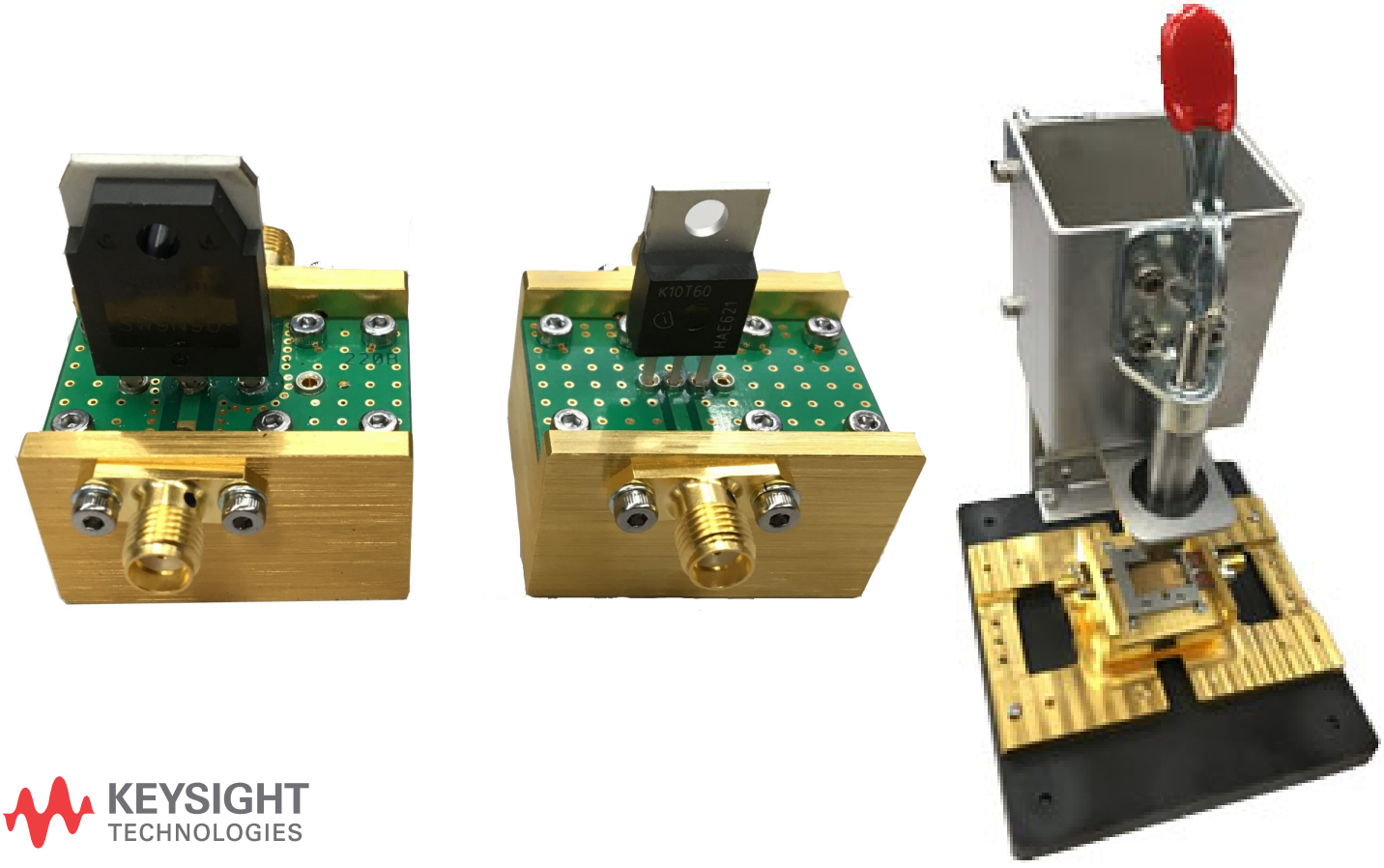
Operating Guide

Part of PD1000A Option -SPK Accessory Kit
TO-220, TO-247, and Surface Mount Devices

Keysight PD1000A Power Device Test Fixtures for S-Parameter Measurements



KEYSIGHT TECHNOLOGIES

Notices

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www.keysight.com/find/PD1000A

(product-specific information and support, software and documentation updates)

www.keysight.com/find/assist (worldwide contact information for repair and service)

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The following general safety precautions must be observed during all phases of operation of these instruments. Failure to comply with these precautions or with specific warnings or operating instructions in the product manuals violates safety standards of design, manufacture, and intended use of the instruments. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements.

General

Do not use these instruments in any manner not specified by the manufacturer. The protective features of these instruments must not be impaired if it is used in a manner specified in the operation instructions.

Before Applying Power

Verify that all safety precautions are taken. Make all connections to the instruments before applying power. Note the external markings described under "Safety Symbols".

Ground the Instrument

Keysight instruments are provided with a grounding-type power plug. The instruments must be connected to an electrical ground to minimize shock hazard. The ground pin must be firmly connected to an electrical ground (safety ground) terminal at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Unless otherwise noted in the specifications, these instruments or system is intended for indoor use in an installation category II, pollution degree 2 environment per IEC 61010-1 and 664 respectively. They are designed to operate at a maximum relative humidity of 5% to 80% at 40 °C or less (noncondensing). These instruments or system are designed to operate at altitudes up to 3000 meters, and at temperatures between 0 and 55 °C.Do Not Operate in an Explosive Atmosphere Do not operate in the presence of flammable gases or fumes.

Do Not Operate Near Flammable Liquids

Do not operate the instruments in the presence of flammable liquids or near containers of such liquids.

Cleaning

Clean the outside of the Keysight instruments with a soft, lint-free, slightly dampened cloth. Do not use detergent or chemical solvents.

Do Not Remove Instrument Cover

Only qualified, service-trained personnel who are aware of the hazards involved should remove instrument covers. Always disconnect the power cable and any external circuits before removing the instrument cover.

Keep away from live circuits

Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers and shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.

DO NOT operate damaged equipment

Whenever it is possible that the safety protection features built into these instruments have been impaired, either through physical damage, excessive moisture, or any other reason, REMOVE POWER and do not use the instrument until safe operation can be verified by service-trained personnel. If necessary, return the product to a Keysight Technologies Sales and Service Office for service and repair to ensure the safety features are maintained.

DO NOT block the primary disconnect

The primary disconnect device is the appliance connector/power cord when an instrument used by itself, but when installed into a rack or system the disconnect may be impaired and must be considered part of the installation.

Do Not Modify the Instrument

Do not install substitute parts or perform any unauthorized modification to the product. Return the product to a Keysight Sales and Service Office to ensure that safety features are maintained.

In Case of Damage

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

Measurement Limits

The Truevolt Series DMMs provide protection circuitry to prevent damage to the instrument and to protect against the danger of electric shock, provided the Measurement Limits are not exceeded. To ensure safe operation of the instrument, do not exceed the Measurement Limits shown on the front and rear panel.

The DMMs comply with EN/IEC 61326-2-1, for sensitive test and measurement equipment.

When subjected to transient radiated and/or conducted electromagnetic phenomena, the DMMs may have temporary loss of function or performance which is self-recovering. Recovery may take longer than 10 seconds.

When subjected to continuously present electromagnetic phenomena, some degradation of performance may occur.

Safety Symbols and Notices

CAUTION

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

WARNING

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

Products display the following symbols:

Indicates that antistatic precautions should be taken.

NOTE

Electro-Magnetic Compatibility (EMC) Information

The Test Solution is sensitive to electro-magnetic disturbances in the frequency range of 80 MHz to 6 GHz.
To minimize the risk of incorrect measurements avoid intentional radiators in close proximity to the Test Solution.

Contents

General Information

Keysight's PD1000A Power Device Measurement System for Advanced Modeling System option -SPK Accessory Kit provides three device test fixtures:

- One for 3-terminal devices with TO-220 style packages (Keysight p/n. PD1000-67900).
- One for 3-terminal devices with TO-247 style packages (Keysight p/n. PD1000-67901).
- One for Surface Mount Devices (SMD) with 7-pin TO-263 packages (Keysight p/n. PD1000-67902).

This accessory kit is used for making S-Parameter measurements.

Incoming Inspection

After unpacking the Test Fixture(s), carefully inspect them for any shipping damage. Report any damage to the shipping agent immediately, as such damage is not covered by the warranty.

Returning for Service

If you need to return a test fixture for service, attach a tag indicating the type of service required, your return address, and model number of the device to be repaired.

Repackaging the device requires original shipping containers and materials or their equivalents. Keysight Technologies can provide packaging materials identical to the original materials. Contact Keysight as per "Sales and Technical Support" in the front matter of this manual.

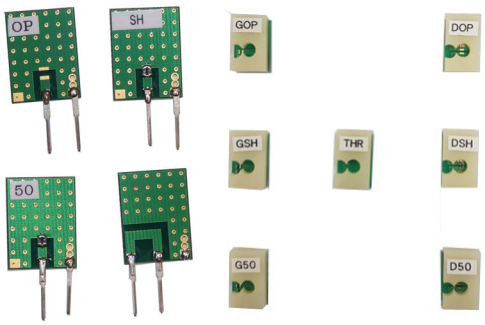
Preparation for Use

The PD1000A Test Fixtures connect the device to be tested (DUT) to the Bias T Networks. Refer to Figure 1 on page 12 for a typical test setup.

NOTE **Licensing is required to use the PD1000A Power Device Measurement System Control Software for making On State and Off State S-Parameter measurement. Refer to the PD1000A Startup Guide for licensing information.**

Associated Products

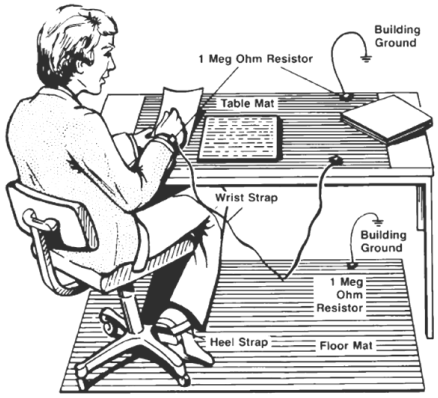
In addition to the three test fixtures, the PD1000A-SPK Accessory Kit includes the following items for S-Parameter measurements.

Description	Qty.	Photos below are representative, what you receive may be different.
0.56 N-m (5 lb-in) 5/16 in. break-over torque wrench, Keysight 8710-1582	1	
Type N, Male to SMA Female Adapter 50Ω Nominal Keysight PN: 1250-2879	2	
SMA male to SMA Male Cable Keysight PN: 5062-6682 7-inch cable	2	
Stackable Banana Plug (each end) Cables Keysight PN: 8121-2006 Black cable 8121-2007 Red cable	8	 4 red and 4 black
PD1000A-BST Bias Tee Networks Keysight PN: PD1000-67903 PD1000-67904 Two are required for the PD1000A system		
Calibration Standards for each test fixture. Calibration Standards for TO-247 Test Fixture shown on left (Keysight PN: PD1000-67905). Calibration Standards for the TO-220 Test Fixture are similar (Keysight PN: PD1000-67906). Calibration Standards for the Surface Mount Device (SMD) Test Fixture are shown on right (Keysight PN: PD1000-67907).		

Static-safe Handling Procedures

Electrostatic discharge (ESD) can damage or destroy electronic components. Use a static-safe work station to perform at work on electronic assemblies. The figure shows a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination
- Conductive floor-mat and heel-strap combination



Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground.

General Test Setup

Figure 1 below shows the general test setup for the three PD1000A Test Fixtures (the Surface Mount Device (SMD) fixture is shown in the photo). Note the two PD1000A Bias T networks attached to the test fixture, the E5080A ENA Network Analyzer behind the test fixture, and the B2902A Precision SMU (on top of the E2080A ENA) providing bias voltage to the two Bias T networks.

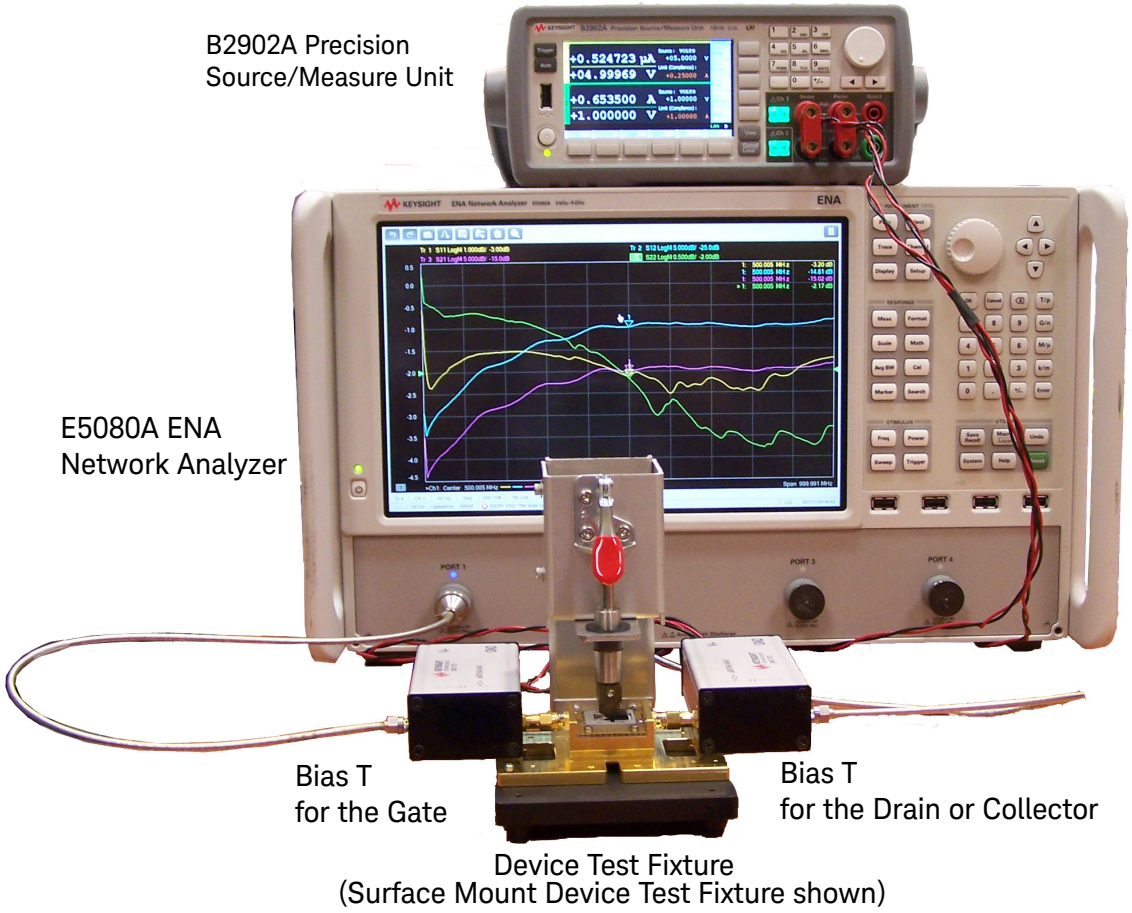


Figure 1 General Test Setup for the PD1000A S-Parameter Test System

NOTE Do not excessively bend, flex, or stretch the SMA cables. Check the SMA cables regularly, and replace them if they are damaged in any way. It is possible for the outside shielding of the cables to break. See “Troubleshooting” on page 37.

Use with PD1000A Bias T Networks

Two Bias T devices are provided with the PD1000A Accessory Kit. Figure 2 shows the two PD1000A Bias T Networks ready to connect to a PD1000A TO-220 or TO-247 Test Fixture. Figure 3 shows the Surface Mount Device (SMD) Test Fixture.

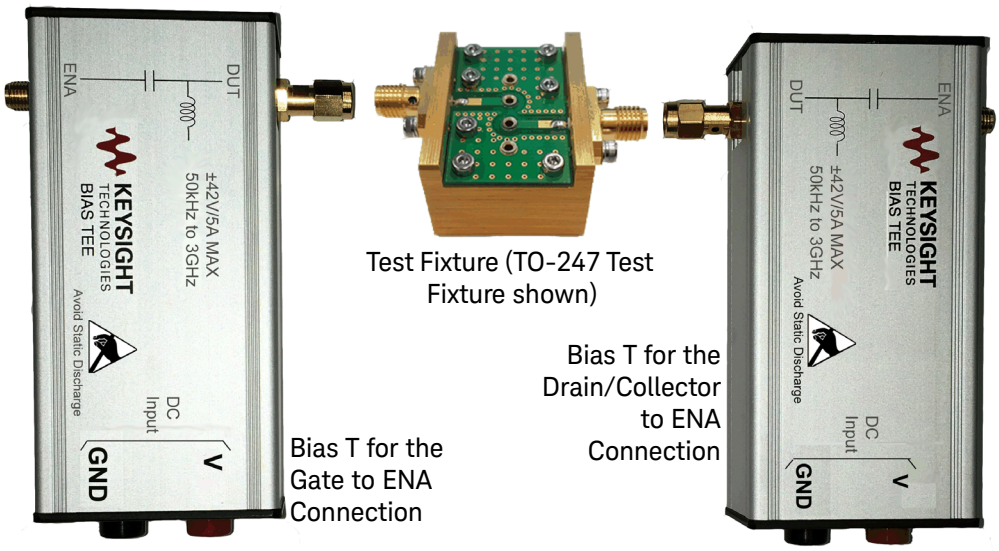


Figure 2 PD1000A Bias T Networks with TO-220 and TO-247 Test Fixture

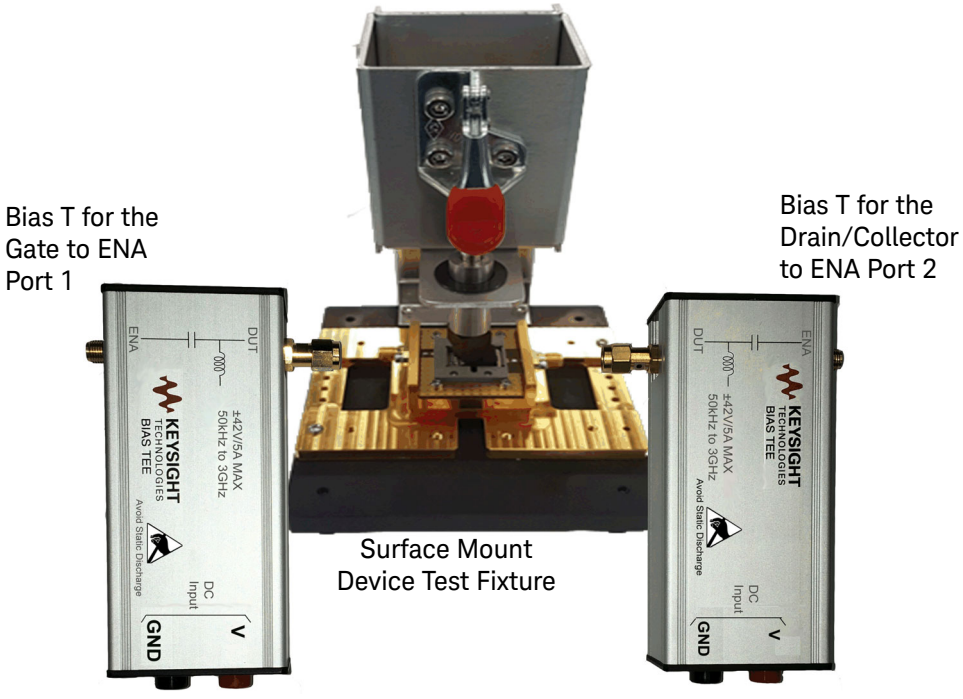


Figure 3 PD1000A Bias T Networks with PD1000A SMD Test Fixture

Connecting the Bias T Networks to a Keysight B2902A SMU

Figure 4 below shows how to connect two PD1000A Bias T Networks to the B2902A Source Measure Unit (SMU). Channel 1 on the SMU (front panel) connects to the PD1000A Bias T for the RF input (Gate) to the device under test (DUT). Channel 2 on the SMU (rear panel) connects to the PD1000A Bias T for the RF output (drain or collector) of the DUT.

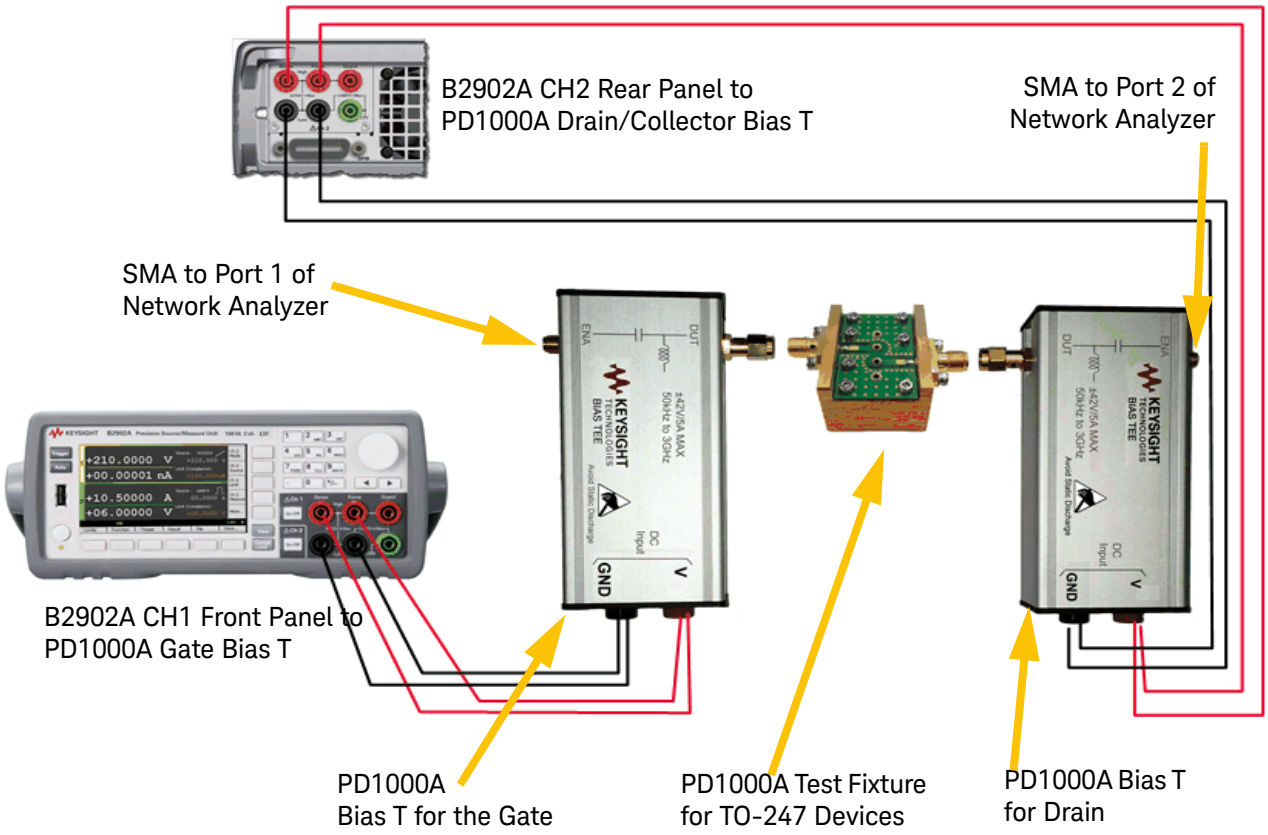


Figure 4 PD1000A Bias T Networks used with the B2902A SMU

PD1000A TO-220 and TO-247 Device Test Fixtures

TO-220 and TO-247 device packages are generally designed as through-hole devices. Other package types, including the TO-257 (an hermetically sealed metal package that is otherwise equivalent to the TO-220) and the TO-262 (I^2PAK) package may also be tested with this fixture.

NOTE Some device data sheets refer to a case style ITO-220 which refers to a TO-220 style case but with an isolated tab. The tab is used only as a heat sink.

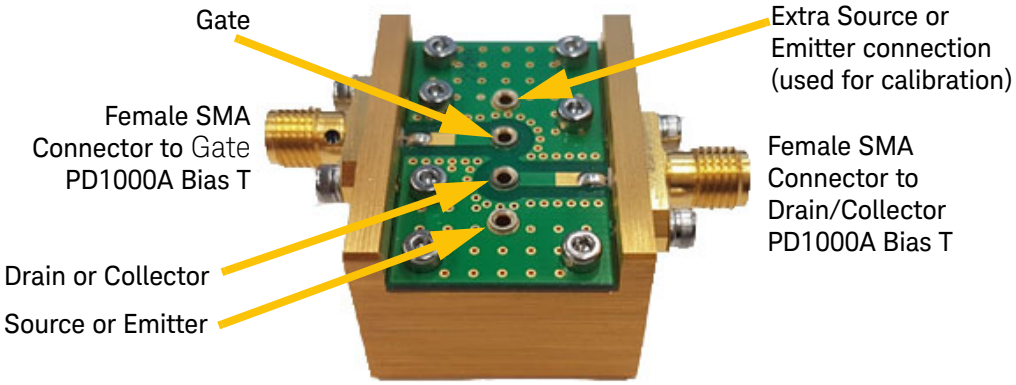


Figure 5 Keysight PD1000A TO-247 and TO-220 Test Fixture

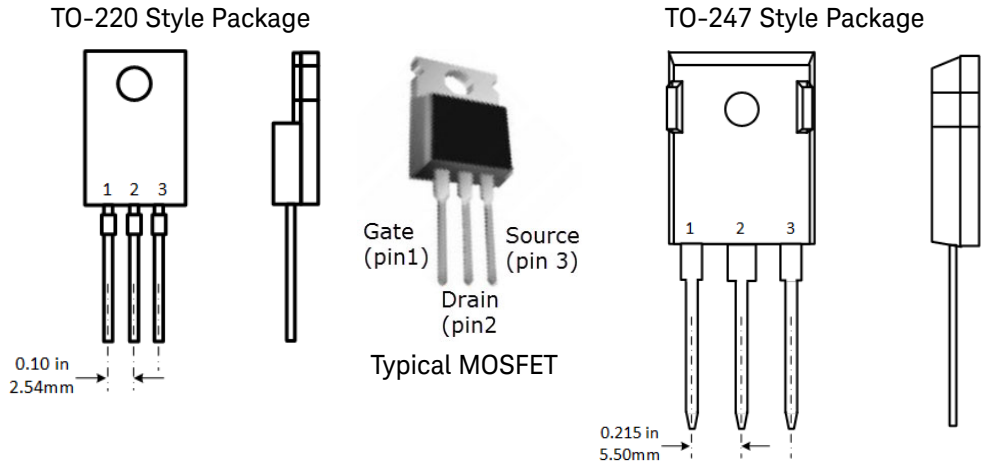


Figure 6 Typical TO-220 Device and TO-247 Device Packaging

NOTE Make certain the Test Fixture work station is ESD protected. See “Static-safe Handling Procedures” on page 11 for details.

Inserting Devices into the TO-220 and TO-247 Test Fixtures

Figure 7 below shows the proper orientation for inserting TO- style devices into the Test Fixtures. Always observe proper orientation when inserting devices. The sockets on the test fixture are spring-loaded to ensure proper contact with the device leads. Press the device all the way into the fixture sockets.

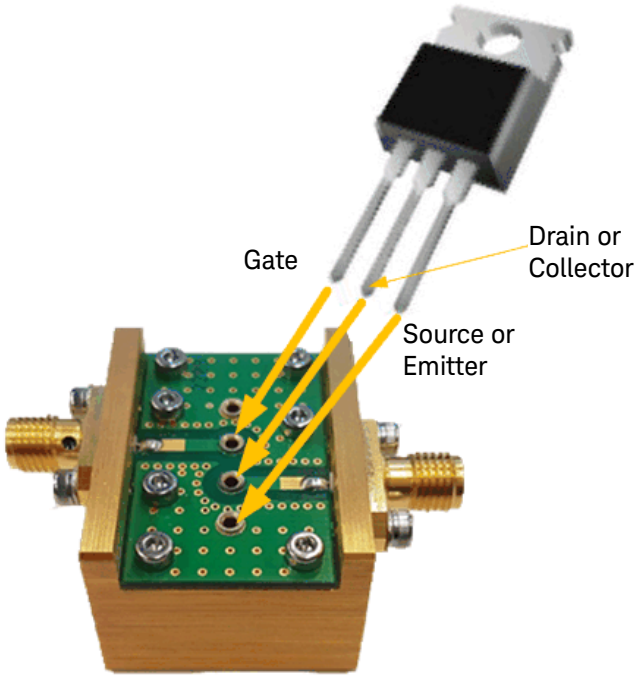


Figure 7 Inserting TO- Style Devices into the TO-220/TO-247 Test Fixtures

Removing the Device from the Fixture

To remove the device form the fixture, hold the fixture securely down on a table or workbench. Carefully and slowly lift the device straight up from the fixture. Do not rock the device back and forth to remove it.

PD1000A Surface Mount Device Test Fixture

Keysight's PD1000A SMD Test Fixture is designed for testing surface mount device packages such as the 7-pin TO-263 (also known as D^2PAK or DDPAK) SMD devices. Other SMD devices may also be tested with the SMD Test Fixture. This test fixture provides a clamp to hold the SMD in place while the tests are running.

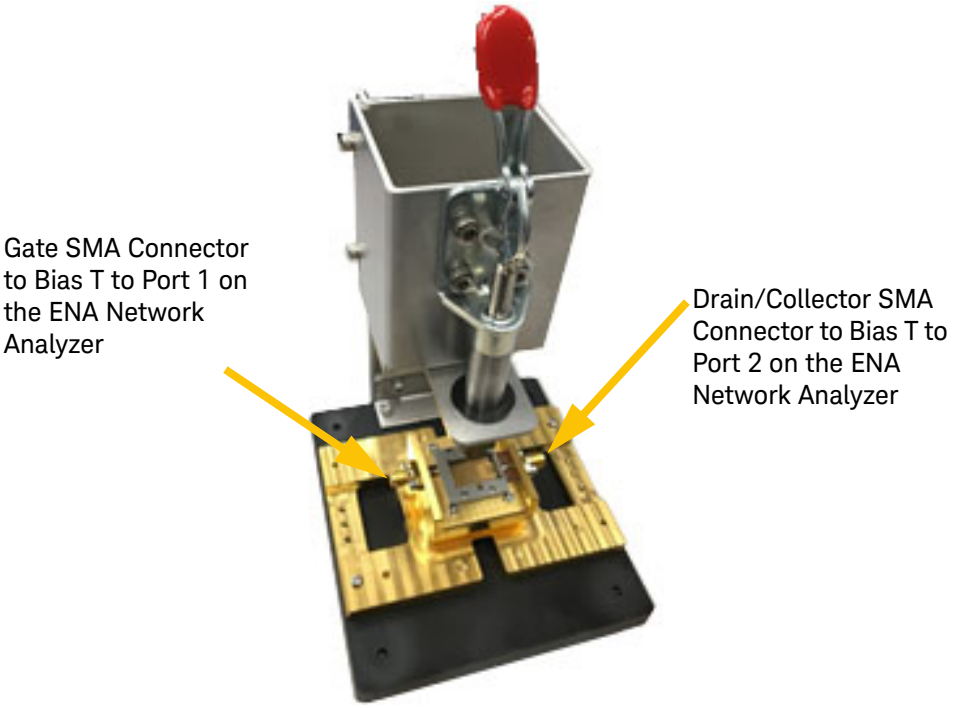


Figure 8 Keysight PD1000A Surface Mount Device Test Fixture

NOTE Make certain the Test Fixture work station is ESD protected. See "Static-safe Handling Procedures" on page 11 for details.

Inserting Devices into the SMD Test Fixture

Figure 9 shows the proper orientation for inserting Surface Mount Devices (SMD) into the Test Fixture. Always observe proper orientation when inserting devices. Gently place the device into the Frame Guide of the Test Fixture. Ensure it is properly aligned with the PC Board contact pattern. Ensure the SMD device fits securely and completely into the positioning frame guide. Press the Test Fixture handle down until it latches to firmly hold the device in place while being tested.

The frame guide provided with the SMD test fixture is for devices with dimensions: 10 mm wide and 15 mm top of tab to bottom of pins.

When finished testing a device, lift up on the Test Fixture handle and carefully remove the DUT.

NOTE If your SMD device does not have the pin-out shown below, or if your device has different dimensions than the standard device, you will need to create a custom frame and PC Board. Refer to "Customizing an SMD Test Fixture" on page 30.

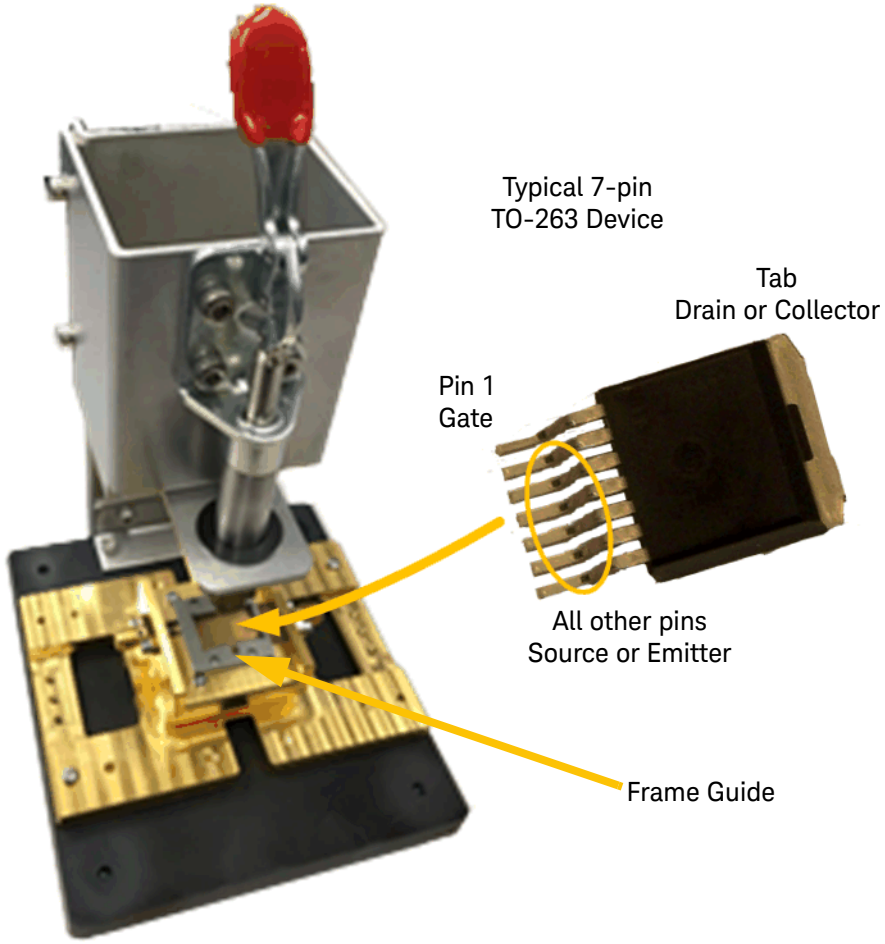


Figure 9 Inserting Surface Mount Devices into the SMD Test Fixture

Test Fixture Calibration

NOTE Due to slight degradation of the TO-220/TO-247 test fixture contacts over time, especially with frequent use, you should recalibrate the test fixtures periodically.

Required Equipment

- E5080A ENA Network Analyzer used with your PD1000A Power Device Measurement System for Advanced Modeling
- PD1000A Bias T Networks (quantity 2 required)
- Type 'N' Male to SMA Female Adapters (Keysight PN 1250-1250, quantity 2 required)
- SMA cables (Keysight PN: 5062-6682, 7 inch cable, quantity 2 required)
- Torque wrench (Keysight 8710-1765, 0.90N-m (8 lb-in) 5/16 inch break-over torque wrench) to properly tighten SMA connectors.
- Mechanical Calibration Standards (shown in Figure 10 and Figure 11 below). These Calibration Standards are provided with your test fixture. and are shown in Figure 10 and Figure 11.
- Test Fixture to be calibrated. Either the TO-220/TO-247 or the SMD fixture.
- Two downloadable Calibration Kit files, used for the three test fixtures: **TO_Fixture_In.xkt** for the Input Port and the **TO_Fixture_Out.xkt** for the Output Port.
  - -- If your E5080A has an Internet connection, download these files directly onto the E5080A hard drive. Otherwise, download the files and copy them to a USB memory stick.
  - -- The Calibration Kit files are available for download at: https://www.keysight.com/main/software.jspx?ckey=2984719&lc=eng&cc=US&nid=-11143.0.00&id=2984719

The TO-220/TO-247 Calibration Standard kits have four devices labeled **OPEN**, **SHORT**, **LOAD**, and **THRU**.

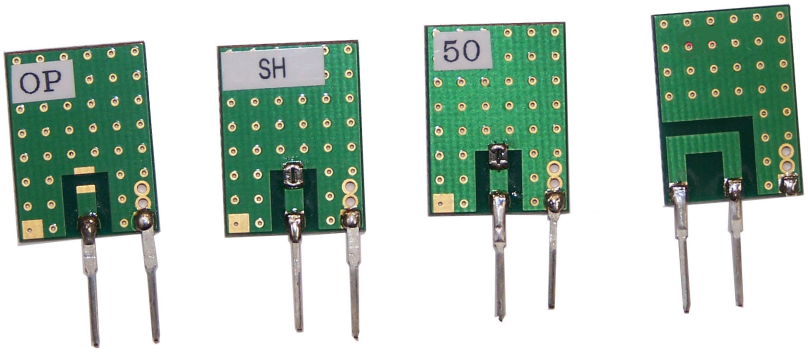


Figure 10 Calibration Standards for PD1000A TO-247 Test Fixture. Calibration Standards for the TO-220 fixture are similar but with narrower pin spacing.

The SMD Calibration Standard kit has seven devices: Input Port Open (labeled **GOP**), Short (labeled **GSH**), 50Ω (labeled **G50**) termination, Output Port Open (labeled **DOP**), Short (labeled **SDH**), 50Ω (labeled **D50**) termination, and Through (**THR**).

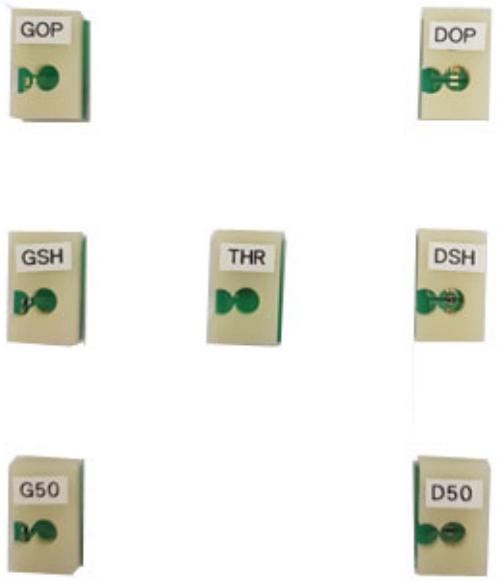


Figure 11 Calibration Standards for PD1000A SMD Test Fixture.

Additional or replacement Calibration Standards are available at: www.keysight.com/find/PD1000A.

Fixture Calibration Procedure

The PD1000A Test Fixtures were developed to test semiconductor devices with standard device packaging. Each fixture type has its own Calibration Standards kit.

NOTE Calibration procedures for the PD1000A Test Fixtures are the same. Use the appropriate mechanical calibration standard devices supplied with your test fixture. Do not use an E-CAL standard.

NOTE The following procedure describes the Keysight E5080A ENA Vector Network Analyzer Calibration procedure. If you are using a different analyzer, the procedure may be different. For detailed calibration procedures, refer to the analyzer's documentation.

Install the Calibration Kit Files

The two Calibration Kit files (**TO_Fixture_In.xkt** for the Input Port and the **TO_Fixture_*.xkt** for the Output Port) are available from www.keysight.com/find/PD1000A. If you have not already done so, download these files directly to the E5080A hard drive (if it has an Internet connection) or onto a USB memory stick.

1. If you have not already done so, download the two Calibration Kit files (**TO_Fixture_In.xkt** for the Input Port and the **TO_Fixture_*.xkt** for the Output Port) from www.keysight.com/find/PD1000A.
   - If your E5080A has an Internet connection, download the files directly to the E5080A hard drive. Otherwise, download the files and copy them to a USB memory stick.
2. Press the **CAL** button.
3. Touch **CAL Sets & Cal Kits > Cal Kit... .**
4. Click the **Import** button.
5. Navigate to where you stored the two Cal Kit files.
6. Select the **TO_Fixture_In.xkt** file.
7. Click **Open**.
8. Select the ENA folder: **D:/User > PNACalKits > user**.
9. Repeat steps 3 through 6 for the **TO_Fixture_Out.xkt** file.
10. If you have not already saved the .xkt files, select both files and click **Save** to save them to a location on the ENA hard drive. (The files, which are stored in the ENA's volatile memory, are otherwise lost when you cycle the power.)

Perform the Calibration

1. Connect the text fixture to the E5080A ENA as shown below. Use two PD1000A-BST Bias Tees. See Figure 4 on page 14.
2. Setup the analyzer as follows:

Parameter	Value
Start Frequency	Set the desired Start and Stop frequencies for the frequency range you want to measure. In general, they should be in the range of 10 kHz to 1 GHz (or 3 GHz).
Stop Frequency	
Number of Points	25
Time Domain Mode	Low-pass Step
Calibration Type	2-port SOLT

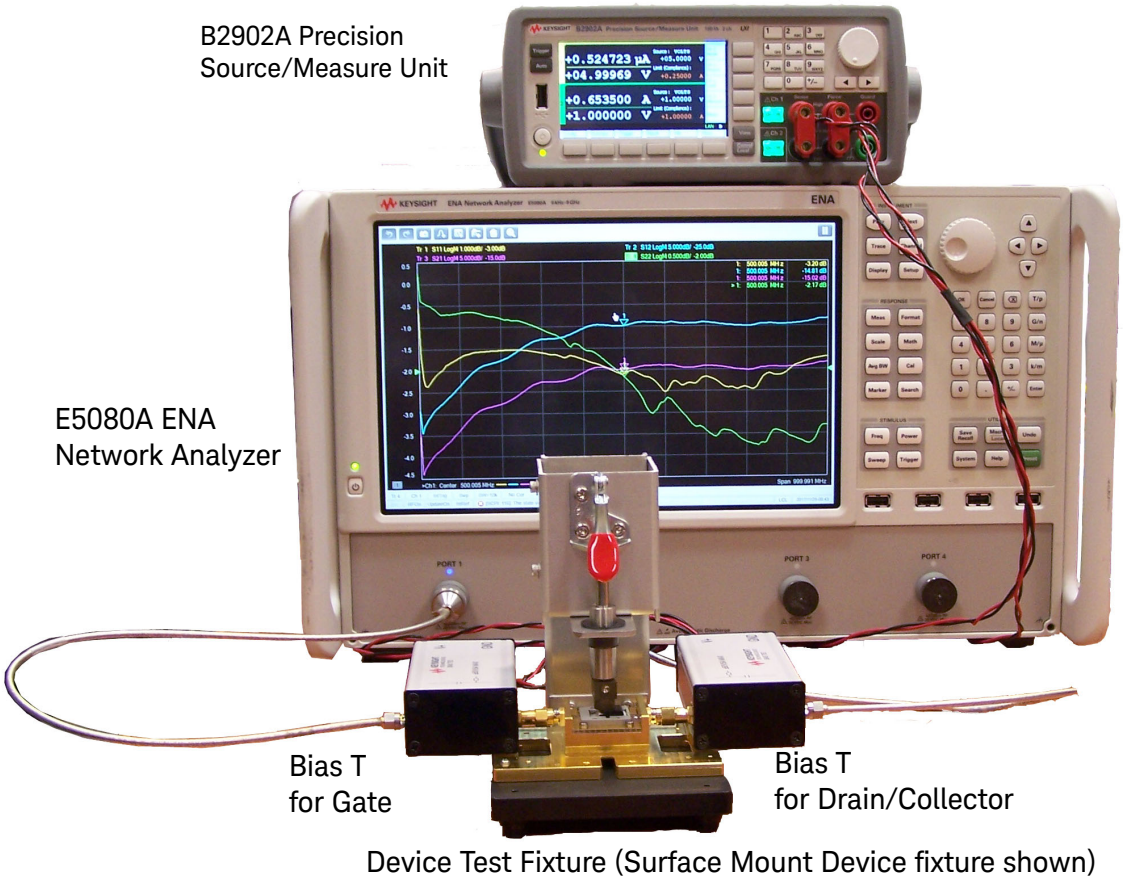
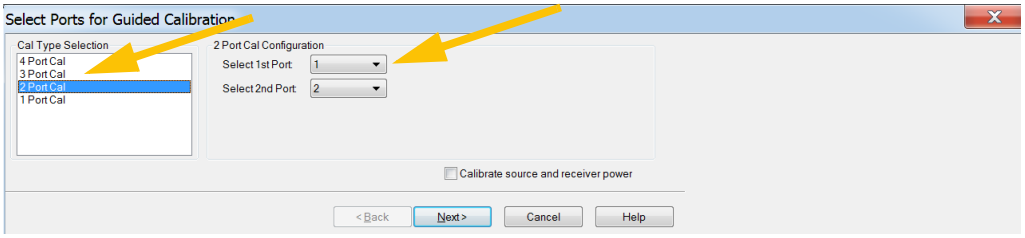


Figure 12 Calibration Setup for the PD1000A SMD Test Fixture.
Setup for the TO-220/TO-247 Fixtures is similar.

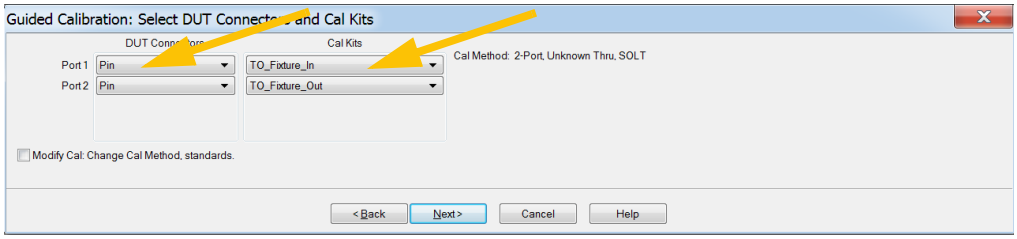
3 Once all parameters have been set in the ENA, the calibration can be performed. Press the **Cal button.** This opens the **Select Ports** screen.

4 Touch **Other Cals > Smart Cal.**



5 Select **2PortCal**. Specify **Port 1** as the First Port and **Port 2** as the Second Port.

6 Click **Next**. This opens the following screen.



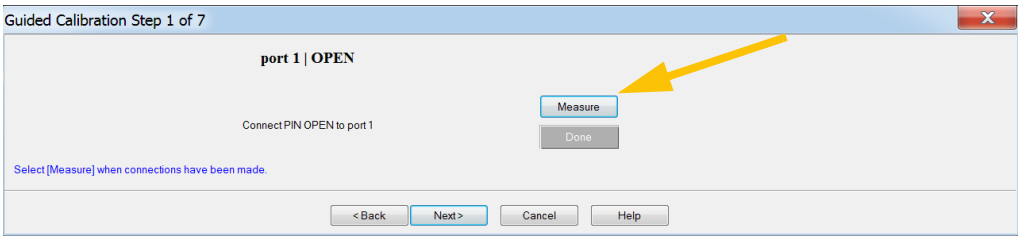
7 Specify the DUT connector type for both ports to '**PIN**'.

8 Specify the Cal Kit files. Select **TO_Fixture_In.xkt** for the Input Port 1 and **TO_Fixture_Out.xkt** for the Output Port 2. These Cal Kit files are used for all three test fixtures (TO-220/TO-247 and SMD).

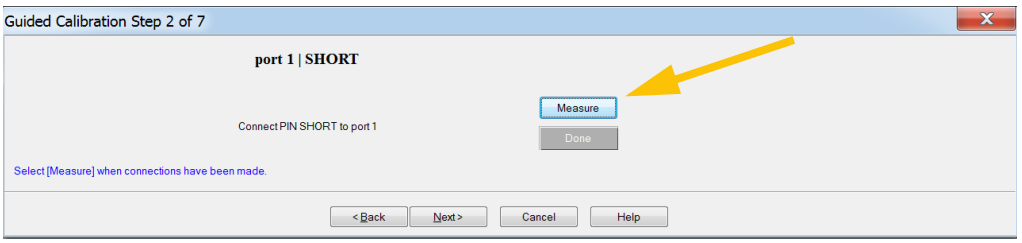
NOTE

The remainder of this procedure involves inserting the Calibration Standards into the Test Fixtures. Refer to "Inserting Cal Standards into the PD1000A TO-220/TO-247 Test Fixtures" on page 27 and "Inserting the Cal Standards into the PD1000A SMD Test Fixture" on page 29 for detailed instructions on inserting the Calibration Standards.

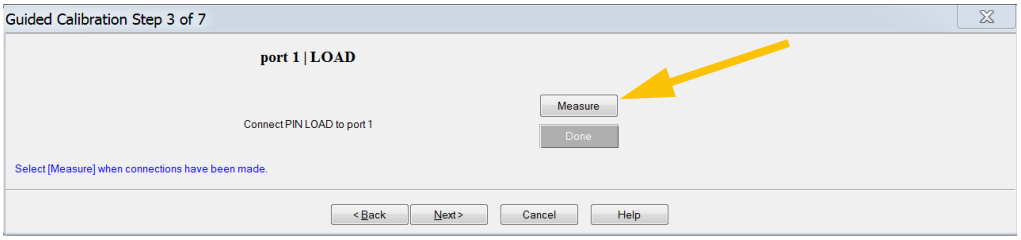
9 Click **Next**. This opens the following screen:



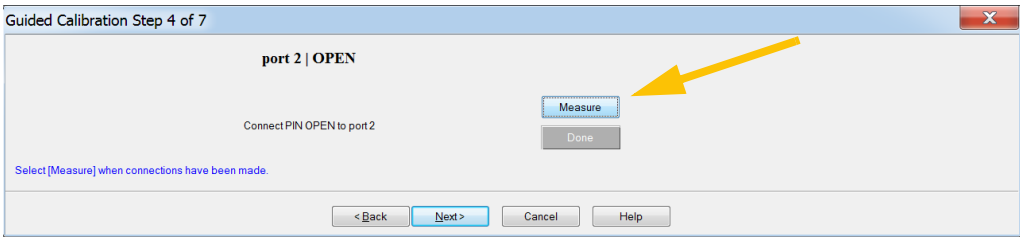
10 Insert the Port 1 **OPEN** Cal Standard into the test fixture. The **OPEN** Cal Standard goes between the Gate and Drain/Collector. Click **Measure**.



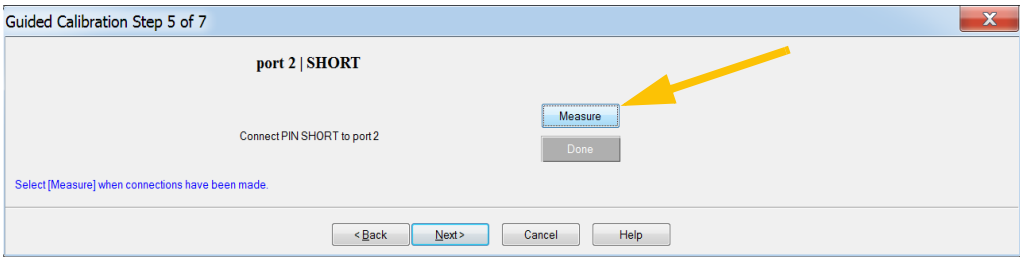
11 Insert the Port 1 **SHORT** Cal Standard into the test fixture. The **SHORT** Cal Standard goes between the Gate and Drain/Collector. Click **Measure**.



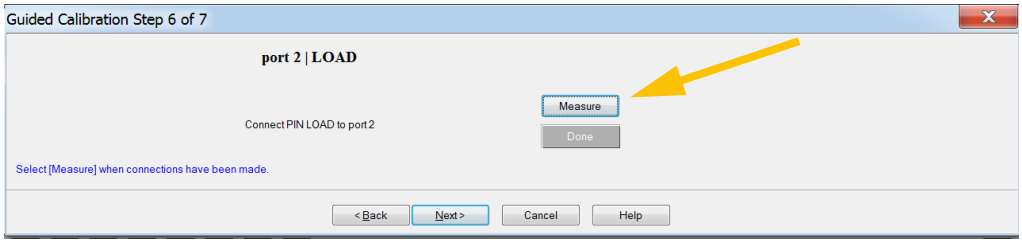
12 Insert the Port 1 **50 Ω LOAD** Cal Standard into the test fixture. The **50 Ω LOAD** Cal Standard goes between the Gate and Drain/Collector. Click **Measure**.



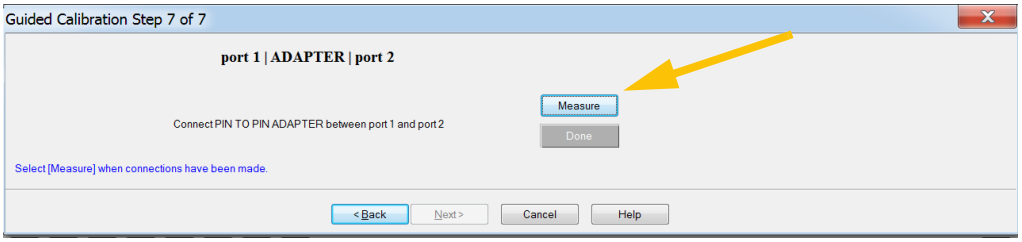
13 Insert the Port 2 **OPEN** Cal Standard into the test fixture. The Port 2 **OPEN** Cal Standard goes between the Source/Emitter and Drain/Collector. Click **Measure**. Note: for the TO-220/TO-247 Test Fixtures, use the same **OPEN** Cal. Standard as before, but turn it around to fit into the correct sockets on the test fixture.



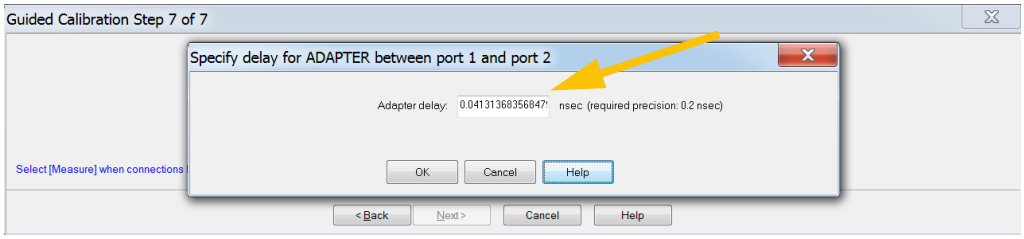
14 Insert the Port 2 **SHORT** Cal Standard into the test fixture. The **SHORT** Cal Standard goes between the Source/Emitter and Drain/Collector. Click **Measure**. Note: for the TO-220/TO-247 Test Fixtures, use the same **SHORT** Cal. Standard as before, but turn it around to fit into the correct sockets on the test fixture.



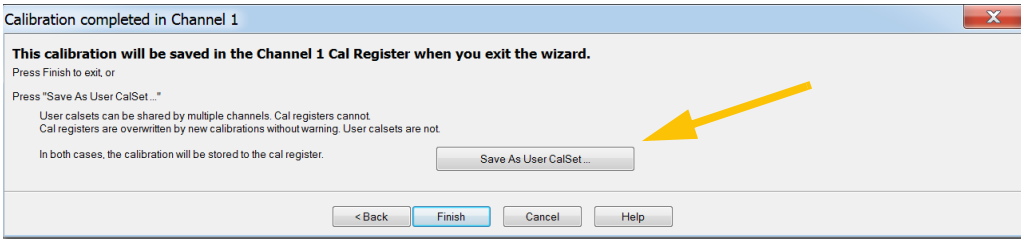
15 Insert the Port 2 **50 Ω LOAD** Cal Standard into the test fixture. The **50 Ω LOAD** Cal Standard goes between the Gate and Drain/Collector. Click **Measure**.



16 Insert the **THROUGH** Calibration Standard into the Test Fixture. Click **Measure.**



17 In this screen, the display shows the calculated delay through the **THROUGH** Cal Standard. Ensure that the displayed value is less than 0.2 nS. Click **OK**.



18 Click **Save As User CalSet**. Click **Finish** to complete the calibration procedure.

19 Remove the Calibration Standard from the Test Fixture.

Inserting Cal Standards into the PD1000A TO-220/TO-247 Test Fixtures

Inserting Calibration Standards into the Test Fixtures is the same as inserting your device to be tested. This section shows the orientation of the Calibration Standards inserted into the Test Fixture.

NOTE **Important:** Notice the orientation of each standard.

Input Standards

Two pins on each **OPEN**, **SHORT**, and **50 Ω LOAD** Calibration Standards. The Calibration Standards connects between the Gate and Source/Emitter.

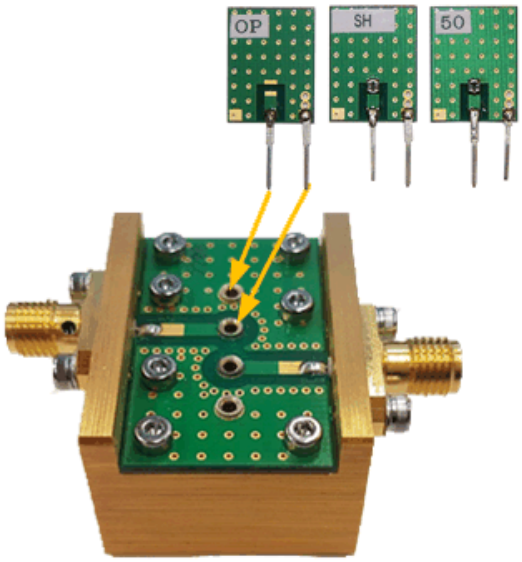


Figure 13 Inserting the Input **OPEN**, **SHORT**, **LOAD** Standards into the Test Fixture

Output Standards

Two pins on each **OPEN**, **SHORT**, and **50 Ω LOAD** Calibration Standards. These are the same standards used on the Input. The Calibration Standards connect between the Drain/Collector and Source/Emitter.

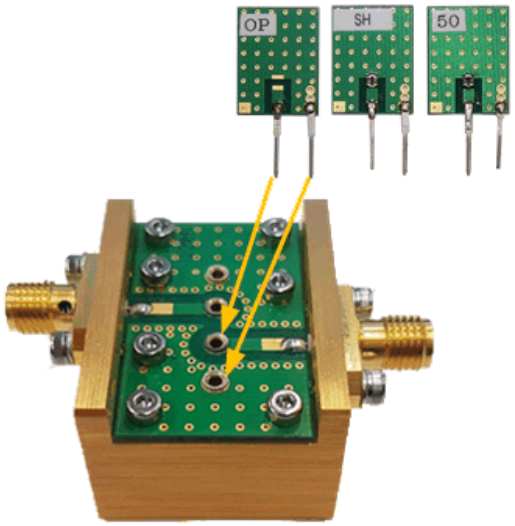


Figure 14 Inserting Output **OPEN**, **LOAD**, or **Short** Standards into the Test Fixture

THROUGH Standard

Two pins on the **THROUGH** Standard. There is no label on this standard It connects between the Gate and the Drain/Collector.

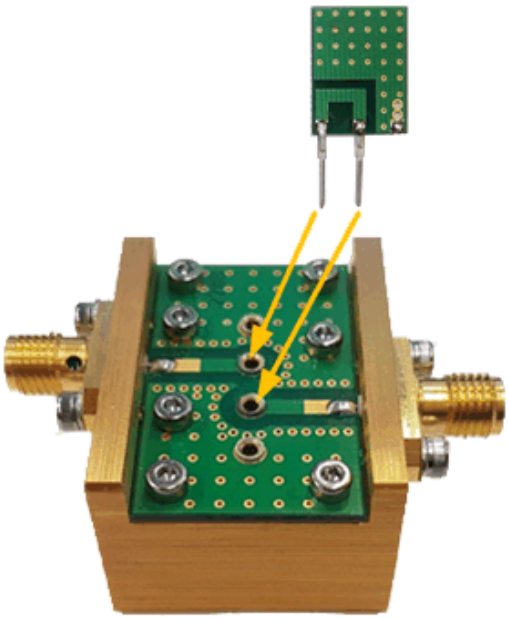


Figure 15 Inserting the **THROUGH** Standard into the Test Fixture

Inserting the Cal Standards into the PD1000A SMD Test Fixture

Use the Test Fixture PC Board, Vertically Conductive Sheet, and Frame Guide supplied with the SMD Test Fixture for fixture calibration.

Inserting Calibration Standards into the Test Fixture is the same as inserting your device to be tested. This section shows the orientation of the Calibration Standards inserted into the Test Fixture.

NOTE **Important:** Notice the orientation of the standards, see Figure 16 below. Insert all seven Calibration Standards with the same orientation.

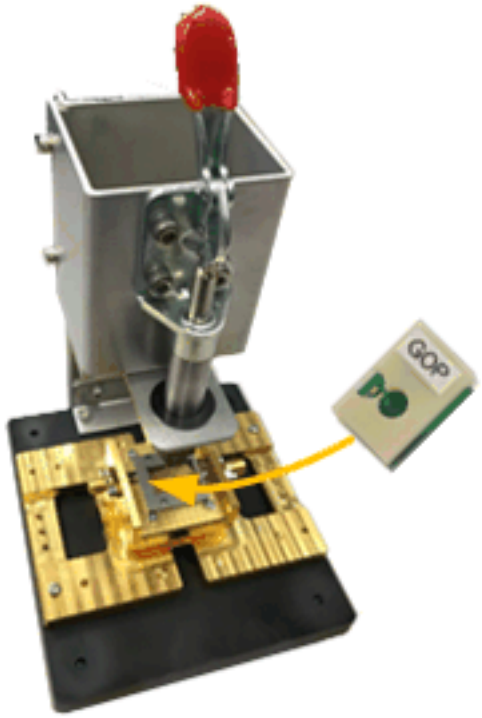


Figure 16 Placing an **OPEN**, **SHORT**, or **LOAD** Standard into the SMD Test Fixture

Customizing an SMD Test Fixture

The SMD Test Fixture and as provided by Keysight is suitable for TO-263 seven pin SMD devices. These devices must have Pin 1 connected to the Gate of the device under test. The device Tab must connect to the Drain or Collector. The Source or Emitter pin(s) must connect to GND.

NOTE

IMPORTANT: Because each SMD devices is unique, the customer is required to create and assemble a PC board, frame guide, and Calibration Standards specific to the device(s) they intend to test. This section provides general guidelines to customize the SMD test fixture.

Detailed CAD files (.dxf) for the PC Board, the Frame Guide and Calibration Standards for standard MOSFET and IGBT devices are available as part of the PD1000A installation.

You will also need to purchase a Keysight Frame.

Figure 16 shows the primary components of the SMD Test Fixture. Refer to the following instructions.

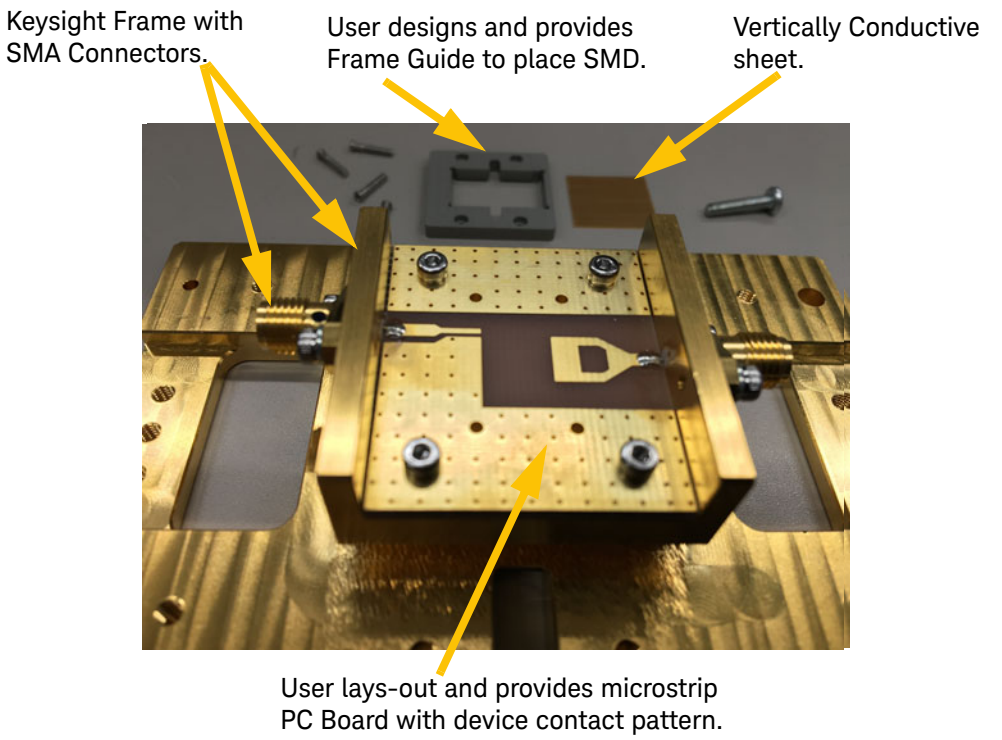


Figure 17 PD1000A SMD Test Fixture Components

Create a New PC Board

The customer is responsible to design and layout a microstrip line PC board with the contact pattern to match the device(s) being tested. A DXF CAD file for the PC board is available at www.keysight.com/find/PD1000A. Carefully layout the microstrip line PC board following the guidelines in the DXF CAD file. The board must not exceed the 30 mm x 36 mm (shown below) to fit inside the SMD Test Fixture frame. Solder pads must extend to the edges of the board to permit soldering the frame SMA center connector pins to the PC board.

Figure 18 below shows the microstrip line PC board provided with the PD1000A SMD Test Fixture. Yours will be different. TO-263-7 package shown for orientation and size reference. Dimensions shown are the critical dimensions, all dimensions are in mm. Shaded area represents copper clad on the PC board.

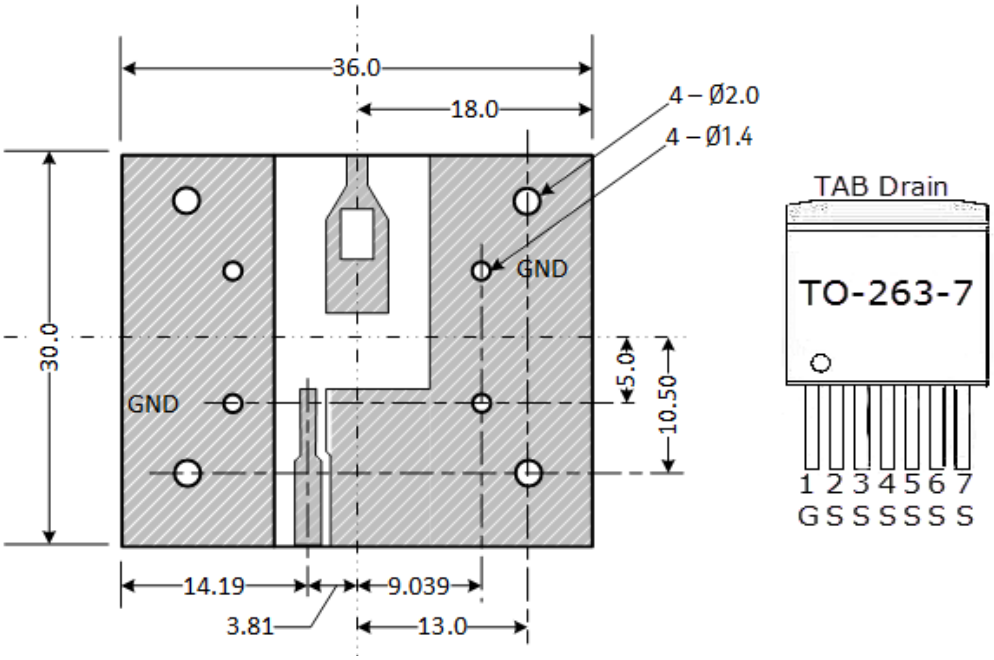


Figure 18 PD1000A SMD Test Fixture PC Board Guidelines. All dimensions in mm.

NOTE **Important:** The RF signal lines must maintain a 50 Ω impedance by microstrip line.

Several very good web sites that provide calculations for microstrip line layout to maintain the 50 Ω characteristic impedance. The following example presents general guidelines.

Example:

See Figure 19 below. Assume a PC Board of FR4 material with a thickness (h) of 0.5 mm. If *t* = 1 mm (the thickness of the trace), then *w* ≈ 0.877 mm. The distance from the RF Line to GND is >2*t*, or ≈ 2 mm. These are only approximations.

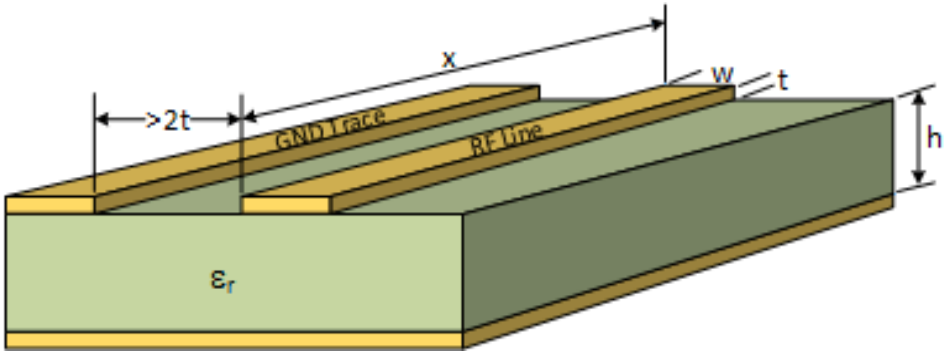


Figure 19 Microstrip Line Example for 50 Ω Impedance

The following microstrip line equations helps determine the width and length of the microstrip line for a give impedance.(Z_o). The substrate parameters ε_r and h are required.

NOTE To use the following microstrip substrate equations, the distance between the RF trace line and the GND must be greater than twice the thickness of the PC Board trace.

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\frac{1}{\sqrt{1 + 12\frac{H}{W}}} + 0.04\left(1 - \frac{W}{H}\right)^2\right]$$

$$Z_o = \frac{60}{\sqrt{\varepsilon_{eff}}}\ln\left(\frac{8H}{W} + \frac{W}{4H}\right)\Omega$$

Where: H=h-2t
ε_{eff} = Effective relative ε_r
ε_r = Dielectric Constant
Z_o = Characteristic impedance (use 50 Ω)

Create the Frame Guide

The Frame Guide must be made of ESD protected, heat resistant (>100 °C) material. Keysight recommends the standard SCM5100 ESD grade IC Test Socket available from PBI Advanced Materials: http://www.pbi-am.com/contents/esd/index.html?lang=EN. This material is easily machined to size and deburred. The following diagram shows the dimensions of the Frame Guide supplied with the SMD Test Fixture. You Frame Guide may vary. Screw holes are for M2 screws.

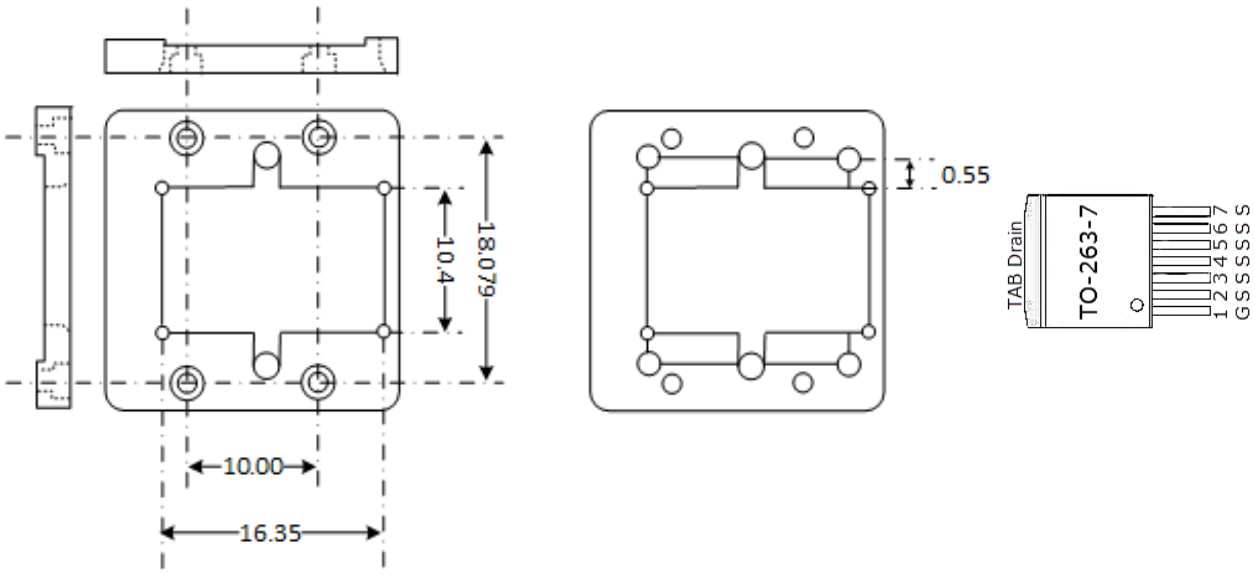
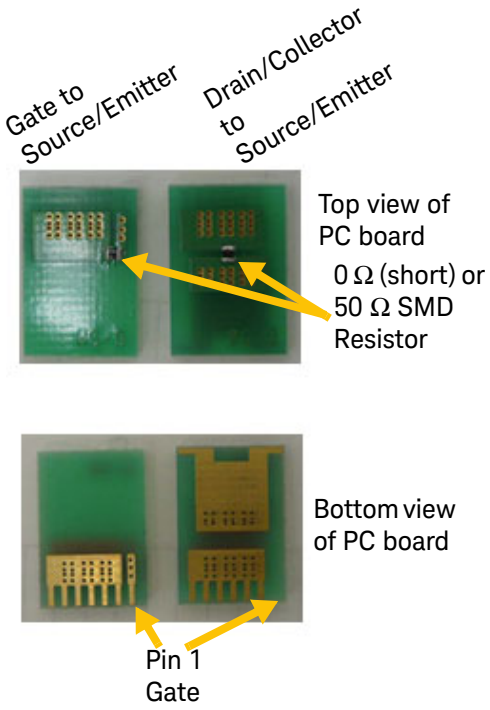


Figure 20 PD1000A SMD Frame Guide Outside Dimensions. Inside dimensions are for a TO-263-7 package. TO-263-7 shown for orientation purposes. All dimensions in mm.

Create New Calibration Standards

Along with the customized microstrip line PC Board and Frame Guide, you will need to create seven new Calibration Standards. These Cal Standards are small microstrip line PC boards with Open, Short, and Through; two boards have 50 Ω SMD resistors. The dimensions of the seven new Cal Standards must be the same as the outside dimensions of your DUT; the thickness of the Cal Standard must be the same thickness as your DUT. The seven PC boards must be designed as follows (use the provided TO-263-7 Cal Standards as examples):

Cal Standard	Connection Requirements
Port 1 Open	No connection, Gate to Source/Emitter.
Port 1 Short	Direct connection, Gate to Source/Emitter.
Port 1 50 Ω Load	Gate to Source/Emitter. Use a 50 Ω SMD resistor. The resistor must go on the top side of the PC board, not the trace side. See Figure 21 below.
Port 2 Open	No connection, Drain/Collector to Source/Emitter.
Port 2 Short	Direct connection, Drain/Collector to Source/Emitter.
Port 2 50 Ω Load	Drain/Collector to Source/Emitter. Use a 50 Ω SMD resistor. The resistor must go on the top side of the PC board, not the trace side. See Figure 21.
Through	Gate to Drain/Collector.



Example Calibration Standards for the "Gate to Source/Emitter" and the "Drain/Collector to Source Emitter". The traces on the bottom of the PC Board must match the pin-out of the DUT. The 0 Ω SMD resistor (short) or 50 Ω SMD resistor must be placed on the top of the PC Board.

Figure 21 Constructing the two 50 Ω SMD Cal Standards

Vertically Conductive Sheet

Additional sheets of the conductive material are available from ShinEtsu Chemical Co. (Japan). Use part number:

MTTE0.1*0.1*18*15*0.25 for 18 mm x 15 mm sheet, 0.25 mm thick

MTTE0.1*0.1*10*10*0.25 for 10 mm x 10 mm sheet, 0.25 mm thick

Cut a piece slightly larger than the cutout opening of the Frame Guide. When assembled to the Test Fixture, the Frame Guide holds the Vertically Conductive sheet in place.

Assembling the Customized SMD Test Fixture

1. Place the PC Board on the PD1000A-SMD Test Fixture. The copper traces must face upward. Slide the PC board under the SMA connector center pins.
2. Attach the PC Board to the SMD Fixture using four T6 hex-head screws provided with the SMD Test Fixture. Do not over tighten the screws.
3. Solder the PC Board to the SMA Connectors as shown below. Be careful to not damage the SMA connectors.

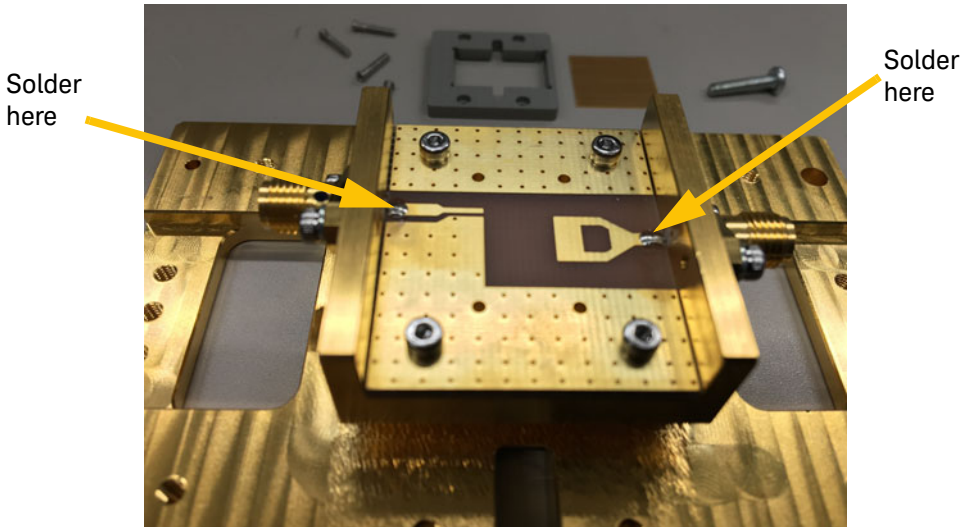


Figure 22 Solder the PC Board Pads to the SMA Connector Pins

4. Place the vertically conductive sheet over the PC board contact pattern.
5. Place the frame guide over the vertically conductive sheet. Secure it with four M2 screws. Hand tighten only, do not over tighten the screws.

Figure 23 below shows the assembled SMD Test Fixture.

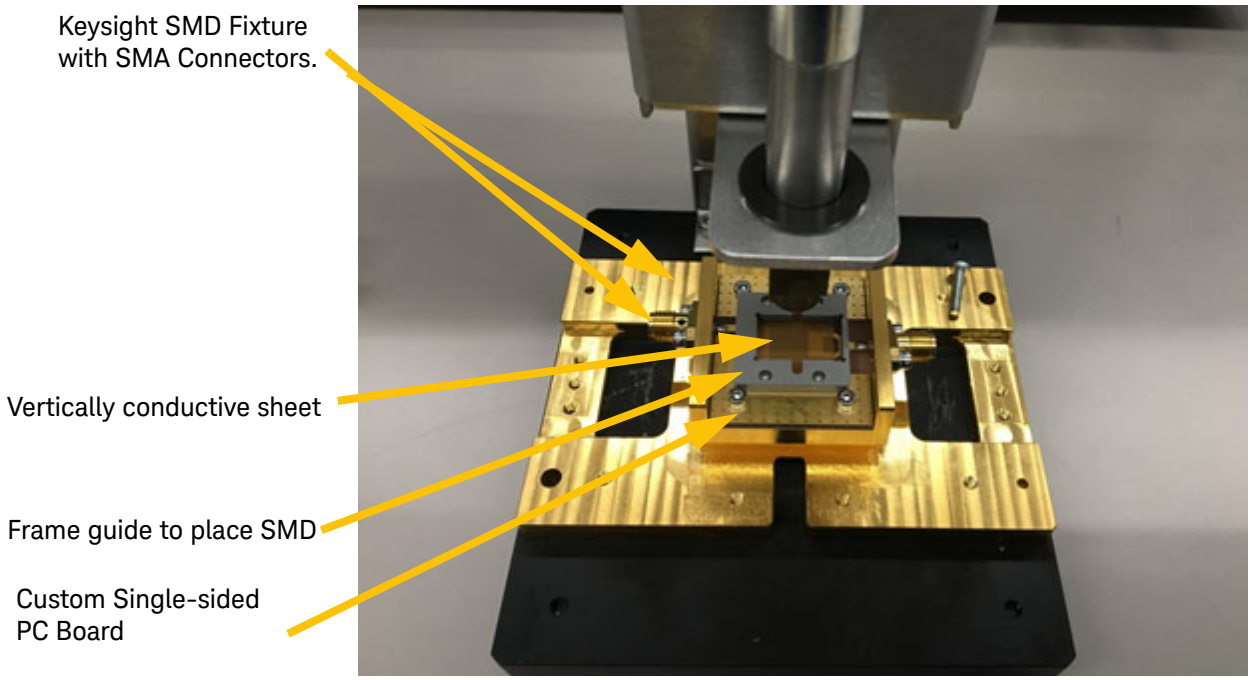


Figure 23 Assembling the SMD Test Fixture

Adjusting the Height of the Push Rod

You can adjust the height (and thereby the force that the push rod exerts on the SMD device) of the push rod on the test fixture by loosening the 1.5 mm hex socket (Allen) set screw on the side of the push rod head and sliding the head up or down then tightening the set screw. See the figure below.

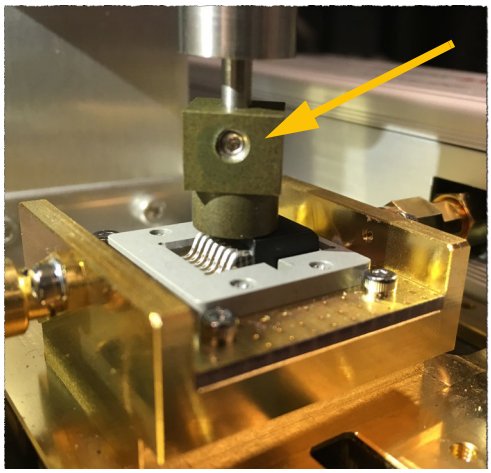


Figure 24 Allen Screw to Adjust the Height of the Push Rod

Troubleshooting

This section provides a simple functional verification procedure to test the PD1000A Test Fixtures, cables, and Calibration Standards. This test procedures do not verify the resistance accuracy of the Calibration Standards.

SMA Cables

Do not excessively bend, flex, or stretch the SMA cables. Check the SMA cables regularly, and replace them if they are damaged in any way. It is possible for the outside shielding of the cables to break.

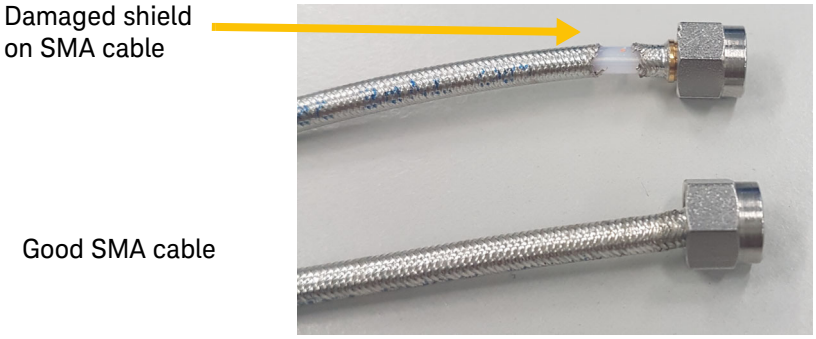


Figure 25 Damaged SMA Cable

Measuring the DC Resistance of the Calibration Standards

A simple verification test for the Calibration Standards is to measure the DC resistance of the standards. To the TO-220 and TO-247.

Measure the resistance between the two Cal. Standard pins or SMD pads. As shown below, the Calibration Standards should measure open (infinite resistance), short (0 Ω), 50 Ω, and pass-through (Gate to Drain/Collector).

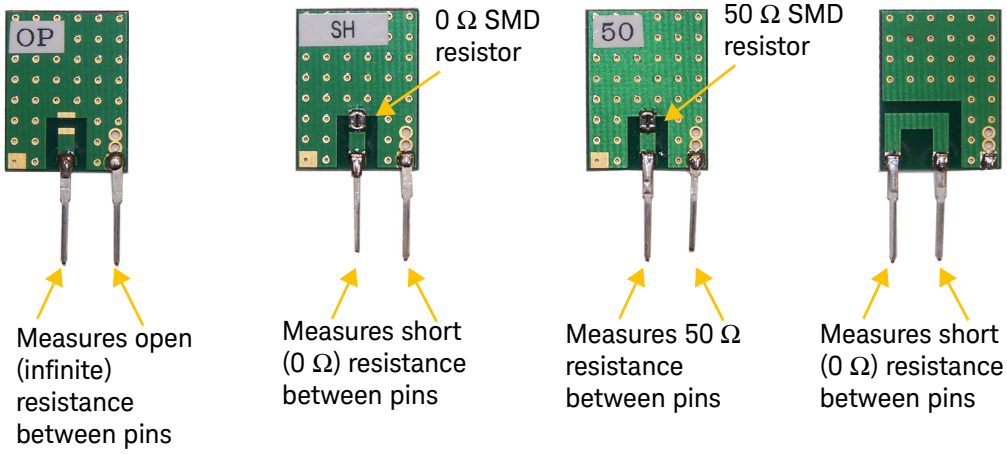


Figure 26 Measuring the DC Resistance of the TO-220/TO-247 Cal Standards

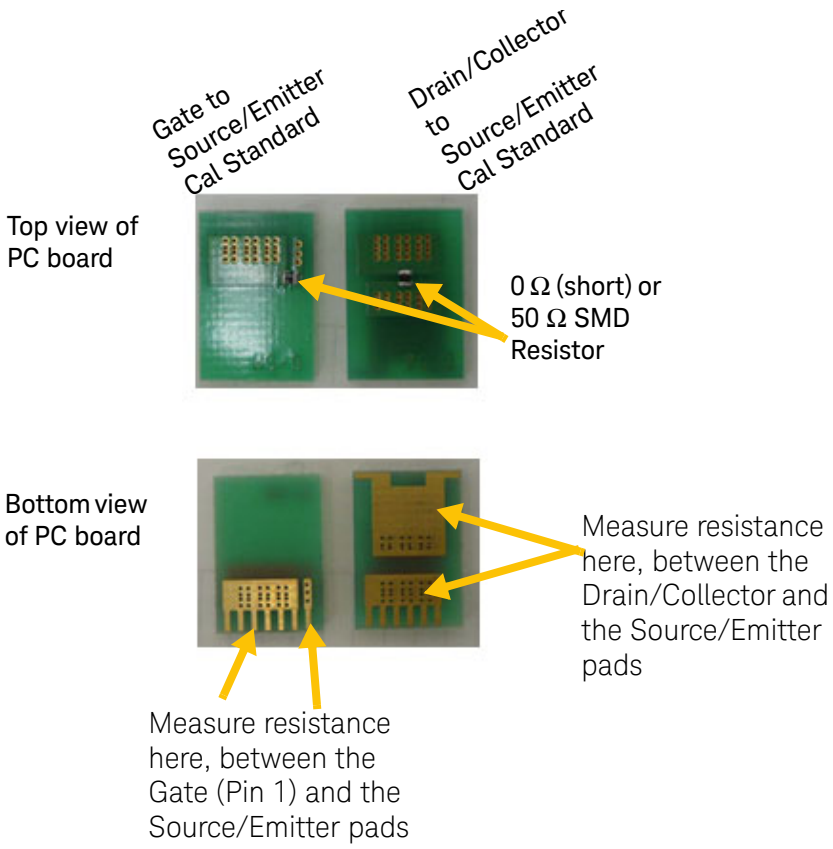


Figure 27 Measuring the DC Resistance of the SMD Calibration Standards

Use Proper SMA Connector Care and Connection Techniques

Good connections are essential for accurate calibrations and measurements and require a skilled operator. The most common cause of measurement error is poor connections.

SMA connectors will mate with 2.92 and 3.5 mm connectors. However, a damaged SMA connector, or a used SMA connector with a slightly bent pin can destroy a 2.92 or 3.5 mm connector. In SMA connectors, the center pin connects first, before the threads. If an SMA pin is bent or off-center for any reason, then the pin will make contact with the 2.92/3.5 mm female contacts which are unsupported as an air dielectric is used, and the female contact may be pushed out of place.

1. Ground yourself and all devices. Wear a grounded wrist strap and work on a grounded, conductive table mat.
2. Visually inspect the connectors. If necessary, clean the connectors.
3. Carefully align the connectors. As you make the actual connection, be sure the connectors align perfectly.
4. Push the connectors straight together. Do not twist or screw the connectors together.
5. Engage the connector nut (of the connector with the retracted sleeve) over the threads of the other connector (the connector with the extended sleeve). Turn only the connector nut. Let the connector nut pull the two connectors straight together.
6. Do not over tighten this connection. A connection in which the outer conductors make gentle contact at all points on both mating surfaces is sufficient. Very light finger pressure is enough to accomplish this.
7. Make sure the connectors are properly supported. Relieve any side pressure on the connection from long or heavy devices or cables.
8. Torque the connection according to the procedures described below.

Final Connection Using a Torque Wrench

Using a torque wrench guarantees the connection is not too tight, preventing possible connector damage. It also guarantees that all connections are equally tight. Prevent the rotation of anything other than the connector nut that you are tightening.

Use a Keysight 8710-1582, 0.56N-m (5 lb-in) 5/16 inch break-over torque wrench to make a final connection. A Torque wrench is supplied as part of the PD1000A-SPK Accessory Kit.

Figure 7 Keysight 8710-1582 SMA Torque Wrench

NOTE The Keysight 8710-1582, 5 lb-in Torque Wrench is a precision instrument and should be treated and maintained like a measuring instrument.

1. Turn the connector nut. This may be possible to do by hand if one of the connectors is fixed (as on a test port). However, it is recommended that you use a second open-end wrench to keep the body of the device from turning.
2. Position both wrenches within 90 degrees of each other before applying force. Wrenches opposing each other (greater than 90 degrees apart) will cause a lifting action that can misalign and stress the connections of the device involved. This is especially true when several devices are connected together. Refer to the following figure.

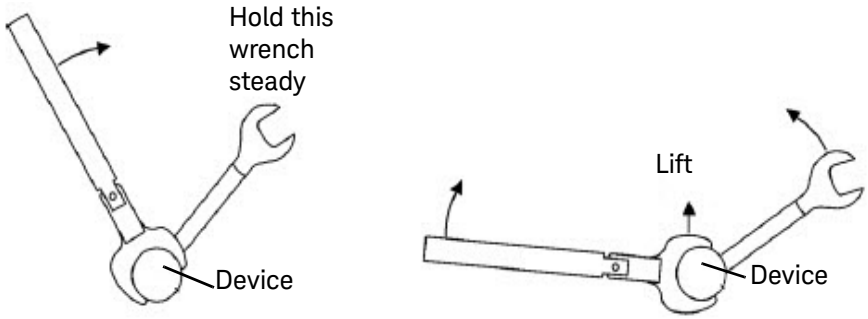


Figure 8 Wrench Positions

3 Hold the torque wrench lightly, at the end of the handle only (beyond the groove). See the following figure.

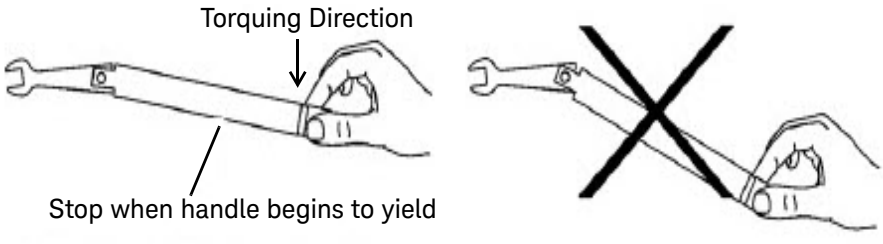


Figure 9 Using the Torque Wrench

4 Apply force downward to the wrench handle. This applies torque to the connection through the wrench. Do not hold the wrench so tightly that you push the handle straight down along its length rather than pivoting it, otherwise you apply an unknown amount of torque.

CAUTION **You don't have to fully break the handle of the torque wrench to reach the specified torque; doing so can cause the handle to kick back and loosen the connection. Any give at all in the handle is sufficient torque.**

5 Tighten the connection just to the torque wrench break point. The wrench handle gives way at its internal pivot point. Do not tighten the connection further.

Separating Connections

To avoid lateral (bending) force on the connector mating plane surfaces, always support the devices and connections.

CAUTION **Do not turn the device body. Only turn the connector nut. Damage to the center conductor can occur if the device body is twisted.**

1 Use an open-end wrench or spanner wrench to prevent the device body from turning.

2 Use another open-end wrench or the torque wrench to loosen the connector nut.

3 Complete the separation by hand, turning only the connector nut.

4 Pull the connectors straight apart without twisting, rocking, or bending.

Inspect and Clean Connectors

Clean connector interfaces prolong connector life and produce more accurate and repeatable measurements. When using SMA female connectors, pay special attention to the contact fingers on the female center conductor. These can be bent or broken, and damage to them is not always easy to see. A connector with damaged contact fingers will not make good electrical contact and must be repaired or replaced.

Inspect each connector to make sure that no particles or residue are present.

Connector Cleaning

WARNING **Always use protective eye-wear when using compressed air or nitrogen.**

WARNING **Keep isopropyl alcohol away from heat, sparks, and flame. Store in a tightly closed container. Isopropyl alcohol 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 regulation.

- Use compressed air to loosen particles on the connector mating plane surfaces.
- Apply a small amount of isopropyl alcohol to a lint-free swab. Clean the connector threads. Let the alcohol evaporate, then blow the threads dry with a gentle stream of clean, low-pressure compressed air or nitrogen. Always completely dry a connector before you reassemble or use it.

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