

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

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

NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.



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

For any assistance, contact Keysight Technologies. Refer to [page 6-4](#) for a list of Keysight contacts.

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- Go to www.keysight.com.
- Enter the document's part number (located on the title page) in the **Search** box.
- Click **Search**.
- Open the PDF and print the document.

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1 General Information

Calibration Kit Overview

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

Kit Contents

Use the Contents List in the shipping container to verify the completeness of your shipment. Although this list is the most accurate, you can also use the illustrations in Chapter 7 to verify the items in your shipment. If your shipment is not complete, contact Keysight Technologies - refer to “[Contacting Keysight](#)” on page 6-4.

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.

Calibration Definitions

The calibration kit must be selected and the calibration definitions for the devices in the kit installed in the network analyzer prior to performing a calibration.

The calibration definitions can be:

- resident within the analyzer
- manually entered from the front panel

Class assignments and standard definitions may change as more accurate model and calibration methods are developed. You can download the most accurate class assignments and standard definitions from Keysight’s Calibration Kit Definitions Web page at <http://na.support.keysight.com/pna/caldefs/stddefs.html>.

Refer to your network analyzer user’s guide or embedded Help for instructions on manually entering calibration definitions, selecting the calibration kit, and performing a calibration.

NOTE The 8510 network analyzer is no longer being sold or supported by Keysight. However, you can download the 8510 class assignments and standard definitions from Keysight’s Calibration Kit Definitions Web page at <http://na.support.keysight.com/pna/caldefs/stddefs.html>.

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 Keysight 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 a calibration definitions disk to support the Keysight 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

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 Keysight” on page 6-4](#). Keysight 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 Keysight” on page 6-3](#).

Recording the Device Serial Numbers

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.

When to Calibrate

A network analyzer calibration remains valid as long as the changes in the systematic error are insignificant. This means that changes to the uncorrected leakages (directivity and isolation), mismatches (source match and load match), and frequency response of the system are small (<10%) relative to accuracy specifications.

Change in the environment (especially temperature) between calibration and measurement is the major cause in calibration accuracy degradation. The major effect is a change in the physical length of external and internal cables. Other important causes are dirty and damaged test port connectors and calibration standards. If the connectors become dirty or damaged, measurement repeatability and accuracy is affected. Fortunately, it is relatively easy to evaluate the general validity of the calibration. To test repeatability, remeasure one of the calibration standards. If you can not obtain repeatable measurements from your calibration standards, maintenance needs to be performed on the test port connectors, cables and calibration standards. Also, maintain at least one sample of the device under test or some known device as your reference device. A verification kit may be used for this purpose. After calibration, measure the reference device and note its responses. Periodically remeasure the device and note any changes in its corrected response which can be attributed to the test system. With experience you will be able to see changes in the reference responses that indicate a need to perform the measurement calibration again.

General Information
Preventive Maintenance

2 Specifications

Environmental Requirements

Table 2-1 Environmental Requirements

Parameter	Limits
Temperature	
Operating ¹	+20 °C to +26 °C
Storage	–40 °C to +75 °C
Error-corrected range ²	±1 °C of measurement calibration temperature
Relative humidity	Type tested, 0% to 95% at 40 °C, non-condensing

1. The temperature range over which the calibration standards maintain performance to their specifications.
2. 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.

Mechanical Characteristics

Table 2-2 and Table 2-3 list the typical characteristics of the adapters and 1/4 wavelength shims in your kit. These are *not* specifications, but are included as additional information.

Table 2-2 Mechanical Characteristics of Adapters

Frequency band	SWR ¹	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

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

1/4 Wavelength Shims

Figure 2-1. 1/4 Wavelength Shims

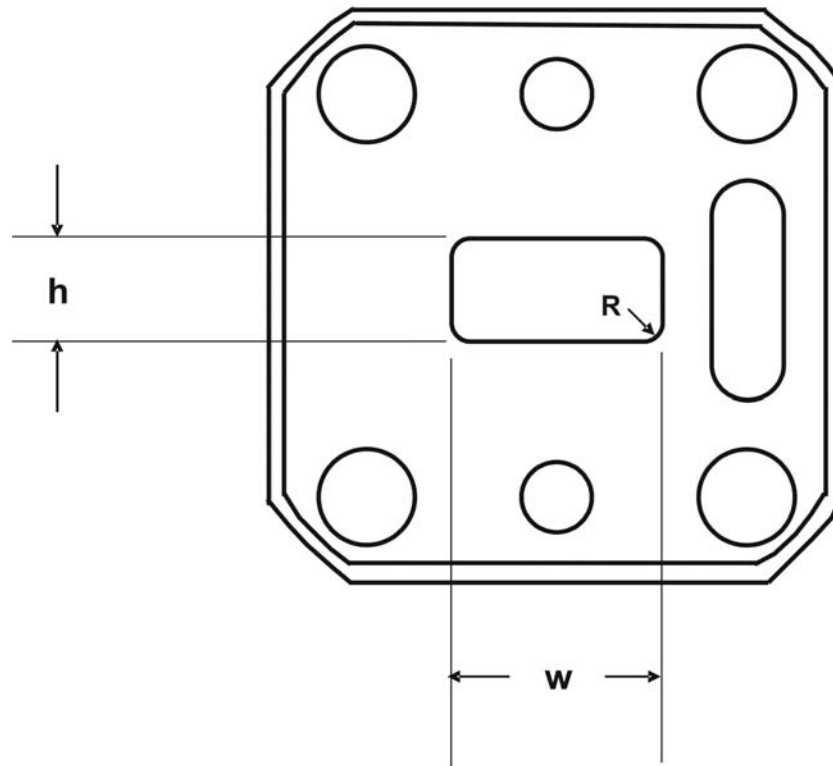


Table 2-3 Mechanical Characteristics of 1/4 Wavelength Shims

Frequency band	Waveguide Band	W (mm)	H (mm)	R (mm)	Thickness (mm)
11664-20021	WR90	22.86 ±0.01	10.16 ±0.01	0.13 max	9.78 ±0.02
11664-20020	WR62	15.80 ±0.01	7.90 ±0.01		6.50 ±0.02
11664-20019	WR42	10.671 ±0.08	4.318 ±0.008		4.5 ±0.02

Shorts

All waveguide shorts are flat within 0.008 mm.

Electrical Specifications

Table 2-4 through Table 2-5 list the electrical specifications of the terminations, ¼ wavelength shims, and standard sections in your kit.

Table 2-4 Electrical Characteristics and Specifications

Device	Frequency	Termination Specification
X11644A WR-90	8.2 to 12.4 GHz	return loss \geq 42 dB ¹
P11644A WR-62	12.4 to 18 GHz	return loss \geq 42 dB ¹
K11644A WR-42	18 to 26.5 GHz	return loss \geq 42 dB ¹

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

Table 2-5 Electrical Specifications of ¼ Wavelength Shims

Part Number	Waveguide Band	Return Loss (dB) ¹
11664-20021	WR90	55
11664-20020	WR62	
11664-20019	WR42	

1. Return loss specification is guaranteed by mechanical specifications.

Table 2-6 Electrical Specifications of Standard Sections

Device	Frequency	Standard Section Specification
X11644A WR-90	8.2 to 12.4 GHz	Return loss \geq 42 dB
P11644A WR-62	12.4 to 18 GHz	Return loss \geq 42 dB
K11644A WR-42	18 to 26.5 GHz	Return loss \geq 42 dB

Measurement Uncertainty

Vector Network Analyzer (VNA) measurement accuracy depends on the accuracy of the calibration standards, the calibration method employed, instrumentation accuracy and stability, environmental factors, and the actual characteristic of the device under test (DUT). Because of the complexity in these relationships, Keysight created uncertainty computation tools to calculate the overall measurement uncertainty of a VNA system. In the past, when the Keysight 8510 VNA system was being produced, a “Specification and Verification” RMB program was included to perform an uncertainty calculation. Currently, for the Keysight PNA and ENA families of network analyzers, a customer can download the VNA Uncertainty Calculator program. (To access this program from the Web, navigate to www.keysight.com and enter “calculator” in the Search function.) Explanations of the uncertainty model are provided in the PNA embedded Help files. Additional references on VNA measurements are available from the Keysight Applications Notes and Technical Papers Web page, accessed from www.keysight.com by clicking on the Application Notes and Technical Papers hyperlink.

Certification

Keysight Technologies certifies that this product met its published specifications at the time of shipment from the factory. Keysight 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 Keysight Verifies the Devices in Your Kit](#)” on page 5-2 for more information.

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 $\frac{1}{4}$ 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 $\frac{1}{4}$ wavelength shim.

$\frac{1}{4}$ Wavelength Shim

A $\frac{1}{4}$ wavelength shim is also called an offset, or $\frac{1}{4}$ 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.

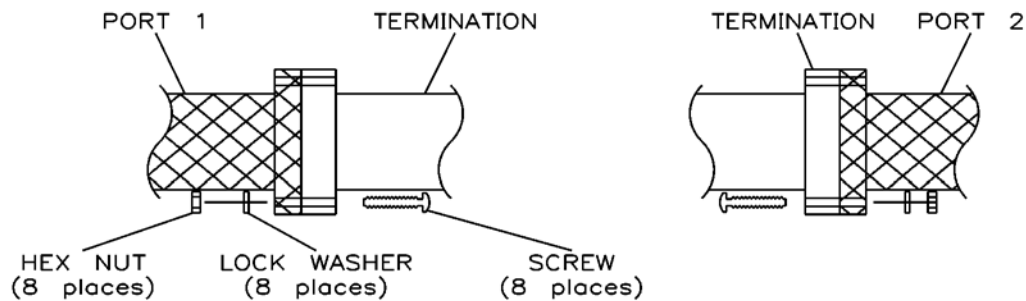
Measurement Applications

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

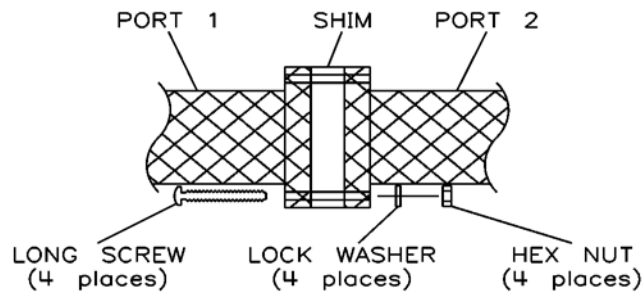


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Line

Connect the shim between port 1 and port 2, as shown in [Figure 3-2](#).

Figure 3-2 Connecting the Shim

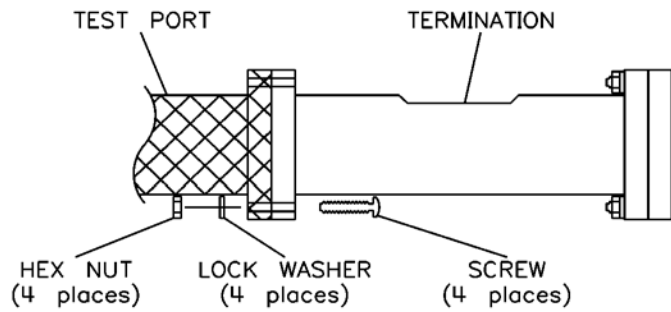


wx402a

Load

Connect the termination to the appropriate test port, as shown in [Figure 3-3](#).

Figure 3-3 Test Port and Termination

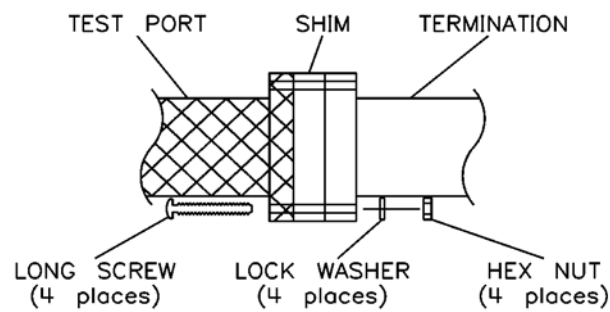


wx403a

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

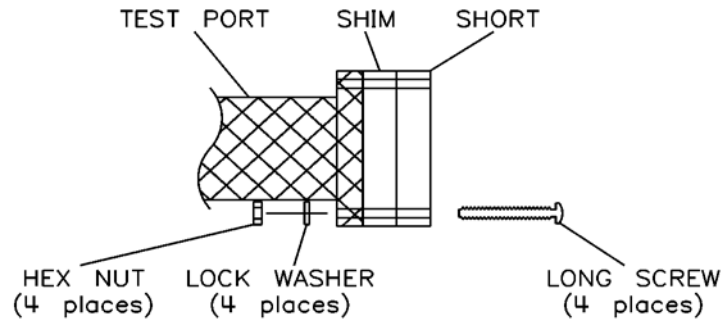


wx404a

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

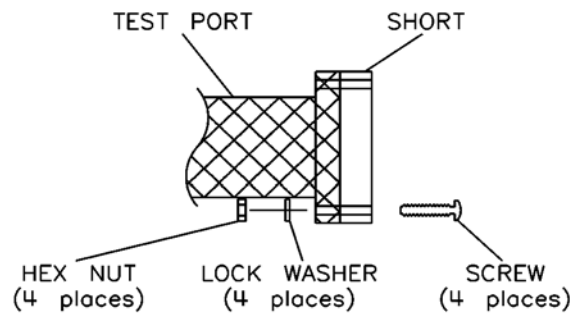


wx405a

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



wx406a

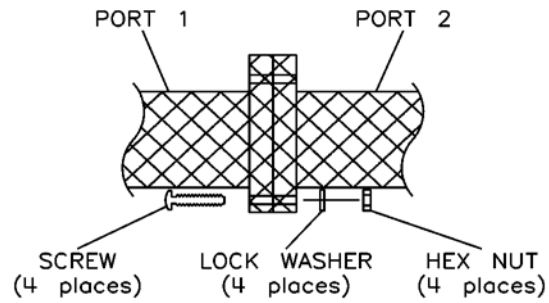
Short

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



wx407a

$\frac{1}{4}$ Wavelength Load

See ["Offset Load"](#)

$\frac{1}{4}$ 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:

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

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**Electrostatic Discharge**

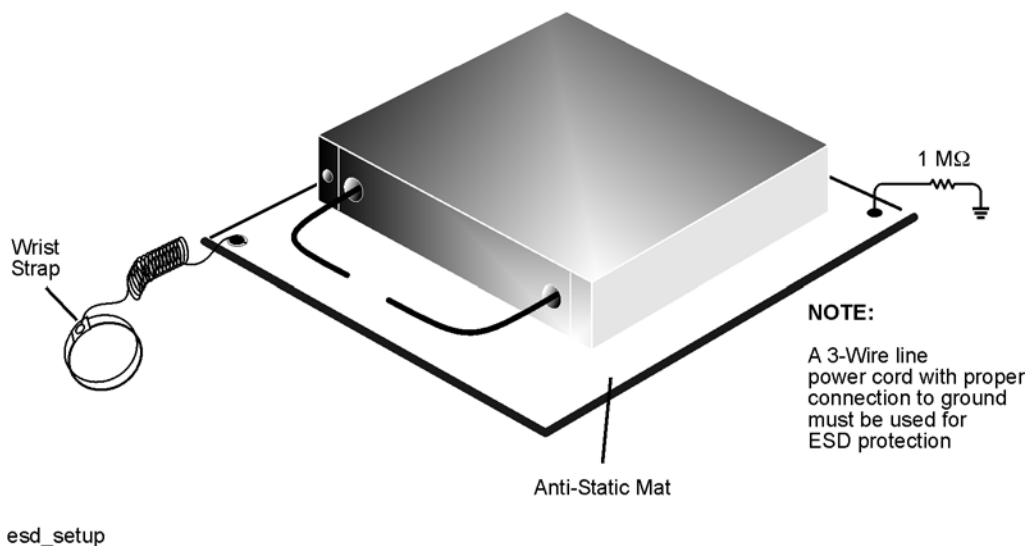
Protection against electrostatic discharge (ESD) is essential while connecting, inspecting, or cleaning connectors attached to a static-sensitive circuit (such as those found in test sets).

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 M Ω 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.

Magnification is helpful when inspecting mating surfaces, but it is not required and may actually be misleading. Defects and damage that cannot be seen without magnification generally have no effect on electrical or mechanical performance. Magnification is of great use in analyzing the nature and cause of damage and in cleaning mating surfaces, but it is not required for inspection.

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.

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.

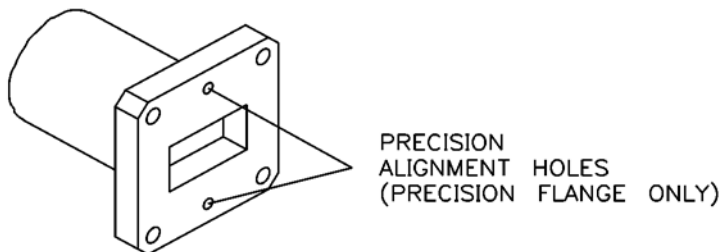
Waveguide Devices

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

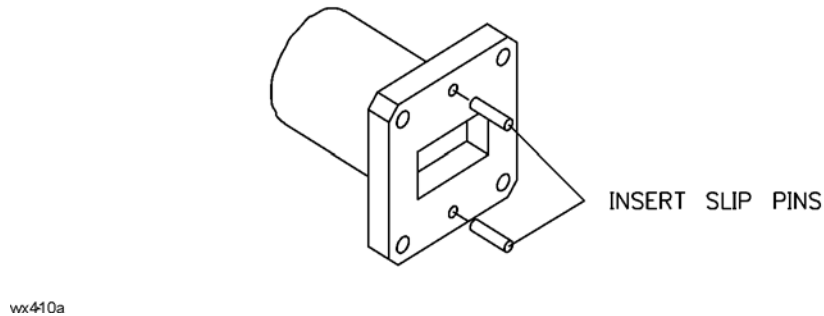


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Aligning Two Precision Flanges

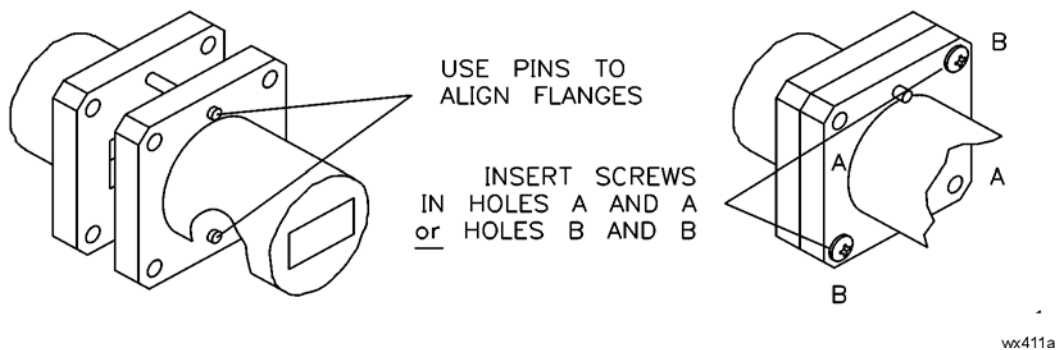
1. Place the slip pins in the top and bottom holes of one flange, as shown in [Figure 4-3](#).

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

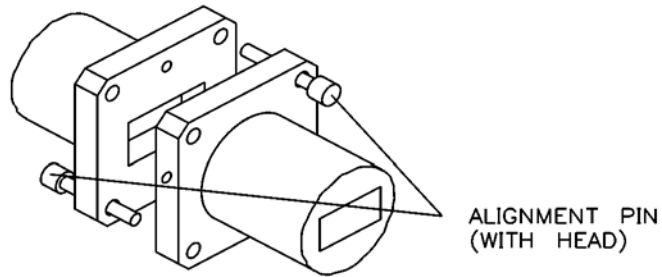


3. Place a lock washer and nut on each screw, and finger tighten.
4. Insert the remaining two screws.
5. Place a lock washer and nut on each screw, and finger tighten.
6. Remove the slip pins.
7. Go to ["Tightening a Flange Connection"](#) on page 4-8.

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**



wx412a

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.

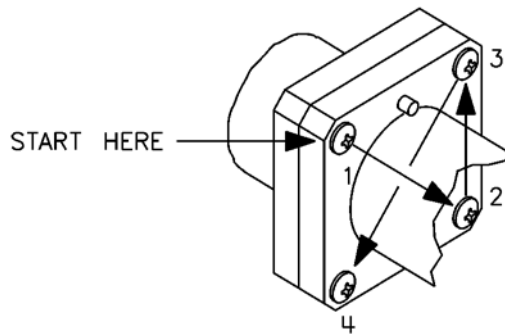
Connections

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



wx413a

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.

Use, Maintenance, and Care of the Devices
Handling and Storage

5 Performance Verification

Introduction

The performance of your calibration kit can only be verified by returning the kit to Keysight 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 Keysight Verifies the Devices in Your Kit

Keysight 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, Keysight 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 Keysight 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 Keysight 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.

Keysight Technologies offers a *Standard* calibration for the recertification of the kit. For more information, contact Keysight Technologies. Refer to [“Contacting Keysight” on page 6-4](#) 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

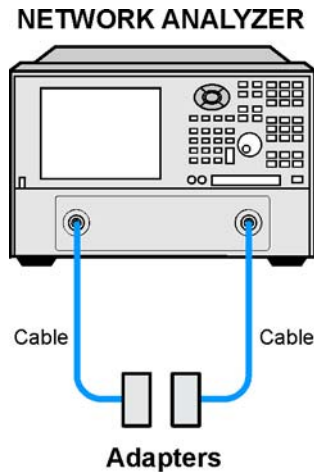
Contact Keysight Technologies for information on where to send your kit for recertification. Contact information is listed on [page 6-4](#). Refer to [“Returning a Kit or Device to Keysight” on page 6-3](#) for details on sending your kit.

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



wx425a

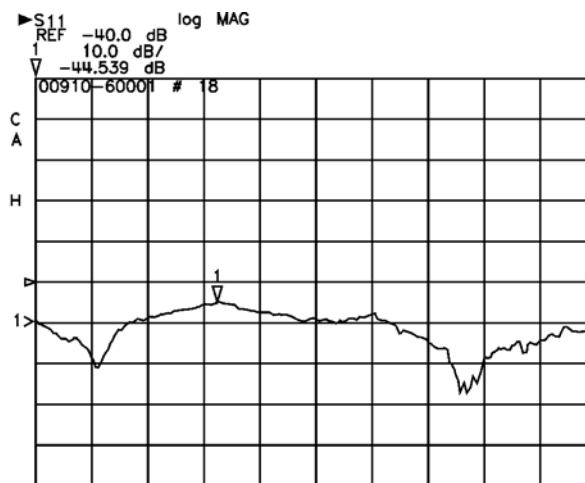
1. Connect the equipment as shown in [Figure 5-1](#). Turn on and preset the network analyzer. Let the equipment warm up for at least one hour.

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



wx415a

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 [“Electrical Specifications” on page 2-5](#).

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

NOTE The 8510 network analyzer is no longer being sold or supported by Keysight. However, you can download the 8510 class assignments and standard definitions from Keysight's Calibration Kit Definitions Web page at www.na.tm.keysight.com/pna/caldefs/stddefs.html

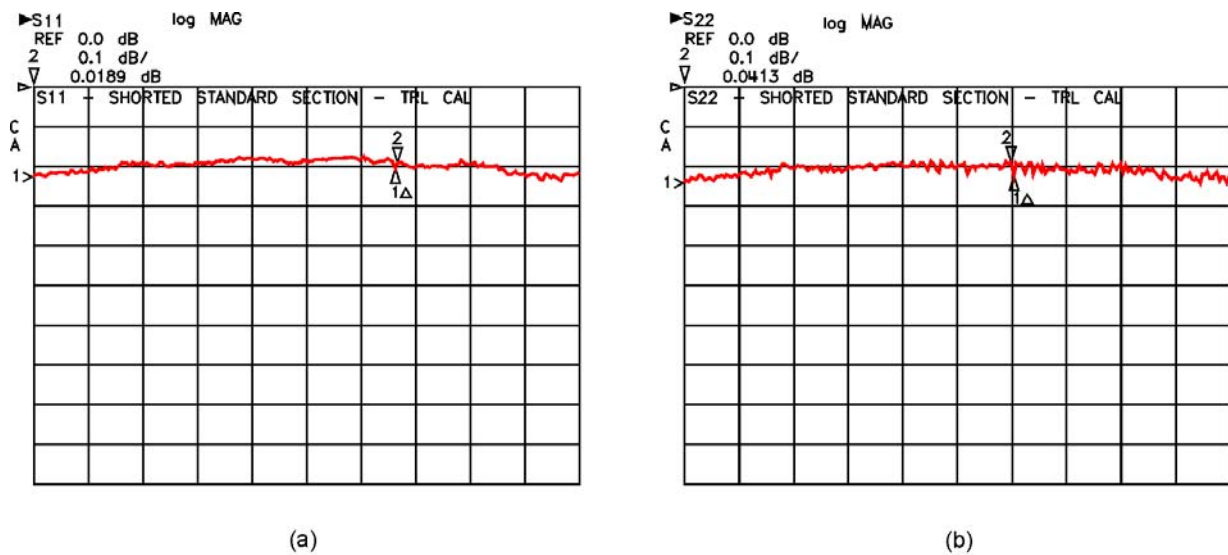
1. Short the standard section and perform an S_{11} and an S_{22} measurement to verify that the ripple on the reflection of the shorted waveguide section does not exceed the limits listed in the tables on [page 5-11](#). If the ripple is less than the acceptable value, then the combination of directivity 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 [Table 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 [**S₁₁**].
 - 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 S₁₁ and S₂₂ Standard Section Ripple



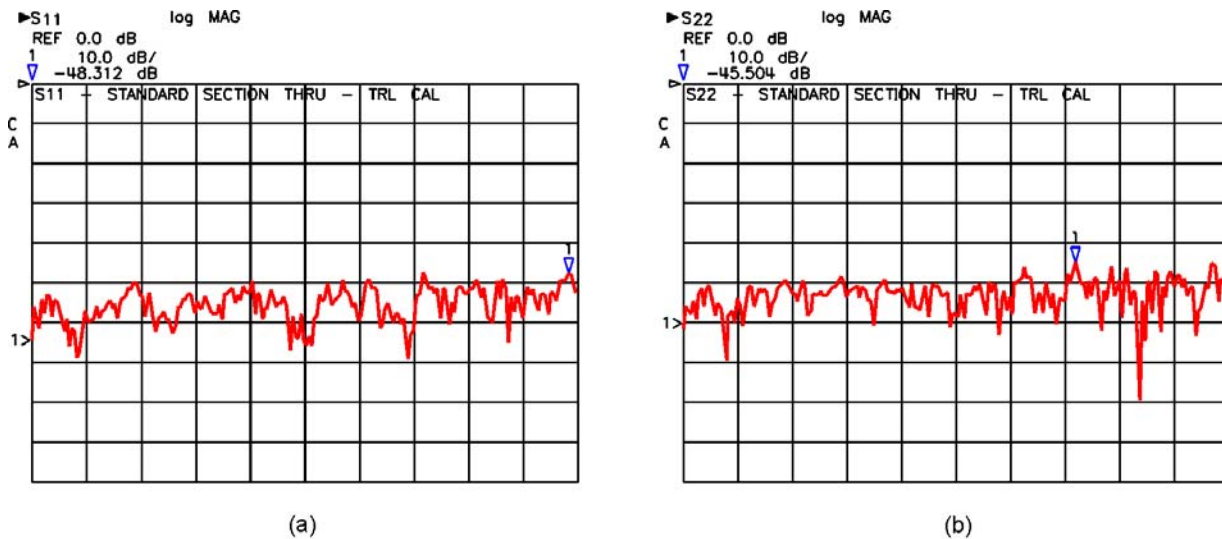
wx420a

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 S₂₂ 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

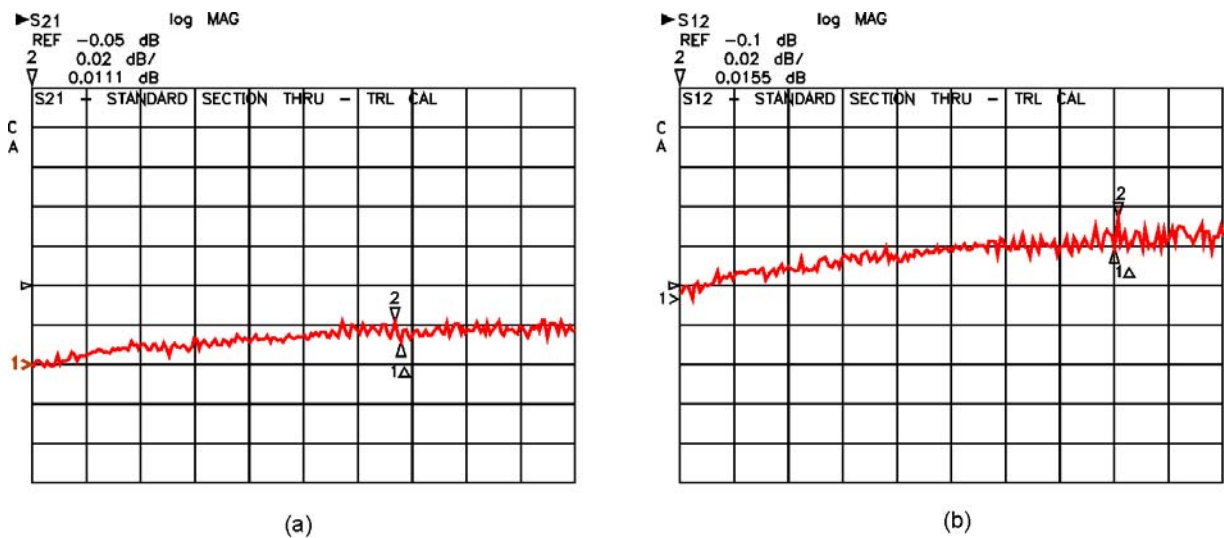


wx421a

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



wx422a

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. Re-enter commands, if necessary, including the calibration kit definitions. (You can download class assignments and standard definitions from Keysight's Calibration Kit Definitions Web page at www.na.tm.keysight.com/pna/caldefs/stddefs.html) 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}	

System Operation Checks**872x 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 [Table 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 **Ref: 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.)

- Record the maximum peak-to-peak value in the appropriate table on [page 5-15](#).
- Turn off the delta marker mode.
- 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

- Verify that the calibration is still on.
- Connect the standard section to ports 1 and 2 to form a thru connection.
- To set the display:
 - Press **[MEAS]** and select **Refl: FWD S_{11}** .
 - Press **[SCALE REF] [10] [x1]**.
 - Select **REFERENCE POSITION** and press **[10] [x1]**.
 - Select **REFERENCE VALUE** and press **[0] [x1]**.
 - Press **[MEAS]** and select **MEASURE RESTART**.
- After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in [Figure 5-4](#).
- Determine the maximum value on the trace (you can use a marker).
- Record the maximum value in the appropriate table on [page 5-15](#).
- 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

- Verify that the calibration is still on.
- Connect the standard section to ports 1 and 2 to form a thru connection.
- To set the display:
 - Press **[MEAS]** and select **Trans: FWD S_{21}** .
 - Press **[SCALE] [.02] [x1]**.
 - Select **REFERENCE POSITION [5] [x1]**.
 - Select **[REFERENCE VALUE $\pm.2$] [5] [x1]**.
 - Press **[MEAS]** and select **MEASURE RESTART**.
- After one complete measurement sweep, the displayed trace should look similar to the typical corrected trace shown in [Figure 5-5](#).
- If necessary, select **Press to Continue** to update the trace.
- 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.
- Record the maximum peak-to-peak value in the appropriate table on [page 5-15](#).

Performance Verification
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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. Re-enter commands, if necessary, including the calibration kit definitions. (However, you can download class assignments and standard definitions from Keysight's Calibration Kit Definitions Web page at www.na.tm.keysight.com/pna/caldefs/stddefs.html) 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		≤ 0.15 dB _{p-p}	
S ₂₂ , shorted		≤ 0.15 dB _{p-p}	
S ₁₁ , thru		≤ -40 dB	
S ₂₂ , thru		≤ -40 dB	
S ₂₁ , thru		≤ 0.06 dB _{p-p}	
S ₁₂ , thru		≤ 0.06 dB _{p-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		≤ 0.26 dB _{p-p}	
S ₂₂ , shorted		≤ 0.26 dB _{p-p}	
S ₁₁ , thru		≤ -37 dB	
S ₂₂ , thru		≤ -37 dB	
S ₂₁ , thru		≤ 0.07 dB _{p-p}	
S ₁₂ , thru		≤ 0.07 dB _{p-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		≤ 0.40 dB _{p-p}	
S ₂₂ , shorted		≤ 0.40 dB _{p-p}	
S ₁₁ , thru		≤ -35 dB	
S ₂₂ , thru		≤ -35 dB	
S ₂₁ , thru		≤ 0.01 dB _{p-p}	
S ₁₂ , thru		≤ 0.01 dB _{p-p}	

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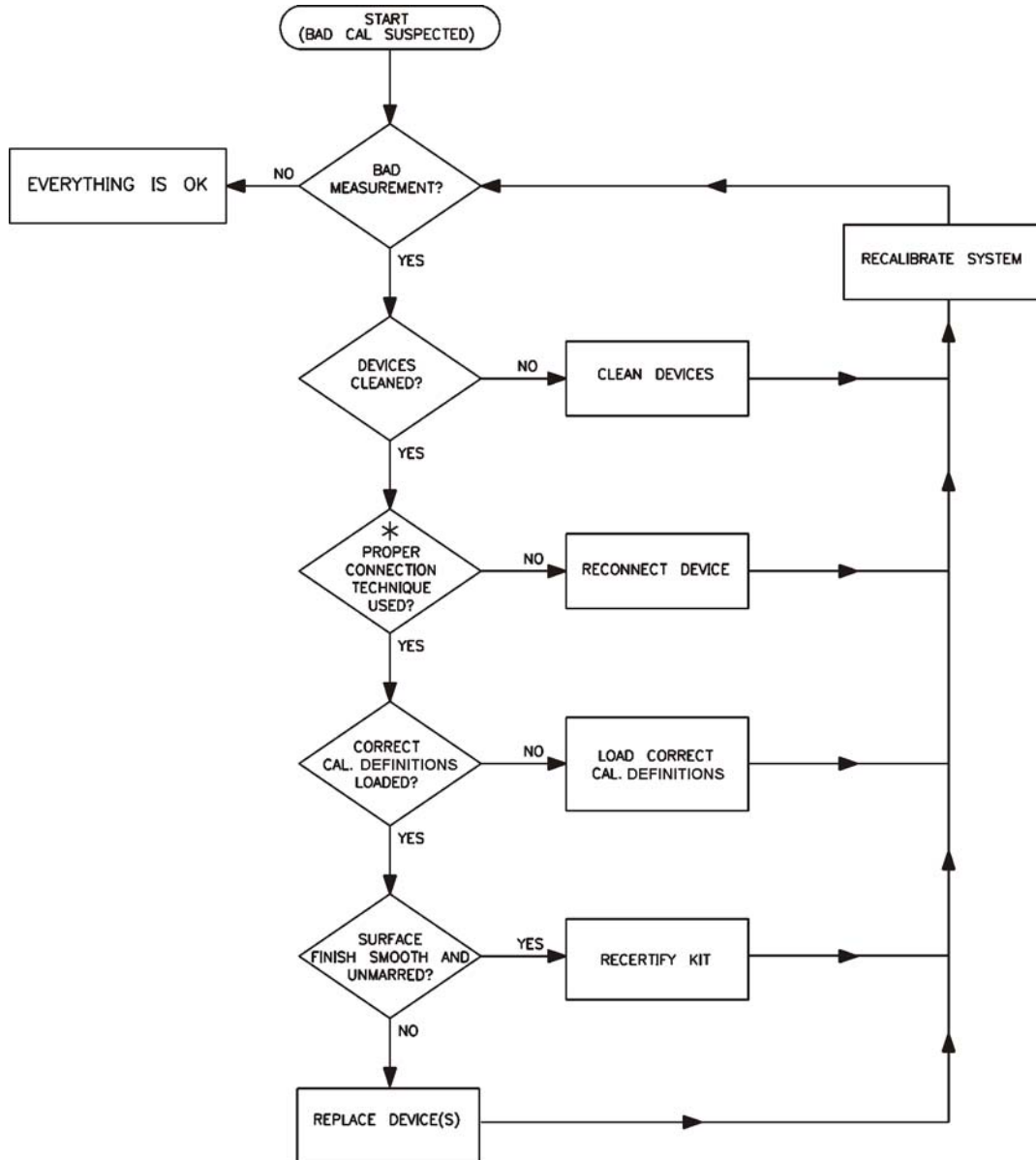
6 Troubleshooting

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



* NO GAPS; WAVEGUIDE WALLS FLUSH;
EVEN AND SYMMETRICAL TIGHTENING.

wx416a

Where to Look for More Information

This manual contains limited information about network analyzer system operation. For detailed information on using a VNA, ENA or PNA series network analyzer, refer to the appropriate user guide or online Help.

- To view the ENA or PNA online Help, press the Help key on the front panel of the network analyzer.
- To view an online VNA user guide, use the following steps:
 1. Go to www.keysight.com.
 2. Enter your VNA model number (Ex: 8753ES) in the Search box and click **Search**.
 3. Under the heading **Manuals & Guides**, click on the title/hyperlink for the document PDF you want to view.

If you need additional information, see [“Contacting Keysight” on page 6-4](#).

Returning a Kit or Device to Keysight

If your kit or device requires service, contact Keysight Technologies for information on where to send it - see [“Contacting Keysight” on page 6-4](#). 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)

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.

7 Replaceable Parts

Introduction

The following tables list the replacement part numbers for the Keysight 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.

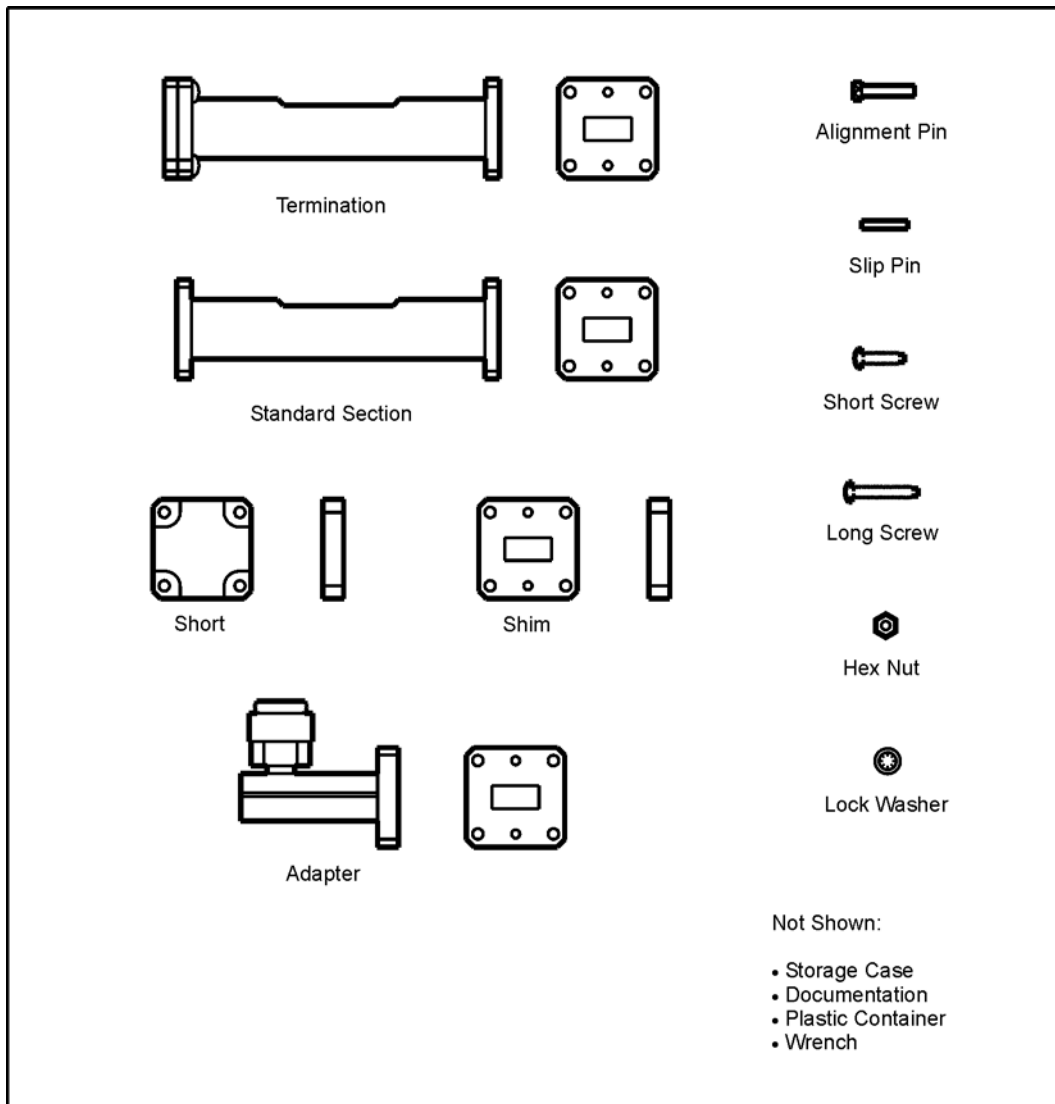
To order a listed part, note the description, part number, and the quantity desired. Telephone or send your order to Keysight Technologies. Refer to **“Contacting Keysight” on page 6-4** for further information.

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

Description	Qty Per Kit	Keysight 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	1	11644-90371
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

1. See "Printing Copies of Documentation from the Web" on page -ii in the front section.

Figure 7-1 X-Band Component Identification Sheet



wx423a

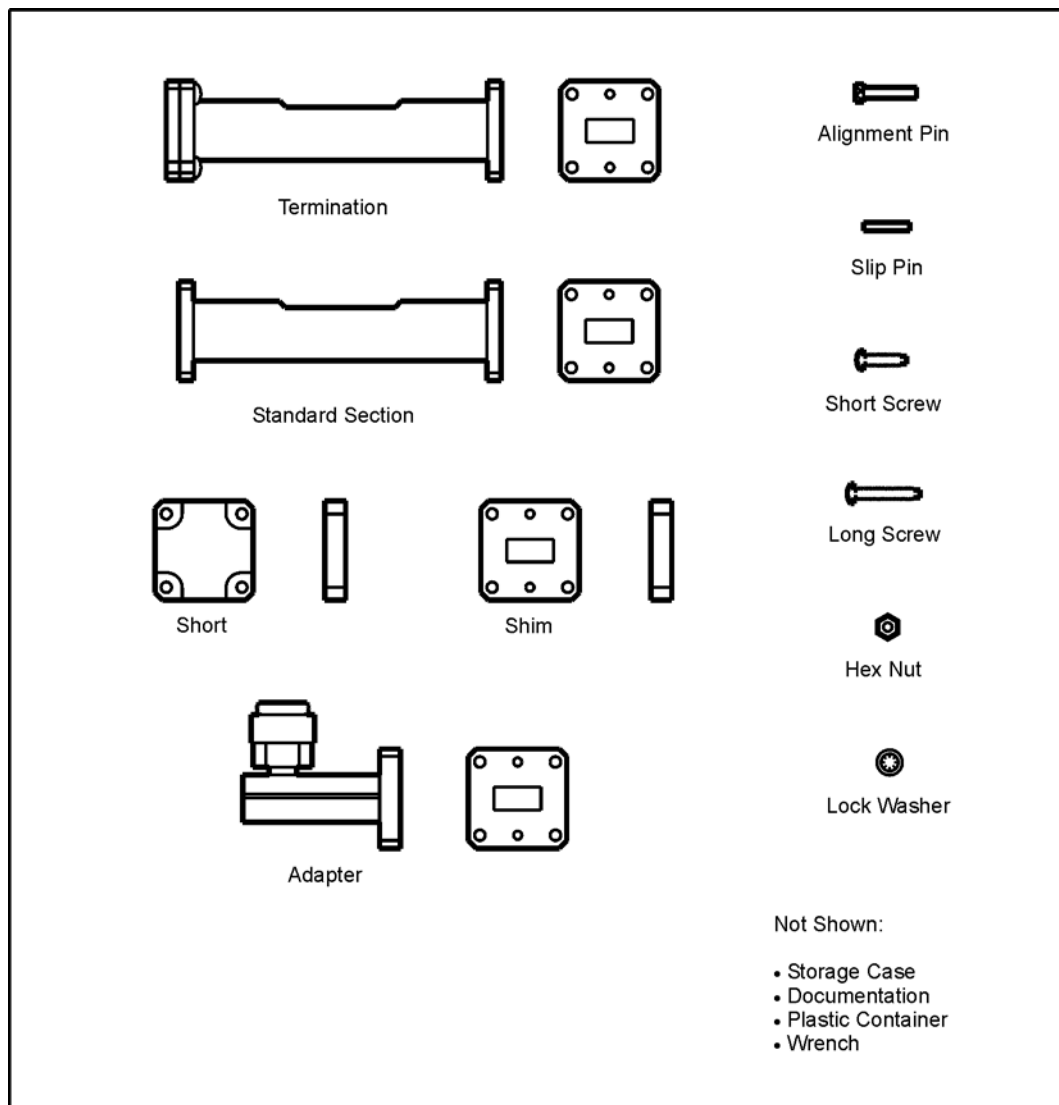
Introduction

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

Description	Qty Per Kit	Keysight 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	1	11644-90371
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

1. See "Printing Copies of Documentation from the Web" on page -ii in the front section.

Figure 7-2 P-Band Component Identification Sheet



wx423a

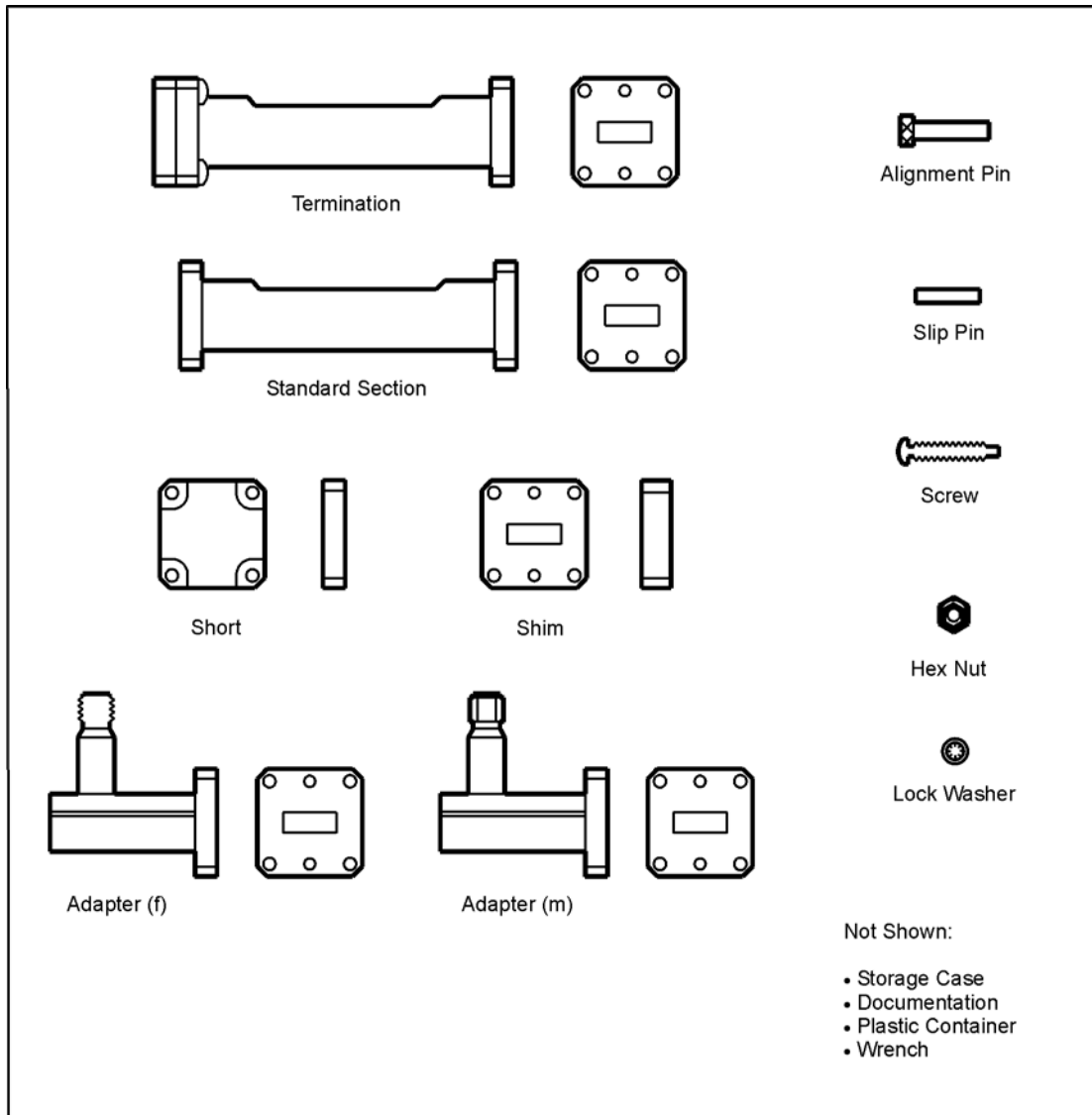
Introduction

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

Description	Qty Per Kit	Keysight 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	1	11644-90371
Calibration Kit Storage Case		
Storage case	1	5181-5720
Box	2	1540-0216
Foam pad (set)	1	11644-80032

1. See "Printing Copies of Documentation from the Web" on page -ii in the front section.

Figure 7-3 K-Band Component Identification Sheet



wx424a

Introduction

Table 7-4 Items Not Included in the Calibration Kit

Description	Qty	Keysight 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		
Anhydrous isopropyl alcohol (>92% pure) ¹	--	--
Foam-tipped cleaning swabs	100	9301-1243

1. Keysight can no longer safely ship isopropyl alcohol, so customers should purchase it locally.

A Standard Definitions

Class Assignments and Standard Definitions Values are Available on the Web

Class assignments and standard definitions may change as more accurate model and calibration methods are developed. You can download the most accurate class assignments and standard definitions from Keysight's Calibration Kit Definitions Web page at <http://na.support.keysight.com/pna/caldefs/stddefs.html>.

For a detailed discussion of calibration kits, refer to the Keysight Application Note, "Specifying Calibration Standards and Kits for Keysight Vector Network Analyzers." This application note covers calibration standard definitions, calibration kit content and its structure requirements for Keysight vector network analyzers. It also provides some examples of how to set up a new calibration kit and how to modify an existing calibration kit definition file. To download a free copy, go to www.keysight.com and enter literature number 5989-4840EN in the Search window.

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January 2015



11644-90371
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