Keysight M937xA PXIe Vector Network Analyzer Modules

M9370A, 300 kHz to 4 GHz
M9371A, 300 kHz to 6.5 GHz
M9372A, 300 kHz to 9 GHz
M9373A, 300 kHz to 14 GHz
M9374A, 300 kHz to 20 GHz
M9375A, 300 kHz to 26.5 GHz

KEYSIGHT TECHNOLOGIES

Service Guide

Notices

Trademark Acknowledgments

Manual Part Number

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1400 Fountaingrove Parkway
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Warranty

Technology Licenses

Restricted Rights Legend

Safety Notices

CAUTION

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

WARNING

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Where to Find the Latest Information

For the latest information about these products, including the M937xA Help System, instrument software upgrades, application information, and product information, browse to one of the following URLs:

http://na.support.keysight.com/pxi

http://www.keysight.com/find/pxi

To receive the latest updates by email, subscribe to Keysight Email Updates at the following URL:

http://www.keysight.com/find/emailupdates

Information on preventing analyzer damage can be found at:

http://www.keysight.com/find/tips

Safety and regulatory information can be found in the Startup Guide, available online at:

http://literature.cdn.keysight.com/litweb/pdf/M9370-90001.pdf

Is your product software up-to-date?

Periodically, Keysight releases software updates to fix known defects and incorporate product enhancements. To search for software updates for your product, go to the Keysight Technical Support website at:

http://na.support.keysight.com/pxi/firmware

Table of Contents

1 General Product Information

Information in This Chapter

Chapter 1 at-a-Glance

Section Title	Summary of Content
Maintenance	Cleaning instructions for the external surfaces of your network analyzer. Hyperlink to online information on connector care.
Keysight Support, Services, and Assistance	Hyperlink for Contacting Keysight. How to get information on service and support options available. Important information about shipping your module to Keysight for service or repair.
Error Terms	How to use error term data as a diagnostic tool.
Option Enable Utility	How to use the Option Enable Utility to enable or remove options, and install or change a serial number.
Firmware Upgrades	How to get firmware upgrades.

Maintenance

WARNING **To prevent electrical shock, remove analyzer module from chassis slot for cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

Physical Maintenance To remove dirt or dust from the external case of the network analyzer, clean the case using a dry or slightly dampened cloth only.

Electrical Maintenance For online information on connector care, go to http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm.

Keysight Support, Services, and Assistance

Information on the following topics is included in this section.

- Service and Support Options
- Contacting Keysight
- Shipping Your Network Analyzer for Service or Repair

Service and Support Options

The network analyzer's standard warranty is a 1-year return to Keysight Technologies service warranty.

NOTE **There are many other repair and calibration options available from the Keysight Technologies support organization. These options cover a range of service agreements with varying response times. Contact Keysight for additional information on available service agreements for this product. Refer to Contacting Keysight.**

Contacting Keysight

Assistance with test and measurement needs and information on finding a local Keysight office are available on the Web at: www.keysight.com/find/assist. If you do not have access to the Internet, please contact your Keysight field engineer.

NOTE **In any correspondence or telephone conversation, refer to the Keysight product by its model number and full serial number. With this information, the Keysight representative can determine whether your product is still within its warranty period.**

Shipping Your Network Analyzer for Service or Repair

Should it become necessary to return a network analyzer for repair or service, follow the steps below:

1. Review the warranty information shipped with your product.
2. Contact Keysight to obtain a Return Material Authorization (RMA) and return address. For assistance finding Keysight contact information, go to www.keysight.com/find/assist (worldwide contact information for repair and service).
3. Write the following information on a tag and attach it to the network analyzer.
   - Name and address of owner. A P.O. box is not acceptable as a return address.

- network analyzer serial numbers. The serial number label is located on the side panel of the module. The serial number can also be read from the Soft Front Panel (SFP) interface, after the hardware is installed.
- Description of the failure or service required.

4. On the shipping label, write ATTENTION REPAIR DEPARTMENT and the RMA number.
5. Ship the analyzer module using the original packaging materials. Shipping the analyzer module in anything other than the original packaging may result in non-warranted damage.

Error Terms

Using Error Terms as a Diagnostic Tool

By examining error terms, you can monitor system performance for preventive maintenance and troubleshooting purposes.

The magnitude and shape of the error terms are affected by:

- calibration kit devices
- cables
- adapters and accessories
- test port connectors

Calibration kit devices, cables, adapters and accessories are the most common cause of error term anomalies. Make sure of the following:

- Connectors must be clean, gaged, and within specification.
- Use proper connection technique during measurement and calibration. For online information on connector care, go to http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm, or to the calibration kit's user's and service manual.

Preventive Maintenance

If you print or plot the error terms at set intervals (weekly, monthly, etc), you can compare current error terms to these records. A stable system should generate repeatable error terms over long intervals, (for example, six months). Look for the following:

- A long-term trend often reflects drift, connector and cable wear, or gradual degradation, indicating the need for further investigation and preventive maintenance. Yet, the system may still conform to specifications. The cure is often as simple as cleaning and gaging connectors and cables.
- A sudden shift in error terms may indicate the need for troubleshooting.

Troubleshooting

Refer to error term descriptions in "Error Term Data" on page 1-9.

NOTE **Always suspect calibration devices, cables, or improper connector maintenance as the primary cause of an error term anomaly.**

Performing Measurement Calibration

CAUTION

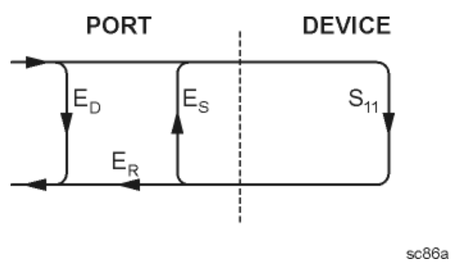
Follow ESD-safe practices when working with the network analyzer. For more information, refer to Chapter 1 in the M937xA Startup Guide, viewable online at
http://literature.cdn.keysight.com/litweb/pdf/M9370-90001.pdf

1. Connect a test cable to Port 2.
2. Perform a full 2-port calibration. Refer to Help if necessary.

Using Flowgraphs to Identify Error Terms

Flowgraphs are a graphical representation of signal flow through the measurement path. The flowgraphs in Figure 1-1 and Figure 1-2 illustrate the error terms associated with measurement calibration for 1-port and 2-port configurations respectively.

Figure 1-1 Flowgraph of 1-Port Error Terms for Port 1



Where:

E = Error term

Subscript:

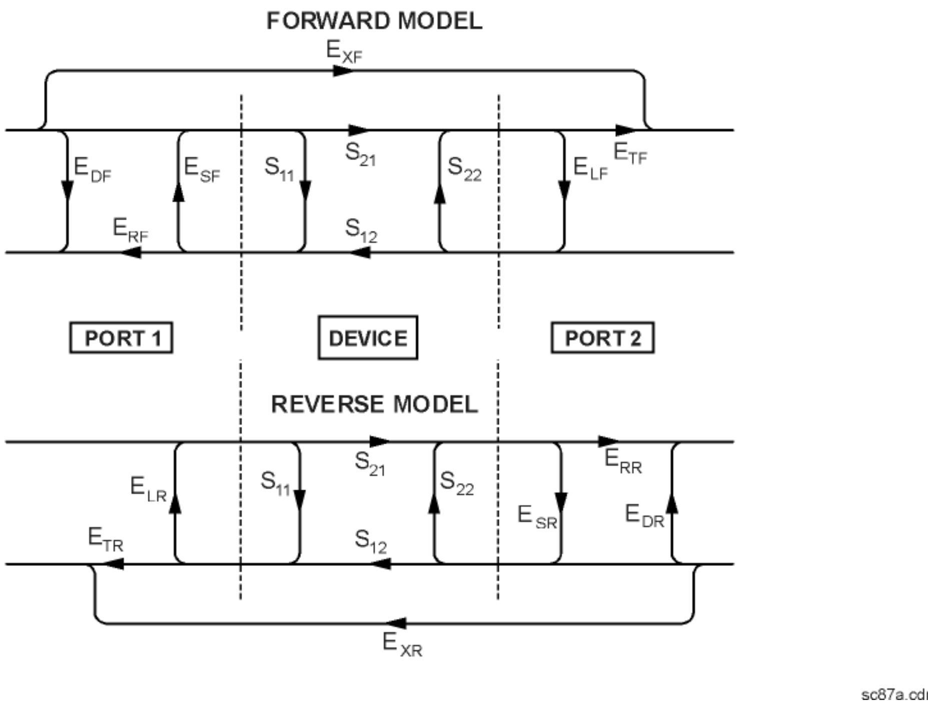
D = Directivity

S = Source Match

R = Reflection Tracking

The error terms are the same for a 1-port measurement on Port 2 (S_{22}).

Figure 1-2 Flowgraph of 2-Port Error Terms



Where:

E = Error term

1st Subscript:

D = Directivity

S = Source Match

R = Reflection Tracking

X = Crosstalk (Isolation)

L = Load Match

T = Transmission Tracking

2nd Subscript:

F = Forward measurement (Port 1 to Port 2)

R = Reverse measurement (Port 2 to Port 1)

Accessing Error Terms

Error terms can be accessed either manually or programmatically:

Manually

"Soft Front Panel Access to Error Terms" on page 1-8

Programmatically

"GPIB Access to Error Terms" on page 1-8

Manual Access to Error Terms

Soft Front Panel Access to Error Terms

NOTE Ensure the calibration correction is active by making sure that the check box for Correction on/OFF has been selected.

To access the error terms from the soft front panel, perform the following steps:

1. In the System menu, click **Response > Cal > ManageCals > Cal Set Viewer**. The Cal Set Viewer tool bar appears directly above the trace window.
2. In the Cal Sets drop-down list, select the desired cal set.
3. Click **Standards** to view the raw measurement data of the Standard (ONLY available with Unguided Cal (not ECal or Guided Cal)), or click **Error Terms** to view the corrected error term data.
4. Use the Error Term box drop-down list to select an error term or standard to view.
5. Select the Enable check box to view the data on the PC display.
6. Compare the displayed measurement trace to the equivalent data that starts in "Error Term Data" on page 1-9, or to previously measured data, or to the uncorrected performance specifications listed in Table 1-1 on page 1-9.
7. Print numerical data or print a plot of the measurement results.

Programmatic Access to Error Terms

GPIB Access to Error Terms

You can access error terms by way of GPIB with Standard Commands for Programmable Instruments (SCPI).

For more information on GPIB and SCPI, refer to Help. Search for keywords "error, systematic" in the index.

Error Term Data

The error term descriptions in this section include the following information:

- a table of error terms
- description and significance of each error term
- measurements affected by each error term
- typical cause of failure for each error term

The same description applies to both the forward (F) and reverse (R) terms.

NOTE

Data are listed here as a convenience only. Detailed instrument specifications are in the Data Sheet, viewable online at http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf

Table 1-1 Error Term Data[a]

Frequency Range	Directivity	Source match	Load match	Crosstalk[b]
300 kHz to < 2 MHz	9	9	9	97
2 MHz to 1 GHz	21	19	21	95
> 1 to 2 GHz	21	20	19	123
> 2 to 4 GHz	21	20	15	121
> 4 to 6.5 GHz	20	15	11	121
> 6.5 to 9 GHz	11	11	9	119
> 9 to 14 GHz	9	9	7	110
> 14 to 20 GHz	4	6	6	98
> 20 to 24 GHz	3	5	4	82

a. The data in this table are uncorrected system performance. The values apply over an environmental temperature range of 25 °C ±5 °C, with less than 1 °C deviation from the calibration temperature.
b. All crosstalk values are typical.

If Error Terms Seem Worse than Expected

To verify that the system still conforms to specifications, perform a system verification. Refer to “System Verification” on page 2-20.

Directivity (E_{DF} and E_{DR})

E_{DF} and E_{DR} are the uncorrected forward and reverse directivity error terms of the system. The directivity error of the test port is determined by measuring the S_{11} and S_{22} reflection of the calibration kit load. The load has a much better return loss specification than does the uncorrected text port. Therefore, any power detected from this measurement is assumed to be from directivity error.

The measurements most affected by directivity errors are measurements of low reflection devices.

Typical Cause of Failure

The calibration kit load is the most common cause of directivity specification failure.

If the load has been gaged and its performance independently verified, the analyzer requires repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Source Match (E_{SF} and E_{SR})

E_{SF} and E_{SR} are the forward and reverse uncorrected source match terms of the driven port. They are obtained by measuring the reflection (S_{11}, S_{22}) of an open, and a short that are connected directly to the ports. Source match is a measure of the match of the coupler, as well as the match between all components from the source to the output port.

The measurement most affected by source match errors are reflection and transmission measurements of highly reflective DUTs.

Typical Cause of Failure

The calibration kit open or short is the most common cause of source match specification failure.

If the open or short performance are independently verified, the analyzer requires repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Load Match (E_{LF} and E_{LR})

Load match is a measure of the impedance match of the test port that terminates the output of a 2-port device. The match of test port cables is included in this response. Load match error terms are characterized by measuring the S_{11} and S_{22} responses of a "thru" configuration during the calibration procedure.

The measurements most affected by load match errors are all transmission measurements, and reflection measurements of a low insertion loss, 2-port device, such as an airline.

Typical Cause of Failure

The calibration kit load or a bad “thru” cable is the most common cause of load match specification failure.

If the load and “thru” cable performance are independently verified, the analyzer requires repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Reflection Tracking (E_{RF} and E_{RR})

Reflection tracking is the difference between the frequency response of the reference path (R1 or R2 path) and the frequency response of the reflection test path (A or B input path). These error terms are characterized by measuring the reflection (S_{11}, S_{22}) of the open and the short during the measurement calibration.

All reflection measurements are affected by the reflection tracking errors.

Typical Cause of Failure

The calibration kit open or short is the most common cause of reflection tracking specification failure.

If the open or short performance has been independently verified, the analyzer requires repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Transmission Tracking (E_{TF} and E_{TR})

Transmission tracking is the difference between the frequency response of the reference path (including the R input) and the frequency response of the transmission test path (including the A or B input) while measuring transmission. The response of the test port cables is included. These terms are characterized by measuring the transmission (S_{21}, S_{12}) of the “thru” configuration during the measurement calibration.

All transmission measurements are affected by the transmission tracking errors.

Typical Cause of Failure

The test port cable is the most common cause of transmission tracking specification failure.

If the test port cable performance has been independently verified, the analyzer requires repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Isolation (E_{XF} and E_{XR})

Isolation, or crosstalk, is the uncorrected forward and reverse isolation error terms that represent leakage between the test ports and the signal paths. The isolation error terms are characterized by measuring the transmission (S_{21},

S_{12}) with loads attached to both ports during the measurement calibration. Isolation errors affect transmission measurements primarily where the measured signal level is very low.

The measurements most affected by isolation error terms are DUTs with large insertion loss. Since these terms are low in magnitude, they are usually noisy (not very repeatable).

Typical Cause of Failure

A loose cable connection or leakage between components is the most likely cause of isolation problems.

After verifying the cable and its connections, the analyzer requires repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

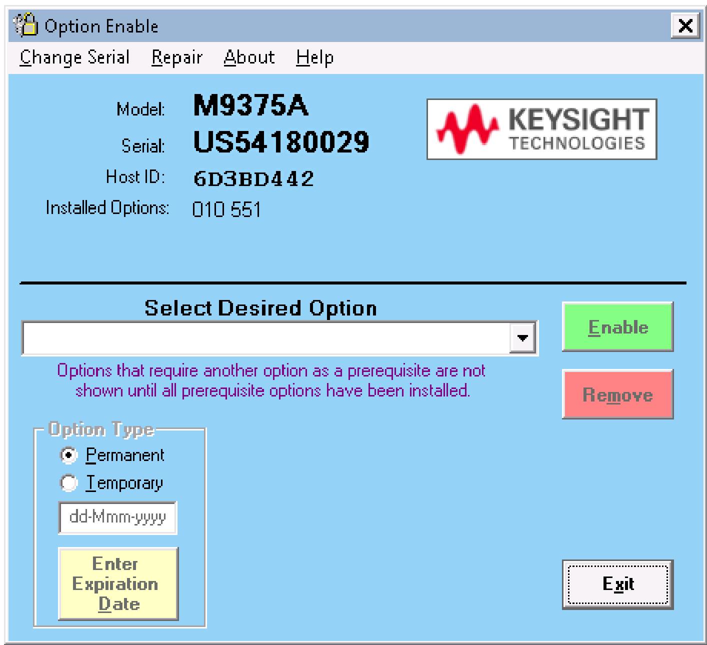
Option Enable Utility

Accessing the Option Enable Utility

To start the option enable utility:

- Click **Utility > System > Service > Option Enable**.
- The dialog box illustrated in Figure 1-3 is displayed.

Figure 1-3 Option Enable Dialog Box



Enabling or Removing Options

Software options add features or functionality to the analyzer without the need for additional hardware. These options are enabled using a special keyword. They are enabled using the option enable utility.

NOTE **Options require a license key that is provided by Keysight. If you do not have the required license key, contact Keysight for assistance. Refer to "Contacting Keysight" on page 1-3.**

To enable or remove an option:

1. Start the option enable utility. Refer to Accessing the Option Enable Utility.
2. Click the arrow in the Select Desired Option box. A list of available options, similar to the following list, will appear.

   010 Time Domain

   551 Multiport

102 Advanced Features

??? Enter Unlisted Option

3. Click on the option that you wish to either enable or remove, and then click **Enable** or **Remove**, whichever is appropriate.
4. If the desired option is not available in the list (unlikely to occur), select **Enter Unlisted Option**. A dialog box appears that will allow you to enter the option number. Enter the option number and follow the instructions on the display.

Changing a Serial Number

NOTE To change an incorrect serial number, a clear code keyword is required. Contact Keysight to obtain the clear code keyword. You must provide the current serial number, as displayed in the Change Serial Number dialog box (see Step 1 below). Refer to "Contacting Keysight" on page 1-3.

NOTE Use extreme care when entering the serial number, as only one attempt is allowed.

1. To change a serial number, select **Change Serial** from the Option Enable menu bar (refer to Figure 1-3 on page 1-13). The current serial number is displayed in the Change Serial Number dialog box. If no serial number has previously been entered, the word "NONE" will be displayed.
2. VERY CAREFULLY, type the new serial number into the space provided.
3. Type the Clear Code keyword into the space provided.
4. Click **Change**.
5. Note the serial number displayed in the Option Enable dialog box, then click **Exit**.
6. If the wrong serial number is displayed, obtain another clear code from Keysight, and repeat the steps above.

Firmware Upgrades

How to Check the Current Firmware Version

1. With the Network Analyzer application running, click **Help > About Network Analyzer**. A dialog box showing the current installed Application Code Version is displayed.
2. To determine if a firmware update is available, proceed to Downloading from the Internet below.

Downloading from the Internet

If your network analyzer is connected to the Internet, there are two methods available for checking the availability of, and downloading, new firmware.

- Download directly from http://na.support.keysight.com/pxi/firmware.
- On the System menu, click **Service > AgileUpdate**. AgileUpdate compares the firmware revision currently installed in your network analyzer to the latest version available and assists you in downloading and installing the most recent version.

2 Tests, Adjustments, and Troubleshooting

Information in This Chapter

This chapter contains procedures to help you check, verify, adjust, and troubleshoot your network analyzer.

- The checks verify the operation of the assemblies in your network analyzer.
- The verification compares the operation of your analyzer to a gold standard.
- The adjustments allow you to tune your network analyzer for best performance.
- The troubleshooting assists you in finding the cause of a failure.

Chapter 2 at-a-Glance

Section Title	Summary of Content
Before You Begin	Items to consider or procedures to perform before testing is begun: -Get the Required Service Test Equipment. -Verify the Operating Environment. -Protect Against Electrostatic Discharge. -Allow the Analyzer to Warm Up. -Review the Principles of Connector Care.
About System Verification and Performance Tests	Descriptions of: -System Specifications -Instrument Specifications -System Verification Procedure -Performance Tests -Certificate of Calibration
ANSI/NCSL Z540.3-2006 and ISO/IEC 17025 Verification	The ANSI/NCSL Z540.3-206 and ISO/IEC 17025 process of verifying your network analyzer.

Section Title	Summary of Content
Non-Standards Compliant Verification	The Non-Standards Compliant process of verifying your network analyzer.
Preliminary Checks	Performing the Operator's Check. Checking your test cables. **NOTE** *Perform these checks before performing system verification.*
System Verification	What the system verification does. How to perform the verification test. How to interpret the results.
Performance Tests	A brief summary of each performance test: -Source Power Accuracy -Source Maximum Power Output Test -Source Power Linearity Test -Frequency Accuracy Test -Trace Noise Test -Receiver Compression Test -Noise Floor Test -Calibration Coefficients Test -Dynamic Accuracy Test
-Adjustments[a] (except System Receiver Cal[b])	Setups and procedures for adjusting your network analyzer: -10 MHz Frequency Reference Adjustment -Source Adjustment -Receiver Adjustment -System Receiver Cal
Troubleshooting	A list of troubleshooting suggestions.

a. These adjustments are included in the analyzer's firmware on all models and options.
b. The System Receiver Cal adjustment is required for Option 009. This adjustment is included in the analyzer's firmware in all models with serial number prefix ≥MY5544 / US5544 & serial numbers: 2000 /2000.

Before You Begin

Before checking, verifying, or adjusting the analyzer, refer to the following paragraphs to:

- get the required Service Test equipment
- make sure the operating environment is within its requirements
- make sure that proper electrostatic discharge (ESD) protection is provided
- make sure the analyzer has warmed up properly to achieve system stability
- review the principles of connector care

Get the Required Service Test Equipment

NOTE The test equipment in this list covers the full 26.5 GHz range of the M9375A module. For lower frequency modules, the list can be modified to use the appropriate lower frequency equipment. For example, with a M9370A 4 GHz module, a valid substitution for the N8485A power sensor is the N8482A (specified to only 6 GHz).

NOTE Equipment required for System Verification is listed in Table 2-1, “Equipment Used in the System Verification Procedure”, on page 2-23

Equipment	Critical Specifications	Recommended Model or Part Number	Alternate Model Number	Use[a]
Test Instruments and Software				
PNA[b]	Published port match specifications	N5241A/42A, or N5221A/22A, or E8363C/64C	None	P
Compression test set[b]	None specified	U3070AK01	None	P
Dynamic accuracy test set[b]	None specified	U3020AD01	None	P
Frequency counter[b]	Freq: 10 MHz to 20 GHz Accuracy: ±0.5 ppm	53151A Option 001	Any equivalent	P, A
Signal generator[b]	CW Freq: 1.185 GHz	N5181A	E8257D Option 520	P
USB Thermocouple Power Sensor	Freq: DC to 33 GHz Range: –35 to +20 dBm	U8485A Option 200	N8485A power sensor (for Adjustments, also requires N8482A for frequencies below 10 MHz) with N1912A/13A/14A power meter[b]	P, A
ECal module, 3.5 mm	Freq: 300 kHz to 26.5 GHz	N4691B	85052B	P
Optional: Printer, Mouse, Keyboard	N/A	Any printer with Microsoft Windows 7 driver.		--
Cables				
BNC cable	50 ohm, length ³60 cm	8120-1839	Any equivalent	A
3.5 mm test cable (-m- to -f-), (Qty 3)	N/A	8121-2111 (60 cm), or N4373-61604 (90 cm)	Any equivalent	P
3.5 mm test cable (-m- to -m-)	N/A	11500E	Any equivalent	A
GPIB controller cable	N/A	M9036-31301[c]	Any equivalent	P, A
GPIB cable (Qty 2)	N/A	10833A (1 m)	Any	P

Equipment	Critical Specifications	Recommended Model or Part Number	Alternate Model Number	Use[a]
		Adapters		
3.5 mm (-m- to -m-)	Return Loss: ^{3}32 dB	83059A	85052-60014[d]	P, A
3.5 mm (-f- to -f-)	Return Loss: ^{3}32 dB	83059B	85052-60012[d]	P
2.4 mm (-m-) to 3.5 mm (-m-), (Qty 2)	Return Loss: ^{3}24 dB	11901A	Any equivalent	P
		Attenuators		
3.5 mm (-m- to -f-), 10 dB fixed attenuator, (Qty 2)	Accuracy: ±0.5 dB Freq: DC to 26.5 GHz	8493C Option 010	Any equivalent	P
		Tools		
5/16 inch (8 mm), open-end torque wrench	1.13 N.m (10 in-lb) setting (for semi-rigid cables and 50 ohm loads)	N/A	N/A	P, A
Cable removal tool	N/A	5002-3361[e]	N/A	P, A

a. P = Performance tests, A = Adjustments
b. Refer to "Get the Hardware Required for your GPIB Instruments" on page 2-5.
c. Required only if using an embedded controller. Refer to "Get the Hardware Required for your GPIB Instruments" on page 2-5.
d. Included in the 85052B/D calibration kits.
e. Included with the M937xA shipment.

Get the Hardware Required for your GPIB Instruments

The hardware required to connect your GPIB instruments to the network analyzer depends on the type of controller you use.

- If using an embedded controller, you need an M9036-31301 GPIB Micro 2 cable.
- If using a remote controller, you need a GPIB card for the PC.

Verify the Operating Environment

For Operating Environment information, refer to the online Data Sheet at http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf.

Protect Against Electrostatic Discharge (ESD)

For information on protecting against electrostatic discharge (ESD), refer to the online Startup Guide at http://literature.cdn.keysight.com/litweb/pdf/M9370-90001.pdf

Allow the Analyzer to Warm Up

NOTE To achieve the maximum system stability, allow the network analyzer to warm up for at least 15 minutes.

Review the Principles of Connector Care

For online information on connector care, go to
http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm.

About System Verification and Performance Tests

The performance of the network analyzer is specified in two ways: system specifications and instrument specifications. It is the end user's responsibility to determine which set of specifications is applicable to their use of the network analyzer.

A network analyzer measurement "system" includes the network analyzer, calibration kit, test cables, and any necessary adapters. **The system verification software is used to verify the system's conformance to the "system" specifications.** A "pass" result demonstrates that the network analyzer test cables and adapters perform correctly as a system. It DOES NOT demonstrate that any one component performs according to its individual specifications. A change to any part of this measurement system requires a re-verification of the system.

Instrument specifications specify the network analyzer's uncorrected measurement port characteristics and its output and input behavior. **The performance tests are used to verify the module's conformance to "instrument" specifications.**

System Specifications

System specifications specify warranted performance of the measurement system when making error-corrected measurements using the same calibration kit and test cables used during the system verifications routine. System specifications are applicable only when the measurement system is used to make error-corrected measurements.

The network analyzer's system specifications are described in the Data Sheet, available online at
http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf.

System specifications are expressed in two ways:

- residual errors of the measurement system shown as tabular specification values
- graphs of measurement uncertainty versus reflection and transmission coefficients

System specifications are verified in one of the following ways:

- Complete the system verification procedure using a certified verification kit and certified calibration kit that will be used for future measurements.
- Complete all of the performance tests using a certified calibration kit that will be used for future measurements. This alternative verifies both the system specifications and the instrument specifications for the network analyzer.

Instrument Specifications

The network analyzer's instrument specifications are described in the Data Sheet, available online at
http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf.

These specifications apply when the network analyzer is used to make either raw or error-corrected measurements.

System Verification Procedure

The system verification procedure tests the network analyzer measurement "system," as defined previously, against the system specifications. If confirmation is successful, the measurement system is capable of making measurements to the accuracy specified by the graphs of measurement uncertainty.

The procedure consists of calibrating the analyzer with a calibration kit, measuring a set of characterized devices, and comparing the resultant measured data to the data and uncertainty limits supplied with the verification kit. The device data provided with the verification kit has a traceable path to NIST. The total measurement uncertainty limits for the performance verification are the sum of the factory measurement uncertainties and the uncertainties associated with measuring the same devices on the system being verified. The difference between the factory-measured data and the verification-measured data must fall within the total uncertainty limits at all frequencies for the total system uncertainty test to pass.

NOTE **Calibration kits are different from verification kits. Calibration kits are used to determine the systematic errors of a network analyzer measurement system. Verification kits are used to confirm system specifications and are not used to generate error correction.**

Performance Tests

Performance tests are used to confirm network analyzer performance against the "instrument" specifications. If confirmation is successful, the network analyzer meets the instrument specifications.

Performance tests are contained in the network analyzers' firmware with Options 897 or 898 and are described at "Performance Tests" on page 2-30.

An illustrated outline of the performance verification procedure

- for ANSI/NCSL Z540.3-206 and ISO/IEC 17025 verification, is shown in Figure 2-1 on page 2-10.
- for Non-Standards Compliant verification, is shown in Figure 2-2 on page 2-11.

Certificate of Calibration

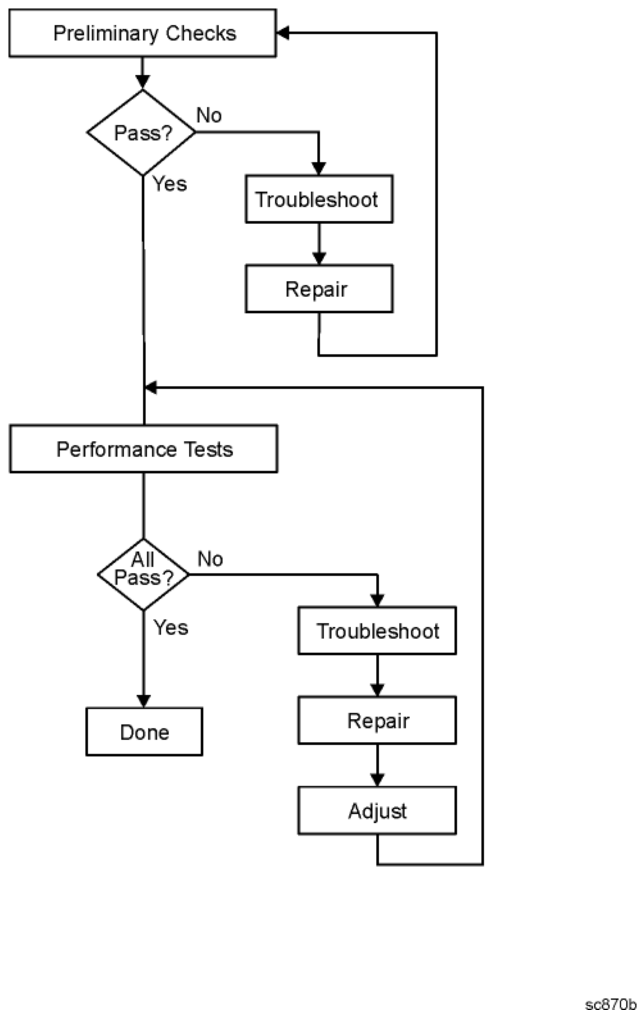
Keysight Technologies will issue a certificate of calibration upon successful completion of system verification or completion of the performance tests. The certificate of calibration will apply to the “system” (network analyzer, calibration kit, test cables, and any necessary adapters) if the system verification procedure is used to confirm the system specifications. If the performance tests are used to confirm instrument specifications, the certificate of calibration will apply to the network analyzer as an independent instrument. The equipment and measurement standards used for the tests must be certified and must be traceable to recognized standards.

NOTE If you have a measurement application that does not use all of the measurement capabilities of the network analyzer, you may ask your local Keysight Technologies service office to verify only a subset of the specifications. However, this “limited calibration” creates the possibility of making inaccurate measurements if you then use the analyzer in an application requiring additional capabilities.

ANSI/NCSL Z540.3-2006 and ISO/IEC 17025 Verification

To meet the criteria for ANSI/NCSL Z540.3-2006 and ISO/IEC 17025 verification, perform the preliminary checks and all performance tests *without stopping to repair or adjust.*[1] Refer to Figure 2-1 for test flow. Print data at the completion of all the tests, even if you are aware that the network analyzer did not pass. If there is a failure, complete the verification before you troubleshoot, repair, and adjust. After the failure has been corrected, repeat the entire set of performance tests and generate a new set of data.

Figure 2-1 ANSI/NCSL Z540.3-2006 and ISO/IEC 17025 Verification Flowchart

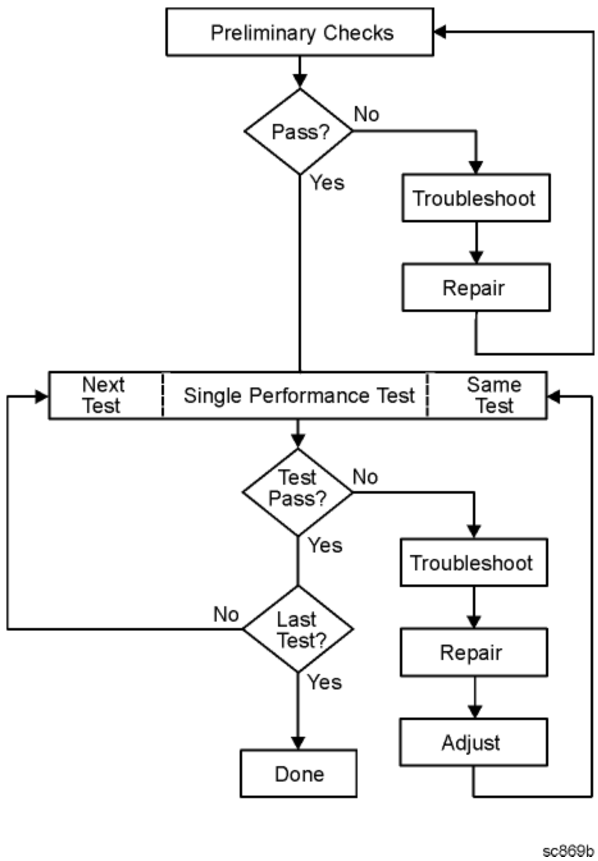


1. Stop only in case of a catastrophic failure or cable connector damage.

Non-Standards Compliant Verification

To meet the criteria for non-standards compliant verification, perform the preliminary checks and the performance tests *while stopping to troubleshoot.* Refer to Figure 2-2 for test flow. Troubleshoot and repair the first problem encountered without continuing to other tests. After you troubleshoot, repair, and adjust, repeat the *last failed* portion and generate a new set of data.

Figure 2-2 Non-Standards Compliant Verification Flowchart



Preliminary Checks

Preliminary checks include the following:

- The Operator’s Check

  The Operator’s Check tests the basic functionality of the source, switches, and receivers in the network analyzer.

- “The Test Port Cable Checks” on page 2-14

  The test port cable checks are not required, but are recommended to verify the performance of the test port cables before performing the verification test.

The Operator’s Check

NOTE **Allow the network analyzer to warm up for at least 15 minutes before performing the Operator’s Check.**

The Operator’s Check is a software driven test that checks the basic operation of the assemblies in all of the measurement port signal paths. By performing the Operator’s Check, the following are determined:

- attenuation ranges of all internal attenuators
- calibration of the receivers
- frequency response of the receivers
- phase lock
- noise floor and trace noise
- various voltages throughout the network analyzer

Accessories Used in the Operator’s Check

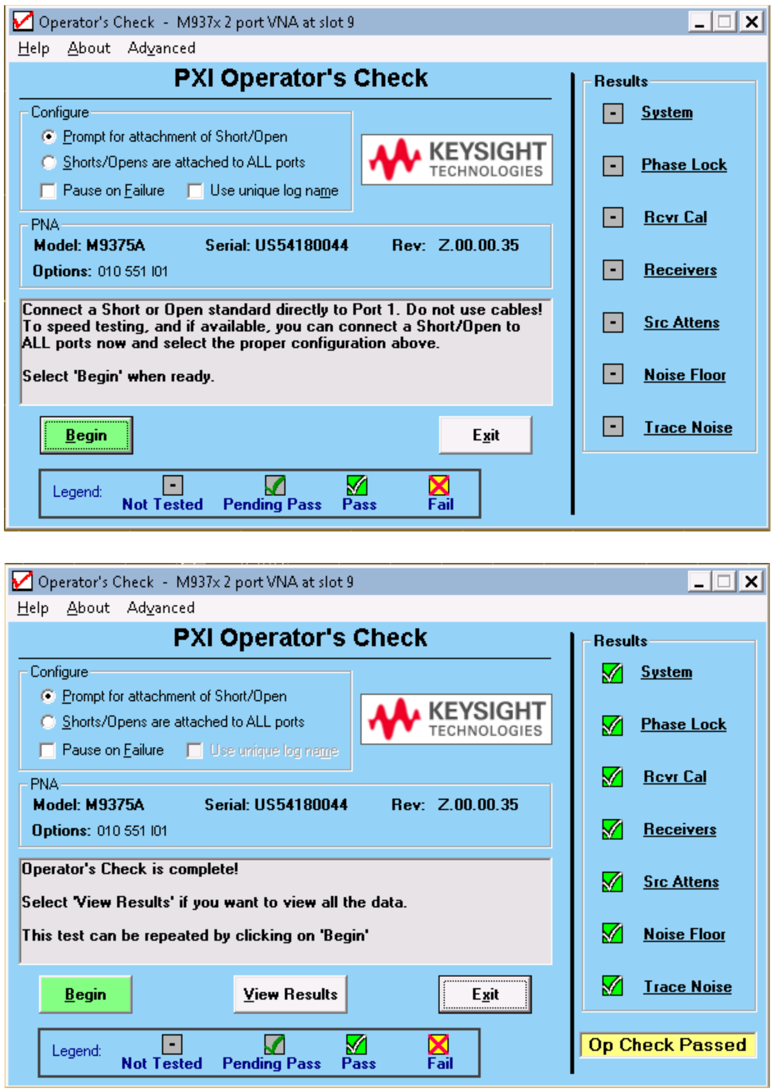
Male short(s) or open(s) from a 3.5 mm calibration kit.

Performing the Operator’s Check

1. On the soft front panel, click **Utility > System > Service > Operator’s Check**.
2. In the PXI Operator’s Check dialog box (refer to Figure 2-3), under Configure, click either **Prompt for attachment of Short/Open**, to pause at each step in the process to allow moving the short/open to the appropriate port, or **Shorts/Opens are attached to ALL ports**, to run through the test without stopping. Shorts and opens can be mixed on the test ports.
   In most cases, the short/open is not required since the analyzer test port’s female connector acts an “open.” However, if the test fails, confirm the failure with a short/open attached.

3. Click **Begin**.
4. If shorts and opens are not connected to all ports, you will be prompted to connect them as they are needed.
5. The result of the Operator's Check will be shown as a PASS or FAIL to each test (refer to Figure 2-3).

Figure 2-3 Operator's Check Dialog Boxes



If the Operator's Check Fails

1. Clean the test ports, and the open(s) or short(s), and torque to specification. Repeat the check.
2. If the check still fails, return the network analyzer to Keysight. See "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

The Test Port Cable Checks

A faulty test port cable can cause a failure in the verification test. The following checks are not required, but are recommended to verify the performance of the test port cable.

- "Cable Return Loss Check" on page 2-14
- "Cable Insertion Loss Check" on page 2-15
- "Cable Magnitude and Phase Stability Check" on page 2-16
- "Cable Connector Repeatability Check" on page 2-17

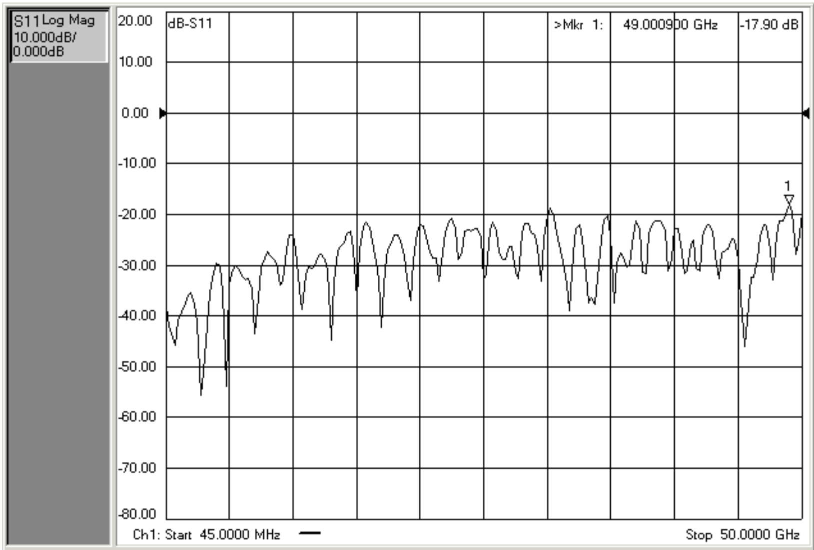
Accessories Used in the Test Port Cable Checks

Equipment Type	Model or Part Number	Alternate Model or Part Number
Calibration Kit, 3.5 mm	85052B	85052D
Test cable, 3.5 mm (-m- to -m-)	11500E	Any equivalent

Cable Return Loss Check

1. On your PC screen, click the Network Analyzer icon.
2. Make your network analyzer configuration settings.
3. Click **Utility > Preset**.
4. Click **Cal > Start Cal > Cal Wizard**, and perform a 1-port reflection calibration on Port 1. Refer to Help if necessary.
5. Connect the test port cable to Port 1.
6. Connect a broadband load to the other end of the cable. Tighten to the specified torque for the connector type. The analyzer now displays the return loss of the cable.
7. Click **Marker/Analysis > Marker Search > Max**.
8. The marker annotation on the screen indicates the worst case return loss. Refer to the cable manual to see if it meets the return loss specification. For an example of a typical return loss measurement, see Figure 2-4 on page 2-15.

Figure 2-4 Typical Cable Return Loss Response



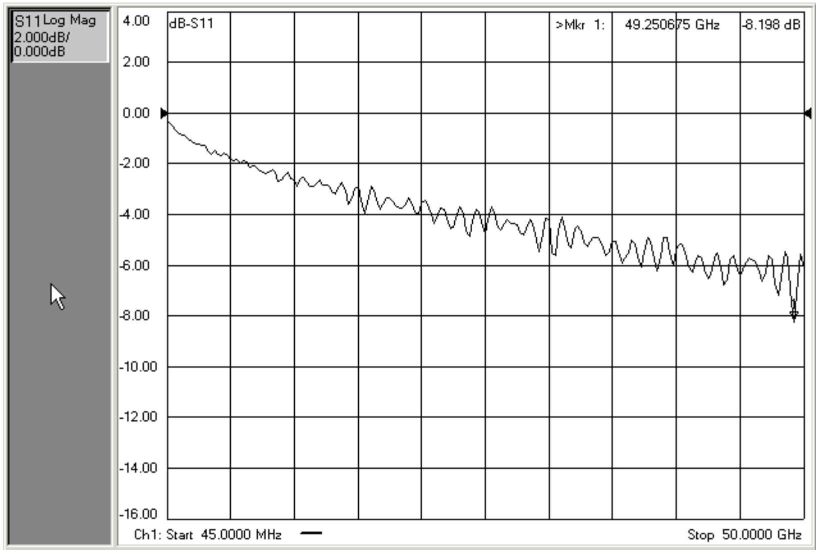
If the Cable Return Loss Check Fails

1. Clean the cable and devices and torque to specification. Repeat the check.
2. If the check still fails, the cable should be repaired or replaced.

Cable Insertion Loss Check

1. With the test port cable still connected to Port 1, connect a short to the other end of the cable.
2. Press **Marker/Analysis > Marker Search > Min**.
3. The displayed response is twice the actual loss. To get the actual worst case insertion loss (approximate), divide the value at the marker annotation by two. Refer to the cable manual to see if it meets the insertion loss specification. For an example of a typical insertion loss measurement, see Figure 2-5 on page 2-16.

Figure 2-5 Typical Cable insertion Loss Response



If the Cable Insertion Loss Check Fails

1. Clean the cable and devices and torque to specification. Repeat the check.
2. If the check still fails, the cable should be repaired or replaced.

Cable Magnitude and Phase Stability Check

1. With the test port cable still connected to Port 1, connect a short to the other end of the cable.
2. Press **Utility > Preset**.
3. Press **Trace/Channel > Trace > New Trace**.
4. In the New Trace dialog box:

   a. Click the S11 box.

   b. Click **OK**.
5. Press **Response > Format > Phase**.
6. To provide a good reference, hold the test cable in a straight line.
7. For both Trace 1 and Trace 2, perform the following steps:

   a. To normalize the data trace, click **Marker/Analysis > Memory > Normalize**.

   b. Slowly make a 180 degree bend in the middle of the cable and hold it in that position.

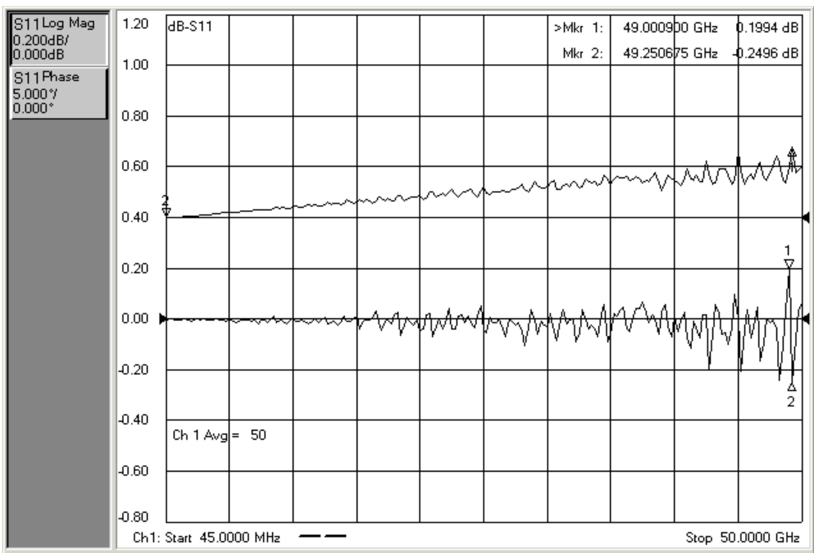
   c. For each trace, press **Response > Scale > Scale**.

d. In the **Scale** box, set the **Scale Per Division** for optimum viewing as shown in Figure 2-6.

8. Place a marker on the largest deflection that goes above the reference line and is within the cable's specified frequency range. For a typical response of cable magnitude and phase stability, see Figure 2-6.
9. Place a marker on the largest deflection that goes below the reference line and is within the cable's specified frequency range.

In this S_{11} measurement, the displayed trace results from energy being propagated down the cable and reflected back from the short. Therefore, the measured deflection value must be divided in half to reach the correct value.

Figure 2-6 Typical Cable Magnitude and Phase Stability Response



If the Cable Magnitude and Phase Stability Check Fails

1. Clean the cable and devices and torque to specification. Repeat the check.
2. If the check still fails, the cable should be repaired or replaced.

Cable Connector Repeatability Check

NOTE

The connector repeatability measurement should be done at the test port as well as at the end of the test port cable.

1. With the test port cable still connected to Port 1, connect a broadband load to the other end of the cable.
2. **Press Utility > Preset**.
3. Press **Response > Avg > Average**.
4. In the **Average** dialog box:

a. Click the check box for **Average ON**.

b. Select an Averaging Factor of **100.**

c. Use the default Average Type selection of **Sweep**.

d. Click **OK.**

5. Wait for the analyzer to average the measurement 100 times (approximately five seconds).
6. To normalize the data trace, click **Marker/Analysis > Memory > Normalize**.
7. To adjust the display scale:

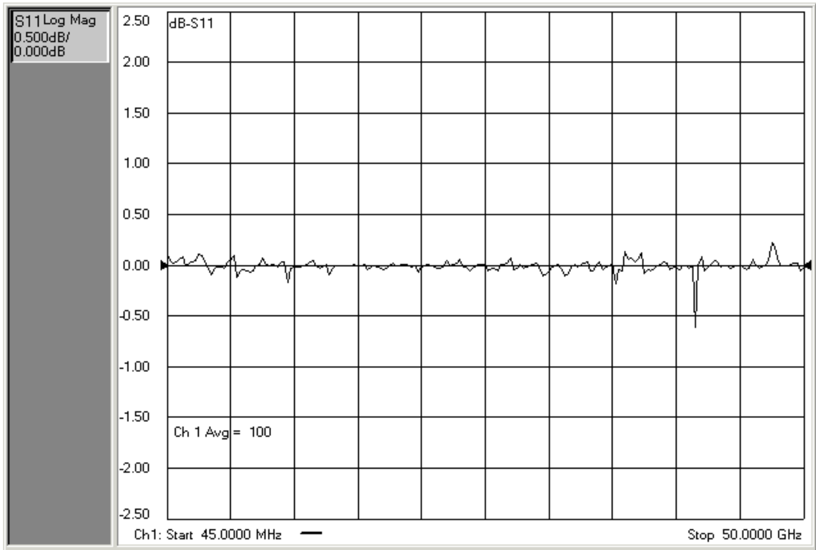
   a. Press **Response > Scale > Scale**.

   b. In the Scale box, set the **Scale Per Division** for **0.5 dB**.

   c. Click **OK**.
8. Disconnect and then reconnect the cable to the test port. Tighten the connection to the specified torque for the connector type.
9. Click **Response > Avg > Averaging Restart**.
10. Look at the trace for spikes or modes.
11. To re-normalize the data trace of the reconnected cable, click **Marker/Analysis > Memory > Data -> Memory**.
12. Repeat steps 9 through 11 at least three times to look for modes. Modes appear when a harmonic of the source fundamental frequency is able to propagate through the cable or connector. It is helpful to print a plot of the trace each time to compare several connections. If any mode appears each time the cable is connected and reconnected, measurement integrity will be affected.

    For a typical response of cable connector repeatability, see Figure 2-7 on page 2-19.
13. For the Port 2, 3, and 4 Check, connect the cable (with the load attached) to the respective port and repeat steps 2 through 13.

Figure 2-7 Typical Cable Connector Repeatability Response



If the Cable Connector Repeatability Check Fails

1. Clean the cable and devices and torque to specification. Repeat the check.
2. If the check still fails, the cable should be repaired or replaced.

System Verification

System verification is used to verify system-level, error-corrected uncertainty limits for network analyzer measurements. The verification procedure is automated and is contained in the firmware of the network analyzer.

The device data provided with the verification kit has a traceable path to a national standard. The difference between the supplied traceable data and the measured data must fall within the total uncertainty limits at all frequencies for the system verification to pass.

The total measurement uncertainty limits for the system verification are the sum of the factory measurement uncertainties for the verification devices and the uncertainties associated with the system being verified.

NOTE **Passing this system verification does not guarantee that the network analyzer meets all of its performance specifications. However, it does show that the network analyzer being verified measures the same devices with the same results as a factory system which has had all of its specifications verified and its total measurement uncertainty minimized.**

What the System Verification Verifies

The system verification procedure verifies proper operation of the:

- network analyzer
- calibration kit
- test port cables

together as a “system.” It DOES NOT verify that any of these components pass their specifications independently. The user is responsible for independently calibrating and verifying the proper operation of the calibration kit and test port cables prior to performing the system verification.

NOTE **Additional equipment or accessories used with the above system are not verified by system verification.**

Measurement Uncertainty

Measurement uncertainty is defined as the sum of the residual systematic (repeatable) errors, and the random (non-repeatable) errors in the measurement system after calibration.

The systematic errors are:

- directivity
- source match
- load match

- reflection and transmission frequency tracking, and
- isolation (crosstalk)

The random errors include:

- noise
- drift
- connector repeatability
- test cable stability

A complete description of system errors and how they affect measurements is provided in the network analyzer's Help system (search for Measurement Errors).

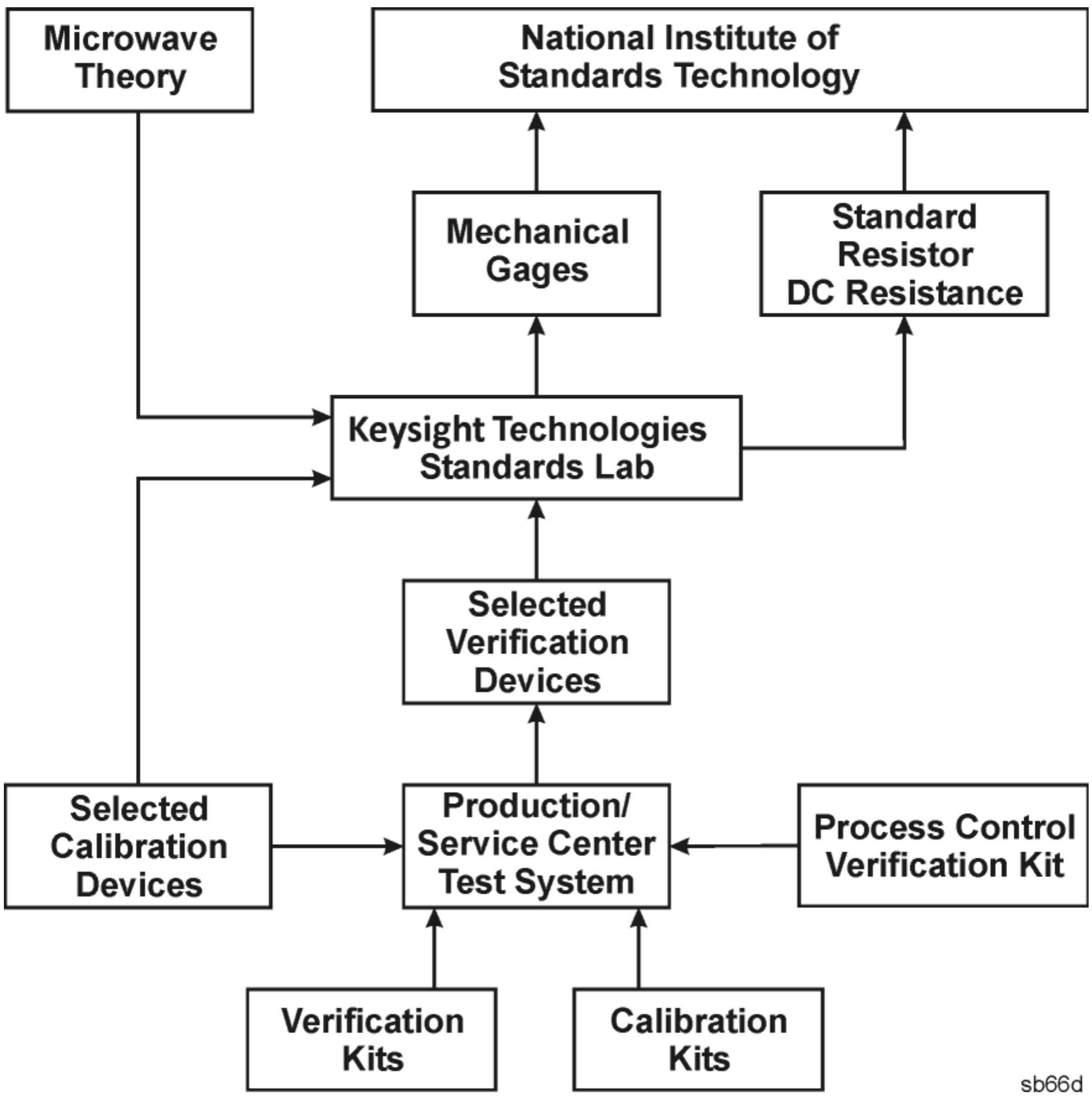
Any measurement result is the vector sum of the actual test device response plus all error terms. The precise effect of each error term depends on its magnitude and phase relationship to the actual test device response. When the phase of an error response is not known, phase is assumed to be worst-case (–180° to +180°). Random errors such as noise and connector repeatability are generally combined in a root-sum-of-the-squares (RSS) manner.

Measurement Traceability

To establish a measurement traceability path to a national standard for a network analyzer system, the overall system performance is verified through the measurement of devices that have a traceable path. This is accomplished by measuring the devices in a Keysight verification kit.

The measurement of the devices in the verification kit has a traceable path because the factory system that measured the devices is calibrated and verified by measuring standards that have a traceable path to the National Institute of Standards and Technology (NIST) (see Figure 2-8).

Figure 2-8 NIST Traceability Path for Calibration and Verification Standard



Performing System Verification

The following verification procedure is automated by the network analyzer firmware. The process for the verification is:

- connect cables to the analyzer test ports
- perform a calibration or recall a recent calibration
- run the system verification program for the verification devices

Each time through the verification process, you are prompted to make necessary connections and perform or recall a calibration as part of performing the verification. If you select to perform a calibration, you are guided through the calibration procedure. This part of the process can be eliminated if you choose to load an existing recent calibration. If necessary, refer to the network analyzer's Help system for information on storing and recalling calibrations.

For each verification device, the analyzer reads a file from the verification disk and sequentially measures the magnitude and phase for all four S-parameters.

NOTE For system verification to perform correctly, it is NECESSARY that the verification devices be measured with their female connectors connected to the network analyzer's Port 1 and male connectors to Port 2.

NOTE Although the performance for all S-parameters are measured, the S_{11} and S_{22} phase uncertainties for the attenuators and airlines are less important for verifying system performance. Therefore, the limit lines will not appear on the printout.

Equipment Used in the System Verification Procedure

Table 2-1 Equipment Used in the System Verification Procedure

Equipment Type	3.5 mm	Type-N
Calibration kit	85052B, C, D N4691B ECal	85054B/D N4690B ECal
Verification kit	85053B	85055A
Cables	Single cable: 11500E Cable pair: 11500E and 8121-2111	Single cable: 11500E with 1250-1744 adapter Cable pair: 11500E with 1250-1744 adapter, and 8121-2111 with 1250-1750 adapter
Adapters	None required	With single cable: an 85130C adapter and a 7 mm to Type-N adapter from the 85054B calibration kit. With cable pair: Two 7 mm to Type-N adapters from the 85054B calibration kit.

Cable Substitution

The test port cables specified for the network analyzer system 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. Refer to the plots in the cable tests (earlier in this chapter) that show the performance of good cables. It is highly recommended that the test port cables be regularly tested.

If the system verification is performed with a non-Keysight cable, ensure that the cable meets or exceeds the specifications for the test cable specified in Table 2-1. Refer to the cable's user's guide for specifications.

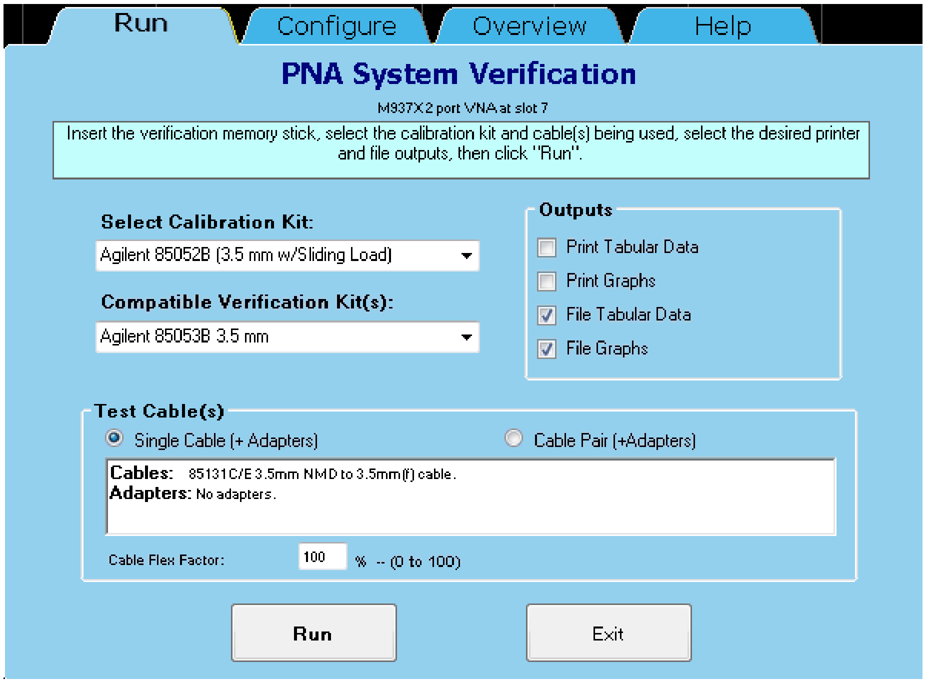
Kit Substitution

Non-Keysight calibration kits and verification kits are not recommended nor supported.

System Verification Procedure

1. If you want printed test outputs, connect a printer to the embedded or remote controller. For the printer, ensure that the correct driver is loaded and the printer is defined as the default printer. Refer to the network analyzer's Help system for information on printer setup.
2. Let the analyzer warm up for at least 15 minutes.
3. Insert the verification kit memory stick in a USB port of the embedded or remote controller.
4. Click **Utility > System > Service > System Verification**. The System Verification dialog box is displayed, as shown in Figure 2-9.

Figure 2-9 System Verification Dialog Box



5. In the Select Calibration Kit box, click on the calibration kit or electronic calibration module (ECal) being used. The corresponding verification kit to use is selected for you and displayed in the **Compatible Verification Kit(s)** box.

6. Under **Outputs**, click one of the following options. Refer to Figure 2-9.

   -**Print Tabular Data**: Prints the verification data in tabular form which includes measured data and uncertainty limits. For an example, refer to Figure 2-11 on page 2-28.

   -**Print Graphs**: Prints the verification data in graphical form. The graphical form includes measured data trace, factory supplied data trace, and uncertainty limits. For an example, refer to Figure 2-12 on page 2-29.

   -**File Tabular Data**: Writes the tabular data to a text file in the C:\Users\Public\Public Documents\Network Analyzer\SysVer\ directory.

   - **File Graphs**: Saves a screen image in PNG format in the C:\Users\Public\Public Documents\Network Analyzer\SysVer\ directory.

NOTE

For printed output, it is assumed that the printer has been tested and the Windows driver is installed for the printer that is being used. The system verification test prints to the printer that has been designated as the default printer. (On the Windows Desktop display, click on Start > Devices and Printers to verify the printer setup.

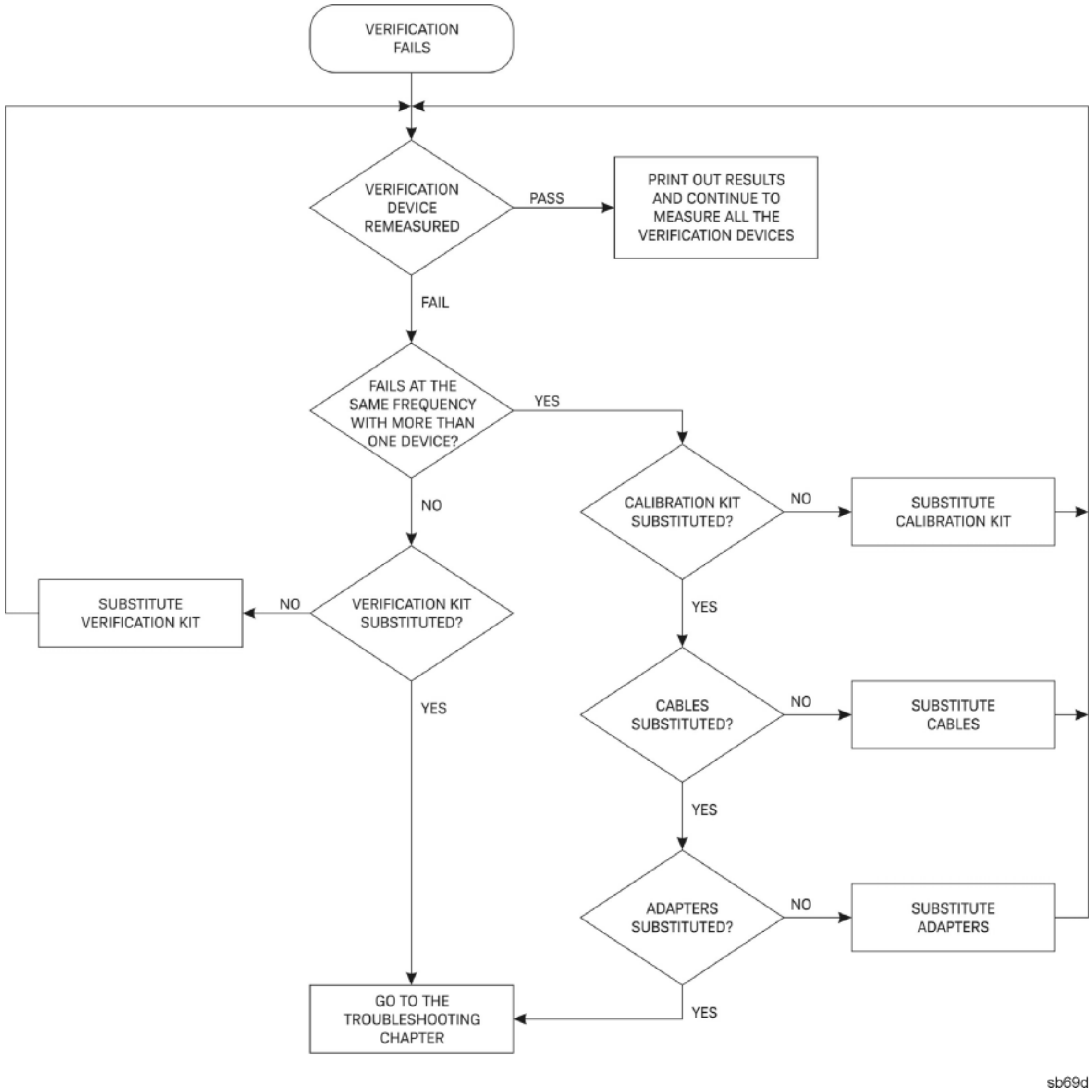
7. To modify the number of ports to be verified or to change the number of devices to measure, click on the **Configure** tab and make the desired selections.
8. Click **Run**.
9. Follow the instructions for performing a full calibration or recalling an existing recent calibration.
10. Follow the instructions for performing the system verification, inserting the verification devices as prompted.

If the System Fails the Verification Test

NOTE Inspect all connections. DO NOT remove the cable from the network analyzer test port. This will invalidate the calibration that you performed earlier.

1. Disconnect and clean the device that failed the verification test.
2. Reconnect the device, making sure that all connections are torqued to the proper specifications.
3. Measure the device again.
4. If the analyzer still fails the test, check the measurement calibration by viewing the error terms as described in "Accessing Error Terms" on page 1-7.
5. Refer to Figure 2-10 on page 2-27 for additional troubleshooting steps.

Figure 2-10 System Verification Failure Flowchart



Interpreting the Verification Results

Figure 2-11 shows an example of typical verification results with **Print Tabular Data** selected in the **Output** area of the **System Verification** dialog box.

At the top of the printed output is the name of the device, the serial number of the device, and the date tested.

Each S-parameter measurement result is printed with frequency tested, lower and upper limit lines, the measured data, and the result of the test.

Figure 2-11 Example of Printed Tabular Verification Results

PNA System Verification

Model: N5230A 225 Ser. Num.: US43390055 Test Time: 12/8/2004 2:08:35 PM
Device: 20 dB Attenuator, Serial #02743 S11 Results PASS

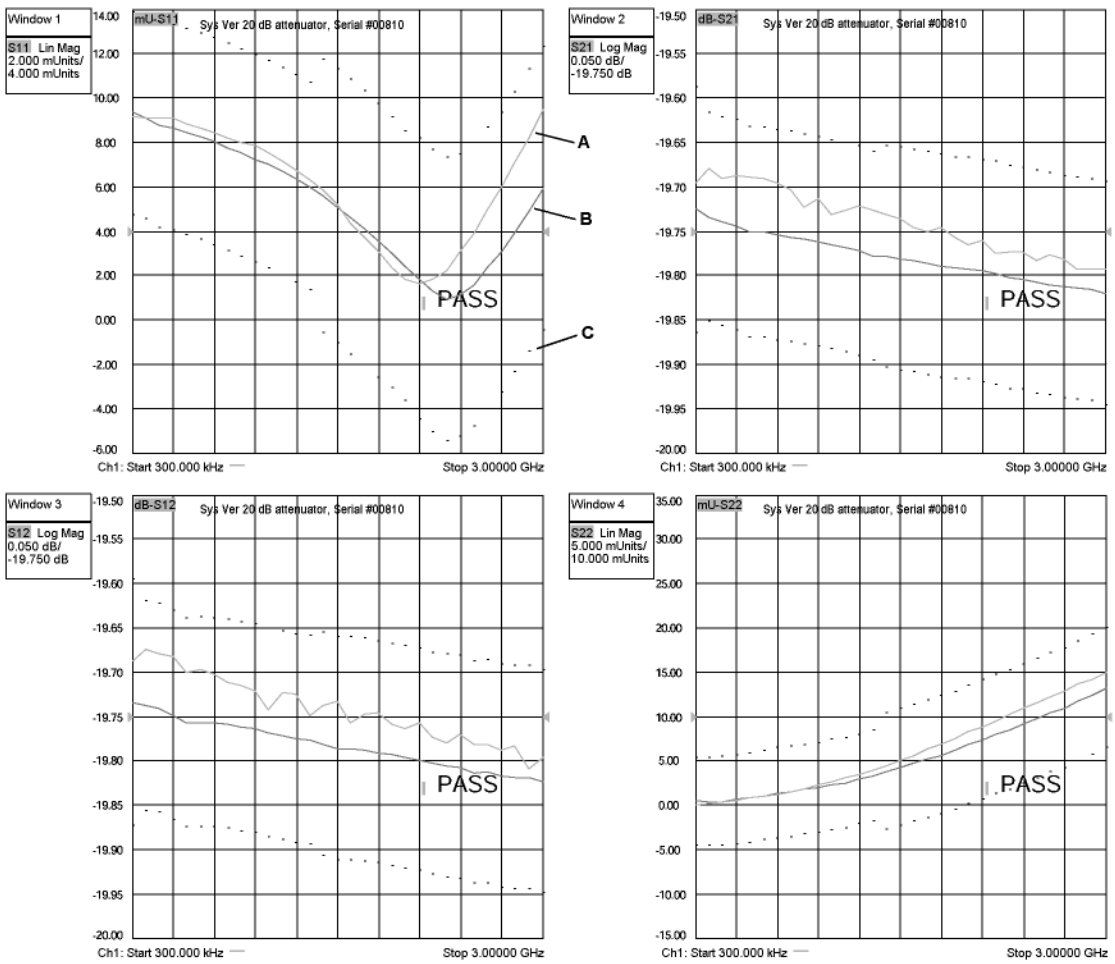
	S11 MAGNITUDE (lin)				S11 PHASE (deg)			
Freq [GHz]	Lower Limit (lin)	Meas'd Data (lin)	Upper Limit (lin)	Total Uncert +/-	Lower Limit (deg)	Meas'd Data (deg)	Upper Limit (deg)	Total Uncert +/-
0.045	0.0067	0.0045	0.0113	0.0090	n/a	177.46	n/a	n/a
0.50	0.0067	0.0046	0.0114	0.0091	n/a	155.77	n/a	n/a
1.00	0.0057	0.0047	0.0125	0.0091	n/a	127.90	n/a	n/a
1.50	0.0043	0.0050	0.0139	0.0091	n/a	99.52	n/a	n/a
2.00	0.0034	0.0055	0.0148	0.0091	n/a	72.43	n/a	n/a
2.50	0.0076	0.0061	0.0208	0.0142	n/a	46.58	n/a	n/a
3.00	0.0068	0.0067	0.0216	0.0142	n/a	21.57	n/a	n/a
3.50	0.0066	0.0075	0.0227	0.0146	n/a	-0.45	n/a	n/a
4.00	0.0060	0.0086	0.0233	0.0146	n/a	-20.94	n/a	n/a
4.50	0.0056	0.0098	0.0237	0.0147	n/a	-39.48	n/a	n/a
5.00	0.0053	0.0109	0.0241	0.0147	n/a	-56.13	n/a	n/a
5.50	0.0051	0.0118	0.0242	0.0147	n/a	-71.75	n/a	n/a
6.00	0.0050	0.0125	0.0244	0.0147	n/a	-86.47	n/a	n/a
6.50	0.0049	0.0131	0.0244	0.0147	n/a	-100.81	n/a	n/a
7.00	0.0057	0.0136	0.0236	0.0147	n/a	-113.94	n/a	n/a
7.50	0.0061	0.0138	0.0232	0.0147	n/a	-125.68	n/a	n/a
8.00	0.0059	0.0138	0.0234	0.0147	n/a	-135.63	n/a	n/a
8.50	0.0110	0.0136	0.0287	0.0198	n/a	-144.53	n/a	n/a
9.00	0.0107	0.0133	0.0290	0.0199	n/a	-152.31	n/a	n/a
9.50	0.0101	0.0130	0.0297	0.0199	n/a	-159.32	n/a	n/a
10.00	0.0092	0.0129	0.0305	0.0199	n/a	-165.12	n/a	n/a
10.50	0.0080	0.0129	0.0317	0.0199	n/a	-169.47	n/a	n/a
11.00	0.0066	0.0130	0.0332	0.0199	n/a	-172.95	n/a	n/a
11.50	0.0051	0.0135	0.0347	0.0199	n/a	-176.46	n/a	n/a
12.00	0.0035	0.0140	0.0364	0.0199	n/a	-179.98	n/a	n/a

Figure 2-12 shows an example of typical verification results with **Print Graphs** selected in the **Output** area of the **System Verification** dialog box. The printed graphical results show the following:

- the name of the device measured
- the serial number of the device
- the parameters measured

- Results of the measurements. Labeled as A in Figure 2-12.
- Data measured at the factory from the verification kit. Labeled as B in Figure 2-12.
- Upper and lower limit points as defined by the total system uncertainty system. Labeled as C in Figure 2-12.

Figure 2-12 Example of Printed Graphical Verification Results



Performance Tests

The performance tests verify the electrical performance of your network analyzer.

The model numbers of the equipment used by these performance tests are specified under “Get the Required Service Test Equipment” on page 2-3.

There are nine performance tests:

Power Measurement Receiver System (PNAasPowerMeter)

The PXI VNA source has harmonic content which is high enough to distort power measurements made with a broadband power sensor. Therefore, we use a calibrated PNA receiver system as the filtered power level measurement standard for several of these tests. This receiver is the combination of a PNA, a test cable connected to one of the PNA test ports, and a 10 dB attenuator connected to the end of the test cable. Some tests add an adapter between the test cable and the PNA in order to reverse the sex of the connection at the end of the attenuator. This power measurement receiver system will be referred to as **PNAasPowerMeter**.

Source Power Accuracy Test

Function of the Test

To confirm the accuracy of the source output power of your network analyzer over its full frequency range.

Specification Tested

Test Port Output – Power Level Accuracy

Equipment Used

- Components for the PNAasPowerMeter[1]:
  - PNA (N5241A/42A, or N5221A/22A, or E8363C/64C[2])
  - 10 dB attenuator
  - 3.5 mm (-m- to -f-) test cable
- Components for calibrating the PNAasPowerMeter:
  - U8485A USB Thermocouple Power Sensor (or N8485A power sensor with N1912A/13A/14A power meter)
  - ECal module (N4691B)

Description of the Test

1. The PNA, with cable and 10 dB attenuator, is calibrated for use as a highly accurate, tuned power meter. This set is referred to as PNAasPowerMeter.
2. The analyzer is Preset.
3. The analyzer is set up for a CW reflection measurement on the test port to be measured.
4. The PNAasPowerMeter is connected to the test port.
5. The analyzer frequency is set to the desired value.
6. The PNAasPowerMeter is set to the same frequency.
7. The output power is measured, and the value is compared to the Preset setting.
8. This process is repeated at hundreds of frequencies across the full range of the analyzer. The difference between the measured power and the output setting must be within the specified accuracy range at all points for the test to pass.

1. Refer to Power Measurement Receiver System (PNAasPowerMeter).
2. **Refer to** Get the Hardware Required for your GPIB Instruments.

If the Analyzer Fails this Test

- Perform the “Source Adjustment” on page 2-45 and repeat this test.
- If the analyzer still fails this test, return it to Keysight for repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Source Maximum Power Output Test

Function of the Test

To confirm the maximum source output power of your network analyzer over its full frequency range.

Specification Tested

Test Port Output – Maximum Leveled Power

Equipment Used

- Components for the PNAasPowerMeter[1]:
  - PNA (N5241A/42A, or N5221A/22A, or E8363C/64C[2])
  - 10 dB attenuator
  - 3.5 mm (-m- to -f-) test cable
- Components for calibrating the PNAasPowerMeter:
  - U8485A USB Thermocouple Power Sensor (or N8485A power sensor with N1912A/13A/14A power meter[1])
  - ECal module (N4691B)

Description of the Test

1. The PNA, with cable and 10 dB attenuator, is calibrated for use as a highly accurate, tuned power meter. This set is referred to as PNAasPowerMeter.
2. The analyzer is Preset.
3. The analyzer is set up for a CW reflection measurement on the test port to be measured.
4. The PNAasPowerMeter is connected to the test port.
5. The analyzer frequency is set to the desired value.
6. The PNAasPowerMeter is set to the same frequency.
7. The analyzer output power is set above its maximum output level. The firmware will automatically set the hardware to its maximum output power.
8. The power level at this point is measured and compared to the maximum output power specification.
9. This process is repeated at hundreds of frequencies across the full range of the analyzer in every specified path configuration.

1. **Refer to** Power Measurement Receiver System (PNAasPowerMeter)**.**
2. **Refer to** Get the Hardware Required for your GPIB Instruments**.**

If the Analyzer Fails this Test

- If the analyzer fails this test, return it to Keysight for repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Source Power Linearity Test

Function of the Test

To verify that the power level is linear over the analyzer's frequency range and to check the linearity of the automatic leveling control (ALC).

Specification Tested

Power Sweep Range and Power Level Linearity

Equipment Used

- Test cable
- Any necessary adapters

Description of the Test

Ports 1 and 2 are tested as a pair. The Port 2 receiver is used to test the linearity of the source power out of Port 1, and vice versa. The receiver linearity is the standard against which the source linearity is checked.

1. The analyzer is Preset.
2. The analyzer is set up for a CW transmission measurement on the test port to be measured.
3. A test cable is connected between the port pair to be tested with 20 dB of attenuation in series with the cable. This is done with an external 20 dB attenuator. This attenuation ensures that the receiver remains in its linear range.
4. The receiver measurement is normalized at this Preset power level.
5. The source setting is then stepped from the minimum to the maximum ALC power setting range in 1 dB steps, and the receiver power is measured at each setting.
6. The non-linearity in dB at each frequency point is calculated as the difference between the change in the source power setting away from Preset and the change in the receiver power reading.
7. This power linearity measurement is repeated at several CW frequencies across the full frequency range of the analyzer.

If the Analyzer Fails this Test

- Perform the "Source Adjustment" on page 2-45 and repeat this test.

- If the analyzer still fails this test, return it to Keysight for repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Frequency Accuracy Test

Function of the Test

To verify the frequency accuracy and range of the analyzer's source output.

Specification Tested

Test Port Output – CW Accuracy

Equipment Used

- Frequency counter[1]
- Test cable
- Any necessary adapters

Description of the Test

This test is performed at key frequencies over the frequency range of the source voltage controlled oscillator (VCO), not the full frequency range of the analyzer. To generate the higher frequencies, the analyzer passes the signal through a series of frequency doublers. These doublers exactly double the source frequency, so the deviation from a perfectly accurate frequency is exactly doubled. The frequency accuracy is specified as the ratio parts per million (ppm), so this ratio is unaffected by the signal doubling. Therefore, only the frequency accuracy of the VCO needs to be tested.

1. The analyzer is Preset.
2. The analyzer is set up for a CW measurement on Port 1.
3. A test cable is connected between Port 1 and a frequency counter with any necessary adapters.
4. The signal frequency is measured and compared with the analyzer source frequency setting. The difference must be less than the source frequency divided by 10^6 for a 1 part per million (ppm) specification.
5. This test is repeated at several frequencies across the range of the VCO.

If the Analyzer Fails this Test

- Verify the accuracy of the 10 MHz REF OUT by using a frequency counter. If the 10 MHz reference is off by more than 10 Hz, perform the "10 MHz Frequency Reference Adjustment" on page 2-44 and then repeat this test.

1. **Refer to Get the Hardware Required for your GPIB Instruments.**

Trace Noise Test

Function of the Test

To confirm the stability of a signal in the internal source and receiver system of your analyzer.

Specification Tested

Test Port Input – Trace Noise Magnitude and Trace Noise Phase

Equipment Used

- A test cable
- Any necessary adapters

Description of the Test

Trace Noise is a calculation of the standard deviation of a 201 point CW measurement. In a healthy analyzer, this measurement is only affected by the sampling error of the analog to digital conversion.

Ports 1 and 2 are tested as a pair using S_{21} and S_{12} measurements.

1. The analyzer is Preset.
2. The analyzer is set up for a 201 point CW transmission measurement for the port pair to be tested with the specified IF bandwidth (typically 1 kHz). Both a magnitude and a phase trace are displayed.
3. A test cable is connected between the port pair to be tested.
4. The analyzer is set to a series of CW frequencies across its full frequency range. The analyzer's trace statistics function is used to calculate the standard deviation of both the magnitude trace and the phase trace.
5. The standard deviation values are reported as the analyzer's trace noise and are compared with the Trace Noise magnitude and phase specifications.

If the Analyzer Fails this Test

If the analyzer fails this test, return it to Keysight for repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Receiver Compression Test

Function of the Test

To measure the compression at the analyzer's specified maximum power level for the receivers.

Specification Tested

Test Port Input – Maximum Test Port Input Level

Equipment Used

- U3070AK01 Compression Test Set[1]
- Two 3.5 mm (-m- to -f-) test cables
- Two 11901A 2.4 mm (-m-) to 3.5 mm (-m-) adapters
- Components for the PNAasPowerMeter[1]:
  - PNA (N5241A/42A, or N5221A/22A, or E8363C/64C[2])
  - 10 dB attenuator
  - 3.5 mm (-m- to -f-) test cable
  - 83059B 3.5 mm (-f- to -f-) adapter
- Components for calibrating the PNAasPowerMeter:
  - U8485A USB Thermocouple Power Sensor (or N8485A power sensor with N1912A/13A/14A power meter[1])
  - ECal module (N4691B)

Description of the Test

For most analyzer models, the receiver compression level is higher than the maximum source output power. Therefore, an external amplifier is required. This test also requires that two attenuators be switched in and out of the RF path. These requirements are met with the use of the Compression Test Set. The procedure outlined here is for those models which require the test set.

1. The PNA, with cable, adapter, and 10 dB attenuator, is calibrated for use as a highly accurate, tuned power meter. This set is referred to as PNAasPowerMeter.
2. Connect one of the 11901A 2.4 mm to 3.5 mm adapters to a 3.5 mm test cable, then connect the adapter end of the cable to the compression test set input port.

1. Refer to Power Measurement Receiver System (PNAasPowerMeter).
2. Refer to Get the Hardware Required for your GPIB Instruments.

3. Connect the other 11901A 2.4 mm to 3.5 mm adapter to a 3.5 mm test cable, then connect the adapter end of the cable to the compression test set output port.
4. The analyzer is Preset. The two compression test set output attenuators are set to 0 dB.
5. The analyzer is set up for a 201 point CW transmission measurement for the port pair to be tested with the specified IF bandwidth (typically 1 kHz).
6. The test cable on the compression test set input port is connected to the analyzer source port.
7. The test cable on the compression test set output port is connected to the PNAasPowerMeter.
8. For a series of CW frequencies across the full frequency range of the analyzer, the source output level is adjusted to achieve the specified receiver compression power level (typically the receiver’s maximum input power level.)
9. The PNAasPowerMeter is disconnected from the test cable and the cable is connected to the port to be tested.
10. The analyzer steps through each CW frequency as the absolute log magnitude value (dBm) and the relative phase for the receiver under test is read (P_a).
11. The first compression test set output attenuator is set to 20 dB.
12. The magnitude and phase measurements using the receiver under test are read: (P_b).
13. The second compression test set output attenuator is set to 20 dB.
14. The magnitude and phase measurements using the receiver under test are read: (P_c).
15. The first compression test set output attenuator is set to 0 dB.
16. The magnitude and phase measurements using the receiver under test are read: (P_d).
17. The compression for each point is calculated as $(P_a - P_b) - (P_d - P_c)$

If the Analyzer Fails this Test

If the analyzer fails this test, return it to Keysight for repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Noise Floor Test

Function of the Test

To measure the absolute power level of the noise floor for the receivers.

Specification Tested

Test Port Input – Maximum Test Port Noise Floor

Equipment Used

- 3.5 mm (-m- to -f-) test cable
- 83059A 3.5 mm (-m- to -m-) adapter
- 10 dB attenuator
- 50 ohm loads (available in a mechanical calibration kit)
- Components for the PNAasPowerMeter[1]:
  - PNA (N5241A/42A, or N5221A/22A, or E8363C/64C[2])
  - 10 dB attenuator
  - 3.5 mm (-m- to -f-) test cable
  - 83059B 3.5 mm (-f- to -f-) adapter
- Components for calibrating the PNAasPowerMeter:
  - U8485A USB Thermocouple Power Sensor (or N8485A power sensor with N1912A/13A/14A power meter[1])
  - ECal module (N4691B)

Description of the Test

This test uses the source signal out of one analyzer test port as part of the noise floor measurement on another test port. Port 2 is the source port when measuring the noise floor of Port 1. Port 1 is the source port when measuring the noise floor of Port 2.

1. The PNA, with cable, adapter, and 10 dB attenuator, is calibrated for use as a highly accurate, tuned power meter. This set is referred to as PNAasPowerMeter.
2. The analyzer is Preset.
3. The analyzer is set up for a CW transmission measurement between the source port and the test port to be measured. The analyzer is set to an IF bandwidth of 1 kHz and 801 points per sweep.

1. **Refer to** Power Measurement Receiver System (PNAasPowerMeter)**.**
2. **Refer to** Get the Hardware Required for your GPIB Instruments**.**

4. Connect the 83059A (-m- to -m-) adapter to the 3.5 mm (-m- to -f-) test cable.
5. Connect a 10 dB attenuator to the other end of the test cable.
6. Connect the adapter end of the test cable to the M937xA Port 1.
7. The PNAasPowerMeter is connected to the 10 dB attenuator at the end of the test cable.
8. For hundreds of frequencies across the full range of the analyzer, the source power, P_{source}, is measured at the end of the cable at the Preset power level.
9. The PNAasPowerMeter is disconnected, and the test cable end with the 10 dB pad is connected to the port to be tested.
10. A CW linear measurement sweep is measured for each test point. The receiver reference power level, P_{ref}, is calculated in dBm for each point from the mean of each sweep.
11. The test cable is removed and loads are connected to both ports.
12. A CW linear measurement sweep is measured for each test point. The receiver test power level, P_{test}, is calculated in dBm for each point from the mean of each sweep.
13. The corrected noise floor is calculated in dBm for a 10 Hz IF bandwidth using $P_{NoiseFloor} = P_{test} - 19.96\text{ dB} - (P_{source} - P_{ref})$. (19.96 dB is the conversion factor between the 1 kHz IFBW measurement and 10 Hz IFBW specification.)

If the Analyzer Fails this Test

- If the analyzer fails this test, return it to Keysight for repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3.

Calibration Coefficients Test

Function of the Test

To verify the uncorrected calibration coefficients of your analyzer. The calibration coefficients are specified at the test port without any cables, so calibrations must be performed in both the forward and reverse directions to eliminate the effects of the test cable.

Specification Tested

Uncorrected System Performance

Equipment Used

- N4691B ECal module (or 3.5 mm mechanical calibration kit)
- A test cable
- Any necessary adapters

Description of the Test

A full SOLT 2-port calibration is performed on Ports 1 and 2. The ports are tested as a pair. Isolation is turned off during each calibration.

1. A test cable is connected to Port 1.
2. A calibration is performed between the end of the test cable and Port 2. The Port 2 directivity and source match and the S_{21} load match are retrieved from the analyzer.
3. The test cable is moved to Port 2.
4. A calibration is performed between the end of the test cable and Port 1. The Port 1 directivity and source match and the S_{12} load match are retrieved from the analyzer.

If the Analyzer Fails this Test

- If the analyzer fails this test, return it to Keysight for repair. Refer to “Shipping Your Network Analyzer for Service or Repair” on page 1-3

Dynamic Accuracy Test

Function of the Test

To measure the relative power linearity of the analyzer's receivers.

Specification Tested

Test Port Input – Dynamic Accuracy

Equipment Used

- U3020AD01 dynamic accuracy test set[1]
- Signal generator
- U8485A USB Thermocouple Power Sensor (or N8485A power sensor with N1914A power meter[1])
- Two test cables
- Any necessary adapters

Description of the Test

1. The analyzer's test ports are tested separately at a specific CW frequency and a reference power level of –20 dBm.
2. A test cable is connected between the analyzer's source port and the dynamic accuracy test set's Source 1 In port. A test cable is connected between the signal generator and the test set's Source 2 In port. A test cable is connected to the test set's Receiver Out port, and the power sensor is connected to the end of this cable.
3. The test set's output attenuator is set to 20 dB. With the signal generator RF turned off, the analyzer source power is adjusted until the power sensor reads –20 dBm. The analyzer source is then turned off, the signal generator RF is turned on, and the signal generator power is adjusted until the power sensor reads –20 dBm.
4. The power sensor is disconnected and the test cable is attached to the analyzer port under test.
5. Both sources are turned on and the signal generator's frequency is set to 2 Hz above the analyzer's frequency. By combining these two signals together, the resultant signal will be a perfect sine wave with a magnitude which varies from –17 dBm to –23 dBm at a rate of 2 Hz.
6. The analyzer's receiver measurement is retrieved and compared with a perfect sine wave. Any deviation is due to receiver non-linearity.

1. **Refer to** Get the Hardware Required for your GPIB Instruments**.**

7. The test set's output attenuator is changed in 5 dB steps from 0 to 60 dB, and this measurement is repeated.
8. With the 1 dB of overlap in each measurement, the data for each attenuator setting can be stitched together to provide a complete receiver linearity profile from +3 dBm to –63 dBm.
9. This test is repeated for each receiver.

If the Analyzer Fails this Test

- If the analyzer still fails this test, repeat the test.
- If the analyzer fails this test, return it to Keysight for repair. Refer to "Shipping Your Network Analyzer for Service or Repair" on page 1-3.

Adjustments

These adjustments are firmware-driven tests that are used to fine-tune your analyzer. If multiple adjustments are to be performed, perform them in the order listed.

- 10 MHz Frequency Reference Adjustment
- Source Adjustment
- Receiver Adjustment

10 MHz Frequency Reference Adjustment

The 10 MHz frequency adjustment is used to adjust the frequency accuracy of the network analyzer's 10 MHz frequency reference.

Equipment Used for the 10 MHz Frequency Reference Adjustment

Equipment Type	Model or Part Number	Alternate Model or Part Number
Cable, BNC, 50 Ohm, 24 inch	8120-1839	Any equivalent
Frequency counter	53151A, Option 001[a]	Any that will accurately measure a signal at 10 MHz

a. Refer to "Get the Hardware Required for your GPIB Instruments" on page 2-5.

Procedure

NOTE This adjustment typically adjusts to within ±0.01 ppm.

1. Make the proper connections for your GPIB equipment. Refer to "Get the Hardware Required for your GPIB Instruments" on page 2-5.
2. Press **Utility > System > Service > Adjustments**.
3. In the Select Desired Adjustment dialog box, click **10 MHz Freq Adjustment**.
4. Follow the instructions and prompts as they are displayed. Ensure the GPIB settings are correct if using the automated mode of operation.

Source Adjustment

The source calibration is used to adjust your network analyzer for a flat source power across its full frequency range. There are differences between each test port; therefore, an adjustment is required for each port.

Equipment Used for the Source Adjustment

Equipment Type	Model or Part Number	Alternate Model or Part Number
USB Thermocouple power sensor	U8485A Option 200	N8485A power meter[a]
Adapter, 3.5 mm -m- to 3.5 mm -m-	83059A	85052-60014

a. Refer to “Get the Hardware Required for your GPIB Instruments” on page 2-5.

Procedure

1. Connect the USB power sensor and adapter to the analyzer Port 1. If using a power meter, make the proper GPIB connections. Refer to “Get the Hardware Required for your GPIB Instruments” on page 2-5.
2. Press **Utility > System > Service > Adjustments**.
3. In the Select Desired Adjustment dialog box, click **Source Adjustment**.
4. Follow the instructions and prompts as they are displayed. If using a power meter, ensure the GPIB settings for the sensor(s) are correct in the dialog box.

Receiver Adjustment

The receiver calibration is used to adjust your network analyzer for a flat response across its full frequency range:

1. A USB power sensor is connected to analyzer Port 1 to establish a reference for flatness.
2. A cable is inserted between the power sensor and the test port to establish a reference for the cable.
3. The same cable is connected between analyzer Port 1 and Port 2, and a signal from Port 1 is used to adjust the “B” receiver at Port 2.
4. The adjustment is repeated using a signal from Port 2 to adjust the “A” receiver at Port1.

Data obtained during this adjustment are stored in the analyzer and used in subsequent measurements. Data can be recreated by performing another receiver calibration adjustment.

Equipment Used for the Receiver Adjustment

Equipment Type	Model or Part Number	Alternate Model or Part Number
USB Thermocouple power sensor	U8485A Option 200[a]	N8485A power meter[b]
Adapter, 3.5 mm -m- to 3.5 mm -m-	83059A	85052-60014
RF cable, 3.5 mm (-m- to -m-)	11500E	Any equivalent

a. If not available, use any power meter with one or two sensors that cover the frequency range of the DUT.
b. Refer to “Get the Hardware Required for your GPIB Instruments” on page 2-5.

Procedure

1. Connect the USB power sensor and adapter to the analyzer Port 1. If using a power meter, make the proper GPIB connections. Refer to “Get the Hardware Required for your GPIB Instruments” on page 2-5.
2. Press **Utility > System > Service > Adjustments**.
3. In the Select Desired Adjustment dialog box, click **Receiver Adjustment**.
4. Follow the instructions and prompts as they are displayed. If using a power meter, ensure the GPIB settings for the sensor(s) are correct in the dialog box.

Troubleshooting

Where you begin troubleshooting depends upon the symptoms of the failure. Start by checking the basics as outlined in the following section.

Check the Basics

CAUTION **PXI hardware does not support "hot-swap" (changing network analyzer modules while power is applied to the chassis) capabilities. Before installing or removing a module to/from the chassis, power-off the chassis to prevent damage to the module.**

1. Is there power at the mains receptacle?
2. Is the chassis powered on? Check to see if the LED for the chassis line switch glows.
3. Is the analyzer powered on? Check to see if the analyzer's front panel LED glows.

   Explanation of LED colors:

   - OFF: Power supply off. Safe to remove/reinstall the analyzer module from the chassis.
   - AMBER: Power supply is on, but no firmware is in control.
   - GREEN: Firmware is in control; analyzer is probably idle.
   - FLASHING GREEN: A sweep or measurement has been triggered.
   - RED: Last sweep had an error.
4. If multiple analyzer modules are present, make sure the SMB cables connecting the modules are fully inserted on the module front panels.

   For information on installing cables to multiple analyzer modules, refer to the online Startup Guide at http://literature.cdn.keysight.com/litweb/pdf/M9370-90001.pdf.
5. If other equipment, cables, and connectors are being used with the analyzer module, make sure they are clean, connected properly, and operating correctly.
6. Review the procedure for the measurement being performed when the problem appeared. Are all the settings correct?
   If the analyzer is not functioning as expected, return the unit to a known state by clicking **Utility > Preset**.
7. Is the measurement being performed, and the results that are expected, within the specifications and capabilities of the analyzer? Refer to the online Data Sheet at http://literature.cdn.keysight.com/litweb/pdf/M9370-90002.pdf for analyzer specifications.

8. If the problem is thought to be due to firmware, check to see if the instrument has the latest firmware before troubleshooting further. Check for firmware updates at: http://na.support.keysight.com/pxi/firmware.

9. Perform the "The Operator's Check" on page 2-12 and "System Verification Procedure" on page 2-8.

3 Replaceable Parts and Connector Replacement Procedure

Information in This Chapter

Chapter 3 at-a-Glance

Section Title	Summary of Content
Replaceable Parts	Replaceable parts for your network analyzer.
Connector Replacement Procedure	A procedure for replacing 3.5 mm or SMA connectors.

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Replaceable Parts

The following table is a list of semi-rigid cables that are available for purchase. For purchasing information, refer to "Contacting Keysight" on page 1-3.

Cable Description	Connector Type	Qty	Part Number
RF, LO jumper cable (module LO Out port to adjacent module LO In port)	SMA	1	M9370-20006
SMB trigger cable (module Trig Out port to adjacent module Trig In port)	SMB	1	M9370-20018
SMB reference jumper (module Ref Out port to adjacent module Ref In port)	SMB	1	M9370-20019

The following table is a list of Service Kits that are available for purchase. For purchasing information, refer to "Contacting Keysight" on page 1-3.

Service Kit Description	Service Kit Model or Option Number	Service Kit Contents
Multiport Cable Kit	Y1242A	RF, LO jumper cable, qty 1 SMB trigger jumper cable, qty 1 SMB reference jumper cable, qty 1
Tool Kit for SMA and SMB Connectors	Y1281A	5/16 inch socket adapter for 50 ohm loads SMB cable removal tool
Connector Replacement Kits	Y1283A, Option 101	SMA LO port connector, qty 2 Nut for connector, qty 2
	Y1283A, Option 102	3.5 mm test port connector, qty 2 Nut for connector, qty 2
	Y1283A, Option 103	SMA LO port connector, qty 2 Nut for SMA connector, qty 2 3.5 mm test port connector, qty 2 Nut for 3.5 mm connector, qty 2 "Spark plug" adapter Torque wrench (for "spark plug" adapter)

Connector Replacement Procedure

Parts Required

Refer to "Replaceable Parts" on page 3-2.

- SMA or 3.5 mm connectors
- Nuts for connectors

Tools Required

Refer to "Replaceable Parts" on page 3-2.

- "Spark plug" adapter
- Torque wrench (for "spark plug" adapter)
- ESD equipment:

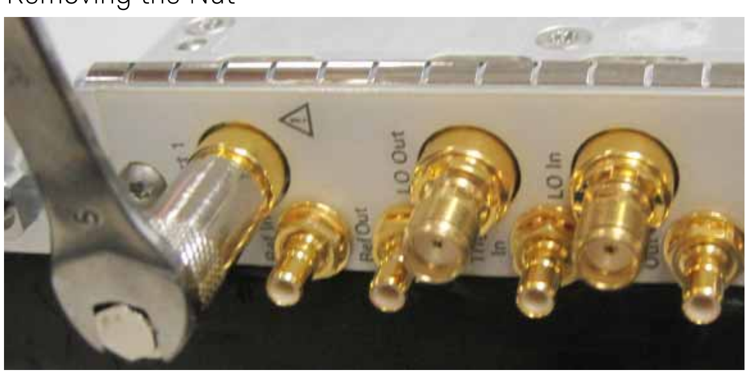
Description	Keysight Part Number
ESD grounding wrist strap	9300-1367
5-ft grounding cord for wrist strap	9300-0980
2 x 4 ft conductive table mat and 15-ft grounding wire	9300-0797
ESD heel strap (for use with conductive floors)	9300-1308

Removal Procedure

NOTE Although the photos in this section show a 3.5 mm connector being replaced, the procedure is the same for SMA connectors.

1. Place the module on its side on an ESD safe, flat surface.
2. Place the "spark plug" adapter on the nut of the connector you are going to replace. The adapter must fit snugly into the slots of the nut. Refer to Figure 3-1 on page 3-3.

Figure 3-1 Removing the Nut



3. Use the torque wrench with the adapter to remove the nut.

4. Use the torque wrench to remove the connector. Refer to Figure 3-2.

Figure 3-2 Removing the Connector

Replacement Procedure

1. Reverse the order of the removal procedure.
   Be careful to install the nut with the slots facing outward.
2. Perform the Op Check to verify the new connectors are functional. Refer to "The Operator's Check" on page 2-12. If it fails, perform the Adjustments (refer to "Adjustments" on page 2-44), then repeat the Op Check.
3. For complete assurance that the connectors are meeting all criteria, perform the following Performance Tests:
   - "Source Power Accuracy Test" on page 2-31
   - "Source Maximum Power Output Test" on page 2-33
   - "Calibration Coefficients Test" on page 2-41

If any of the tests fail, perform the Adjustments (refer to "Adjustments" on page 2-44), then repeat the tests.

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