both minimum and maximum gain, to ensure that subsequent stages in a system are not under or over driven.

What Is Flatness?

Flatness specifies how much the amplifier's gain can vary over the specified frequency range. Variations in the flatness of the amplifier's gain can cause distortion of signals passing through the amplifier.

Why Measure Small-Signal Gain and Flatness?

Deviations in gain over the bandwidth of interest will induce distortion in the transmitted signal because frequency components are not amplified equally. Small-signal gain allows you to quantify the amplifier's gain at a particular frequency in a 50-ohm system. Flatness allows you to view the deviations in the amplifier's gain over a specified frequency range in a 50-ohm system.

Accuracy Considerations

- The amplifier may respond very differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

- The output power of the amplifier should be sufficiently attenuated if necessary. Too much output power could:

  - damage the analyzer receiver

 - exceed the input compression level of the analyzer receiver, resulting in inaccurate measurements.

Attenuation of the amplifier's output power can be accomplished using:

  - attenuators

  - couplers

The frequency-response effects and mismatches of the attenuators and couplers must be accounted for during calibration since they are part of the test system. Proper error-correction techniques can reduce these effects.

- The frequency response is the dominant error in a small-signal gain and flatness measurement setup. Performing a thru-response measurement calibration significantly reduces this error. For greater accuracy, perform a 2-port measurement calibration.

- Reducing IF bandwidth or using averaging improves measurement dynamic range and accuracy, at the expense of measurement speed.

How to Measure Gain and Flatness

1. Preset the analyzer.

2. Select an S21 measurement parameter.

3. Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 10-dB below the 1-dB compression point).

4. Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port-2.
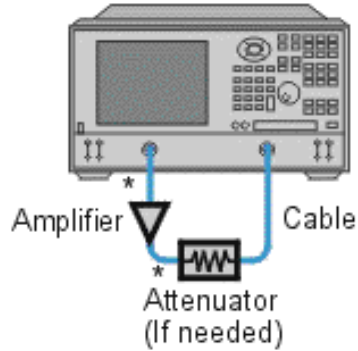
* Direct Connection

5. Connect the amplifier as shown in the following graphic, and provide the dc bias.

6. Select the analyzer settings for your amplifier under test.

7. Remove the amplifier and perform a measurement calibration. Be sure to include the attenuator and cables in the calibration setup if they will be used when measuring the amplifier.

8. Save the instrument-state to memory.

9. Reconnect the amplifier.

10. Scale the displayed measurement for optimum viewing and use a marker to measure the small signal gain at a desired frequency.

11. Measure the gain flatness over a frequency range by using markers to view the peak-to-peak ripple.

12. Print or save the data to a disk.

13. This type of measurement can be automated.

Gain Compression

_____

Gain compression measures the level of input power applied to an amplifier that will cause a distorted output.

- What Is Gain Compression?
- Why Measure Gain Compression?
- Accuracy Considerations
- How to Measure Gain Compression

See other Amplifier Parameter topics

What Is Gain Compression?

Gain compression occurs when the input power of an amplifier is increased to a level that reduces the gain of the amplifier and causes a nonlinear increase in output power.

The analyzer has the ability to do power sweeps as well as frequency sweeps. Power sweeps help characterize the nonlinear performance of an amplifier. Refer to the graphic below (a plot of an amplifier's output power versus input power at a single frequency) for the following discussion.
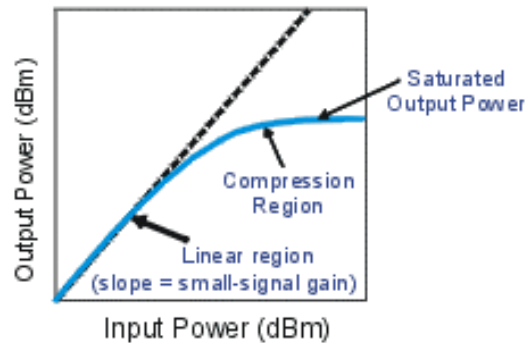
- The amplifier has a linear region of operation where gain is constant and independent of power level. The gain in this region is commonly referred to as "small-signal gain."

- As the input power increases, the amplifier gain appears to decrease, and the amplifier goes into compression.

- The most common measurement of amplifier compression is the 1-dB compression point. This is defined as the input power (or sometimes the output power) which results in a 1-dB decrease in amplifier gain (relative to the amplifier's small-signal gain).

Why Measure Gain Compression?

When driven with a sinusoid, the output of an amplifier is no longer sinusoidal in the compression region. Some of the amplifier output appears in harmonics, rather than occurring only at the fundamental frequency of the input signal.

As input power is increased even more, the amplifier becomes saturated, and output power remains constant. At this point, further increases in amplifier input power result in no change in output power.

In some cases (such as with TWT amplifiers), output power actually decreases with further increases in input power after saturation, which means the amplifier has negative gain.

Since gain is desired in amplifier operation, it is important to know the limit of input signal that will result in gain compression.

Accuracy Considerations

The network analyzer must provide sufficient power to drive the amplifier into saturation. If you need a higher input-power level than the source of the analyzer can provide, use a preamplifier to boost the power level prior to the amplifier under test. (See High-Power Component Measurements.) If using a preamplifier, you can increase measurement accuracy in the following ways:

- Use a coupler on the output of the preamplifier so that a portion of the boosted input signal can be used for the analyzer's reference channel. This configuration removes the preamplifier's frequency response and drift errors from the measurement (by ratioing).

- Perform a thru-response calibration including the preamplifier, couplers, and attenuators in the test setup.

The output power of the amplifier should be sufficiently attenuated if necessary. Too much output power could:

- Damage the analyzer receiver
- Exceed the input compression level of the analyzer receiver

Attenuation of the amplifier's output power can be accomplished using:

- Attenuators
- Couplers

The frequency-response effects of the attenuators and couplers must be considered during calibration since they are part of the test system. Proper error-correction techniques can reduce these effects.

- The frequency response is the dominant error in a gain compression measurement setup. Performing a thru-response measurement calibration significantly reduces this error.

- The amplifier may respond very differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

- Reducing IF bandwidth or using measurement averages improves accuracy, at the expense of measurement speed.

How to Measure Gain Compression

This procedure shows you how to make the following three measurements used to determine amplifier gain compression:

1. A Swept-Frequency Gain Compression measurement locates the lowest frequency at which the 1-dB gain compression first occurs.

2. A Swept-Power Gain Compression measurement shows the input power at which a in a 1-dB drop in gain occurs as a power ramp is applied to the amplifier at a particular frequency point (found in measurement 1).

3. An Absolute Power measurement shows the absolute power out (in dBm) at compression.

Swept-Frequency Gain Compression Measurement

A measurement of swept frequency gain compression locates the frequency point where 1-dB compression first occurs.

1. Preset the analyzer.

2. Select an S_{21} measurement parameter.

3. Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 10-dB below the 1-dB compression point).

4. Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port-2.

5. Connect the amplifier as shown in the following graphic, and provide the dc bias.

6. Select the analyzer settings for your amplifier under test. To reduce the effects of noise, you may want to specify a narrower IF bandwidth.

Amplifier ▽   Cable

Attenuator
(If needed)
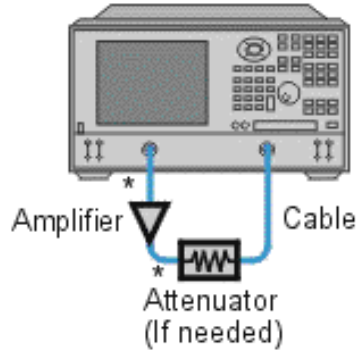
* Direct Connection

7. Remove the amplifier and perform a thru-response calibration. Be sure to include the attenuator and cables in the calibration setup if they will be used when measuring the amplifier.

8. Save the instrument-state to memory.

9. Reconnect the amplifier.

10. Position a marker at approximately mid-span.

11. Adjust the analyzer's scale to 1 dB per division.

12. Store the trace in memory and display Data/Mem.

13. Gradually increase the source power until a 1-dB decrease in gain is observed at the first frequency over some portion of the trace.

14. Use markers to locate the frequency where the 1-dB decrease in gain first occurs. Note this frequency for use in the following measurement.

15. Print the data or save it to a disk.

Swept-Power Gain Compression Measurement

A swept-power gain compression measurement shows the input power resulting in a 1-dB drop in gain as a power ramp at a particular frequency (found in step 13 of the previous measurement) is applied to the amplifier.

1. If not already done, perform the previous measurement of swept-frequency gain compression.

2. Setup an S_{21} measurement in the power-sweep mode. Include the following settings:

   - Set the CW frequency to the frequency noted in step 14 of the previous measurement of swept-frequency gain compression.

   - Enter the start and stop power levels for the sweep. The start power should be in the linear region of the amplifier's response (typically 10 dB below the 1-dB compression point). The stop power should be in the compression region of the amplifier's response.

3. Adjust the scale to 1-dB per division.

4. Use markers (including reference marker) to find the input power where the 1-dB decrease in gain occurs.

5. Print the data or save it to a disk.

Absolute Output Power Measurement

An absolute-power measurement shows the absolute power-out (in dBm) of the amplifier at

compression.

1. Select an unratioed (absolute) power measurement. Choose the B input if using the test setup in the previous graphic.

2. Retain the CW frequency used in the previous measurement of swept-power gain compression.

3. Set a marker to the input power level where the 1-dB decrease in gain occurs (found in step 4 of the previous measurement).

4. Scale the displayed measurement for optimum viewing.

5. Read the marker value to find the absolute output power of the amplifier (in dBm) where the 1-dB decrease in gain occurs.

6. Print the data or save it to a disk.

Note: The measurement calibration does not apply to absolute power. Therefore, if there is any attenuation external to the analyzer, you will have to correct for it manually.

Reverse Isolation
_____

Reverse isolation is a measure of amplifier reverse transmission response- from output to input.

▪ What is Reverse Isolation

▪ Why Measure Reverse Isolation?

▪ Accuracy Considerations

▪ How to Measure Reverse Isolation

See other Tutorials

What is Reverse Isolation?

Reverse isolation is a measure of how well a signal applied to the device output is "isolated" from its input.

The measurement of reverse isolation is similar to that of forward gain, except:

• The stimulus signal is applied to the amplifier's output port.

• The response is measured at the amplifier's input port.

The equivalent S-parameter is S12.

Why Measure Reverse Isolation?

An ideal amplifier would have infinite reverse isolation-no signal would be transmitted from the output back to the input. However, reflected signals can pass through the amplifier in the reverse direction. This unwanted reverse transmission can cause the reflected signals to interfere with the desired fundamental signal flowing in the forward direction. Therefore, reverse isolation is important to quantify.

Accuracy Considerations

Since amplifiers often exhibit high loss in the reverse direction, generally there is no need for any attenuation that may have been used to protect the port 2 receiver during forward transmission measurements. Removing the attenuation will:

- Increase the dynamic range, resulting in improved measurement accuracy.

- Require a new calibration for maximum accuracy.

The RF source power can be increased to provide more dynamic range and accuracy.

Note: With the attenuation removed and the RF source power increased, a forward sweep could damage the analyzer's port 2 receiver. Do not perform a forward sweep or use 2-port calibration unless the forward power is set low enough to avoid causing port 2 receiver compression or damage.

If the isolation of the amplifier under test is very large, the transmitted signal level may be near the noise floor or crosstalk level of the receiver. To lower the noise floor:

- Use or increase measurement averages.

- Reduce the IF bandwidth of the analyzer.

Note: Reducing IF bandwidth or using averaging improves measurement dynamic range and accuracy, at the expense of reduced measurement speed.

- When crosstalk levels affect the measurement accuracy, reduce the crosstalk error term by performing a response and isolation calibration. When performing the isolation part of the calibration it is important to use the same average factor and IF bandwidth during the calibration and measurement.

- The frequency response of the test setup is the dominant error in a reverse isolation measurement. Performing a thru-response measurement calibration significantly reduces this error. This calibration can be done as part of the response and isolation calibration.

- The amplifier may respond very differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

How to Measure Reverse Isolation

1. Connect the amplifier as shown in the following graphic.
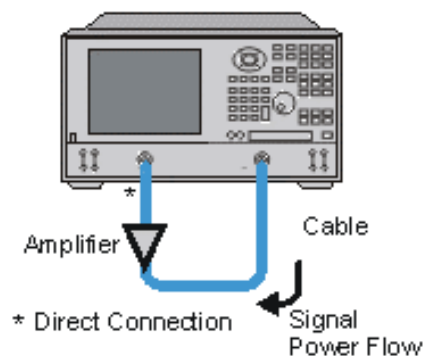
2. Preset the analyzer.

3. Select an S12 measurement.

4. Select the settings for your amplifier under test.

5. Remove the amplifier and perform a thru-response calibration or a response and isolation calibration.

6. Scale the displayed measurement for optimum viewing and use a marker to measure the

reverse isolation at a desired frequency.

7. Print or save the data to a disk.

Absolute Output Power

_____

An absolute output-power measurement displays absolute power versus frequency.

- What is Absolute Output Power?

- Why Measure Absolute Output Power?

- Accuracy Considerations

- How to Measure Absolute Output Power

See other Amplifier Parameters topics

What is Absolute Output Power?

An absolute-output power measurement displays the power present at the analyzer's input port. This power is absolute-it is not referenced (ratioed) to the incident or source power. In the log mag format, values associated with the grid's vertical axis are in units of dBm, which is the power measured in reference to 1 mW.

- 0 dBm = 1 mW

- -10 dBm = 100 μW

- +10 dBm = 10 mW

In the linear mag format, values associated with the grid's vertical axis are in units of watts (W).

Why Measure Absolute Output Power?

Absolute output power is measured when the amplifier's output must be quantified as absolute power rather than a ratioed relative power measurement. For example, during a gain compression measurement, it is typical to also measure absolute output power. This shows the absolute power out of the amplifier where 1-dB compression occurs.

Accuracy Considerations

The output power of the amplifier should be sufficiently attenuated if necessary. Too much output power could:

- Damage the analyzer receiver

- Exceed the input compression level of the analyzer receiver, resulting in inaccurate measurements.

Attenuation of the amplifier's output power can be accomplished using either attenuators or couplers

The amplifier may respond very differently at various temperatures. The tests should be done when the amplifier is at the desired operating temperature.

How to Measure Absolute Power

Do the following to measure absolute output power:

1. Preset the analyzer.

2. Select an unratioed power measurement (receiver B).

3. Set the analyzer's source power to 0 dBm.

4. Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer's port-2.

5. Connect the amplifier as shown in the following graphic, and provide the dc bias.
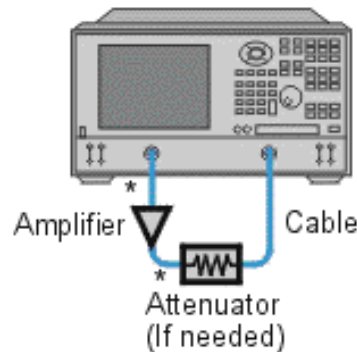
6. Select the analyzer settings for your amplifier under test.

7. Remove the amplifier and connect the measurement ports together. Store the data to memory. Be sure to include the attenuator and cables in the test setup if they will be used when measuring the amplifier.

8. Save the instrument state to memory.

9. Reconnect the amplifier.

10. Select the data math function Data/Memory.

11. Scale the displayed measurement for optimum viewing and use a marker to measure the absolute output-power at a desired frequency.

12. Print or save the data to a disk.

Time Domain

Time Domain Overview

_____

With the Time Domain Option 010 installed, you can view a device response as a function of time. Click on the following buttons to learn more.

- What Is a Time Domain Measurement?
- Similarity to Time Domain Reflectometry
- Sequence for Time Domain Measurements
- How to Make a Time Domain Measurement

What Is a Time Domain Measurement?

- In normal operation, the analyzer measures the RF performance characteristics of a test device as a function of frequency.

- When the analyzer has Time Domain Option 010, it can use a mathematical technique (the inverse Fourier transform) to transform frequency domain data into the time domain.

- The measurement is shown with time as the horizontal display axis.

- The response values appear separated in time, permitting a different analysis of the network performance and limitations.

The graphic below compares the same cable reflection measurement data in the frequency and time domains. The cable has two bends, where each bend creates a mismatch or change in the line impedance.
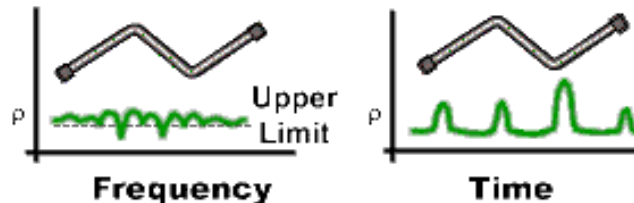
- **The frequency domain response** measured at the input port shows composite reflection response (ripple) caused by interactions between mismatches in the cable, but it is difficult to determine where in the cable the mismatches occur.

- **The time domain response** provides a way to look inside the cable and determine both the location and the magnitude of each mismatch. In the example above, the response indicates that the second cable bend is the location of a significant mismatch.

Fourier Transform

When the responses are in the time domain, the analyzer can also filter out undesired responses, using the gating function. The analyzer can then transform the desired response back to the frequency domain. This allows you to characterize the network response to a particular signal or modulated waveform without including the effects of external devices such as connectors or adapters. The analyzer uses the following transforms for this process.

- **Inverse Fourier transform --** changes the frequency measurement data into time domain data.

- **Fourier transform --** returns the time domain data back to the frequency domain.

Inverse Fourier Transform

F^{-1}

Frequency Domain Response

Time Domain Response

F

Fourier Transform
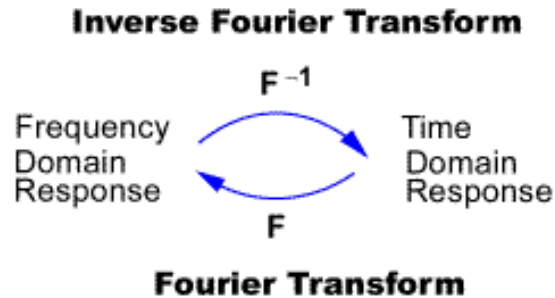
Similarity to Time Domain Reflectometry

- The time domain mode simulates a traditional Time-Domain Reflectometry (TDR) where you can determine the characteristics of electrical lines by observing reflected waveforms.

- By the shape and location of responses, you can determine the impedance and distance to the discontinuity.

Time Domain Reflectometry Analysis

- Traditional TDR analysis launches an actual impulse or step signal into the test device and observes the energy reflected.

- The incident step, along with the reflected waveform, is displayed on the TDR screen.

- By analyzing the magnitude, duration, and shape of the reflected waveform, you can determine the nature of the impedance variation in the transmission system.

Analyzer Time Domain Analysis

- The analyzer does not launch an actual incident impulse or step, but instead makes swept frequency response measurements.

- With the frequency response data, the analyzer calculates the step, impulse, or band pass response of the device, depending on the transform that you selected.

- The analyzer displays the data in a time domain response (TDR-like display).

Sequence for Time Domain Measurements
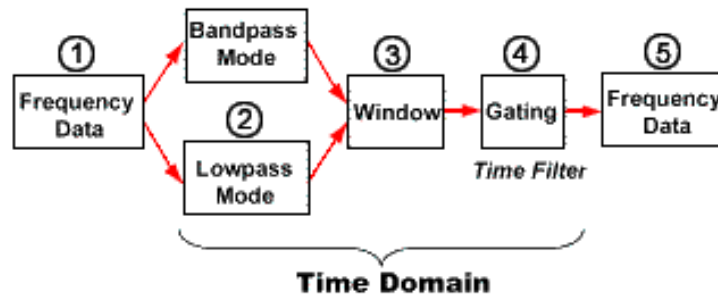
1. **Frequency Data --** is collected when the analyzer measures a device response in the frequency domain.

2. **Band Pass Mode and Low Pass Modes --** selection depends on the frequency characteristics of the device under test and the desired display response.

   - **The Band Pass** mode is the most flexible of the modes. Best suited for devices which will not pass all frequencies, such as filters. Only the impulse response is available.

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- **The Low Pass** mode simulates the traditional TDR. Best suited for devices which pass all frequencies down to DC, such as cables. The frequencies in the sweep are harmonically related. Both impulse and step responses are available.

3. **Window --** selection optimizes the time domain response by providing smooth transitions to zero at the ends of the sample period. This supresses unwanted sidelobes in the response, making lower level responses visible. Minimum windows provide the best resolution and highest sidelobes.

4. **Gating --** is a time filter that removes the effects of unwanted responses.

5. **Frequency Data --** can be viewed after the analyzer transforms the responses back to the frequency domain. The measurement shows the effects of only the particular responses that remain after gating.

How to Make a Time Domain Measurement

Click on the buttons to see the general steps to make a time domain measurement.

- Measurement Setup
- Optimize the Results
- Interpret the Displayed Data

Measurement Setup

1. Select the setting for a measurement in the frequency domain. See Set Up Measurements.

2. Decide which transform mode to use.

   - If the device under test has a measurement response down to DC, you should use the low pass mode with step response.

   - If the device under test does not have a measurement response at DC, you should use the band pass mode.

   See Band Pass and Low Pass Modes.

3. To obtain the necessary response resolution and measurement range for the device under test, calculate the values of the measurement settings:

   - Frequency range
   - Number of points
   - Window width

      See Resolution and Range.

4. Set the values for frequency span, and number of points that you calculated in the previous step. See Set Up a Measurement.

5. If you selected low pass mode, do these steps:

   a. Leave the start frequency at 300 kHz and enter the stop frequency and number of points.

   b. In the **Trace** menu, click **Transform, Set Freq. Low Pass**. This automatically sets all frequencies.

6. Transform the data to the time domain and apply the window value that you calculated in the earlier step. Determine if the response resolution and the measurement range are sufficient for your measurement application.

   a. If the current settings do not allow you to measure the device response, modify the frequency span, number of points, and the window width. See Time Domain

Resolution and Range.

7. Switch off the transform and perform a measurement calibration that is best for the measurement setup and accuracy needs. See Select and Perform a Measurement Calibration.

8. Transform the data to the time domain.

Optimize the Results

1. Autoscale the measurement response.

2. To get the maximum display resolution, center the response of interest on the display.

3. Set up and switch on gating (time filtering) to remove unwanted responses from the displayed measurement. See Gate Responses.

Interpret the Displayed Data

1. Interpret the type of impedance at the discontinuity. See Fault Location

2. To view the gated data in the frequency domain, switch the gating function on and switch the transform off.

Band Pass and Low Pass Time Domain Modes

You must select the time domain mode before you set up the measurement values. The selection is mostly dependent on the device under test.

▪ Band Pass vs Low Pass Mode

▪ Impulse and Step Responses

▪ Useful Data Formats

▪ How to Set the Time Domain Mode

Note: Time Domain measurements are only available on PNAs with Option 010. See PNA Options

Other Time Domain topics

Band Pass vs Low Pass Mode

Band Pass Mode - Use for Bandpass, band reject or highpass filters.

• Easiest to use

• Useful for measuring band pass devices that do not operate down to DC (0 Hz)

• Allows measured frequencies to be any set of start and stop frequencies

• Allows only impulse response because transformed data does not include a DC term

• Works for both reflection and transmission measurements

• Allows fault location

Low Pass Mode - Use for Lowpass devices that pass all frequencies down to DC, even if the

response rolls off at the low frequencies.

- Simulates traditional Time Domain Reflectometer (TDR)

- Allows both impulse and step responses because transformed data includes a DC term

- Allows fault location and identification of type of impedance (capacitive, inductive) present at the discontinuity

- Works for both reflection and transmission measurements

- Has higher response resolution (x2) than band pass mode for the same frequency span

- Requires equally spaced data points

- The analyzer sets all of the measurement frequencies to harmonics of the Start frequency. (Click **Set Freq. Low Pass)**

Low pass mode requires measured frequencies to be harmonically related with a DC term extrapolated from the first few data points in the frequencies domain. The following formula places a limit on the Stop frequency for the Number of Points setting in the measurement.

FSTOP = N X FSTART (N = number of points)

For example:

FSTOP = 101 * 300kHz

FSTOP = 30.3MHz

Impulse and Step Responses
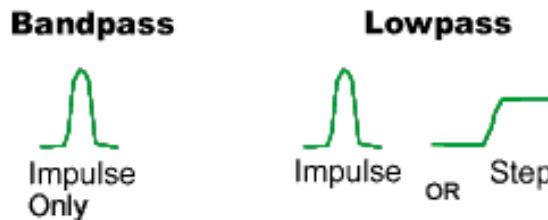
The PNA can present the time domain response as if either an impulse function or a step function stimulated the device under test.

- **Impulse stimulus --** is a voltage waveform that transitions from zero to unity, and back to zero. The impulse width is determined by the frequency span used in the frequency domain measurement.

- **Step stimulus --** is a voltage waveform that transitions from zero to unity. The step rise time is determined by the highest frequency used in the frequency domain measurement.

Note: The step response in the low pass mode is the easiest mode to use for interpreting types of discontinuities. This combination also gives the commonly accepted TDR display of inductive and capacitive discontinuities.

- With the frequency response data, the analyzer calculates the step, impulse, or band pass response of the device, depending on the transform that you selected.

- The analyzer displays the data in a time domain response (TDR) display.

See Resolution and Range for more information on how the frequency span affects the impulse width and rise time.

Useful Data Formats

For Band Pass Mode

Linear Magnitude

- For reflection measurements, this format shows the average linear magnitude of the reflection coefficient (ρ) over the frequency range that has been measured.

- For transmission measurements, this format shows the average transmission coefficient (τ) for the transmission path over the frequency range of the measurement.

- This format is useful for viewing responses that are close in magnitude.

Log Magnitude

- For reflection measurements, this format shows the response in units of return loss (dB). The value displayed represents the average return loss of the discontinuity over the frequency range of the measurement.

- For transmission measurements, this format shows the response in units of transmission loss or gain (dB). This represents the average loss for the transmission path over the frequency range of the measurement.

- This format is useful for viewing a wide dynamic range of transmission responses.

Standing Wave Ratio
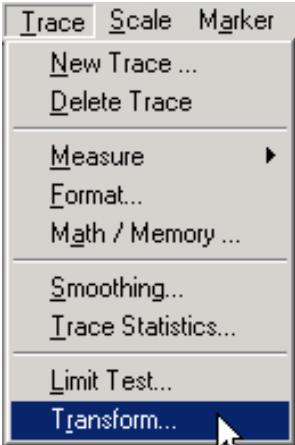
- For reflection measurements, this format shows the average Standing Wave Ratio (SWR) of the discontinuity over the frequency range of the measurement.

Useful Format for Low Pass Mode

Real

- This format shows the device response in real units.

How to set the Time Domain Mode
Trace Scale Marker New Trace ... Delete Trace Measure ▶ Format... Math / Memory ... Smoothing... Trace Statistics... Limit Test... Transform...
Learn more about using the front panel interface

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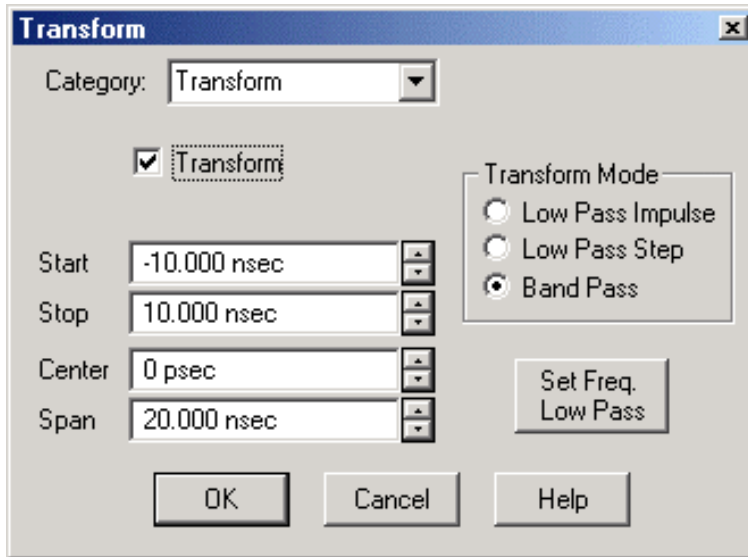
Transform dialog box help
Transform Check to transform frequency data to time domain data.
Start Specifies the beginning of the time frame where the analyzer measures data. A start time of 0 seconds sets the beginning of the measurement range at the measurement reference plane.
Stop Specifies the end of the time frame where the analyzer measures data. That is, the time since a stimulus signal was launched.
Center Specifies the value at the center of the measurement range. This value can be anywhere in the analyzer range.
Span Specifies the range of values measured to either side of the center value.
Transform Mode   **Low Pass Impulse** Specifies the measurement mode for devices that operate down to dc. Displays impulse response measurements.   **Low Pass Step** Specifies the measurement mode for devices that operate down to dc. Displays step response measurements.   **Band Pass** Specifies the measurement mode for devices that are band-limited devices and do not operate down to dc. This mode displays impulse response measurements only.
Set Freq. Low Pass Distributes the measurement points evenly over the range., when using the low pass mode. This allows you to perform a measurement calibration, before the data is transformed to the time domain.   If the stop frequency changes to a value significantly different from what you specified, then the initial value was lower than the minimum frequency range for low pass mode. If this occurs, reduce the number of points, set up the frequency span again, and click Set Frequency Low Pass again.

Time Domain Resolution and Range
_____

To ensure that you can view all of the available time domain data for a device response, consider the following settings that will provide the best resolution and maximum range.

- Response Resolution
- Display Resolution
- Measurement Range
- How to Set the Resolution and Range

Note: Time Domain measurements are only available on PNAs with Option 010. See PNA Options

Other Time Domain topics

Response Resolution

Time domain response resolution is the ability to distinguish between two closely spaced responses. There are several factors that determine the resolution of the measured response in the time domain.

- Frequency Span
- Window Width
- Time Domain Mode

Frequency Span Influence on Response Resolution

The graphic below shows the effect of both a narrow and wide frequency span on the response resolution.

- The response measured with a narrow frequency span is shown overlaid upon the individual responses of the connectors, measured with a relatively wide frequency span.

- The wider frequency span enables the analyzer to resolve the two connectors into separate, distinct responses.
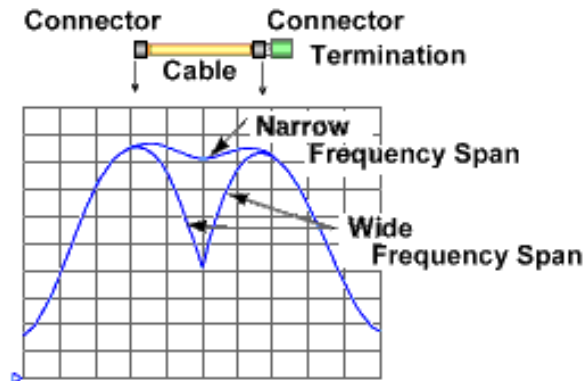
- The relationship between the frequency span and the pulse width in time is inversely proportional.

- The wider the frequency span, the narrower the impulse width, or step rise time.

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Frequency Domain — Time Domain

Narrow Span → Wide Width

Wide Span → Narrow Width
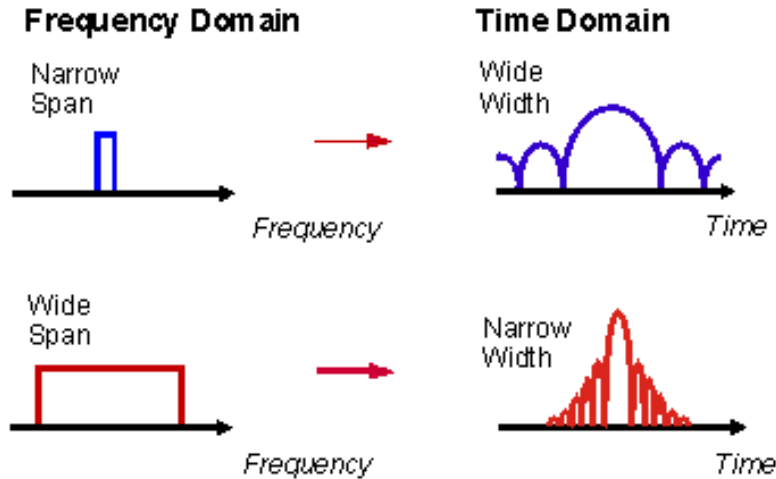
- For responses of equal amplitude, the response resolution is equal to the impulse width which is defined as the 50% (–6 dB) points, or to the step rise time which is defined as the 10% to 90% points.
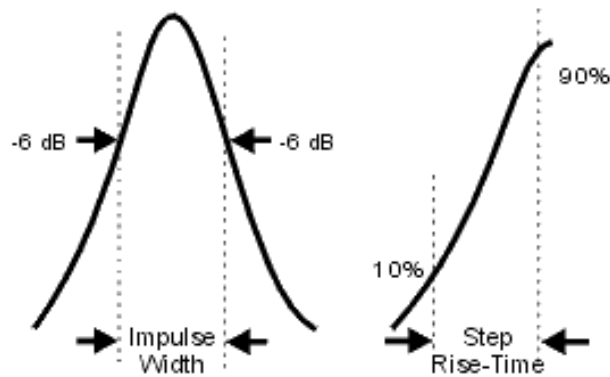
Window Width Influence on Response Resolution

- The response resolution is also a function of the window used in the transform.

- The approximate response resolution can be calculated using the formulas shown below. These formulas apply only for responses of equal amplitude and calculate the 50% impulse width, or 10%-90% step rise time.

Lowpass Step

$$\frac{Response}{Resolution} = \frac{0.45}{Fspan} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 2.2 \text{ Normal Window} \\ 3.3 \text{ Maximum Window} \end{cases}$$

Lowpass Impulse

$$\frac{Response}{Resolution} = \frac{0.6}{Fspan} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

Bandpass Impulse

$$\frac{Response}{Resolution} = \frac{1.2}{Fspan} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

The graphic below shows how the selection of the window width is dependent on the device responses.
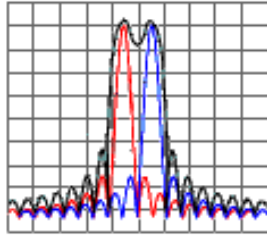
Minimum Window
Higher Resolution
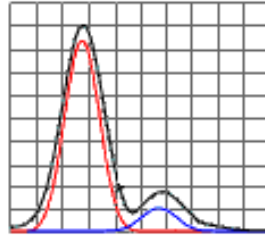
Maximum Window
Larger Dynamic Range

- For equal-level signals, use minimum window to improve resolution.
- For different-level signals, use maximum window to improve dynamic range.

Time Domain Mode Influence on Response Resolution

- There is a difference in response resolution between the band pass and low pass modes of time domain.
- For the same frequency span and number of points, the low pass mode has higher resolution, reducing the impulse width in half when compared to the band pass mode.
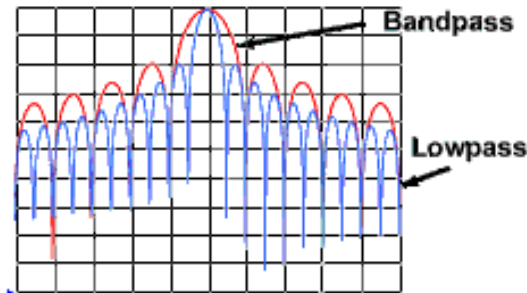
Display Resolution

The time domain display resolution is the ability to accurately locate a single response in time. A finer display resolution allows you to locate the peaks and nulls of a response with improved accuracy. This improvement is directly influenced by the time span and the number of points selected.

Display Resolution = T_{Span} / Points – 1

You can improve the display resolution in two ways:

- Decrease the time span.
- Increase the number of points.

Note: Increasing the number of points may invalidate your measurement calibration.

In the example below, both measurements are made with 201 points.

- The 50 psecond resolution has a time span of 10 nseconds.
- The 12.5 psecond resolution has a time span of 2.5 nseconds.

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Span 10 nsec   Span 2.5nsec
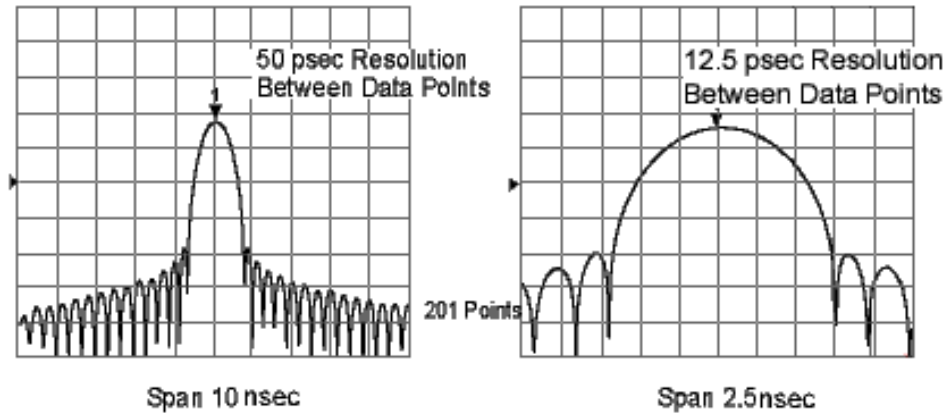
Note: The ability to resolve two closely spaced signals has not been affected. However, if your measurement is in low pass mode, changing of the number of points can affect the frequency span.

Tips for Optimizing Resolution

- In most cases, you should choose the largest valid frequency span to obtain the highest resolution in time. However, the frequency must be kept within the usable frequency range of the device under test.

- The response resolution is dependent on frequency span, window width, and time domain mode.

Measurement Range

In the time domain, the measurement range is defined as the length in time over which a measurement can be made without encountering a repetition of the response.

Note: Range and response resolutions are inversely related. Improving one, degrades the other.

Response repetition (or aliasing) occurs at regular intervals of time. In the example below, the actual response near zero seconds is repeated at about 60 nanoseconds and again at about 120 nanoseconds.

Start -20ns   Stop 201ns
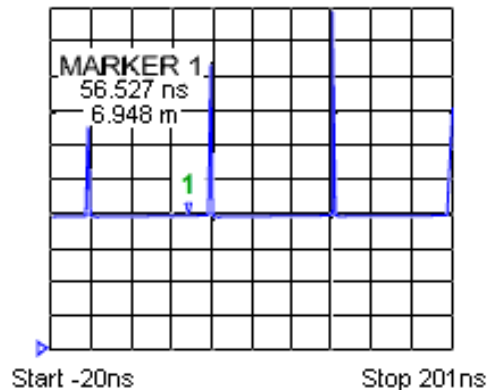
The range is related to the spacing between frequency points in the measured frequency response of the device.
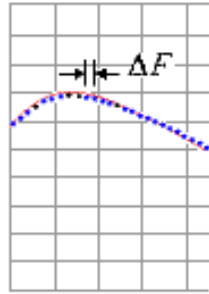
$$\Delta F = \frac{\text{Frequency Span}}{\# \text{ of Points - 1}}$$

For Example:
Span = 1 GHz
# of Points = 201
ΔF = 5 MHz

The measurement range is proportional to the (number of points–1) and inversely proportional to the frequency span. To increase the range, you can modify two settings:

- Increase the number of points.
- Decrease the frequency span.

Note: Either of these modifications should be done before performing a measurement calibration.

To find the measurement range in meters, multiply the time interval by the speed of light in free space (3 x 10^8 meters/second). To calculate the actual physical length of the measurement range, multiply this value by the relative velocity of the transmission medium.

- Vpolyethylene = 0.66
- Vteflon = 0.70

$$\text{Time} = \frac{1}{\Delta F}$$

$$\frac{\text{Time Corrected}}{\text{for Velocity}} = \frac{V}{\Delta F}$$

$$\text{Distance} = \frac{V}{\Delta F} \cdot 3 \times 10^8 \text{ meters/sec}$$

Note: Setting the instrument for the longest range possible reduces the response resolution in the time domain. Maximum range also depends on the cable loss. If the returning signal is too small to measure, the range is limited by this attenuation regardless of the frequency span.

How to Set the Resolution and Range

Response Resolution

1. To achieve the necessary response resolution, calculate the frequency span and window width.

Lowpass Step

$$\frac{\text{Response}}{\text{Resolution}} = \frac{0.45}{\text{Fspan}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 2.2 \text{ Normal Window} \\ 3.3 \text{ Maximum Window} \end{cases}$$

Lowpass Impulse

$$\frac{\text{Response}}{\text{Resolution}} = \frac{0.6}{\text{Fspan}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

Bandpass Impulse

$$\frac{\text{Response}}{\text{Resolution}} = \frac{1.2}{\text{Fspan}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

2. In the **Trace** menu, click **Transform**.

3. In the **Category** box, click the down arrow and select **Window**.

4. Select a window width that helps achieve the resolution that you need for your measurement application.

    - Choose a minimum window if you need to measure signals that are the same magnitude.

    - Choose a maximum window if you need to measure signals that are very different in magnitude.

5. In the **Channel** menu, click **Start/Stop** and enter values to increase the frequency range.

6. If you still need more response resolution, and the device under test operates down to dc, use the low pass transform mode. See Time Domain Modes.

Display Resolution

1. In the **Trace** menu, click **Transform**.

2. In the **Center** box, enter a value that places the responses you are measuring in the center of the screen.

3. In the **Span** box, enter a value that decreases the time span.

4. If you still need more display resolution, increase the number of points. In the **Sweep** menu, click **Number of Points** and select a higher value.

Measurement Range

When response repetition or aliasing occurs, it is generally not possible to visually distinguish a real response from an aliased response without a test.

1. Increase the time span and see if there are obvious repetitions with observable spaces between them.

2. If you are still not sure that the response is real, center the response on the screen and store the trace.

3. Reduce the frequency span by about 5%, and measure the device again.

    - If the time domain response is valid, then it will remain in the center of the display.

    - If the response is an alias, then it will move along the time axis when the frequency range is changed.

4. Calculate the frequency span and the number of points that achieves the necessary measurement range.
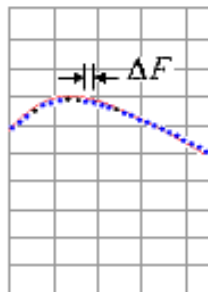
$$\Delta F = \frac{\text{Frequency Span}}{\text{\# of Points} - 1} \qquad \text{Time} = \frac{1}{\Delta F}$$

For Example:
Span = 1 GHz
\# of Points = 201
ΔF = 5 MHz

$$\text{Time Corrected for Velocity} = \frac{V}{\Delta F}$$

$$\text{Distance} = \frac{V}{\Delta F} \cdot 3x10^{8} \text{ meters/sec}$$

5. In the **Sweep** menu, click **Number of Points** and select a higher value.

6. In the **Channel** menu, click **Start/Stop** and enter the values from the calculation to achieve the necessary measurement range.

Note: After you have modified the measurement settings to achieve the necessary resolution and

range, switch off the transform, perform a measurement calibration, and then switch on the transform.

Window Filter for Displayed Data

The PNA provides a windowing feature that makes time domain measurements more useful for isolating and identifying individual responses. This function has the effect of changing the impulse width, sidelobe level, and step risetime of the time domain results.

- Benefits of Window Filtering
- Appropriate Window Value
- How to Set Window Value

Note: Time Domain measurements are only available on PNAs with Option 010. See PNA Options

Other Time Domain topics

Benefits of Window Filtering

There are abrupt transitions in a frequency domain measurement at the start and stop frequencies, causing overshoot and ringing in a time domain response. The window feature is helpful in lessening the abruptness of the frequency domain transitions.

- **The impulse width or step risetime --** caused by the bandlimited nature of the test system, limits the ability to resolve two closely spaced responses. The impulse width is inversely proportional to the frequency span of the measurement, and the only way that the impulse width can be made narrower is to increase the frequency span.

- **The impulse sidelobes --** caused by the abrupt cutoff at the stop frequency, limits the dynamic range of the time domain measurement by hiding low level responses within the sidelobe of adjacent higher level responses.
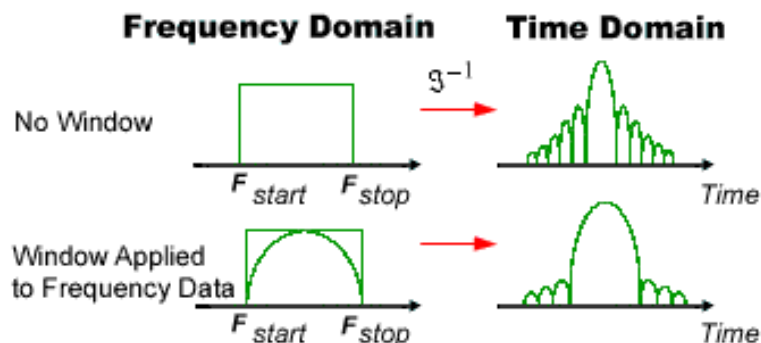
Window Filtering Effects

- **Response Resolution** is improved by reducing the impulse width, allowing you to resolve between two closely spaced responses.
- **Dynamic Range** is improved by reducing the impulse sidelobes, allowing you to measure

low-level responses.

You can vary the windowing values:

Window Value	Sidelobe Levels	Impulse Width	Best for...
Minimum	Higher	Smallest	Response Resolution
Maximum	Lower	Largest	Dynamic Range
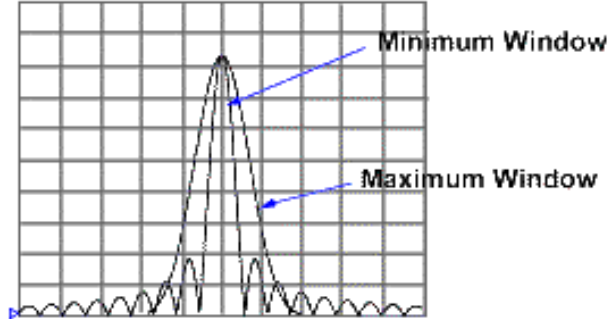
Note: The resolution is proportional to the window function applied, and inversely proportional to the frequency span measured. See Response and Range Resolution.

The analyzer can modify device responses by using a window filter on the measured data, with the following effects.

- **In the impulse stimulus --** the limitations in time resolution are altered, due to sidelobe and impulse width effects.

- **In the step stimulus --** (low pass only) the overshoot and ringing are reduced.

Appropriate Window Value

You can choose the window that is best for the types of responses that you expect from the device under test.

- **If the measured device has two equal amplitude level responses**, select the narrowest impulse width: minimum window to improve resolution.

- **If the measured device has two responses of different amplitude**, select the lowest sidelobe level: maximum window to improve dynamic range.

Window Characteristics

The following dependencies exist and are shown as example values in the next table.

	Dependency
Sidelobe Levels	Window Selected
Step Rise Time and Impulse Width	• Window Selected
	Frequency Span

Example window characteristics are shown for a 2.997 GHz frequency span.

Window Characteristics		Response Resolution*		Dynamic Range
		Step Rise Time (10% - 90% Level)	Impulse Width (50% Level)	Side Lobe Level
Low Pass Step	Minimum	150 ps		−21 dBc
	Normal	330 ps		−60 dBc
	Maximum	494 ps		< −70 dBc
Low Pass Impulse	Minimum		200 ps	−13 dBc

	Normal	320 ps	−44 dBc
	Maximum	481 ps	< −75 dBc
Band Pass	Minimum	400 ps	−13 dBc
Impulse	Normal	641 ps	−44 dBc
	Maximum	961 ps	< −75 dBc

Response Resolution Equations

Lowpass Step

$$\text{Response Resolution} = \frac{0.45}{Fspan} \times \begin{cases} 1.0 & \text{Minimum Window} \\ 2.2 & \text{Normal Window} \\ 3.3 & \text{Maximum Window} \end{cases}$$

Lowpass Impulse

$$\text{Response Resolution} = \frac{0.6}{Fspan} \times \begin{cases} 1.0 & \text{Minimum Window} \\ 1.6 & \text{Normal Window} \\ 2.3 & \text{Maximum Window} \end{cases}$$
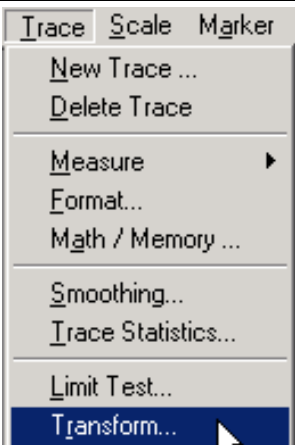
Bandpass Impulse

$$\text{Response Resolution} = \frac{1.2}{Fspan} \times \begin{cases} 1.0 & \text{Minimum Window} \\ 1.6 & \text{Normal Window} \\ 2.3 & \text{Maximum Window} \end{cases}$$

The following graphic shows the typical effects of various windows applied to a response of a short circuit reflection measurement.
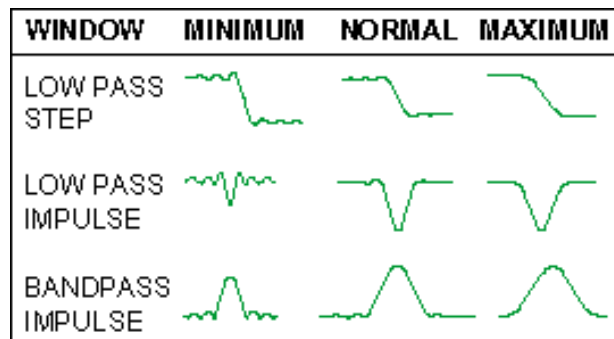
How to Set the Window Filter
Learn more about using the front panel interface

In the Transform dialog box - **Category** box, click the down arrow and select **Window**.
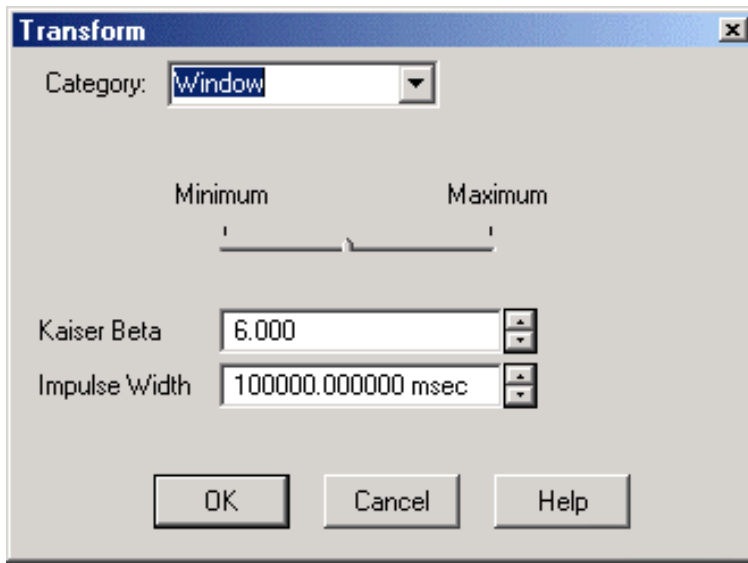
Transform - Window dialog box help
Minimum Specifies the window filter that provides a narrow impulse width, allowing the best response resolution.
Maximum Specifies the window filter that lowers a signal's side lobes, providing the best dynamic range.
Kaiser Beta Allows you to define the window characteristics using a Kaiser Beta value.
Impulse Width Allows you to define the window characteristics using an impulse width value.
Learn more about Windowing (top)

Time Gating Filter
_____

Gating allows you to select and mathematically remove (time filter) time domain responses. Then the analyzer can transform the remaining time domain responses back to the frequency domain for viewing.

After you apply gating to the time domain response, you can switch off the transform and study the frequency response of the device with the gate still active. For example, in a transmission measurement, you can remove the effects of multiple transmission paths. You can also view each time domain response individually and analyze the effect of each individual response in the frequency domain.

- Gating Operation
- Gate Shapes
- Gate Characteristics
- How to Set the Gate Filter

Gating Operation

1. Measure a device in the frequency domain.

2. Switch on the time domain transform. The network analyzer computes the time domain response (low pass or bandpass).

3. Set up the gate boundaries.

   - **For a bandpass gate type --** center the gate on the responses(s) that you want to keep in the measurement. Switch on the gate, and the responses outside the gate are mathematically removed from the displayed measurement.

   - **For a notch gate type --** center the gate on the response(s) that you want to remove from the measurement. Switch on the gate, and responses inside the gate are mathematically removed from the displayed measurement.

4. Switch off the time domain transform to view the responses in the frequency domain and see the effects of removing the responses outside the gate span (or inside the gate span for a notch gate type). The following example shows the operation of a bandpass shaped gate.
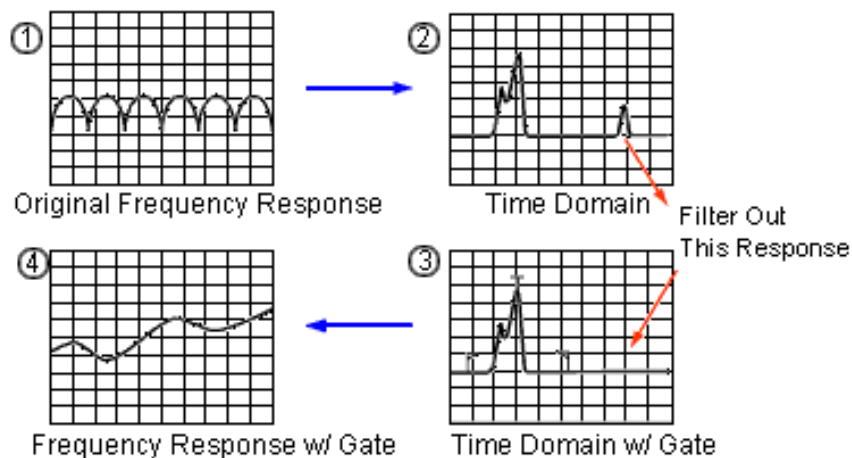
Gate Shapes

A gate also has a filter shape similar to the window filter described in Window Filter for Displayed Data. You can optimize the measurement by selecting one of a series of gate shapes: minimum, normal, wide, maximum.

- **Minimum Shape --** has the highest sidelobes, sharpest roll-off, and the largest passband ripple.

- **Maximum Shape --** has the lowest sidelobes, slowest roll-off, and smallest passband ripple.

Gate Passband Ripple

The gate is a bandpass-shaped filter, and each of the four gate shapes has different filter characteristics. The following graphic shows the difference in passband ripple for each of the four gate shapes at 0.5 dB/division. The minimum gate has the largest ripple.

Minimum Normal
Wide Maximum
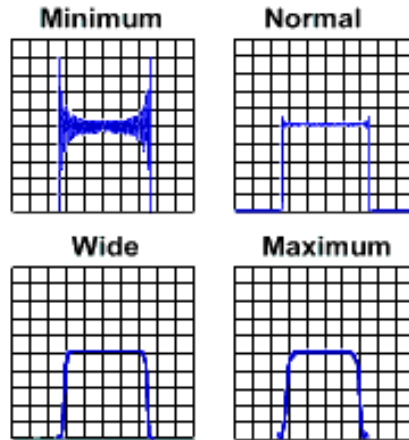
Gate Sidelobes

This graphic below compares the sidelobe levels of each of the four gate shapes. The lower sidelobe levels are achieved at a tradeoff with an increase in the cutoff rate.

- **The minimum gate** has the highest sidelobe levels, a fast cutoff rate, and is the most useful in gating out an undesired response that is closely spaced in time to a desired response.

- **The maximum gate** has the lowest sidelobe levels and has a cutoff rate that is slower, giving a wider gate shape and the greatest attenuation of responses outside the gate span.

Minimum Normal
Wide Maximum
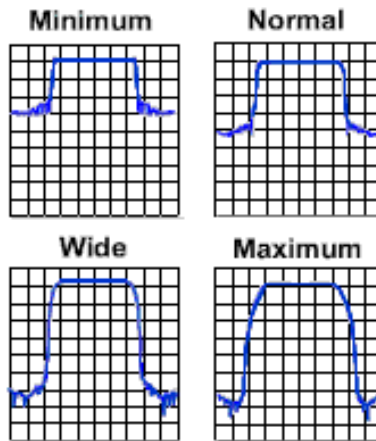
Gate Characteristics

Each of the four gate shapes available has different characteristics:

- **Passband ripple and sidelobe levels --** describe the gate shape.

- **Cutoff time --** is the time between the stop time (-6 dB on the filter skirt) and the peak of the first sidelobe.

- **Minimum gate span --** is twice the cutoff time.

Each gate shape has a minimum recommended gate span for proper operation.

Gate Shape	Passband Ripple	Sidelobe Levels	Cutoff Time	Minimum Gate Span
Minimum	±0.01 dB	-48 dB	1.4/Freq Span	2.8/Freq Span

Normal	±0.01 dB	-68 dB	2.8/Freq Span	5.6/Freq Span
Wide	±0.01 dB	-57 dB	4.4/Freq Span	8.8/Freq Span
Maximum	±0.01 dB	-70 dB	12.7/Freq Span	25.4/Freq Span

Cutoff Time

The diagram below shows the overall gate shape and lists the characteristics for each gate shape.

- T_1 is the gate span, which is equal to the stop time minus the start time.

- T_2 is the time between the edge of the passband and the –6 dB point, representing the cutoff rate of the filter.

- T_3 is the time between the –6 dB point and the edge of the gate stopband.

For all filter shapes T_2 is equal to T_3, and the filter is the same on both sides of the center time.
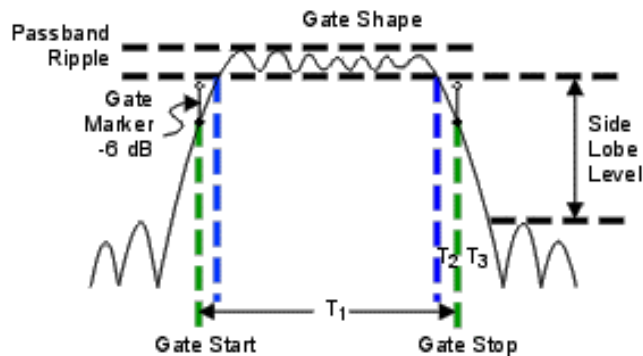
Minimum Gate Span

Each gate shape has a minimum recommended gate span for proper operation. This is a consequence of the finite cutoff rate of the gate. The minimum recommended gate span is given by the following equation, which makes the filter passband equal to 0 seconds.

$$T_{1MIN} = 2 \times T_2$$

If you specify a gate span that is smaller that the minimum span, the analyzer will produce the following effects:

- distorted gate shape that has no passband

- distorted shape

- incorrect indications of start and stop times

- may have increased sidelobe levels

How to Set the Window Gating
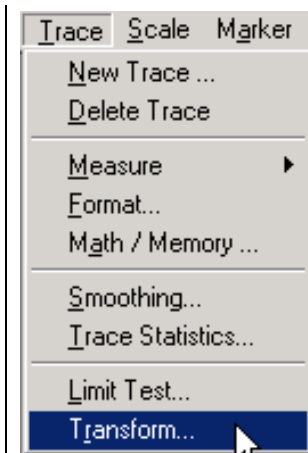
Learn more about using the front panel interface.

In the Transform dialog box - **Category** box, click the down arrow and select **Gating**.
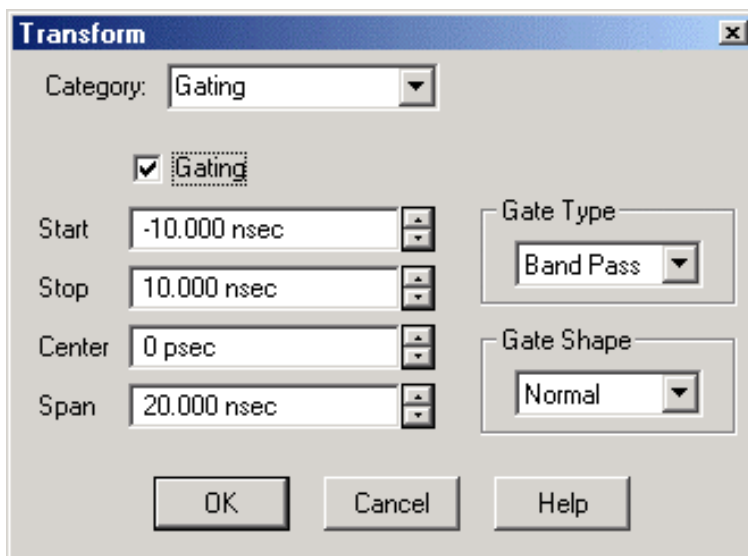
Transform Gating dialog box help
Gating Applies a time filter, removing selected time domain responses.
Start Specifies the start time for the time filter.
Stop Specifies the stop time for the time filter.
Center Specifies the value at the center of the area that is affected by the gating function. This value can be anywhere in the analyzer range.
Span Specifies the range to either side of the center value of area that is affected by the gating function.
Gate Type Defines the type of filtering that will be performed for the gating function.
• Select **Bandpass** to remove the displayed responses outside the gate span.
• Select **Notch** to remove the displayed responses within the gate span.
Gate Shape Defines the filter characteristics of the gate function. Each gate shape has a minimum recommended gate span for proper operation. **Gate Shape** **Passband Ripple** **Sidelobe Levels**

**Cutoff Time
Minimum Gate Span**

Minimum
±0.01 dB
-48 dB
1.4/Freq Span
2.8/Freq Span

Normal
±0.01 dB
-68 dB
2.8/Freq Span
5.6/Freq Span

Wide
±0.01 dB
-57 dB
4.4/Freq Span
8.8/Freq Span

Maximum
±0.01 dB
-70 dB
12.7/Freq Span
25.4/Freq Span

Learn more about Transform Gating (top)

Time Domain Measurement Data
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To help you understand device responses in the time domain, this topic shows examples of various types of measurements.

- Masking

- Reflection Measurement in Band Pass Mode

- Transmission Measurement in Band Pass Mode

- Fault Location using Low Pass Mode

- Reflection Measurement in Low Pass Mode

- Transmission Measurement in Low Pass Mode

- How to Interpret Time Domain Measurement Data

Note: Time Domain measurements are only available on PNAs with Option 010. See PNA Options

Masking

Because masking affects the responses you view in a time domain measurement, it is helpful to understand what it is when you interpret measurement data.

- Masking occurs when a discontinuity or loss closest to the reference plane affects the response of each subsequent discontinuity.

- The energy reflected or absorbed from the first discontinuity never reaches the second or later discontinuities.

- The result is that each subsequent response is smaller than it would have been had the first response not been present.

Masking Due to Energy Reflection

Masking due to reflection, occurs whenever a large mismatch is encountered. This masking phenomenon is shown in the following example where the line impedance varies.

- A 50-ohm line, connected to 25-ohm air line, connected to a 50-ohm line

- The first discontinuity has a reflection coefficient of about 0.333 (which is correct for a 25-ohm impedance).

- At the end of the 25-ohm section, the response does not show a 0.333 reflection coefficient, (which it should at a 50-ohm impedance). As indicated by the two delta markers, there is a difference of 35.355 mU in their magnitudes. The reason is that the impulse incident on the second response has an amplitude of less than unity because of the energy reflected in the first mismatch.

ρ
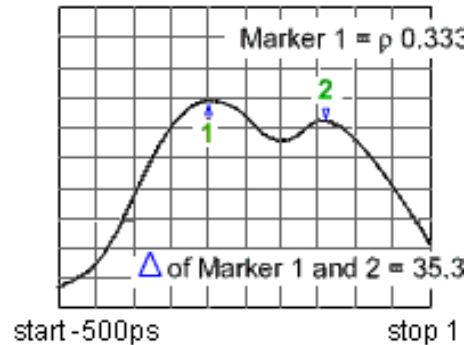
Masking Due to Energy Absorption

Masking due to energy absorption, occurs when a lossy circuit is measured. This masking phenomenon is shown in the following example where a cable is terminated by an open circuit.

- The response of the open circuit shows a return loss of -2.445 dB at Marker 1 (viewed in the Log Mag format).

- The expected response is the typical value for the open circuit (0 dB).

- The marker value represents the sum of the forward and reverse path losses.

dB
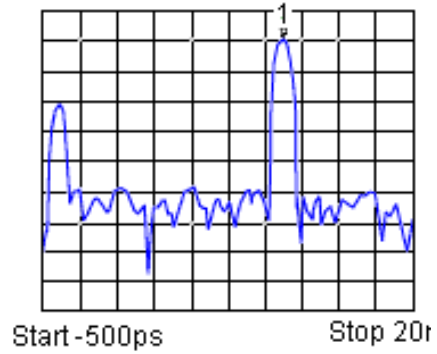
Start -500ps   Stop 20r

Reflection Measurement in Band Pass Mode

Data from the Horizontal Axis

- Time it takes for an impulse launched at the test port to reach a discontinuity and return to the test port.

Data from the Vertical Axis

- Return loss (dB) if using Log Mag format

- Reflection coefficient (rho) if using Lin Mag format

The following example shows a reflection measurement in band pass mode.

- There is a pulse at zero time point, representing the propagation time of the first discontinuity (connector) encountered from the test port output.

- The subsequent pulse represents the next discontinuity (connector) that the impulse encountered.

dB

Start -1ns   Stop 9ns
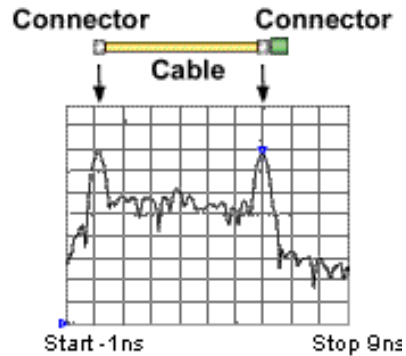
Transmission Measurement in Band Pass Mode

Data from the Horizontal Axis

- Propagation delay through the device under test

Data from the Vertical Axis

- Transmission loss or gain (dB) if using Log Mag format

- Transmission coefficient (rho) if using Lin Mag format

The following example is a transmission measurement in the band pass mode.

374

- This shows how this mode can provide information about multiple paths of travel within a Surface Acoustic Wave (SAW) filter.

- The pulse closest to the zero time point represents the propagation time of the shortest path from input to output of the network. It may or may not be the largest pulse or represent the desired path.

- Each subsequent pulse represents another possible path, from input to output, which happens to be longer than the shortest path.

dB
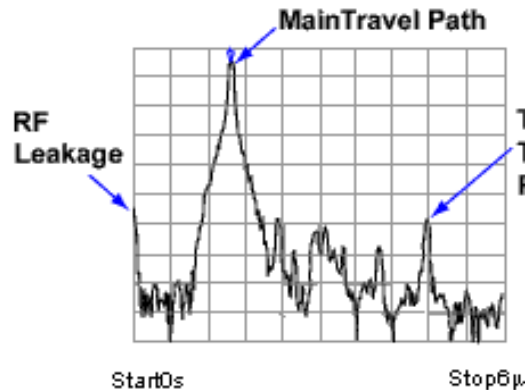
Tip: To see the response of just the SAW filter main path, you can set the gate to block all but the main pulse. Then in the frequency domain, only the frequency response of the main path is displayed.

Fault Location Using Low Pass Mode

The low pass mode can simulate the Time Domain Reflectometer (TDR) response of the test device. This response contains information useful in determining the type of discontinuity present.

The following chart shows the low pass responses of known discontinuities. Each circuit element was simulated to show the corresponding low pass time domain S_{11} response waveform. The low pass mode allows you to view a response to either a step or impulse stimulus.

Tip: The step response allows you to more easily identify discontinuity characteristics. This mode most closely resembles traditional TDR measurements.

ρ
(rho)

Reflection Measurement in Low Pass Mode

Data from the Horizontal Axis

- Time it takes for an impulse launched at the test port to reach a discontinuity and return to the test port.

Note: To determine the actual physical length, enter the appropriate velocity factor.

Data from the Vertical Axis

- Reflection coefficient (ρ) if using Real format

The following example is the same reflection measurement in low pass mode, shown with an impulse response, overlaid with a step response in Log Mag format.
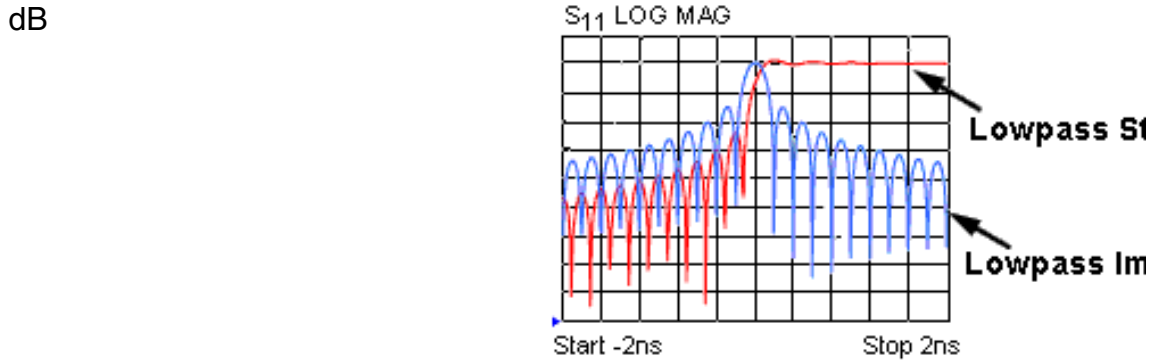
- The following example shows low pass reflection measurements of two different cables in the Real format.
- The low pass response contains information on where the discontinuity is located and what type of impedance is present.
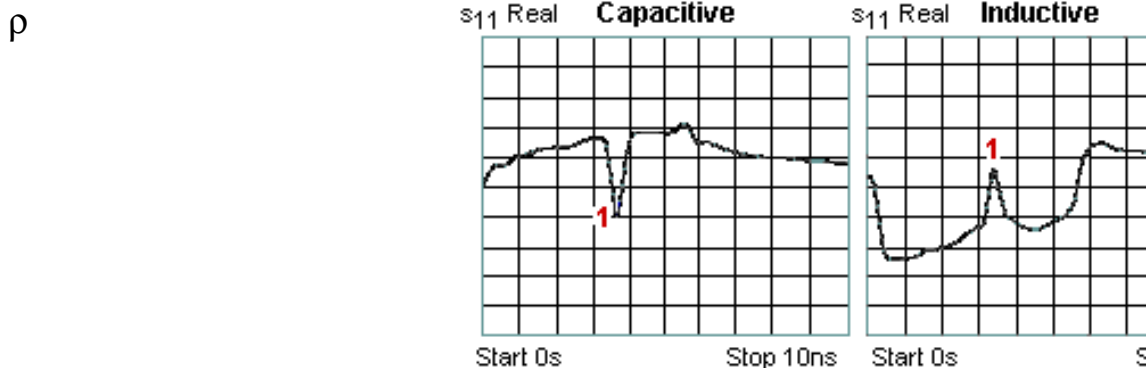
- **The left measurement --** shows a response of a crimped cable that has a capacitive discontinuity.
- **The right measurement --** shows a response of a frayed cable that has an inductive discontinuity.

Transmission Measurement in Low Pass Mode

Data from the Horizontal Axis

- Average transit time through a device over a frequency range
- Electrical delay of a device in time

Data from the Vertical Axis

- Real units (for example, volts) if using Real format
- Transmission loss or gain (dB) if using Log Mag format (for impulse mode only)

The following example shows the low pass step response of an amplifier.

- The average group delay over the measurement frequency range is the difference in time between the step and the amplifier response.

- The step rise time is proportional to the highest frequency in the frequency domain sweep: the higher the frequency, the faster the rise time.

- The ringing in the amplifier response indicates an under-damped design.

Real

Units

ie

Volts

Tip: For low pass step response, the most useful format is Real (reflection coefficient units). For Impulse, you can also use the Real format, but for the best dynamic range to simultaneously view large and small discontinuities, use the Log Mag format.

How to Interpret Time Domain Measurement Data

1. Set the start time to –1 sec to see the responses beginning at the test port.
   a. In the **Trace** menu, click **Transform**.
   b. Click the **Start** box and enter –1 sec.

2. In the **Trace** menu, click **Autoscale** to view the entire measurement response.

3. To get the maximum display resolution, center the response of interest on the display and reduce the time span.
   a. In the **Trace** menu, click **Transform**.
   b. Click the **Start** box and enter –1 sec.

4. If you need better response resolution, you can modify the window and the measurement settings. See Time Domain Resolution and Range.

5. To determine the correct time and distance to responses, set the correct velocity factor.
   a. In the **Scale** menu, click **Electrical Delay**.
   b. In the **Velocity Factor** box, enter a value between 0 and 1.0.

      - speed of light in a vacuum = 1.0
      - Polyethylene (most cables) = 0.66
      - Teflon = 0.7

   c. Use a marker to view both the time (x2) and the electrical length (x2) to a discontinuity.

Note: To determine the physical length, rather than the electrical length, change the velocity factor to that of the medium under test. To cause the markers to read the actual one-way distance to a discontinuity, rather than the two-way distance, enter one-half the actual velocity factor.

6. If you are using the low pass mode, determine the magnitude and phase of an impedance change. See Fault Location Using Low Pass.

High Power Measurements

High-Power Amplifier Measurements Using a PNA

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Note: This information applies to all PNA models. For information that applies to your specific analyzer, see High-Power Amplifier Measurements.

Challenge	Solution
DUT output power is too high	Components that reduce DUT output power
Phase-lock lost when using a Booster Amplifier	Disable Auto-Frequency Calibration
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

Components that Reduce DUT Output Power

Maximum input power at the analyzer's receivers must not be exceeded. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) If your DUT has a high output-power level, it must be reduced to a level that can be safely handled by the analyzer's receivers. As shown in the following graphic, when testing a CDMA base-station amplifier, some or all of the following components are configured to reduce amplifier output power:

- An external high-power **coupler** can be installed at the output of the amplifier. A special **load** that can dissipate high power is used to terminate the through-arm of the coupler.

- An external high-power **attenuator** can be attached to the analyzer's input port.
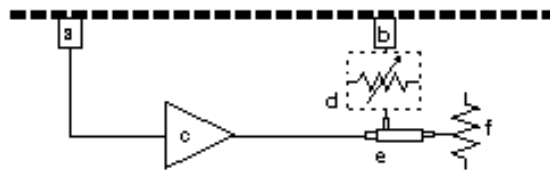
Item	Description	Item	Description
a	PORT 1	**e**	Directional coupler, customer supplied
b	PORT 2	**f**	Load, customer supplied
c	CDMA base station amplifier, customer supplied		
d	Variable attenuator (optional), customer supplied. (If your E835x analyzer is equipped with Option 015, it has receiver		

attenuation and does
not require external
attenuation. See
Analyzer Options.)

To protect your analyzer's receiver from too much input power, follow these steps to
determine values of an external attenuator or coupler and load (or both).

1. Determine the maximum power out of the amplifier [Ex: 40 dBm).

2. Subtract 15 dB (the coupling-factor value of the directional coupler inside the
    analyzer) [Ex: 40 dBm - 15dBm = 25 dBm).

3. Subtract the power level required at the receiver [Ex: 25 dBm - (-10 dBm)].

4. The result is the appropriate value of the external attenuator or coupler and load or
    both [Ex: 35 dB].

Note: Refer to the specifications for the coupler, load, and attenuator to ensure they have
adequate power-handling capability.

Find more information about testing CDMA amplifiers at **http://www.tm.agilent.com**. Click
"Library" and use the search function to search for CDMA amplifiers.

Disable Automatic Frequency Calibration when using Booster Amps.

When using a booster amplifier, or whenever removing either R1 or R2 front-panel loops to
provide a reference signal that is coupled from the test port, you may see a phase-lock lost
indication. This can occur if you use a narrow-band filter or coupler in your test setup.

If phase-lock lost indication occurs, the PNA will automatically re-calibrate the tuning curve of the
internal source. To prevent the PNA from re-calibrating itself, disable the Automatic Frequency
Calibration while the PNA is still phase locking correctly.

To do this, Click **System**, then point to **Configure**, then click **SICL/GPIB**. At the prompt, type
DIAG:AUTOCAL OFF.

The PNA may still lose phase-lock outside of the pass band of your coupler or filter, but the PNA
will not try to re-calibrate itself.

Note: For best performance, the R channel power must be 22dB (+/-5dB) below the power at the
test port.

Calibration Standards that Withstand High Power

*   The line, open, short, and thru standards are not a problem with high-power levels since
    they do not dissipate any energy.

*   The load dissipates energy. To prevent causing damage to the load, read its
    specifications to verify it can handle the power level.

CAUTION: When using an open or a short during calibration, be sure that the incident power
level is low enough so that the reflected signal does not exceed the maximum input to the
analyzer's receiver. See your analyzer's Technical Specifications for the damage level of a
receiver.

If you are using an Electronic Calibration (ECal) Module, refer to its specifications for maximum
input power.

Thermal Requirements for DUTs and Loads

Thermal conditions during the high-power measurement should also be considered for accurate
measurements. For example:

*   The high-power DUT may respond very differently at various temperatures. The tests

should be done when the amplifier is at the desired temperature.

- The load should be allowed to temperature-stabilize if its impedance characteristics change significantly versus temperature.

Stimulus-Sweep Recommendation for a DUT with an AGC Loop

It is recommended that you set the analyzer to sweep across only one frequency band if you are testing an amplifier with an AGC loop. This will require a separate measurement across each of the required frequency bands, but it will ensure the safety of your amplifier.

Turning off the amplifier's source power is a problem for amplifiers (DUTs) containing an AGC (Automatic-Gain Control) loop. The problem occurs when the analyzer's source power sweeps through its band-crossings. The analyzer keeps power constant while sweeping or retracing if only **one** frequency band is used. If switching frequency bands, the analyzer blanks, or turns off, the source power as it sweeps or retraces.

When the analyzer's source power is blanked, the AGC loop of the amplifier tries to compensate by increasing its gain to keep the output power level constant. When blanking stops and the sweep begins again, the analyzer restores its signal, and suddenly there is power again at the input of the amplifier, which has ramped-up its gain. If the AGC loop cannot respond quickly enough, the momentary high output power can damage or destroy the amplifier under test and the analyzer's receiver.

View your analyzer's frequency band crossings.

Procedure for Measuring High-Power Amplifiers

Caution: Avoid expensive repairs to your PNA. Read Electrostatic Discharge Protection.

1. Select the correct analyzer configuration for your DUT and your measurement requirements. Do not connect the DUT yet.

2. Preset the analyzer.

3. If necessary, adjust the analyzer's source power:

   - Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 10 dB below the 1 dB compression point).

   - Select an external attenuator (if needed) so the amplifier's output power will be sufficiently attenuated to avoid causing receiver compression or damage to the analyzer.

4. Select the desired measurement.

5. Connect the DUT.

6. Select the settings for the DUT.

7. Remove the DUT and perform a measurement calibration. Be sure to include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT.

8. Save the instrument state to memory.

9. Reconnect the DUT.

10. Scale the displayed measurement for optimum viewing and use markers to read-out measurement results.

11. Print the data or save it to a disk.

External Leveling Circuitry that Uses a DC Preamplifier

Note: This circuitry will not work with E836x models; they do not have an External Leveling input on the rear panel.

The graphic below is a schematic diagram of **external leveling circuitry** (provided by the user) that uses a DC preamplifier. A preamplifier is recommended when the input power-level to the detector diode is less than 20 dBm.
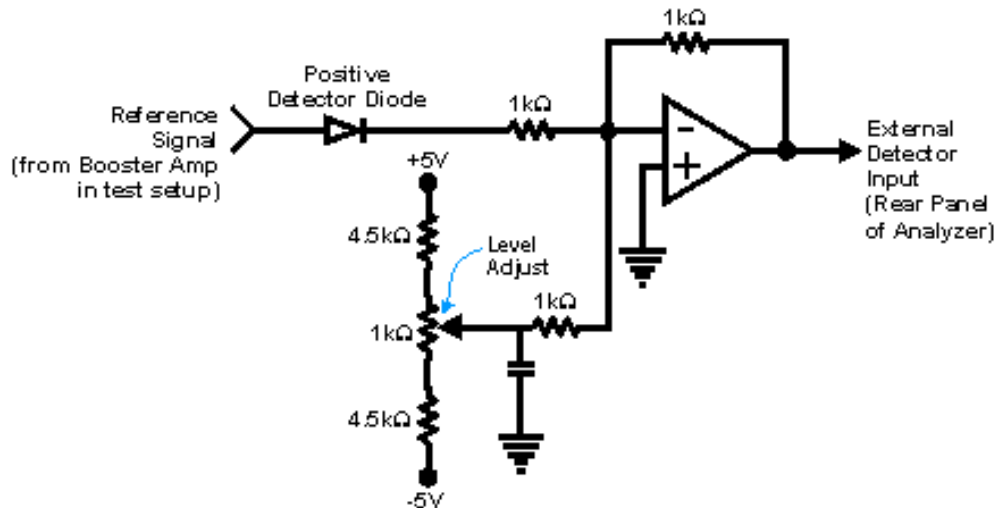
- The external leveling circuitry consists primarily of

  - A detector diode

  - An operational amplifier

- Changes in the power measured by the diode are detected by the operational amplifier circuit. This circuit regulates the voltage at the analyzer's External Detector Input, adjusting the analyzer's source power to achieve a flat response at the DUT on a real-time basis.

- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.

- Making too great a change in the reference-signal power can cause the external-leveling function to become ineffective due to the limited power-control range of the analyzer's source.

E835x Standard

High-Power Amplifier Measurements Using the E8356A, E8357A, and E8358A

High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

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Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to http://www.agilent.com/find/accessories and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp limits the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External Leveling for Booster Amplifiers.

Here are two ways to configure booster amp circuitry.

1. Simple Configuration using One Booster Amplifier

Limitations

- Allows only a Thru Response Cal for boosted forward transmission (S_{21}) measurements.

- Allows only a 1-Port Reflection Cal or Open/Short Response Cal for nonboosted reverse reflection (S_{22}) measurements.

- Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

- Reflection measurements on Port 1 or reverse transmission measurements are not possible. The signal is blocked by the booster amplifier.

How to connect

1. Position the booster amplifier between Port 1 and the DUT.

2. Connect the coupled-arm portion of the boosted source signal to the R1 IN channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and

the DUT.

3. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

4. Add an external attenuator between the DUT and Port 2.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

2. <u>More Accurate Configuration</u> using One Booster Amplifier

Limitations

Reverse *boosted-power* measurements are not possible.

How to connect

Use the components in the previous "Simple Configuration", plus:

1. Add a reverse coupler between the booster amplifier and the DUT.

2. Add an external attenuator to protect the A receiver from excessive power reflected from the DUT. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

3. Configuration using Two Booster Amplifiers

Limitations

None.

How to connect

Use the components in the previous "More Accurate Configuration", plus:

1. Position a booster amplifier between Port 2 and the DUT.

2. Add a directional coupler between the booster amplifier and the DUT.

3. Connect the coupled-arm portion of the boosted source signal to the R2 IN channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

5. Connect a reverse coupler to the output of the DUT.

6. Connect the coupled-arm of the reverse coupler to the B IN channel.

7. Add an external attenuator to protect the B IN receiver from excessive power reflected from the DUT.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Analyzer Upgrades can Expand the Possibilities for Including a Booster Amplifier

You can choose from other booster amplifier configurations by purchasing the **Option 015** upgrade (Configurable Test Set). See Analyzer Options. Discover the Option 015 measurement possibilities. Option 014 (Configurable Test Set) is not compatible with your analyzer.

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External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output

of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

How do I Determine If I Need to Use External Leveling with my Booster Amplifier?

Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How do I Provide External Leveling?

External leveling circuitry is shown in three different test setup configurations:

- external leveling using one booster amplifier
- external leveling using one booster amplifier and a reverse coupler
- external leveling using two booster amplifiers and two reverse couplers

Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to a power splitter. From the power splitter, the reference signal gets routed to two places:

- The analyzer's front-panel "R1 IN" or "R2 IN" input (or both) for the internal reference receiver(s).
- The **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.

- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.

- Making too great a change in the reference-signal power can cause the external leveling function to become ineffective due to the limited power-control range of the analyzer's source.

View external leveling circuitry that uses a DC preamplifier (recommended when the input power-level to the detector diode is less than -20 dBm).

Note: When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

Which Analyzer Menu Choices Do I Select for External Leveling?

1. Select the **Sweep** menu.

2. Select **Sweep Setup**. Select the **External** checkbox.

3. Select the **Channel** menu.

4. Select **Power**. In the **Attenuator Control** section of the dialog box, clear the **Auto** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer:

- configuration for non-boosted high-power measurements in both forward and reverse directions

    Possible calibration choices:

    o **2-Port Calibration** (TRL or SOLT) for forward and reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse non-boosted transmission or reflection measurements.

o configuration for high-power measurements in the forward direction (response cal only)

    Possible calibration choices:

    o **Thru Response** for forward high-power transmission measurements.

    o **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.

o configuration for high-power measurements in the forward direction (2-port cal)

    Possible calibration choices:

    o **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response)

for forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements

- configuration for high-power measurements in both forward and reverse directions

   Possible calibration choices:

   o **2-Port Calibration** (TRL or SOLT) for forward and reverse high-power transmission and reflection measurements.

   o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse high-power transmission or reflection measurements.

Compare with: Basic Configuration.

More information on calibration choices:

- Thru, Reflection, Line (TRL) **2-port calibration**: the most accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of only three calibrations standards using both forward and reverse signals. For more information, see TRL Cal.

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

_____

Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) Receiver power levels can be measured with a power meter where your external circuitry connects to:

- A In

- B In

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

See graphic: Measuring Calibration Power Levels

More information on High-Power Amplifier Measurements:

- <u>Disable Auto-Frequency calibration</u>
- <u>Components that reduce DUT output power</u>
- <u>Calibration standards that withstand high power</u>
- <u>Thermal requirements for DUTs and loads</u>
- <u>Stimulus-sweep recommendation for a DUT with an AGC loop</u>
- <u>Procedure for Measuring High-Power Amplifiers</u>

Diagram: (E835x) Basic Configuration
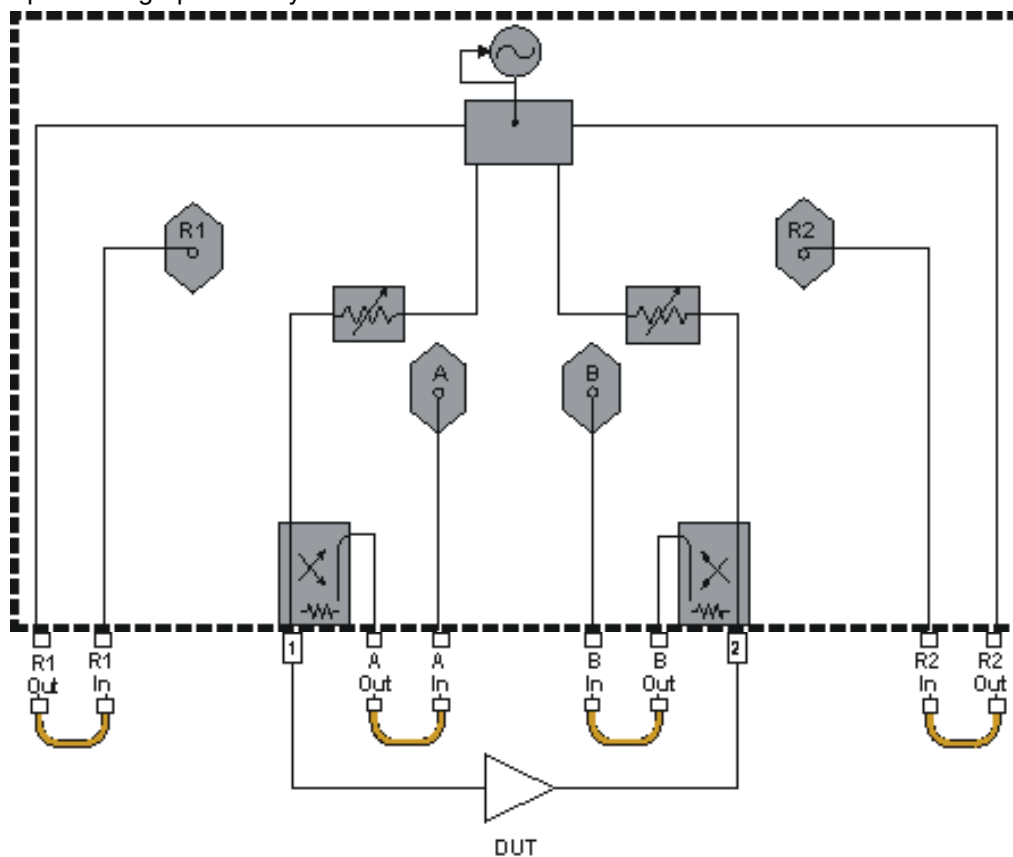
Explore the graphic with your mouse.

Diagram: (E835x) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)

Explore the graphic with your mouse.
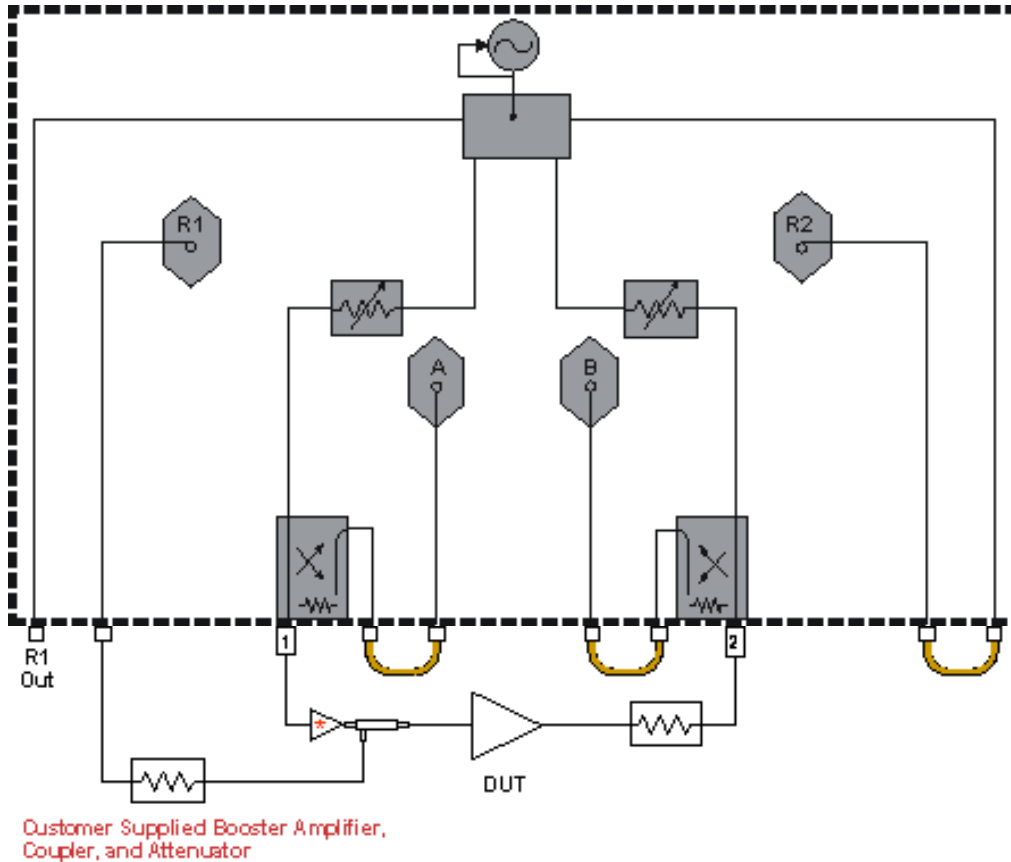
Diagram: (E835x) Configuration for High-Power Measurements in the Forward Direction (2-Port Cal)

Explore the graphic with your mouse.
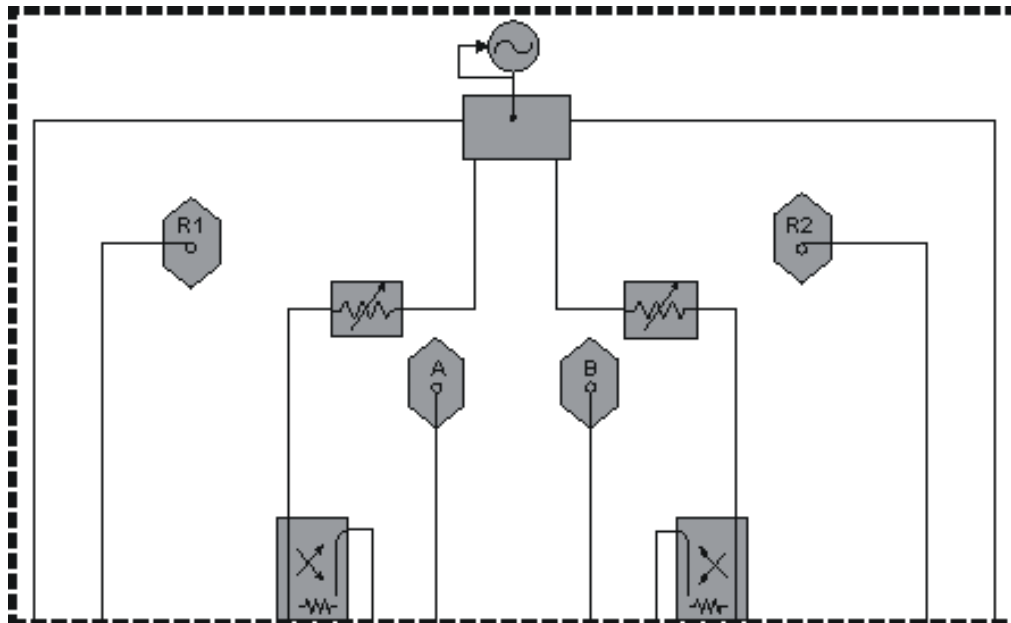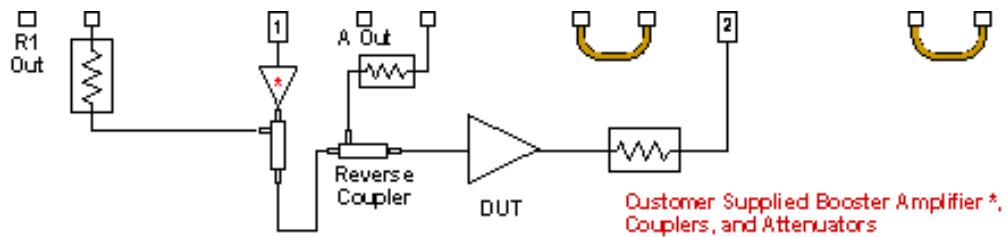
Customer Supplied Booster Amplifier *,
Couplers, and Attenuators

Diagram: (E835x) Configuration for Non-Boosted High-Power Measurements in both Forward & Reverse Directions

Explore the graphic with your mouse.

For Reverse
Measurements

DUT

For Forward
Measurements
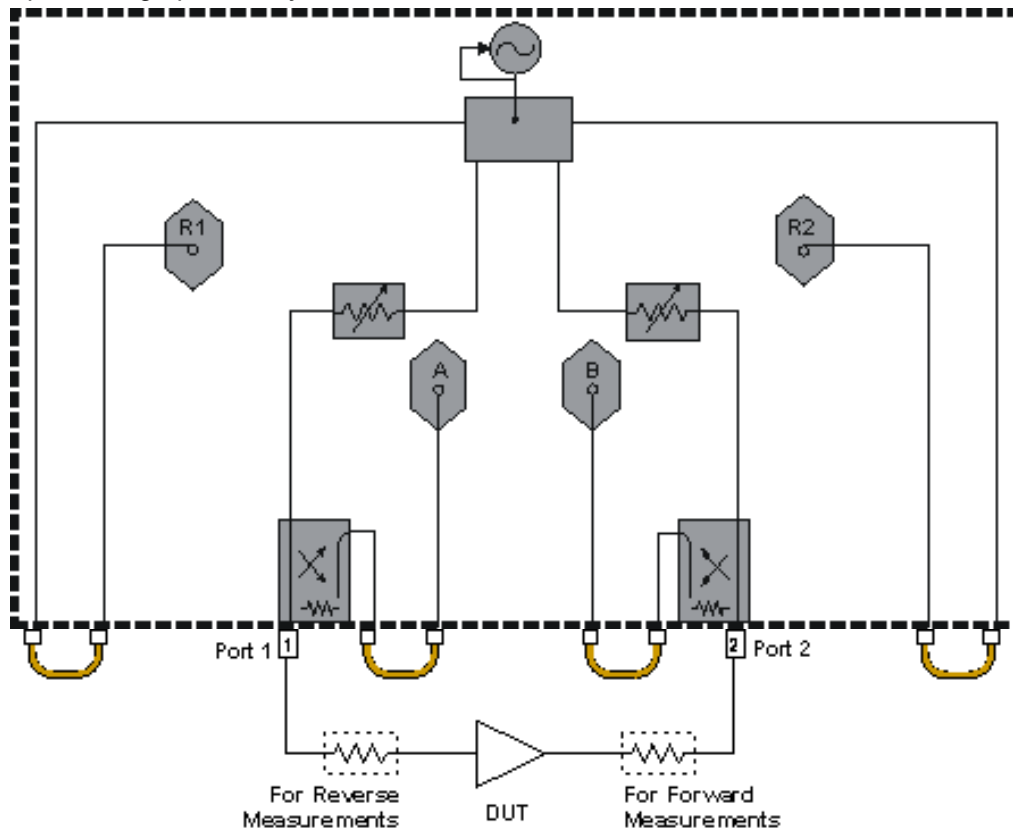
Customer Supplied Attenuator - Location
dependent on direction of measurement

Diagram: (E835x) Configuration for High-Power Measurements in both the Forward & Reverse Directions (2-Port Cal)

Explore the graphic with your mouse.
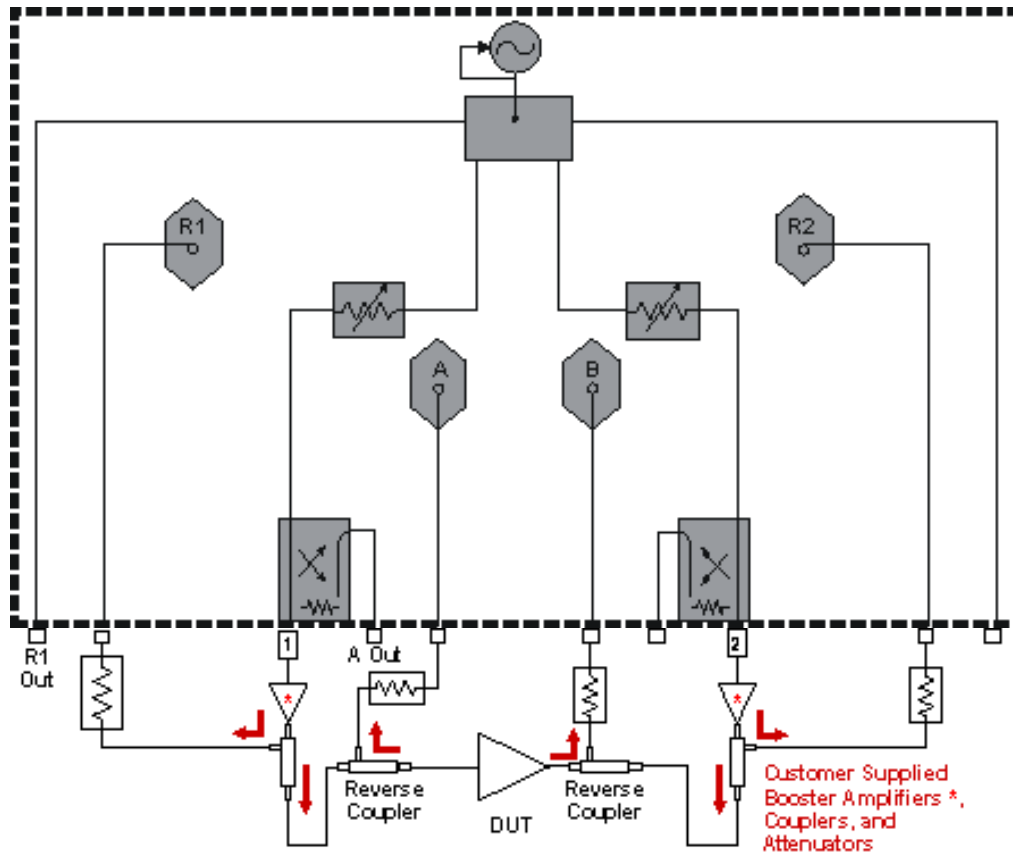
Diagram: (E835x) Simple Configuration using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, and an attenuator.

Customer Supplied BoosterAmplifier *,
Coupler, and Attenuators
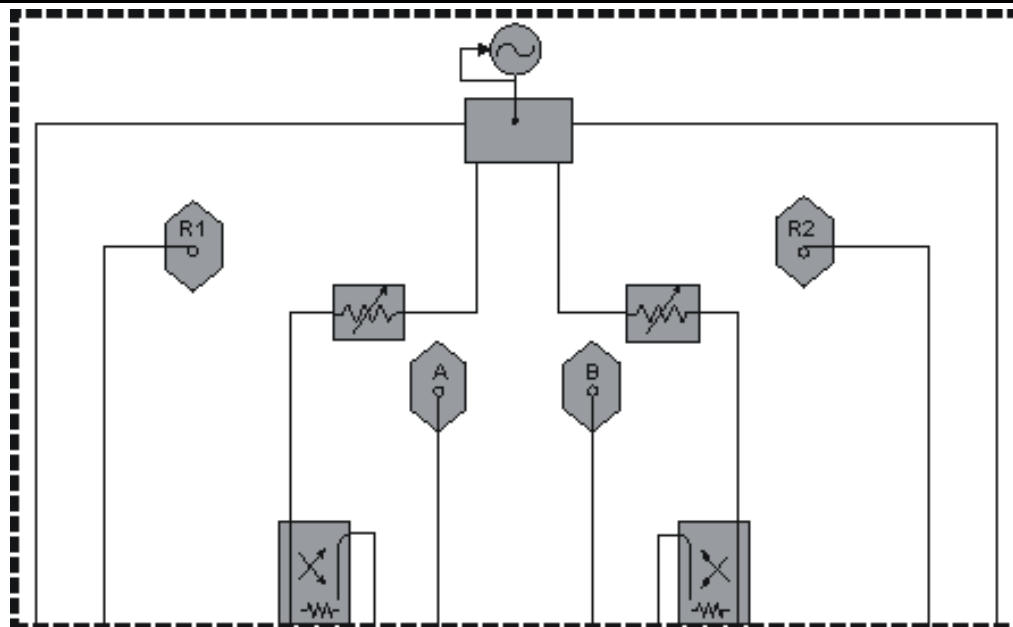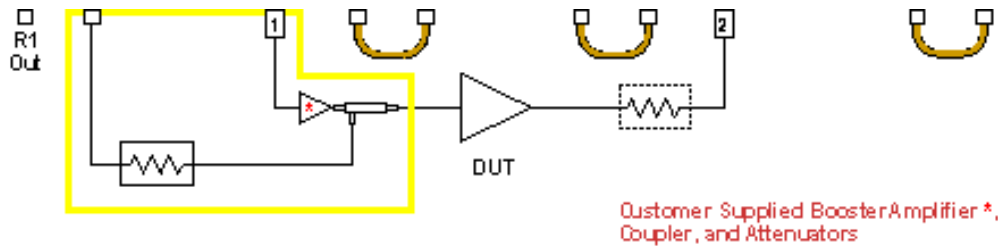
Diagram: (E835x) More Accurate Configuration using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amp, a forward coupler, a reverse coupler (allows S11 measurements), and two attenuators.

Customer Supplied Booster Amplifier *,
Couplers, and Attenuators
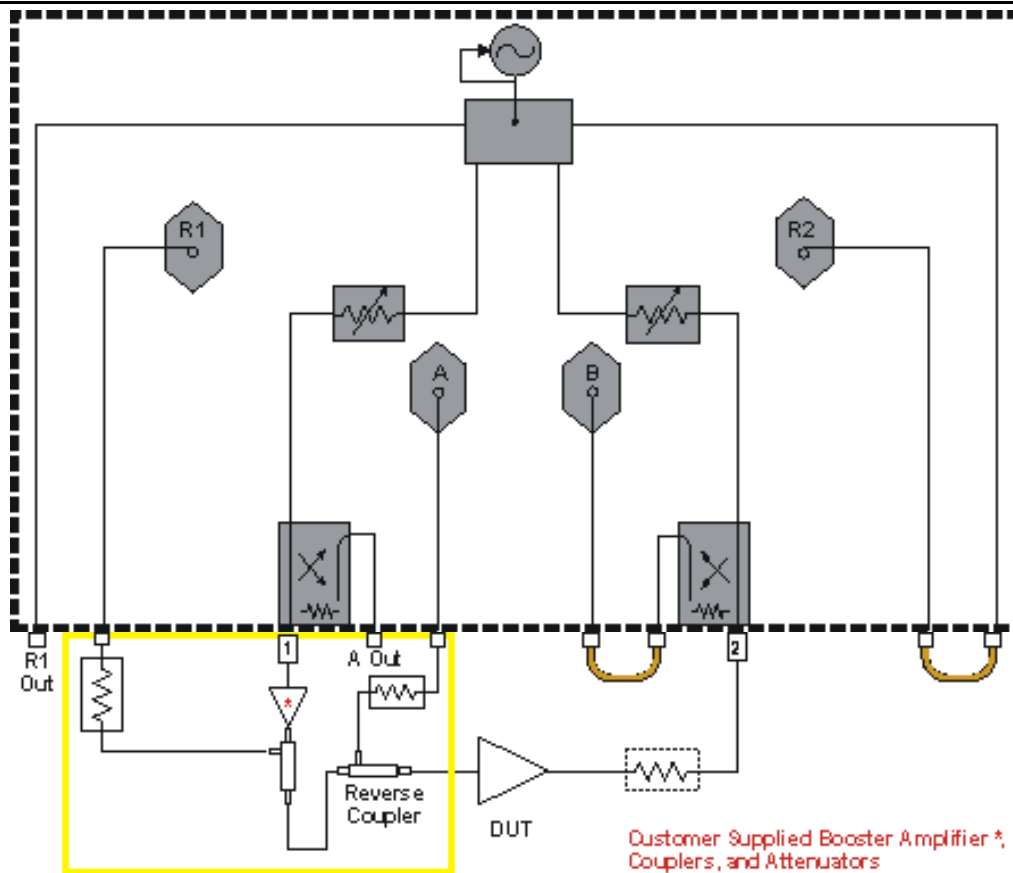
Diagram: (E835x) Configuration using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amps, 2 forward couplers, 2 reverse couplers (allows S11 and S22 measurements), and 4 attenuators.
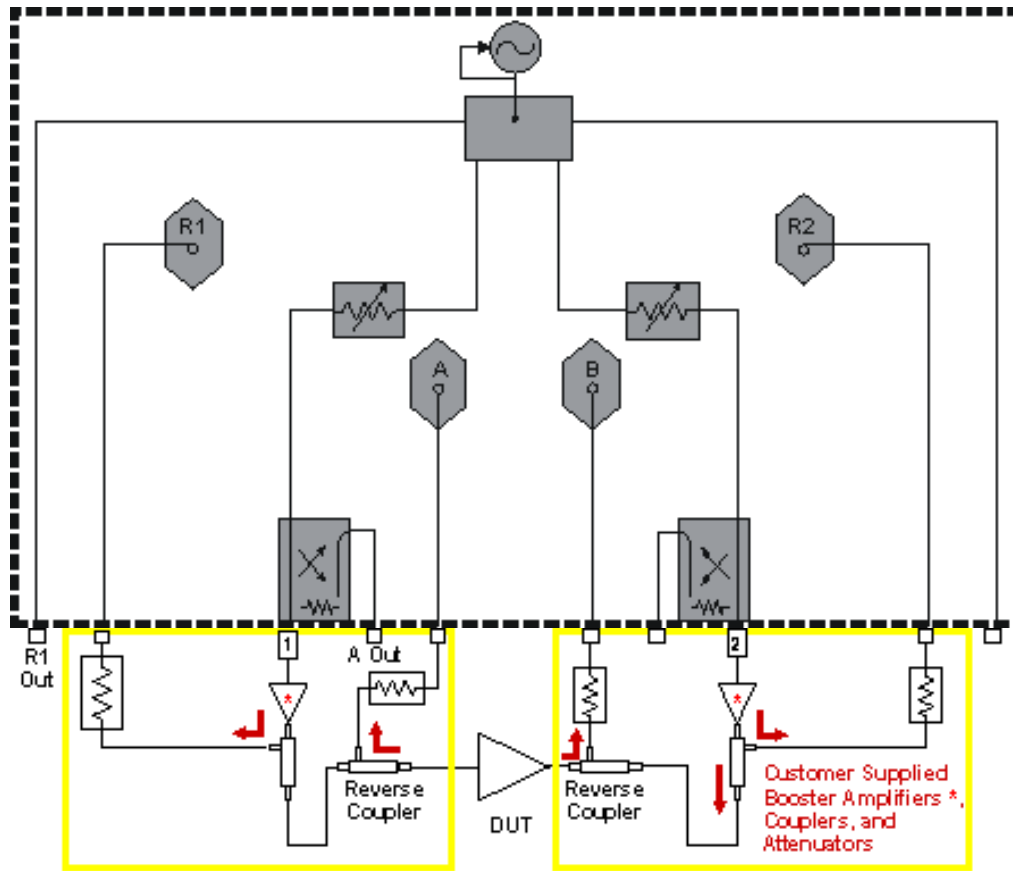
Diagram: (E835x) External Leveling using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, forward coupler, power splitter, two attenuators, and a negative detector diode.
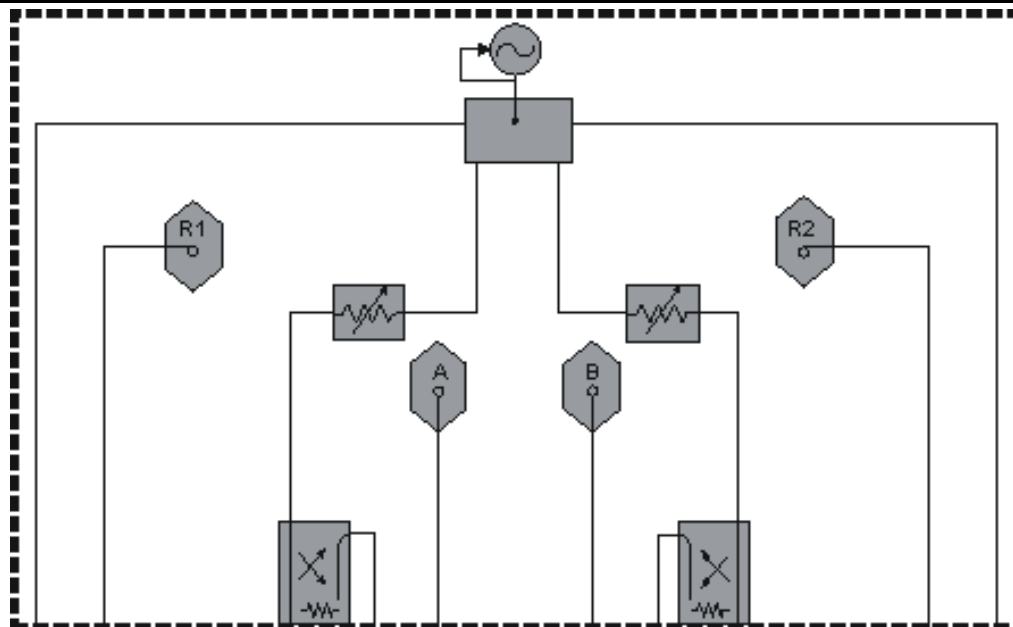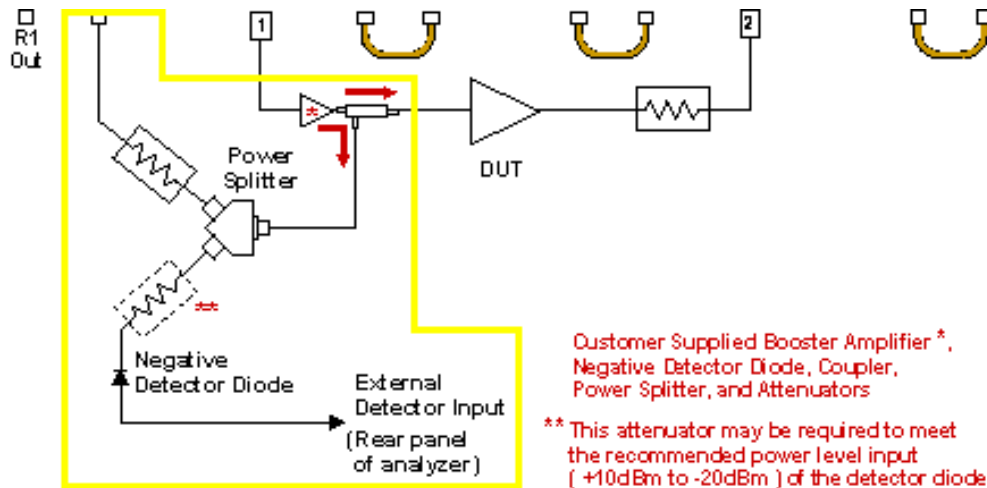
Diagram: (E835x) External Leveling using One Booster Amplifier and a Reverse Coupler

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amp, forward coupler, reverse coupler (allows S11 measurements), power splitter, three attenuators, and a negative detector diode.
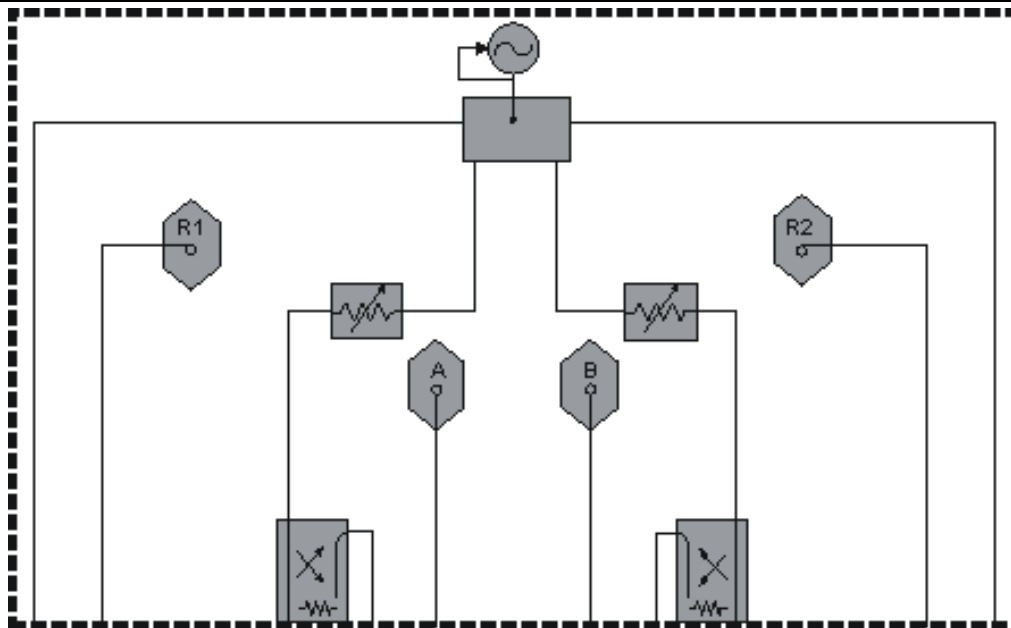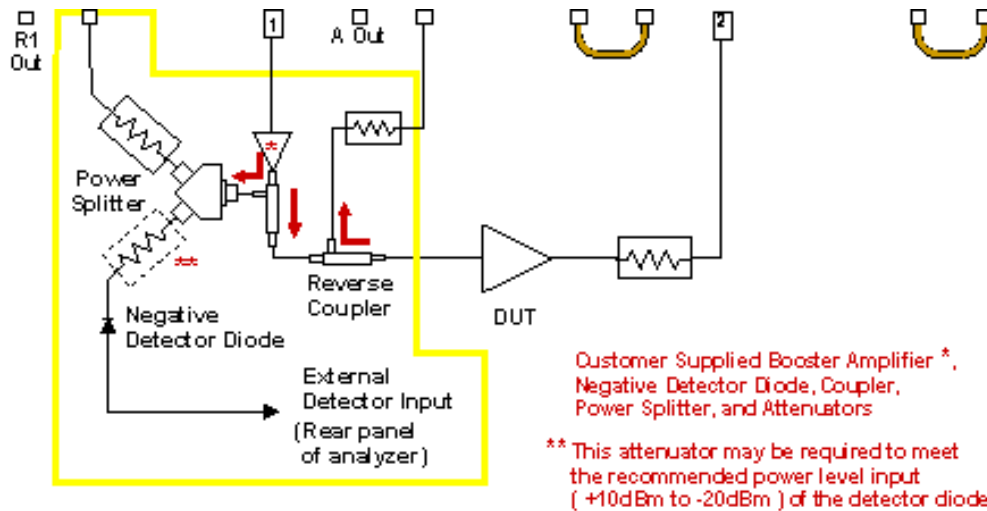
Diagram: (E835x) External Leveling using Two Booster Amplifiers and Two Reverse Couplers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - 2 booster amps, 2 forward couplers, 2 reverse couplers (allow S11 and S22 measurements), 2 power splitters, 6 attenuators, and a negative detector diode.

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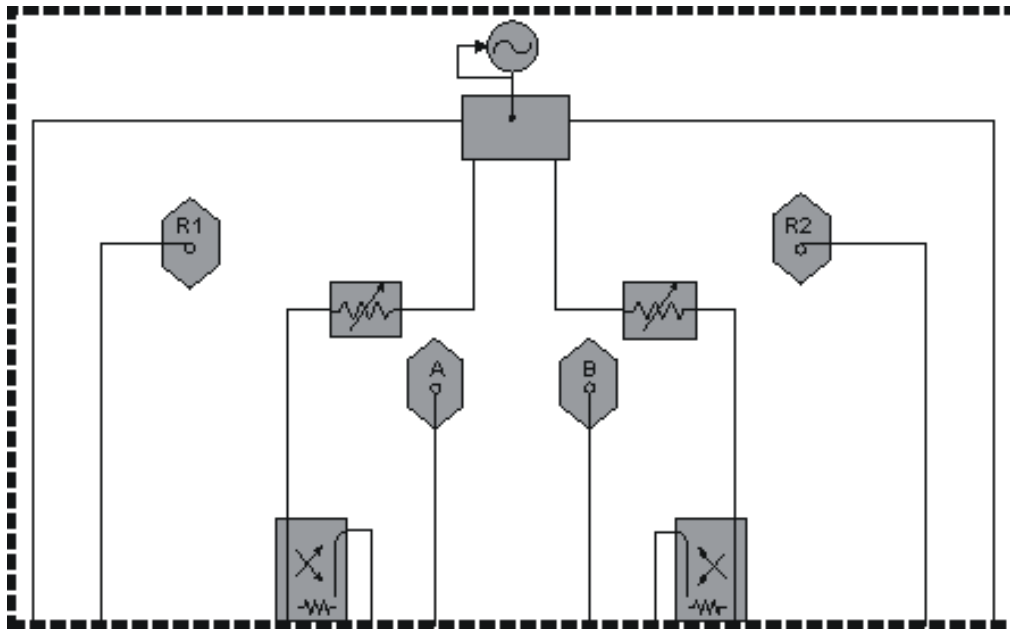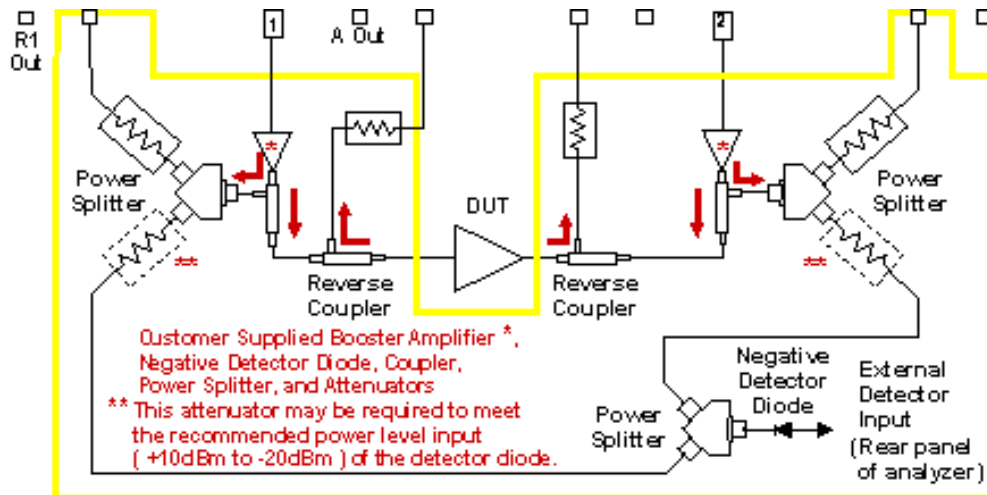
Diagram: (E835x) Measuring Calibration Power Levels
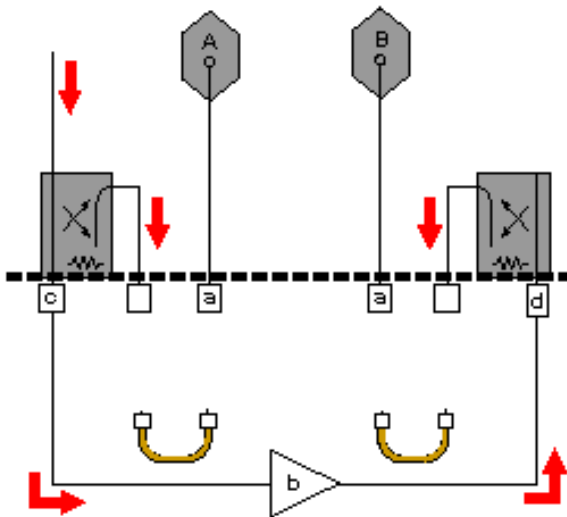
Description
Measure the receiver input power where your external circuitry connects here
DUT, customer supplied
PORT 1
PORT 2

E835x Opt 015

High-Power Amplifier Measurements Using the E8356A *Option 015*, E8357A *Option 015*, and E8358A *Option 015*

High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

——

Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp may limit the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External Leveling for Booster Amplifiers.

Here are two ways to configure booster amp circuitry.

1. Configuration Using One Booster Amplifier

Limitations

Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Coupler In channel.

3. Connect the coupled-arm portion of the boosted source signal to the R1 In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to the receiver.)

5. Connect an isolator between the Port 2 Coupler In and the Port 2 Source Out.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

2. Configuration Using Two Booster Amplifiers

Limitations

None.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Coupler In channel.

3. Connect the coupled-arm portion of the boosted source signal to the R1 In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to the receiver.)

5. Connect a booster amplifier to the Port 2 Source Out channel.

6. Connect a coupler between the booster amplifier and the Port 2 Coupler In channel.

7. Connect the coupled-arm portion of the boosted source signal to the R2 In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 2 and the DUT.

8. Add an external attenuator to protect the R2 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to the receiver.)

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Your **Option 015** (Configurable Test Set) analyzer allows you a choice of booster amplifier configurations. Option 014 (Configurable Test Set) is not compatible with your analyzer.

_____

External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

How do I Determine If I Need to Use External Leveling with my Booster Amplifier?

Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

DUT Response with Mismatch Ripple of Amplifier

True DUT Response

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How do I Provide External Leveling?

External leveling circuitry is shown in two different test setups:

- external leveling using one booster amplifier
- external leveling using two booster amplifiers.

Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to a power splitter. From the power splitter, the reference signal gets routed to two places:

- The analyzer's front-panel "R1 IN" input or "R2 IN" input (or both) for the internal reference receiver(s).
- The **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.
- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.
- Making too great a change in the reference-signal power can cause the external leveling function to become ineffective due to the limited power-control range of the analyzer's source.

View external leveling circuitry that uses a DC preamplifier (recommended when the input power-level to the detector diode is less than -20 dBm).

Note: When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

Which Analyzer Menu Choices Do I Select for External Leveling?

1. Select the **Sweep** menu.

2. Select **Sweep Setup**. Select the **External ALC** checkbox.

3. Select the **Channel** menu.

4. Select **Power**. In the **Attenuator Control** section of the dialog box, clear the **Auto** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for high-power measurements in the forward direction

    Possible calibration choices:

  o **2-Port Calibration** (TRL or SOLT) For forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) For forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration (with an isolator) for high-power measurements in the forward direction

    Possible calibration choices:

  o **2-Port Calibration** (TRL or SOLT) For forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) For forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in both forward and reverse directions

    Possible calibration choices:

  o **2-Port Calibration** (TRL or SOLT) For forward and reverse high-power transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) For forward or reverse high-power transmission or reflection measurements.

Compare with: Basic Configuration.

 More information on calibration choices:

- Thru, Reflection, Line (TRL) **2-port calibration**: the most accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of only three calibrations standards using both forward and reverse signals. For more information, see TRL Cal.

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four

calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

_____

Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) Receiver power levels can be measured with a power meter where your external circuitry connects to:

- A In
- B In

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

See graphic: Measuring Calibration Power Levels

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More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
- Procedure for Measuring High-Power Amplifiers

Diagram: (E835x, Option 015) Basic Configuration
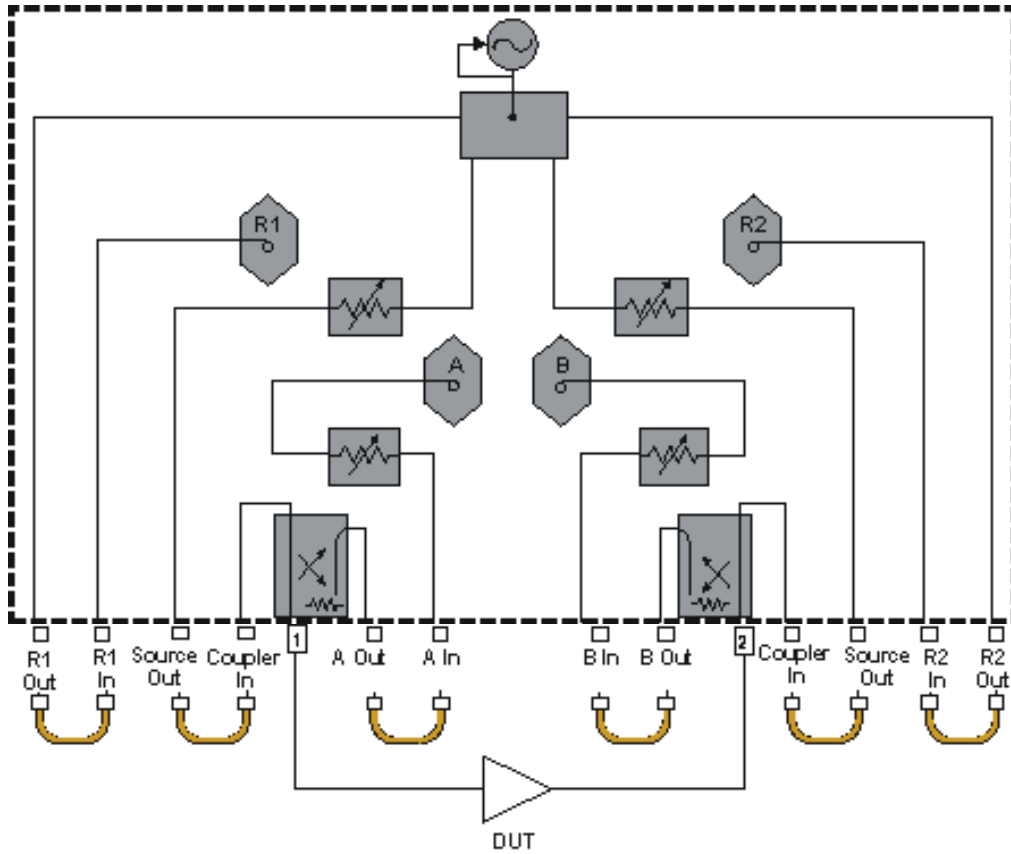
Explore the graphic with your mouse.

Diagram: (E835xA, Option 015) Configuration for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

Customer Supplied Booster Amplifier *,
Coupler, and Attenuator

DUT

Diagram: (E835xA, Option 015) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

R1
Out

Customer Supplied Booster Amplifier*,
Coupler, and Attenuator

DUT

Customer Supplied Isolation
(for DUT Output above +10 dBm)

Diagram: (E835xA, Option 015) Configuration for High-Power Measurements in both Forward & Reverse Directions

Explore the graphic with your mouse.

402
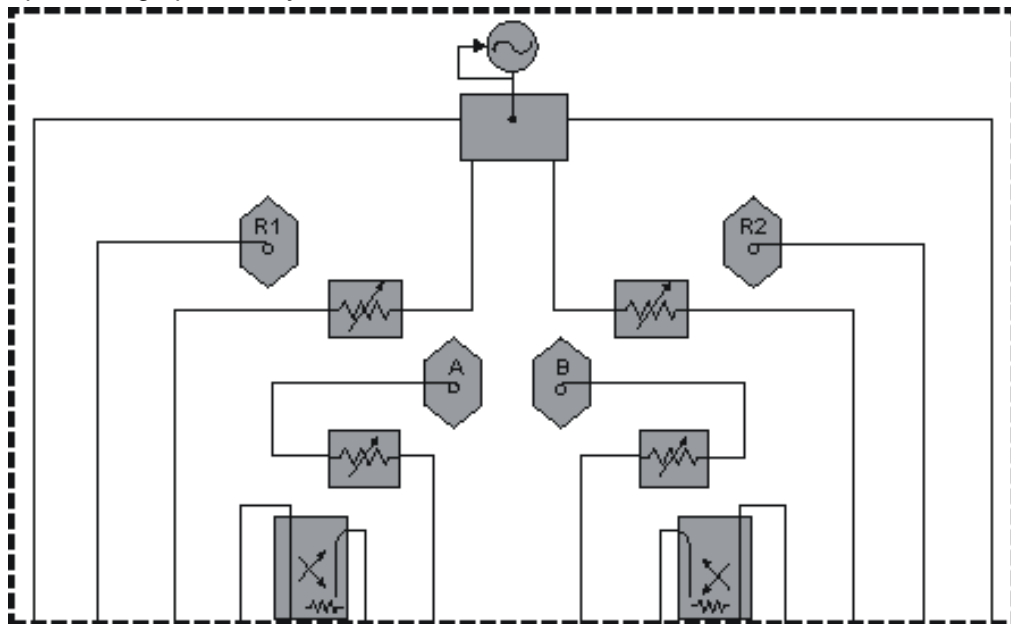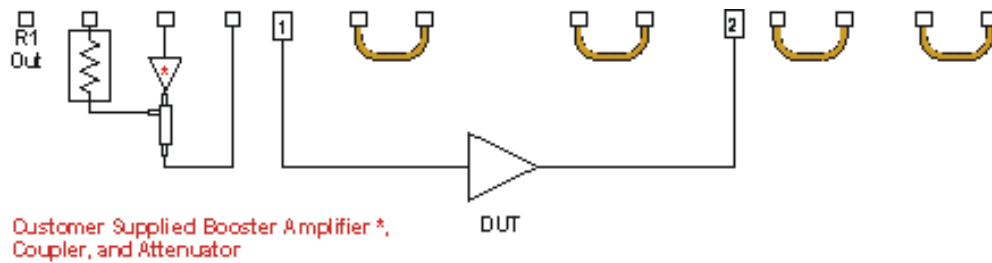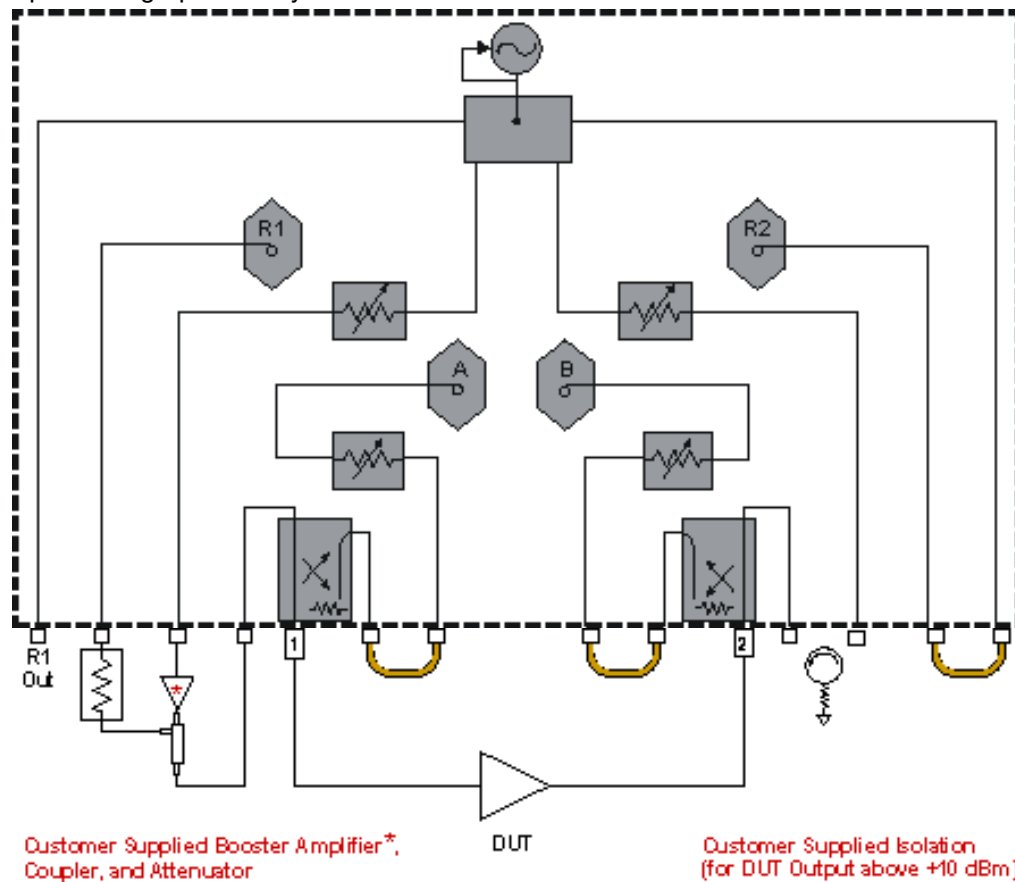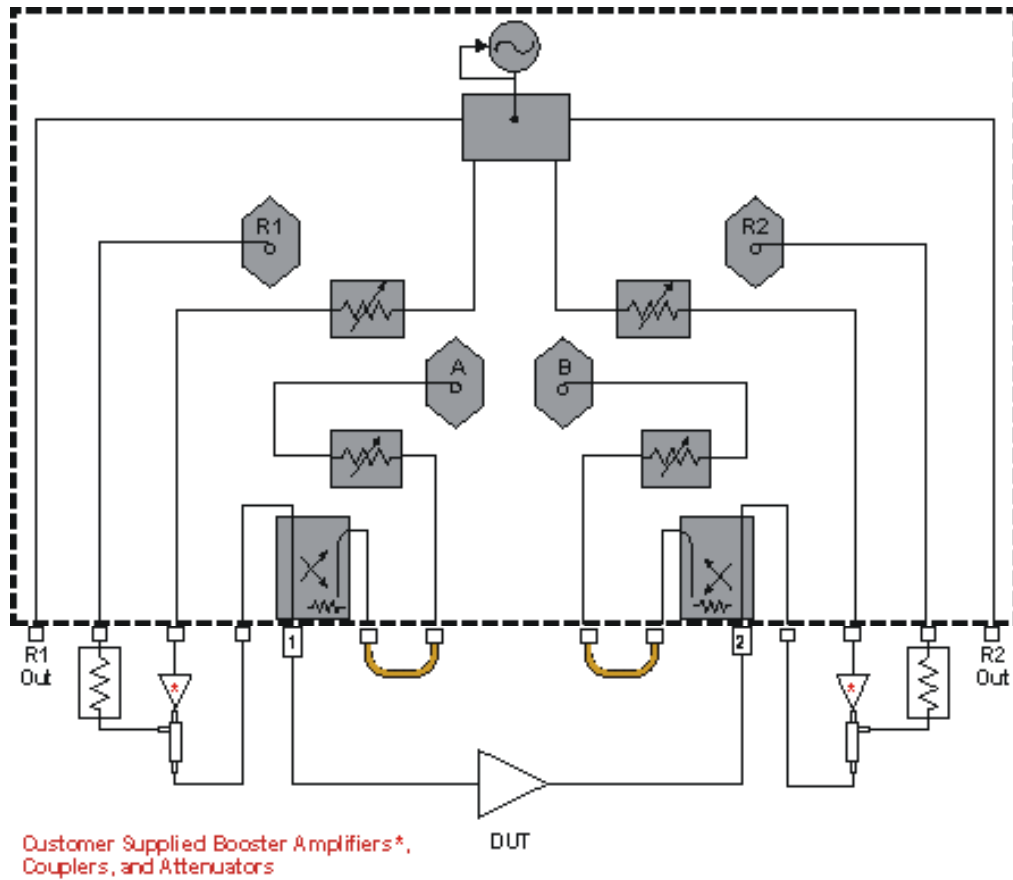
Diagram: (E835x, Option 015) Configuration using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you: a booster amplifier, a forward coupler, and an attenuator.
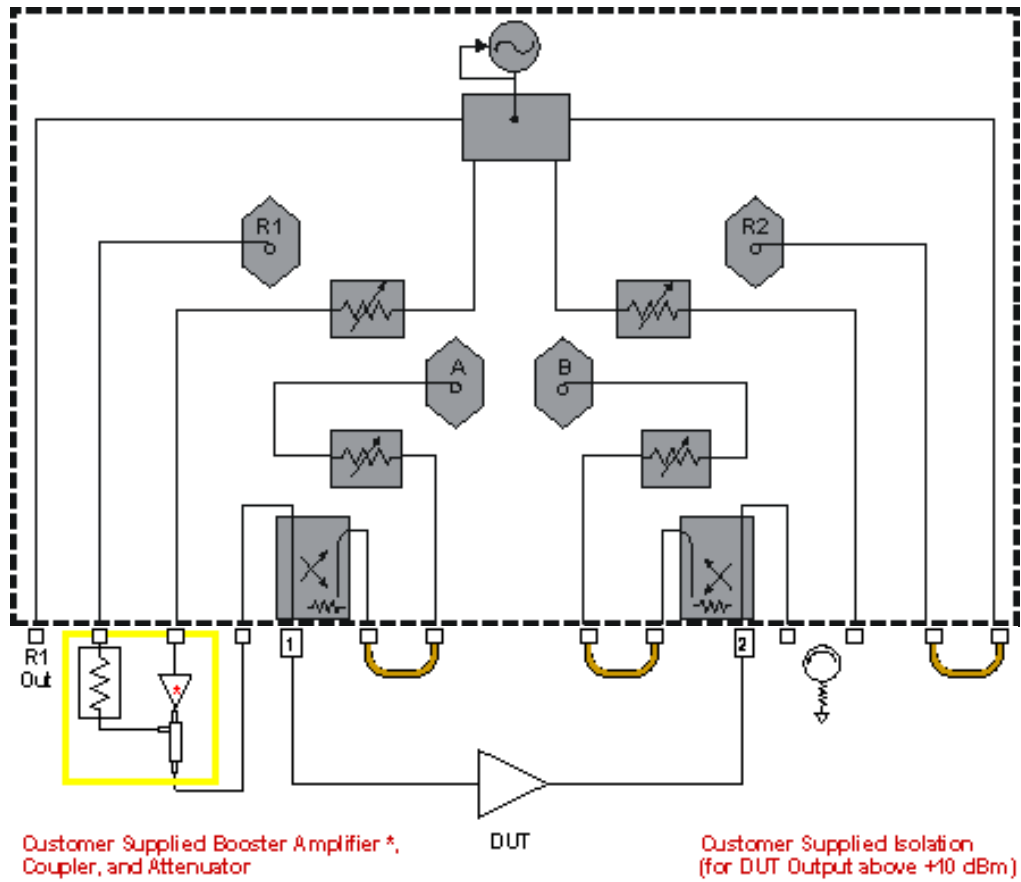
Diagram: (E835xA, Option 015) Configuration Using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you: two booster amps, two forward couplers, and two attenuators.
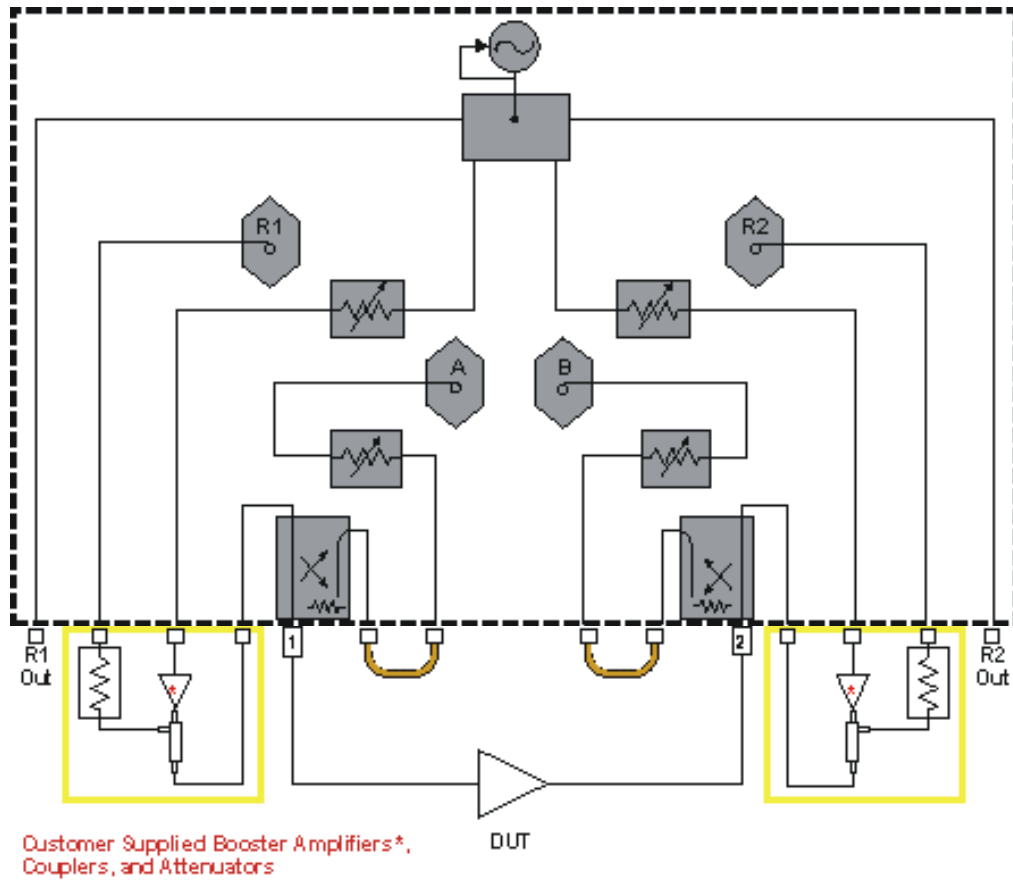
Diagram: (E835x, Option 015) External Leveling using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, power splitter, two attenuators, and a negative detector diode.

R1
Out

Power
Splitter

**

Negative
Detector Diode

External
Detector
Input
(Rear panel
of analyzer)

DUT
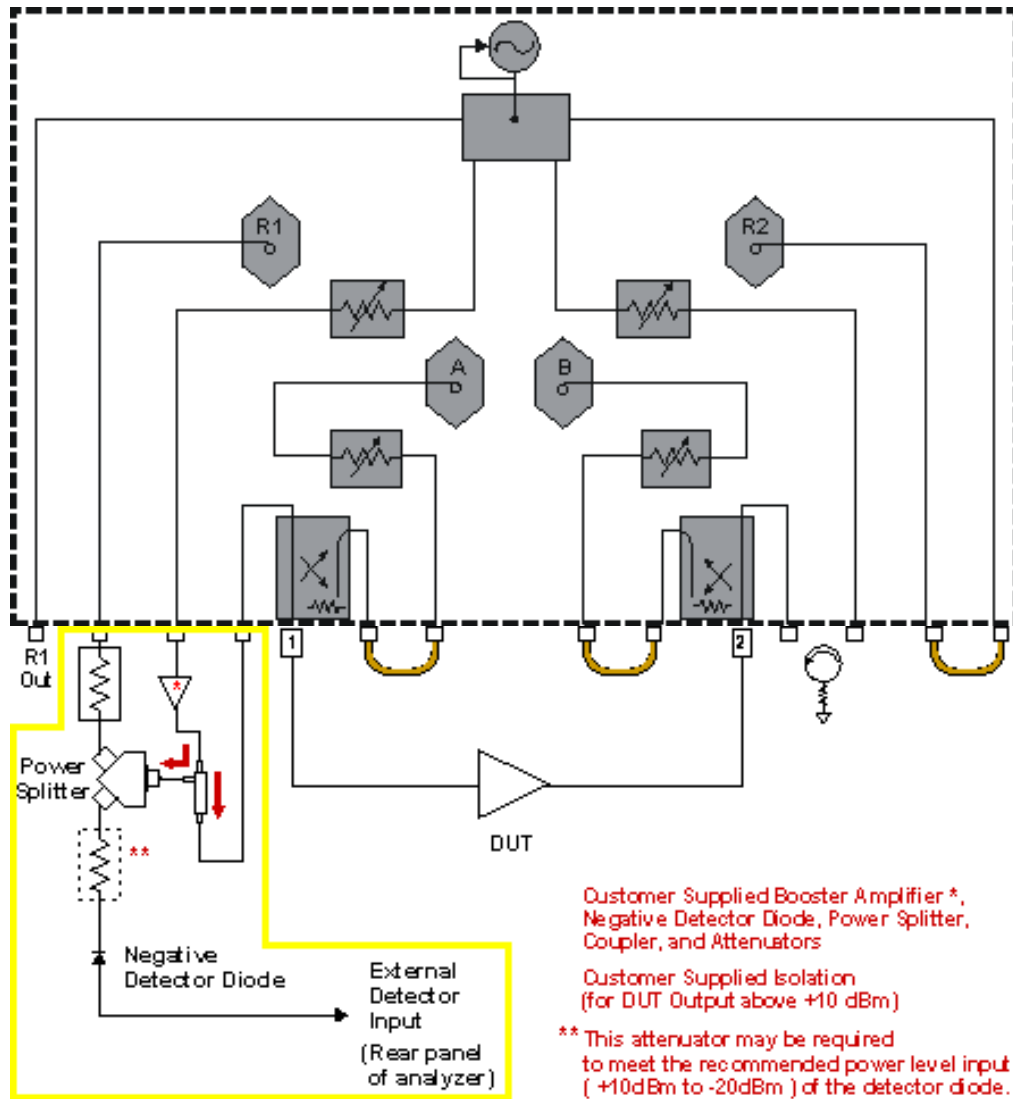
Diagram: (E835xA, Option 015) External Leveling using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you: two booster amps, two forward couplers, three attenuators, three power splitters, and a negative detector diode.
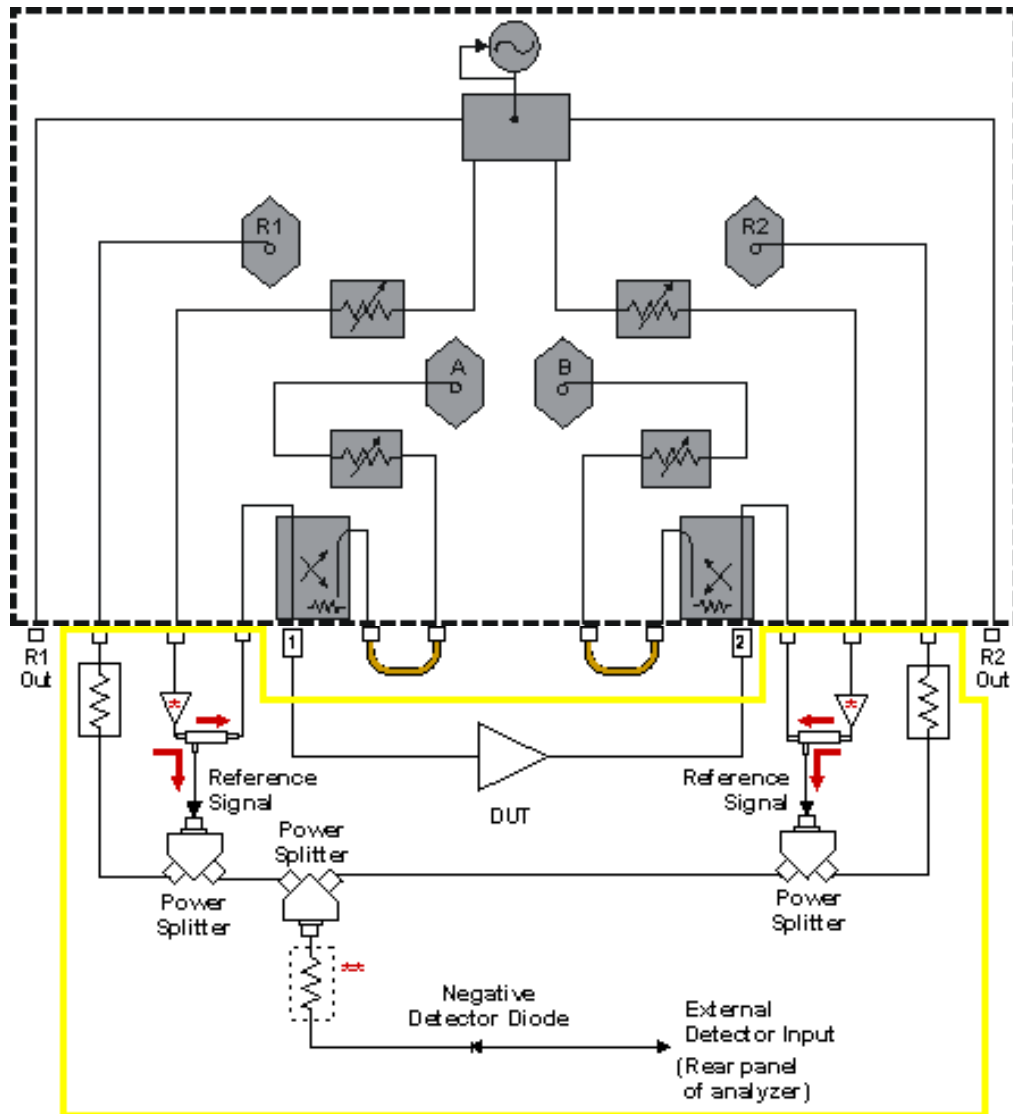
Customer Supplied Booster Amplifiers *, Negative
Detector Diode, Couplers, Power Splitters and Attenuators

** This attenuator may be required to meet
the recommended power level input
(+10dBm to -20dBm) of the detector diode.

Diagram: (E835xA, Option 015) Measuring Calibration Power Levels

Forward Signal
A
B
35 dB
35 dB
1
2
Measure the receiver input power where your external circuitry connects here
DUT
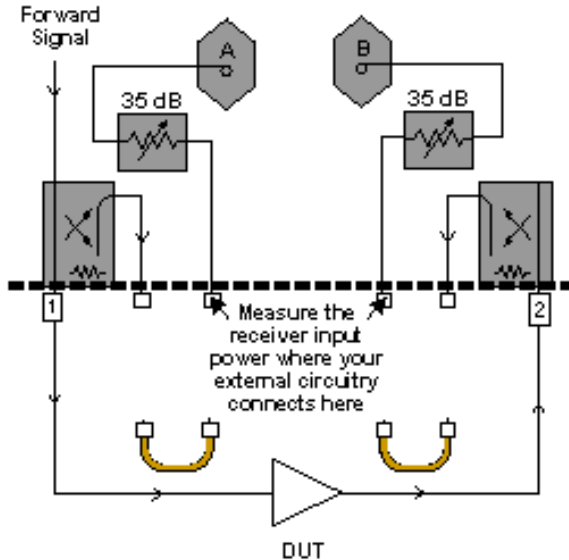
E836x Standard

High-Power Amplifier Measurements Using the E8362A, E8363A, E8364A
_____

High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

_____

Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (The output power capability of your

analyzer is dependent on its configuration, power range, and the output frequency of its source. Find your analyzer's power range in the Technical Specifications.) However, using a booster amp limits the types of testing and calibration you can perform.

Configuration using a booster amp.

Limitations

- Allows only a Thru Response Cal for boosted forward transmission (S_{21}) measurements.

- Allows only a 1-Port Reflection Cal or Open/Short Response Cal for nonboosted reverse reflection (S_{22}) measurements.

- Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

- Reflection measurements on Port 1 or nonboosted reverse transmission measurements are not possible with this configuration. The signal is blocked by the booster amplifier.

How to connect

1. Position the booster amplifier between Port 1 and the DUT.

2. Add an external attenuator to protect the B receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

3. Add an external attenuator between the DUT and Port 2.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers .

Analyzer Upgrades Can Expand the Possibilities for Including a Booster Amplifier

You can choose from other booster amplifier configurations by purchasing the **Option 014** upgrade (Configurable Test Set). See Analyzer Options. Discover the Option 014 measurement possibilities. Option 015 (Configurable Test Set) is not compatible with your analyzer.

Note: External leveling is not possible with the E8362A, E8363A, E8364A.

_____

Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for non-boosted high-power measurements in both forward and reverse directions

    Possible calibration choices:

  o **2-Port Calibration** (TRL or SOLT) for forward and reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in the forward direction (response cal only)

    Possible calibration choices:

  o **Thru Response** for forward high-power transmission measurements.

  o **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection

measurements.

Compare with: Basic Configuration.

As stated earlier, you can choose from the following types of calibration, depending on the configuration you use:

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

_____

Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate and measure with a power level at the A and B receivers that minimizes receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

When making **boosted-power measurements**, adjust the power during calibration (when the DUT is removed) to get a power level at the receivers that safely minimizes receiver compression. Later, **decrease** the power during measurements (when the DUT is installed) to maintain the safe power level at the receivers.

When making **nonboosted-power measurements**, adjust the power during calibration (when the DUT is removed) to get a power level at the receivers that safely minimizes receiver compression. Later, **adjust** the power during measurements (when the DUT is installed) to maintain the safe power level at the receivers.

_____

More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
- Procedure for Measuring High-Power Amplifiers

Diagram: (E8362A, E8363A, E8364A) Basic Configuration

Explore the graphic with your mouse.
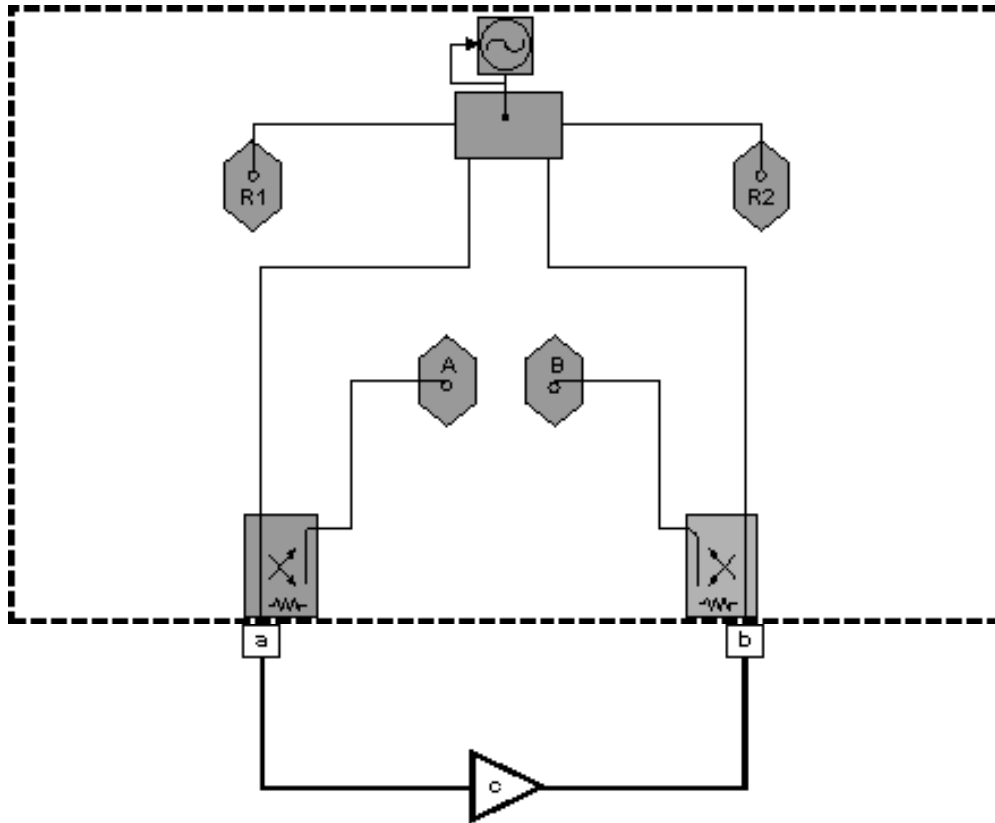
Description
PORT 1
PORT 2
DUT, customer
supplied

Diagram: (E8362A, E8363A, E8364A) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)

Explore the graphic with your mouse.

Description	Description
PORT 1	Attenuator (for forward measurements), customer supplied
PORT 2 Booster amplifier, customer supplied DUT, customer supplied	

Diagram: (E8362A, E8363A, E8364A) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions

Explore the graphic with your mouse.
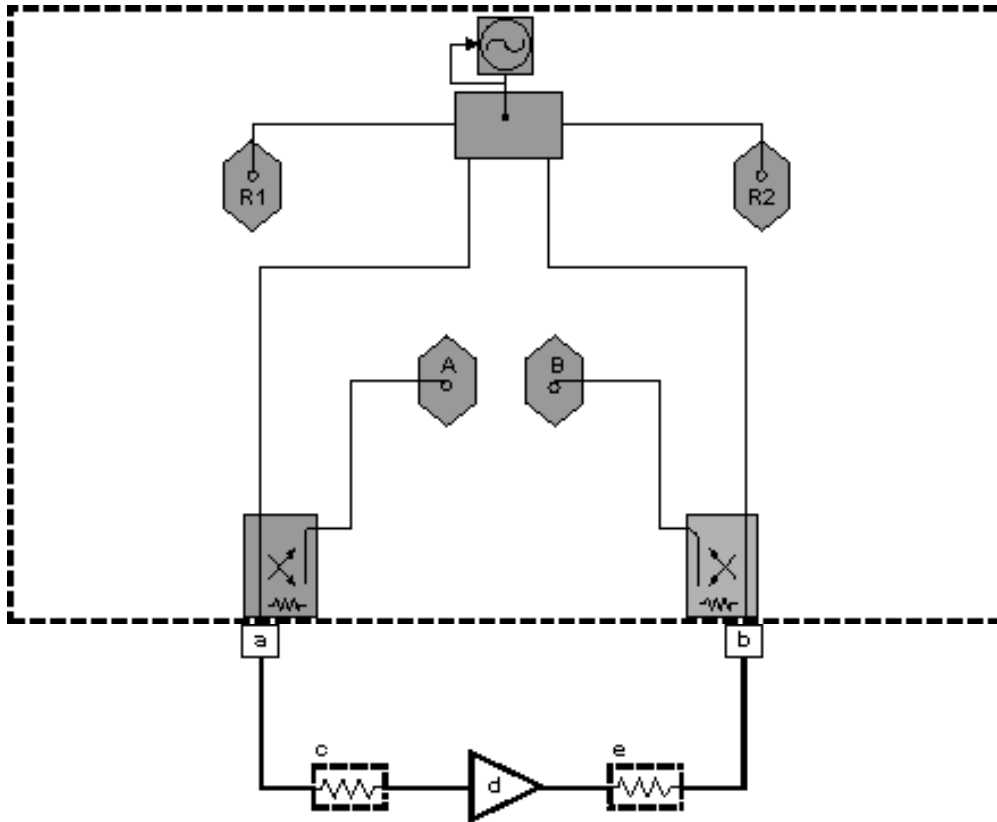
Description	Description
PORT 1	Attenuator (for forward measurements), customer supplied
PORT 2 Attenuator (for reverse measurements), customer supplied DUT, customer supplied	

Diagram: (E8362A, E8363A, E8364A) Configuration using a Booster Amp

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains a booster amplifier supplied by you.
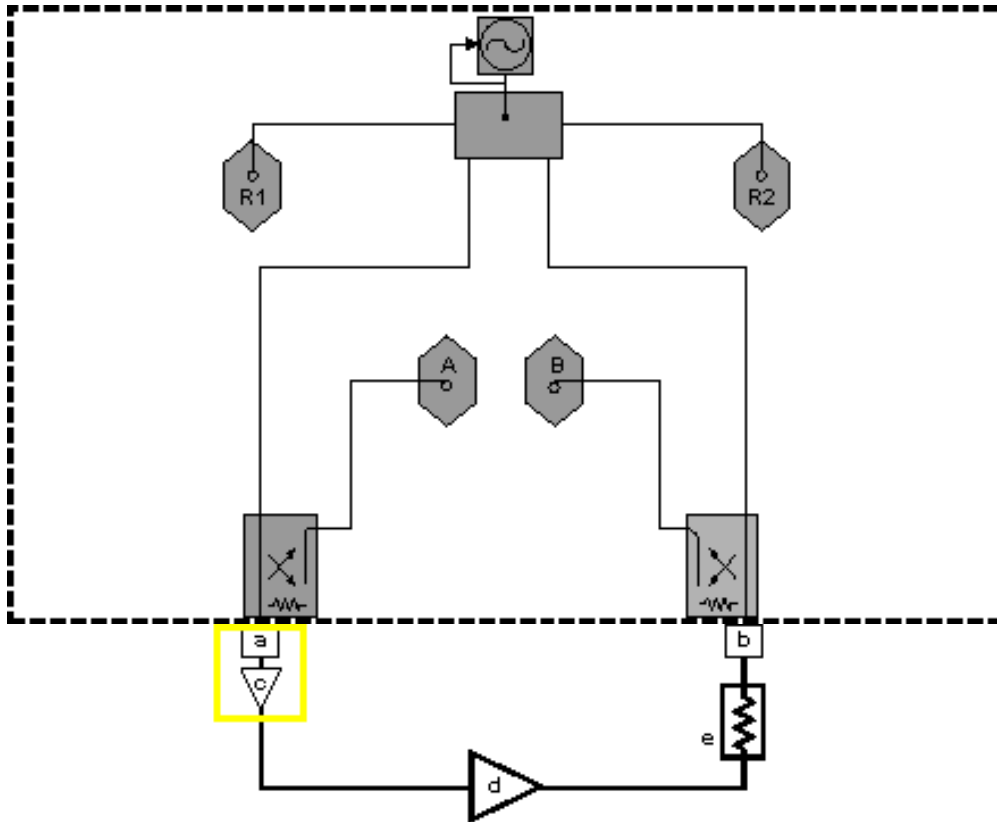
Description	Description
PORT 1	Attenuator (for forward measurements), customer supplied
PORT 2 Booster amplifier, customer supplied DUT, customer supplied	

E836x Opt 014

High-Power Amplifier Measurements Using the E8362A, E8363A, E8364A *Option 014*

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High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.
- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices

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What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

——

Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (The output power capability of your analyzer is dependent on its configuration, power range, and the output frequency of its source. Find your analyzer's output power capability in the Technical Specifications.) However, using a booster amp may limit the types of testing and calibration you can perform.

Here are two ways to configure booster amp circuitry.

1. Configuration Using One Booster Amplifier

Limitations

Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Coupler In channel.

3. Connect the coupled-arm portion of the boosted source signal to the R1 In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

5. Connect an isolator between the Port 2 Coupler In and the Port 2 Source Out.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

2. Configuration Using Two Booster Amplifiers

Limitations

None.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Coupler In channel.

3. Connect the coupled-arm portion of the boosted source signal to the R1 In channel. This

signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

5. Connect a booster amplifier to the Port 2 Source Out channel.

6. Connect a coupler between the booster amplifier and the Port 2 Coupler In channel.

7. Add an external attenuator to protect the R2 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Your **Option 014** (Configurable Test Set) analyzer allows you a choice of booster amplifier configurations. Option 015 (Configurable Test Set) is not compatible with your analyzer.

Note: External leveling is not possible with the E8362A, E8363A, E8364A.

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for high-power measurements in the forward direction

    Possible calibration choices:

    o **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration (with an isolator) for high-power measurements in the forward direction

    Possible calibration choices:

    o **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in both forward and reverse directions

    Possible calibration choices:

    o **2-Port Calibration** (TRL or SOLT) for forward and reverse high-power transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse high-power transmission or reflection measurements.

Compare with: Basic Configuration.

More information on calibration choices:

- Thru, Reflection, Line (TRL) **2-port calibration**: the most accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the

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analyzer. Can be used to measure all four S-parameters. Requires measurement of only three calibrations standards using both forward and reverse signals. For more information, see TRL Cal.

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

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Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate and measure with a power level at the A and B receivers that minimizes receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) Receiver power levels can be measured with a power meter where your external circuitry connects to:

- RCVR A IN
- RCVR B IN

When making **boosted-power measurements**, adjust the power during calibration (when the DUT is removed) to get a power level at the receivers that safely minimizes receiver compression. Later, **decrease** the power during measurements (when the DUT is installed) to maintain the safe power level at the receivers.

When making **nonboosted-power measurements**, adjust the power during calibration (when the DUT is removed) to get a power level at the receivers that safely minimizes receiver compression. Later, **adjust** the power during measurements (when the DUT is installed) to maintain the safe power level at the receivers.

See graphic: Measuring Calibration Power Levels

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More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop

Diagram: (E8362A, E8363A, E8364A, Option 014) Basic Configuration

Explore the graphic with your mouse.

Description	Description	Description
SOURCE OUT	RCVR B IN	DUT, customer supplied
RCVR R1 IN	CPLR ARM	
SOURCE OUT	PORT 2	
CPLR THRU	CPLR THRU	
PORT 1	SOURCE OUT	
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Configuration for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

Description	Description	Description
SOURCE OUT	RCVR B IN	Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	CPLR THRU	DUT, customer supplied
PORT 1	SOURCE OUT	
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

Description	Description	Description
SOURCE OUT	RCVR B IN	Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	CPLR THRU	DUT, customer supplied
PORT 1	SOURCE OUT	Isolator, customer supplied (for DUT output above +10 dBm)
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Configuration using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you: a booster amplifier, a forward coupler, and an attenuator.

Description	Description	Description
SOURCE OUT	RCVR B IN	Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	COUPLER THRU	DUT, customer supplied
PORT 1	SOURCE OUT	Isolator, customer supplied (for DUT output above +10 dBm)
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Configuration Using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you: two booster amps, two forward couplers, and two attenuators.

Description	Description	Description
SOURCE OUT	RCVR B IN	Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	CPLR THRU	DUT, customer supplied
PORT 1	SOURCE OUT	
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Configuration for High-Power Measurements in both Forward & Reverse Directions

Explore the graphic with your mouse.

a b c d e f g h i j k l m n

o q r q o

Description	Description	Description
SOURCE OUT	RCVR B IN	Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	CPLR THRU	DUT, customer supplied
PORT 1	SOURCE OUT	
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

Diagram: (E8362A, E8363A, E8364A, Option 014) Measuring Calibration Power Levels

Description

Measure the receiver input power where your external circuitry connects here
DUT, customer supplied
PORT 1
PORT 2

E880x Standard

High-Power Amplifier Measurements Using the E8801A, E8802A, and E8803A

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High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

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Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp limits the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External leveling for booster amplifiers.

Configuration using a booster amp.

Limitations

- Allows only a <u>Thru Response Cal</u> for boosted forward transmission (S_{21}) measurements.

- Allows only a <u>1-Port Reflection Cal</u> or Open/Short Response Cal for nonboosted reverse reflection (S_{22}) measurements.

- Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

- Reflection measurements on Port 1 or nonboosted reverse transmission measurements are not possible with this configuration. The signal is blocked by the booster amplifier.

How to connect

1. Position the booster amplifier between Port 1 and the DUT.

2. Add an external attenuator to protect the B receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

3. Add an external attenuator between the DUT and Port 2.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Analyzer Upgrades Can Expand the Possibilities for Including a Booster Amplifier

You can choose from other booster amplifier configurations by purchasing the **Option 014** upgrade (Configurable Test Set) See Analyzer Options. Discover the Option 014 measurement possibilities. Option 015 (Configurable Test Set) is not compatible with your analyzer.

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External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

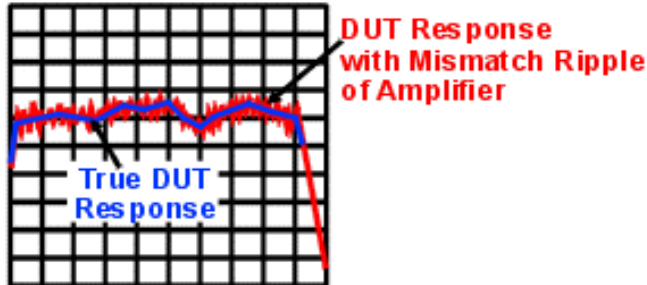### How Do I Determine If I Need to Use External Leveling with my Booster Amplifier?

Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of

peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How Do I Provide External Leveling?

See external leveling configuration. Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to the **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.
- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.
- Making too great a change in the reference-signal power can cause the external leveling function to become ineffective due to the limited power-control range of the analyzer's source.

View external leveling circuitry that uses a DC preamplifier (recommended when the input power-level to the detector diode is less than -20 dBm).

Note: When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

Which Analyzer Menu Choices Do I Select for External Leveling?

1. Select the **Sweep** menu.

2. Select **Sweep Setup**. Select the **External ALC** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for non-boosted high-power measurements in both forward and reverse directions

    Possible calibration choices:

  o **2-Port Calibration** (SOLT) for forward and reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in the forward direction (response cal only)

    Possible calibration choices:

  o **Thru Response** for forward high-power transmission measurements.

  o **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.

Compare with: <u>Basic Configuration</u>.

As stated above, you can choose from the following types of calibration, depending on the configuration you use:

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see <u>1-Port Reflection Cal</u> .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

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Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

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More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
- Procedure for Measuring High-Power Amplifiers

Diagram: (E880xA) Basic Configuration
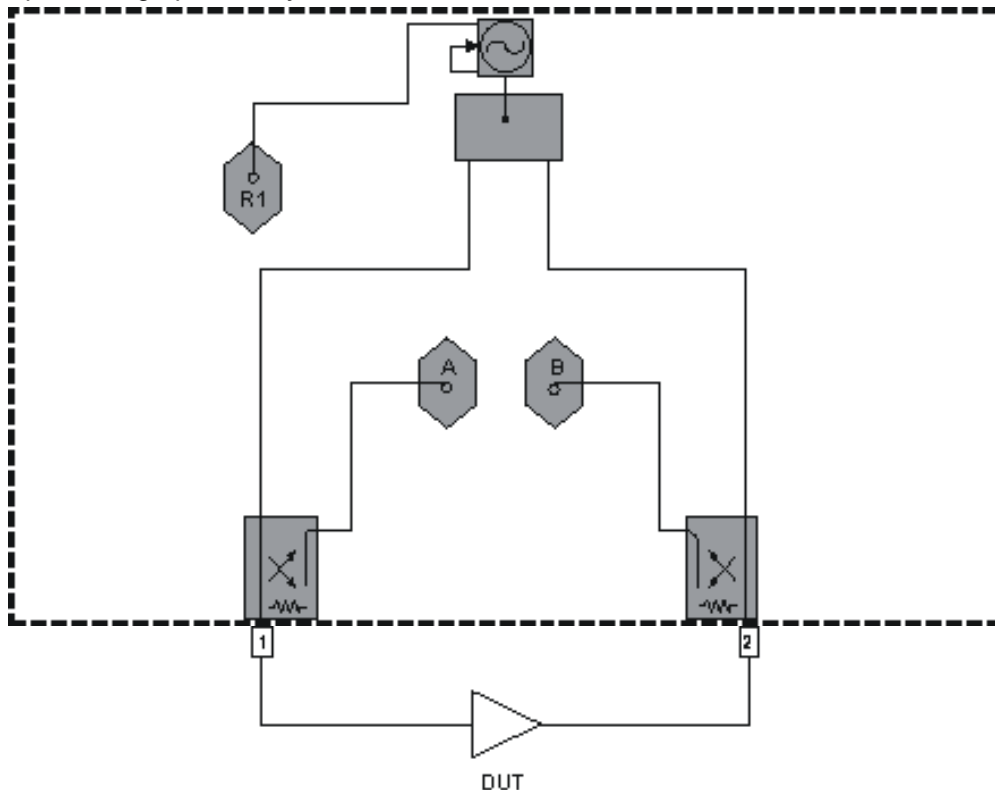
Explore the graphic with your mouse.

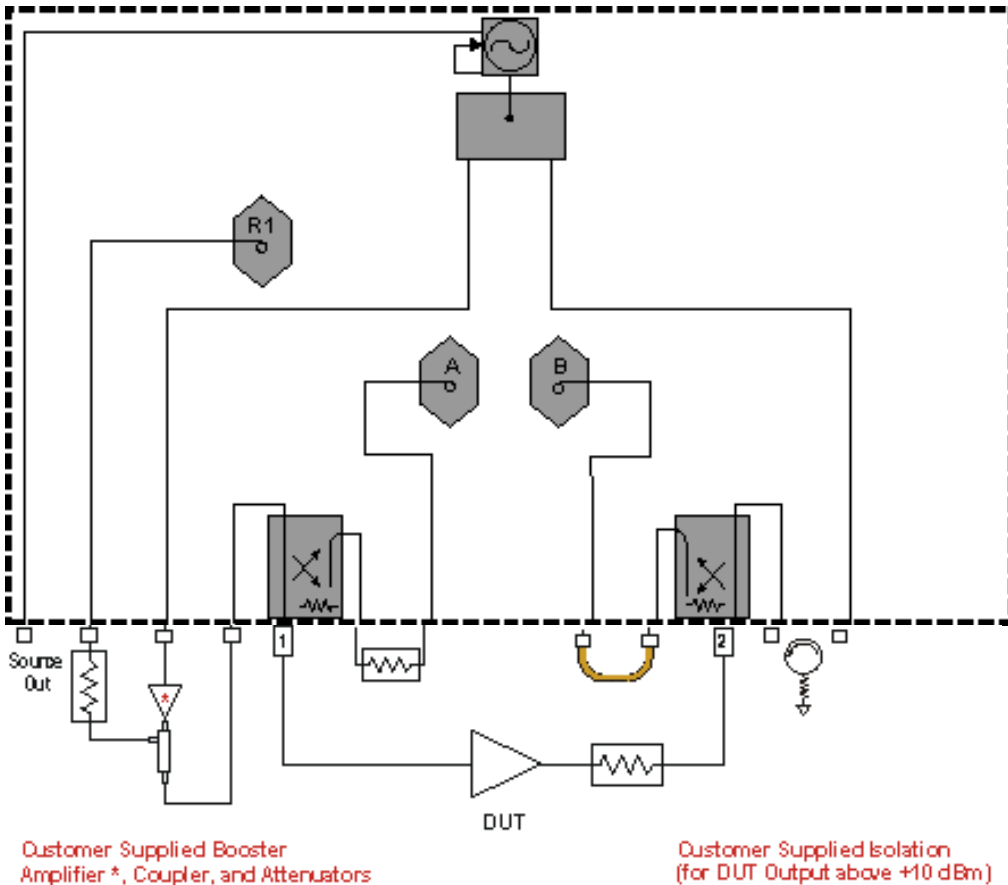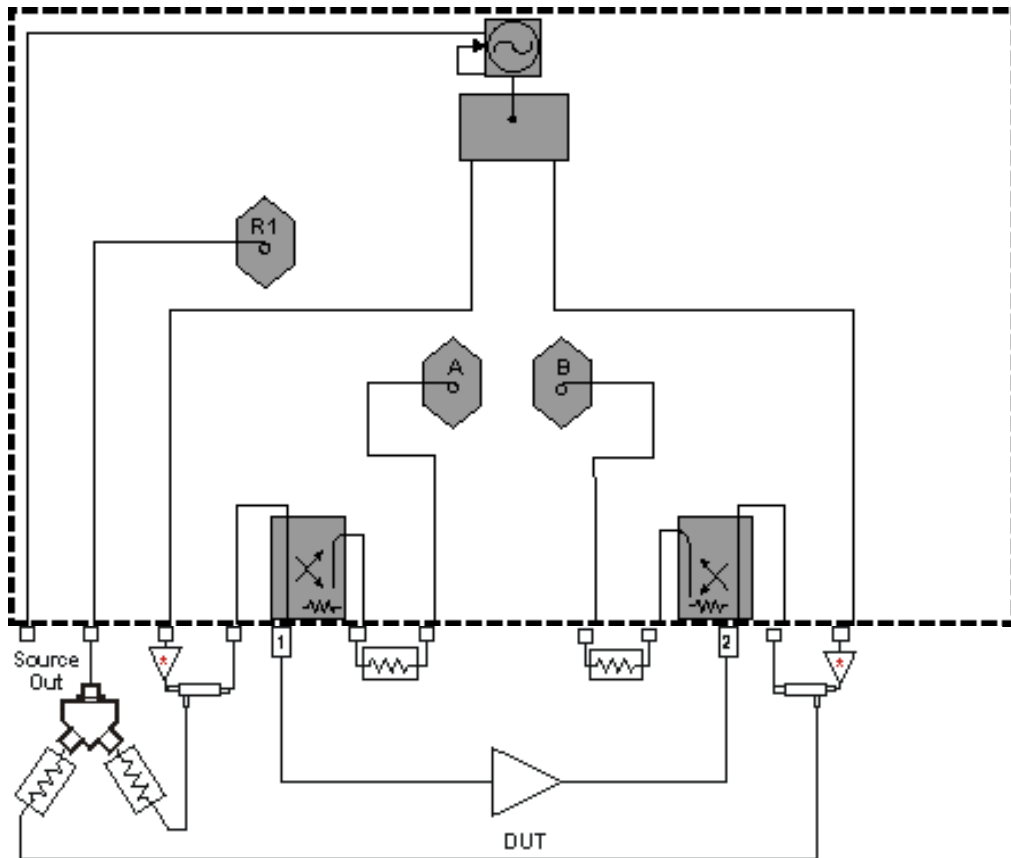## Diagram: (E880xA) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)

Explore the graphic with your mouse.

Customer Supplied Booster
Amplifier *, Coupler and Attenuators

Customer Supplied
External Leveling Circuitry

Diagram: (E880xA) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions

Explore the graphic with your mouse.

For reverse measurements

DUT
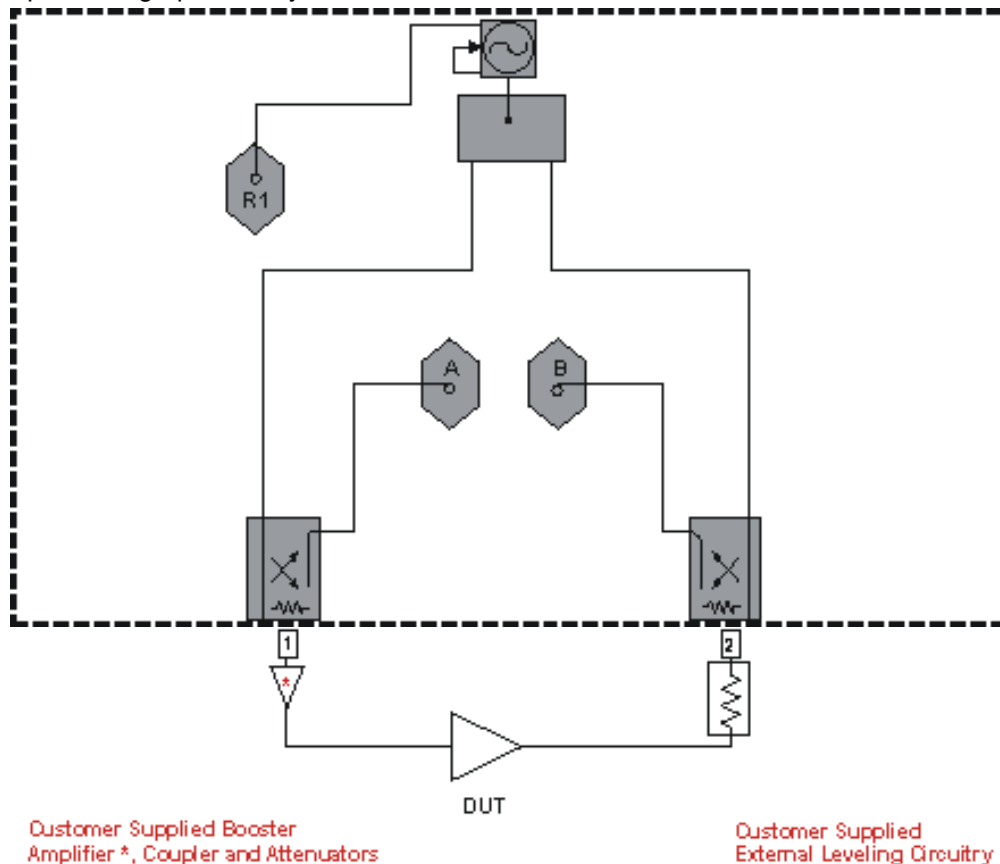
For forward measurements
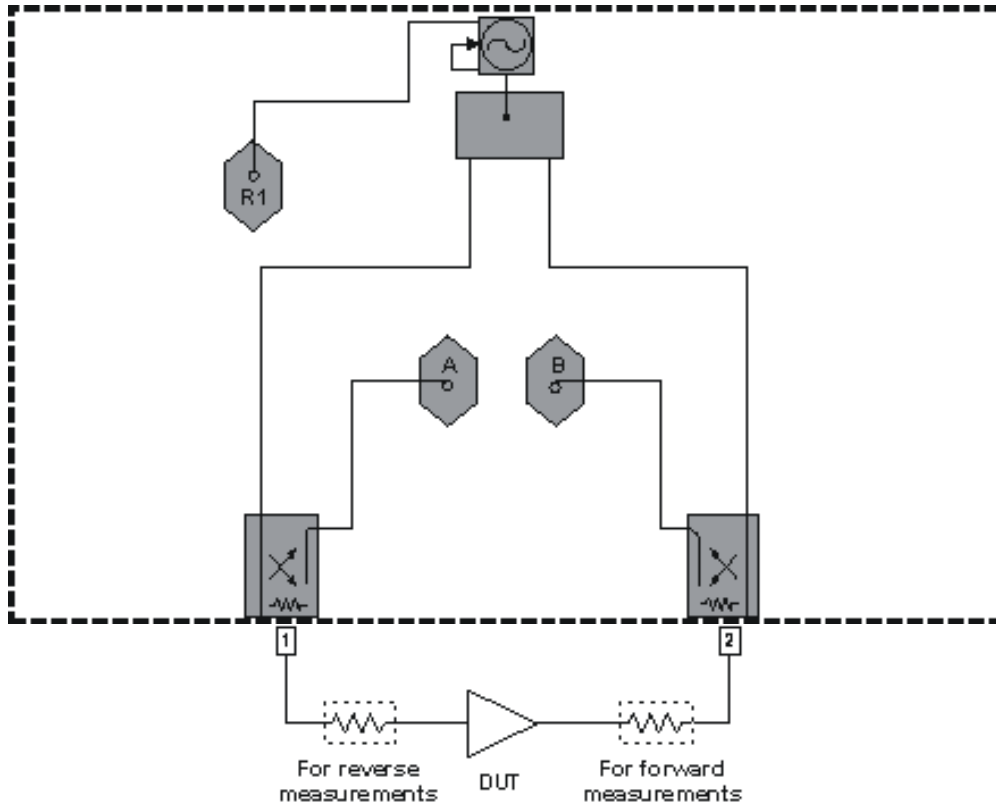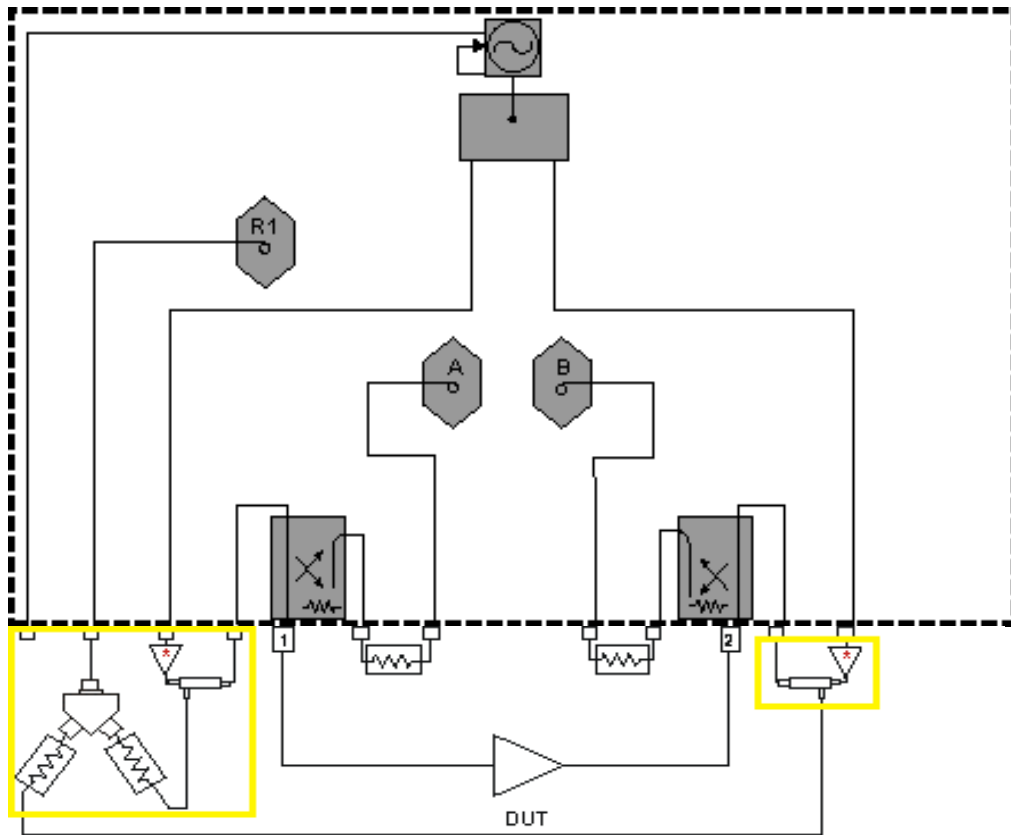
Customer Supplied Attenuator - Location Dependent on Direction of Measurement

Diagram: (E880xA) Configuration using a Booster Amp

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains a booster amplifier supplied by you.

Customer Supplied Booster
Amplifier *, Coupler and Attenuator

Customer Supplied
External Leveling Circuitry
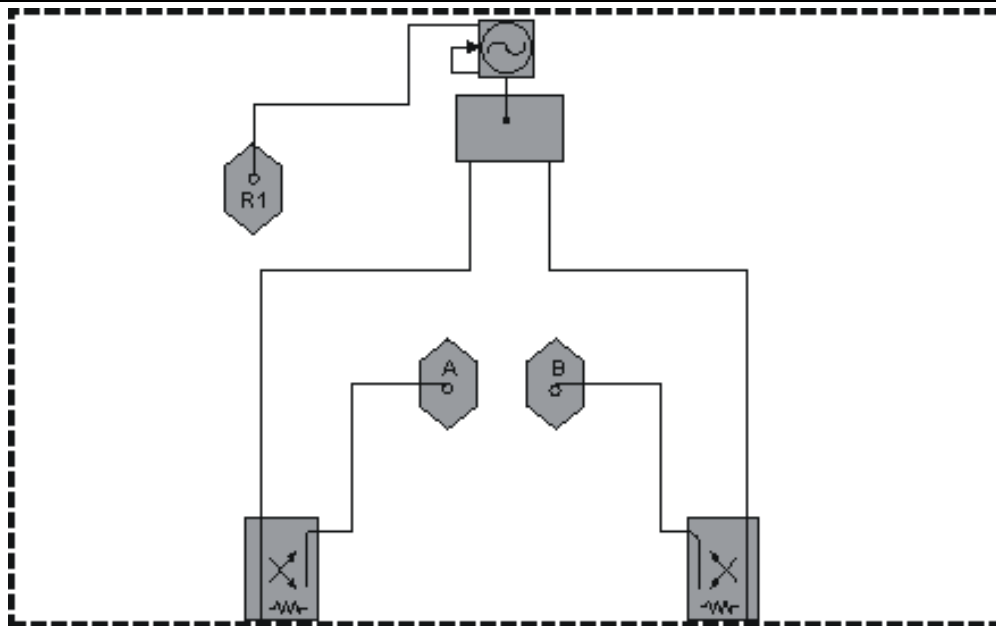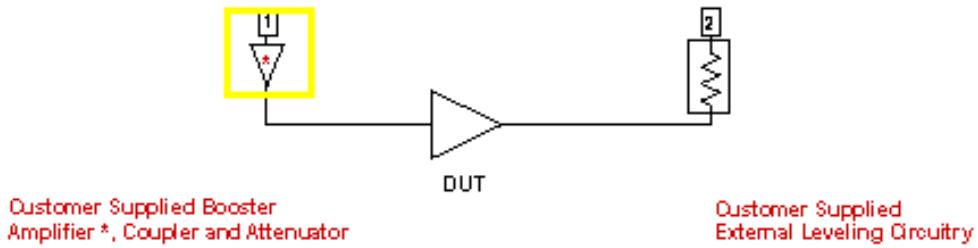
Diagram: (E880xA) External Leveling Configuration

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, forward coupler, attenuator, and negative detector diode.
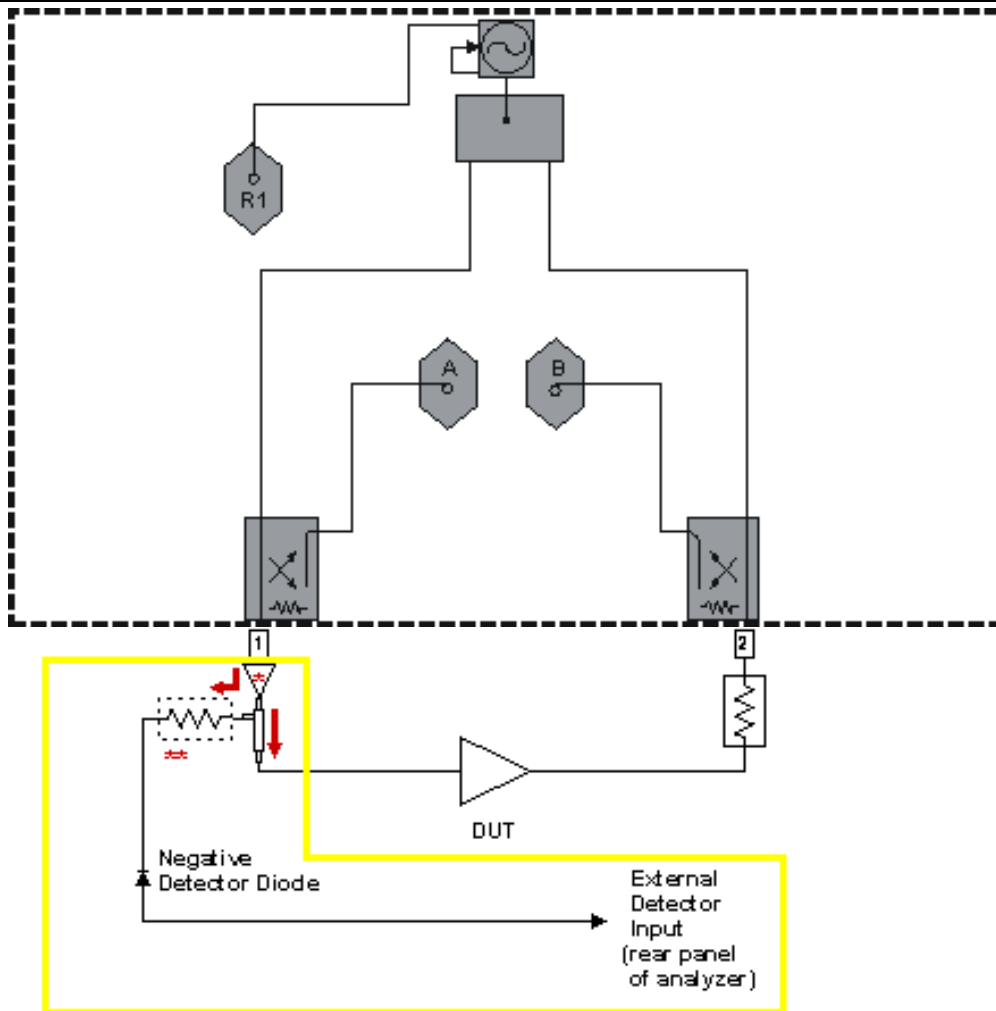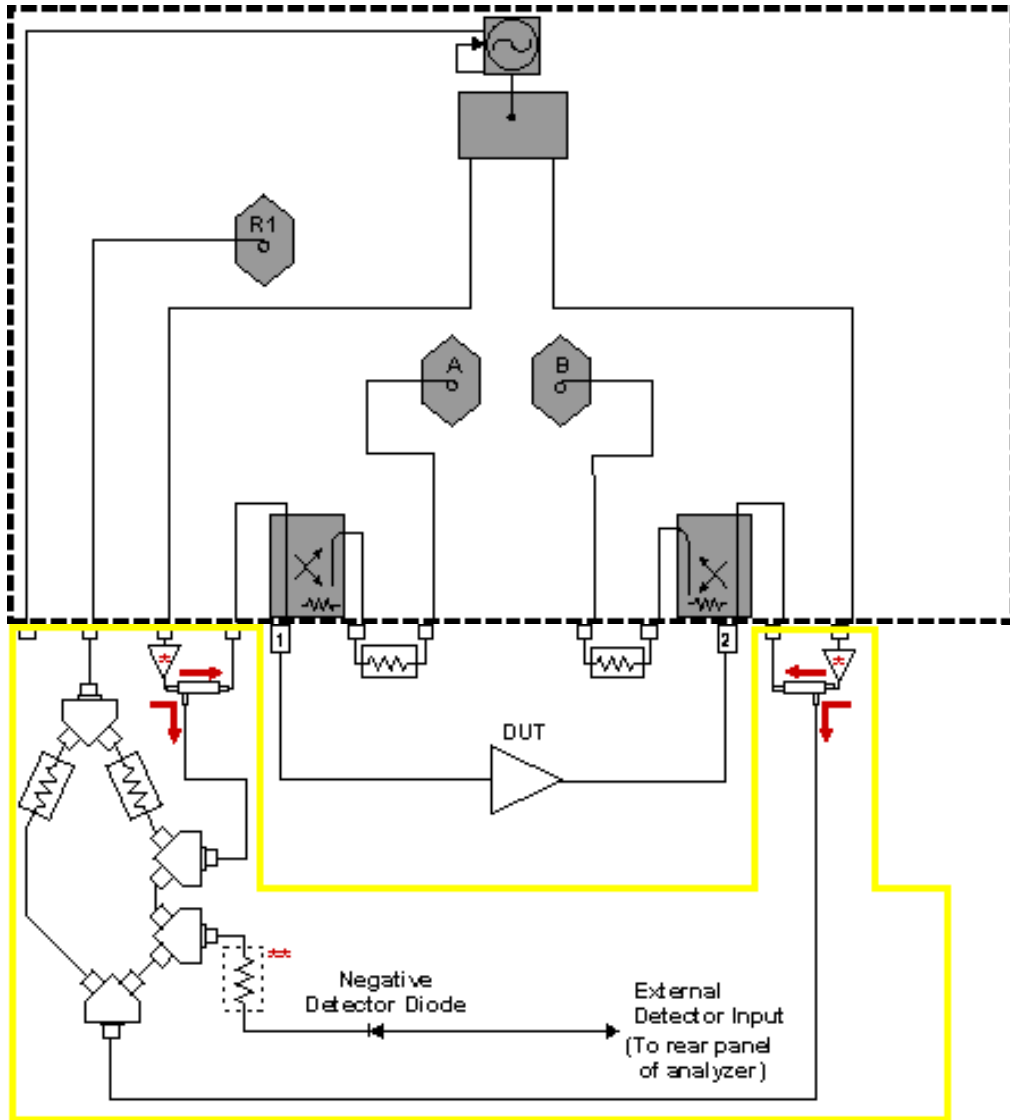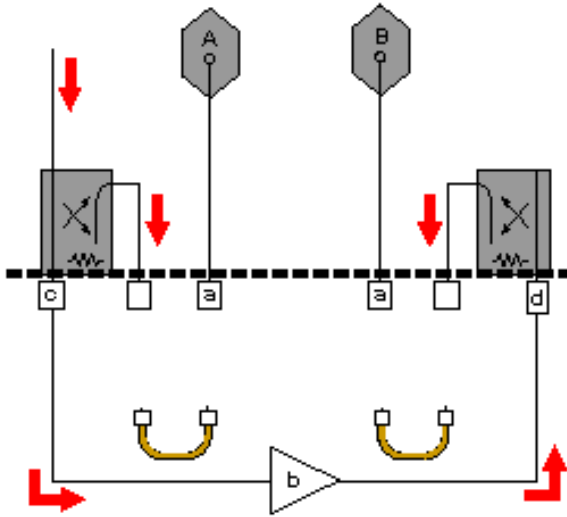

Customer Supplied Booster Amplifier *,
Negative Detector Diode, Coupler and Attenuators

** This attenuator may be required to meet
the recommended power level input
(+10dBm to -20dBm) of the detector diode.

E880x Opt 014

High-Power Amplifier Measurements Using the E8801A *Option 014*, E8802A *Option 014*, and E8803A *Option 014*

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High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

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Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp may limit the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External Leveling for Booster Amplifiers.

Here are two ways to configure booster amp circuitry.

1. Configuration Using One Booster Amplifier

Limitations

Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Cplr Thru channel.

3. Connect the coupled-arm portion of the boosted source signal to the Rcvr R In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

5. Add an external attenuator between the Cplr Arm and the Rcvr A In to protect the A receiver from excessive power.

6. Add an external attenuator between the DUT and Port 2.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

2. Configuration Using Two Booster Amplifiers

Limitations

None.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Cplr Thru channel.

3. Connect a booster amplifier to the Port 2 Source Out channel.

4. Connect a coupler between the booster amplifier and the Port 2 Cplr Thru channel.

5. Connect a power splitter to the Rcvr R In channel.

6. Connect attenuators to each arm of the power splitter to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

7. Connect the coupler at the Port 1 booster amplifier to an arm of the power splitter.

8. Connect the coupler at the Port 2 booster amplifier to the other arm of the power splitter.

9. Add an external attenuator between the Cplr Arm and the Rcvr A In to protect the A receiver from excessive power.

10. Add an external attenuator between the Cplr Arm and the Rcvr B In to protect the B receiver from excessive power.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Your **Option 014** (Configurable Test Set) analyzer allows you a choice of booster amplifier configurations. Option 015 (Configurable Test Set) is not compatible with your analyzer.
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External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

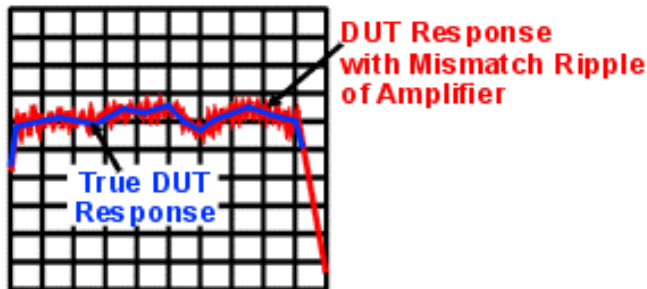### How do I Determine If I Need to Use External Leveling with my Booster Amplifier?

Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How do I Provide External Leveling?

External leveling circuitry is shown in two different test setup configurations:

- external leveling using one booster amplifier
- external leveling using two booster amplifiers.

Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to a power splitter (see graphics above). From the power splitter, the reference signal gets routed to two places:

- The analyzer's front-panel "Rcvr R In" input for the internal reference receiver.
- The **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.
- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.
- Making too great a change in the reference-signal power can cause the external leveling function to become ineffective due to the limited power-control range of the analyzer's source.

View <u>external leveling circuitry that uses a DC preamplifier</u> (recommended when the input power-level to the detector diode is less than -20 dBm).

Note: When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

Which Analyzer Menu Choices do I Select for External Leveling?

1. Select the **Sweep** menu.
2. Select **Sweep Setup**. Select the **External ALC** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."
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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for high-power measurements in the forward direction

    Possible calibration choices:

  o **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration (with an isolator) for high-power measurements in the forward direction

    Possible calibration choices:

  o **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Also for reverse non-boosted transmission or reflection measurements.

  o configuration for high-power measurements in both forward and reverse directions

    Possible calibration choices:

  o **2-Port Calibration** (SOLT) for forward and reverse high-power transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse high-power transmission or reflection measurements.

Compare with: <u>Basic Configuration</u>.

 More information on calibration choices:

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see

SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

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Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) Receiver power levels can be measured with a power meter where your external circuitry connects to:

- RCVR A IN
- RCVR B IN

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

See graphic: Measuring Calibration Power Levels
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More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
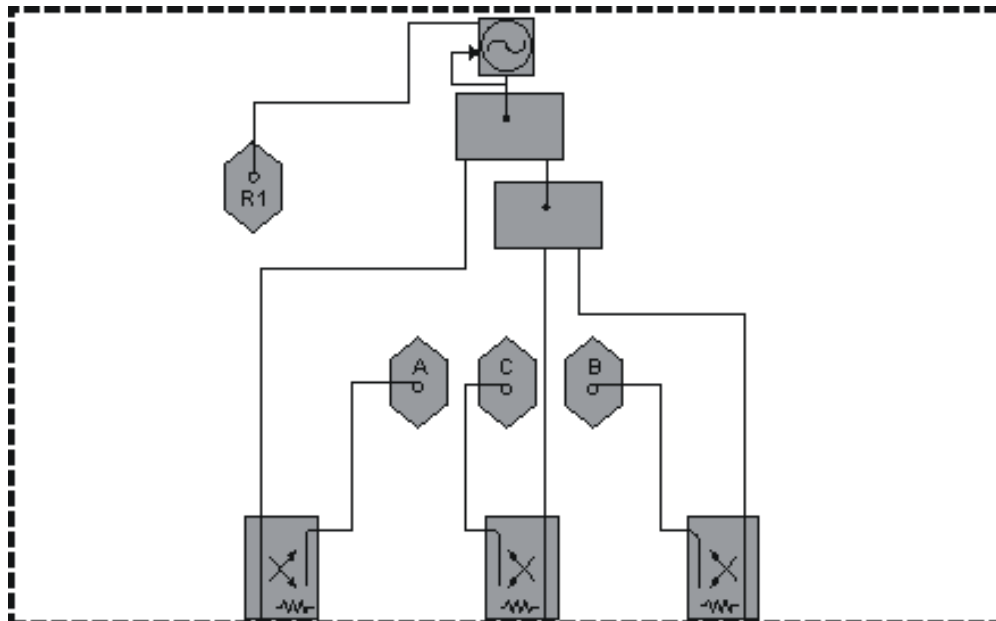- Procedure for Measuring High-Power Amplifiers
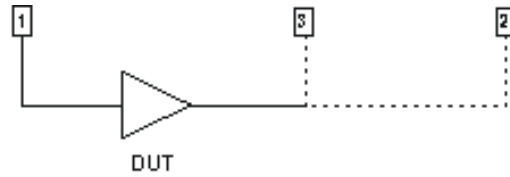
Diagram: (E880xA, Option 014) Basic Configuration

Explore the graphic with your mouse.

Diagram: (E880xA, Option 014) Configuration for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

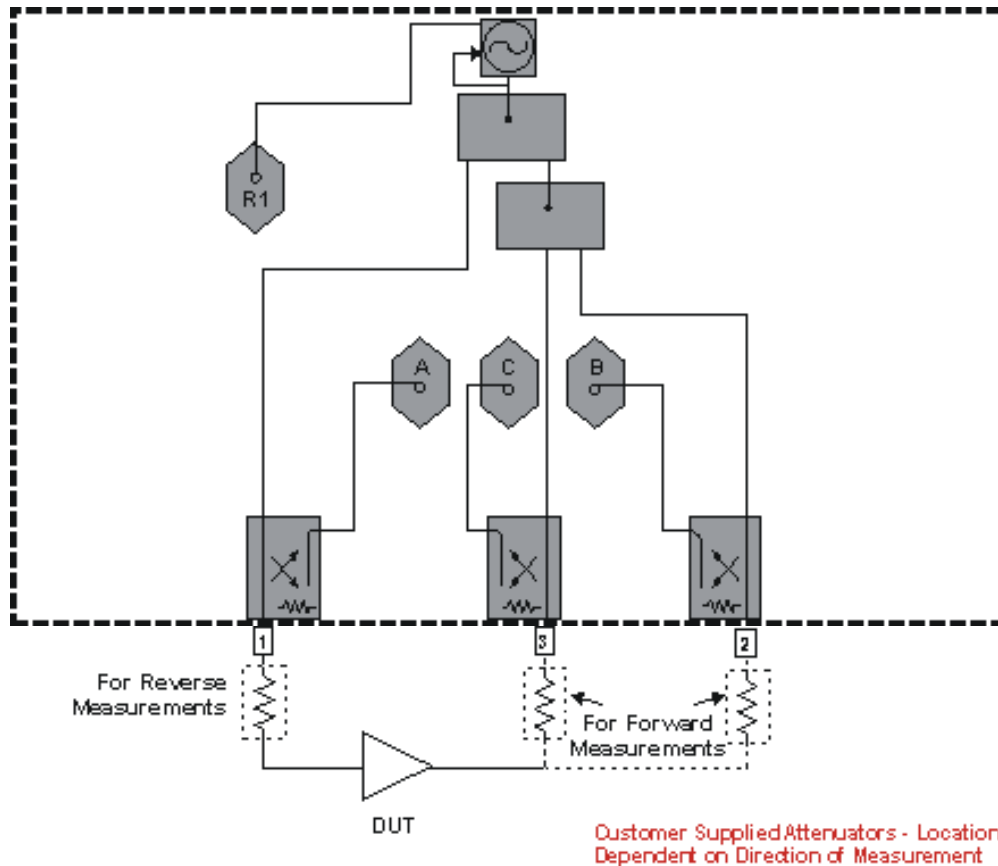Customer Supplied Booster
Amplifier *, Coupler, and Attenuators

Diagram: (E880xA, Option 014) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

Customer Supplied Booster
Amplifier *, Coupler, and Attenuators

Customer Supplied Isolation
(for DUT Output above +10 dBm)

Diagram: (E880xA, Option 014) Configuration for High-Power Measurements in both Forward and Reverse Directions

Explore the graphic with your mouse.

Customer Supplied Booster Amplifiers *,
Couplers, Attenuators and Power Splitter

Diagram: (E880xA, Option 014) Configuration Using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, and an attenuator.

Customer Supplied Booster
Amplifier *, Coupler, and Attenuators

Diagram: (E880xA, Option 014) Configuration Using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amplifiers, two forward couplers, two attenuators, and a power splitter.

Customer Supplied Booster Amplifiers *,
Couplers, Attenuators and Power Splitter

Diagram: (E880xA, Option 014) External Leveling using One Booster Amplifier

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, two attenuators, a power splitter, and a negative detector diode.

Power Splitter

Negative Detector Diode

External Detector Input (Rear panel of analyzer)

DUT

Customer Supplied Booster Amplifier *, Negative Detector Diode, Coupler, Power Splitter, and Attenuators

** This attenuator may be required to meet the recommended power level input (+10dBm to -20dBm) of the detector diode.

Diagram: (E880xA, Option 014) External Leveling using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amplifiers, two forward couplers, two attenuators, four power splitters, and a negative detector diode.

**** This attenuator may be required to meet
the recommended power level input
(+10dBm to -20dBm) of the detector diode.

Customer Supplied Booster Amplifiers *,
Couplers, Negative Detector Diode,
Attenuators and Power Splitters

Diagram: (E880xA, Option 014) Measuring Calibration Power Levels

Description
Measure the receiver input power where your external circuitry connects here
DUT, customer supplied
PORT 1
PORT 2

N338x Standard

High-Power Amplifier Measurements Using the N3381A, N3382A, and N3383A

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High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

_____

Note: Many of the external components shown in the test set-up configurations of this tutorial are

available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp limits the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External leveling for booster amplifiers.

Configuration using a booster amplifier

Limitations

- Allows only a Thru Response Cal for boosted forward transmission (S_{21}) measurements.

- Allows only a 1-Port Reflection Cal or Open/Short Response Cal for nonboosted reverse reflection (S_{22}) or (S_{33}) measurements.

- Reverse *boosted-power* measurements are not possible unless the booster amp is relocated.

- Reflection measurements on Port 1 or nonboosted reverse transmission measurements are not possible with this configuration. The signal is blocked by the booster amplifier.

How to connect

1. Position the booster amplifier between Port 1 and the DUT.

2. Add an external attenuator between the DUT and Port 2 or Port 3 to protect the B or the C receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Analyzer Upgrades can Expand the Possibilities for Including a Booster Amplifier

You can choose from other booster amplifier configurations by purchasing the **Option 014** upgrade (Configurable Test Set). See Analyzer Options. Discover the Option 014 measurement possibilities. Option 015 (Configurable Test Set) is not compatible with your analyzer.

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External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

How do I Determine if I Need to Use External Leveling with my Booster Amplifier?

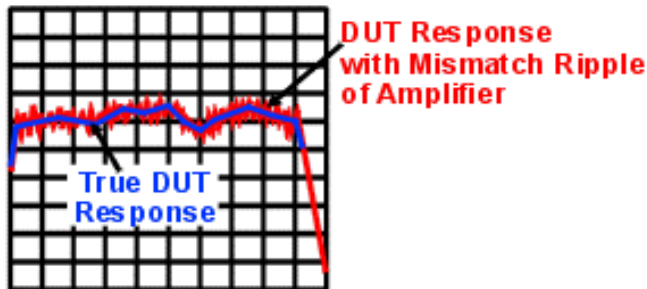Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

DUT Response with Mismatch Ripple of Amplifier

True DUT Response

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How do I Provide External Leveling?

External leveling circuitry is shown in external leveling configuration. Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to the **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.
- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.
- Making too great a change in the reference-signal power can cause the external leveling function to become ineffective due to the limited power-control range of the analyzer's source.

View external leveling circuitry that uses a DC preamplifier (recommended when the input power-level to the detector diode is less than -20 dBm).

Which Analyzer Menu Choices do I Select for External Leveling?

1. Select the **Sweep** menu.
2. Select **Sweep Setup**. Select the **External ALC** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for non-boosted high-power measurements in both forward and reverse directions

  Possible calibration choices:

  o **2-Port Calibration** (SOLT) for forward and reverse non-boosted transmission and reflection measurements.

  o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in the forward direction (response cal only)

  Possible calibration choices:

  o **Thru Response** for forward high-power transmission measurements.

  o **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.

Compare with: Basic Configuration.

Note: If testing a duplex base-station filter with a built-in preamp, you would ideally use a 3-port calibration.

As stated above, you can choose from the following types of calibration, depending on the configuration you use:

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either

a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
- Procedure for Measuring High-Power Amplifiers

Diagram: (N338x) Basic Configuration

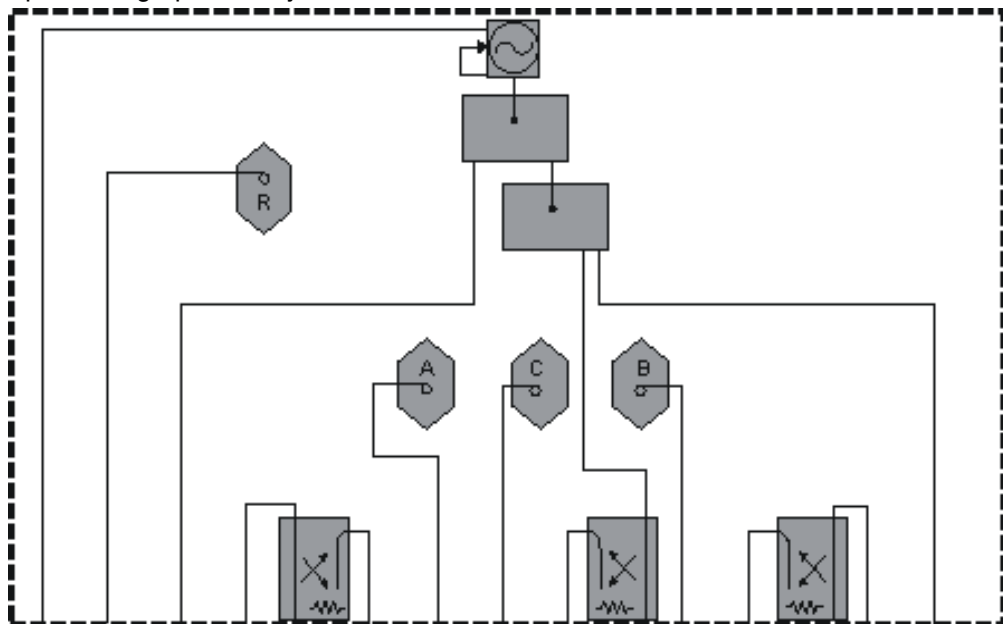Explorethe graphic with your mouse.

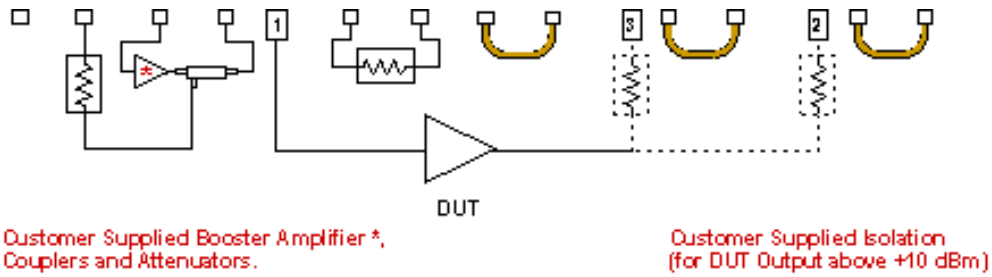
Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

DUT

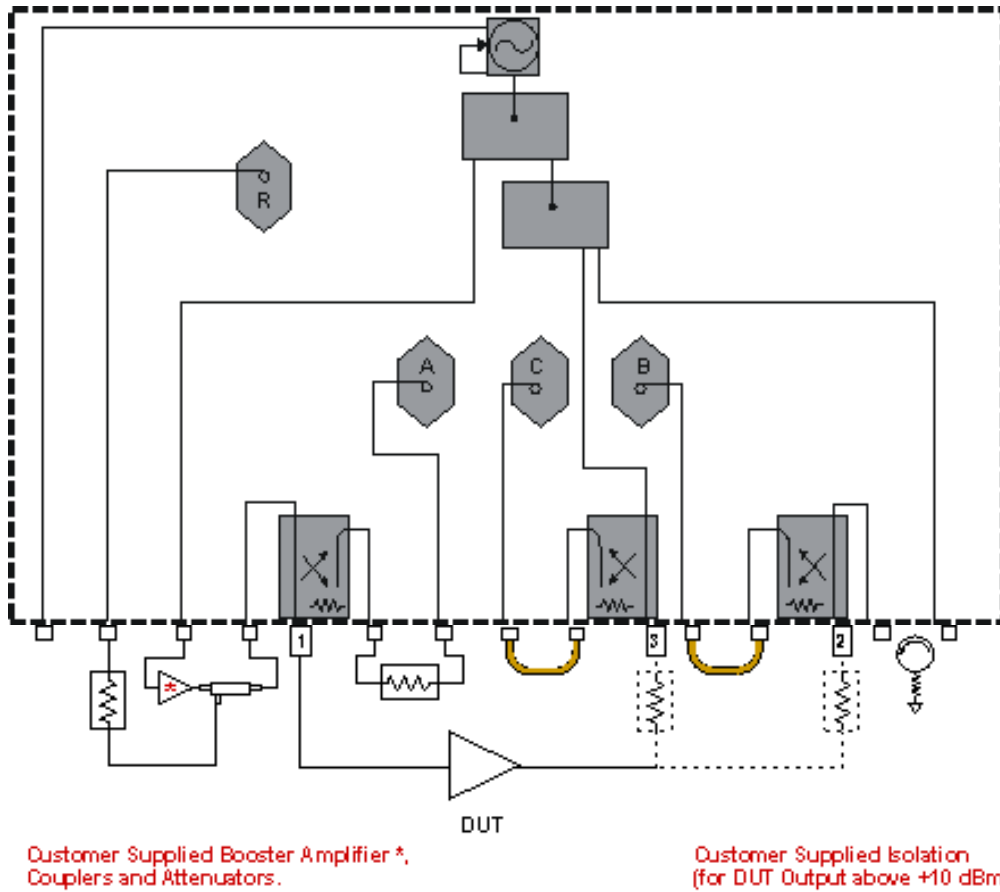## Diagram: (N338x) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

R1

A   C   B

Booster Amp

1   3   2

DUT

Customer Supplied Booster
Amplifier and Attenuator

Diagram: (N338x) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

For Reverse Measurements

For Forward Measurements

DUT

Customer Supplied Attenuators - Location
Dependent on Direction of Measurement

Diagram: (N338x) Configuration using a Booster Amplifier

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT. The circuitry inside the yellow lines contains a booster amplifier supplied by you.

Customer Supplied Booster
Amplifier and Attenuator

Diagram: (N338x) External Leveling Configuration

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT. The circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, an attenuator, and a negative detector diode.
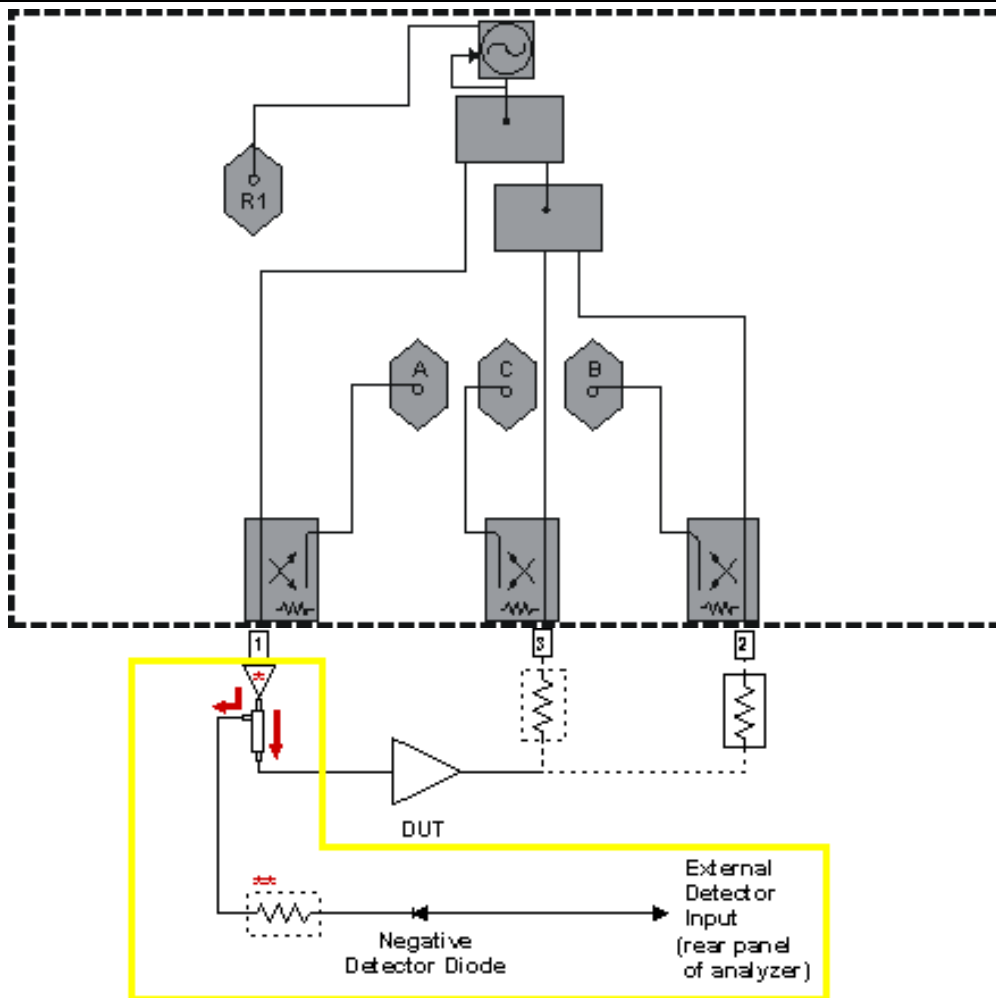
Customer Supplied Booster Amplifier *,
Negative Detector Diode, Coupler and Attenuators

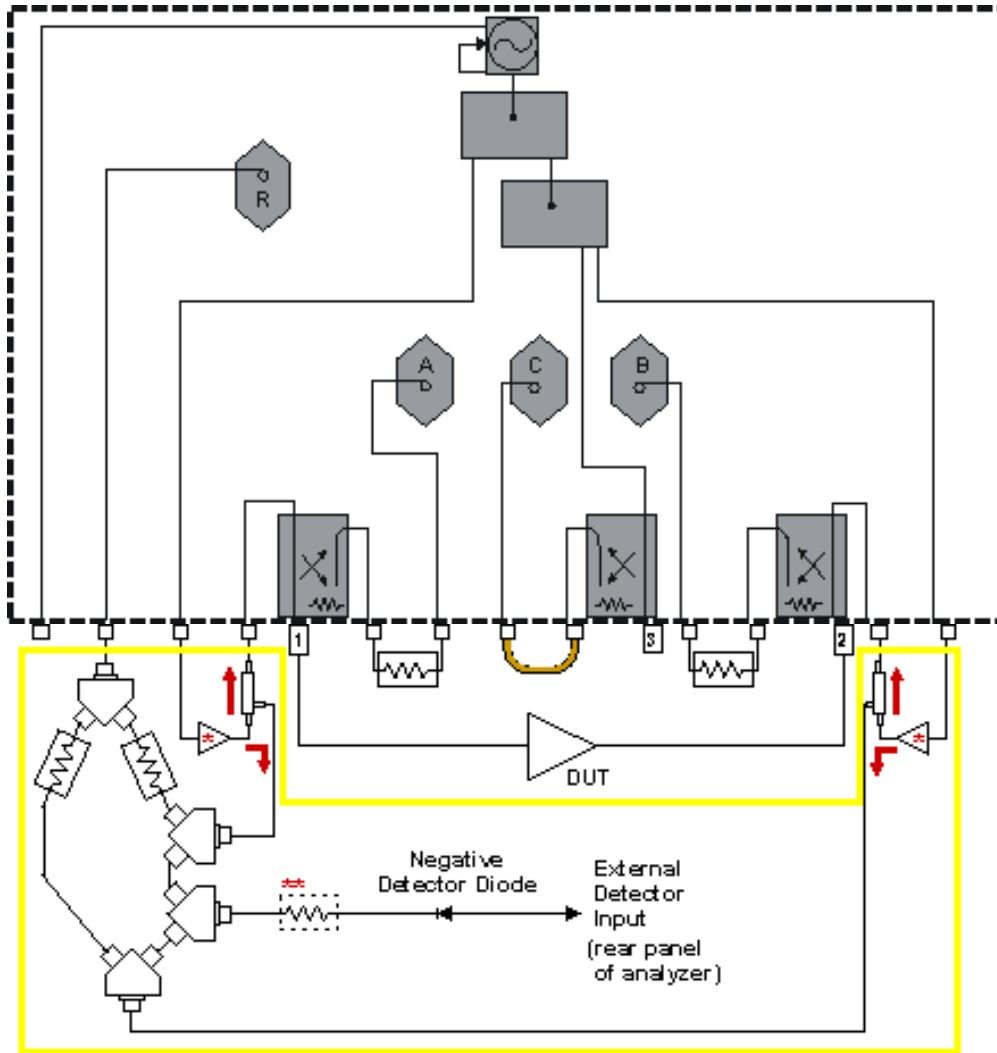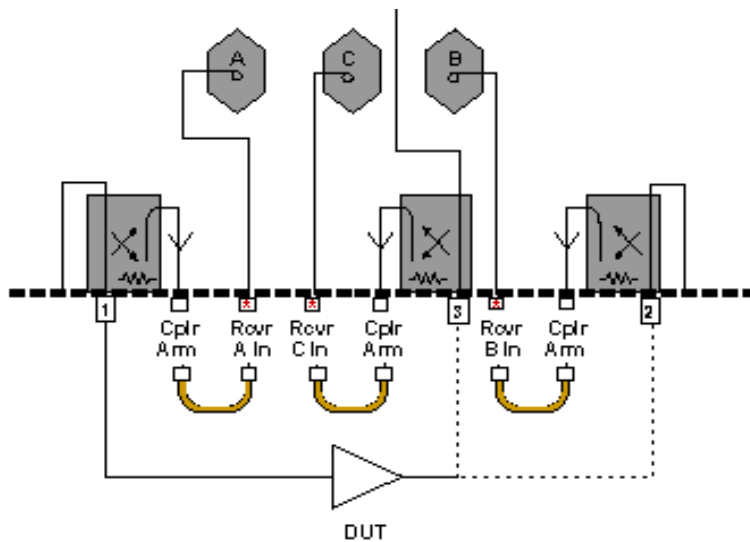** This attenuator may be required to meet
the recommended power level input
(+10dBm to -20dBm) of the detector diode.

N338x Opt 014

High-Power Amplifier Measurements Using the N3381A *Option 014*, N3382A *Option 014*, and N3383A *Option 014*

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High-power amplifiers have one or both of the following attributes:

- They require more input power than a standard analyzer can provide.

- They deliver more output power than a standard analyzer can measure.

Click on a solution to learn to make measurements of high-power amplifiers:

Challenges and Solutions

Challenge	Solution
DUT input-power is too low	Booster amplifiers in the test setup
Booster amplifier response is not flat	External leveling for booster amplifiers
Phase-lock lost when using a booster amplifier	Disable auto-frequency calibration
Which measurement calibration do I use?	Measurement calibration choices
What calibration power levels do I use?	Power-level recommendations for calibration
DUT output power is too high	Components that reduce DUT output power
Will my calibration standards withstand high power?	Calibration standards that withstand high power
Thermal variations occur in my test setup	Thermal requirements for DUTs and loads
DUT has an Automatic Gain Control (AGC) loop	Stimulus-sweep recommendation for a DUT with an AGC loop
What procedure do I use to measure high-power amplifiers?	Procedure for Measuring High-Power Amplifiers

_____

Note: Many of the external components shown in the test set-up configurations of this tutorial are available from Agilent Technologies. For example, Agilent sells couplers, power splitters, and attenuators. Go to **http://www.agilent.com/find/accessories** and use the search function to locate information on components you may want to purchase. You can also get Agilent technical support by telephone or fax.

Booster Amplifiers in the Test Setup

If your DUT requires more input power to be tested accurately than the analyzer can provide, you need to provide a booster amplifier in your test setup. (See your analyzer's power range in the Technical Specifications.) However, using a booster amp may limit the types of testing and calibration you can perform. Also, your booster amplifier may not provide a consistent power level to your DUT over the frequency range of interest. This would require you to provide a leveling loop. See External Leveling for Booster Amplifiers.

Here are two ways to configure booster amp circuitry.

1. Configuration Using One Booster Amplifier

Limitations

Reverse *boosted-power* measurements are not possible unless the booster amplifier is relocated.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Cplr Thru channel.

3. Connect the coupled-arm portion of the boosted source signal to the Rcvr R In channel. This signal becomes the reference signal used in ratioing-out mismatch between Port 1 and the DUT.

4. Add an external attenuator to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

5. Add an external attenuator between the Port 1 Cplr Arm and the Rcvr A In to protect the A receiver from excessive power.

6. Connect an isolator between the Port 2 Cplr Thru and the Port 2 Source Out.

7. Connect an external attenuator between the DUT and either Port 2 or Port 3 to protect the B or the C receiver from excessive power.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Measurement Calibration Choices.

2. <u>Configuration Using Two Booster Amplifiers</u>

Limitations

Reverse *boosted-power* measurements are not possible from Port 3. This is because Port 3 does not have Source Out and Coupler Thru channels.

How to connect

1. Connect a booster amplifier to the Port 1 Source Out channel.

2. Connect a coupler between the booster amplifier and the Port 1 Cplr Thru channel.

3. Connect a booster amplifier to the Port 2 Source Out channel.

4. Connect a coupler between the booster amplifier and the Port 2 Cplr Thru channel.

5. Connect a power splitter to the Rcvr R In channel.

6. Connect attenuators to each arm of the power splitter to protect the R1 receiver from excessive power. (See your analyzer's Technical Specifications for the maximum input power to a receiver.)

7. Connect the coupler at the Port 1 booster amplifier to an arm of the power splitter.

8. Connect the coupler at the Port 2 booster amplifier to the other arm of the power splitter.

9. Add an external attenuator between the Port 1 Cplr Arm and the Rcvr A In to protect the A receiver from excessive power.

10. Add an external attenuator between the Port 2 Cplr Arm and the Rcvr B In to protect the B receiver from excessive power.

CAUTION: When using an open or a short during calibration, be sure that the incident power level is low enough so that the reflected signal doesn't exceed the maximum input to the analyzer's receivers.

Your **Option 014** (Configurable Test Set) analyzer allows you a choice of booster amplifier configurations. Option 015 (Configurable Test Set) is not compatible with your analyzer.
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External Leveling for Booster Amplifiers

If the boosted response of your DUT is not as flat as you expect, it may be attributed to the output of your external booster amp. If the output has ripple across the frequency band of interest, your DUT will amplify that ripple. You can add your own external leveling circuitry to compensate for poor flatness of an external booster amplifier in your test setup.

How do I Determine If I Need to Use External Leveling with my Booster Amplifier?

Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of

peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

Note: Be sure to calibrate before measuring the peak-to-peak ripple of your booster amplifier. Calibration will prevent noise (if present) from varying the look of your measurement during each sweep of the analyzer.

As shown in the following graphic, a booster-amplifier without external leveling may have ripple that causes DUT response ripple.

Some causes of booster-amplifier ripple:

- Low quality booster amplifier (poor match or flatness)
- Noisy power-supply voltage for booster amplifier
- Saturated booster amplifier

How do I Provide External Leveling?

External leveling circuitry is shown in two different test setup configurations:

- external leveling using one booster amplifier
- external leveling using two booster amplifiers

Compare with Basic Configuration.

In measurement configurations with external leveling circuitry, the booster amplifier is followed by a coupler whose coupled arm directs the reference signal to a power splitter (see graphics above). From the power splitter, the reference signal gets routed to two places:

- The analyzer's front-panel "Rcvr R In" input for the internal reference receiver.
- The **input** of the external leveling circuitry.

The analyzer's test port power should be maintained between **+10 dBm and -15 dBm** for proper phase lock and ALC (automatic level control) operation. If no external DC preamplifier is used at the DC output of the detector diode, the power applied to the input of the detector diode should be maintained between **+10 dBm and -20 dBm**. This power range is necessary to achieve an adequate DC output from the detector diode for proper ALC operation. A negative-output detector diode should be used, such as an Agilent 3330C (you can find information about this detector diode at **http://www.agilent.com/find/accessories**.) The DC output of the detector is connected directly (using a coaxial cable) to the analyzer's rear panel "Ext Detector Input."

More information about the external leveling circuitry:

- The detector diode's output voltage, applied to the analyzer's External Detector Input, adjusts the source power to achieve a flat response at the DUT on a real-time basis.
- For external leveling to work correctly, the voltage at the analyzer's External Detector Input must be between -0.002 mVDC and -6 VDC, depending on frequency and power level.
- Making too great a change in the reference-signal power can cause the external leveling

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function to become ineffective due to the limited power-control range of the analyzer's source.

View external leveling circuitry that uses a DC preamplifier (recommended when the input power-level to the detector diode is less than -20 dBm).

Note: When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

Which Analyzer Menu Choices do I Select for External Leveling?

1. Select the **Sweep** menu.

2. Select **Sweep Setup**. Select the **External ALC** checkbox.

Find more information about using external leveling at **http://www.tm.agilent.com**. Click "Library" and use the search function to search for "ALC."

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Measurement Calibration Choices

Calibration choices are determined by the measurement configuration you use. The following high-power measurement configurations and calibrations are possible with your analyzer.

- configuration for high-power measurements in the forward direction

    Possible calibration choices:

    o **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Also for reverse non-boosted transmission or reflection measurements.

- configuration (with an isolator) for high-power measurements in the forward direction

    Possible calibration choices:

    o **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Or, for reverse non-boosted transmission or reflection measurements.

- configuration for high-power measurements in both forward and reverse directions

    Possible calibration choices:

    o **2-Port Calibration** (SOLT) for forward and reverse high-power transmission and reflection measurements.

    o **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward or reverse high-power transmission or reflection measurements.

Compare with: Basic Configuration.

Note: If testing a duplex base-station filter with a built-in preamp, you would ideally use a 3-port calibration.

More information on calibration choices:

- Short, Open, Load, Thru (SOLT) **2-port calibration**: very accurate because it removes all systematic errors in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure all four S-parameters. Requires measurement of four calibration standards using both forward and reverse signals. For more information, see SOLT Cal.

- **1-Port Reflection calibration**:less accurate, removing only three systematic errors (directivity, source match, and reflection tracking) in the measurement setup, ideally to where the DUT connects to the analyzer. Can be used to measure S_{11} or S_{22}. Requires measurement of three calibrations standards using either a forward or a reverse signal. For more information, see 1-Port Reflection Cal .

- Thru, Open, or Short **Response calibration**: least accurate, removing only the frequency-tracking errors. Frequency-tracking errors are associated with the differences in frequency response between one channel and another. Can be used to measure only one S-parameter. Requires a measurement of only one calibration standard using either a forward or a reverse signal. For more information, see Open/Short Response Cal or Thru Response Cal.

Note: Calibration should be performed with all hardware in place. For example, include any booster amplifiers, cables, attenuators, or couplers that will be used when measuring the DUT. For more calibration information, refer to Select a Calibration Type.

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Power Level Recommendations for Calibration

For greatest measurement accuracy, calibrate at the highest possible power below the onset of receiver compression. This power level depends on the frequency of the response being measured. (See your analyzer's Technical Specifications for the maximum input power to a receiver.) Receiver power levels can be measured with a power meter where your external circuitry connects to:

- RCVR A IN
- RCVR B IN or RCVR C IN

During calibration (when the DUT is removed) adjust the power to get a power level at the receivers that safely minimizes receiver compression. During measurements (when the DUT is installed) adjust the power to maintain the safe power level at the receivers.

See graphic: Measuring Calibration Power Levels

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More information on High-Power Amplifier Measurements:

- Disable auto-frequency calibration
- Components that reduce DUT output power
- Calibration standards that withstand high power
- Thermal requirements for DUTs and loads
- Stimulus-sweep recommendation for a DUT with an AGC loop
- Procedure for Measuring High-Power Amplifiers

Diagram: (N338xA, Option 014) Basic Configuration

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

Diagram: (N338xA, Option 014) Configuration for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

Customer Supplied Booster Amplifier *,
Couplers and Attenuators.

Customer Supplied Isolation
(for DUT Output above +10 dBm)

Diagram: (N338xA, Option 014) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction

Explore the graphic with your mouse.

DUT

Customer Supplied Booster Amplifier *,
Couplers and Attenuators.

Customer Supplied Isolation
(for DUT Output above +10 dBm)

Diagram: (N338xA, Option 014) Configuration for High-Power Measurements in both Forward and Reverse Directions

Explore the graphic with your mouse.

Customer Supplied Booster Amplifiers *,
Couplers, Attenuators and Power Splitter

Diagram: (N338xA, Option 014) Configuration Using One Booster Amplifier

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT. The circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, and an attenuator.

DUT

Customer Supplied Booster Amplifier *,
Couplers and Attenuators.

Customer Supplied Isolation
(for DUT Output above +10 dBm)

Diagram: (N338xA, Option 014) Configuration Using Two Booster Amps

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amplifiers, two forward couplers, two attenuators and a power splitter.

Customer Supplied Booster Amplifiers *,
Couplers, Attenuators and Power Splitter

Diagram: (N338xA, Option 014) External Leveling using One Booster Amplifier

Explore the graphic with your mouse.

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT. The circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, two attenuators, a power splitter and a negative detector diode.

Diagram: (N338xA, Option 014) External Leveling using Two Booster Amplifiers

Explore the graphic with your mouse.

Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amplifiers, two forward couplers, two attenuators, three power splitters, and a negative detector diode.

Diagram: (N338xA, Option 014) Measuring Calibration Power Levels

Note: Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

* Measure the receiver input power where
  your external circuitry connects here.

Networking the PNA
Easy versus Secure Configuration
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When upgrading Firmware on the PNA, you encounter a **Choose Configuration** dialog box. This is used to determine the level of security set for the DCOM interface on the PNA. For more detailed information on the security settings for the DCOM interface, including a procedure for making these settings manually, see Configure for COM-DCOM Programming.

Comparison of the "Easy and More Secure" settings are as follows:

Easy Connection:

- No configuration of the PNA required for remote access to connect.

- Anyone on the local subnet can access the PNA remotely.

- People from other NT domains can connect to the PNA.

More Secure:

- Requires creating users on the PNA or adding the PNA to a domain

- An administrator of the PNA can specify users or groups that are allowed remote access to the PNA application

Changing Network Client
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If your PC network uses Novell NetWare servers, a change must be made to the PNA setup before it can operate on your network. If you are unsure, ask one of your local IT personnel.

Note: Do NOT **Uninstall** "Client for Microsoft Networks". This will prevent proper operation of the PNA..

To remove "Client for Microsoft Networks" (Remove is different from Uninstall)

1. From the PNA Desktop, right-click **My Network Places**
2. Click **Properties**
3. Right-click **Local Area Connection**
4. Click **Properties**
5. Click (remove the check from) **Client for Microsoft Networks**

To install "Client Service for NetWare".

1. Click **Install**
2. In **Select Network Component Type**, make sure **Client** is selected
3. Click **Add**
4. In **Select Network Client**, make sure **Client Service for NetWare** is selected
5. Click **OK**.

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