User's and Service Guide

Agilent Technologies 11644A
X, P, and K
Waveguide Calibration Kits

This manual applies to 11644A series calibration kits with serial number prefix 3032A.

Agilent Technologies

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Documentation Warranty

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent products.

For any assistance, contact Agilent Technologies. Refer to page 6-3 for a list of Agilent contacts.

Contents

1 General Information

Calibration Kit Overview

This waveguide calibration kit is used to calibrate network analyzer systems (such as the Agilent 8510 or 872*x* series). With the calibration data properly loaded in the network analyzer and a measurement calibration completed, systematic errors are minimized.

Kit Contents

Refer to Chapter 7, “Replaceable Parts,” for a complete list of kit contents and their associated part numbers.

The basic 11644A calibration kit includes the following items:

- user’s and service guide
- 7 mm (P-band and X-band) or 3.5 mm (K-band) coax-to-waveguide adapters
- short, shim, termination, and standard sections
- data disks that contain the calibration definitions of the devices in the calibration kit

The standards in this calibration kit allow you to perform simple 1- or 2-port and TRM (thru-reflect-match) calibrations.

For your convenience, two different lengths of screws are provided in this kit. While you can use the long screws for any connection, the shorter screws provide a faster connection for two-flange connections.

NOTE A backup copy of each data disk should be made immediately upon receipt of the calibration kit. Refer to your analyzer user’s guide or embedded help system for instructions on duplicating a disk.

Compatible Network Analyzers

The 11644A calibration kits are intended to be used with the following Agilent network analyzers:

- 8510 series
- 872*x* series
- PNA microwave series

If this calibration kit is used with other network analyzers, the calibration definitions must be manually entered into the network analyzer. Refer to your network analyzer user’s guide or embedded help for instructions.

Equipment Required but Not Supplied

Cleaning supplies and various electrostatic discharge (ESD) protection devices are not supplied with the calibration kit but are required to ensure successful operation of the kit. Refer to Table 7-4 on page 7-10 for their associated part numbers.

Calibration Kit History

This manual applies to any Agilent 11644A series (X, P, or K) waveguide calibration kits whose serial number prefix is 3032A and above. If your calibration kit has a different serial number prefix, refer to the next section for information on how this manual applies.

11644A Series Kits with Serial Prefix 3012A

These calibration kits did not have the calibration definitions disk to support the Agilent 8510C network analyzer. The part numbers provided in this manual are the recommended replacement parts for these kits. The devices in these kits should meet the specifications published in this manual.

Incoming Inspection

Refer to "Kit Contents" on page 1-2 to verify a complete shipment. Use Table 1-1 in this chapter to record the serial numbers of all serialized devices in your kit.

Verify that the case and its contents are not damaged. The foam-lined storage case provides protection during shipping. If the case or any device appears damaged, or if the shipment is incomplete, refer to "Contacting Agilent" on page 6-3. Agilent will arrange for repair or replacement of incomplete or damaged shipments without waiting for a settlement from the transportation company. Refer to "Returning a Kit or Device to Agilent" on page 6-3.

Recording the Device Serial Numbers

In addition to the kit serial number, the devices in the kit are individually serialized (serial numbers are labeled onto the body of each device). Record these serial numbers in the appropriate table. Recording the serial numbers will prevent confusing the devices in this kit with similar devices from other kits.

Table 1-1 Serial Number Record

Device	Serial Number
Frequency band	______________
Calibration kit	______________
Termination	______________
Termination	______________
Standard section	______________
Shim	______________
Short	______________
Adapters	
7 mm coax-to-waveguide (X-band WR-90)	______________
7 mm coax-to-waveguide (X-band WR-90)	______________
7 mm coax-to-waveguide (P-band WR-62)	______________
7 mm coax-to-waveguide (P-band WR-62)	______________
(f) 3.5 mm coax-to-waveguide (K-band WR-42)	______________
(m) 3.5 mm coax-to-waveguide (K-band WR-42)	______________

Preventive Maintenance

The best techniques for maintaining the integrity of the devices in the kit include:

- routine visual inspection
- routine cleaning
- proper gaging
- proper connection techniques

All of these are described in Chapter 4. Failure to detect and remove dirt or metallic particles on a mating plane surface can degrade repeatability and accuracy and can damage any device mated to it. Improper connections resulting from poor connection techniques, can also damage these devices.

2 Specifications

Environmental Requirements

Table 2-1 Environmental Requirements

Parameter	Limits
Temperature	
Operating[a]	+20 °C to +26 °C
Storage	–40 °C to +75 °C
Error-corrected range[b]	±1 °C of measurement calibration temperature
Altitude	
Operating	< 4,500 meters (≈15,000 feet)
Storage	< 15,000 meters (≈50,000 feet)
Relative humidity	Always non-condensing
Operating	0 to 80% (26 °C maximum dry bulb)
Storage	0 to 90%

a. The temperature range over which the calibration standards maintain performance to their specifications.
b. The allowable network analyzer ambient temperature drift during measurement calibration and during measurements when the network analyzer error correction is turned on. Also, the range over which the network analyzer maintains its specified performance while correction is turned on.

Temperature—What to Watch Out For

Changes in temperature can affect electrical characteristics. Therefore, the operating temperature is a critical factor in performance. During a measurement calibration, the temperature of the calibration devices must be stable and within the range shown in Table 2-1.

IMPORTANT Avoid unnecessary handling of the devices during calibration because your fingers act as a heat source and may increase the temperature of the device.

Electrical Specifications

Table 2-2 Electrical Characteristics and Specifications

Device	Frequency	Specification
X11644A WR-90	8.25 to 12.4 GHz	return loss ≥ 42 dB[a]
P11644A WR-62	12.4 to 18 GHz	return loss ≥ 42 dB[a]
K11644A WR-42	18 to 26.5 GHz	return loss ≥ 42 dB[a]

a. Effective return loss accounts for line section, connector, and load stability as used in a network analyzer to define directivity after calibration.

Certification

Agilent Technologies certifies that this product met its published specifications at the time of shipment from the factory. Agilent further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (NIST) to the extent allowed by the institute's calibration facility, and to the calibration facilities of other International Standards Organization members. See "How Agilent Verifies the Devices in Your Kit" on page 5-2 for more information.

Mechanical Characteristics

Table 2-3 lists the typical characteristics of the adapters in your kit. These are *not* specifications, but are included as additional information.

Table 2-3 Adapter Characteristics

Frequency band	SWR[a]	Insertion Loss	Center Conductor	Pin Recession Tolerance	Equivalent Flange Type
X11644A WR-90	< 1.05	0.08 dB	0.0076 to 0.038 mm	(0.0003 to 0.0015 in)	UG-135/U
P11644A WR-62	< 1.06	0.10 dB	0.0076 to 0.038 mm	(0.0003 to 0.0015 in)	UG-419/U
K11644A WR-42	< 1.07	0.12 dB	0.0076 to 0.038 mm	(0.0003 to 0.0015 in)	UG-597/U

a. As measured with no gap between the full diameters of the male and female center conductors.

Residual Errors after Calibration

The Agilent 8510 specifications and performance verification software can be used to obtain a printout of the residual errors after a calibration has been performed. Refer to the "Specifications and Performance Verification" section of the Agilent 8510C *On-Site Service Manual* for information on how to use the software.

3 User Information

Calibration Devices and Their Use

The P, K, and X11644A waveguide calibration kits contain termination load, standard sections, shim, and short.

For measurement convenience, these kits contain either 7 mm coax-to-waveguide adapters for P-band and X-band, or 3.5 mm coax-to-waveguide adapters for K-band. The adapters are intended for adapting coaxial test sets to waveguide.

The following briefly describes the design and construction of all the calibration kit devices.

Short

A short is also called a flush short. It is connected directly to the test port, or used as an offset short when combined with the ¼ wavelength shim.

Termination

A termination is also called a load. It is connected directly to the test port, or used as an offset load when combined with the ¼ wavelength shim.

¼ Wavelength Shim

A ¼ wavelength shim is also called an offset, or ¼ wavelength section. The shim is terminated by the short, fixed load, or the second test port of the analyzer.

Standard Section

A standard section is used to check system operation after you complete a calibration.

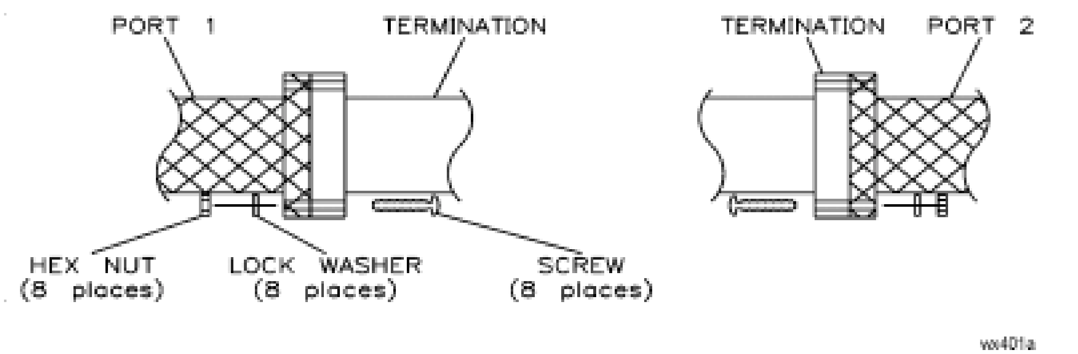
Measurement Applications

NOTE For your convenience, two different lengths of screws are provided in this kit. While you can use the long screws for any connection, the *shorter screws* provide a faster connection for two-flange connections.

Isolation

In most cases, select the **OMIT ISOLATION** softkey on your network analyzer. You may also use the termination and the short as the port terminations by connecting one load to port 1 and the other load to port 2. See Figure 3-1.

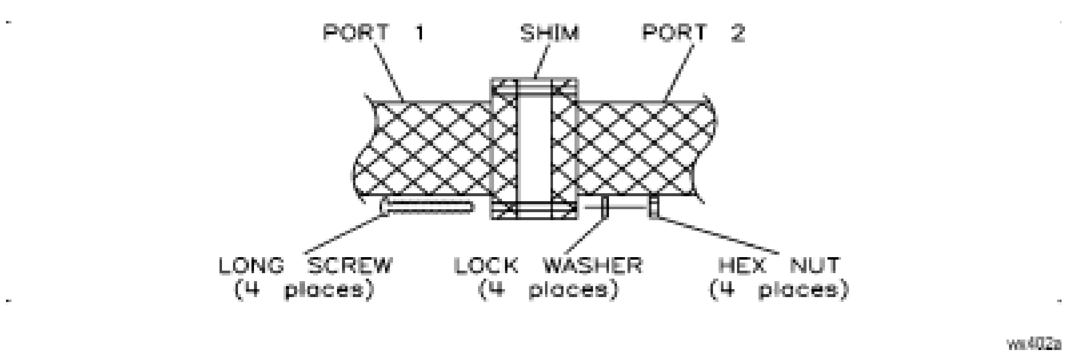
Figure 3-1 Termination and Short



Line

Connect the shim between port 1 and port 2, as shown in Figure 3-2.

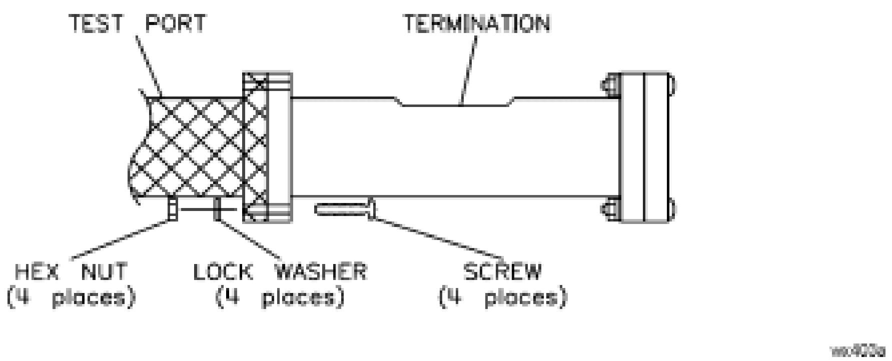
Figure 3-2 Connecting the Shim



Load

Connect the termination to the appropriate test port, as shown in Figure 3-3.

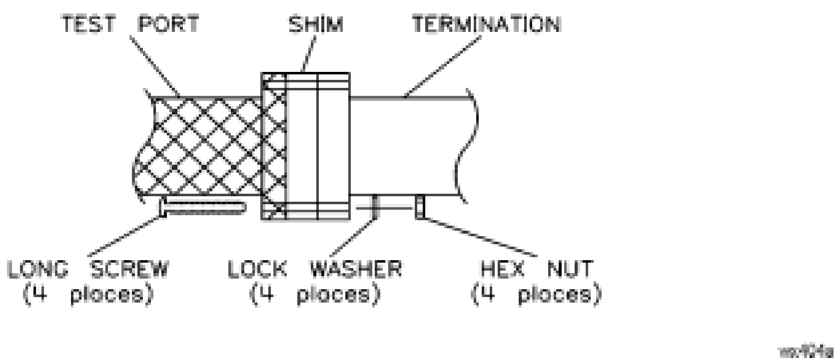
Figure 3-3 Test Port and Termination



Offset Load

Connect the shim and the termination to the appropriate test port, as shown in Figure 3-4.

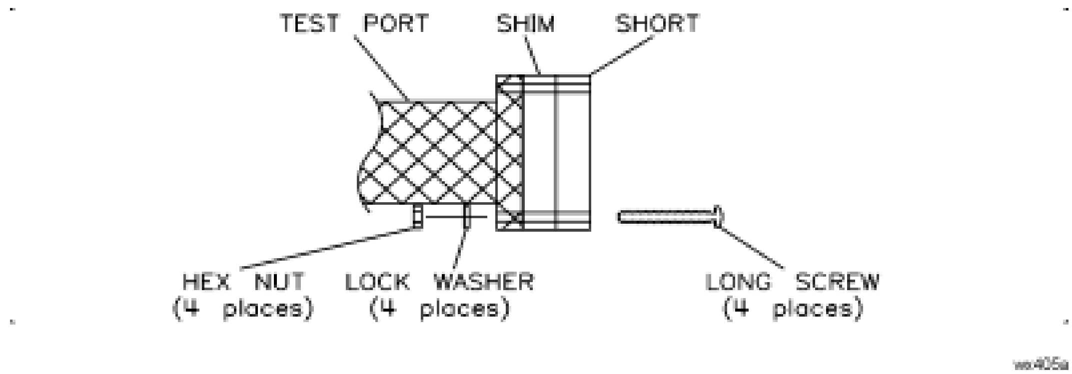
Figure 3-4 Connect the Shim, Termination, and Test Port



Offset Short

Connect the shim and the short to the appropriate test port, as shown in Figure 3-5.

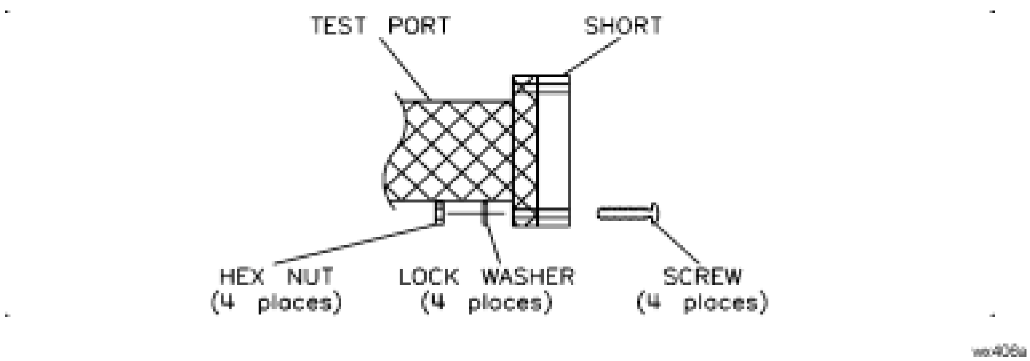
Figure 3-5 Connect the Shim, Short, and Test Port



Reflect

Connect the short to the appropriate test port, as shown in Figure 3-6.

Figure 3-6 Connect the Short to the Test Port



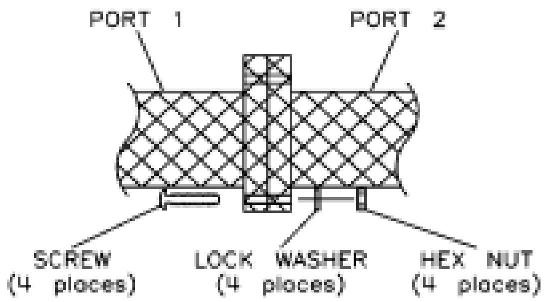
Short

See "Reflect."

Thru

No device is required for this. Connect port 1 to port 2, as shown in Figure 3-7.

Figure 3-7 Port 1 and Port 2



¼ Wavelength Load

See "Offset Load."

¼ Wavelength Short

See "Offset Short."

Changing the ¼ Wavelength Shim Calibration Definition

The calibration kit definition data provided with this kit has a nominal value for the ¼ wavelength shim offset delay. You may use the nominal value provided, or measure the exact thickness of the shim and use that value to calculate its exact offset delay. Use the following procedure to change the nominal value of the ¼ wavelength shim delay to reflect the specific device in your kit.

1. Load the calibration kit data into Cal Kit 1.
2. Using the formula below, calculate the offset delay:

$$\frac{\text{length of } \frac{1}{4}\text{wavelengh section (mm)}}{299.6953\ \frac{mm}{ns}\text{(propagation velocity in air)}} = \text{offset delay (ns)}$$

NOTE The value of the propagation velocity in air is corrected for a temperature of 23 °C, 50% relative humidity, and 760 mm Hg of pressure.

4 Use, Maintenance, and Care of the Devices

Electrostatic Discharge

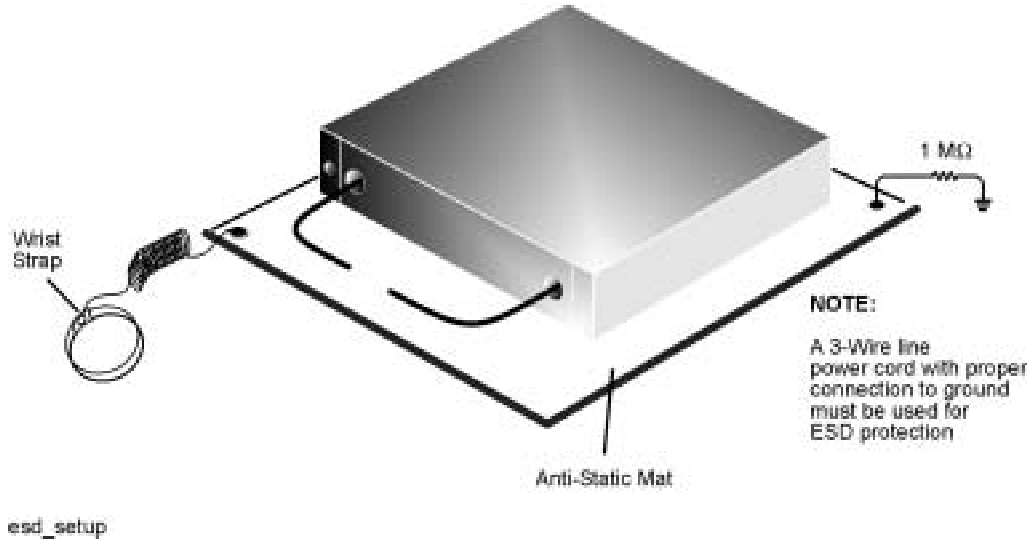
Protection against electrostatic discharge (ESD) is essential while connecting, inspecting, or cleaning connectors attached to a static-sensitive circuit (such as those found in test sets).

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. Devices such as calibration components and devices under test (DUT), can also carry an electrostatic charge. To prevent damage to the test set, components, and devices:

- *always* wear a grounded wrist strap having a 1 MΩ resistor in series with it when handling components and devices or when making connections to the test set.
- *always* use a grounded antistatic mat in front of your test equipment.
- *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.
- Remove the short from the cable.

Figure 4-1 shows a typical ESD protection setup using a grounded mat and wrist strap. Refer to Table 7-4 on page 7-10 for information on ordering supplies for ESD protection.

Figure 4-1 ESD Protection Setup



Visual Inspection

Visual inspection and, if necessary, cleaning should be done every time a connection is made. Inspect mating surfaces for dirt, dust, foreign particles, or scratches, which can degrade device performance. A damaged mating surface can damage any good surface connected to it. If necessary, clean all mating surfaces.

Cleaning the Mating Plane Surfaces

1. **Use Compressed Air or Nitrogen**

WARNING **Always use protective eyewear when using compressed air or nitrogen.**

Use compressed air (or nitrogen) to loosen particles on the mating plane surfaces. Clean air cannot damage a device or leave particles or residues behind.

You can use any source of clean, dry, low-pressure compressed air or nitrogen that has an effective oil-vapor filter and liquid condensation trap placed just before the outlet hose.

Ground the hose nozzle to prevent electrostatic discharge, and set the air pressure to less than 414 kPa (60 psi) to control the velocity of the air stream. High-velocity streams of compressed air can cause electrostatic effects when directed into a device. These electrostatic effects can damage the device. Refer to "Electrostatic Discharge" earlier in this chapter for additional information.

WARNING **Keep isopropyl alcohol away from heat, sparks, and flame. Store in a tightly closed container. It is extremely flammable. In case of fire, use alcohol foam, dry chemical, or carbon dioxide; water may be ineffective.**

Use isopropyl alcohol with adequate ventilation and avoid contact with eyes, skin, and clothing. It causes skin irritation, may cause eye damage, and is harmful if swallowed or inhaled. It may be harmful if absorbed through the skin. Wash thoroughly after handling.

In case of spill, soak up with sand or earth. Flush spill area with water.

Dispose of isopropyl alcohol in accordance with all applicable federal, state, and local environmental regulations.

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2. **Clean the Mating Plane Surfaces**
   a. Apply a small amount of isopropyl alcohol to a lint-free cleaning swab.
   b. Clean the mating plane surfaces.
   c. Let the alcohol evaporate, then blow the mating plane surface dry with a gentle stream of clean, low-pressure compressed air or nitrogen. Always completely dry a device before you reassemble or use it.
3. **Inspect**
   a. Inspect the mating plane surface to make sure that no particles or residue remain. "Visual Inspection" on page 4-3.

Connections

Good connections require a skilled operator. Slight errors in operator technique can have a significant effect on measurements and measurement uncertainties. *The most common cause of measurement error is poor connections.*

The following procedures illustrate how to make good connections.

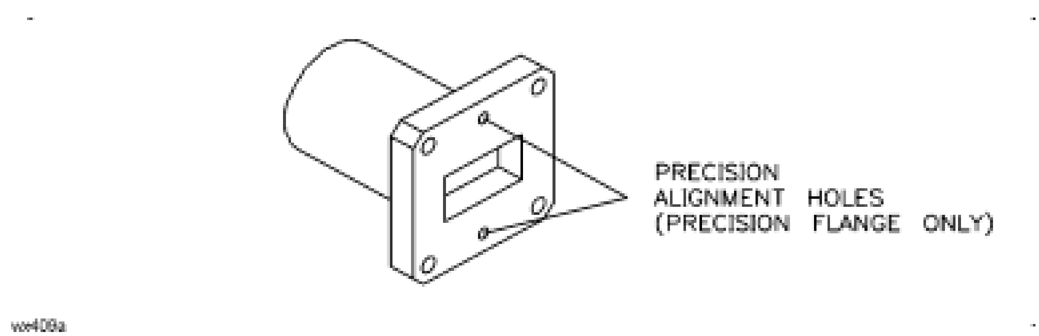
Waveguide Devices

IMPORTANT Unlike threaded devices, the WR-90, WR-62, WR-42 waveguide mating planes are flanges (often precision) that you must carefully screw together. Always connect waveguide in the same flange orientation. For example, use the label as a reference and always connect a device with the label facing the same direction.

Precision Flanges

A precision flange has four corner screw holes *and* two precision alignment holes, as shown in Figure 4-2. A non-precision flange has only four corner screw holes.

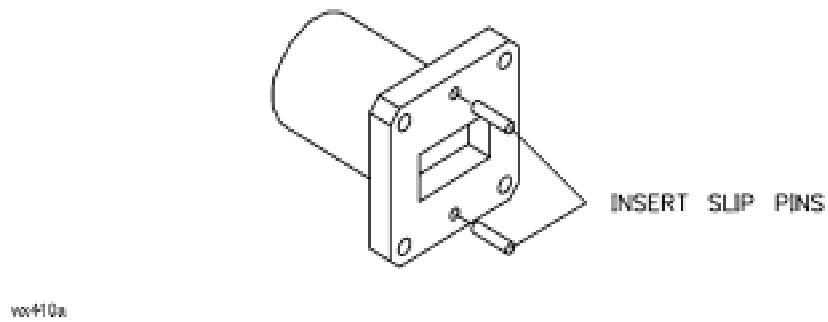
Figure 4-2 Precision Alignment Holes



Aligning Two Precision Flanges

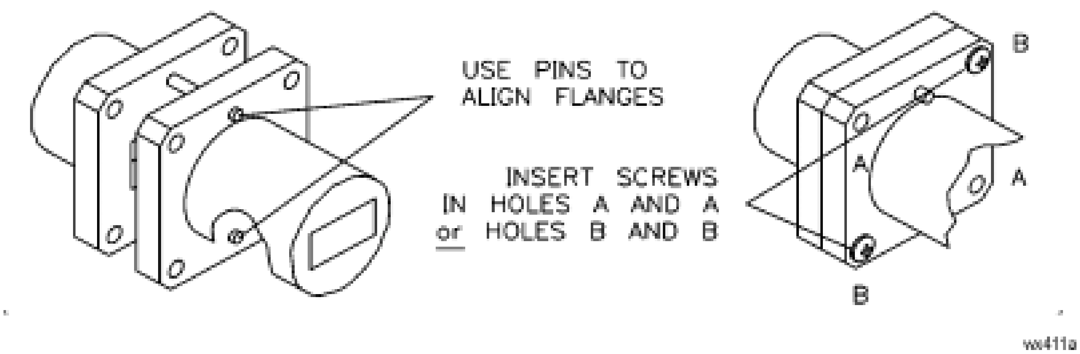
1. Place the slip pins in the top and bottom holes of one flange, as shown in Figure 4-3.

Figure 4-3 Inserting Slip Pins



2. Using the pins as guides, carefully align the flanges and insert two screws in the diagonal corner holes, as shown in Figure 4-4.

Figure 4-4 Aligning Flanges

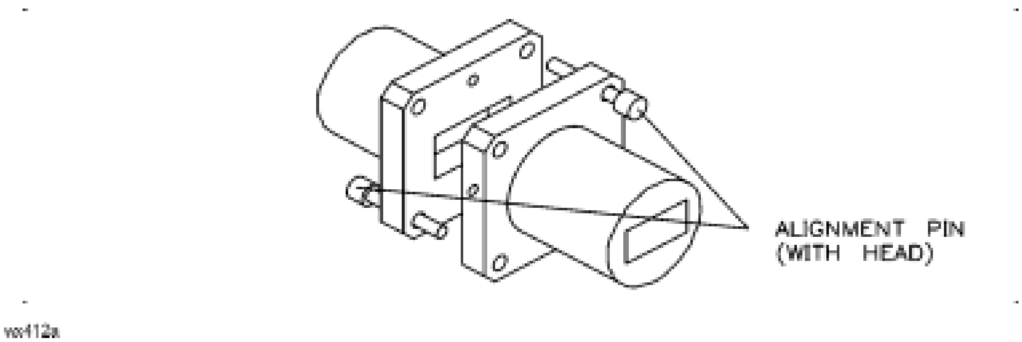


3. Place a lock washer and nut on each screw, and finger tighten.
4. Insert the remaining two screws.
5. Place a lock washer and nut on each screw, and finger tighten.
6. Remove the slip pins.
7. Go to "Tightening a Flange Connection" on page 4-8.

Aligning a Precision and a Non-Precision Flange

1. Place an alignment pin (with head) in the corner hole of one flange. Place a second alignment pin in the diagonal corner hole of the second flange, as shown in Figure 4-5.

Figure 4-5 Aligning Pins



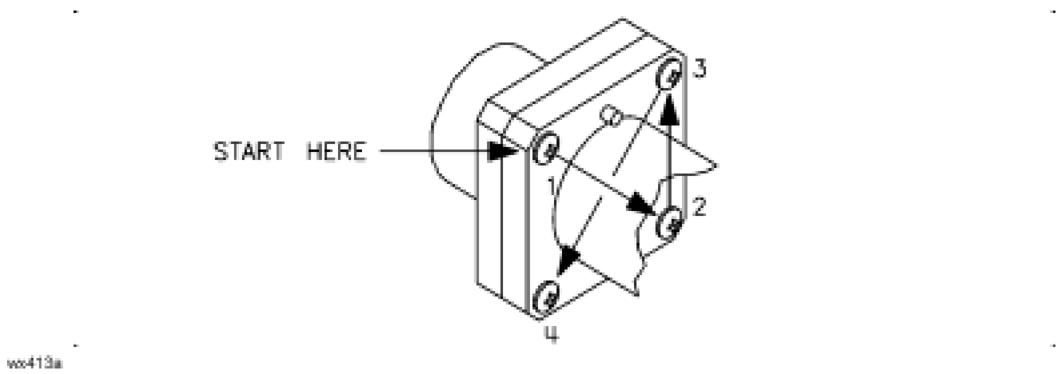
2. Using the pins as guides, carefully align the flanges and insert two screws in the diagonal corner holes.
3. Place a lock washer and nut on each screw, and finger tighten.
4. Remove the alignment pins and insert the remaining two screws.
5. Place a lock washer and nut on each screws, and finger tighten.
6. Go to “Tightening a Flange Connection” on page 4-8.

Tightening a Flange Connection

NOTE The best connection has symmetrical pressure applied as you gradually tighten the screws.

1. In an "X" pattern (for equal compression), tighten all four screws using a hex ball driver. Do *not* over-tighten. See Figure 4-6.
2. Visually inspect the connection. Refer to the following section "Inspecting a Flange Connection."

Figure 4-6 "X" Screw Pattern



Inspecting a Flange Connection

Inspect the flange connection as follows:

1. Place an electric light or white paper behind the connection.
2. Check the flange matings for any gap. A good connection has no gaps between the connected waveguide flanges, and the waveguide walls are flush. There is no step or offset.
3. Ensure that all four screws are equally tight.

NOTE The most common cause of measurement error is a poor connection.

Handling and Storage

- Install the protective end caps and store the calibration devices in the foam-lined storage case when not in use.
- Never store devices loose in a box, or in a desk or bench drawer. This is the most common cause of device damage during storage.
- Keep devices clean.
- Do not touch mating plane surfaces. Natural skin oils and microscopic particles of dirt are easily transferred to a device and are very difficult to remove.
- Do not set devices contact-end down on a hard surface. The plating and the mating plane surfaces can be damaged if the interface comes in contact with any hard surface.

5 Performance Verification

Introduction

The performance of your calibration kit can only be verified by returning the kit to Agilent Technologies for recertification. The equipment and calibration standards required to verify the specifications of the limits of the devices in the kit have been specially manufactured and are not commercially available.

How Agilent Verifies the Devices in Your Kit

Agilent verifies the specifications of these devices as follows:

1. The residual microwave error terms of the test system are verified with precision airlines and shorts that are directly traced to the National Institute of Standards and Technology (NIST). The airline and short characteristics are developed from mechanical measurements. The mechanical measurements and material properties are carefully modeled to give very accurate electrical representation. The mechanical measurements are then traced to NIST through various plug and ring gages and other mechanical measurements.
2. Each calibration device is electrically tested on this system. For the initial (before sale) testing of the calibration devices, Agilent includes the test measurement uncertainty as a guardband to guarantee each device meets the published specification. For recertifications (after sale), no guardband is used and the measured data is compared directly with the specification to determine the pass or fail status. The measurement uncertainty for each device is, however, recorded in the calibration report that accompanies recertified kits.

These two steps establish a traceable link to NIST for Agilent to the extent allowed by the institute’s calibration facility. The specifications data provided for the devices in the kit is traceable to NIST through Agilent Technologies.

Recertification

The following will be provided with a recertified kit:

- a new calibration sticker affixed to the case
- a certificate of calibration
- a calibration report for each device in the kit listing measured values, specifications, and uncertainties

NOTE A list of NIST traceable numbers may be purchased upon request to be included in the calibration report.

Agilent Technologies offers a *Standard* calibration for the recertification of the kit. For more information, contact Agilent Technologies. Refer to "Contacting Agilent" on page 6-3 for a list of offices.

How Often to Recertify

The suggested initial interval for recertification is 12 months or sooner. The actual need for recertification depends on the use of the kit. After reviewing the results of the initial recertification, you may establish a different recertification interval that reflects the usage and wear of the kit.

NOTE The recertification interval should begin on the date the kit is *first used* after the recertification date.

Where to Send a Kit for Recertification

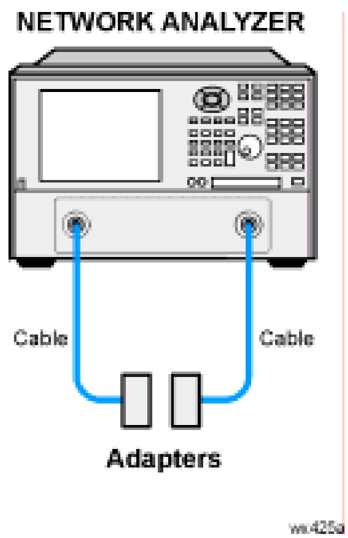
Contact Agilent Technologies for information on where to send your kit for recertification. Contact information is listed on page 6-3. Refer to "Returning a Kit or Device to Agilent" on page 6-3 for details on sending your kit.

Performance Test

Termination Return Loss Measurement

For your convenience the following procedures have been included in this kit. Use this test, as needed, to check the performance of the terminations in this kit.

Figure 5-1 Return Loss Test Setup



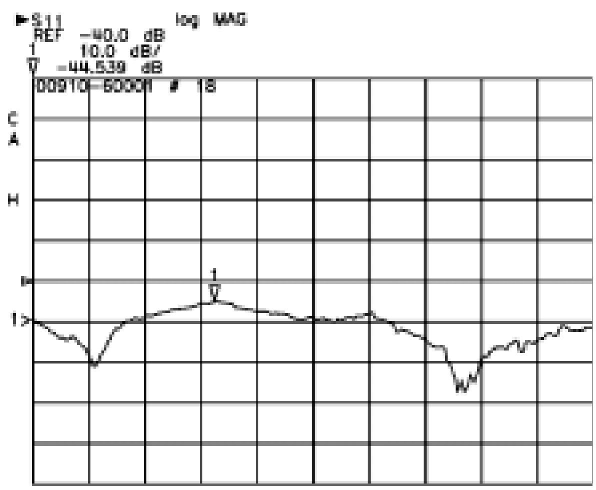
1. Connect the equipment as shown in Figure 5-1. Turn on and preset the network analyzer. Let the equipment warm up for at least one hour.

NOTE The calibration kit definitions must already be loaded in the analyzer. Refer to your analyzer user's guide for information on how to load the calibration definitions.

2. Set the appropriate start frequency to:
   - 8.25 GHz (X-band)
   - 12.4 GHz (P-band)
   - 18 GHz (K-band)
3. Set the appropriate stop frequency to:
   - 12.4 GHz (X-band)
   - 18 GHz (P-band)
   - 26.5 GHz (K-band)

4. Set the averaging factor to 512.
5. At the adapter test port, perform a 2–port TRL calibration.
6. Turn on the calibration.
7. Connect the termination you wish to test to port 1.
8. Measure the return loss (S_{11}) of the load.
9. After one complete measurement sweep, the displayed trace should look similar to that shown in Figure 5-2.
10. If necessary, update the trace.
11. Use a marker to determine the maximum value on the trace. This marker determines worst-case return loss.

Figure 5-2 Typical Termination Return Loss



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In Case of Failure

If a termination fails this test, clean all flanges and carefully reconnect the devices. Repeat the test. If the termination fails again, replace it. Refer to Table 2-2, "Electrical Characteristics and Specifications," on page 2-3.

System Operation Checks

Use the following procedures and the standard section in this kit to verify the operation of your calibrated system.

NOTE If you are using a different analyzer, refer to its documentation for specific measurement instructions.

8510 System Operation Check

1. Short the standard section and perform an S_{11} and an S_{22} measurement to verify that the ripple on the reflection of the shorted waveguide section does not exceed the limits listed in the tables on page 5-11. If the ripple is less than the acceptable value, then the combination of directivity and source match errors of the calibrated system is within the factory specified values.
2. Check the S_{11} and S_{22} of a thru measurement. As in the previous step, the results of this check contain the directivity error, but, because of the thru connection to port 2, this measurement also contains errors contributed by other terms, including load match, the S_{11} and S_{22} of the standard sections, and transmission tracking. The actual or absolute return loss of the standard section should not exceed the acceptable values listed on page 5-11.
3. Make an S_{21} and an S_{12} measurement. Ideally, the standard section is low loss. These measurements verify that the combination of source match error and load match error do not cause excess ripple on the trace. The trace ripple should not exceed the acceptable values listed in the tables on page 5-11.
4. Record the results of each test in Tables 5-1 through 5-3.

The S_{11} and S_{22} of a Shorted Standard Section

1. Set the averaging factor to 512.
2. Perform a TRL calibration.
3. Turn on the calibration.
4. Connect the standard section to port 1.
5. Connect the short to terminate the standard section.
6. Connect the load to port 2.

7. To set the display:

   a. Press **[S_{11}]**.

   b. Press **RESPONSE [SCALE] [.1] [x1]**.

   c. Select **[REF POSN] [10] [x1]**.

   d. Select **[REF VALUE] [0] [x1]**.

   e. Press **MEASUREMENT [RESTART]**.

8. After one complete measurement sweep, the displayed trace should look similar to the typical trace shown in Figure 5-3.

9. If necessary, select **Press to Continue** to update the trace.

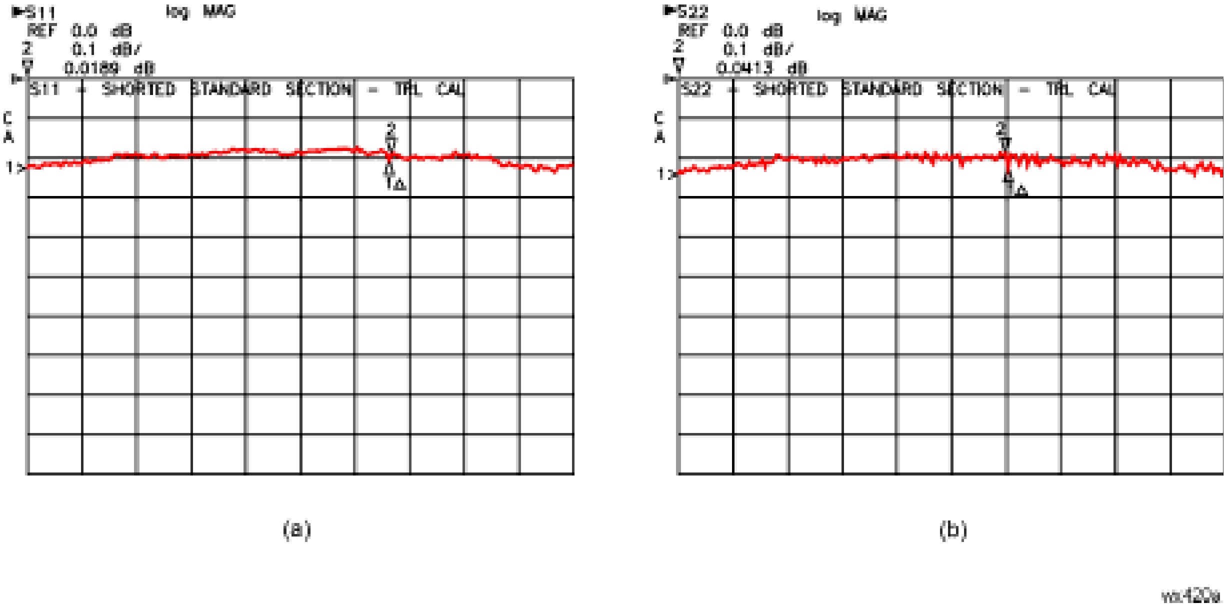
10. Use the markers to determine the greatest peak-to-peak deviation of the ripple on the displayed trace (this is any positive peak to any adjacent negative peak):

    a. Press **MENUS [MARKER]** and select **delta MODE MENU**.

    b. Set the reference to marker 2.

    c. Switch between markers 1 and 2 (in the delta mode) and position them to the highest and lowest peaks. (You may have to practice using the marker features to get the desired results.)

Figure 5-3 Typical S_{11} and S_{22} Standard Section Ripple



11. Record the maximum peak-to-peak value in the appropriate table on page 5-11.

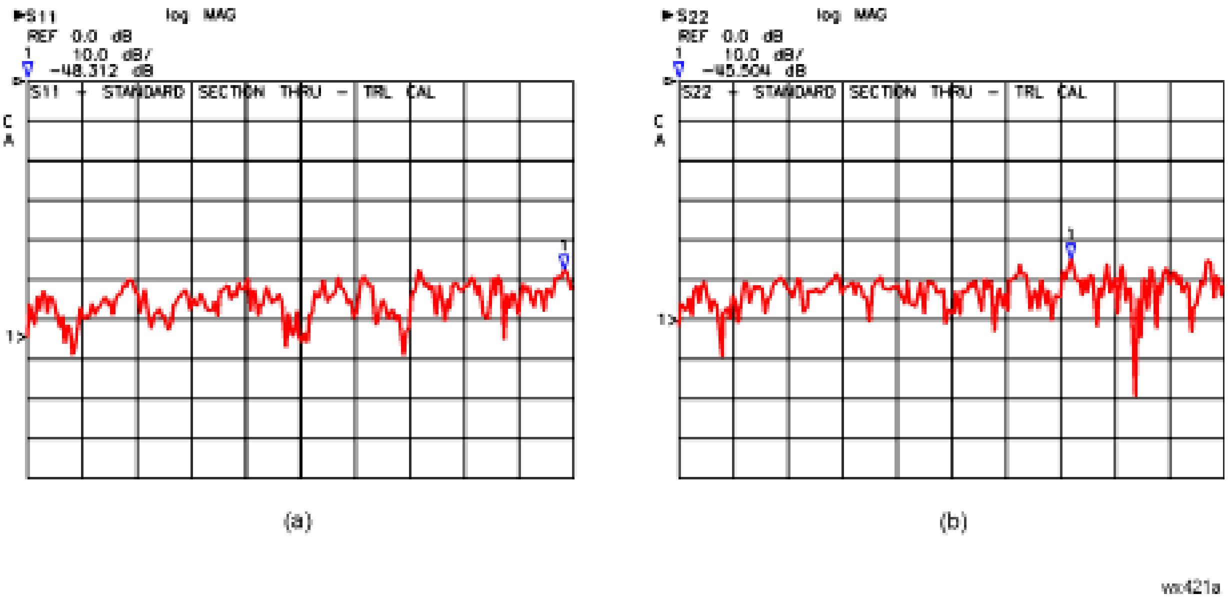
12. Turn off the delta marker mode.

13. Repeat this procedure from step 7, and make an S_{22} measurement on the standard section. Record the measured value in the appropriate table on page 5-11.

The S_{11} and S_{22} of a Thru Measurement

1. Verify that the calibration is still on.
2. Verify that the averaging factor is set to 512.
3. Connect the standard section to ports 1 and 2 to form a thru connection.
4. To set the display:
   a. Press **[S_{11}]**.
   b. Select **RESPONSE [REF POSN] [10] [x1]**.
   c. Press **[SCALE] [10].**
   d. Press **MEASUREMENT [RESTART]**.
5. After one complete measurement sweep, the displayed trace should look similar to the typical trace shown in Figure 5-4.
6. If necessary, select **Press to Continue** to update the trace.
7. Determine the maximum value on the trace (you can use a marker).
8. Record the maximum value in the appropriate table on page 5-11.
9. Repeat this procedure from step 4, and make an S_{22} measurement. Record the measured value in the appropriate table on page 5-11.

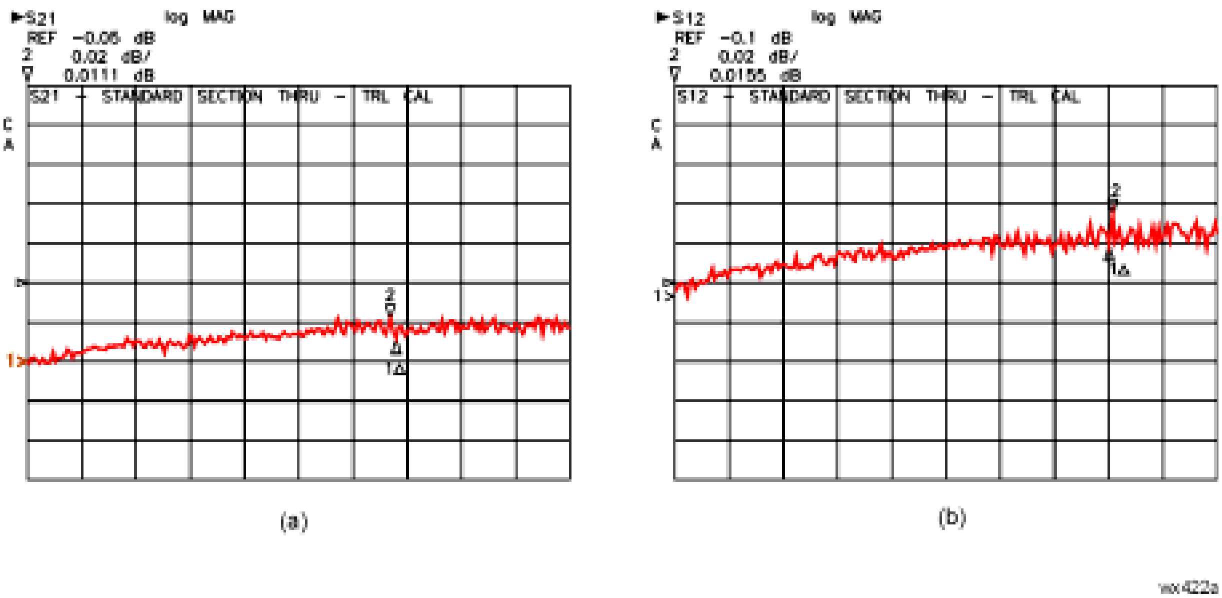
Figure 5-4 Typical Corrected S_{11} and S_{22} Standard Section Thru



The S_{21} and S_{12} of a Thru Measurement

1. Verify that the calibration is still on.
2. Verify that the averaging factor is set to 512.
3. Connect the standard section to ports 1 and 2 to form a thru connection.
4. To set the display:
   a. Press **[S_{21}]**.
   b. **RESPONSE [REF POSN] [5] [x1]**
   c. Select **[REF VALUE [0] [x1]**.
   d. Press **[SCALE] [.02] [x1]**.
   e. Select **MEASUREMENT [RESTART]**.
5. After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in Figure 5-5.
6. If necessary, select **Press to Continue** to update the trace.
7. Determine the greatest peak-to-peak deviation (this is any positive peak to any adjacent negative peak). You can use the markers, as described in the first test, to determine the peak-to-peak value.
8. Record the maximum peak-to-peak value in the appropriate table on page 5-11.
9. Repeat this procedure from step 4, and make an S_{12} measurement. Record the measured value in the appropriate table on page 5-11.
10. If you used the delta marker mode, don't forget to turn it off.

Figure 5-5 Typical Corrected S_{21} and S_{12} Standard Section Ripple



In Case of Failure

If a system check fails, recalibrate the system and repeat the entire procedure (all three measurements). Remember that poor connections are the most common cause of measurement errors. Also, both the hardware state and the instrument state must be correct. Reload disks or re-enter commands, if necessary, including the calibration kit definitions. If the test continues to fail:

- Save the instrument state.
- Write down *all* of the symptoms.
- Refer to Chapter 6 for troubleshooting and contact information.

Table 5-1 Using a TRL Calibration X11644A WR-90 (X-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		≤ 0.15 dB_{p-p}	
S_{22}, shorted		≤ 0.15 dB_{p-p}	
S_{11}, thru		≤ –45 dB	
S_{22}, thru		≤ –45 dB	
S_{21}, thru		≤ 0.017 dB_{p-p}	
S_{12}, thru		≤ 0.017 dB_{p-p}	

Table 5-2 Using a TRL Calibration P11644A WR-62 (P-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		≤ 0.26 dB_{p-p}	
S_{22}, shorted		≤ 0.26 dB_{p-p}	
S_{11}, thru		≤ –42 dB	
S_{22}, thru		≤ –42 dB	
S_{21}, thru		≤ 0.021 dB_{p-p}	
S_{12}, thru		≤ 0.021 dB_{p-p}	

Table 5-3 Using a TRL Calibration K11644A WR-42 (K-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		≤ 0.40 dB_{p-p}	
S_{22}, shorted		≤ 0.40 dB_{p-p}	
S_{11}, thru		≤ –40 dB	
S_{22}, thru		≤ –40 dB	
S_{21}, thru		≤ 0.030 dB_{p-p}	
S_{12}, thru		≤ 0.030 dB_{p-p}	

872*x* System Operation Check

1. Short the standard section and perform an S_{11} and an S_{22} measurement to verify that the ripple on the reflection of the shorted waveguide section does not exceed the limits listed in the tables on page 5-15. If the ripple is less than the acceptable value, then the combination of directivity and source match errors of the calibrated system is within the factory specified values.
2. Check the S_{11} and S_{22} of a thru measurement. As in the previous step, the results of this check contain the directivity error, but, because of the thru connection to port 2, this measurement also checks the limit of the combination of a number of error terms, including load match and transmission tracking.
3. Make an S_{21} and an S_{12} measurement. Ideally, the standard section is low loss. These measurements verify that the combination of source match error and load match error do not cause excess ripple on the trace. The trace ripple should not exceed the acceptable values listed in page 5-15.
4. Record the results of each test in Tables 5-4 through 5-6.

The S_{11} and S_{22} of a Shorted Standard Section

1. Using a IF bandwidth of 10 Hz, perform a full 2-port calibration. (Refer to your network analyzer documentation for specific instructions.)
2. Leave the calibration turned on.
3. Connect the standard section to port 1.
4. Connect the short to terminate the standard section.
5. Connect the load to port 2.
6. To set the display:
   a. Press **[MEAS]** and select **Refl: FWD S11**.
   b. Press **[SCALE REF] [.1] [x1]**.
   c. Select **REFERENCE POSITION** and press **[10] [x1]**.
   d. Select **REFERENCE VALUE** and press **[0] [x1]**.
   e. Press **[MEAS]** and select **MEASURE RESTART**.
7. After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in Figure 5-3.
8. Use the markers to determine the greatest peak-to-peak deviation of the ripple on the displayed trace (this is any positive peak to any adjacent negative peak):
   a. Press **[MKR]** and select **delta MODE MENU**.
   b. Set the reference to marker 2.
   c. Switch between markers 1 and 2 (in the delta mode) and position them to the highest and lowest peaks. (You may have to practice using the marker features to get the desired results.)

9. Record the maximum peak-to-peak value in the appropriate table on page 5-15.
10. Turn off the delta marker mode.
11. Repeat this procedure from step 6, and make an S_{22} measurement on the standard section. Record the measured value in the appropriate table on page 5-15.

The S_{11} and S_{22} of a Thru Measurement

1. Verify that the calibration is still on.
2. Connect the standard section to ports 1 and 2 to form a thru connection.
3. To set the display:
   a. Press **[MEAS]** and select **Refl: FWD S11**.
   b. Press **[SCALE REF] [10] [x1]**.
   c. Select **REFERENCE POSITION** and press **[10] [x1].**
   d. Select **REFERENCE VALUE** and press **[0] [x1]**.
   e. Press **[MEAS]** and select **MEASURE RESTART**.
4. After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in Figure 5-4.
5. Determine the maximum value on the trace (you can use a marker).
6. Record the maximum value in the appropriate table on page 5-15.
7. Repeat this procedure from step 3, and make an S_{22} measurement. Record the measured value in the appropriate table on page 5-15.

The S_{21} and S_{12} of a Thru Measurement

1. Verify that the calibration is still on.
2. Connect the standard section to ports 1 and 2 to form a thru connection.
3. To set the display:
   a. Press **[MEAS]** and select **Trans: FWD S_{21}**.
   b. Press **[SCALE] [.02] [x1]**.
   c. Select **REFERENCE POSITION [5] [x1].**
   d. Select **[REFERENCE VALUE [±.2] [5] [x1]**.
   e. Press **[MEAS]** and select **MEASURE RESTART**.
4. After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in Figure 5-5.
5. If necessary, select **Press to Continue** to update the trace.
6. Determine the greatest peak-to-peak deviation (this is any positive peak to any adjacent negative peak). You can use the markers, as described in the first test, to determine the peak-to-peak value.

7. Record the maximum peak-to-peak value in the appropriate table on page 5-15.
8. Repeat this procedure from step 3, and make an S_{12} measurement. Record the measured value in the appropriate table on page 5-15.
9. If you use the delta marker mode, don't forget to turn it off.

In Case of Failure

If a system check fails, recalibrate the system and repeat the entire procedure (all three measurements). Remember that poor connections are the most common cause of measurement errors. Also, both the hardware state and the instrument state must be correct. Reload disks or re-enter commands, if necessary, including the calibration kit definitions. If the test continues to fail:

- Save the instrument state.
- Write down *all* of the symptoms.
- Refer to Chapter 6 for troubleshooting and contact information.

Table 5-4 Using a Full 2-Port Calibration X11644A WR-90 (X-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		$\leq 0.15\ dB_{p\text{-}p}$	
S_{22}, shorted		$\leq 0.15\ dB_{p\text{-}p}$	
S_{11}, thru		≤ -40 dB	
S_{22}, thru		≤ -40 dB	
S_{21}, thru		$\leq 0.06\ dB_{p\text{-}p}$	
S_{12}, thru		$\leq 0.06\ dB_{p\text{-}p}$	

Table 5-5 Using a Full 2-Port Calibration P11644A WR-62 (P-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		$\leq 0.26\ dB_{p\text{-}p}$	
S_{22}, shorted		$\leq 0.26\ dB_{p\text{-}p}$	
S_{11}, thru		≤ -37 dB	
S_{22}, thru		≤ -37 dB	
S_{21}, thru		$\leq 0.07\ dB_{p\text{-}p}$	
S_{12}, thru		$\leq 0.07\ dB_{p\text{-}p}$	

Table 5-6 Using a Full 2-Port Calibration K11644A WR-42 (K-band)

Test	Measured Value	Acceptable Value	Pass (Yes/No)
S_{11}, shorted		$\leq 0.40\ dB_{p\text{-}p}$	
S_{22}, shorted		$\leq 0.40\ dB_{p\text{-}p}$	
S_{11}, thru		≤ -35 dB	
S_{22}, thru		≤ -35 dB	
S_{21}, thru		$\leq 0.01\ dB_{p\text{-}p}$	
S_{12}, thru		$\leq 0.01\ dB_{p\text{-}p}$	

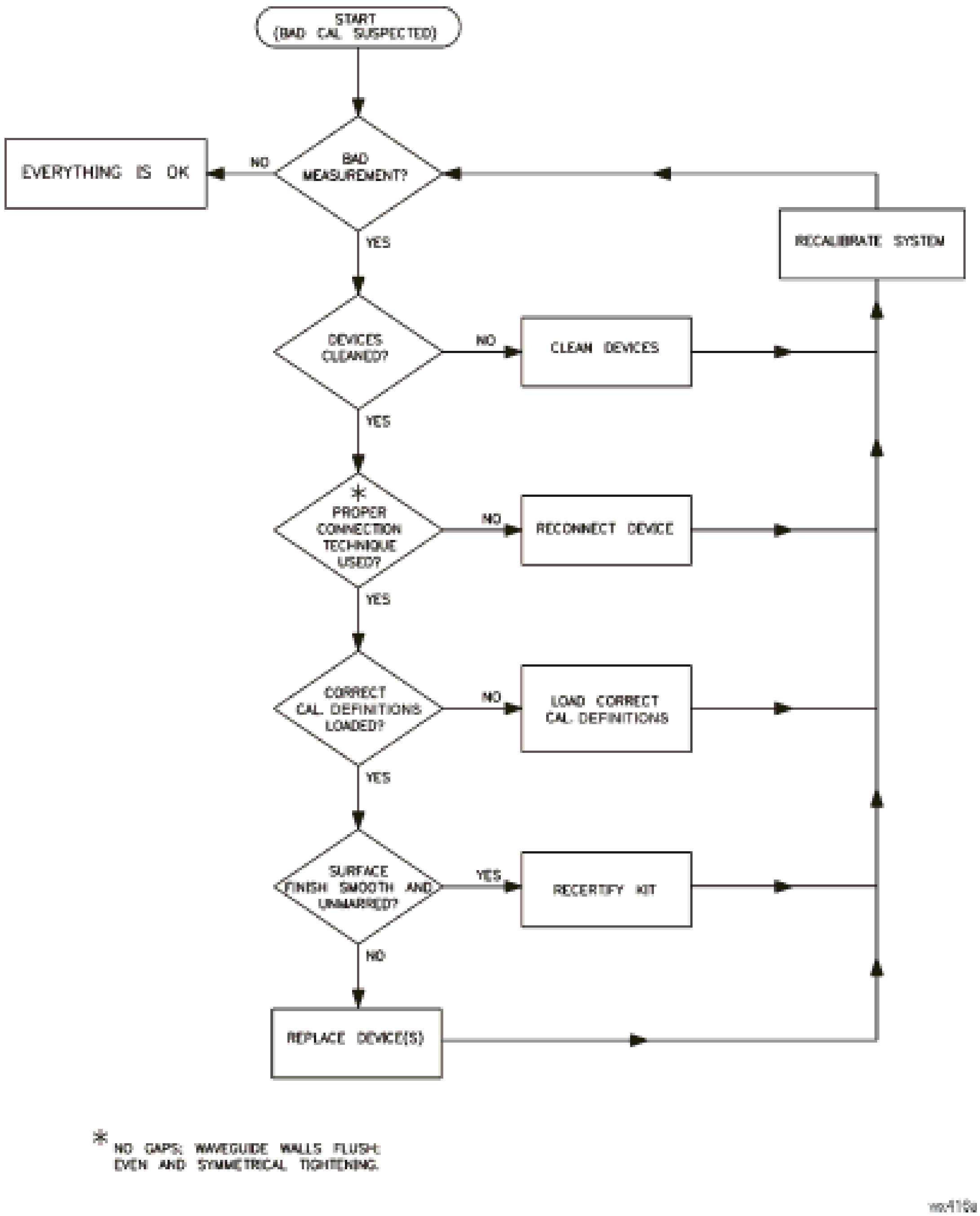
6 Troubleshooting

Troubleshooting Process

This manual contains limited information about network analyzer system operation. For complete information, refer to the instrument documentation.

If you suspect a bad calibration, or if your network analyzer does not pass performance verification, follow the steps in Figure 6-1

Figure 6-1 Troubleshooting Flowchart



Returning a Kit or Device to Agilent

If your kit or device requires service, contact Agilent Technologies for information on where to send it. See Table 6-1 for contact information. Include a service tag (located near the end of this manual) on which you provide the following information:

- your company name and address
- a technical contact person within your company, and the person's complete telephone number
- the model number and serial number of the kit
- the part number and serial number of each device
- the type of service required
- a *detailed* description of the problem and how the device was being used when the problem occurred (such as calibration or measurement)

Where to Look for More Information

This manual contains limited information about network analyzer system operation. For complete information, refer to the instrument documentation. If you need additional information, contact Agilent Technologies.

Contacting Agilent

Table 6-1 Contacting Agilent

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

7 Replaceable Parts

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Introduction

The following tables list the replacement part numbers for the Agilent P11644A, K11644A, and X11644A waveguide calibration kits. Table 7-4 lists the replacement part numbers for items *not* included in the calibration kit that are either required or recommended for successful operation of this kit.

To order a listed part, note the description, part number, and the quantity desired. Telephone or send your order to Agilent Technologies. Refer to "Contacting Agilent" on page 6-3 for further information.

Table 7-1 Replaceable Parts for the X11644A WR-90

Description	Qty Per Kit	Agilent Part Number
Calibration Devices		
Termination	2	00910-60003
Standard section	1	00896-60008
Short	1	11644-20018
¼ Wavelength shim	1	11644-20021
7 mm coax-to-waveguide adapter	2	X281C Option 006
Hardware		
Alignment pin	6	11644-20024
Slip pin	6	11644-20025
8-32 pozi drive screw (0.625 in length)	6	2510-0109
8-32 pozi drive screw (1.0 in length)	6	2510-0115
Lock washer	12	2190-0009
8-32 hex nut	12	2580-0002
¼ Wrench	1	8720-0014
Miscellaneous Items		
User's and service guide	1	11644-90371
Calibration definitions disk (X-band)	1	11644-10011
Calibration definitions disk (PNA)	1	11644-10021
Connector care-quick reference card	1	08510-90360
Calibration Kit Storage Case		
Storage case	1	5181-5720
Box	2	1540-0216
Foam pad (set)	1	11644-80034
Disk holder	1	5180-8491

Figure 7-1 X-Band Component Identification Sheet

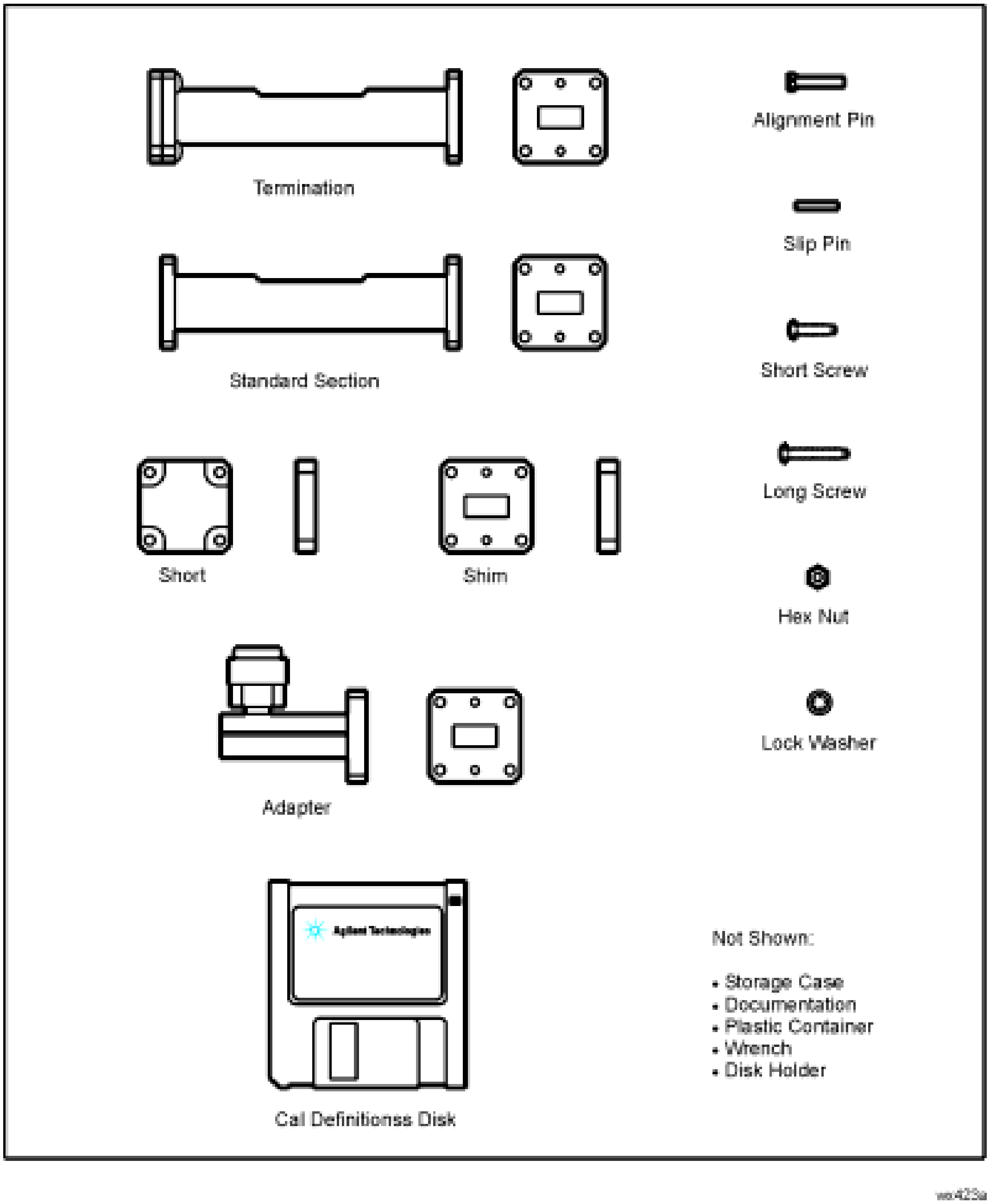

Table 7-2 Replaceable Parts for the P11644A WR-62

Description	Qty Per Kit	Agilent Part Number
Calibration Devices		
Termination	2	00910-60002
Standard section	1	00896-60007
Short	1	11644-20017
¼ Wavelength shim	1	11644-20020
7 mm coax-to-waveguide adapter	2	P281C Option 006
Hardware		
Alignment pin	6	11644-20023
Slip pin	6	11644-20025
6-32 pozi drive screw (0.875 in length)	6	2360-0207
6-32 pozi drive screw (.562 in length)	6	2360-0229
lock washer (0.141 inch)	12	2190-0007
6-32 hex nut	12	2420-0003
¼ Wrench	1	8720-0014
Miscellaneous Items		
User's and service guide	1	11644-90371
Calibration definitions disk (P-band)	1	11644-10009
Calibration definitions disk (PNA)	1	11644-10018
Connector care-quick reference card	1	08510-90360
Calibration Kit Storage Case		
Storage case	1	5181-5720
Box	2	1540-0216
Foam pad (set)	1	11644-80033
Disk holder	1	5180-8491

Figure 7-2 P-Band Component Identification Sheet

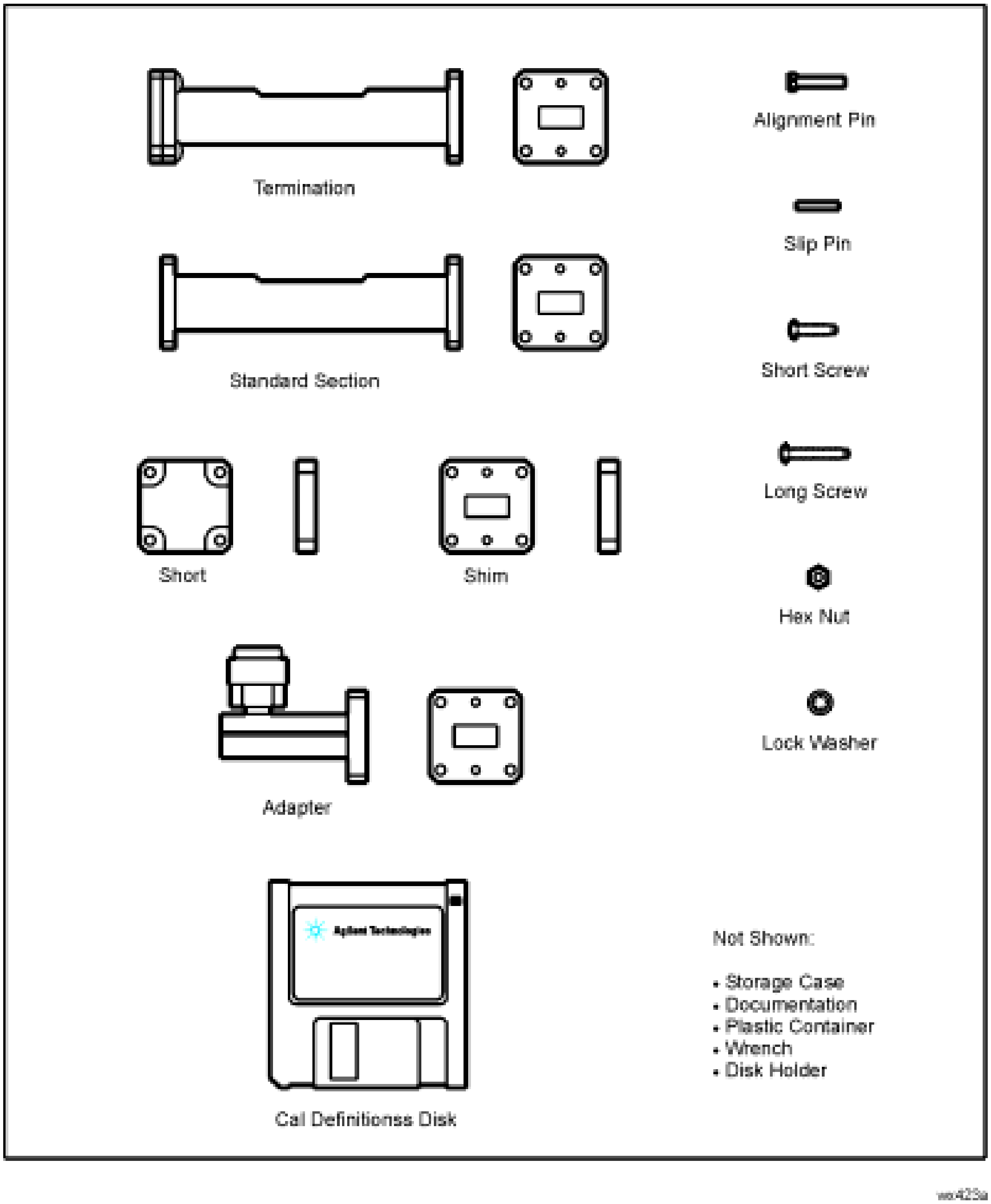

Table 7-3 Replaceable Parts for the K11644A WR-42

Description	Qty Per Kit	Agilent Part Number
Calibration Devices		
Termination	2	00910-60001
Standard section	1	00896-60006
Short	1	11644-20016
¼ Wavelength shim	1	11644-20019
3.5 mm coax-to-waveguide adapter (m)	1	00281-60001
3.5 mm coax-to-waveguide adapter (f)	1	K281C Option 006
Hardware		
Alignment pin	6	11644-20022
Slip pin	6	11644-20027
4-40 pozi drive screw (0.750 in length)	12	2200-0151
lock washer	12	2190-0643
4-40 hex nut	12	2260-0002
3/16 Wrench	1	8720-0013
Miscellaneous Items		
User's and service guide	1	11644-90371
Calibration definitions disk (P-band)	1	11644-10007
Calibration definitions disk (PNA)	1	11644-10017
Connector care-quick reference card	1	08510-90360
Calibration Kit Storage Case		
Storage case	1	5181-5720
Box	2	1540-0216
Foam pad (set)	1	11644-80032
Disk holder	2	5180-8491

Figure 7-3 K-Band Component Identification Sheet

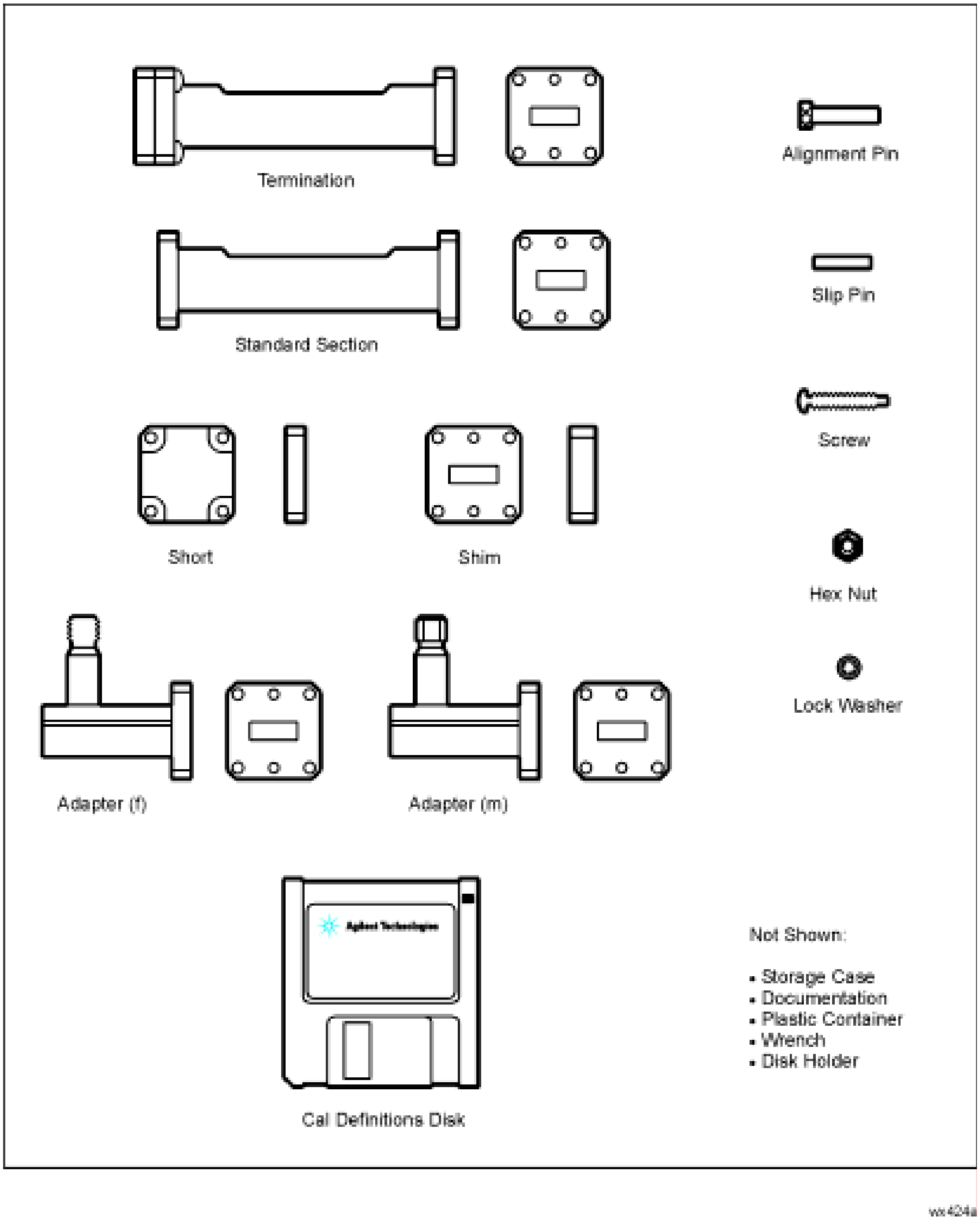

Table 7-4 Items Not Included in the Calibration Kit

Description	Qty	Agilent Part Number
ESD Protection Devices		
Grounding wrist strap	1	9300-1367
5 ft grounding cord for wrist strap	1	9300-0980
2 ft by 4 ft conductive table mat with 15 ft grounding wire	1	9300-0797
ESD heel strap	1	9300-1308
Cleaning Supplies		
Isopropyl alcohol	30 ml	8500-5344
Foam-tipped cleaning swabs	100	9301-1243

A Standard Definitions

Version Changes

Class assignments and standard definitions may change as more accurate model and calibration methods are developed. The disk shipped with the kit will contain the most recent version.

Standard Class Assignments

Class assignment organizes calibration standards into a format compatible with the error models used in the measurement calibration. A class or group of classes corresponds to the systematic errors to be removed from the measured network analyzer response. Tables A-1 and A-3 list the classes of the devices in the kit for the 8510 and PNA series respectively. This information resides on the calibration definitions disks included in the kit. Some network analyzers have the information stored in memory.

Table A-1 Standard Class Assignments for the 8510 Network Analyzer

Disk File Name: CK_WR-90, or CK_WR-62, or CK_WR-42								Calibration Kit Label: WR-90 A.1, or WR-62 A.1, or WR-42 A.1
Class	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Standard Class Label**
$S_{11}A$	1							Short
$S_{11}B$	3							Offset
$S_{11}C$	9	20						Loads
$S_{22}A$	1							Short
$S_{22}B$	3							Offset
$S_{22}C$	9	20						Loads
Forward transmission	11							Thru
Reverse transmission	11							Thru
Forward match	11							Thru
Reverse match	11							Thru
Forward isolation[a]	9							Isol'n Std
Reverse isolation	9							Isol'n Std
Frequency response	1	11						Response
TRL thru	14							TRL thru
TRL reflect	1							TRL reflect
TRL line	15							TRL line
Adapter	13							Adapter
TRL Option								
Cal Z_0: _____ System Z_0 __X__ Line Z_0								
Set ref: __X__ Thru _____ Reflect								
Lowband frequency: __________								

a. Forward isolation standard is also used for isolation part of response and isolation calibration.

Table A-2 Standard Class Assignments for the PNA Series P-band (WR-62)

Calibration Kit Label: PNA Series P-Band	
Class	**A** [a]
$S_{11}A$	1
$S_{11}B$	2
$S_{11}C$	3, 4, 5
Forward transmission	6, 7, 8
$S_{22}A$	1
$S_{22}B$	2
$S_{22}C$	3, 4, 5
Isolation	3, 4, 5

a. For additional ports, make sure values match the correct sex of the port.

IMPORTANT The following calibrations are only supported by certain PNA analyzers. See your PNA network analyzer embedded help system.

Notes:

1. **If you are performing a TRL calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *line* standards.
2. **If you are performing a TRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
3. **If you are performing an LRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *line* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
4. **$S_{11}B$ and $S_{11}C$ must be defined as the same standard.**
5. **$S_{22}B$ and $S_{22}C$ must be defined as the same standard**.

Table A-3 Standard Class Assignments for the PNA Series X-band (WR-90) and K-band (WR-42)

Calibration Kit Label: PNA Series X, K-Band	
Class	**A** [a]
$S_{11}A$	1
$S_{11}B$	2
$S_{11}C$	3, 5
Forward transmission	6, 7, 8
$S_{22}A$	1
$S_{22}B$	2
$S_{22}C$	3, 5
Isolation	3, 5

a. For additional ports, make sure values match the correct sex of the port.

IMPORTANT The following calibrations are only supported by certain PNA analyzers. See your PNA network analyzer embedded help system.

Notes:

1. **If you are performing a TRL calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *line* standards.
2. **If you are performing a TRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
3. **If you are performing an LRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *line* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
4. **$S_{11}B$ and $S_{11}C$ must be defined as the same standard.**

5. **$S_{22}B$ and $S_{22}C$ must be defined as the same standard**.

Blank Forms

The standard class assignments may be changed to meet your specific requirements. Tables A-4 and A-5 are provided to record the modified standard class assignments.

Table A-4 Blank Form for the 8510 Network Analyzer

Disk File Name:					**Calibration Kit Label:**			
Class	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**Standard Class Label**
$S_{11}A$								
$S_{11}B$								
$S_{11}C$								
$S_{22}A$								
$S_{22}B$								
$S_{22}C$								
Forward transmission								
Reverse transmission								
Forward match								
Reverse match								
Forward isolation[a]								
Reverse isolation								
Frequency response								
TRL thru								
TRL reflect								
TRL line								
Adapter								
TRL Option								
Cal Z_0: ____ System Z_0 ____ Line Z_0								
Set ref: ____ Thru ____ Reflect								
Lowband frequency: ________								

a. Forward isolation standard is also used for isolation part of response and isolation calibration.

Table A-5 Blank Form for the PNA Series Network Analyzer

Calibration Kit Label: ______________________	
Class	**A**[a]
$S_{11}A$	
$S_{11}B$	
$S_{11}C$	
Forward transmission	
$S_{22}A$	
$S_{22}B$	
$S_{22}C$	
Isolation	

a. For additional ports, make sure values match the correct sex of the port.

IMPORTANT The following calibrations are only supported by certain PNA analyzers. See your PNA network analyzer embedded help system.

Notes:

1. **If you are performing a TRL calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *line* standards.
2. **If you are performing a TRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *thru* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
3. **If you are performing an LRM calibration:**
   - $S_{21}T$ and $S_{12}T$ must be defined as *line* standards.
   - $S_{11}A$ and $S_{22}A$ must be defined as *reflection* standards.
   - $S_{11}B$, $S_{11}C$, $S_{22}B$, and $S_{22}C$ must be defined as *match* standards.
4. **$S_{11}B$ and $S_{11}C$ must be defined as the same standard.**
5. **$S_{22}B$ and $S_{22}C$ must be defined as the same standard**.

Nominal Standard Definitions

Standard definitions provide the definitions needed to mathematically model the electrical characteristics (delay, attenuation, and impedance) of each calibration standard. The nominal values of these definitions are theoretically derived from the physical dimensions and material of each calibration standard, or from actual measured response. These values are used to determine the measurement uncertainties of the network analyzer. The standard definitions in Tables A-6 through A-11 list typical calibration kit parameters used by the 8510, 872*x*, and PNA series to specify the mathematical model of each device. This information must be loaded into the network analyzer to perform valid calibrations. Refer to your network analyzers user's guide for instructions on loading calibration definitions.

NOTE The values in the standard definitions table are valid *only* over the specified operating temperature range.

Setting the System Impedance

This kit contains only waveguide devices. Ensure the system impedance (Z_0) is set to 1 ohm. Refer to your network analyzer user's guide for instructions on setting system impedance.

Version Changes

Class assignments and standard definitions may change as more accurate model and calibration methods are developed. The disk shipped with the kit for use wit the 8510 will contain the most recent version. The default version that comes with the 872*x* network analyzer firmware may be outdated.

Table A-6 Standard Definitions for the 8510 with X-band (WR-90)

System Z_0[a] = 1 Ω **Calibration Kit Label: WR-90 A.1**
Disk File Name: CK_WR-90

Standard[b]		$C0 \times 10^{-15}$ F	$C1 \times 10^{-27}$ F/Hz	$C2 \times 10^{-36}$ F/Hz^2	$C3 \times 10^{-45}$ F/Hz^3	Fixed, Sliding, or Offset[c]	Offset			Frequency in GHz[d]		Coax or Waveguide	Standard Label
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-42}$ H/Hz^3		Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max		
1	Short[e]						0	1	0	6.555	13.111	WG	Short
2													
3	Short/ offset						32.633	1	0	6.555	13.111	WG	λ/4 Offset
4													
5													
6													
7													
8													
9	Load					Fixed	0	1	0	6.555	13.111	WG	Fixed
10													
11	Delay/ thru						0	1	0	6.555	13.111	WG	Thru
12													
13													
14	Delay/ thru						0	1	0	6.555	13.111	WG	Thru
15	Delay/ thru						32.633	1	0	6.555	13.111	WG	λ/4 Delay
16													
17													
18													
19													
20	Load/ offset					Offset	32.633	1	0	6.555	13.111	WG	λ/4 Offset
21													

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. Load or arbitrary impedance only.
d. For waveguide, the lower frequency is the same as F_{CO}.
e. Typical values only. Disk values may be different.

Table A-7 Standard Definitions for the 8510 with P-band (WR-62)

System Z_0[a] = 1 Ω
Disk File Name: CK_WR-62
Calibration Kit Label: WR-62 A.1

Standard[b]		C0 $\times 10^{-15}$ F	C1 $\times 10^{-27}$ F/Hz	C2 $\times 10^{-36}$ F/Hz^2	C3 $\times 10^{-45}$ F/Hz^3	Fixed, Sliding, or Offset[c]	Offset			Frequency in GHz[d]		Coax or Waveguide	Standard Label
Number	Type	L0 $\times 10^{-12}$ H	L1 $\times 10^{-24}$ H/Hz	L2 $\times 10^{-33}$ H/Hz^2	L3 $\times 10^{-42}$ H/Hz^3		Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max		
1	Short[e]						0	1	0	9.485	18.97	WG	Short
2													
3	Short/ offset						21.689	1	0	9.485	18.97	WG	λ/4 Offset
4													
5													
6													
7													
8													
9	Load					Fixed	0	1	0	9.485	18.97	WG	Fixed
10	Load					Sliding	0	1	0	9.485	18.97		Sliding
11	Delay/ thru						0	1	0	9.485	18.97	WG	Thru
12													
13													
14	Delay/ thru						0	1	0	9.485	18.97	WG	Thru
15	Delay/ thru						21.689	1	0	9.485	18.97	WG	λ/4 Delay
16													
17													
18													
19													
20	Load/ offset					Offset	21.689	1	0	9.485	18.97	WG	λ/4 Offset
21													

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. Load or arbitrary impedance only.
d. For waveguide, the lower frequency is the same as F_{CO}.
e. Typical values only. Disk values may be different.

Table A-8 Standard Definitions for the 8510 with K-band (WR-42)

System Z_0[a] = 1 Ω
Disk File Name: CK_WR-42

Calibration Kit Label: WR-42 A.1

Standard[b]		$C0 \times 10^{-15}$ F	$C1 \times 10^{-27}$ F/Hz	$C2 \times 10^{-36}$ F/Hz^2	$C3 \times 10^{-45}$ F/Hz^3	Fixed, Sliding, or Offset[c]	Offset			Frequency in GHz[d]		Coax or Waveguide	Standard Label
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-42}$ H/Hz^3		Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max		
1	Short[e]						0	1	0	14.047	28.094	WG	Short
2													
3	Short/ offset						15.015	1	0	14.047	28.094	WG	λ/4 Offset
4													
5													
6													
7													
8													
9	Load					Fixed	0	1	0	14.047	28.094	WG	Fixed
10													
11	Delay/ thru						0	1	0	14.047	28.094	WG	Thru
12													
13													
14	Delay/ thru						0	1	0	14.047	28.094	WG	Thru
15	Delay/ thru						15.015	1	0	14.047	28.094	WG	λ/4 Delay
16													
17													
18													
19													
20	Load/ offset					Offset	15.015	1	0	14.047	28.094	WG	λ/4 Offset
21													

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. Load or arbitrary impedance only.
d. For waveguide, the lower frequency is the same as F_{CO}.
e. Typical values only. Disk values may be different.

Table A-9 Standard Definitions for the PNA Series with X-band (WR-90)

System Z_0[a] = 1 Ω							Calibration Kit Label: X-Band						
Standard[b]		$C0 \times 10^{-18}$ F	$C1 \times 10^{-30}$ F/Hz	$C2 \times 10^{-39}$ F/Hz^2	$C3 \times 10^{-48}$ F/Hz^3		Offset			Frequency in GHz[c]			
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-45}$ H/Hz^3	Fixed or sliding	Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max	Coax or Waveguide	Standard Label
1	Short/ offset	0	0	0	0		32.633	1	0	6.555	13.111	WG	λ/4 Offset short
2	Short	0	0	0	0		0	1	0	6.555	13.111	WG	Short
3	Load					Fixed	0	1	0	6.555	13.111	WG	Load
4													
5	Offset load					Fixed	32.633	1	0	6.555	13.111	WG	λ/4 Offset load
6	Delay/ thru						0	1	0	6.555	13.111	WG	Thru
7	Delay/ thru						0	1	0	6.555	13.111	WG	Thru
8	Delay/ thru						32.633	1	0	6.555	13.111	WG	λ/4 Delay

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. For waveguide, the lower frequency is the same as $F_{CO.}$

Table A-10 Standard Definitions for the PNA Series with P-Band (WR-62)

System Z_0[a] = 1 Ω		Calibration Kit Label: P-Band											
Standard[b]		$C0 \times 10^{-18}$ F	$C1 \times 10^{-30}$ F/Hz	$C2 \times 10^{-39}$ F/Hz^2	$C3 \times 10^{-48}$ F/Hz^3		Offset			Frequency in GHz[c]			
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-45}$ H/Hz^3	Fixed or sliding	Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max	Coax or Waveguide	Standard Label
1	Short/ offset	0	0	0	0		21.689	1	0	9.485	18.970	WG	λ/4 Offset short
2	Short	0	0	0	0		0	1	0	9.485	18.970	WG	Short
3	Load					Fixed	0	1	0	9.485	18.970	WG	Load
4	Sliding load					Sliding	0	1	0	9.485	18.970	WG	Sliding load
5	Offset load					Fixed	21.689	1	0	9.485	18.970	WG	λ/4 Offset load
6	Delay/ thru						0	1	0	9.485	18.970	WG	Thru
7	Delay/ thru						0	1	0	9.485	18.970	WG	Thru
8	Delay/ thru						21.689	1	0	9.485	18.970	WG	λ/4 Delay

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. For waveguide, the lower frequency is the same as F_{CO}.

Table A-11 Standard Definitions for the PNA Series with K-Band (WR-42)

System Z_0[a] = 11 Ω						Calibration Kit Label: K-Band							
Standard[b]		$C0 \times 10^{-18}$ F	$C1 \times 10^{-30}$ F/Hz	$C2 \times 10^{-39}$ F/Hz^2	$C3 \times 10^{-48}$ F/Hz^3		Offset			Frequency in GHz[c]			
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-45}$ H/Hz^3	Fixed or sliding	Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max	Coax or Waveguide	Standard Label
1	Short/ offset	0	0	0	0		15.015	1	0	14.047	28.094	WG	λ/4 Offset short
2	Short	0	0	0	0		0	1	0	14.047	28.094	WG	Short
3	Load					Fixed	0	1	0	14.047	28.094	WG	Load
4													
5	Offset load					Fixed	15.015	1	0	14.047	28.094	WG	λ/4 Offset load
6	Delay/ thru						0	1	0	14.047	28.094	WG	Thru
7	Delay/ thru						0	1	0	14.047	28.094	WG	Thru
8	Delay/ thru						15.015	1	0	14.047	28.094	WG	λ/4 Delay

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. For waveguide, the lower frequency is the same as F_{CO}.

Blank Forms

The standard definitions may be changed to meet your specific requirements. Tables A-12 and A-13 are provided to record the modified standard definitions.

Table A-12 Blank Form for the 8510 Network Analyzer

System Z_0[a] = 1 Ω **Calibration Kit Label:**
Disk File Name:

Standard[b]		$C0 \times 10^{-15}$ F	$C1 \times 10^{-27}$ F/Hz	$C2 \times 10^{-36}$ F/Hz^2	$C3 \times 10^{-45}$ F/Hz^3	Fixed, Sliding, or Offset[c]	Offset			Frequency in GHz[d]		Coax or Waveguide	Standard Label
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-42}$ H/Hz^3		Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max		
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. Load or arbitrary impedance only.
d. For waveguide, the lower frequency is the same as F_{CO}.

Table A-13 Blank Form for the PNA Series Network Analyzer

System Z_0[a] = _______________ Calibration Kit Label: ___________________________

Standard[b]		$C0 \times 10^{-18}$ F	$C1 \times 10^{-30}$ F/Hz	$C2 \times 10^{-39}$ F/Hz^2	$C3 \times 10^{-48}$ F/Hz^3		Offset			Frequency in GHz[c]			
Number	Type	$L0 \times 10^{-12}$ H	$L1 \times 10^{-24}$ H/Hz	$L2 \times 10^{-33}$ H/Hz^2	$L3 \times 10^{-45}$ H/Hz^3	Fixed or sliding	Delay in ps	Z_0 Ω	Loss in GΩ/s	Min	Max	Coax or Waveguide	Standard Label
1													
2													
3													
4													
5													
6													
7													
8													

a. Ensure system Z_0 of network analyzer is set to this value.
b. Open, short, load, delay/thru, or arbitrary impedance.
c. For waveguide, the lower frequency is the same as F_{CO}.

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