

# **User's Information**

*(Printed Version of Help)*

## **Agilent Technologies PNA Series Network Analyzers**



**Part Number: E8356-90028  
Printed in USA  
January 2003**

Supersedes December 2002

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## What's New in PNA Code Version 3.1

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- Support for new PNA model E8361A - 67 GHz
- Frequency Converter Application (Opt. 083) -
- Expanded Math calibration algorithm

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

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## What's New in 3.0

- Frequency Offset Measurements - Stimulus and Response can be tuned to different frequencies.
  - Support for new PNA models - E8362B, E8363B, E8364B.
  - Increased Points (16,001), Channels (32), and Windows (16)  
See Note about processing speed.
  - Fixturing Macro - Helps compensate for the effects of test fixturing.
  - X-axis Point Spacing - Alternate display method for Segment Sweep.
  - Copy Channels - Copies channel settings to a new or existing channel.
  - Trigger IN / OUT - Support for edge-triggering on new PNA models.
  - Calibration enhancements - Converged cal kits (no longer Version 1 and Version 2).  
Replaces Cal Kit Manager.
- 

## What's New in 2.6

- Arbitrary Impedance calibration standard selections
  - Many improvements to printed Help documentation including Programming Command Finder.
- 

## 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 (Removed in Rev 3.0).
- 

## 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.

### Suggestions Please!

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

- Did you find what you were looking for?
- Was the information you found helpful?
- Are there links that appear to be broken?

- 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.

## 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

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

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### 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

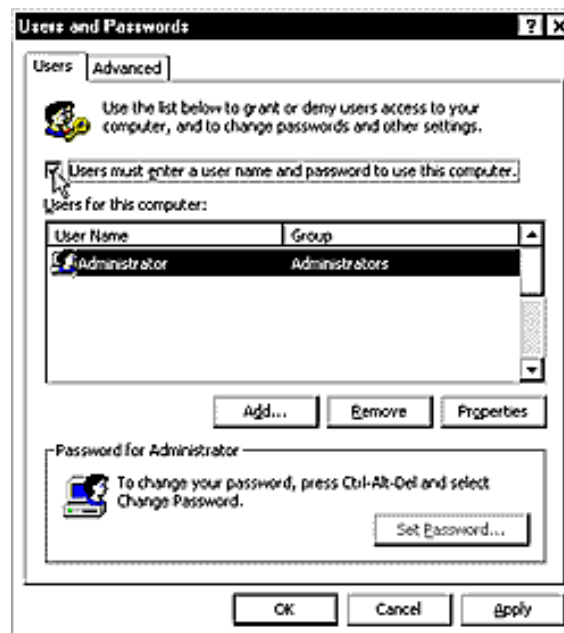
If the analyzer is in an environment that requires different levels of users, you can designate yourself as the administrator and then set the analyzer to allow others to use it with reduced permissions. That is, other people can be signed on to use the analyzer but they will not have the ability to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

#### 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.



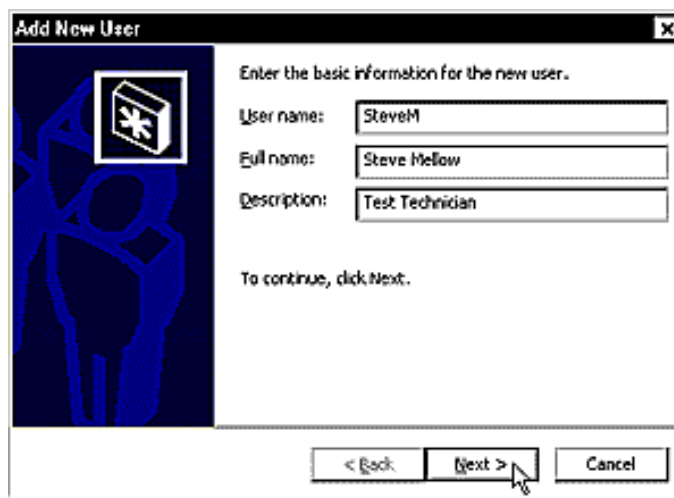
3. On the **Users** tab, if the **Add** button appears dimmed, select the **Users must enter a user name and password to use this computer** check box near the top of the window.



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**.



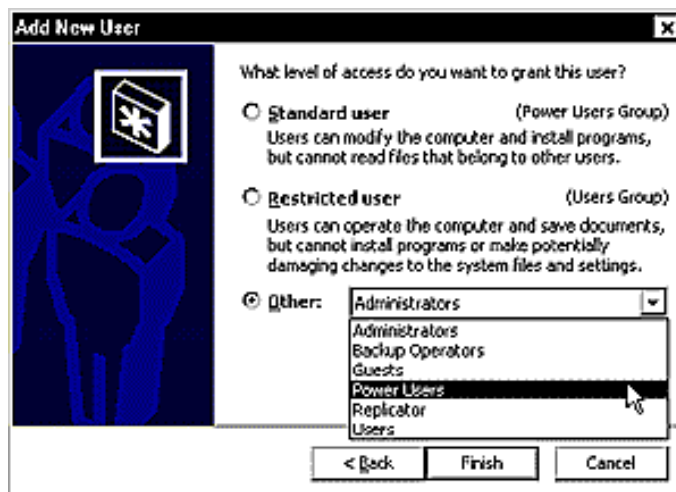
7. In the **Password** box, have the user type a password. Have the user retype the password in the **Confirm password** box. Then, click **Next**.



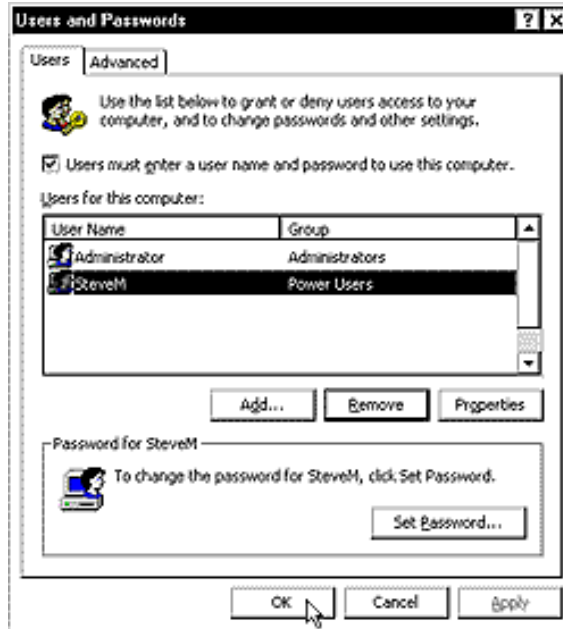
8. Select the level of access that you wish to grant this user

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

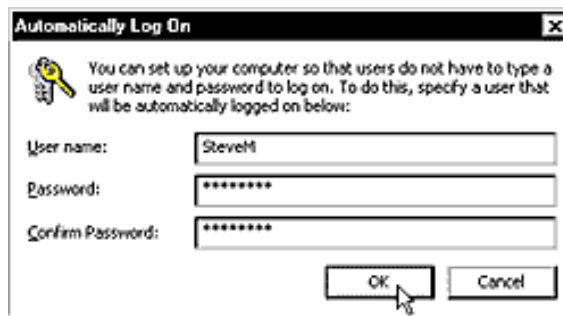
There are several other levels of security that you may grant in the **Other** list. A description of each of these other levels is displayed beneath the **Other** box when it is selected. Then, click **Finish**.



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

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

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**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.

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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.

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### 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.

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**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.

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**Note:** Windows NT or 2000 cannot be used!

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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.

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**Important Note:** You can use the Operating System Recovery procedure to restore the Operating System as it was shipped from the factory. However, you may lose some files or PNA settings.

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

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

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**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**.
- 

### 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.

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### Using USB

The PNA has two USB ports for connecting devices: one on the front panel and one on the rear 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

---

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

---

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

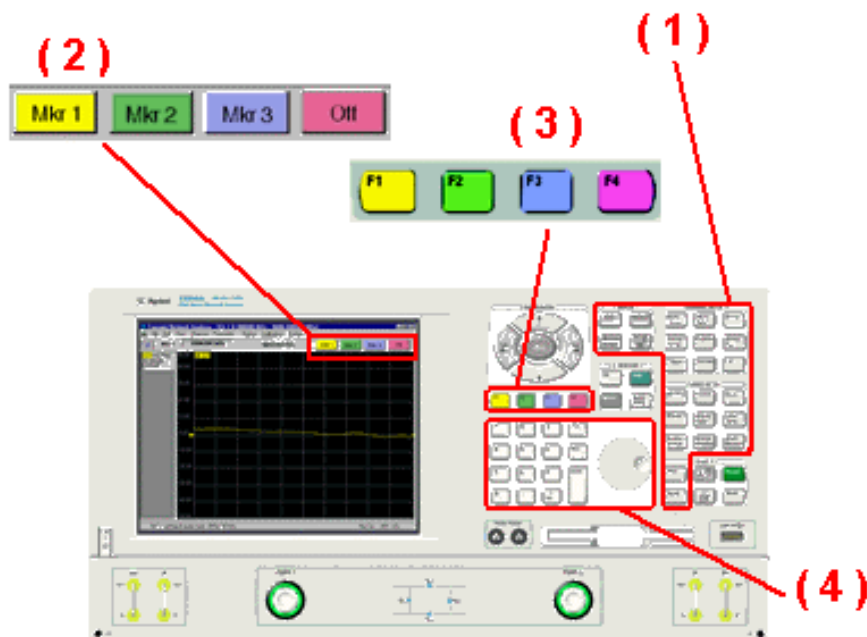
---

### 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.

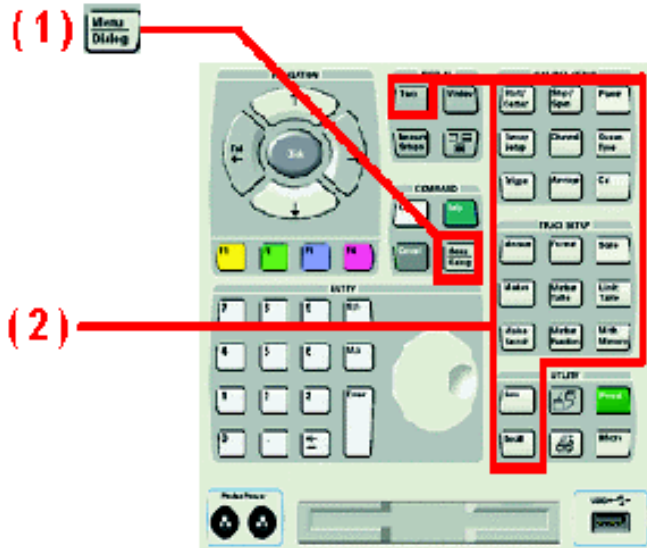
- ( 1 ) Press a key
- ( 2 ) View active entry
- ( 3 ) Select a function
- ( 4 ) Enter a value (if necessary)



### Launch Dialog Boxes,

To quickly launch MOST dialog boxes:

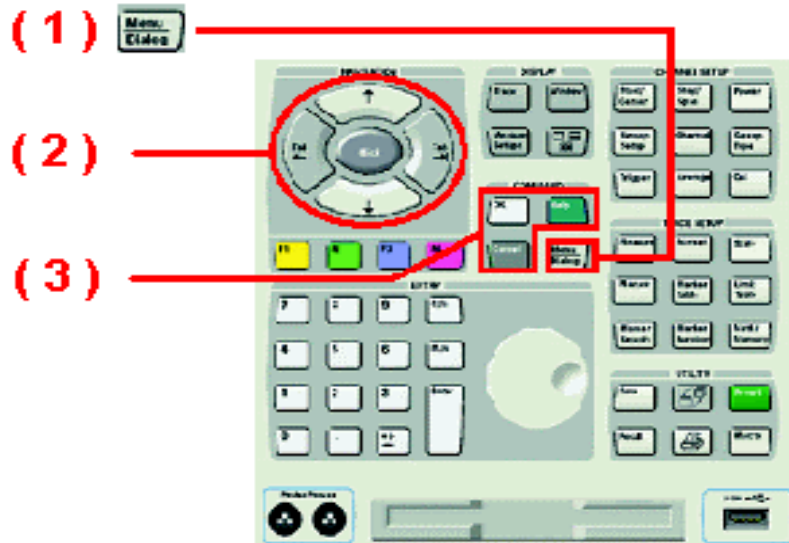
- ( 1 ) Press the Menu/Dialog Key
- ( 2 ) Select a function key



### Navigate Menus

You can access ALL PNA functions using Menu:

- ( 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

---

It is critical to understand the meaning of the following terms as they are used on the PNA.

- Traces
- Channels
- Windows
- Managing Windows

---

**Note:** You may experience a significant decrease in computer processing speed with combinations of the following: increased number of points, number of traces, and calibration error terms (full 2-port or 3-port). If this becomes a problem, you can increase the amount of RAM with PNA Option 022. To monitor the amount of PNA memory usage, press **Ctrl Alt Delete**, select **Task Manager**, then click on the **Performance** tab.

---

---

Other Quick Start topics

---

**Traces** are a series of measured data points.

Trace settings affect the mathematical operations and presentation of the measured data. A trace must be selected (active) to modify its settings. To select a trace, click the Trace Status button. The following are Trace 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 **32 independent channels**.

Channel settings determine **how** the trace data is measured . All traces that are assigned to a channel share the same channel settings. A channel must be selected (active) to modify its settings. To select a channel, click the Trace Status button of a Trace in that channel. The following are channel settings:

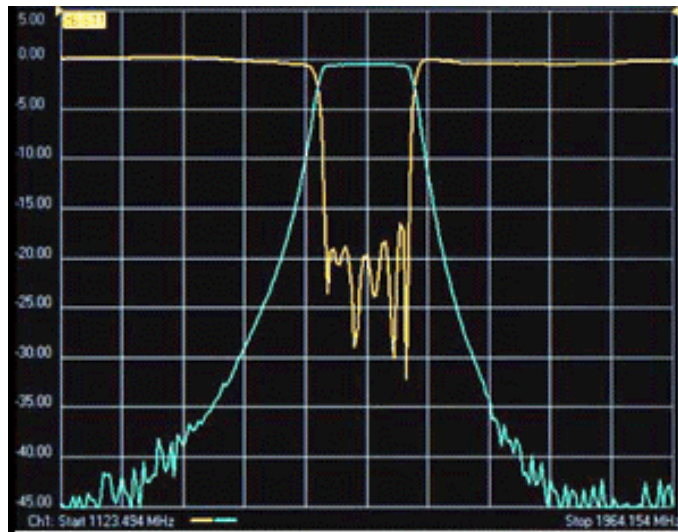
- Frequency span
- Power
- Calibration data
- IF Bandwidth
- Number of Points
- Sweep Settings
- Average

- Trigger (some settings)

**Windows** are used for viewing traces.

- The PNA can show up to **16 windows** on the screen.
- Each window can contain up to **4 traces**.
- Windows are completely independent of channels.
- Most Window settings are made from the **View** menu. See Customize the PNA screen for details.
- Learn to create and manage windows.

The following is a window containing two traces. Both traces use the same channel 1 settings as indicated by the annotation at the bottom of the window.



## Managing Windows

### How to create a new window

Use one of the following methods:

- Press  +    
- Click **Trace, New Trace**. Check **New Window**.
- Click **Window** then **New**. A new window appears with a default trace (S11, Ch1).


Learn more about using the front panel interface

### How to view a window with the full screen view:

When more than four windows are on the screen, the Trace Status pane is hidden and resolution becomes poor. To view the window with the full screen:

Select the trace:

- Press  +    

Then press . Press again to minimize the window





## Basic Measurement Sequence

---

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

---

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. The pdfs are on the CDROM that was shipped with your PNA. You can also download them from internet at [www.Agilent.com](http://www.Agilent.com). Search for PNA and click on the library inks.

## 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

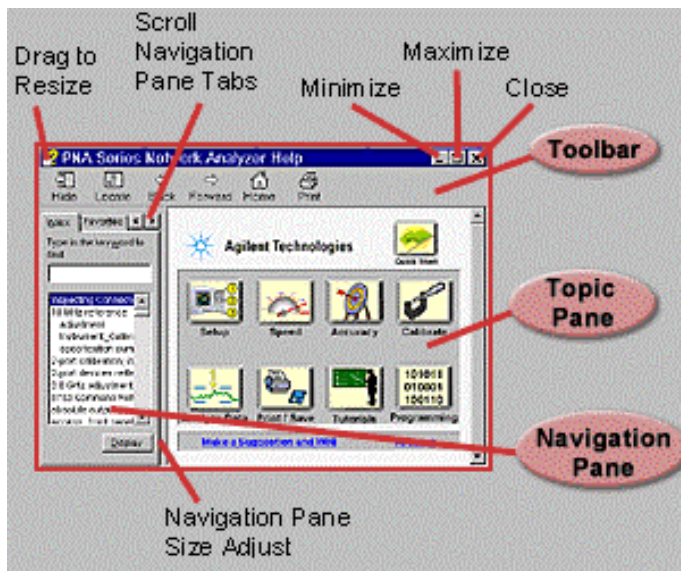
The Help system can be launched in three ways:

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

## Navigating Help

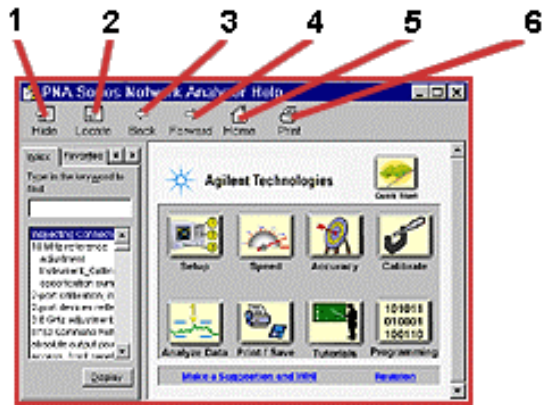
The Help Window contains 3 panes (regions):

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:

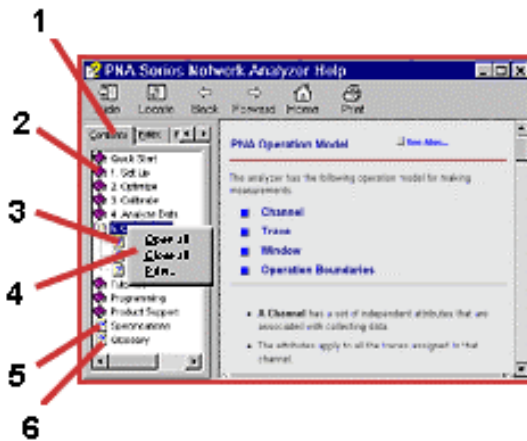
Table of Contents Tab

Index Tab

Search Tab

Favorites Tab

### (Table of) Contents Tab



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

- Click to display glossary

### Index Tab

The index tab allows you to type a keyword and go to only the most applicable topics.



- Click tab to select index.
- Type keyword to find topics of interest.
- View suggested topics. (Double-click to display topic.)
- Click to display topic.

### Search Tab

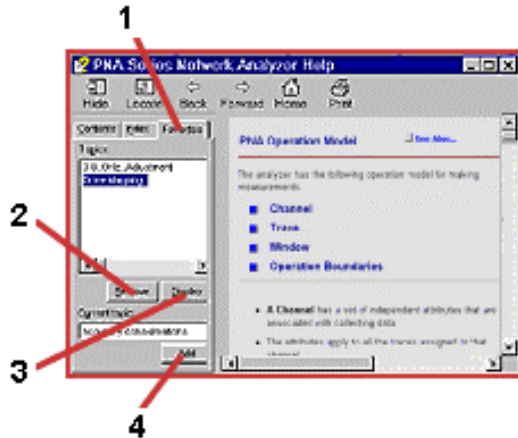
The following rules apply for using full-text search:

- 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 "calibration"

### 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**

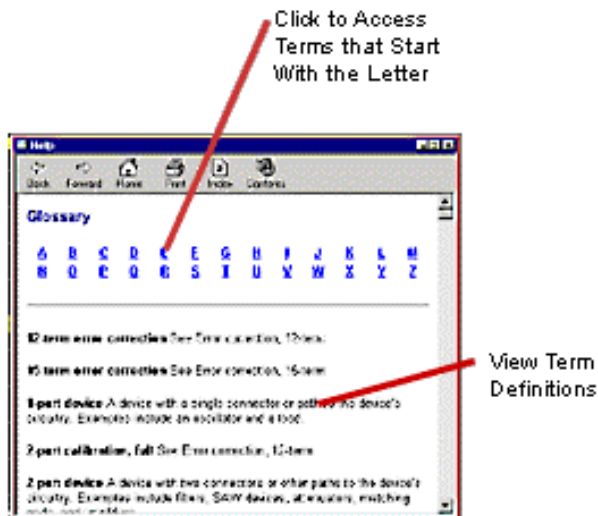
These changes may cause the Windows 2000 fonts to become small. To change them back to larger fonts, change the following settings:

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.

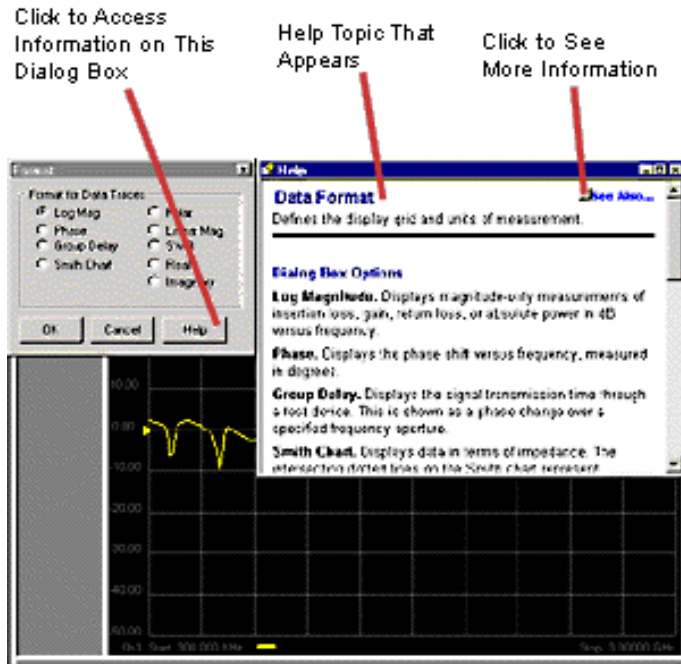


---

**Note:** Click on a word in green text to see the glossary definition.

---

## Dialog Boxes



## 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

---


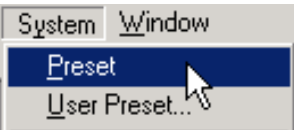
See other 'Setup Measurements' topics

---

### 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 PNA configurations 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 E8362/3/4 A or B, standard -15 dBm for E8361A -17 dBm for E8362/3/4 A or B with 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	PNA start frequency
Stop Frequency	1 MHz for E8356/7/8A 1 MHz for E8801/2/3A 1 MHz for N3381/2/3A 1 GHz for E836xA/B
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 or B -15 dBm for E8361A -17 dBm for E8362/3/4A or B 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

---

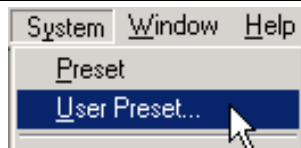
### Global Display Settings:

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

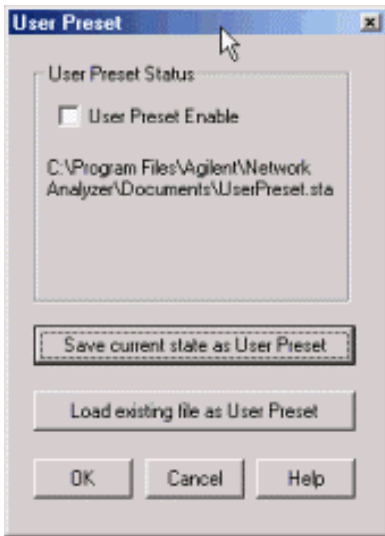
### User Preset Conditions

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

---

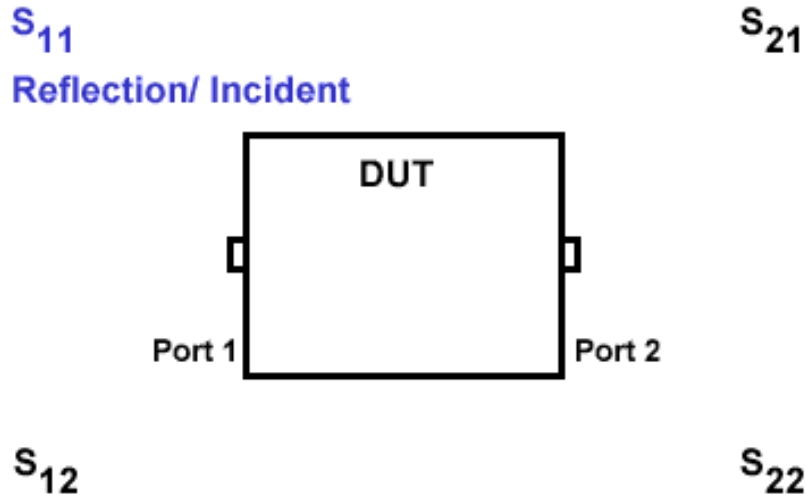
### **S-Parameters**

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**<sub>out - in</sub>

**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:



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 ( $S_{11}$ and $S_{22}$ )

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

$S_{11}$ ,  $S_{22}$

#### Transmission Measurements ( $S_{21}$ and $S_{12}$ )

- 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.

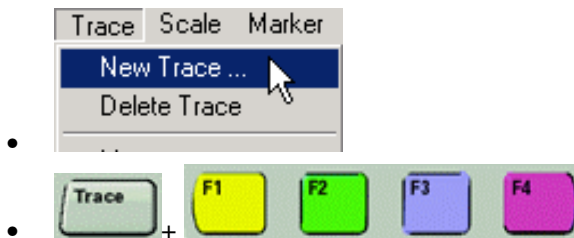
---

**Note:** Unratioed parameters cannot be used for phase or group delay measurements, or any measurement that has averaging activated.

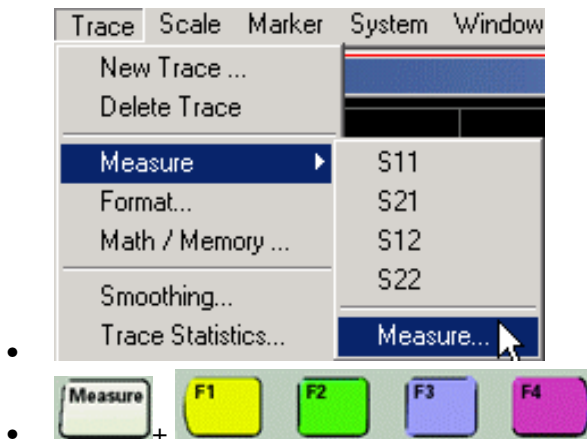
---

### How to select a Measurement Parameter

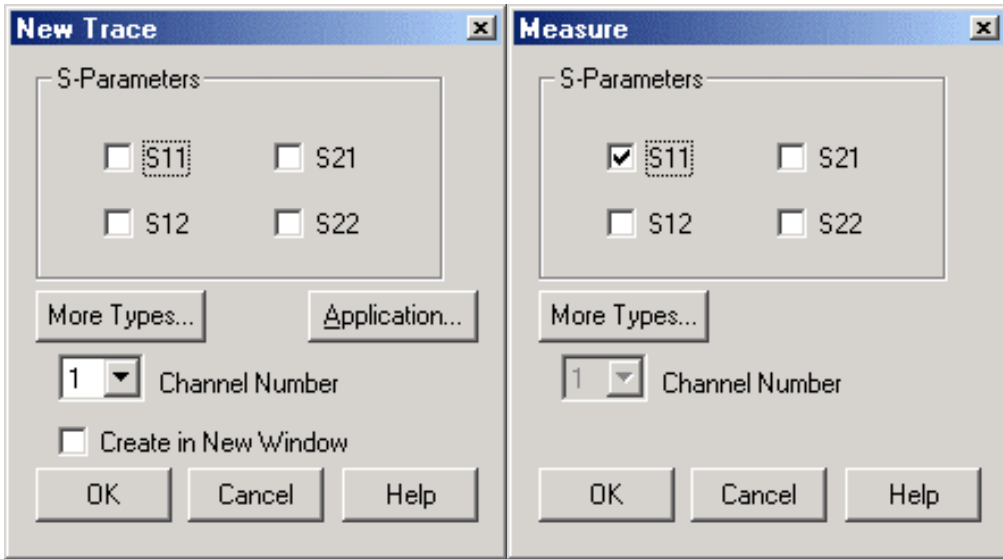
Use either of the following methods to create a new trace:



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)

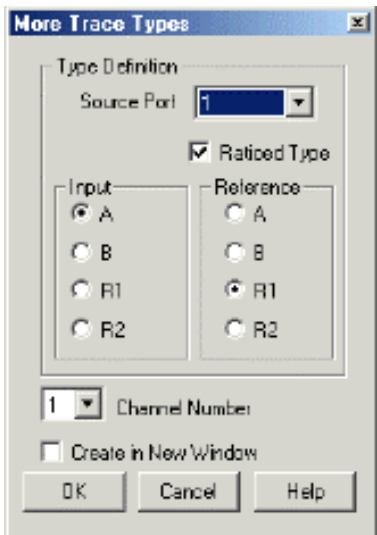
**Application...** Press to list the measurement applications installed on the analyzer (see [Application Measurements](#))

**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)



<p><b>More Types</b> dialog box help</p> <p><b>Source Port</b> Select the PNA port that will emit the source power</p> <p><b>Ratioed Type</b> Check to create a ratioed measurement (then select both Input and Reference receivers) Clear to create an unratioed measurement (then select Input receiver only)</p> <p><b>Input</b> 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>.</p> <p><b>Reference</b> 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</p> <p><b>Channel Number</b> (New Trace only) Select the channel to add the new trace to.</p> <p><b>Create in New Window</b> (New Trace only) Check to create the trace in a new window. Clear to create the trace in the active window</p> <p>About Measurement Parameters (top of page)</p>
--



## Frequency Range






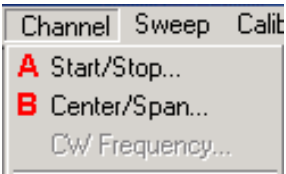
Frequency range is the span of frequencies you specify for making a device measurement.

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

---

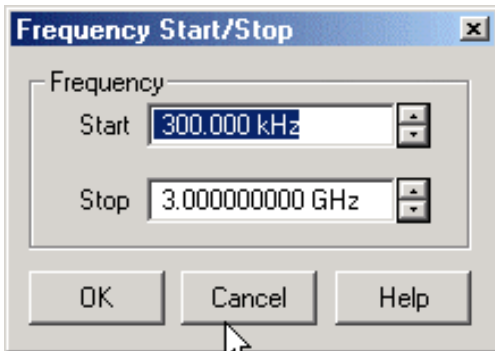
See other 'Setup Measurements' topics

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<p><b>How to set Frequency Range</b></p> <p>There are two ways to set the frequency range:</p> <ol style="list-style-type: none"> <li>A. Specify the Start and Stop frequencies of the range.</li> <li>B. Specify the Center frequency and desired span of the range.</li> </ol> <p>The following will accomplish both methods:</p> <ul style="list-style-type: none"> <li>•  +    </li> </ul> <p>The following settings will open dialog boxes:</p> <ul style="list-style-type: none"> <li>• </li> </ul>
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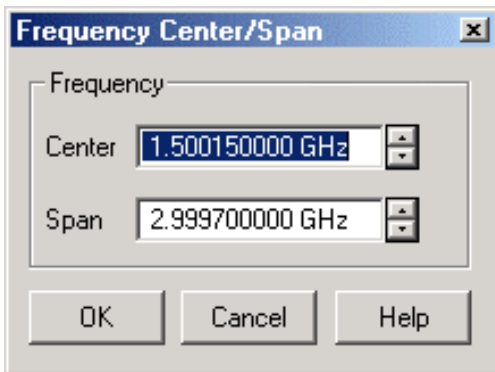
Learn more about using the front panel interface  
See the frequency ranges of all PNA models



#### 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

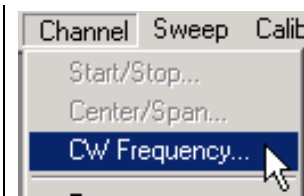
Measurements with a CW Time sweep or Power sweep as stimulus are made at a single frequency rather than over a range of frequencies.

#### How to set CW Frequency

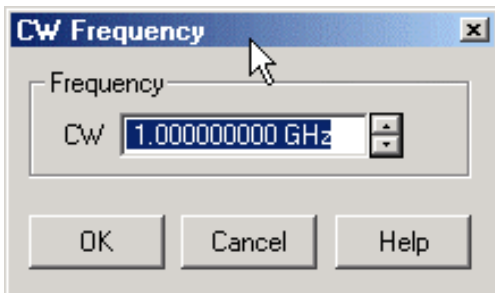
First specify CW Sweep Type

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 PNA models E8362 / 63/ 64 A/B**  
(A models do not have band 0)

Band	Freq (GHz)	Band	Freq (GHz)	Band	Freq (GHz)
0	.045				
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

**For PNA model E8361A**

Band	Freq (GHz)	Band	Freq (GHz)	Band	Freq (GHz)
0	.045	9	10.00	18	32.00
1	0.748	10	12.00	19	36.00
2	1.500	11	12.80	20	40.00
3	3.00	12	15.40	21	44.70
4	3.80	13	16.00	22	46.20
5	4.00	14	20.00	23	51.20
6	4.50	15	24.00	24	60.00
7	6.00	16	25.60	25	64.00
8	77.00	17	30.00		



## 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

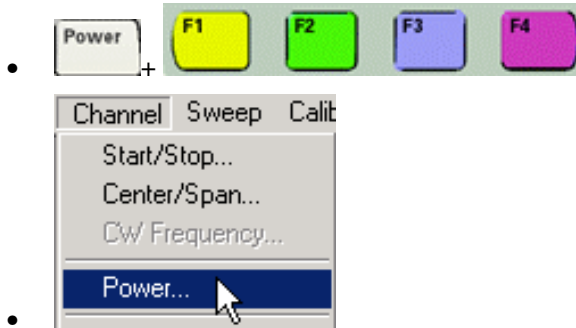
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## Power Settings

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

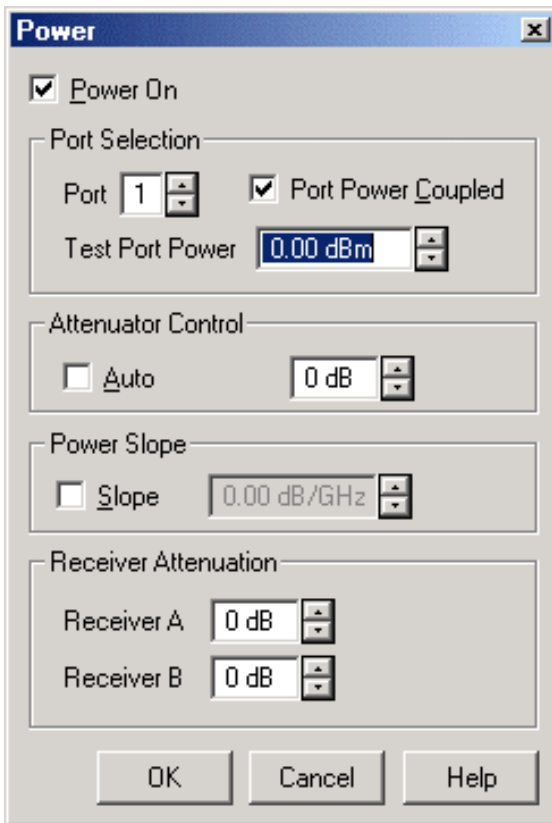
## How to make Power settings

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.

Learn more about using the front panel interface



### 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 on some PNA models as option 015 and option 016 (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:

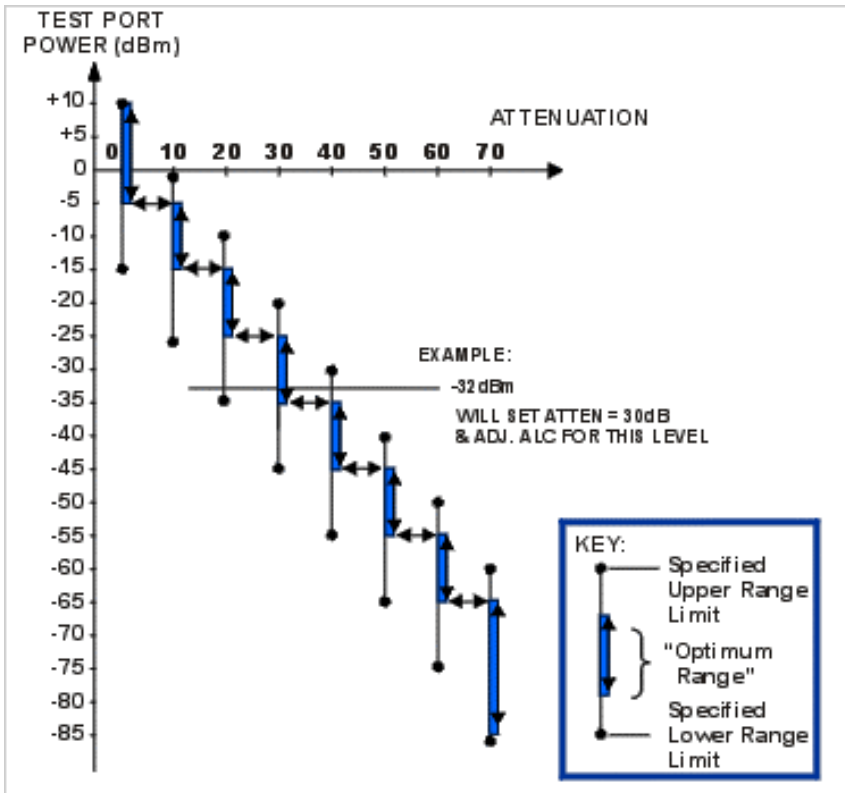
- **Testing Reflection Amplifiers** (oscillators or conditionally unstable amplifiers) . This requires a very good impedance match with the source (20dB return loss) over a wide frequency range. Choose **Auto Off**, with an attenuation level of 10 or 20 dB (or more) to ensure the best source match.
-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

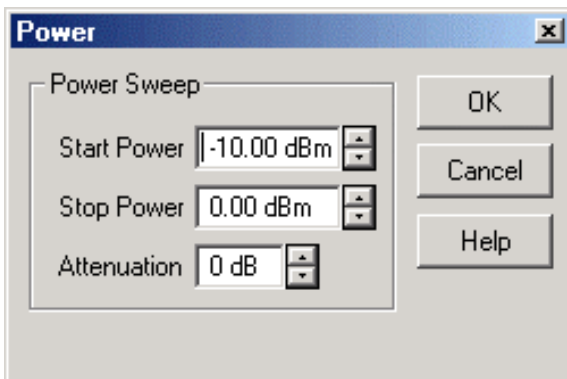
(Attenuator ranges vary, this particular range is 70 dB)



**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

Some PNA models Option UNL have a source attenuator with each port. The Test Port power levels can be set independently.

Some PNA models Option 1E1 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.

Some PNA models Option 015 or Option 016 provide internal attenuators and direct access to both port receivers. The 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

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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

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## Sweep Type

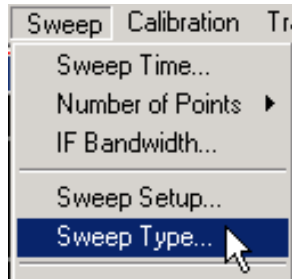
There are five sweep types in the PNA:

- **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

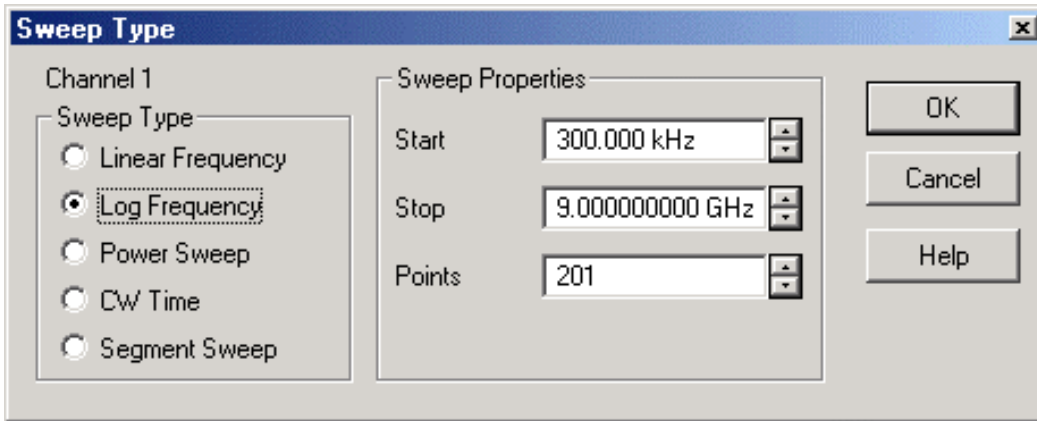
### How to set Sweep Type

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 16001.(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 16001. (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 16001.(Default is 201).

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

#### Properties

**Independent Power Levels** Check to set the source power level for each segment.

**Independent IF Bandwidth** Check to set the IF bandwidth for each segment.

**Independent Sweep Time** Check to set the duration of the measurement for each segment.

**X-Axis Point Spacing** Check to scale the X-Axis to include only the segments. Learn more.

**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 consists of 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:

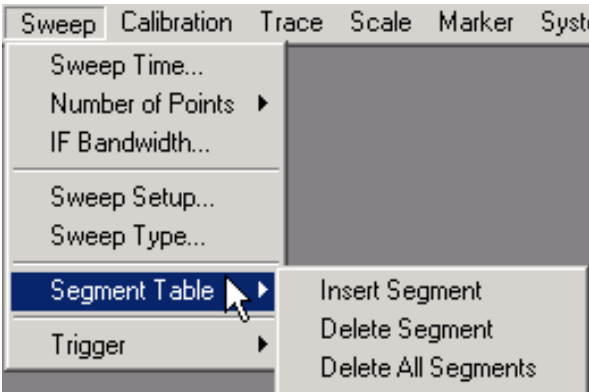
- Sorts all the defined segments in order of increasing frequency
- Measures each point
- Displays a single trace that is a composite of all data taken

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 should 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**.

Ch1: Start 300.000 kHz							
	STATE	START	STOP	POINTS	IFBW	POWER	TIME
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 (**KHz**, **Mhz**, **GHz**). 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 (**KHz**, **Mhz**, **GHz**). 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

### X-Axis Point Spacing

This feature applies to Segment Sweep only and affects how a trace is drawn on the screen.

#### How to select X-Axis Point Spacing

On the Sweep Type dialog box, click **Segment Sweep**

Then check **X-Axis Point Spacing**

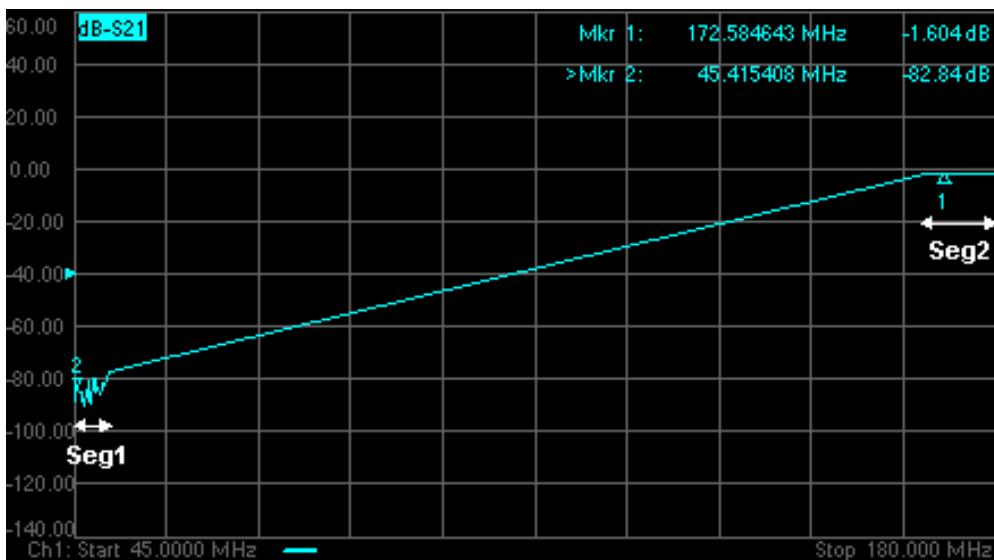
Learn more about using the front panel interface

Without X-axis point spacing, a multi-segment sweep trace can sometimes result in squeezing many measurement points into a narrow portion of the x-axis.

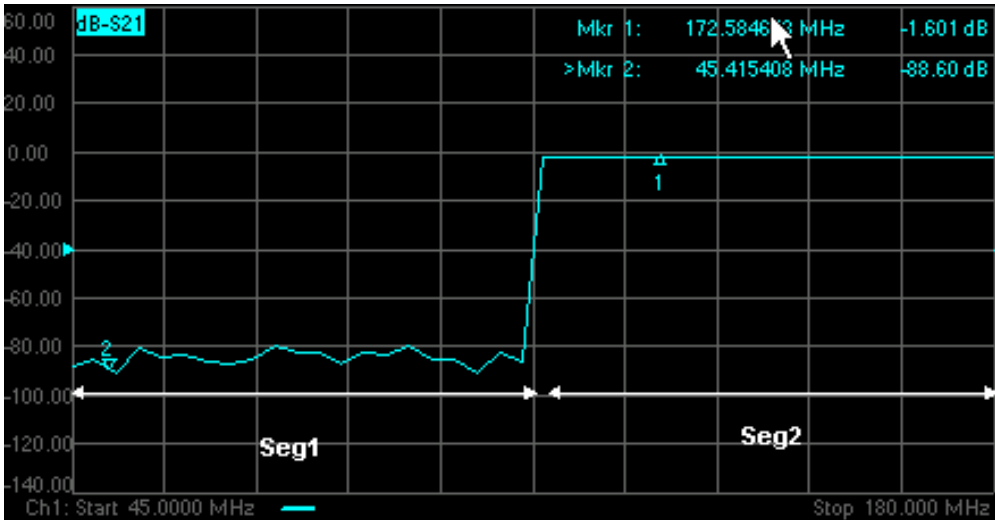
With X-Axis Point Spacing, the x-axis position of each point is chosen so that all measurement points are evenly spaced along the x-axis.

For example, given the following two segments:

	STATE	START	STOP	POINTS
1	ON	45.000000 MHz	50.000000 MHz	21
2	ON	170.000000 MHz	180.000000 MHz	21



Without X-Axis Point Spacing



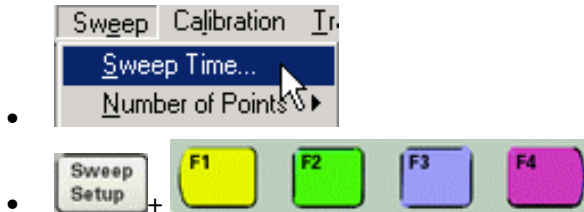
With X-Axis Point Spacing

## Sweep Time

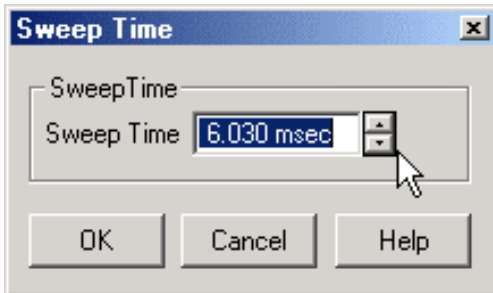
The PNA automatically maintains the fastest sweep time possible with the selected measurement settings. However, you can also set a specific sweep time if it is within the capability of the PNA.

### 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**.

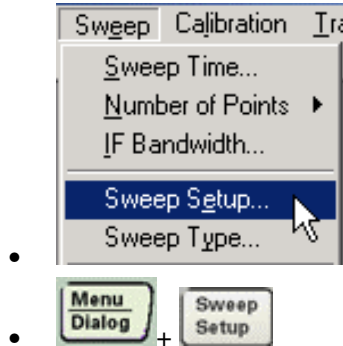
**Note:** If the Sweep Time is 0.3 seconds or greater, a sweep indicator will appear on the screen and follow the measurement sweep from point to point. The sweep indicator is a small arrow pointing

upward to the point on the data trace that was most-recently computed.

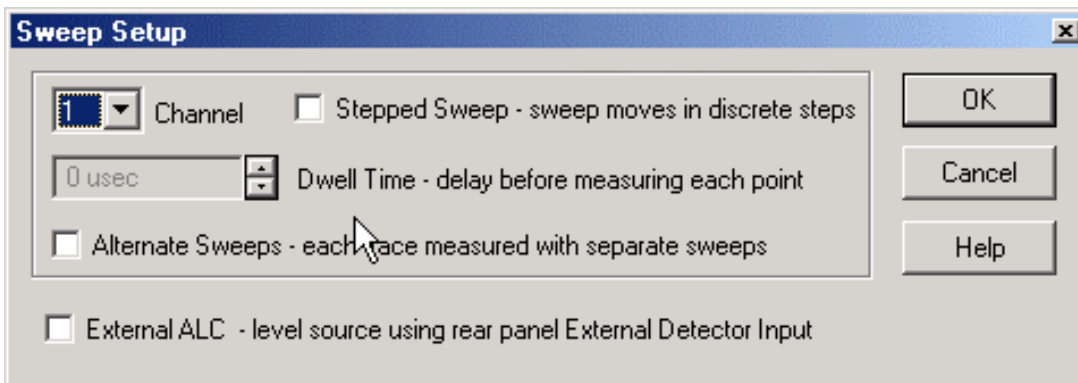
## Sweep Setup

### 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

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
- Edge Triggering

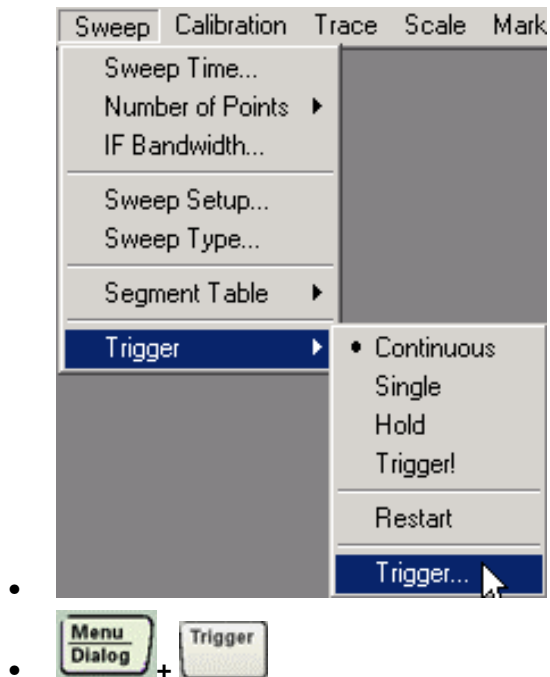
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See other 'Setup Measurements' topics

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### How to Set Trigger

Use one of the following methods:



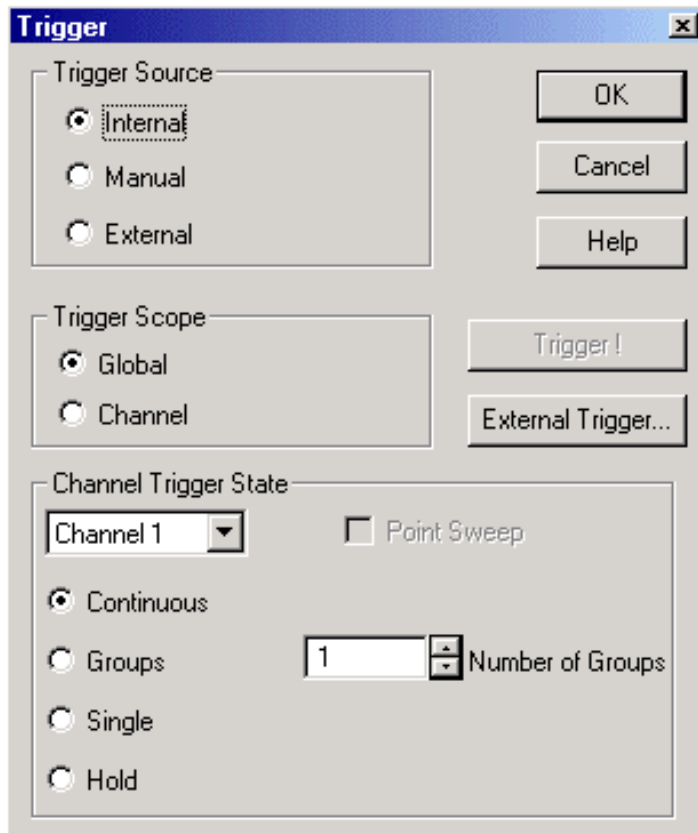
Learn more about using the front panel interface

---

**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

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

#### 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, the active toolbar, or 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 channels not in Hold receive the trigger signal [Default setting]

**Channel** Only the next channel that is not in Hold receives the trigger signal. This is not very obvious or useful unless Trigger Source is set to Manual. This setting enables Point Sweep mode.

#### 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 text box, then goes into Hold. Before selecting groups you must first increment the Number of Groups text box to greater than one.

**Number of Groups** Specify the number of trigger signals the channel will accept before going into Hold. First increment to desired number, then select Groups.

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

**Hold** The channel accepts NO trigger signals.

**Point Sweep** 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 channel that is not in Hold is triggered. (Only available with Trigger Scope:CHANNEL).

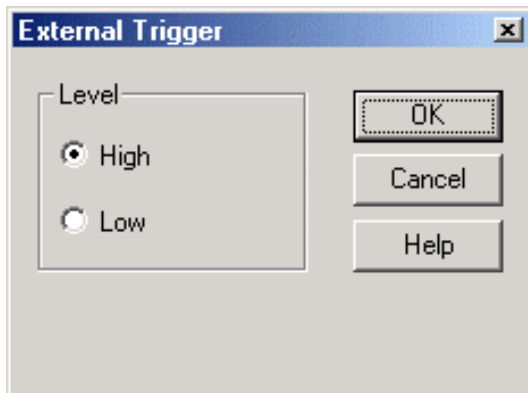
**Trigger!** - Manually sends one trigger signal to the PNA.

**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).

## Edge Triggering

Edge Triggering allows the PNA to either trigger, or be triggered, with a positive-going or negative-going signal.

- The PNA can trigger an external signal source (such as an 8360, PSG, or ESG) through the Trigger Out BNC connector on the rear panel.
- The PNA can be triggered by an external source through the Trigger IN BNC or Aux I/O - pin 19 (input) connectors. The last trigger input to be controlled with a SCPI command (the active input) responds to edge triggering.

Edge triggering can only be used with CONTROL:SIGNAl SCPI commands.

Edge triggering is only available on PNA models E8361A, E8362B, E8363B, and E8364B.

To use edge triggering, the channel to be triggered must be in Point Sweep Mode.



## 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  $\rho$  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**

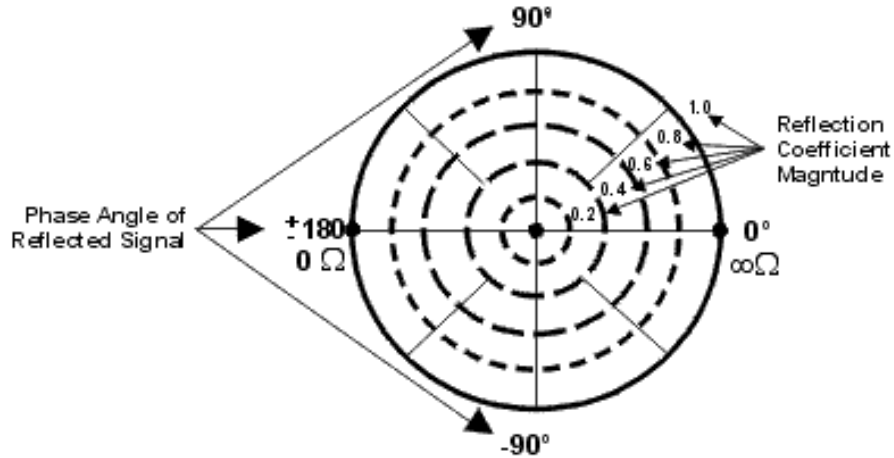
- Displays only the imaginary (reactive) portion of the measured data.
- Y - axis: Unitless
- Typical Measurements:
  - impedance for designing matching network

#### **Polar Format**

Polar format is used to view the magnitude and phase of the reflection coefficient ( $\Gamma$ ) 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 ( $\Gamma$ ) of 1, or total reflected signal. The center of the circle represents a reflection coefficient ( $\Gamma$ ) 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  $90^\circ$ ,  $\pm 180^\circ$ , and  $-90^\circ$  correspond to the top, left-most, and bottom positions on the polar display, respectively.

### Smith Chart Format

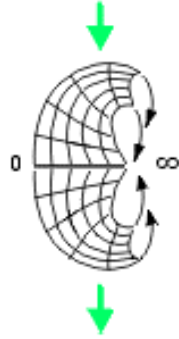
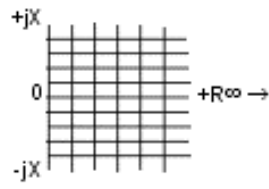
The Smith chart is a tool that maps the complex reflection coefficient ( $\Gamma$ ) to the test device's impedance.

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 ( $R + jX$ ).

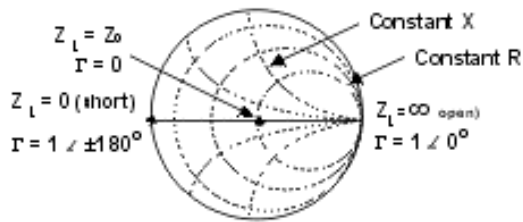
You can use Markers to display the following:

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

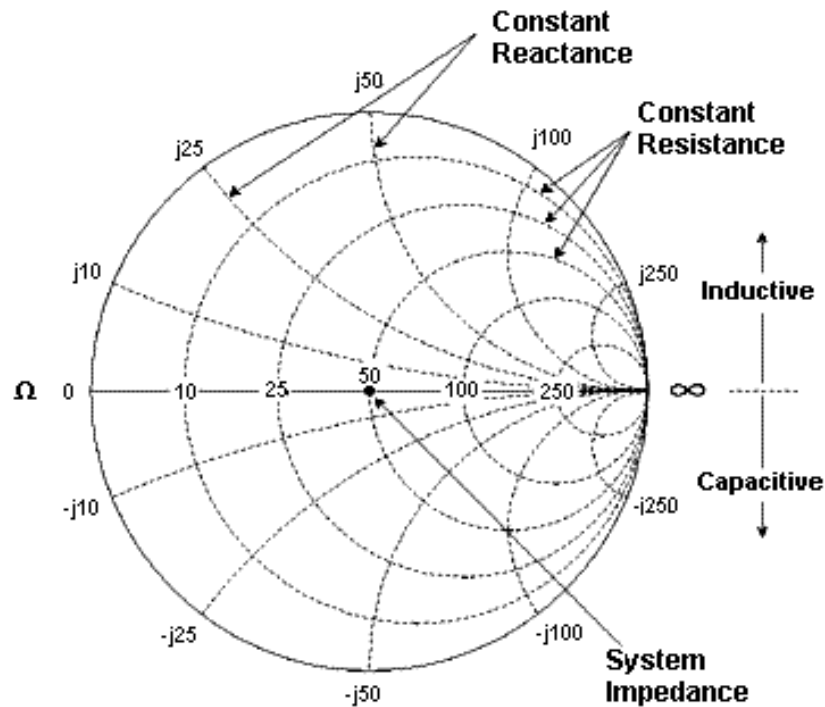
### Rectilinear Impedance Plane



### Smith Chart



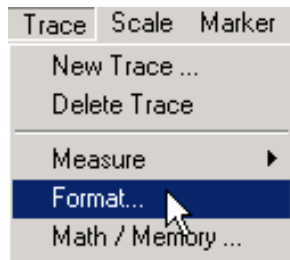
### Interpreting the Smith Chart




- 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.

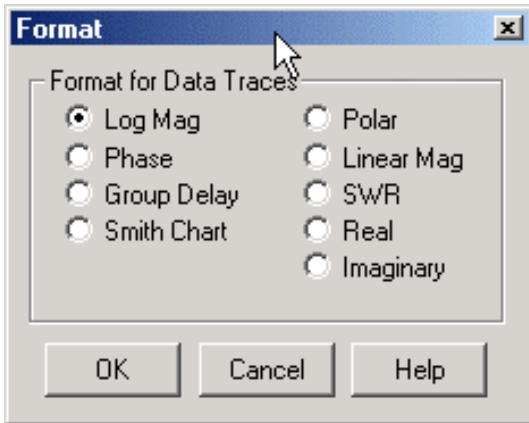
#### How to set the Format

Use one of the following methods:



-  +    
-  + 

Learn more about using the front panel interface



**Format dialog box help**

**Log Mag**

**Phase**

**Group Delay**

**Smith Chart**

**Polar**

**Linear Mag**

**SWR**

**Real**

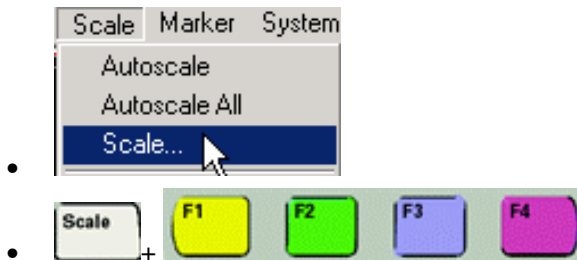
**Imaginary**

**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.

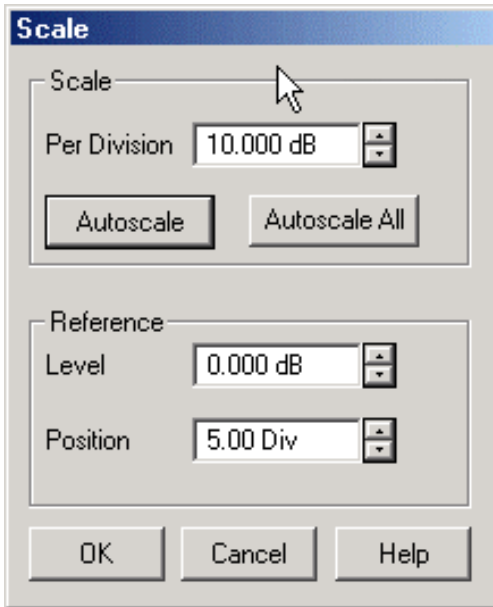
**How to set Scale, Reference Level, and Position**

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

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- Pre-configured setups for NEW measurements
- Pre-configured arrangements for EXISTING measurements

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

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See other 'Setup Measurements' topics

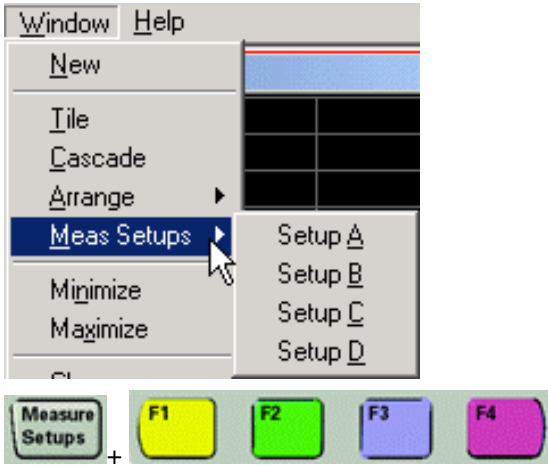
---

### 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**

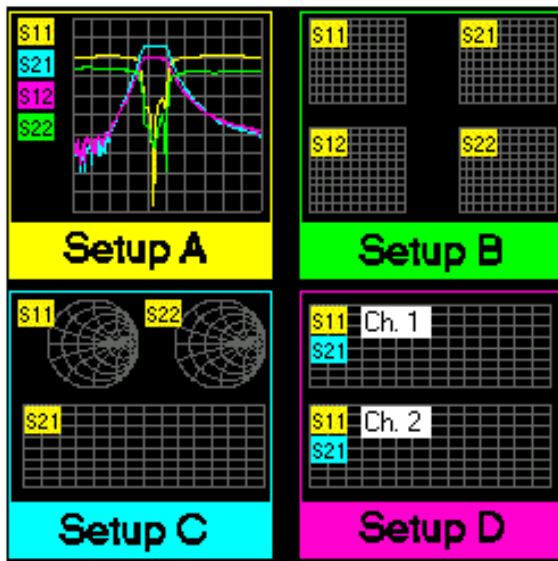
Use one of the following methods:



The screenshot shows a software window with a menu bar containing 'Window' and 'Help'. The 'Meas Setups' menu is open, displaying options: 'New', 'Tile', 'Cascade', 'Arrange', 'Meas Setups', 'Minimize', and 'Maximize'. The 'Meas Setups' option is highlighted, and a sub-menu is visible with 'Setup A', 'Setup B', 'Setup C', and 'Setup D'. Below the menu, a front panel interface is shown with a 'Measure Setups' button and four function keys labeled F1 (yellow), F2 (green), F3 (blue), and F4 (purple).

Learn more about using the front panel interface

The following are the four pre-configured measurement setups:

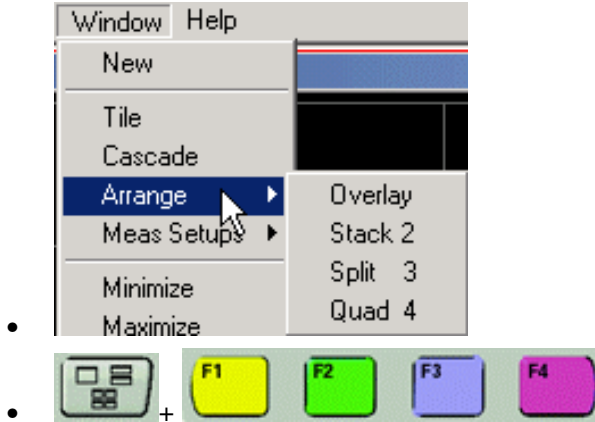


### Arranging Existing Measurements

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

### How to select an Existing measurement arrangement

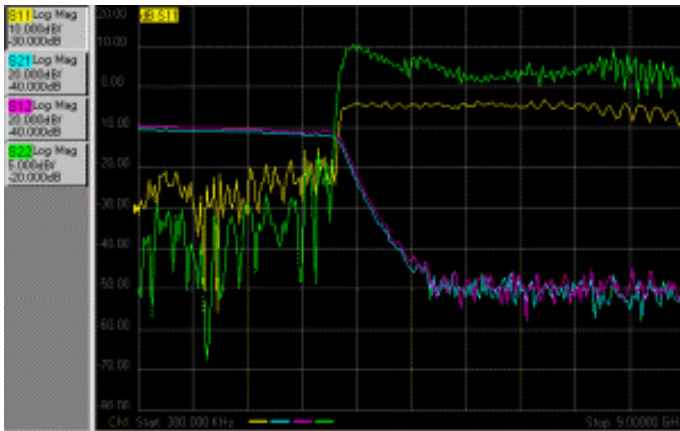
Use one of the following methods:



Learn more about using the front panel interface

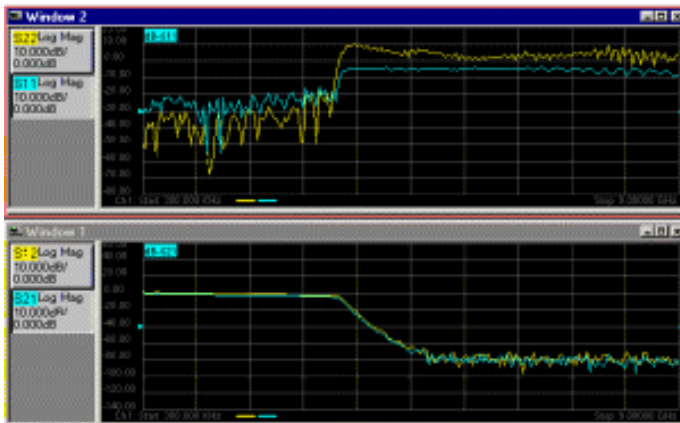
### Overlay Arrangement

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



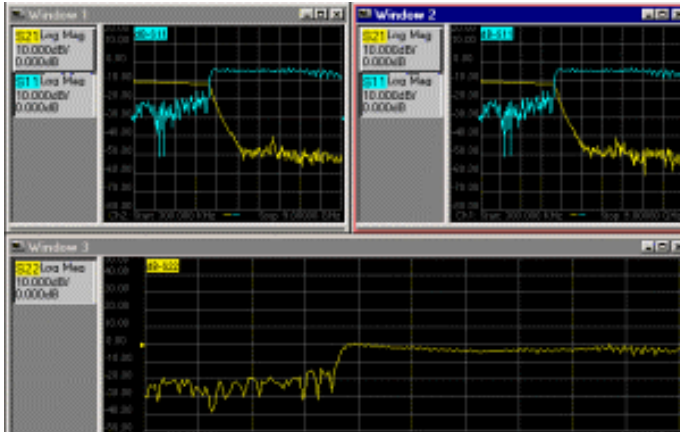
### Stack 2 Arrangement

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



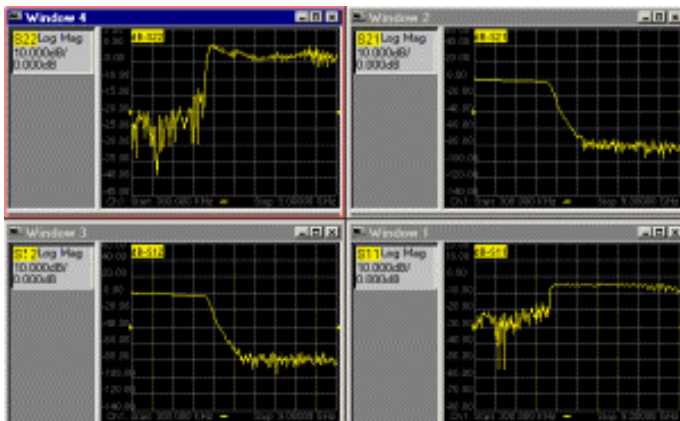
### Split 3 Arrangement

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

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

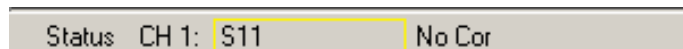
Learn about Traces, Channels, and Windows on the PNA

---

See other 'Setup Measurements' topics

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### Status Bar



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

The status bar will not change (ON or OFF) when the PNA is Preset.

#### How to display the Status bar

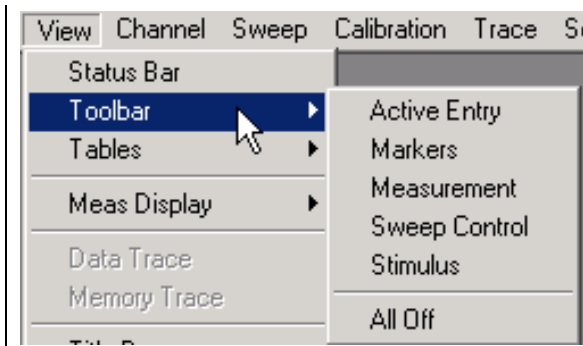


Learn more about using the front panel interface

### 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.

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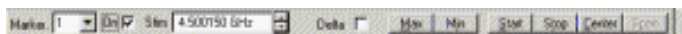
### Active Entry Toolbar



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



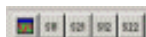
The markers toolbar allows you to set up and modify markers. It shows:

- 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**

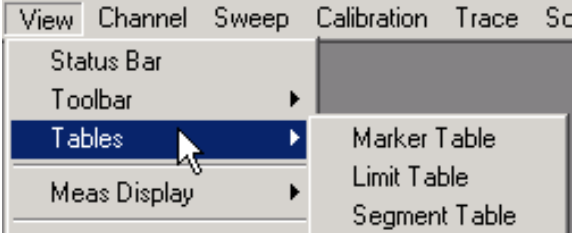
### All Off

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

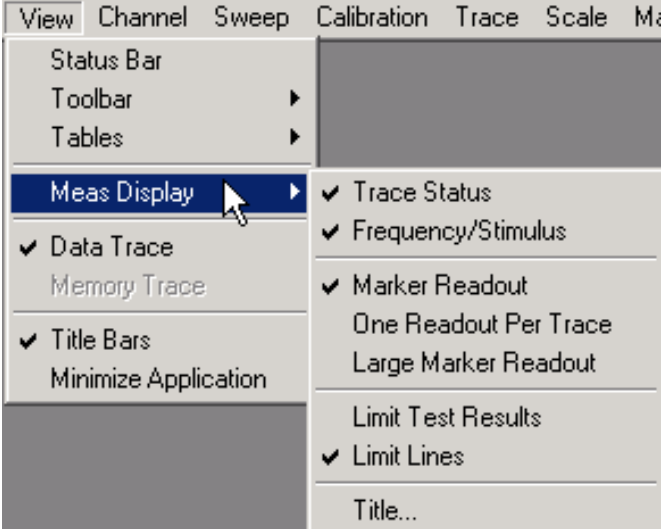
You can display, set up, and modify a table of segment sweep settings. These include:

- 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**

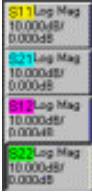


Learn more about using the front panel interface

- 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.

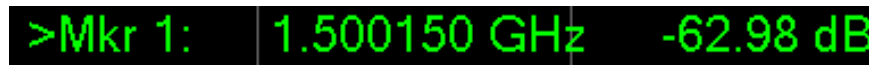
### Frequency/Stimulus



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.



## Copy Channels

You can copy the channel settings from an existing channel to a new or another existing channel.

- Why Copy Channels
- How to Copy Channels

- List of Channel Settings

## Why Copy Channels

Copy channel settings if you need to create several channels that have slightly different settings.


For example, you have an amplifier that you want to characterize over a frequency span with several different input power levels.

Follow these steps:

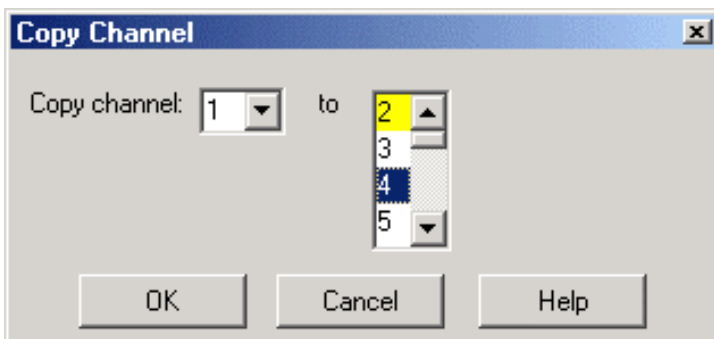
1. Create one measurement with your optimized channel settings.
2. Copy that channel to new channels.
3. Change the power level on the new channels.

The alternative to using Copy Channels is to create new default measurements on new channels. Then change every channel setting to your new requirement. This is very time consuming and thus shows the benefit of the Copy Channels feature.

**How to copy channels**



Learn more about using the front panel interface



### Copy Channel dialog box help

Copies an existing channel's settings to another channel.

**Copy channel:** Select a channel to copy.

**to:** Scroll to select a channel to copy settings to. Channel numbers that are currently being used are

highlighted. They can be selected and overwritten.

**Notes:**

- You can copy channel settings to **ONLY** one new or existing channel. Repeat this operation to copy to more than one channel.
- The new channel is **ALWAYS** copied to the Active window. If you want the new channel in its own window, first create a new measurement in a new window. Then make sure it is the Active window before you copy the channel into it.
- The measurement in the new channel becomes the active measurement.
- Only the channel settings are copied. The measurement trace is **NOT** copied to the new channel.
  - If measurements already exist on a channel being copied to, the measurements on that channel will not change, but they will assume the new channel settings.
  - If a **NEW** channel is copied **TO**, an S11 measurement is created in order to view the channel settings.

For example:

1. **Existing** channel 1: S21 measurement
2. **Copy** channel 1 to NEW channel 2
3. **Result:** channel 2: S11 measurement with channel 1 copied settings. Both measurements are in the same window. The S11 measurement is the active measurement.

For more information see Traces, Channels, and Windows on the PNA

## List of Channel Settings

- Frequency Span
- Power
- Cal Set usage
- Source Power Cal data
- IF Bandwidth
- Number of Points
- Sweep Settings
- Average
- Trigger (some settings)

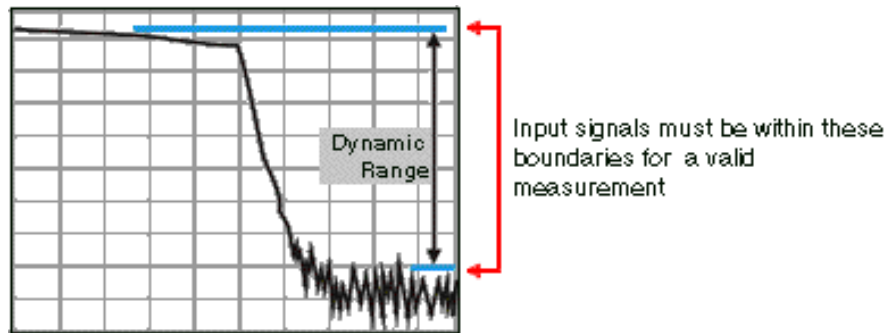
## 2. Optimize

### Dynamic Range

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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)

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Other topics about Optimizing Measurements

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### 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.)
- 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 [Dynamic Range - 4 Jumpers](#). 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 [Dynamic Range - Configurable Test Set Option](#). 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

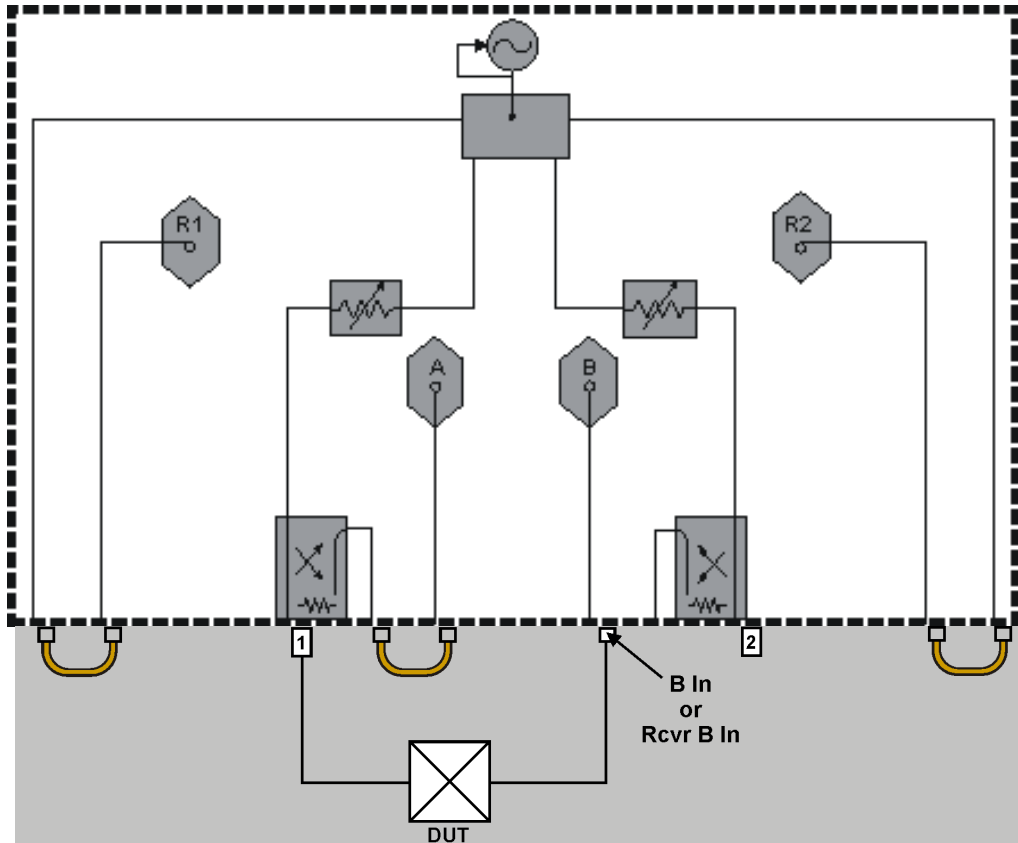
To improve dynamic range you can bypass the test-port coupler and apply the signal directly into the receiver. As shown in the following graphic, the signal is applied to the front-panel connector for the B In or Rcvr B In front-panel jumper rather than Port 2. Using this configuration, you can achieve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

---

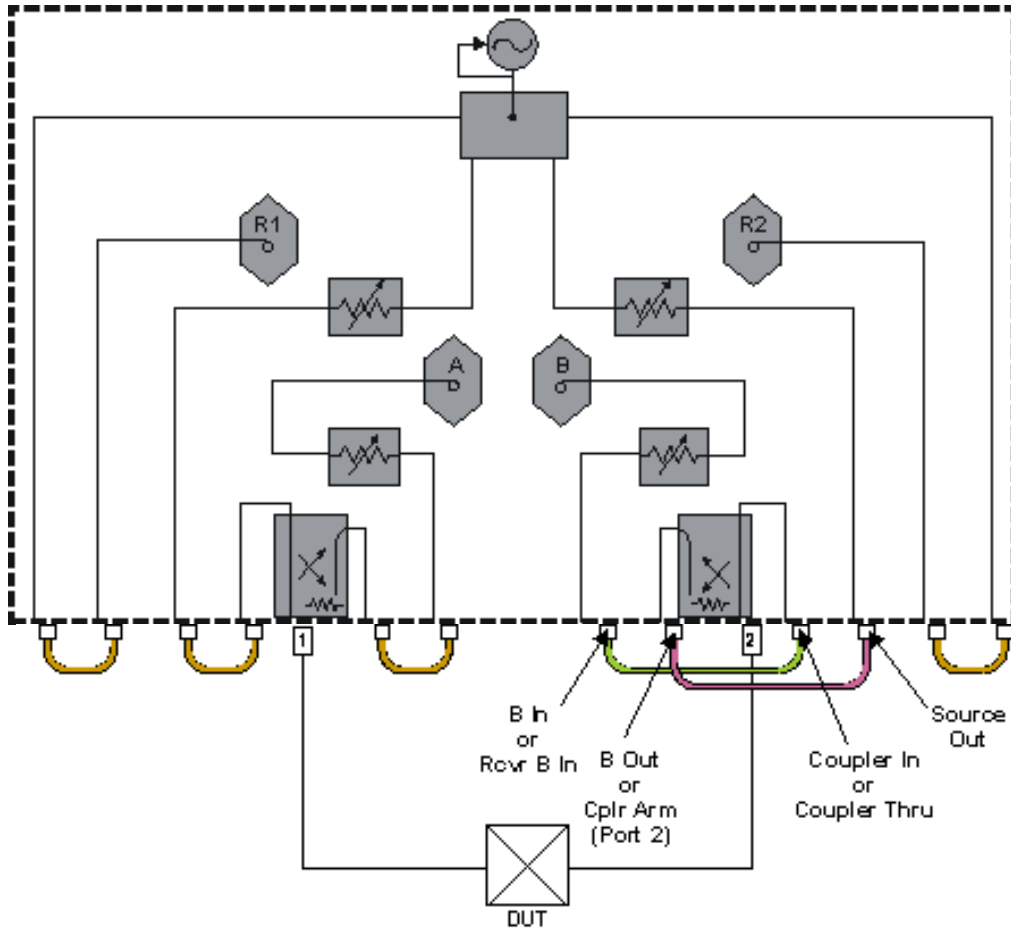


## Improving Dynamic Range with Configurable Test Set Option

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.



## 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.

**Note:** You may experience a significant decrease in computer processing speed with increased number of points, number of traces, and calibration error terms (full 2-port or 3-port). If this becomes a problem, you can increase the amount of RAM with PNA Option 022.

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.

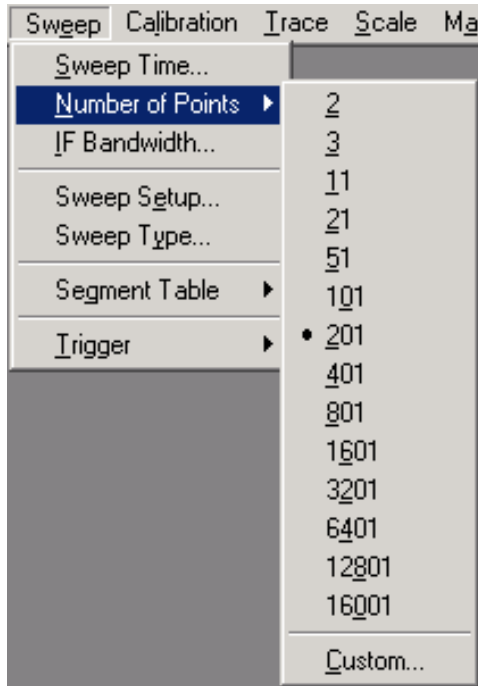


- To find an optimized number of points, look for a value where there is not a significant difference in the measurement when you increase the number of points.
- To ensure an accurate measurement calibration, perform the calibration with the same number of points that will be used for the measurement.

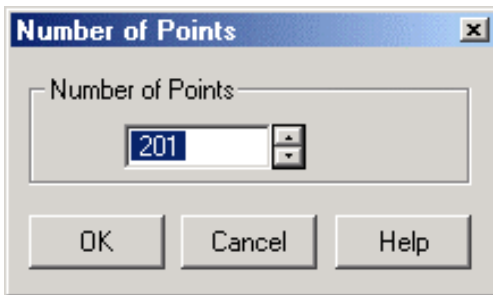
### How to change the number of data points

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 16001.

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](#)

---

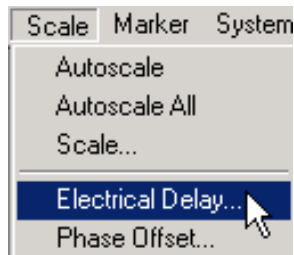
### Electrical Delay

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

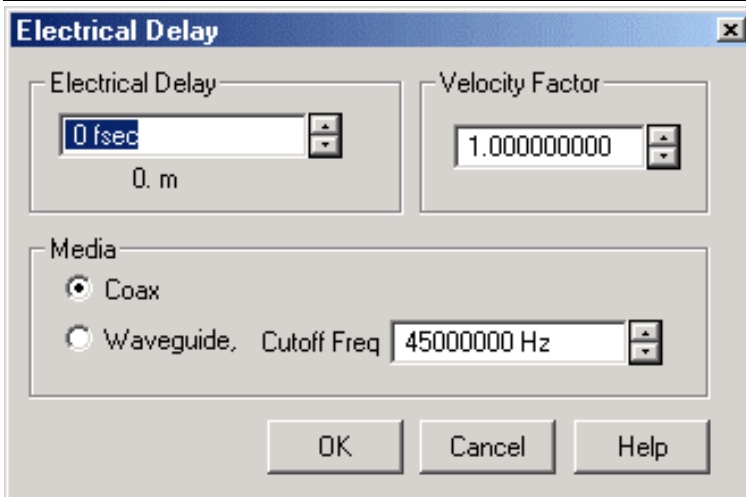
Use the electrical delay feature to compensate for the linear phase shift through a device. This feature allows you to look at only the deviation from linear phase of the device.

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:

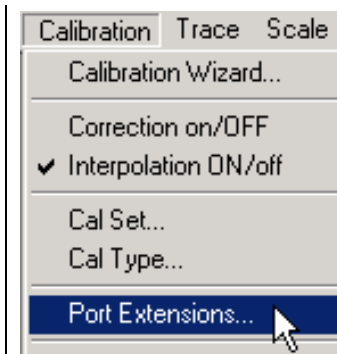
1. Connect a short in place of the device.
2. Adjust the port extension until the phase response is flat.

---

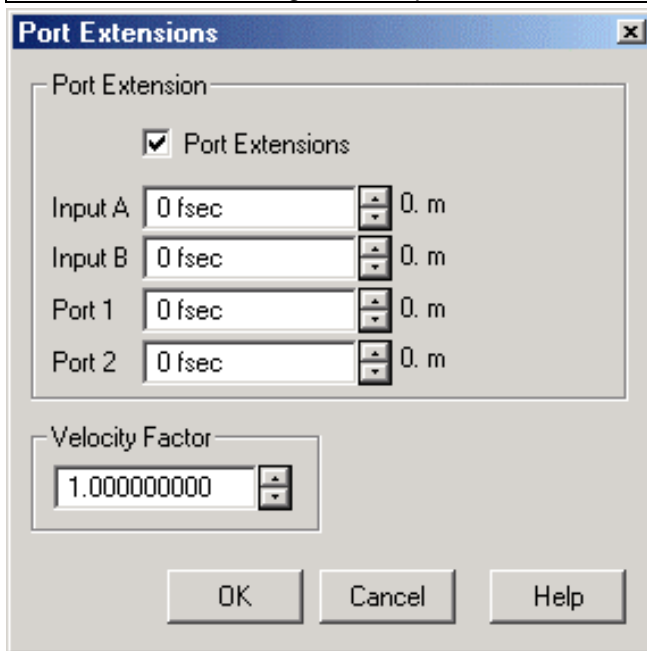
**Note:** Most short-circuit calibration standards have a non-zero delay. Therefore, adjusting delay with this method results in a delay error equal to two times the short delay. Determine the offset delay of the calibration short by examining the standard definition.

---

### How to set Port Extensions



Learn more about using the front panel interface



#### 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

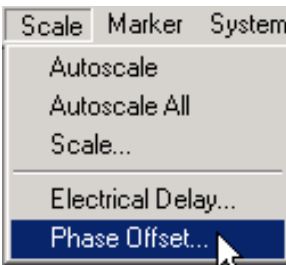
Phase offset mathematically adjusts the phase measurement by a specified amount, up to 360°.

Use this feature in the following ways:

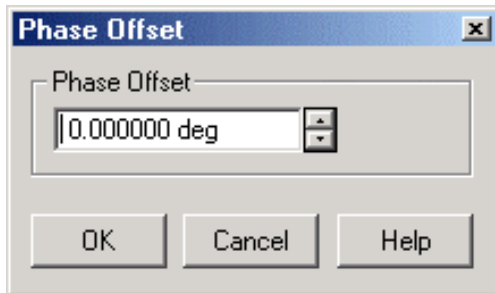
- **Improve the display of a phase measurement.** This is similar to the way you would change the reference level in an amplitude measurement. Change the phase response to center or align the response on the screen.

- **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)

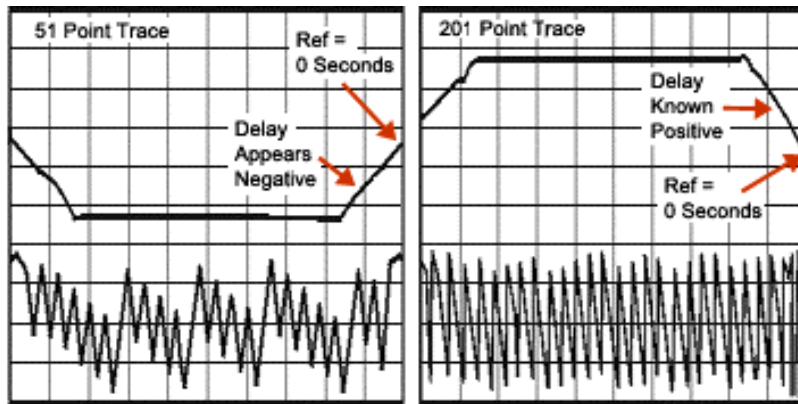
### Spacing Between Frequency Points (Aliasing)

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  $>180^\circ$  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

---

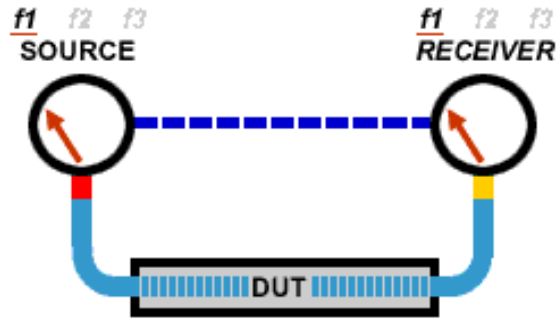
Other topics about Optimizing Measurements

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### 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

---

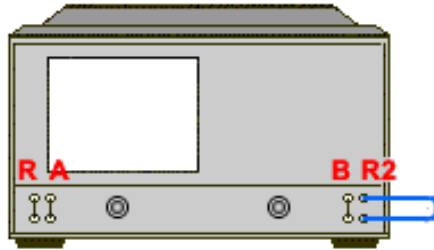
**Note:** This method applies to PNA models with front panel loops.

---

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

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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

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Other topics about Optimizing Measurements

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### Why Terminate the Unmeasured Port

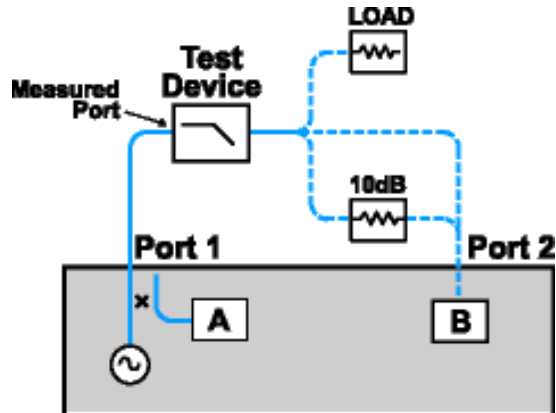
A 2-port calibration corrects for all 12 twelve error terms. A 1-port calibration corrects for directivity, source match and frequency response, but not load match. Therefore, for highest accuracy, you must make the load match error as small as possible. This especially applies for low-loss, bi-directional 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.



#### 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)
<b>Filter:</b>	
Insertion loss ( $F_{IL}$ )	= 1dB (.891)
Return loss ( $F_{RL}$ )	= 16 dB (.158)
<b>Attenuator:</b>	
Insertion loss ( $A_{IL}$ )	= 10 dB (.316)
SWR ( $A_{SWR}$ )	= 1.05 (.024)
	32.26 dB Return Loss

---

### Calculations:

	Without Attenuator	With Attenuator
$\rho_{NA}$	$= (F_{IL}) * (NA_{LM}) * (F_{IL})$ $= (.891) * (.126) * (.891)$ $= .100$	$= (F_{IL}) * (A_{IL}) * (NA_{LM}) * (A_{IL}) * (F_{IL})$ $=$ $(.891) * (.316) * (.126) * (.316) * (.891)$ $= .010$
$\rho_{Attenuator}$	NA	$= (F_{IL}) * (A_{SWR}) * (F_{IL})$ $= (.891) * (.126) * (.891)$ $= .019$
<b>Worst Case Error (<math>E_{WC}</math>)</b>	$= \rho_{NA}$ $= .1$	$= \rho_{NA} + \rho_{Attn.}$ $= .01 + .019$ $= .029$
<b>Uncertainty Adds</b>	$= -20\log(F_{RL}) + (E_{WC}) + (NA_D)$ $= -20\log(.158) + (.100) + (.010)$ $= \mathbf{11.4\ dB}$	$= -20\log(F_{RL}) + (E_{WC}) + (NA_D)$ $= -20\log(.158) + (.029) + (.010)$ $= \mathbf{14.1\ dB}$
<b>Uncertainty Subtracts</b>	$= -20\log(F_{RL}) - (E_{WC}) - (NA_D)$ $= -20\log(.158) - (.100) - (.010)$ $= \mathbf{26.4\ dB}$	$= -20\log(F_{RL}) - (E_{WC}) - (NA_D)$ $= -20\log(.158) - (.029) - (.010)$ $= \mathbf{18.5\ dB}$



## 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

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Other topics about Optimizing Measurements

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### 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.

## 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  $\pm$ 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  $\pm$ 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.

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[Other topics about Optimizing Measurements](#)

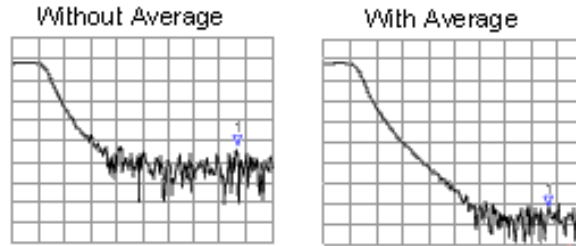
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### Sweep Average

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 unratiod (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 unratiod 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

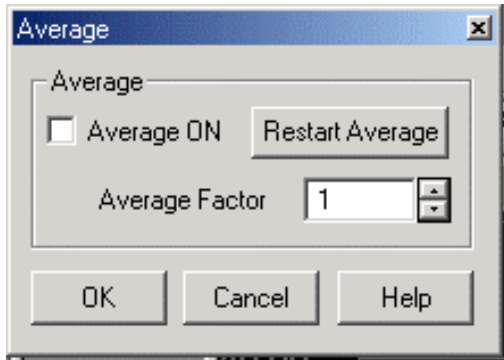


**How to Set Averaging**

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)

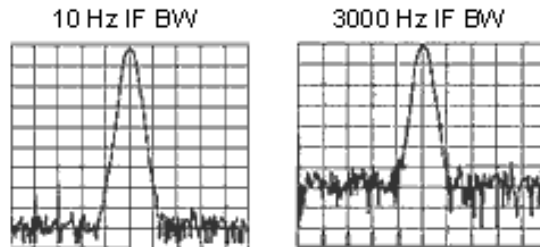
**IF Bandwidth**

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**

Sweep Calibration Tr...

Sweep Time...

Number of Points ▶

**IF Bandwidth...**

Learn more about using the front panel interface

**IF Bandwidth** [X]

IF Bandwidth

35.000 kHz

OK Cancel Help

**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.

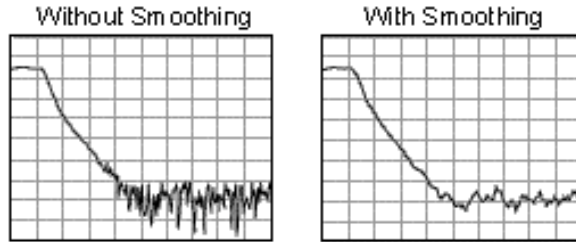
Trace Smoothing reduces the peak-to-peak noise values on broadband measured data. It

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**

A screenshot of a software menu. The menu is titled 'Trace' and has sub-items: 'Scale', 'Marker', 'New Trace ...', 'Delete Trace', 'Measure', 'Format...', 'Math / Memory ...', 'Smoothing...', and 'Trace Statistics...'. The 'Smoothing...' option is highlighted with a blue background.

Learn more about using the front panel interface

A dialog box titled 'Smoothing' with a close button (X) in the top right corner. It contains a section labeled 'Smoothing' with a checkbox 'Smoothing ON' which is checked. Below this are two input fields: 'Percent of Span' with a value of '1.49%' and 'Points' with a value of '3'. Both input fields have up and down arrow buttons. At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

**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

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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

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Other topics about Optimizing Measurements

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### 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

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Other topics about Optimizing Measurements

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### 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
    - 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

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Other topics about Optimizing Measurements

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### 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

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### 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.

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.

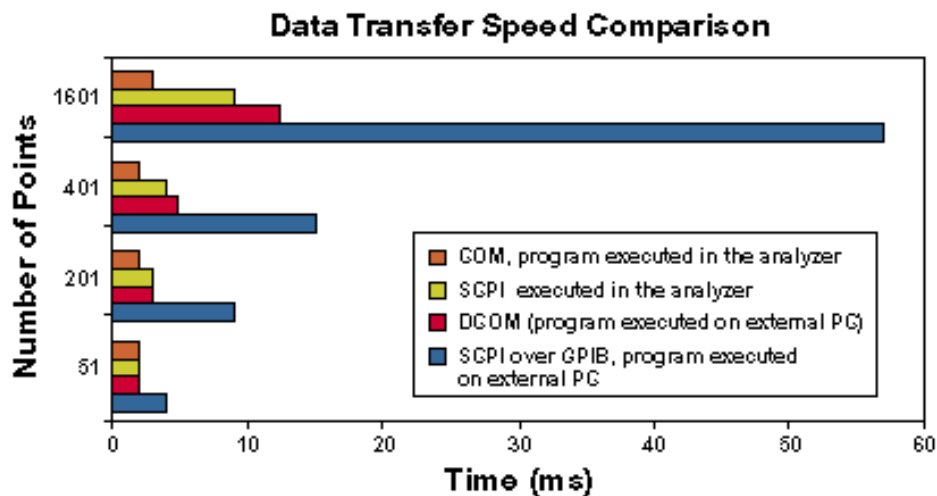


## Data Transfer Speed

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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.



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Other topics about Optimizing Measurements

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## Using Macros

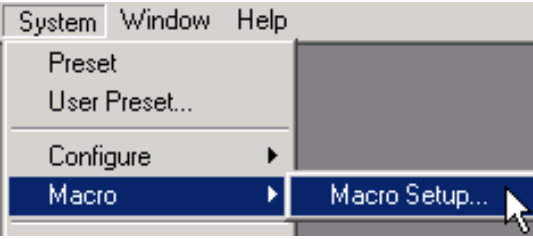

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Macros are executable programs that you write, load into the analyzer, and then run from the analyzer. You can have up to 12 macros set up to run on the analyzer.

- How to Setup Macros
- How to Run Macros
- Macro Example

### How to Setup Macros

Use one of the following methods to access the Macro Setup dialog box:

1. A screenshot of a software menu system. The menu bar includes 'System', 'Window', and 'Help'. The 'System' menu is open, showing options: 'Preset', 'User Preset...', 'Configure', 'Macro', and 'Macro Setup...'. The 'Macro' option is highlighted in blue, and a mouse cursor is pointing at the 'Macro Setup...' option.
2. A screenshot showing two buttons: 'Menu Dialog' and 'Macro Local', separated by a plus sign.

#### In the Macro Setup dialog box:

Click on a blank line below the last entry. (There may be NO entry.)

Click **Edit**

In the **Macro Title** box, type a descriptive title for your macro.

Click **Browse**.

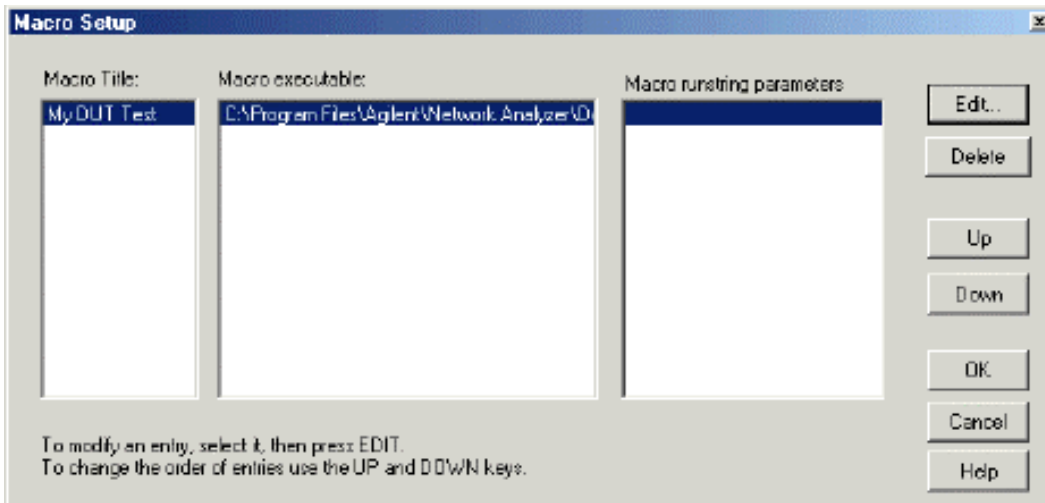
Change **Files of Type**

Find and click your macro file

Click **OK**

Click **OK** on the Macro Setup dialog box.

Learn more about using the front panel interface



### Macro Setup dialog box help

Allows you to create a set of 12 macros so that you can launch other programs from within the PNA application.

To add a Macro, select a blank line then click **Edit**

**Macro Title** Shows the titles that appear in the active entry toolbar when you press the Macro key. These titles are associated with the executable files and should be descriptive so you can easily identify them. For example, if you wanted to launch the Agilent Home Page, you could title the executable "Agilent Home."

**Macro Executable** Lists the complete path to the executable file. To follow the example of launching the Agilent PNA Series Home Page, the path to the executable could be "C:\Program Files\Internet Explorer\iexplore.exe."

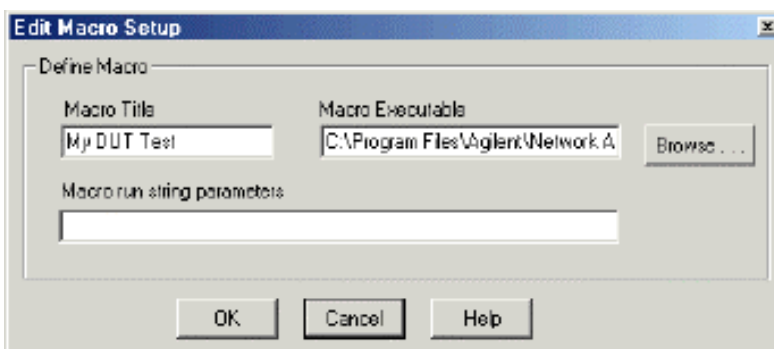
**Macro Runstring Parameters** Lists parameters that are passed to the program referenced in the executable file. Again following the example of launching the PNA Series Home Page, you could assign the runstring parameters "http://www.agilent.com/find/pna"

**Edit** Invokes the Macro Edit dialog box.

**Delete** Deletes the selected macro.

**Up** Allows you to reorder the macros, moving the selected macro up one line. For the 12 possible macros there are 12 lines, indicating the order that they appear in the active entry toolbar when you press the Macro key. Since there are four titles that can be shown at one time in the toolbar, when you repeatedly press the Macro key, the toolbar changes the macro titles to the next set of four macro titles.

**Down** Moves the selection down one line in the list of macros.





### Macro Edit dialog box help

**Macro Title** Allows you to modify the title that appears in the active entry toolbar.

**Macro Executable** Allows you to modify the complete path to the macro executable file.

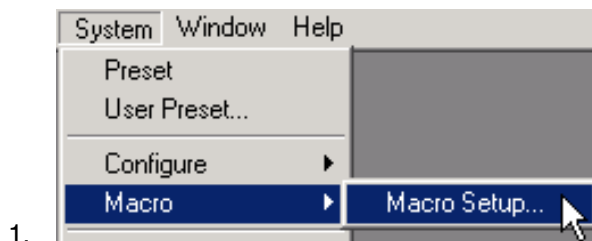
**Browse** Allows you to look through drives and directories, to locate the macro executable file and establish the complete path to the file.

**Macro run string parameters** Allows you to modify the parameters that are passed to the program referenced in the executable file.

See Macro Setup dialog box

### How to Run Macros

Use one of the following methods to access the Macro Setup dialog box:



#### In the Macro Setup dialog box:

1. Click on a blank line below the last entry. (There may be NO entry.)
2. Click **Edit**
3. In the **Macro Title** box, type a descriptive title for your macro.
4. Click **Browse**.
5. Change **Files of Type**
6. Find and click your macro file
7. Click **OK**
8. Click **OK** on the Macro Setup dialog box.

Learn more about using the front panel interface

### Macro Example

The following is an example Visual Basic Scripting (vbs) program that you can copy, install, and run on your PNA

---

**Note:** Print these instructions if viewing in the analyzer. This topic will be covered by the Macro Setup dialog box.

---

1. Copy the following code into a Notepad file.
2. Save the file on the analyzer hard drive in the **C:\Documents** folder. Name the file **FilterTest.vbs**
3. Close Notepad

4. Setup the macro in the PNA
5. Run the macro

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
'This program creates a S21 measurement, with Bandwidth
'markers for testing a 175MHz Bandpass filter
'It is written in VBscript using COM commands

Set PNA = CreateObject("AgilentPNA835x.Application")
PNA.Preset
Set chan=PNA.activechannel
Set meas=PNA.activemeasurement
Set limits = meas.LimitTest
Set trce = PNA.ActiveNAWindow.ActiveTrace

meas.ChangeParameter "S21",1
chan.StartFrequency = 45e6
chan.StopFrequency = 500e6
trce.ReferencePosition = 8
PNA.TriggerSignal = 3

'Do Test
for t=1 to 5
call measure
call compare
next
msgbox("Done Testing")

sub measure
msgbox("Connect Device " & t & " and press OK")
PNA.ManualTrigger True
meas.SearchFilterBandwidth
end sub

sub compare
BW = meas.FilterBW
if bw>6.5e7 then msgbox("Failed BW: " & BW)
Loss = meas.FilterLoss
if loss>5 then msgbox("Failed Loss: " & Loss)
end sub
'End copying here
```



## 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?



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[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

---

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

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

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See other Calibration Topics

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**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

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**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: <b>Full SOLT 2-Port</b>
General Accuracy: High
Calibration Method: Unguided Calibration, Guided Calibration, ECal
Parameters: All
Standards Required: (SHORT, OPEN, LOAD, THRU) or ECal module
Systematic Errors Corrected: <ul style="list-style-type: none"> <li>• Directivity</li> <li>• Source match</li> <li>• Isolation</li> <li>• Load match</li> <li>• Frequency response transmission tracking</li> <li>• Frequency response reflection tracking</li> </ul>
Application: <ul style="list-style-type: none"> <li>• Use for all S-parameter measurements.</li> <li>• 12-term error-correction</li> </ul>

Type: <b>Full TRL 2-Port</b>
<b>Only on PNA Models E8356A, E8357A, E8358A, E8362A, E8363A, E8364A</b>
Calibration Method: Unguided Calibration
General Accuracy: Very High
Parameters: All
Standards Required: THRU, REFLECT, LINE
Systematic Errors Corrected: <ul style="list-style-type: none"> <li>• Directivity</li> <li>• Source match</li> <li>• Isolation</li> <li>• Load match</li> <li>• Frequency response transmission tracking</li> <li>• Frequency response reflection tracking</li> </ul>
Application: <ul style="list-style-type: none"> <li>• Use for all S-parameter measurements.</li> <li>• 12-term error-correction</li> <li>• Highest accuracy of all calibrations</li> </ul>

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: <b>Full SOLT 3-Port</b>
<b>Only on PNA Models N3381A, N3382A, N3383A</b>
General Accuracy: High
Calibration Method: Guided, ECal
Parameters: All
Standards Required: (SHORT, OPEN, LOAD, THRU) or ECal module
Systematic Errors Corrected: <ul style="list-style-type: none"> <li>• Directivity</li> <li>• Source match</li> <li>• Isolation</li> <li>• Load match</li> </ul>

- Frequency response transmission tracking
- Frequency response reflection tracking

Application:

- Use for all S-parameter measurements.
- 27-term error-correction



## Calibration Wizard

The Calibration Wizard allows you to choose a Calibration method and then perform the calibration.

- **How to Start Calibration Wizard**
- Guided Calibration: Mechanical Standards
- Unguided Calibration
- Saving a Calibration
- Calibration Preferences

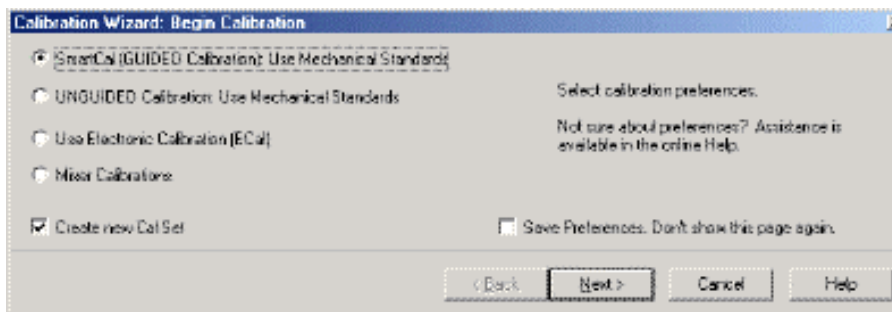
Other Cal Topics...

### How to start Calibration Wizard

Use one of the following methods:

-  +    
-  + 
- 
  - Calibration
  - Trace
  - Scale
  - Marker
  - Calibration Wizard...**
  - Preferences...

Learn more about using the front panel interface



Calibration Wizard dialog box help

Allows you to select the calibration method:

### **SmartCal (Guided Calibration Use Mechanical Standards)**

This method provides a step-by-step "wizard" interface. You describe the connectors on your DUT and the cal kits you will use; it walks you through the most accurate calibration possible.

- Does NOT support simple response cals (open, short, thru).

See Guided Calibration-Mechanical Standards

### **Unguided Calibration Use Mechanical Standards**

This method provides a familiar calibration interface. You choose the type of cal to perform; it allows you the flexibility to measure the standards in any order.

- Supports full 1-port and 2-port cals
- Supports simple response cals (open, short, thru)
- Does NOT support full 3-port cal type

See Unguided Calibration

### **Use Electronic Calibration**

This method provides fast, software controlled, 1-port, 2-port, and 3-port calibrations.

See Using ECal

### **Mixer Calibration**

This method is only available if the PNA has the Frequency Converter Application (option 083).

### **Create new Cal Set**

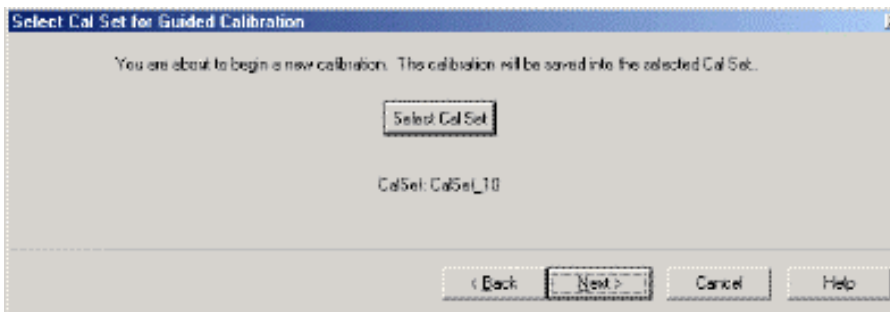
Check to create a new Cal Set for the calibration to be performed.

Clear to overwrite an existing Cal Set with the new calibration data. When cleared, click **Next** to invoke the Select Cal Set dialog box.

### **Save Preferences**

When checked, saves your calibration method choice. You will not see this page again until you need to change the calibration method. To change, on the **Calibration** menu, click **Preferences**.

When cleared, you will continue to see this page on subsequent calibrations.



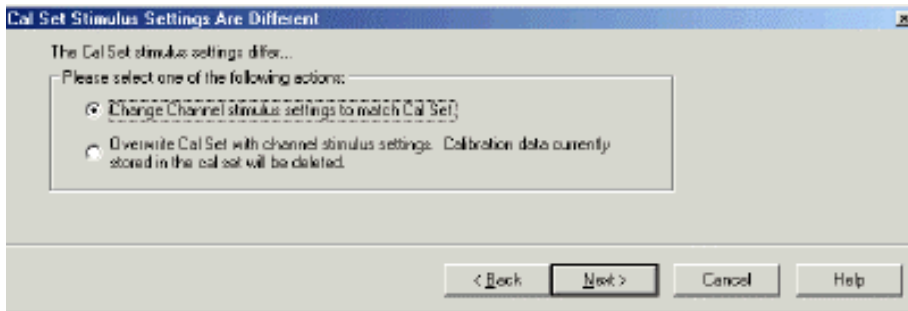
### **Select Cal Set dialog box help**

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 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 Cal Set will be created and displayed.



#### Cal Set Stimulus Settings Are Different dialog box help

The cal set that you selected has stimulus settings that differ from the active channel stimulus settings.

**Change channel stimulus settings to match Cal Set** This does NOT apply the Cal Set data, only change the stimulus settings. You will finish and apply the calibration that you are performing.

**Overwrite cal set with channel stimulus settings. Calibration data currently stored in the cal set will be deleted.** Overwrites the stimulus settings of the cal set with the channel stimulus settings. Deletes the calibration data currently stored in the cal set.

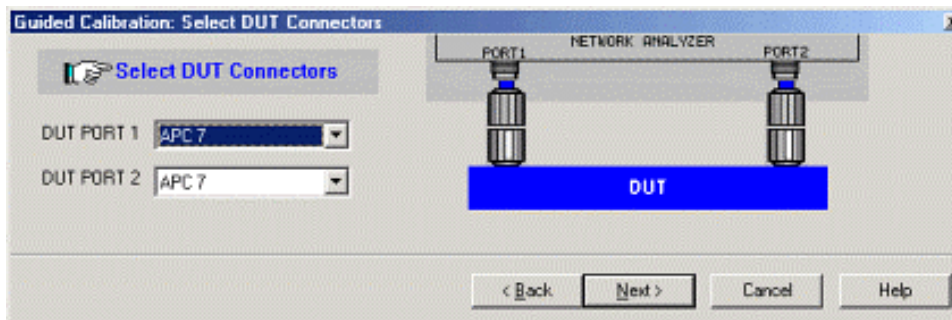
### Guided Calibration Mechanical Standards

Depending on the DUT connector types you specify, the "wizard" automatically determines the calibration type and suggests a calibration kit.

**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:

- Select DUT Connectors
- Select Cal Kits
- Preview/Modify Settings
- Guided Calibration Steps



#### Select DUT Connectors dialog box help

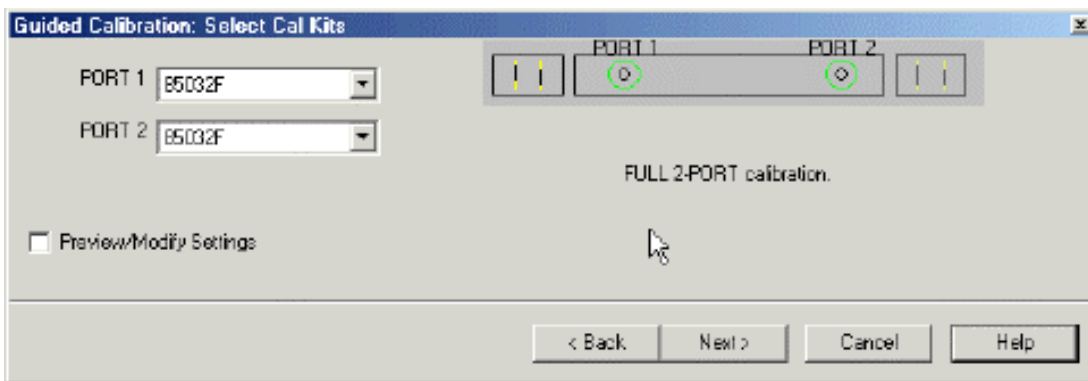
Allows you to select the DUT connector types.

**Note:** 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 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 Calibration kits).

**Non-insertable** Guided Cal will perform an Adapter Removal calibration. This requires that you have an adapter that has the same connectors as the DUT. To override this behavior, check Preview/Modify Settings in the following dialog box.



#### Select 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** (on a three-port PNA) Lists the calibration kits available with port 3

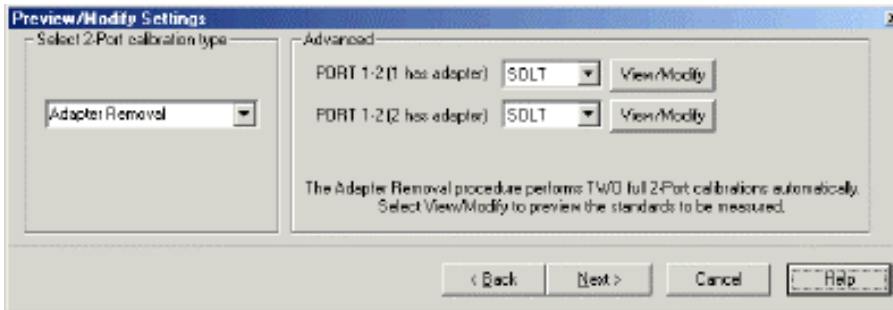
**Preview/Modify Settings** Invokes a dialog box that shows the calibrations to be performed based on your selections in the previous dialog boxes.

#### To perform a Guided TRL cal:

1. Select the connector types (previous dialog box).
2. Select a Cal Kit that supports TRL cal (this dialog box). If one does not exist, or you are unsure, use Advanced Modify Cal Kits to construct or install a TRL cal kit.
3. Check Preview / Modify Settings
4. Click **Next**. In the Preview / Modify Settings dialog box, click the arrow next to the ports that require a TRL cal. Select **TRL** cal. If TRL is not available, then the Cal Kit you selected does not support TRL cal.
5. To change the Reference Plane and Impedance settings:
  1. From the **Calibration** menu click **Advanced Modify CalKit**

2. Select a Cal Kit
3. Click **Edit**
4. In the **Class Assignments** list, click **TRL**. Then click **Edit**.
5. Learn about the Modify Calibration Class Assignments dialog box

Learn more about TRL calibration.



#### Preview/Modify Settings dialog box help

**Note:** This dialog box looks slightly different on a 3 port PNA but functionally works the same.

#### Select calibration type

Shows the calibrations to be performed based on your selections in the previous dialog boxes. Click to select a different calibration type. Depending on your situation, there may be NO choices available.

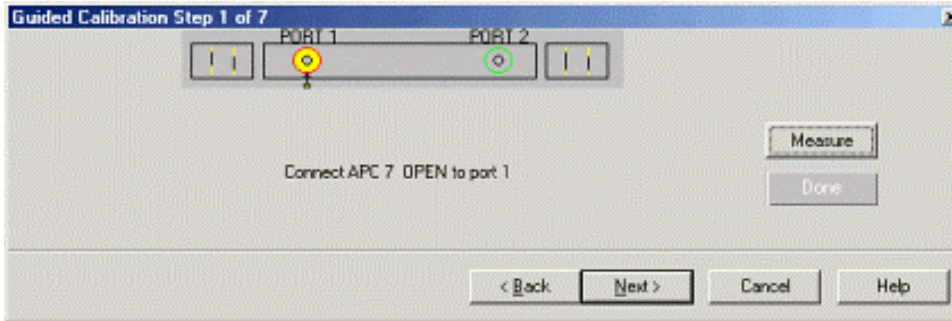
The potential choices include:

- Adapter Removal
- Unknown Thru
- Insertable - (use zero-length thru)
- TRL

#### Advanced

Shows calibrations to be performed on individual ports. Click to select a different calibration type. Depending on your situation, there may be NO choices available.

**View/Modify** Invokes the Modify Calibration Class Assignments dialog box. Use this to view or change the standards associated with a calibration measurement.



#### Guided Calibration Steps dialog box help

Prompts for standards to be measured.

**Measure** Click to measure the standard.

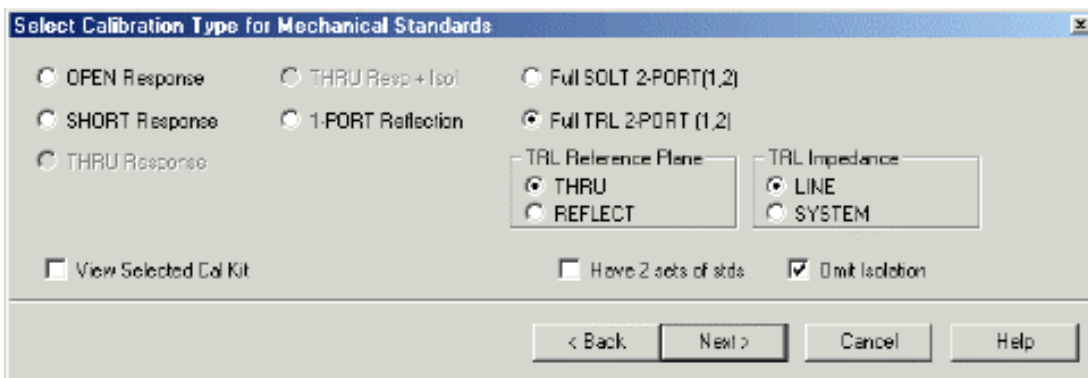
**Done** Click **after** a standard is re-measured and all measurements for the calibration are complete.

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

- Select Calibration Type for Mechanical Standards
- Select Cal Kit
- Measure Mechanical Standards
- Multiple Standards
- Sliding Load Measurement



#### Select Calibration Type for Mechanical Standards dialog box help

Allows you to select the calibration type and settings. The Calibration types that are available depend on the parameter that is selected for the active channel and the PNA model. For example, if an S11 measurement is selected, then Thru Response cal type is not available.

**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.

**Full SOLT 3-PORT** 3-port PNAs only

**TRL Reference Plane (when TRL is selected)**

**THRU** The THRU standard is used to establish 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.

**View Selected Cal Kit** Check to view the selected cal kit or select a different cal kit. Invokes the Select Cal Kit dialog box.

**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.

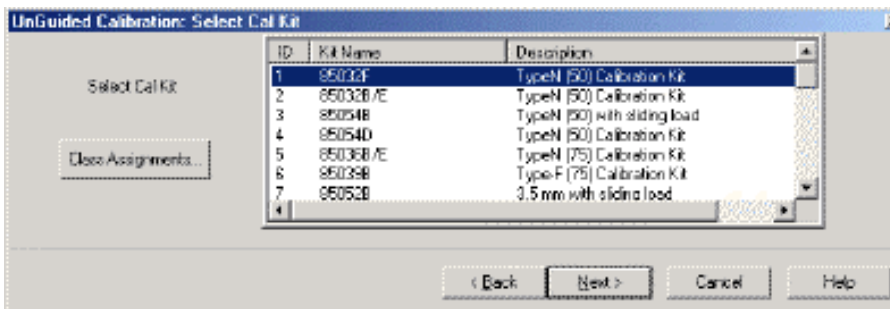
**Omit Isolation** Check to NOT correct for crosstalk (isolation). Use when your measurement does not require high dynamic range. Clear to calibrate and correct for isolation. Use when your measurement requires maximum dynamic range (> 90 dB). See also Isolation Portion of 2-Port Calibration.

**Next** Click to continue to Measure Mechanical Standards dialog box.

**Notes:**

- If the DUT connector type is has an impedance other than 50 ohms (waveguide = 1 ohm) 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).



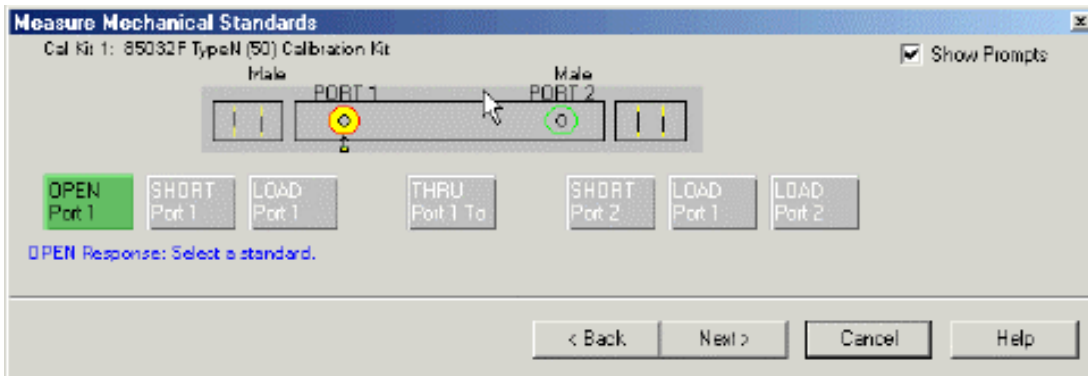
Select Cal Kit dialog box help

Displays the calibration kit files available for Unguided calibration.

Select the desired calibration kit file and click **Next**

**Class Assignments** Allows modification of the selected Cal Kit class assignments.

To learn to substitute other calibration kits, see Advanced Modify Cal Kits

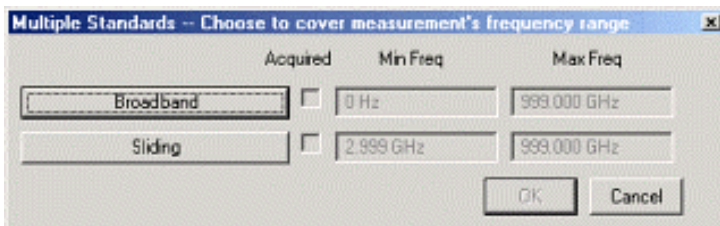


#### Measure Mechanical Standards dialog box help

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.



#### Multiple Standards dialog box help

Select the standards to be measured.

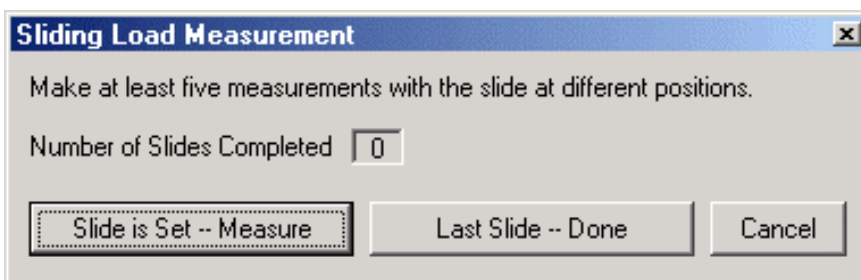
**Note:** You may see both male and female standards. The Unguided cal has no knowledge of the gender of your connector types. For highest accuracy, choose **ONLY** the correct standard; then click OK.

To modify this calibration class to show only one standard, on the Calibration menu, click **Advanced**

**Modify Cal Kits.** Select the Cal kit and click **Edit Kit**. In **Class Assignment**, click **Edit**. Learn more about Modify Calibration Class Assignments.

- Connect the standard to the measurement port and click its associated button. A check mark in the **Acquired** box indicates the standard has been measured.
- To cover the entire frequency range, you may need to measure more than one standard. The order in which the standards are measured is important. The last standard that is 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. This is because the frequency range of the sliding load is a subset of the broadband load.

Learn more about Modify Calibration Class Assignments



#### **Sliding Load Measurement** dialog box help

Allows you to measure the sliding load standard.

#### **To Measure a Sliding Load:**

1. Connect the sliding load to the measurement port.
2. Position the sliding element, then click **Slide is Set -- Measure**. Do not move the sliding element until measurement is complete.
3. 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.

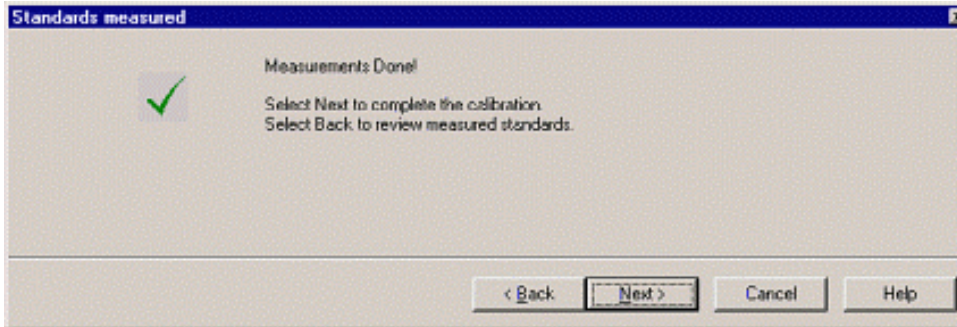
Measure the remaining standards.

### **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





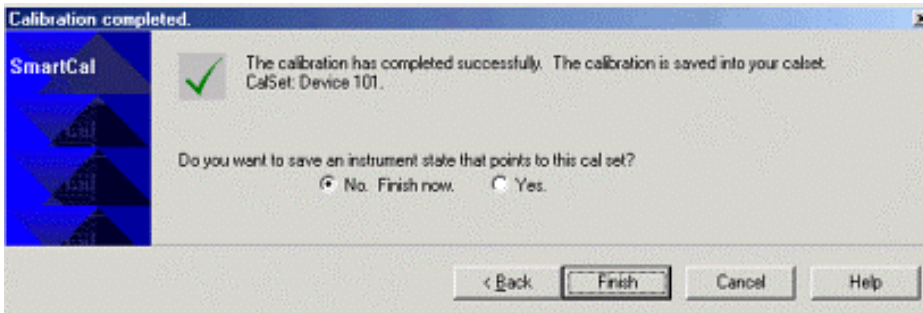
**Standards Measured** dialog box help

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 exit the calibration wizard or continue to **Save** options.

**No. Finish now.** Exits calibration wizard

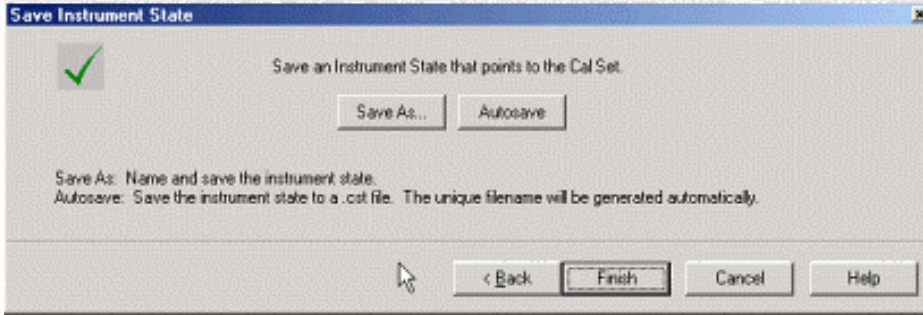
**Yes** Allows selection of Save options.

**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:

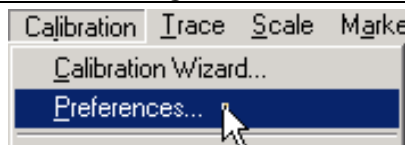
- You can recall the instrument settings and calibration data from memory or recall just the Cal Set. See Using Cal Sets.

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

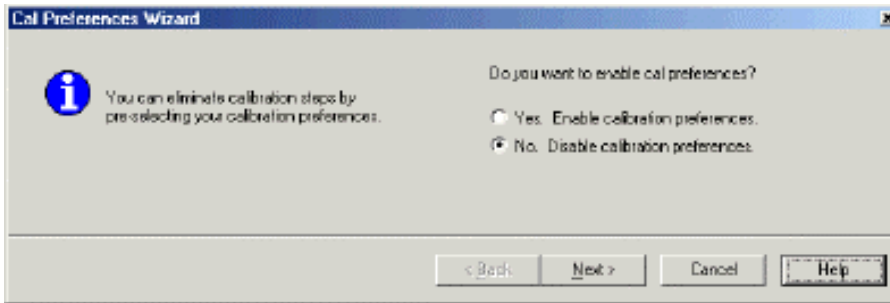


## Calibration Preferences

### How to change Cal Preferences



Learn more about using the front panel interface



#### Cal Preferences dialog box help

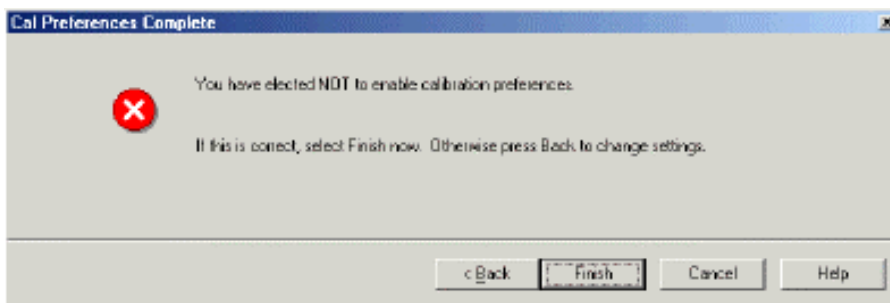
Cal preferences allows you to save the following selections from the Begin Calibration page of the Cal Wizard:

- Cal method (Guided, UnGuided, ECAL)
- Create New Cal Set (checked or cleared)

**Yes. Enable calibration preferences** The selections will always be made and you will not see the Begin Calibration page again until you disable calibration preferences. Click **Next** to make your selections on the Begin Calibration page.

**Note:** you can also Enable calibration preferences directly from the Begin Calibration page.

**No. Disable calibration preferences** See the Begin Calibration page every time you start Cal Wizard. Click **Next** to see the following dialog box confirming your choice to disable preferences.



#### Cal Preferences Complete dialog box help

Click **Finish** to complete cal preferences.


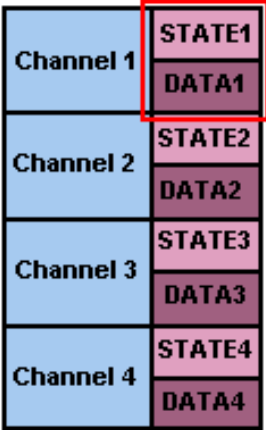
## Using Calibration Sets

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

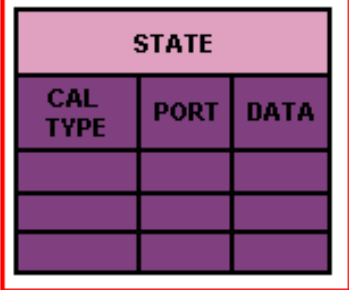
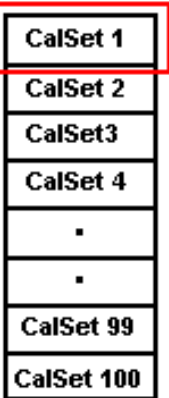
- PNA Calibration Data, past and present
- Creating a Cal Set
- Managing Cal sets
- Applying Cal Sets
- Examples of Cal Set Usage
- Archiving Cal Sets using .cal files

## PNA Calibration Data, past and present

### Past

One .cst File	Analyzer set up
	
<ul style="list-style-type: none"> <li>• Instrument <b>State</b> and Cal <b>Data</b> were stored and recalled in <b>.sta</b> and <b>.cal</b> files (<b>.cst</b> files are both).</li> <li>• Cal data was tied to the channel it came from</li> <li>• Cal data could not be shared between Channels.</li> </ul> <p>Limited ability to apply different <b>calibration types</b> on the same channel.</p>	

### Present with Cal Sets

One Cal Set	Cal Set file
	
<ul style="list-style-type: none"> <li>• Cal Data and Instrument Data are separated in two files, <b>.cst</b> for State and <b>PNACalSets.dat</b> for data.</li> <li>• Cal Data has been expanded to allow storage of multiple Cal Types.</li> </ul>	

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:

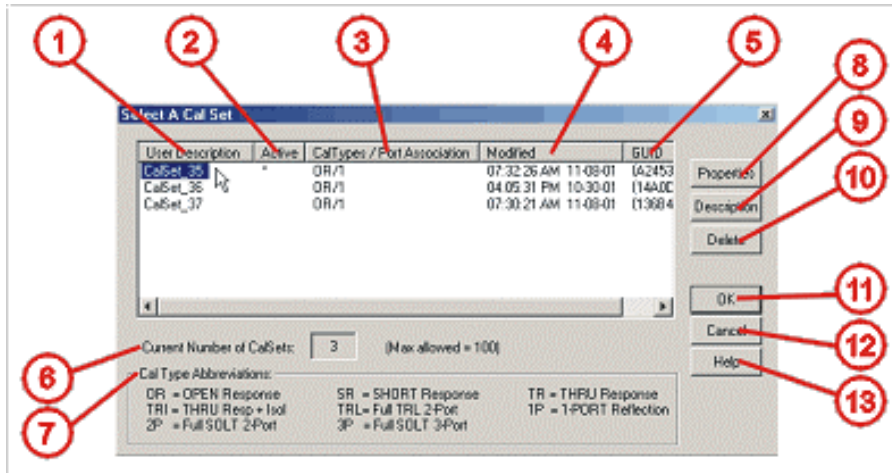
1. From the Calibration Wizard for both guided and non-guided methods.
2. From COM programming using the Calibrator::SetCalInfo method.
3. From COM programming using the CalManager::CreateCalSet method.
4. From SCPI programming using the SYST:CORR:WIZARD to start the Cal Wizard.

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**.
  - 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.

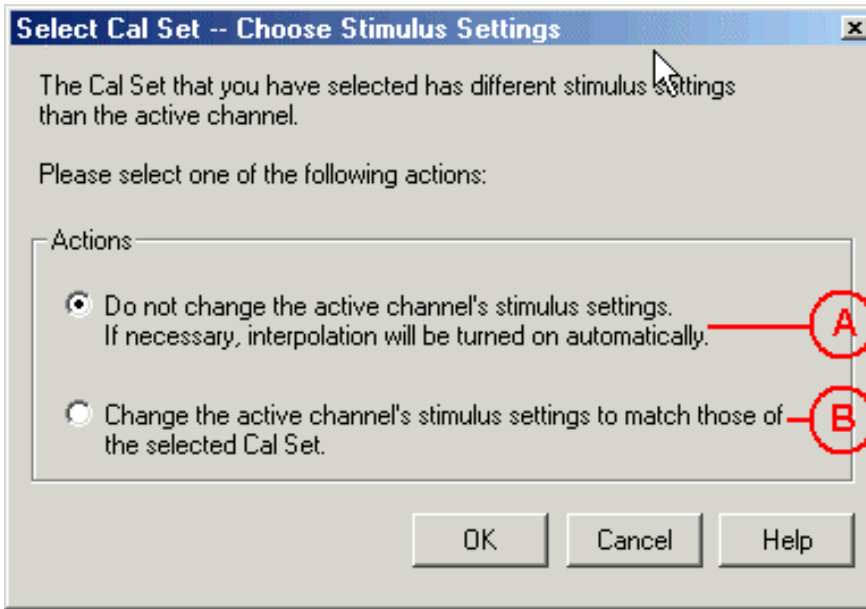
### Differences between Cal Set and Measurement Attributes

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.**

	<b>Frequency Range</b>
Cal Set	-----
Measurement	-----

Then choose

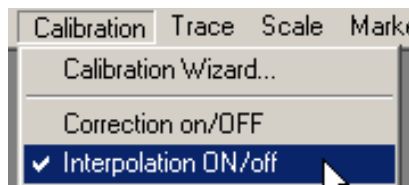


either:

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. [Learn more about Interpolation Accuracy](#)

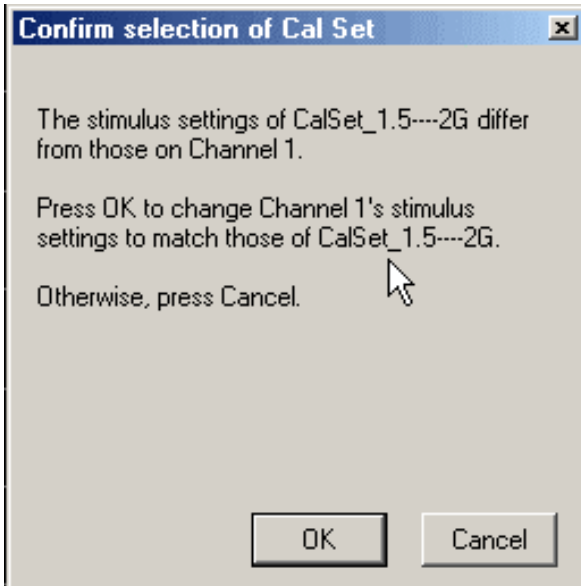


If the frequency span of the **Cal Set is less than the measurement.**

**Frequency Range**

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

Then choose either:



**OK** Reduce the measurement frequency span

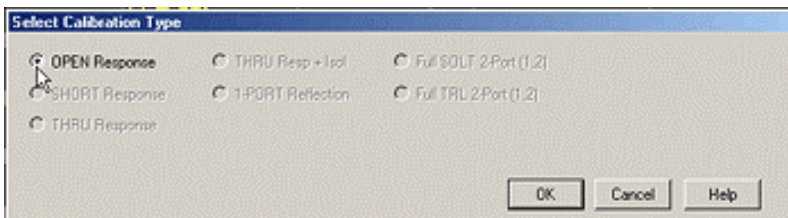
**Cancel** Cal Set will NOT be applied

**How to Select a Calibration Type**

 A screenshot of a software menu. The menu is open, showing options: "Calibration Wizard...", "Correction ON/off" (checked), "Interpolation ON/off" (checked), "Cal Set...", and "Cal Type...". A mouse cursor is hovering over the "Cal Type..." option.

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.

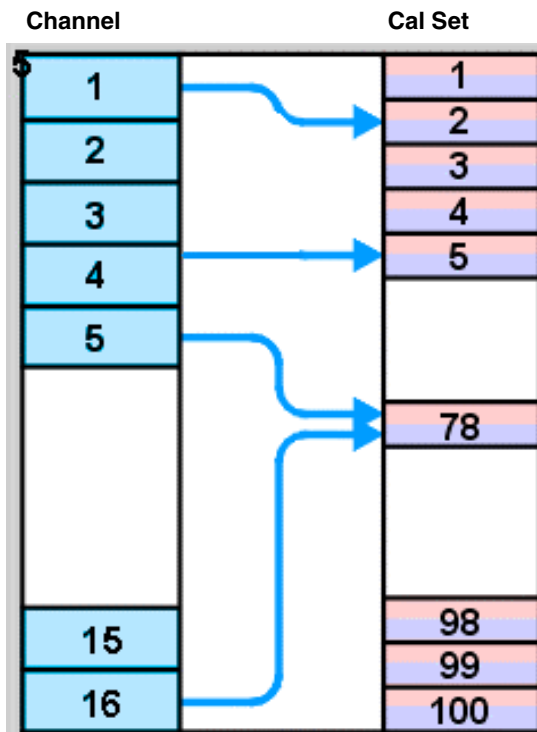
**Here is how:** First do some planning. After examining the stimulus settings for the group of S-parameter Measurements, the Cal Set stimulus range is designed to be a super-set of the whole group. Each measurement can then use the same Cal Set.

---

**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 Using ECAL
- ECAL User-Characterization
- Restore ECAL Module Memory

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[See other Calibration Topics](#)

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### ECal Overview

ECal is a complete solid-state calibration solution. Every 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 calibration
- Full 2-Port calibration
- Full 3-Port calibration

You can validate the accuracy of a mechanical or ECAL calibration with ECAL confidence check.

### 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 provided with your ECal module.

### Connect ECal Module to the PNA

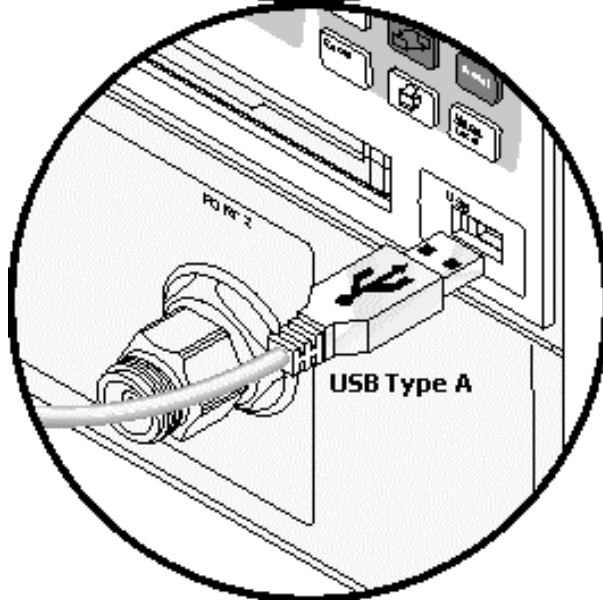
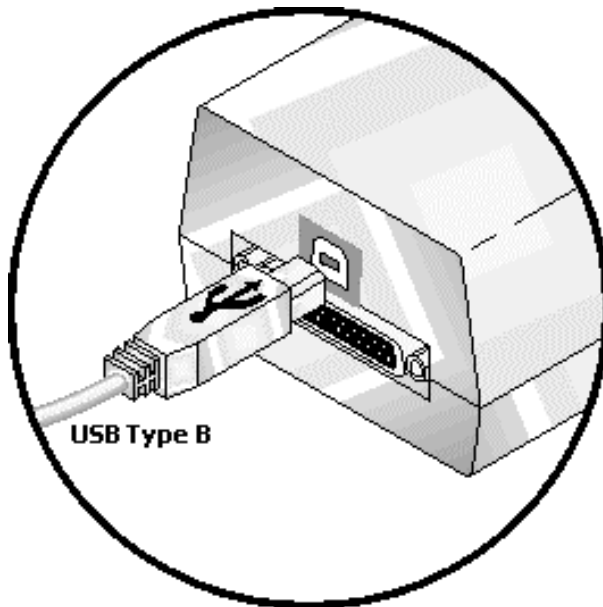
ECal modules are controlled and powered through a USB connection to the PNA. When you connect the module, the PNA automatically recognizes the type of module, frequency range, and connector type.

ECal modules connect to the USB port on the front or rear panel of the PNA.

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.

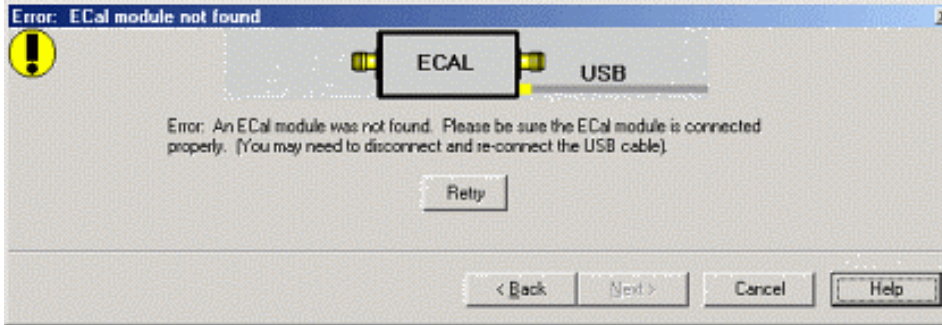
**ECal Module USB Port**

**Analyzer Front Panel USB Port**



**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.



**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 alibration.

For best accuracy, allow the ECal module to warm-up until it indicates READY.

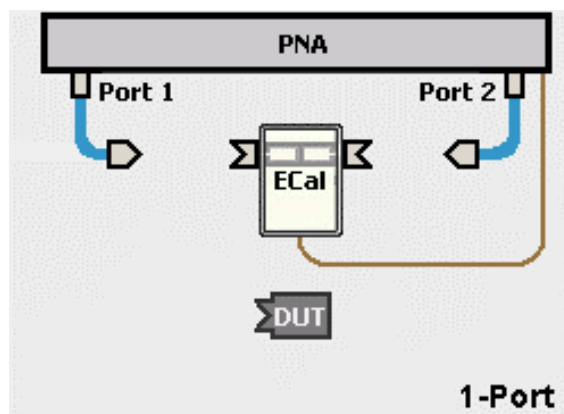
See Connect ECal Module USB to PNA USB.

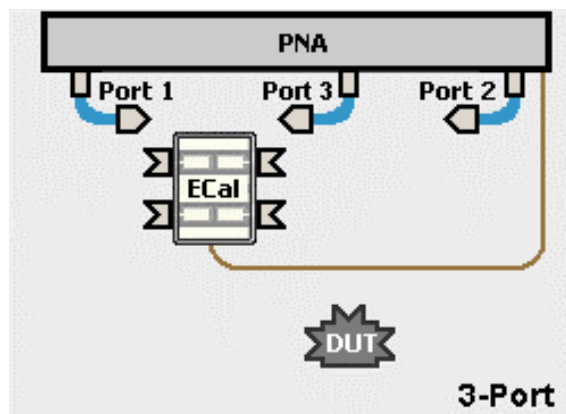
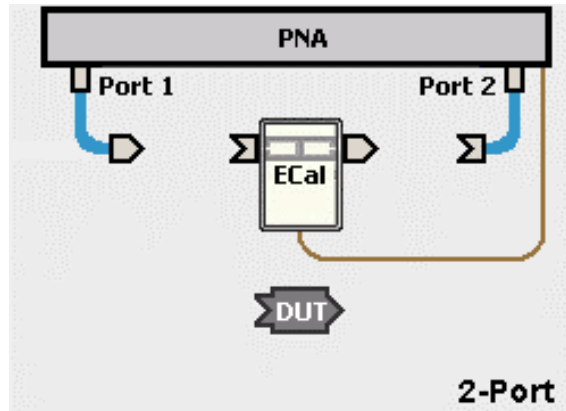
**Perform a Calibration Using ECal**

The following graphics show the typical connections for 1-port, 2-port, and 3-port calibrations and DUT measurements.

**Note:** Terminate any unused ECAL ports with a 50 ohm load.

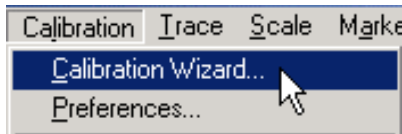
Select an ECal module that has connectors of the same type and gender as the DUT. If such an ECal module is not available, a module with connectors different from the DUT can be used by using Advanced Settings or User Characterization.



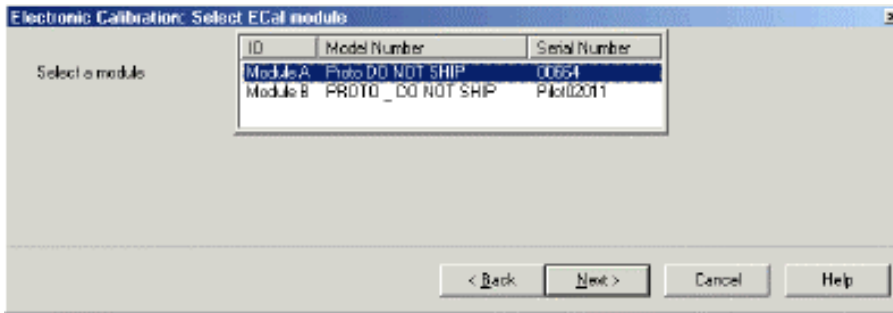


**How to Perform a Calibration Using ECal:**

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:

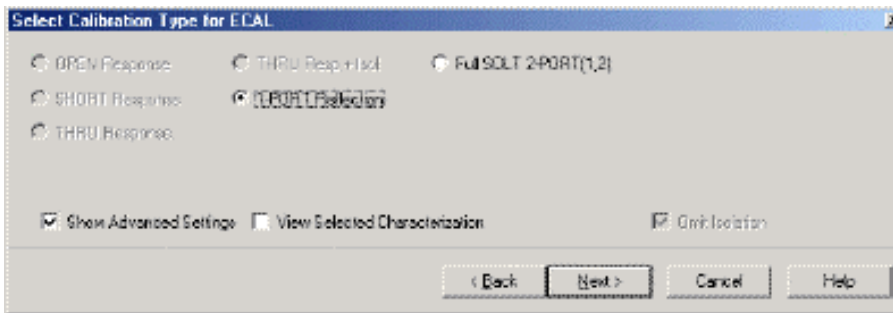


5. In the **Calibration Wizard** dialog box, click **Use Electronic Cal (ECal)**



**Select ECAL Module** dialog box help

If the PNA detects more than one ECAL module, select one of the modules, then click **Next**.



**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.

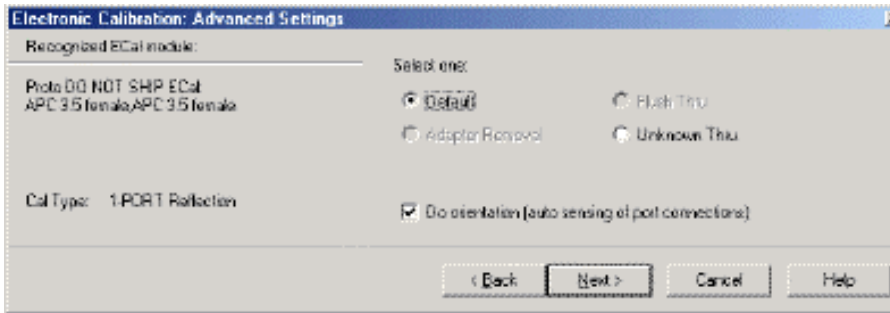
**Show Advanced Settings** Check to display the Advanced Settings for the calibration type selected.

**View Selected Characterization** Check to invoke a dialog box to View the Selected Characterization (user or factory) for performing the ECAL. Learn more about User Characterization.

If the frequency range of the active channel is greater than that of the selected characterization, a **Caution: Additional Standards Required** message is displayed. To correct the problem, perform one of the following solutions:

- Reduce the frequency range of the active channel.
- Select a different characterization that covers the required frequency range.
- Re-characterize the module with an increased frequency range.

**Omit Isolation** Check to omit the isolation measurement when performing a Full 2-port or Full 3-port calibration. Clear to perform isolation measurement.



### 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.

### Select One

The following requires that you understand the terms "insertable and non-insertable" devices. See Calibration Accuracy to learn about these terms.

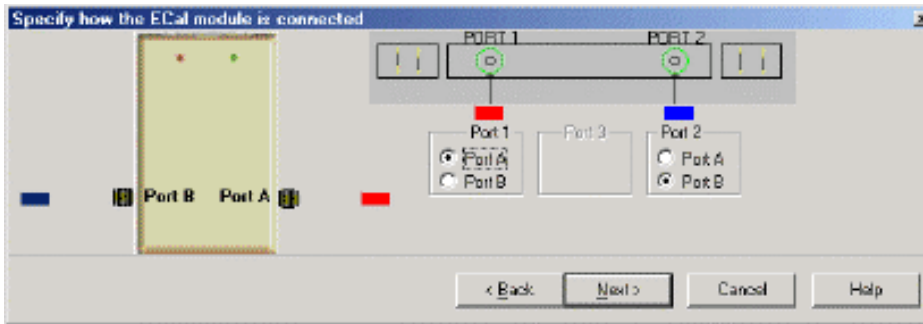
**Adapter Removal** Use adapter removal setting with a Full 2-Port or Full 3-Port calibration to perform a calibration for a non-insertable device, using an insertable module and adapter. This setting characterizes and removes the effects of the adapter connected to the module. The adapter must be reversible, and for best accuracy should be instrument grade or better. This setting requires an ECal module having insertable connectors. Learn more about Adapter Removal.

**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. When this setting is checked, you will be prompted to remove the ECal module and connect the two reference planes directly together (zero-length thru).

**Unknown Thru** If your ECAL module has connectors, you cannot use a zero-length thru. However, you can use the Unknown Thru setting to achieve higher accuracy than using the Thru standard in the ECAL module. The ECal module is removed and a mechanical thru adapter is connected between the measurement ports. Learn more about Unknown Thru.

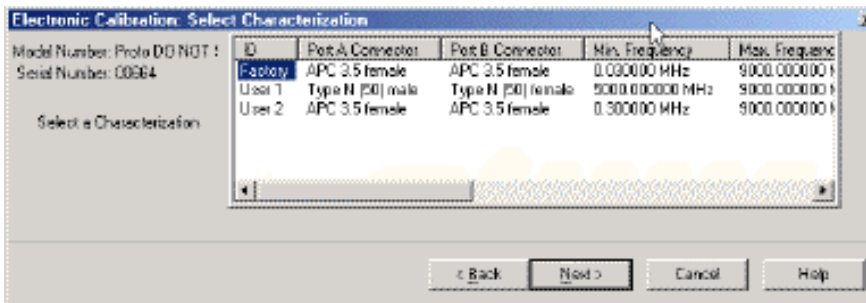
**Do orientation** When this box is checked (default) the PNA senses the model and direction in which an ECAL module port is connected to the PNA ports. If power to the ECAL module is too low, it will appear as if there is no ECAL module connected. If you use low power and are having this problem, clear this check box to provide the orientation manually.

**Note:** Orientation occurs first at the middle of the frequency range that you are calibrating. If a signal is not detected, it tries again at the lowest frequency in the range. If you have an E8361A or E836xB PNA and do an ECAL completely within 10 - 20 MHz OR 60 - 67 GHz, you may need to do orientation manually. There may not be sufficient power to orient the ECAL module at those frequencies.



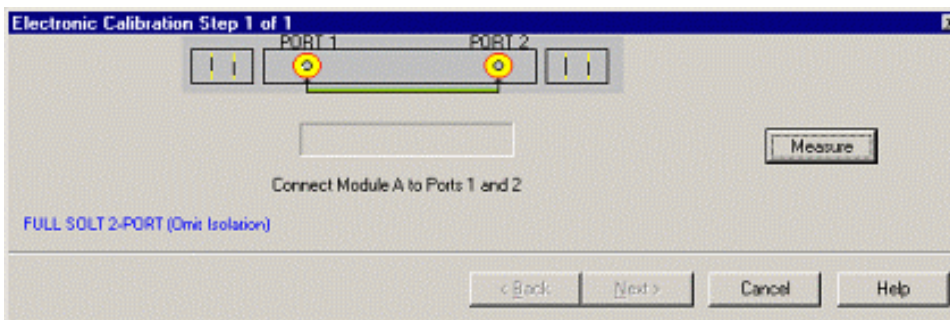
**Specify how the ECAL module is connected** dialog box help

This dialog box appears when the **Do orientation** checkbox in the previous dialog box is cleared. Click Port A and B to reflect the orientation of the ECAL module.



**Select Characterization** dialog box help

Select either the Factory Characterization of your ECAL module or a User Characterization. Once selected, that characterization becomes the default selection until the PNA is turned OFF and restarted. When restarted, **Factory** again becomes the default selection.

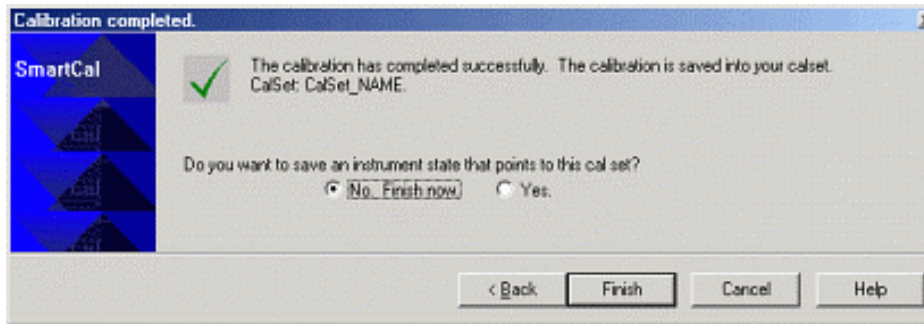


**Electronic Calibration Steps** dialog box help

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.

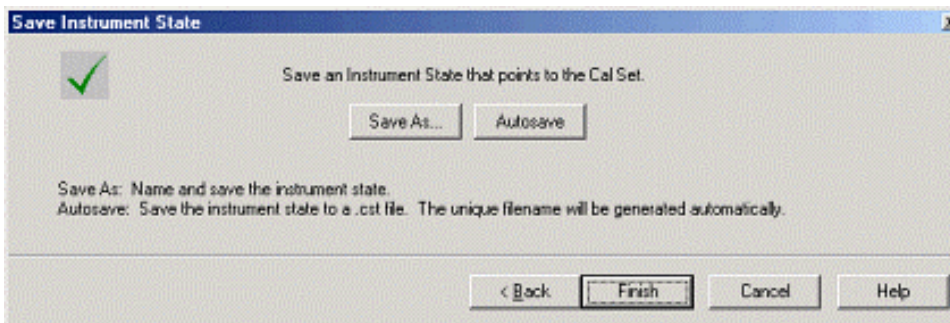
**No. Finish now.** Completes calibration.

**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.

**ECAL 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.

There are several reasons you might want to perform a user characterization:

- If you need to use adapters with your ECAL module, you could characterize your ECAL module with the adapters attached and perform subsequent ECALS with a single step.

- If you have a 4-port ECAL module, you could configure the module with adapters of different connector types. Then perform a user characterization of the module. When you need to test a DUT with a pair of the connector types on your module, calibrate the PNA with a 1-step ECAL using the two connectors of the User characterized module.
- If you test devices in a fixture, you could embed the characterization of the fixture in the characterization of the module. To do this, during the mechanical calibration portion of the user characterization, calibrate at the reference plane of the device as you would normally calibrate. Then remove the fixturing to be embedded and insert the ECAL module to be characterized. When measuring the ECAL module, the PNA removes the effects of the fixturing and stores the measurement results in the user characterized ECAL module. Subsequent calibrations with that user characterized module will also remove the fixture effects.

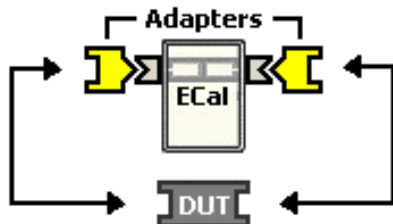
**Notes:**

- 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.
- You can save up to five different user characterizations in a single ECAL module. There are memory limitations; the PNA will determine if the contents of a user characterization will fit inside the module before it is performed. **Note:** This is a new feature with PNA Rev. 3.0. Previous versions of PNA will NOT recognize more than one user characterization.
- Both 2-port and 4-port ECal modules support user characterization.

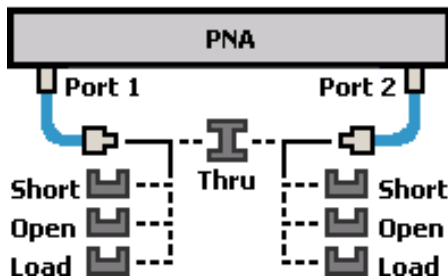
**How to Perform a User Characterization**

**SUMMARY** (A detailed procedure follows.)

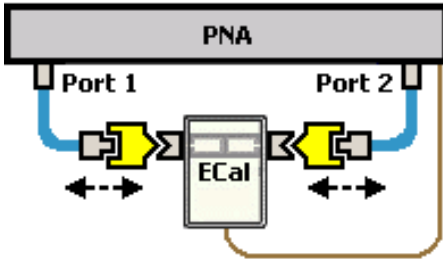
1. Select adapters for the module to match the connector configuration of the DUT.



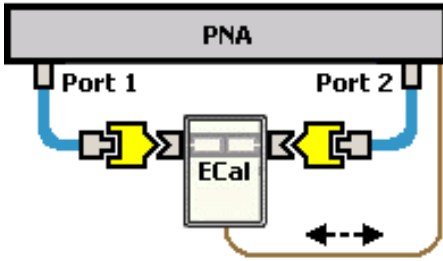
2. Either perform a Guided calibration using mechanical standards or recall a Cal Set. This is required to make accurate measurements of the ECAL module and adapters.



3. Measure the ECal module, including adapters, as though it were a DUT.

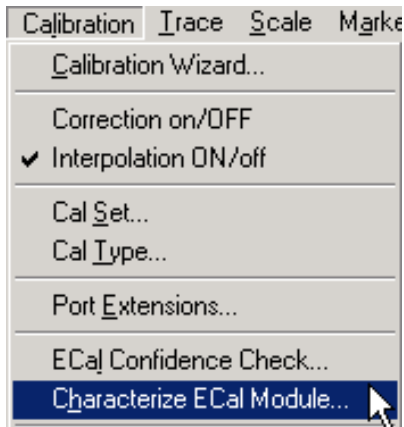


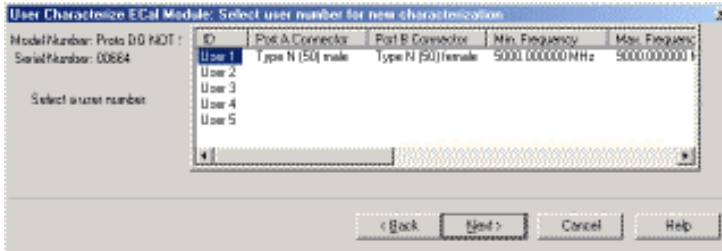
4. The measurement result is the characterization data that then gets stored inside the module.



#### Detailed steps to Perform a User Characterization:

1. Connect the 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. For best accuracy, the **IF bandwidth** should be set to **1 kHz** or less.
5. Start the **Characterize ECAL Module** Wizard:

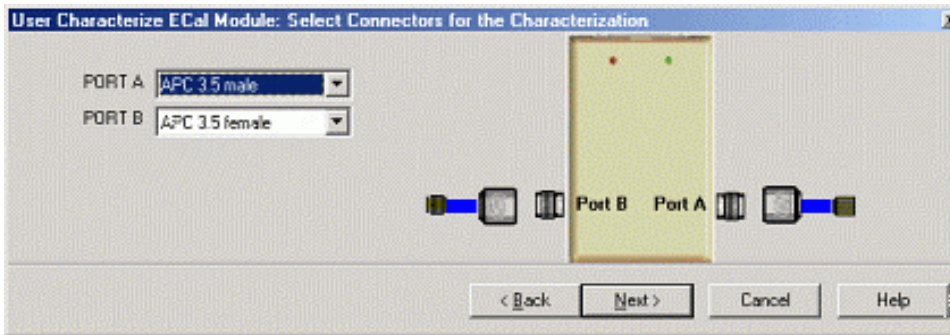




#### Select user number for new characterization dialog box help

Shows the characterizations already in the module. Scroll to view the all of the parameters of the stored characterizations. Select an empty location or overwrite an existing characterization.

**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 **No adapter** if no adapter is used on a port.

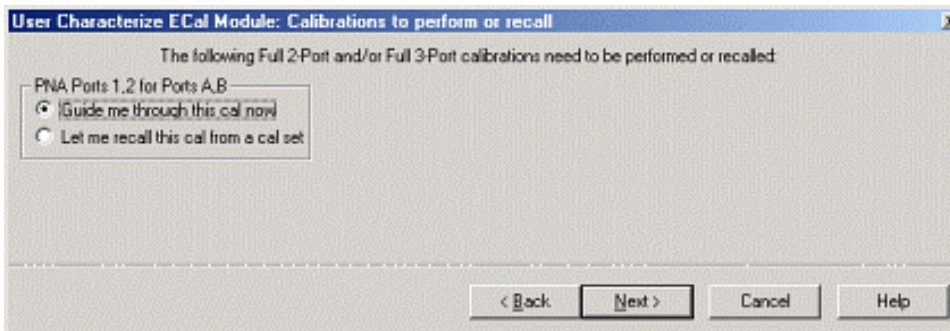
**PORT A** Lists the connector types available for Port A.

**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.



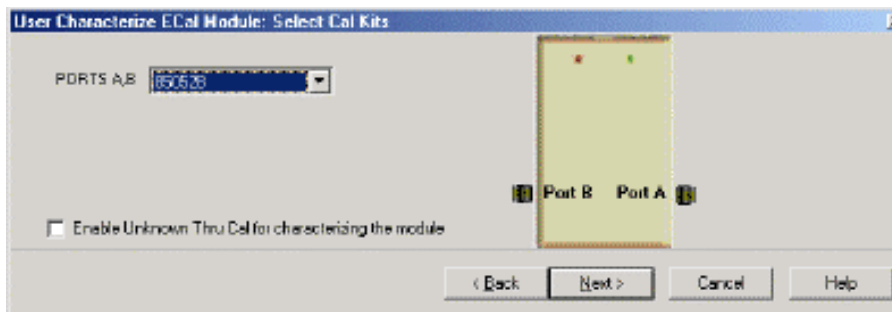
#### Calibrations to perform or recall dialog box help

The PNA must be calibrated before measuring the ECAL module and necessary adapters. This dialog box displays the number and types of mechanical calibrations required for the characterization.

**Guide me through this cal now** Click to perform a Guided calibration. 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 Cal Kits or the Select Cal Set dialog box.

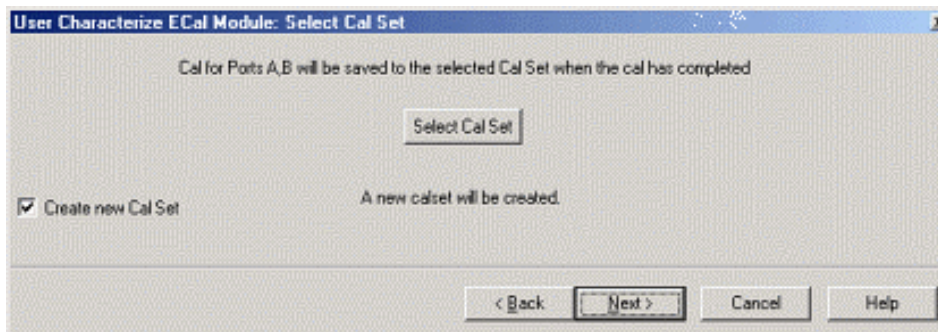


#### Select Cal Kits dialog box help

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. Learn more about Unknown Thru Cal This setting is available only on E835xA and E836xA series network analyzers.

**Next** Click to continue to the Select Cal Set dialog box.



#### Select Cal Set dialog box help

The calibration that you perform will be written to a Cal Set. This dialog box allows you to select a Cal Set to overwrite, or to write to a new Cal Set. The current choice is visible below the **Select Cal Set** button.

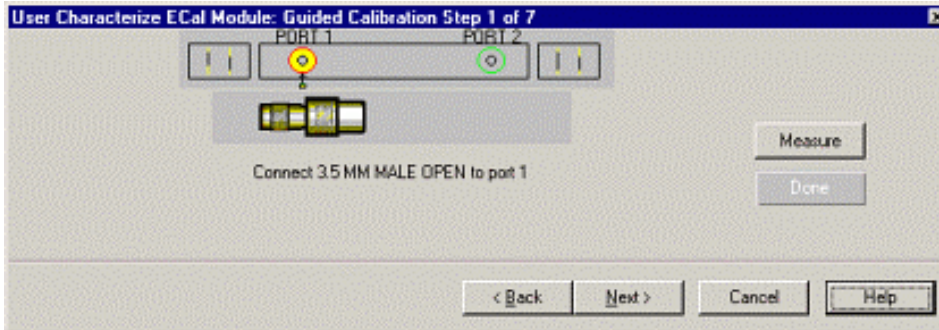
**Select Cal Set** Click to open the **Select A Cal Set** dialog box.



**Create new Cal Set** Check to create a new Cal Set to store the calibration. Clear to select and overwrite a stored Cal Set.

**Next** Click to continue to the Guided Calibration Steps dialog box.

**Note:** Make a note of the Cal Set 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.

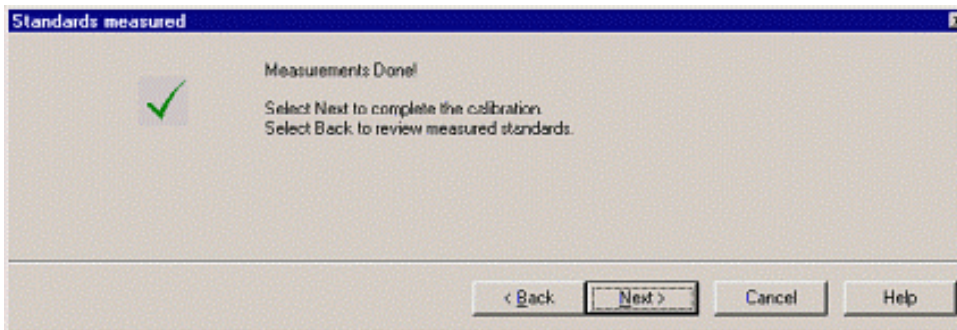
**Back** Click to repeat one or more calibration steps.

**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.

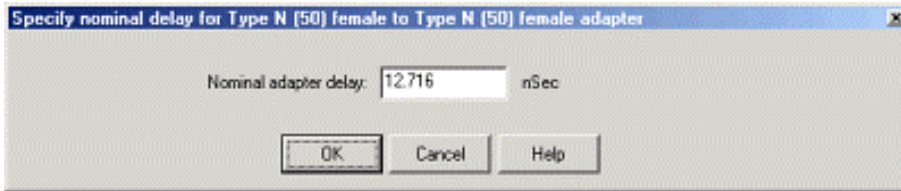


#### **Standards measured** dialog box help

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**

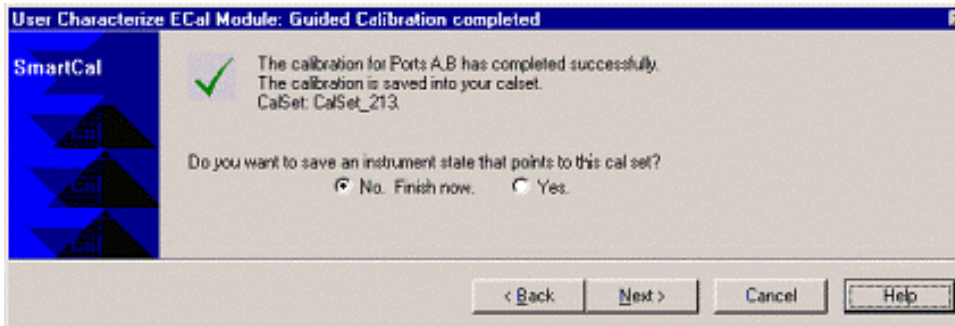
An estimate of the nominal delay is required.

**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



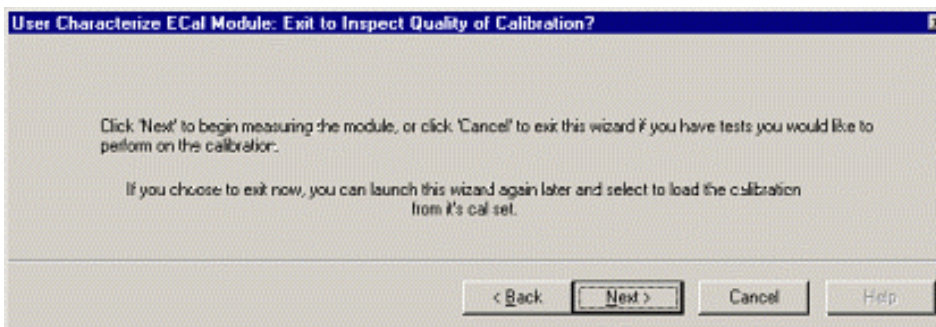
**Guided Calibration completed dialog box help**

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.

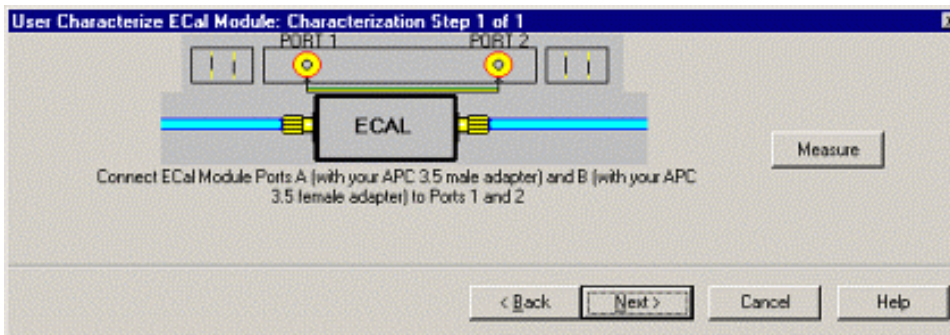
**Next** Click to continue to the Characterization Steps dialog box.

**Cancel** Exits the Calibration.

To return to the current step:

1. Start User Characterization.
2. In the **Select user number for new characterization** 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, recall the Cal Set that you just performed.

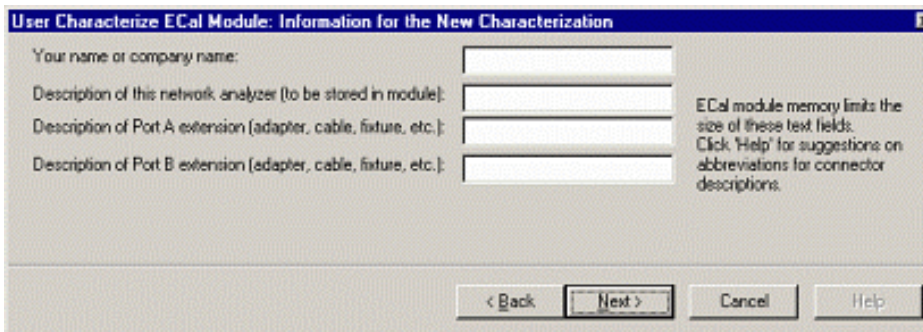


### Characterization Steps dialog box help

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

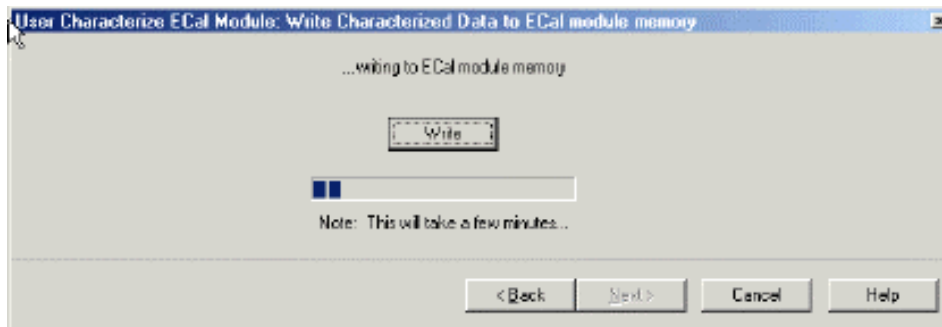
Allows you to describe the properties of the User Characterization.

**Next** Click to continue to the Write Characterized Data to the ECal module dialog box.

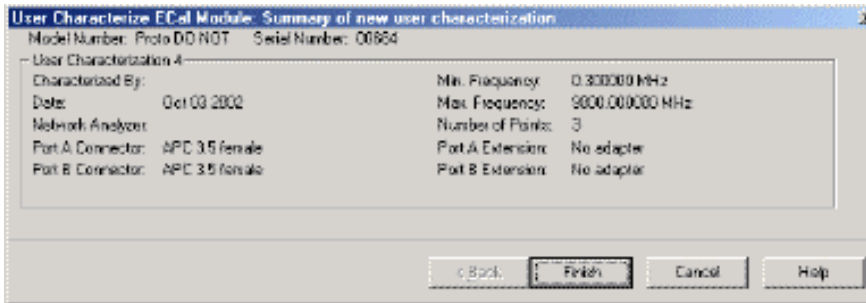


To minimize the number of characters, use the following 3-character codes to describe the connectors listed.

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	N5F
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
<p>The PNA writes User Characterization and factory characterization data to the ECal module memory. For more information, see Restore ECAL module memory.</p> <p><b>Write</b> Click to write data into the ECal module.</p> <p>The Updated Summary of ECal modules detected on USB dialog box opens after data is saved to module.</p>



### 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).

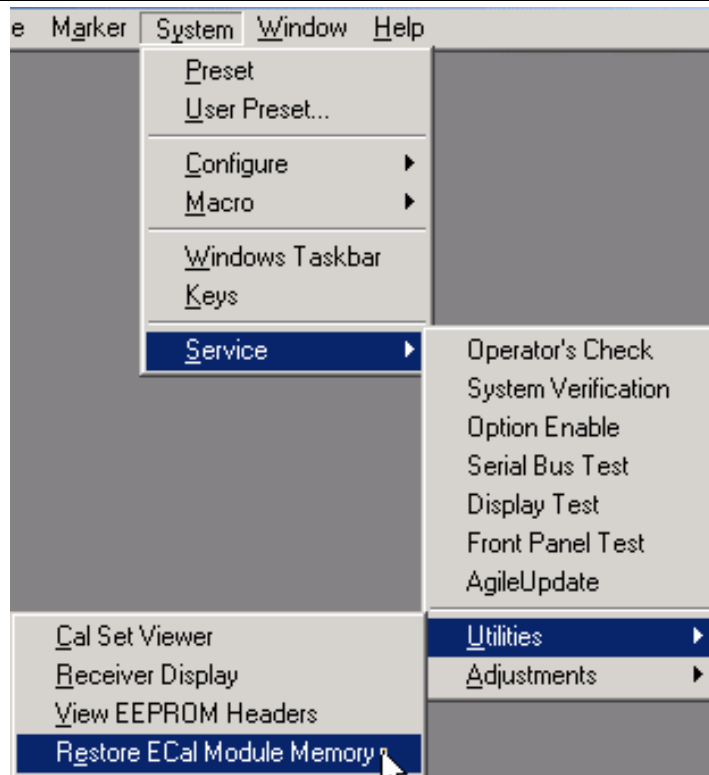
**Finish** Click to exit (characterization complete).



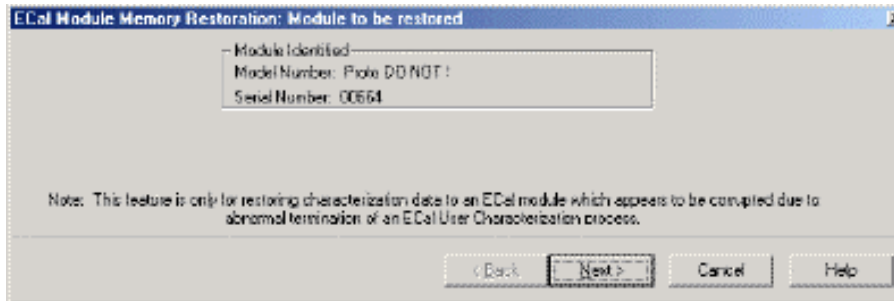
### Restore ECAL Module Memory

When user-characterized data is written to the ECAL module, the entire contents of ECAL memory is also written to the PNA hard drive. In the unlikely event that your ECAL module memory is lost, you can restore the user-characterized data to ECAL memory.

#### How to Restore ECAL Module Memory



Learn more about using the front panel interface



#### **Module to be restored** dialog box help

Verify the Serial number of the module to be restored. If two modules are connected to the PNA , choose the one to have data restored.

**Next** Click to write data to the module.

## **Accurate Measurement Calibrations**

---

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
- Isolation Portion of 2-Port Calibration
- Calibrating for Non-insertable Devices

Learn how to determine the validity of your calibration.

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[See other Calibration Topics](#)

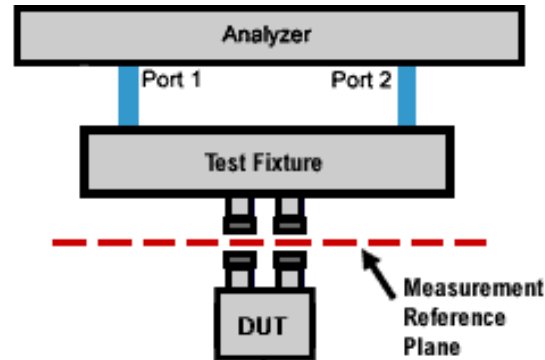
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### **Measurement Reference Plane**

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, suppose your device has 3.5mm connectors, but 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.

### Accuracy Level of Interpolated Measurement

When your current instrument settings do not exactly match those under which the calibration was performed, the PNA may automatically interpolate your calibration. Therefore, 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. See *Validity of a Calibration*, to learn more about interpolation and determining the accuracy of your calibration.

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**Note:** Interpolation accuracy degrades significantly at frequencies above 10 GHz.

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### Effects of Power Level

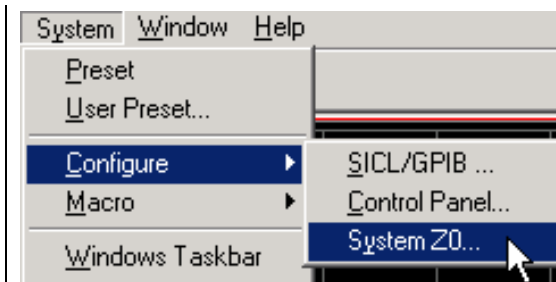
Most accurate error correction applies only for the power level at which a measurement calibration was performed. However, when changing power within the same attenuator range at which the measurement calibration was performed, S-parameter measurements can be made with only a small degradation of accuracy. 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*.

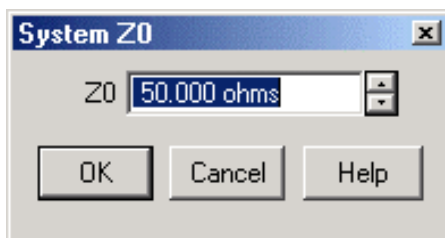
### Setting System Impedance

The system impedance can be changed for making waveguide measurements or devices with an impedance other than 50 ohms.

<b>How to change the System Impedance</b>
---



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](#).

## 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.

**Note:** The isolation calibration can add noise to the error model when 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.
- Set a narrow IF Bandwidth

### 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 match), place terminations on both ports of the analyzer.

### Calibrating for 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:

- Definition of Non-insertable Devices
- Uncharacterized Thru Adapter
- Unknown Thru
- Adapter Removal
- Swap Equal Adapters

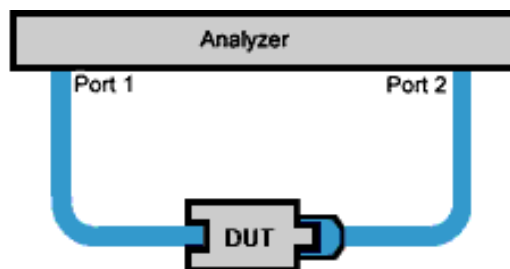
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**Note:** Guided Calibration automatically applies an adapter removal calibration for non-insertable devices.

---

### An Insertable Device

An **insertable** device is one that, when removed, the test cables can be connected directly together, as in the following graphic.

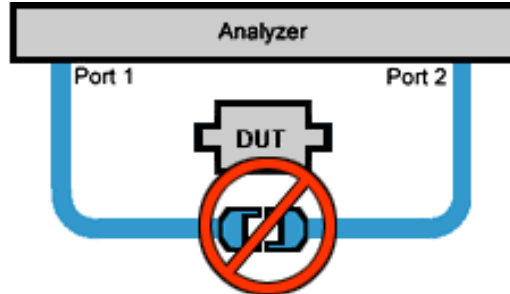


When calibrating for an insertable device, the test ports at your measurement reference plane connect directly together. This is called a zero-length thru. That means the definition, or electrical description the analyzer uses in the calibration process, has zero-length: no delay, no loss, no capacitance, and no inductance.

Your calibration kit may not have a thru standard because it is assumed you have an insertable device and will be using a zero-length thru.

### A Non-Insertable Device

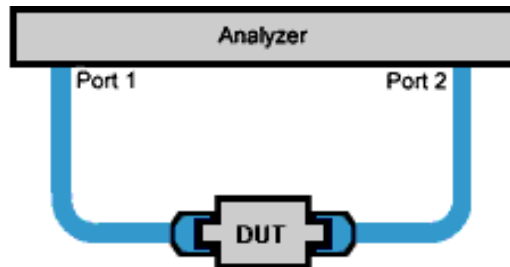
If your device is **non-insertable**, the test ports at your measurement reference plane cannot connect directly together, as shown in the graphic below.



When calibrating for a non-insertable device, 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
- Unknown Thru Cal
- Swap Equal Adapters
- Adapter Removal

### 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. Using an uncharacterized thru also results in degraded transmission tracking error terms.

### Unknown Thru Cal

When making transmission measurements on a DUT having connectors, you need to use a thru standard to calibrate instead of a zero-length thru. The Unknown Thru setting requires ONE

additional step, the measurement of the thru standard. The PNA automatically reads the A, B, R1, and R2 receivers to determine the thru standard S-parameter characterization. The results are used to improve the transmission tracking error term.

- There must be fewer than 16 windows open when selecting **Unknown Thru**. The 16th window is used by the calibration process.
- The Unknown Thru Cal setting is available only on E835xA and E836xA/B series network analyzers.
- For high accuracy, the PNA asks for the approximate delay value of the thru standard. The PNA computes an estimate for this and allows you to verify the value.

Unknown Thru setting is available in Guided mechanical and ECAL Calibrations. See Using ECAL for accuracy considerations for ECAL thru calibration.

### Delay Value

In both techniques, after the measurement steps are completed, the PNA estimates the electrical length of the adapter. A message is displayed provided to see if the guess of the electrical length of the thru adapter is approximately correct. Typically customers can accept the guess. The guess may be wrong in the case of too few frequency points over the given frequency span.

For CW sweep or frequency sweeps with large frequency steps, overwrite the estimate, then click OK. Or compute delay by calculating the physical length of the adapter divided by the propagation velocity.

Delay = Length / Propagation velocity

### Adapter Removal Calibration

The Adapter Removal technique determines the characterization of the THRU standard with additional cal standard connection steps, typically totaling 13 steps.

Adapter removal calibration provides the most accurate way to measure non-insertable devices. However, it requires additional calibration steps. 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.

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.

See Guided Calibration in Calibration Wizard.

### Swap-Equal-Adapters Method

Swap-equal-adapters calibration method is not recommended in the PNA. Adapter Removal calibration is easier and more accurate.





## Validity of a Calibration

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

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See other Calibration Topics

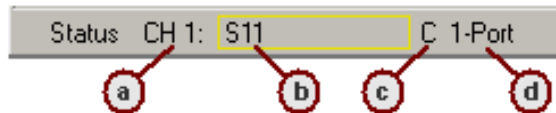
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### Viewing Correction Level

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

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**Note:** Changing frequency outside of Start/Stop will turn correction **OFF**.

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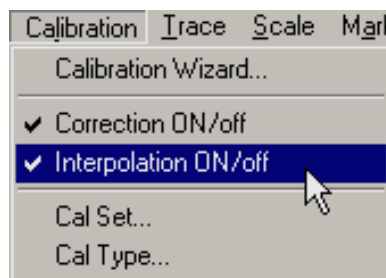
### No Correction

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. For more information see Accuracy Level of Interpolated Measurements.

**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 verify 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.

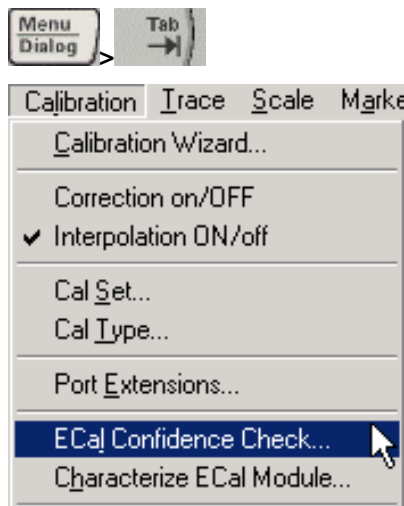
## ECal Confidence Check

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. **Note:** Terminate any unused ECAL ports with a 50 ohm load.
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.

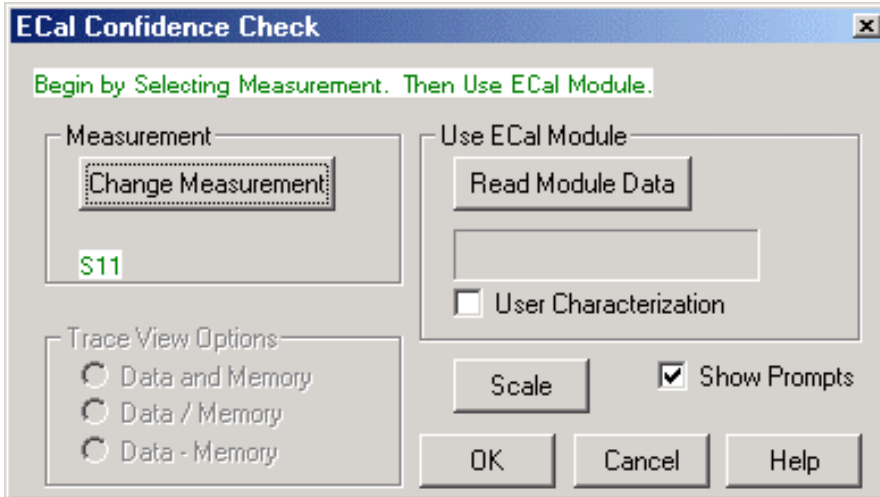
4. Click **Read Module Data**. The following occurs:
  - ECal module is set to "confidence state".
  - Analyzer reads and displays stored data.
  - Analyzer measures and displays "confidence state".
5. If you want to view a different parameter, select **Change Measurement** and select the check box for 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).

#### 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

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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

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[See other Calibration Topics](#)

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### 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

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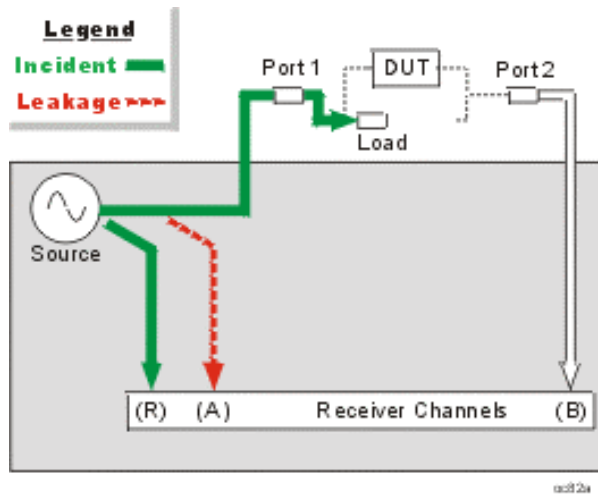
**Note:** The figures for the following six systematic errors show the relevant hardware configured for a forward measurement. For reverse measurements, internal switching in the analyzer makes Port 2 the source and Port 1 the receiver. Channel 'A' becomes the transmitted receiver, channel 'B' becomes 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.

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### 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.

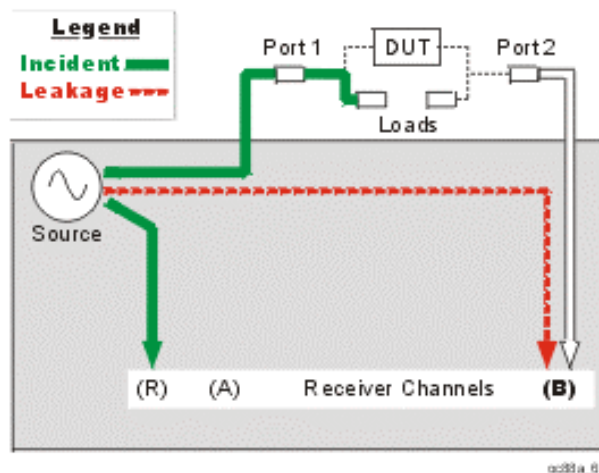
1. During calibration, a load standard is connected to Port 1. We assume no reflections from the load.
2. The signal measured at channel 'A' results from the incident signal leakage through the coupler.
3. Directivity error is subtracted from subsequent reflection measurements.

#### 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.

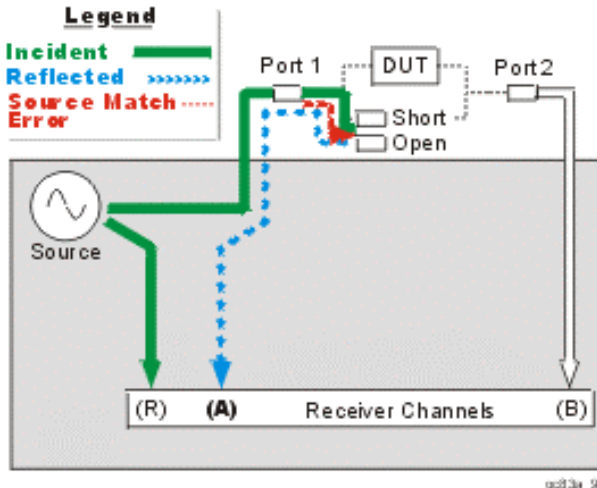
2. The signal measured at channel 'B' is leakage through various paths in the analyzer.
3. This isolation error is subtracted from subsequent transmission measurements.

### 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.

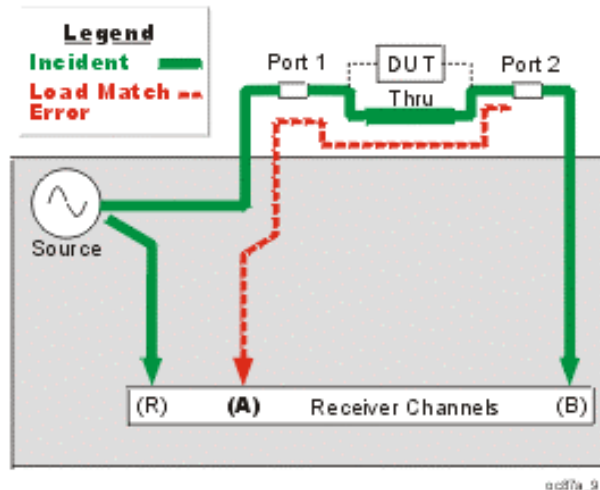
### Load Match Error

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

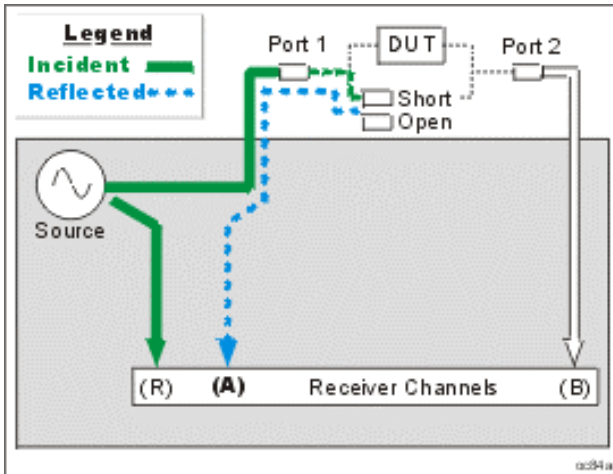
Reflection measurements are made by comparing signal at channel 'A' (the reflection channel) to signal at channel 'R1' (the reference channel). This is called a ratio measurement or "A over R1" (A/R1).

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:

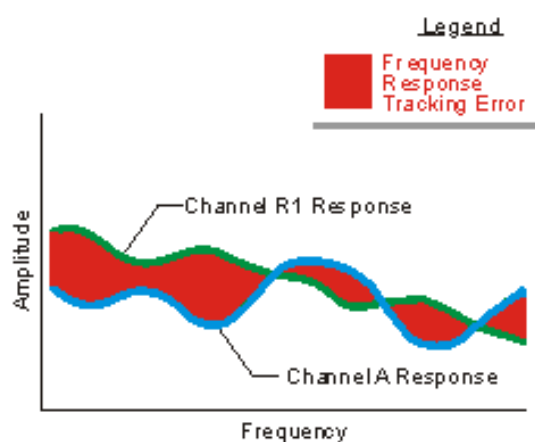
- signal-separation devices
- test cables
- adapters
- variations between the reference and test signal paths

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).

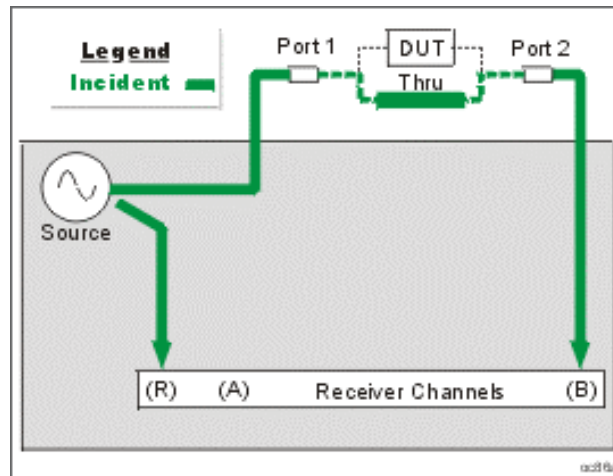
For ideal transmission measurements, the frequency response of the channel 'B' and channel 'R1' receivers would be identical.

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:

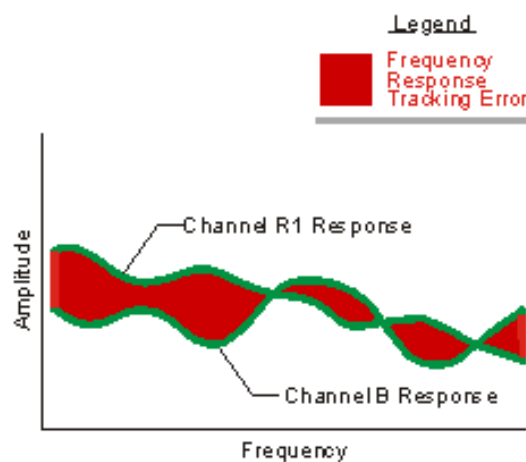
- signal-separation devices
- test cables
- adapters
- variations between the reference and test signal paths

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.



### Monitoring Error Terms using Cal Set Viewer

The PNA calculates error terms by measuring well-defined calibration devices over the frequency range of interest. It then compares the measured data with an ideal model for each device. The differences of the compared data represent systematic (repeatable) errors of the analyzer system. These differences are stored as error terms and removed from subsequent measurements when error correction is on. Learn about these error terms.

You can use **Cal Set Viewer** to monitor the measured data and the calculated error term. This will help to determine the health of your PNA and the accuracy of your measurements.

By printing or saving the error terms, you can periodically compare current error terms with previously recorded error terms that have been generated by the same PNA, measurement setup, and calibration kit. If previously generated values are not available, refer to Typical Error Term Data in Appendix A, "Error Terms", of the Service Guide.

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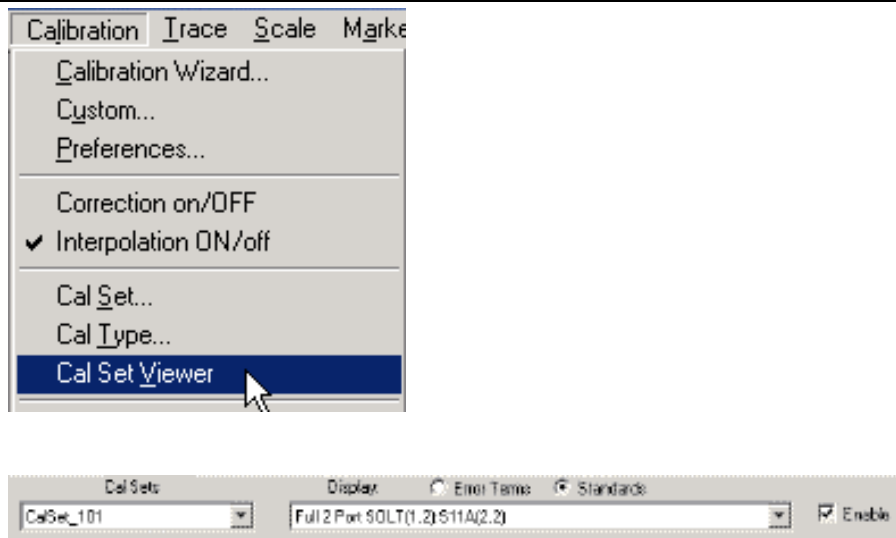
**Note:** The service guide for your PNA is available at <http://www.agilent.com/find/pna>

It is also on the CDROM that was shipped with your PNA.

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- 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



Use the down arrow to select a Cal Set

Click either

- **Error Terms** - calculated data
- **Standards** - the raw measurement data of the Standard

Use the down arrow to select the desired error term or standard of interest

Select the **Enable** check box to view the data on the PNA screen.

Learn more about using the front panel interface

#### Viewing Cal Set Data

- Existing measurement traces are unaffected by the Cal Set Viewer.
- The Cal Set data trace is presented in the highest unused channel number (usually 32) in the active window.
- The Cal Set data trace is labeled as S11 in the status bar regardless of the type of error term or standard.
- Only one Cal Set error term or standard data can be viewed at a time. However, you can store a data trace into memory and compare it with the same error term from another Cal Set.
- ECAL data does not include standard data, only error terms.

### 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 calibration kit files using Advanced Modify Cal Kits.

- About Modifying Calibration Kits
- How to Modify Cal Kits

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**Note:** The PNA used Version 1 and Version 2 Cal Kits in revisions before 3.0. With 3.0, all Cal kits can be read by the PNA and format translation takes place automatically. This functionality replaces Cal Kit Manger which was introduced in rev. 2.5.

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[See other Calibration Topics](#)

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### About Modifying Calibration Kits

You can modify calibration kit files or create a custom one.

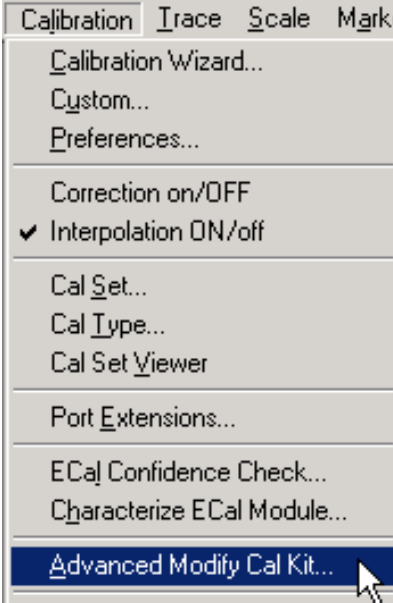
For most applications, the default calibration kit models provide sufficient accuracy for your calibration. However, several situations exist that may require you to create a custom calibration kit:

- 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.

## How to Modify Cal Kits

The series of dialog boxes that follow allow you to modify the standard definitions or class assignments of calibration kit files.

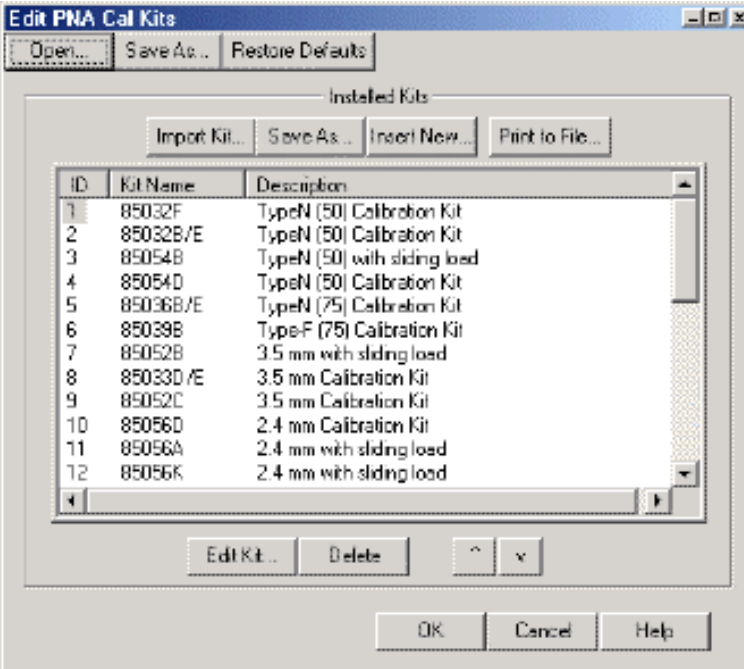
**How to start Advanced Modify Cal Kit**



The screenshot shows a software menu titled 'Calibration' with sub-menus 'Trace', 'Scale', and 'Mark'. The 'Calibration' sub-menu is open, listing several options. The option 'Advanced Modify Cal Kit...' is highlighted in blue, and a mouse cursor is pointing at it.

Learn more about using the front panel interface

## Edit PNA Cal Kits



The screenshot shows the 'Edit PNA Cal Kits' dialog box. It has buttons for 'Open...', 'Save As...', and 'Restore Defaults'. Below these are buttons for 'Import Kit...', 'Save As...', 'Insert New...', and 'Print to File...'. A table lists installed kits with columns for ID, Kit Name, and Description. At the bottom are buttons for 'Edit Kit...', 'Delete', and navigation arrows. At the very bottom are 'OK', 'Cancel', and 'Help' buttons.

ID	Kit Name	Description
1	85032F	TypeN (50) Calibration Kit
2	85032B/E	TypeN (50) Calibration Kit
3	85054B	TypeN (50) with sliding load
4	85054D	TypeN (50) Calibration Kit
5	85036B/E	TypeN (75) Calibration Kit
6	85039B	Type-F (75) Calibration Kit
7	85052B	3.5 mm with sliding load
8	85033D/E	3.5 mm Calibration Kit
9	85052C	3.5 mm Calibration Kit
10	85056D	2.4 mm Calibration Kit
11	85056A	2.4 mm with sliding load
12	85056K	2.4 mm with sliding load

### Edit PNA Cal Kits dialog box help

Provides access to all Agilent cal kits and allows modification of their standard definitions.

**Open** Opens a list of cal kits (in .wks file type) and standard definitions.

**Save As** Saves the current list of cal kits (using .wks file type).

**Restore Defaults** Re-installs the default contents of all Agilent cal kits from the PNA hard drive.

#### Installed Kits

**Import Kit** Invokes the Import Kit dialog box.

**Save As** Saves the selected calibration kit and definitions (using .ckt file type).

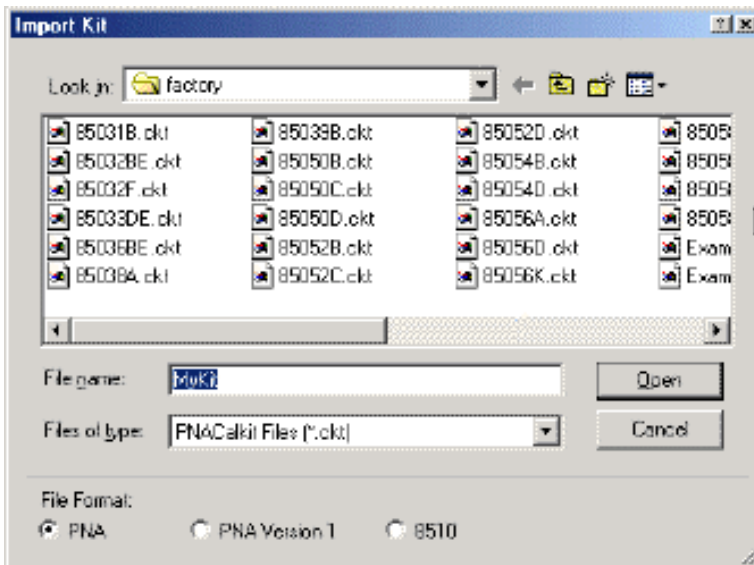
**Insert New** Invokes a blank Edit Kit dialog box to create new calibration kit definitions.

**Print to File** Prints the contents of the selected cal kit to a .prn file

**Edit Kit...** Invokes the Edit Kit dialog box to modify selected calibration kit definitions.

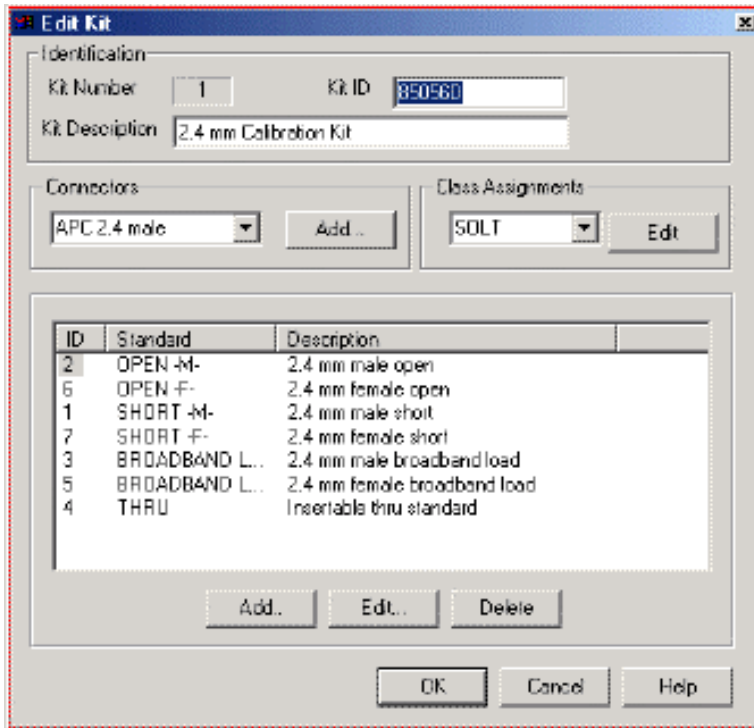
**Delete** Deletes selected calibration kit file.

^ Selects previous / next calibration kit in list.



#### Import Kit dialog box help

Imports calibration kit definitions from hard disk or other drive that are saved in the .ckt file format. You must specify the File format of the selected kit.



## Edit Kit dialog box help

### Identification

**Kit Number** Displays the number of the selected calibration kit.

**Kit ID** Displays the model of the selected calibration kit.

**Kit Description** Displays description of the selected calibration kit.

### Connectors

Click the down arrow to change the connector type.

**Add** Invokes the Add Connector dialog box which allows you to add new connector type to the calibration kit.

### Class Assignments

Click the down arrow to change the Class Assignment.

**Edit** Invokes the Modify Calibration Class Assignments dialog box.

### Standards in Kit

Lists the current standards and descriptions in the cal 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.



**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**

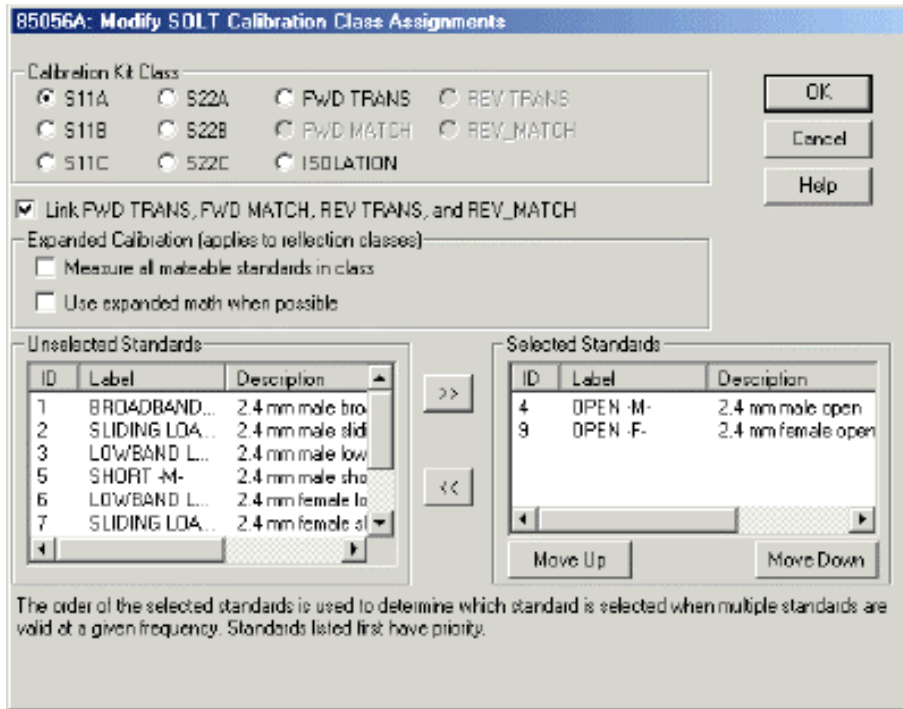
Allows you to define the connector gender.

**Impedance**

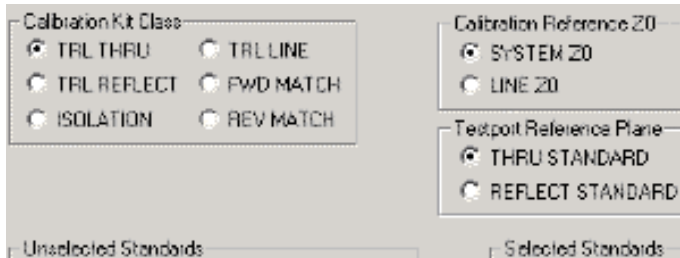
Allows you to define the impedance of the offset between the standard and the calibration plane.

**Media**

Allows you to define the material the connector is made from (COAX or WAVEGUIDE).



If TRL is selected as Class Assignment in the Edit Kit dialog box, the following changes appear:



### Modify Calibration Class Assignments dialog box help

Allows you to assign single or multiple standards to classes.

**Note:** Depending on your **Class Assignment** selection in the Edit Kit dialog box, some of the selections in this dialog box may not be available.

#### Calibration Kit Class

Select a Class to view or modify

**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.

#### Expanded Math

The following two check boxes **apply ONLY during Guided Calibrations**. For Unguided Calibration, these check boxes are ignored, including the case where the multiple standards dialog box is presented.

**Note:** You can make these selections during the calibration process with Preview/Modify settings selected from within the Cal Wizard or by modifying the cal kit from Advanced Modify Cal Kit.

**Measure all mateable standards in class** Check this box to attain the very highest accuracy possible. For example, if a cal kit contains several load standards, during the calibration process

you will be prompted to measure each of the standards. This could require a significant amount of calibration time. When checked, the "Use expanded math when possible" box is also checked automatically.

**Use expanded math when possible** Some kits contain multiple calibration standards that together cover a very wide frequency range. If a calibration requires more than one standard to cover the calibration frequency range, there can be regions of overlapping measurements. When checked, this function automatically computes the most accurate measurement in the overlap regions using a "weighted least squares fit" algorithm. This selection is recommended for all calibration kits containing standards that have overlapping frequency ranges.

#### **Calibration Reference Z0**

**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.

**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 is assumed to be part of the directivity error.

#### **Testport Reference Plane**

**Thru Standard** The THRU standard is used to establish the measurement reference plane. Select if the THRU standard is zero-length or very short.

**Reflect Standard** 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.

#### **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.

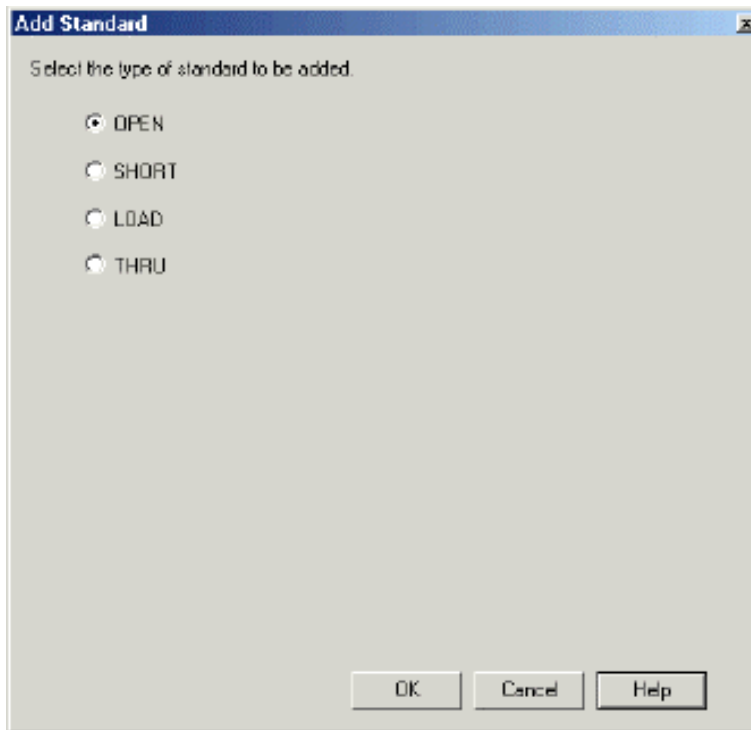
#### **Selected Standards**

Displays the list of standards that are available to be USED in the current class assignment. Move standards to the Unselected Standard field by selecting and clicking the right arrow.

---

**Note:** During an Unguided Cal all of the **Selected Standards** are presented. You then choose which of these standards to measure.

---



#### **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 a blank Edit Standards: Open, Short, Load, or Thru 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 boxed areas of previous graphic applies to all standard types:**

#### Identification

**Standard ID** Number in list of standards

**Label** Type of standard.

**Description** Description 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.

#### Connector

Indicates the type and 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 applies to standard types Open, Short, Load, and Thru

### Open Standard

Open Characteristics					
C0	89.939	F(e-12)	C2	-264.9901	F(e-36)/Hz <sup>2</sup>
C1	2536.7999	F(e-27)/Hz	C3	13.4	F(e-45)/Hz <sup>3</sup>

**C0, C1, C2, C3** Specifies the fringing capacitance.

### Short Standard

Short Characteristics					
L0	0.7563	H(e-12)	L2	-52.429	H(e-33)/Hz <sup>2</sup>
L1	459.8799	H(e-24)/Hz	L3	1.5846	H(e-42)/Hz <sup>3</sup>

**L0, L1, L2, L3** Specifies the residual inductance.

### Load Standard

Load Type		Complex Impedance	
<input type="radio"/> Fixed Load	<input checked="" type="radio"/> Arbitrary Impedance	Real	50
<input type="radio"/> Sliding Load		Imag	0

Allows you to select the type of load.

### Load Type

**Fixed Load** Specifies the load type as Fixed

**Sliding Load** Specifies the load type as Sliding

**Arbitrary Impedance** Specifies the load type to be have an impedance value different from system Z0. Only when Arbitrary Impedance is selected are the following settings available:

- **Real** The real portion of the impedance value.
- **Imaginary** The imaginary portion of the impedance value.

### Thru Standard

Connectors	
Port	Type A (50) female
Port	Type A (50) female

### Connectors

Defines connector type at both ports.



## 3-Port Measurements

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

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### Overview

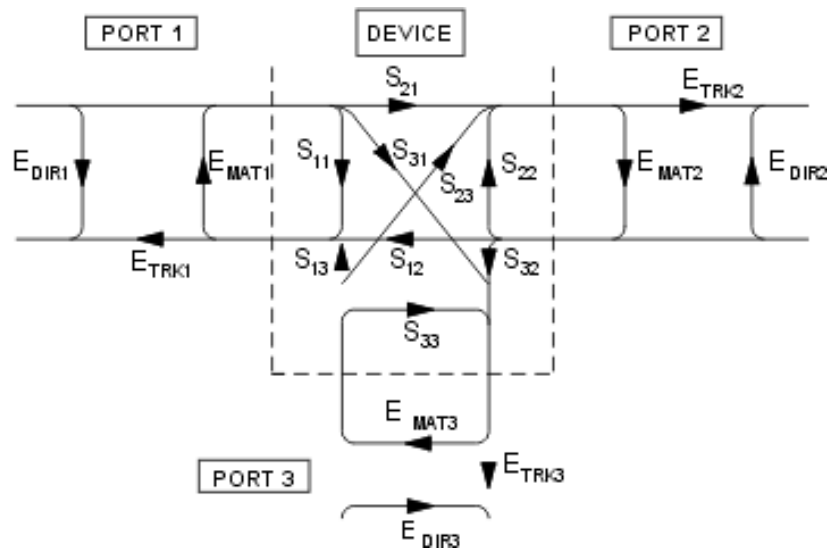
3-port PNA Series network analyzers offer complete characterization of three-port devices quickly, compared to two-port analyzers. You can measure devices like directional couplers, splitters, and antenna diplexers without setup changes. 3-port measurements allow viewing up to nine different S-parameters 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

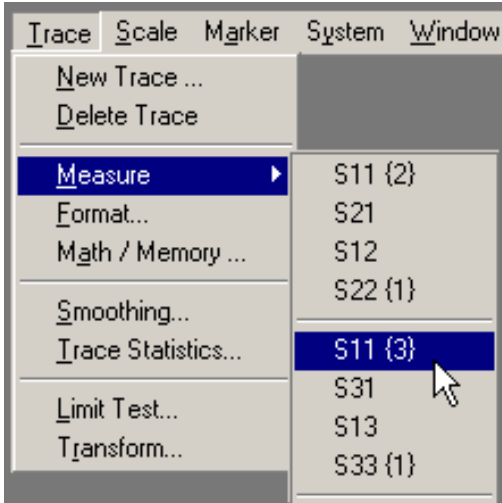
TRK = Forward Reflection Tracking and Reverse Transmission Tracking

### 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:



Select these and other parameters as you would on a 2-port PNA. See How to select a measurement



## Power Calibration

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

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### 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.

---

**Note:** Be sure that the frequency range of your power sensor covers the frequency range of your measurement. This does NOT occur automatically.

---

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.

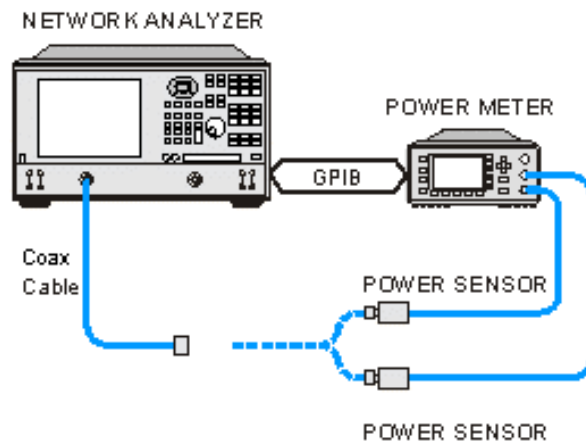
### Power Meters

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.

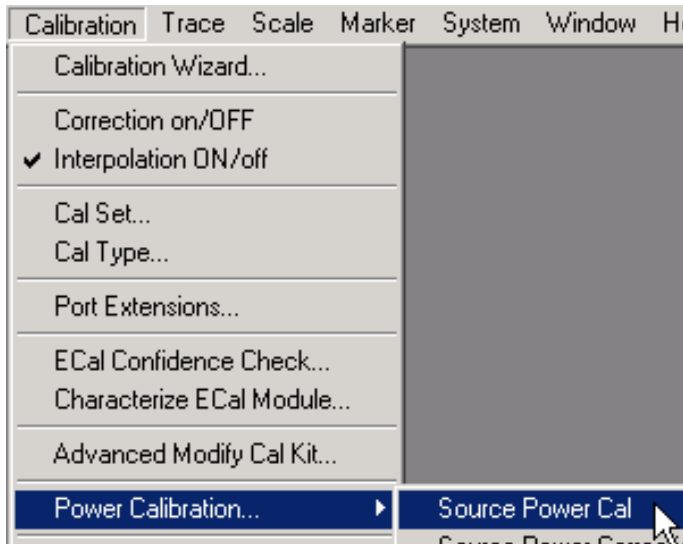
### How to perform Source Power Calibration

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:



**Note:** You can use the 82357A USB/GPIB Interface to control the power meter.

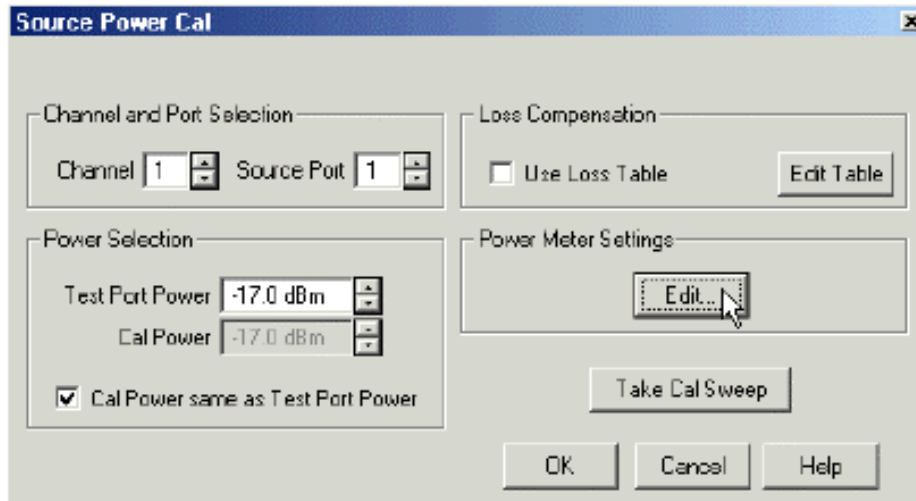
3. Apply power to the power meter and allow 30 minutes warm-up time before beginning calibration.
4. Select **Source Power Cal** as follows:



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 measurement calibration interpolation. 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.

**Note:** This setting always **defaults to channel 1**. It does NOT automatically change to the active channel.

**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.

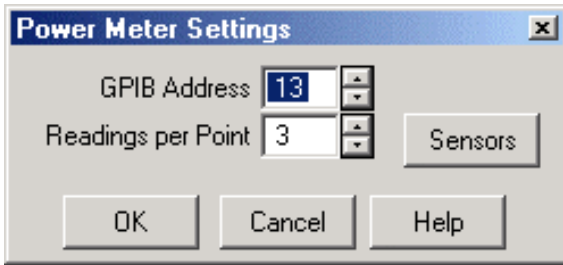
#### Power Meter Settings

**Edit** Invokes the Power Meter Settings dialog box

**Take Cal Sweep** Begins source power calibration measurement.

**OK** Applies calibration.

**Cancel** Cancels calibration.



**Power Meter Settings** dialog box help

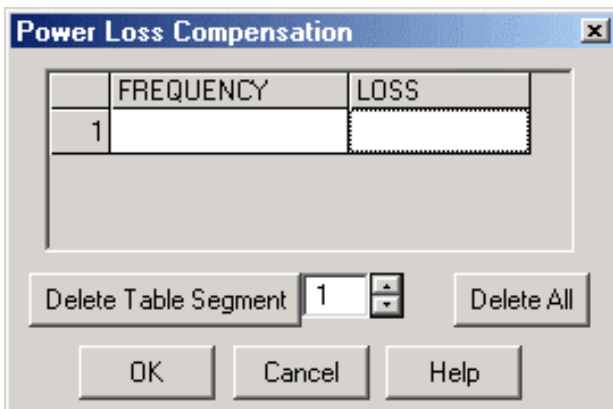
Allows you to compensate for losses that occur when you use an adapter or coupler to connect the power sensor to the measurement port.

**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.



**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.

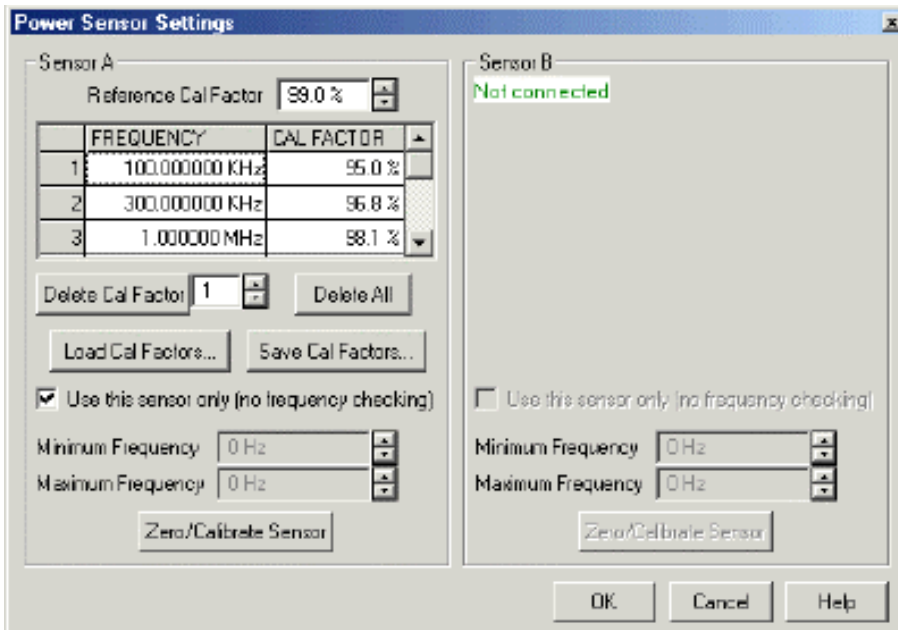
**Delete Table Segment** Deletes row indicated in the field.

**Delete All** Deletes all data in the table.

**Note: To Add a Row** to the table, click on a row in the table and press the down arrow on either the PNA front panel or keyboard.

- 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.



#### Power Sensor dialog box help

**Note:** Be sure that the frequency range of your power sensor covers the frequency range of your measurement. This does NOT occur automatically.

**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.

**Perform Sensor Zeroing and Calibration** Zero and calibrate the power sensor before taking data.

**Note: To Add a Row** to the table, click on a row in the table and press the down arrow on either the PNA front panel or keyboard. A row is added to the bottom of the table. The table is automatically sorted by frequency when OK is pressed.

## 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**.

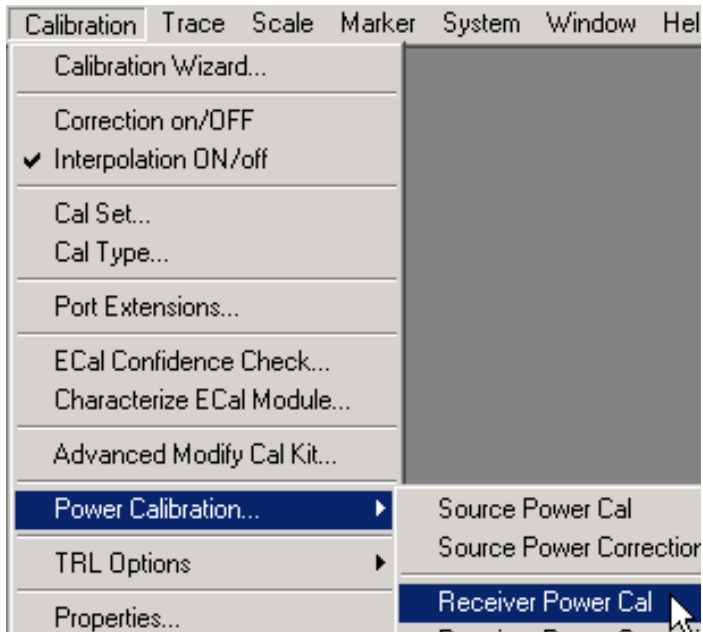
Use Receiver Power Calibration to make very accurate absolute power (amplitude) measurements.

Receiver Power Calibration:

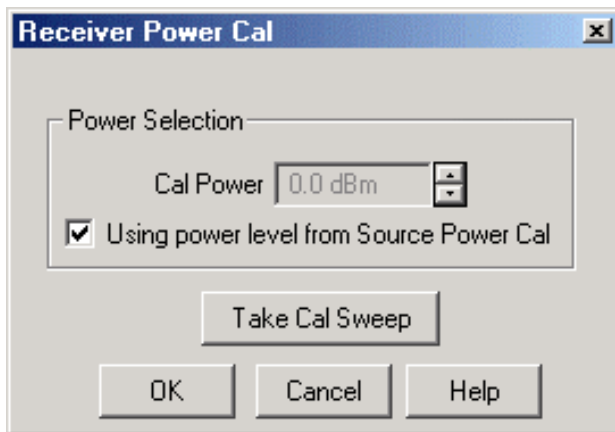
- Always requires that a source power calibration be performed first.
- Is ONLY allowed when making absolute power (unratioed) measurements.
- ONLY applies to the active measurement.

## 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 thru line from the source port to the receiver port. If you are performing a receiver power cal on a reference receiver, no connection is necessary as the receiver is internally connected to the source.
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.

Notes:

- 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

---

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

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[See other Calibration Topics](#)

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### 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.

For a list of calibration kits, 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, Z <sub>0</sub>
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.
- **Z<sub>0</sub>** 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:

$$\text{Loss} \left( \frac{\Omega}{s} \right) = \frac{\text{loss (dB)} \times Z_0(\Omega)}{4.3429(\text{dB}) \times \text{delay (s)}}$$

### Capacitance model equation:

**C0, C1, C2, C3.** Specifies the fringing capacitance for the open standard.

- $C = (C_0) + (C_1 \times F) + (C_2 \times F^2) + (C_3 \times F^3)$
- (F is the measurement frequency).
- The terms in the equation are defined when specifying the open as follows:
  - C<sub>0</sub> term is the constant term of the third-order polynomial and is expressed in Farads.
  - C<sub>1</sub> term is expressed in F/Hz (Farads/Hz).
  - C<sub>2</sub> term is expressed in F/Hz<sup>2</sup>.
  - C<sub>3</sub> term is expressed in F/Hz<sup>3</sup>.

### Inductance model equation:

**L0, L1, L2, L3.** Specifies the residual inductance for the short standard.

- $L = (L_0) + (L_1 \times F) + (L_2 \times F^2) + (L_3 \times F^3)$
- (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<sup>2</sup>.
  - L3 term is expressed in H/Hz<sup>3</sup>.

## **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 ( $\pm 90$  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.

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**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.

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## 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

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**Note:** You can perform a TRL cal only on PNA models with 2 reference receivers. See PNA Standard Configurations for a list of model numbers.

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[See other Calibration Topics](#)

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### 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

These standards must be defined in your TRL cal kit:

### 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 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  $f_1 \times f_2$ ).

### 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

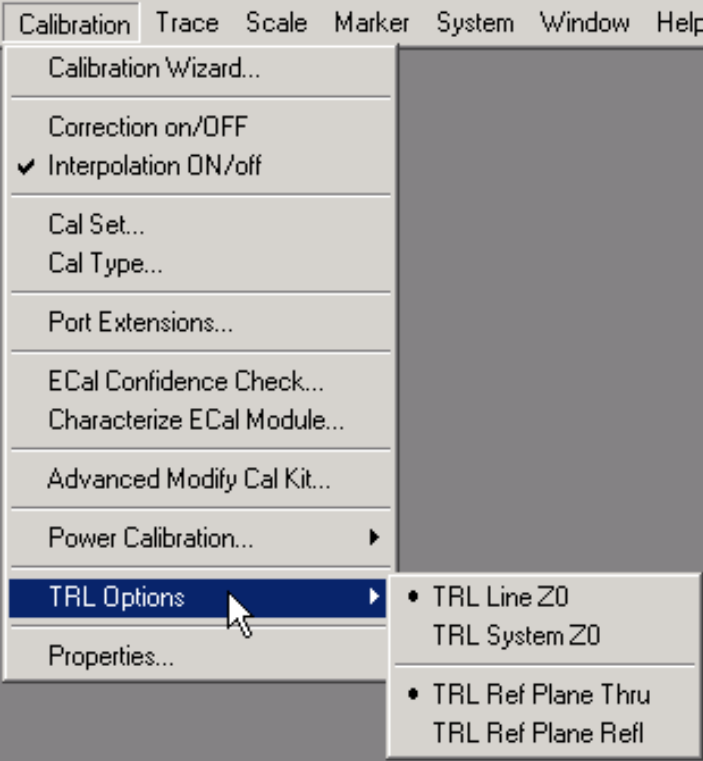
measurement.

**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 is assumed to be part of the directivity error. The impedance of the line standard must be included in the cal kit LINE definition.

**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. Learn how to change System Z0.

## 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

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

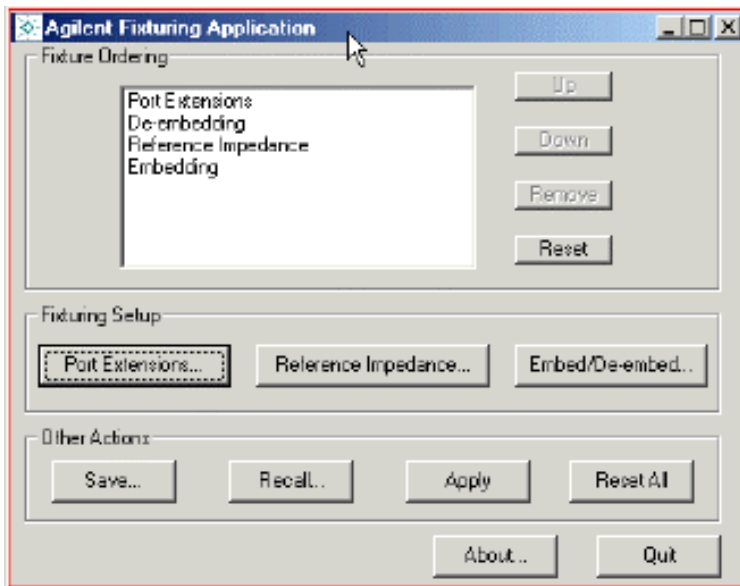
creating three measurement channels, each channel at a different reference impedances. No physical connection changes are required.

### 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.

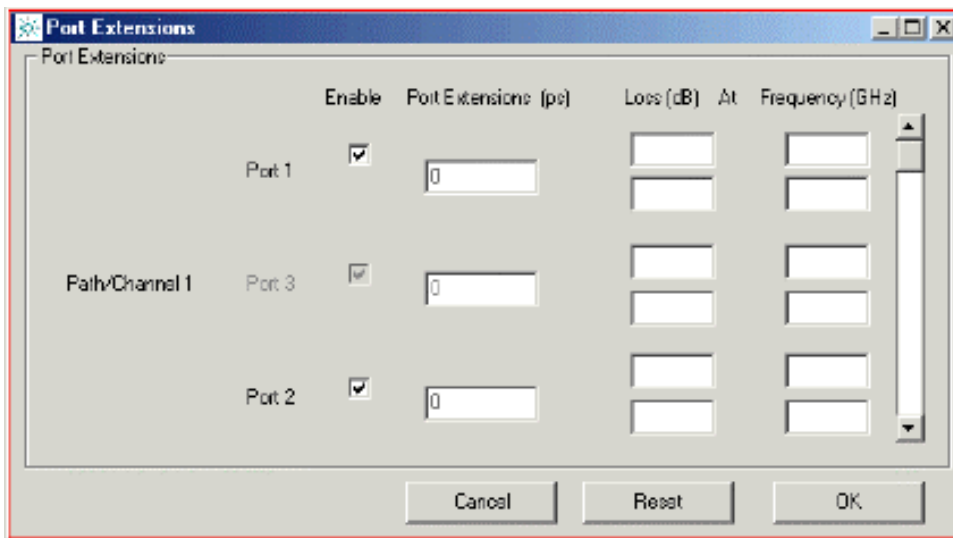


**Recall** Recalls a previously saved fixturing file. Click Apply to apply the recalled fixturing information.

**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:

$$L(f) = \text{Loss} (1 \text{ GHz}) * f^{.5}$$

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:

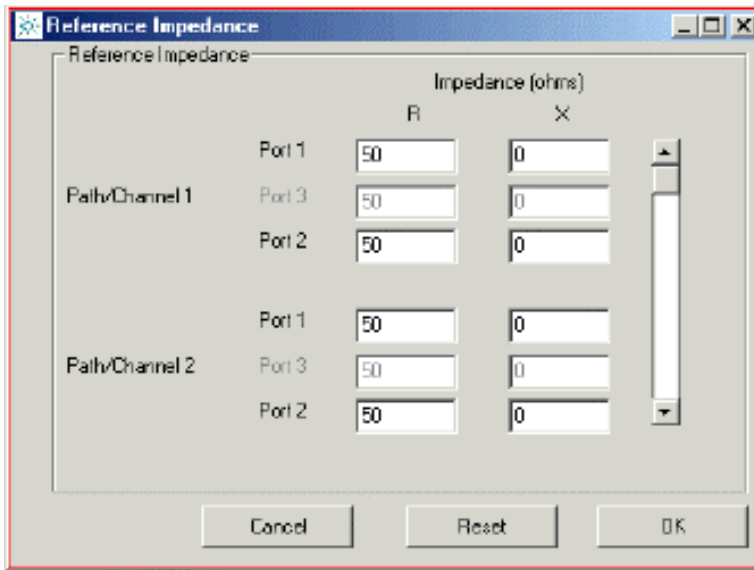
L1 and L2 are the loss in dB at f1 and f2 (in GHz) respectively.

**OK** Saves the entries

**Reset** Restores the form back to default values

**Cancel** Exits without saving the entries.

Learn about Port Extensions



The image shows a software dialog box titled "Reference Impedance". It contains a table for setting impedance values for two channels. Each channel has three ports (Port 1, Port 3, Port 2) with input fields for Resistance (R) and Reactance (X). The R field is set to 50 and the X field is set to 0 for all ports. A vertical scrollbar is on the right side of the table. At the bottom are "Cancel", "Reset", and "OK" buttons.

		Impedance (ohms)		
		R	X	
Path/Channel 1	Port 1	50	0	[Scrollbar]
	Port 3	50	0	
	Port 2	50	0	
Path/Channel 2	Port 1	50	0	
	Port 3	50	0	
	Port 2	50	0	

**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.

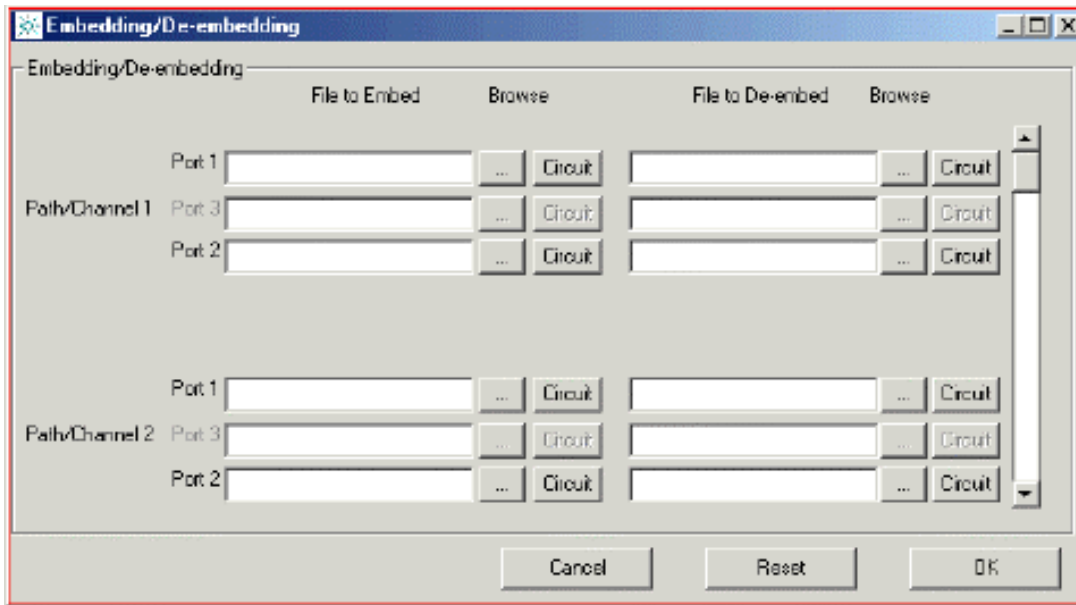
**R** Resistance part of the desired reference impedance for the specified port and channel.

**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



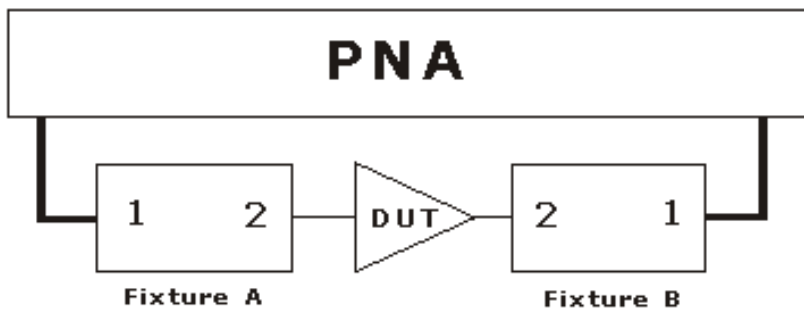
#### Embed/De-Embed dialog box help

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.

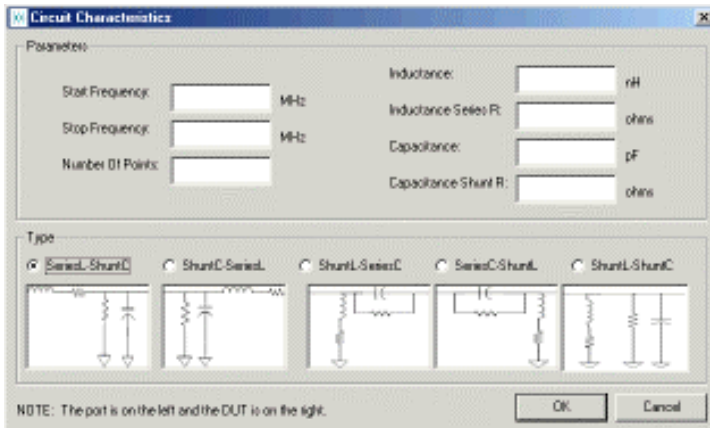


Do one of the following for each port on each channel:

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.



## 4. Analyze Data

### Markers

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.

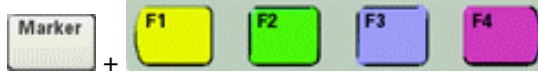
**Note:** Marker Readout can be turned ON / OFF and customized from the **View** menu. See Marker Readout

- Creating and Moving Markers
- Delta Markers
- Searching with Markers
- Marker Functions (Change Instrument Settings)
- Advanced Marker Settings
- Marker Table

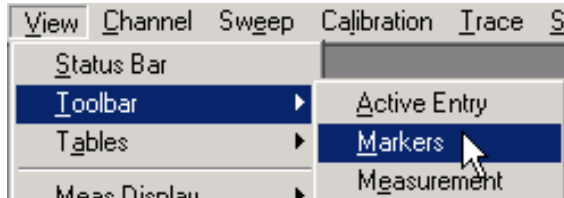
### How to Create and Move Markers

Use one of the following methods:

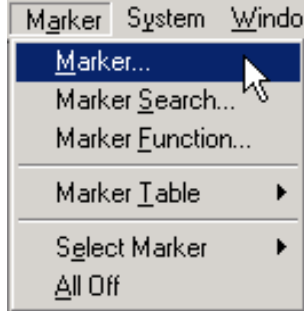
- Active Entry toolbar



- Marker toolbar




- Marker dialog box



Learn more about using the front panel interface

#### Create a Marker

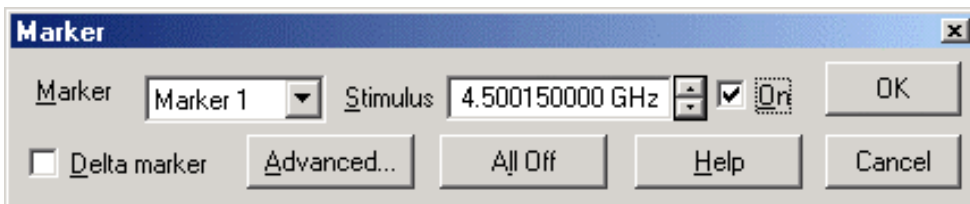
- From the Active Entry toolbar, press a marker number. To access markers 4 through 9, press  repeatedly.
- From the Marker Toolbar or Marker Dialog Box, select a marker number and click **ON**

#### 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**

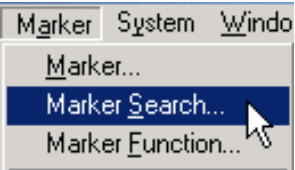

Delta Markers allow you to view data that is relative to the **reference** marker.  
 A delta marker can be set from the Marker dialog box or the Marker Toolbar.  
 When a Delta marker is created, the reference marker will be activated automatically.

**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.

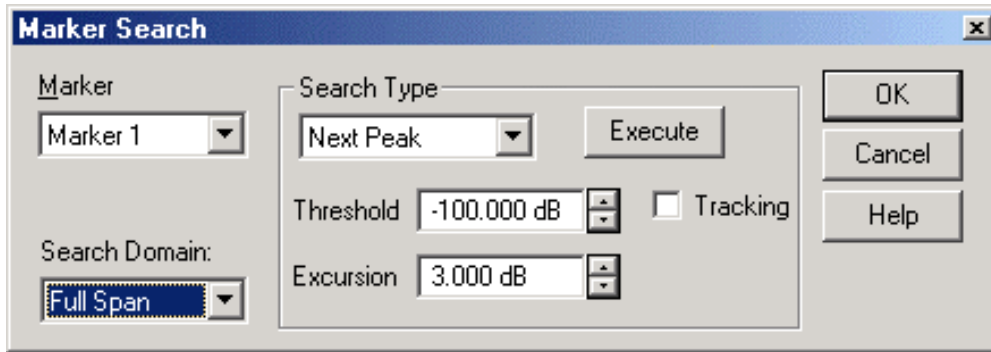
**How to Search with Markers**

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.

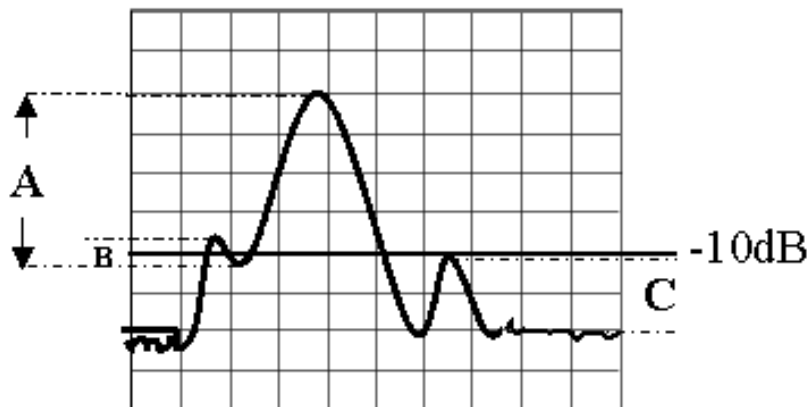
#### Example:

Threshold Setting: -10dB

Excursion Setting: 1dB

Scale = 1 dB / Division

**Mouse over the graphic to find a valid peak.**





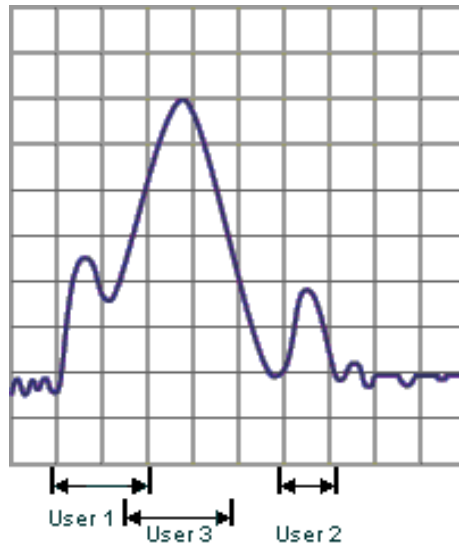
Peak A = Valid Peak (Above Threshold and Excursion Settings)  
 Peak B = Invalid Peak (Below Excursion Setting)  
 Peak C = Invalid Peak (Below Threshold Setting)

### 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.

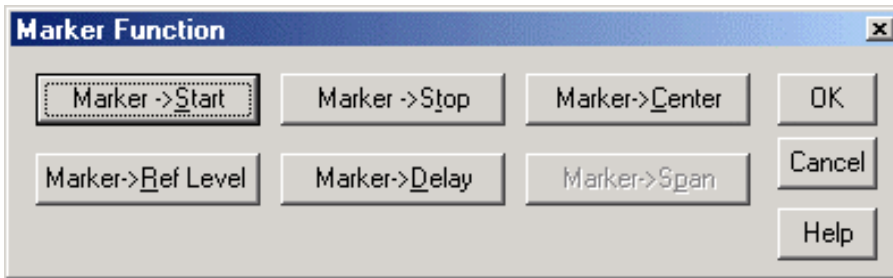
The graphic below shows examples of search domains.



### 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 <b>Center</b> , <b>Ref Level</b> , and <b>Delay</b> 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.

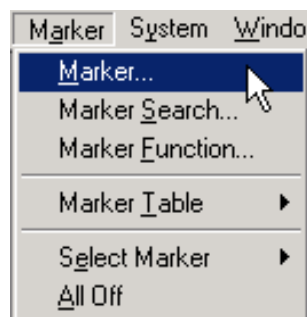
**Marker =>Ref Level** Sets the screen reference level to the value of the active marker.

**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.)

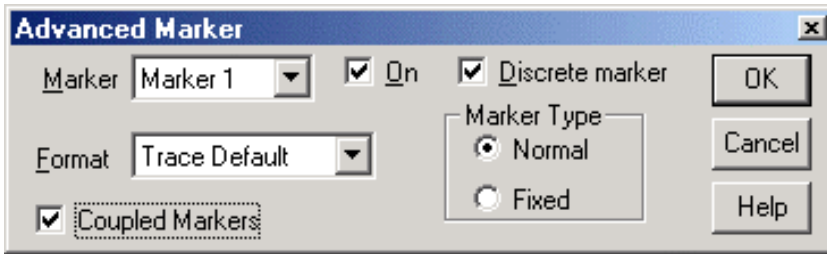
**Marker =>Span** Sets the sweep span to the span that is defined by the delta marker and the marker that it references. Unavailable if there is no delta marker.

#### 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 is 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.

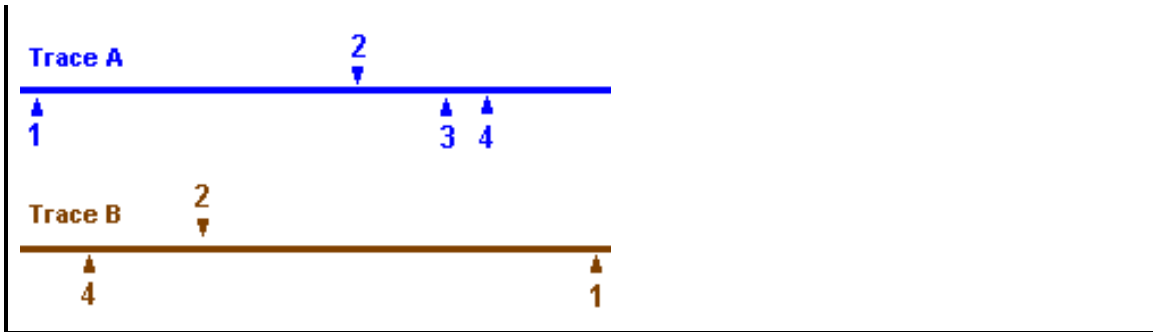
### Coupled Markers

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.)

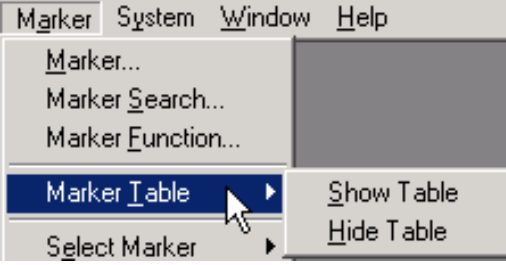
Set Coupled Markers from the Advanced Markers dialog box.






## 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

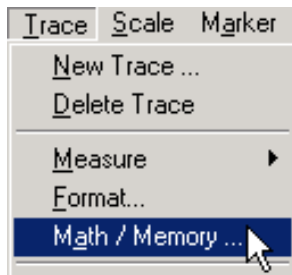
To perform any of the math operations, you must first store a trace to memory. You can display the memory trace using the View options.

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:



•

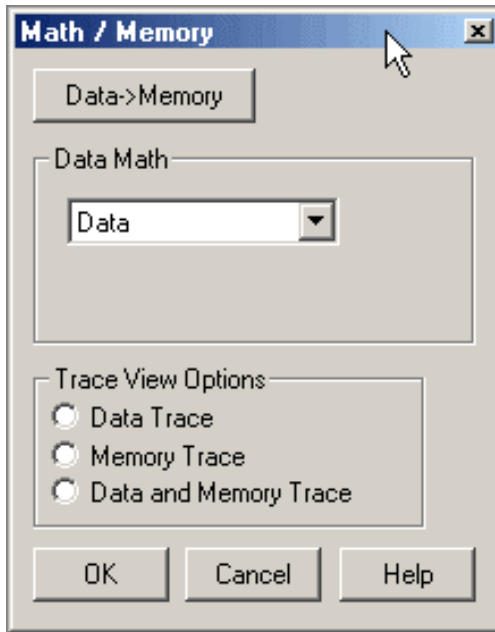


•

Only the following are available from Active Entry

- **Data>>Mem** (stores Data trace into Memory)
- **Data/Mem** (performs math operation: Data divided by memory)
- **Data** (displays data trace with no math operation applied)
- **Mem on/OFF** (turns Memory trace on or off)

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.

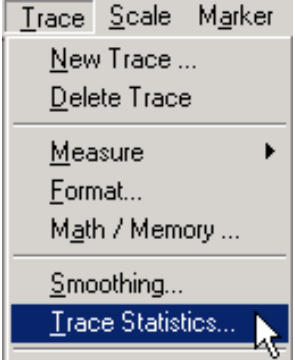
There are nine user ranges per channel. These user ranges are the same as the search domains specified for a marker search in that same channel; they use the same memory registers and thus share the same stimulus spans. If you specified search domains with marker search for a channel, you can recall 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.

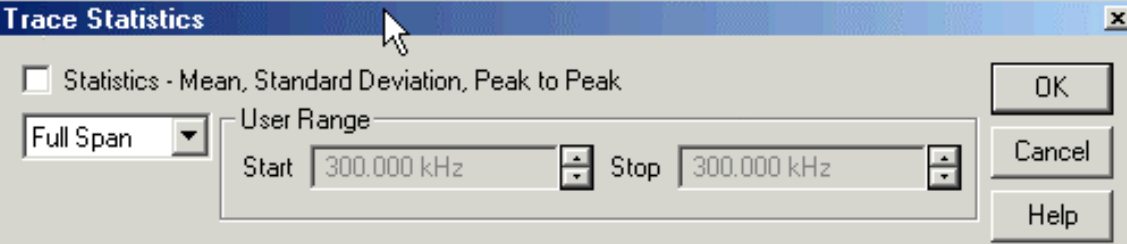
The trace statistics are calculated based on the format used to display the data.

- 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



The dialog box is titled "Trace Statistics" and contains the following elements:

- A checkbox labeled "Statistics - Mean, Standard Deviation, Peak to Peak" which is currently unchecked.
- A dropdown menu set to "Full Span".
- A "User Range" section with two frequency input fields: "Start" and "Stop", both set to "300.000 kHz".
- Buttons for "OK", "Cancel", and "Help" on the right side.

**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

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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

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### 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.

Limit lines are made up of discrete lines with four coordinates:

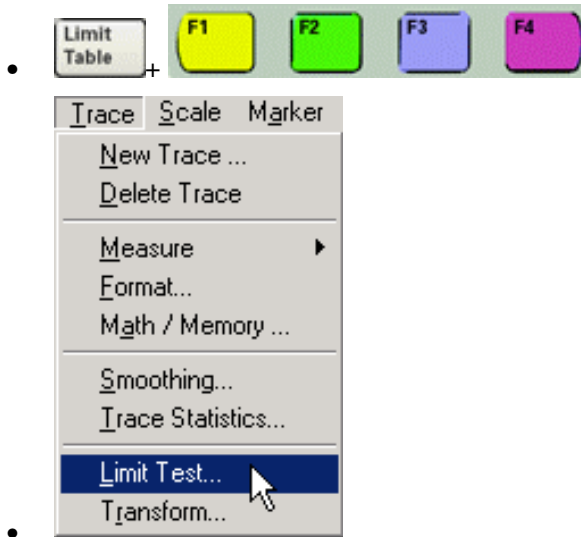
- BEGIN and END stimulus - X-axis values
- BEGIN and END response - Y-axis values.

**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	90.000000 dB
3	MAX	2.050000 GHz	3.000000 GHz	-50.000000 dB	-60.000000 dB
4	OFF	0.000000 Hz	0.000000 Hz	0.000000 dB	0.000000 dB

**Note:** To ADD a limit line to the table, change the last limit line to either MAX or MIN

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.

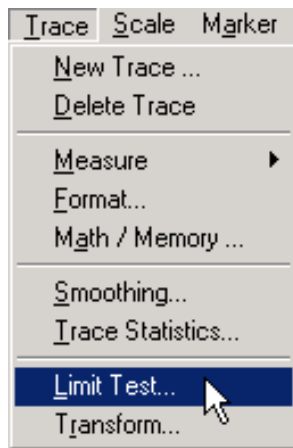
You can choose to provide a visual and / or audible PASS / FAIL indication.

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.

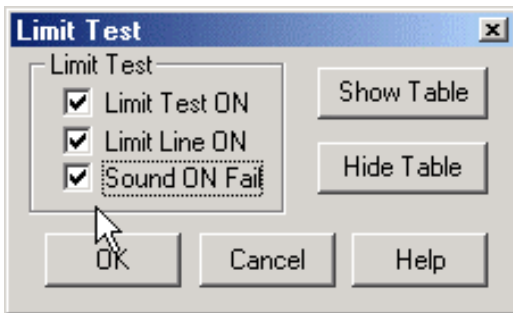
**How to display and test with Limit Lines**

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



**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.

---

**Note:** To ADD a limit line to the table, change the last limit line to either MAX or MIN

---

Learn more about displaying and testing with Limits (scroll up)

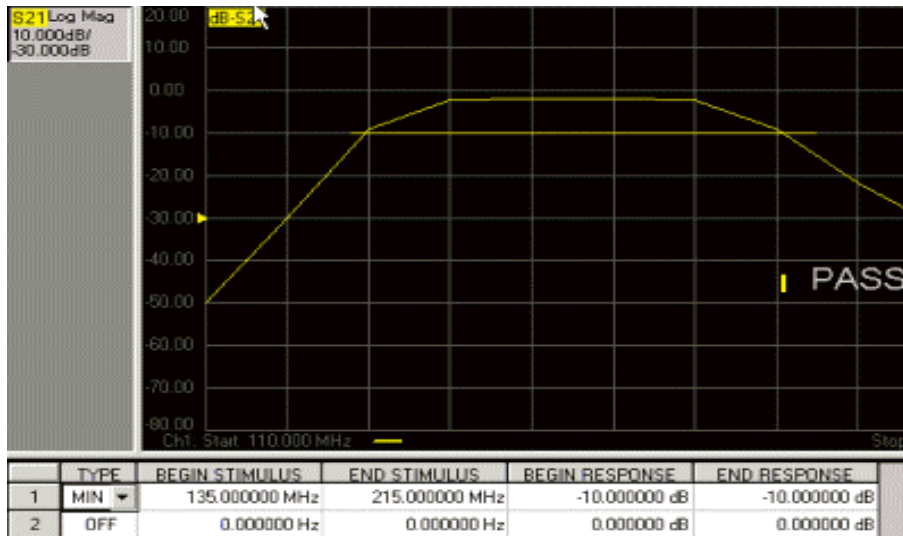
## Testing with Sufficient Data Points

**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.

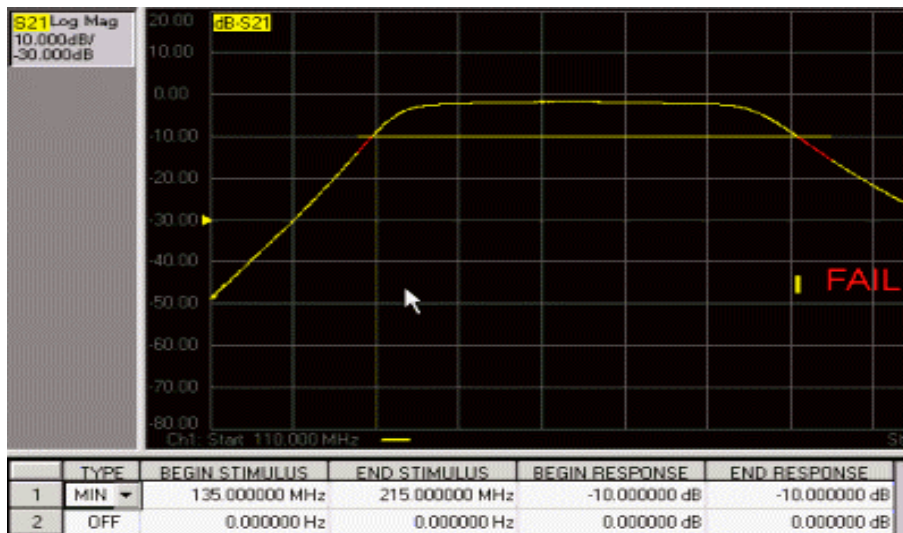
The following image is a data trace of an actual filter using 11 data points (approximately one every vertical graticule). The filter is being tested with a minimum limit line (any data point under the limit line fails).

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.



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.



## 5. Output Data

### Save and Recall a File

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

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Other Data Outputting topics

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## 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:

<b>"S<sub>11</sub> Log Mag"</b>	
<b>"Frequency (Hz)",</b>	<b>"dB"</b>
<b>3.000000e+005</b> ,	<b>-3.528682e+001</b> ,
<b>4.529850e+007</b> ,	<b>-2.817913e+001</b> ,
<b>9.029700e+007</b> ,	<b>-3.216808e+001</b> ,
<b>1.352955e+008</b> ,	<b>-3.101017e+001</b> ,

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## 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.

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- 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

## Interpreting MDIF Data

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**Note:** Frequency Converter Application .S2P files are saved in slightly different manner. To learn how, see Using FCA, Save 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

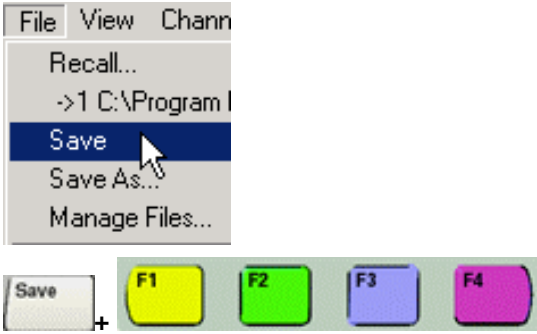
If full Error correction is performed and turned on, the PNA makes all 4 S-parameter measurements even though they may not be displayed. Therefore, for all 3 file types, the data that is saved is only valid if full error correction has been performed and turned on.

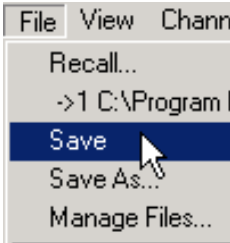
For example, If you are making S11 and S21 measurements and:

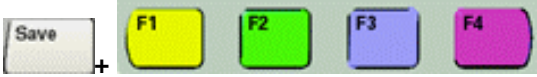
- You HAVE performed a full 2-port calibration and error correction is ON.  
Then All FOUR S-parameters are saved and all data is valid
- You HAVE NOT performed a full 2-port calibration and error correction is OFF.  
Then ONLY the active trace data is valid, and it is uncorrected data. All other S-parameter data are zeroes

#### How to Save a File

Use one of the following methods:



•  Save

•  Save + F1

Learn more about using the front panel interface

---

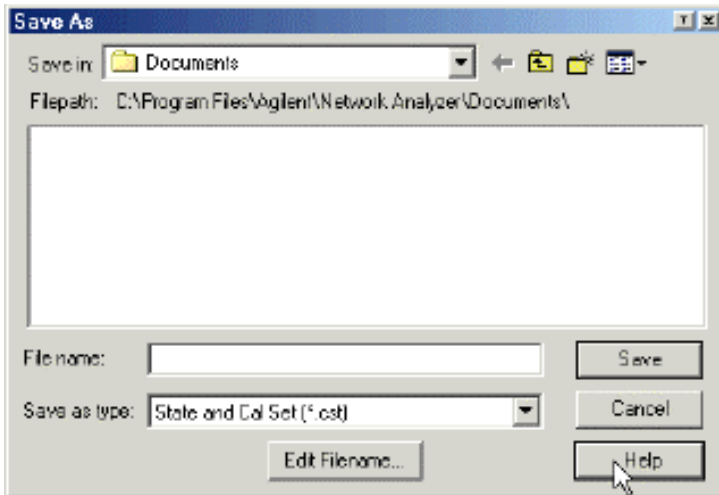
**Note:** You can NOT save Frequency Converter Application .S2P files using this method. To learn how, see Using FCA, Save Data.

---

**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

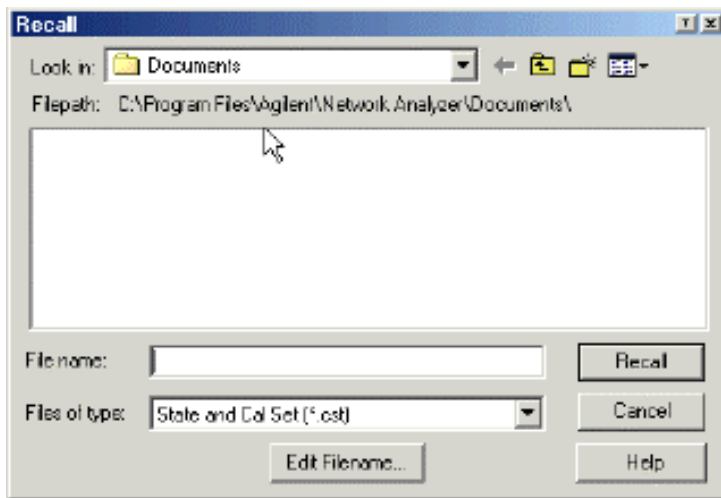
Opens calibration and state (binary) files to be used on the PNA.

### How to Recall a file

Use one of the following methods:

- 
- Press  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.

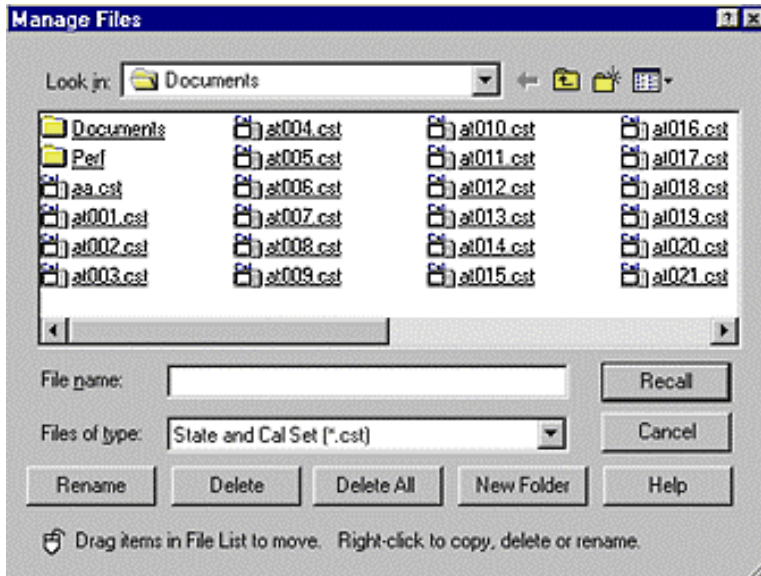
**Recall** Recalls the file displayed in the file name box.

### 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

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

---

**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

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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

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### 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**.

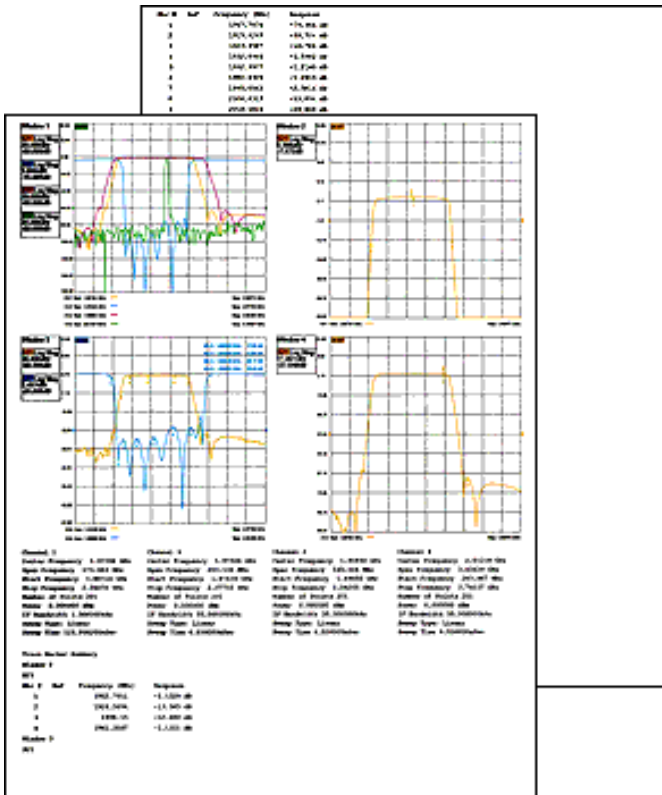
For more information, refer to the Windows 2000 Help or your printer documentation.

### Printing

- Print a Hardcopy
- Print Options
- Print to File

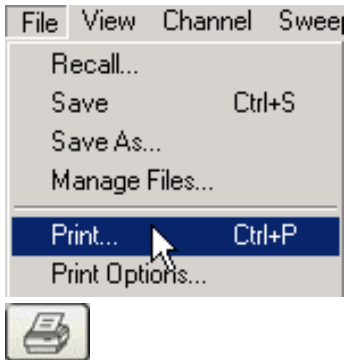
The measurement information on the screen can be printed to any local or networked printer that is connected to the analyzer. The amount of measurement information printed is selected by the print options settings.

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



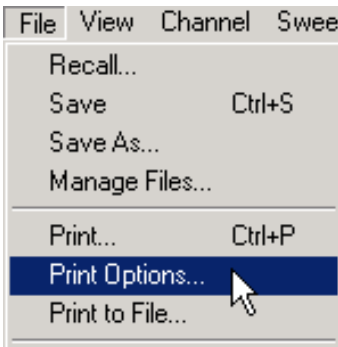
Learn more about using the front panel interface

**Note:** For information on the choices in the Print dialog box, see Windows 2000 Help.

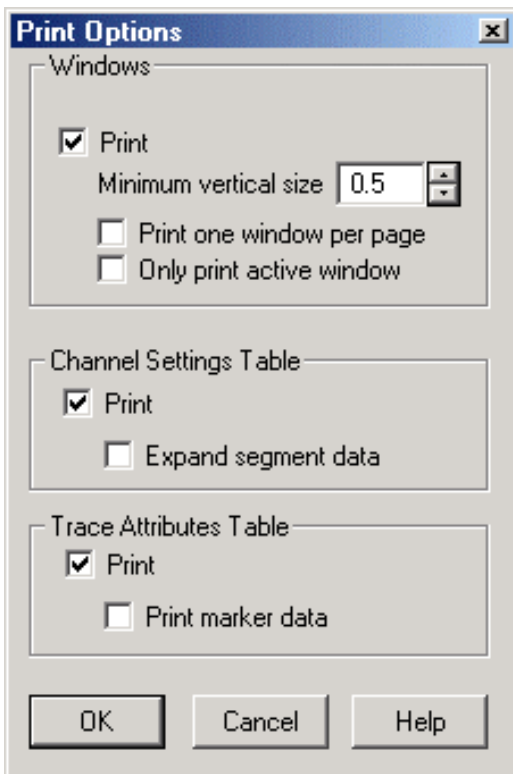
### Print Options

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

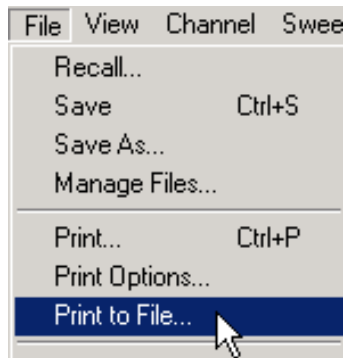
The analyzer can save a screen-capture image in any of the following formats:

- **.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

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## Other Support Topics

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### 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

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- 512 - 667 Calibrate
- 772 - 868 Hardware
- 1025 - 1128 Measure
- 1281 - 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).

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#### Cal Errors 512 - 667

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##### 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: 514**

"Calibration set has been recalled using a file previously saved on an analyzer that had a different hardware configuration."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68020202 (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: 522**

"The calibration type you selected cannot be set up."

**Severity:** Informational

**Further explanation:** "Please use the SCPI command ROUTe:PATH:DEFine:PORT <num>,<num> for full 2 port type port assignment."

**Suggestions:**

**EventID:** 6802020A (hex)

---

**Message: 523**

"The calibration path you selected cannot be set up because it is not valid for the current measurement."

**Severity:** Informational

**Further explanation:** "Please use the SCPI command ROUTe:PATH:DEFine:PORT <num>,<num> for full 2 port type port assignment related to your current measurement."

**Suggestions:**

**EventID:** 6802020B (hex)

---

**Message: 524**

"The source power calibration is complete."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 6802020C (hex)

---

**Message: 525**

"You have specified more than 7 standards for one or more calibration classes."

**Severity:** Informational

**Further explanation:** These have been truncated to 7 selections.

**EventID:** 6802020D (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: Could not open ECal module memory backup file"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020212 (hex)

---

**Message: 531**

"EXECUTION ERROR: Access to ECal module memory backup file was denied"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020213 (hex)

---

**Message: 532**

"EXECUTION ERROR: Failure in writing to ECal module memory backup file"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020214 (hex)

---

**Message: 533**

"EXECUTION ERROR: Failure in reading from ECal module memory backup file"

**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: Unable to orient ECal module. Please ensure the module is connected to the necessary measurement ports."

**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. If your measurement requires the power level to be less than that, clear the **Do orientation** checkbox to bypass the automatic detection step.

**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)

---

**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)

---

**Message: 647**

"Custom cal type not found."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020287 (hex)

---

**Message: 648**

"Custom correction algorithm defers to the client for interpolation."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020288 (hex)

---

**Message: 649**

"Custom cal dll threw an exception."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020289 (hex)

---

**Message: 650**

"Could not load the ecal.dll library"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E802028A (hex)

---

**Message: 656**

"The argument specified is not a valid cal type."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020290 (hex)

---

**Message: 657**

"The function found existing interpolated data"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020291 (hex)

---

**Message: 658**

"The function computed new interpolation values."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020292 (hex)

---

**Message: 659**

"The source power measurement failed."

**Severity:** Error

**Further explanation:**

**Suggestions:** Please check GPIB, power meter settings and sensor connections.

**EventID:** E8020293 (hex)

---

**Message: 660**

"Duplicate session found. Close session and retry."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020294 (hex)

---

**Message: 661**

"The session does not exist. Open the session and try again."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020295 (hex)

---

**Message: 662**

"Attempt to launch a custom calibration failed."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020296 (hex)

---

**Message: 663**

"Request to measure a cal standard failed."

**Severity:** Error

**Further explanation:** Please ensure you are requesting to measure standards which are defined for this calibration.

**Suggestions:**

**EventID:** E8020297 (hex)

---

**Message: 664**

"Since Electronic Calibration Kit is selected, Mechanical Cal Kit parameter cannot be changed."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8020298 (hex)

---

**Message: 665**

"Frequencies of the active channel are below minimum or above maximum frequencies of the ECal module factory characterization."

**Further explanation:**

**Suggestions:** Change the channel frequencies, or select another ECal module.

**Severity:** Error

**EventID:** E8020299 (hex)

---

**Message: 666**

"Calset chosen for characterizing the ECal Module Ports %1 does not contain a calibration for PNA Ports %2."

**Severity:** Error

**Further explanation:**

**Suggestions:** Go back to select another calset or to perform another cal.

**EventID:** E802029A (hex)

---

**Message: 667**

"ECal module only has sufficient memory remaining to store a maximum of %1 points in User Characterization %2."

**Severity:** Error

**Further explanation:**

**Suggestions:** Decrease your number of points, or choose to overwrite another user characterization.

**EventID:** E802029B (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 unlevelled."

**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 multipoint 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 unratiod 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 1281 - 1535**

---

**Message: 1281**

"You have sent a read command to the analyzer without first requesting data with an appropriate output command. The analyzer has no data in the output queue to satisfy the request."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68050501 (hex)

---

**Message: 1282**

"You must remove the active controller from the bus or the controller must relinquish the bus before the analyzer can assume the system controller mode."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68050502(hex)

---

**Message: 1283**

"The analyzer did not receive a complete data transmission. This is usually caused by an interruption of the bus transaction."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68050503 (hex)

---

**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 %1: "%2"."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68050505 (hex)

---

**Message: 1286**

"The INET LAN server has been started as process number %1."

**Severity:** Informational

**Further explanation:**

**Suggestions:**

**EventID:** 68050506 (hex)

---

**Message: 1360**

"Execution of the SCPI command has failed"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050550 (hex)

---

**Message: 1361**

" The INET/LAN device is not accessible."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050551 (hex)

---

**Message: 1362**

"The INET/LAN driver was not found. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050552 (hex)

---

**Message: 1363**

"The INET/LAN driver was not found."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050553 (hex)

---

**Message: 1364**

"The INET/LAN device is unable to acquire the necessary resources. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050554 (hex)

---

**Message: 1365**

"The INET/LAN device generated a generic system error. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050555 (hex)

---

**Message: 1366**

"Invalid address for the INET/LAN device."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050556 (hex)

---

**Message: 1367**

"The INET I/O library was not found. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050557 (hex)

---

**Message: 1368**

"An error occurred in the INET system. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050558 (hex)

---

**Message: 1369**

"Access to the INET/LAN driver was denied. "

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E8050559 (hex)

---

**Message: 1370**

"Could not load error system message dll."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E805055A (hex)

---

**Message: 1371**

"ErrorMessage.dll does not export the right function."

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E805055B (hex)

---

**Message: 1372**

"Custom scpi library was not able to be knitted"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E805055C (hex)

---

**Message: 1373**

"Could not knit the scpi error messages from the ErrorSystemMessage lib"

**Severity:** Error

**Further explanation:**

**Suggestions:**

**EventID:** E805055D (hex)

---

**Message: 1535**

"Parser got command: %1."

**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
- 

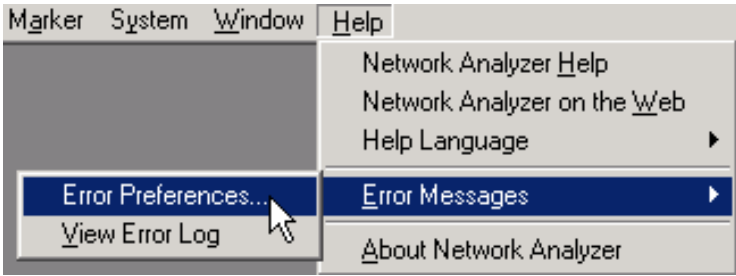
Other Support topics

---

## Error Preferences

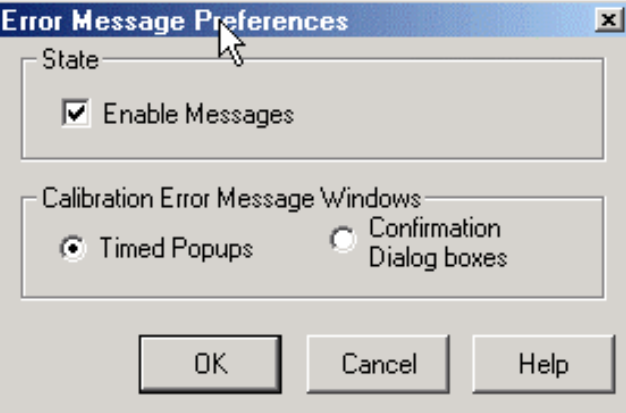
By default, error messages appear on the PNA screen for a brief period. You can choose to have them stay on the screen until you click an OK button, or have them not appear at all. When they stay on the screen, a Help button is available to provide further assistance.

**How to select Error Preferences**



The screenshot shows the Network Analyzer software interface with the 'Help' menu open. The 'Error Preferences...' option is highlighted, and a mouse cursor is pointing at it. The 'Error Messages' sub-menu is also visible, showing options like 'Error Messages', 'About Network Analyzer', and 'View Error Log'.

Learn more about using the front panel interface



The screenshot shows the 'Error Message Preferences' dialog box. It has a title bar with a close button. The 'State' section contains a checked checkbox for 'Enable Messages'. The 'Calibration Error Message Windows' section has two radio buttons: 'Timed Popups' (selected) and 'Confirmation Dialog boxes'. At the bottom are 'OK', 'Cancel', and 'Help' buttons.

### 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

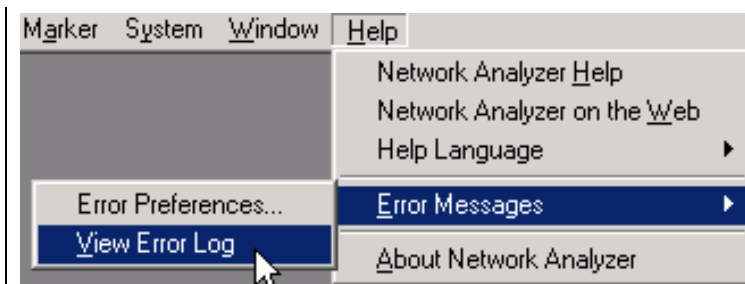
**Timed Popups** Displays error messages on the screen for a duration of time proportional to the length of the message. You can then view the message in the error log and get further assistance.

**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.

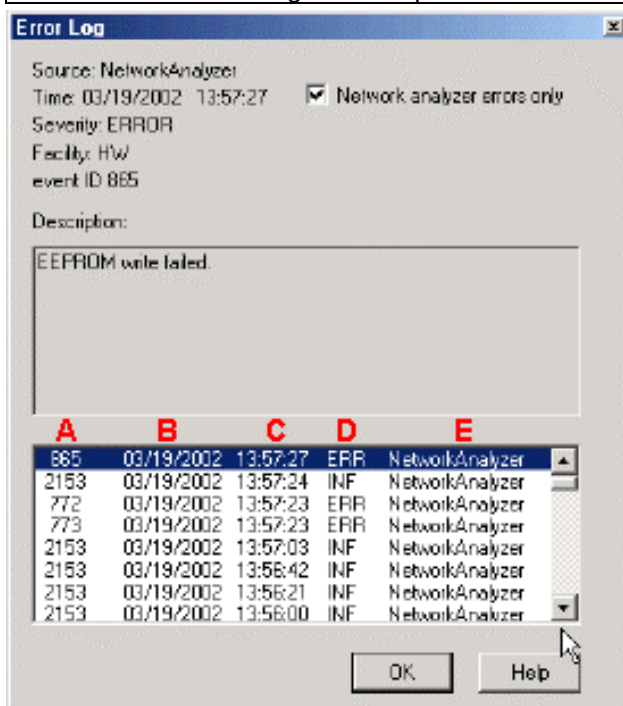
## View Error Log

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

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### Other Support topics

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For product and order information:

- Call 1-800-452-4844 (8am-8pm EST)
- Visit [www.agilent.com/find/accessories](http://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
85038A	7-16	7.5 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
85058B/E	1.85 mm	67 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	<b>CD RW drive</b> - with USB cable.
N4689A	<b>USB 4-port hub</b> - for connecting additional USB peripherals.
82357A	<b>USB/GPIB Interface</b> - for controlling GPIB devices through USB. Learn more about using the 82357A with the PNA

## 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



## 82357A USB/GPIB Interface

The Agilent 82357A is an adapter that creates a GPIB Interface from one of your unused PNA USB ports.

- Applications
  - Installing
  - Configuring
  - Connecting
  - Communicating with other Equipment
- 

## Applications

The 82357A can be used for the following PNA applications:

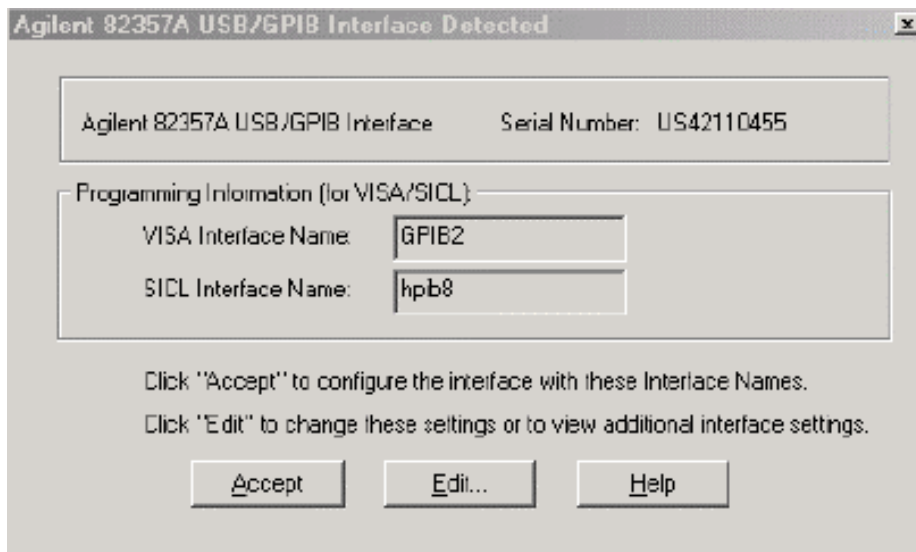
- **Frequency Converter Application** - The 82357A is included with the Frequency Converter Application (option 083). All GPIB test equipment (power meter, external sources) MUST be connected to this Interface. See connecting diagram below.
- **PNA Controller** - The 82357A can be used by the PNA to control other GPIB devices. This frees the default GPIB interface to perform other GPIB operations, such as control the PNA from an external PC.
- **Source Power Cal** - The 82357A can be used to run a source power calibration.

## Installing the 82357A USB/GPIB Interface

1. Download and install firmware revision 3.0 or greater. To check the revision of your PNA firmware, click **Help** then **About Network Analyzer**.
2. Upgrade to the latest Agilent IO libraries from the CDROM that was shipped with the 82357A. If not available, download them from [www.Agilent.com](http://www.Agilent.com) (search for **82357A**)

## Configure the 82357A USB/GPIB Interface

When the 82357A is connected to the PNA USB, the following dialog box appears:



Normally, you do NOT need to edit these settings. The following background information describes situations when you would need to change these settings.

The 82357A USB/GPIB Interface is configured automatically as the next unused interface.

- **GPIB2** is usually the next available interface unless you have already configured it for another purpose.
- **GPIB0** is the PNA rear-panel GPIB connector. This default GPIB interface can be used to

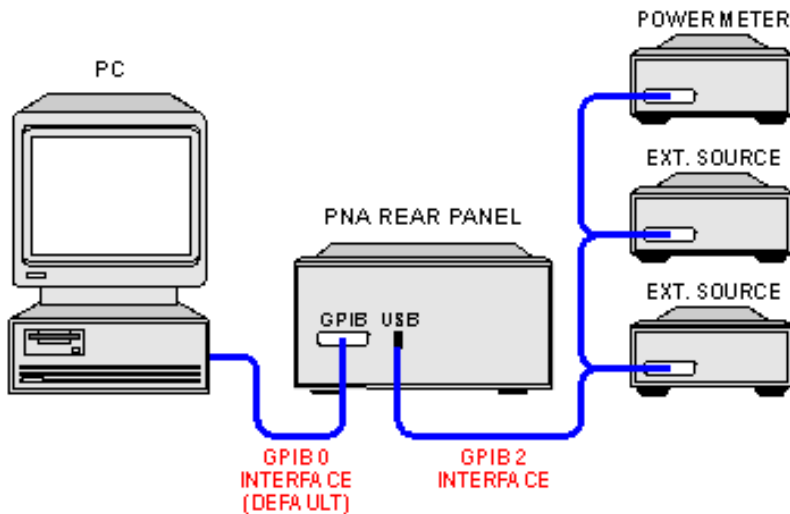
control the PNA **OR** for the PNA to control external equipment; IT CAN NOT DO BOTH IN THE SAME PROGRAM. However, the 82357A USB/GPIB Interface can be used to control other equipment on GPIB2 while the default GPIB0 is being used to control the PNA from a remote PC.

- **GPIB1** is used in the PNA as an internal interface for programs running on the PNA to control itself.

### Connecting the 82357A USB/GPIB Interface

The following diagram illustrates how to connect GPIB test equipment using the USB/GPIB Interface.

- Plug the USB/GPIB Interface into any unused PNA USB port.
- The default GPIB Interface and USB/GPIB Interface should never be connected together.



### Communicating with Equipment Connected to the USB/GPIB Interface

- The Frequency Converter Application will automatically find and communicate with test equipment that is connected to the USB/GPIB Interface.
- Source power calibration will automatically find and communicate with the power meter that is connected to the USB/GPIB Interface.
- To control other devices through your own program using the 82357A, you must include the new GPIB Interface number when addressing the devices.

## 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

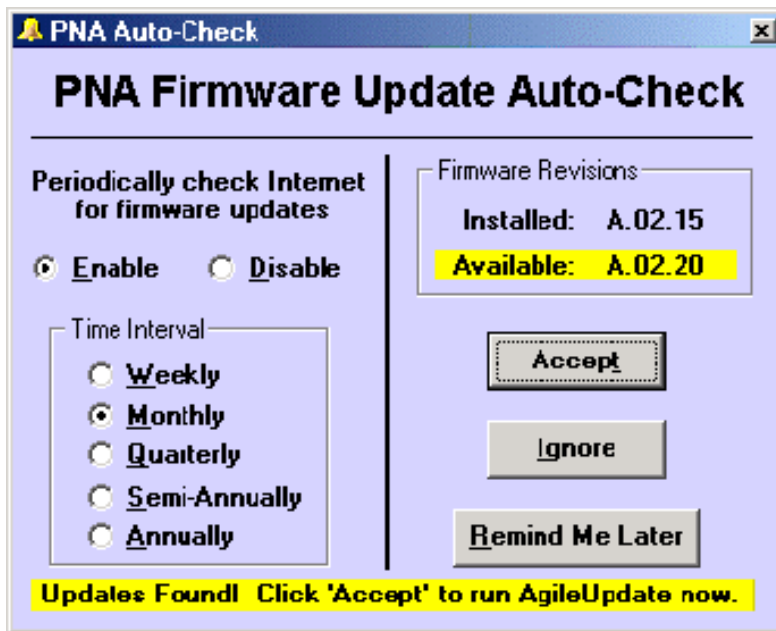
With Internet access to your PNA, Auto-Check automatically and regularly checks the Internet for new PNA firmware revisions. If a new revision is found, a notification message prompts you to run the AgileUpdate utility, which then performs the actual download.

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.

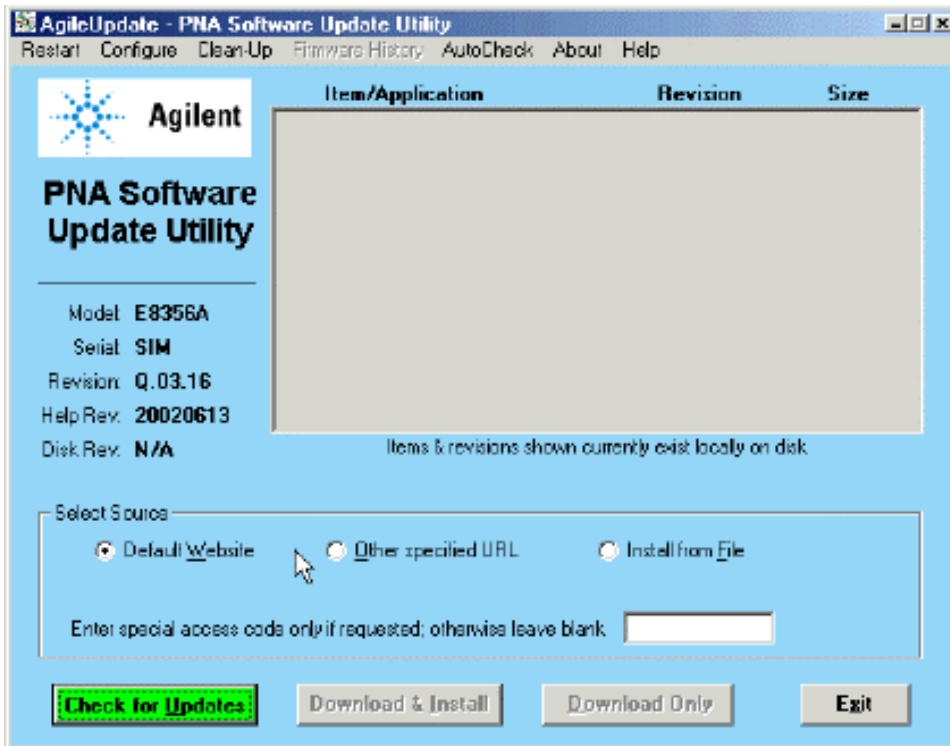
**Remind me Later** This dialog box will be shown again in 1 to 20 days. (The number of days depends on the selected Time Interval.)

## 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.

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**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.

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### 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.

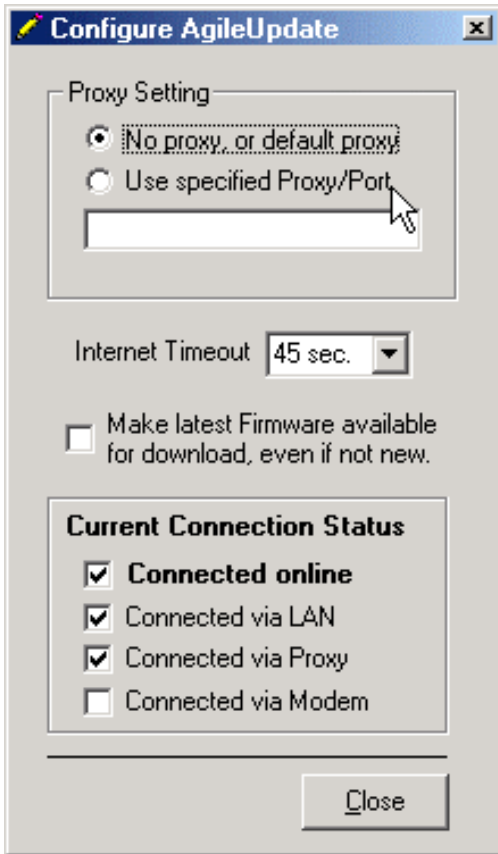
**Install from File** Click if you have already downloaded the InstallShield package and want AgileUpdate to install it for you.

**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.

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**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.

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## PNA Standard Configurations

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The following is a list of PNA standard models and relevant information. See the options available for each model.

Click the model number to see the block diagram.

PNA Model	Frequency Range	Ports	Reference Receiver	Front Panel jumpers
E8356A	300 kHz to 3 GHz	2	2	4
E8357A	300 kHz to 6 GHz	2	2	4
E8358A	300 kHz to 9 GHz	2	2	4
E8801A	300 kHz to 3 GHz	2	1	0
E8802A	300 kHz to 6 GHz	2	1	0
E8803A	300 kHz to 9 GHz	2	1	0
N3381A	300 kHz to 3 GHz	3	1	0
N3382A	300 kHz to 6 GHz	3	1	0
N3383A	300 kHz to 9 GHz	3	1	0
E8361A	10 MHz* to 67 GHz (tunable to 70 GHz)**	2	2	0
E8362A	45 MHz to 20 GHz	2	2	0
E8363A	45 MHz to 40 GHz	2	2	0
E8364A	45 MHz to 50 GHz	2	2	0
E8362B	10 MHz* to 20 GHz	2	2	0
E8363B	10 MHz* to 40 GHz	2	2	0
E8364B	10 MHz* to 50 GHz	2	2	0

\* Typical specs apply from 10 to 45 MHz

\*\* Typical specs apply from 67 to 70 GHz

New PNA Models

## PNA Options



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
- Certification
- Service and Support Options

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**Note:** To view the options that are installed on your analyzer, click **Help** then **About Network Analyzer**

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Other Support Topics

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## 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	<b>Upgrade to 6 GHz frequency range.</b> 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	<b>Upgrade to 9 GHz frequency range.</b> 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	<b>Time-domain</b> 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/ 02/ 03A N3381/ 82/ 83A E8361A E8362/ 63/ 64A E8362/ 63/ 64B	<b>Configurable test set</b> 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/ 57/ 58A	<b>Configurable test set</b> 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
016	E8362/ 63/ 64B	<b>Receiver Attenuators</b> Adds a 35dB attenuators between both test ports and their corresponding receivers. Requires option UNL.
022	E8361A E8362/ 63/ 64A E8362/ 63/ 64B	<b>Extended Memory</b> Adds more RAM for a total of 512MB
080	E8362/ 63/ 64B	<b>Frequency Offset</b>

		Enables you to set the PNA source independently from where the receivers are tuned. This capability is important for measuring mixers, converters, and amplifiers. To control the additional hardware, a basic user interface, SCPI, and COM commands are provided. Requires option 014.
<b>081</b>	E8362/ 63/ 64B	<p><b>Reference Switch</b> Adds an internal solid state switch in the R1 reference path for controlling an external reference mixer. Requires option 014.</p> <p>See a block diagram of reference switch.</p>
<b>083</b>	E8361A/ 62B/ 63B/ 64B	<p><b>Frequency Offset Measurement Application</b> Provides an intuitive user-interface for making extremely accurate amplitude and phase conversion loss measurements on mixers and converters. Exceptional amplitude and phase accuracy is achieved through two new calibration techniques: match-corrected power meter calibration and vector mixer calibration. The application also provides automatic control of all of Agilent's major signal sources. Requires option 014, 080, and 081.</p>
<b>098</b>	E8356/ 57/ 58A	<p><b>CPU board upgrade</b> Replaces the 266 MHz CPU board with a 500 MHz CPU board. Includes installation at an Agilent service center.</p> <p><b>To check your PNA CPU speed:</b></p> <ol style="list-style-type: none"> <li>1. On the PNA, click <b>View</b>, then <b>Minimize Application</b>.</li> <li>2. On the desktop, right-click <b>My Computer</b>, then click <b>Manage</b>.</li> <li>3. Open <b>System Tools</b> folder, then click <b>System Information</b>.</li> </ol> <p>Click <b>System Summary</b>. After refreshing, read the <b>Processor</b> entry. The end of the line states the CPU speed.</p>
<b>099</b>	All	<p><b>Firmware upgrade kit</b> 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.</p>
<b>1E1</b>	E8801/ 02/ 03A N3381/ 82/ 83A	<p><b>70 dB step attenuator</b> 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/ 57/ 58A.</p>
<b>1E5</b>	E8801/ 02/ 03A N3381/ 82/ 83A	<p><b>High stability 10 MHz time base</b> Replaces 10 ppm time base with a 1 ppm time base. High stability time base is standard with PNA models E8356/ 57/ 58A and E8362/ 63/ 64B.</p>
<b>UNL</b>	E8362/ 63/ 64A E8362/ 63/ 64B	<p><b>60 dB step attenuators and bias tees</b> 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.</p>

## Certification

<b>Option</b>	<b>Supported Models</b>	<b>Description</b>
<b>1A7</b>	All	Complete set of measurement data which was acquired from

<b>UK6</b>	All	testing your PNA to published specifications. Includes calibration label, calibration certificate, and data report. Conforms to ISO 9001. Complete set of measurement data which was acquired from testing your PNA to published specifications. Includes calibration label, ISO 17025 calibration certificate, data report, measurement uncertainties and guardbands on all specifications. Conforms to ISO17025 and ISO 9001.
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## Documentation and Localization

Option	Description
<b>AVK</b>	Adds printed version of Help, which includes a User's Guide and Programmer's documentation.
<b>0BW</b>	Adds printed copy of assembly-level service manual.
<b>ABD</b>	Adds printed version of Help in German.
<b>ABE</b>	Adds printed version of Help in Spanish.
<b>ABF</b>	Adds printed version of Help in French.
<b>ABJ</b>	Adds printed version of Help in Japanese.

## Service and Support Options

Option	Description
<b>W01</b>	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/ 63/ 64B. See Agilent Contacts.
<b>W31</b>	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/ 63/ 64B. See Agilent Contacts.
<b>W32</b>	Adds three-year return-to-Agilent commercial calibration agreement.
<b>W34</b>	Adds three-year return-to-Agilent standards-compliant calibration agreement.
<b>W50</b>	Extends return-to-Agilent service warranty to five years.
<b>W51</b>	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/ 63/ 64B. See Agilent Contacts.
<b>W52</b>	Adds five-year return-to-Agilent commercial calibration agreement.
<b>W54</b>	Adds five-year return-to-Agilent standards-compliant calibration agreement.

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**Note:** For on-line information about Agilent's service and support products visit:  
[www.agilent.com/find/tm\\_services](http://www.agilent.com/find/tm_services)

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## Option Enable Utility

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.

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**Note:** If you are unsure if this routine needs to be done, run it; no harm will result.

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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.)

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**Note:** Use extreme care when entering the serial number; only one entry chance is allowed!

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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

## 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 Instrument, (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

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#### -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.
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-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 than 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 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, an 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
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		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 because 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	Macro parameter - Indicates that the macro definition improperly used a macro parameter placeholder, see IEEE 488.2, 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



-362	std_framing	data received for example, on a serial port. 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_terminated	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

### 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 measurements."
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	calNotValidForConfidenceCheck	"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	standardMeasurementRequired	"The attempted operation can only be performed on a standard measurement type."
170	noDivisorBuffer	"A valid divisor buffer is required before normalization can be turned on."
171	invalidReceiverPowerCalParagraph	"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	userCharacterizationNotFound	"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."



## Technical Support

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Click on the region of interest.



- For assistance with your test and measurement needs go to [www.agilent.com/find/assist](http://www.agilent.com/find/assist)
- Or contact the test and measurement experts at Agilent Technologies.

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### Other Support Topics

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#### **United States:**

(tel) 1 800 452 4844

#### **Canada**

(tel) 1 877 894 4414

(fax) 1 (905) 206 4120

#### **Europe:**

(tel) (31 20) 547 2000

#### **Japan:**

(tel) (81) 426 56 7832

(fax) (81) 426 56 7840

#### **Latin America:**

(tel) (305) 267 4245

(fax) (305) 267 4286

#### **Australia:**

(tel) 1 800 629 485

(fax) (61 3) 9272 0749

#### **New Zealand**

(tel) 0 800 738 378

(fax) 64 4 495 8950

## Asia Pacific:

(tel) (852) 3197 7777

(fax) (852) 2506 9284



## Diagnostic Tools and Adjustments

### 3.8 GHz Frequency Adjustment

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This routine 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.

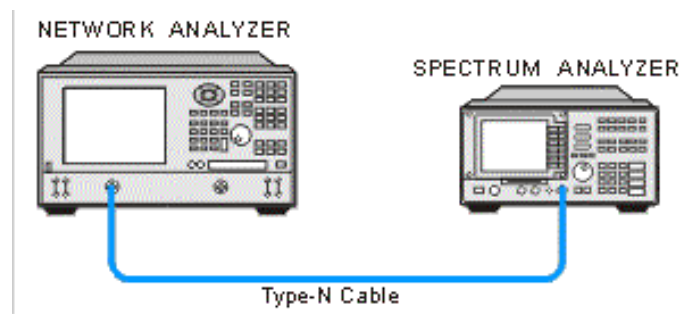
#### Procedure (For Compatible Spectrum Analyzers Only)

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**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.

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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)

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**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 stabilize.
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 stabilize.

---

## 10 MHz Reference Frequency Adjustment

---

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



---

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.

### Offset LO Power Adjustment

---

**Note:** This adjustment is only performed on PNAs with Frequency Offset Mode (option 080).

---

The Offset LO Adjustment sets the LO power for the offset mixer to a consistent value across all bands. It requires access to the internal components of the PNA so that the power sensor can be connected to the LO output. Because the LO frequency does not exceed 3 GHz, almost any power sensor can be used. The adjustment is relatively simple and only takes a couple of minutes.

### When to perform

This adjustment should be performed when any of the following occur:

- the A13 Frequency Offset Receiver is significantly modified or replaced
- the A9 Synthesizer is replaced (that is where the correction data resides)

### How to perform Offset LO Power adjustment

1. To start the Offset LO adjustment, click **System**, point to **Service, Adjustments**, then click **Offset LO Adjust**.
2. You will be prompted to zero and cal the power sensor. (You can do this before beginning.)
3. Connect the sensor to J3 of the A13 LO output by removing the existing cable (or simply disconnecting one end) as shown in the Set-up diagram in the program.
4. Connect the power meter to the PNA using a GPIB cable. Make sure the GPIB address shown in the program matches the actual power meter address (default is 13.)
5. Click **Adjust** to begin the test and follow the instructions.

The program automatically adjusts all bands; no user input is needed. The program repeats several times as this is an iterative process. The progress of the adjustment is shown on the screen.

The Configure menu selection is for factory personnel ONLY.

Once completed, to verify the actual results, click Verify.

Upon exiting, the PNA application will restart; this takes several seconds.

## Operator's Check

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- Overview
- To Display the Operator's Check
- The Operator's Check Procedure

### Overview

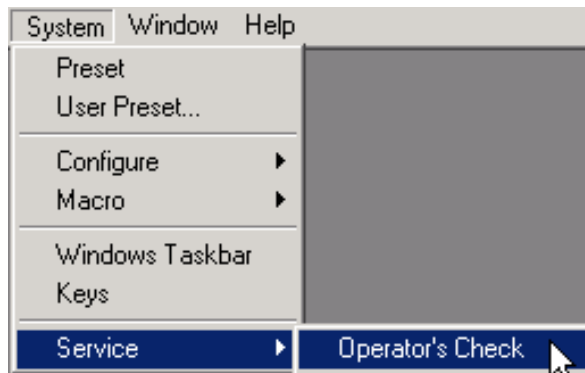
The Operator's Check should be performed when you first receive your analyzer, and any time you wish to have confidence that the analyzer is working properly. The Operator's Check does not verify performance to specifications, but should give you a high degree of confidence that the instrument is performing properly.

To verify PNA performance to specifications, run System Verification.

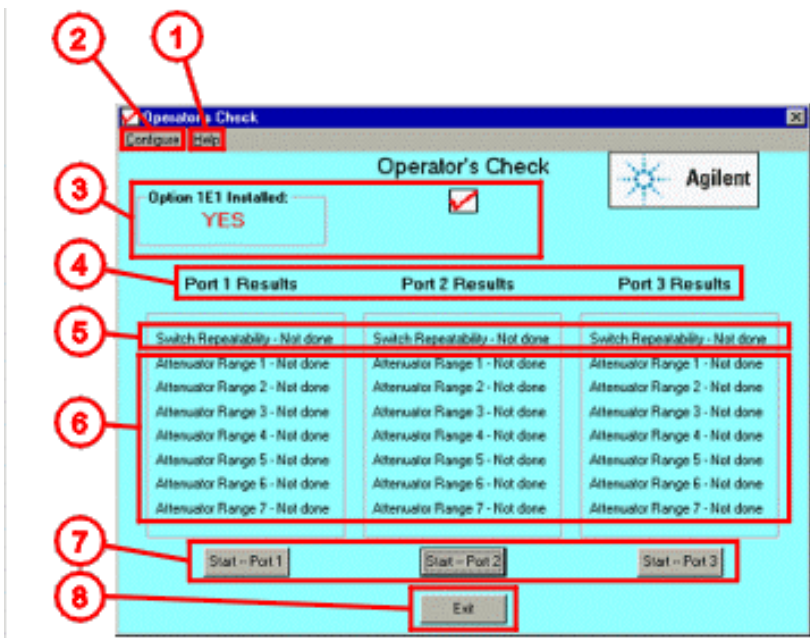
Use the Operator's Check to check for obvious failures in the following portions of the network analyzer hardware:

- 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.

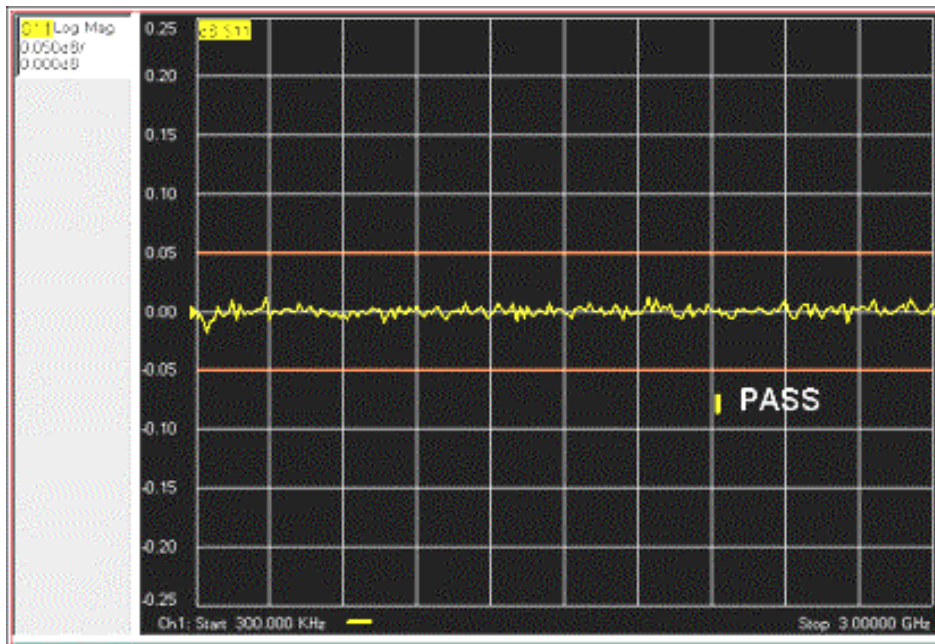
On the pull down menu click **Configure**, select **Automatic** or **Prompted Sequencing**.

- **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.

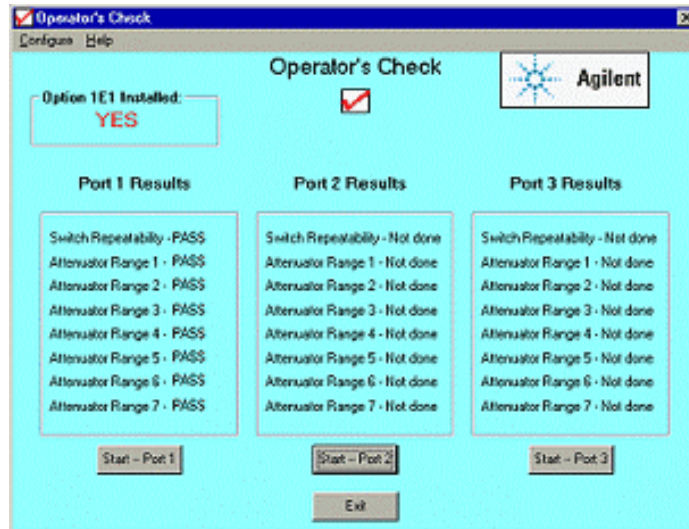
### 2. Start Test on Port 1

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.

## Phase-Lock IF Gain Adjustment

The E836x A/B PNA models have a variable gain control for the phase-lock loop IF signal. By dynamically changing the gain as a function of frequency and power, the phase-lock signal amplitude can be adjusted to a constant level for the entire operating range of the instrument. This constant level is important for phase-lock acquisition and stability.

### When to perform

Phase-Lock IF Gain Adjustment should be performed when any of the following occur:

- a source calibration
- an assembly in the reference receiver path (R1,R2) is replaced.
- the Test Set Motherboard is replaced
- the Phase Lock board is replaced
- **Phase Lock Lost** error message appears after replacing a source or receiver assembly

### How to perform Phase-Lock IF Gain adjustment

1. From the **System** menu, click **Service**, then **Adjustments**, then **IF Gain Adjustment**.
2. Select any special test set options installed, otherwise leave the selection at **None**.
3. No connections to the test ports are required.
4. Click **Begin Adj.** The adjustment takes about a minute to complete.
5. The advanced screen is for factory personnel only.

## System Verification

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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

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**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.

Equipment Type	Model	Alternate Model
Calibration kit, Type-N or ECAL Module	85032F	85033E (3.5mm)
Verification kit, Type-N	85092B	85093B (3.5mm)
RF Cable, Type-N	85055A	85053B (3.55mm)
	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	85133C	85133E

mm (f)

### 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.

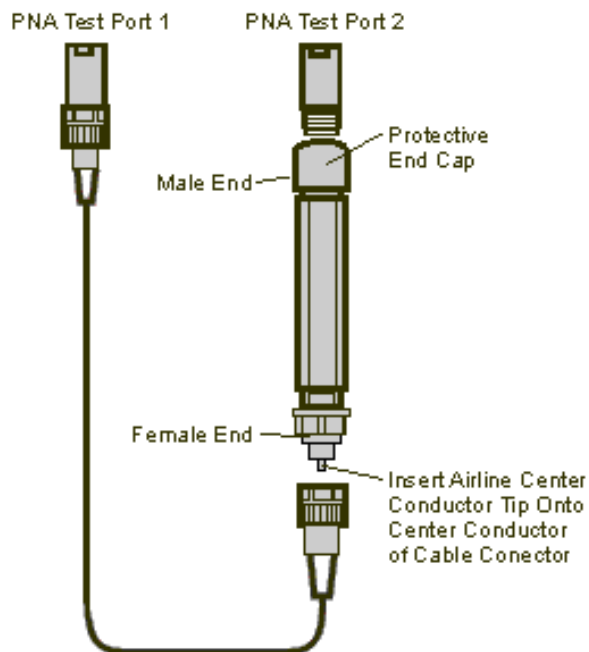
### Calibration Kit Substitution

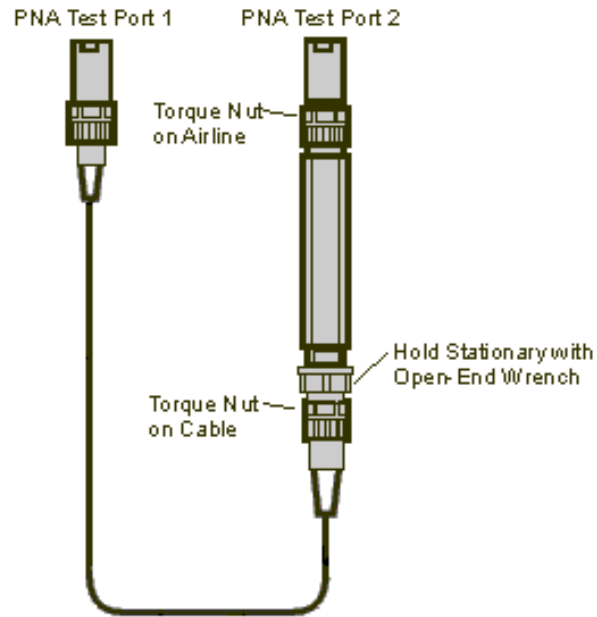
Non-Agilent calibration kits are not recommended or supported.

### 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.

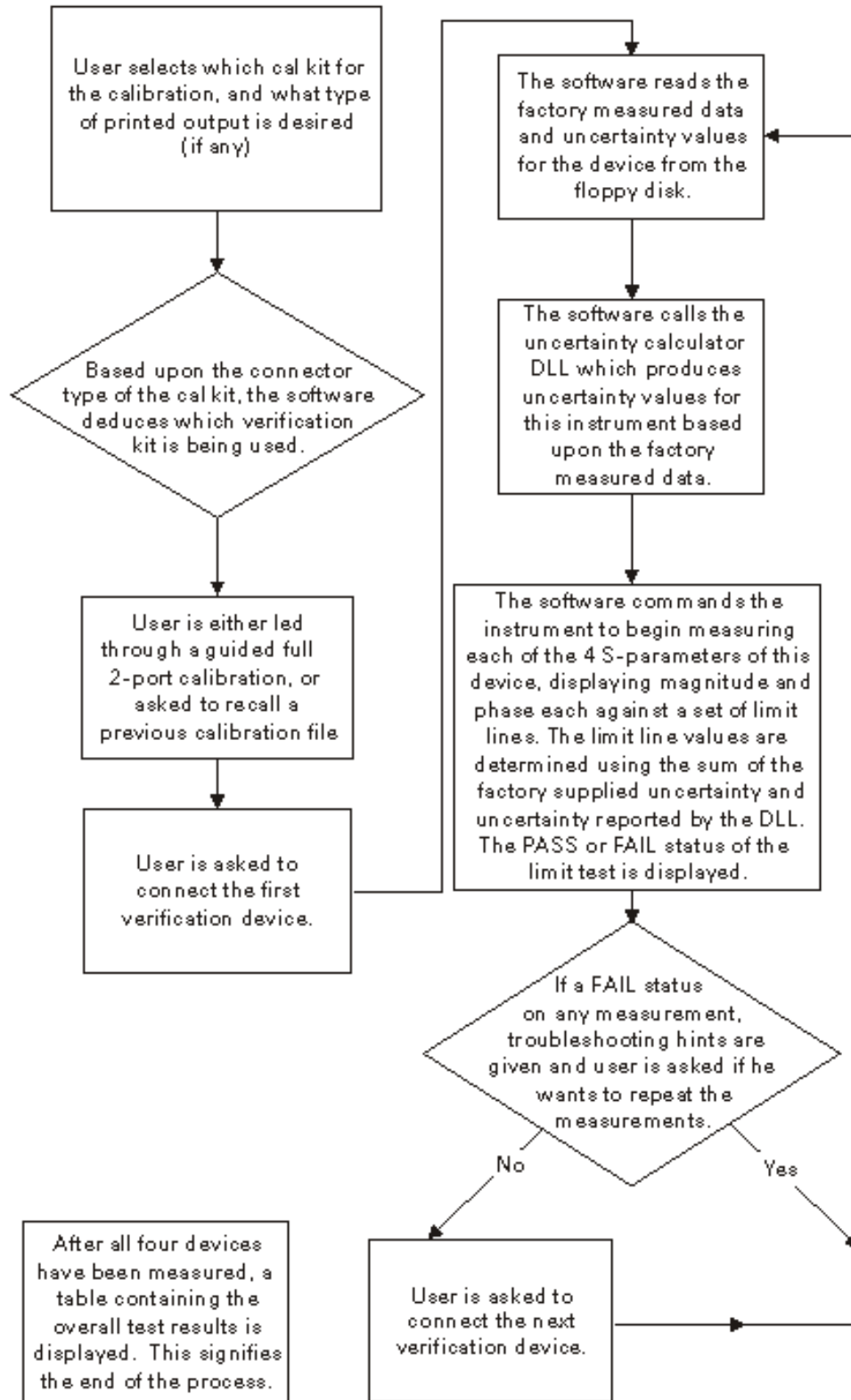




### Flow Diagram of Procedure

The operational flow of the software is depicted by the flowchart shown below.



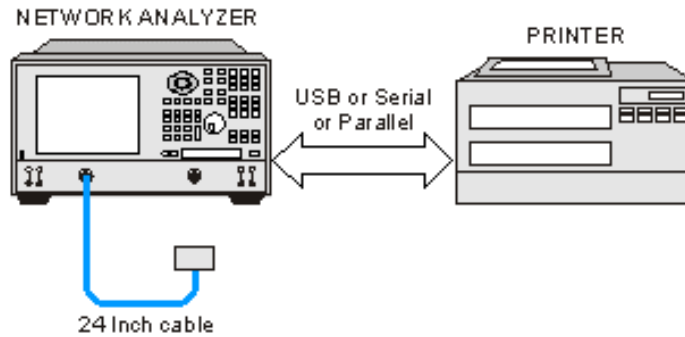


### Procedure for System Verification

1. Connect a cable to Port 2 on the analyzer. If you want printed test outputs, connect a

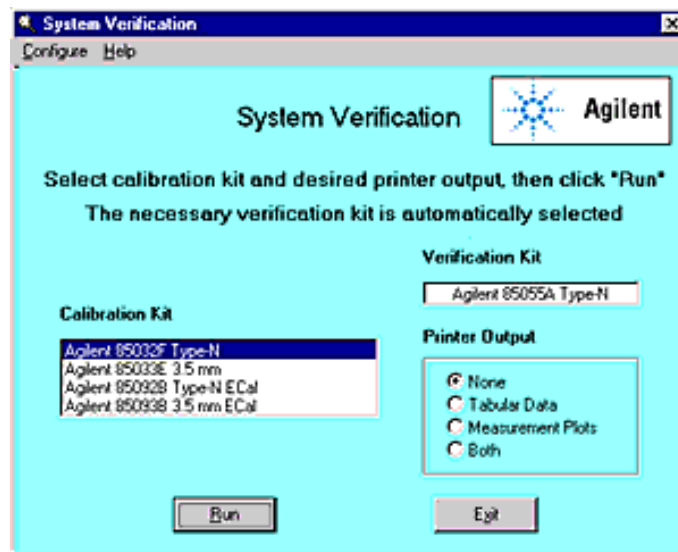
printer to the analyzer. Let the analyzer warm up for at least 30 minutes.

### 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.

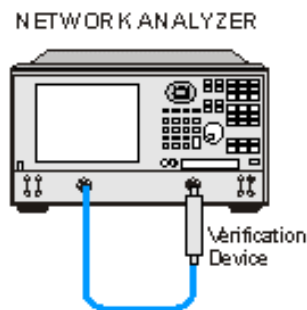
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**Note:** If you want printed output, it is assumed you have already installed the Windows 2000 driver for your particular printer, and have tested that you can print to the printer from the network analyzer. This software is designed to print to whichever 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




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#### 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.

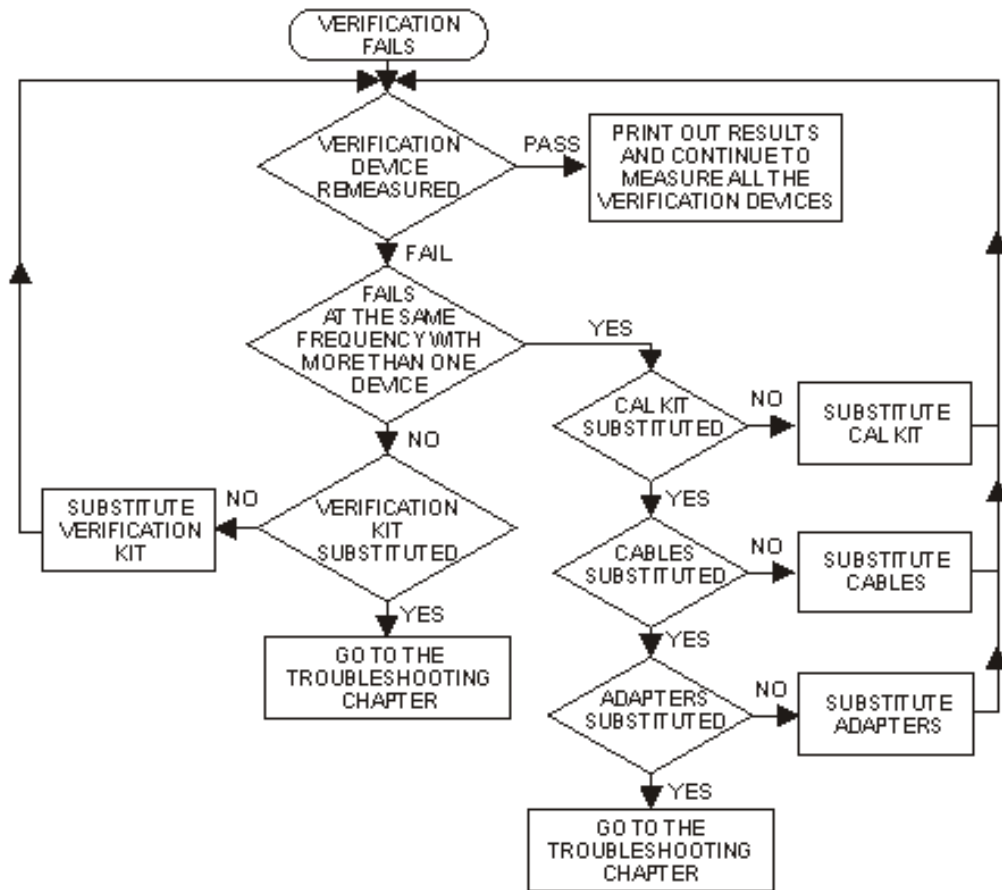
6. The user clicks a button when ready to view phase measurements. The four windows get updated for phase format, phase memory traces, phase limits and PASS/FAIL result.
7. If the limit test of any of the four S-parameters (magnitude or phase) indicates a FAIL status, the software suggests troubleshooting 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**



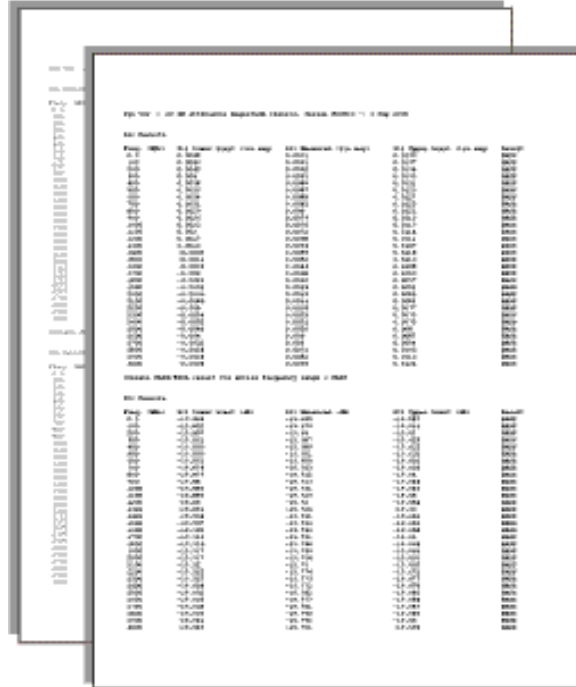
### Interpreting the Verification Results

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.

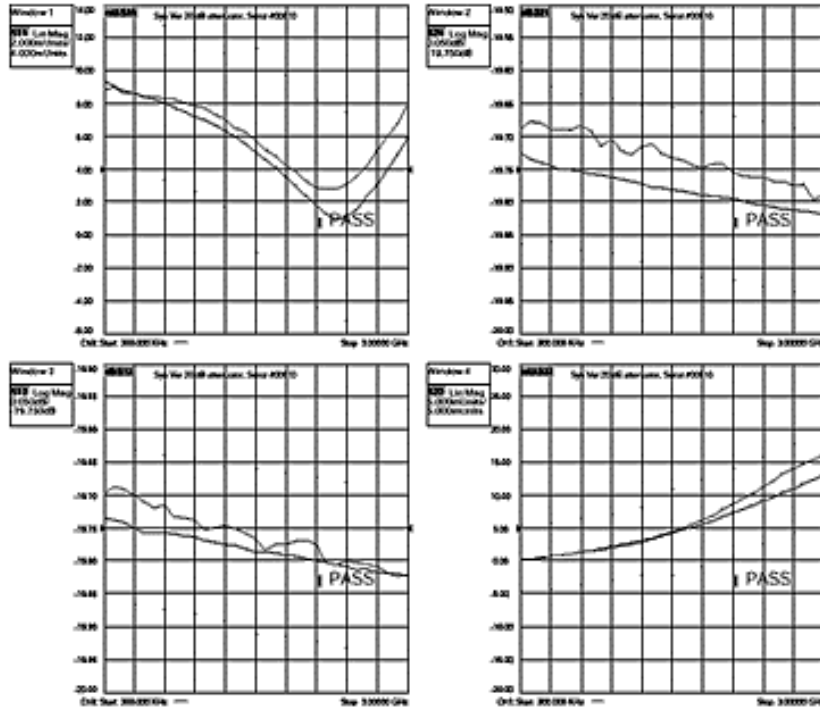
#### Printout of Tabular Verification Results



**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

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
E8361A	8487A (use with adapter 11900B) and V8486A (use with adapter V281B)	N4697-60001

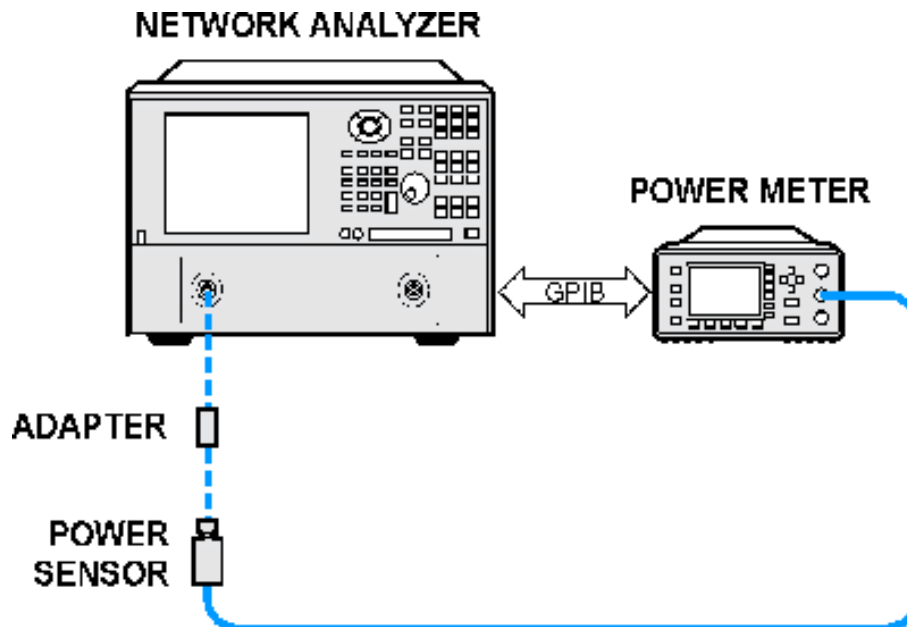
	** See E8361A procedure below	
E8362A / B	E4413A	85131E
E8363A/B E8364A/B	8487A (use with adapter 11900B)	85133E

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





## Additional Information

All ports are tested on all PNAs. Source calibration takes approximately 20 to 90 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.

## E8361A Procedure

Source and Receiver calibration requires the power meter to measure the source power over the full range of each of the PNA internal bands. Because the 8487A can not measure accurately above 50 GHz, it can only be used up to the next highest band switch frequency at 46.2 GHz. The V8486A sensor and V281B adapter are used from 46.2 GHz to 67 GHz.

For highest accuracy, the V8486A and V281B should be sent to Agilent for a custom calibration from 45 GHz to 70 GHz.

For the next highest accuracy level, the following procedure shows how to measure correction factors yourself from 46 to 50 GHz. This procedure assumes you have already loaded correction factors for both sensors into the power meter.

1. On your power meter, add 46 and 48 GHz to the Cal Factor Table.
2. Preset the PNA
3. Tune the PNA to 46 GHz (CW frequency)
4. Using the 8487A, measure power at port 1. Record this value.
5. Tune the PNA to 48 GHz (CW frequency)
6. Using the 8487A, measure power at port 1. Record this value.
7. Connect the V8486A, V281A, and 1.85 f-f adapter to the power meter.
8. Tune the PNA to 46 GHz (CW frequency)
9. Adjust the cal factor table 46 GHz setting until the power meter reading matches the power readings from step 4.
10. Tune the PNA to 48 GHz (CW frequency)
11. Adjust the cal factor table 48 GHz setting until the power meter reading matches the power readings from step 8.

## Receiver Calibration

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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

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**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).

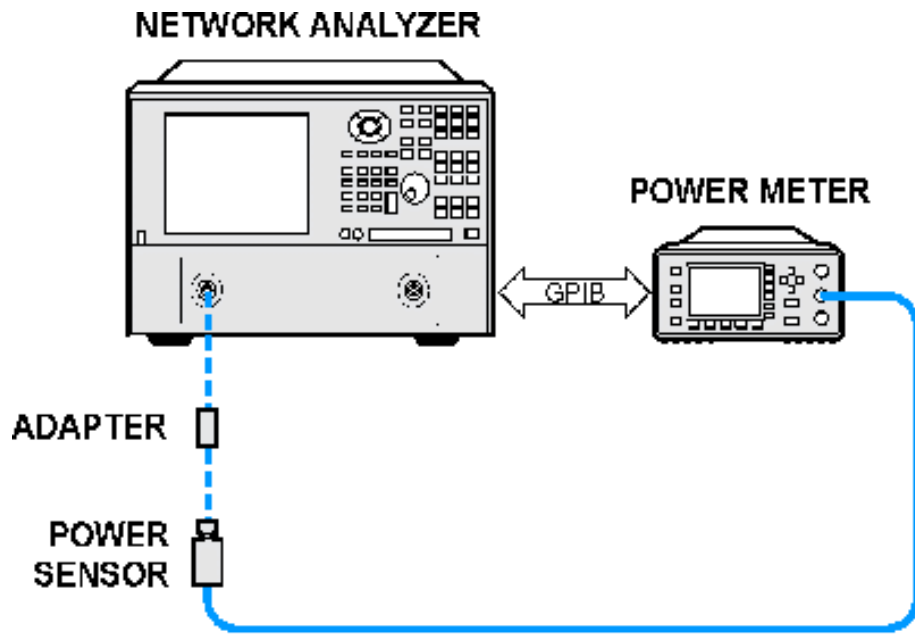
PNA Model	Power Sensor(s)	Cable
E8356A	8482A	N6314A
E8357A/E8358A	8482A and E4412A	N6314A
E8801A	8482A	N6314A
E8802A/E8803A	8482A and E4412A	N6314A
N3381A	8482A	N6314A
N3382A/N3383A	8482A and E4412A	N6314A
E8361A	8487A (use with adapter 11900B) and V8486A (use with adapter V281B) ** See E8361A procedure	N4697-60001
E8362A / B	E4413A	85131E
E8363A/B E8364A/B	8487A (use with adapter 11900B)	85133E

See PNA Accessories

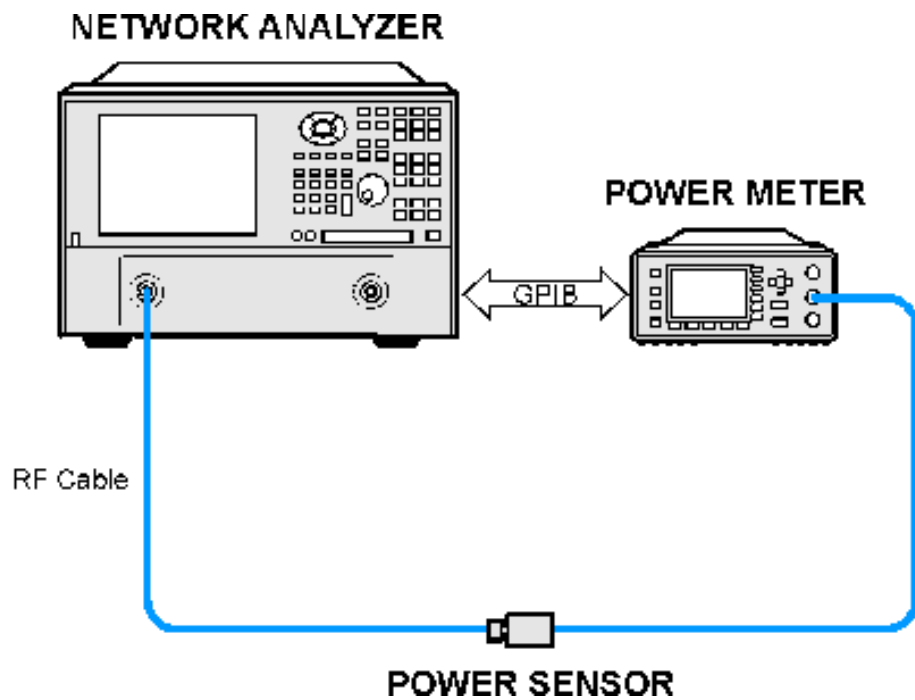
### Procedure

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

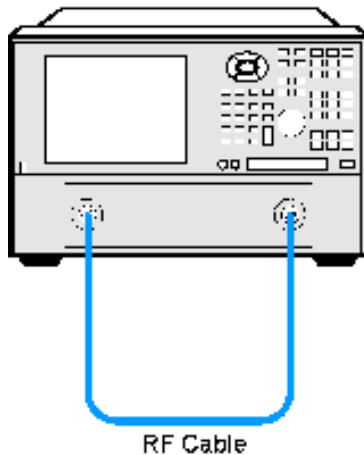


Connecting adapter and cable between sensor and PNA



Through connection using the specified cable

## NETWORK ANALYZER



### 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

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- The Receiver Display as a Troubleshooting Tool
- How to start the Receiver Display

---

Other Support Topics

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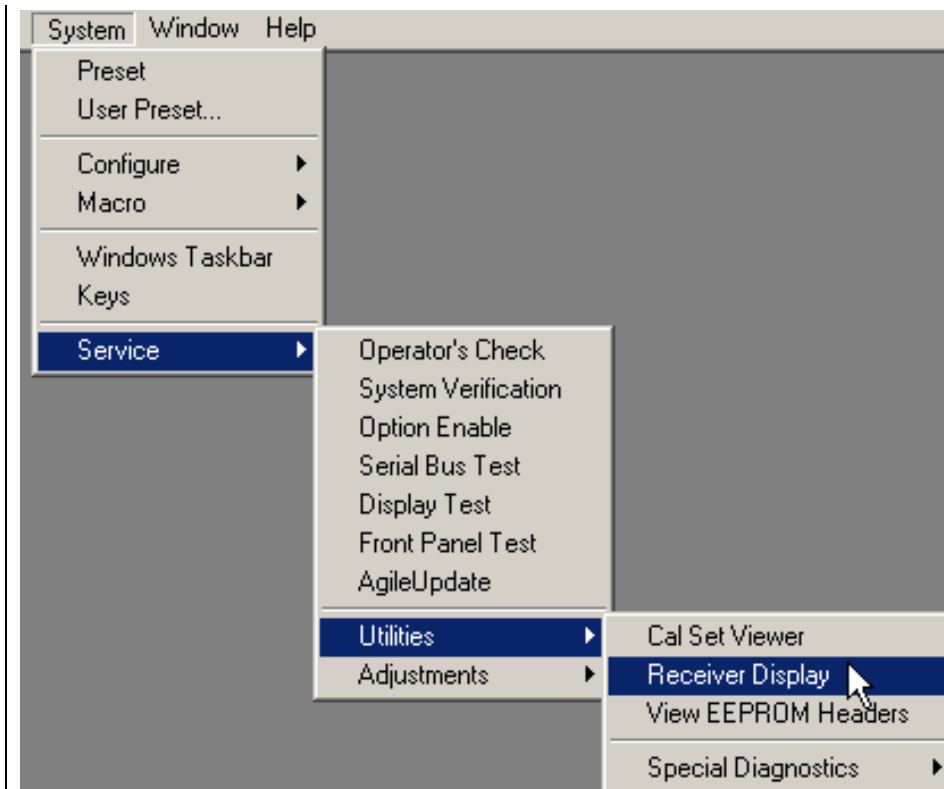
### The Receiver Display as a Troubleshooting Tool

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).

<b>How to Start the Receiver Display</b>
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Learn more about using the front panel interface

## Serial Bus Test

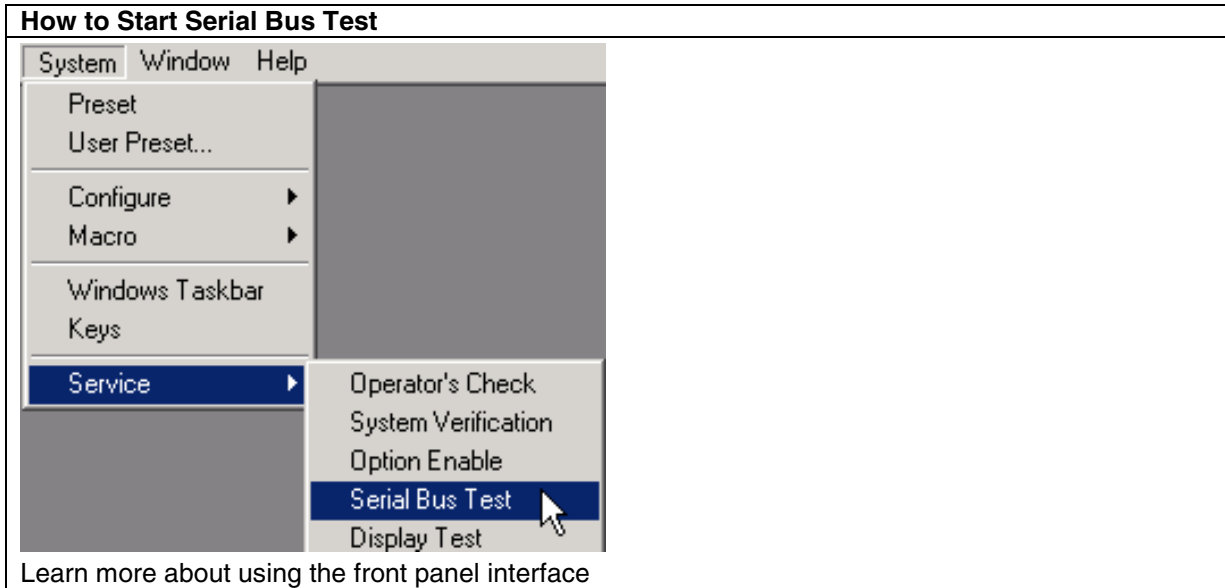
This test is designed to work with the PNA Series Network Analyzer as it was originally manufactured. If any of the following assemblies have been replaced in the analyzer, this test may not show accurate pass/fail results.

- 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 exceeded their tolerances are highlighted in the application and the data file.

The assemblies tested and their associated node numbers are as follows:

<b>Board Assembly</b>	<b>Node Numbers</b>
A12 Source Assembly	111 to 118
A10 Frequency Reference	211 to 218
A11 Phase Lock	311 to 318




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**Note:** If any errors are reported, refer to the service guide.

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## 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:

<b>Standard</b>	Includes a certificate of calibration, stating the instrument has been calibrated and is operating within the published specifications.
<b>Option UK6</b>	Includes the test data from the calibration and the standard certificate, stating the instrument has been calibrated and is operating within the published specifications.
<b>Option M40 (Special)</b>	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.

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Other Support Topics

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## Tutorials

### Network Analyzer Basics

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**This multimedia presentation is intended to run on the PNA.**

Click to proceed with Network Analyzer Basics.

To view this presentation on an external PC, copy the all of the files from the PNA C:\WINNT\Help\NABasics to the same location on your PC's hard drive. The total file size is approximately 100MB.

## 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

- Keep connectors clean
- Protect connectors with plastic end caps
- Keep connector temperature same as analyzer

##### Do Not

- Touch mating-plane surfaces
- Set connectors contact-end down
- Store connectors loose in box or drawer

## Visual Inspection

### Do

Inspect connectors with magnifying glass.  
Look for metal debris, deep scratches or dents

## Cleaning Connectors

### Do

Clean surfaces first with clean, dry compressed air

Use lint-free swab or brush

Use minimum amount of alcohol

Clean outer conductor mating surface and threads

## Gaging Connectors

### Do

Inspect and clean gage, gage master and device tested

Use correct torque wrench

zero gage before use

Use multiple measurements and keep record of readings

## Making Connections

### Do

Align connectors first

Rotate only the connector nut

Use correct torque wrench

### Do Not

Use a connector with a bent or broken center conductor

Use a connector with deformed threads

### Do Not

Use high pressure air (>60 psi)

Use any abrasives

Allow alcohol into connector support beads

Apply lateral force to center conductor

### Do Not

Use an out of specification connector

Hold connector gage by the dial

### Do Not

Cross thread the connection

Twist connector body to make connection

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

Lint-Free Swabs, small 100 ct.  
IPA 99.5% alcohol, 30 ml bottle  
Compressed Air, 235 ml can

### Agilent P/N

9301-1243  
8500-5344  
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 M $\Omega$  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.

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**Note:** In general, Metrology grade connectors should not be mated with Production grade connectors.

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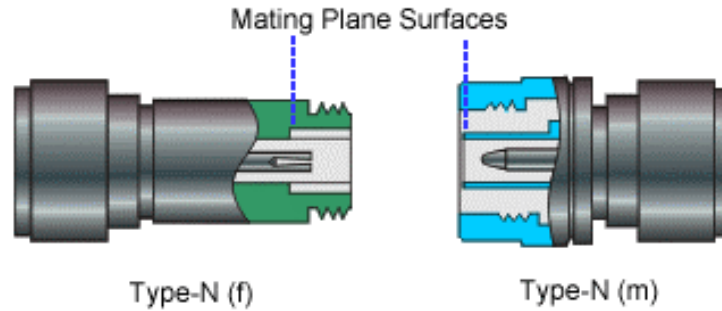
## Adapters as Connector Savers

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).

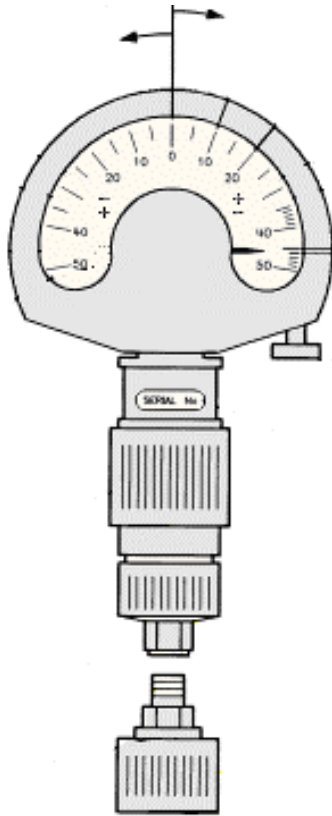


### Gaging Fundamentals

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

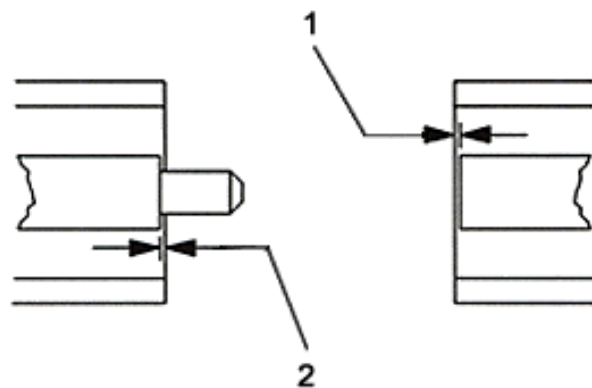
RECESSION                      PROTRUSION



### 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.

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**Note:** Before gaging any connector, the mechanical specifications provided with that connector or device should be checked.

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### To Gage Connectors

1. Wear a grounded wrist strap (having a 1 M $\Omega$  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.

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**Caution:** If the gage indicates excessive protrusion or recession, the connector should be marked for disposal or sent out for repair.

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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 M $\Omega$  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

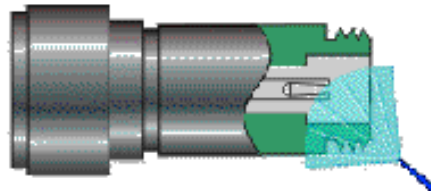
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**Caution:** A damaged or out-of-specification device can destroy a good connector attached to it even on the first connection. Any connector with an obvious defect should be marked for disposal or sent out for repair.

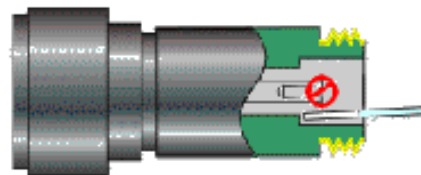
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### To Clean Connectors

1. Wear a grounded wrist strap (having a 1 M $\Omega$  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.

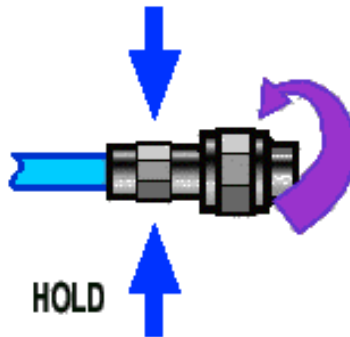
7. If defects are still visible after cleaning, the connector itself may be damaged and should not be used. Determine the cause of damage before making further connections.

### To Make Connections

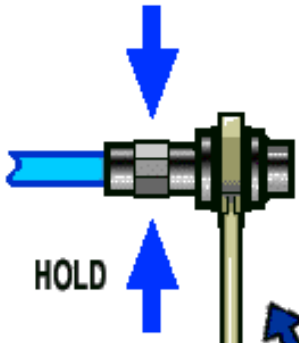
1. Wear a grounded wrist strap (having a 1 M $\Omega$  series resistor).
2. Inspect, clean, and gage connectors. All connectors must be undamaged, clean, and within mechanical specification.
3. Carefully align center axis of both devices. The center conductor pin from the male connector must slip concentrically 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.



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.

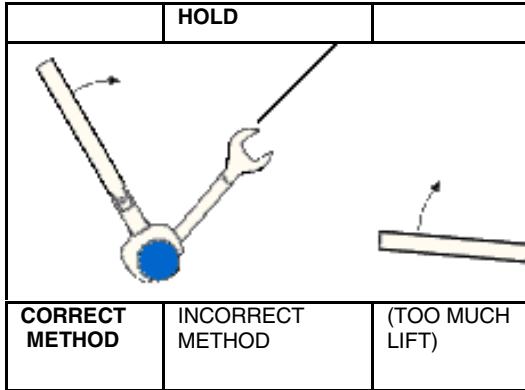


### To Separate a Connection

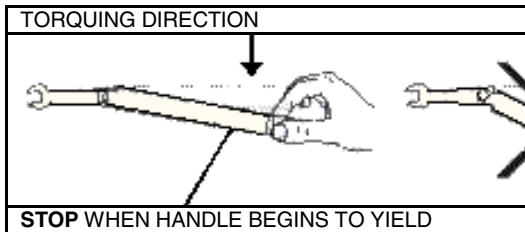
1. Support the devices to avoid any twisting, rocking or bending force on either connector.
2. Use an open-end wrench to prevent the device body from turning.
3. Use another open-end wrench to loosen the connector nut.
4. Complete the disconnection by hand, turning only the connector nut.
5. Pull the 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.



3. Hold torque wrench lightly at the end of handle then 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.



### 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).

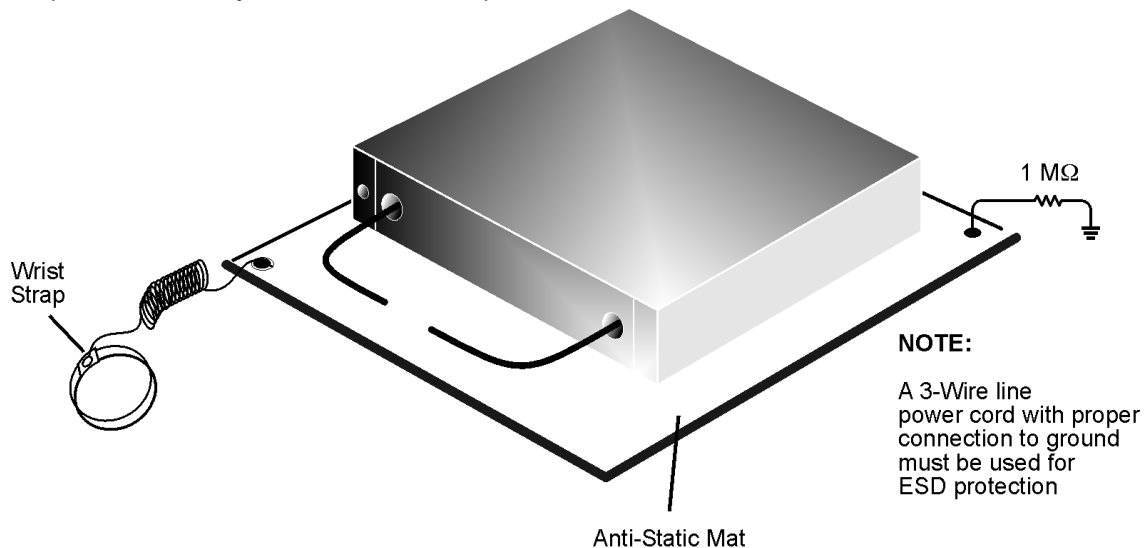


### Electrostatic Discharge (ESD) Protection

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.
- *Always* 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.
- *Always* 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.
- *Always* 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.
- *Always* 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.



esd\_setup

## Impedance Matching Model

Impedance matching is a procedure used in circuit design to match unequal source and load impedances, thereby optimizing the power delivered to the load from the source. Impedance matching is accomplished by inserting matching networks into a circuit between the source and the load.

- Introduction to the Model
- Impedance Matching Model
- Description of Exercises



- Smith Chart Circuit Elements Paths
- Forbidden Regions of the Smith Chart

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Other Tutorials topics

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## Introduction

In this model, Smith Charts are used to visualize the interactive process of impedance matching to optimize transmitted power in simple circuits. Simple series/shunt, inductance/capacitance matching networks are used, and you can interactively adjust the values of corresponding L and C components. Adjusting the matching network components changes the reflectance of the overall circuit. The reflectance of each part of the circuit is indicated on the Smith Chart as a red ● or blue ● ball.

As you adjust the sliders and modify the component values, the model calculates new values for the circuit reflectance and moves the red ● and blue ● balls on the Smith Chart. The goal of each exercise is to move the reflectance point from the center of the Smith Chart, which represents

either the load or source, into the appropriate  red and  blue rings which represent the desired matching condition. You can select three different impedance matching problems of increasing difficulty by clicking on one of the three labeled tabs.

## Impedance Matching Model

Maximize this window for optimum viewing. Click if the Impedance model is not visible.

This applet is intended to be viewed on the analyzer display. To view the applet on your PC, copy the following files from either the analyzer's C:\WINNT\Help directory or the CDROM that came with the analyzer, to your PC's C:\WINNT\Help directory.

- DemoTimer.class
- DisplaySim.class
- DisplayXLine.class
- imatch.class
- MessageSim.class
- ParamXLine.class
- Postit.class
- RunSim.class
- SpecAnimation.class
- SymbolButton.class
- XLine.class

## Description of Exercises

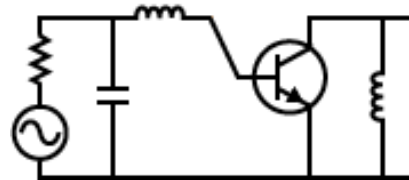
### L-C Matching Network

The first exercise lets you use the Smith Chart to perform basic impedance matching between a resistive source and a resistive load. A simple series-inductance shunt-capacitance network is used to match the 50 ohm source to the 300 ohm load. The source reflectance of the circuit

looking from the load toward the source is represented by the red ball ●, while the 300 ohm load is indicated by the stationary ○ red ring.

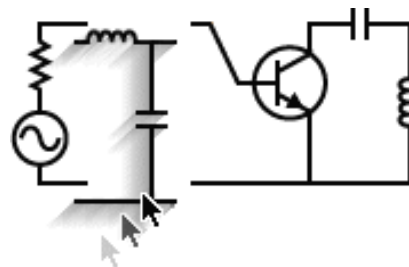
The objective of the exercise is to interactively match these two impedances by adjusting the L and C sliders. The model will provide graphical feedback by moving the red ball indicating circuit reflectance on the Smith Chart. Adjust the series L and shunt C sliders to move the reflectance point ● from the center of the Smith Chart to the matching impedance position inside the red ring. You can study the Smith Chart Circuit Element Paths below for hints on how different circuit elements change circuit reflectance on the Smith Chart.

### Transistor Amplifier-I



The second exercise provides the impedance matching experience of optimizing the transducer power gain of a transistor amplifier. Matching the 50 ohm source to the input reflectance of the transistor,  $s_{11}^*$ , and matching the 50 ohm load to the output reflectance of the transistor,  $s_{22}^*$ , optimizes the power delivered from the source, through the transistor, to the load. You are required to match both the input red ball ● and output blue ball ● of the transistor separately. Adjust the component values to move both reflectance points to their proper positions within the red ○ and blue ○ rings.

### Transistor Amplifier-II



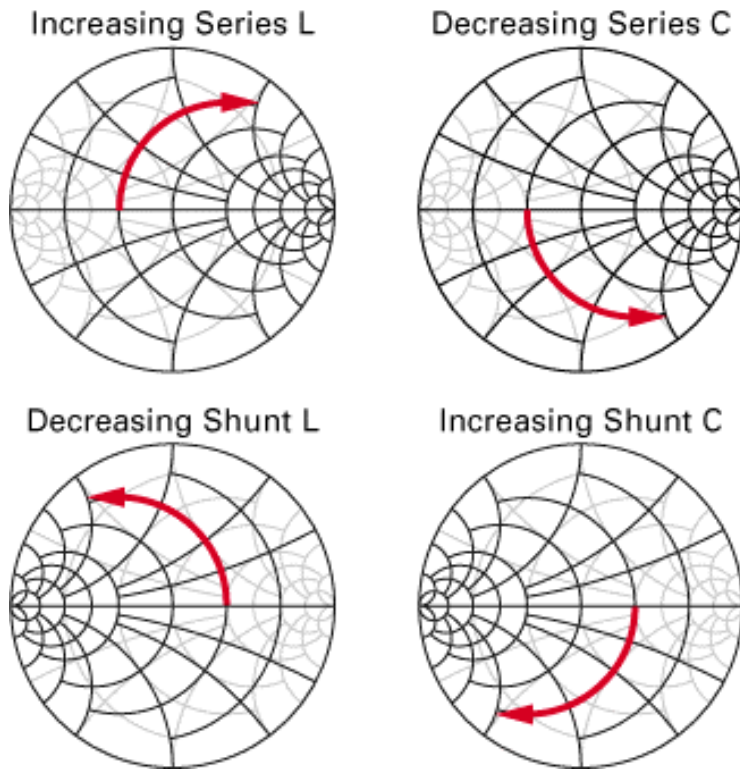
The third part of the interactive impedance matching model is a collection of exercises involving a modular circuit. You begin by constructing a circuit with either one or two modular drag-and-drop matching network components. Once the matching networks have been added to the circuit, the sliders will become active and allow you to adjust the component values. Then you will engage in impedance matching for the circuit you have just created! There are 8 different circuits you can construct and there are 5 different value pairs for  $s_{11}^*$  and  $s_{22}^*$  on the Smith Chart, altogether 40 impedance matching exercises. **You will find that not all matching networks will work!** For some of the circuits you will be able to construct, you will not be able to position the red ball ● within the red ring or the blue ● ball within the blue ring. To determine in advance which matching networks will work, take a close look at the Forbidden Regions of the Smith Chart below. There are 5 different location pairs for  $s_{11}^*$  and  $s_{22}^*$  corresponding to different frequencies that can be matched. Use the frequency indicator to select an operating frequency, and then drag-and-drop appropriate matching networks into the circuit and adjust the component values to move both reflectance points to their proper positions within the red ○ and blue rings.

### Smith Chart Circuit Elements Paths

The graphs below demonstrate how the various shunt and series L and C components change the circuit reflectance on the Smith Chart. Assuming the given component is the last component in the matching network, the circuit reflectance will move as indicated along constant resistance or constant conductance circles.

You can think of impedance matching using the Smith Chart as driving a car to a specific

destination in Smith Town - a city where none of the streets are straight! By adjusting circuit components in appropriate order, we can constrain the circuit reflectance to paths along constant resistance or constant conductance circles. Just like road signs can direct a car along the circular streets of Smith Town, so can we reach the matching impedance condition in a straightforward and deterministic way.



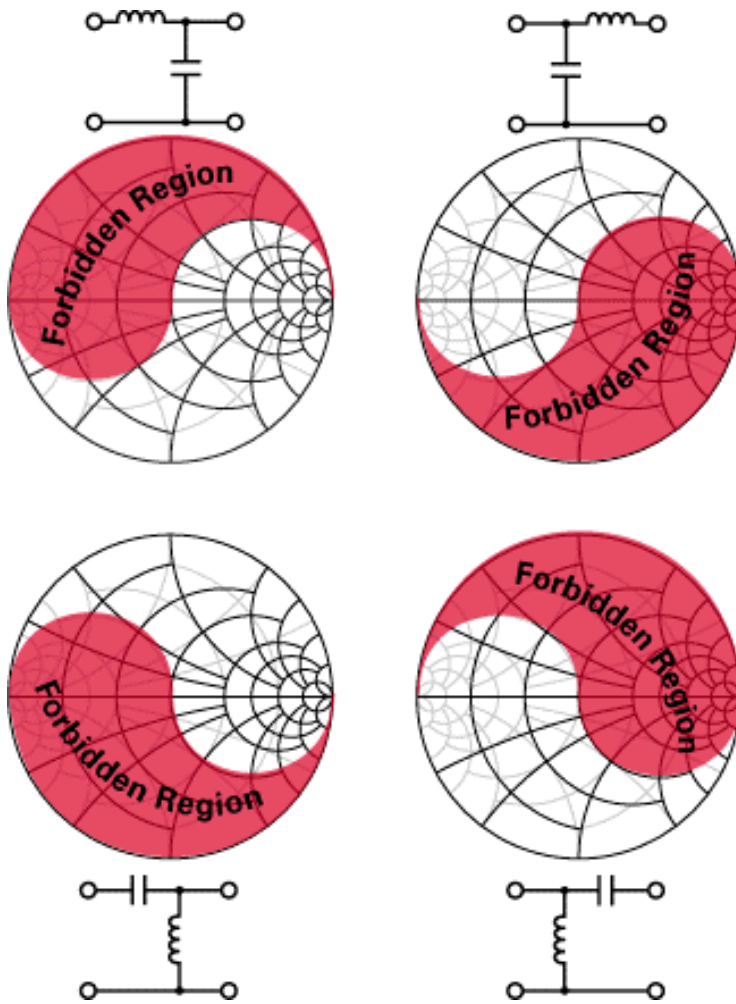
### Forbidden Regions of the Smith Chart

For a given load reflectance, only certain L-C matching networks will be capable of transforming the source impedance to the load impedance. In fact, for any load reflectance, exactly two of the four possible L-C matching networks in the Transistor Amplifier-II model above will be able to do the matching job. But which two?

The charts below can be used to determine which matching networks will work in a given load situation. If the load reflectance lies within the forbidden region of the Smith Chart for the indicated matching network, then that network cannot perform the required matching operation.

**You cannot drive your car into the forbidden neighborhoods of Smith Town! They are unpaved!**

Use these charts to determine which matching network should be used. First, visually locate the position of the load reflectance from the Transistor Amplifier-II model above on each of the four color Smith Charts below. Then, eliminate the two networks whose forbidden regions overlap the reflectance point, and use one of the remaining two networks to perform the impedance match.



## Reflected Waves Along a Transmission line

---

When a sine wave from an RF signal generator is placed on a transmission line, the signal propagates toward the load. This signal, shown here in yellow, appears as a set of rotating vectors, one at each point on the transmission line.

Maximize this window for optimum viewing. Click if the applet is not visible.

This applet is intended to be viewed on the analyzer display. To view this outside of the analyzer, copy the following files from either the analyzer's C:\WINNT\Help directory or the CDROM that came with the analyzer, to your C:\WINNT\Help directory.

- DemoTimer.class
- DisplaySim.class
- DisplayXLine.class

- imatch.class
- MessageSim.class
- ParamXLine.class
- Postit.class
- RunSim.class
- SpecAnimation.class
- SymbolButton.class
- XLine.class

In our example, the transmission line has a characteristic impedance of 50 ohms. If we choose a load of 50 ohms, then the amplitude of the signal will not vary with position along the line. Only the phase will vary along the line, as shown by the rotating vectors in yellow.

If the load impedance does not perfectly match the characteristic impedance of the line, there will be a reflected signal that propagates toward the source. At any point along the transmission line, that signal also appears to be a constant voltage whose phase is dependent upon physical position along the line.

The voltage seen at one particular point on the line will be the vector sum of the transmitted and reflected sinusoids. We can demonstrate this by looking at two examples.

### **Example 1: Perfect Match: 50 Ohms**

Set the terminating resistor to 50 ohms by using the "down arrow" dialog box. Notice there is no reflection. We have a perfect match. Each rotating vector has a normalized amplitude of 1. If we were to observe the waveform at any point with a perfect measuring instrument, we would see equal sine wave amplitudes anywhere along the transmission line. The signal amplitudes are indicated by the green line.

### **Example 2: Mismatched Load: 200 Ohms**

Now let's intentionally create a mismatched load. Set the terminating resistor to 200 ohms by using the down arrow. Hit the PLAY button and notice the change in the reflected waveform. If it were possible to measure just the reflected wave, we would see that its amplitude does not vary with position along the line. The only difference between the reflected (blue) signal, say at point z6 and point z4, is the phase.

But the amplitude of the resultant waveform, indicated by the standing wave (green), is not constant along the entire line because the transmitted and reflected signals (yellow and blue) combine. Since the phase between the transmitted and reflected signals varies with position along the line, the vector sums will be different, creating what's called a "standing wave".

With the load impedance at 200 ohms, a measuring device placed at point z6 would show a sine wave of constant amplitude. The sine wave at point z4 would also be of constant amplitude, but its amplitude would differ from that of the signal at point z6. And the two would be out of phase with each other. Again, the difference is shown by the green line, which indicates the amplitude at that point on the transmission line.

The impedance along the line also changes, as shown by the points labeled z1 through z7.



## Reflection Measurements

---

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

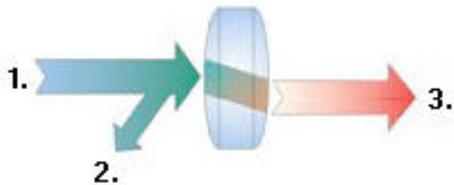
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[See other Tutorials](#)

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### 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 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

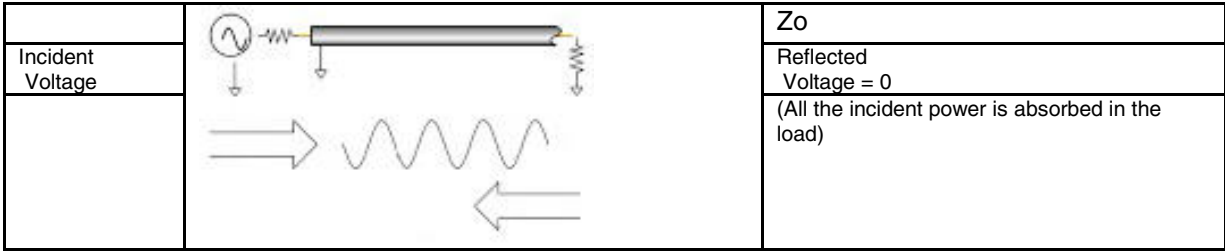
Another way of expressing reflection measurements is reflection coefficient gamma ( $\Gamma$ ). Gamma includes both magnitude and phase.

The magnitude portion of gamma is called rho ( $\rho$ ). Reflection coefficient is the ratio of the reflected signal voltage to the incident signal voltage. The range of possible values for  $\rho$  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.

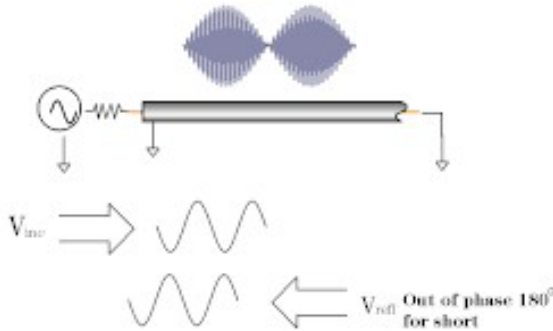
Now for the phase information. At high frequencies, where the wavelength of the signal is smaller than the length of conductors, reflections are best thought of as waves moving in the opposite direction of the incident waves. The incident and reflected waves combine to produce a single "standing" wave with voltage that varies with position along the transmission line.



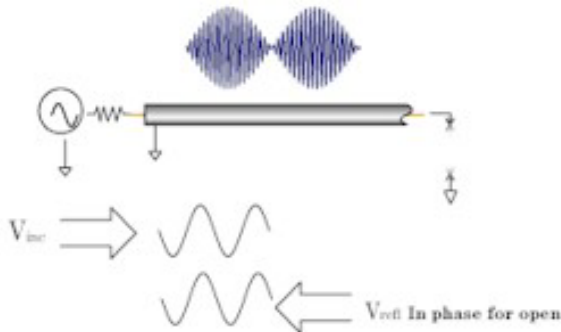
When a transmission line is terminated in its characteristic impedance ( $Z_0$ ) there is no reflected signal. All of the incident signal is transferred to the load, as shown in the following graphic. There is energy flowing in one direction along the transmission line.



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.

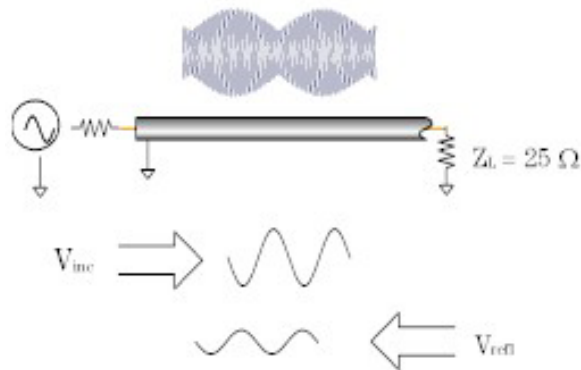


When a transmission line is terminated in an open circuit termination, all of the energy is reflected back to the source. The reflected wave is equal in magnitude to the incident wave ( $\rho = 1$ ). However, no current can flow in an open circuit. Therefore, the voltage of the reflected wave will be in phase with the voltage of the incident wave.



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.



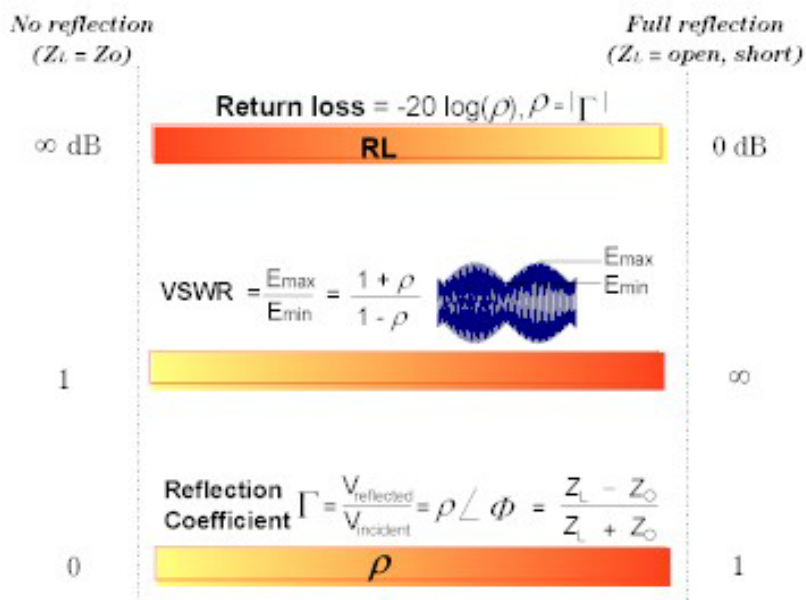


For more information, see Phase Measurements.

### Impedance

Impedance is another way of expressing reflection data. For more information on Impedance, see Smith Charts.

### Summary of the Expressions of Reflection Measurements:



### Phase Measurements

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

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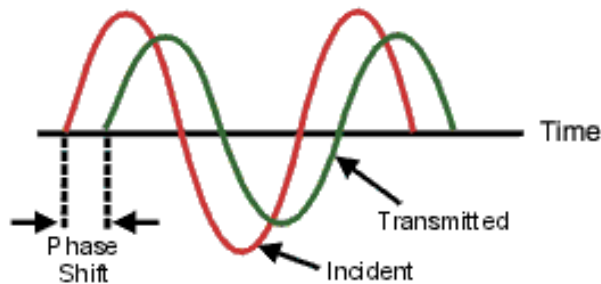
See other Tutorials

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### What are Phase Measurements?

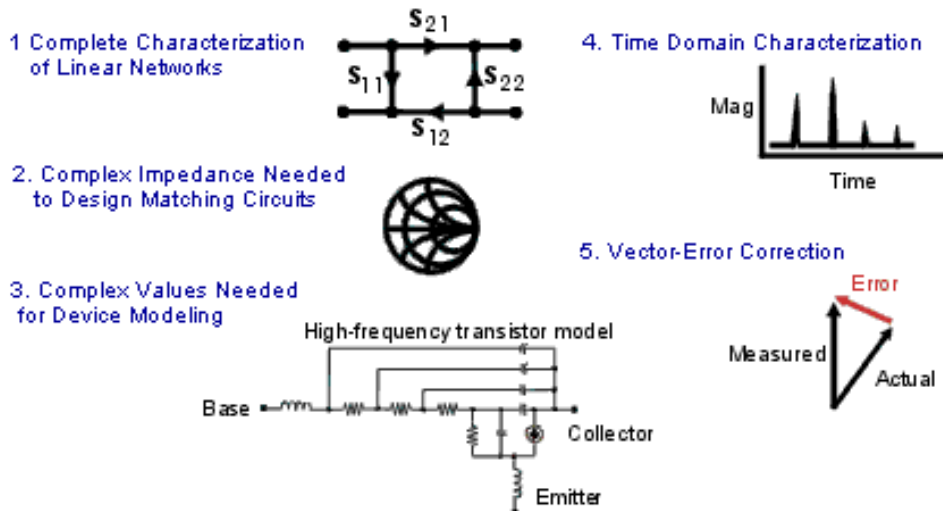
Phase measurements are made using S-parameters, just like amplitude measurements. A phase measurement is a relative (ratio) measurement and not an absolute measurement. Phase measurements compare the phase of the signal going into a device (the incident signal) to the phase of the device's response signal. 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:

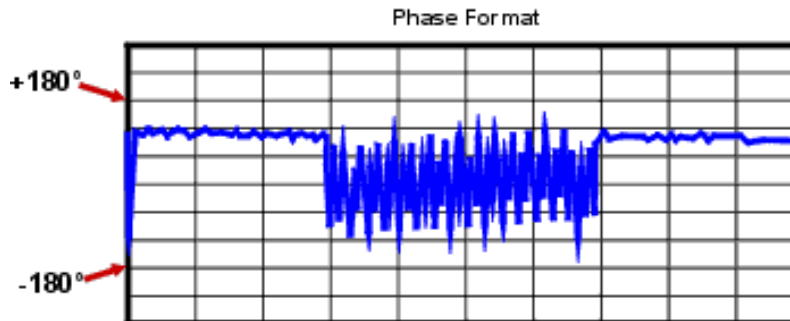
- Linear, where flat magnitude and linear phase shift versus frequency is not maintained over the bandwidth of interest.

- 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  $\pm 180$  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.



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 ( $^{\circ}/\text{dB}$ ).

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,  $\rho$ )
- Complex Impedance
- Gain Compression
- AM-to-PM Conversion

### Gain

$$\tau = \frac{V_{\text{trans}}}{V_{\text{inc}}}$$

$$\text{Gain (dB)} = -20 \log_{10} |\tau|$$

$$\text{Gain (dB)} = P_{\text{out}} \text{ (dBm)} - P_{\text{in}} \text{ (dBm)}$$

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,  $50\Omega$ .

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

$$\begin{aligned}\tau_g (\text{sec}) &= - \frac{\Delta \theta}{\Delta \omega} \\ &= - \frac{1}{360} * \frac{\Delta \theta}{\Delta f}\end{aligned}$$

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)

$$\begin{aligned}\Gamma &= \frac{V_{\text{refl}}}{V_{\text{inc}}} = \rho \angle \theta \\ \text{Reflection coefficient} &= \rho \\ \text{Return loss (dB)} &= -20 \log_{10} \rho \\ \text{SWR} &= \frac{1+\rho}{1-\rho}\end{aligned}$$

The measure of the reflection mismatch at the input or output of the amplifier relative to the system  $Z_0$  characteristic impedance.

### Complex Impedance

$$\begin{aligned}Z &= \frac{1+\Gamma}{1-\Gamma} * Z_0 \\ &= -R + jX\end{aligned}$$

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

$$AM/PM = \frac{\Delta \theta}{\Delta P}$$

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

---

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

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Other Tutorials topics

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### 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:

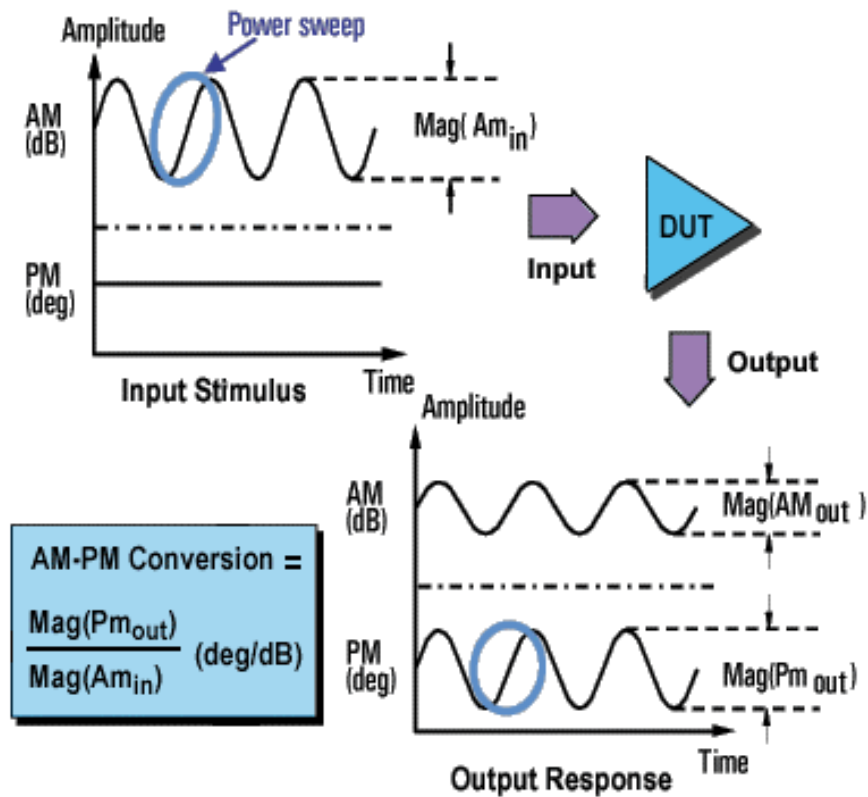
#### Unintentional amplitude variations (AM)

- 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 ( $^{\circ}/dB$ ). An ideal amplifier would have no interaction between its phase response and the power level of the input signal.



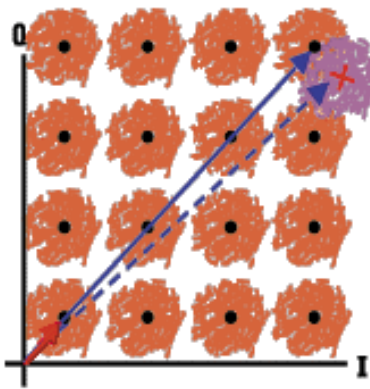
### Why Measure AM-PM Conversion

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**

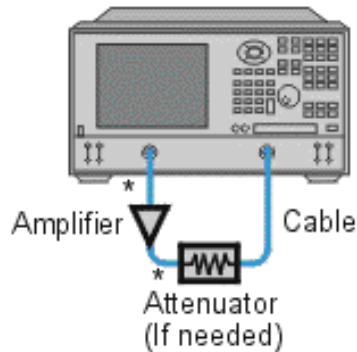
With this method of measuring AM-to-PM conversion, the modulation frequency is approximately the inverse of the sweep time. Even with the fastest power sweep available on most network analyzers, the modulation frequency ends up being fairly low (typically less than 10 Hz). This could cause a slight temperature 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**



1. Preset the analyzer.
2. Select an S<sub>21</sub> 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.



\* Direct Connection

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<sub>21</sub> 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

This topic describes how to setup the PNA to make S<sub>21</sub> measurements on an array of antennas.

Measurements can be made on up to 100 antenna arrays (Ports) and up to 15 discrete 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.

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**Note:** Print these instructions if viewing in the PNA. This topic will be covered by the Macro Setup dialog box.

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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

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

---

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 ( $\Gamma$ ) 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  $\Gamma$  corresponds uniquely to a complex device impedance (as a function of frequency), according to the equation:

$$Z_L = [(1 + \Gamma) / (1 - \Gamma)] \times Z_0$$

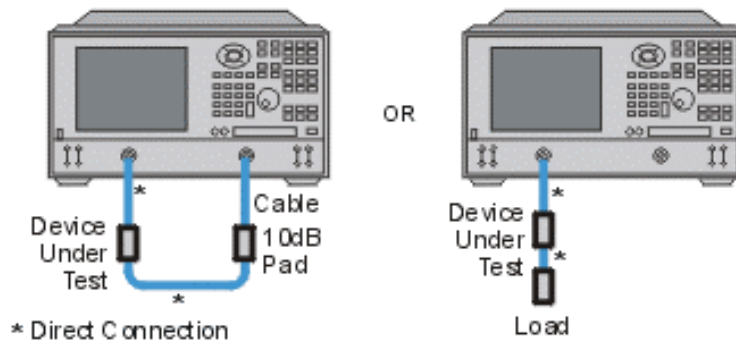
where  $Z_L$  is your test device impedance and  $Z_0$  is the measuring system's characteristic impedance.

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 ( $\Gamma$ ) 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?

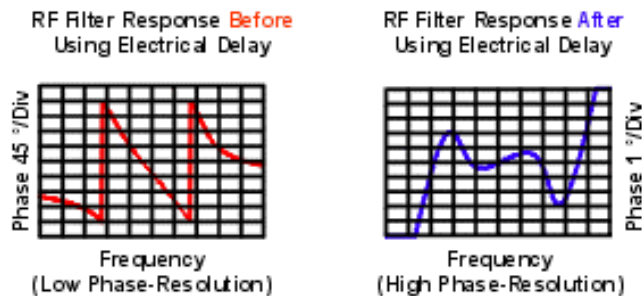
The deviation from linear phase measurement accomplishes the following:

- 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.

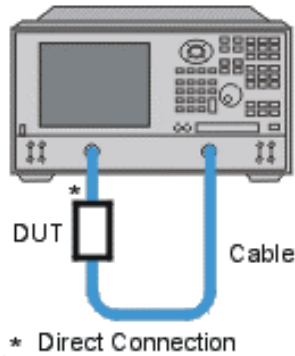


### Accuracy Considerations

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.



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

---

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

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[See other Amplifier Parameter topics](#)

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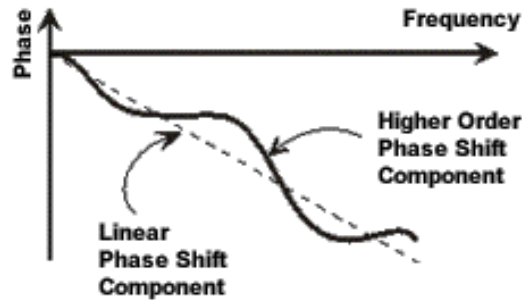
### What Is Group Delay?

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:



$$\begin{aligned} \text{Group Delay} = t_g &= \frac{-d\phi}{d\omega} && \phi \text{ in Radians} \\ &&& \omega \text{ in Radians/Sec} \\ &= \frac{-1}{360^\circ} \cdot \frac{d\Theta}{df} && \Theta \text{ in Degrees} \\ &&& f \text{ in Hz } (\omega = 2\pi f) \end{aligned}$$

The phase characteristic of a device typically consists of both linear and higher order (deviations from linear) phase-shift components.

**Linear phase-shift component:**

Represents average signal transit time.

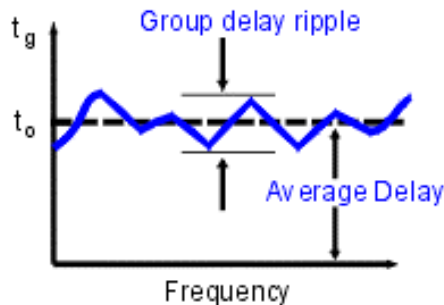
Attributed to electrical length of test device.

**Higher-order phase-shift component:**

Represents variations in transit time for different frequencies.

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:

$$\text{Group Delay} = t_g = \frac{-d\phi}{d\omega}$$

$$= \frac{-1}{360^\circ} \cdot \frac{d\Theta}{df}$$

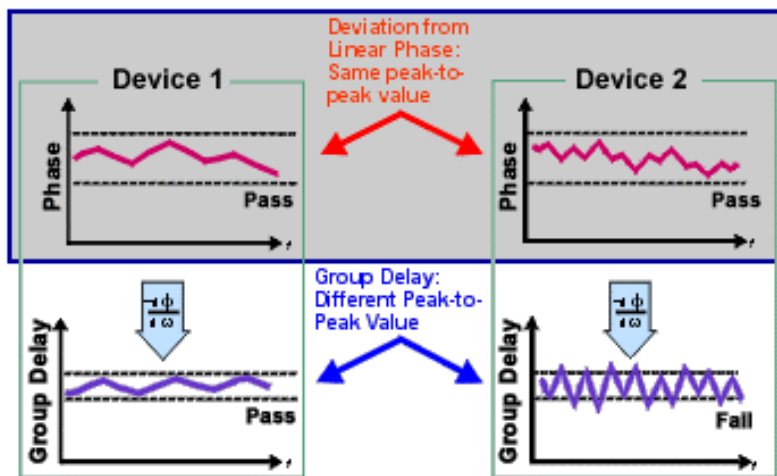
$\phi$  in Radians  
 $\omega$  in Radians/Sec  
 $\Theta$  in Degrees  
 $f$  in Hz ( $\omega = 2\pi f$ )

- 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.



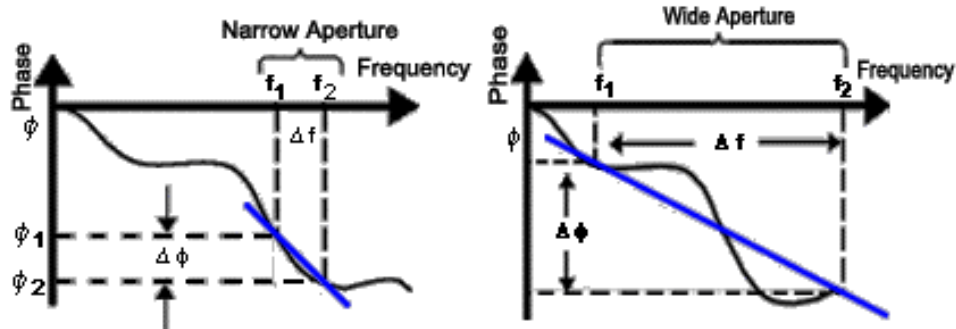
**Group Delay** results are shown in the lower region:

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:



**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.

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**Note:** if the aperture is too wide (more than 180° of phase shift between adjacent frequency points), errors in group delay data will occur.

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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 180° 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

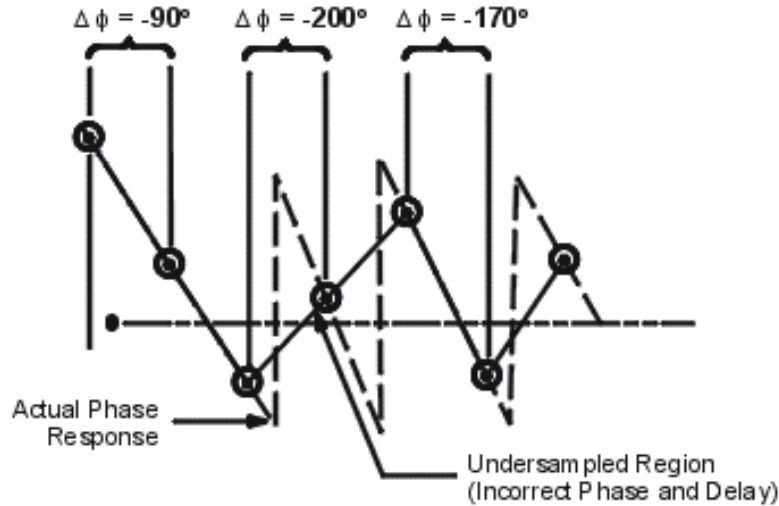
The group delay aperture varies depending on the frequency spacing and point density, therefore the aperture is not constant in segment sweep. In segment sweep, extra frequency points can be defined to ensure the desired aperture.

**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.

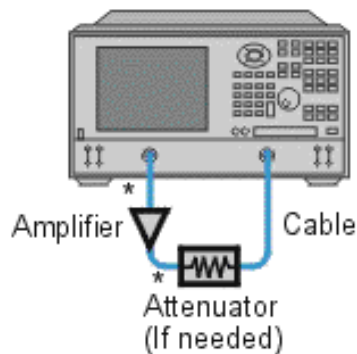


The frequency response is the dominant error in a group delay test setup. Performing a thru-response measurement calibration significantly reduces this error. For greater accuracy, perform a 2-port measurement calibration.

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.



\* 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

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[See other Amplifier Parameter topics](#)

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### 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

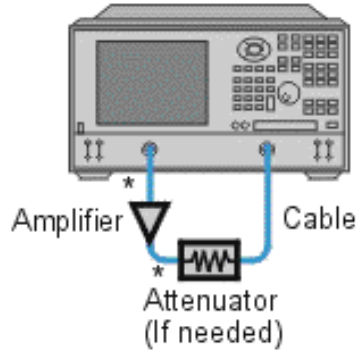
The frequency-response effects and mismatches of the attenuators and couplers must be accounted for during calibration since they are part of the test system. Proper error-correction techniques can reduce these effects.

- 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

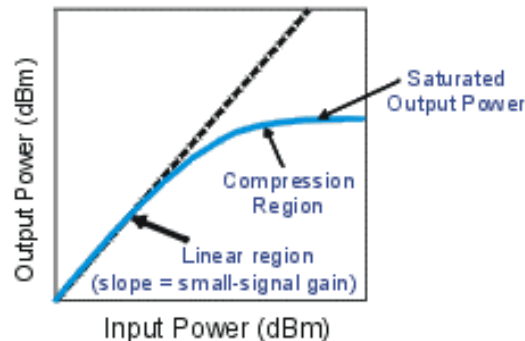
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### What Is Gain Compression?

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

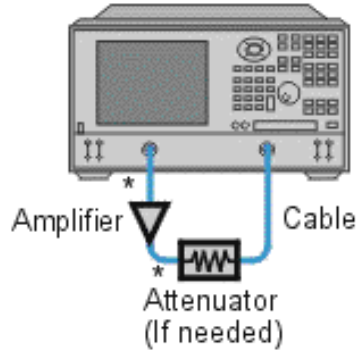
This procedure shows you how to make the following three measurements used to determine amplifier gain compression:

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 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.



\* 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.

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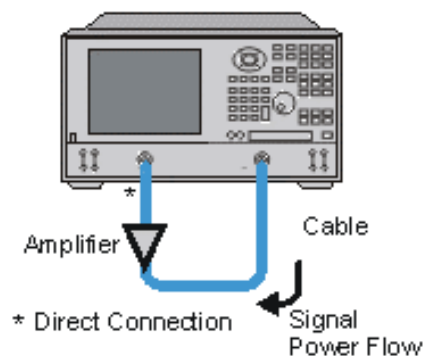
**Note:** Reducing IF bandwidth or using averaging improves measurement dynamic range and accuracy, at the expense of reduced measurement speed.

---

- 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

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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  $\mu$ W
- +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.

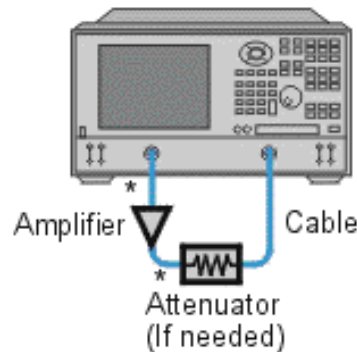
Attenuation of the amplifier's output power can be accomplished using either attenuators or couplers

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 unratiod 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.



\* Direct Connection

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

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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

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**Note:** Time Domain measurements are only available on PNAs with Option 010. See PNA Options

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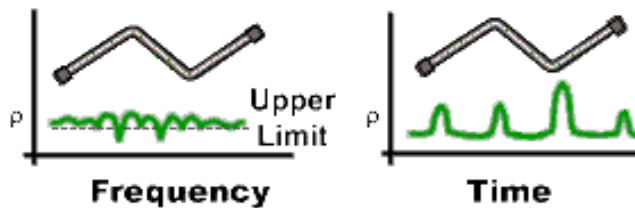
Other Time Domain topics

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### 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.

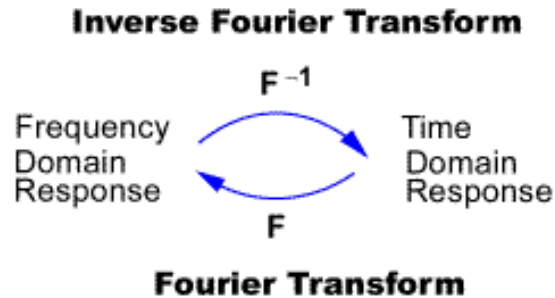


- **The frequency domain response** measured at the input port shows composite reflection response (ripple) caused by interactions between mismatches in the cable, but it is difficult to determine where in the cable the mismatches occur.
- **The time domain response** provides a way to look inside the 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.



### 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.

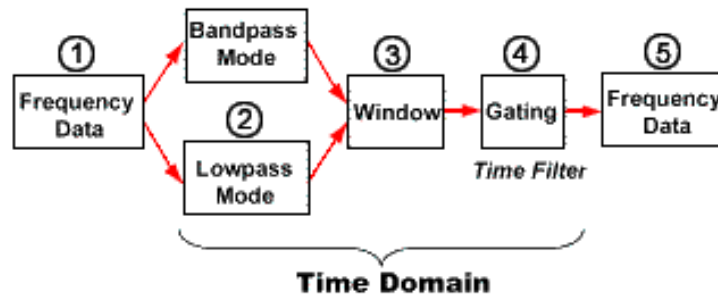
### Time Domain Reflectometry Analysis

- 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.

- **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 suppresses 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

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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](#)

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**Note:** Time Domain measurements are only available on PNAs with Option 010. See [PNA Options](#)

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[Other Time Domain topics](#)

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### 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.

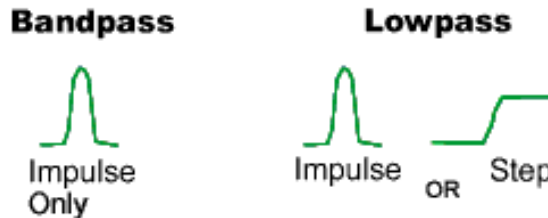
**FSTOP = N X FSTART (N = number of points)**

For example:

$$FSTOP = 101 * 300\text{kHz}$$

$$FSTOP = 30.3\text{MHz}$$

## 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.

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**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 ( $\rho$ ) over the frequency range that has been measured.
- For transmission measurements, this format shows the average transmission coefficient ( $\tau$ ) 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

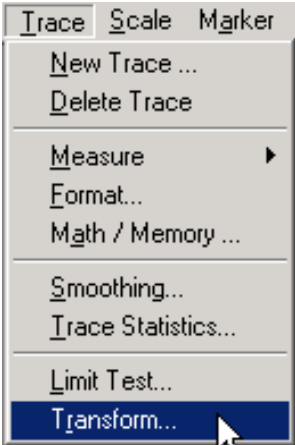
- For reflection measurements, this format shows the average Standing Wave Ratio (SWR) of the discontinuity over the frequency range of the measurement.

### Useful Format for Low Pass Mode

#### Real

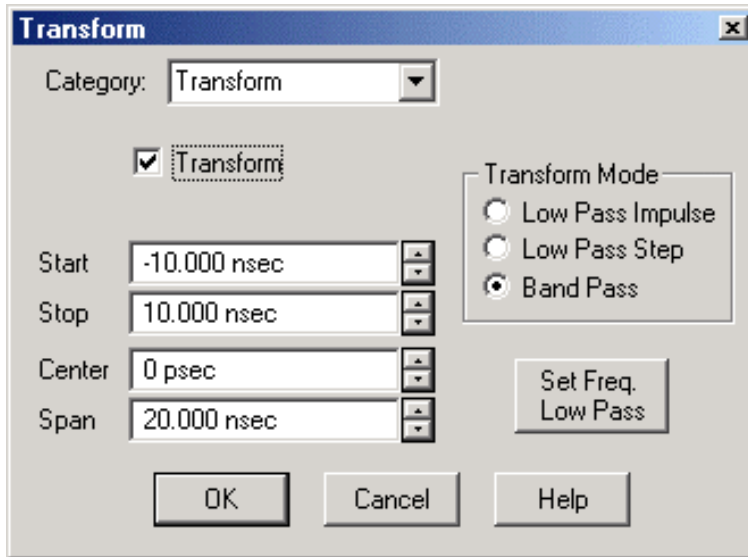
- This format shows the device response in real units.

**How to set the Time Domain Mode**



The screenshot shows a software menu with the following items: Trace, Scale, Marker, New Trace ..., Delete Trace, Measure (with a right-pointing arrow), Format..., Math / Memory ..., Smoothing..., Trace Statistics..., Limit Test..., and Transform... (highlighted in blue with a mouse cursor). The menu is open, and the 'Transform...' option is selected.

Learn more about using the front panel interface



#### 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

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**Note:** Time Domain measurements are only available on PNAs with Option 010. See PNA Options

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Other Time Domain topics

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## Response Resolution

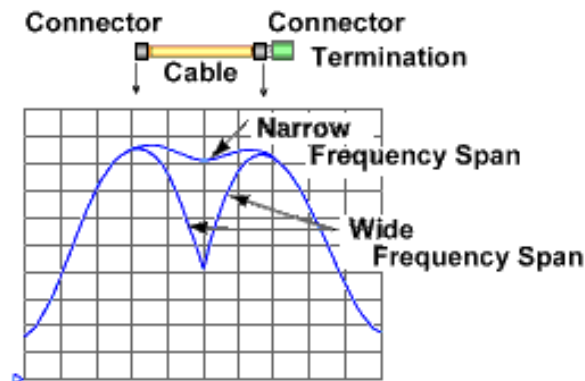
Time domain response resolution is the ability to distinguish between two closely spaced responses. There are several factors that determine the resolution of the measured response in the time domain.

- Frequency Span
- Window Width
- Time Domain Mode

### Frequency Span Influence on Response Resolution

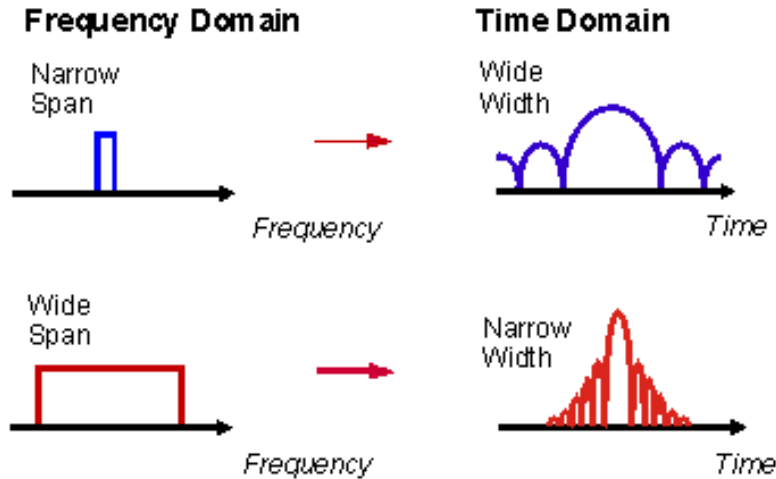
The graphic below shows the effect of both a narrow and wide frequency span on the response resolution.

- 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.

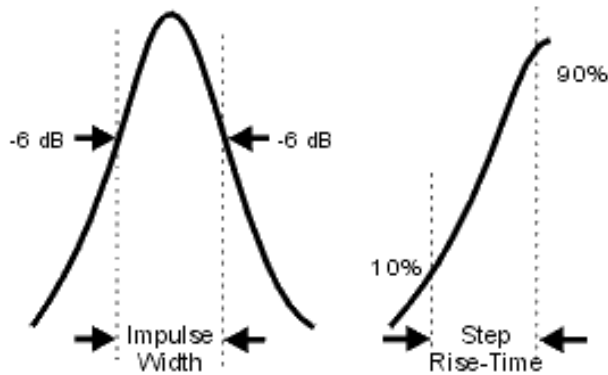


- The relationship between the frequency span and the pulse width in time is inversely proportional.
- The wider the frequency span, the narrower the impulse width, or step rise time.





- 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

$$\text{Response Resolution} = \frac{0.45}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 2.2 \text{ Normal Window} \\ 3.3 \text{ Maximum Window} \end{cases}$$

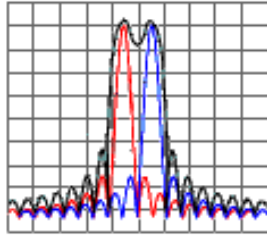
#### Lowpass Impulse

$$\text{Response Resolution} = \frac{0.6}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

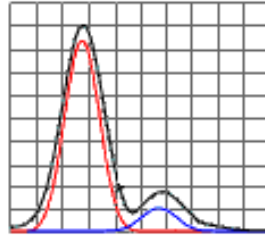
#### Bandpass Impulse

$$\text{Response Resolution} = \frac{1.2}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

The graphic below shows how the selection of the window width is dependent on the device responses.



**Minimum Window  
Higher Resolution**

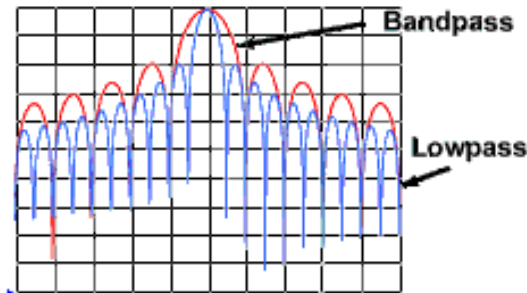


**Maximum Window  
Larger Dynamic Range**

- 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.

$$\text{Display Resolution} = T_{\text{Span}} / \text{Points} - 1$$

You can improve the display resolution in two ways:

- Decrease the time span.
- Increase the number of points.

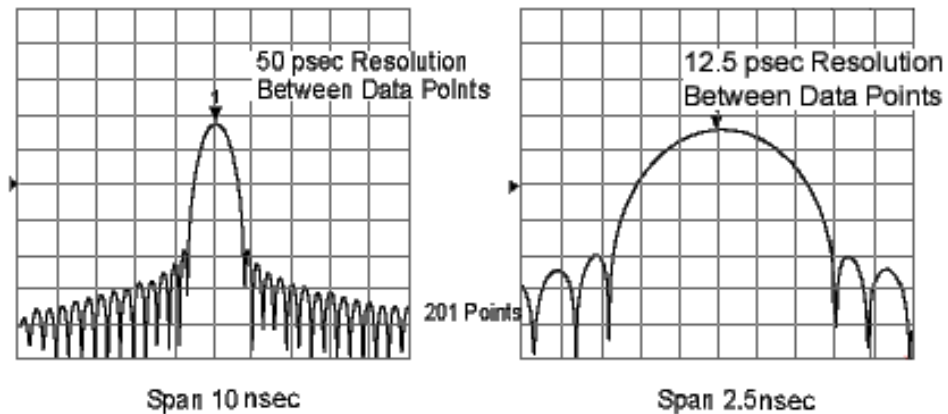
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**Note:** Increasing the number of points may invalidate your measurement calibration.

---

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.




---

**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

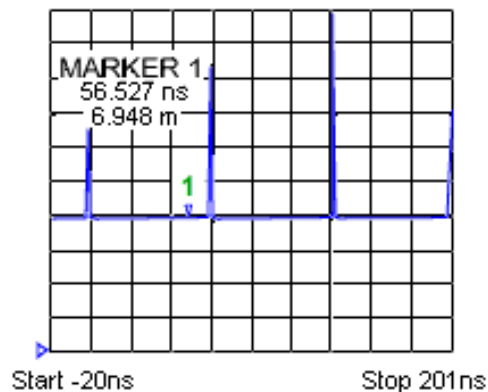
In the time domain, the measurement range is defined as the length in time over which a measurement can be made without encountering a repetition of the response.

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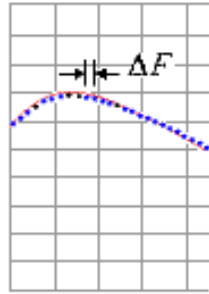
**Note:** Range and response resolutions are inversely related. Improving one, degrades the other.

---

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.



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 ( $3 \times 10^8$  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

$$\text{Time} = \frac{1}{\Delta F}$$

$$\text{Time Corrected for Velocity} = \frac{V}{\Delta F}$$

$$\text{Distance} = \frac{V}{\Delta F} \cdot 3 \times 10^8 \text{ meters/sec}$$

---

**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

$$\text{Response Resolution} = \frac{0.45}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 2.2 \text{ Normal Window} \\ 3.3 \text{ Maximum Window} \end{cases}$$

#### Lowpass Impulse

$$\text{Response Resolution} = \frac{0.6}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

#### Bandpass Impulse

$$\text{Response Resolution} = \frac{1.2}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

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.

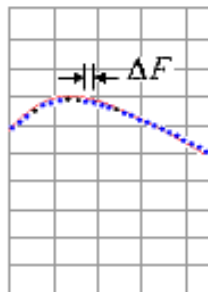
### Display Resolution

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.



$$\Delta F = \frac{\text{Frequency Span}}{\# \text{ of Points} - 1}$$

**For Example:**

Span = 1 GHz  
 # of Points = 201  
 ΔF = 5 MHz

$$\text{Time} = \frac{1}{\Delta F}$$

$$\text{Time Corrected for Velocity} = \frac{V}{\Delta F}$$

$$\text{Distance} = \frac{V}{\Delta F} \cdot 3 \times 10^8 \text{ meters/sec}$$

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

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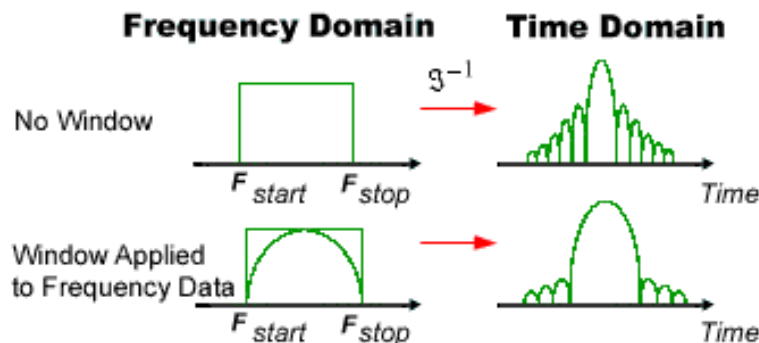
Other Time Domain topics

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### 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.



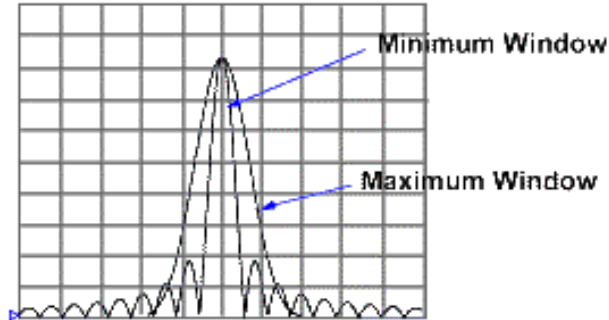
### Window Filtering Effects

- **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.

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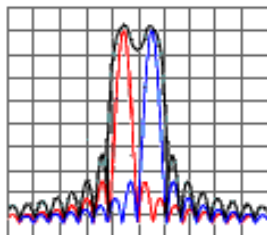
The analyzer can modify device responses by using a window filter on the measured data, with the following effects.

- **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.

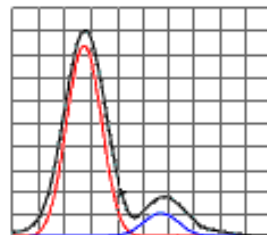
### Appropriate Window Value

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.



**Minimum Window  
Higher Resolution**



**Maximum Window  
Larger Dynamic Range**

### Window Characteristics

The following dependencies exist and are shown as example values in the next table.

	Dependency
<b>Sidelobe Levels</b> <b>Step Rise Time and</b> <b>Impulse Width</b>	Window Selected
	• Window Selected
	Frequency Span

Example window characteristics are shown for a 2.997 GHz frequency span.

Window Characteristics		Response Resolution*		Dynamic Range Side Lobe Level
		Step Rise Time (10% - 90% Level)	Impulse Width (50% 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 Impulse	Minimum		400 ps	-13 dBc
	Normal		641 ps	-44 dBc
	Maximum		961 ps	< -75 dBc

### Response Resolution Equations

#### Lowpass Step

$$\text{Response Resolution} = \frac{0.45}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 2.2 \text{ Normal Window} \\ 3.3 \text{ Maximum Window} \end{cases}$$

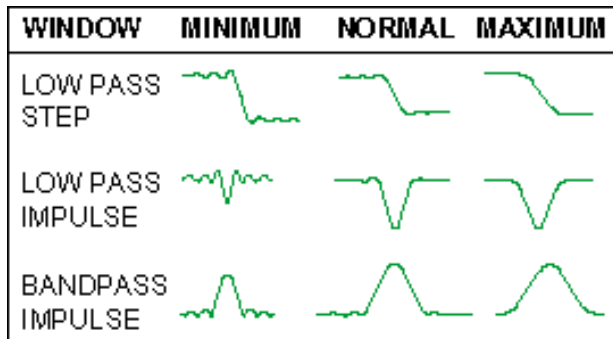
#### Lowpass Impulse

$$\text{Response Resolution} = \frac{0.6}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

#### Bandpass Impulse

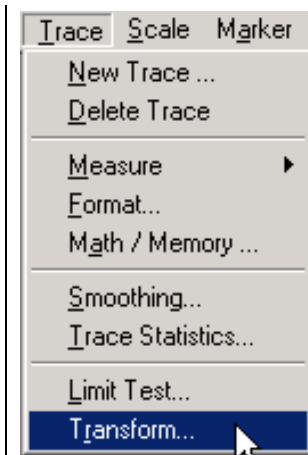
$$\text{Response Resolution} = \frac{1.2}{F_{\text{span}}} \times \begin{cases} 1.0 \text{ Minimum Window} \\ 1.6 \text{ Normal Window} \\ 2.3 \text{ Maximum Window} \end{cases}$$

The following graphic shows the typical effects of various windows applied to a response of a short circuit reflection measurement.



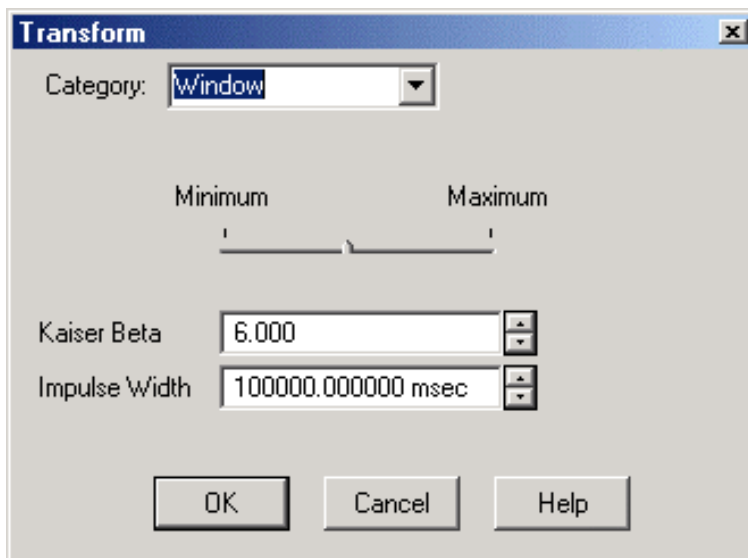
### How to Set the Window Filter





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

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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

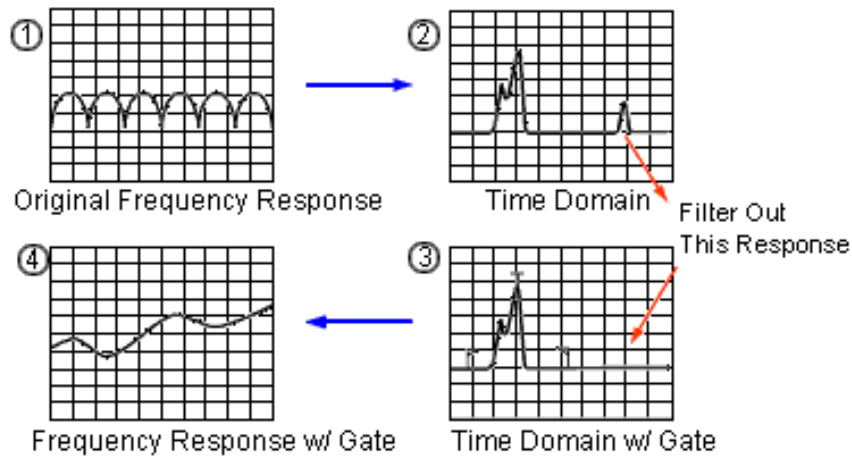
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Other Time Domain topics

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### 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.



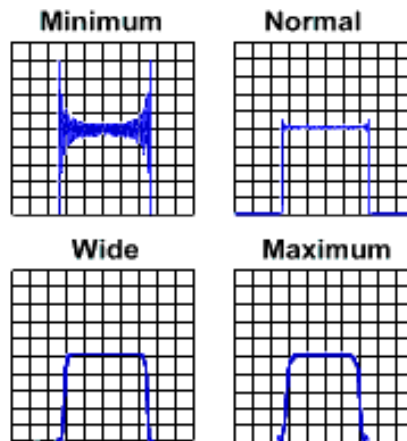
### Gate Shapes

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.

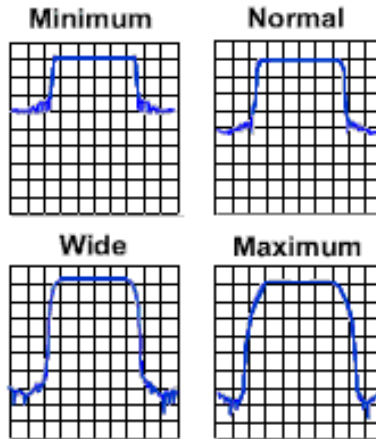


### Gate Sidelobes

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.



### 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.

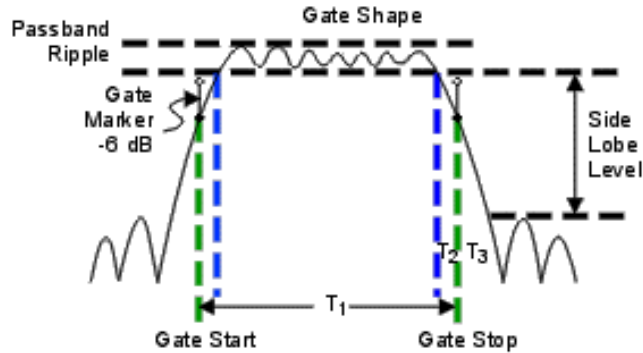
Gate Shape	Passband Ripple	Sidelobe Levels	Cutoff Time	Minimum Gate Span
Minimum	$\pm 0.01$ dB	-48 dB	1.4/Freq Span	2.8/Freq Span
Normal	$\pm 0.01$ dB	-68 dB	2.8/Freq Span	5.6/Freq Span
Wide	$\pm 0.01$ dB	-57 dB	4.4/Freq Span	8.8/Freq Span
Maximum	$\pm 0.01$ dB	-70 dB	12.7/Freq Span	25.4/Freq Span

### 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.

$$T_{1MIN} = 2 \times T_2$$

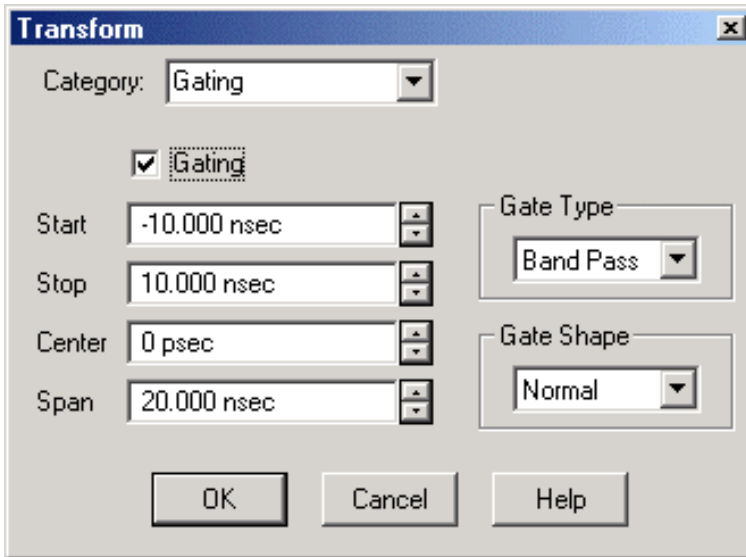
If you specify a gate span that is smaller than the minimum span, the analyzer will produce the following effects:

- 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

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**Note:** Time Domain measurements are only available on PNAs with Option 010. See PNA Options

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[Other Time Domain topics](#)

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### 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.

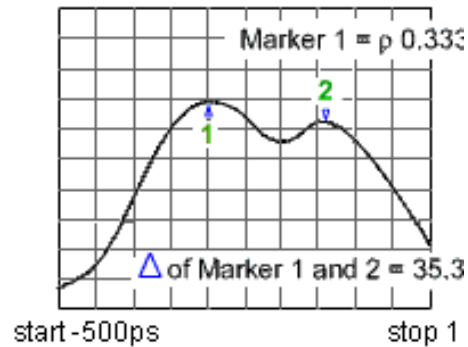
- Masking occurs when a discontinuity or loss closest to the reference plane affects the response of each subsequent discontinuity.
- The energy reflected or absorbed from the first discontinuity never reaches the second or later discontinuities.
- The result is that each subsequent response is smaller 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.

$\rho$

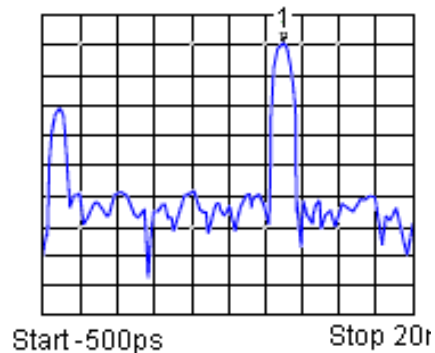


## Masking Due to Energy Absorption

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



## 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.

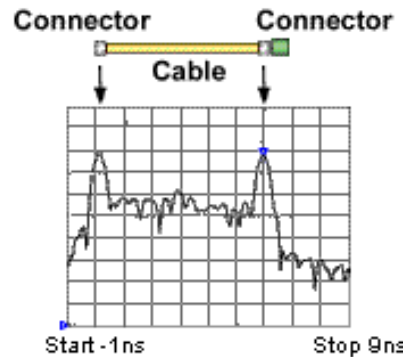
#### Data from the Vertical Axis

- 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



#### Transmission Measurement in Band Pass Mode

##### Data from the Horizontal Axis

- Propagation delay through the device under test

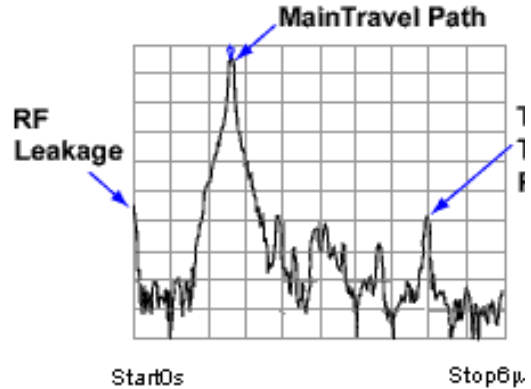
##### Data from the Vertical Axis

- 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.

- 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.

$\rho$   
(rho)

IMPEDANCE	STEP RESPONSE	IMPULSE RESI
OPEN	 Unity Reflection	 Unity Reflec
SHORT	 Unity Reflection = 180	 Unity Reflectic
RESISTOR $R > Z_0$	 Unity Reflection	 Unity Reflec
RESISTOR $R < Z_0$	 Unity Reflection	 Unity Reflec
INDUCTOR	 Unity Reflection	 Unity Reflec
CAPACITOR	 Unity Reflection	 Unity Reflec

### Reflection Measurement in Low Pass Mode

#### Data from the Horizontal Axis

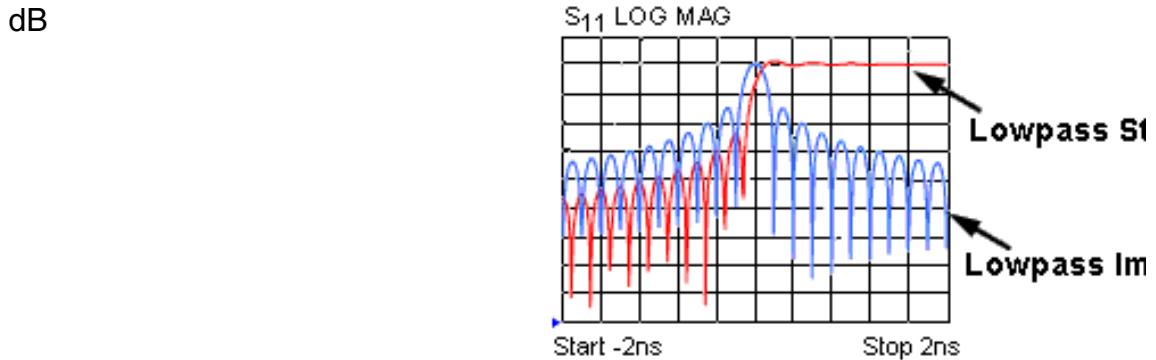
- Time it takes for an impulse launched at the test port to reach a discontinuity and return to the test port.

**Note:** To determine the actual physical length, enter the appropriate velocity factor.

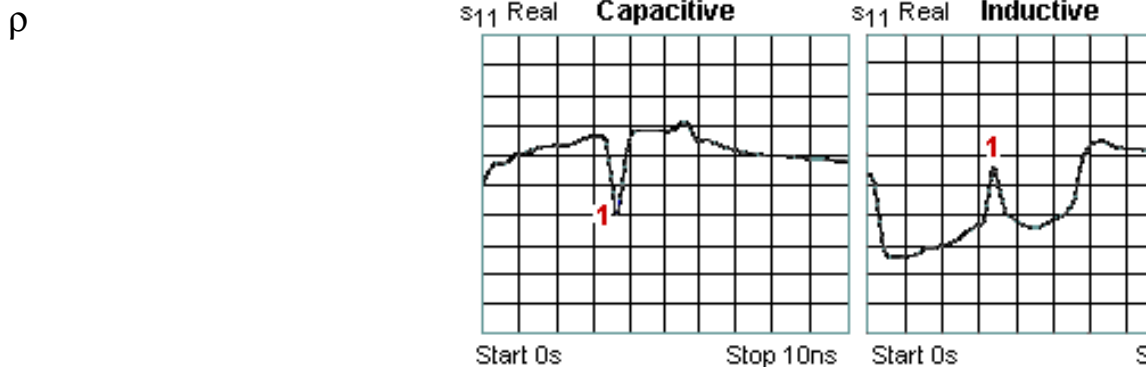
#### Data from the Vertical Axis

- Reflection coefficient ( $\rho$ ) 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

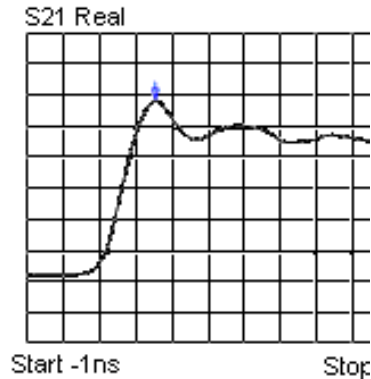
### Data from the Vertical Axis

- 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.

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### 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.

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**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.

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6. If you are using the low pass mode, determine the magnitude and phase of an impedance change. See Fault Location Using Low Pass.



### Frequency Offset (Opt 080)

## Frequency Offset

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The PNA Option 080 provides you with the hardware and basic software to make Frequency Offset Measurements. This topic discusses the PNA settings that are relevant to making these types of measurements. See Frequency Converting Device Measurements for more information on making specific device measurements.

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**Note:** The Frequency Converter Application Option 083 simplifies the task of making extremely accurate frequency offset measurements on MOST frequency converting devices.

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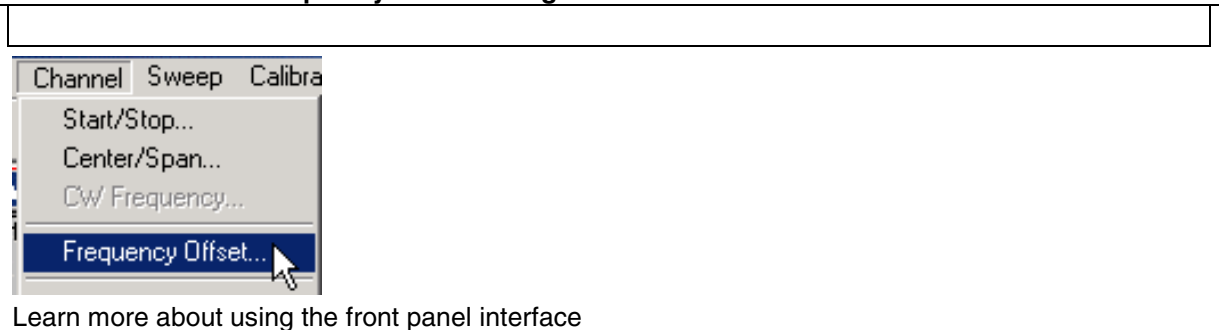
- Frequency Offset Dialog Box
- Setup Examples
- Test Set (Reference Switch) Dialog Box

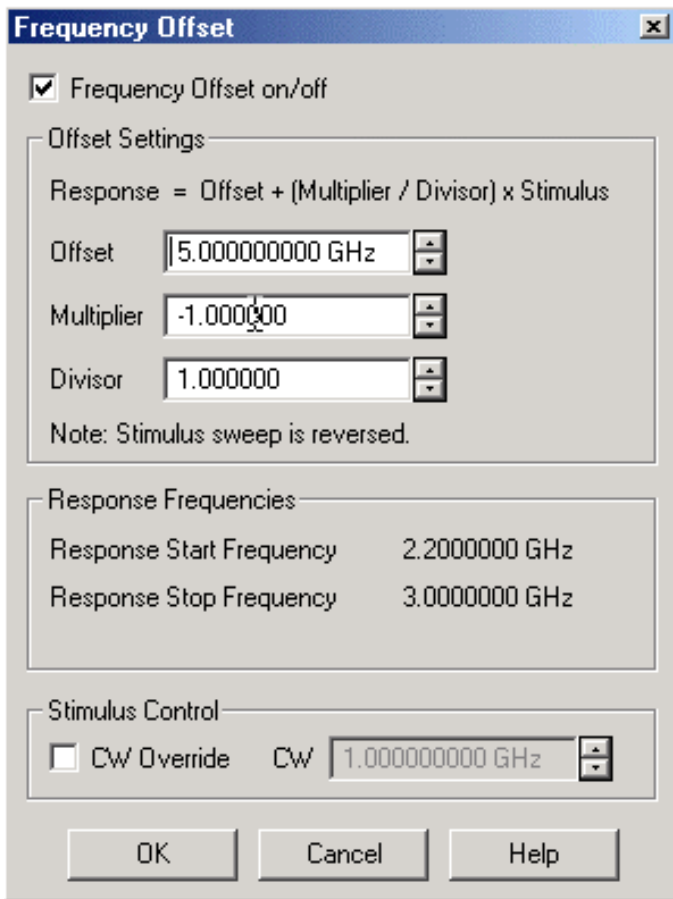
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Other Frequency Offset topics

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### How to access the Frequency Offset dialog





#### Frequency Offset dialog box help

**Note:** With basic Frequency Offset measurements, Port 1 or Port 2 can be configured as either the source (stimulus) or receiver (response). This is NOT true with Option 083.

**Frequency Offset on/off** Enables Frequency Offset Mode on ALL measurements that are present in the active channel. This immediately causes the source and receiver to tune to separate frequencies. The receiver frequencies are specified in the remaining settings in this dialog box. To make the stimulus settings, on the **Channel** menu click **Start / Stop**, then **OK**.

**Tip:** To avoid unnecessary errors, first make other settings on this dialog box, then click **Frequency Offset ON**.

#### Offset Settings

The receivers tune to the frequency specified by the following formula:

**Response = Offset +(Multiplier / Divisor) x Stimulus** (or source)

Where:

**Offset** Specifies an absolute offset frequency in Hz. For mixer measurements, this would be the LO frequency. Range is +/- 1000 GHz. Offsets can be positive or negative. See an example.

**Multiplier** Specifies (along with the divisor) the value to multiply by the stimulus. Range is +/- 1000. Negative multipliers cause the stimulus to sweep in decreasing direction. For mixer measurements, this would be for setups requiring the Input frequency to be less than LO frequency. See an example..

**Divisor** Specifies (along with the multiplier) the value to multiply the stimulus. Range is 1 to 1000

#### Stimulus CW Override

Use this setting to establish a fixed (CW) stimulus frequency while measuring the Response over a swept frequency range. For example, the PNA stimulus may be applied to the RF input of a mixer whose local oscillator (LO) is being swept. Because the IF output of the mixer will be swept, the PNA receivers must also be swept. See an example.

To set up such an instrument state:

1. Set the Stimulus Sweep Type (Linear, Log, or Segment Sweep) and frequency settings as well as the Offset, Multiplier and Divisor to cause the desired Response Start and Stop frequencies.
2. Turn ON Frequency Offset - the receivers will now sweep over the desired frequencies.

Turn ON CW Override and set the desired CW frequency for the source.

#### Notes:

When Frequency Offset is enabled, ALL receivers on the channel tune to the offset frequency, including the reference receiver. Therefore S21 measurements will not display the response frequency relative to the input frequency.

If you want to measure and display measurements at both the stimulus and response frequencies, you must use two channels. These types of ratioed measurements must be computed external to the PNA.

To calibrate for frequency offset measurements, see..Frequency Offset Calibration.

#### Setup Examples

1. **Swept Stimulus** (1000 MHz to 1100 MHz)  
**Swept Response** (2500 MHz to 2700 MHz)

Make the following settings:

On the **Channel** menu click **Start / Stop**

Start Frequency = 1000 MHz

Stop Frequency = 1100 MHz

In the **Frequency Offset** dialog:

Offset = 500 MHz

Multiplier = 2

Divisor = 1

Frequency Offset = ON

The above settings cause the following response frequencies:

Response = Offset + (Multiplier / Divisor) x Stimulus

Response Start Frequency =  $500 + [(2 / 1) * 1000]$   
= 2500 MHz

Response Stop Frequency =  $500 + [(2 / 1) * 1100]$   
= 2700 MHz

- 
2. **Fixed Stimulus** (1000 MHz)  
**Swept Response** (2500 MHz to 2700 MHz)

Make the following settings:

On the **Channel** menu click **Start / Stop**

---

Start Frequency = 2500 MHz

Stop Frequency = 2700 MHz

In the **Frequency Offset** dialog:

Stimulus CW Override: ON

CW Frequency: 1000 MHz

Offset = 0 MHz

Multiplier = 1

Divisor = 1

Frequency Offset = ON

---

3. **Swept Stimulus** (1000 MHz to 1100 MHz)

**Fixed Response** (2500 MHz)

Make the following settings:

On the **Channel** menu click **Start / Stop**

Start Frequency = 1000 MHz

Stop Frequency = 1100 MHz

In the **Frequency Offset** dialog:

Offset = 2500 MHz

Multiplier = 0

Divisor = 1

Frequency Offset = ON

The above settings cause the following response frequencies:

Response = Offset + (Multiplier / Divisor) x Stimulus

Response Start Frequency =  $2500 + [(0 / 1) * 1000]$   
= 2500 MHz

Response Stop Frequency =  $2500 + [(0 / 1) * 1100]$   
= 2500 MHz

---

4. **Swept Stimulus** (2500 MHz to 2600 MHz)

**Swept Response** (1000 MHz to 1100 MHz)

**External LO** (not supplied): 1500 MHz

Start Frequency = 2500 MHz

Stop Frequency = 2700 MHz

In the **Frequency Offset** dialog:

Offset = -1500 MHz

Multiplier = 1

Divisor = 1

Frequency Offset = ON

The above settings cause the following response frequencies:

---



Response = Offset + (Multiplier / Divisor) x Stimulus

Response Start Frequency =  $-1500 + [(1 / 1) * 2500]$   
= 1000 MHz

Response Stop Frequency =  $-1500 + [(1 / 1) * 2600]$   
= 1100 MHz

---

5. **Swept DECREASING Stimulus** (1100 MHz to 1000 MHz)

**Swept INCREASING Response** (1400 MHz to 1500 MHz)

**External LO** (not supplied): 2500 MHz

For some frequency-translating devices, as the input frequency increases, the output frequency decreases. The PNA can only display the response (output) as increasing. Therefore, the same effect can be obtained by sweeping the stimulus decreasing from higher to lower frequency. This causes an increasing response to be measured and displayed.

To accomplish this, set the multiplier to a negative value. This causes the PNA source to automatically sweep in reverse; from the higher frequency to the lower frequency.

Make the following settings:

On the **Channel** menu click **Start / Stop**

Start Frequency = 1000 MHz

Stop Frequency = 1100 MHz

In the **Frequency Offset** dialog:

Offset = 2500 MHz

Multiplier = -1

Divisor = 1

Frequency Offset = ON

The above settings cause the following response frequencies:

Response = Offset + (Multiplier / Divisor) x Stimulus

Response Start Frequency =  $2500 + [(-1 / 1) * 1000]$   
= 1500 MHz

Response Stop Frequency =  $2500 + [(-1 / 1) * 1100]$   
= 1400 MHz

The response cannot sweep backwards, so the PNA reverses the stimulus frequencies.

Stimulus Start Frequency = 11000 MHz

Stimulus Stop Frequency = 1000 MHz

Response Start Frequency = 1400 MHz

Response Stop Frequency = 1500 MHz

---

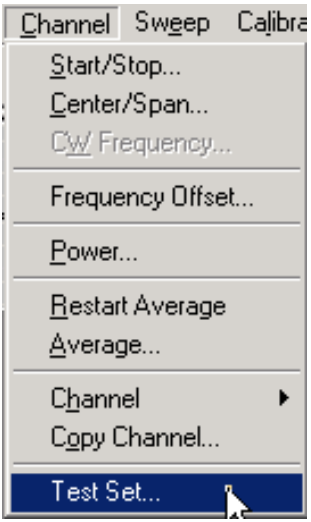
### Test Set Reference Switch

PNA models with option 081 have a switch in the test set that allows you to bypass the port 1 reference receiver through the front panel Reference 1 connectors. This switch lets you easily switch between standard S-Parameter measurements and measurements using a reference mixer. You could use this feature to make standard S11 measurements and converter transmission measurements relative to a reference ("golden") mixer.

**Note:** The Frequency Converter Application Option 083 simplifies the task of making extremely

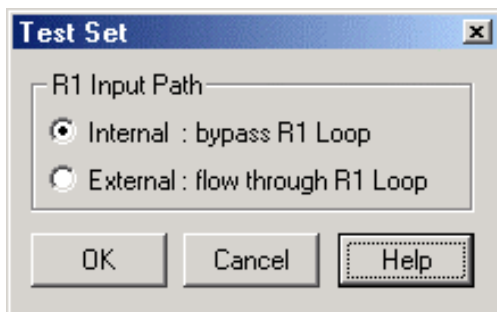
accurate phase measurements on MOST frequency converting devices.

### How to access the Test Set dialog box



The screenshot shows a menu with the following items: Channel, Sweep, Calibra, Start/Stop..., Center/Span..., CW Frequency..., Frequency Offset..., Power..., Restart Average, Average..., Channel, Copy Channel..., and Test Set... (highlighted with a mouse cursor).

Learn more about using the front panel interface



### Test Set dialog box help

**Note:** This feature is only available on PNA models with Option 081 - external reference switch.

#### R1 Input Path

**Internal: bypass R1 Loop** Connects the port 1 source directly to the R1 receiver.

**External: flow through R1 Loop** Allows direct access to the R1 receiver through the Reference 1 front-panel connectors.

See block diagram of reference switch.

## Frequency Converting Device Measurements

Many frequency offset measurements can be made using the PNA with option 080. The following is a list of some of those measurements and how they are made.

- Conversion Loss

- Conversion Compression
- Return Loss and VSWR
- Isolation
- Harmonic Distortion

See Also: Frequency Offset Measurement Accuracy

## Frequency Offset Measurement Accuracy

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This topic discuss methods that can be used to make accurate frequency offset measurements.

- Calibrations
- Mismatch Errors
- Accurate and Stable LO

---

See other Mixer Measurement topics

---

### Calibrations

With Frequency Offset measurements, the stimulus and response frequencies are different. Standard calibration error terms are calculated using reference measurements. Therefore, traditional calibration methods such as full 2-port SOLT cannot be used with frequency offset.

There are two new calibration techniques provided with the Frequency Converter Application (option 083). These offer fully calibrated scalar (Scalar Mixer Calibration) and phase (Vector Mixer Calibration) frequency offset measurements.

If you do not have option 083, Source and Receiver Power calibrations can be used most of the time to calibrate your Frequency Offset measurements. Use the following guidelines to apply these calibration types to your offset measurements.

#### Source Power calibration:

- Sets accurate power level at stimulus frequencies regardless of the receiver that will be used in the measurement.
- Can be copied to other channels with copy channels feature.
- Can be interpolated.

#### Receiver Power Cal:

- Requires a source cal to have already been performed and applied.
- Cannot be copied to other channels.

#### Therefore:

- Start by performing a source power cal over the combined stimulus and response frequencies.
- Copy the channel to other needed channels and the source power cal is copied.
- Change the frequency range of the copied channel to response frequency

- Perform a receiver cal at the response frequencies on individual channels.
- Change the frequency range to stimulus frequency and switch frequency offset ON.
- On Status Bar, ensure that source and receiver cals are ON (source cal will be interpolated).

See Conversion Loss Measurements for an example.

Learn more about source and receiver power calibrations.

## Mismatch Errors

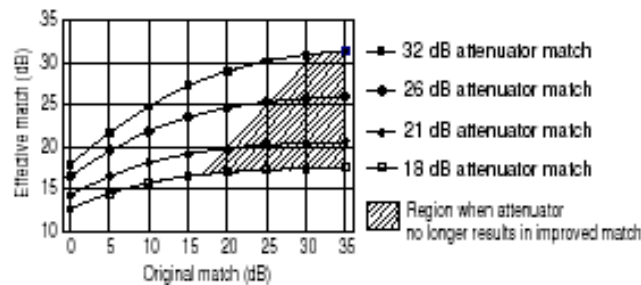
Mismatch errors result when there is a connection between two ports that have different impedances. With S-parameter measurements, these mismatches are measured and mathematically removed during a full 2-port calibration. This is much more difficult with frequency offset measurements. A much easier solution is to use high-quality attenuators on the input and output of the mixer.

By adding a high-quality attenuator to a port, the effective port match can be improved by up to twice the value of the attenuation. For example, a 10-dB attenuator, with a port match of 10 dB into an effective match of 25 dB. However, as the match of the attenuator approaches the match of the original source, the improvement diminishes.

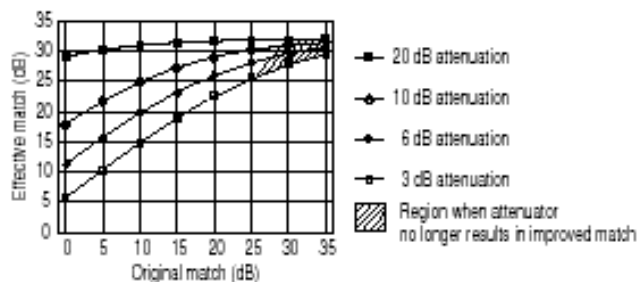
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**Note:** The Frequency Converter Application (option 083) uses calibration techniques that correct for mismatch errors.

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The larger the attenuation, the more nearly the resulting match approaches that of the attenuator, as shown in the following graphic. However, excessive attenuation is not desired because that will decrease the dynamic range of the measurement system.



## Accurate and Stable LO

When using frequency offset mode, if the LO signal is not accurate and stable, the output signal will not be at the expected response frequency. As a result, the output signal can fall on the skirts of the PNA receiver IF filter, or fall completely outside of the receiver filter passband.

Also, the LO power level is critical in mixer measurements. Be sure to monitor these power levels closely.

## Conversion Loss (or Gain)

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- What is Conversion Loss?
- Why Measure Conversion Loss?
- How to Measure Conversion Loss

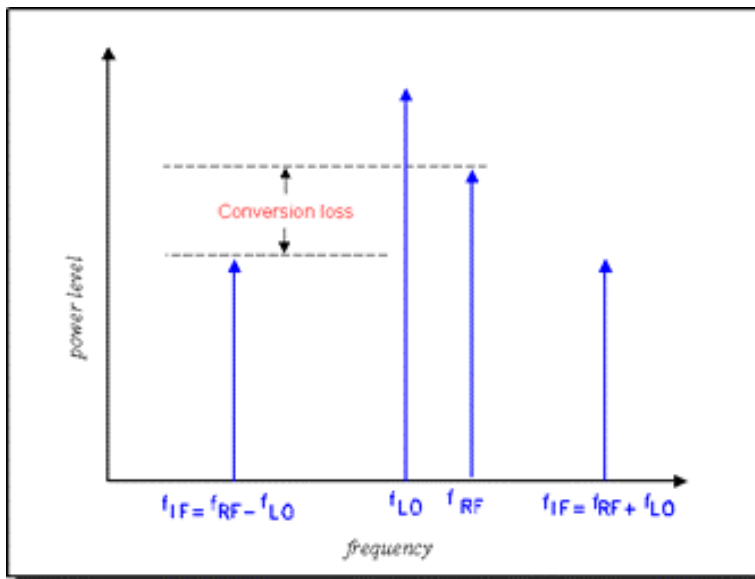
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See other Frequency Converting Device Measurements

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### What is Conversion Loss?

Conversion loss is defined as the ratio of the power at the output frequency to the power at the input frequency with a given LO (local oscillator) power. This is illustrated in the graphic below. A specified LO power is necessary because conversion loss varies with the level of the LO, as the impedance of the mixer diode changes.



### Why Measure Conversion Loss?

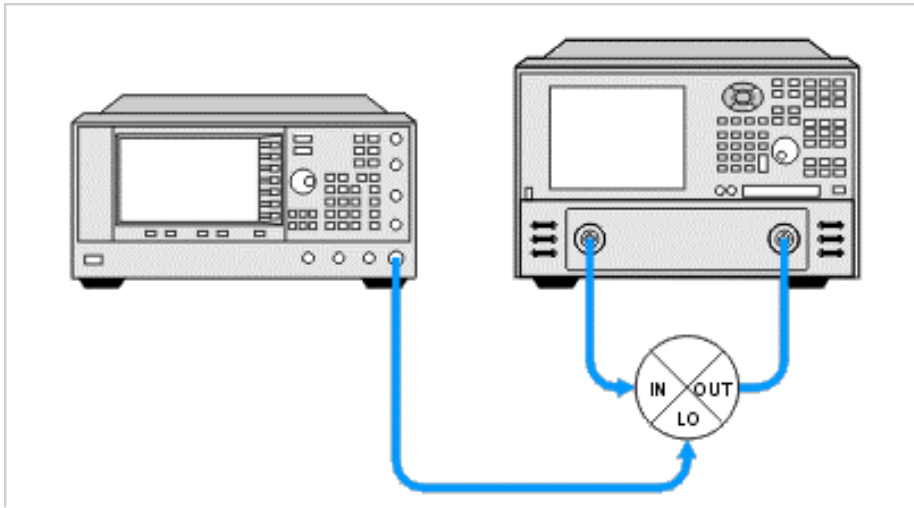
Conversion loss (or gain in the case of many converters and tuners) is a measure of how efficiently a mixer converts energy from the input frequency to the output frequency. If the conversion loss response of a mixer or converter is not flat over the frequency span of intended operation, valuable information may be lost from the resulting output signal.

## How to Measure Conversion Loss

Conversion loss is a transmission measurement. It is measured by applying an input signal (stimulus) and an LO signal at specific known power levels, and measuring the resulting output signal level. Because the output frequency is different from the input frequency, frequency offset mode (option 080) must be used for this measurement.

**Note:** This measurement is made much easier if your PNA has the Frequency Converter Application

### Equipment Setup



### Example: A calibrated Conversion Loss measurement

#### Swept Input with Fixed LO = Swept Output

- Input: 3.1 - 3.3 GHz
- LO: 2.2 GHz
- Output: 900 - 1100 MHz

#### PNA setup and calibrate on channel 1

- On channel 1 create an unratioed R measurement over the ENTIRE input and output frequency span (.9 - 3.3 GHz). This will be the base source power cal that will be copied to the R and B channel measurements.
- Perform a source calibration using a power meter. This makes the power level at the input of the mixer very accurate.

#### Setup Reference measurement on channel 2

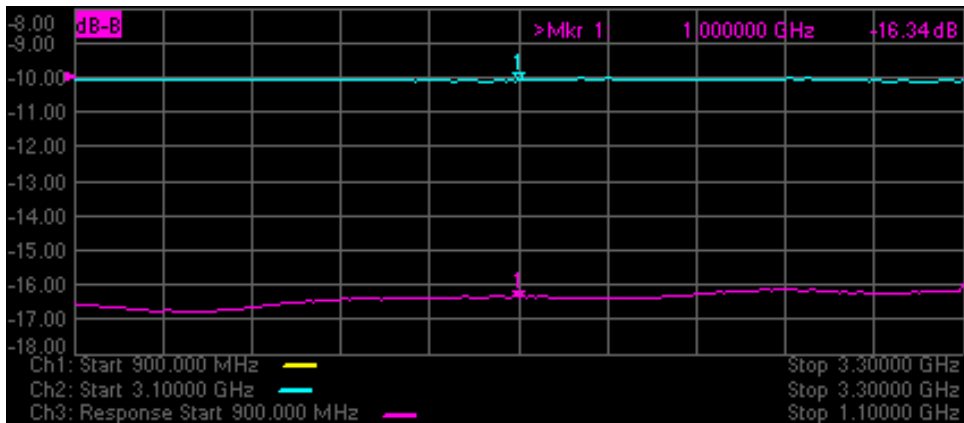
- Copy channel 1 to channel 2 which will display the reference input to the mixer. The channel 1 source power cal is copied with the other channel settings.
- Change measurement to R1 unratioed.
- Change frequency to 3.1 - 3.3 GHz. The source power cal becomes interpolated.
- Perform receiver power cal. Do not need to make physical connections. The PNA source is internally connected to the R1 receiver. Makes the R receiver read the source power level.

### Setup B measurement on channel 3

- Copy channel 1 to channel 3. This channel will display the output of the mixer. The channel 1 source power cal is copied with the other channel settings.
- Change measurement to B unratioed.
- Change frequency to .9 - 1.1 GHz. This causes the source power cal becomes interpolated.
- Connect thru line from port 1 to port 2.
- Perform receiver power cal. This makes the B receiver read the source power at the output frequencies.
- Turn OFF receiver power cal. This prevents an error when changing to input frequencies (next step).
- Change frequency to 3.1 - 3.3 GHz. This changes the channel back to the mixer input frequencies.
- Enable Frequency Offset.
- Change Offset to (-2.2 GHz). This tunes the B receiver to the output frequencies .9 to 1.1 GHz.
- Turn ON receiver power cal.

### Measure the Mixer

- Connect the mixer.
- Adjust scaling to suit your needs.
- Enable markers to read power levels. Math must be performed manually as markers are set individually for each channel.



### Conversion Compression

- What is Conversion Compression?
- Why Measure Conversion Compression?
- How to Measure Conversion Compression

- Measurement Accuracy Considerations

---

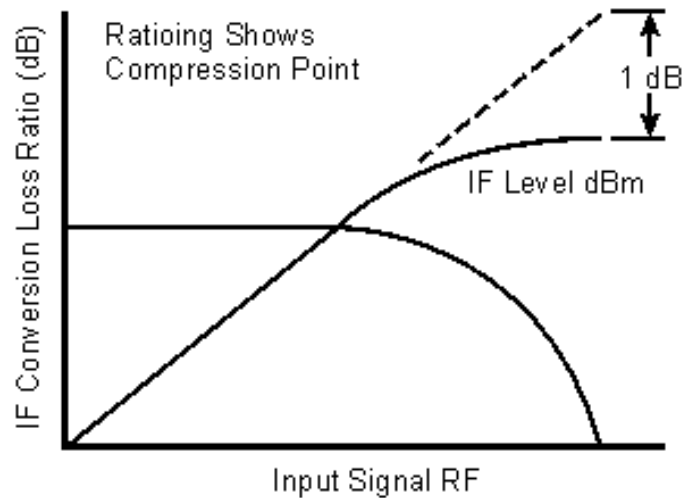
See other Frequency Converting Device Measurements

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### What is Conversion Compression?

Conversion compression is a measure of the maximum RF input signal level for which a mixer will produce linear operation. It is very similar to the gain compression experienced in amplifiers.

To understand conversion compression, you must first understand conversion loss. This is the ratio of the IF output level to the RF input level. This value remains constant over a specified input power range. When the input power level exceeds a certain maximum level, the constant ratio between input and output power levels begins to change. The point at which the ratio has decreased 1 dB is called the 1-dB compression point. This is illustrated in the graphic below.



### Why Measure Conversion Compression?

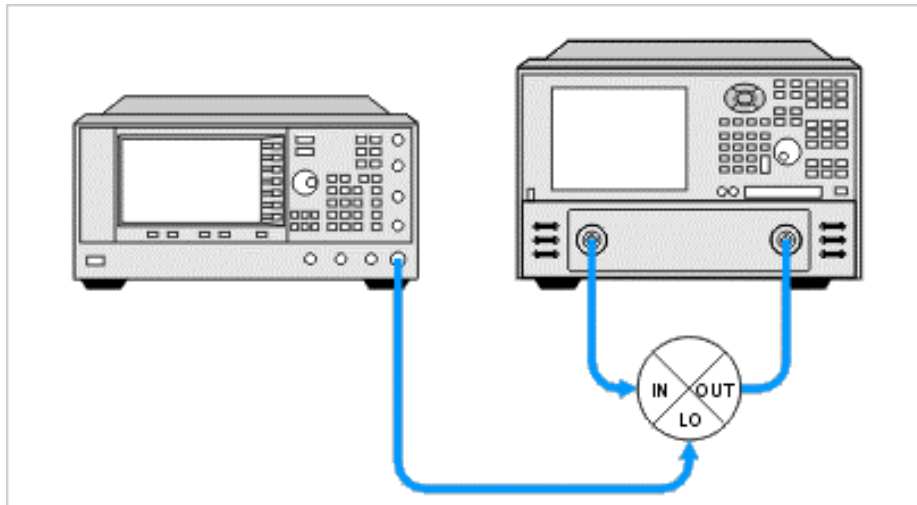
Conversion compression is an indicator of the dynamic range of a device. Dynamic range is generally defined as the difference between the noise floor and the 1-dB compression point.

### How to Measure Conversion Compression

The equipment and setup used to measure conversion compression are essentially the same as for measuring conversion loss and is illustrated in the following graphic.

The PNA performs a power sweep using frequency-offset mode and the resulting display shows the mixer's output power as a function of its input power. The 1-dB compression point (or others such as 3-dB) can be determined using markers.





## Measurement Accuracy Considerations

### Equipment Setup Considerations

- The couplers in the PNA have very good directivity. If the return loss of the DUT is bad, the reflected signal gets sampled by the PNA and can result in errors. This relates to error in DUT gain. To increase the accuracy, an attenuator can be added between the PNA's source port and the DUT's input port. Normally a 6- to 10-dB attenuator is sufficient. Addition of this attenuator, however, decreases the available drive to the DUT.
- With high drive levels the PNA can be driven into compression resulting in measurement error. With excessive drive levels, the PNA can be damaged. Add an attenuator between the output of the DUT and the receiver input of the PNA to avoid these problems.

### Calibration Considerations

- Source power calibration can be used to provide a high level of accuracy for this measurement.
- If your PNA has the Frequency Converter Application (option 083), you can perform a Scalar Mixer Calibration to obtain a more accurate measurement.

## Isolation Measurements of Frequency Converting Devices

- 
- What is Isolation?
  - Why Measure Isolation?
  - How to Measure Isolation

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[See other Frequency Converting Device Measurements](#)

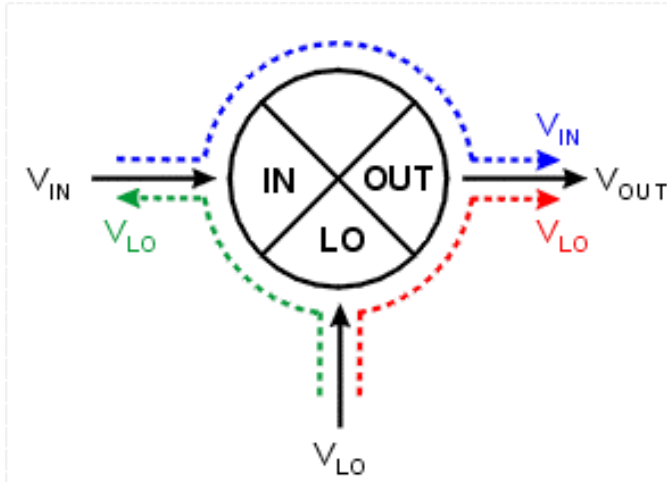
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### What is Isolation?

Isolation is a measure of the leakage, or feedthrough, from one port to another. The more isolation a mixer provides, the lower the amount of feedthrough. Isolation is measured at the same frequency as the stimulus, not the converted or shifted frequency. Therefore, Frequency Offset capability is not necessary for these measurements.

Three main isolation terms are of interest for mixer measurements:

- LO-to-OUT isolation ( $V_{LO}$ )
- LO-to-IN isolation ( $V_{LO}$ )
- IN-to-OUT feedthrough ( $V_{IN}$ )



### Why Measure Isolation?

Any unwanted signal "leaking" through the device will mix with the desired output signal creating intermodulation products, adding to intermodulation distortion. These unwanted signals may be difficult to filter out.

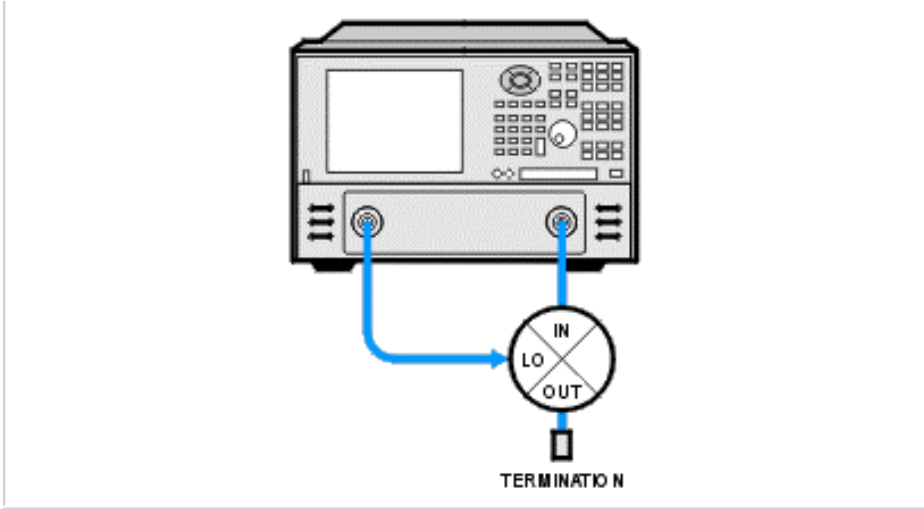
### How to Measure Isolation

Use the following setups to measure the isolation of a mixer:

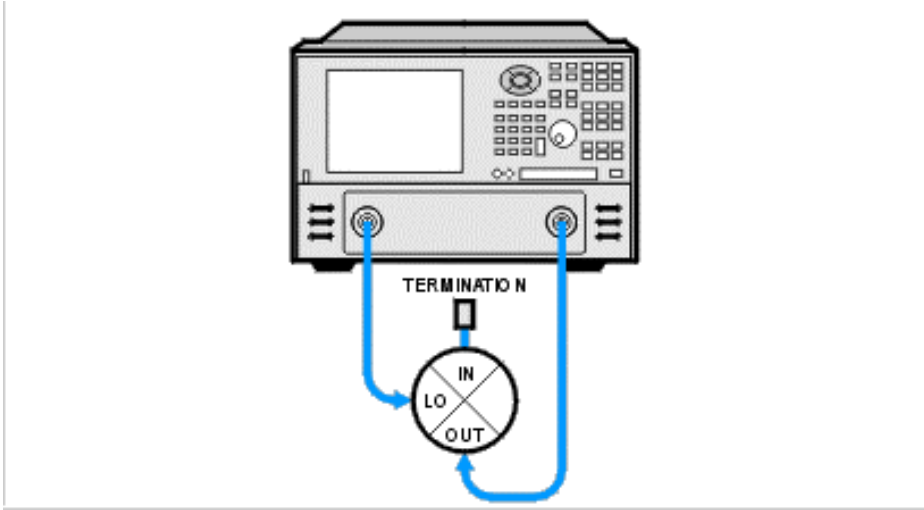
Note the following:

- The Input to Output isolation is very dependent on the LO power level. Isolation should be measured with the LO power at its normal operating level.
- Each of the ports not being tested should be terminated with an impedance typical of actual operation. This may not always be the characteristic impedance,  $Z_0$  (usually 50 or 75 ohms). For example, if the OUT port of a mixer is intended to be directly connected to a filter, then this filter should be used when measuring the feedthrough.

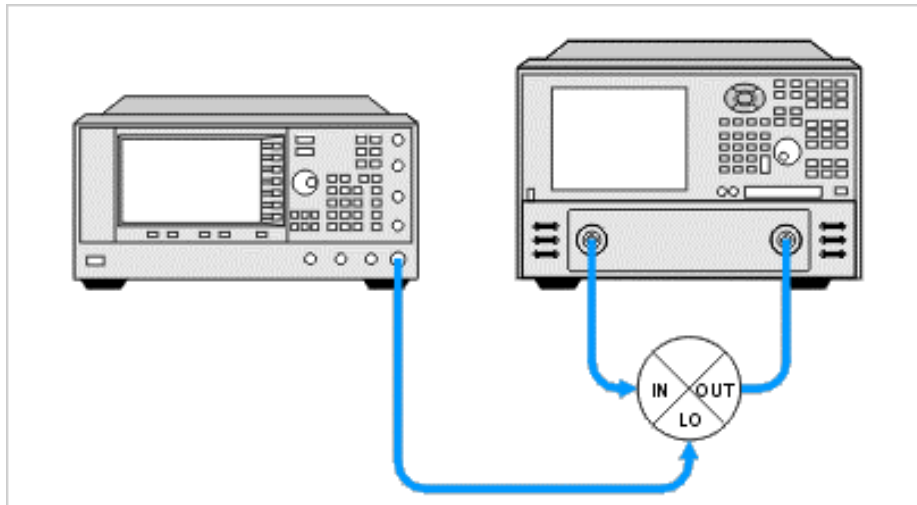
### LO-TO-IN ISOLATION



**LO-TO-OUT ISOLATION**



**IN-TO-OUT ISOLATION**



### Measuring Converters vs. Mixers

Measuring IN-to-OUT feedthrough of a converter is identical to that of a mixer. The IN-to-OUT feedthrough is generally very small for a converter due to the inclusion of an IF filter in the device. Because of this, the measurement may require the PNA to have increased dynamic range.

Measuring LO leakage (LO-to-OUT and LO-to-IN) of a converter requires a different technique because the LO port is typically not accessible:

- The PNA can be tuned to the frequency of the LO signal and either the OUT or IN port connected to the PNA receiver port. The PNA source port is not connected.
- A spectrum analyzer can be connected to either the OUT or IN port and tuned to the frequency of the LO signal.

### Harmonic Distortion

- What is Harmonic Distortion?
- Why Measure Harmonic Distortion?
- How to Measure Harmonic Distortion
- Measurement and Accuracy Considerations

---

See other Frequency Converting Device Measurements

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### What is Harmonic Distortion?

Harmonics are multiples of any signal appearing at the mixer input and also multiples of the LO input. The distortion of the mixer's output characteristics caused by these harmonics is referred to as harmonic distortion. Harmonic distortion is caused by non-linearities in the device.

Harmonics are NOT signals created by two or more signals interacting (mixing); these signals are

known as intermodulation products, which result in intermodulation distortion.

### Why Measure Harmonic Distortion?

- It can degrade the performance of devices connected to the output of the mixer.
- The harmonics can also mix with other signals present in the mixer, adding to the intermodulation distortion of the mixer.

---

### How to measure Harmonic Distortion

---

The harmonics can be measured using the PNA with Frequency Offset (option 80). The frequency of the LO to the mixer is set to zero and multiplier of the RF input is used to set the IF frequency (the harmonic). The equipment setup is shown below.

Since harmonics are specified in dBc, the fundamental RF and both the second and third harmonics are measured and the differences calculated. Multiple channels can be used to do this.

1. Connect the equipment.
2. Setup the measurement for calibration. See also Measurement and Accuracy Considerations.

Use three channels and frequency offset mode:

Channel 1 = F1 to F2

Channel 2 = F1 to 2F2 (frequency offset mode, multiplier = 1)

Channel 3 = F1 to 3F2 (frequency offset mode, multiplier = 1)

- Perform a source power calibration and receiver power calibration over the entire frequency range. See Measurement and Accuracy Considerations.
- Reduce the frequency span and increase the frequency offset multiplier on Channels 2 and 3:

Channel 2 = F1 to F2 (frequency offset mode, multiplier = 2)

Channel 3 = F1 to F2 (frequency offset mode, multiplier = 3)

**Note:** Because the frequency span has been changed from that used for calibration, the source and receiver calibrations will be interpolated.

- Connect the DUT, make the measurement, and calculate the harmonic response:  
Set up markers on Channels 1, 2 and 3, and determine the difference between the marker values to get the dBc value of each harmonic.

Channel 1 - Channel 2 = 2nd harmonic (dBc)

Channel 1 - Channel 3 = 3rd harmonic (dBc)

**Note:** Be sure to set the markers to the appropriate stimulus. Channel 2 markers should be set to twice the frequency of Channel 1 markers. Channel 3 markers should be set to three times the frequency of Channel 1 markers.

---

## Measurement and Accuracy Considerations

### Equipment Setup Considerations

- A filter must be used at the input of the mixer to remove the PNA source harmonics.

### Calibrations

- If your PNA has the Frequency Converter Application (FCA), you can perform a Scalar Mixer Calibration to obtain a more accurate measurement.

### Return Loss and VSWR

- What are Return Loss and VSWR?
- Why Measure Return Loss and VSWR?
- How to Measure Return Loss and VSWR

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See other Frequency Converting Device Measurements

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### What is Return Loss and VSWR?

Return loss and VSWR are both linear reflection measurements, even when testing frequency conversion devices, because the reflected frequency is not converted. These measurements are essentially the same as for filters and amplifiers. Learn more about Reflection Measurements.

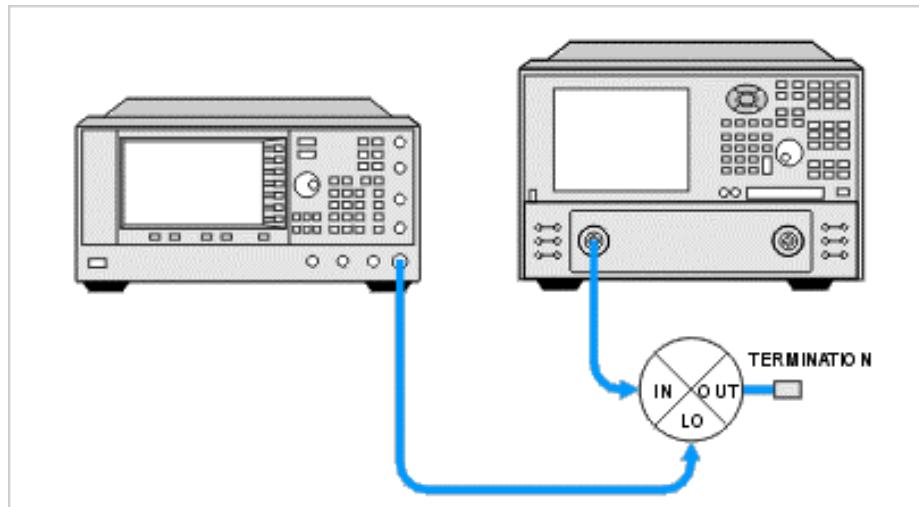
### Why Measure Return Loss and VSWR?

Devices which have poor return loss and VSWR result in loss of signal power or degradation of signal information.

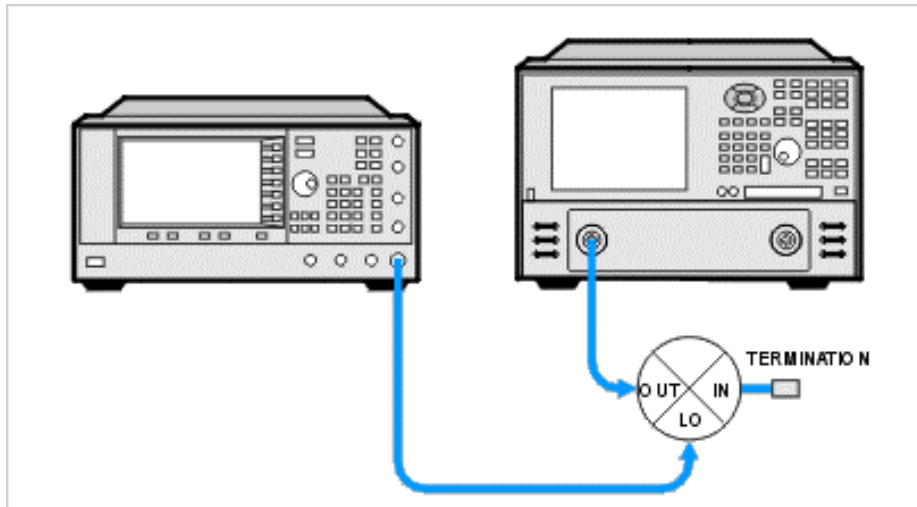
### How to Measure Return Loss and VSWR

Setup the PNA measure return loss and VSWR as you would any two-port device. Connect your frequency converting device as shown in the following diagrams:

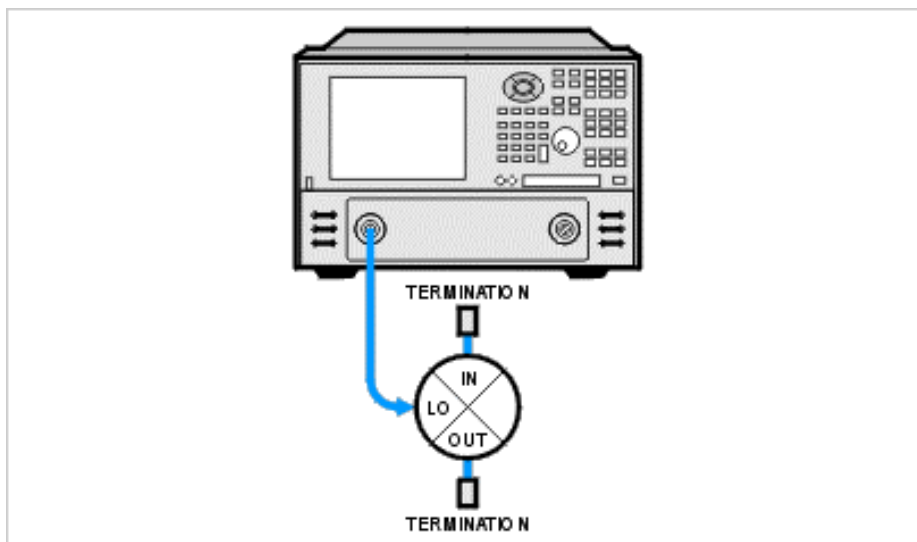
**RETURN LOSS AND VSWR OF MIXER INPUT PORT**



**RETURN LOSS AND VSWR OF MIXER OUTPUT PORT**



### RETURN LOSS AND VSWR OF MIXER LO PORT



## Frequency Converter Application (Opt 083)

### Known Issues with Frequency Converter Application

The following are known issues, and suggestions, with the Frequency converter Application (option 083) at the time of PNA Revision 3.1.

#### Issue 1: Applying Cal Sets to an FCA Measurement

When applying an existing Cal Set to an FCA measurement, the Mixer Setup must be identical to, or an acceptable subset of, the values contained in the applied Cal Set. To learn more about "acceptable" subsets, see Cal Sets. The PNA does NOT automatically make the corrections to

the Mixer setup after applying a Cal Set that does not match. Although the PNA may indicate that it is changing the channel parameters to match the Cal Set, it does not change the necessary mixer-test parameters.

If the setup does not match the applied Cal Set, your measurement data will be corrupt.

### **Issue 2: Channel Conflict**

FCA measurements and non-FCA measurements can NOT share the same channel. The FCA application will not allow this condition. An error message will appear on the screen indicating that the two measurements are incompatible.

### **Issue 3: Embedded LOs Not Supported**

At this time, Converters with embedded LOs cannot be measured accurately with the FCA application. To make accurate measurements the LO must be phase locked and the frequency known very accurately.

### **Issue 4: Fixed IF Measurements Not Supported**

To produce a fixed IF measurement, the Input and LO frequencies need to be swept together at exactly the same time. The FCA does not currently synchronize the PNA source with an external LO source.

#### **Suggestion:**

You can accomplish this measurement through an external program. Step the PNA Input source in CW, then step the external LO source, then make a measurement. The FCA application is fully supported through both SCPI and COM commands.

### **Issue 5: Frequency Offset as part of User Preset Not Supported**

Although the PNA will allow it, do NOT save a Frequency Offset or Frequency Converter Application measurement as part of a User Preset. The measurement data will be corrupt.

#### **Suggestion:**

Save the Frequency Offset or Frequency Converter Application measurement as a .cst file and recall it as required.

### **Issue 6: Only Linear Sweep Supported with FCA Measurements**

Although you can change sweep type by using the PNA Menu bar, the only sweep type currently supported with FCA measurements is Linear sweep.

## **Using the Frequency Converter Application (Option 083)**

---

- Overview
- Create a Measurement
- Change a Measurement
- Measurements Offered
- Scalar Measurement Setup



- Vector Measurement Setup
- Save Trace Data
- Avoid Spurs

Not sure if your analyzer is equipped with Option 083? Here's how to identify your analyzer.

1. On the PNA menu, click **Help**.
  - Or, on the front panel, press **Menu/Dialog**. Next, in the **NAVIGATION BLOCK**, press the Left Tab several times to move to **Help**. Press **Click**.
2. Click **About Network Analyzer**.
  - Or, in the front panel **NAVIGATION BLOCK**, press the Down Arrow several times to move to **About Network Analyzer**. Press **Click**.

Other Frequency Converter Application topics

## Overview

The following is an overview of how to make an FCA measurement:

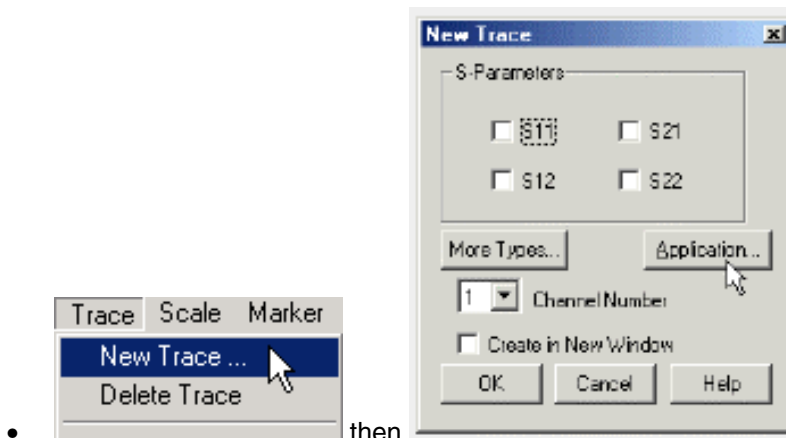
1. DECIDE to make either a Scalar measurement or Vector measurement. The calibration method is unique to each of these. You cannot apply a vector calibration to a scalar measurement, or vice versa. See a comparison of these two measurement types.
2. CREATE one of the following default Conversion loss measurements: Learn how Forward Scalar SC21, Reverse Scalar SC12, or Vector VC21
3. CHANGE the measurement if you want to measure something other than S21. Learn the various FCA measurements that are offered and how to CHANGE an FCA measurement.
4. CALIBRATE your SCALAR or VECTOR measurement.

**For advanced users:** you can calibrate first over a wide frequency range, then later configure a mixer measurement and apply the calibration. Learn how.

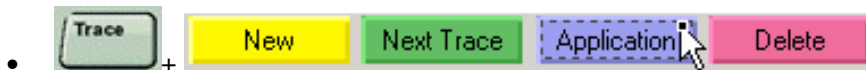
**Note:** An FCA measurement and a non-FCA measurement can NOT reside on the same channel. Learn more.

### How to CREATE a Frequency Converter Application Measurement

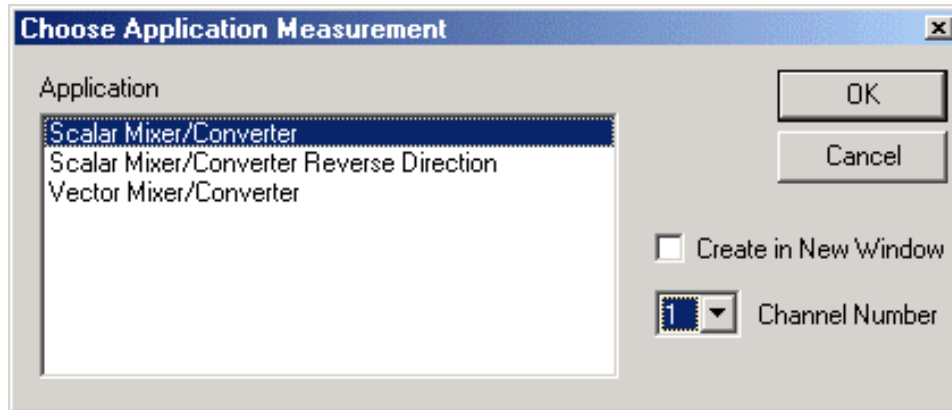
Use any of the following methods to open the Choose Application Measurement dialog box:



OR



Then select the conversion loss measurement:

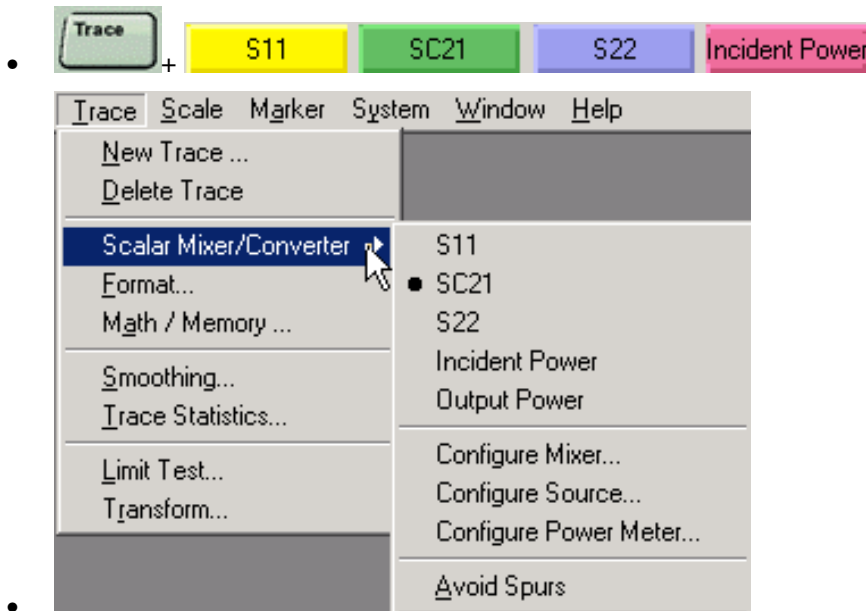


**Note:** Each of these three measurements must be created in a separate channel. They can NOT share the same channel.

Learn more about using the front panel interface

### How to CHANGE a Frequency Converter Application Measurement

Use any of the following methods. Although a Scalar measurement is shown, changing a Vector measurement is exactly the same.



Learn more about using the front panel interface

### FCA Measurements Offered

To make these measurements:

1. CREATE the default Scalar Forward, Scalar Reverse, or Vector measurement.
2. CHANGE the measurement to one of the measurements in that category.

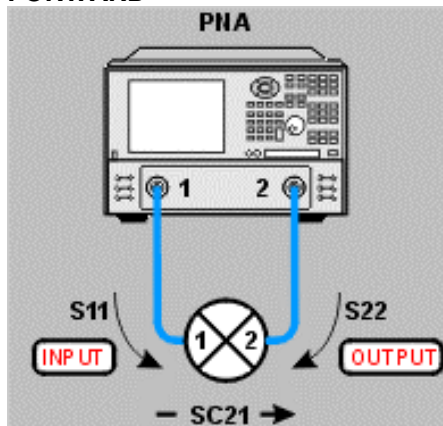
### Understanding Scalar FORWARD and REVERSE Mixer measurements

Mixers are typically reciprocal devices ( $S_{21} = S_{12}$ ) and are therefore used and measured in both directions. To help avoid confusion, the following diagrams do not use the traditional mixer labels RF and IF. They are labeled ports 1 and 2. The LO port is not relevant to this discussion.

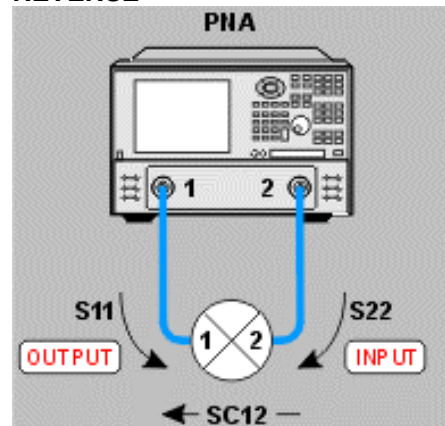
During Calibration you specify **Input**, **Output**, or **Both** directions. Learn more.

**Input** and **Output** correspond to frequencies in the Mixer setup dialog box.

#### FORWARD



#### REVERSE



#### Note:

A and R1 are port 1 receivers  
B and R2 are port 2 receivers

#### Scalar Forward Direction

- **SC21 Conversion Loss/Gain (default)**
- **S11** at Input frequency
- **S22** at Output frequency
- **Incident Power** Absolute R1 power at Input frequency - stimulus at Port 1
- **Output Power** Absolute B power at Output frequency - stimulus at Port 2

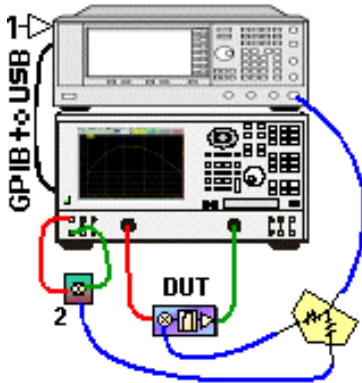
#### Scalar Reverse Direction

- **SC12 Conversion Loss/Gain (default)**
- **S11** Output frequency
- **S22** Input frequency
- **Incident Power** Absolute R2 power at Input frequency - stimulus at Port 2
- **Output Power** Absolute A power at Output frequency - stimulus at Port 1

**Vector** (Forward Direction Only because of the use of a reference mixer)

- **VC21 Conversion Loss/Gain (default)**
- **S11**
- **S22**

## Vector Measurement Setup



1: External source (fixed LO signal)

2: Reference mixer

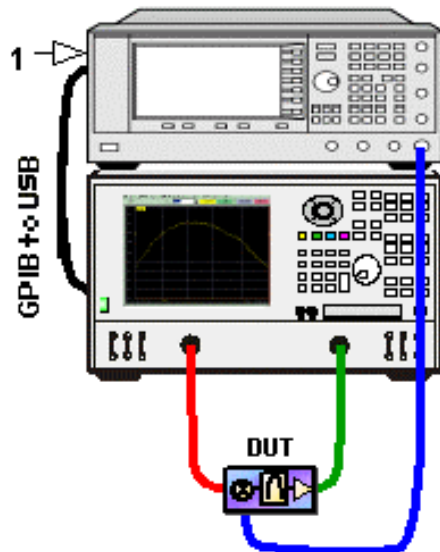
Learn how to calibrate a Vector Mixer measurement.

---

**Note:** All Frequency Conversion Application (Option 083) GPIB test equipment (Ex: sources, power meter) must be connected to the PNA using the Agilent 82357A USB/GPIB Interface.

---

## Scalar Measurement Setup



1: External source (fixed LO signal)

Learn how to calibrate a Vector Mixer measurement

---

**Note:** All Frequency Conversion Application (Option 083) GPIB test equipment (Ex: sources, power meter) must be connected to the PNA using the Agilent 82357A USB/GPIB Interface.

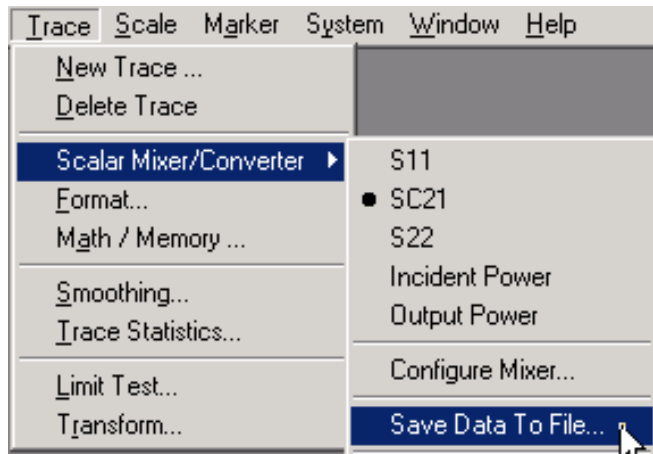
---

## Save Trace Data

You can save you Frequency Converter measurement data in S2P format to disk.

**How to Save Trace Data**

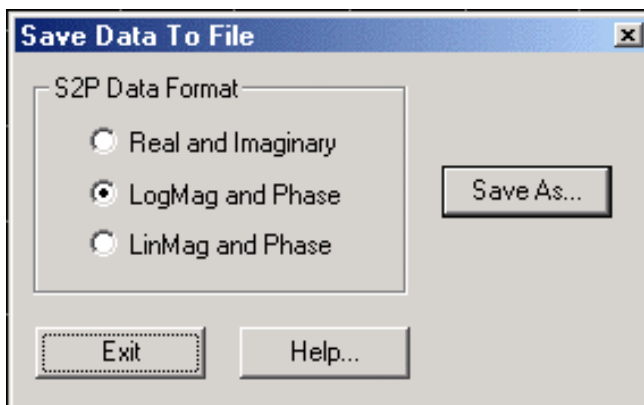
First create an FCA measurement. Then, either



OR

Click File then Save As.

Learn more about using the front panel interface



#### Save Data to File dialog box help

Allows you to save Frequency Converter measurement data to an S2P file. The data is saved in S2P format much like standard PNA data. Learn more about .S2P files.

**Note:** This is the only method to save Frequency Converter .S2P files.  
Do NOT click **File, Save As...** to save these S2P data files.

**S2P Data Format** Select the data format. This selection is independent of the PNA display.

**Save As** Click to specify a file name and location for the saved data.

**Exit** Closes the dialog box.

Notes:

Each record contains 1 stimulus value and 4 parameters (total of 9 values) as follows:

Stim Real(p1) Imag(p1) Real(p2) Imag(p2) Real(p3) Imag(p3) Real(p4) Imag(p4)

where **pX** is the parameter depending on measurement type:

**Measurement Type**

**p1**

p2  
p3  
p4

**Scalar**

S11  
SC21 (FWD)  
SC12 (REV)  
S22

**Vector**

S11  
VC21  
VC12  
S22

**Mixer Characterization**

Directivity  
Source Match  
Reflection Tracking  
M21

- If correction is OFF, data is only saved for the active parameter. Zeros are saved for all other parameters.
- If correction is ON, data is saved for all of the parameters.

All files contain the following Header Information: Brackets [ ] contain parameters.

```
!Agilent [Instrument Model Number]: [version]
!Mixer S2P File: [Mixer Measurement Type]
!Parameters: [Parameter List]
!Calibration State: [On/Off]

!# Begin Mixer Setup
![Mixer Setup parameters listed here]
![Mixer Parameter 1]
.
.
![Mixer Parameter n]
!# End Mixer Setup

# [S2P data here]
```

**Avoid Spurs**

The Avoid Spurs feature of the Frequency Converter Application prevents unwanted mixing products from appearing on the PNA screen. The Avoid Spurs feature does not significantly impact measurement speed.

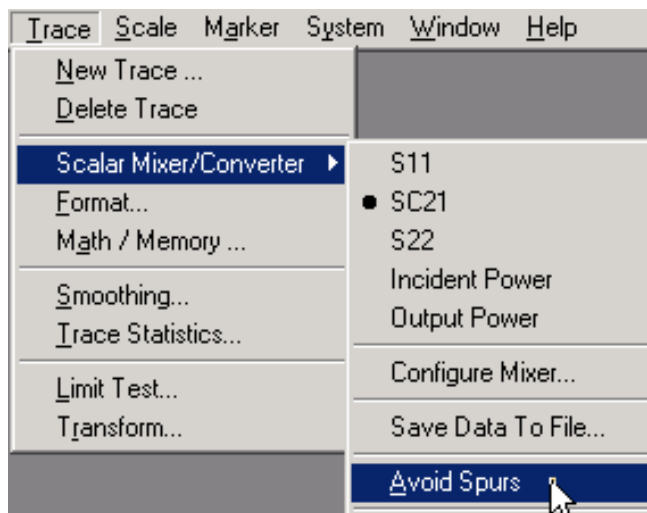
---

**Note:** The Avoid Spurs feature is automatically turned OFF for FCA calibrations. For highest accuracy, make measurements with the Avoid Spurs feature OFF.

---

## How to Avoid Spurs

First create an FCA measurement. Then, either



OR

Check Avoid Spurs on the Mixer Setup dialog box.

Learn more about using the front panel interface

### Description

A spur, or spurious signal, is a term used to describe the unwanted product of two signals mixing together. When you configure the mixer setup dialog box for a desired Output, the PNA computes the frequencies of potential unwanted signals. By manipulating internal PNA hardware, these signals are avoided and do not appear on the PNA display. This means you do not need to use external filters to prevent spurious signals from appearing on the PNA display.

The time required for the PNA to compute the frequencies of unwanted spurious signals MAY be noticeable depending on the number of data points in your measurement. However, once computed, the time required for the PNA to avoid the spurs is usually insignificant.

### Limitations

The Avoid Spurs utility cannot avoid every spur. However, when there is a choice of spurs to avoid, it will display the smallest of the spurs.

### The Computation of Avoided Spurs

The Avoid Spur computer avoids the following spurs:

- LO, and its interaction with internal PNA components, and 16 of its harmonics.
- Input frequencies and 16 of its harmonics.
- Undesired Image frequencies (Sum or Difference) and 16 of its harmonics.

## Frequency Converter Application (Option 083) Calibrations

---

Frequency Converter Application (Option 083) offers advanced calibration choices for mixer or

converter measurements that provide exceptional amplitude and phase accuracy.

- Calibration Setup
- Comparison of Scalar and Vector Mixer Cals
- How to Perform an FCA Calibration
- Apply an FCA Cal Set

See [Scalar Mixer Calibration](#) and [Vector Mixer Calibration](#) for details of these two Calibration methods.

---

**Note:** An FCA measurement and a non-FCA measurement can NOT reside on the same channel. [Learn more.](#)

---

Not sure if your analyzer is equipped with Option 083? Here's how to identify your analyzer.

1. On the PNA menu, click **Help**.
  - Or, on the front panel, press **Menu/Dialog**. Next, in the **NAVIGATION BLOCK**, press the Left Tab several times to move to **Help**. Press **Click**.
2. Click **About Network Analyzer**.
  - Or, in the front panel **NAVIGATION BLOCK**, press the Down Arrow several times to move to **About Network Analyzer**. Press **Click**.

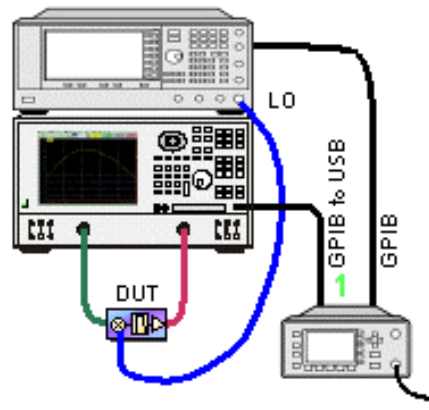
---

Other Frequency Converter Application topics

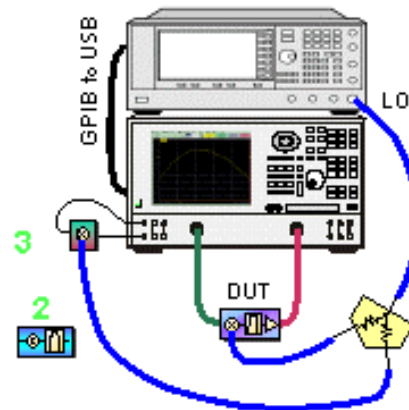
---

## Calibration Setup

### Scalar Mixer Calibration



### Vector Mixer Calibration



- 1: Power meter
- 2: Calibration mixer/filter
- 3: Reference mixer

### Notes:

- There is no need for an external filter after the mixer/converter to filter out mixing products. Because the PNA frequency offset mode tunes the receiver to the correct offset frequency, other mixing products are filtered out and do not cause measurement error.
- The external source, controlled by the analyzer, supplies the fixed LO signal. View the list of external sources that are compatible with the PNA.



- All GPIB test equipment (Ex: sources, power meter) must be connected to the PNA using the Agilent 82357A USB/GPIB Interface.

## Comparison of Scalar and Vector Mixer Cals


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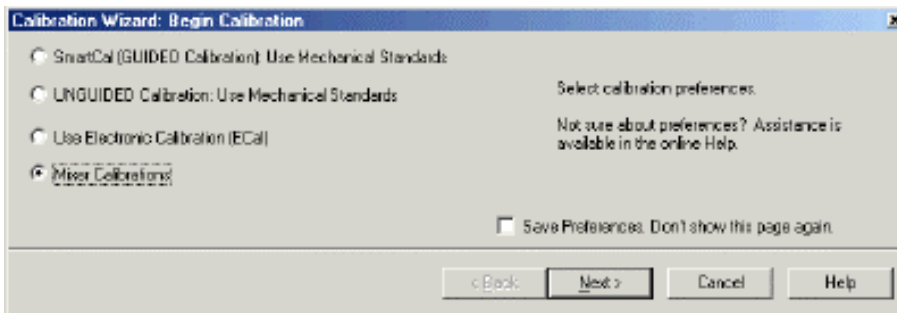
**Note:** Find more information comparing these two mixer calibration types at <http://www.tm.agilent.com>. Click "Library" and use the search function to find the white-paper titled "Comparison of Mixer Characterization Using New Vector Characterization Techniques".

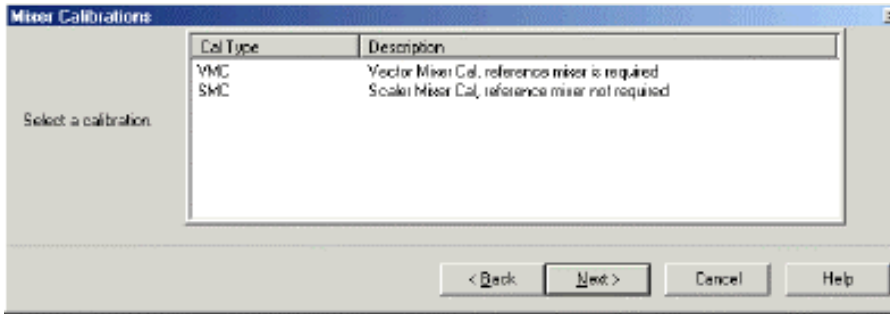
---

## How to Perform an FCA Calibration

Start an FCA calibration as you would any PNA calibration:

1. Click **Calibration**, then **Calibration Wizard**.
2. Then select **Mixer Calibrations**.



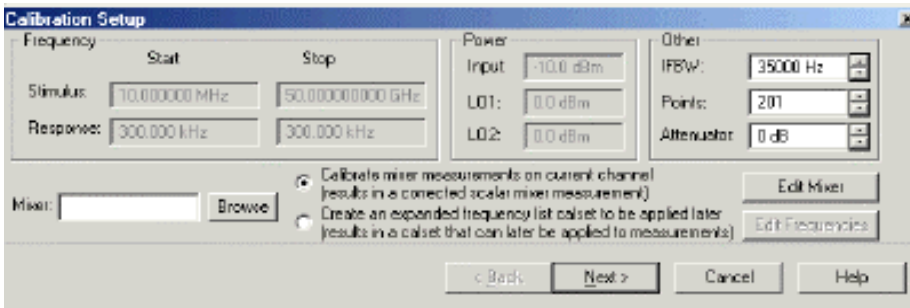


#### Mixer Calibrations dialog box help

Allows you to select a mixer/converter calibration method:

**VMC Vector Mixer Cal** Selects the Vector Mixer Cal.

**SMC Scalar Forward Mixer Cal** Selects the Scalar Mixer Cal.



#### Calibration Setup dialog box help

Allows you to review and change the settings for your mixer calibration.

- To change **Frequency** and **Power** settings click **Edit Mixer**
- To change **Other** settings (IFBW, Points, Attenuator) scroll or type in a new value.

**Mixer** Allows you to load an existing mixer setup file. Click **Browse** and navigate to a file that contains the configuration settings for your mixer.

**Edit Mixer** Displays the Configure Mixer dialog box.

For **Scalar Mixer Calibration ONLY**; (This selection is NOT offered for Vector Mixer Calibration).

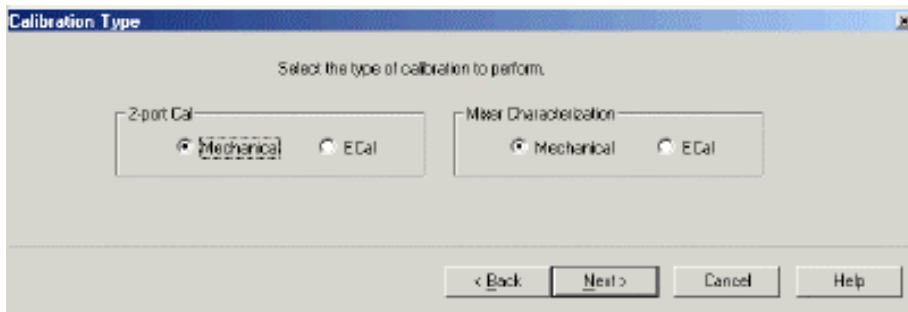
#### **Calibrate mixer measurements on current channel (results in a corrected scalar mixer measurement).**

Allows you to make corrected scalar measurements of your DUT on the current channel. When the calibration is completed, a Cal Set is saved and the PNA automatically creates an SC<sub>21</sub> measurement.

#### **Create an expanded frequency list calset to be applied later (results in a calset that can later be applied to measurements).**

Allows you to select a calibration frequency range that is wider than the frequency range of your DUT. When the calibration is completed, a Cal Set is saved but the PNA does NOT automatically create a measurement. To make a measurement, you must apply the Cal Set to the desired channel and select a measurement. Click **Edit Frequencies** to display the Edit Calibration Setup dialog box where you can expand the frequency range of the calibration beyond the range of your DUT. Learn

more.



**Calibration Type** dialog box help

Allows you to specify either ECal or mechanical calibration.

**Mechanical** Specifies mechanical calibration.

**ECal** Specifies ECal calibration.

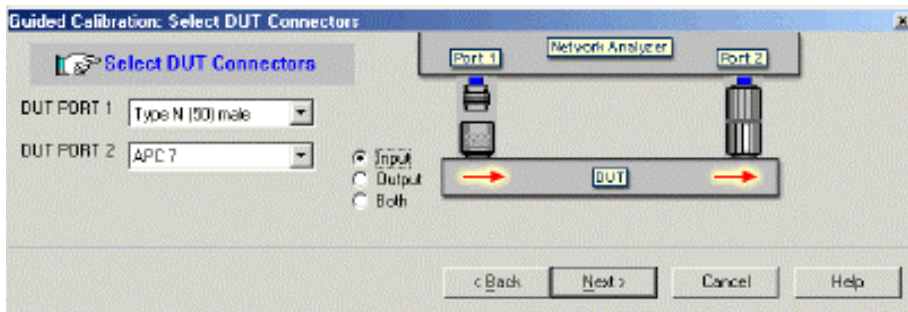
**For VMC ONLY:**

Mixer Characterization

**Mechanical** Specifies mechanical calibration.

**ECal** Specifies ECal calibration.

Learn more about Mixer Characterization



**Select DUT Connectors** dialog box help

Allows you to specify the connector type of each DUT port and, for Scalar Mixer Calibration ONLY, to designate DUT port 1 as "input", "output" or "both".

**DUT Port 1** Specify the connector type of DUT port 1.

**DUT Port 2** Specify the connector type of DUT port 2.

**Note:** 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 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 Calibration kits).
- **Non-insertable** Guided Cal automatically performs an Adapter Removal calibration. This requires that you have an adapter that has the same connectors as the DUT.

#### Scalar Mixer Calibration ONLY:

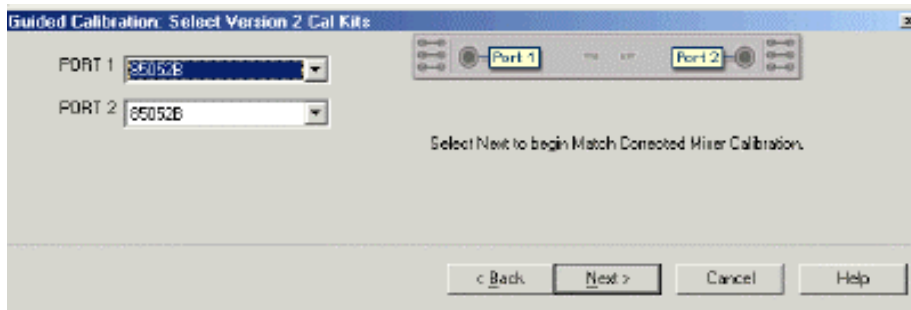
**Input** Forward direction ONLY. Input frequencies are associated with the DUT port that is connected to PNA port 1.

**Output** Reverse direction ONLY. Output frequencies are associated with the DUT port that is connected to PNA port 1.

**Both** Provides Scalar calibration for measurements in both Forward and Reverse directions.

Scalar Mixer Calibrations produce separate Cal Sets for Forward and Reverse directions.

Learn more about Forward and Reverse Scalar Measurements



#### Select 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



#### Measure Calibration Standards dialog box help

Illustrates how to connect the calibration standard specified in the prompt. The illustration will vary depending on which calibration standard you are measuring. The illustration will also vary depending

on whether you are performing a calibration mixer characterization or a full system calibration, and whether your test setup includes a single LO or a dual LO.

**Measure & Next** Measures the mechanical standard and continue to the next calibration step.

**Back** Returns to the previous dialog box.

**Next** Appears only after clicking Back. Allows you to proceed to the next required step. Does NOT make a measurement.

**ReMeasure** Appears only after clicking Back. Allows you to remeasure a standard.

## Create and Apply an FCA Cal Set

You can create an FCA measurement and apply an existing Cal Set. When you apply an FCA Cal Set, be sure to apply the appropriate Cal Type to the FCA measurement. See table below. Learn more about Cal Sets.

**Note:** When applying an existing Cal Set to an FCA measurement, the Mixer Setup must be identical to, or an acceptable subset of, the applied Cal Set. The PNA does NOT automatically make the corrections to the Mixer setup after applying a Cal Set that does not match. If the setup does not match the applied Cal Set, your measurement data will be corrupt.

**For advanced users:** You can calibrate first over a wide frequency range, save the calibration as a Cal Set, then later configure a mixer measurement and apply the Cal Set.

FCA Cal Type	FCA Measurement
SMCFwd (source is Port 1)	SC21 S11 (Input Reflection) S22 (Output Reflection) Incident Power Output Power
SMCRev (source is Port 2)	SC12 S11 (Output Reflection) S22 (Input Reflection) Incident Power Output Power
VMC (source is Port 1)	VC21 S11 S22

## Configure a Mixer

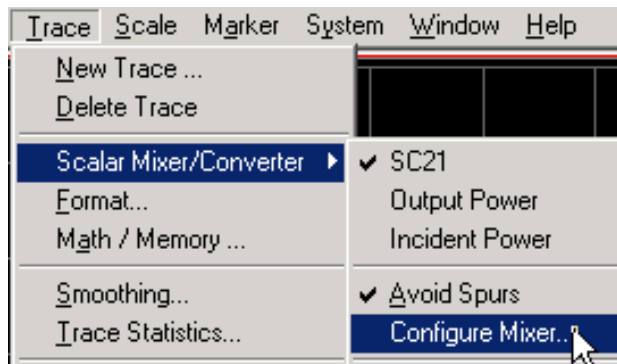
- How to Start the Mixer Setup dialog box
- Learning the Mixer Setup Dialog Box
- Rules for Configuring a Mixer
- Fractional Multiplier Examples

Other Frequency Converter Application topics

**How to start the Mixer Setup dialog box**

Choose any of the following methods:

1. Create an FCA measurement. Then



2. Create an FCA measurement. Then press one of these buttons:

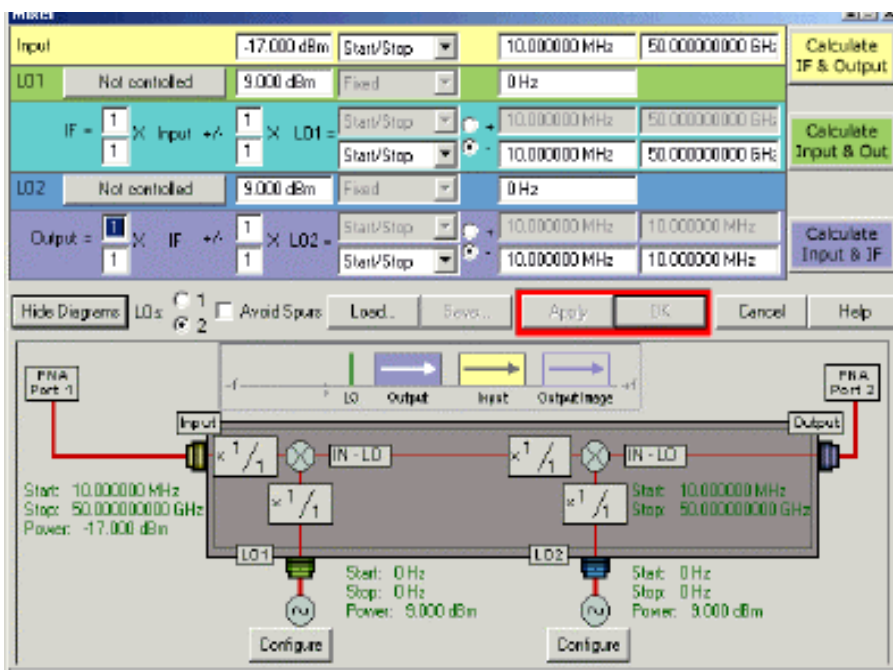


3. Click **Calibration**, then **Calibration Wizard**  
Click **Mixer Calibration**  
Click **Edit Mixer**

Learn more about using the front panel interface

### Mixer Setup dialog box

Click on sections of the image to learn about a setting.



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**Note:** This image shows two LOs.

---

See Fractional Multiplier Examples (below)

<p><b>Mixer Setup</b> dialog box help</p> <p><b>Rules for Using the Mixer Setup Dialog Box</b></p> <p>Red <b>Apply</b> and <b>OK</b> buttons indicate that one or more of the following settings are invalid.</p> <ol style="list-style-type: none"><li>1. The INPUT start frequency can NOT exceed the stop frequency.(The OUTPUT start frequency CAN exceed the stop frequency.)</li><li>2. INPUT or OUTPUT frequencies cannot be outside the range of the PNA</li><li>3. Any combination of Input and LO which results in an Output that sweeps through zero Hz is NOT allowed.</li><li>4. The range for the numerator and denominator of a fractional multiplier is from +1 to +10. Negative values are not allowed.</li></ol> <hr/> <p><b>Note:</b> Throughout the dialog box, the Mixer / converter ports are color coded (Input, LO1, IF1, LO2, Output)</p> <hr/> <p><b>Power</b> Sets the power level of the input signal, and both LO signals.</p> <p><b>Frequency Format</b> Selects the format to specify the frequency information for each signal in your test setup. The Input, IF, and Output frequency information can be specified using start/stop or center/span formats. Return to <b>Mixer Setup</b> image</p> <p><b>Source Configuration Buttons</b> Performs the same function as the configuration buttons on the lower diagram. The current source is displayed on the button label.</p> <p><b>Resulting Frequencies</b> Either sets or calculates the frequency values for each of the signals in your test setup. For example, if you enter the Input frequency range and press the Calculate button adjacent to the Input, the PNA will calculate and display the Output frequencies. Return to <b>Mixer Setup</b> image</p> <p><b>Fractional Multiplier</b> The combination of (numerator / denominator) forms a fractional value that is multiplied by the input and LO frequency ranges (also the IF and LO2 frequency ranges for a test setup with two LOs). These values are used to Calculate the response frequency of the PNA receiver. Use the fractional multipliers to:</p> <ul style="list-style-type: none"><li>• Duplicate the action of harmonic mixers</li><li>• Duplicate the action of multipliers and dividers that may exist in your test setup</li><li>• Tune the PNA receiver frequency to a harmonic of the mixer/converter</li></ul> <p>See Fractional Multiplier examples. Return to <b>Mixer Setup</b> image</p> <p><b>Mixer-Product Selector</b> Determines whether the receivers will tune to the Sum (+) or the Difference (-) of the Input and LO frequencies. Click the adjacent Calculate button after your selection.</p> <p><b>Calculate buttons</b> Calculates frequency information based on your other mixer settings. The mixer port settings next to the Calculate button you press remains fixed. For example, in a 1-LO scenario, specify the Input and LO frequencies, specify + (sum), then click the <b>Calculate</b> button next to the Input. The input remains fixed and the output frequency range is calculated for you. Return to <b>Mixer Setup</b> image</p> <p><b>Hide / Show Diagrams</b> Hides and displays the test setup diagram. Your measurement trace is displayed when the diagram is hidden.</p> <p><b>LOs</b> Click <b>1</b> or <b>2</b> to select the number of external LO sources in your test setup. Measurements of a</p>
---

DUT with an embedded LO are not supported at this time.)

Return to **Mixer Setup** image

**Avoid Spurs** Check to invoke the Avoid Spurs program

**Load** Loads a previously-configured mixer attributes file (.mxr).

**Save** Saves the settings for your mixer/converter test setup to a mixer attributes file (.mxr).

**Apply** Applies the settings for your mixer/converter test setup to the measurement. The mixer setup dialog box remains OPEN. If shaded red, see rules.

Return to **Mixer Setup** image

**OK** Applies the settings for your mixer/converter test setup to the measurement. The mixer setup dialog box CLOSES. If shaded red, see rules.

**Cancel** Closes the mixer setup dialog box and does NOT apply the settings.

**Frequency Diagram:** Provides a graphical display of the frequency information for the signals in the test setup.

- Each signal is color-coded to match the colors in the upper part of the dialog box
- Vertical lines represent a fixed-frequency signal.
- Right-pointing arrows represent signals sweeping UP in frequency.
- Left-pointing arrows represent signals sweeping DOWN in frequency.

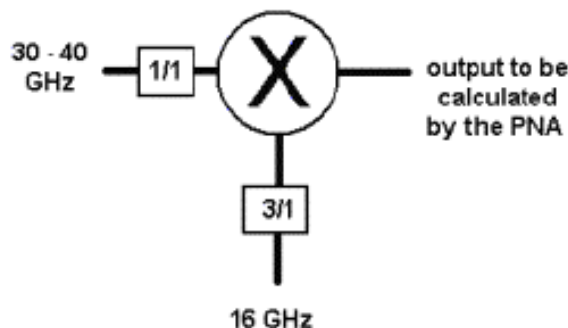
**Configure Source** Displays the External Source Configuration dialog box. To configure your external source with this dialog box, the source must be connected to the PNA with the Agilent 82357 USB/GPIB Interface provided with the Frequency Converter Application (Option 083).

Return to **Mixer Setup** image

## Fractional Multiplier Examples

### Example 1

Use the LO fractional multiplier to replicate the action of the third-harmonic mixer so the PNA can accurately calculate the receiver frequency. The input and LO frequencies are known.



Enter these settings in the **Mixer Setup** dialog box:

- **Input Start Freq: 30 GHz**
- **Input Stop Freq: 40 GHz**
- **LO Fixed Freq: 16 GHz**
- Mixer-Product Selector: - (difference)
- LOs: 1
- LO fractional multiplier: 3/1



- INPUT fractional multiplier: 1/1

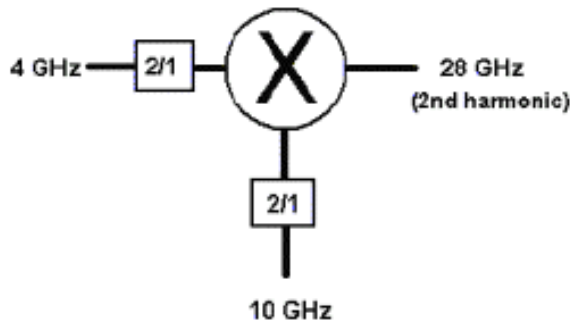
Click **Calculate Output**

Results:

- **Output Start Freq: 18 GHz**
- **Output Stop Freq: 8 GHz**

### Example 2

Use the fractional multipliers to tune the PNA receiver frequency to the second harmonic of the mixer's 14 GHz fundamental output. The input, LO, and output frequencies are known.



Enter these settings in the **Mixer Setup** dialog box:

- **Input Start Freq: 4 GHz**
- **Input Stop Freq: 4 GHz**
- **LO Fixed Freq: 10 GHz**
- Mixer-Product Selector: + (Sum) of the input and LO signals
- LOs: 1
- INPUT fractional multiplier = 2/1
- LO fractional multiplier = 2/1

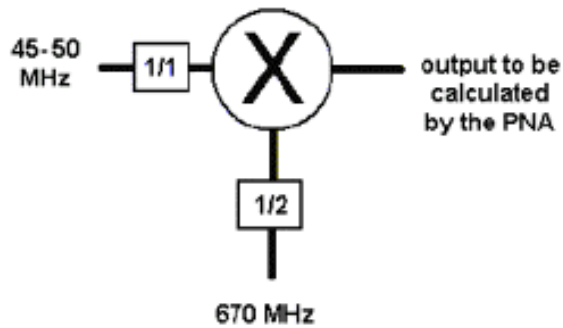
Click **Calculate Output**

Results:

- **Output Start Freq: 28 GHz**
- **Output Stop Freq: 28 GHz**

### Example 3

Use the LO fractional multiplier to replicate the action of the divide-by-two mechanism inside the mixer package. Having done this, the PNA can accurately calculate the receiver frequency. The input and LO frequencies are known.



Enter these settings in the **Mixer Setup** dialog box:

- **Input Start Freq: 45 MHz**
- **Input Stop Freq: 50 MHz**
- **LO Fixed Freq: 670 MHz**
- Mixer-Product Selector: + (Sum) of the input and LO signals
- LOs: 1
- INPUT fractional multiplier = 1/1
- LO fractional multiplier = 1/2

Click **Calculate Output**

Results:

- **Output Start Freq: 380 MHz**
- **Output Stop Freq: 385 MHz**

## Scalar Mixer Calibration

---

Scalar Mixer Calibration is a new calibration method for frequency converting devices such as mixers and converters. It provides unparalleled accuracy for measurements of scalar conversion loss/gain.

- Features
- Equipment Required
- How to Perform Scalar Mixer Calibration
  - Overview
  - Expanded SMC Calibration
  - Detailed Procedure

To better understand how error terms are calculated, see [Scalar Mixer Calibration Theory of Operation](#)

Not sure if your PNA is equipped with options? Here's how to identify your PNA.

1. On the PNA menu, click **Help**.
  - Or, on the front panel, press **Menu/Dialog**. Next, in the **NAVIGATION BLOCK**, press

the Left Tab several times to move to **Help**. Press **Click**.

2. Click **About Network Analyzer**.

- Or, in the front panel **NAVIGATION BLOCK**, press the Down Arrow several times to move to **About Network Analyzer**. Press **Click**.

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## Other Frequency Converter Application topics

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### Features

- Best amplitude accuracy of the mixer or converter calibration choices offered with Option 083
- Both forward-direction and reverse-direction conversion loss measurements are possible.
- For amplitude-only conversion loss/gain measurements, corrects for the mismatch between:
  - PNA source and the power sensor
  - DUT input and the PNA source
  - DUT output and the PNA receiver
- For absolute power measurements, corrects for the mismatch between the PNA source and the power sensor.
- Does NOT require:
  - a reference mixer
  - a calibration mixer
  - PNA Option 081 (reference channel transfer switch)

### Equipment Required

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**Note:** All GPIB test equipment (Ex: sources, power meter) must be connected to the PNA using the Agilent 82357A USB/GPIB Interface.

---

- mechanical calibration kit or ECal module (compatible with the E836xB and E8361A PNA)
- Agilent 82357A USB/GPIB Interface (provided with the Frequency Converter Application, Option 083)
- external power meter and sensor
  - E441x series Power Meters
  - 438A Power Meter
  - 437B Power Meter
  - "generic" - develop your own custom driver
- external source (if your DUT requires an LO source)
  - 836x series Synthesized Signal Generators
  - 837x series Synthesized Signal Generators
  - ESG series RF Signal Generators
  - PSG series uW Signal Generators
  - 8648 series RF Signal Generators

- o "generic" - develop your own custom driver

---

**Note:** Option 083 (frequency-converter application) can control a maximum of two external sources.

---

Avoid expensive repairs to your PNA and devices. Read Electrostatic Discharge Protection.

## How to Perform Scalar Mixer Calibration

### Overview

The following is an overview of the Scalar Mixer Calibration. For more information see SMC Theory. See a detailed procedure below.

1. Perform two 2-port calibrations: one over the INPUT frequencies and one over the OUTPUT frequencies of the DUT. (If your DUT is a linear device, the calibration uses only the INPUT frequency range.) Use either a mechanical calibration kit or an ECal module.
2. Connect a power meter sensor to PNA Port 1. At each step of the input and output frequency, the PNA measures:
  - input match of the power sensor
  - source power of the PNA

During the DUT measurement process, the PNA applies the results of the calibration to reduce measurement errors.

### Detailed Procedure

Connect the Agilent 82357A USB/GPIB Interface (provided with Option 083) to the power meter GPIB connector and one of the PNA USB connectors. Learn how.








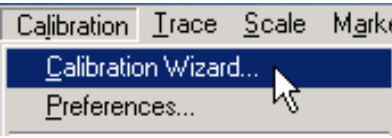
### Configure your power meter (if not already done).

1. On the PNA **Calibration** menu, point to **Power Calibration**, then click **Source Power Cal**
2. Click **Edit**. Enter the GPIB address of your power meter. Learn more about Power Meter Settings

### Begin the Calibration Wizard.

**How to start Calibration Wizard**

Use one of the following methods:

-  +    
-  + 
- 

Learn more about using the front panel interface

In the Calibration Wizard: Begin Calibration dialog box, select **Mixer Calibrations**.

In the Mixer Calibrations dialog box, select **Scalar Mixer Calibration**.

In the Calibration Setup dialog box, review the frequency, power, and other (Ex: IF bandwidth) settings for the mixer calibration.

To calibrate over an expanded frequency range, click **Create an expanded frequency list calset to be applied later**. then enter the expanded frequency ranges in the Frequencies dialog box.

### Expanded SMC Calibration

You can save calibration time by performing an SMC calibration over a wide frequency range. After this calibration is saved to a Cal Set, it can be later applied to other Scalar measurements with the same **physical setup**.

An SMC calibration does not require that the calibration input and output frequencies match the current mixer IF frequency calculations. For example, you can perform an SMC calibration over the following frequencies:

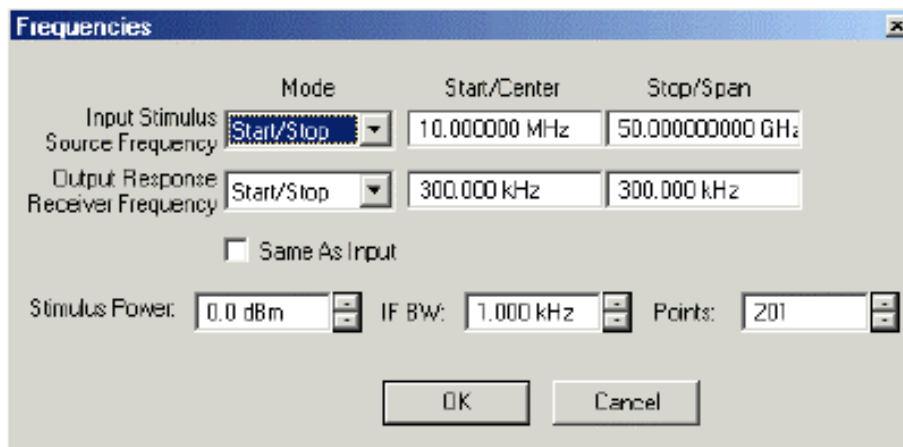
- Input frequency range: 10 MHz to 20 GHz
- Output frequency range: 10 MHz to 20 GHz.

Once this calibration is performed, you can save and apply it to any SMC measurement with Input and Output frequencies between 10 MHz and 20 GHz that share the same physical measurement setup.

Scalar Measurements save separate Cal Sets in the Forward and Reverse directions. A forward Cal Set cannot be applied to a Reverse measurement. Learn more about Forward and Reverse Scalar measurements.

To do this, in the Calibration Setup dialog box, select **Create an expanded frequency list calset to be applied later**.

For high measurement accuracy, use a high number of data points. Learn more about Interpolation Accuracy.



#### Frequencies dialog box help

Allows you to edit your calibration frequency range so that it is wider than the frequency range of your DUT.

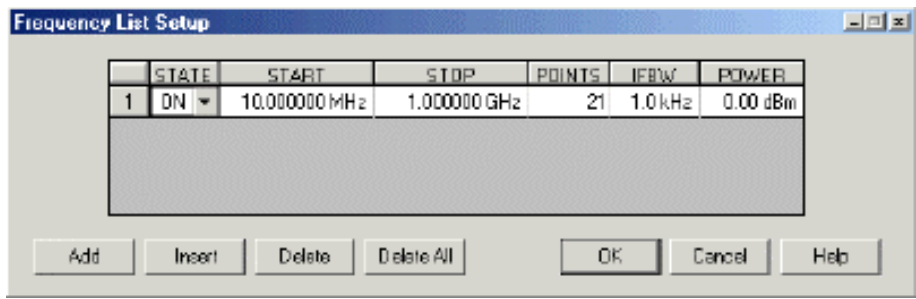
**Mode** Selects the format to specify the frequency information in your test setup. Frequency information can be specified using start/stop, center/span, fixed, or list formats.

**Start/Center** Allows you to enter the start frequency (for Start/Stop mode) or the center frequency (for Center/Span mode).

**Stop/Span** Allows you to enter the stop frequency (for Start/Stop mode) or the frequency span (for Center/Span mode).

**Same As Input** Select this checkbox to set the output response frequency the same as the input

stimulus frequency.



**Frequency List Setup** dialog box help

Allows you to create a frequency list of sub-sweeps called segments. For more information, see Segment Sweep.

**Insert** 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** removes the selected segment

**Delete All** removes all segments

**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 (**KHz**, **Mhz**, **GHz**). 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 (**KHz**, **Mhz**, **GHz**). 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.

**IFBW** Sets the IF Bandwidth for the segment.

**POWER** Sets the power level for the segment.

**TIME** Sets the Sweep time for the segment.

In the Calibration Type dialog box, specify either ECal or mechanical calibration.

**If using ECal:**

In the Advanced Settings dialog box, choose the settings for your ECal calibration.

In the Electronic Calibration Steps dialog box, follow the instructions for using the ECal module.

**If using mechanical calibration:**

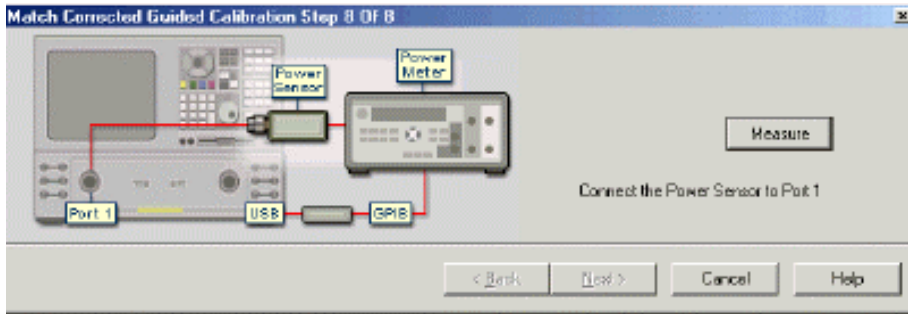
In the Select DUT Connectors dialog box, select the connectors for port 1 and port 2 and designate port 1 as input, output, or both.

In the Select Cal Kits dialog box, select the calibration kit used with each measurement port.

In the Measure Calibration Standards dialog box, connect the appropriate standard, and then click Measure. The PNA measures the mechanical standard and then automatically continues to

the next step.

**For both ECal and mechanical calibration:**



**Scalar Mixer Calibration Power Cal dialog box help.**

Allows you to perform the power-meter section of the calibration.

Connect your power sensor to the port shown in the diagram. The diagram will vary depending if port 1 was designated as "output" "input" or "both" in the Select DUT Connectors dialog box.

begins the power meter calibration on Port 1, 2, or both.

**Measure** Begins the power meter measurements and then continues to the next step.

**Back** Returns to the previous dialog box.

**Next** Continues to the next calibration step. Does NOT make a measurement.

In the Standards Measured dialog box, select **Next** to complete the calibration and save the calset. Select **Back** to remeasure standards.

In the Calibration Completed dialog box click **No. Finish now** to exit the Calibration Wizard. If you want to save the instrument state, click **Yes** and then **Next**.

In the Save Instrument state dialog box, click **Save As** to name and save the instrument state in a .cst file that points to the cal set. Click **Autosave** to save the instrument state in a .cst file using an automatically generated filename that points to the cal set. Click **Finish** when done.

## Vector Mixer Calibration

Vector Mixer Calibration is a new calibration method for frequency converting devices such as mixers and converters. It provides unparalleled accuracy for measurements of relative phase and absolute group delay.

- Features
- Equipment Required
- How to Perform Vector Mixer Calibration
- Apply a Saved Cal Set

To better understand how error terms are calculated, see Vector Mixer Calibration Theory of Operation

Find more information on Vector Mixer Calibration at <http://www.tm.agilent.com>. Click "Library"

and use the search function to find the white-paper titled "Novel Method for Vector Mixer Characterization and Mixer Test System Vector Error Correction".

Not sure if your PNA is equipped with options? Here's how to identify your PNA.

1. On the PNA menu, click **Help**.
  - Or, on the front panel, press **Menu/Dialog**. Next, in the **NAVIGATION BLOCK**, press the Left Tab several times to move to **Help**. Press **Click**.
2. Click **About Network Analyzer**.
  - Or, in the front panel **NAVIGATION BLOCK**, press the Down Arrow several times to move to **About Network Analyzer**. Press **Click**.

---

## Other Frequency Converter Application topics

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### Features

- The only calibration choice for **phase** measurements offered with Option 083 (frequency converter application).
- Corrects the measurements of both reciprocal and non-reciprocal mixers or converters-under-test.
- Forward-direction conversion measurements ( $VC_{21}$ ) only.
- Corrects for the input and output mismatch effects of the mixer or converter-under-test.
- Does NOT require:
  - a filter on the output port of the mixer or converter-under-test
  - attenuators on the input and output ports of the mixer or converter-under-test (to improve mismatch)

### Equipment Required

---

**Note:** When using this measurement and any other functions of the Frequency Conversion Application (Option 083), all GPIB test equipment (Ex: sources, power meter) must be connected to the PNA using the Agilent 82357A USB/GPIB Interface.

---

- **Cal Kit** - Mechanical or ECal module (compatible with the E836xB or E8361A PNA)
- **Agilent 82357A** USB/GPIB Interface (provided with the Frequency Converter Application, Option 083)
- **Calibration mixer/filter** combination that meets the following requirements:
  - The mixer must be reciprocal. This means that it has the same magnitude and phase response in the up-converting and down-converting directions ( $C_{21} = C_{12}$ ).
  - If the Input and Output frequency ranges are overlapping, the mixer must have Input to Output Isolation greater than 10 dB more than the conversion loss in the overlapping range.
  - The filter must reject the undesired mixing product at the output of the mixer. For example, if you have selected the **Input + LO** mixing product in the mixer setup, you must filter the **Input - LO** mixing product when characterizing the calibration mixer. If this is not practical, see further details about the Reflection Measurements of the Calibration Mixer/Filter.
- **Reference mixer** whose signal is synchronously converted with the device under test. This means the reference mixer and the mixer or converter-under-test use LO signals in a constant frequency and phase relationship.



- **External source**
  - 836x series Synthesized Signal Generators
  - 837x series Synthesized Signal Generators
  - ESG series RF Signal Generators
  - PSG series uW Signal Generators
  - 8648 series RF Signal Generators
  - "generic" - user supplied text string

**Note:** Option 083 (frequency converter application) can control a maximum of two external sources.

Avoid expensive repairs to your PNA and devices. Read Electrostatic Discharge Protection.

## How to Perform Vector Mixer Calibration

### Overview

The following is an overview of the Vector Mixer Calibration. For more information see VMC Theory.

The first three steps characterize the calibration mixer that is used as the THRU standard during the calibration process.

1. Perform two 2-port calibrations over the INPUT and OUTPUT frequency ranges of the DUT. Use either a mechanical calibration kit or an ECal module.
2. Characterize (measure) the input and output match of the calibration mixer/filter combination with the external LO connected and the output terminated with an open, short, and load.
3. Connect a reference mixer/filter combination between the Source Out and Rcvr R1 front-panel connectors. Connect the output port of the calibration mixer/filter combination to PNA Port 2 (or at the end of the cable attached to the port).
4. With the PNA in frequency offset mode, use the calibration mixer/filter combination as the THRU calibration standard in a  $C_{21}$  measurement.
5. The PNA calculates the error terms necessary to make corrected phase measurements of your mixer/converter under test.








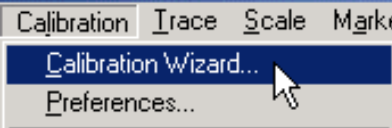
### Detailed Procedure

Connect the Agilent 82357A USB/GPIB Interface (provided with Option 083) to the power meter GPIB connector and one of the PNA USB connectors. Learn how.

Begin the calibration wizard.

**How to start Calibration Wizard**

Use one of the following methods:

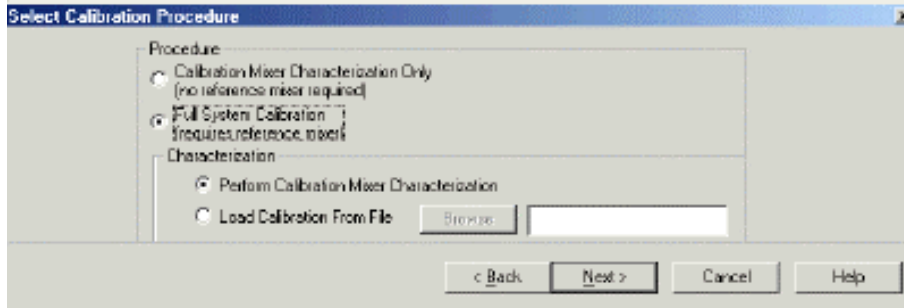
-  +    
-  + 
- 

Learn more about using the front panel interface

In the Calibration Wizard dialog box, select **Mixer Calibrations**.

In the Mixer Calibrations dialog box, select **Vector Mixer Calibration**.

In the Calibration Setup dialog box, review the frequency, power, and other (Ex: IF bandwidth) settings for the mixer calibration. To load settings from a file, click **Browse**. To edit settings and to configure your external LO source, click **Edit Mixer**.



#### Select Calibration Procedure dialog box help

Allows you to perform calibration mixer characterization only or perform a full system calibration.

#### What is Calibration Mixer Characterization?

For a brief explanation, see Overview.

For a detailed explanation see Vector Mixer Calibration Theory of Operation.

#### Procedure

**Calibration Mixer Characterization Only** Performs a 2-port calibration and characterizes the calibration mixer. Does not require a reference mixer. Choose this if you want to save the mixer characterization data to a file that will be downloaded later as part of a full system calibration.

**Full System Calibration** Performs a full system calibration. Requires a reference mixer.

**Characterization** - Only available if performing a Full System Calibration

**Perform calibration mixer characterization** Characterizes the calibration mixer. Choose this selection if you do NOT have the mixer characterization data on file.

**Load characterization from file** Loads calibration mixer characterization data from your file. Use the **Browse** function to locate the file.

In the Calibration Type dialog box, specify either ECal or mechanical calibration.

#### If using ECal:

In the Advanced Settings dialog box, choose the settings for your ECal calibration.

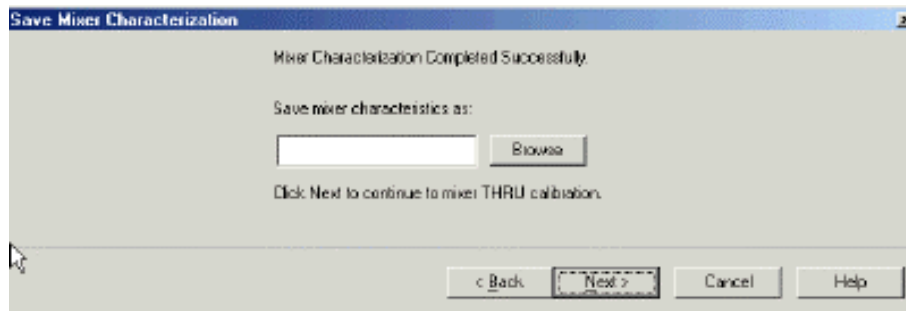
In the Electronic Calibration Steps dialog box, follow the instructions for using the ECal module.

#### If using mechanical calibration:

In the Select DUT Connectors dialog box, select the connectors for port 1 and port 2.

In the Select Version 2 Cal Kits dialog box,, select the calibration kit used with each measurement port.

In the Measure Calibration Standards dialog box, connect the appropriate standard, and then click Measure. The PNA measures the mechanical standard and then automatically continues to the next step.



<b>Save Mixer Characterization</b> dialog box help
Allows you to save the characterization data of your calibration mixer.
<b>Browse</b> Navigate to the location where you want to save the characterization data of your calibration mixer. Either use the default file name or enter a custom file name.
<b>Next</b> Saves the mixer characterization file and continues with the next step in the full system calibration routine.
<b>Finish</b> Replaces <b>Next</b> if you are only characterizing the calibration mixer instead of performing a full system calibration. Saves the mixer characterization file and exits the mixer characterization routine.

**If performing a full system calibration:**

In the Standards Measured dialog box, select **Next** to complete the calibration and save the Cal Set. Select **Back** to remeasure standards.

In the Calibration Completed dialog box, click **No. Finish now** to exit the Calibration Wizard. If you want to save the instrument state, click **Yes** and then **Next**.

In the Save Instrument State dialog box, click **Save As** to name and save the instrument state in a .cst file that points to the cal set. Click **Autosave** to save the instrument state in a .cst file using an automatically generated filename that points to the cal set. Click **Finish** when done.

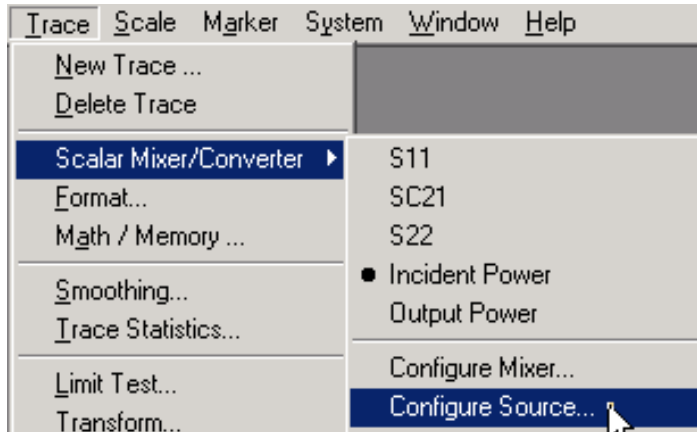
**Apply a Saved Cal Set**

You can calibrate first over a wide frequency range, then later configure a mixer measurement and apply the calibration. [Learn more.](#)

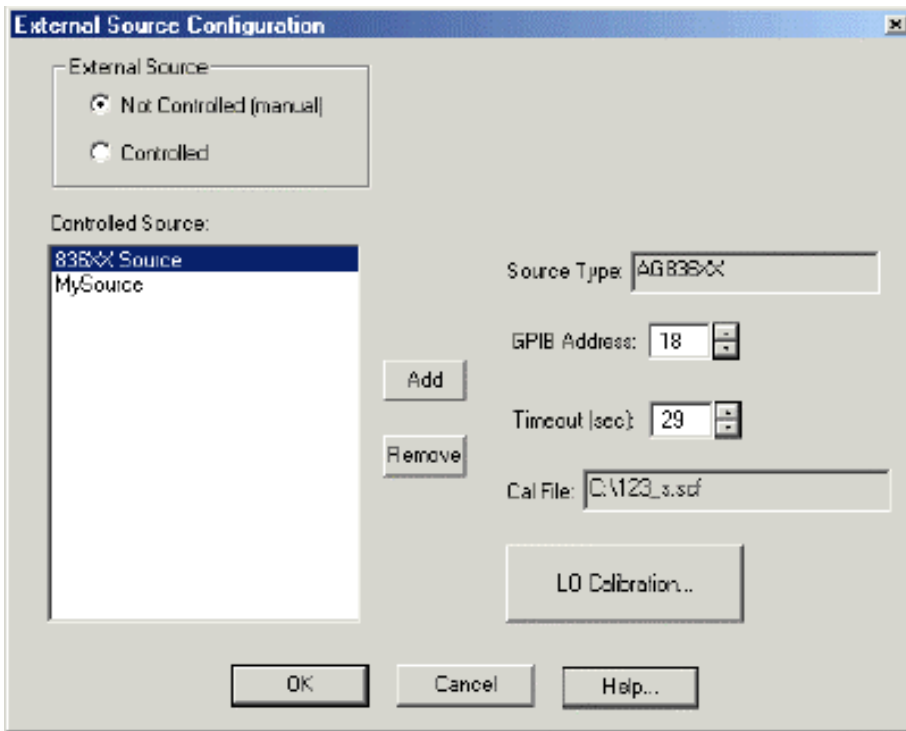
## Configure an External LO Source

You can configure a LO source to be used when making either SCALAR or VECTOR Frequency Converter Application (option 083) measurements.

<b>How to Configure an External LO Source</b>
1. Create an FCA measurement
2. Then



If a Vector Measurement is active, this selection will look slightly different.  
 Learn more about using the front panel interface



**External Source Configuration** dialog box help

Allows you to remotely configure your external source(s).

**External Source Configuration**

**Not Controlled (manual)** Assigns manual control of the external source via its front panel.

**Controlled** Assigns remote control of the external source to the PNA via the GPIB interface.

**Add** Displays the Add New Source dialog box.

**Remove** Removes an external source from your setup.

**Source Type** Shows the model number of the external source that is selected in the displayed

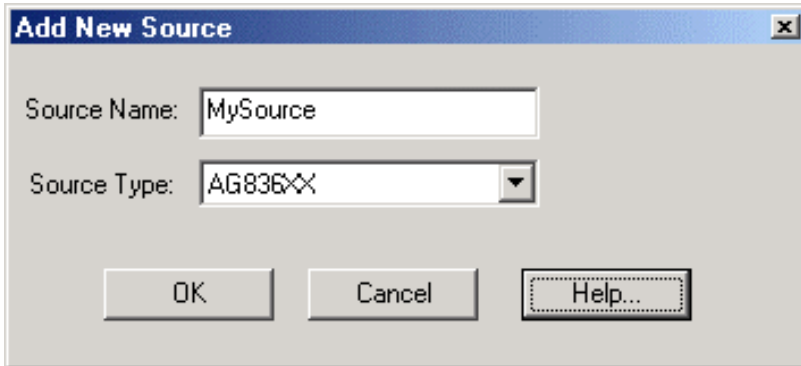
list.

**GPIB Address** Sets the GPIB address of the selected external source.

**Timeout (sec)** Sets a time limit for the source to make contact with the PNA. If this time limit is exceeded, the PNA stops the measurement procedure and displays a diagnostic-type error message. If this occurs, check the connections of your PNA and source.

**Cal File:** Displays the calibration file that is in use with the selected external source.

**LO Calibration** Displays the LO Calibration dialog box.



#### **Add New Source** dialog box help

Allows you to add an external source. The new source appears in the list of sources displayed in the External Source Configuration dialog box.

**Source Name** Allows you to enter a name for your source.

**Source Type** Allows you to select a source type from the scrolling list.

To use an Generic external source (not listed) Select **AGGeneric**

Learn how to control the Generic source remotely.

### **Controlling a Generic Source**

Control of an unlisted "Generic" source is accomplished through code written using Notepad and saved as an .rcm file.

A blank Notepad page is presented automatically the first time that you create a Generic controlled source. To edit the file after the first time, you must open Notepad and then open the file in the following rcm folder:

**C:\Program Files\Agilent\Network Analyzer\Documents\rcm**

The PNA always makes a backup copy of the .rcm file.

#### **Generic Source Control Syntax**

```
string <command type> "<command>"
```

```
/* comments begin and end with a star and forward slash */
```

The following is a list of commands types and comments:

**CMD\_OPC** Operation Complete? .

**CMD\_Preset** Presets the source

**CMD\_CWFrequency** Sets CW Frequency to value in Mixer Setup dialog

**CMD\_FreqSweepMode** Sets source sweep mode

**CMD\_Power** Sets source power to value in Mixer Setup dialog

**CMD\_PowerState** Turns Power ON or OFF

The following examples control an Agilent 8360 source:

```
string CMD_OPC "*OPC" /*The question mark is not required */
```

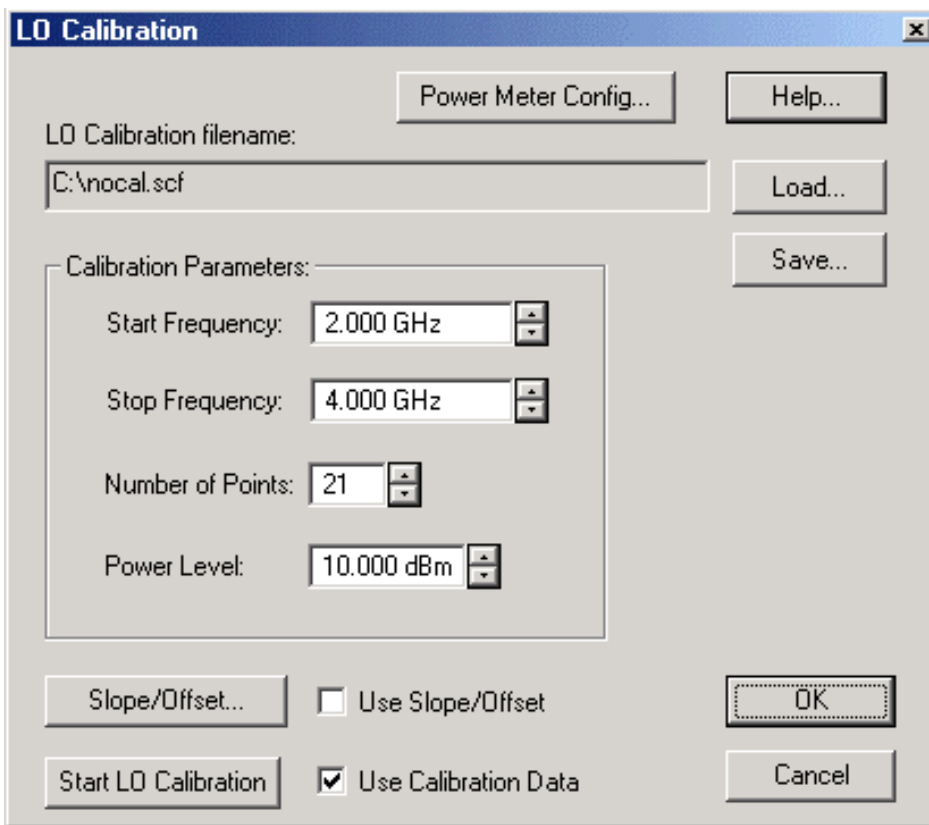
```
string CMD_Preset "*RST"
```

```
string CMD_CWFrequency "FREQ: CW"
```

```
string CMD_FreqSweepMode "FREQ: MODE CW"
```

```
string CMD_Power "POW"
```

```
string CMD_PowerState "POW: STAT"
```



#### **LO Calibration** dialog box help

Allows you to select the calibration settings for your external source. Also, you can load, perform, and save an LO calibration, set the slope/offset, and configure your power meter,.

#### **Calibration Parameters**

**Start Frequency** Sets the start frequency for the LO calibration.

**Stop Frequency** Sets the stop frequency for the LO calibration.

**Number of Points** Sets the number of data points that the power meter measures in the

frequency range of the LO calibration.

**Power Level** Sets the power level for the LO calibration.

**Slope/Offset** Displays the Slope/Offset dialog box.

**Use Slope/Offset** Check to apply the slope/offset settings to your external source. Using the slope/offset settings is a faster (but less thorough) way to improve LO accuracy than performing an LO calibration. These settings can be used in addition to an LO calibration. For example, if you add an adapter in your LO path, you can use the slope/offset settings to compensate for the effects of the adapter rather than repeat the LO calibration.

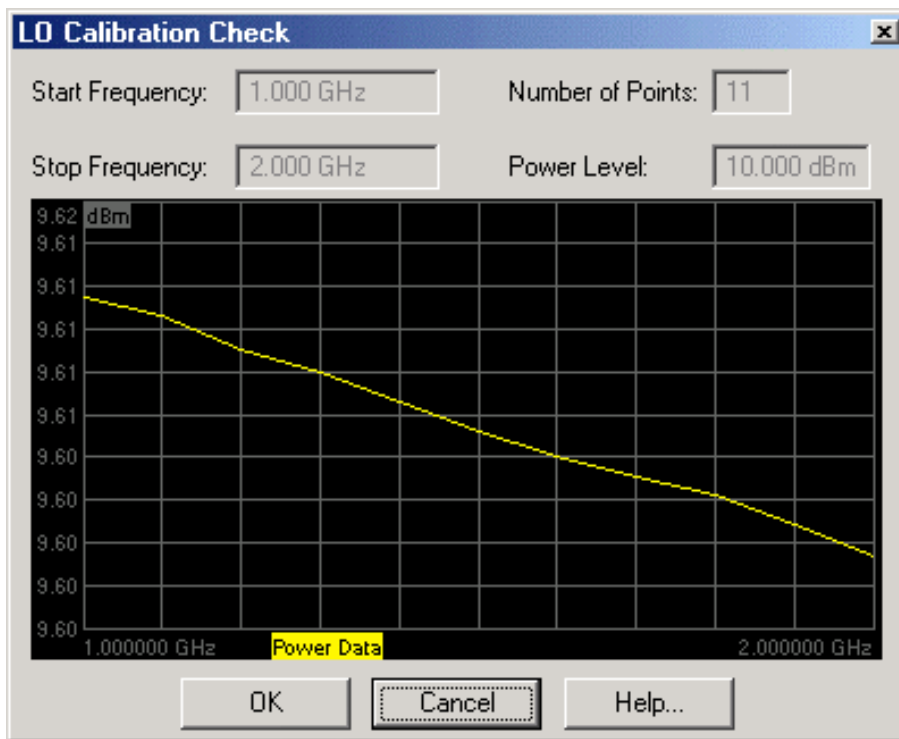
**Start LO Calibration** Launches the LO Calibration Check dialog box.

**Use Calibration Data** Select this checkbox to use the calibration data to correct your external source. The calibration data may come from a source calibration file (.scs) that you have loaded, or from a new LO calibration.

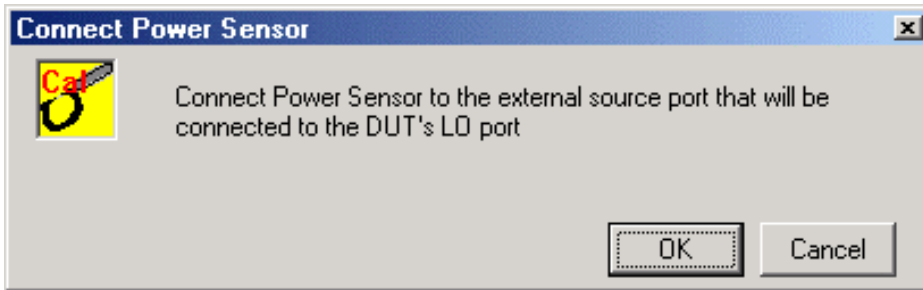
**Power Meter Config** Displays the Power Meter Settings dialog box.

**Load** Loads a source calibration file (.scf) of your choice.

**Save** Saves your LO calibration data in a source calibration file (.scf).



When the above screen appears, the following prompt also appears:

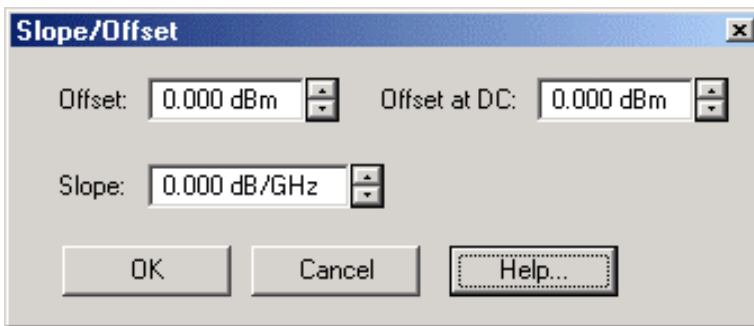


This means: Connect the power sensor to the external source connector at the point where it mates to the input of the mixer (after cables and other components).

**LO Calibration Check** dialog box help

Allows you to view the power calibration sweep. The text boxes are for information only; they can NOT be edited in this dialog box.

You should see a very flat response with no spikes or power holes. The display Autoscales after the sweep completes. Click **OK** after an acceptable sweep completes.



**Slope/Offset** dialog box help

Allows you to select the power slope and offset settings for the calibration of your external LO source.

**Offset** Sets the amount of offset power applied to each measurement point of the LO calibration frequency range. This power is offset from the power setting of the Slope feature.

**Offset at DC** Sets the amount of offset power applied at DC.

**Slope** Allows you to set the power slope (dB)/GHz. Compensates for cable and test fixture power loss by increasing the PNA output power over frequency.

**Power Meter Settings** See Source Power Calibration

**Sensors** See Source Power Calibration

## Mixer Measurement Theory of Operation

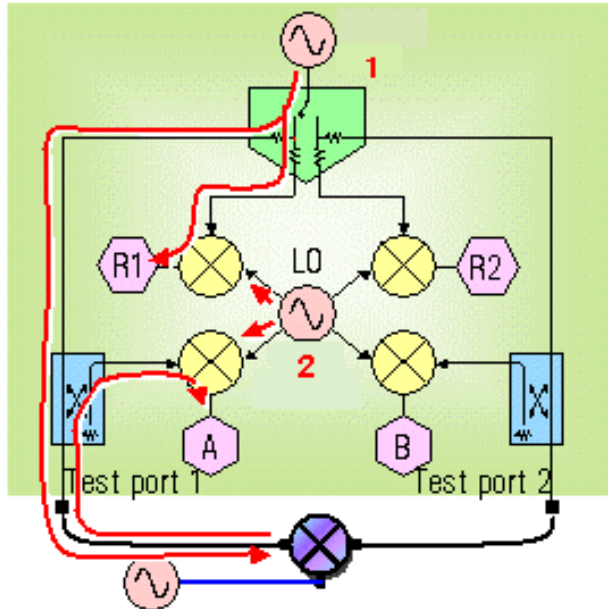
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- Scalar Mixer Measurement: Theory of Operation
- Vector Mixer Measurement: Theory of Operation

### Theory of Operation: $SC_{21}$ Measurement

#### Measurement Sweep 1, Input Reflection

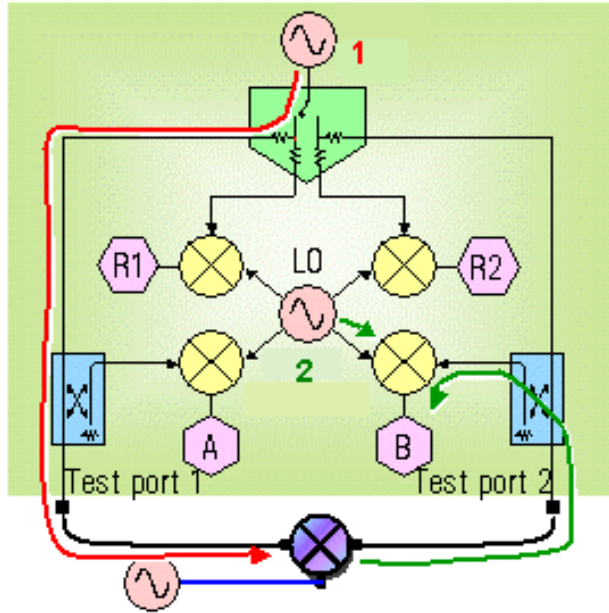


1: Internal source tuned to DUT input

2: Internal LO tuned to DUT input

- The internal source is set to the mixer/converter input frequency.
- The analyzer is NOT in frequency offset mode. The internal LO and all receivers are tuned to the mixer/converter input frequency.
- Absolute-power measurements are made at the A and R1 receivers.
- A corrected  $S_{11}$  measurement ( $A/R1$ ) is performed. The  $S_{11}$  value is used to compensate for the input mismatch between the mixer/converter and the analyzer. This mismatch correction factor is part of the equation for calculating  $C_{21}$  (conversion loss/gain).

#### Measurement Sweep 2, Forward Transmission

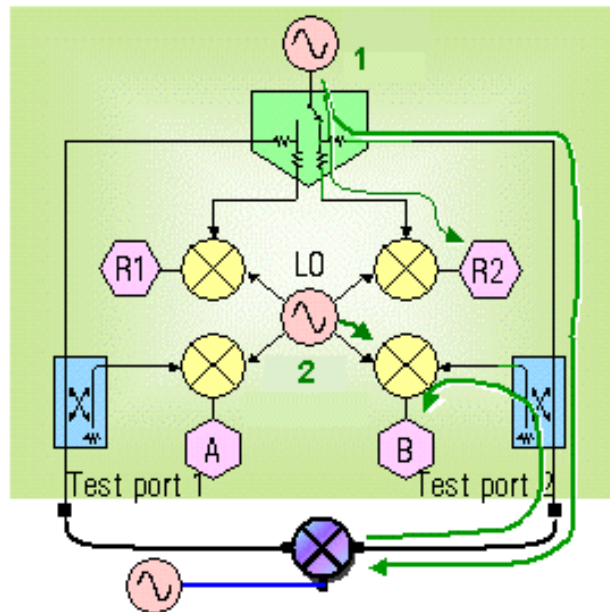


1: Internal source tuned to DUT input

2: Internal LO tuned to DUT output

- The internal source is set to the mixer/converter input frequency.
- Since the analyzer is in frequency offset mode, the internal LO and all receivers are tuned to the mixer/converter output frequency.
- An absolute-power transmission measurement is automatically made at the B receiver. The B value is used in the B/R1 ratio that, when corrected, results in the  $C_{21}$  value (conversion loss/gain).

### Measurement Sweep 3, Output Reflection



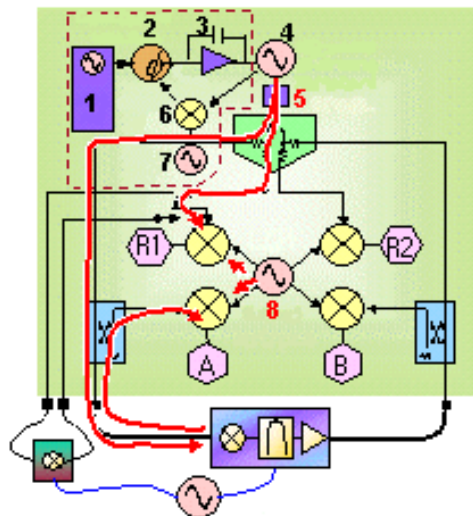
1: Internal source tuned to DUT input

2: Internal LO tuned to DUT output

- The internal source is set to the mixer/converter output frequency.
- The analyzer is NOT in frequency offset mode. The internal LO and all receivers are tuned to the mixer/converter output frequency.
- Absolute-power measurements are made at the B and R2 receivers.
- A corrected  $S_{22}$  measurement (B/R2) is performed. The  $S_{22}$  value is used to compensate for the output mismatch between the mixer/converter and the analyzer. This mismatch correction factor is part of the equation for calculating  $C_{21}$  (conversion loss/gain).
- The analyzer's Frequency Converter Application program uses the error terms in the "Scalar Mixer Calibration Final Error Model" and measurement values to calculate the  $C_{21}$  value (conversion loss/gain).

### Theory of Operation: $VC_{21}$ Measurement

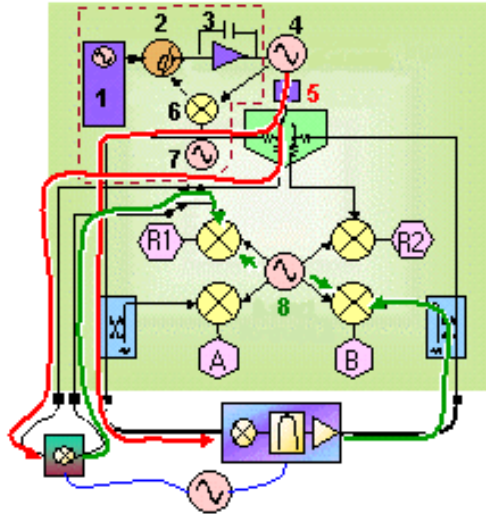
#### Measurement Sweep 1, Input Reflection



Item	Description	Item	Description
1	8.33 MHz reference	5	Multipliers (2, 4, 8), tuned to input
2	Offset phase-lock loop	6	Offset Rx
3	$V_{tune}$	7	Offset LO
4	YIG source (3-10 GHz)	8	LO, tuned to input

- The internal source is set to the mixer/converter input frequency.
- The analyzer is NOT in frequency offset mode. The internal LO and all receivers are tuned to the mixer/converter input frequency.
- Absolute-power measurements are made at the A and R1 receivers.
- A corrected  $S_{11}$  measurement (A/R1) is performed. The  $S_{11}$  value is used to compensate for the input mismatch between the mixer/converter and the analyzer. This mismatch correction factor is part of the equation for calculating  $C_{21}$  (conversion loss/gain).

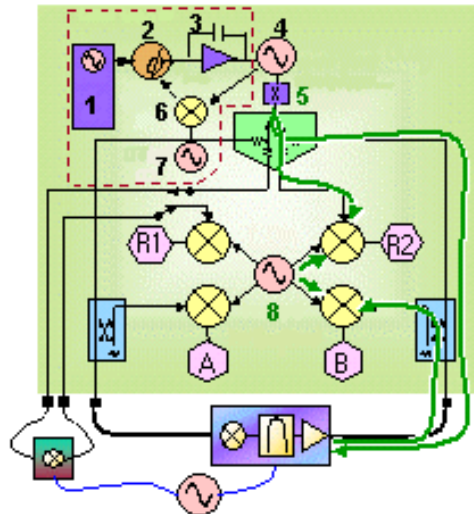
#### Measurement Sweep 2, Forward Transmission



Item	Description	Item	Description
1	8.33 MHz reference	5	Multipliers (2, 4, 8), tuned to input
2	Offset phase-lock loop	6	Offset Rx
3	$V_{\text{tune}}$	7	Offset LO
4	YIG source (3-10 GHz)	8	LO, tuned to output

- The internal source is set to the mixer/converter input frequency.
- Since the analyzer is in frequency offset mode, the internal LO and all receivers are tuned to the mixer/converter output frequency.
- The reference mixer receives the same input and external LO as the mixer/converter, allowing receiver R1 to measure the output frequency.
- Absolute-power measurements are made at the B and R1 receivers.
- The B and R1 values are used in the  $B/R1$  ratio that, when corrected, results in the  $C_{21}$  value (conversion loss/gain).

### Measurement Sweep 3, Output Reflection



Item	Description	Item	Description
------	-------------	------	-------------

1	8.33 MHz reference	5	Multipliers (2, 4, 8), tuned to output
2	Offset phase- lock loop	6	Offset Rx
3	$V_{\text{tune}}$	7	Offset LO
4	YIG source (3- 10 GHz)	8	LO, tuned to output

- The internal source is set to the mixer/converter output frequency.
- The analyzer is NOT in frequency offset mode. The internal LO and all receivers are tuned to the mixer/converter output frequency.
- Absolute-power measurements are made at the B and R2 receivers.
- A corrected  $S_{22}$  measurement (B/R2) is performed. The  $S_{22}$  value is used to compensate for the output mismatch between the mixer/converter and the analyzer. This mismatch correction factor is part of the equation for calculating  $C_{21}$  (conversion loss/gain).
- The analyzer's Frequency Converter Application program uses the error terms in the "Vector Mixer Calibration Final Error Model" and measurement values to calculate the  $C_{21}$  value (conversion loss/gain).

## Mixer Calibration Theory of Operation

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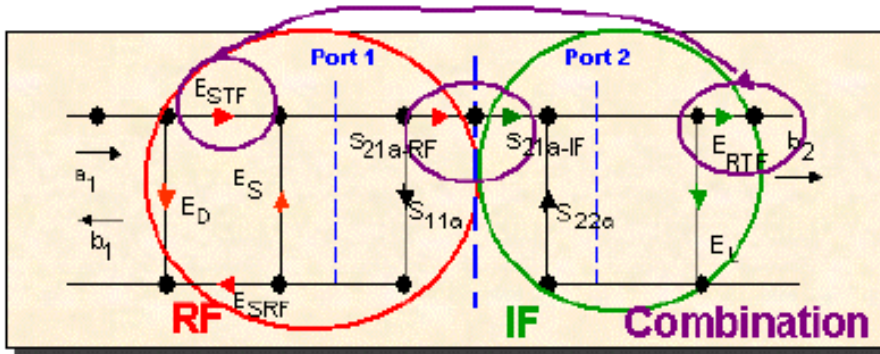
- Scalar Mixer Calibration: Theory of Operation
- Vector Mixer Calibration: Theory of Operation

### Scalar Mixer Calibration: Theory of Operation

You can easily perform a Scalar Mixer Calibration by following the prompts in the dialog boxes of the calibration procedure. This topic can help you better understand the details of the procedure. This topic does NOT contain additional steps required for the calibration.

### How Scalar Mixer Calibration Corrects Conversion Loss/Gain Measurements

You can NOT use a traditional 2-port calibration to provide error correction for a conversion loss/gain measurement. This is because the mixer or converter stimulus (input) and response (output) signals are at **different** frequencies. Scalar Mixer Calibration corrects for the same systematic error terms as the 2-port model by using a new calibration error model and equations. As illustrated below, the Scalar Mixer Calibration error model uses a combination of error-term types. Complex terms (ratio of identical frequencies) are used for the reflection errors and a scalar term (ratio of different frequencies) is used for the frequency translated  $E_{TF}$  transmission error.



$$E_{TF} = (E_{STF} * E_{RTF}) \quad C_{21a} = (S_{21a-RF} * S_{21a-IF})$$

$$E_{RF} = (E_{STF} * E_{SRF})$$

Term	Description	Term	Description
$E_{TF}$	Transmission tracking error term (frequency translated, forward)	$E_{SRF}$	Reflection tracking error term (stimulus, forward)
$E_{STF}$	Transmission tracking error term (stimulus, forward)	$C_{21a}$	Conversion loss or gain measurement, actual (frequency translated, forward)
$E_{RTF}$	Transmission tracking error term (response, forward)	$S_{21aRF}$	Transmission measurement, actual (RF frequency, forward)
$E_{RF}$	Reflection tracking error term (forward)	$S_{21aIF}$	Transmission measurement, actual (IF frequency, forward)

Scalar Mixer Calibration includes a combination of a 2-port calibration and a power meter calibration that characterizes the mismatch of the power sensor at each frequency step. The remainder of this topic will discuss each step of Scalar Mixer Calibration and how the error terms are characterized.

**Note:** If the input and output frequencies of your DUT are the same, the Scalar Mixer Calibration routine will not include a DUT output frequency as it does in the following example.

**Calibration Step 1A**

**Perform a 2-port calibration over the INPUT frequency range of the DUT.**

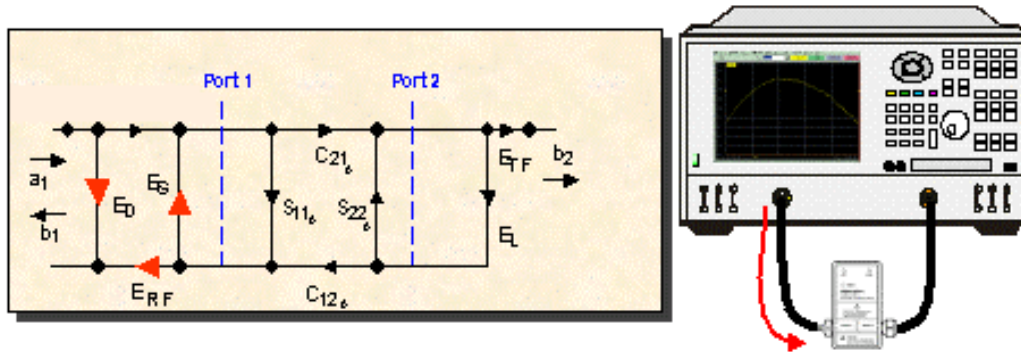
This 2-port calibration accomplishes the following:

- Establishes a reference plane at the end of the test port cables for a calibration over the INPUT frequency range of the DUT.
- Characterizes the following three error terms that need correction for  $S_{11}$  measurements on the DUT:
  - forward directivity ( $E_D$ )



- forward source match ( $E_S$ )
- forward frequency response reflection tracking ( $E_{RF}$ )
- Prepares the PNA to correct the  $S_{11}$  measurements of the power sensor over the INPUT frequency range. This occurs in calibration step 2 when source power is being calibrated.

In steps 1A - 1C of the Scalar Mixer Calibration, a 2-port calibration is performed using segment sweep. Segments are from both the input and output frequency ranges. Scalar Mixer Calibration selects the error terms that are needed for its error model and ignores the rest. In step 1A for example, the forward load match and the transmission response are not needed at the input frequencies. Note their absence from the following "Scalar Mixer Calibration Final Error Model" table.



Input frequency

Scalar Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	
$E_S$	●	
$E_{RF}$	●	
$E_L$		
$E_{TF}$ (frequency translated)		
$E_X$		

### Calibration Step 1B

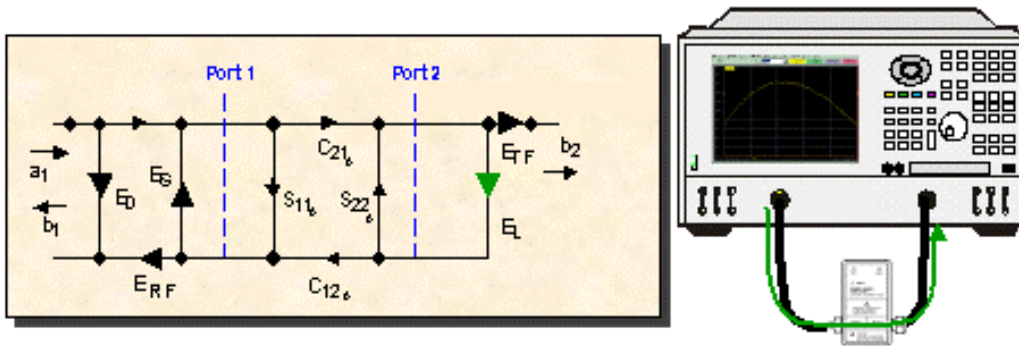
Perform a 2-port calibration over the OUTPUT frequency range of the DUT.

The FORWARD sweep of the 2-port calibration accomplishes the following:

- Establishes a reference plane at the end of the test port cables for a calibration over the OUTPUT frequency range of the DUT.
- Characterizes the load match error term ( $E_L$ ) for correction of DUT measurements.
- Characterizes the following three error terms so the PNA can correct the  $S_{11}$  measurements of the power sensor over the OUTPUT frequency range. This occurs in calibration step 2 when source power is being calibrated.
  - forward directivity ( $E_D$ )

- forward source match ( $E_S$ )
- forward frequency response reflection tracking ( $E_{RF}$ )

Since the OUTPUT frequency will never be measured at Port 1 during the measurement of the DUT, these error terms are NOT needed for the final Scalar Mixer Calibration error model (note their absence from the following table).



Output frequency

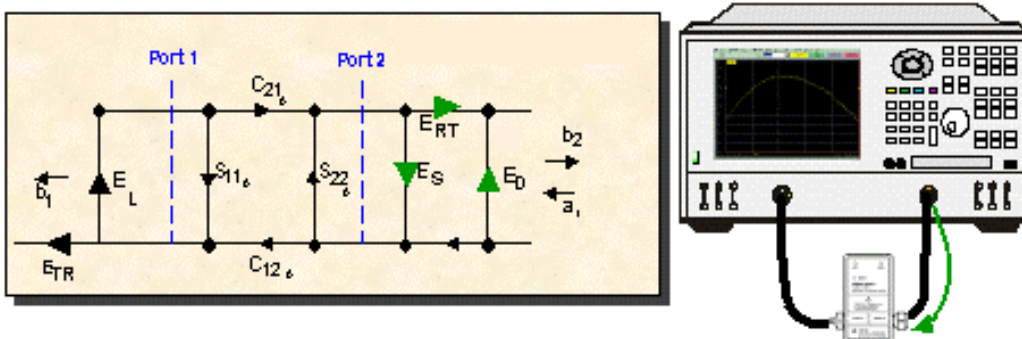
Scalar Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	
$E_S$	●	
$E_{RF}$	●	
$E_L$	●	
$E_{TF}$ (frequency translated)		
$E_X$		

### Calibration Step 1C

The REVERSE sweep of the 2-port calibration accomplishes the following:

- Characterizes the following three error terms that need correction for  $S_{22}$  measurements on the DUT:
  - reverse directivity ( $E_D$ )
  - reverse source match ( $E_S$ )
  - reverse frequency response reflection tracking ( $E_{RT}$ )





Output frequency

Scalar Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	●
$E_S$	●	●
$E_{RF}$	●	●
$E_L$	●	
$E_{TF}$ (frequency translated)		
$E_X$		

## Calibration Step 2

**Perform a match corrected power meter calibration over the INPUT and OUTPUT frequencies of the DUT.**

This calibration transfers the absolute accuracy of a power meter to the PNA for making unratioed measurements.

The second step of the calibration is composed of the following segments:

- The power meter sensor is connected to Port 1 (or at the end of the cable attached to the port). An  $S_{11}$  measurement of the power sensor is performed over the INPUT and OUTPUT frequency ranges of the DUT. These measurements have the benefit of vector error correction using the error terms that were characterized in step 1.
- The PNA performs a source power calibration over the INPUT and OUTPUT frequency ranges of the DUT. Each power meter reading is corrected using the  $S_{11}$  data from the measurement on the power sensor. The PNA compares each corrected power meter reading to the power seen at the R1 reference receiver. A power correction table is established that creates an absolute power reference at Port 1 (or at the end of the cable attached to the port). Since the R1 receiver will never be read at the OUTPUT frequencies during DUT measurements, this information will be used to calibrate the B receiver at the OUTPUT frequencies.

The remaining segments of this calibration step are for calculating the frequency translated  $E_{TF}$  error term. In Scalar Mixer Calibration,  $E_{TF}$  is calculated because the error term ratio's stimulus frequency (input) is different from the response frequency (output).

- Using error terms characterized earlier in the calibration, and data from the power meter segment of the calibration, the values of  $E_{STF}$  and  $E_{RTF}$  are calculated using the following

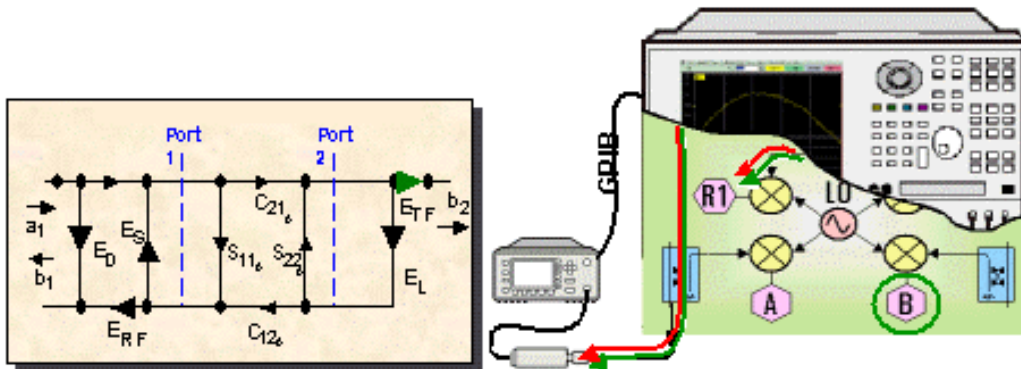
equations.

$$E_{STF} = \frac{\sqrt{P_{\text{sensor}} |1 - E_S^* \Gamma_{\text{sensor}}|}}{|R1|}$$

$$E_{RTF} = \frac{E_{TF}}{\sqrt{P_{\text{sensor}} |1 - E_S^* \Gamma_{\text{sensor}}|}} \cdot |R1|$$

- Frequency translated  $E_{TF}$ , the remaining unsolved error term in the Scalar Mixer Calibration Final Error Model, is calculated by the following equation.

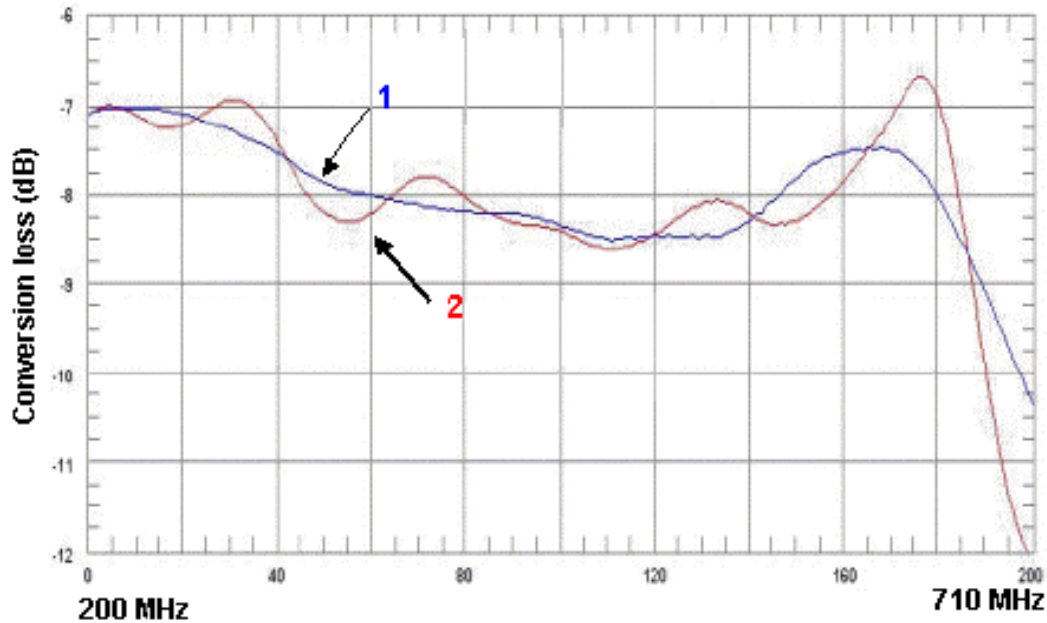
$$E_{TF} = (E_{STF} * E_{RTF})$$



Scalar Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency		●
Error Term	Forward	Reverse
$E_D$	●	●
$E_S$	●	●
$E_{RF}$	●	●
$E_L$	●	not used
$E_{TF}$ (frequency translated)	●*	not used
$E_X$	not used	not used

\* Scalar term

### Comparison of the Traditional Power Calibration and Scalar Mixer Calibration



1: Scalar Mixer Calibration

2: Traditional power meter calibration

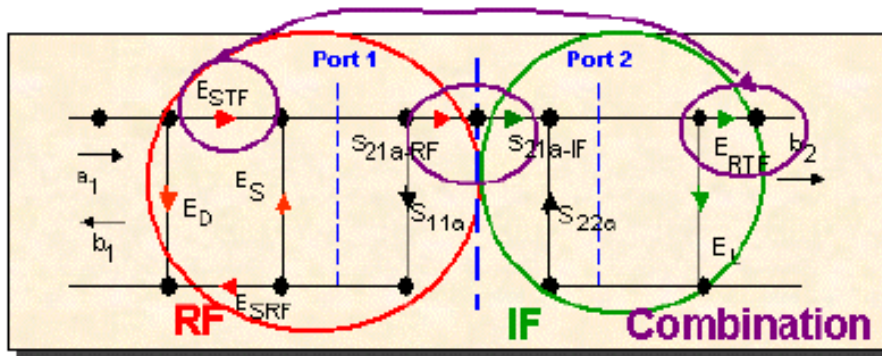
This graph shows a comparison of the two power calibration techniques, measured on a test system with a poor match of -5 dB. The blue (smooth) trace is a measurement using Scalar Mixer Calibration. The red trace is a measurement using a traditional source and receiver power calibration.

### Vector Mixer Calibration: Theory of Operation

You can perform a Vector Mixer Calibration by following the prompts in the dialog boxes of the calibration procedure. This topic can help you better understand the details of the procedure. This topic does NOT contain additional steps required for the calibration.

### How Vector Mixer Calibration Corrects Conversion Loss/Gain Measurements

You cannot use a traditional 2-port calibration to provide error correction for a conversion loss/gain measurement. This is because the mixer or converter stimulus (input) and response (output) signals are at **different** frequencies. Vector Mixer Calibration corrects for the same systematic error terms as the 2-port model by using a new calibration error model and equations.



$$E_{TF} = (E_{STF} * E_{RTF}) \quad C_{21a} = (S_{21a-RF} * S_{21a-IF})$$

$$E_{RF} = (E_{STF} * E_{SRF})$$

Term	Description	Term	Description
$E_{TF}$	Transmission tracking error term (frequency translated, forward)	$E_{SRF}$	Reflection tracking error term (stimulus, forward)
$E_{STF}$	Transmission tracking error term (stimulus, forward)	$S_{21aRF}$	Transmission measurement, actual (RF frequency, forward)
$E_{RTF}$	Transmission tracking error term (response, forward)	$S_{21aIF}$	Transmission measurement, actual (IF frequency, forward)
$E_{RF}$	Reflection tracking error term (forward)	$C_{21a}$	Conversion loss or gain measurement, actual (frequency translated, forward)

Vector Mixer Calibration includes a combination of a 2-port calibration,  $S_{11}$  measurements, and a  $C_{21}$  measurement to characterize the calibration mixer/filter combination and to calibrate the test system.

Vector Mixer Calibration is analogous to a characterized thru measurement. However, Vector Mixer Calibration performs a thru measurement with frequency translation by using a characterized mixer/filter combination as the thru. The mixer/filter's conversion loss ( $T1 * T2$ ), input match (D), and output match (M) are used to calculate the frequency translated transmission tracking error ( $E_{TF}$ ) in the Vector Mixer Calibration final error model.

The remainder of this topic will discuss each step of Vector Mixer Calibration and how the error terms are characterized.

### Calibration Step 1A

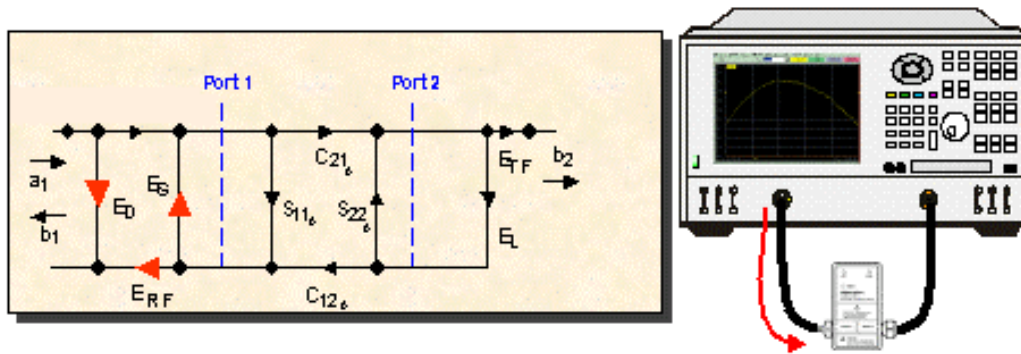
**Perform a 2-port calibration over the INPUT frequency range of the DUT.**

This 2-port calibration accomplishes the following:

- Establishes a reference plane at the end of the test port cables for a calibration over the INPUT frequency range of the DUT.

- Characterizes the following three error terms that need correction for  $S_{11}$  measurements on the DUT:
  - forward directivity ( $E_D$ )
  - forward source match ( $E_S$ )
  - forward frequency response reflection tracking ( $E_{RF}$ )
- Prepares the PNA to correct the  $S_{11}$  measurements of the calibration mixer/filter when terminated with an open, short and load over the INPUT frequency range. This occurs in calibration step 2 when the calibration mixer/filter is being characterized.

In steps 1A - 1C of the Vector Mixer Calibration, a 2-port calibration is performed using segment sweep. (Segments are from both the input and output frequency ranges.) Vector Mixer Calibration selects the error terms that are needed for its error model and ignores the rest. In step 1 for example, the forward load match ( $E_L$ ) and the frequency-translated transmission response ( $E_{TF}$ ) are not needed at the INPUT frequencies (note their absence from the following "Vector Mixer Calibration Final Error Model" table).



Input frequency

Vector Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	
$E_S$	●	
$E_{RF}$	●	
$E_L$		
$E_{TF}$ (frequency-translated)		
$E_X$		

### Calibration Step 1B

**Perform a 2-port calibration over the OUTPUT frequency range of the DUT.**

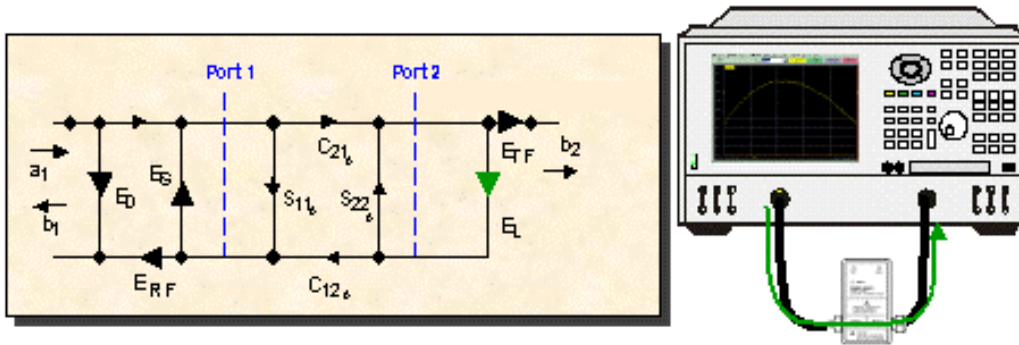
The FORWARD sweep of the 2-port calibration accomplishes the following:

- Establishes a reference plane at the end of the test port cables for a calibration over the OUTPUT frequency range of the DUT.
- Characterizes the following three error terms over the OUTPUT frequency range so the PNA can make a corrected measurement of the load match error term ( $E_L$ ). As shown in

the following table, this  $E_L$  error term is used for correction of DUT measurements .

- forward directivity ( $E_D$ )
- forward source match ( $E_S$ )
- forward frequency response reflection tracking ( $E_{RF}$ )

Since the OUTPUT frequency will never be measured at Port 1 during the measurement of the DUT, these error terms are NOT needed for the Vector Mixer Calibration final error model (note their absence from the following table).



Output frequency

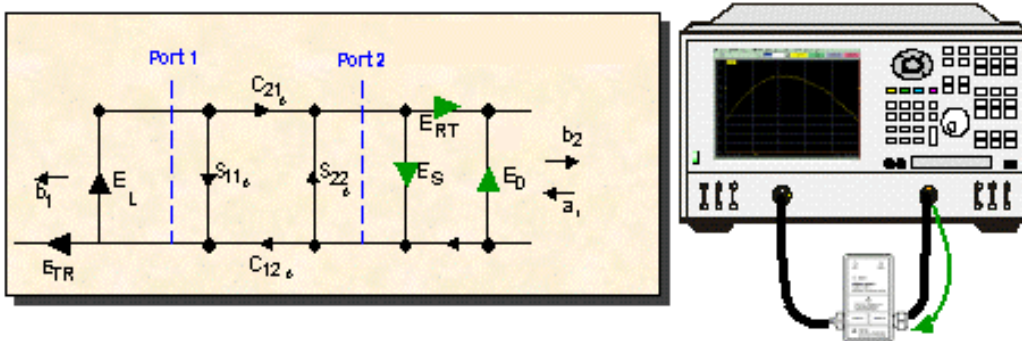
Vector Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	
$E_S$	●	
$E_{RF}$	●	
$E_L$	●	
$E_{TF}$ (frequency-translated)		
$E_X$		

### Calibration Step 1C

The REVERSE sweep of the 2-port calibration accomplishes the following:

- Characterizes, at the OUTPUT frequency range, the following three error terms that need correction for  $S_{22}$  measurements on the DUT:
  - reverse directivity ( $E_D$ )
  - reverse source match ( $E_S$ )
  - reverse frequency response reflection tracking ( $E_{RF}$ )





Output frequency

Vector Mixer Calibration Final Error Model		
Input frequency	●	
Output frequency	●	
Error Term	Forward	Reverse
$E_D$	●	●
$E_S$	●	●
$E_{RF}$	●	●
$E_L$	●	
$E_{TF}$ (frequency-translated)		
$E_X$		

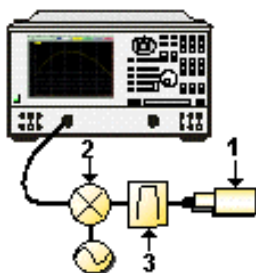
### Calibration Step 2

#### Characterize the calibration mixer/filter combination at the INPUT frequency.

Connect the calibration mixer/filter combination to Port 1 (or to the end of the cable attached to the port). Connect the external LO source to the LO port of the calibration mixer. Connect an open, short, and load to the output of the calibration mixer/filter combination. Perform a corrected  $S_{11}$  measurement on each of the three calibration standards.

These three  $S_{11}$  measurements, corrected using the INPUT frequency error terms characterized in step 1, accomplish the following:

- Provide values for the calculation of "mixer terms" that are used in the equation for solving the frequency-translated error term  $E_{TF}$ . This error term is calculated in calibration step 3. View the details on characterizing the calibration mixer/filter, and calculating the "mixer terms" and  $C_{21a}$ .
- Correct for the input and output mismatch effects of the calibration mixer/filter combination.



1: Open, Short, and Load

(mechanical standards or ECal module)

2: Calibration mixer

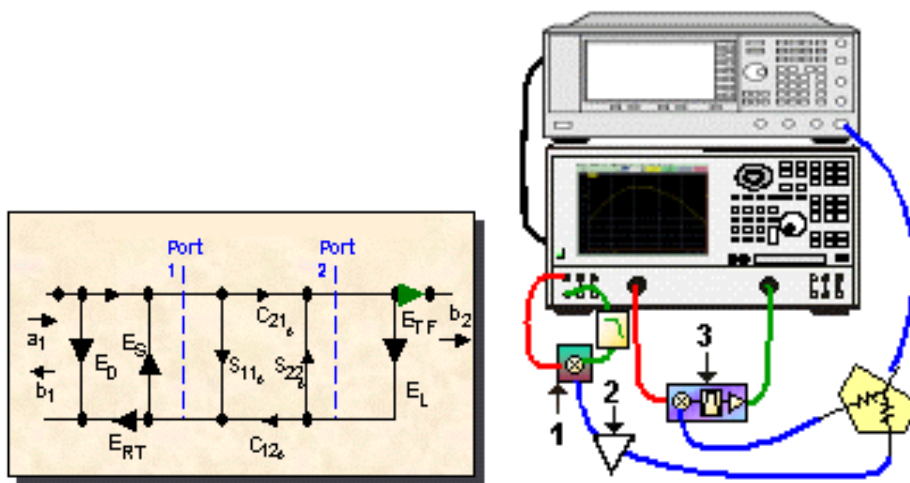
3: IF filter (selects either the sum or difference mixing product, depending on your application)

### Calibration Step 3

With the PNA in frequency-offset mode, use the calibration mixer/filter combination as a "thru" calibration standard, and make a forward transmission measurement ( $C_{21m}$ ).

This measurement accomplishes the following:

- Provides the value of the uncorrected  $C_{21m}$  measurement, used in the equation for solving the frequency-translated  $E_{TF}$  error term.
- Removes the effects of the reference mixer.



1: Reference mixer/filter

2: Amplifier\* (optional)

3: Calibration mixer/filter

\* To prevent mixing products generated in the reference mixer from interfering with the calibration mixer/filter or DUT.

The last segment of this calibration step calculates the frequency-translated  $E_{TF}$  error term using the mixer terms, error terms,  $C_{21a}$ , and the  $C_{21m}$  measurement. In Vector Mixer Calibration, the frequency-translated  $E_{TF}$  is calculated because the error term ratio's stimulus frequency (input) is different from the response frequency (output).

$$E_{TF} = \frac{C_{21m}}{C_{21a}} (1 - M * E_{LF} - D * E_{SF} - E_{SF} * T1 * T2 * E_{LF} + E_{SF} * M * D * E_{LF})$$

#### Vector Mixer Calibration Final Error Model

Input frequency ●

Output frequency ●

Error Term	Forward	Reverse
$E_D$	<span style="color: red;">●</span>	<span style="color: green;">●</span>



$E_S$	●	●
$E_{RF}$	●	●
$E_L$	●	not used
$E_{TF}$ (frequency-translated)	●	not used
$E_X$	not used	not used

## Vector Mixer Calibration: Characterizing the Calibration Mixer/Filter and Calculating Mixer Terms

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Vector Mixer Calibration uses a special technique to accurately characterize the calibration mixer/filter. The key to this new concept is to look at three reflection measurements of the calibration mixer/filter and analyze the content of the signals. These three measurements are vector-error corrected with the 2-port calibration performed in calibration step 1. The measurement values allow the calculation of "mixer terms" and  $C_{21a}$ . These are used in an equation to solve for frequency translated  $E_{TF}$  in the Vector Mixer Calibration final error model.

- Understanding the Reflection Measurements of the Calibration Mixer/Filter
  - Composite Terms of a Reflection Measurement
  - Effects of the Open, Short, and Load Measurements
- Understanding the Mixer Terms
  - "D" Mixer Term
  - "M" Mixer Term
  - "T1 \* T2" Mixer Term
- Calculating  $C_{21a}$  (Conversion Gain Magnitude and Phase)

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Other Frequency Converter Application topics

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### Understanding the Reflection Measurements of the Calibration Mixer/Filter

The reflections from the calibration mixer, at the selected frequencies, from the terminations (open,short,load, etc) must not be affected by the reflections, at the non-selected frequencies, as measured by reflections at the input port. The primary and well-known method for achieving this objective is to use a reflective type filter to present a virtually constant reflection at the un-selected frequencies.

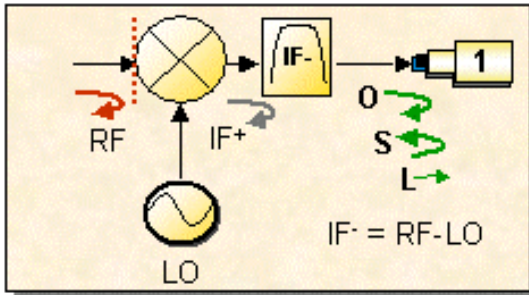
#### Composite Terms of a Reflection Measurement

The following three composite terms are summed together to make the  $S_{11}$  reflection measurements:

Term	Explanation
RF	reflected input signal
IF +	output signal: RF + LO (undesired signal* in this example)
IF-	output signal: RF - LO (desired signal* in this example)

\* The calibration mixer can be used in either the up-conversion or down-conversion mode.

The following graphic shows the reflections that occur when a variety of loads are connected to the output of the mixer/filter.



1: Mechanical calibration standard or ECal module.

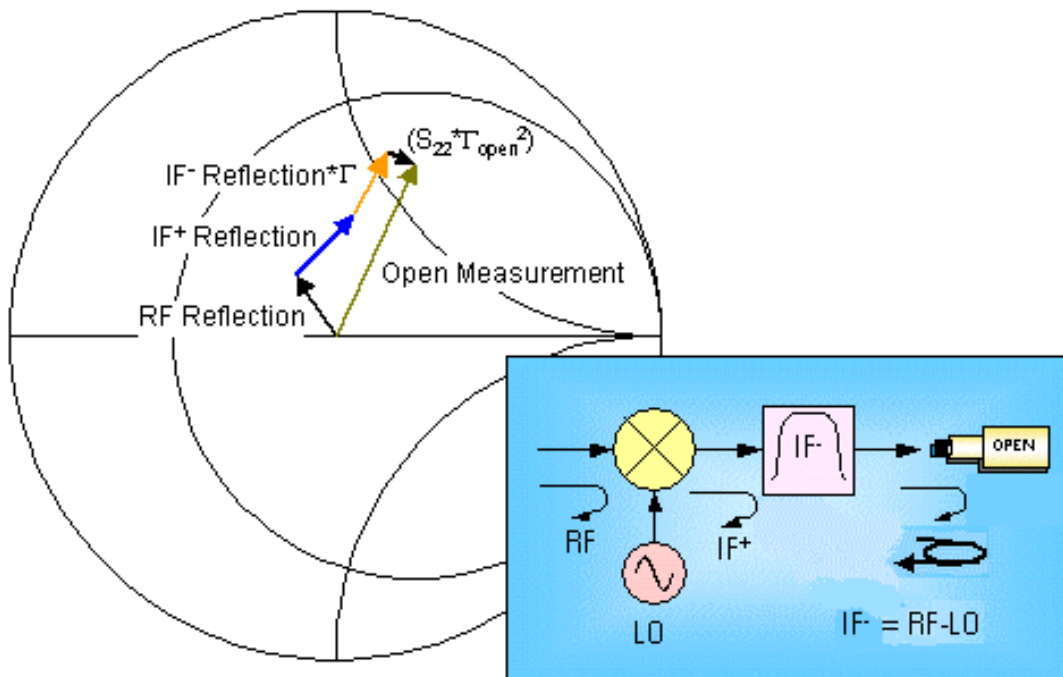
- The RF signal is the portion of the incident signal that is reflected as a function of the input mismatch of the mixer. It is not affected by termination of the IF filter.
- The undesired IF+ signal is unaffected by the termination, and its contribution to the total RF signal going back to the VNA is likewise unchanged. It will be reconverted by the LO to the input frequency.
- The IF- signal will pass through the filter, reflect off the termination, pass back through the mixer and be reconverted to the input frequency, again with twice the conversion loss.

All of these signals add to what will be measured in a reflection ( $S_{11}$ ) measurement of the mixer, but only the portion attributable to the IF- signal will change with the load impedance.

### Effects of the Open, Short, and Load Measurements

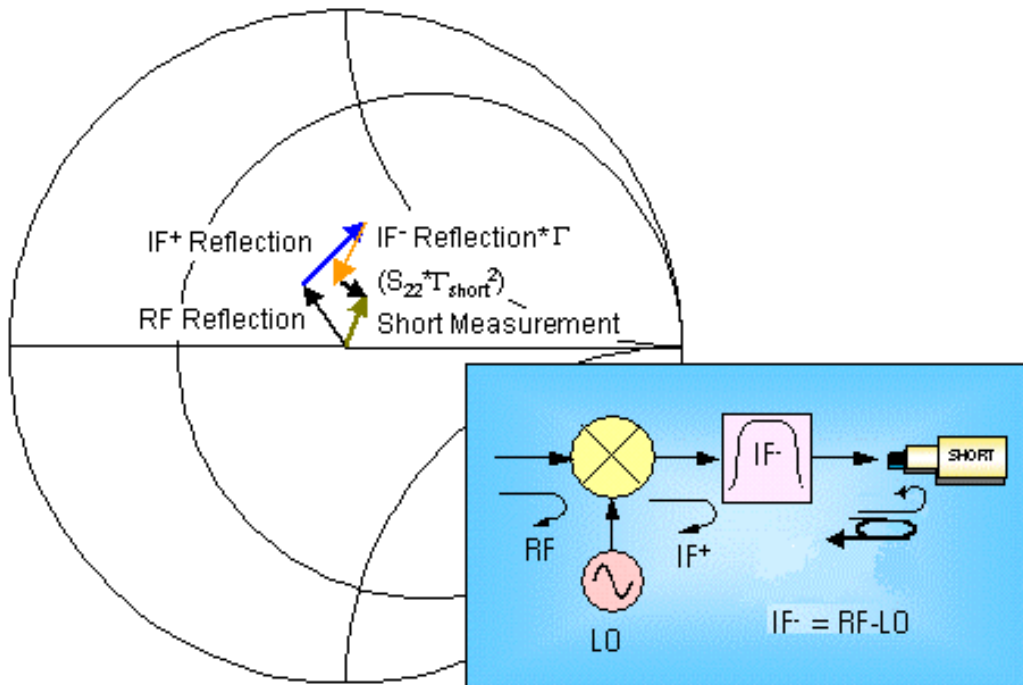
**NOTE:** the following vector plots represent the same frequency point from the input frequency range.

#### Open Measurement



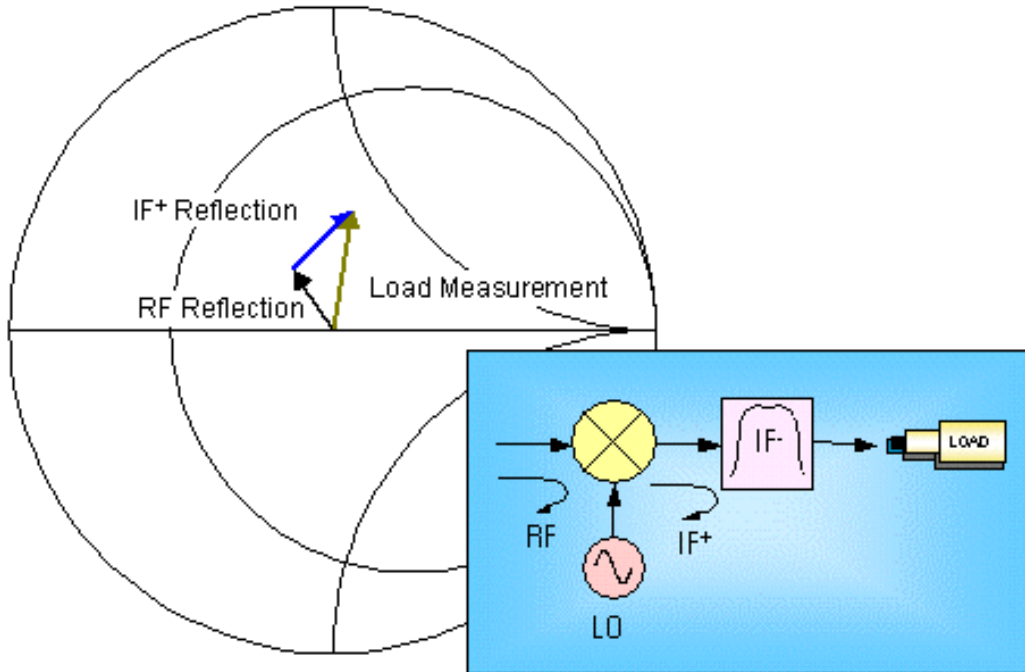
This vector plot shows the three composite terms of the reflection signal, along with a fourth term ( $S_{22} * \Gamma_{\text{Termination}}^2$ ), which represents the re-reflection of the IF- image off the termination, and back off the output match (or  $S_{22}$ ) of the mixer/filter. The open measurement is the vector sum of these four terms. The IF- reflection is twice the conversion loss of the mixer (as the  $\Gamma_{\text{Termination}} = 1$  for an open), and the fourth term, representing output match, can be reduced to  $S_{22}$  because the term ( $\Gamma_{\text{Termination}} = 1$ ) when squared is 1.

**Short Measurement**



This vector plot shows how the terms combine to make the short measurement. Note in this case that the RF and IF+ reflections are not changed from the open measurement. The IF- reflection has changed phase by 180 degrees, because the  $\Gamma_{\text{Termination}} = -1$  for a short. However, the fourth term ( $S_{22} * \Gamma_{\text{Termination}}^2$ ) is in the same direction as for the open. This is because the term ( $\Gamma_{\text{Load}} = -1$ ) is 1 when squared, just as with the open.

**Load Measurement**

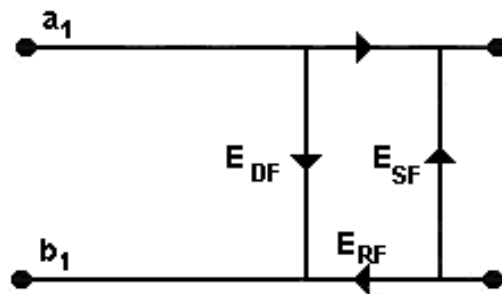


This vector plot shows how the terms combine to make the load measurement. Since  $\Gamma_{\text{Termination}} = 0$  for a load, there is no IF- term, and no fourth term associated with the  $S_{22} * \Gamma_{\text{Termination}}$ .

### Understanding the Mixer Terms

The breakthrough for the Vector Mixer Calibration method of characterizing the calibration mixer is recognizing that these three reflection measurements have a close corollary with the 1-port error model.

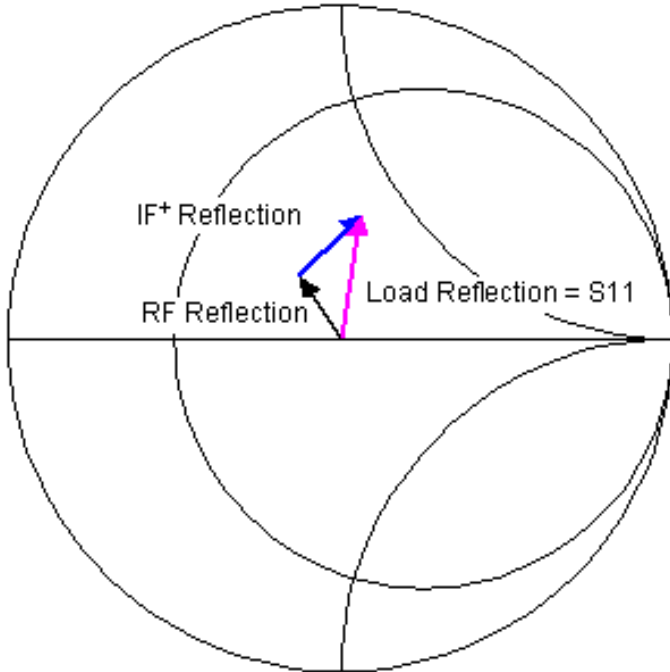
- Mixer  $S_{11}$  (also called D) maps to the  $E_{DF}$  (Forward Directivity) error term
- Mixer  $S_{22}$  (also called M) maps to the  $E_{SF}$  (Forward Source Match) error term
- The two-way response of the mixer,  $C_{21} * C_{12}$  (also called T1 \* T2), maps to the  $E_{RF}$  (Forward Reflection Tracking) error term



### "D" Mixer Term

- $E_{DF}$  (directivity) error term:  $S_{11} = \text{load measurement}$ ; also called the **"D" mixer term**

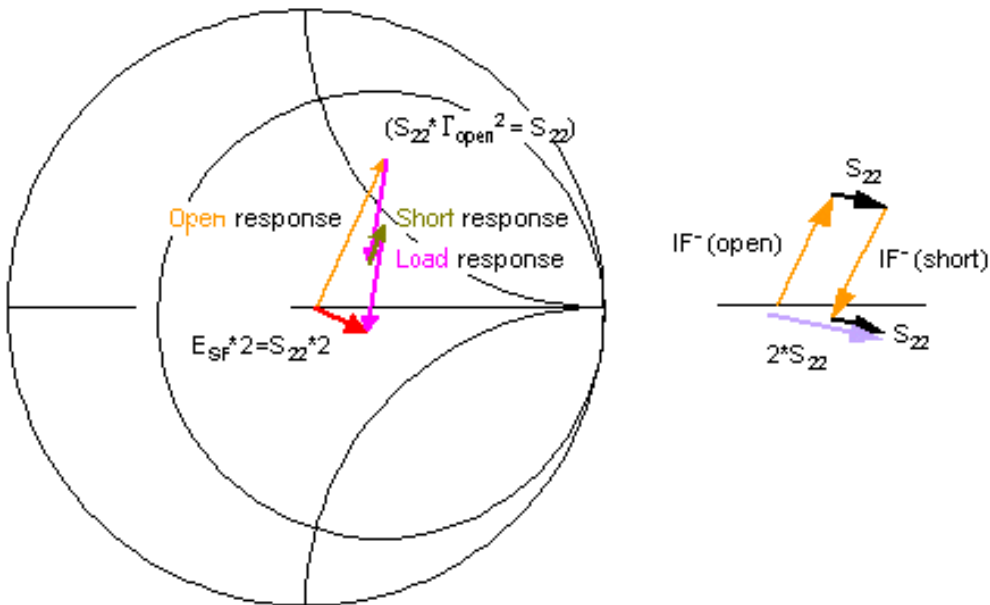
The  $E_{DF}$  term is the mixer "D" (or  $S_{11}$ ) term because the definition of  $S_{11}$  is the reflection at port 1 with all other ports terminated. The condition for measuring  $E_{DF}$  is to terminate the output port. Therefore, it is the same measurement as  $S_{11}$ .  $E_{DF}$  is the value used for the mixer term D ( $S_{11}$ ) because other calibration techniques that don't require open/short/load measurements yield an identical value.



**"M" Mixer Term**

- $E_{SF}$  (source match) error term:  $S_{22} = ((O - L) + (S - L)) / 2$ ; also called the **"M" mixer term**

The mapping of the "M" mixer term is shown in the equation, and is basically the open/short average, after removing the load response from each. The following vector plot shows the sum of these terms. The load is subtracted from the open (or rather, the negative of the load is added to the open), then the short is added to the result and the load is again subtracted. The resulting vector is twice the source match. Taking one-half of this vector yields the same vector as the  $S_{22}$  portion of terms that added to the open response.

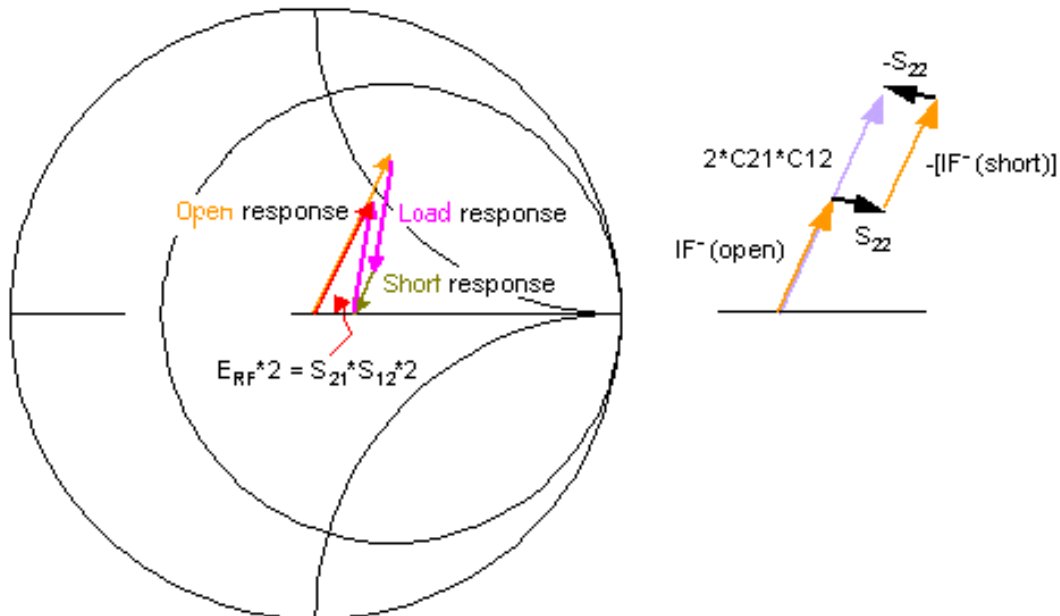


**"T1 \* T2" Mixer Term**

- $E_{RF}$  (reflection tracking) error term:  $S_{21} * S_{12} = ((O - L) - (S - L)) / 2$ ; also called the **"T1 \* T2" mixer term**

## T2" mixer term

The mapping of mixer term "T1 \* T2" is shown in the equation, and is basically one-half the open/short difference, after removing the load response. The following vector plot shows the sum of these terms. The load is subtracted from the open (or rather, the negative of the load is added to the open), then the short is subtracted from the result and finally the load is again added. The resulting vector is twice the reflection tracking. Taking one-half this vector yields the same vector as the IF- portion of terms that added to the open response. This IF- term is the same as the  $C_{21} * C_{12}$  of the mixer/filter.



## Calculating $C_{21a}$ (Conversion Gain Magnitude and Phase)

$$C_{21a} = \sqrt{T1 * T2}$$

$C_{21a}$  is used in an equation to solve for frequency translating  $E_{TF}$  in the Vector Mixer Calibration final error model.

$T1 * T2$  represents the two-way complex insertion loss (magnitude and phase) through the calibration mixer/filter. It is assumed that the calibration mixer is reciprocal in nature, taking the square root of  $T1 * T2$  gives the one-way insertion loss of the mixer, that is,  $T1 = T2$  or  $C21a$ .

To get the conversion gain magnitude is easy, by taking the square root of the  $T1 * T2$  term. Solving for the phase response is a little more difficult. The square root function applied to phase is really dividing the phase by 2. However, the phase wraps every 360 degrees, so dividing by 2 will yield the wrong result. For example, the max phase is 180 degrees, so divided by 2 the max phase is 90 degrees. But that doesn't represent the real situation where the conversion phase can go to 180 degrees. Instead, what is needed is to unwrap the phase (sometimes called expanded phase), then shift the first-point phase reference to the proper offset value ( and likewise shift all the other points). This shifted value is found by finding the delay (or phase slope) around the first point, and projecting it back to the zero frequency. The value at zero frequency is the offset for the phase trace. Once this is applied, the resulting trace is divided by two. Converting from the polar representation to the real/imaginary representation will re-wrap this new phase response.

## High Power Measurements

### High-Power Amplifier Measurements Using a PNA

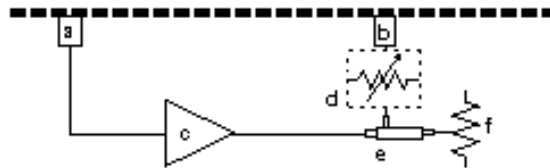
**Note:** This information applies to all PNA models. For information that applies to your specific analyzer, see High-Power Amplifier Measurements.

Challenge	Solution
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Phase-lock lost when using a Booster Amplifier	<a href="#">Disable Auto-Frequency Calibration</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

#### 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 PNA is equipped with Option 015, or your E836x PNA is equipped with Option 016, 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 an internal receiver attenuator, if equipped with Option 015 or 016) 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 an internal receiver attenuator, if equipped with Option 015 or 016) 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**

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**Caution:** Avoid expensive repairs to your PNA. Read [Electrostatic Discharge Protection](#).

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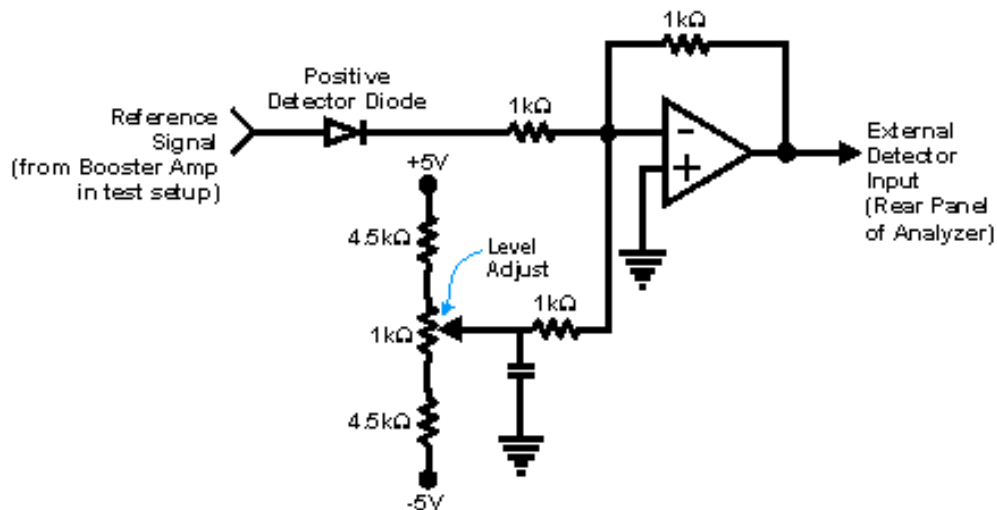
1. Select the correct analyzer configuration for your DUT and your measurement requirements. Do not connect the DUT yet.
2. Preset the analyzer.
3. If necessary, adjust the analyzer's source power:
  - Set the analyzer's source power to be in the linear region of the amplifier's output response (typically 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	<a href="#">Booster amplifiers in the test setup</a>
Booster amplifier response is not flat	<a href="#">External leveling for booster amplifiers</a>
Phase-lock lost when using a booster amplifier	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

---

**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. More Accurate Configuration 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.

---

## 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?

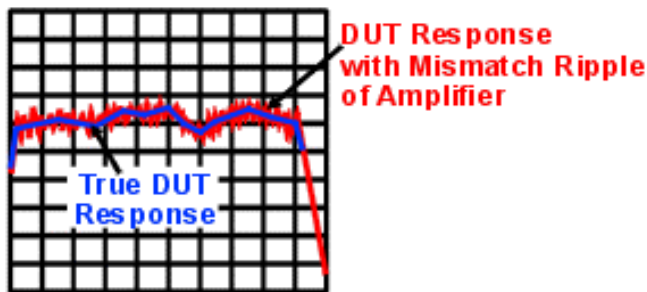
Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

---

**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."

---

### 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:
    - **2-Port Calibration** (TRL or SOLT) for forward and reverse non-boosted transmission and reflection measurements.
    - **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:
    - **Thru Response** for forward high-power transmission measurements.
    - **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.
- configuration for high-power measurements in the forward direction (2-port cal)
  - Possible calibration choices:
    - **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.

- **1-Port Calibration** (Thru Response, 1-Port Reflection, or Open/Short Response) for forward high-power transmission or reflection measurements. Or, for reverse non-booster transmission or reflection measurements
- configuration for high-power measurements in both forward and reverse directions
  - Possible calibration choices:
    - **2-Port Calibration** (TRL or SOLT) for forward and reverse high-power transmission and reflection measurements.
    - **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 calibration 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 calibration 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](#)

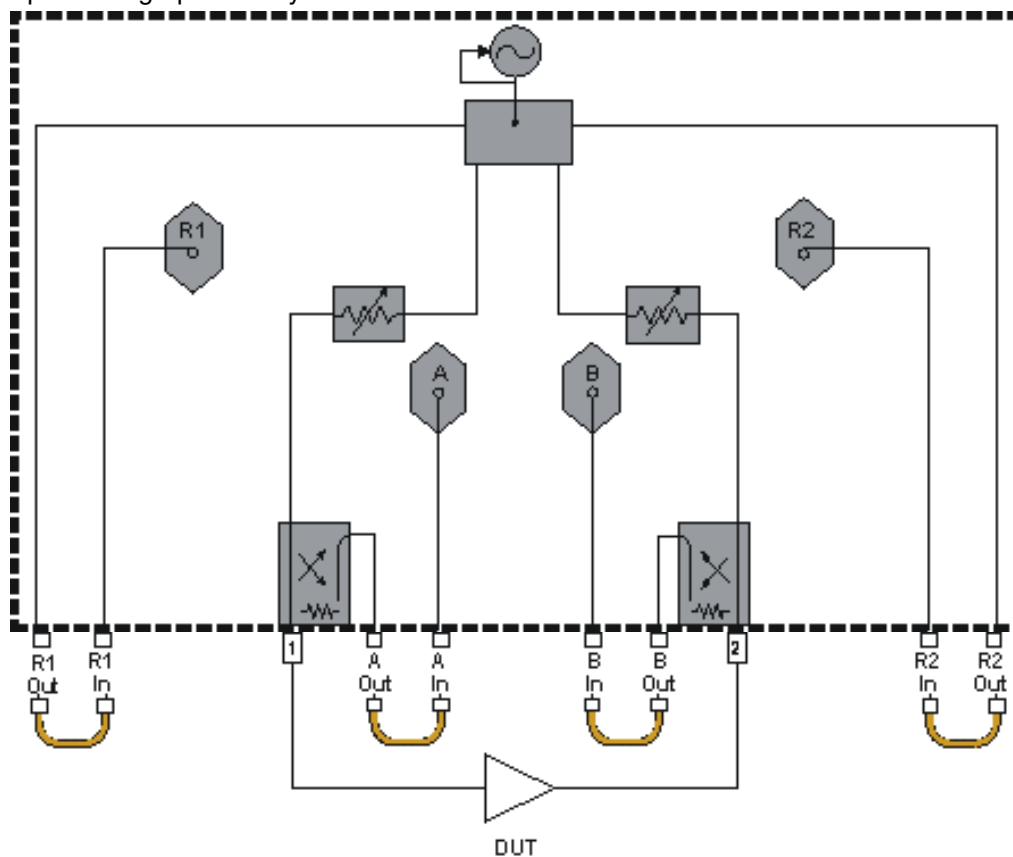
More information on High-Power Amplifier Measurements:

- [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) Basic Configuration

Explore the graphic with your mouse.

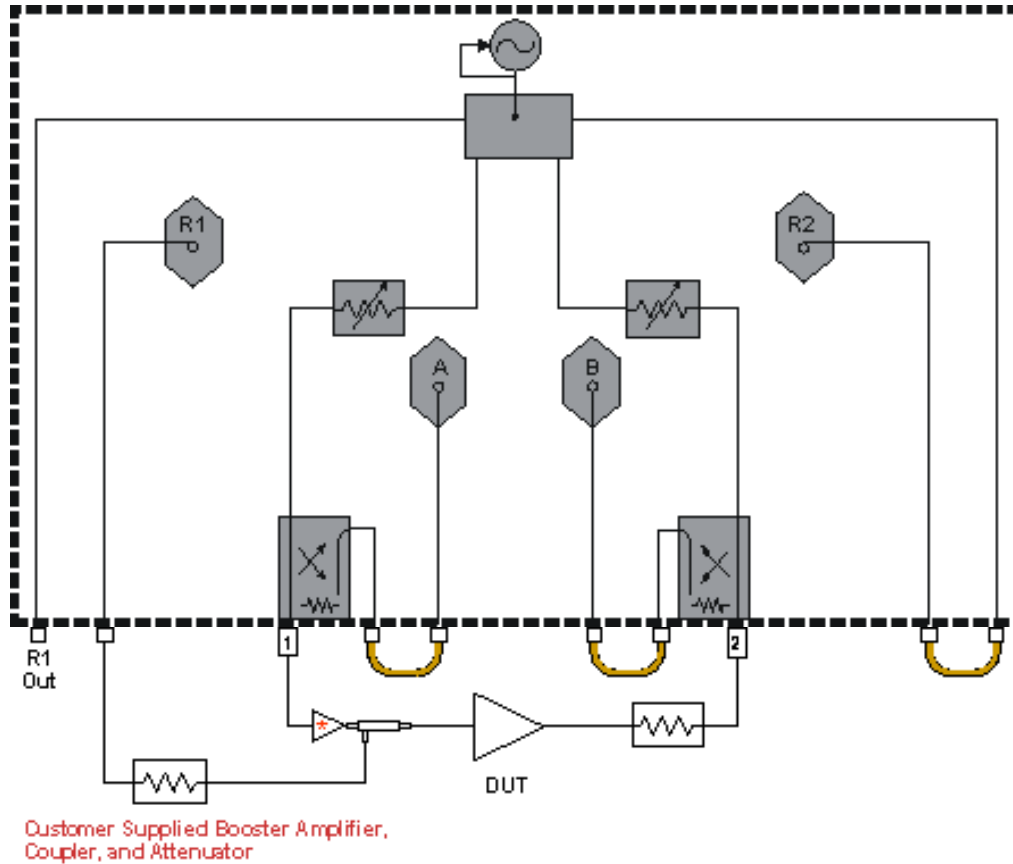


### Diagram: (E835x) Configuration for High-Power Measurements in the



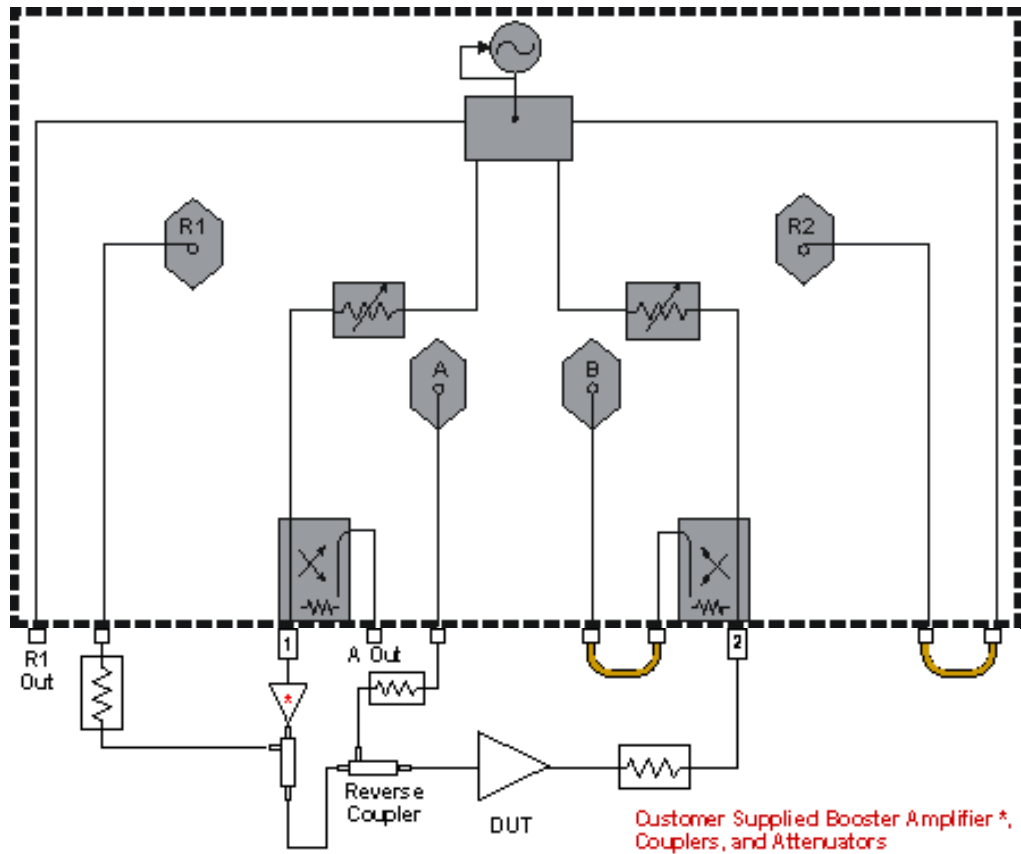
## Forward Direction (Response Cal Only)

Explore the graphic with your mouse.



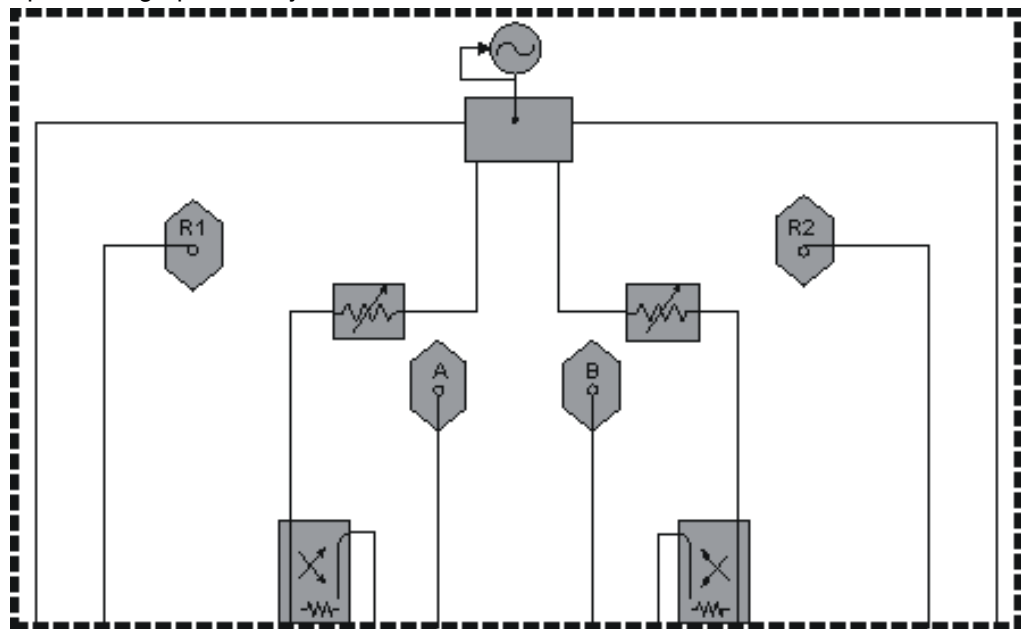
## Diagram: (E835x) Configuration for High-Power Measurements in the Forward Direction (2-Port Cal)

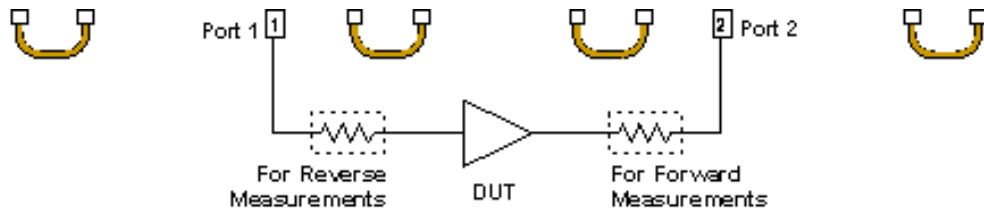
Explore the graphic with your mouse.



**Diagram: (E835x) Configuration for Non-Boosted High-Power Measurements in both Forward & Reverse Directions**

Explore the graphic with your mouse.

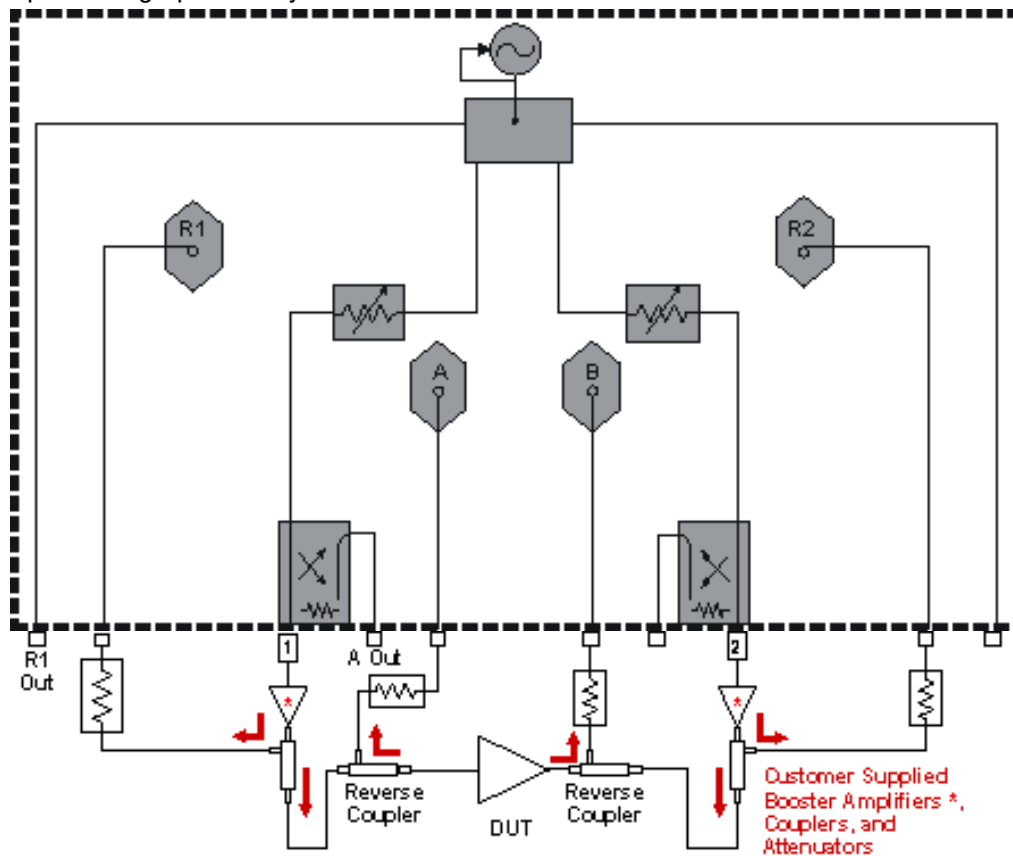




Customer Supplied Attenuator - Location dependent on direction of measurement

### Diagram: (E835x) Configuration for High-Power Measurements in both the Forward & Reverse Directions (2-Port Cal)

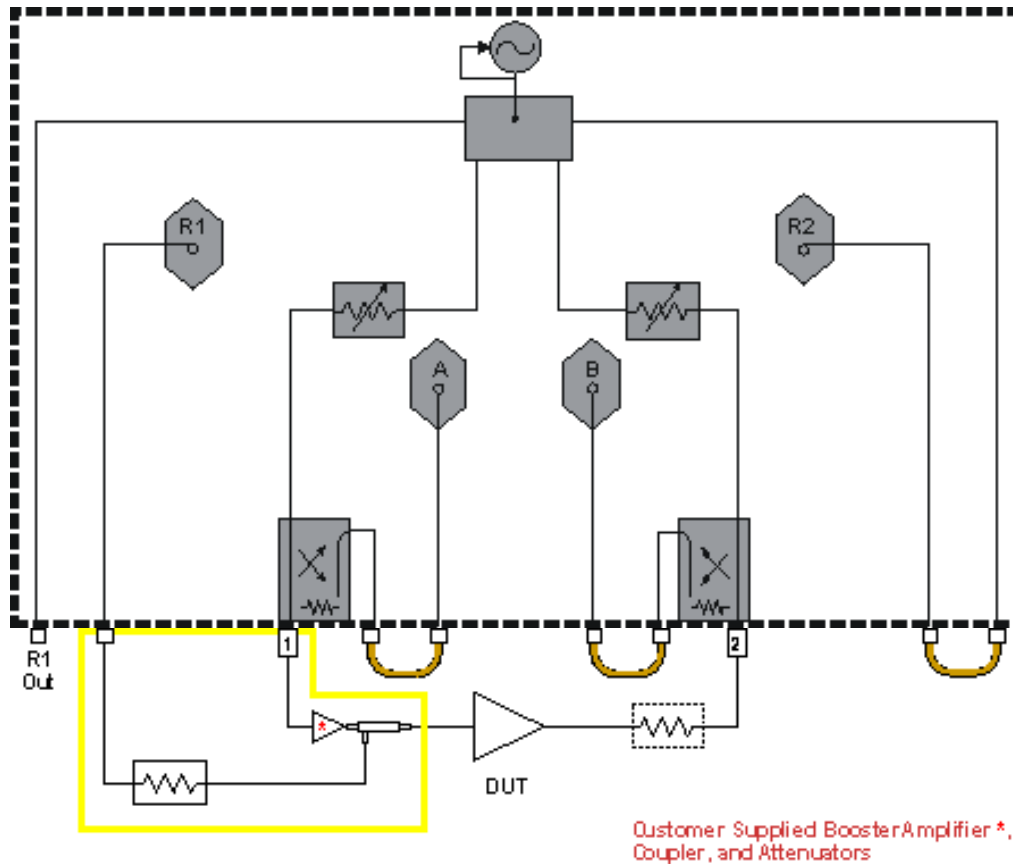
Explore the graphic with your mouse.



### 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.



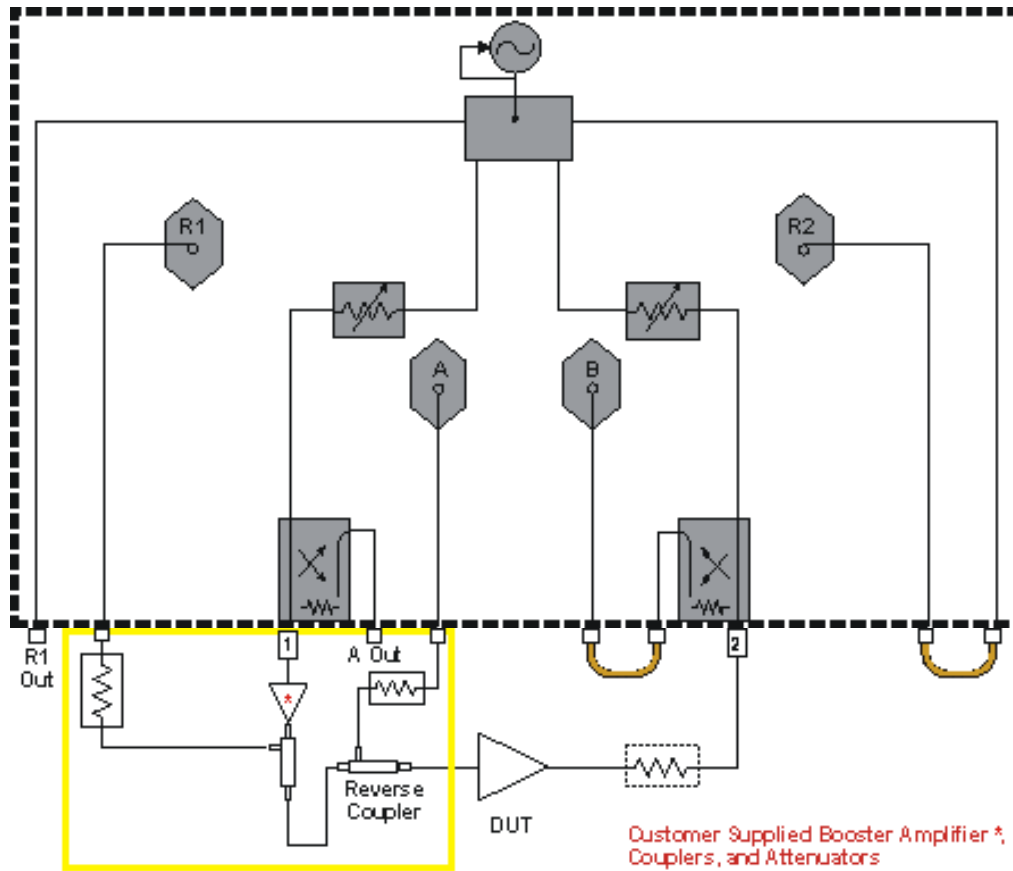
### Diagram: (E835x) More Accurate Configuration using One Booster Amplifier

Explore the graphic with your mouse.

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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.

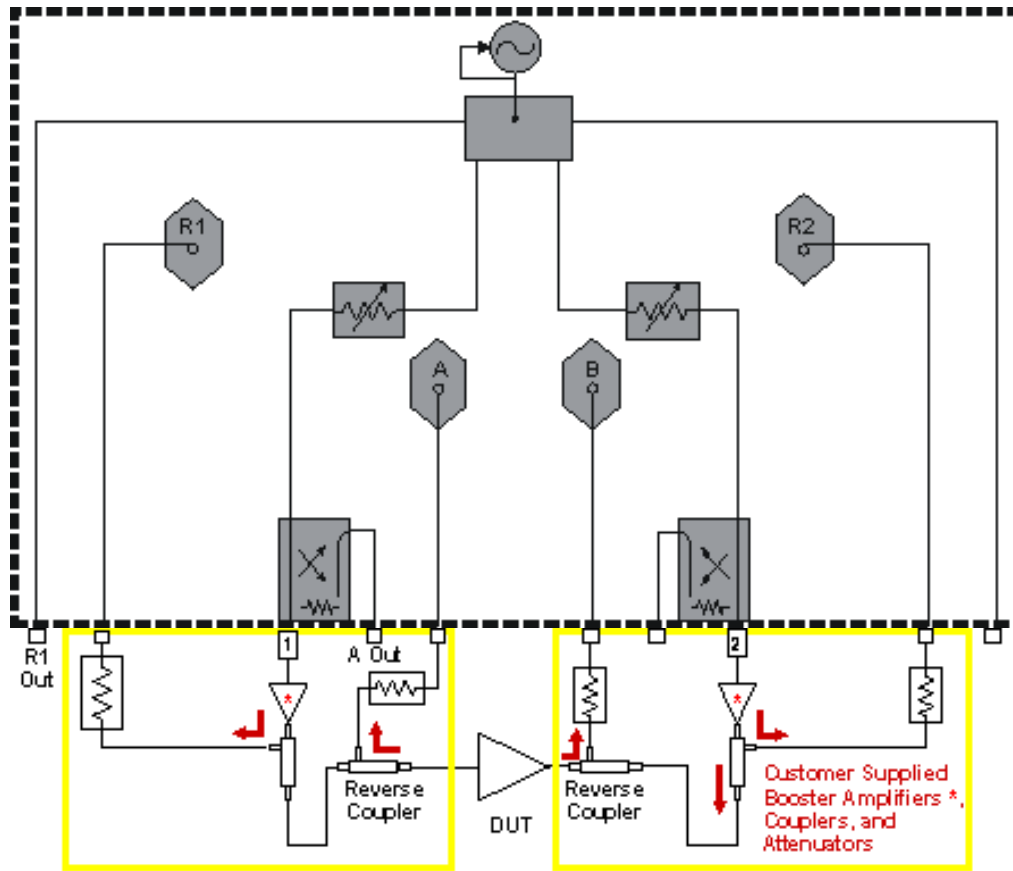
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### Diagram: (E835x) Configuration using Two Booster Amplifiers

Explore the graphic with your mouse.

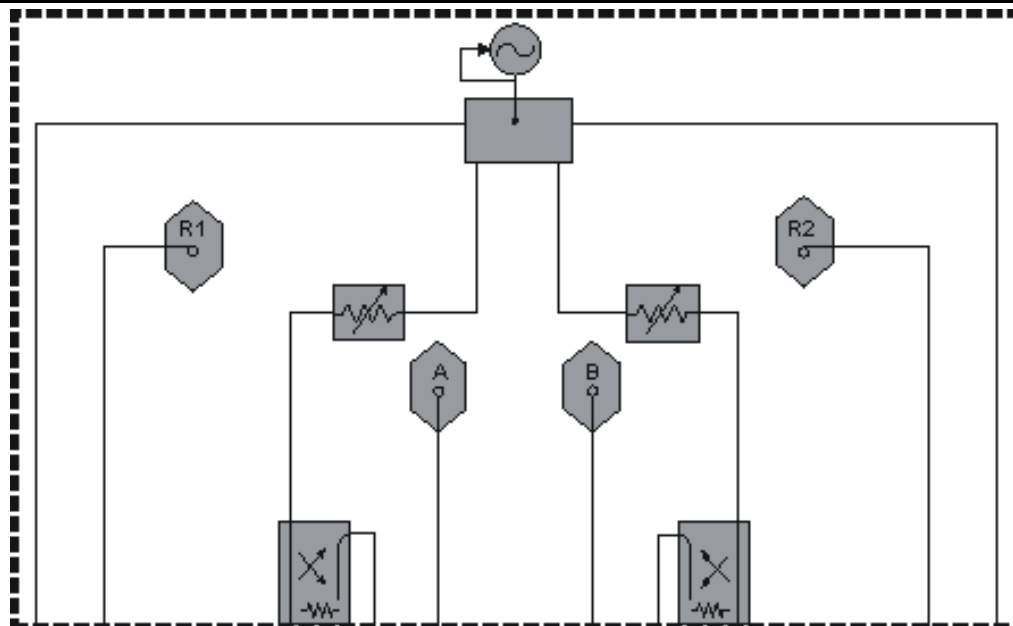
Note: the circuitry inside the yellow lines contains the following components supplied by you - two booster amps, 2 forward couplers, 2 reverse couplers (allows S11 and S22 measurements), and 4 attenuators.

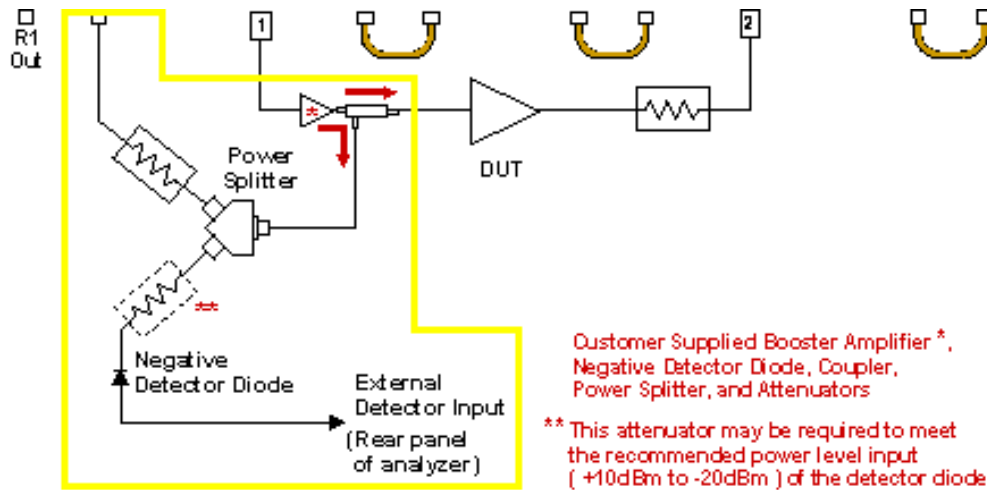


**Diagram: (E835x) External Leveling using One Booster Amplifier**

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.

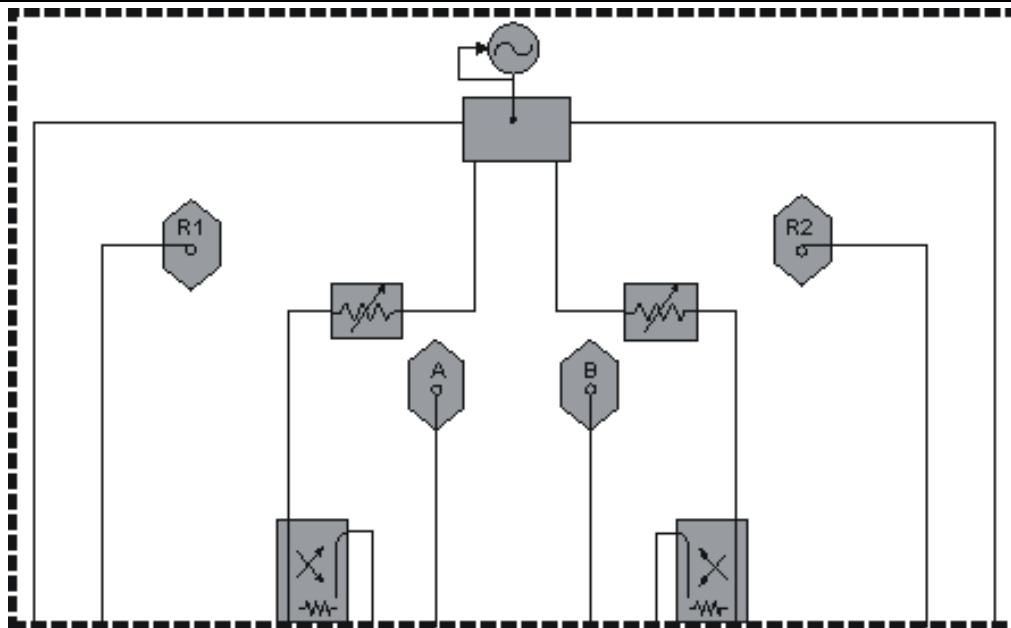


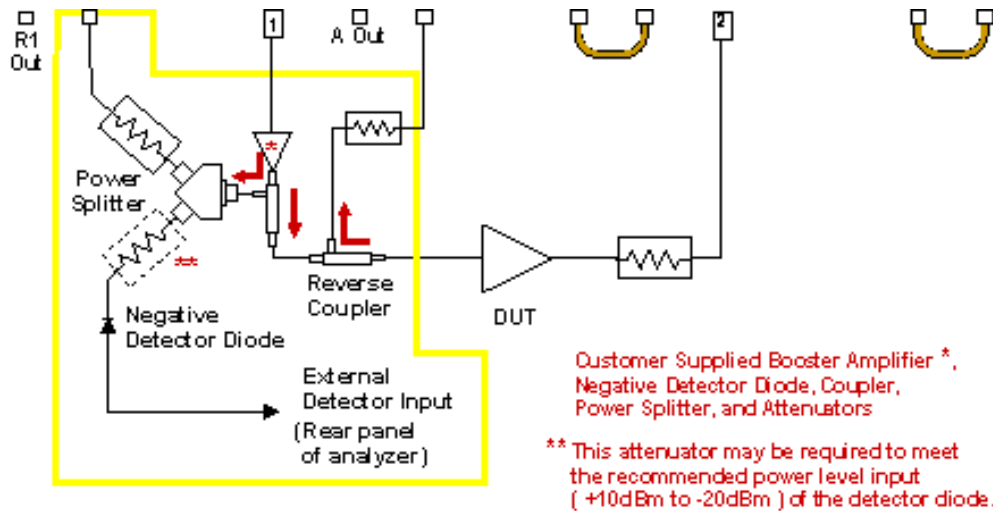


### Diagram: (E835x) External Leveling using One Booster Amplifier and a Reverse Coupler

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.

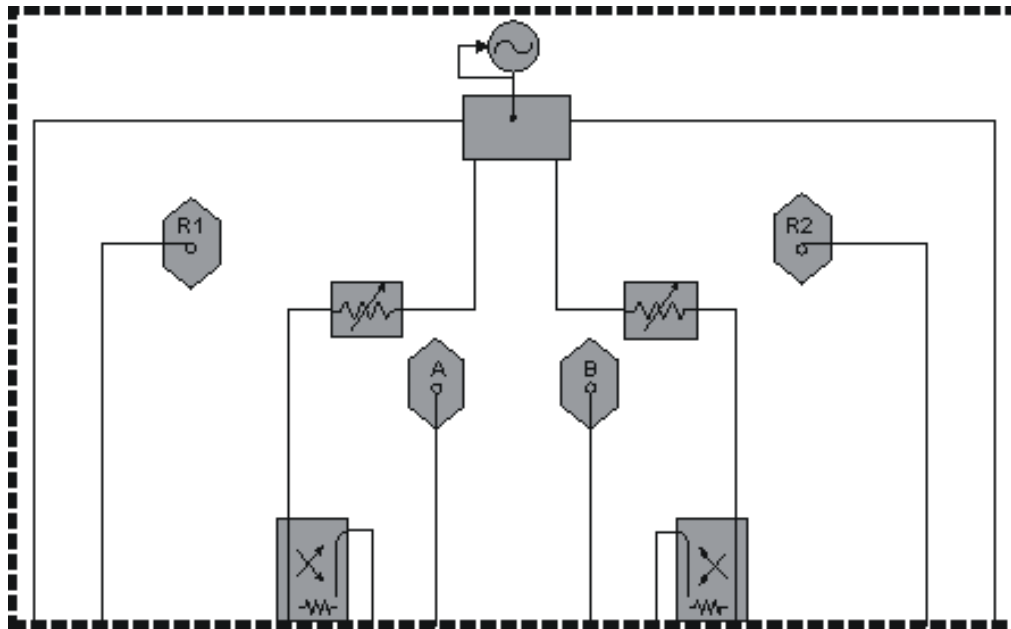




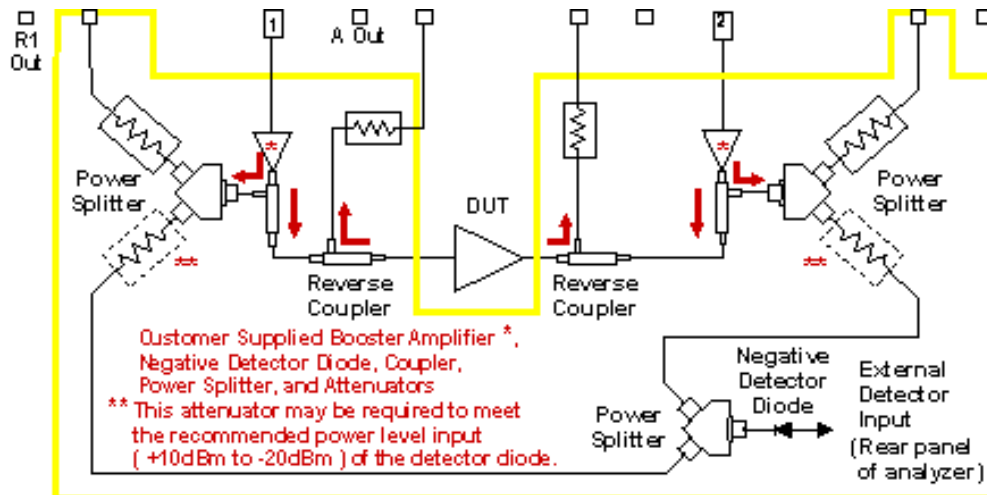
### Diagram: (E835x) External Leveling using Two Booster Amplifiers and Two Reverse Couplers

Explore the graphic with your mouse.

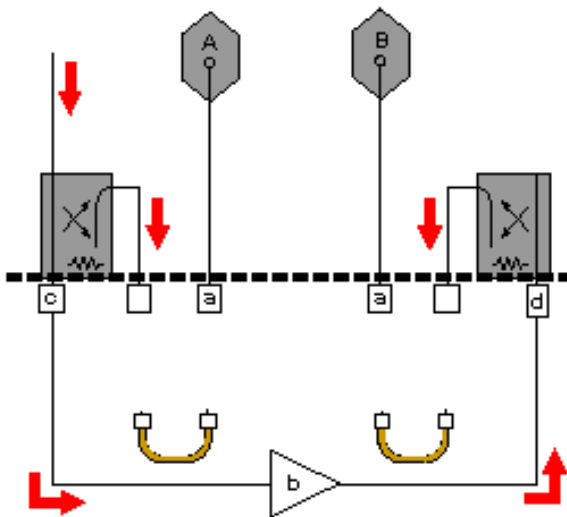
**Note:** the circuitry inside the yellow lines contains the following components supplied by you - 2 booster amps, 2 forward couplers, 2 reverse couplers (allow S11 and S22 measurements), 2 power splitters, 6 attenuators, and a negative detector diode.







**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	<a href="#">Booster amplifiers in the test setup</a>
Booster amplifier response is not flat	<a href="#">External leveling for booster amplifiers</a>
Phase-lock lost when using a booster amplifier	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

---

**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?**

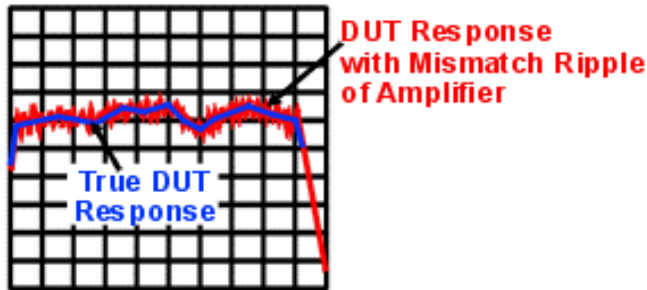
Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

---

**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.



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."

---

## 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:
    - **2-Port Calibration** (TRL or SOLT) For forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
    - **2-Port Calibration** (TRL or SOLT) For forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
    - **2-Port Calibration** (TRL or SOLT) For forward and reverse high-power transmission and reflection measurements.
    - **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 calibration 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](#)

---

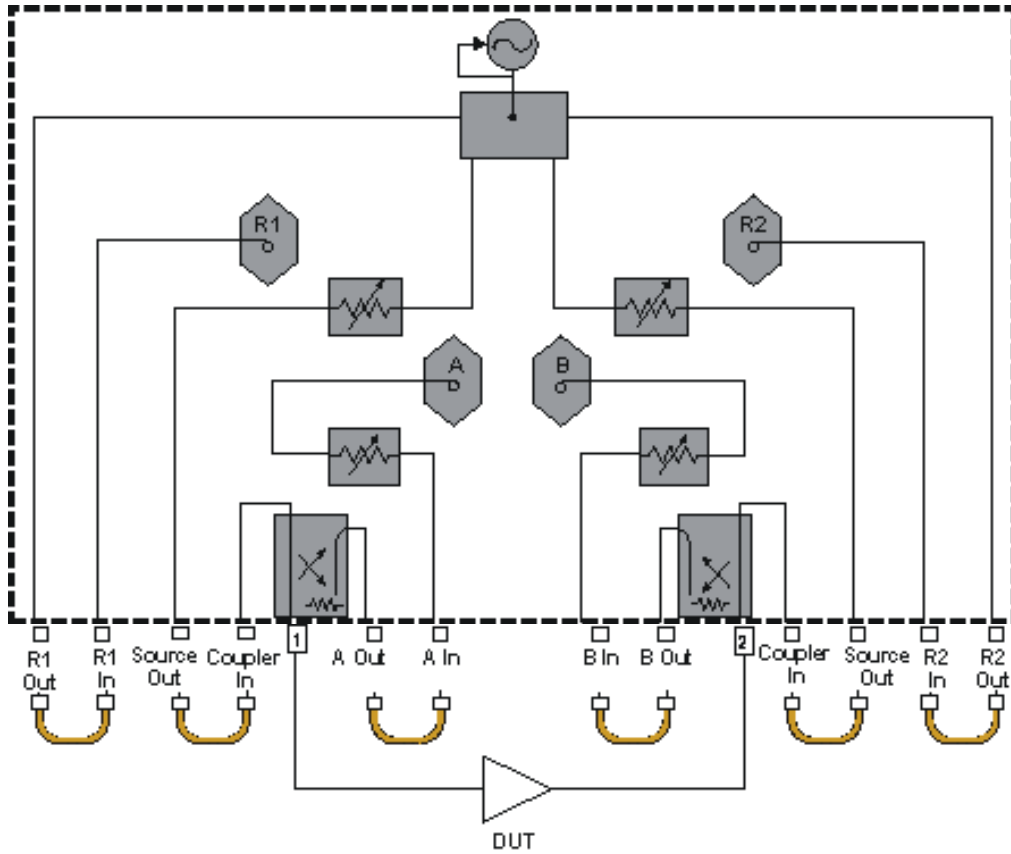
More information on High-Power Amplifier Measurements:

- [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](#)



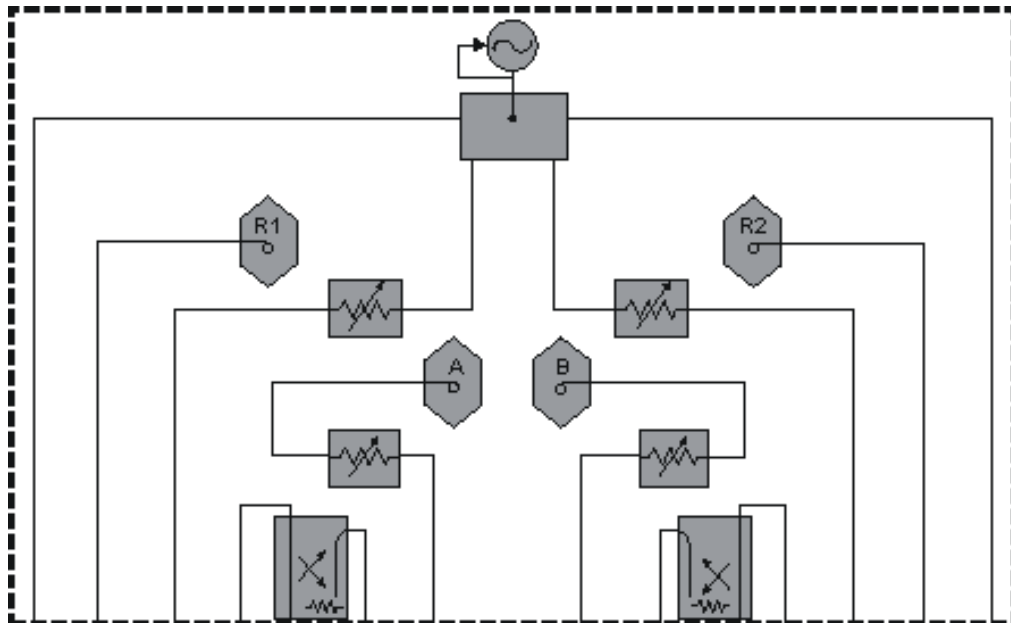
### Diagram: (E835x, Option 015) Basic Configuration

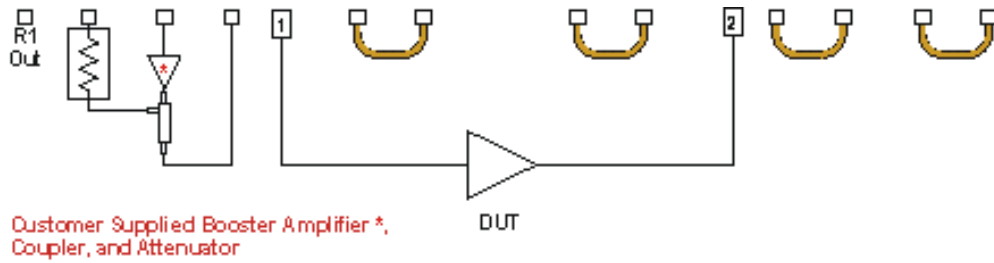
Explore the graphic with your mouse.



**Diagram: (E835xA, Option 015) Configuration for High-Power Measurements in the Forward Direction**

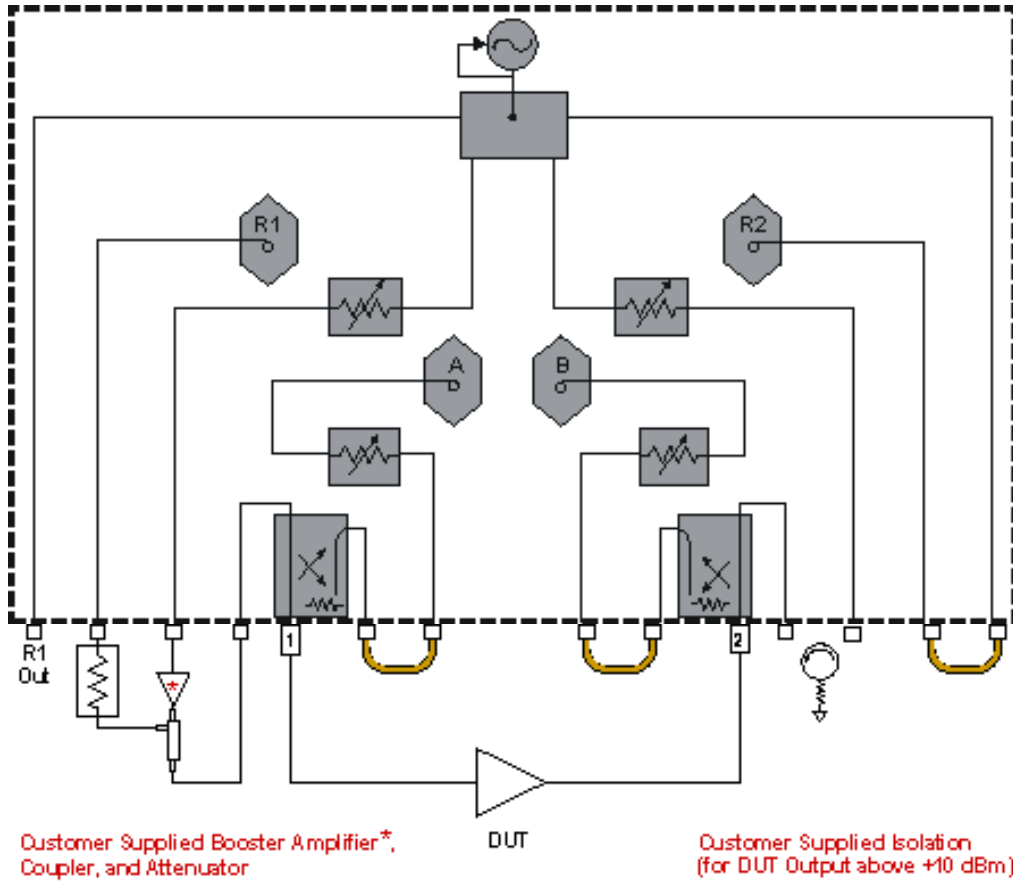
Explore the graphic with your mouse.





**Diagram: (E835xA, Option 015) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction**

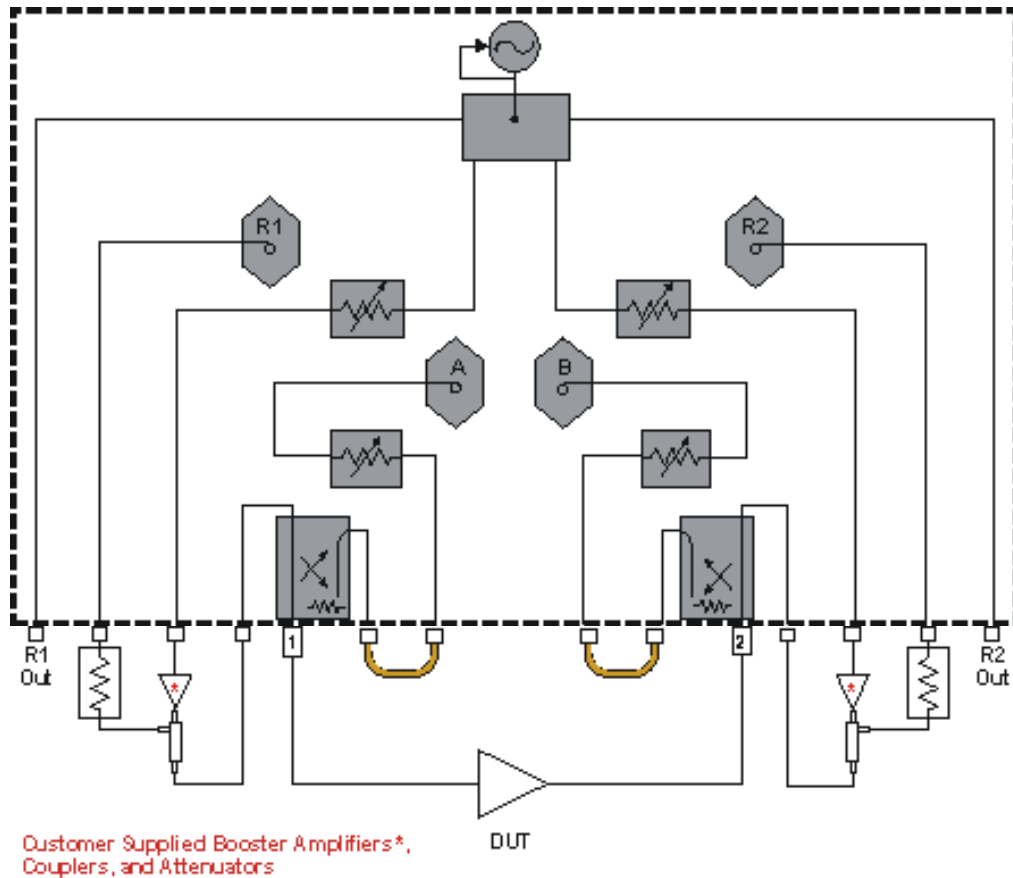
Explore the graphic with your mouse.



**Diagram: (E835xA, Option 015) Configuration for High-Power Measurements in both Forward & Reverse Directions**

Explore the graphic with your mouse.





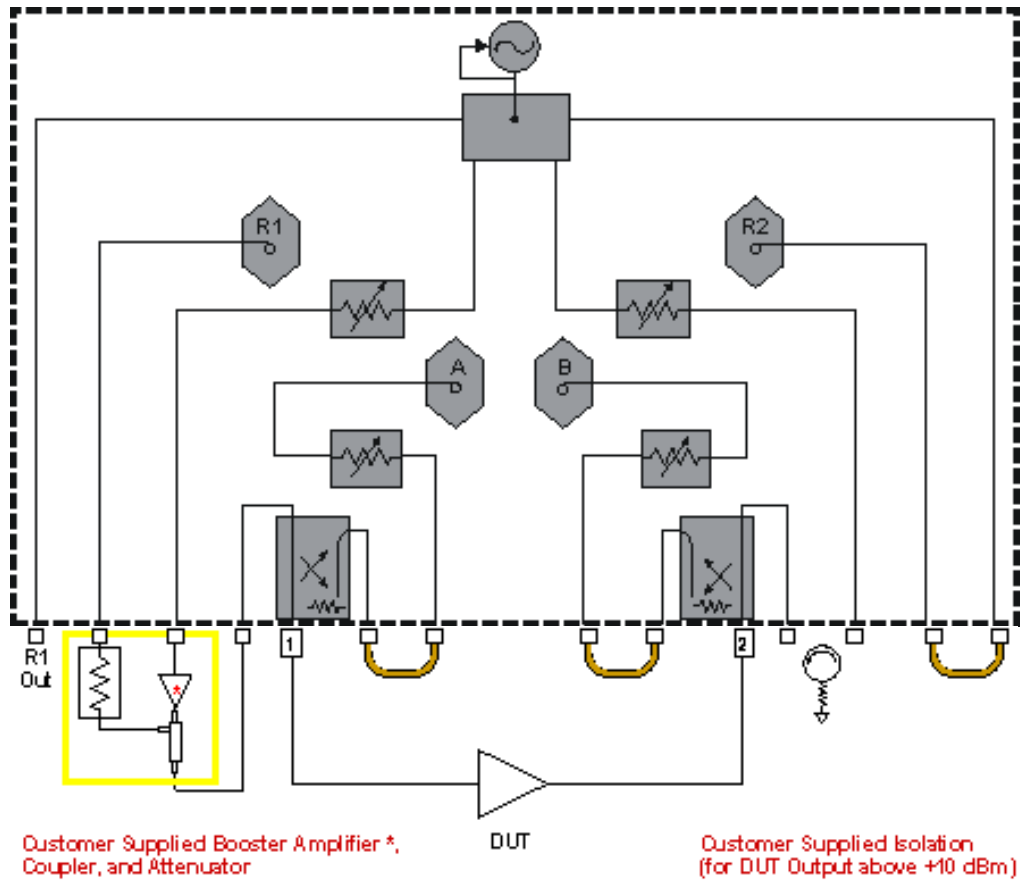
### Diagram: (E835x, Option 015) Configuration using One Booster Amplifier

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.

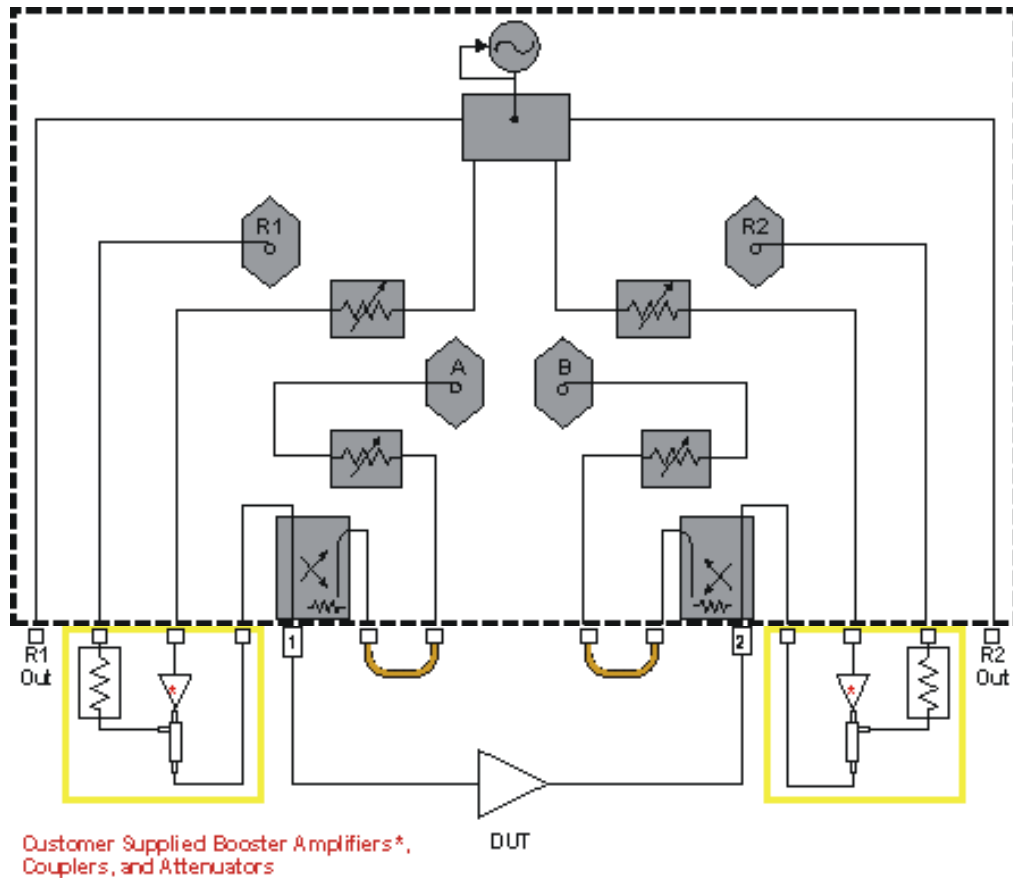
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### Diagram: (E835xA, Option 015) Configuration Using Two Booster Amplifiers

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.



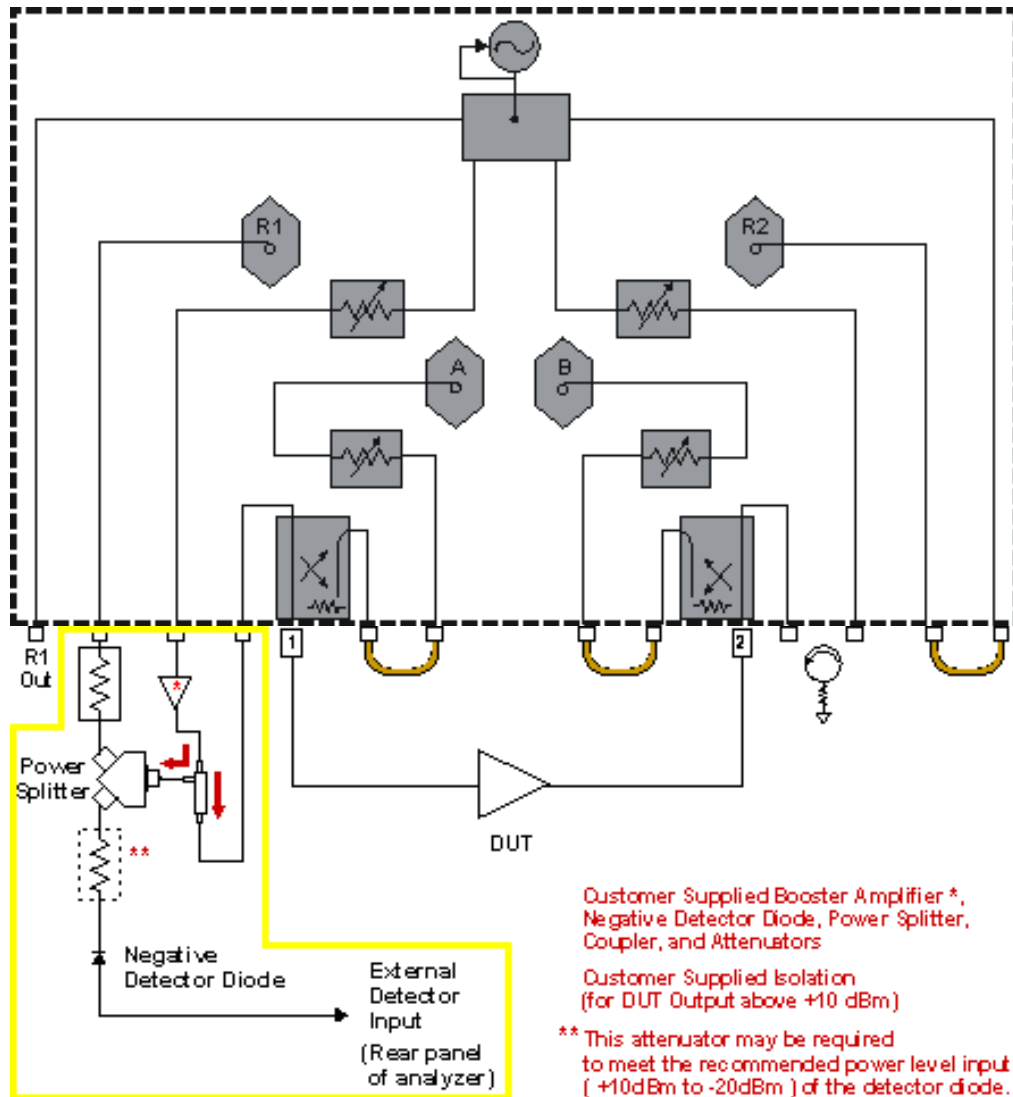
### Diagram: (E835x, Option 015) External Leveling using One Booster Amplifier

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.

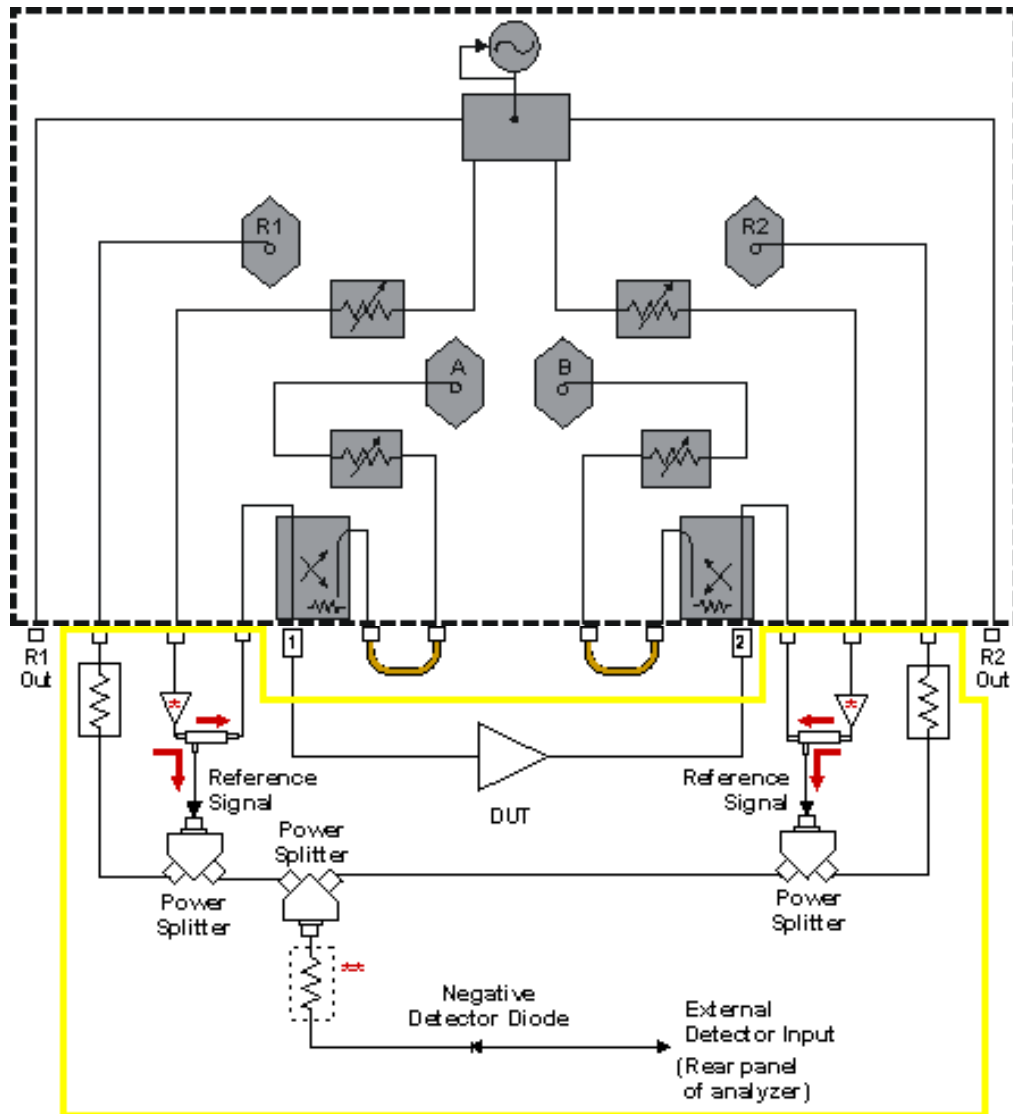
---



### Diagram: (E835xA, Option 015) External Leveling using Two Booster Amplifiers

Explore the graphic with your mouse.

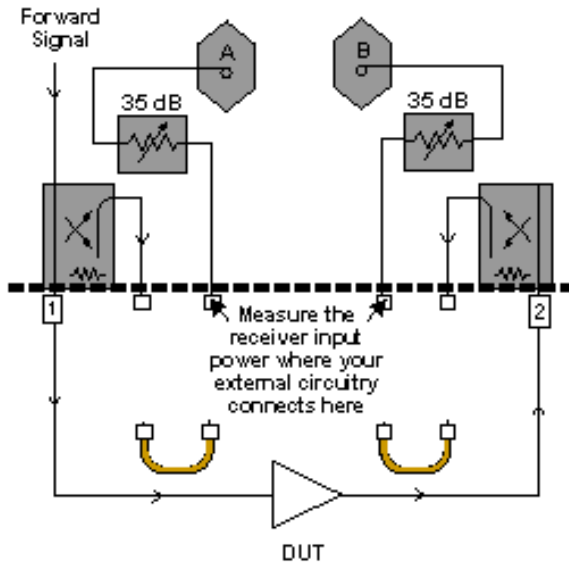
**Note:** the circuitry inside the yellow lines contains the following components supplied by you: two booster amps, two forward couplers, three attenuators, three power splitters, and a negative detector diode.



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**



E836x Standard

## High-Power Amplifier Measurements Using the E8361A, E8362A/B, E8363A/B, E8364A/B

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	<a href="#">Booster amplifiers in the test setup</a>
Phase-lock lost when using a booster amplifier	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

**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 E8361A, E8362A/B, E8363A/B, E8364A/B.

---

### **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:
    - **2-Port Calibration** (TRL or SOLT) for forward and reverse non-boosted transmission and reflection measurements.
    - **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:
    - **Thru Response** for forward high-power transmission measurements.

- **1-Port Reflection, Open/Short Response** for reverse non-booster 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 calibration 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:

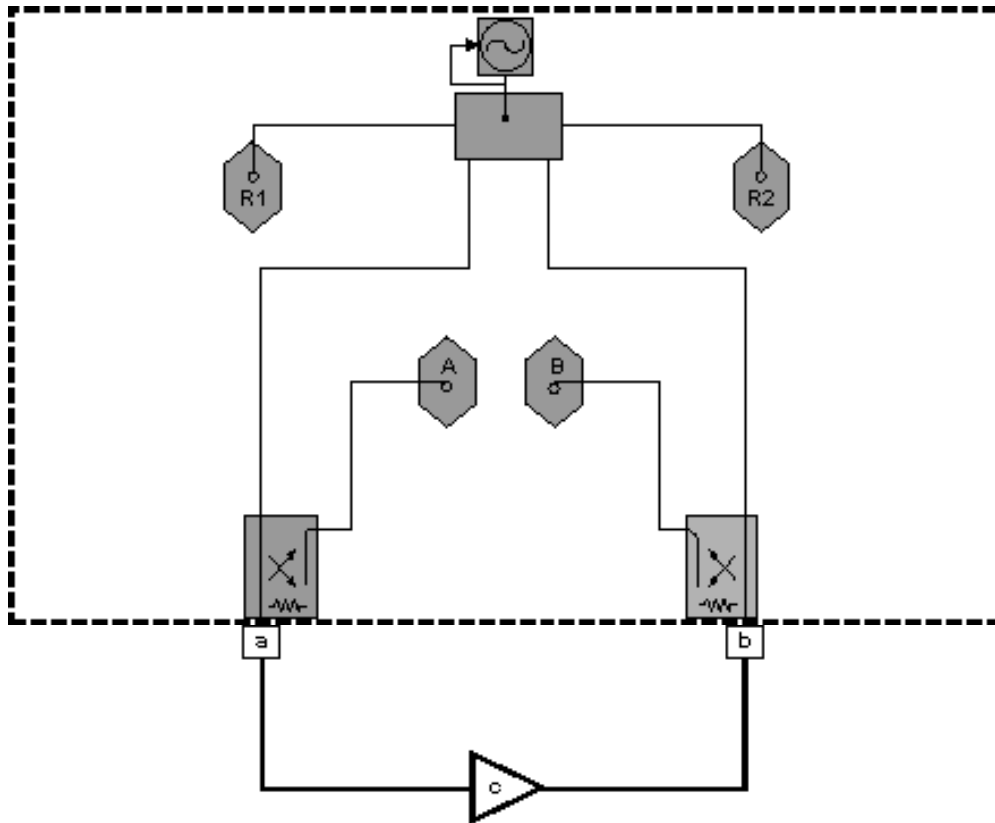
- [Disable auto-frequency calibration](#)
- [Components that reduce DUT output power](#)
- [Calibration standards that withstand high power](#)
- [Thermal requirements for DUTs and loads](#)
- [Stimulus-sweep recommendation for a DUT with an AGC loop](#)
- [Procedure for Measuring High-Power Amplifiers](#)





### Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B) Basic Configuration

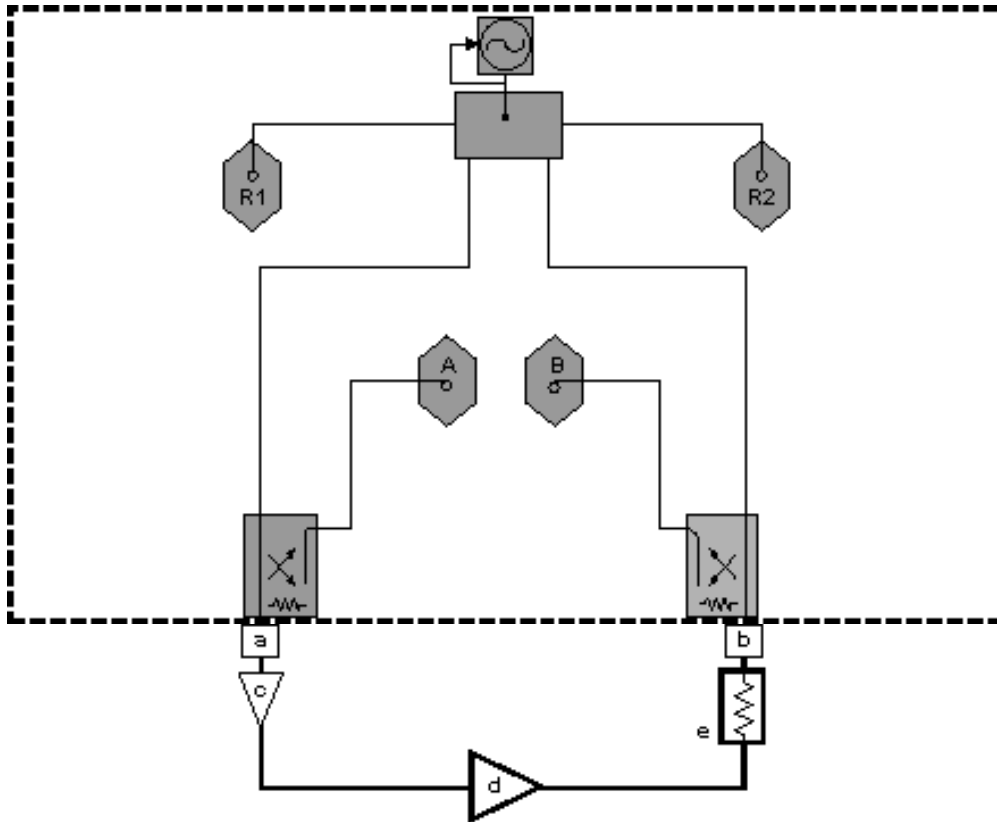
Explore the graphic with your mouse.



**Description**  
PORT 1  
PORT 2  
DUT, customer  
supplied

### Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)

Explore the graphic with your mouse.



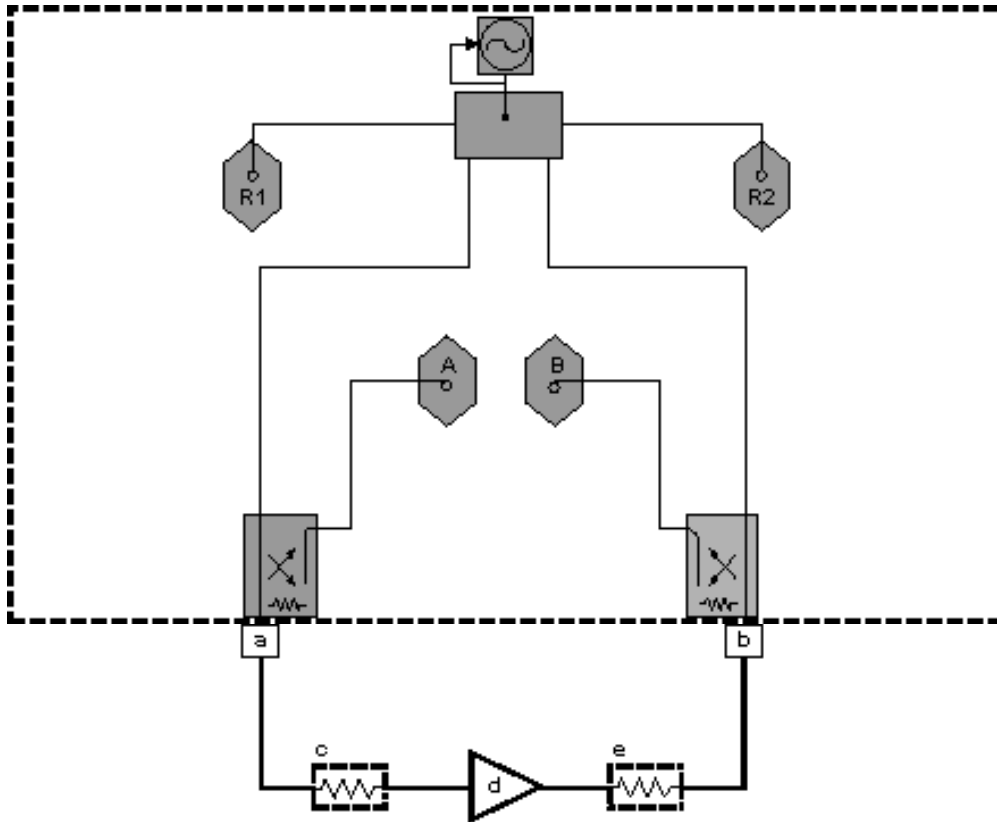
**Description**  
PORT 1

PORT 2  
Booster amplifier,  
customer supplied  
DUT, customer  
supplied

**Description**  
Attenuator (for forward  
measurements),  
customer supplied

**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions**

Explore the graphic with your mouse.



**Description**  
PORT 1

PORT 2  
Attenuator (for reverse  
measurements),  
customer supplied  
DUT, customer  
supplied

**Description**  
Attenuator (for forward  
measurements),  
customer supplied

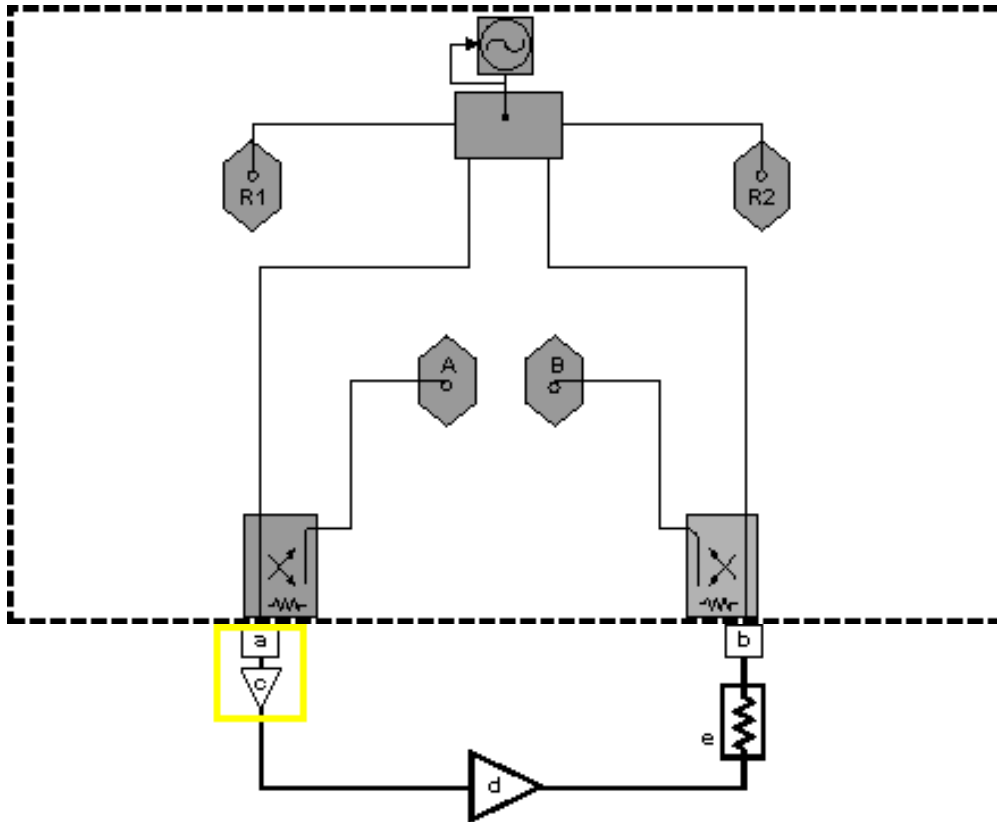
**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B) Configuration using a Booster Amp**

Explore the graphic with your mouse.

---

**Note:** the circuitry inside the yellow lines contains a booster amplifier supplied by you.

---



**Description**  
PORT 1

PORT 2  
Booster amplifier,  
customer supplied  
DUT, customer  
supplied

**Description**  
Attenuator (for forward  
measurements),  
customer supplied

E836x Opt 014

### High-Power Amplifier Measurements Using the E8361A, E8362A/B, E8363A/B, E8364A/B *Option 014*

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	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>

What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

---

**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 E8361A, E8362A/B, E8363A/B, E8364A/B.

---

## 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:
    - **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
    - **2-Port Calibration** (TRL or SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
    - **2-Port Calibration** (TRL or SOLT) for forward and reverse high-power transmission and reflection measurements.
    - **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 calibration 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 calibration 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.) 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](#)

---

More information on High-Power Amplifier Measurements:

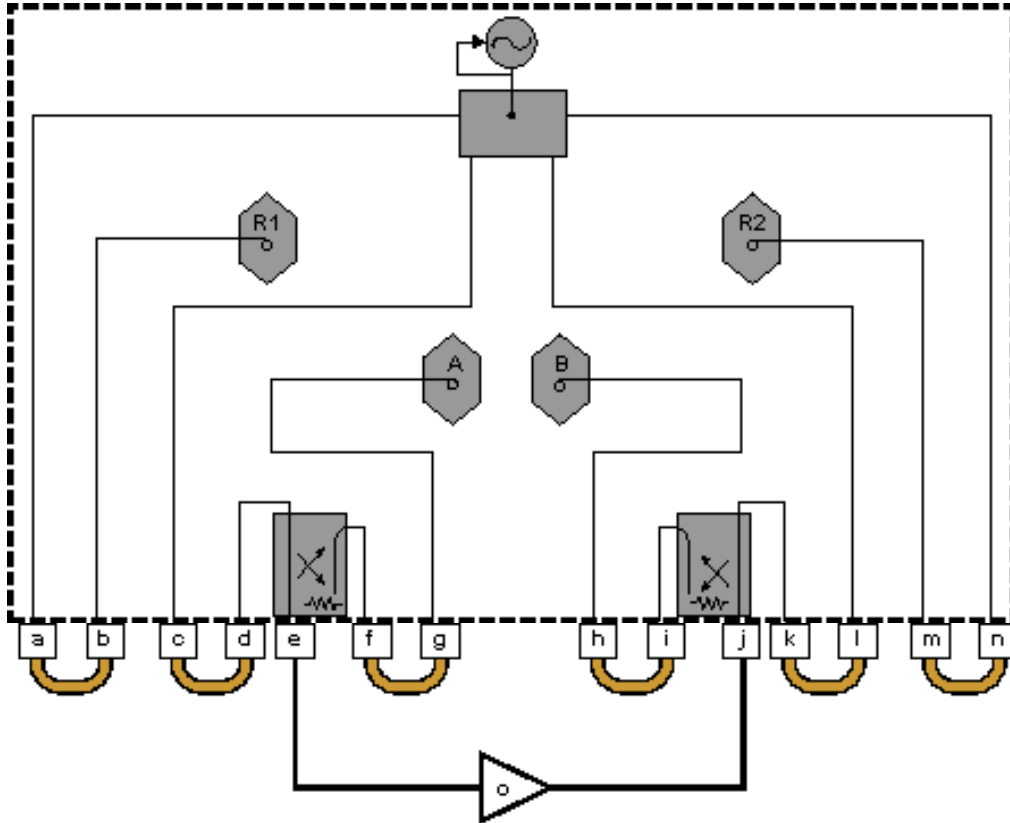
- [Disable auto-frequency calibration](#)
- [Components that reduce DUT output power](#)
- [Calibration standards that withstand high power](#)
- [Thermal requirements for DUTs and loads](#)

- [Stimulus-sweep recommendation for a DUT with an AGC loop](#)
- [Procedure for Measuring High-Power Amplifiers](#)



**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, Option 014) Basic Configuration**

Explore the graphic with your mouse.



**Description**  
SOURCE OUT  
  
RCVR R1 IN  
SOURCE OUT  
CPLR THRU  
PORT 1  
CPLR ARM  
RCVR A IN

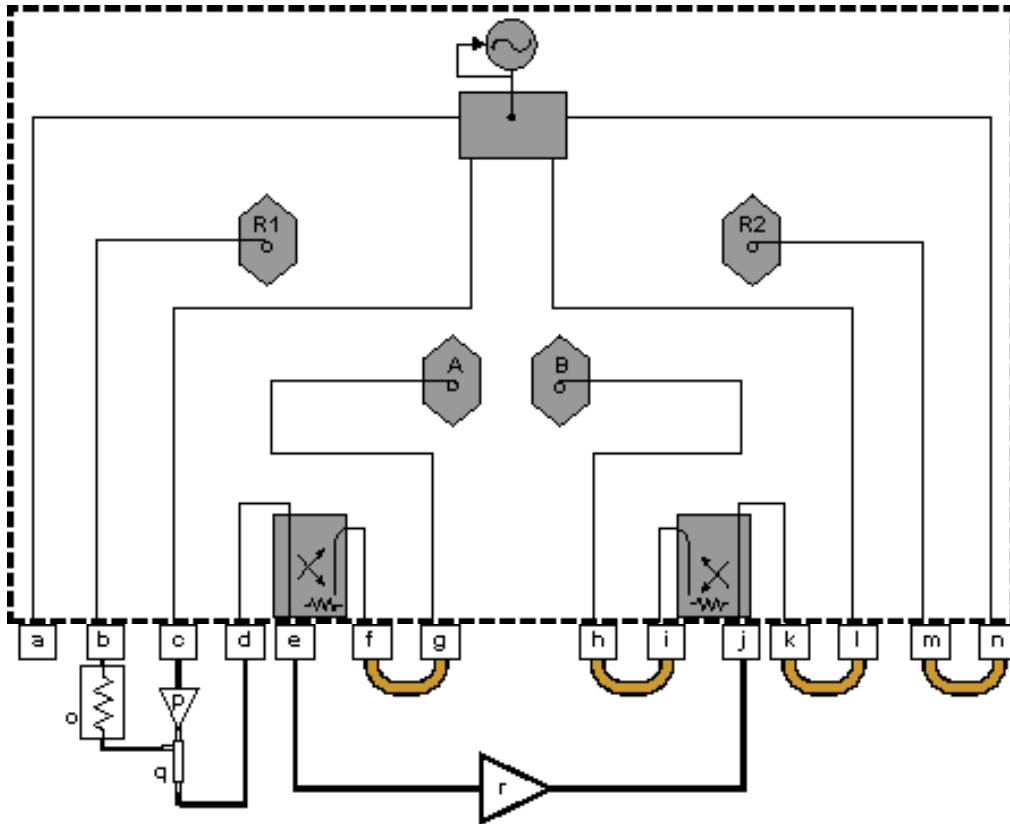
**Description**  
RCVR B IN  
  
CPLR ARM  
PORT 2  
CPLR THRU  
SOURCE OUT  
RCVR R2 IN  
SOURCE OUT

**Description**  
DUT, customer  
supplied

**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, Option 014) Configuration for High-Power Measurements in the Forward Direction**

Explore the graphic with your mouse.





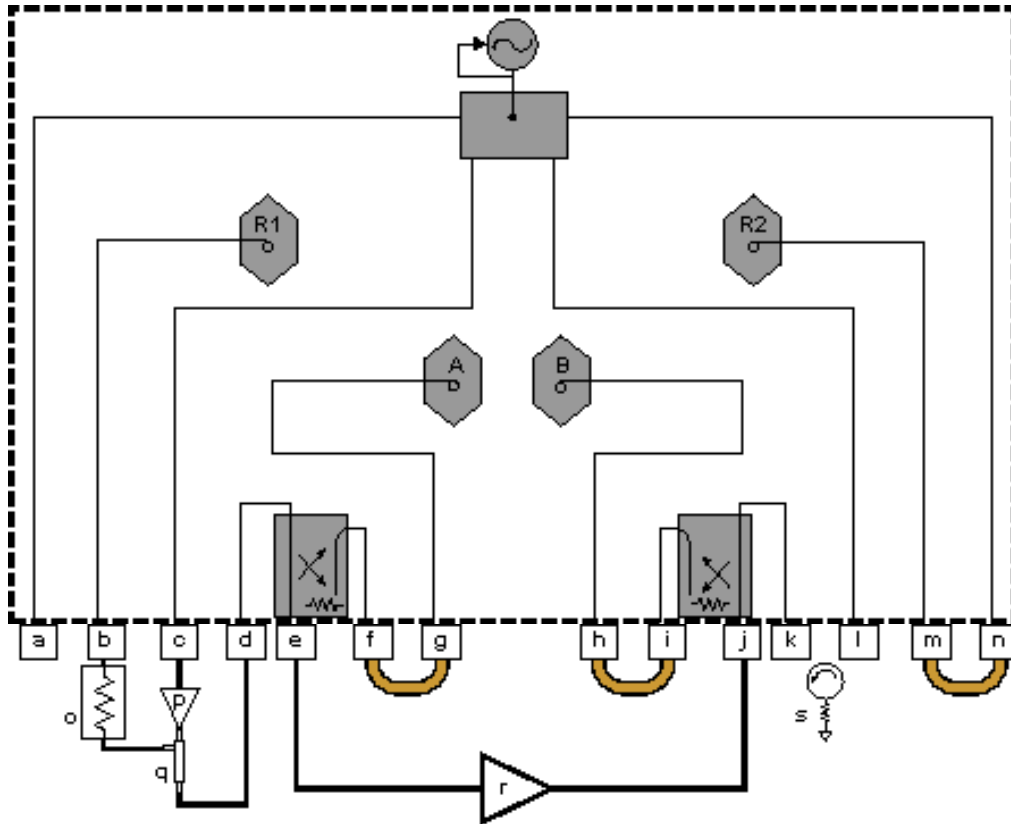
**Description**  
 SOURCE OUT  
 RCVR R1 IN  
 SOURCE OUT  
 CPLR THRU  
 PORT 1  
 CPLR ARM  
 RCVR A IN

**Description**  
 RCVR B IN  
 CPLR ARM  
 PORT 2  
 CPLR THRU  
 SOURCE OUT  
 RCVR R2 IN  
 SOURCE OUT

**Description**  
 Attenuator, customer  
 supplied  
 Booster amplifier,  
 customer supplied  
 Directional coupler,  
 customer supplied  
 DUT, customer  
 supplied

**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, Option 014)  
 Configuration (with an Isolator) for High-Power Measurements in the  
 Forward Direction**

Explore the graphic with your mouse.

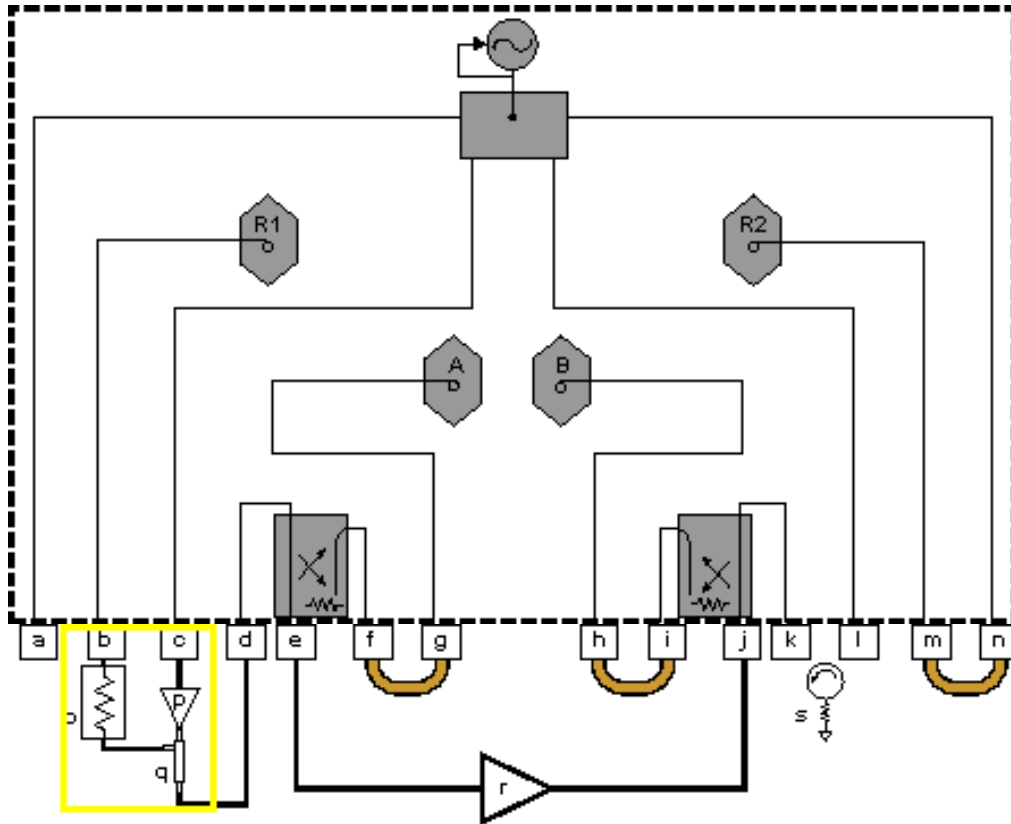


<b>Description</b> SOURCE OUT	<b>Description</b> RCVR B IN	<b>Description</b> Attenuator, customer supplied
RCVR R1 IN	CPLR ARM	Booster amplifier, customer supplied
SOURCE OUT	PORT 2	Directional coupler, customer supplied
CPLR THRU	CPLR THRU	DUT, customer supplied
PORT 1	SOURCE OUT	Isolator, customer supplied (for DUT output above +10 dBm)
CPLR ARM	RCVR R2 IN	
RCVR A IN	SOURCE OUT	

### Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, 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**  
SOURCE OUT

RCVR R1 IN

SOURCE OUT

CPLR THRU

PORT 1

CPLR ARM

RCVR A IN

**Description**  
RCVR B IN

CPLR ARM

PORT 2

COUPLER THRU

SOURCE OUT

RCVR R2 IN

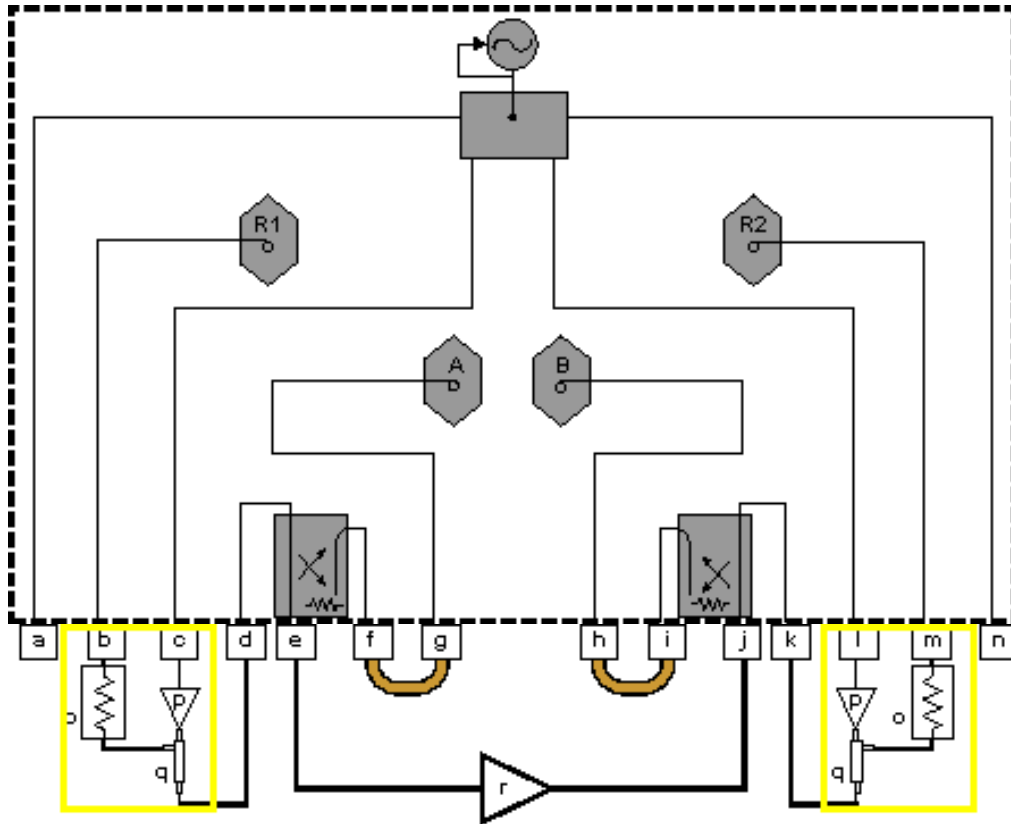
SOURCE OUT

**Description**  
Attenuator, customer  
supplied  
Booster amplifier,  
customer supplied  
Directional coupler,  
customer supplied  
DUT, customer  
supplied  
Isolator, customer  
supplied (for DUT  
output above +10 dBm)

### Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, 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.



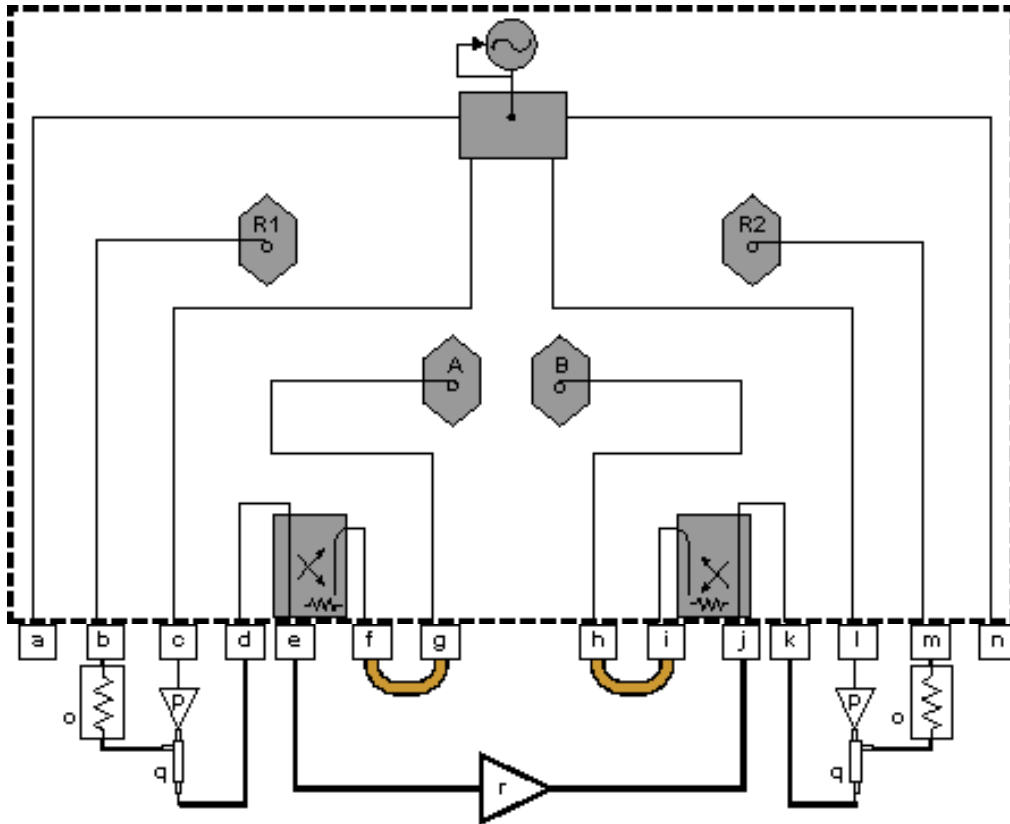
**Description**  
 SOURCE OUT  
 RCVR R1 IN  
 SOURCE OUT  
 CPLR THRU  
 PORT 1  
 CPLR ARM  
 RCVR A IN

**Description**  
 RCVR B IN  
 CPLR ARM  
 PORT 2  
 CPLR THRU  
 SOURCE OUT  
 RCVR R2 IN  
 SOURCE OUT

**Description**  
 Attenuator, customer  
 supplied  
 Booster amplifier,  
 customer supplied  
 Directional coupler,  
 customer supplied  
 DUT, customer  
 supplied

**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, Option 014)  
 Configuration for High-Power Measurements in both Forward & Reverse  
 Directions**

Explore the graphic with your mouse.



**Description**  
SOURCE OUT

RCVR R1 IN

SOURCE OUT

CPLR THRU

PORT 1

CPLR ARM

RCVR A IN

**Description**  
RCVR B IN

CPLR ARM

PORT 2

CPLR THRU

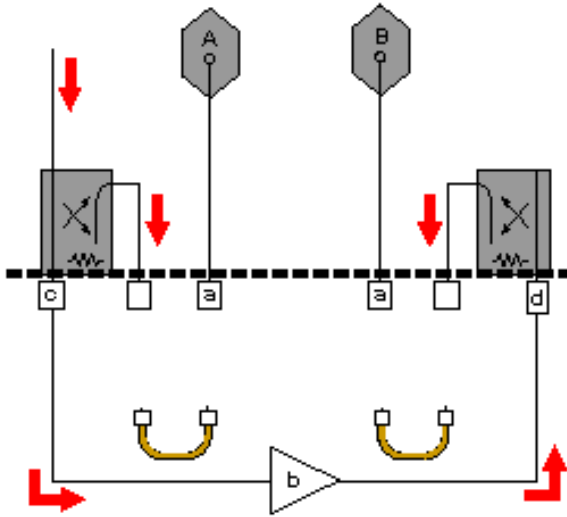
SOURCE OUT

RCVR R2 IN

SOURCE OUT

**Description**  
Attenuator, customer  
supplied  
Booster amplifier,  
customer supplied  
Directional coupler,  
customer supplied  
DUT, customer  
supplied

**Diagram: (E8361A, E8362A/B, E8363A/B, E8364A/B, 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**

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	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

---

**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 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.

---

## 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

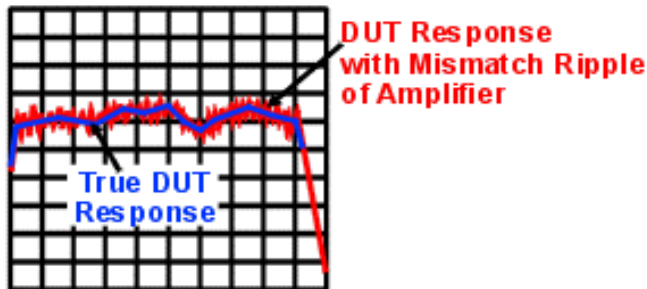
peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

---

**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."

---

## 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:
    - **2-Port Calibration** (SOLT) for forward and reverse non-boosted transmission and reflection measurements.
    - **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:
    - **Thru Response** for forward high-power transmission measurements.
    - **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.

Compare with: [Basic Configuration](#).

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 calibration 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.

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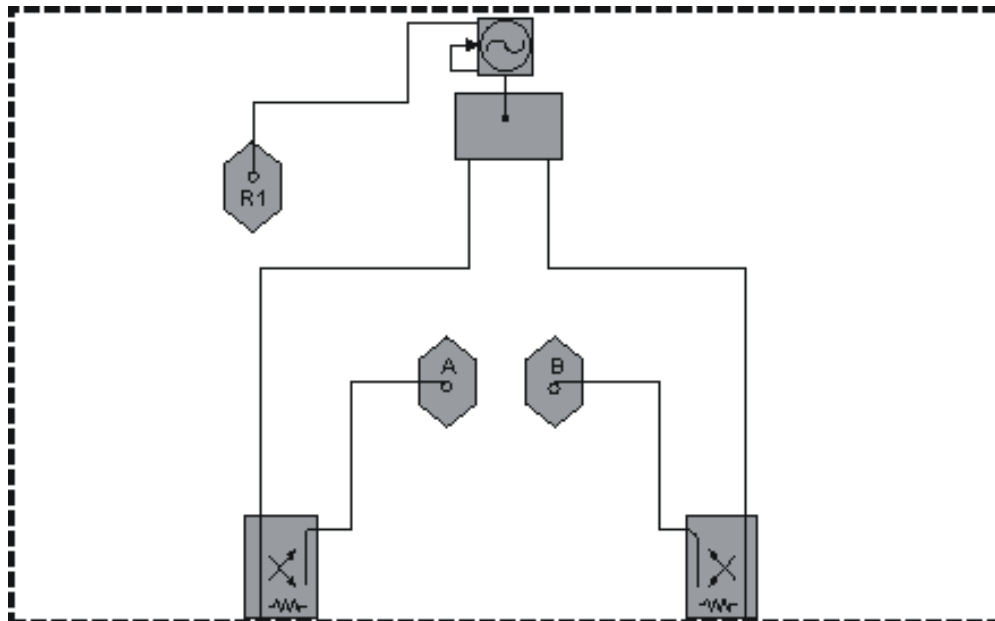
More information on High-Power Amplifier Measurements:

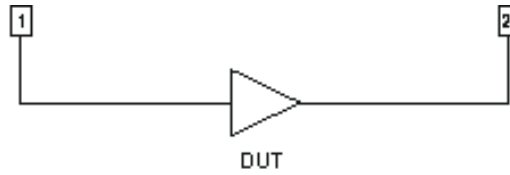
- [Disable auto-frequency calibration](#)
- [Components that reduce DUT output power](#)
- [Calibration standards that withstand high power](#)
- [Thermal requirements for DUTs and loads](#)
- [Stimulus-sweep recommendation for a DUT with an AGC loop](#)
- [Procedure for Measuring High-Power Amplifiers](#)



### Diagram: (E880xA) Basic Configuration

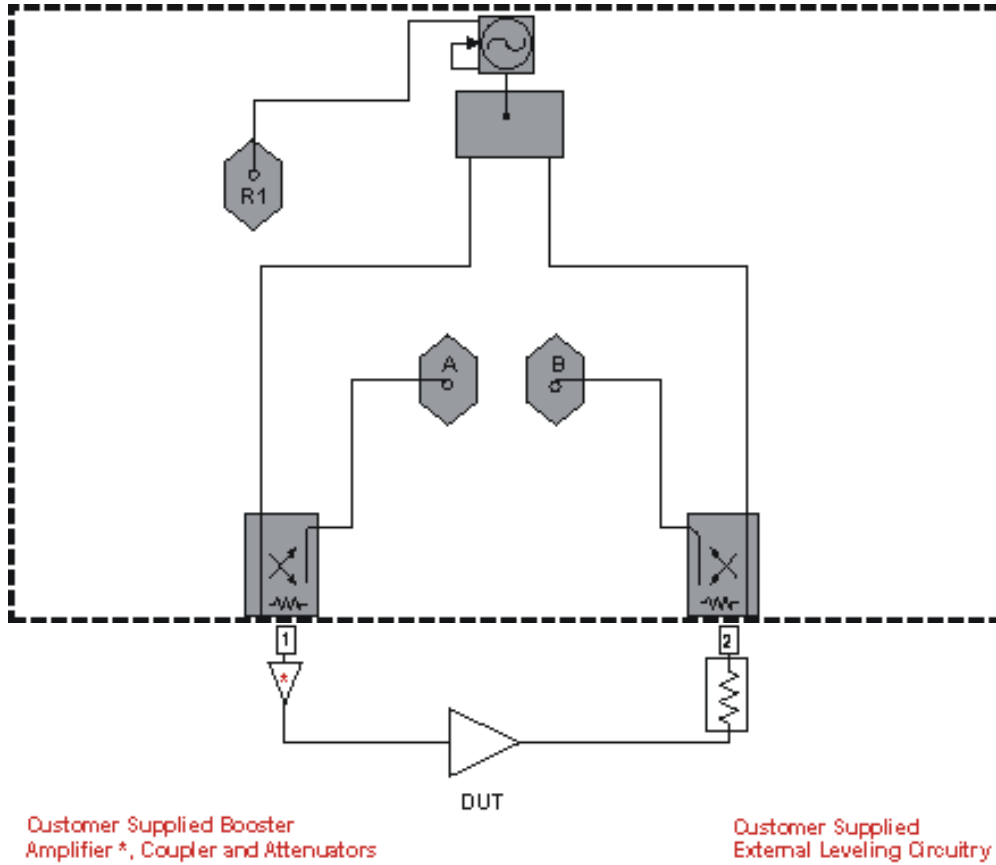
Explore the graphic with your mouse.





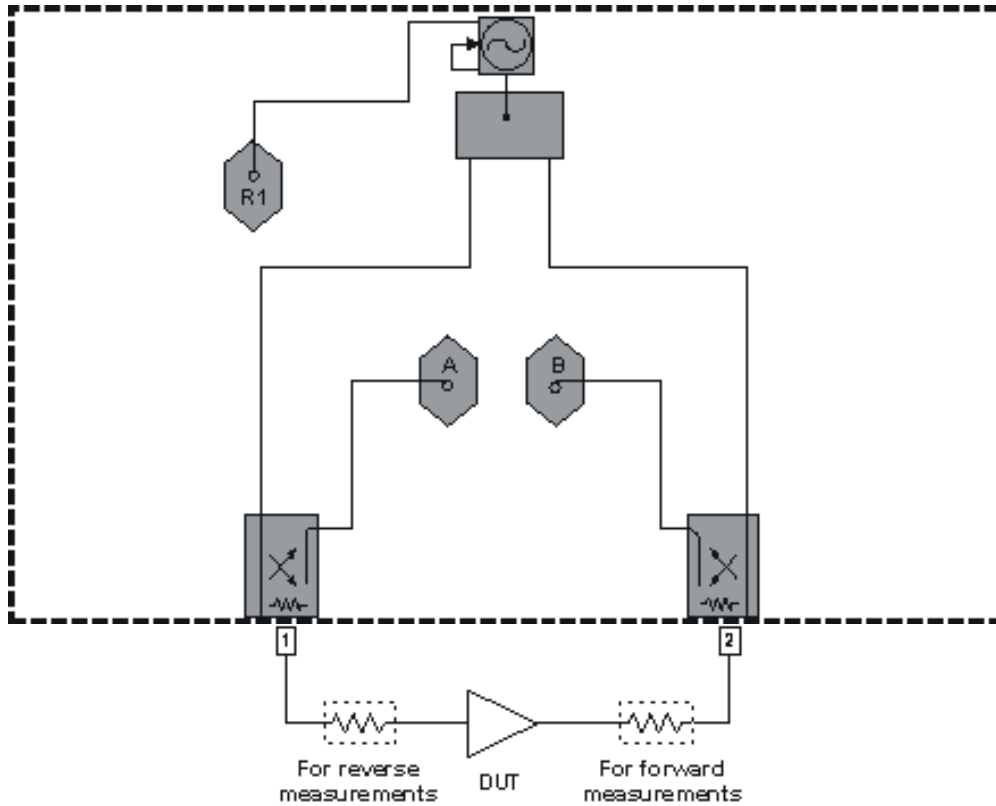
**Diagram: (E880xA) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)**

Explore the graphic with your mouse.



**Diagram: (E880xA) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions**

Explore the graphic with your mouse.

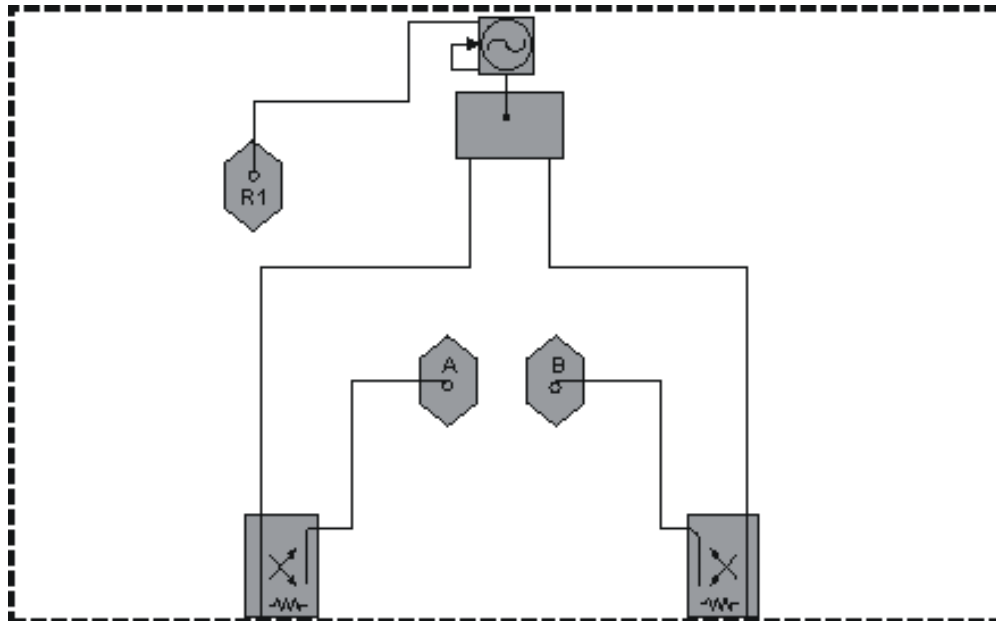


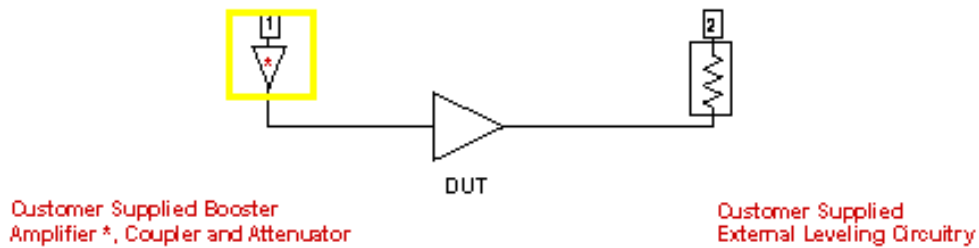
Customer Supplied Attenuator - Location  
Dependent on Direction of Measurement

### 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.

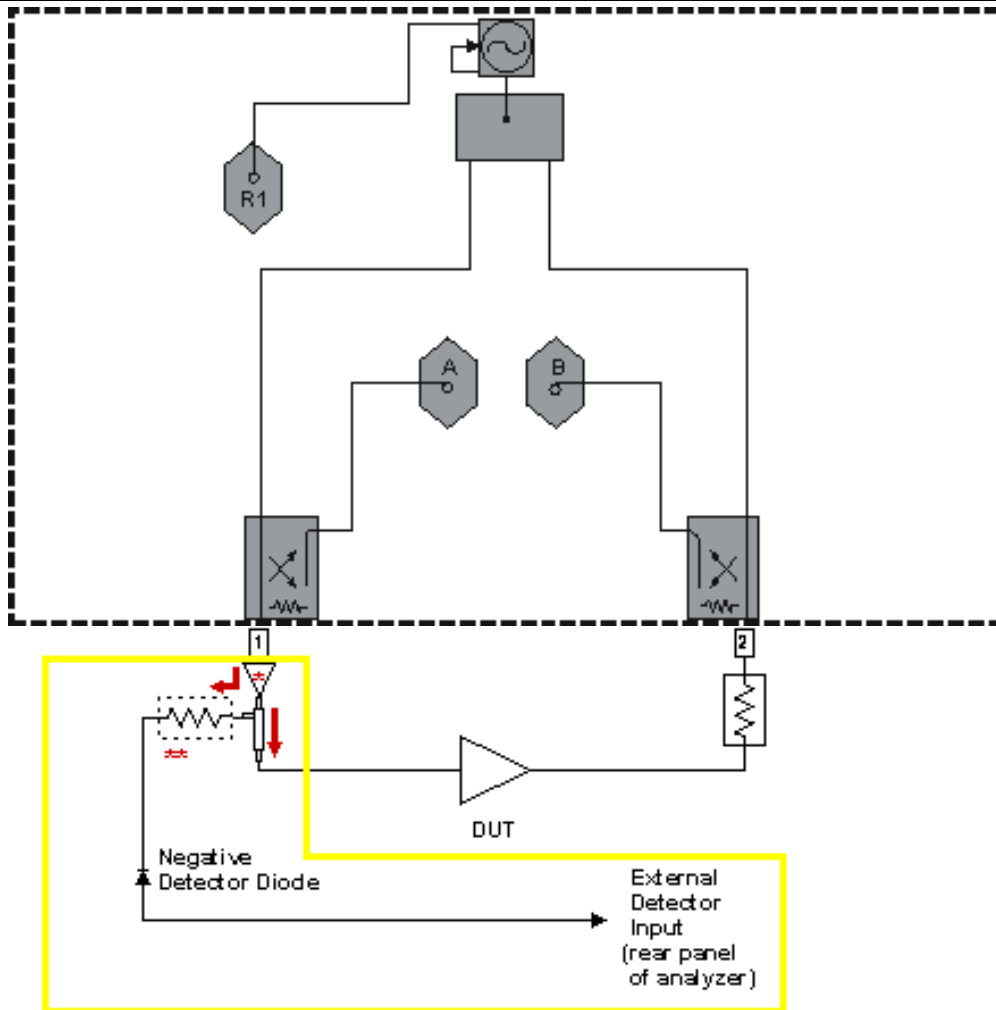




### Diagram: (E880xA) External Leveling Configuration

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.

## High-Power Amplifier Measurements Using the E8801A *Option 014*, E8802A *Option 014*, and E8803A *Option 014*

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	<a href="#">Booster amplifiers in the test setup</a>
Booster amplifier response is not flat	<a href="#">External leveling for booster amplifiers</a>
Phase-lock lost when using a booster amplifier	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

**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.

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**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.

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## **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.

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**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.

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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

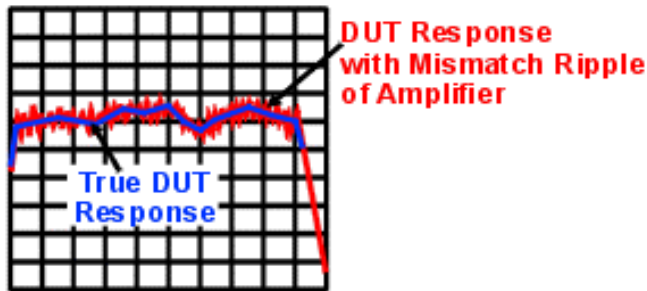
leveling.

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**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.

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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 [external leveling circuitry that uses a DC preamplifier](#) (recommended when the input power-level to the detector diode is less than -20 dBm).

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**Note:** When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

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### 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:
    - **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
    - **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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 for high-power measurements in both forward and reverse directions
  - Possible calibration choices:
    - **2-Port Calibration** (SOLT) for forward and reverse high-power transmission and reflection measurements.
    - **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:

- **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 calibration 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](#).

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**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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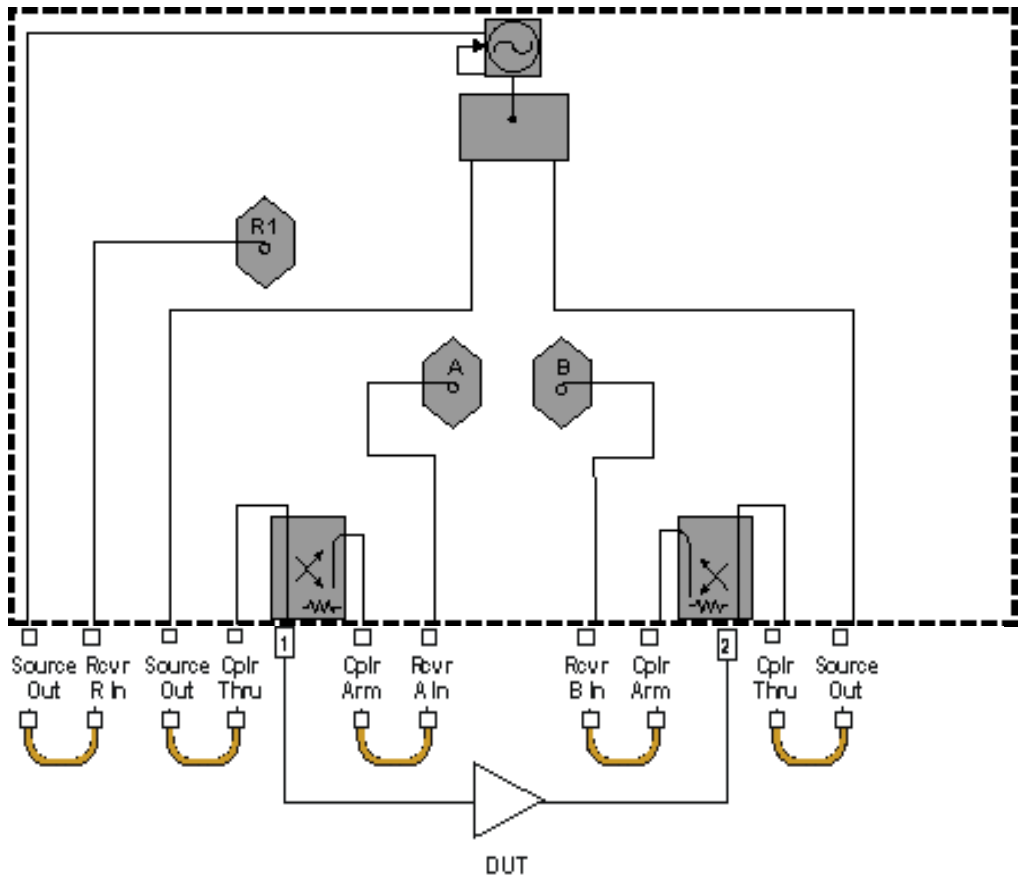
More information on High-Power Amplifier Measurements:

- [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](#)



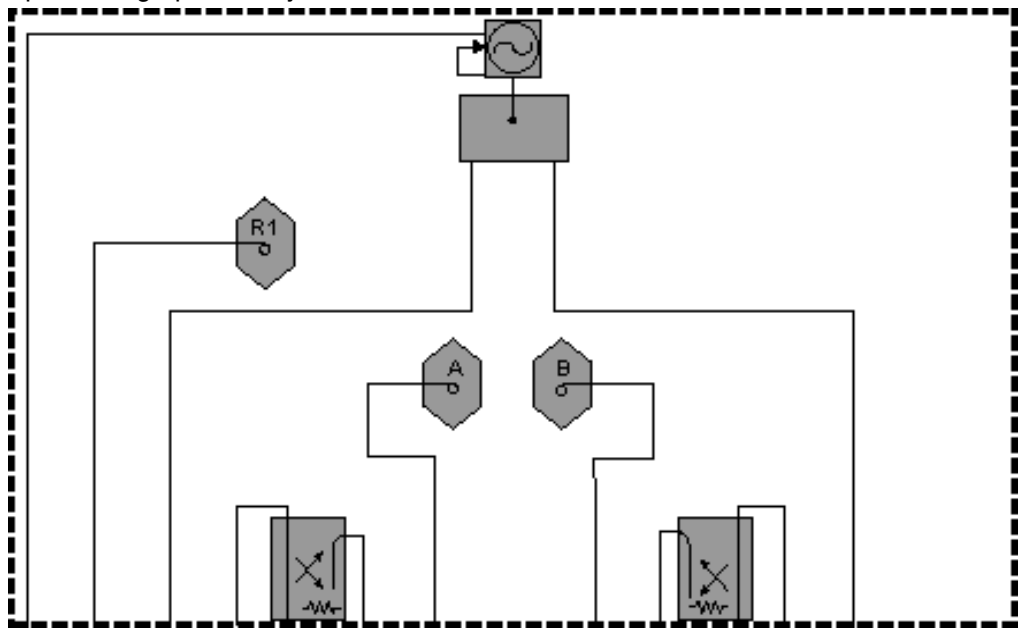
## Diagram: (E880xA, Option 014) Basic Configuration

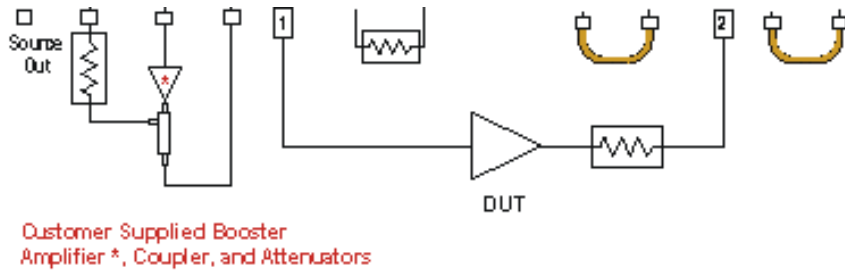
Explore the graphic with your mouse.



**Diagram: (E880xA, Option 014) Configuration for High-Power Measurements in the Forward Direction**

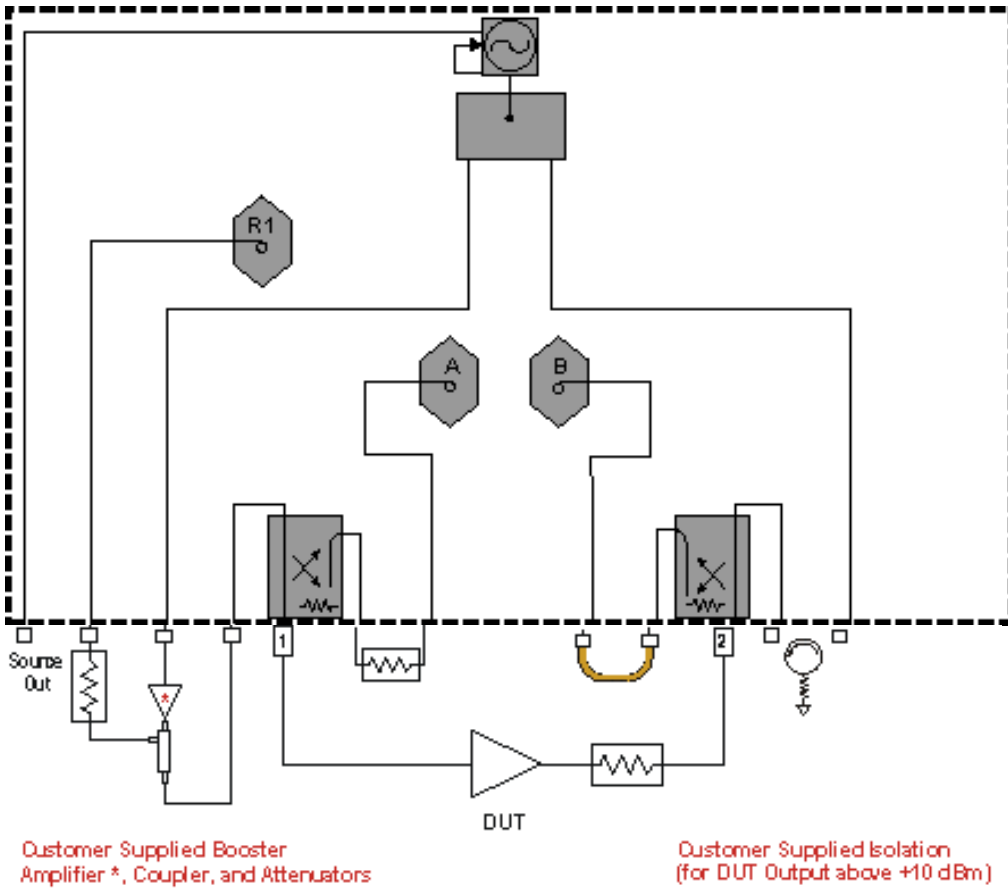
Explore the graphic with your mouse.





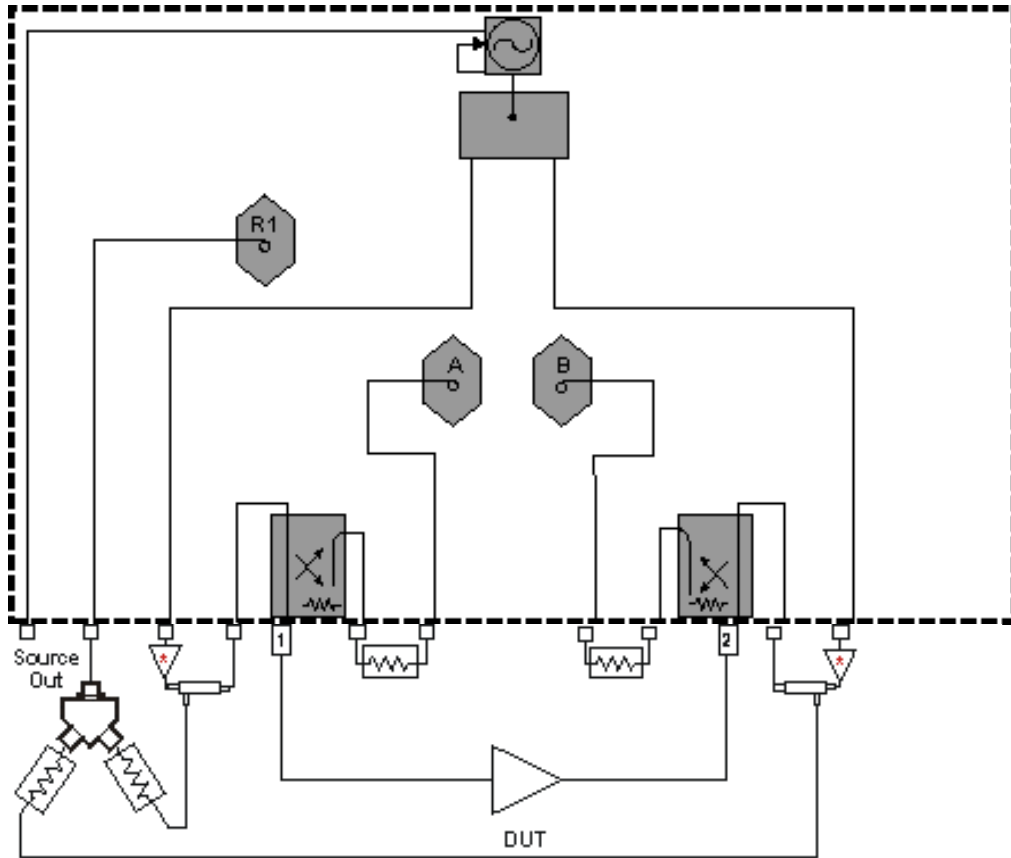
**Diagram: (E880xA, Option 014) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction**

Explore the graphic with your mouse.



**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

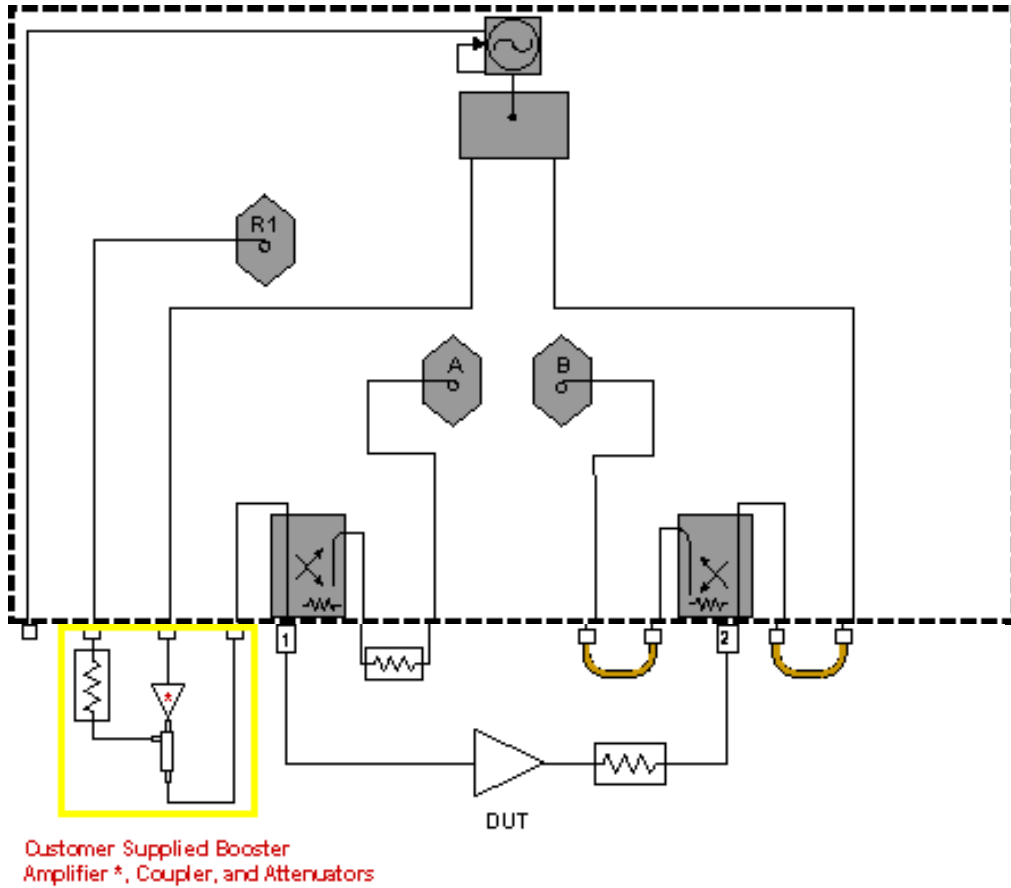
### Diagram: (E880xA, Option 014) Configuration Using One Booster Amplifier

Explore the graphic with your mouse.

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**Note:** the circuitry inside the yellow lines contains the following components supplied by you - a booster amplifier, a forward coupler, and an attenuator.

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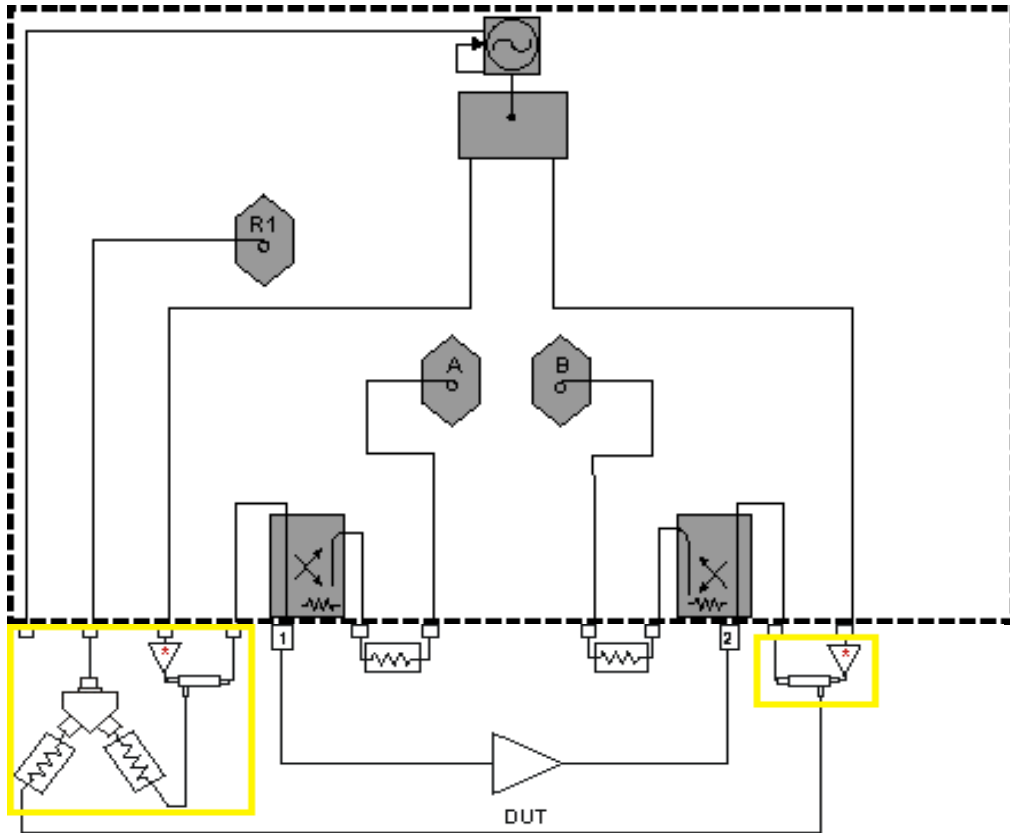
### Diagram: (E880xA, Option 014) Configuration Using Two Booster Amplifiers

Explore the graphic with your mouse.

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**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.

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Customer Supplied Booster Amplifiers \*,  
Couplers, Attenuators and Power Splitter

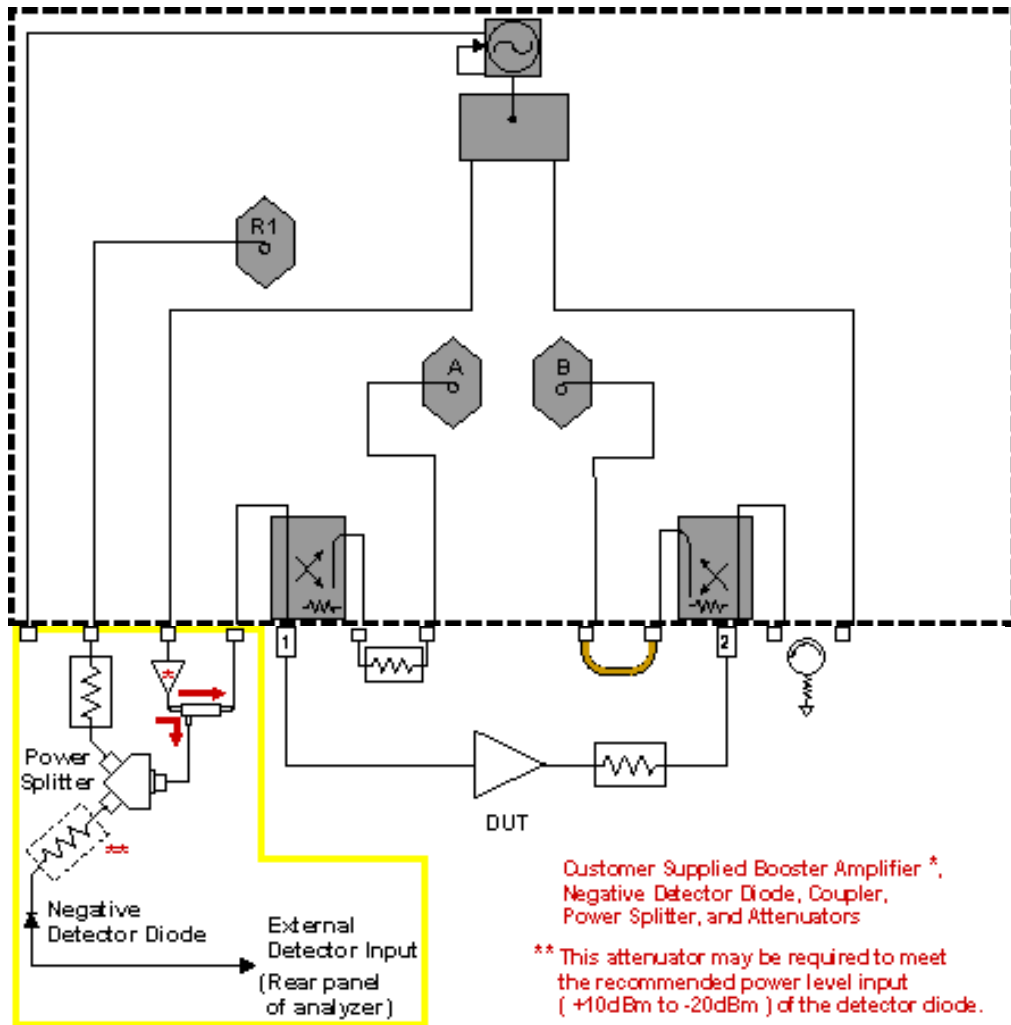
### Diagram: (E880xA, Option 014) External Leveling using One Booster Amplifier

Explore the graphic with your mouse.

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**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.

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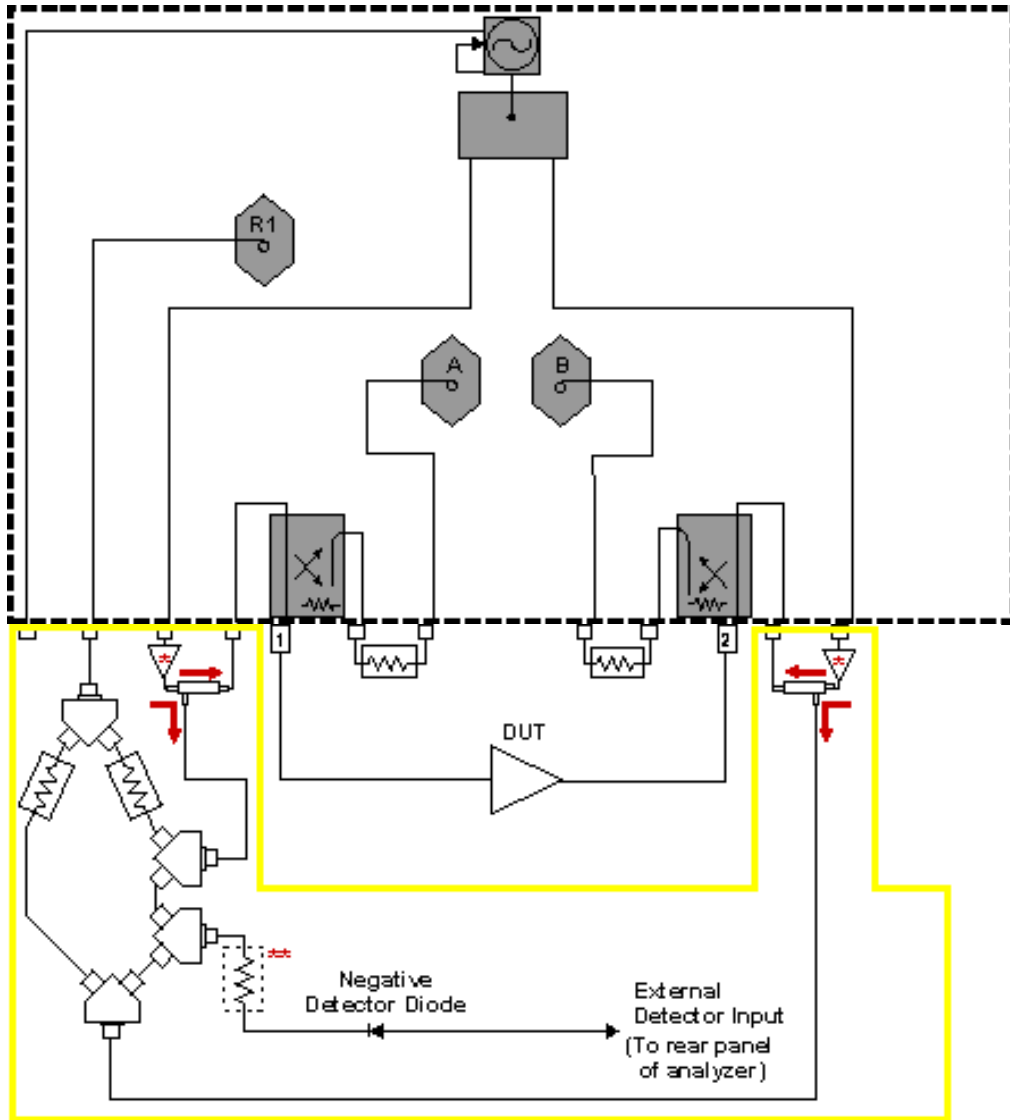


### Diagram: (E880xA, Option 014) External Leveling using Two Booster Amplifiers

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.

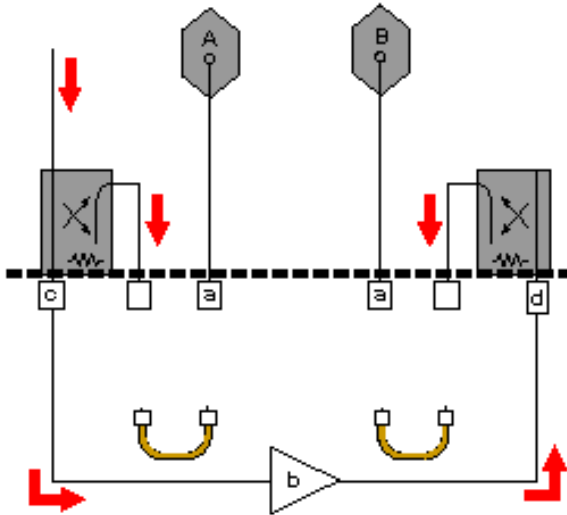




\*\* This attenuator may be required to meet the recommended power level input ( +10dBm to -20dBm ) of the detector diode.

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**

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	<a href="#">Booster amplifiers in the test setup</a>
Booster amplifier response is not flat	<a href="#">External leveling for booster amplifiers</a>
Phase-lock lost when using a booster amplifier	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

**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.

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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 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.)

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**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.

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**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.

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## 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?

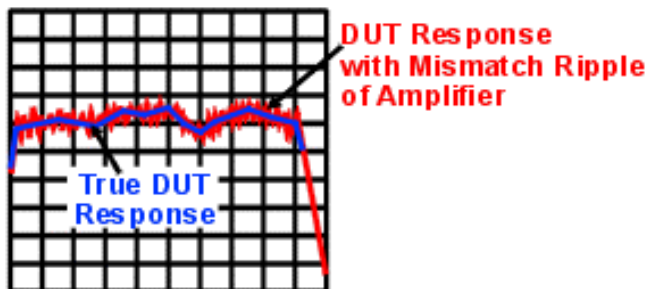
Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

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**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 [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).

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**Note:** When performing a calibration, keep the source-leveling process active, just as it will be during the measurement.

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### 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:
    - **2-Port Calibration** (SOLT) for forward and reverse non-boosted transmission and reflection measurements.
    - **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:
    - **Thru Response** for forward high-power transmission measurements.
    - **1-Port Reflection, Open/Short Response** for reverse non-boosted reflection measurements.

Compare with: [Basic Configuration](#).

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**Note:** If testing a duplex base-station filter with a built-in preamp, you would ideally use a 3-port calibration.

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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 calibration 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.

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**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](#)



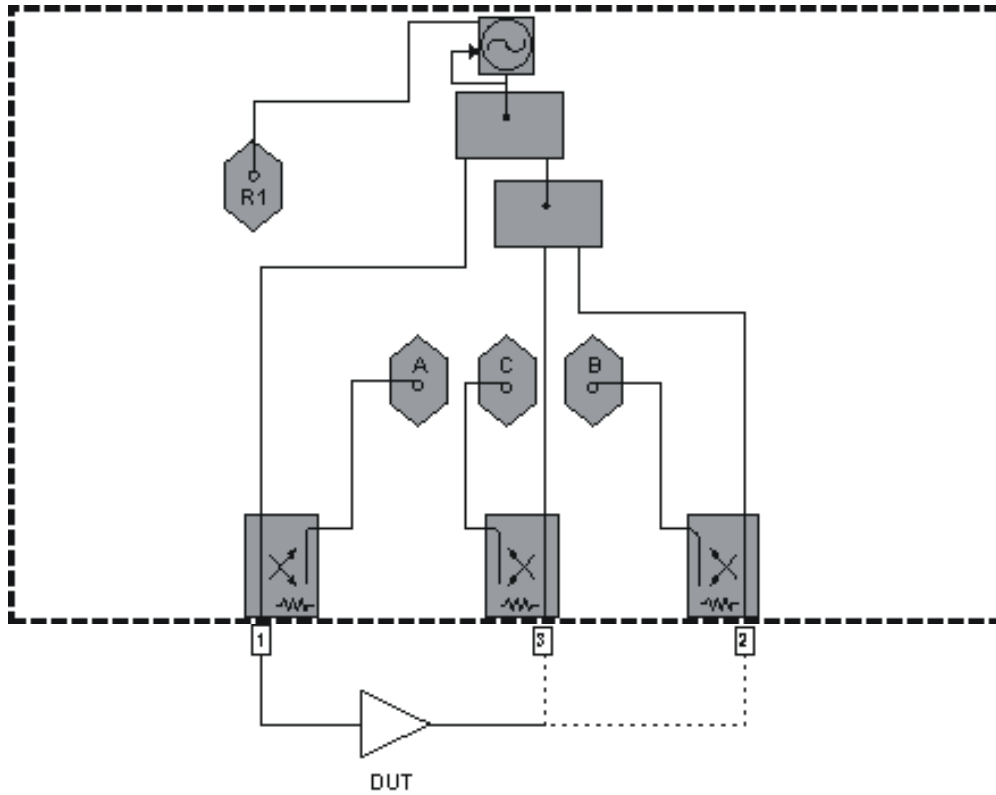
### Diagram: (N338x) Basic Configuration

Explore the graphic with your mouse.

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**Note:** Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

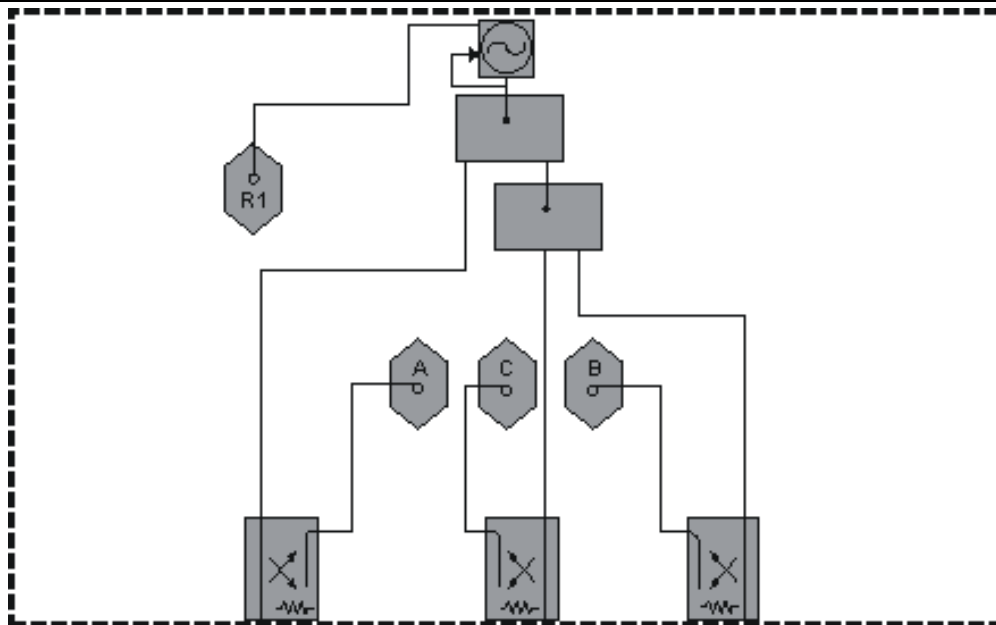
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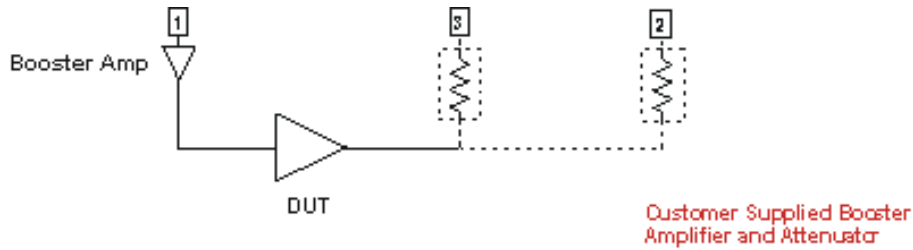


**Diagram: (N338x) Configuration for High-Power Measurements in the Forward Direction (Response Cal Only)**

Explore the graphic with your mouse.

**Note:** Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

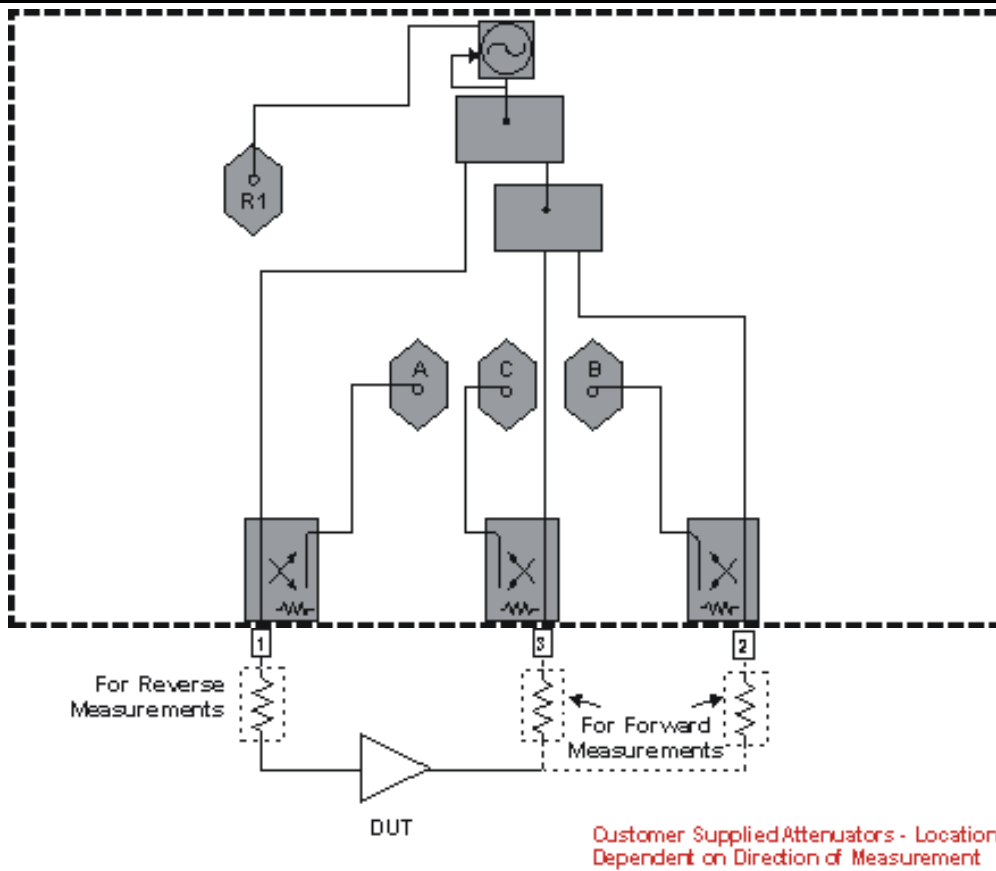




**Diagram: (N338x) Configuration for Non-Boosted High-Power Measurements in both Forward and Reverse Directions**

Explore the graphic with your mouse.

**Note:** Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

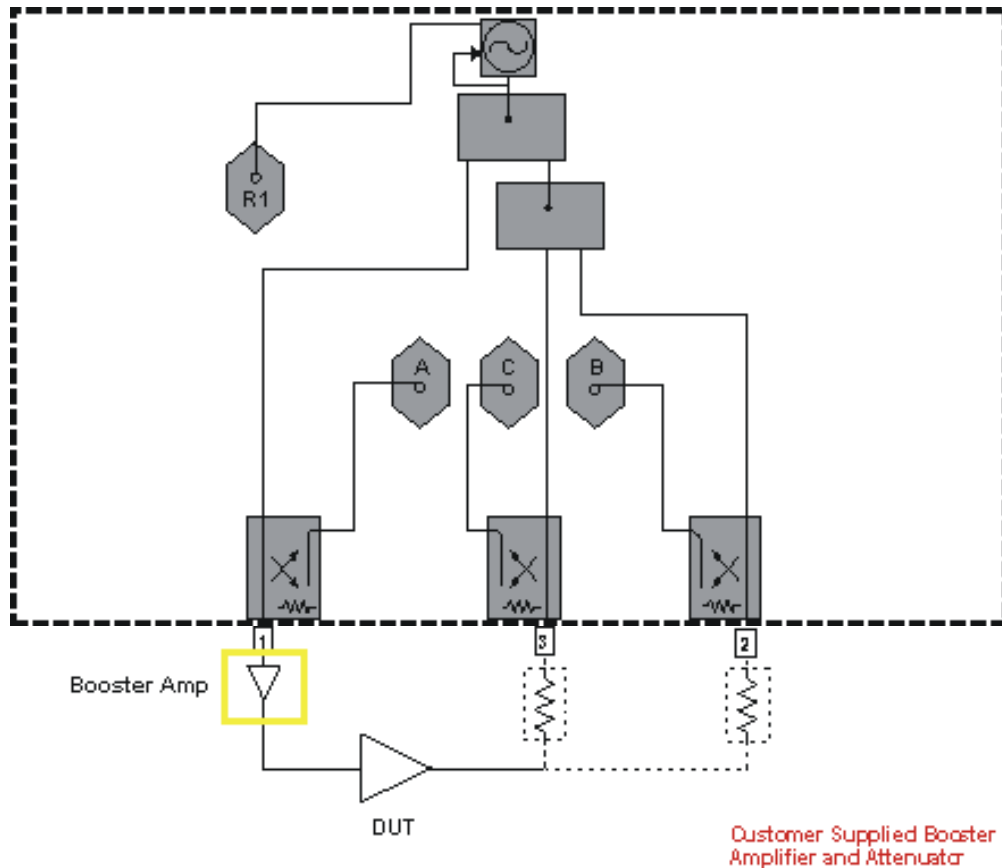


**Diagram: (N338x) Configuration using a Booster Amplifier**

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.

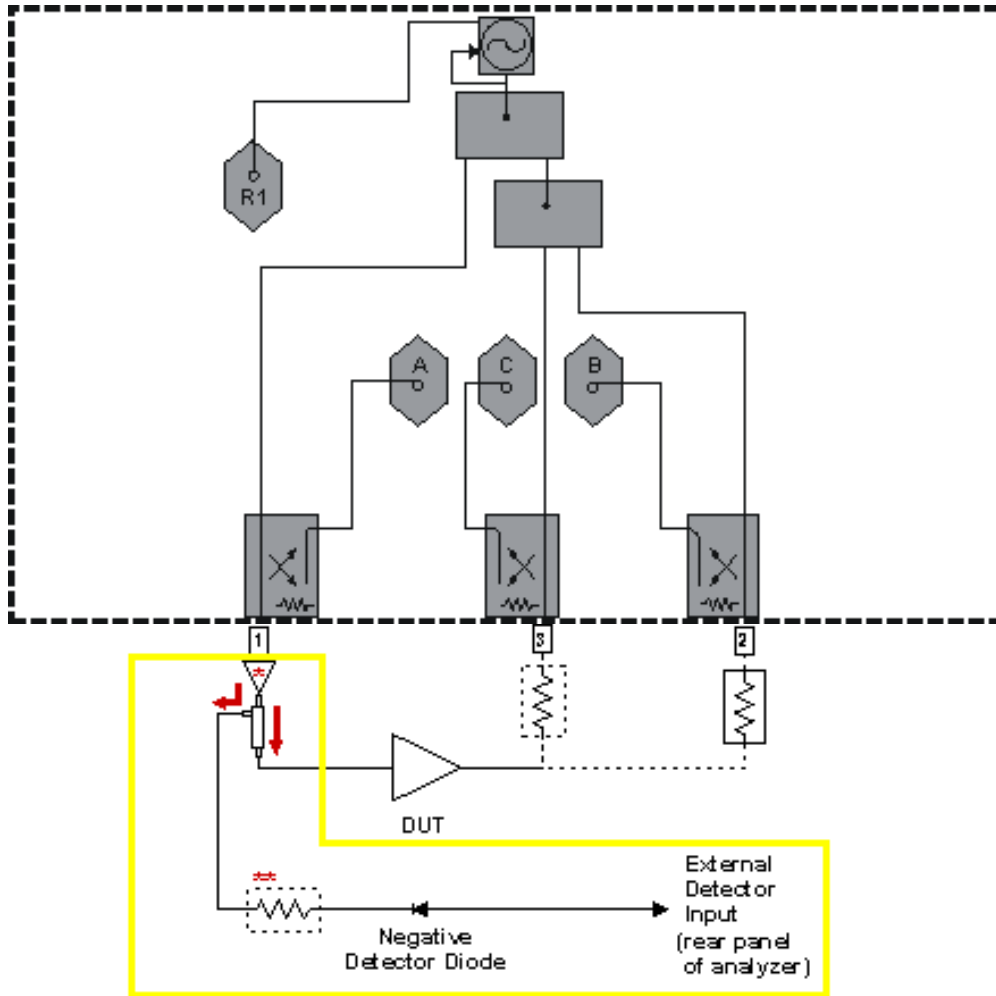




### Diagram: (N338x) External Leveling Configuration

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*

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	<a href="#">Disable auto-frequency calibration</a>
Which measurement calibration do I use?	<a href="#">Measurement calibration choices</a>
What calibration power levels do I use?	<a href="#">Power-level recommendations for calibration</a>
DUT output power is too high	<a href="#">Components that reduce DUT output power</a>
Will my calibration standards withstand high power?	<a href="#">Calibration standards that withstand high power</a>
Thermal variations occur in my test setup	<a href="#">Thermal requirements for DUTs and loads</a>
DUT has an Automatic Gain Control (AGC) loop	<a href="#">Stimulus-sweep recommendation for a DUT with an AGC loop</a>
What procedure do I use to measure high-power amplifiers?	<a href="#">Procedure for Measuring High-Power Amplifiers</a>

---

**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. Configuration Using Two Booster Amplifiers

### 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.

---

### 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?

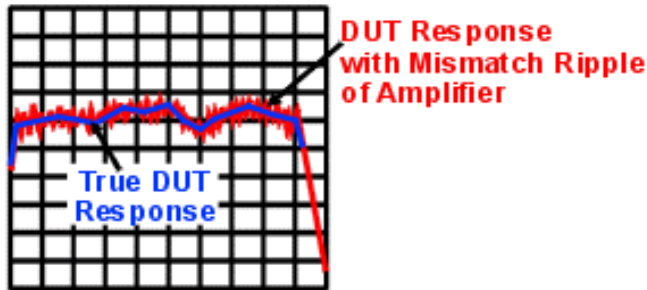
Use your analyzer to measure the peak-to-peak ripple of your booster amplifier. If the level of peak-to-peak ripple is unacceptable for the measurement accuracy you require, use external leveling.

---

**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 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."

---

## 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:
    - **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
    - **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:
      - **2-Port Calibration** (SOLT) for forward high-power transmission and reflection measurements. Also for reverse non-boosted transmission and reflection measurements.
      - **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:
      - **2-Port Calibration** (SOLT) for forward and reverse high-power transmission and reflection measurements.
      - **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 calibration 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:

- 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](#)

---

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](#)



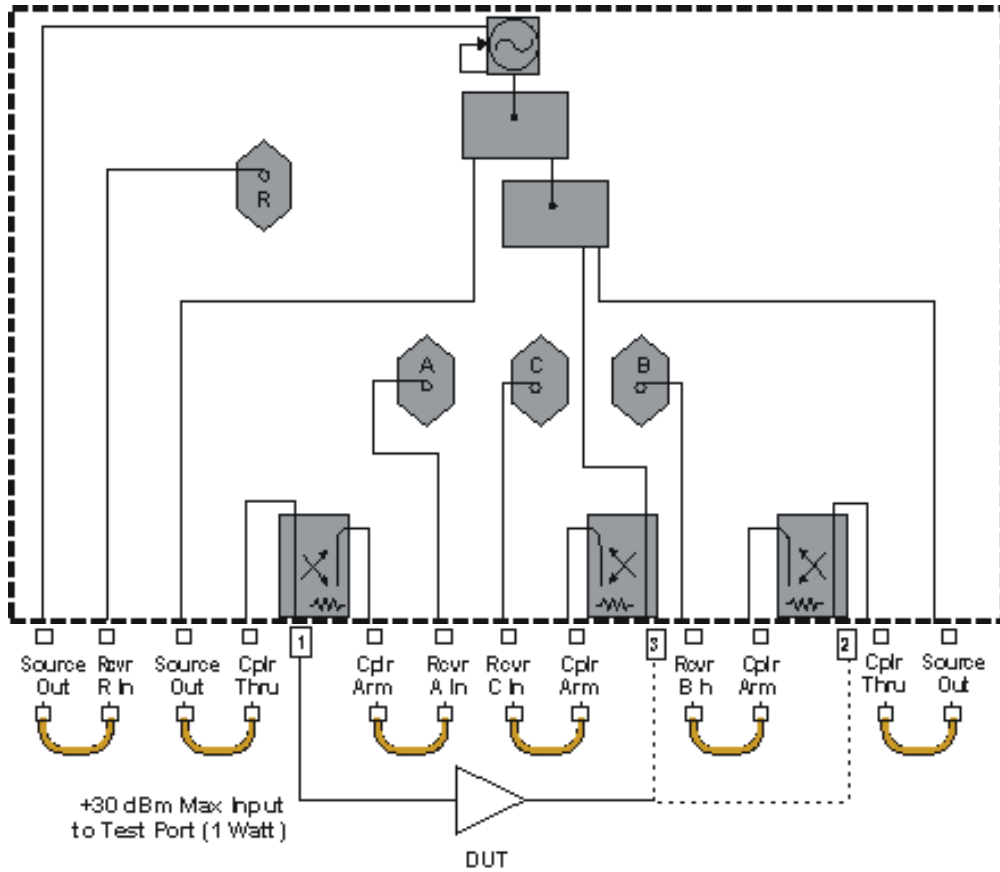
### Diagram: (N338xA, Option 014) Basic Configuration

Explore the graphic with your mouse.

---

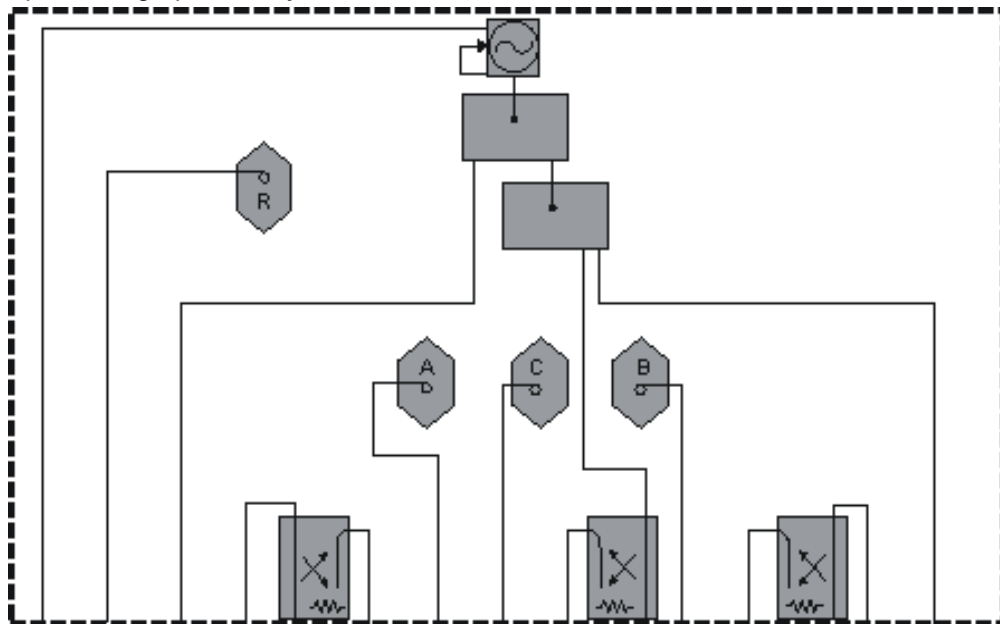
**Note:** Either Port 2 or Port 3 can be used for testing a 2-Port DUT.

---

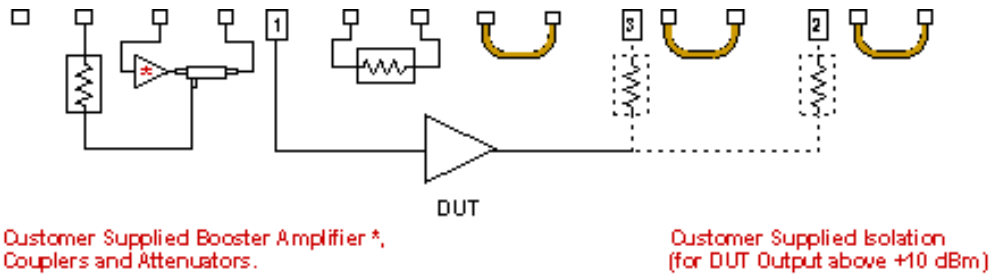


**Diagram: (N338xA, Option 014) Configuration for High-Power Measurements in the Forward Direction**

Explore the graphic with your mouse.

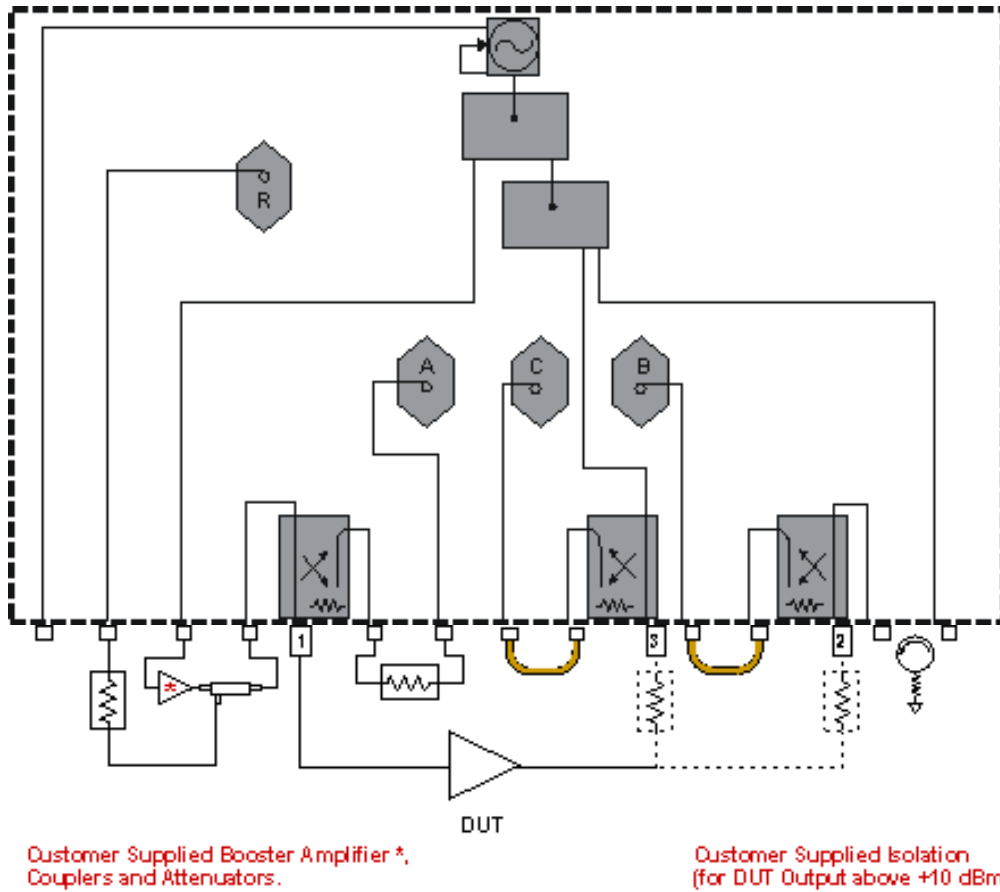






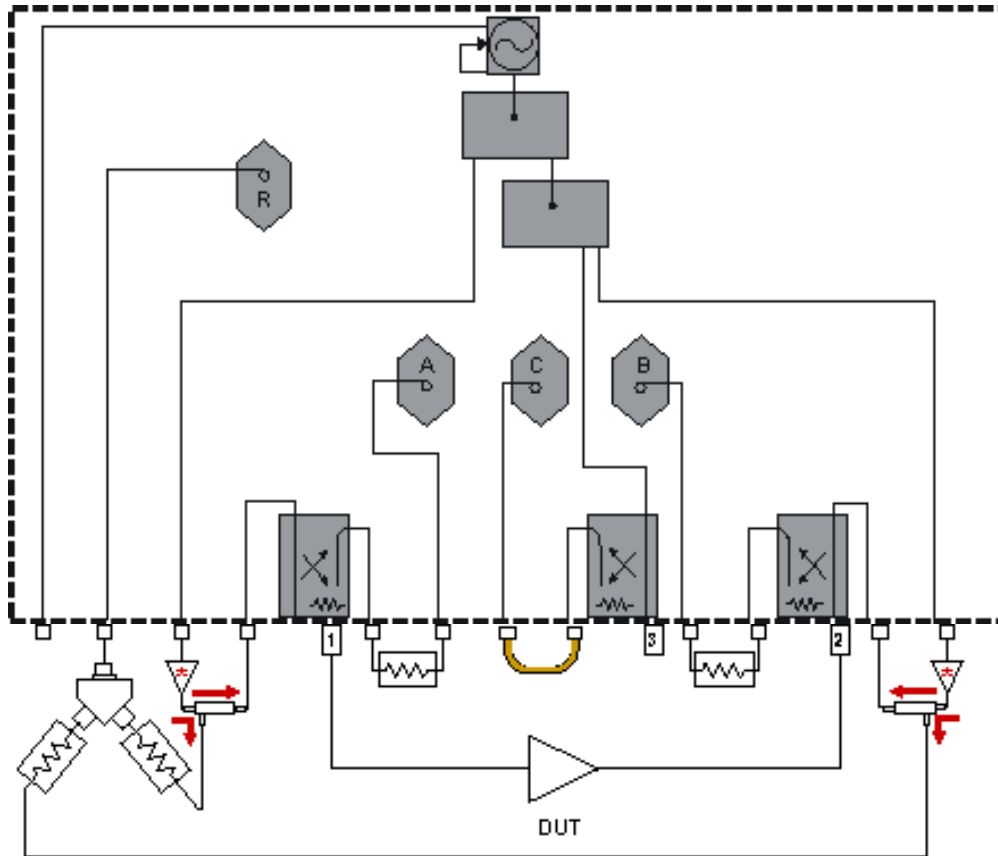
**Diagram: (N338xA, Option 014) Configuration (with an Isolator) for High-Power Measurements in the Forward Direction**

Explore the graphic with your mouse.



**Diagram: (N338xA, Option 014) Configuration for High-Power Measurements in both Forward and Reverse Directions**

Explore the graphic with your mouse.

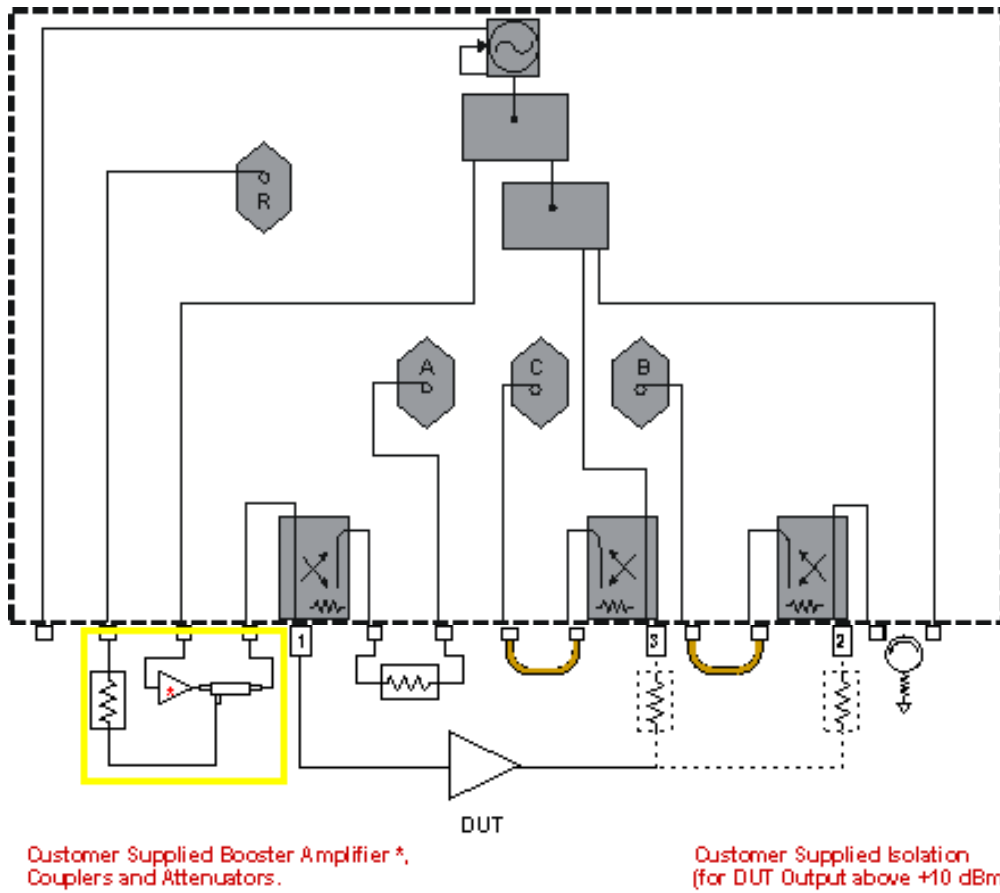


Customer Supplied Booster Amplifiers \*,  
Couplers, Attenuators and Power Splitter

### 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.



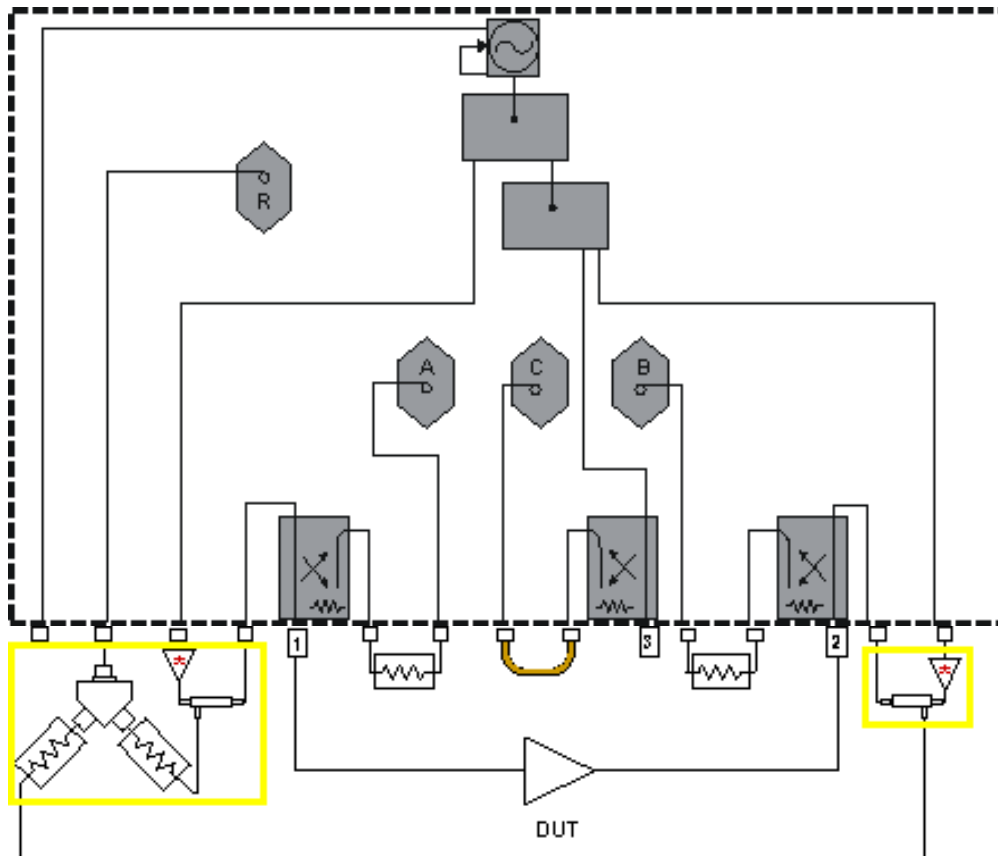
### Diagram: (N338xA, Option 014) Configuration Using Two Booster Amps

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.

---

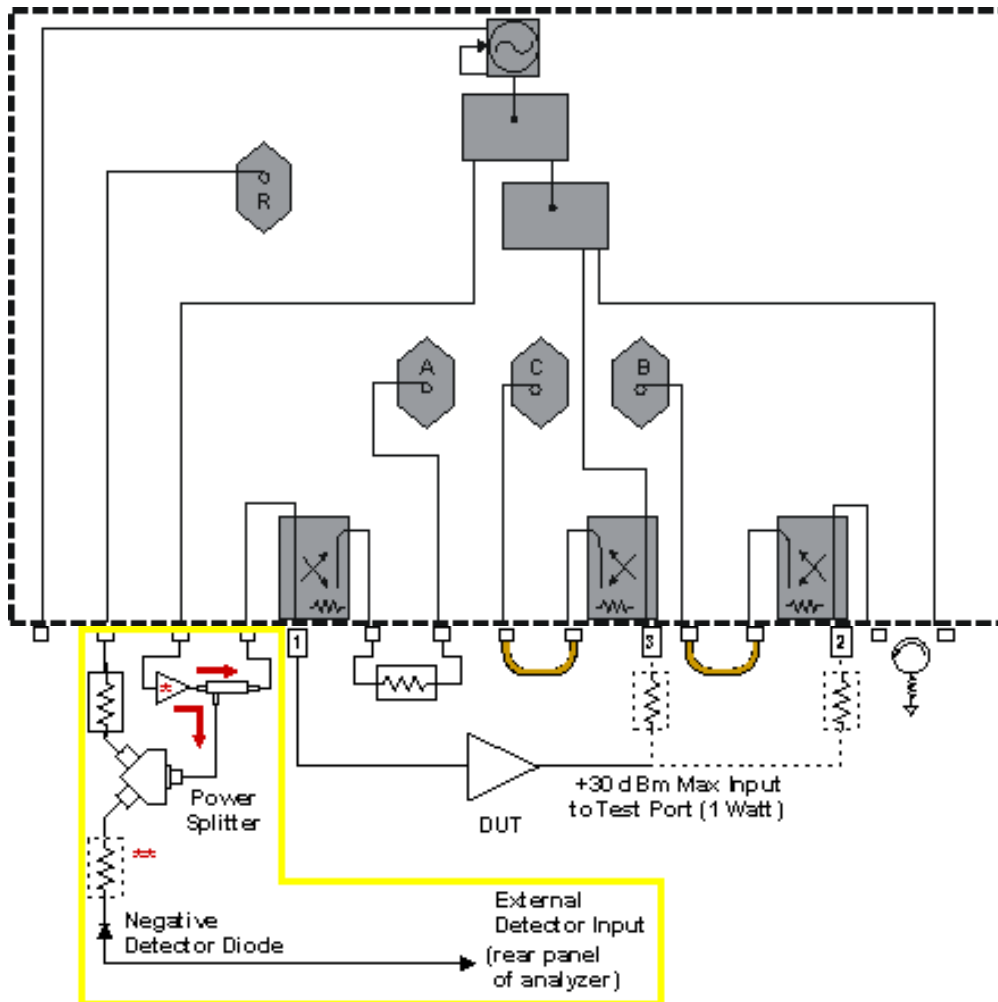


Customer Supplied Booster Amplifiers \*,  
Couplers, Attenuators and Power Splitter

### 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.



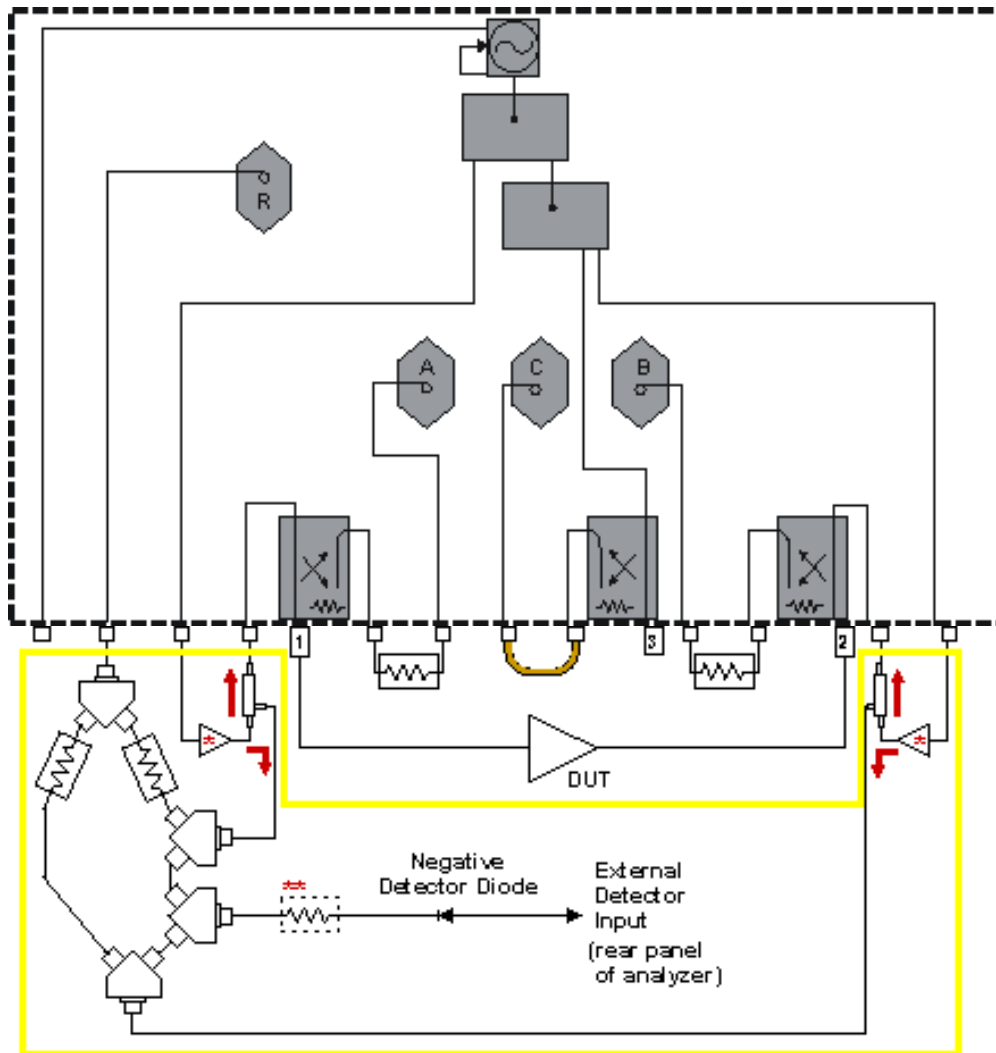
Customer Supplied Booster Amplifier \*,  
Negative Detector Diode, Couplers and Attenuators.

Customer Supplied Isolation  
(for DUT Output above +10 dBm)

### 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.

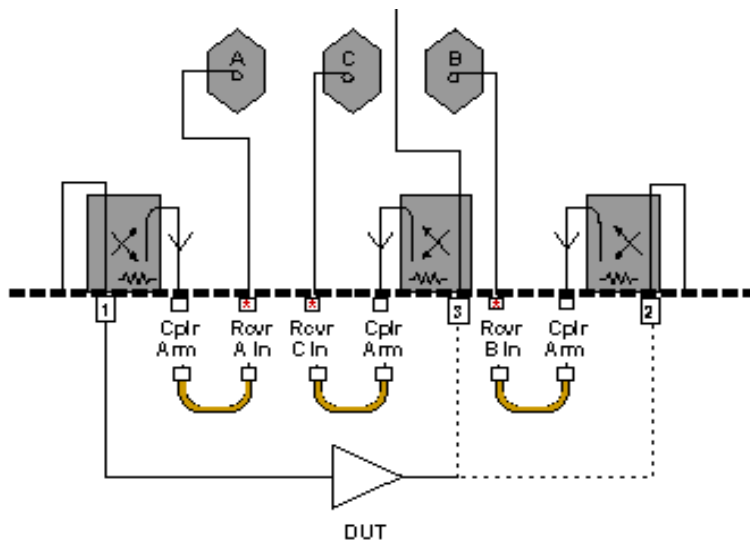


Customer Supplied Booster Amplifier \*,  
 Negative Detector Diode, Coupler,  
 Power Splitter, and Attenuators

\*\* This attenuator may be required to meet  
 the recommended power level input  
 ( +10dBm to -20dBm ) of the detector diode.

### Diagram: (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

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

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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