Keysight N4377A Lightwave Detector

Wide operating frequency range
calibrated lightwave detector

User's Guide

KEYSIGHT
TECHNOLOGIES

Notices

Manual Part Number

N4377-91B01

Edition

Edition 1.0, December 2019

Keysight Technologies Deutschland GmbH
Herrenberger Strasse 130,
71034 Böblingen, Germany

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

U.S. Government Rights

The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement

("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at
http://www.keysight.com/find/sweula.

The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight:

(1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Warranty

Safety Notices

CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like 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 notice denotes a hazard. It calls attention to an operating procedure, practice, or the like 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.

Safety Summary

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

Initial Inspection

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically. The Performance Tests give procedures for checking the operation of the instrument. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Keysight Technologies Sales/Service Office.

WARNING To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

General

This product is a Safety Class 3 instrument. The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes.

Do Not Remove the Instrument Cover

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified personnel.

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

Regulatory Markings

The Table 1 lists the definitions of markings that may be on or with the product.

Table 1   Regulatory Markings

KC MSIP-REM-Kst-XXXXXXXXX	This symbol is a South Korean Class A EMC Declaration. This is a Class A instrument suitable for professional use and in electromagnetic environment outside of the home.		This symbol indicates that anti-static precautions shall be taken when handling the product.
40	This symbol indicates 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 the product.		This product complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical/electronic product in domestic household waste. To return products, contact your nearest Keysight Service Center, or see http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.
RCM	The RCM mark is a registered trademark of the Spectrum Management Agency of Australia. This signifies compliance with the Australian EMC Framework Regulations under the terms of the Radio Communications Act of 1992.		The recycling symbol indicates that the product is capable of being recycled.
CSA C US	The CSA mark is a registered trademark of the Canadian Standards Association.	ICES/NMB-001 **C€** ISM GRP 1-A	The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives. ICES/NMB-001 indicates that this ISM product complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.

Environmental Conditions

The N4377A is designed for indoor use in an area classifying as pollution degree 2. The table below shows the general environmental requirements for this instrument.

Table 2   N4377A Environmental Conditions

Environment condition	Requirement
Temperature	Operating condition +10 °C to +40 °C
	Storage condition –40 °C to 70 °C
Humidity	Up to 80% RH at 40°C (non-condensing)
Maximum Operating Altitude	Up to 2000 m

Regulatory Information

The N4377A complies with the following Electromagnetic Compatibility (EMC) compliances:

- IEC 61326-1/EN 61326-1
- Canada: ICES/NMB-001
- Australia/New Zealand: AS/NZS CISPR11

Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

- www.keysight.com/find/N4377A

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

- www.keysight.com/find/assist

  (worldwide contact information for repair and service)

Contents

1 Getting Started

This chapter provides an overview of N4377A lightwave detector.

KEYSIGHT
TECHNOLOGIES

Overview

The Keysight N4377A is a calibrated lightwave detector with a wide operating frequency range and integrated power meter capability.
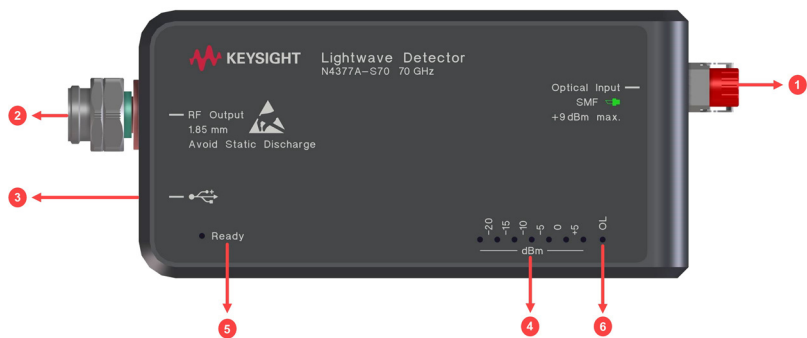
Table 3   N4377A

Label number	Option	Functionality
1	Optical Input	Depending on the product option, this is either an FC/APC SMF (Option S40, S70) or a FC/PC MMF (Option M40) input. The connector may be detached for cleaning purposes. For more information, refer to Cleaning the Fiber-Optic Connectors on page 38.
2	RF Output	Depending on the product option, this is either a 2.4 mm male (S40, M40) or a 1.85 mm male (S70) connector. **NOTE**: The RF Output is DC coupled.
3	USB connector	Used to power and control the Lightwave Detector by connecting it to a PC-based instrument such as a Vector Network Analyzer. The N4377A supports the USBTMC protocol for programming. Additionally, S-Parameter compensation data can be downloaded from the device.
4	Power bar	Indicates the optical input power as measured by the internal power meter.
5	Ready	▪ Green - The device is powered-on and functional. ▪ Green Flashing - Autozero running, power bar LEDs indicate progress. ▪ Red - A failure occurred, the power bar LEDs encode the error that occurred. This information will help Keysight service to identify the type of issue.
6	OL	Overload indicator ▪ Off - The optical input power is below the damage level of the device ▪ Red - The optical input power is above the absolute maximum rating. Reduce the optical input power to avoid damaging the device.

Theory of Operation

The N4377A lightwave detector utilizes a reverse biased photodiode to convert optical power to an electrical current. The photodiode's output is directly connected to the ruggedized RF output port for easy connection to instruments such as spectrum or network analyzers. Additionally, the bias voltage supply senses and digitizes the current flowing into the photodiode. The microcontroller then converts the current reading into a power level based on the calibrated responsivity value at the set wavelength. The power level is displayed in 5 dB-steps on the power indicator LEDs on the instrument and can be read using SCPI commands.
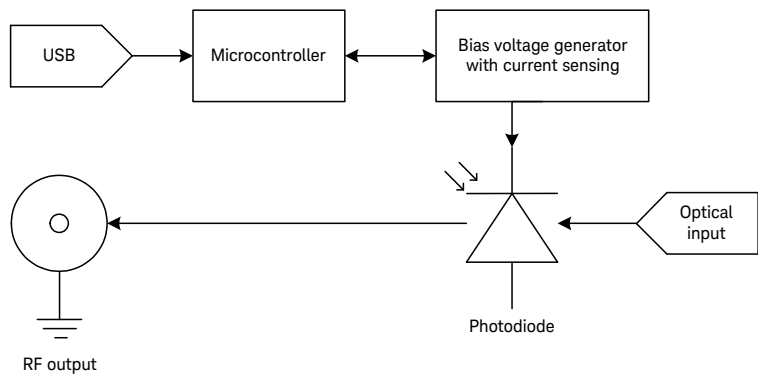
Initial Inspection

When you receive the N4377A lightwave detector, inspect the shipping container for damages. If the shipping container or packaging material is damaged, it should be kept until the contents of the shipment have been checked mechanically and electrically. If there is any mechanical damage, notify the nearest Keysight Sales and Service Office. Keep the damaged shipping materials (if any) for inspection by the carrier and a Keysight representative.

Standard shipped items

Verify that you have received the following items. If anything is missing or damaged, contact the nearest Keysight Sales Office.

Quantity	Part number	Description
1	N4377A	Lightwave Detector
1	8121-1242	USB cable, type A-B, 1 meter
1	5972-3356	Calibration report notification
1	9320-6654	China RoHS Addendum for Photonic Test and Measurement Products

2 Remote Programming

KEYSIGHT
TECHNOLOGIES

Remote Programming Overview

This chapter introduces the basic concepts of remote programming of an N4377A Lightwave Detector using SCPI commands.

Instructions

Instructions, both commands and queries, normally appear as strings embedded in a statement of your host language, such as Visual Basic for Applications (VBA), Visual Basic, Python, .NET, C#, C, etc.

Instructions are composed of two main parts:

· The header, which specifies the command or query to be sent.
· The program data, which provides additional information to clarify the meaning of the instruction.

Instruction Header

The instruction header is one or more command mnemonics separated by colons (:). They represent the operation to be performed by the instrument. Queries are formed by adding a question mark (?) to the end of the header. Many instructions can be used as either commands or queries, depending on whether or not you include the question mark. The command and query forms of an instruction usually have different program data. Many queries do not use any program data.

White Space (Separator)

White space is used to separate the instruction header from the program data. If the instruction does not require any program data parameters, you do not need to include any white space. In this manual, white space is defined as one or more spaces. ASCII defines a space to be character 32 in decimal.

Braces

When several items are enclosed by braces, { }, only one of these elements may be selected. A vertical line (|) indicates "or". For example, {ON | OFF} indicates that either ON or OFF may be selected, not both.

Ellipsis

... An ellipsis (trailing dots) indicates that the preceding element may be repeated one or more times.

Square Brackets

Items enclosed in square brackets, [ ], are optional.

Program Data

Program data is used to clarify the meaning of the command or query. It provides necessary information, such as whether a function should be on or off. Each instruction's syntax definition shows the program data and the values they accept.

When there is more than one data parameter, they are separated by commas (,). You can add spaces around the commas to improve readability.

Calibration Commands

[:CALibration]:ZERO

Command	**[:CALibration]:ZERO**
Syntax	[:CALibration]:ZERO
Description	Starts the autozero process. No power readings are taken while autozero is in progress. The ready LED flashes while autozero is running, the power bar LEDs indicate progress.
	NOTE: Ensure that there is no optical power applied to the input during the autozero process.
Parameters	None
Response	None
Example	ZERO

[:CALibration]:ZERO?

Query	**[:CALibration]:ZERO?**
Syntax	[:CALibration]:ZERO?
Description	Queries autozero status.
Parameters	None
Response	0: No autozero has been run yet, using values from factory
	1: Autozero is running
	2: Autozero completed successfully
	3: Autozero has failed due to optical power being present, factory values have been restored
Example	ZERO? → 2<END>

Configure Commands

:[CONFigure][:POWer]:UNIT

Command	:[CONFigure][:POWer]:UNIT
Syntax	:[CONFigure][:POWer]:UNit<wsp>DBM|0|Watt|1
Description	Sets the power unit.
Parameters	0: dBm 1: Watt DBM WATT
Response	None
Example	UNIT WATT

:[CONFigure][:POWer]:UNIT?

Query	:[CONFigure][:POWer]:UNIT?
Syntax	:[CONFigure][:POWer]:UNIT?
Description	Queries the power unit
Parameters	None
Response	Integer value: 0: dBm, 1: Watt
Example	UNIT? → 1<END>

:[CONFigure][:POWer]:WAVelength

Command	:[CONFigure][:POWer]:WAVelength
Syntax	:[CONFigure][:POWer]:WAVelength<wsp><value>|MIN|MAX|DEF [NM|UM|MM|M]
Description	Sets the wavelength to determine the correction factor for the power meter.
Parameters	The wavelength as a float value in meters. MIN: minimum programmable value MAX: maximum programmable value DEF: default value (1550 nm for options S40, S70; 850 nm for option M40)
Response	None
Example	WAV 1550nm

:[CONFigure][:POWer]:WAVelength?

Query	:[CONFigure][:POWer]:WAVelength?
Syntax	:[CONFigure][:POWer]:WAVelength?[<wsp>MIN|MAX|DEF]
Description	Returns the last wavelength set. For min/max/def the value specified by the symbolic constant is returned.
Parameters	MIN: minimum programmable value MAX: maximum programmable value DEF: default value
Response	The wavelength as a float value in meters.
Example	WAV? → 1.55e-6<END>

Common Commands

*OPT?

Query	***OPT?**
Syntax	*OPT?
Description	Returns the installed option.
Parameters	None
Response	String: S40/M40/S70
Example	*OPT? → S70<END>

Read Commands

:READ[:POWer]?

Query	**:READ[:POWer]?**
Syntax	:READ[:POWer]?
Description	Returns the last valid power reading. The update rate of the internal power meter is 2 readings per second.
Parameters	None
Response	The last valid power reading as a float value in dBm or W as set by the :[CONFigure][:READ]:UNit command.
Example	READ? → -0.284116<END>

:[READ]:TEMPerature?

Query	**:[READ]:TEMPerature?**
Syntax	:[READ]:TEMPerature?
Description	Returns the temperature of the optical assembly.
Parameters	None
Response	Optical assembly temperature in degree Celsius.
Example	TEMP? → 31.4159

System Commands

:SYSTem:PON:TIME?

Query	**:SYSTem:PON:TIME?**
Syntax	:SYSTem:PON:TIME?
Description	Returns the duration the instrument has been powered on.
Parameters	None
Response	Time since power up in seconds.
Example	SYST:PON:TIME? → 1337<END>

Memory Command

[:MMEMory]:CORRection?

Query	**[:MMEMory]:CORRection?**
Syntax	[:MMEMory]:CORRection? <wavelength> [,<power>]
Description	Returns the S2P compensation data for the requested wavelength and power. The S2P data is returned as a string. If the exact wavelength and power are not available, the closest data set will be returned. **NOTE**: The data returned is identical to the S2P files available on the USB drive.
Parameters	The wavelength as a float value in meters. MIN: minimum programmable value MAX: maximum programmable value DEF: default value (1550 nm for options S40, S70; 850 nm for option M40) The power as a float value in the unit specified by :[CONFigure][:POWer]:UNIT
Response	S2P data
Example	CORR? 1310nm → <S2P data>

3   Using the N4377A

KEYSIGHT
TECHNOLOGIES
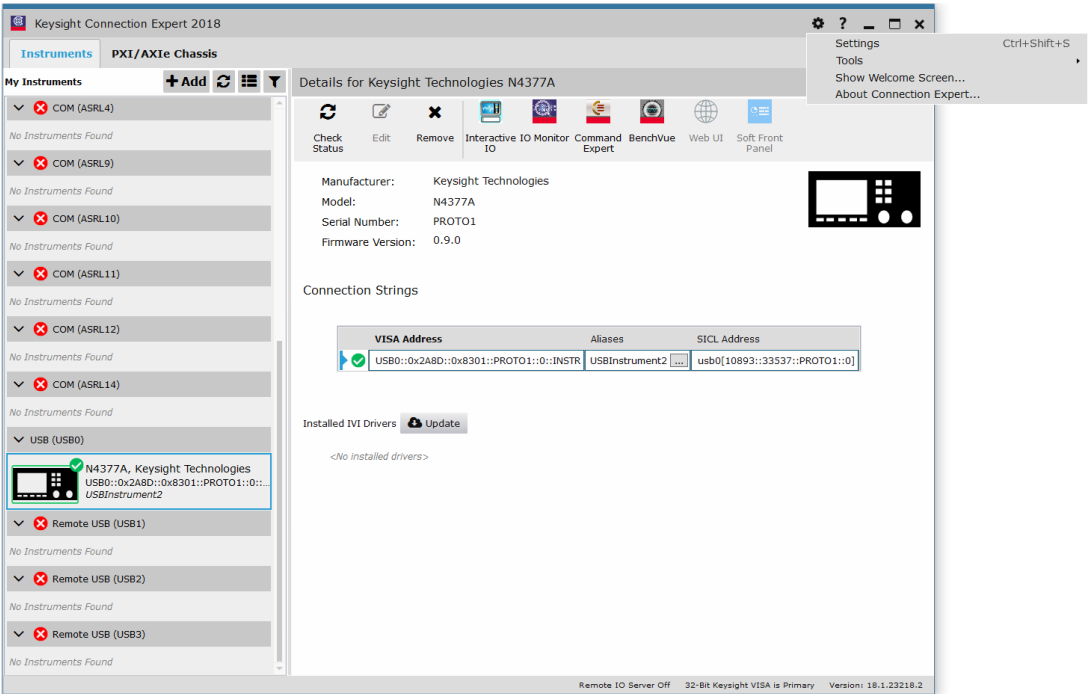
N4377A Remote Access

You can use the Remote IO Server included in the Keysight IO Libraries to program the N4377A without a direct USB connection.
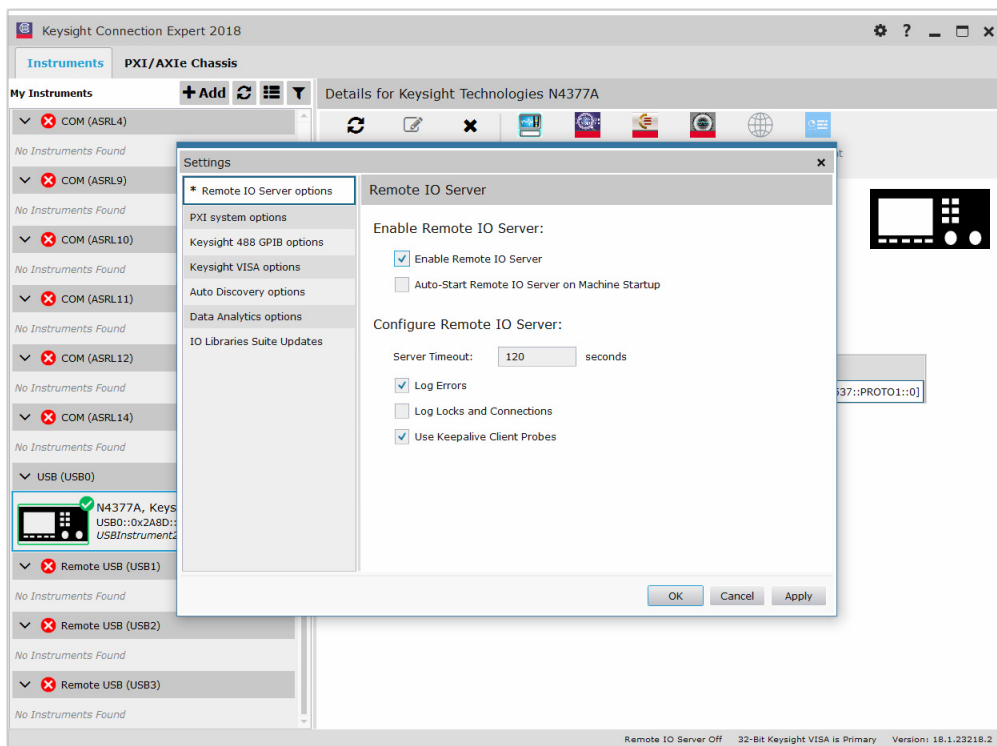
To do so, follow the steps below:

1   On the Windows-based instrument that your N4377A is connected to, do the following:

   a   Open the **Keysight Connection Expert**.
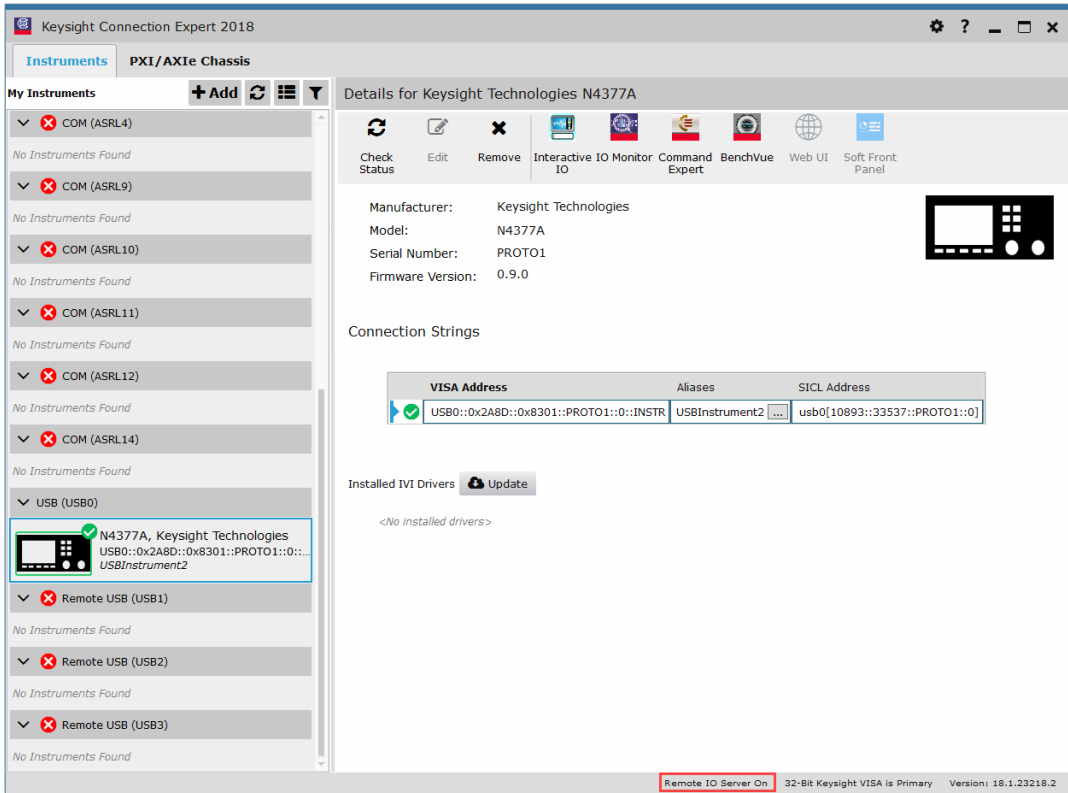

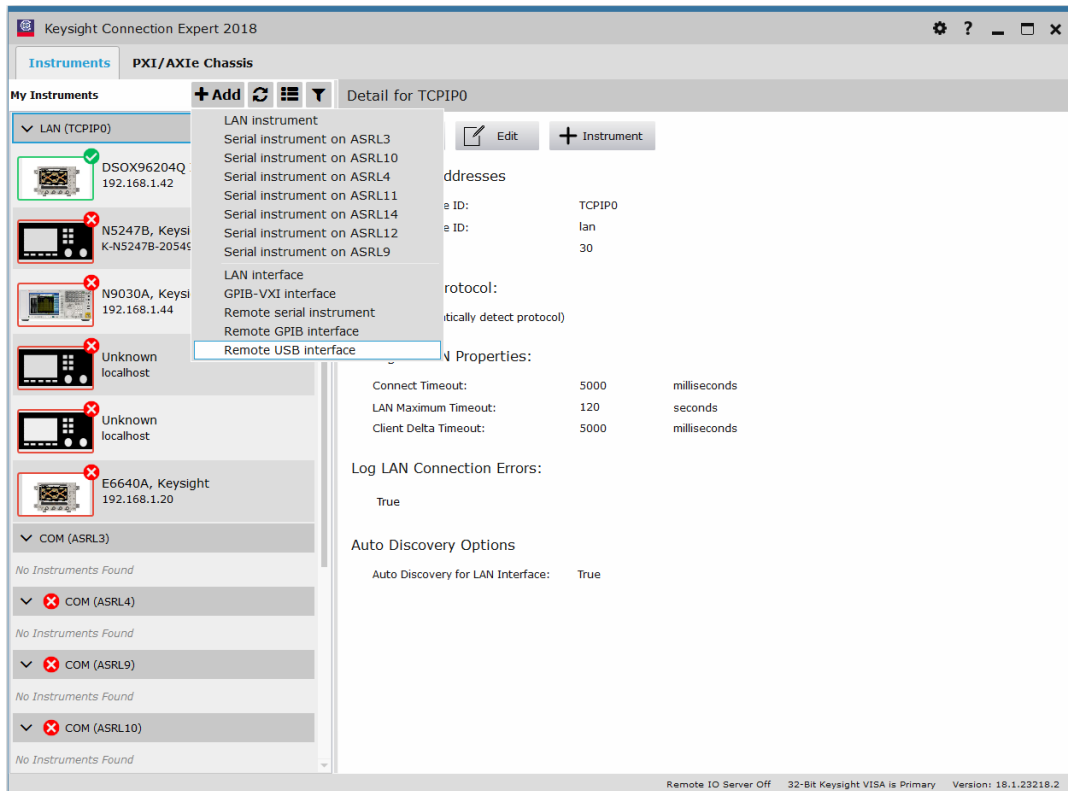   b   On the upper-right corner, click the ⚙ icon and then select **Settings**.

c   In the **Settings** window, select the **Enable Remote IO Server** check box, and then click **OK**.

d   Confirm that the **Remote IO Server** is On.

2   On the Windows-based instrument from which you want to access the N4377A, do the following:

  a   Go to **My Instruments** pane, click **Add**, and then select **Remote USB interface**.

b In the **Add Remote USB interface** window, type the host name or IP address of the computer running the Remote IO Server, and then click **OK**. All other settings can be left as-is.
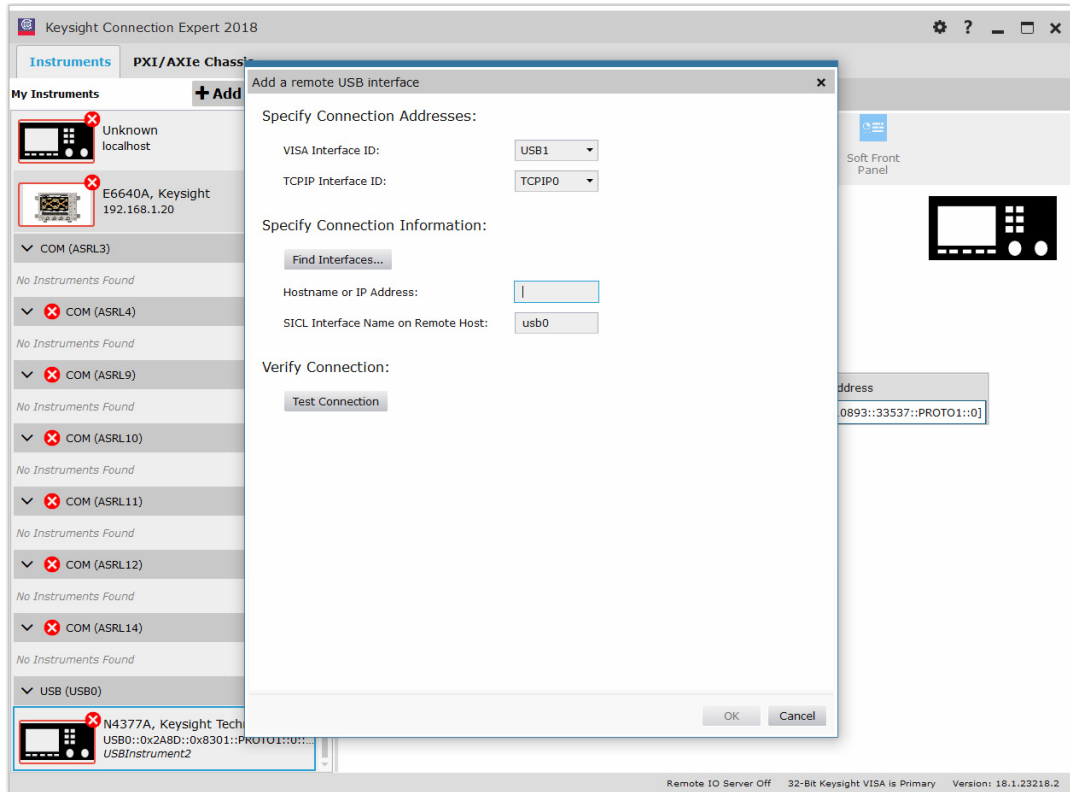
The remote N4377A appears after a short delay.
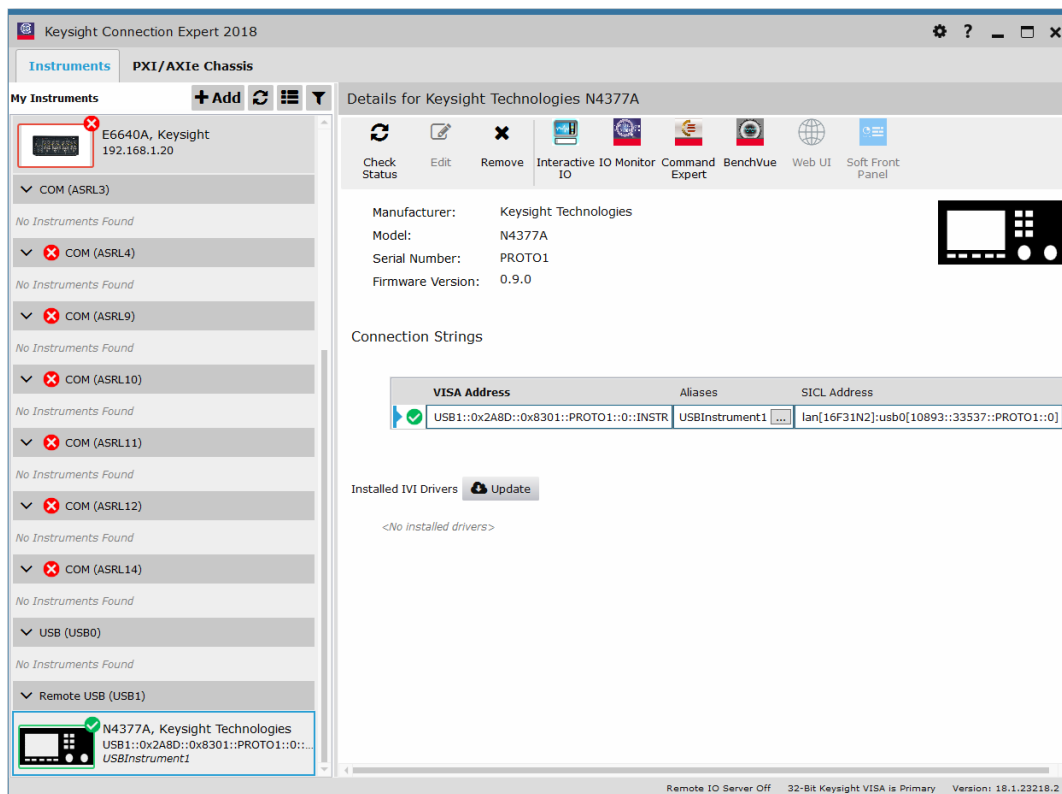
For more details, refer to http://www.keysight.com/find/iosuite.

Using S2P Compensation Data

The S2P compensation files can be loaded from the N4377A's read-only USB drive to a computer, e.g. a network analyzer.

For automation purposes, the same compensation data can be retrieved using the [:MMEMory]:CORRection? query. For more details see [:MMEMory]:CORRection? on page 22.

Deembedding the N4377A's response on a network analyzer

1   To access the fixture settings, press the **Cal button** on the front panel of the instrument.
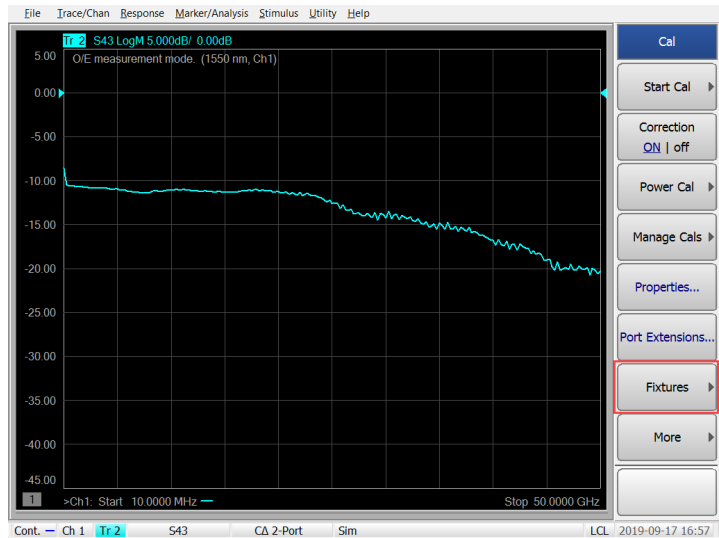
2 Navigate to the 2-Port deembed window by selecting **Fixtures** followed by **2-Port Deembed**.

3 In the **2 Port De-embedding** window, select the port to which the N4377A is connected.
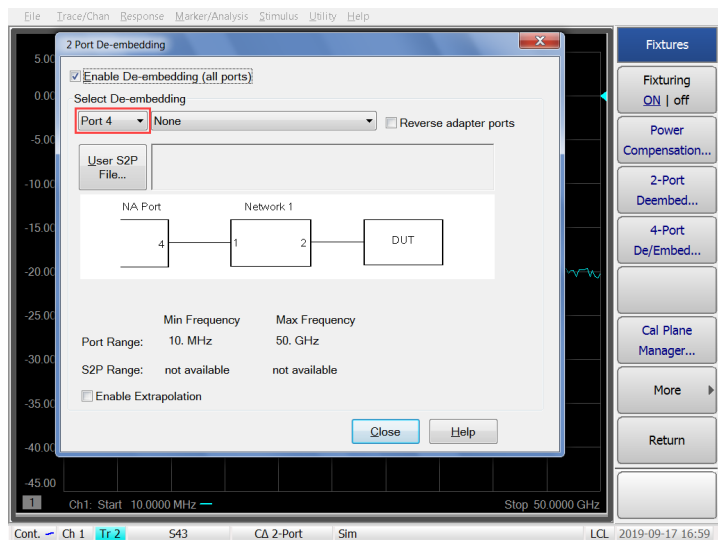
4   Click the **User S2P File...** option.
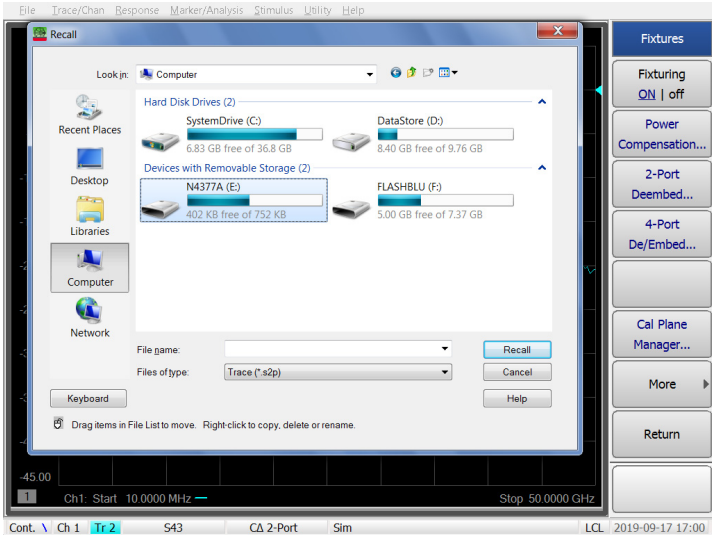
5   Navigate to the S2P File, stored on the N4377A in the folder
     Compensation Data:
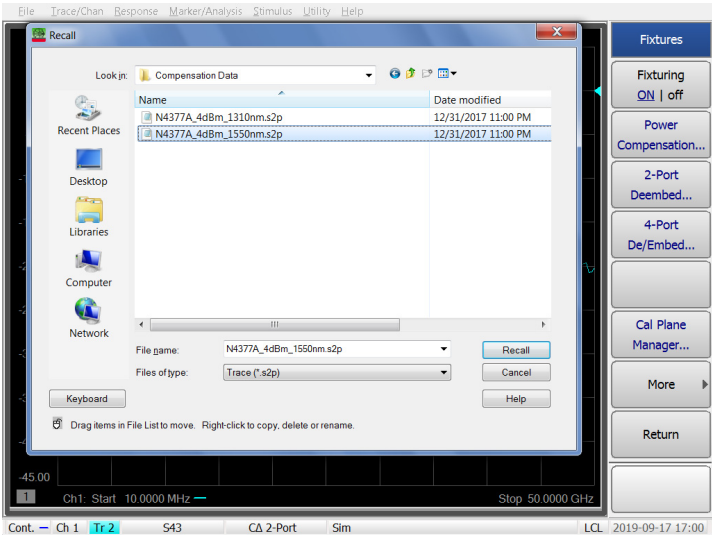
6   After the appropriate file has been selected, change the mode from **None** to **User Defined**.
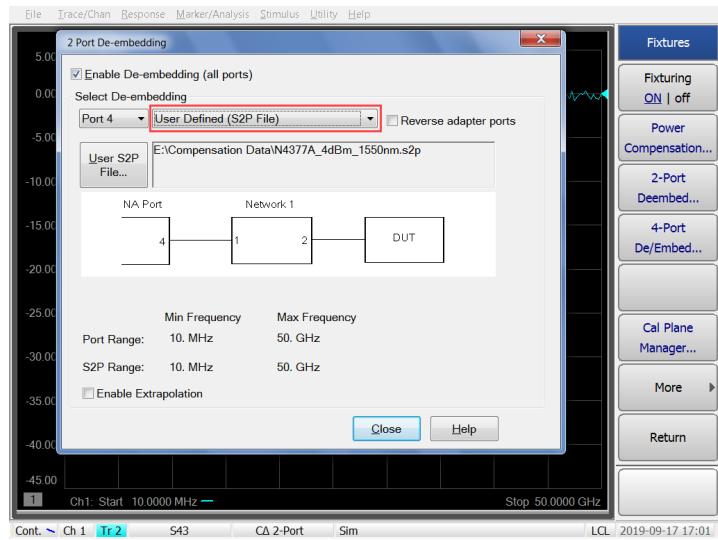
7   Close the window and verify that the displayed S-Parameters are compensated for the response of the N4377A.
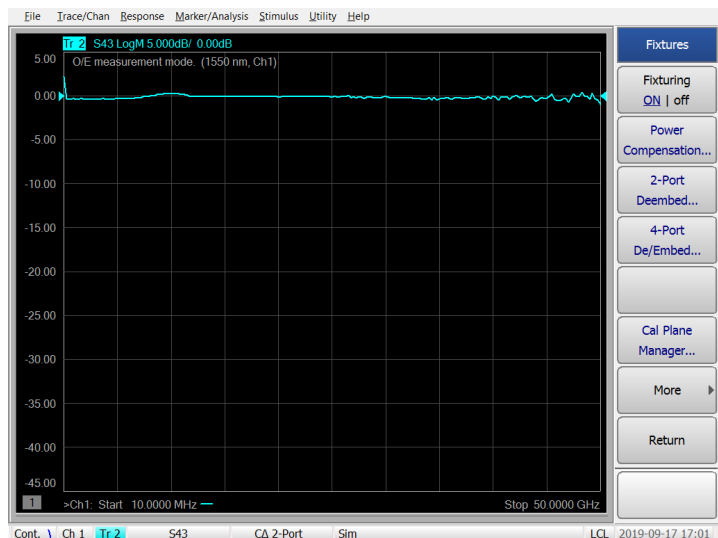
4 Characteristics and Specifications

For the characteristics and specifications of the N4377A, refer to the datasheet at
http://literature.cdn.keysight.com/litweb/pdf/5992-4214EN.pdf.

Declarations of Conformity for this product and for the Keysight products may be downloaded from the Web. Go to
http://www.keysight.com/go/conformity.

You can then search by product number to find the latest Declaration of Conformity.

KEYSIGHT
TECHNOLOGIES

5 Maintenance and Operating Precautions

KEYSIGHT
TECHNOLOGIES

Cleaning the Fiber-Optic Connectors

Treat all fiber-optic connectors like the high-quality lens of an expensive camera. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices can:

· degrade measurement accuracy and repeatability and

· cause expensive damage to instruments.

Because fiber-optic connectors are susceptible to damage that is not immediately obvious to the naked eye, it is very easy to make bad measurements without being aware of a connector problem. Learning about proper handling and cleaning techniques will help you to avoid any degradation in connector performance. With glass-to-glass interfaces, any damage of the ferrule or end of the fiber, any stray particles, or finger oil can have a significant effect on connector performance.

The picture below shows the end of a clean, problem-free fiber-optic connector. The dark center circle is the fiber's 125 µm core and cladding which carries the light. The surrounding area is the soft nickel-silver ferrule.
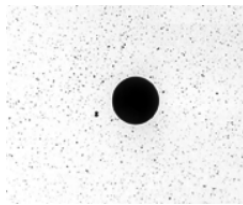
The next picture shows a fiber end that is dirty from neglect or improper cleaning. Loose particles or oils are smeared and ground into the end of the fiber causing light scattering and poor reflection. Not only is the precision polish lost, but this action can also grind off the glass face and destroy the connector.
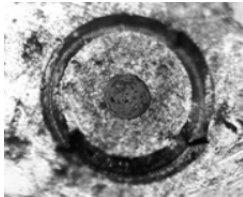
The next picture now shows physical damage to the glass fiber end caused by either repeated connections made without removing loose particles from the fiber end or by using improper cleaning tools. This damage can be severe enough to transfer the damage from the connector end to a good connector that comes in contact with it.
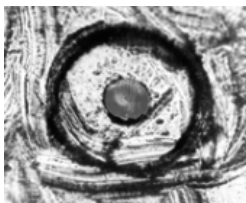
The cure for these problems is disciplined connector care. Visual inspection of fiber ends can be helpful. Contamination or imperfections on the cable end face can be detected as well as cracks or chips in the fiber itself. Use a microscope (100X to 200X magnification) to inspect the entire end face for contamination, raised metal, dents in the metal, and any other imperfections. Visible imperfections not touching the fiber core may not affect performance, unless the imperfections keep the fibers from contacting.

WARNING Always remove both ends of fiber-optic cables from any instrument, system, or device before visually inspecting the fiber ends. Disable all optical sources before disconnecting fiber-optic cables. Failure to do so may result in permanent injury to your eyes.

CAUTION Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty.

To clean a front-panel fiber-optic input connector

Use caution as fiber-optic end surfaces can easily be damaged by applying improper cleaning techniques. Repairs can be expensive. To access and clean the fiber-optic end surface:

1   Lift the receptacle latch as shown in the following picture.
2   Carefully pull off the receptacle without touching the ferrule or fiber end.
3   Clean the removed receptacle.
4   To clean the fiber-optic end, use a professional fiber-optic cleaning product.

Many products are available and are easily found via an internet search on "fiber optic cleaning products". You can purchase tools designed specifically for the type of fiber-optic connector or cable that you are using.
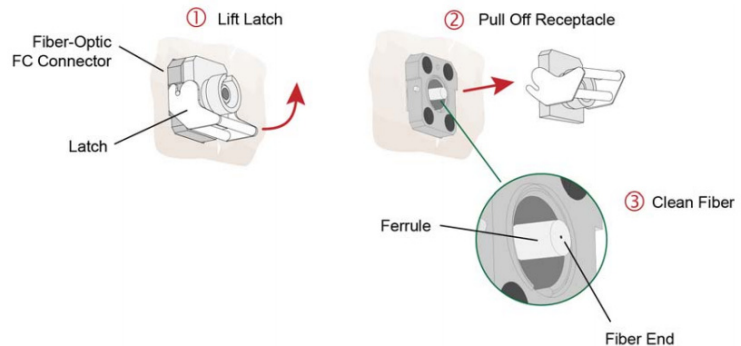
Removing the receptacle to expose the fiber end.

NOTE	To avoid damaging the N4377A front-panel fiber-optic connector, use proper connection techniques.

Preventing RF Port Connector Damage

Proper connector care and connection techniques are critical for accurate and repeatable measurements. The following table contains tips on connector care.

Handling and Storage	
Do	**Do Not**
▪ Keep connectors clean	▪ Touch mating-plane surfaces
▪ Extend sleeve or connector nut	▪ Set connectors contact-end down
▪ Use plastic end-caps during storage	▪ Store connectors or adapters loose

Visual Inspection	
Do	**Do Not**
▪ Inspect all connectors carefully	▪ Use a damaged connector - ever
▪ Look for metal particles, scratches, and dents	

Connector Cleaning	
Do	**Do Not**
▪ Try compressed air first	▪ Use any abrasives
▪ Use isopropyl alcohol (see warning below)	▪ Get liquid into plastic support beads
▪ Clean connector threads	

Gaging Connectors	
Do	**Do Not**
▪ Clean and zero the gage before use	▪ Use an out-of-specification connector
▪ Use the correct gage type	
▪ Use correct end of calibration block	
▪ Gage all connectors before first use	

Making Connections	
Do	**Do Not**
▪ Align connectors carefully	▪ Apply bending force to connection
▪ Make preliminary connection contact lightly	▪ Over tighten preliminary connection
▪ Turn only the connector nut	▪ Twist or screw any connection
▪ Use a torque wrench for final connection	▪ Tighten past torque wrench "break" point

NOTE   Keysight strongly recommends that adapters be used as connector savers to minimize the wear on the detector test port connectors. Use instrument-grade quality adapters or better.

WARNING   Cleaning connectors with alcohol shall only be done with the instrument USB cable removed and in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to reapplying power to the instrument.
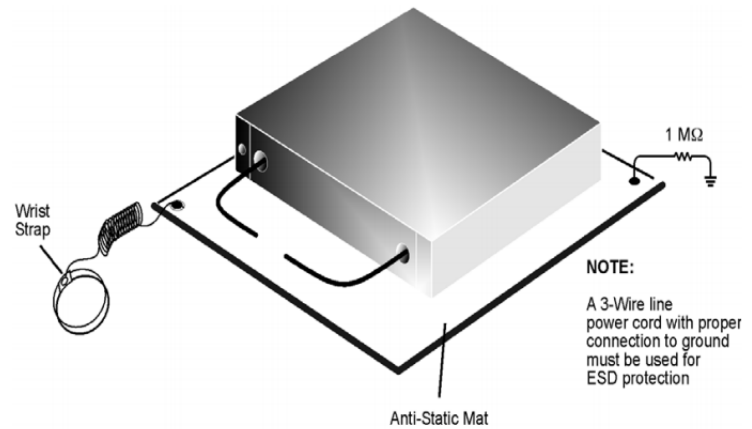
For more information on the proper use and maintenance of connectors, see

http://na.support.keysight.com/pna/connectorcare/Connector_Care.htm

Preventing Electrostatic Discharge Damage

Protection against electrostatic discharge (ESD) is essential while removing assemblies from or connecting cables and assemblies (DUT) to a network analyzer. Static electricity can build up on your body and can easily damage sensitive internal circuit elements when discharged. Static discharges too small to be felt can cause permanent damage. To prevent damage to the instrument:

- always have a grounded, conductive table mat in front of your test equipment.
- always wear a grounded wrist strap, connected to a grounded conductive table mat, having a 1 MΩ resistor in series with it, when handling components and assemblies or when making connections.
- always wear a heel strap when working in an area with a conductive floor. If you are uncertain about the conductivity of your floor, wear a heel strap.
- always ground yourself before you clean, inspect, or make a connection to a static-sensitive device or test port. You can, for example, grasp the grounded outer shell of the test port or cable connector briefly.
- always ground the center conductor of a test cable and DUT before making a connection to the analyzer test port or other static-sensitive device. This can be done as follows:

1 Connect a short (from your calibration kit) to one end of the cable and DUT to short the center conductor to the outer conductor.

2 While wearing a grounded wrist strap, grasp the outer shell of the cable and DUT connector.

3 Connect the other

1 MΩ

Wrist
Strap

NOTE:

A 3-Wire line
power cord with proper
connection to ground
must be used for
ESD protection

Anti-Static Mat

esd_setup

ESD Protection Setup

The following table lists Keysight part numbers for ESD protection devices.

Description	Keysight Part Number
Grounding wrist strap	9300-1367
5-ft grounding cord for wrist strap	9300-0980
2 x 4 ft conductive table mat and 15-ft grounding wire	9300-0797

N4377-91B01

KEYSIGHT
TECHNOLOGIES

www.keysight.com