Operating and Service Manual

HP 11644A Series R, Q, U, V, and W Waveguide Calibration Kits

SERIAL NUMBERS

This manual applies directly to HP 11644A-series calibration kits with serial number prefix 3032A and above. The calibration devices in this kit are individually serialized. Record the device serial numbers in the table provided in this manual (see "Device Serial Numbers" in Chapter 1).

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1

General Information

Calibration Kit Overview

The HP R,Q,U,V, or W band millimeter–waveguide calibration kits are used to calibrate network analyzer systems (such as the HP 8510 or HP 8720 Series). With the calibration data properly loaded in the network analyzer and a measurement calibration completed, you measure the calibration devices to correct for systematic errors.

Note TRL calibrations require HP 8510 operating system firmware revision B.05.12 or greater.

The calibration kit consists of the following:

- Short, shim, termination, and standard sections.
- A data disk that contains the calibration constants of the devices in the kit for HP 8510 systems and HP 8720 series analyzers.

Option 002 adds the following:

- A data tape that contains the calibration constants of the devices in the kit for HP 8510 systems.

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

This manual describes the HP R11644A, Q11644A, U11644A, V11644A, and W11644A waveguide calibration kits and provides replacement part numbers, specifications, and procedures for using, maintaining and troubleshooting the kit.

Note This manual assumes you know proper connector care. If not, refer to "Principles of Microwave Conector Care—Quick Reference Card", located in the back of this manual. Refer to Chapter 7, "Replaceable Parts", for HP part number if another copy is needed.

Or, contact your nearest HP Sales office for the customer training course: "Understanding Connectors Used With Network Analyzers".

- HP 85050A + 24A (on site)
- HP 85050A + 24D (at HP sales office)

Equipment Required but Not Supplied

Various connector cleaning supplies are *not* supplied with this kit. (Refer to Chapter 7, "Replaceable Parts", for ordering information.)

Serial Numbers

A serial number label is attached to this calibration kit. A typical kit serial number label is shown in Figure 1-1. The first four digits followed by a letter comprise the serial number prefix; the last five digits are the suffix, unique to each calibration kit.

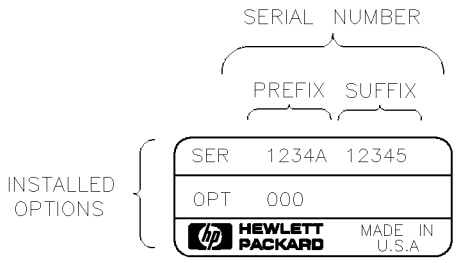

Figure 1-1. Typical Kit Serial Number Label

Calibration Kits Documented in this Manual

This manual applies to any HP 11644A-series (R, Q, U, V, or W) waveguide calibration kits whose serial prefix are listed on the title page. If your calibration kit has a different serial number prefix than the one listed on the title page, refer to the "Calibration Kit History" section below for information on how this manual applies.

Calibration Kit History

This section describes calibration kits with serial number prefixes lower than the ones listed on the title page.

HP 11644A-series R, Q, U, V, or W Kits with Serial Prefix 3012A

These calibration kits did not have the calibration constants disk to support the HP 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.

Device Serial Numbers

In addition to the kit serial number, the devices in this kit are individually serialized (serial numbers are either labeled on or scribed onto the body of each device). Record these serial numbers in the appropriate following table. This can help you avoid confusing the devices in this kit with similar devices from other kits. Kit integrity is an important part of compliance with U.S. MIL–STD 45662A, should you need to comply with this standard. The adapters are for measurement convenience only and are not regarded as devices requiring a traceable path in order to comply with MIL–STD 45662A.

Table 1-1. R-Band Kit and Device Serial Number Record

Device	Serial Number
Calibration Kit	_____
Termination	_____
Standard Section (5 cm)	_____
Standard Section (10 cm)	_____
Waveguide Straight	_____
Shim	_____
Short	_____

Table 1-2. Q-Band Kit and Device Serial Number Record

Device	Serial Number
Calibration Kit	_____
Termination	_____
Standard Section (5 cm)	_____
Standard Section (10 cm)	_____
Waveguide Straight	_____
Shim	_____
Short	_____

Table 1-3. U-Band Kit and Device Serial Number Record

Device	Serial Number
Calibration Kit	_____
Termination	_____
Standard Straight (5 cm)	_____
Standard Straight (10 cm)	_____
Waveguide Straight	_____
Shim	_____
Short	_____

Table 1-4. V-Band Kit and Device Serial Number Record

Device	Serial Number
Calibration Kit	_____
Termination	_____
Standard Section	_____
Standard Section	_____
Standard Section	_____
V-band Shim	_____
Short	_____

Table 1-5. W-Band Kit and Device Serial Number Record

Device	Serial Number
Calibration Kit	_____
Termination	_____
Standard Section	_____
Standard Section	_____
Standard Section	_____
W-band Shim	_____
Short	_____

Incoming Inspection

Refer to Figure 7-1 to verify a complete shipment. Use Tables 1-1 through 1-5 as appropriate for your kit and record the serial numbers of all serialized devices. To verify the electrical performance of the devices in this kit, see Chapter 5, "Performance Verification."

The foam lined storage case provides protection during shipping. If the case or any device appears damaged, contact the nearest Hewlett–Packard sales and service office (listed at the rear of this manual). Hewlett–Packard will arrange for repair or replacement of incomplete or damaged shipments without waiting for a settlement from the transportation company. When you send the kit or device to Hewlett–Packard, include a service tag (found at 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 phone number.
- If you are returning a complete kit, include the model number and serial number.
- If you are returning one or more devices, include the part numbers and serial numbers.
- Indicate the type of service required.
- Include any applicable information.

Preventive Maintenance

The best techniques for maintaining the integrity of the devices in this kit include routine visual inspection and cleaning, and proper connection techniques. Failure to detect and remove dirt or metallic particles on a mating plane surface can degrade repeatability and accuracy and can damage any connector mated to it. Improper connections from poor connection techniques, can also damage devices.

Visual inspection, cleaning techniques, and connection techniques are all described in Chapter 4, "Making Connections."

2

Specifications

Verifying Specifications

Hewlett–Packard verifies the specifications of the terminations in this kit as follows:

1. Hewlett–Packard first precisely measures the physical dimensions of a group of terminations, then theoretically determines their expected performance. The best device from this group is used as a standard that provide a link from Hewlett–Packard to the National Institute of Standards and Technology (NIST).
2. The terminations in this kit are tested and copared to the standard chosen in step 1.

These two steps establish a traceable likt to NIST for Hewlett–Packard to the extent allowed by the institutes calibration facility. The terminations in this kit are traceable to NIST through Hewlett–Packard.

Environmental Requirements

Table 2-1. Environmental Requirements

Parameter	Required Values/Ranges
Operating Temperature[1]	20° to 26°C (68° to 79°F)
Error–Corrected Temperature Range[2]	±1°C of measurement calibration temperature
Storage Temperature	−40° to +75°C (−40° to +167°F)
Altitude	
Operation	< 4,500 metres (≈15,000 feet)
Storage	< 15,000 metres (≈50,000 feet)
Relative Humidity	Always Non–Condensing
Operation	0 to 80% (26°C maximum dry bulb)
Storage	0 to 90%

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 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

Due to the small dimensions of the calibration devices, electrical characteristics will change with temperature. Therefore, the operating temperature is a critical factor in their performance. During a measurement calibration, the temperature of the calibration devices must be stable and within the range shown in Table 2-1.

Remember Your fingers are a heat source, so avoid handling the devices unnecessarily during calibration.

Performance verification and measurements of devices under test need not be performed within the operating temperature range of the calibration devices, but they must be within the error–corrected temperature of the network analyzer (±1°C of the measurement calibration temperature). For example, if the calibration is performed at +20°C, the error–corrected temperature range is +19° to +21°C. It is then appropriate to perform measurements and performance verifications at +19°, which is outside the operating temperature range of the calibration devices, since only the actual calibration must be performed within the operating temperature range.

HP R,Q,U,V,W11644A Series Mechanical Characteristics

For the mechanical characteristics and applicable specifications please refer to the "*Microwave Test Accessories Catalog*". Refer to chapter 7 "Replaceable Parts" for ordering information.

Electrical Characteristics and Specifications

Table 2-2. HP R11644A WR-28 Electrical Specifications

Device	Specification
Frequency Range	26.5 to 40 GHz
Termination	≥46 dB Effective Return Loss[1]

1 Effective Return Loss accounts for Line Secton, Connector, and Load Stability as used in a network analyzer to define directivity after calibration.

Table 2-3. HP Q11644A WR-22 Electrical Specifications

Device	Specification
Frequency Range	30 to 50 GHz
Termination	≥46 dB Effective Return Loss[1]

1 Effective Return Loss accounts for Line Secton, Connector, and Load Stability as used in a network analyzer to define directivity after calibration.

Table 2-4. HP U11644A WR-19 Electrical Specifications

Device	Specification
Frequency Range	40 to 60 GHz
Termination	≥ 46 dB Effective Return Loss[1]

1 Effective Return Loss accounts for Line Secton, Connector, and Load Stability as used in a network analyzer to define directivity after calibration.

Table 2-5. HP V11644A WR-15 Electrical Specifications

Device	Specification
Frequency Range	50 to 75 GHz
Termination	≥38.2 dB Return Loss
Element SWR	±1.025

Table 2-6. HP W11644A WR-10 Electrical Specifications

Device	Specification
Frequency Range	75 to 110 GHz
Termination	≥36.6 dB Return Loss
Element SWR	±1.03

Residual Errors after Calibration

The HP 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 HP 8510C *On–Site Service Manual* for information on how to use the software.

3

User Information

The Calibration Devices and Their Use

The HP R11644A, Q11644A, U11644A, V11644A, and W11644A waveguide calibration kits may contain some or all of the following: termination loads, short band, standard section, and waveguide straights.

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

Termination

Termination is also called a load. It is connected directly to the test port, or used as an offset load when combined with the 1/4 wavelength shim.

Short

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 1/4 wavelength shim.

1/4 Wavelength Shim

A 1/4 wavelength shim is also called an offset, or 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.

Waveguide Straight Section (verification device)

Waveguide straight is included as a system verification device. Be sure to keep it protected from wear and damage. When using it, always connect the same side, in the same orientation, for consistant and accurate mating.

Waveguide Striaght Section (port 1 and 2)

Two waveguide straights, provided in this kit, are used as port 1 and port 2 measurement planes when properly connected to the directional couplers (DC2 and DC3). These are provided in the band dependent HP 11643A-series Test Set Kit. Because these straight sections are used as port 1 and 2 for device connections, they reduce wear that would otherwise occur to the coupler flanges. These particular straights should be replaced or renewed whenever the calibration devices are replaced or renewed.

Calibration Applications

Note For your convenience, two lenghs 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 softkey `OMIT ISOLATION`, or use the termination and the short as the port terminations (connect one of the loads to port 1 and the other load to port 2).

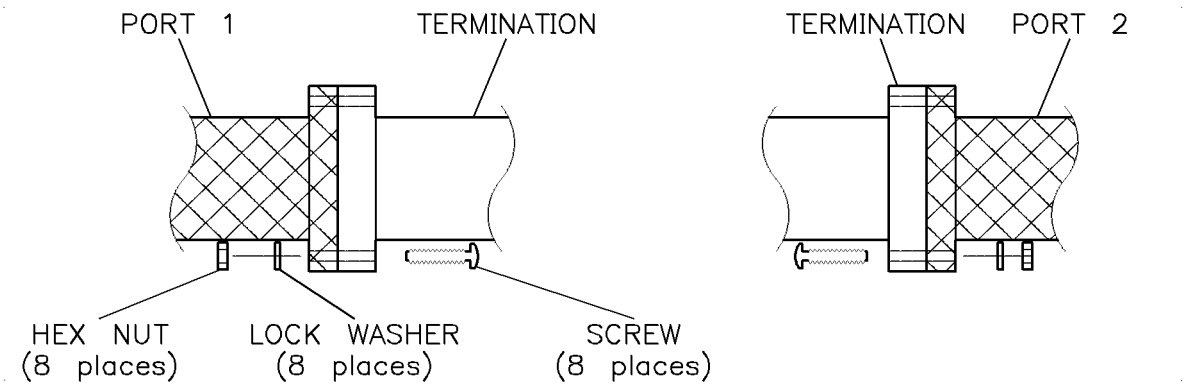

Figure 3-1.

Line

Connect the shim between port 1 and port 2.

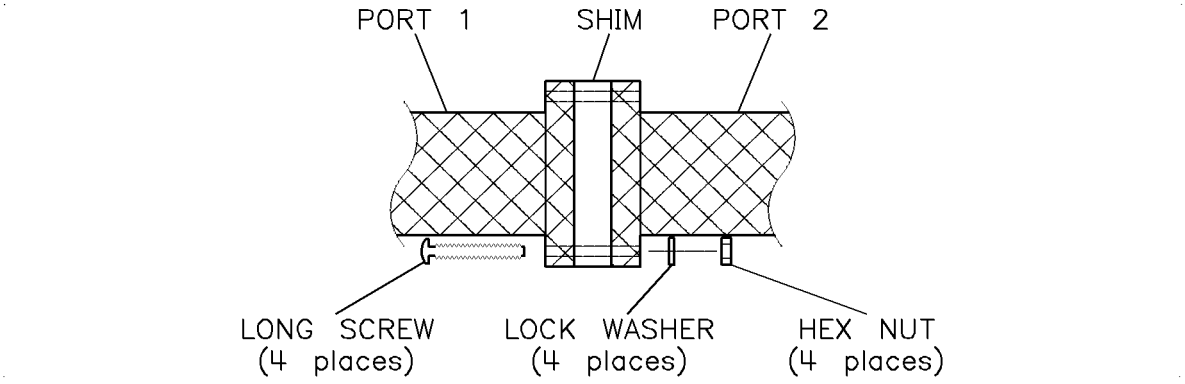

Figure 3-2.

Load

Connect the termination to the appropriate test port.

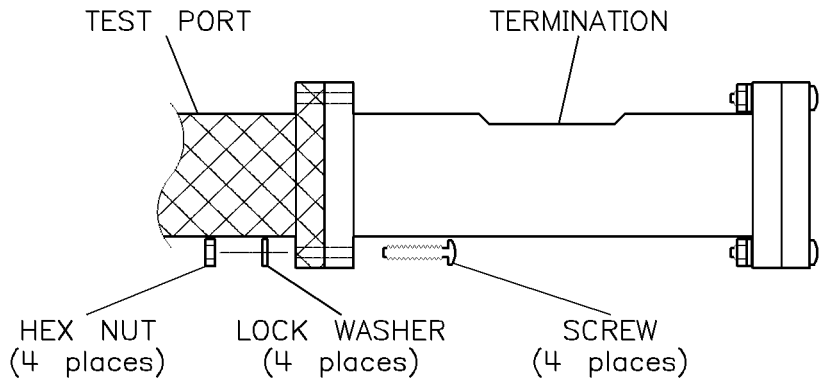

Figure 3-3.

Offset Load

Connect the shim and the termination to the appropriate test port.

Note For offset load calibration with the HP R11644A WR-28, HP Q11644A WR-22, and HP U11644A, the moving load must be in a locked position. For more information refer to "HP 8510 *Operating and Programming*", chapter 8 "Calibrating for System Measurements". For ordering information see chapter 7, "Replaceable Parts".

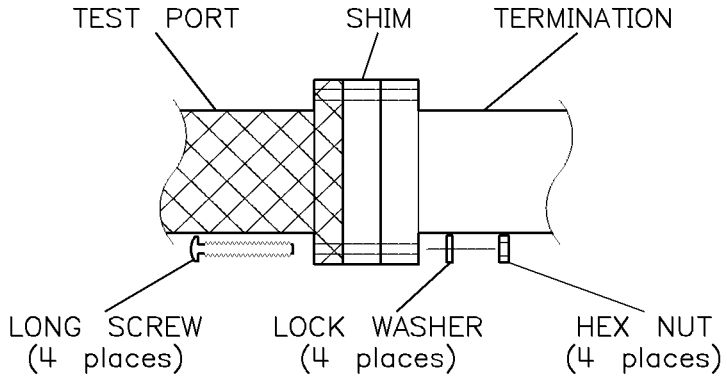

Figure 3-4.

Offset Short

Connect the shim and the short to the appropriate test port.

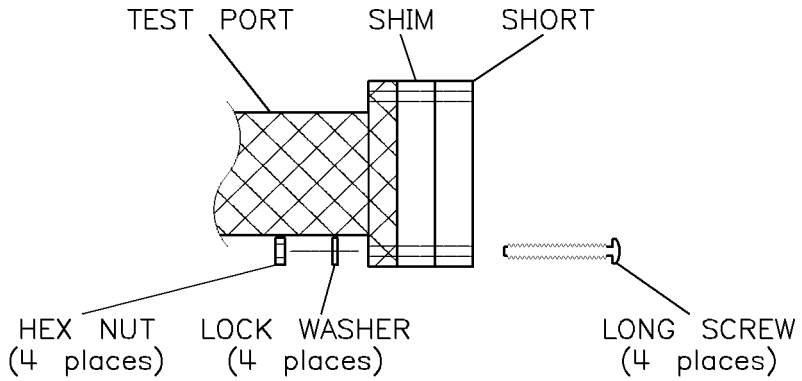

Figure 3-5.

Reflect

Connect the short to the appropriate test port.

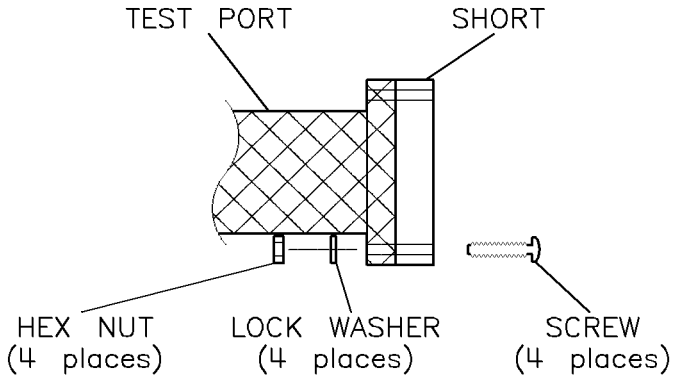

Figure 3-6.

Short

See "Reflect."

Thru

No device is required for this. Connect port 1 to port 2.

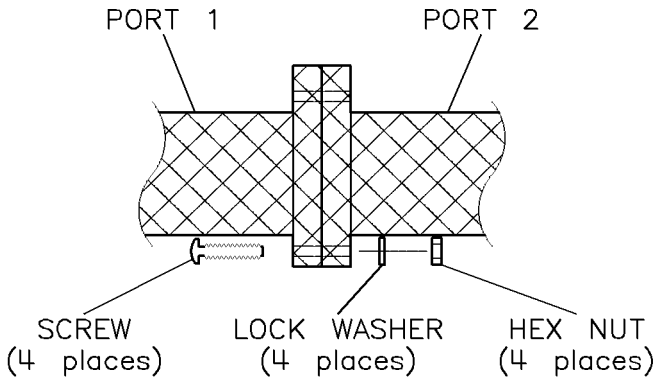

Figure 3-7.

1/4 Load

See "Offset Load."

1/4 Short

See "Offset Short."

HP 8510 Information

Loading Calibration Constants

Use one of the following procedures to load the calibration constants into HP 8510 memory.

For HP 8510A/B

1. Insert the calibration constants (option 002) tape into the HP 85101 drive.
2. Press (TAPE/DISC).
3. Select `LOAD`.
   The analyzer displays `SELECT DATA TYPE TO LOAD`.
4. Select `CAL KIT 1-2`.
5. Select either `* 1` or `* 2`.
   The analyzer displays `SELECT CAL KIT FILE TO LOAD`.
6. Select `* FILE 1` to load the calibration constants into memory.
7. Remove the tape from the drive.

For HP 8510C

1. Insert the calibration constants disk into the HP 85101 drive.
2. Press (DISC).
3. Select `LOAD`.
   The analyzer displays `SELECT DATA TYPE TO LOAD`.
4. Select `CAL KIT 1-2`.
5. Select either `* 1` or `* 2`.
   The analyzer displays `USE KNOB OR STEP KEYS TO SELECT A FILE`.
6. Select the following appropriate key from the display menu:

   `WR-28 A0` (for R-band calibration)

   `WR-22 A0` (for Q-band calibration)

   `WR-19 A0` (for U-band calibration)

   `WR-15 A0` (for V-band calibration

   `WR-10 A0` (for W-band calibration
7. Select `LOAD FILE`.
8. Remove the disk from the drive.

For HP 8720 Series

Use the following procedure to load the calibration constants into an HP 8720. If you are using an HP 8510, see "Loading Calibration Constants" in this manual. If you are using an analyzer other than an HP 8510 or HP 8720, refer to the documentation for your analyzer.

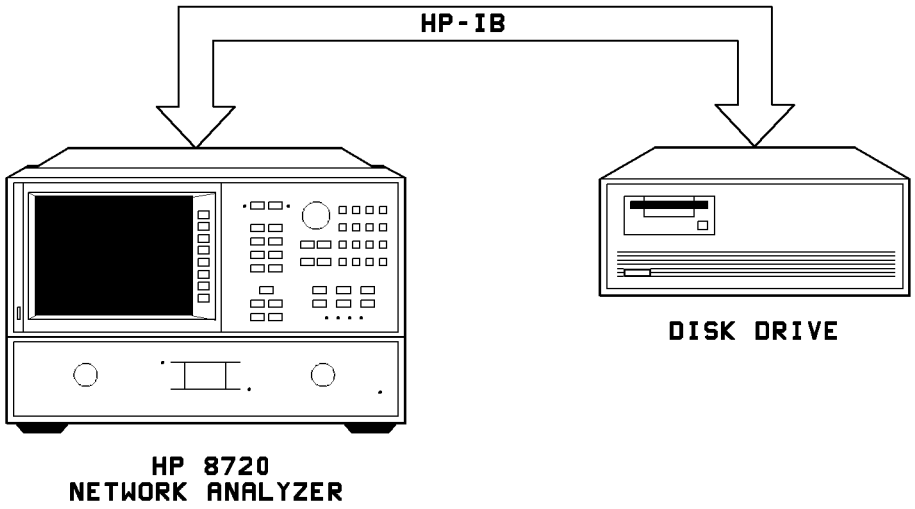

Figure 3-8. Setup to Load Calibration Constants into an HP 8720

1. Connect the equipment as shown in figure 3–8. Turn on the disk drive.
2. Turn on the network analyzer.
3. Insert the calibration constants disk from this kit into drive 0.
4. On the analyzer, press (LOCAL), and select `SYSTEM CONTROLLER` `SET ADDRESSES` `ADDRESS: DISK`.
   Ensure that the disk drive address displayed on the analyzer matches the address set on the disk drive.
5. Press (RECALL), and select `LOAD FROM DISK` `READ FILE TITLES`.
   The analyzer displays the files that are on the disk.
6. Select the appropriate softkey to load the information for this calibration kit.

Duplicating a Calibration Constants Disk

Use the following procedure to make a backup copy of a calibration constants disk on an HP 8510C network analyzer. If you are using a different network analyzer, or are using an external disk drive, refer to the analyzer documentation.

1. Load the original calibration constants disk (see previous procedure).
2. Initialize a blank disk:
   a. Insert the disk into the HP 85101 disk drive.
   b. Press (DISC).
   c. Select STORAGE IS INTERNAL SETUP DISC INITIALIZE DISC YES.
3. With an initialized disk in the HP 85101 disk drive, transfer the calibration constants:
   a. Press (DISC) (STORE).
   b. Select CAL KIT/12 CAL KIT/*1.
   c. Select the appropriate data type.
4. Remove, write protect, and label the disk.

Performing a Calibration

Use the following steps to set up an HP 8510 network analyzer for your specific 11644A series calibration.

1. Be sure that the system impedance is set to 1 ohm by pressing (CAL) MORE SET Z0.
2. If the display does *not* read 1 Ω, press (1) (×1).
3. Load the following appropriate file from the calibration constants disk or tape (option 002):

   WR-28 A0 (for R-band calibration)

   WR-22 A0 (for Q-band calibration)

   WR-19 A0 (for U-band calibration)

   WR-15 A0 (for V-band calibration)

   WR-10 A0 (for W-band calibration)

   Refer to the "Loading Calibration Constants" section of this chapter.
4. Press (CAL) then the appropriate softkey WR-28 A0, WR-22 A0, WR-19 A0, WR-15 A0, or WR-10. The calibration options are available as softkeys on the display. As selections are made, more softkeys appear.
5. Follow the prompts on the display or refer to the HP 8510 *Operating Manual* for more information.

Examining Calibration Constants

Use the following procedure to examine the calibration constants of a short. To examine the calibration constants of a different standard, substitute the standard number in step 3 with the standard number of the device you want to examine. For example, to examine the calibration constants for an open, press (2) (x1). See Table A-4 through Table A-9 at the end of this manual, for the appropriate standard numbers for your kit.

1. Press (CAL).
2. Select:
   a. MORE.
   b. MODIFY 1 or MODIFY 2 (depending on where the calibration constants are loaded).
   c. DEFINE STANDARD.
3. Press (1) (x1) (the calibration standard number).
   The softkey SHORT is underlined.
4. Select:
   a. SHORT LO L1 L2 L3 (the analyzer displays the value of each L–term as the softkeys are selected).
   b. SPECIFY OFFSET.
   c. OFFSET DELAY (the analyzer displays the value).
   d. OFFSET LOSS (the analyzer displays the value).
   e. OFFSET ZO (the analyzer displays the value).
   f. MINIMUM FREQUENCY (the analyzer displays the minimum frequency).
   g. MAXIMUM FREQUENCY (the analyzer displays the value).
      The softkey COAX is underlined.
5. Select (PRIOR MENU) LABEL STD.
   SHORT is displayed on the analyzer (in the upper left corner of the display).
6. Press:
   a. (PRIOR MENU) three times.
      The top softkey is DEFINE STANDARD.
   b. (ENTRY OFF).

Changing Calibration Constants

Use the following procedure to change the calibration constants of a short. To change the calibration constants of a different standard, substitute the standard number in step 3 with the standard number of the device you want to change. For example, to change the calibration constants for an open, press 2 x1. See Table A-4 through Table A-9 at the end of this manual for the appropriate standard numbers for your kit.

Note Hewlett-Packard provides this procedure for users who wish to customize standards definitions for their own special purposes. Customers who do this need to be aware that doing so may invalidate the published specifications of their network analyzer.

For more information on how to modify calibrations kit definitions, see product note 8510-5A (for ordering information see Chapter 7 "Replaceable Parts").

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1. Press CAL.
2. Select:
   a. MORE.
   b. MODIFY 1 or MODIFY 2 (depending on where the calibration constants are loaded).
   c. DEFINE STANDARD.
3. Press 1 x1 (the calibration standard number).
   The softkey SHORT is underlined.
4. Select:
   a. SHORT L0, and enter the new L–term value. Do the same for L1, L2 and L3.
   b. SPECIFY OFFSET.
   c. OFFSET DELAY, and enter the new offset delay.
   d. OFFSET LOSS, and enter the new offset loss.
   e. OFFSET Z0, and enter the new Z_0.
   f. MINIMUM FREQUENCY, and enter the new minimum frequency.
   g. MAXIMUM FREQUENCY, and enter the new maximum frequency.
      The softkey COAX is underlined.

5. Select (PRIOR MENU) `LABEL STD`.
   `SHORT` is displayed on the analyzer (in the upper left corner of the display).
6. Select `TITLE DONE` `STD DONE (DEFINED)`.
7. Relabel the kit:
   a. Select `LABEL KIT` and follow the instructions on the analyzer. You can enter a total of 10 characters.
   b. Select `TITLE DONE`.

Changing the 1/4 Wavelength Shim Calibration Definition

The thickness of each 1/4 wavelength shim is within the mechanical tolerance documented in the "Mechanical Characteristics" section of this manual. The calibration constants data provided with this kit has a nominal value for the shim offset delay. Either 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 1/4 wavelength shim delay to relflect the specific device in your kit.

1. Load the calibration kit data into Cal Kit 1 (see "Loading Calibration Constants").
2. Using the formula below, calculate the offset delay:

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

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

3. Calculate as follows:
   a. Define the offset delay in the HP 8510:
      i. Press (CAL) and select `MORE` `MODIFY 1` `DEFINE STANDARD`
      ii. Press (3) [x1]] (the calibration standard number)
      iii. Select `SHORT` `SPECIFY OFFSET` `OFFSET DELAY`
      iv. Enter the vallue calculated above, and press (G/n). Although you enter the value in nanoseconds, it is displayed in picoseconds.
      v. Select `STD OFFSET DONE` `STD DONE (DEFINED)`
   b. Define the offset delay at the offset short standard:
      i. Select `DEFINE STANDARD`, and press (15) (x1)
      ii. Select `DELAY/THRU` `SPECIFY OFFSET` `OFFSET DELAY`
      iii. The analyzer displays the offset delay in picoseconds and milimeteres (length). Use the RPG knob to "dial in" the delay defined in step 3.
      iv. Select `STD OFFSET DONE` `STD DONE`
   c. Define the offset delay at the offset load standard:
      i. Select `DEFINE STANDARD`, and press (2) (0) (x1)
      ii. Select `LOAD` `SPECIFY OFFSET` `OFFSET DELAY`
      iii. Use the RPG knob to "dial in" the delay defined in step 3
      iv. Select `STD OFFSET DONE` `STD DONE`

d. Relabel the kit:

   i. Select `LABEL KIT` and follow the instructions displayed on the analyzer

   ii. Select `TITLE DONE`

   iii. To save the modified kit, select `KIT DONE (MOD)`

e. Store the modified Cal Kit 1 on disk or tape (option 002):

   i. Press (TAPE/DISC) and select `STORE CALKIT *1`

   ii. For tape, select `*FILE 2`; for disk, enter the file name. The asterisk indicates data in FILE 2. The original data is FILE 1 is unchanged. You can also store FILE 1 on a separate disk or tape.

Remember If you change and store the offset value on tape or disk, the media no longer contains the nominal value. Be sure to label it appropriately.

4

Making Connections

Electrostatic Discharge

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

Static electricity builds up on the body and can easily damage sensitive internal circuit elements when discharged by contact with the center conductor. Static discharges too small to be felt can nevertheless cause permanent damage. Devices such as calibration components and devices under test can also carry an electrostatic charge.

- Always have a grounded antistatic mat in front of your test equipment and wear a grounded wrist strap attached to it.
- 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 briefly to discharge static from your body.
- Discharge static electricity from a device before connecting it: touch the device briefly (through a resistor of at least 1 MΩ) to either the outer shell of the test port or to another exposed ground. This discharges static electricity and protects test equipment circuitry.

Refer to Chapter 7, "Replaceable Parts", for information on ordering supplies for ESD protection.

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, lean all mating surfaces. For details see "Principles of Microwave Connector Care—Quick Reference Card", located in the rear of this manual, refer to Chapter 7 for the HP part number if another copy is needed.

Obvious Defects or Damage

Examine the connectors first for obvious defects or damage: badly worn plating, deformed threads or bent, broken, or misaligned center conductors. Connector nuts should move smoothly and be free of burrs, loose metal particles, and rough spots.

Any connector that has obvious defects should be discarded or sent for repair.

Mating Plane Surfaces

Flat contact between the connectors at all points on their mating plane surfaces is required for a good connection. Look especially for deep scratches or dents, and for dirt and metal particles on the connector mating plane surfaces.

Also look for bent or rounded edges on the mating plane surfaces of the center and outer conductors and for signs of damage due to excessive or uneven wear or misalignment.

Light burnishing of the mating plane surfaces is normal, and is evident as light scratches or shallow circular marks distributed more or less uniformly over the mating plane surface. Other small defects and cosmetic imperfections are also normal. None of these affect electrical or mechanical performance.

If a connector shows deep scratches or dents, particles clinging to the mating plane surfaces, or uneven wear, clean and inspect it again. Damaged connectors should be discarded or sent for repair. Try to determine the cause of damage before connecting a new, undamaged connector in the same configuration.

Connector Wear

Connector wear eventually degrades performance. The more use a connector gets, the faster it wears and degrades. The wear is greatly accelerated when connectors are not kept clean. Calibration devices should have a long life if their use is on the order of a few times per week. The test port connectors on the network analyzer test set may have many connections each day, and are therefore more subject to wear. It is recommended that an adapter be used as a test port saver to minimize the wear on the test set's test port connectors. Replace all worn connectors.

Cleaning Connectors

For details on cleaning connectors, "Principles of Microwave Connector Care—Quick Reference Card", located at the back of this manual. Refer to Chapter 7, "Replaceable Parts", for the HP part number if another copy is needed.

Connections

Good connections require a skilled operator. Instrument sensitivity and coaxial connector mechanical tolerances are such that 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.*

Connecting Waveguides

Unlike threaded devices, the WR-28, WR-22, WR-19, WR-15, and WR-10 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.

Precison Flanges

A precision flange has four corner holes (for the screws) *and* two precision alignment holes, as shown in Figure 4-1. A non-precision flange has only the four corner holes.

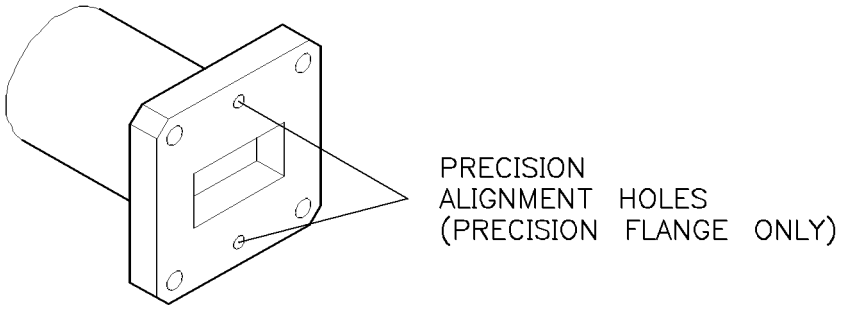


Figure 4-1.

If you wish to connect two precision flanges, begin at "Aligning a Precision and Non–Precision Flange."

Aligning Two Precision Flanges

1. Place slip pins in the top and bottom holes of one flange (see Figure 4-2).

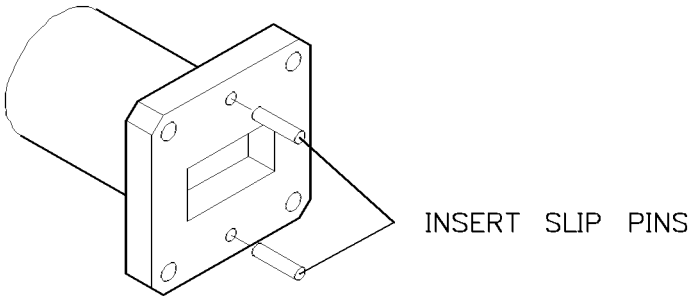


Figure 4-2.

2. Using the pins a guides, carefully align the flanges, and insert screws in two opposite corner holes (Figure 4-3).

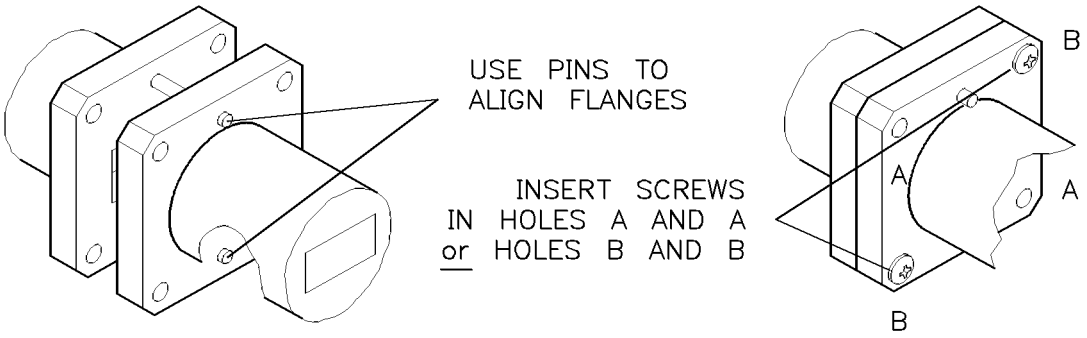


Figure 4-3.

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

Aligning a Precision and 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 (Figure 4-4).

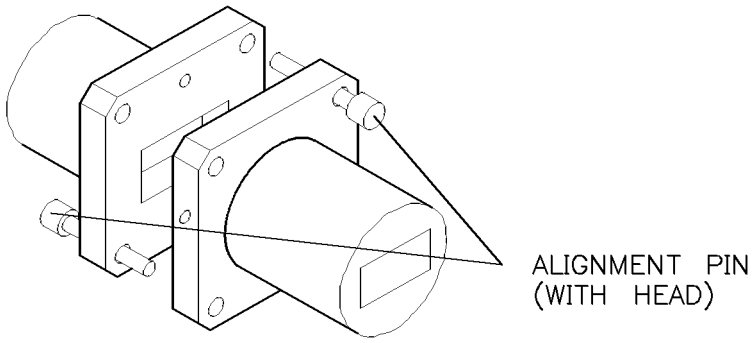


Figure 4-4.

2. Using the pins a guides, carefully align the flanges, and insert screws in the two open 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 screw, and finger tighten.
6. Go to "Tightening a Flange Connection".

Tightening A Flange Connection

1. In an X pattern (for equal compression), tighten all four screws (Figure 4-5). Do not over-tighten.

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

---

2. visually inspect the connection (see "Inspecting a Flange Connection").

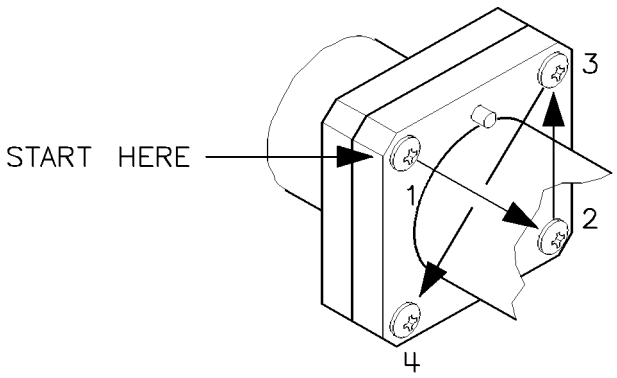


Figure 4-5.

Inspecting a Flange Connection

Visually inspect a 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. Ensures that all four screws are equally torqued.

Remember The most common cause of measurement error is poor connections.

Handling and Storage

- Store calibration devices in a foam–lined storage case.
- Never store connectors loose in a box, in a desk, or in a bench drawer. This is the most common cause of connector damage during storage.
- Keep connectors clean.
- Do not touch mating plane surfaces. Natural skin oils and microscopic particles of dirt are easily transferred to a connector interface and are very difficult to remove.
- Do not set connectors 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.
- When you are not using a connector, use plastic end caps over the mating plane surfaces to keep them clean and protected.

5

Performance Verification

The performance of your calibration kit can only be verified by returning the kit to Hewlett–Packard for recertification. The equipment and calibration standards required to verify the specifications limits of the devices inside the kit have been specially manufactured and are not commercially available. Hewlett–Packard recognizes its responsibility to provide you with procedures to reconfirm the published specifications of any product offered. That commitment applies equally to the HP P11644A WR-62, HP X11644A WR-90, and HP K11644A WR-42 waveguide calibration kit. If it is imperative that the performance test processes for this kit be explained or made available to you, contact the nearest Hewlett–Packard sales and service office listed at the back of this service manual.

To confirm that your calibration kit is performing accurate calibrations use the appropriate HP 11645A Verification Kit with the "Specifications & Performance Verification" disk included in this kit.

What Recertification Provides

The following will be provided with a recertified kit:

- New calibration sticker affixed to the case.
- Certificate of Calibration.
- List of NIST (United States National Institute of Standards and Technology) traceable numbers.
- A calibration report for each device in the kit listing measured values, specifications, and uncertainties.

For more information, contact the nearest Hewlett–Packard office (sales and service offices are listed in the rear of this manual).

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 In some cases, the first time a kit is used after being recertified occurs some time after the actual recertification date. The recertification interval should begin on the date the kit is *first used*.

Where to Send a Kit for Recertification

Contact the sales and service office nearest you for information on where to send your kit for recertification (offices are listed in the rear of this manual). When you return the kit, fill out and attach a service tag. (Refer to "Returning a Kit or Device to HP" in Chapter 6, "Troubleshooting.")

How Hewlett–Packard Verifies the Devices in this Kit

Hewlett–Packard verifies the specifications of these devices as follows:

The residual microwave error terms of the test system are verified with precision airlines and shorts, or low frequency resistance. The resistance is then directly traced back to NIST (United States National Institute of Standards and Technology). 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 back to NIST through various plug and ring gages and other mechanical measurements.

Each calibration device is electrically tested on this test system to the specifications listed in this manual.

These two steps establish a traceable link to NIST for Hewlett–Packard to the extent allowed by the Institute's calibration facility. The devices in this kit are traceable to NIST through Hewlett–Packard.

Performance Test

Termination Return Loss Measurement

Use this test to check the performance of the terminations in this kit.

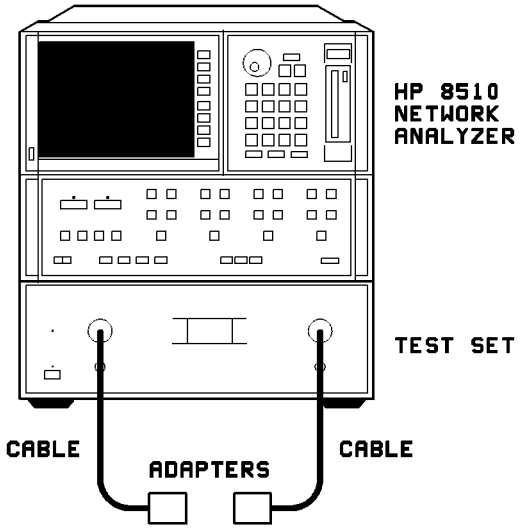


Figure 5-1. Return Loss Test Setup

1. Connect the equipment as shown in Figure 5-1. Turn on and preset the HP 8510. Let the setup warm up for at least one hour.

Note The calibration kit coefficients must already be loaded in the analyzer. If not, see "HP 8510 System Operation Check".

2. Set the appropriate start frequency to:

   26.5 GHz (for R-band)

   33 GHz (for Q-band)

   40 GHz (for U-band)

   50 GHz (for V-band)

   75 GHz (for W-band)

3. Set the appropriate stop frequency to:

   40 GHz (for R-band)

   50 GHz (for Q-band)

   60 GHz (for U-band)

   75 GHz (for V-band)

   110 GHz (for W-band)

4. Set the averaging factor to 1024.

5. At the adapter test port, perform a 2–port TRL calibration:
   a. Press (CAL). The calibration selections appear as softkeys on the display. As you make a selection, more softkeys appear.
   b. Select the appropriate softkey:
      `WR-28` (for R–band calibration).
      `WR-22` (for Q–band calibration).
      `WR-19` (for U–band calibration).
      `WR-15` (for U–band calibration).
      `WR-10` (for U–band calibration).
   c. Select `TRL 2-Port`.
   d. Follow the prompts on the display.
6. Turn on the calibration.
7. Connect the termination you wish to test to port 1.
8. Press:
   a. (S11)
   b. RESPONSE (REF POSN) (1) (0) (x1)
   c. (REF VALUE) (0) (x1)
   d. (SCALE) (1) (0) (x1)
   e. MEASUREMENT (RESTART)
9. After one complete measurement sweep, the displayed trace should look similar to that shown in Figure 5-2
10. If necessary, select `Press to Continue` to update the trace.
11. Use a marker to determine the maximum value on the trace:
    a. Press MEMUS (MARKER) (1)
    b. Select `More Maximum`
       The market displays the maximum return loss value.

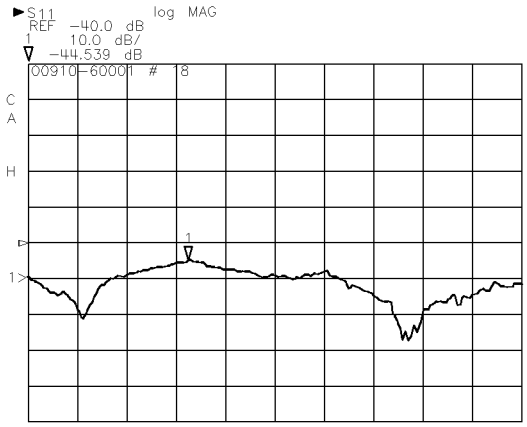


Figure 5-2. Typical Termination Return Loss

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.

6

Troubleshooting

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

Returning a Kit or Device to HP

If your kit or device requires service, contact the HP office nearest you for information on where to send it see sales and service offices listed at the rear of this manual. When you send the kit or device to Hewlett–Packard, include a service tag (found in the rear 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 phone number.
- If you are returning a complete kit, include the model number and serial number.
- If you are returning one or more devices, include the part number and serial number.
- Indicate the type of service required.
- Include any applicable information.

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 your local Hewlett–Packard representatives. Sales and service offices are listed in the rear of this manual.

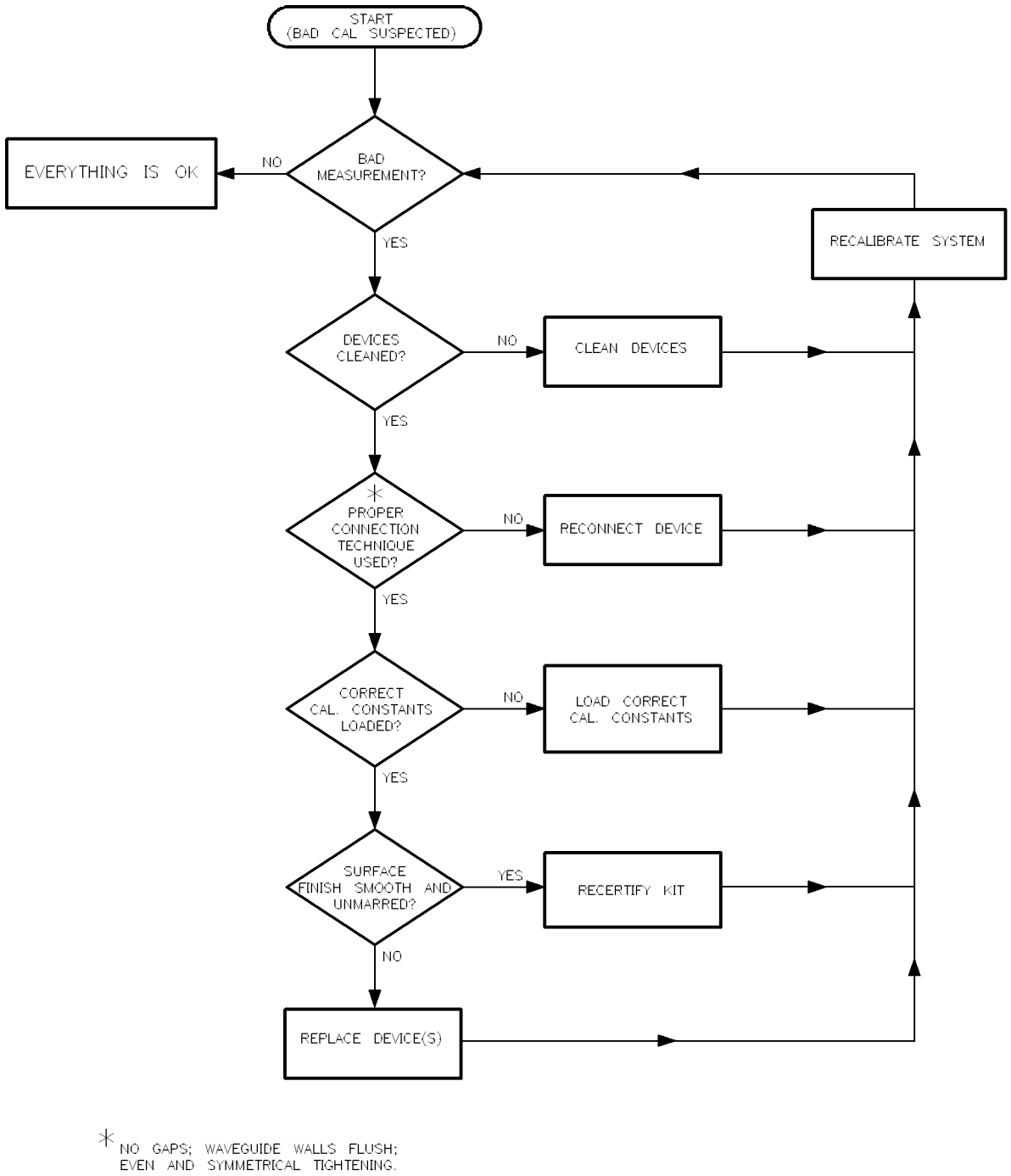


Figure 6-1.
HP R11644A, Q11644A, U11644A, V11644A, and W11644A
Troubleshooting Flowchart

7

Replaceable Parts

The following tables list the replacement part numbers for the HP R11644A, Q11644A, U11644A, V11644A, and W11644A waveguide calibration kit contents. To order a listed part, note the description, HP part number, and the quantity desired. Telephone or send your order to the nearest Hewlett–Packard sales and service office (listed at the rear of this manual).

Table 7-1. HP R11644A WR-28 Replaceable Parts

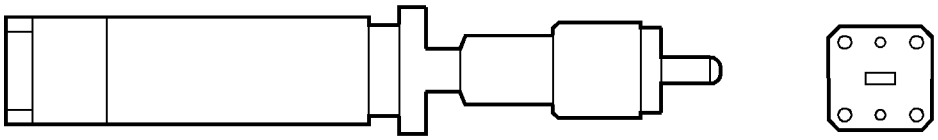
Description	Qty Per Kit	HP Replacement Part Number
Calibration Devices		
Standard Section (5 cm)	2	11644–60016
Standard Section (10 cm)	2	11644–60001
Waveguide Load	1	00914–60028
Short	1	11644–20005
R-band Shim	1	11644–20003
Hardware		
Alignment Pin	6	11644–20009
Slip Pin	6	11644–20006
4-40 Hex Nut .094 inches thick	12	2260–0002
4-40 SKT HD Screw .750 inches long	12	3030–0721
Lock Washer .115 inches	12	2190–0030
Open End Wrench	1	8720–0013
Hex Ball	1	8710–1539
Miscellaneous Items		
Operating and Service Manual	1	11644–90369
Calibration Constants Disk	1	11644–10012
Calibration Constants Tape (option 002)	1	11644–10001
Program Data Disk	1	08510–10033
Connector Care—Quick Reference Card	1	08510-90360
Items Not Included in Kit		
Blank Tape (for data backup)		9164–0166
Microwave Test Accessories Catalog		5091–4269
Operating and Programming		08510–90281
HP Product Note 5A		08510–90352
Isopropyl Alcohol (30 ml)		8500–5344
Cleaning Swabs (100)		9301–1243
Grounding Wrist Strap		9300–1367
5 ft Grounding Cord for Wrist Strap		9300–0980
2 × 4 ft Conductive Table Mat and 15 ft Ground Wire		9300–0797
ESD Heel Strap (for conductive floors)		9300–1126

R-Band: HP 11644A CALIBRATION KIT COMPONENT IDENTIFICATION SHEET

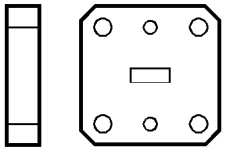
A1 - 10 cm Straight Verification Line (1)

Used for system verification only.

A2 - Waveguide Load

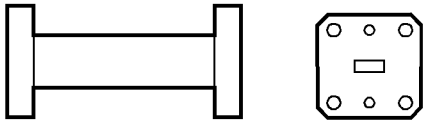


A3 - 1/4 Wavelength Section (1)



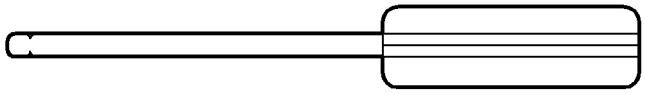
Has mechanical length labeled on side or recessed area.

W24 - W25 5 cm Waveguide Straight (2)

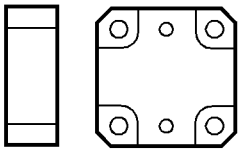


Used as port 1 and 2

MP1 - 3/32 inch Hex Ball Driver (1)

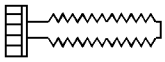


A4 - Flush Short (1)



MP2 - Alignment Pin (short) (6)

MP3 - Alignment Pin (long) (6)

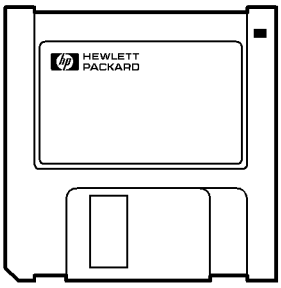


MP4 - 4-40 Skt. Hd. Screw (12)

MP5 - Lock Washer (12)

MP6 - 4-40 Hex Nut

Data Disc (1)



NOTE: Short pins used on Cal devices, long pins used on DUT's.

partsr.cdr

Figure 7-1. HP R11644A WR-28 Replaceable Parts

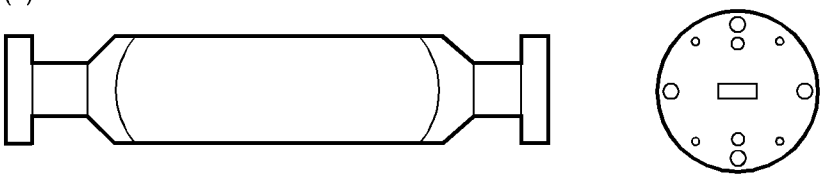
Table 7-2. HP Q11644A WR-22 and U11644A WR-19 Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Calibration Devices		
Q-band Standard Section (5 cm)	2	11644–60017
U-band Standard Section (5 cm)	2	11644–60018
Q-band Standard Section (10 cm)	2	11644–60002
U-band Standard Section (10 cm)	2	11644–60003
Q-band Waveguide Load	1	11644–60005
U-band Waveguide Load	1	11644–60006
Q-band Shim	1	11644–20001
U-band Shim	1	11644–20002
Short (Q/U band)	1	11644–20004
Hardware		
Alignment Pin	6	11644–20008
Slip Pin	6	11644–20006
4-40 SKT HD Screw .500 inches long	12	3030–0209
4-40 Captive Screw .43 inches long	12	1390–0764
4-40 Captive Screw .31 inches long	24	1390–0671
Hex Ball	1	8710–1539
Miscellaneous Items		
Operating and Service Manual	1	11644–90369
Q-band Calibration Constants Disk	1	11644–10013
U-band Calibration Constants Disk	1	11644–10014
Q-band Calibration Constants Tape (option 002)	1	11644–10002
U-band Calibration Constants Tape (option 002)	1	11644–10003
Program Data Disk	1	08510–10033
Connector Care—Quick Reference Card	1	08510-90360
Items Not Included in Kit		
Blank Tape (for data backup)		9164–0166
Microwave Test Accessories Catalog		5091–4269
Operating and Programming		08510–90281
HP Product Note 5A		08510–90352
Isopropyl Alcohol (30 ml)		8500–5344
Cleaning Swabs (100)		9301–1243
Grounding Wrist Strap		9300–1367
5 ft Grounding Cord for Wrist Strap		9300–0980
2 × 4 ft Conductive Table Mat and 15 ft Ground Wire		9300–0797
ESD Heel Strap (for conductive floors)		9300–1126

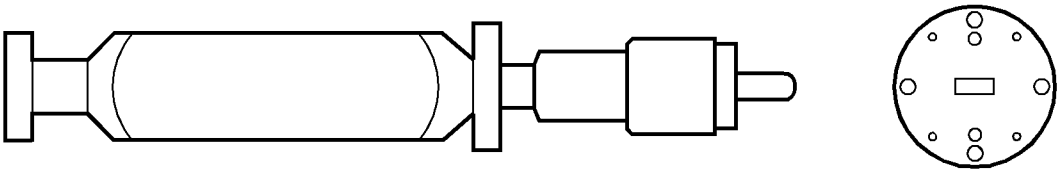
Q and U BAND: HP 11644A CALIBRATION KIT COMPONENT IDENTIFICATION SHEET

A1 - 10 cm Straight Verification Line (1)

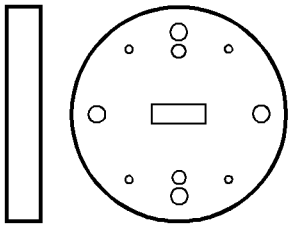
Used for system verification only.



A2 - Waveguide Load

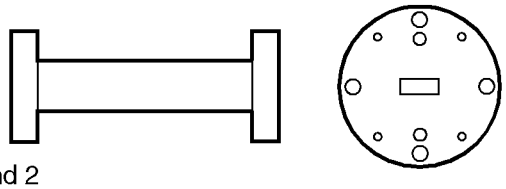


A3 - 1/4 Wavelength Section (1)



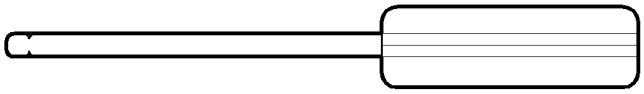
Has mechanical length labeled on side or recessed area.

W24 - W25 5 cm Waveguide Straight (2)

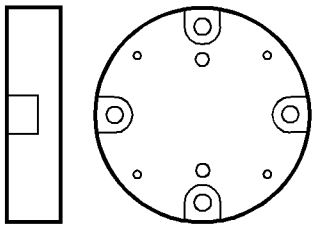


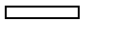
Used as port 1 and 2

MP1 - 3/32 inch Hex Ball Driver (1)

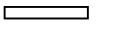


A4 - Flush Short (1)

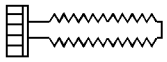




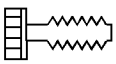
MP2 - Alignment Pin (short) (6)



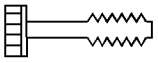
MP3 - Alignment Pin (long) (6)



MP4 - 4-40 Skt. Hd. Screw (12)

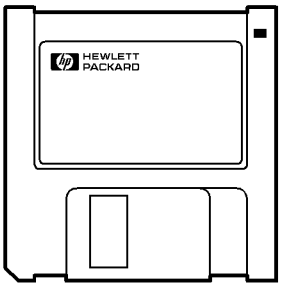


MP5 - 4-40 Captive Screw



MP6 - 4-40 Captive Screw

Data Disc (1)



NOTE: Short pins used on Cal devices, long pins used on DUT's.

partsqu.cdr

Figure 7-2. HP K11644A WR-42 Replaceable Parts

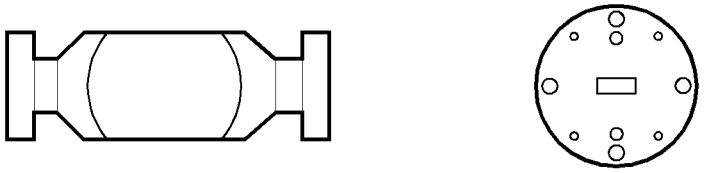
Table 7-3. HP V11644A WR-15 and W11644A WR-10 Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Calibration Devices		
V-band Fixed Load	1	11643–60025
W-band Fixed Load	1	11643–60026
V-band Standard Section	3	11644–60012
W-band Standard Section	3	11644–60013
V-band Shim	1	11644–20013
W-band Shim	1	11644–20014
Short (V/W band)	1	11644–20015
Hardware		
Slip Pin	6	11644–20007
4-40 Captive Screw .41 inches long	12	1390–0765
4-40 Captive Screw .31 inches long	24	1390–0671
Hex Ball	1	8710–1539
Miscellaneous Items		
Operating and Service Manual	1	11644–90369
V-band Calibration Constants Disk	1	11644–10015
W-band Calibration Constants Disk	1	11644–10016
V-band Calibration Constants Tape (option 002)	1	11644–10004
W-band Calibration Constants Tape (option 002)	1	11644–10005
Program Data Disk	1	08510–10033
Connector Care—Quick Reference Card	1	08510-90360
Items Not Included in Kit		
Blank Tape (for data backup)		9164–0166
Microwave Test Accessories Catalog		5091–4269
Operating and Programming		08510–90281
HP Product Note 5A		08510–90352
Isopropyl Alcohol (30 ml)		8500–5344
Cleaning Swabs (100)		9301–1243
Grounding Wrist Strap		9300–1367
5 ft Grounding Cord for Wrist Strap		9300–0980
2 × 4 ft Conductive Table Mat and 15 ft Ground Wire		9300–0797
ESD Heel Strap (for conductive floors)		9300–1126

V and W BAND: HP 11644A CALIBRATION KIT COMPONENT IDENTIFICATION SHEET

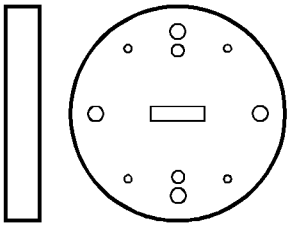
A1 - 5 cm Straight Verification Line (1)

Used for system verification only.



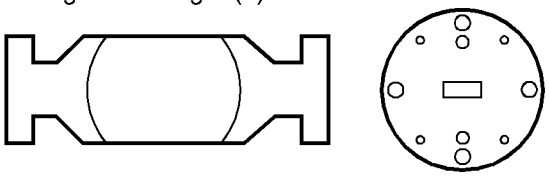
A2 - Fixed Load (1)

A3 - 1/4 Wavelength Section (1)



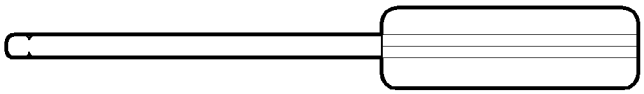
Has mechanical length labeled on side or recessed area.

W24 - W25 5 cm Waveguide Straight (2)

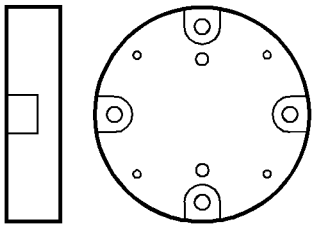


Used as port 1 and 2

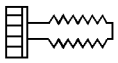
MP1 - 3/32 inch Hex Ball Driver (1)



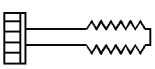
A4 - Flush Short (1)



MP2 - Alignment Pin (6)

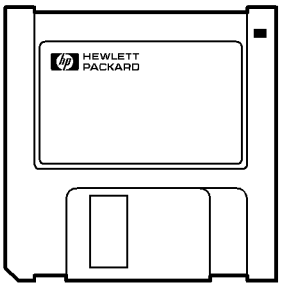


MP3 - 4-40 Captive Screw (24)



MP4 - 4-40 Captive Screw (12)

Data Disc (1)



NOTE: Short pins used on Cal devices, long pins used on DUT's.

partsvw.odr

Figure 7-3. HP X11644A WR-90 Replaceable Parts

A

Standard Definitions

Electrical Characteristics

Standard Class Assignments

Class assignment organizes calibration standards into a format compatible with the error models used in measurement calibration. A class or group of classes corresponds to the systematic errors to be removed from the measured network analyzer response. Table A-1 lists the classes used by the HP 8510.

Nominal Standard Definitions

Standard definitions provide the constants needed to mathematically model the electrical characteristics (delay, attenuation, and impedance) of each calibration standard. The nominal values of these constants 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 tables list typical calibration kit parameters used by the HP 8510 and HP 8722 to specify the mathematical model of each device.

Note The values in the standard class assignments and in the standard definitions tables are valid *only* over the specified operating temperature range. For information on how to generate alternate characteristics for temperatures outside this range, refer to HP product note 8510–5A, "Specifying Calibration Standards for the HP 8510 Network Analyzer." This product note provides information on modifying calibration constants, parameters, and classes.

Version Changes

Class assignments and standard definitions may change as more accurate model and calibration methods are developed. The disk (or option 002 tape) shipped with the kit for use with the HP 8510 will contain the most recent version. The default version that comes with the HP 8722 network analyzer firmware may be outdated.

Table A-1.
Standard Class Assignments
for the HP 8510

Calibration Kit Label: `WR-28 A.2`, or `WR-22 A.2`, or `WR-19 A.2`

Disk File Name: `CK_WR-28`, or `CK_WR-22`, or `CK_WR-19`

Tape File Number: `* FILE 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	10	20					Loads
$S_{22}A$	1							Short
$S_{22}B$	3							Offset
$S_{22}C$	9	10	20					Loads
Forward Transmission	11							Thru
Reverse Transmission	11							Thru
Forward Match	11							Thru
Reverse Match	11							Thru
Frequency Response	1	11						Response

Table A-2.
Standard Class Assignments
for the HP 8510

Calibration Kit Label: `WR-15 A.2` ,or `WR-10 A.2`

Disk File Name: `CK_WR-15`, or `CK_WR-10`

Tape File Number: `* FILE 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
Frequency Response	1	11						Response

Table A-3.
Standard Class Assignments
Blank Form

Calibration Kit Label: _____

Disk File Name: _____

Tape File Number: _____

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								
Frequency Response								

Table A-4.
Standard Definitions
HP 8510 with R–band (WR-28)

Calibration Kit Label: WR-28 A.3

Disk File Name: CK_WR-28

STANDARD[b]		C0 x10^{-15} F	C1 x10^{-27} F/Hz	C2 x10^{-36} F/Hz^2	C3 x10^{-45} F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 x10^{-12} H	L1 x10^{-24} H/Hz	L2 x10^{-33} H/Hz^2	L3 x10^{-42} H/Hz^3			DELAY ps	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1	Short[e]							0	1	0	21.071	42.142	WG	Short
2														
3	Short[e]							10.07	1	0	21.071	42.142	WG	λ/4 Offs
4														
5														
6														
7														
8														
9	Load					Fixed		0	1	0	21.071	42.142	WG	Fixed
10	Load					Sliding		0	1	0	21.071	42.142	WG	Sliding
11	Delay/Thru							0	1	0	21.071	42.142	WG	Thru
12														
13	Undefined													
14	Delay/Thru							0	1	0	21.069	42.138	WG	Thru
15	Delay/Thru							10.0702	1	0	21.069	42.138	WG	λ/4 Delay
16														
17														
18														
19														
20	Load					Offset		10.0702	1	0	21.071	42.142	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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

Table A-5.
Standard Definitions
HP 8510 with Q–band (WR-22)

Calibration Kit Label: WR-22 A.3

Disk File Name: CK_WR-22

STANDARD[b]		C0 x10^{-15} F	C1 x10^{-27} F/Hz	C2 x10^{-36} F/Hz^2	C3 x10^{-45} F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 x10^{-12} H	L1 x10^{-24} H/Hz	L2 x10^{-33} H/Hz^2	L3 x10^{-42} H/Hz^3			DELAY ps	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1	Short[e]							0	1	0	26.338	52.676	WG	Short
2														
3	Short[e]							8.082	1	0	26.338	52.676	WG	λ/4 Offs
4														
5														
6														
7														
8														
9	Load					Fixed		0	1	0	26.338	52.676	WG	Fixed
10	Load					Sliding		0	1	0	26.338	52.676	WG	Sliding
11	Delay/Thru							0	1	0	26.338	52.676	WG	Thru
12														
13	Undefined													
14	Delay/Thru								1	0	26.338	52.676	WG	Thru
15	Delay/Thru							8.084	1	0	26.338	52.676	WG	λ/4 Delay
16														
17														
18														
19														
20	Load					Offset		8.082	1	0	26.338	52.676	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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

Table A-6.
Standard Definitions
HP 8510 with U–band (WR-19)

Calibration Kit Label: WR-19 A.3

Disk File Name: CK_WR-19

STANDARD[b]		C0 x10^{-15} F	C1 x10^{-27} F/Hz	C2 x10^{-36} F/Hz^2	C3 x10^{-45} F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 x10^{-12} H	L1 x10^{-24} H/Hz	L2 x10^{-33} H/Hz^2	L3 x10^{-42} H/Hz^3			DELAY ps	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1	Short[e]							0	1	0	31.386	62.772	WG	Short
2														
3	Short[e]							6.643	1	0	31.386	62.772	WG	λ/4 Offs
4														
5														
6														
7														
8														
9	Load					Fixed		0	1	0	31.386	62.772	WG	Fixed
10	Load					Sliding		0	1	0	31.386	62.772	WG	Sliding
11	Delay/Thru							0	1	0	31.386	62.772	WG	Thru
12														
13	Undefined													
14	Delay/Thru							0	1	0	31.386	62.772	WG	Thru
15	Delay/Thru							6.646	1	0	31.386	62.772	WG	λ/4 Delay
16														
17														
18														
19														
20	Load					Offset		6.643	1	0	31.386	62.772	WG	λ/4 Offset
13														

[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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

Table A-7.
Standard Definitions
HP 8510 with V–band (WR-15)

Calibration Kit Label: WR-15 A.3

Disk File Name: CK_WR-15

STANDARD[b]		C0 x10^{-15} F	C1 x10^{-27} F/Hz	C2 x10^{-36} F/Hz^2	C3 x10^{-45} F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 x10^{-12} H	L1 x10^{-24} H/Hz	L2 x10^{-33} H/Hz^2	L3 x10^{-42} H/Hz^3			DELAY ps	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1	Short[e]							0	1	0	39.873	79.745	WG	Short
2														
3	Short[e]							5.376	1	0	39.873	79.745	WG	λ/4 Offs
4														
5														
6														
7														
8														
9	Load					Fixed		0	1	0	39.873	79.745	WG	Fixed
10	Load					Sliding		0	1	0	39.873	79.745	WG	Sliding
11	Delay/Thru							0	1	0	39.873	79.745	WG	Thru
12														
13	Undefined													
14	Delay/Thru								1	0	39.873	79.745	WG	Thru
15	Delay/Thru							5.378	1	0	39.873	79.745	WG	λ/4 Delay
16														
17														
18														
19														
20	Load					Offset		5.376	1	0	39.873	79.745	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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

Table A-8.
Standard Definitions
HP 8510 with W–band (WR-10)

Calibration Kit Label: WR-10 A.3

Disk File Name: CK_WR-10

STANDARD[b]		C0 x10^{-15} F	C1 x10^{-27} F/Hz	C2 x10^{-36} F/Hz^2	C3 x10^{-45} F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 x10^{-12} H	L1 x10^{-24} H/Hz	L2 x10^{-33} H/Hz^2	L3 x10^{-42} H/Hz^3			DELAY ps	Z_0 Ω	LOSS Ω/s	MIN	MAX		
1	Short[e]							0	1	0	59.024	118.05	WG	Short
2														
3	Short[e]							3.620	1	0	59.024	118.05	WG	λ/4 Offs
4														
5														
6														
7														
8														
9	Load					Fixed		0	1	0	59.024	118.05	WG	Fixed
10	Load					Sliding		0	1	0	59.024	118.05	WG	Sliding
11	Delay/Thru							0	1	0	59.024	118.05	WG	Thru
12														
13	Undefined													
14	Delay/Thru							0	1	0	59.024	118.05	WG	Thru
15	Delay/Thru							3.620	1	0	59.024	118.05	WG	λ/4 Delay
16														
17														
18														
19														
20	Load					Offset		3.620	1	0	59.024	118.05	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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

Table A-9.
Standard Definitions
Blank Form

System Z_0[a] **=** _____ **Calibration Kit Label:** _____

Disk File Name: _____ **Tape File Number:** _____

STANDARD[b]		C0 $x10^{-15}$ F	C1 $x10^{-27}$ F/Hz	C2 $x10^{-36}$ F/Hz^2	C3 $x10^{-45}$ F/Hz^3	FIXED[c] or SLIDING or OFFSET	TERMMINAL[d] IMPEDANCE Ω	OFFSET			FREQ[e] (GHz)		COAX or WG	STND LABEL
NO.	TYPE	L0 $x10^{-12}$ H	L1 $x10^{-24}$ H/Hz	L2 $x10^{-33}$ H/Hz^2	L3 $x10^{-42}$ H/Hz^3			DELAY s	Z_0 Ω	LOSS Ω/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] Arbitrary impedance only, device terminating impedance.

[e] For waveguide, lower frequency is same as F_{CO}.

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