Operating Guide

Part of PD1000A Option -SPK Accessory Kit
Bias T Networks

Keysight PD1000A Power Device Bias T for S-Parameter Measurements

KEYSIGHT
TECHNOLOGIES

Notices

Manual Part Number

PD1000-90004

Edition

Second Edition, March 2019

Published by
Keysight Technologies, Inc.
900 S. Taft Ave.
Loveland, CO 80537 USA

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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 and Regulatory Symbols

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:

Refer to manual for additional safety information.

Earth Ground.

Chassis Ground.

Alternating Current (AC).

Direct Current (DC).

Standby Power. Unit is not completely disconnected from AC mains when power switch is in standby position

Indicates that antistatic precautions should be taken.

The CE mark is a registered trademark of the European Community. This product complies with the relevant European legal Directives: EMC Directive and Low Voltage Directive.

ICES/NMB-001 indicates that this ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme à la norme NMB-001 du Canada.

ISM GRP 1-A indicates that this instrument is an industrial scientific and Medical Group 1 Class A product.

Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC

This product complies with the WEEE Directive (2002/96/EC) marking requirement. The affixed product label (see below) indicates that you must not discard this electrical/electronic product in domestic household waste.

Product Category: With reference to the equipment types in the WEEE directive Annex 1, this product is classified as a "Monitoring and Control instrumentation" product.

Do not dispose in domestic household waste.

To return unwanted products, contact your local Keysight office for more information.

This symbol represents the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of this product.

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

The PD1000A Bias T Networks (part of the PD1000A Power Device Measurement System for Advanced Modeling option -SPK Accessory Kit) provide a means of supplying dc bias to the center conductor of a coaxial line of a bias-able component or device while blocking the dc bias to the Network Analyzer input port. Two Bias Ts are included with option -SPK accessory kit to the Keysight PD1000A Power Device Measurement System for Advanced Modeling. This accessory kit is used for making S-Parameter measurements.

Incoming Inspection

After unpacking the Bias T devices, 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 the Bias T networks 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.

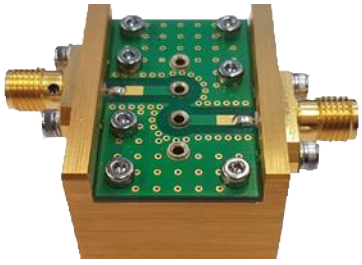
Preparation for Use

The PD1000A Bias T Networks connect in line with the device to be tested. Refer to Figure 2 on page 14 for a typical test setup. A bias voltage is applied from the DC source (e.g., the B2902A Precision Source Measure Unit) to the banana jacks on the Bias T networks.

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.**

Additional Products in the -SPK Accessory Kit

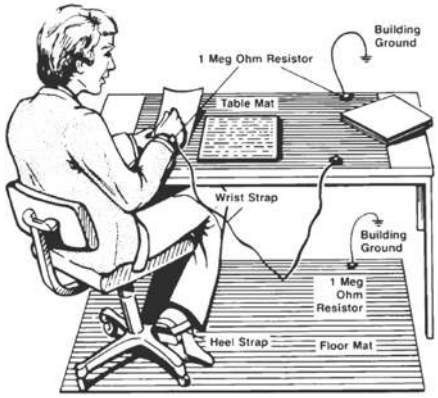
In addition to the two Bias T networks, the -SPK Accessory Kit includes the following items for S-Parameter measurements. Additional RF adapters are available at: Keysight Adapters.

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 p/n: 8710-1582	1	
Type N, Male to SMA Female Adapter 50Ω Nominal Keysight p/n: 1250-2879	2	
SMA male to SMA Male Cable Keysight p/n: 5062-6682 7-inch cable	2	
Stackable Banana Plug (each end) Cables Keysight p/n: 8121-2006 Black cable 8121-2007 Red cable	8	 4 red and 4 black
PD1000A Test Fixture for TO-220 style devices Keysight p/n: PD1000-67900 Keysight p/n: PD1000-67905 Calibration Standards PD1000A Test Fixture for TO-247 style devices Keysight p/n: PD1000-67901 Keysight p/n: PD1000-67906 Calibration Standards	1 1	
PD1000A Test Fixture for Surface Mount Devices Keysight p/n: PD1000-67902 Keysight p/n: PD1000-67907 Calibration Standards	1	

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.

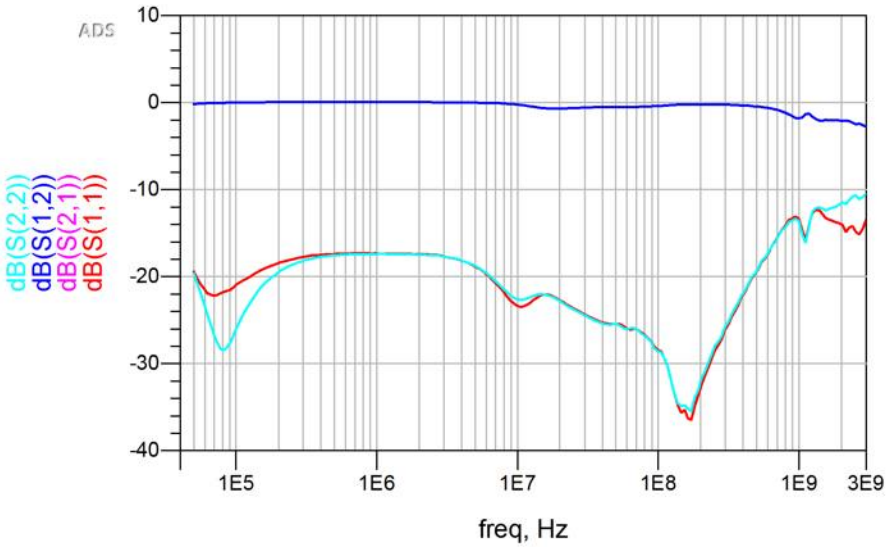
PD1000A Specifications

Specifications describe warranted performance of the device.

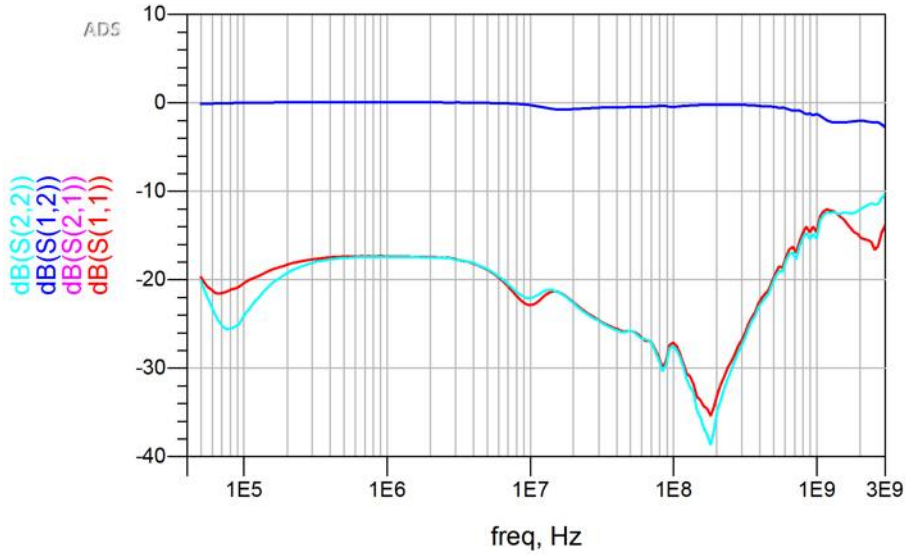
Table 1 PD1000A Bias T Specifications

Parameter	PD1000A (Typical)
Impedance	50 Ω
Maximum Voltage	±42 V
Maximum Current	5 A
Resistance (bias input to RF port)	70 mΩ
Frequency Range	50 kHz to 3 GHz (typical)
Rise Time	100 pS (typical)
Environmental Temperature	23 °C ±5 °C with less than 1 °C deviation from the calibration temperature
Capacitance (RF port 1 to port 2)	0.15 μF
Inductance	185 μH
RF Connectors	SMA female to ENA, SMA male to Test Fixture
DC Connectors	4 mm jack (banana jacks)

PD1000A Bias T Networks Frequency Response



Bias T used for Gate



Bias T used for Drain/Collector

Using the Bias Ts

Figure 1 shows a schematic diagrams of the Bias T networks. The circuit is a 'tee' filter in which the capacitor in the pass-through acts as a dc block/high pass filter. The series inductance acts as a low pass filter.

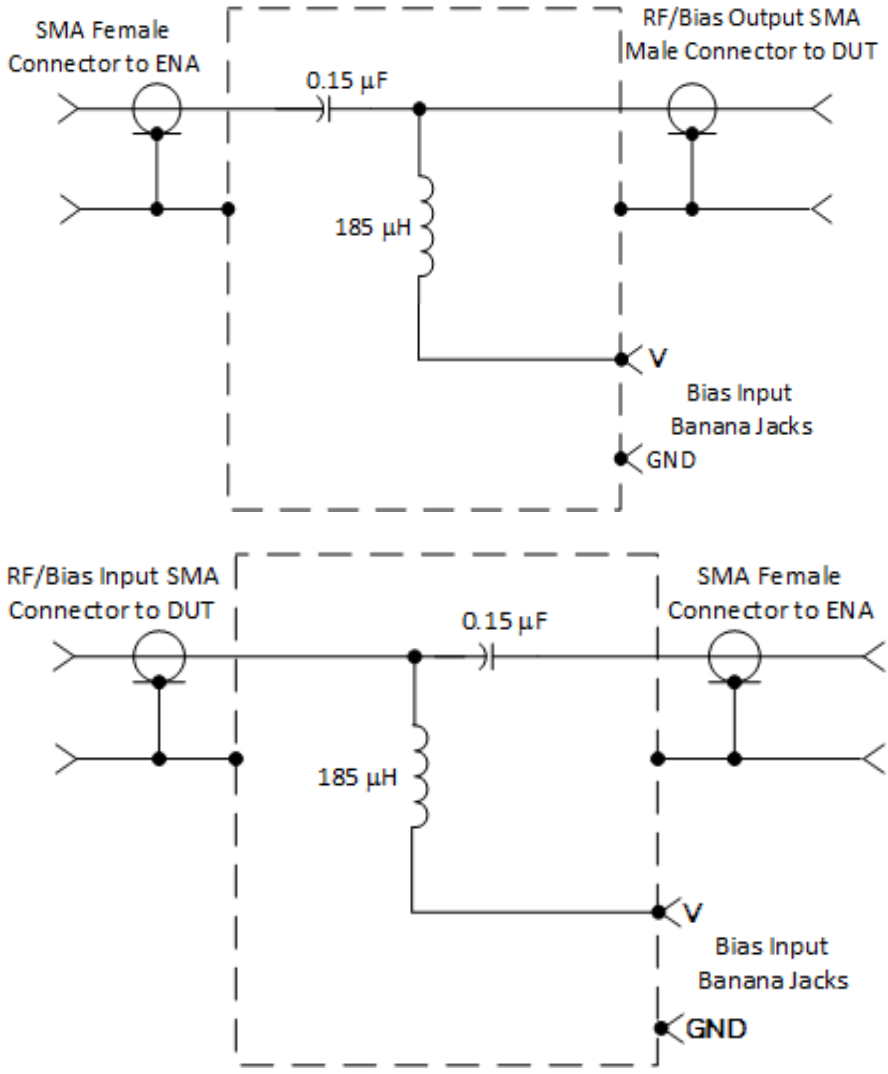


Figure 1 PD1000A Bias T Network Schematic Diagrams

On the Bias T networks, the "V" terminal connects to the Source Measure Unit (SMU) "V_{out}" or "V_{force}" and the "V_{sense}" terminals. Stack the banana plugs at the Bias T device for the Sense connections. See Figure 5 on page 17.

Two Bias T devices are provided in the accessory kit.

Figure 2 shows the PD1000A Bias T Networks connected in a typical measurement setup. Other applications are possible; the general method of setup and operation is the same.

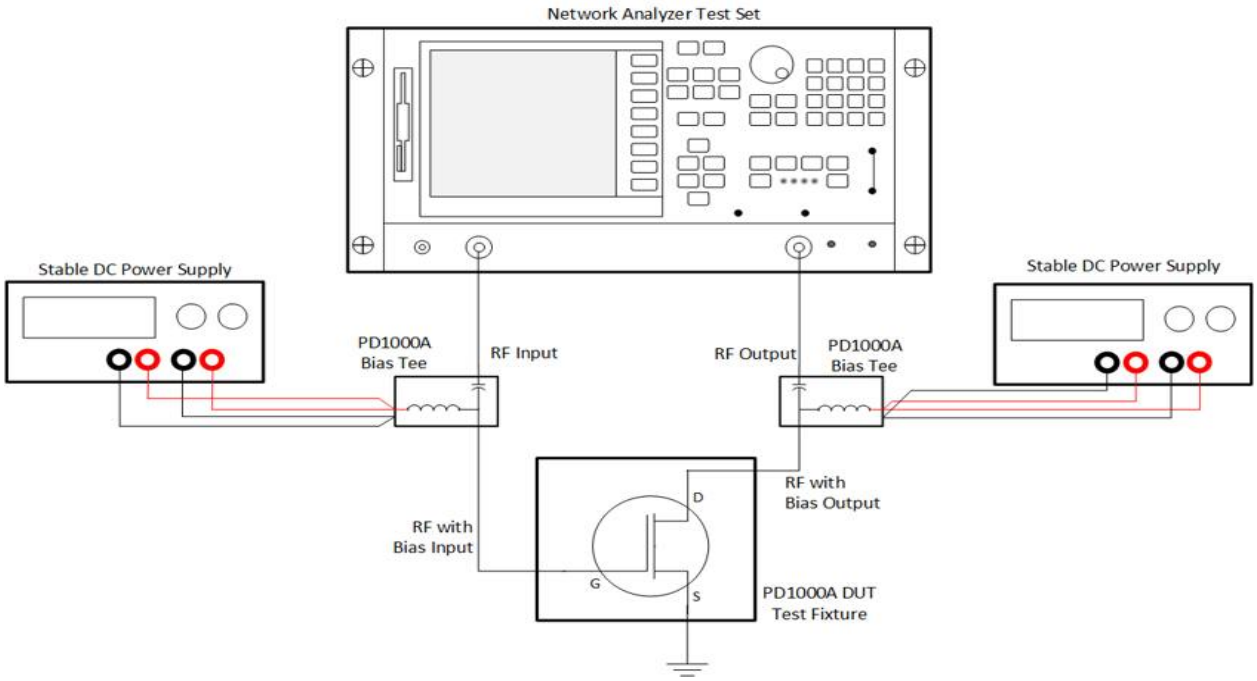


Figure 2 Typical (simplified) Measurement Setup

NOTE When an RF cable more than 50 cm (19.6 in.) in length is used, a 50 Ω, 1 dB attenuator should be inserted at the RF Input Connector.

NOTE When a bias voltage is applied to the network, both the RF input and the RF output terminals must be terminated at 50 Ω to prevent oscillations.

Use with PD1000A Power Device Measurement System

Keysight's PD1000A Bias T networks are designed to be used with the PD1000A Power Device Measurement System to provide high current bias for semiconductor devices. Specifically they are designed for use with the PD1000A Test Fixtures. The following diagrams show how to connect the bias networks to the Test Fixtures.

NOTE Make sure the SMA connectors are properly supported and level with the test fixture. Relieve any side pressure on the connection from long or heavy devices or cables.

PD1000A with TO-220 and TO-247 Device Style Test Fixtures

Figure 3 PD1000A Bias T Networks with PD1000A TO-220 and TO-247 Fixtures

PD1000A Surface Mount Device (SMD) Test Fixture

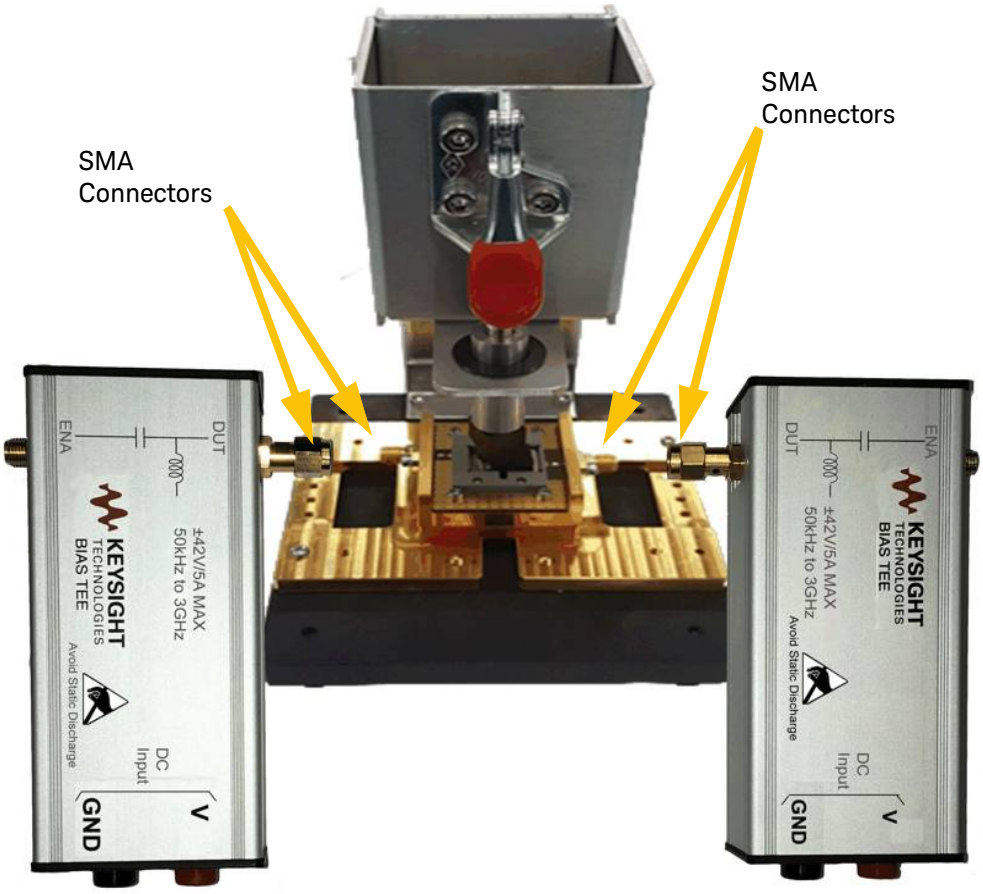


Figure 4 PD1000A Bias T Networks with PD1000A SMD Test Fixture

Connecting the PD1000A Bias Ts to a Keysight B2902A SMU

Figure 5 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.

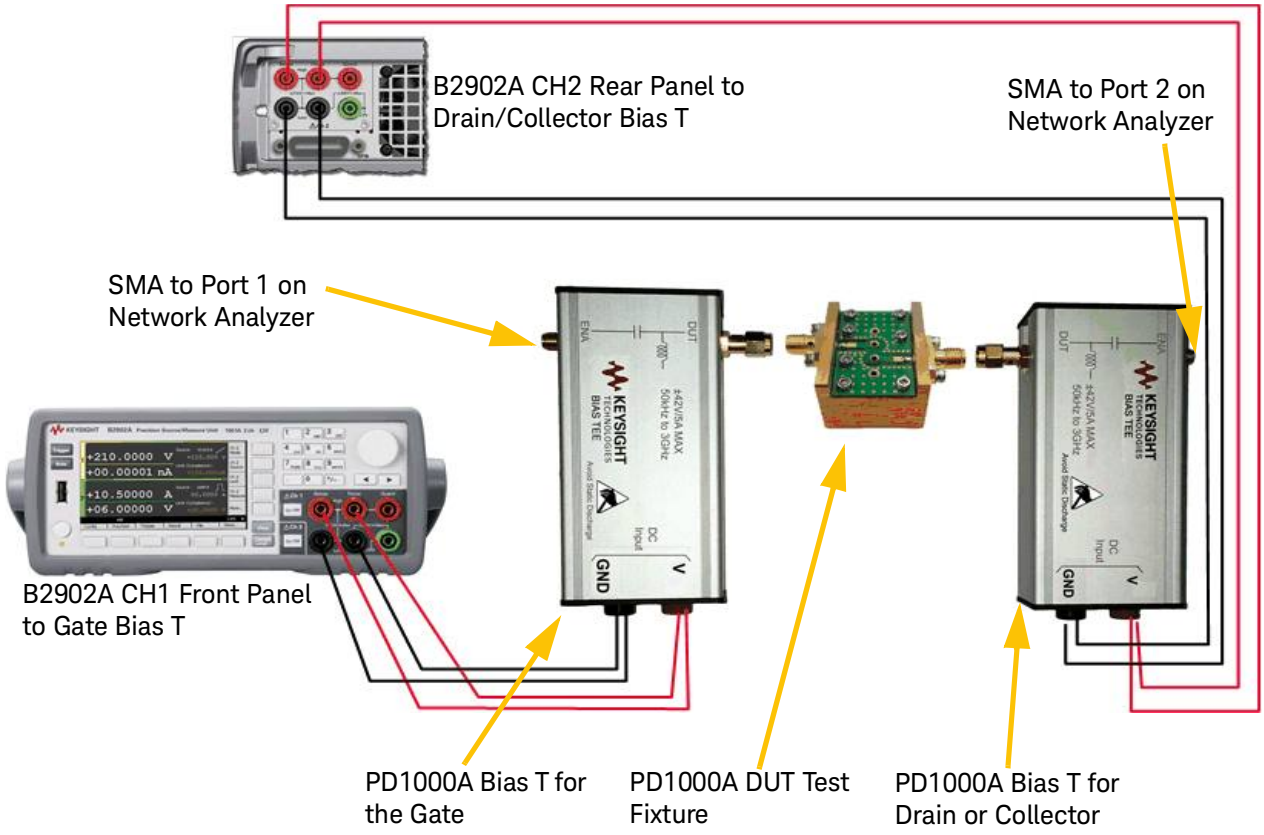


Figure 5 PD1000A Bias T Networks Connected to the B2902A SMU

General Test Setup

Figure 6 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.

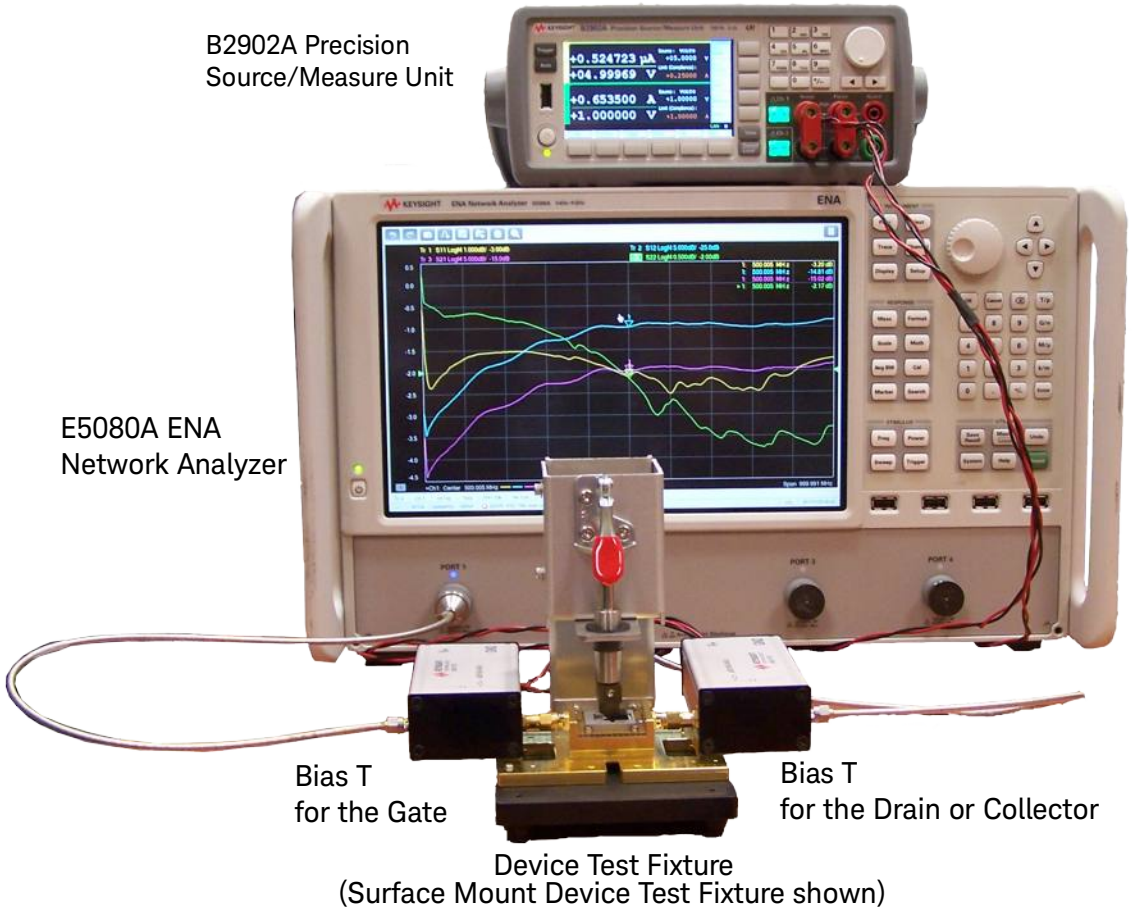


Figure 6 General Test Setup for the PD1000A S-Parameter Test System

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.

Performance Tests

The procedures in this section test the electrical performance of the PD1000A Bias T Network using the specifications of Table 1 as performance standards.

Performance may be verified using either a vector or scalar network analyzer setup. Errors due to directivity, source match, and return loss of the 'opposite port' termination (and detector match in a scalar system) will add uncertainties to your measurement. The most accurate method uses an error corrected instrument. However, a scalar system will have acceptable results depending on the quality of the components.

Record the results of the performance tests in Table 2 on page 20.

Return Loss of Input and Output Ports

The following instructions apply to both vector and scalar network analyzers.

1. Connect the equipment for a standard reflection measurement.
2. Calibrate the system with an open and a short.
3. Connect the appropriate RF port of the PD1000A Bias T Network to the test port. Terminate the opposite port with a 50 Ω load.

NOTE **The return loss of the terminating load should be at least 20 dB better than the desired measurement value.**

4. Measure the return loss. The specifications are listed in "PD1000A Specifications" on page 11.
5. Record the results of the performance tests in Table 2 on page 20.

Insertion Loss

1. Connect the equipment for a standard insertion loss measurement.
2. Calibrate the system the system with a through line.
3. Replace the through line with the PD1000A Bias T Network.
4. Measure the insertion loss. The specifications are listed in "PD1000A Specifications" on page 11.
5. Record the results of the performance tests in Table 2 on page 20.

Table 2 PD1000A Performance Test Record

PD1000A Model Number: _____	Test Date: _____ Tested By:_____
Return Loss	**PD1000A Measured Value**
0.0 to 1GHz	_____
Insertion Loss	
0.0 to 3 GHz	_____

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

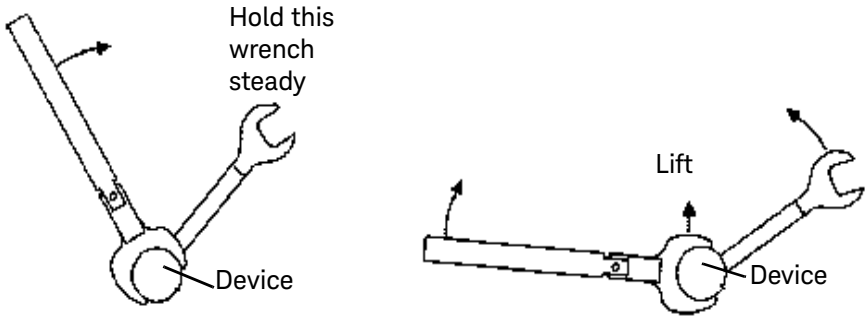
Using a torque wrench guarantees the connection is not too tight, preventing possible connector damage. It also guarantees that all connections are equally tight. Prevent the rotation of anything other than the connector nut that you are tightening.

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.



Correct method
(reduces lift on connection)

Incorrect method
(too much lift on connection)

Figure 8 Wrench Positions

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

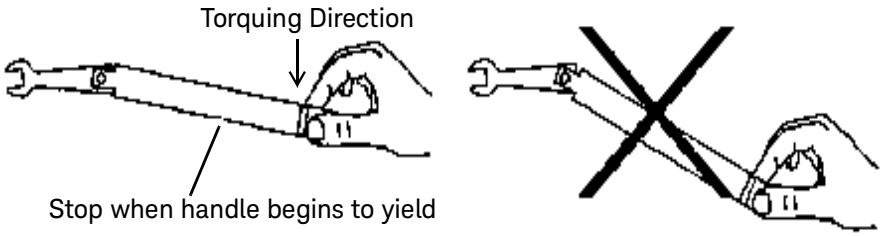


Figure 9 Using the Torque Wrench

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.

Printed in Malaysia
Edition 2, March 2019

PD1000-90004
www.keysight.com