

Reference Guide

Keysight Electronic Calibration Modules

This manual provides documentation for the following models:

RF 2-Port: N7550A, N7551A, N7552A

RF 4-Port: N4431D

Microwave 2-Port: N4690D, N4691D, N4692D, N4693D, N4694D, N4696D, N7553A, N7554A, and N7555A

Microwave 4-Port: N4432D, and N4433D

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1 General Information

Manual Overview

The purpose of this manual is to help you use your Electronic Calibration (ECal) module confidently and effectively. ECal is a precision, single-connection calibration technique which uses fully traceable and verifiable electronic standards. Each module has unique S-parameter data that is stored in the module's memory. During calibration, ECal uses this data to calculate the error terms for your network analyzer.

This manual provides instructions for operating and maintaining your ECal module. Also included are mechanical specifications and replaceable parts available for each model.

The N4690/1/2/3/4/6D series provide two-port calibration solutions with operating frequencies starting as low as DC and ending as high as 67 GHz. and N7550/1/2/3/4/5A series provide two-port calibration solutions with operating frequencies starting as low as DC and ending as high as 26.5 GHz. The N4431/2/3D series provide four-port calibration solutions with operating frequencies starting as low as DC and ending as high as 26.5 GHz.

Prerequisite Knowledge

This manual assumes you are trained in proper connector care. Because an accurate calibration depends on the integrity and cleanliness of the connector interface, a damaged connector will invalidate the calibration achieved with that module. Refer to the **“Connector Care” on page 2-10**.

Clarifying the Terminology of a Connector Interface

In this manual, adapters, ECal modules, and gage masters are referred to by way of their interface connector. For example:

- A female adapter has a female interface.
- A male adapter has a male interface.

A connector gage is referred to by way of the connector it measures. For example:

- A male connector gage has a female interface so it can measure male devices.

- A female connector gage has a male interface so it can measure female devices.

Accuracy of Electronic Calibration versus Mechanical Calibration

CAUTION

N755xA ECals can be used for S-parameter measurement calibrations. The residual measurement uncertainty makes them unsuitable for advanced applications, such as load pull, noise figure, etcetera.

As the number of DUT test ports increases, the required number of calibration measurements also increases. This boosts the probability of bad connections and bad calibrations when mechanical calibration standards are used rather than ECal. Also, test port cable repeatability and stability errors are amplified by the increased number of connections and disconnections. To perform an SOLT 4-port calibration, a minimum of twelve 1-port standards and three 2-port (thru) standards are measured, requiring a total of eighteen connections. The same calibration using a 2-port ECal module (N755xA and N469xD) requires only four connections.

Ignoring connection related errors, the following table compares the accuracy of ECal versus mechanical calibration in various calibration options.

Mechanical Calibration Type	ECal Thru Type	Measurement	ECal	Mechanical Calibration
1-Port, calibration constant (not data-based) SOL	NA	Reflection	++	
1-Port, short, open, sliding load	NA	Reflection	+	
1-Port, data-based, expanded	NA	Reflection		+
2-Port TRL	All types	Reflection Transmission		++ ++
≥2-Port, calibration constant SOL, flush thru ^a	Characterized	Reflection Transmission	++	++
	Internal unknown	Reflection Transmission	++	
	External flush ^a	Reflection Transmission	++	
≥2-Port, calibration constant SOL, unknown thru	Characterized	Reflection Transmission	++	++
	Internal unknown	Reflection Transmission	++ =	=

General Information
When to Calibrate

Mechanical Calibration Type	ECal Thru Type	Measurement	ECal	Mechanical Calibration
≥2-Port, data-based, expanded, flush thru ^a	Characterized	Reflection		+
		Transmission		++
	Internal unknown	Reflection		+
		Transmission		+
	External flush ^a	Reflection		+
		Transmission		+
≥2-Port, data-based, expanded, unknown thru	Characterized	Reflection		+
		Transmission		++
	Internal unknown	Reflection		+
		Transmission		+

++ better; + slightly better; = same

a. Flush thru should NOT be used when the test port connectors are not the same type as the calibration standards. SMA and 3.5 mm connectors are mateable but are NOT the same type.

When to Calibrate

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

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

Models and Options

This section provides the model number, operating characteristics and connector options available with Keysight RF and microwave ECal modules. You can order ECal modules by selecting the model number followed by the desired options.

N755xA Modules (RF Two-Port)

ECal modules from this series are available with the connector types and frequency ranges shown in [Table 1-1 on page 1-6](#). Mixed connector options allow you to configure the module with a different connector type at each port (as shown in [Figure 1-2](#)).

Figure 1-1 Model N755xA Option Type-N m and f shown



Figure 1-2 Model N7554A Option 3.5 mm m and f shown



General Information
Models and Options

Table 1-1 N755xA Modules

Model Number	Connector Type	Operating ^a Frequency	Port A and B Option		
			-m- and -f-	-m- and -m-	-f- and -f-
N7550A	Type-N 50 ohm	DC to 4 GHz	N7550A-NMF	N7550A-NMM	N7550A-NFF
	3.5 mm		N7550A-3MF	N7550A-3MM	N7550A-3FF
N7551A	Type-N 50 ohm	DC to 6.5 GHz	N7551A-NMF	N7551A-NMM	N7551A-NFF
	3.5 mm		N7551A-3MF	N7551A-3MM	N7551A-3FF
N7552A	Type-N 50 ohm	DC to 9 GHz	N7552A-NMF	N7552A-NMM	N7552A-NFF
	3.5 mm		N7552A-3MF	N7552A-3MM	N7552A-3FF
N7553A	Type-N 50 ohm	DC to 14 GHz	N7553A-NMF	N7553A-NMM	N7553A-NFF
	3.5 mm		N7553A-3MF	N7553A-3MM	N7553A-3FF
N7554A	Type-N 50 ohm	DC to 18 GHz	N7554A-NMF	N7554A-NMM	N7554A-NFF
	3.5 mm		N7554A-3MF	N7554A-3MM	N7554A-3FF
N7555A	3.5 mm	DC to 26.5 GHz	N7555A-3MF	N7555A-3MM	N7555A-3FF

a. Option ODC frequency range is DC to xx.x GHz. Option 100 frequency range is 10 MHz to xx.x GHz.

N755xA Other Options	Description
A6J	ANSI Z540-1-1994 Calibration
1A7	Calibration + Uncertainties + Guardbanding
UK6	Adds commercial calibration certificate with measured data.
SPS	Post Sales Support
150	ECal ruggedized plastic storage box – See also “ ECal Kit Storage Box (Option 150) – (N755xA Only) ” on page 4-23

N4431D Modules (RF Four-Port)

ECal modules from this series are available with the connector types and frequency ranges shown in [Table 1-1 on page 1-6](#). Mixed connector options allow you to configure the module with a different connector type at each port (as shown in [Figure 1-2 on page 1-5](#)).

Figure 1-3 Model N4431D Option Type-N m and f shown



Figure 1-4 Model N4431D Option 3.5 mm f and f shown

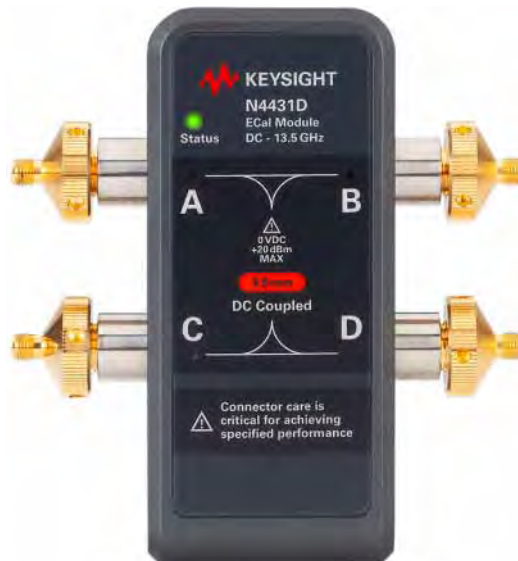


Figure 1-5

Model N4431D Option 4.3-10 m and f shown



Figure 1-6

Model N4431D Option 7-16 m and f shown



Table 1-2 N4431D Modules (All connectors are female)

Model Number	Connector Type Port A, B, C, D	Operating Frequency	Option
N4431D	3.5 mm -f-	DC to 13.5 GHz	010
	Type-N 50Ω -f-	DC to 13.5 GHz	020

Table 1-3 N4431D Mixed Connector Options

Connector Type	Port A Option	Port B Option	Port C Option	Port D Option
3.5 mm -f-	101	201	301	401
3.5 mm -m-	102	202	302	402
Type-N 50Ω -f-	103	203	303	403
Type-N 50Ω -m-	104	204	304	404
7-16 -f- ^a	105	205	305	405
7-16 -m- ^a	106	206	306	406
4.3-10-f- ^b	107	207	307	406
4.3-10-m- ^b	108	208	308	407

- a. Limits ECal module high frequency to 7.5 GHz.
b. Limits ECal module high frequency to 12 GHz.

N4431D Other Options	Description
A6J	Adds ANSI Z540-1-1994 Calibration
1A7	Calibration + Uncertainties + Guardbanding
UK6	Adds commercial calibration certificate with measured data.

N469xD Modules (Microwave Two-Port)

ECal modules from this series are available with the connector types and frequency ranges shown in [Table 1-1 on page 1-6](#). Mixed connector options allow you to configure the module with a different connector type at each port (as shown in [Figure 1-2](#)).

Figure 1-7 Model N4690D Option Type-N m and f shown



Figure 1-8 Model N4691D Option 3.5 mm m and f shown



Figure 1-9 Model N4692D Option 2.92 mm m and f shown



Figure 1-10 Model N4693D Option 2.4 mm m and f shown



Figure 1-11 Model N4694D Option 1.85 mm m and f shown



Figure 1-12 Model N4696D Option 7 mm



General Information
Models and Options

Table 1-4 N469xD Modules

Model Number	Connector Type	Operating Frequency ^a	Port A and B Option		
			-m- and -f-	-m- and -m-	-f- and -f-
N4690D	Type-N 50 ohm	DC to 18 GHz (ODC) 300 kHz to 18 GHz (003)	N4690D-M0F	N4690D-M0M	N4690D-F0F
N4691D	3.5 mm	DC to 26.5 GHz (ODC) 300 kHz to 26.5 GHz (003)	N4691D-M0F	N4691D-M0M	N4691D-F0F
N4692D	2.92 mm	DC to 40 GHz (ODC) 10 MHz to 40 GHz (100)	N4692D-M0F	N4692D-M0M	N4692D-F0F
N4693D	2.4 mm	DC to 50 GHz (ODC) 10 MHz to 50 GHz (100)	N4693D-M0F	N4693D-M0M	N4693D-F0F
N4694D	1.85 mm	DC to 67 GHz (ODC) 10 MHz to 67 GHz (100)	N4691D-M0F	N4691D-M0M	N4691D-F0F
N4696D	7.0 mm	DC to 18 GHz (ODC) 300 kHz to 18 GHz (003)	n/a	n/a	n/a

a. Option 0DC frequency range is DC to xx.x GHz. Option 003 frequency range is 300 kHz to xx.x GHz. Option 100 frequency range is 10 MHz to xx.x GHz.

N469xD Other Options	Description
A6J	Adds ANSI Z540-1-1994 Calibration
1A7	Adds ISO 17025 Calibration + Uncertainties + Guardbanding
UK6	Adds commercial calibration certificate with measured data.
SPS	Post Sales Support
00A	Adds one -m- to -m- and one -f- to -f adapter
--	ECal ruggedized plastic storage box – Order spare storage box with foam part number 1540-2345.

N4432D and N4433D Modules (Microwave Four-Port)

ECal modules from this series are available with the connector types and frequency ranges shown in [Table 1-1 on page 1-6](#). Mixed connector options allow you to configure the module with a different connector type at each port (as shown in [Figure 1-2](#)).

Figure 1-13 Model N4432D Option Type-N m and f shown



Figure 1-14 Model N4432D Option 3.5 mm f and f shown

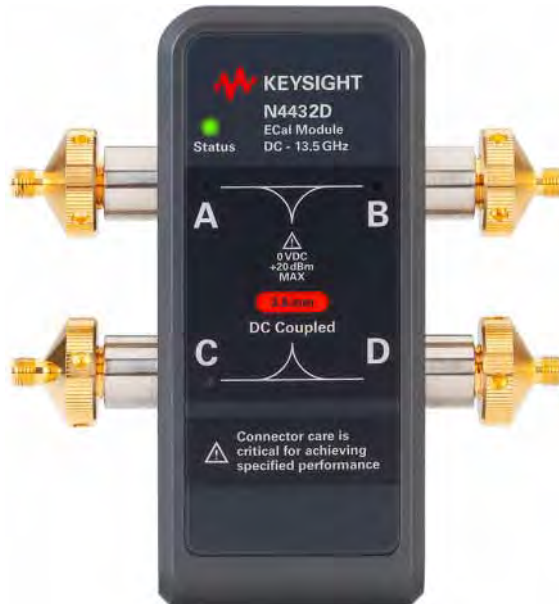


Figure 1-15 Model N4433D Option 3.5 mm f and f shown

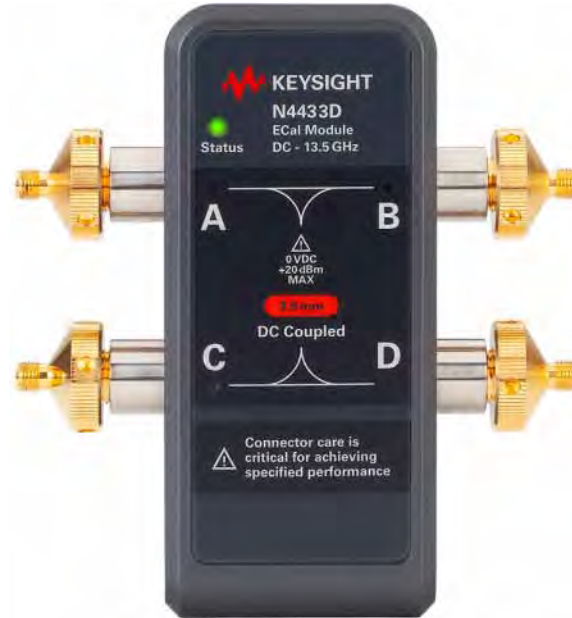


Table 1-5 N4432D and N4433D Modules (All connectors are female)

Model Number	Connector Type Port A, B, C, D ^a	Operating Frequency	Option
N4433D	3.5 mm -f-	DC to 26.5 GHz (ODC)	010
		300 kHz to 26.5 GHz (003)	
N4432D	Type-N 50Ω -f-	DC to 18 GHz (ODC)	020
		300 kHz to 18 GHz (003)	

a. Option ODC frequency range is DC to xx.x GHz. Option 003 frequency range is 300 kHz to xx.x GHz.

Table 1-6 N4432D Mixed Connector Options

Connector Type	Port A Option	Port B Option	Port C Option	Port D Option
3.5 mm -f- ^a	101	201	301	401
3.5 mm -m- ^a	102	202	302	402
Type-N 50Ω -f-	103	203	303	403
Type-N 50Ω -m-	104	204	304	404

a. Frequency range of ECal module limited by other connectors.

Table 1-7 N4433D Mixed Connector Options

Connector Type	Port A Option	Port B Option	Port C Option	Port D Option
3.5 mm -f-	101	201	301	401
3.5 mm -m-	102	202	302	402

Other N4432/3D Options	Description
A6J	Adds ANSI Z540-1-1994 Calibration
1A7	Calibration + Uncertainties + Guardbanding
UK6	Adds commercial calibration certificate with measured data.

Compatible Network Analyzers

ECal modules operate with the network analyzer models shown in [Table 1-8](#). Not all ECal module and network analyzer combinations have the same features or capabilities. See your network analyzer user guide or online Help.

Table 1-8 N755xA Compatible Network Analyzers

Network Analyzers	N755xA ECal Module Series	Interface Required ^a
PNA Network Analyzers^b		
N5221/2/4/5/7A&B	Yes	USB
N5231/2/4/5/9A&B	Yes	USB
N5241/2/4/5/7/9A&B	Yes	USB
ENA Network Analyzers		
E5072A ^c	Yes	USB
E5071C ^d	Yes	USB
E5063A ^e	Yes	USB
E5061B ^f	Yes	USB
E5080A ^g	Yes	USB
E5080B ^h	Yes	USB
PXIe Vector Network Analyzer Modulesⁱ		
M980xA, M9370/1/2/3/4/5A, M9485A	Yes	USB
Streamline Series USB-VNA Vector Network Analyzer Modules^j		
P500xA, P502xA, 9370/1/2/3/4/5A	Yes	USB
FieldFox Handheld Analyzers^{k,l}		
N9923A	Yes	USB
N9913/4/5/6/7/8A/B	Yes	USB
N9925/6/7/8A	Yes	USB
N9950/1/2A	Yes	USB

a. N755xA supports any USB 2.0 compliant hub. It can communicate at High Speed (480 Mbps) and Full Speed (12 Mbps).

General Information

Compatible Network Analyzers

- b. Compatible PNA instruments must have firmware version \geq A.10.49.07.
- c. Compatible ENA E5072A instruments must have firmware version \geq B.02.39.
- d. Compatible ENA E5071C instruments must have firmware version \geq B.13.29.
- e. Compatible ENA E5063A instruments must have firmware version \geq A.03.72.
- f. Compatible ENA E5061B instruments must have firmware version \geq B.04.86.
- g. Compatible ENA E5080A instruments must have firmware version \geq A.12.55.05.
- h. ENA E5080B instruments have no restrictions on firmware revision.
- i. Compatible PXIe instruments must have firmware version \geq A.03.10.
M980xA instruments have no firmware restrictions.
- j. Compatible USB-VNA instruments must have firmware version \geq A.10.55.07
- k. Compatible FieldFox Handheld instruments must have firmware version \geq A.10.2x (CPU2 units) and \geq A.08.19 (CPU1 units).
- l. The N9912A FieldFox does not support ECal.

Table 1-9 N443xD Compatible Network Analyzers

Network Analyzers	N4431D/32D ECal Module Series	N4433D ECal Module Series	Interface Required ^a
PNA Network Analyzers^{b,c}			
N5221/2/4/5/7A&B	Yes	Yes	USB
N5231/2/4/5/9A&B	Yes	Yes	USB
N5241/2/4/5/7/9A&B	Yes	Yes	USB
ENA Network Analyzers			
E5072A	Yes	No	USB
E5071C	Yes	No	USB
E5063A	Yes	No	USB
E5061B	Yes	No	USB
E5080A ^d	Yes	Yes	USB
E5080B ^e	Yes	Yes	USB
PXIe Vector Network Analyzer Modules^f			
M980xA, M9370/1/2/3/4/5A, M9485A	Yes	Yes	USB
Streamline Series USB-VNA Vector Network Analyzer Modules^g			
P500xA,P502xA P9370/1/2/3/4/5A	Yes	Yes	USB
FieldFox Handheld Analyzers^{h,i}			
N9923A	Yes	Yes	USB
N9913/4/5/6/7/8A/B	Yes	Yes	USB
N9925/6/7/8A	Yes	Yes	USB
N9950/1/2A	Yes	Yes	USB

- a. N443xD supports any USB 2.0 compliant hub. It can communicate at High Speed (480 Mbps) and Full Speed (12 Mbps).
- b. Compatible PNA A model instruments must have firmware version \geq A.10.60.04.
- c. Compatible PNA B model instruments must have firmware version \geq A.12.85.00.
- d. Compatible ENA E5080A instruments must have firmware version \geq A.12.55.05.
- e. ENA E5080A instruments have no restrictions on firmware revision.
- f. Compatible M937xA, M9485A PXIe instruments must have firmware version \geq A.10.55.07. M980xA instruments have no restrictions on firmware revision.

General Information

Compatible Network Analyzers

- g. Streamline Series USB-VNA instruments have no firmware revision restrictions.
- h. Compatible FieldFox Handheld instruments must have firmware version \geq A.10.2x (CPU2 units) and \geq A.08.19 (CPU1 units).
- i. The N9912A FieldFox does not support ECal.

Table 1-10 N469xD Compatible Network Analyzers

Network Analyzers	N469xD ECal Module Series	Interface Required ^a
PNA Network Analyzers^b		
N5221/2/4/5/7A&B	Yes	USB
N5231/2/4/5/9A&B	Yes	USB
N5241/2/4/5/7/9&B	Yes	USB
ENA Network Analyzers		
E5072A ^c	Yes	USB
E5071C ^d	Yes	USB
E5063A ^e	Yes	USB
E5061B ^f	Yes	USB
E5080A ^g	Yes	USB
E5080B ^h	Yes	USB
PXIe Vector Network Analyzer Modulesⁱ		
M980xA, M9370/1/2/3/4/5A, M9485A	Yes	USB
Streamline Series USB-VNA Vector Network Analyzer Modules^j		
P500xA, P502xA, P9370/1/2/3/4/5A	Yes	USB
FieldFox Handheld Analyzers^{k,l}		
N9923A	Yes	USB
N9913/4/5/6/7/8A/B	Yes	USB
N9925/6/7/8A	Yes	USB
N9950/1/2A	Yes	USB

- a. N469xA supports any USB 2.0 compliant hub. It can communicate at High Speed (480 Mbps) and Full Speed (12 Mbps).
- b. Compatible PNA A model instruments must have firmware version \geq A.10.60.04. Compatible PNA B model instruments must have a firmware version \geq A.12.85.00.
- c. Compatible ENA E5072A instruments must have firmware version \geq B.02.4x. (ENA E5061B, E5063A, E5071C, and E5072A series analyzers are not compatible with the N4693D and N4694D ECals.)

General Information

Compatible Network Analyzers

- d. Compatible ENA E5071C instruments must have firmware version \geq B.14.0x.
(ENA E5061B, E5063A, E5071C, and E5072A series analyzers are not compatible with the N4693D and N4694D ECals.)
- e. Compatible ENA E5063A instruments must have firmware version \geq A.05.04.
(ENA E5061B, E5063A, E5071C, and E5072A series analyzers are not compatible with the N4693D and N4694D ECals.)
- f. Compatible ENA E5061B instruments must have firmware version \geq B.05.00.
(ENA E5061B, E5063A, E5071C, and E5072A series analyzers are not compatible with the N4693D and N4694D ECals.)
- g. Compatible ENA E5080A instruments must have firmware version \geq A.12.60.0x.
- h. ENA E5080A instruments have no restrictions on firmware revision.
- i. Compatible M9370/1/2/3/5A and M9485A PXIe instruments must have firmware version \geq A.12.60.0x.
N980xA PXIe instruments have no restrictions on firmware revisions.
- j. Streamline Series USB-VNA instruments have no restrictions on firmware revision.
- k. Compatible FieldFox Handheld instruments must have firmware version \geq A.10.2x (CPU2 units) and \geq A.08.19 (CPU1 units).
- l. The N9912A FieldFox does not support ECal.

Service and Recertification

NOTE

N755xA, N469xD, and N443xD must be returned to factory for recertification and service. Refer to “[Definitions](#)”.

N7550A/1/2A are value line products and can be re-certified and serviced. But, because the ECal modules are so intricately constructed and because of the resulting cost of re-certification or minor repairs, it may not be cost effective to return these models to the factory.

Keysight provides a Utility that can be used to verify that your ECal module is performing as expected. Refer to “[ECal Confidence Check – Basic Validation of the Calibration](#)” on page 3-11.

If your ECal module requires service or recertification, contact the Keysight office nearest you for information about where to send it. The performance of your ECal module can only be verified by specially manufactured equipment and calibration standards from Keysight.

Definitions

- Service: Replacement of connectors.
- Recertification: Measure the performance of the device and provide a Pass/Fail. See also, “[Recertification of ECal Modules](#)” on page 1-24.

Contacting Keysight

Assistance with test and measurements needs and information on finding a local Keysight office are available on the Web at:

www.keysight.com/find/assist

If you do not have access to the Internet, please contact your Keysight field engineer.

NOTE

In any correspondence or telephone conversation, refer to the Keysight product by its model number and full serial number. With this information, the Keysight representative can determine whether your product is still within its warranty period.

Returning Devices to Keysight

If you are returning the product to Keysight, please contact Keysight and provide the following information:

- your company name and address
- a technical contact person within your company, and the person’s complete telephone number including country code and area code
- the model number and serial number of the case

- the part number and serial number of each device
- type of service required
- a detailed description of the problem and how the device was being used when the problem occurred (such as calibration or measurement)

NOTE

When transporting the module, use original or comparable packaging.

Recertification of ECal Modules

CAUTION

Only Keysight calibration laboratories use the most accurate reference standards - directly traceable to national and international primary standards - to calibrate ECal modules to their warranted specifications. Calibration services performed by unauthorized calibration service providers will cause ECal modules to perform substantially below specifications. Keysight is not responsible for the poor performance of ECal modules that are calibrated by such unauthorized calibration service providers.

The suggested interval for recertification is 12 months. After reviewing the results of the initial recertification, you may establish a shorter interval that reflects greater use and wear of the module.

Where to Send a Module for Recertification

Contact Keysight for information on where to send your kit for recertification. See [“Contacting Keysight” on page 1-23](#). Refer to [“Returning Devices to Keysight” on page 1-23](#) for instructions on the preparation of returning the device.

How Keysight Verifies Your ECal Module

Keysight verifies the specifications of these devices as follows:

1. The residual microwave error terms of the test system are verified with precision airlines and shorts or low frequency resistance that are directly traced to the National Institute of Standards and Technology (NIST). The airline and short characteristics are developed from mechanical measurements. The mechanical measurements and material properties are carefully modeled to give very accurate electrical representation. The mechanical measurements are then traced to NIST through various plug and ring gages and other mechanical measurements.
2. Each module is electrically tested on this system to the specification listed in [Chapter 5, “Specifications and Characteristics.”](#)

These two steps establish a traceable link to NIST for Keysight to the extent allowed by the Institute's calibration facility. The specifications data provided for the module are traceable to NIST through Keysight Technologies.

What Is Provided with a Recertification

- a new calibration sticker affixed to the module
- a certificate of calibration
- a list of United States National Institute of Standards and Technology (NIST) traceable numbers
- a calibration report for each traceable module listing measured values, specifications, and uncertainties
- a new set of S-parameter data (embedded in module memory) if the old set of S-parameters data no longer allows for a calibration that meets all performance specifications

Keysight Technologies offers different types of calibration for the recertification of the module. For more information, contact Keysight. See **“Contacting Keysight” on page 1-23.**

Safety and Regulatory Information

Review this section to familiarize yourself with safety markings and instructions before you operate the ECal module. This product has been designed and tested in accordance with international standards.

WARNING

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

CAUTION

The **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.

Safety Notices

CAUTION

Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.

Instrument Markings

Table 1-11



The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to the instructions in the documentation.



This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electrical and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive, 2002/96/EC).



The CE marking is a legal compliance marking of the European Community. This CE marking shows that the product complies with all the relevant European Legal Directives.



This mark designates the product is an Industrial Scientific and Medical Group 1 Class A product (reference CISPR 11, Clause 5).



This ISM device complies with Canadian ICES -001.
Cet appareil ISM est conforme a la norme NMB du Canada.



The RCM mark is a registered trademark of the Australian Communications and Media Authority.



China RoHS regulations include requirements related to packaging, and require compliance to China standard GB18455-2001.



Korean Certification (KC) mark; includes the marking's identifier code which follows the format: KCC-REM-YYY-ZZZZZZZZZZZZZZZZ or MSIP-REM-YYY-ZZZZZZZZZZZZZZZZ or R-R-Kst-xxxxxx.

Table 1-11



This symbol indicates compliance with China RoHS regulations for paper/fiberboard packaging.

Compliance Notices

This product has been designated and tested in accordance with accepted industry standards, and has been supplied in a safe condition. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

EMC and Safety Information

EMC

Complies with the essential requirements of the European EMC Directive as well as current editions of the following standards (dates and editions are cited in the Declaration of Conformity):

- IEC/EN 61326-1
- CISPR Pub 11 Group 1, class A
- AS/NZS CISPR 11
- ICES/NMB-001
This ISM device complies with Canadian ICES-001.
Cet appareil ISM est conforme a la norme NMB-001 du Canada.000

South Korean Class A EMC declaration

This equipment has been conformity assessed for use in business environments. In a residential environment this equipment may cause radio interference.

※ This EMC statement applies to the equipment only for use in business environment.

사용자 안내문
이 기기는 업무용 환경에서 사용할 목적으로 적합성평가를 받은 기기로서 가정용 환경에서 사용하는 경우 전파간섭의 우려가 있습니다.

※ 사용자 안내문은 “업무용 방송통신기자재”에만 적용한다.

General Information
Safety and Regulatory Information

Safety Information

European Low Voltage Directive is not applicable for these products.

Declaration of Conformity

A declaration of conformity for any of these ECal modules is available at <http://www.keysight.com/go/conformity> or by contacting Keysight - see “Contacting Keysight” on page 1-23.

General Information
Safety and Regulatory Information

2 Preparing ECal for Use

Inspecting the ECal Kit

Inspect the Kit Contents

Verify the case and its contents are not damaged and that all parts are included (see items listed in [Table 2-2](#)). If the case or any device appears damaged, or if the shipment is incomplete, contact Keysight. Keysight will arrange for repair or replacement of incomplete or damaged shipments without waiting for settlement from the transportation company. See [“Contacting Keysight” on page 1-23](#).

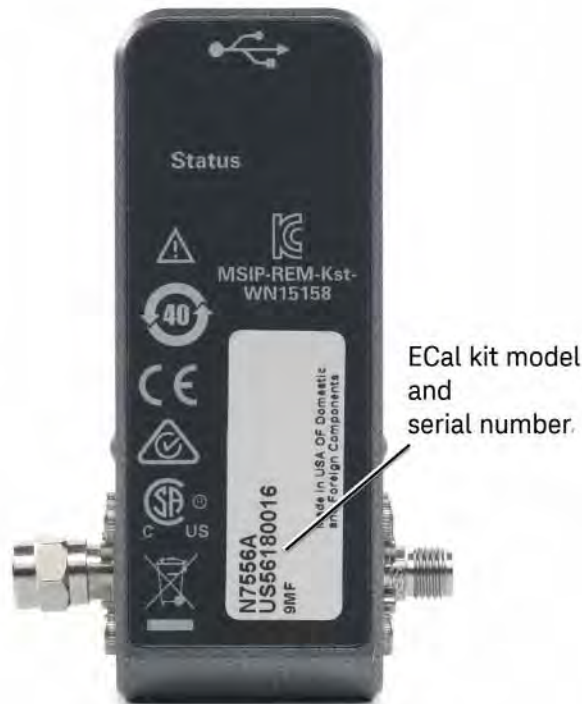
Locate the Serial Number

Your ECal kit has a unique serial number. The serial number is printed on a label on the backside of the ECal module.

ECal Kit Serial Number

The serial number with the MY/US prefix on the backside of the ECal module is assigned to the ECal **kit**. Refer to [Figure 2-1](#). The ECal kit contains the ECal module and, depending on the option configuration, accessories such as wrenches and adapters.

Figure 2-1 ECal Model and Serial Numbers on the Backside of the ECal Module



The ECal kit serial number is intended for identification purposes whenever an ECal kit is returned to Keysight for repair or recertification.

ECal Module Serial Number

The serial number is located on the backside of the ECal module (refer to [Figure 2-1](#)). Each ECal module is unique and is individually serialized. The serial number is stored in the ECal module memory and may be accessed by a network analyzer when the ECal is used to perform a calibration. Test reports for an ECal module will refer to this serial number as the "ECal S/N."

Record the Serial Number

Record the serial number and the date of initial use as a reminder for annual recertification. See **“Recertification of ECal Modules” on page 1-24.**

Table 2-1 Table for Tracking Serial Numbers

ECal Kit Model Number	ECal Kit Serial Number (contains MY/US prefix)	Date of Initial Use

Verify Electrical Performance

To verify electrical performance of the module, see **“Validating a Calibration” on page 3-11.**

Equipment Required but Not Supplied

Pin Depth Gages

Gages for measuring recession or protrusion are not provided in the kit. See **Chapter 6, “Replaceable Parts.”** or contact Keysight to order gages and other test accessories.

Kit Contents

N755xA Series Kit Contents

The following table lists the items in each N755xA kit.

Table 2-2 N755xA Kit Contents

Qty	Description	Part No.
N755xA		
1	N755xA, ECal Module	--
1	South Korean Class A EMC Declaration	5061-7383
1	Calibration certificate	5962-0476
2	Foam cushion set 30.5x23.5x14-cm 0.9-lbs-Density Polyethylene	9220-8151
1	Lanyard	9223-1111
1	China RoHS Addendum for Test Accessories-RF and Microwave	9320-6695
1	Finding Product Manual Sheet	9320-6794
1	Assy, lanyard	N7550-60008
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N7550-90001

N4431D Series Kit Contents

The following tables list the items in each N4431D kit. For the N4431D kit, Option 010 is configured with 3.5 mm -f- connectors on all ports and Option 020 is configured with type-N 50 ohm -f- connectors on all ports. See [Table 1-3 on page 1-9](#) for other configurations available.

Table 2-3 N4431D Kit Contents

Qty	Description	Part No.
N4431D Option 010		
1	N4431D, ECal Module	--
1	Calibration certificate	5962-0476
1	Wrench spanner	08513-20014
1	Wrench-Torque 8 in-lb, 20 mm open end	8710-1764
1	Wrench-Torque 8 in-lb, 5/16 in open end	8710-1765
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N4431-90004

Table 2-4 N4431D Kit Contents

Qty	Description	Part No.
N4431D Option 020		
1	N4431D, ECal Module	--
1	Calibration certificate	5962-0476
1	Wrench-Torque 8 in-lb, 3/4 in open end	8710-1766
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N4431-90004

Table 2-5 N4431D Kit Contents

Qty	Description	Part No.
N4431D Mixed Connector Options^a		
1	N4431D, ECal Module	--
1	Calibration certificate	5962-0476
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N4431-90004

a. Torque wrench varies with options.

N469xD Seres Kit Contents

Table 2-6 N469xD Kit Contents

Qty	Description	Part No.
N469xD		
1	N469xD, ECal Module	--
1	South Korean Class A EMC Declaration	5061-7383
1	Calibration certificate	5962-0476
2	Foam cushion set 46.0x33.0x16.7-cm Density Polyethylene	9220-8171
1	China RoHS Addendum for Test Accessories-RF and Microwave	9320-6695
1	Finding Product Manual Sheet	9320-6794
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	Critical Care Document	85051-90032
1	Transit case	1540-2345
1	Wrench – 1/2 in. to 5/16 in. open end	8710-1770
1	Wrench – Torque 8 in-lb., 20 mm open end	8710-1764 ^a
1	Wrench – Torque 8 in-lb., 20 mm open end	8710-1765 ^a
1	Wrench – Torque 12 in-lb., 3/4 in. open end	8710-1766 ^b
1	QuickStart Guide	N4690-90002

- a. 8710-1764 and 8710-1765 are only available for the N4691/2/3/4D models.
b. 8710-1766 wrench is only available for the N460/6D models.

N4432D and N4433D Series Kit Contents

The following tables list the items in each N4432D and N4433D kit. For the N4432D kit, Option 020 is configured with type-N 50 ohm -f- connectors on all ports. For the N4433D kit, Option 010 is configured with 3.5 mm -f- connectors on all ports. See [Table 1-6 on page 1-16](#) and [Table 1-7 on page 1-16](#) for other configurations available.

Table 2-7 N4432D Kit Contents

Qty	Description	Part No.
N4432D Option 020		
1	N4432D, ECal Module	--
1	Calibration certificate	5962-0476
1	Torque Wrench 3/4 in, 1.3 N-m	8710-1766
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N4431-90004

Table 2-8 N4432D Kit Contents

Qty	Description	Part No.
N4432D Mixed Connector Options^a		
1	N4432D, ECal Module	--
1	Calibration certificate	5962-0476
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	QuickStart Guide	N4431-90004

a. Torque wrench varies with options.

Table 2-9 N4433D Kit Contents

Qty	Description	Part No.
N4433D Option 010		
1	N4433D, ECal Module	--
1	Calibration certificate	5962-0476
1	Torque Wrench 20 mm, 0.9 N-m	8710-1764
1	Torque Wrench 5/16", 0.9 N-m	8710-1765
1	Wrench spanner	N4431-20014
1	USB A-plug to micro-B plug Cable, 2 m	8121-2671
1	Quick Start Reference Guide	N4431-90004

Options

N755xA Options

Where "x" represents the connector type (i.e., "N" for 50 Ω Type-N and "3" for 3.5 mm):

- Option xFF, configures the module with female-to-female connectors.
- Option xMM, configures the module with male-to-male connectors.
- Option xMF, configures the module with male-to-female connectors.

N4431D Options

- Option 010 configures the model with 3.5 mm -f- and 020 configures the module with Type-N 50 ohm -f- connectors on all ports.
- Option UK6 adds a commercial calibration certificate with measured data.

For more, refer to **“N4431D Modules (RF Four-Port)” on page 1-7**

N469xD Options

Where:

- Option F0F, configures the module with female-to-female connectors.
- Option M0M, configures the module with male-to-male connectors.
- Option M0F, configures the module with male-to-female connectors.

N4432D Options

- Option 020 configures the module with Type-N 50 ohm -f- connectors on all ports.
- Option UK6 adds a commercial calibration certificate with measured data.

For more, refer to **“N4432D and N4433D Modules (Microwave Four-Port)” on page 1-14**

N4433D Options

- Option 010 configures the module with 3.5 mm -f- connectors on all ports.
- Option UK6 adds a commercial calibration certificate with measured data.

For more, refer to **“N4432D and N4433D Modules (Microwave Four-Port)”**
on page 1-14

Operating and Safety Precautions

Observe the following guidelines before connecting or operating your ECal module.

ESD Damage

Protection against electrostatic discharge (ESD) is important while handling and operating your ECal module. Static electricity can build up on your body and can easily damage sensitive components when discharged. Static discharges too small to be felt can cause permanent damage to the unit. To prevent damage from ESD:

- Use a grounded anti static mat in front of your test equipment and wear a grounded wrist strap attached to it when handling or operating the ECal module.
- Wear a heel strap when working in an area with a conductive floor.
- Ground yourself before you clean, inspect, or make a connection to an ECal module. You can, for example, grasp the grounded outer shell of the analyzer test port or cable connector briefly.
- Avoid touching the center conductor of the test ports.

For more information about preventing ESD, see **“Electrostatic Discharge”** on **page 4-1**.

Connector Care

Because connectors can become defective due to wear during normal use, all connectors should be inspected and maintained to maximize their service life. For more detailed information, see **“Visual Inspection”** on **page 4-3**.

- Inspect the mating surface each time a connection is made. Metal particles from connector threads often find their way onto the mating surface when a connection is made or disconnected.
- Clean dirt and contamination from the connector mating surface and threads. This simple step can extend the service life of the connector and improve the quality of your calibration and measurements.
- Gage connectors periodically. This not only provides assurance of proper mechanical tolerances, and thus connector performance, but can also indicate situations where the potential for damage to another connector may exist.

CAUTION

ECal modules can be damaged if you apply excessive torque to the connectors. See [Table 4-1 on page 4-21](#) for required torque settings.

Input Power Level

CAUTION

Before performing a calibration, make sure the input power and DC levels do not exceed the values indicated in [Table 2-10](#).

Table 2-10 Input Power Limits

Parameter	ECal Module Series		
	N755xA	N469xD	N4431/2/3D
Typical Maximum Input Power (linearity) ^{a, b}	-15.0 dBm	-5.0 dBm	-7.0 dBm
Typical Maximum DC Level Applied to Test Port ^c	0 Volts	±10 Volts	± 3 Volts
Typical Damage Level	+10.0 dBm	+10.0 dBm	+20.0 dBm

- If the maximum input power is exceeded when calibrating, compression may occur.
- When using the PNA-X, the power level can be increased after calibration with minimal impact on measurement accuracy.
- Maximum DC level applied to test port, where Option ODC for N469xD and N443xD is set to 0 volts.

Operating Temperature

The temperature of the ECal module must be within the following temperature range to meet the operating specifications.

- N755xA Series: +15 °C to +35 °C and up to 75% relative humidity (RH).
- N469xD Series: +20 °C to +26 °C and up to 95% relative humidity (RH) at 40 °C, non-condensing.
- N443xD Series: +20 °C to +26 °C and up to 95% relative humidity (RH) at 40 °C, non-condensing.

For more details, see [“Environmental Specifications” on page 5-2](#).

3 Operating ECal Module

Setting Up a Calibration

Use the following procedure as a starting point for calibrating the network analyzer with an ECal module. For more detailed information about adjusting the settings of your analyzer, refer to the appropriate user guide or online Help.

Understanding the ECal LEDs

The ECal module has three different LEDs that may be displayed during operation:

Table 3-1 N755xA Status LED Operation

Status LED Color	Description
Off	<ul style="list-style-type: none">– ECal is not connected to an instrument or is malfunctioning.– See also, Figure “ECal Troubleshooting” on page 3-14.
Steady Green	<ul style="list-style-type: none">– ECal is connected, functioning, and communicating normally ^a
Orange	<ul style="list-style-type: none">– ECal connected and functioning, but is not communicating with the driver software.– See also, Figure “ECal Troubleshooting” on page 3-14.

a. Status LED briefly flashes orange when the ECal is first connected to an instrument while the driver software loads.

Table 3-2 N443xD and N469xD Status LED Operation

Status LED Color	Description
Off	<ul style="list-style-type: none"> – ECal is not connected to an instrument or is malfunctioning. – See also, Figure “ECal Troubleshooting” on page 3-14.
Orange	<ul style="list-style-type: none"> – ECal is warming up. – ECal connected and functioning, but is not communicating with the driver software. – See also, Figure “ECal Troubleshooting” on page 3-14.
Steady Green	<ul style="list-style-type: none"> – ECal is connected, functioning, warmed up, and communicating normally. ^a
Alternating Green/Orange Flashing	<ul style="list-style-type: none"> – ECal is too cold and unable to regulate internal temperature to setpoint. – Performance may be degraded beyond specifications. – See also, Figure “ECal Troubleshooting” on page 3-14.
Alternating Green/Red Flashing	<ul style="list-style-type: none"> – ECal is too hot and unable to regulate internal temperature to setpoint. – Performance may be degraded beyond specifications. – See also, Figure “ECal Troubleshooting” on page 3-14.

a. Status LED briefly flashes orange when the ECal is first connected to an instrument while the driver software loads.

Required Procedure for All Calibrations (PNA and PXIe)

For all calibration types, complete the following steps:

1. Connect an ECal module to the analyzer having the appropriate frequency range and connector type.
2. Wait until LED turns green.
3. Set up the analyzer in the measurement configuration. Select the frequency, power, sweep and other stimulus settings.
4. View the response (uncorrected) and optimize the analyzer settings as needed.
5. Connect the ECal module to the measurement ports.
6. Navigate to **Response > Cal Wizard**
7. In the Calibration Wizard: Begin Calibration window that opens, select **Use Electronic Calibration (ECal)**, click **Next**, and follow the prompts.
8. When the calibration is complete, remove the ECal module, and connect the DUT.

CAUTION

Excessive torque can damage ECal module connectors. See [Table 4-1 on page 4-21](#) for the required torque setting for each connector type.

NOTE

For optimal results, terminate any unused ECal ports with a 50 ohm load.

Required Procedure for All Calibrations (ENA E5061B, E5063A, E5071C, and E5072A)

For all calibration types, complete the following steps:

1. Connect an ECal module to the analyzer having the appropriate frequency range and connector type.
2. Wait until LED turns green.
3. Set up the analyzer in the measurement configuration. Select the frequency, power, sweep and other stimulus settings.
4. View the response (uncorrected) and optimize the analyzer settings as needed.
5. Connect the ECal module to the measurement ports.
6. Select the channel you want to calibrate: Press **Channel Next/Channel Prev** keys
7. Press **Cal**
8. Click **ECal > 1-Port Cal**

9. Perform a 1-port calibration by clicking the softkey of the selected port.
10. Refer to the ENA User's Guide or Online Help for more details on performing various types of 1-port calibrations. Refer to your instrument's Online Help/User's Guide on <http://www.keysight.com>.
11. When the calibration is complete, remove the ECal module, and connect the DUT.

CAUTION

Excessive torque can damage ECal module connectors. See [Table 4-1 on page 4-21](#) for the required torque setting for each connector type.

NOTE

For optimal results, terminate any unused ECal ports with a 50 ohm load.

Required Procedure for All Calibrations (FieldFox)

For all calibration types, complete the following steps:

1. Connect an ECal module to the FieldFox having the appropriate frequency range and connector type.
2. Wait until LED turns green.
3. Set up the analyzer in the measurement configuration. Select the frequency, power, sweep and other stimulus settings.

NOTE

Verify the FieldFox is set to a frequency range that is within the ECal module's range. If the frequency start and or stop frequency are outside the range of the ECal module, the FieldFox does not recognize the ECal module.

4. View the response (uncorrected) and optimize the analyzer settings as needed.
5. Connect the ECal module to the measurement ports.
6. Set instrument to frequency range that is compatible with your ECal module.
7. Navigate to **Cal 5 > Mechanical Cal / ECal**.

For each test port to be calibrated, press the **Change DUT Connectors** and follow the prompts.

NOTE

IMPORTANT: Until the correct connector-type is selected for your ECal module, the ECal module choice(s) will not be visible in the `Select CalKit` table.

8. Press **Change Cal Type**. The connected ECal module and relevant User Characterizations will appear, with the ECal factory default as the default Cal Kit. In the Select Calkit table that opens, verify the correct ECal model is selected. If not, use the arrow keys to select the correct ECal model.
9. Press **Finish**
10. Press **Start Calibration**.
11. In the Calibration Wizard window that opens, press **Measure**.
12. Continue to follow the prompts for the other port and when the calibration is complete, remove the ECal module, and connect the DUT. For more information on using an ECal module with the FieldFox, refer to the User's Guide for your model on www.keysight.com.

CAUTION

Excessive torque can damage ECal module connectors. See [Table 4-1 on page 4-21](#) for the required torque setting for each connector type.

NOTE

For optimal results, terminate any unused ECal ports with a 50 ohm load.

Calibration Types Available

The following table contains the calibration types and advanced settings available for all compatible network analyzers:

Table 3-3 Calibration Types and Advanced Settings Available

Calibration Types	Model				
	PNA	PXIe	USB-VNA	ENA	FieldFox ^a
1-Port Reflection	Yes	Yes	Yes	Yes	Yes
Full 2-Port	Yes	Yes	Yes	Yes	Yes
Full N-Port where N>2	Yes	Yes	Yes	Yes	No
Enhanced Response	Yes	Yes	Yes	Yes	Yes
QSOLT	Yes	Yes	Yes	No	Yes
Advanced Settings					
Adapter Removal	Yes	Yes	Yes	No	No
Flush (zero length) THRU	Yes	Yes	Yes	No	Yes
Unknown THRU	Yes	Yes	Yes	Yes	Yes
User-Characterization	Yes	Yes	Yes	Yes	Yes ^b

a. ECal calibrations are not supported on the N9912A.

b. FieldFox user-characterizations must be performed on a PNA or ENA. Learn more about User Characterization at the PNA Help website: http://na.support.keysight.com/pna/help/latest/S3_Cals/ECal_User_Characterization.htm

When to Correct for Isolation

Correction for isolation is a consideration when measuring high-loss devices such as saw filters or diplexers. When maximum dynamic range is required, correction for isolation can remove the errors due to crosstalk (between test ports) for transmission measurements.

When you include isolation with a two, three, or four-port calibration, the analyzer automatically applies averaging to reduce noise in the measurement. Without averaging, you will have noise in the measurement of the crosstalk, and could raise the noise floor when the analyzer uses this in its error correction.

The analyzer system isolation is normally sufficient for most measurements, and correction for it is usually unnecessary. As long as crosstalk is below the noise floor, it is best NOT to correct for isolation using ECal. As of PNA firmware release 4.26, measuring isolation as part of the ECal process is no longer supported.

Calibration Methods for Non-Insertable Devices

A “non-insertable” device means that the measurement ports cannot be connected together to establish a THRU connection during calibration for transmission. Because the module typically forms the THRU path, you can use one of the following methods to perform a calibration for non-insertable devices:

Configure ECal Module the Same as Device

The simplest way to calibrate for non-insertable devices is to configure an ECal module with the same connector types as the DUT. RF ECal modules can be configured with mixed connectors to match the connector types on the DUT. Refer to **“Models and Options” on page 1-4**. You can also configure the module with different connector types by performing a User-Characterization (see below).

Use Adapter Removal Calibration

Adapter removal provides an accurate way to calibrate for non-insertable devices, but requires extra calibration steps to characterize the adapter. The adapter type used for this calibration must be a -m- to -m- or -f- to -f- and have the same connector type as the module. In addition, the module must have a male connector on one test port and a female connector on the other test port (of the same connector type).

Use Unknown Thru Calibration

Unknown Thru calibration is currently available with all PNA network analyzers except the E8801/2/3A. It is easy to perform and can be used on any two ports when using a multiport PNA. It causes minimal cable movement if the Thru standard has the same footprint as the DUT. In fact, the DUT can often be the Thru standard. A 1-port calibration is performed on both ports. The unknown Thru is connected between the two ports and measured. Next, the user must confirm the Estimated Delay. This requires knowing the phase response to within 1/4 wavelength. If the phase response is unknown, the Delay value can be measured independently and entered in the dialog box.

Perform a User-Characterization

Normally, when you perform a calibration with an ECal module, the error terms for a calibration are computed using the factory characterization (data) stored in the module. User-Characterization allows you change the characterization of the module in two ways:

- Change the connector configuration: allows you to add an adapter or fixture to the test port of the module and embed the effects into the characterization of the module. The result of the new characterization extends the reference plane from one or more of the module’s test ports to those on the adapter (or fixture).

- Modify the state settings: allows you to specify the number of data points (1601 max.) or other stimulus settings the module uses to perform a calibration.

When you perform a User-Characterization, the factory characterization data remains stored in the module's memory. At calibration, you can select the factory characterization or any of the user-defined characterizations stored in the module. The module can store up to five user-defined characterizations (in addition to the factory characterization data).

User-Characterization is currently available with PNA and PXIe. FieldFox user-characterizations must be performed on a PNA or ENA.

To perform a User-Characterization, a calibration kit (having the same connector type as the new reference plane) is required.

For detailed information on calibration methods using an PNA or PXIe series network analyzer or FieldFox, refer to the appropriate user guide or online Help. To use the Internet to view the PNA or PXIe online Help, use the steps listed in **“Finding More Information on Performing a Calibration” on page 3-10.**

Finding More Information on Performing a Calibration

For detailed information on performing a calibration using an PNA or PXIe series or the FieldFox, refer to the appropriate user guide or online Help.

- To view the PNA or PXIe Help file that is embedded in the analyzer, press the Help key on the front panel of the network analyzer.
- To view a user guide or Help file on the Internet, use the following steps:

1. Go to www.keysight.com.
2. Enter your analyzer model number (Ex: N5242A) in the search function and click Search.
3. Click on the Manuals hyperlink.
4. Open the PDF of the User Guide or Help.

CAUTION

Do not perform a calibration procedure unless you have cleaned and visually inspected all connectors and have taken the necessary ESD precautions.

Validating a Calibration

CAUTION

It is recommended that the Confidence Check be performed after every calibration, to verify the device is still functioning as expected.

NOTE

ECal Confidence Check and System Verification do not apply to the FieldFox.

The accuracy of a completed calibration should be validated after each calibration, because the following sources of error that can invalidate it:

- damaged semiconductor devices caused by static discharge or excess high input power
- bad cables
- dirty or worn connectors
- operator error
- measurement uncertainties from interpolation

The following paragraphs discuss two methods of validating the accuracy of a calibration:

1. Performing the ECal module's ECal Confidence Check.
2. Performing the analyzer's System Verification Procedure using standards in a Keysight verification kit.

Which method you choose depends largely on the level of accuracy required and the availability of a Keysight verification kit.

ECal Confidence Check – Basic Validation of the Calibration

CAUTION

It is recommended that the Confidence Check be performed after every calibration, to verify the device is still functioning as expected.

The ECal Confidence Check allows you to measure an impedance state in the ECal module – called the confidence state – and compare your measurement data with factory measurement data stored in ECal memory (of the same confidence state). The ECal Confidence Check overlays the two measurement traces so that the differences between your data and the factory data can be easily viewed.

- The ECal Confidence Check provides a basic validation that you have completed the ECal calibration correctly and that the calibration is activated.

- The ECal Confidence Check is not a method for system verification. The ECal Confidence Check's impedance state physically shares some of the same hardware as the ECal calibration impedance states. System verification requires a verification kit because it has devices that are physically different from those in a calibration kit.
- Keysight recommends that upon receipt of a new ECal module, you perform the ECal Confidence Check and save the measurement results as a baseline for future reference.
- Periodically, it is recommended that additional ECal confidence checks be performed and the test results compared to the baseline data.
- The interpretation of how much variation is acceptable between your data and the factory data is determined by your level of confidence in the calibration, based on your historical records of baseline data.

Before performing the ECal Confidence Check, the analyzer must be calibrated and the calibration type should be appropriate for the measurement being made. For example, you cannot measure the confidence state with an S22 measurement if an S11 1-port calibration is active.

NOTE

For optimal results, terminate any unused ECal ports with a 50 ohm load.

For detailed information on performing an ECal Confidence Check using a ENA, PNA, or PXIe series instruments, refer to the appropriate online Help. To use the Internet to view the ENA, PNA, or PXIe online Help, use the steps listed in **"Finding More Information on Performing a Calibration" on page 3-10.**

System Verification Procedure – Traceable Accuracy Validation of the Calibrated Measurement System

NOTE

ECal Confidence Check and System Verification do not apply to the FieldFox.

NOTE

This method of validating the calibration requires a Keysight verification kit.

Using your analyzer's built-in System Verification Procedure to measure the standards in a Keysight verification kit provides a traceable accuracy validation of your calibrated measurement system. Following the measurement of each standard, the System Verification Procedure provides a pass/fail result, determining if your calibration provides measurements that meet the limits of uncertainty.

- The analyzer's built-in System Verification Procedure provides a traceable accuracy validation that you have completed the ECal calibration correctly and that the limits of uncertainty are met.

- The System Verification Procedure is also a method for verifying the performance of your analyzer.
- Verification kits use accurately known standards with well defined magnitude and phase response. These kits include precision airlines, mismatch airlines, and precision fixed attenuators.
- Each verification kit standard is measured precisely by Keysight's accredited test laboratory. The measurement data and uncertainty of each standard are provided in each kit on a disk or USB storage drive.
- Verification kits may be re-certified by Keysight. Contact Keysight for information about ordering verification kits - see **“Contacting Keysight” on page 1-23**.

For detailed information on using your analyzer's built-in System Verification Procedure, refer to the appropriate service guide or online Help. To use the internet to view the ENA, PNA, or PXIe online Help, use the steps listed in **“Finding More Information on Performing a Calibration” on page 3-10**.

ECal Troubleshooting

Table 3-4 N469xD/N443xD Troubleshooting

LED Color	Description	Possible Causes	Solutions
Orange	ECal is connected and functioning, but is not communicating with driver software.	ECal module is connected to an instrument (or PC) without the appropriate driver software installed.	Connect the ECal module to a compatible instrument. Ensure that the instrument software is up to date.
		Faulty instrument USB port	Connect to a different USB port on the instrument.
		Faulty USB cable	Connect via a different USB cable.
		Faulty USB hub	Connect ECal directly to a USB port on the instrument.
Alternating Green/Orange Flashing	ECal is too cold and unable to regulate internal temperature to setpoint.	ECal is too cold and unable to regulate internal temperature to setpoint.	Move ECal to a warmer location. Refer to “Environmental Specifications” on page 5-2.
Alternating Green/Red Flashing	ECal is too hot and unable to regulate internal temperature to setpoint.	ECal is too hot and unable to regulate internal temperature to setpoint.	Move ECal to a cooler location. Refer to “Environmental Specifications” on page 5-2.
Off	The ECal is not functioning.	ECal is not connected to instrument.	Double check the USB connectors are firmly inserted.
		Faulty instrument USB port	Connect to a different USB port on the instrument.
		Faulty USB cable	Connect via a different USB cable.
		Faulty USB hub	Connect ECal directly to a USB port on the instrument.
		Faulty ECal module	Return to Keysight for service. Refer to Chapter 1, “Service and Recertification” on page 1-23.

Table 3-5 N755xA Troubleshooting

LED Color	Description	Possible Causes	Solutions
Orange	ECal is connected and functioning, but is not communicating with driver software.	ECal module is connected to an instrument (or PC) without the appropriate driver software installed.	Connect the ECal module to a compatible instrument. Ensure that the instrument software is up to date.
		Faulty instrument USB port	Connect to a different USB port on the instrument.
		Faulty USB cable	Connect via a different USB cable.
		Faulty USB hub	Connect ECal directly to a USB port on the instrument.
Off	The ECal is not functioning.	ECal is not connected to instrument.	Double check the USB connectors are firmly inserted.
		Faulty instrument USB port	Connect to a different USB port on the instrument.
		Faulty USB cable	Connect via a different USB cable.
		Faulty USB hub	Connect ECal directly to a USB port on the instrument.
		Faulty ECal module	Return to Keysight for service. Refer to Chapter 1, "Service and Recertification" on page 1-23.

Operating ECal Module
ECal Troubleshooting

4 Use, Maintenance, and Care of the Devices

Electrostatic Discharge

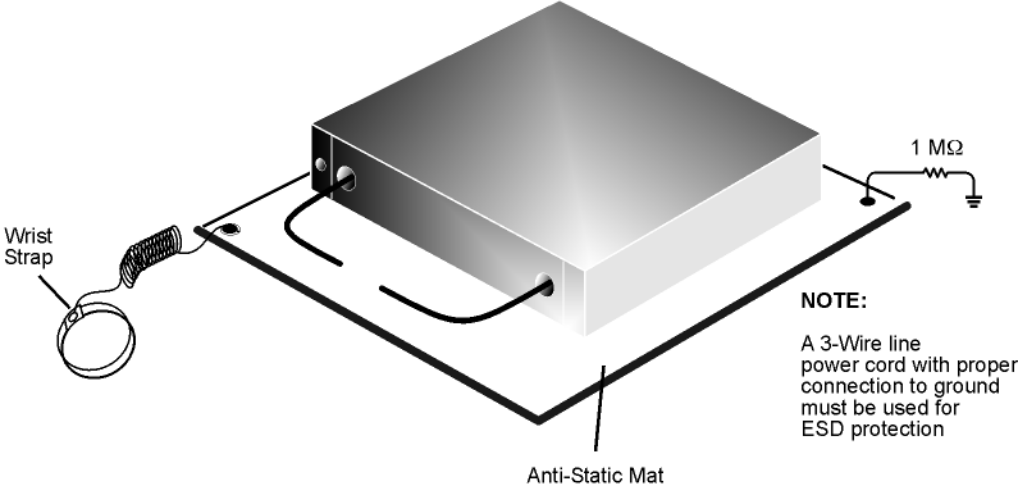
Protection against electrostatic discharge (ESD) is essential while connecting, inspecting, or cleaning devices attached to static-sensitive circuits (such as those found in network analyzers and ECal modules).

Static electricity can build up on your body and can easily damage sensitive internal circuit elements when discharged. Static discharges too small to be felt can cause permanent damage. Devices such as calibration components and devices under test (DUTs), can also carry an electrostatic charge. To prevent damage to network analyzer components and devices:

- **always** wear a grounded wrist strap having a 1 M Ω resistor in series with it when handling components and devices or when making connections to the test set.
- **always** use a grounded, conductive table mat while 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 before making a connection to the analyzer test port or other static-sensitive device. This can be done as follows:
 1. Connect a short (from your calibration kit) to one end of the cable to short the center conductor to the outer conductor.
 2. While wearing a grounded wrist strap, grasp the outer shell of the cable connector.
 3. Connect the other end of the cable to the test port.
 4. Remove the short from the cable.

For parts numbers for ESD protection supplies, refer to **“Other ECal Accessories” on page 6-10.**

Figure 4-1 ESD Protection Using Mat, Wrist Strap, and Grounded Power Cord



esd_setup

Visual Inspection

Visual inspection and, if necessary, cleaning should be done every time a connection is made. Metal particles from the connector threads may fall into the connector when it is disconnected.

CAUTION

Devices with damaged connectors should immediately be discarded or clearly marked and set aside for repair. A damaged device will in turn damage any good connector to which it is attached. Try to determine the cause of the damage before connecting a new, undamaged connector in the same configuration.

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

Look for Obvious Defects and Damage First

Examine the connectors first for obvious defects and damage: badly worn plating on the connector interface, deformed threads, or bent, broken, or misaligned center conductors.

What Causes Connector Wear?

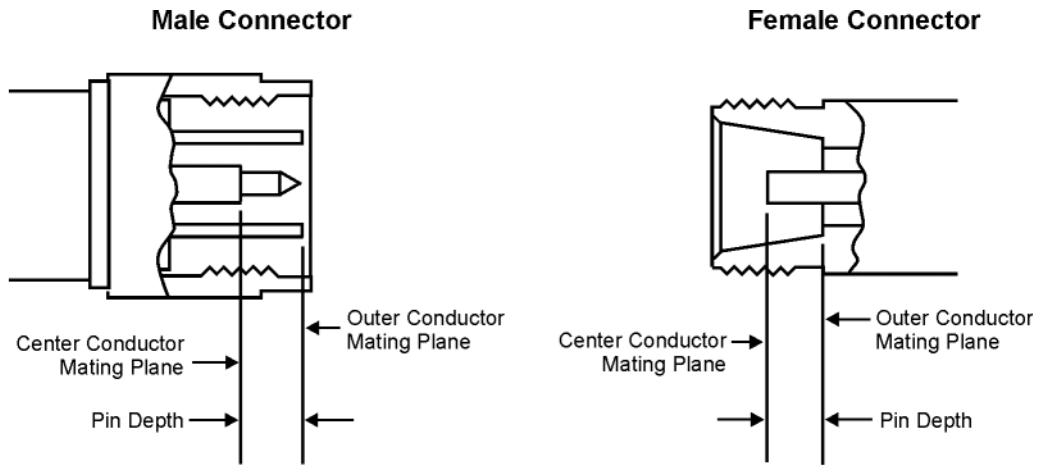
Connector wear is caused by connecting and disconnecting the devices. The more use the device gets, the faster it wears and degrades. The wear is greatly accelerated when connectors are not kept clean, or are not properly connected. This is especially true with electrically characterized devices such as ECal modules. ECal modules should have a long life if their use is on the order of a few times per week.

The test port connectors on the network analyzer may have many connections each day, and are therefore more subject to wear. It is recommended that an adapter be used as a test port saver to minimize the wear on the connectors. Replace devices with worn connectors.

Inspect the Mating Plane Surfaces

Uniform contact between the connectors at all points on their mating plane surfaces is required for a good connection. See **Figure 4-2** for an example of locations of mating plane surfaces. Look especially for deep scratches or dents, and for dirt and metal particles on the connector mating plane surfaces. Also look for signs of damage due to excessive or uneven wear or misalignment.

Figure 4-2 Type-N Connector Pin Depth and Mating Surfaces



k31a

Light burnishing of the mating plane surfaces is normal, and is evident as light scratches or shallow circular marks distributed more or less uniformly over the mating plane surface. Other small defects and cosmetic imperfections are also normal. None of these affect electrical or mechanical performance. If a connector shows deep scratches or dents, particles clinging to the mating plane surfaces, or uneven wear, clean and inspect it again.

Inspect Female Connectors

When using slotless connectors like the 3.5 mm or some Type-N 50 Ω 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.

NOTE

Due to the tighter mechanical specifications of precision devices, inspection is particularly important when you are mating nonprecision to precision devices.

Cleaning Connectors

Clean connector interfaces prolong connector life and produce more accurate and repeatable measurements.

WARNING

Always use protective eyewear when using compressed air or nitrogen.

NOTE

The following cleaning procedure can be used for most coaxial connectors.

Cleaning Coax Connectors

1. Use compressed Air or Nitrogen

Use compressed air (or nitrogen) to loosen particles on the connector mating plane surfaces.

You can use any source of clean, dry, low-pressure compressed air or nitrogen that has an effective oil-vapor filter and liquid condensation trap placed just before the outlet hose.

Ground the hose nozzle to prevent electrostatic discharge, and set the air pressure to less than 414 kPa (60 psi) to control the velocity of the air stream. High-velocity streams of compressed air can cause electrostatic effects when directed into a connector. These electrostatic effects can damage the device. For additional information refer to **“Electrostatic Discharge”** on page 4-1 earlier in this chapter.

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.

2. Clean the Connector Threads

CAUTION

Use ONLY isopropyl alcohol to clean connector surfaces. Any other solvent may damage the insulators, support beads, and seals in the connector.

Never immerse the connector in solvents of any kind. The solvent can become trapped within the assembly and cause SWR, phase, and insertion loss problems.

Moisten (don't soak) a lint-free swab or cleaning cloth with isopropyl alcohol to remove any dirt or stubborn contaminants that cannot be removed with compressed air or nitrogen. Refer to “Other ECal Accessories” on page 6-10 for cleaning swabs and other connector cleaning supplies.

- a. Apply a small amount of isopropyl alcohol to a lint-free swab.
- b. Clean the connector threads.
- c. 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.

3. Clean the Mating Plane Surfaces

- a. Apply a small amount of isopropyl alcohol to a new lint-free cleaning cloth or swab.
- b. Clean the center and outer conductor mating plane surfaces. Refer to Figure 4-2 on page 4-4. When cleaning a female connector; use short strokes to avoid snagging the swab on the center conductor contact fingers.
- c. Let the alcohol evaporate, then blow the mating plane surface dry with a gentle stream of clean, low-pressure compressed air or nitrogen. Always completely dry a connector before you reassemble or use it.

4. Inspect Each Connector

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

Cleaning 7 mm Connectors

Cleaning the Center Collet While It Is in Place

You do not have to remove the center conductor collet to clean a precision 7 mm connector.

With the center collet in place:

1. Place a lint-free cleaning cloth flat on a table.

2. Dispense a drop or two of isopropyl alcohol in the center of the cloth.
3. Retract the connector sleeve threads to expose the connector interface.
4. Gently press the contact end of the connector into the moistened cloth and rotate the connector. The cloth scrubs away dirt on the connector interface without damaging it.
5. Blow the connector dry with a gentle stream of compressed air or nitrogen.
6. When not in use, keep the cloth in a plastic bag or box so that it does not collect dust or dirt.

For fixed connectors (i.e., connectors attached to a device that cannot be freely moved):

1. Fold a lint-free cleaning cloth several times.
2. Moisten the cloth with isopropyl alcohol.
3. Press the moistened cloth against the connector interface and rotate the cloth to clean the connector.
4. Blow the connector dry with a gentle stream of compressed air or nitrogen.

Cleaning a Removed Center Collet

Any time you remove the center conductor collet, clean and inspect the interior surfaces as described in **“Visual Inspection” on page 4-3**.

Gaging Connectors

The gages available from Keysight Technologies are intended for preventive maintenance and troubleshooting purposes only. They are effective in detecting excessive center conductor protrusion or recession, and conductor damage on DUTs, test accessories, and ECal module test ports. Do not use the gages for precise pin depth measurements.

Connector Gage Accuracy

The connector gages are only capable of performing coarse measurements. They do not provide the degree of accuracy necessary to precisely measure the pin depth. This is partially due to the repeatability uncertainties that are associated with pin-depth measurements.

With proper technique, the gages are useful in detecting gross pin depth errors on device connectors. To achieve maximum accuracy, random errors must be reduced by taking the average of at least three measurements having different gage orientations on the connector. Even the resultant average can be in error by as much as ± 0.0001 inch (± 0.0025 mm) due to systematic (biasing) errors usually resulting from worn gages and gage masters. The information in **“Typical Pin Depth Values” on page 5-21** assumes new gages and gage masters. Therefore, these systematic errors were not included in the uncertainty analysis. As the gages endure more use, the systematic errors can become more significant in the accuracy of the measurement.

The measurement uncertainties are primarily a function of the assembly materials and design, and the unique interaction each device type has with the gage. Therefore, these uncertainties can vary among the different devices.

The observed pin depth limits add in these uncertainties to the typical factory pin depth values to provide practical limits that can be referenced when using the gages.

NOTE

When measuring pin depth, the measured value (resultant average of three or more measurements) contains measurement uncertainty and is not necessarily the true value. Always compare the measured value with the **observed** pin depth limits (which account for measurement uncertainties) in **“Typical Pin Depth Values” on page 5-21** to evaluate the condition of device connectors.

When to Gage Connectors

Gage a connector at the following times:

- Prior to using an ECal module for the first time: record the pin depth measurement so that it can be compared with future readings. This serves as a good troubleshooting tool when you suspect damage may have occurred to the device.
- If either visual inspection or electrical performance suggests that the connector interface may be out of typical range (due to wear or damage, for example).
- If a module is used by someone else, or on another system or piece of equipment.
- Initially after every 100 connections, and after that as often as experience suggests.

NOTE

When using the 7 mm ECal Kit module, you must remove the 7 mm collet before gaging the pin depth of the connectors. Refer to “[Gaging Connectors](#)” on [page 4-9](#) for gaging instructions. Use the collet extraction tool provided in your 7 mm kit to remove the collet.

Recognizing Gage Types

A gage is referred to by the sex of the connector it measures. For example, a male gage measures male connectors and therefore has a corresponding female connector.

- See [Figure 4-3 on page 4-11](#) for an illustration of a typical gage for 3.5 mm, 2.92mm, 2.4 mm, and 1.85 mm connectors.
- See [Figure 4-4 on page 4-12](#) for an illustration of a typical gage for Type-N connectors.
- See [Figure 4-5 on page 4-13](#) for an illustration of a typical gage for 7 mm connectors.

NOTE

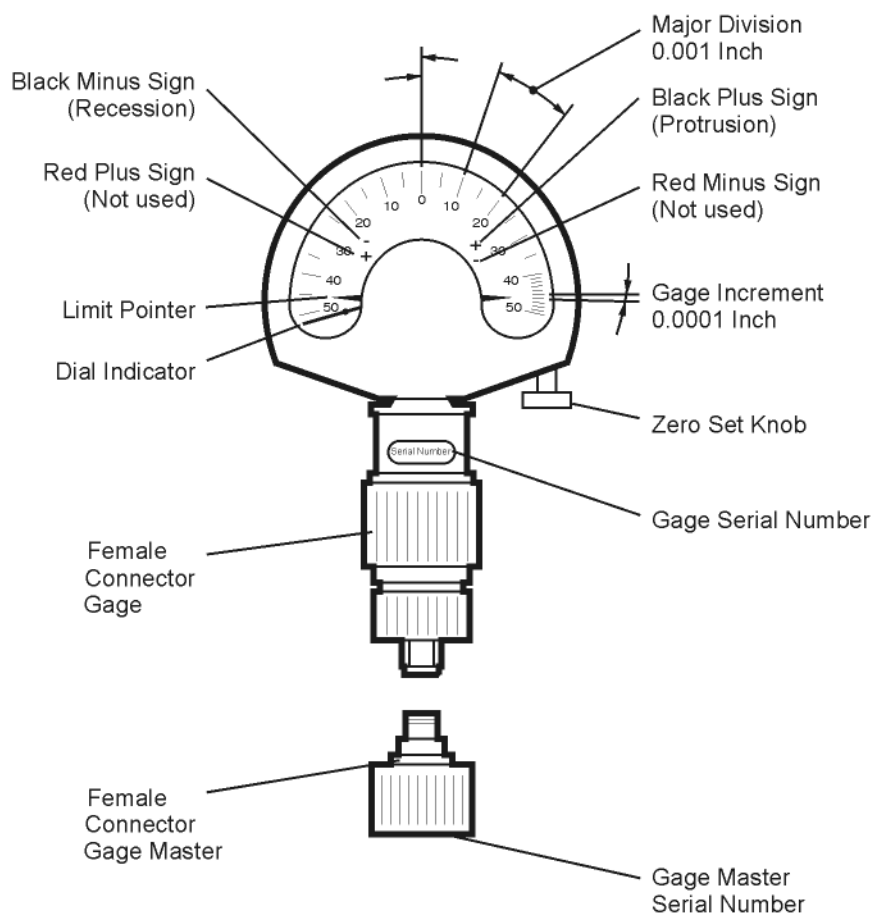
A 3.5 mm gage set can measure 3.5 mm and 2.92 mm connectors. And, a 2.4 mm gage set can measure 2.4 mm and 1.85 mm connectors.

Reading the Connector Gage

The gage dial is divided up into increments of 0.0001 inch (0.0025 mm) and major divisions of 0.001 inch (0.0025 mm). For Type-N gages, see [Figure 4-4 on page 4-12](#). For each revolution of the large dial, the smaller dial indicates a change of 0.01 inch (0.025 mm). Use the small dial as the indicator of multiples of 0.01 inch (0.0025 mm). In most connector measuring applications, this value will be zero.

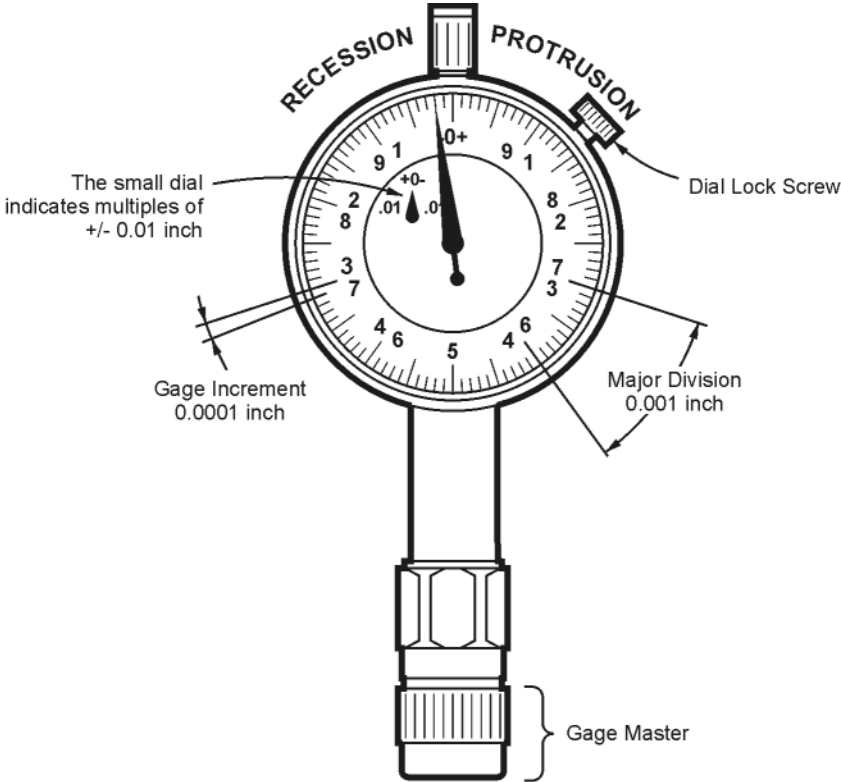
When making a measurement, the gage dial indicator will travel in one of two directions. If the center conductor is recessed from the zero reference plane, the indicator will move counterclockwise to determine the amount of recession, which is read as a negative value. If center conductor protrudes, the indicator will move clockwise to measure the amount of protrusion, which is read as a positive value. Refer to **“Typical Pin Depth Values” on page 5-21** for definitions of protrusion and recession.

Figure 4-3 Typical Gage: 1.85 mm, 2.4 mm, 2.92 mm, and 3.5 mm Connectors



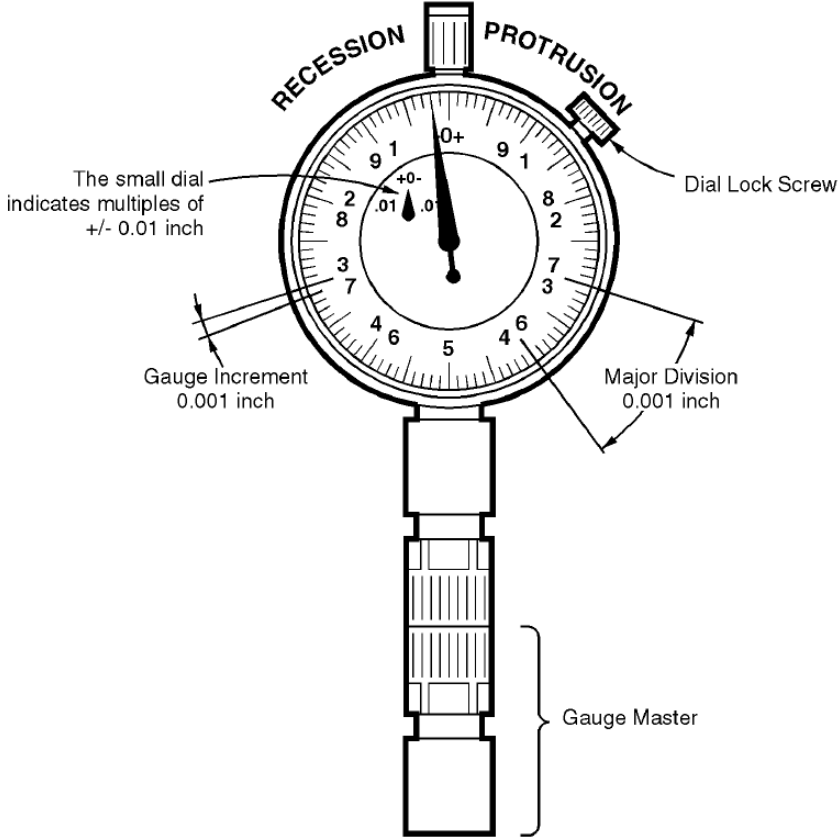
3_5mm

Figure 4-4 Typical Gage: Type-N Connectors



ku311b

Figure 4-5 Typical Gage: 7 mm Connectors



7mm

Gaging Procedures

CAUTION

For 7 mm connectors, you must remove the collet with the collet extractor tool prior to performing pin depth measurements.

Zeroing Connector Gages

For Type-N gages, the paired gage master is labeled with an offset value to compensate for its inaccuracy with its gage. This label appears on the bottom of all Type-N gage masters that have been paired with gages. When setting a Type-N gage with its master, always set the gage to the master offset value shown on the label, not to the zero, unless that is the offset value indicated.

The design of the gages used to measure 3.5 mm, 2.92 mm, 2.4 mm, and 1.85 mm connectors are different than the Type-N gage design. The primary difference is that the Type-N gages require an offset to compensate for inaccuracies in the gage masters.

1. Select the proper gage for your connector. Always use gages that are intended for pin depth measurements. Refer to [Chapter 6, “Replaceable Parts.”](#) for gage model numbers listed with the associated connector types.
2. Inspect and clean the gage, gage master, and device to be gaged. Refer to [“Visual Inspection” on page 4-3](#) and [“Cleaning Connectors” on page 4-6](#).

CAUTION

Before continuing, make sure you are familiar with the proper connection and torque techniques for your connector type. Refer to [“Making Connections” on page 4-17](#).

3. While holding the gage by the barrel, attach the gage to the gage master. Connect the gage master finger tight. Do not overtighten.
4. Use the torque wrench recommended for use with your connector type to tighten the connecting nut to the gage master. Refer to [Table 4-1 on page 4-21](#).
5. Type-N: Loosen the dial lock screw on the gage and rotate the gage dial so that the pointer corresponds to the correction value noted on the gage master. Do not adjust the gage dial to zero unless the correction value on the gage master is zero.

1.85/2.4/2.92/3.5/7 mm: The gage pointer should line up exactly with the zero mark on the gage. If not, adjust the zero set knob or rotate the gage dial until the gage pointer lines up exactly with zero.
6. Tighten the dial lock screw and remove the gage master.
7. Attach and torque the gage master once again to verify that the setting is repeatable. Remove the gage master.

Gaging Technique

1. Connect and torque the device being measured to the gage.
2. Gently tap the barrel of the gage with your finger to settle the gage reading.
3. Type-N and 7 mm: Read the gage indicator dial. If the needle has moved clockwise, the center conductor is **protruding** by an amount indicated by the black numbers. If the needle has moved counterclockwise, the center conductor is **recessed** by an amount indicated by the red numbers. For more on 7 mm connectors, See also, **“Gaging Technique–7 mm Gage” on page 4-16**.

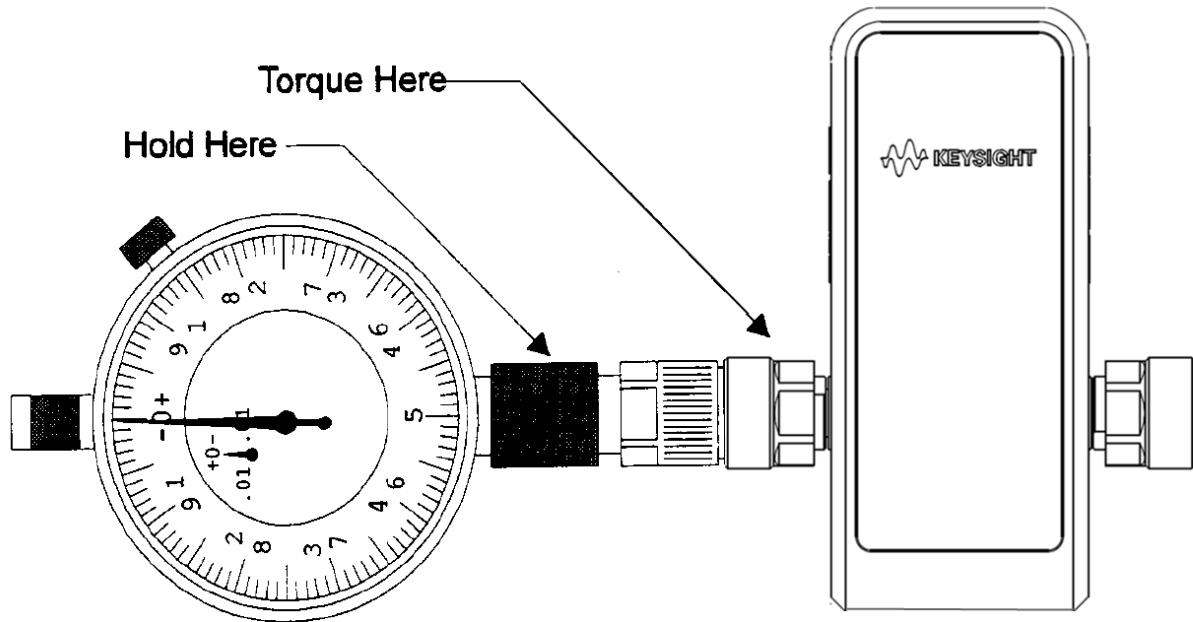
1.85/2.4/2.92/3.5 mm: Read the gage indicator dial. Read only the black \pm signs; not the red \pm signs.
4. For maximum accuracy, measure the connector a minimum of three times and take an average of the readings. After each measurement, rotate the gage a quarter-turn to reduce measurement variations that result from the gage or the connector face not being exactly perpendicular to the center axis.
5. Compare the average reading with the observed pin depth limits in the tables located in **“Typical Pin Depth Values” on page 5-21** for each type of connector.

Gaging Technique—7 mm Gage

CAUTION

You must remove the collet with the collet extractor tool prior to performing pin depth measurements.

Figure 4-6 Using a 7 mm Gage



While performing pin depth measurements, use different orientations of the gage with the connector. Average a minimum of three readings, each taken after a quarter-turn rotation of the gage, to reduce measurement variations that result from the gage or the connector face not being exactly perpendicular to the center axis.

To zero a gauge, review the instructions in **“Zeroing Connector Gages”** on **page 4-14**.

Making Connections

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

1.85 mm, 3.5 mm, 2.4 mm, 2.92 mm, and Type-N Devices

1. Handle the devices at a static-safe work station, only. See **“Electrostatic Discharge” on page 4-1.**
2. Carefully align the connectors. The male connector center pin must slip concentrically into the contact finger of the female connector.

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.

3. Push the connectors straight together and tighten the connector nut finger tight. Do not twist or screw the connector together. As the center conductors mate, there is usually a slight resistance
4. The preliminary connection is tight enough when the mating plane surfaces make uniform, light contact. Do not overtighten 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.

5. Make sure the connectors are properly supported. Relieve any side pressure on the connection from long or heavy devices or cables.
6. Torque the connection according to the procedures described in **“Final Connection Using a Torque Wrench” on page 4-18.**

7 mm Devices

Fully extend the connector sleeve on one of the connectors and fully retract the sleeve on the other. The extended sleeve creates a cylinder into which the second connector fits.

If one of the connectors is fixed (as on a test port), fully extend that connector sleeve (spin its knurled connector nut to make sure the threads are fully extended). Fully retract the connector sleeve on the other connector.

1. Handle the devices at a static-safe work station, only. See **“Electrostatic Discharge” on page 4-1.**
2. Remove the 7 mm collet from the center conductor with the collet extractor tool.1.Remove the 7 mm collet from the center conductor with the collet extractor tool.
3. Carefully align the connectors.

4. As you bring one connector up to the other, and as you make the actual connection, be sure the connectors align perfectly.
5. Push the connectors straight together. Do not twist or screw them together.
6. Engage the connector nut over the threads on the second connector. Turn only the connector nut. Let the connector nut pull the two connectors straight together.
7. Carefully align the connectors. The male connector center pin must slip concentrically into the contact finger of the female connector.

NOTE

IMPORTANT! At this point, you want a connection in which the outer conductors make gentle contact at all points on both mating surfaces. This requires very light finger pressure.

8. Push the connectors straight together and tighten the connector nut finger tight. Do not twist or screw the connector together. As the center conductors mate, there is usually a slight resistance

Final Connection Using a Torque Wrench

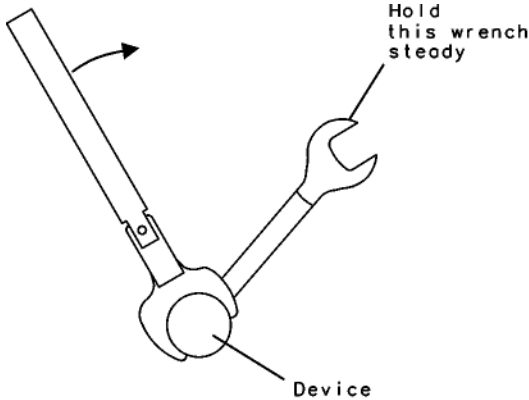
Using a torque wrench guarantees the connection is not too tight, preventing possible connector damage. It also guarantees that all connections are equally tight.

Use the recommended torque wrench to make a final connection. [Table 4-1 on page 4-21](#) provides information on the torque wrench recommended for use with each connector type.

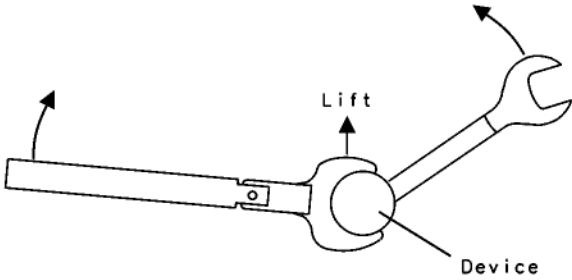
1. Turn the connector nut. This may be possible to do by hand if one of the connectors is fixed (as on a test port). However, it is recommended that you use an open-end wrench to keep the body of the device from turning.
2. Position both wrenches within 90 degrees of each other before applying force. 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 [Figure 4-7](#).

Figure 4-7

Wrench Positions



CORRECT METHOD
(Reduces lift on connection)



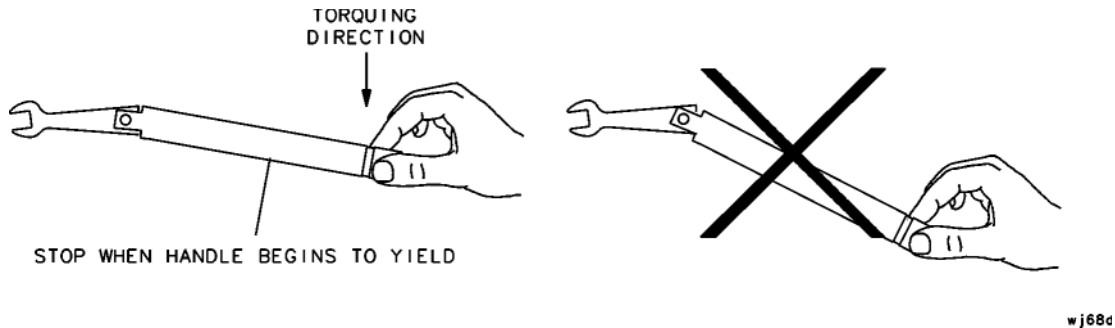
INCORRECT METHOD
(Too much lift on connection)

wj56f

3. Hold the torque wrench lightly, at the end of the handle only (beyond the groove). See **Figure 4-8**.

Figure 4-8

Using the Torque Wrench



4. Carefully align the connectors. As you make the actual connection, be sure the connectors align perfectly.
5. Push the connectors straight together. Do not twist or screw the connectors together. Engage the connector nut over the threads of the other connector. Turn only the connector nut. Let the connector nut pull the two connectors straight together.

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.

6. Make sure the connectors are properly supported. Relieve any side pressure on the connection from long or heavy devices or cables.
7. 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.

8. Relieve any side pressure on the connection from long or heavy devices or cables. This assures consistent torque while making the final connection.
9. Hold the torque wrench with your thumb and index finger behind the groove in the handle.
10. Tighten the connection until the handle begins to break at the torque setting (see technique in Figure 3-5 on page 3-19). It is not necessary to fully break the handle of the torque wrench to reach the specified torque.

Reverse the order of the steps above to disconnect the device

Table 4-1 ECal Module Torque Wrench Information

Connector Type	Torque Wrench Part Number	Wrench Opening	Torque Setting	Torque Tolerance ^a
3.5 mm, 2.92 mm, 2.4 mm, 1.85 mm (test port)	8710-1764	20 mm	90 N-cm (8 in-lb)	±9 N-cm (±0.8 in-lb)
3.5 mm, 2.92 mm, 2.4 mm, 1.85 mm (adapters)	8710-1765	5/16 in	90 N-cm (8 in-lb)	±9 N-cm (±0.8 in-lb)
Type-N 50 Ω	8710-1766	3/4 in	135 N-cm (12 in-lb)	±13.5 N-cm (±1.2 in-lb)
7 mm	8710-1766	3/4 in	135 N-cm (12 in-lb)	±13.5 N-cm (±1.2 in-lb)

a. Many older Keysight calibration module manuals list different torque tolerances for the various torque wrenches. The correct torque tolerance for Keysight torque wrenches is ±10% of the torque setting as listed in this table.

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.

Handling and Storage

- Use the plastic end caps and store the calibration devices in the foam-lined storage case when not in use.
- Never store connectors loose in a box, in a desk, or in a bench drawer. This is the most common cause of connector damage during storage. Keysight recommends that you purchase the optional ECal Storage Box (not included with an ECal kit). Refer to **“ECal Kit Storage Box (Option 150) – (N755xA Only)” on page 4-23**. This is a container for securing your ECal module and accessories, such as a USB cable, wrenches, and adapters. For ordering information, see **“Other ECal Accessories” on page 6-10**.
- Keep connectors clean.
- Do not touch mating plane surfaces. Natural skin oils and microscopic particles of dirt are easily transferred to a connector interface and are very difficult to remove.
- Do not set connectors contact-end down on a hard surface. The plating and the mating plane surfaces can be damaged if the interface comes in contact with any hard surface.

ECal Kit Storage Box (Option 150) – (N755xA Only)

The ECal kit ruggedized plastic storage box that can be ordered separately as Option 150 (refer to [Table 4-2](#) and [Table 4-9 on page 4-24](#)). It is a container for securing the contents of your ECal kit – the ECal module and accessories, such as a USB cable, wrenches and adapters. Inside the storage box, these items are safely placed within the ESD-safe foam cutouts, so they are protected from the work environment and are easily located when needed.

The ECal kit storage box is not designed for shipping. Please retain the original shipping container to ship the ECal module and accessories back to Keysight for repair and recertification.

Table 4-2

N755xA Option 150 Storage Box Part Numbers

Model	Storage Box Part Numbers
N7550A	N7550-60009
N7551A	N7551-60007
N7552A	N7552-60007
N7553A	N7553-60007
N7554A	N7554-60004
N7555A	N7555-60004

Figure 4-9

ECal Kit Ruggedized Plastic Storage Box (Option 150)



5 Specifications and Characteristics

Specifications: Terminology and Definitions

The following terms and definitions apply to Keysight's N755xA series of ECal modules. The definitions are specific to these modules and are not necessarily valid definitions for other Keysight Technologies products.

Table 5-1 Specifications and Characteristics Terminology

Terms	Definitions
Operating Temperature Range	The temperature range over which the ECal modules maintain conformance to their specifications.
Error-Corrected Temperature Range	The allowable network analyzer ambient temperature drift during measurement calibration and during measurements when network analyzer correction is turned on. It is also the range over which the network analyzer maintains its specified performance while correction is turned on. If this temperature range is exceeded, the error-corrected performance of the network analyzer is degraded.
Measurement Calibration	This calibration determines the corrections necessary for accuracy-enhanced (correction on) measurements.
Connector Pin Depth Values	Pin depth is a relative measurement value between the center conductor and outer conductor mating surfaces. All references to pin depth in this manual treat positive (+) values as protrusions of the center conductor, and negative (-) values as recessions of the center conductor. See “Typical Pin Depth Values” on page 5-21
Electrical Specifications	Warranted performance. Specifications include guard bands to account for the expected statistical distribution, measurement uncertainties, and changes in performance due to environmental conditions. Included with Option UK6.
Characteristic Performance	A performance parameter that the product is expected to meet before it leaves the factory, but is not verified in the field and is not covered by the product warranty. A characteristic includes the same guard bands as a specification.
Typical Corrected Performance	Expected performance of an average unit which does not include guard bands. It is not covered by the product warranty.

Environmental Specifications

NOTE

Samples of this product have been type-tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of storage, transportation and end-use; those stresses include but are not limited to temperature, humidity, shock, vibration, and power-line conditions. Test methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.

Table 5-2 Environmental Specifications for all ECal Modules

Specifications	Limits
Temperature	
Operating (N755xA series) - (Typical)	+15 °C to +35 °C – up to 75% RH ^a
Operating (N469xD series)	+20 °C to +26 °C – up to 95% RH (see RH N469xD below)
Operating (N443xD series)	+20 °C to +26 °C – up to 95% RH (see RH N443xD below)
Storage	-40 °C to +70 °C
Error-corrected range	±1 °C of measurement calibration temperature
Relative Humidity (N755xA)	< 75%
Relative Humidity (N469xD)	Type tested, 0% to 95% at 40°C, non-condensing
Relative Humidity (N443xD)	Type tested, 0% to 95% at 40°C, non-condensing

a. Usable, but not specified from -15 to 55 °C –up to 95% RH.

Operating Temperature and Accuracy Enhancement

Because the dimensions of critical components may vary over temperature, certain electrical characteristics may change as well. Thus, the operating temperature is a critical factor in its performance, and must be stable before use. In addition, excessive air flow can prevent the ECal module from warming up properly.

Measurement calibration, performance verification, and actual device measurements must be made within ±1 °C of the error-corrected operating temperature range specification of the network analyzer. If the ambient operating temperature drift of the network analyzer exceeds the allowable error-corrected temperature range, a new measurement calibration must be performed to ensure optimum accuracy.

NOTE

Avoid prolonged handling of the module, connectors, and cables. Your fingers are a heat source that can increase the temperature of these devices.

Barometric Pressure and Relative Humidity

Barometric pressure and relative humidity also affect module performance. The dielectric constant of the air between the inner and outer conductors of the module changes as the air pressure and humidity change.

Electrical Specifications

Electrical performance for RF and microwave ECal modules are provided in the following tables, which describe warranted performance that most units exhibit.

NOTE

ECal modules reflection parameter performance applies to each of the ports.

N755xA Series

Table 5-3 Electrical Performance for N755xA (3.5 mm)^a

Parameter	Frequency Range						
	DC to 500 MHz	500 MHz to 4 GHz	4 to 6.5 GHz	6.5 to 9 GHz	9 to 14 GHz	14 to 18 GHz	18 to 26.5 GHz
Directivity (dB)	42	36	36	36	36	36	36
Source Match (dB)	37	30	30	30	28	28	27
Reflection Tracking (\pm dB)	0.13	0.13	0.18	0.18	0.25	0.25	0.30

a. When applied power exceeds -10 dBm, calibration results will be degraded from the performance indicated in this table.

Table 5-4 Electrical Performance for N755xA (Type-N 50 Ω)^a

Parameter	Frequency Range					
	DC to 500 MHz	500 MHz to 4 GHz	4 to 6.5 GHz	6.5 to 9 GHz	9 to 14 GHz	14 to 18 GHz
Directivity (dB)	42	36	36	36	36	36
Source Match (dB)	37	30	30	30	28	28
Reflection Tracking (\pm dB)	0.13	0.13	0.18	0.18	0.25	0.25

a. When applied power exceeds -10 dBm, calibration results will be degraded from the performance indicated in this table.

N4431D (3.5 mm)

The electrical performance in the following table applies to N4431D Option 010 (3.5 mm female connectors on all ports).

Table 5-5 Electrical Performance for N4431D Option 010^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz
Directivity (dB)	45	53	48	45
Source Match (dB)	36	50	45	37
Reflection Tracking (±dB)	0.10	0.03	0.04	0.10

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

N4431D (Type-N 50 Ω)

The electrical performance in the following table applies to N4431D Option 020 (Type-N female connectors on all ports).

Table 5-6 Electrical Performance for N4431D Option 020^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz
Directivity (dB)	45	50	47	45
Source Match (dB)	36	47	42	37
Reflection Tracking (±dB)	0.10	0.03	0.04	0.10

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

N4431D (7-16)

The electrical performance in the following table applies to N4431D (if any of the ports consist of 7-16 connector).

Table 5-7 Electrical Performance for N4431D (m/f 7-16 connectors)^a

Parameter	Frequency Range		
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 7.5 GHz
Directivity (dB)	45	50	47
Source Match (dB)	36	42	39
Reflection Tracking (±dB)	0.10	0.06	0.09

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

N4431D (4.3-10)

The electrical performance in the following table applies to N4431D (if any of the ports consist of 4.3-10 connector).

Table 5-8 Electrical Performance for N4431D (m/f 4.3-10 connectors)^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	3 GHz to 9 GHz	9 GHz to 12 GHz
Directivity (dB)	45	50	47	35
Source Match (dB)	36	42	39	37
Reflection Tracking (±dB)	0.10	0.06	0.09	0.10

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

N4432D (Type-N 50 Ω)

The electrical performance in the following table applies to N4432D Option 020 (Type-N 50 Ω female connectors on all ports).

Table 5-9 Electrical Performance for N4432D Option 020^a

Parameter	Frequency Range					
	DC to 10 MHz ^b	300 kHz to 10 MHz ^c	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz	13.5 GHz to 18 GHz
Directivity (dB)	50	45	50	47	41	40
Source Match (dB)	41	35	41	37	34	34
Reflection Tracking (\pm dB)	0.06	0.10	0.06	0.10	0.15	0.14

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
- b. For Option ODC.
- c. For option 003.

N4433D (3.5 mm)

The electrical performance in the following table applies to N4433D Option 010 (3.5 mm female connectors on all ports).

Table 5-10 Electrical Performance for N4433D Option 010^a

Parameter	Frequency Range						
	DC to 10 MHz ^b	300 kHz to 10 MHz ^c	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz	13.5 to 20 GHz	20 GHz to 26.5 GHz
Directivity (dB)	50	45	50	47	45	40	36
Source Match (dB)	42	36	42	39	37	31	26
Reflection Tracking (\pm dB)	0.06	0.10	0.06	0.09	0.10	0.18	0.31

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
- b. For Option ODC.
- c. For option 003.

N469xD Series

Table 5-11 Electrical Performance for N4690D (Type-N 50Ω)

Parameter	Frequency Range							
	DC to 2 MHz ^a	2 MHz to 10 MHz ^c	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 18 GHz
Directivity (dB)	45	45	30	40	45	45	40	38
Source Match (dB)	40	40	28	35	40	43	40	35
Reflection Tracking (±dB)	0.05	0.05	0.12	0.07	0.05	0.03	0.03	0.05

- a. For option ODC.
b. For option 003.

Table 5-12 Electrical Performance for N4691D (3.5 mm)

Parameter	Frequency Range								
	DC to 2 MHz ^a	2 MHz to 10 MHz ^c	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 26.5 GHz
Directivity (dB)	46	46	31	41	46	47	46	43	41
Source Match (dB)	41	41	29	36	41	47	45	42	40
Reflection Tracking (±dB)	0.05	0.05	0.11	0.06	0.05	0.02	0.03	0.04	0.05

- a. For Option ODC.
b. For Option 003.

Table 5-13 Electrical Performance for N4692D (2.92 mm)

Parameter	Frequency Range						
	DC to 45 MHz ^a	10 MHz to 45 MHz ^b	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 20 GHz	20 GHz to 30 GHz	30 GHz to 40 GHz
Directivity (dB)	40	29	41	42	38	35	32
Source Match (dB)	38	29	36	36	35	30	29
Reflection Tracking (\pm dB)	0.1	0.18	0.08	0.08	0.1	0.10	0.12

a. For Option ODC.

b. For Option 010.

Table 5-14 Electrical Performance for N4693D (2.4 mm)

Parameter	Frequency Range							
	DC to 45 MHz ^a	10 MHz to 45 MHz ^b	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 40 GHz	40 GHz to 50 GHz
Directivity (dB)	40	27	40	46	47	44	38	34
Source Match (dB)	38	25	44	46	42	37	35	32
Reflection Tracking (\pm dB)	0.05	0.05	0.05	0.03	0.04	0.05	0.06	0.08

a. For Option ODC.

b. For Option 010.

Specifications and Characteristics
Electrical Specifications

Table 5-15 Electrical Performance for N4694D (1.85 mm)

Parameter	Frequency Range									
	DC to 45 MHz ^a	10 MHz to 45 MHz ^b	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 20 GHz	20 GHz to 30 GHz	30 GHz to 40 GHz	40 GHz to 50 GHz	50 GHz to 60 GHz	60 GHz to 67 GHz
Directivity (dB)	41	27	41	41	42	41	40	38	35	33
Source Match (dB)	38	23	38	38	39	35	34	33	30	26
Reflection Tracking (\pm dB)	0.08	0.08	0.04	0.04	0.04	0.05	0.06	0.08	0.08	0.12

a. For Option ODC.

b. For Option 010.

Table 5-16 Electrical Performance for N4696D (7 mm)

Parameter	Frequency Range							
	DC to 2 MHz ^a	2 MHz to 10 MHz ^a	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 18 GHz
Directivity (dB)	46	46	30	40	46	45	44	41
Source Match (dB)	40	40	28	35	40	40	42	36
Reflection Tracking (\pm dB)	0.05	0.05	0.12	0.07	0.05	0.03	0.03	0.05

a. For Option ODC.

b. For Option 003.

Characteristic Performance

Characteristic performance for RF and microwave ECal modules are provided in the following tables, which describe non-warranted performance that most units exhibit.

N755xA Series

Table 5-17 Characteristic Performance for N755xA (3.5 mm)^a

Parameter	Frequency Range						
	DC to 500 MHz	500 MHz to 4 GHz	4 to 6.5 GHz	6.5 to 9 GHz	9 to 14 GHz	14 to 18 GHz	18 to 26.5 GHz
Transmission Tracking (\pm dB) ^b	0.15	0.16	0.22	0.22	0.30	0.30	0.35
Load Match (dB) ^b	34	29	28	22	26	26	24

a. When applied power exceeds -10 dBm, calibration results will be degraded from the performance indicated in this table.

b. Values based on using the network analyzer N5234A Option 200.

Table 5-18 Characteristic Performance for N755xA (Type-N 50 Ω)^a

Parameter	Frequency Range					
	DC to 500 MHz	500 MHz to 4 GHz	4 to 6.5 GHz	6.5 to 9 GHz	9 to 14 GHz	14 to 18 GHz
Transmission Tracking (\pm dB) ^b	0.15	0.16	0.22	0.22	0.30	0.30
Load Match (dB) ^b	34	29	28	22	26	26

a. When applied power exceeds -10 dBm, calibration results will be degraded from the performance indicated in this table.

b. Values based on using the network analyzer N5234A Option 200.

N4431D (3.5 mm)

The characteristic performance in the following table applies to N4431D Option 010 (3.5 mm female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-19 Characteristic Performance for N4431D Option 010^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz
Transmission Tracking (\pm dB) ^b	0.18	0.04	0.08	0.12
Load Match (dB) ^b	35	44	41	38

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

b. Values based on using the network analyzer N5232B 400.

N4431D (4.3-10)

The characteristic performance in the following table applies to N4431D (if any of the ports consist of 4.3-10 connector). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-20 Characteristic Performance for N4431D (m/f 4.3-10 connectors)^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 12 GHz
Transmission Tracking (\pm dB) ^b	0.18	0.05	0.09	0.12
Load Match (dB) ^e	35	42	39	32

a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.

b. Values based on using the network analyzer N5232B Option 400.

N4431D (7-16)

The characteristic performance in the following table applies to N4431D (if any of the ports consist of 7-16 connector). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-21 Characteristic Performance for N4431D (m/f 7-16 connectors)^a

Parameter	Frequency Range		
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 7.5 GHz
Transmission Tracking (\pm dB) ^b	0.18	0.05	0.08
Load Match (dB) ^b	35	42	40

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
b. Values based on using the network analyzer N5232B 400.

N4431D (Type-N 50 Ω)

The characteristic performance in the following table applies to N4431D Option 020 (Type-N 50 Ω female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-22 Characteristic Performance for N4431D (Type-N 50 Ω) Option 020^a

Parameter	Frequency Range			
	DC to 10 MHz	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz
Transmission Tracking (\pm dB) ^b	0.18	0.05	0.08	0.12
Load Match (dB) ^b	35	43	41	38

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
b. Values based on using the network analyzer N5232B 400.

N4432D (Type-N 50 Ω – Microwave)

The characteristic performance in the following table applies to N4432D Option 020 (Type-N female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-23 Characteristic Performance for N4432D Option 020^a

Parameter	Frequency Range					
	DC to 10 MHz ^b	300 kHz to 10 MHz ^c	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz	13.5 GHz to 18 GHz
Transmission Tracking (±dB) ^d	0.17	0.18	0.05	0.09	0.13	0.19
Load Match (dB) ^d	37	35	42	39	35	33

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
- b. For Option 0DC.
- c. For option 003.
- d. Values based on using the network analyzer N5232B 400.

N4433D (3.5 mm – Microwave)

The characteristic performance in the following table applies to N4433D Option 010 (3.5 mm female connectors on all ports). The data describes performance when measuring “thru path” A-B, C-D, A-D, A-D, B-C, and B-D.

Table 5-24 Characteristic Performance for N4433D Option 010^a

Parameter	Frequency Range						
	DC to 10 MHz ^b	300 kHz to 10 MHz ^c	10 MHz to 5 GHz	5 GHz to 9 GHz	9 GHz to 13.5 GHz	13.5 to 20 GHz	20 GHz to 26.5 GHz
Transmission Tracking (±dB) ^d	0.08	0.12	0.08	0.11	0.12	0.22	0.38
Load Match (dB) ^d	39	33	39	36	34	28	23

- a. When applied power exceeds -7 dBm, calibration results will be degraded from the performance indicated in this table.
- b. For Option 0DC.
- c. For option 003.
- d. Values based on using the network analyzer N5222B 405.

N469xD Series

Table 5-25 Characteristic Performance for N4690D (Type-N 50Ω)

Parameter	Frequency Range							
	DC to 2 MHz ^a	2 MHz to 10 MHz ^a	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 18 GHz
Transmission Tracking (±dB)	0.17 ^c	0.06 ^c	0.37 ^c	0.08 ^c	0.10 ^d	0.04 ^d	0.05 ^d	0.09 ^d
Load Match (dB)	36 ^c	41 ^c	26 ^c	37 ^c	33 ^d	42 ^d	39 ^d	34 ^d

- a. For option ODC.
- b. For option 003.
- c. Values based on using the network analyzer N5231B Option 200.
- d. Values based on using the network analyzer N5222B Option 200.

Table 5-26 Characteristic Performance for N4691D (3.5 mm)

Parameter	Frequency Range								
	DC to 2 MHz ^a	2 MHz to 10 MHz ^c	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 26.5 GHz
Transmission Tracking (±dB)	0.21 ^c	0.06 ^c	0.37 ^c	0.08 ^c	0.09 ^d	0.03 ^d	0.04 ^d	0.07 ^d	0.09 ^d
Load Match (dB)	34 ^c	41 ^c	27 ^c	37 ^c	34 ^d	46 ^d	43 ^d	40 ^d	38 ^d

- a. For Option ODC.
- b. For Option 003.
- c. Values based on using the network analyzer N5231B Option 200.
- d. Values based on using the network analyzer N5222B Option 200.

Specifications and Characteristics
Characteristic Performance

Table 5-27 Characteristic Performance for N4692D (2.92 mm)

Parameter	Frequency Range						
	DC to 45 MHz ^a	10 MHz to 45 MHz ^{b,c}	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 20 GHz	20 GHz to 30 GHz	30 GHz to 40 GHz
Transmission Tracking (\pm dB) ^d	0.13	0.28	0.11	0.10	0.14	0.17	0.21
Load Match (dB) ^d	35	27	34	35	33	28	27

- a. For Option 0DC.
- b. For Option 010.
- c. For Option 003.
- d. Values based on using the network analyzer N5224B Option 200.

Table 5-28 Characteristic Performance for N4693D (2.4 mm)

Parameter	Frequency Range							
	DC to 45 MHz ^a	10 MHz to 45 MHz ^{b,c}	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 40 GHz	40 GHz to 50 GHz
Transmission Tracking (\pm dB) ^d	0.08	0.18	0.08	0.04	0.05	0.07	0.11	0.15
Load Match (dB) ^d	36	24	41	45	40	35	33	30

- a. For Option 0DC.
- b. For Option 010.
- c. For Option 003.
- d. Values based on using the network analyzer N5225B Option 200.

Table 5-29 Characteristic Performance for N4694D (1.85 mm)

Parameter	Frequency Range									
	DC to 45 MHz ^a	10 MHz to 45 MHz ^b	45 MHz to 200 MHz	200 MHz to 2 GHz	2 GHz to 20 GHz	20 GHz to 30 GHz	30 GHz to 40 GHz	40 GHz to 50 GHz	50 GHz to 60 GHz	60 GHz to 67 GHz
Transmission Tracking (\pm dB) ^c	0.12	0.28	0.08	0.08	0.08	0.09	0.11	0.14	0.15	0.22
Load Match (dB) ^c	35	22	36	36	37	33	32	31	28	24

- a. For Option 0DC.
- b. For Option 010.
- c. Values based on using the network analyzer N5227B Option 200.

Table 5-30 Characteristic Performance for N4696D (7 mm)

Parameter	Frequency Range							
	DC to 2 MHz ^a	2 MHz to 10 MHz ^a	300 kHz to 2 MHz ^b	2 MHz to 10 MHz ^b	10 MHz to 500 MHz	500 MHz to 2 GHz	2 GHz to 10 GHz	10 GHz to 18 GHz
Transmission Tracking (\pm dB)	0.17 ^c	0.05 ^c	0.37 ^c	0.08 ^c	0.10 ^d	0.04 ^d	0.05 ^d	0.08 ^d
Load Match (dB)	36 ^c	41 ^c	26 ^c	37 ^c	33 ^d	39 ^d	41 ^d	34 ^d

- a. For Option 0DC.
- b. For Option 003.
- c. Values based on using the network analyzer N5231B Option 200.
- d. Values based on using the network analyzer N5222B Option 200.

Mechanical Characteristics

Mechanical characteristics, such as center conductor protrusion and pin depth, are not warranted performance specifications. They are, however, important supplemental characteristics related to the electrical performance of devices. Keysight Technologies verifies the mechanical characteristics of the devices with special gaging processes and electrical testing. These processes ensure that the device connectors do not exhibit any excess center conductor protrusion or improper pin depth when the module leaves the factory.

“**Gaging Connectors**” on page 4-9 explains how to use pin-depth gages. Refer to “**Typical Pin Depth Values**” on page 5-21 for typical and observed pin depth limits.

Pin Depth

Pin depth is the distance the center conductor mating plane differs from being flush with the outer connector mating plane. The pin depth of a connector can be in one of two states: protrusion or recession. The pin depth for a 3.5 mm connector is shown in **Figure 5-1**, although the description also applies to 1.85 mm, 2.4 mm, and 2.92 mm connectors. The pin depth for 4.3–10 is shown in **Figure 5-2**. The pin depth for 7–16 is shown in **Figure 5-3**. The pin depth for Type-N connectors is shown in **Figure 5-4**. Typical pin depths for ECal connectors are listed in “**Typical Pin Depth Values**” on page 5-21.

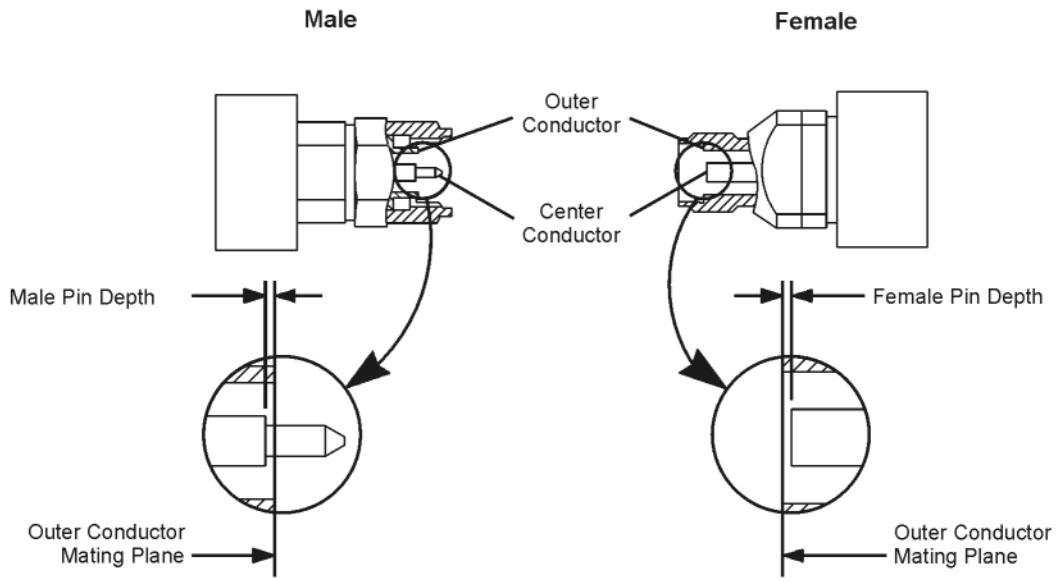
NOTE

No protrusion of the center conductor shoulder is allowable on any 7 mm connector when the slotted collet is removed. The slotted collet must be removed before measuring the pin depth.

Protrusion occurs when the center conductor extends beyond the outer conductor mating plane. It reads as a positive value on the connector gage.

Recession occurs when the center conductor is set back from the outer conductor mating plane. It reads as a negative value on the gage.

Figure 5-1 Pin Depth for a 3.5 mm Connectors



ph51b

Figure 5-2 Pin Depth for a 4.3-10 Connectors

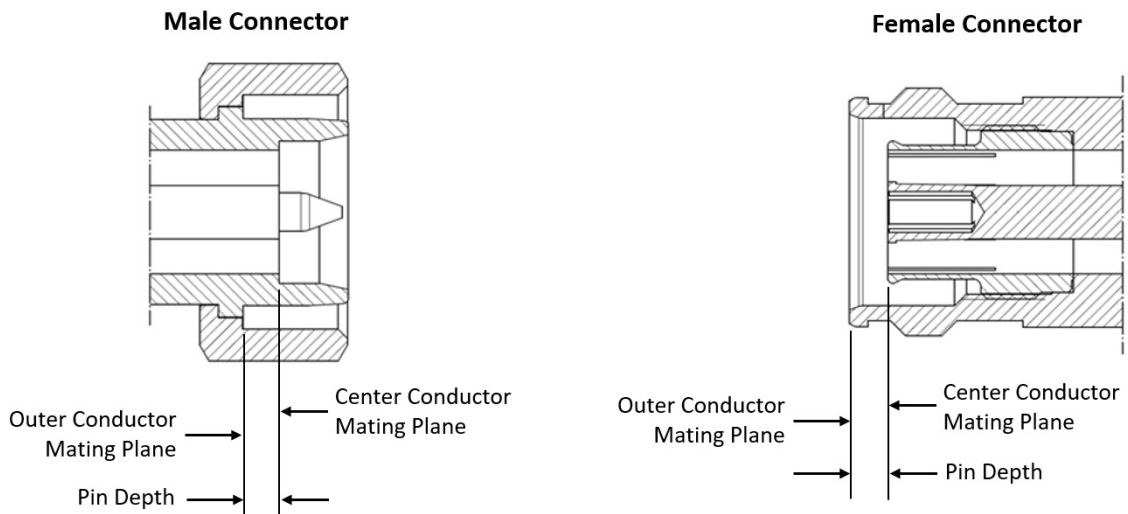
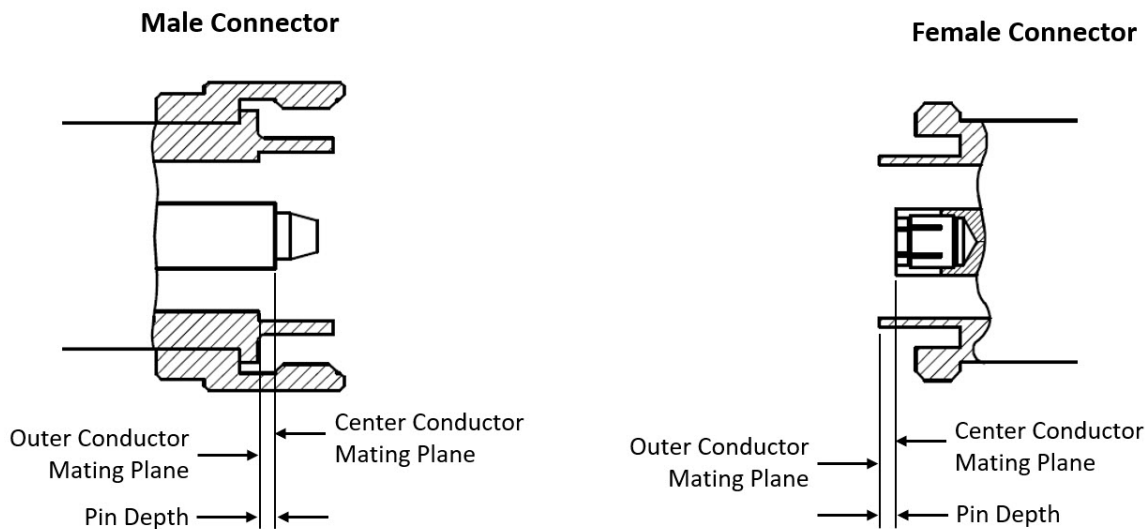


Figure 5-3 Pin Depth for a 7-16 Connectors

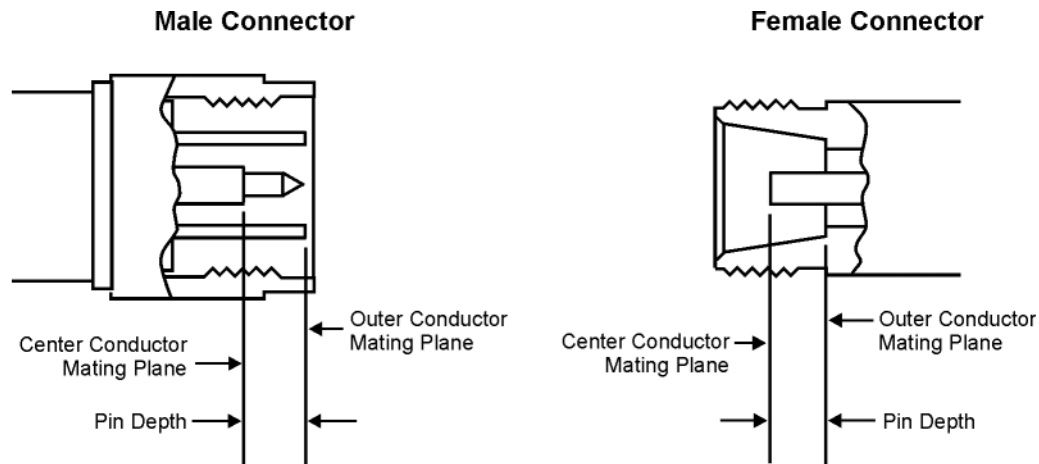


Type-N Characteristics

With Type-N connector, the shoulder position of the male contact pin (not the position of the tip) defines the position of the center conductor. The male contact pin slides into the female contact fingers; the inside surfaces of the tip of the female contact fingers on the sides of the male contact pin provide electrical contact.

Type-N connectors differ from most connector types in that the outer conductor mating plane is offset from the mating plane of the center conductor (see [Figure 5-4 on page 5-20](#)). The outer conductor in the male connector extends in front of the shoulder of the male contact pin. When you make a connection, this outer conductor fits into a recess in the female outer conductor behind the plane defined by the tip of the female contact fingers.

Figure 5-4 Pin Depth for Type-N Connectors



K131a

Critical Type-N Mechanical Characteristics

CAUTION

Never use a Type-N connector if the possibility of interference between the shoulder of the male contact pin and the tip of the female contact fingers exists.

Irreparable damage will occur if a male 50 Ω Type-N connector is mated to a female 75 Ω Type-N connector. If you use both 75 Ω and 50 Ω Type-N connectors, mark the 75 Ω connectors so that they are never accidentally mated with 50 Ω connectors. The diameter of the center conductor, male contact pin, and female contact hole are smaller on 75 Ω connectors.

- *Minimum protrusion* of the female center conductor in front of the outer conductor mating plane is 5.182 mm or 0.204 inches.
- *Maximum protrusion* of the female center conductor in front of the outer conductor mating plane is 5.258 mm or 0.207 inches.
- *Minimum recession* of the shoulder of the male contact pin behind the outer conductor mating plane is 5.258 mm or 0.207 inches.
- *Maximum recession* of the shoulder of the male contact pin behind the outer conductor mating plane is 5.334 mm or 0.210 inches.

In the Keysight precision specification for Type-N connectors, the minimum allowable recession for the male contact pin shoulder is 0.001 inches less than in the MIL-C-39012, Class II specification. Keysight Technologies Type-N pin depth gages set “zero” on the gage to be equal to a nominal 5.258 mm (0.207 inches) offset.

As Type-N connectors wear, the protrusion of the female contact-fingers generally increases. This is due to the wear of the outer conductor mating plane inside the female connector. It is necessary to check this periodically as it decreases the total center conductor contact separation.

Typical Pin Depth Values

The pin depth value of each device is not specified, but is an important mechanical parameter. The electrical performance of the device depends, to some extent, on its pin depth. The electrical specifications for each module takes into account the effect of pin depth on the device's performance. The following tables list the typical pin depths and measurement uncertainties, and provides observed pin depth limits for the devices. If the pin depth of a device does not measure within the observed pin depth limits, it may be an indication that the device fails to meet electrical specification. Refer to [Figure 5-1](#) and [Figure 5-4](#) for a visual representation of proper pin depth (slightly recessed).

Table 5-31 Type-N 50 Ω Connector Pin Depth Characteristics

Device	Typical Pin Depth ^{a,b} in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^c in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
Type-N 50 Ω ECal Module (N755xA)	-0.0508 to -0.3810 (-20.0 to -150.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	-0.0470 to -0.3848 (-18.5 to -21.5)
Type-N 50 Ω ECal Module (N4431D, N4432D)	-0.0254 to -0.0508 (-10.0 to -20.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	-0.0216 to -0.0546 (-8.5 to -21.5)
Type-N 50 Ω ECal Module (N4690D)	-0.0051 to -0.0152 (-2.0 to -6.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	-0.0013 to -0.0190 (-0.5 to -7.5)
Type-N 50 Ω Adapter	0 to -0.0127 (0 to -5.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	+0.0038 to -0.0165 (+1.5 to -6.5)

- a. Measured from a 5.258 mm (0.207 inches) nominal offset.
- b. For N755xA ECals, the Type-N connector is not a precision contact per IEEE precision connector standards.
- c. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Specifications and Characteristics
Typical Pin Depth Values

Table 5-32 4.3-10 Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
4.3-10 mm ECal Module (N4431D)	-0.0000 to -0.1000 (0.0 to -39.0)	+0.0041 to -0.0041 (+1.6 to -1.6)	+0.0041 to -0.1041 (+1.6 to -40.6)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Table 5-33 3.5 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth ^a in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^b in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
3.5 mm ECal Module (N755xA)	-0.0000 to -0.1270 (-0.0 to -50.0)	+0.0041 to -0.0041 (+1.6 to -1.6)	+0.0041 to -0.1311 (+1.6 to -51.6)
3.5 mm ECal Module (N4431D, N4433D)	-0.0254 to -0.0508 (-10.0 to -20.0)	+0.0041 to -0.0041 (+1.6 to -1.6)	-0.0213 to -0.0549 (-8.4 to -21.6)
3.5 mm ECal Module (N4691D)	-0.0025 to -0.0152 (-1.0 to -6.0)	+0.0041 to -0.0041 (+1.6 to -1.6)	+0.0016 to -0.0193 (+0.6 to -7.6)
3.5 mm Adapter	0 to -0.0254 (0 to -10)	+0.0041 to -0.0041 (+1.6 to -1.6)	+0.0041 to -0.0295 (+1.6 to -11.6)

a. On N755xA ECals, the 3.5 mm connector is not a precision contact per IEEE precision connector standards.
b. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Table 5-34 2.92 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
2.92 mm ECal Module (N4692D)	-0.0025 to -0.0152 (-1.0 to -6.0)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0005 to -0.0182 (+0.2 to -7.2)
2.92 mm Adapter	0 to -0.0381 (0 to -15)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0030 to -0.0411 (+1.2 to -16.2)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Specifications and Characteristics
Typical Pin Depth Values

Table 5-35 2.4 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
2.4 mm ECal Module (N4693D)	-0.0025 to -0.0152 (-1.0 to -6.0)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0005 to -0.0182 (+0.2 to -7.2)
2.4 mm Adapter	0 to -0.0381 (0 to -15)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0030 to -0.0411 (+1.2 to -16.2)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Table 5-36 1.85 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
1.85 mm ECal Module (N4694D)	-0.0025 to -0.0152 (-1.0 to -6.0)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0005 to -0.0182 (+0.2 to -7.2)
1.85 mm Adapter	0 to -0.0381 (0 to -15)	+0.0030 to -0.0030 (+1.2 to -1.2)	+0.0030 to -0.0411 (+1.2 to -16.2)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Table 5-37 7 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
7 mm ECal Module (N4696D)	-0.0025 to -0.0152 (-1.0 to -6.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	+0.0013 to -0.0190 (+0.5 to -7.5)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Specifications and Characteristics
 Typical Pin Depth Values

Table 5-38 7-16 Connector Pin Depth Characteristics

Device	Typical Pin Depth in Millimeters (10 ⁻⁴ inches)	Measurement Uncertainty ^a in Millimeters (10 ⁻⁴ inches)	Observed Pin Depth Limits in Millimeters (10 ⁻⁴ inches)
7-16 ECal Module (N4431D)	-0.0000 to -0.0381 (0.0 to -15.0)	+0.0038 to -0.0038 (+1.5 to -1.5)	+0.0038 to -0.0419 (+0.5 to -16.5)

a. Approximately +2 sigma to -2 sigma of gage uncertainty based on studies performed at the factory using precision digital gages according to recommended procedures.

Supplemental Mechanical Characteristics

Table 5-39 N755xA Series Mechanical Characteristics

Characteristic	Limits
Net weight with case	
Standard	0.8 kilograms (1.8 lbs)
Shipping weight	
Standard	1.6 kilograms (3.5 lbs)
Shipping dimensions	
Length	45.0 cm (17.7inches)
Width	28.0 cm (11.0 inches)
Height	15.0 cm (5.9 inches)

Table 5-40 N469xD Series Mechanical Characteristics

Characteristic	Limits
Net weight with case	
Standard	2.4 kilograms (5.3 lbs)
Shipping weight	
Standard	3.6 kilograms (7.9 lbs)
Shipping dimensions	
Length	53.0 cm (20.87 inches)
Width	38.0 cm (14.96 inches)
Height	20.0 cm (7.87 inches)

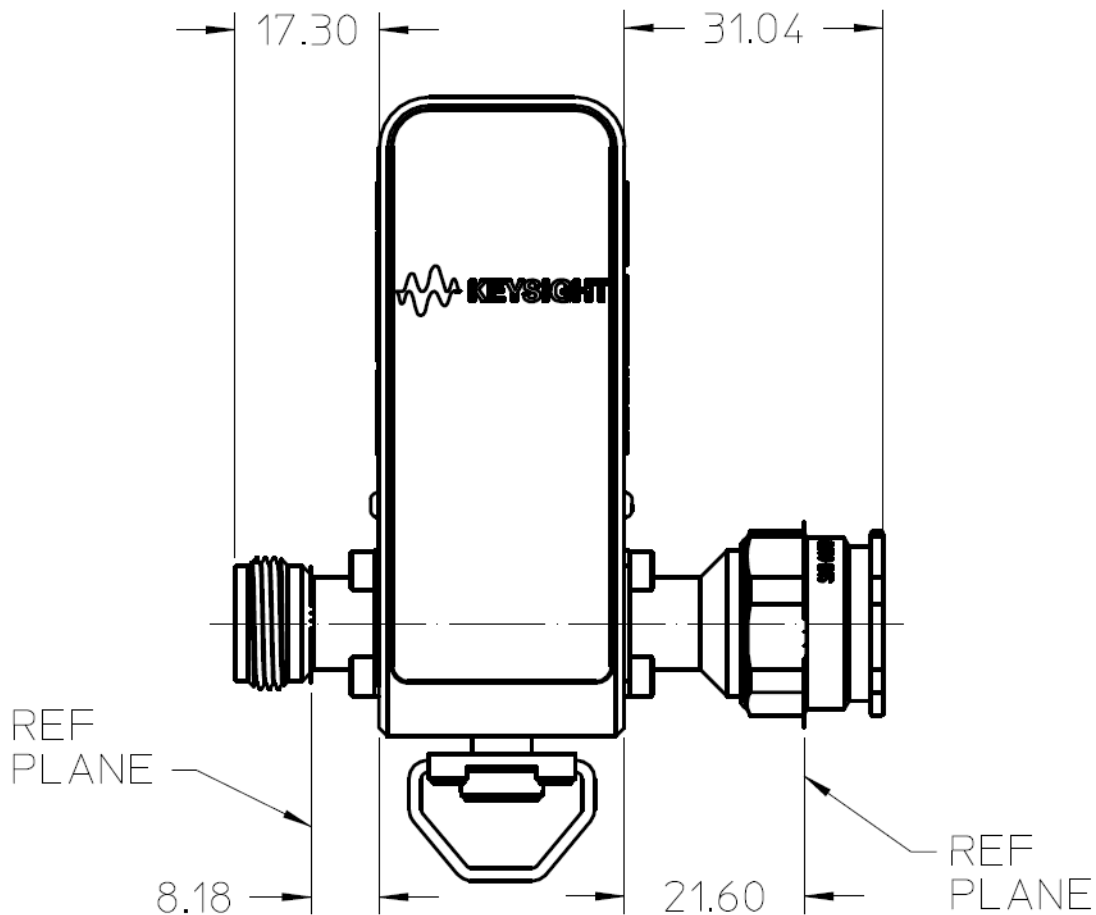
Table 5-41 N443xD Series Mechanical Characteristics

Characteristic	Limits
Net weight with case	
Standard	3.2 kilograms (7.1 lbs)
Shipping weight	
Standard	4.4 kilograms (9.7 lbs)
Shipping dimensions	
Length	53 cm (20.87 inches)
Width	38 cm (14.96 inches)
Height	20 cm (7.87 inches)

Mechanical Dimensions of the Modules

N755xA Mechanical Dimensions (mm)

Figure 5-5 N755xA Modules (2-Port) - Type N Male/Female



TYPE N MALE/FEMALE

Figure 5-6 N7555A Modules (2-Port) – 3.5 mm Male/Female

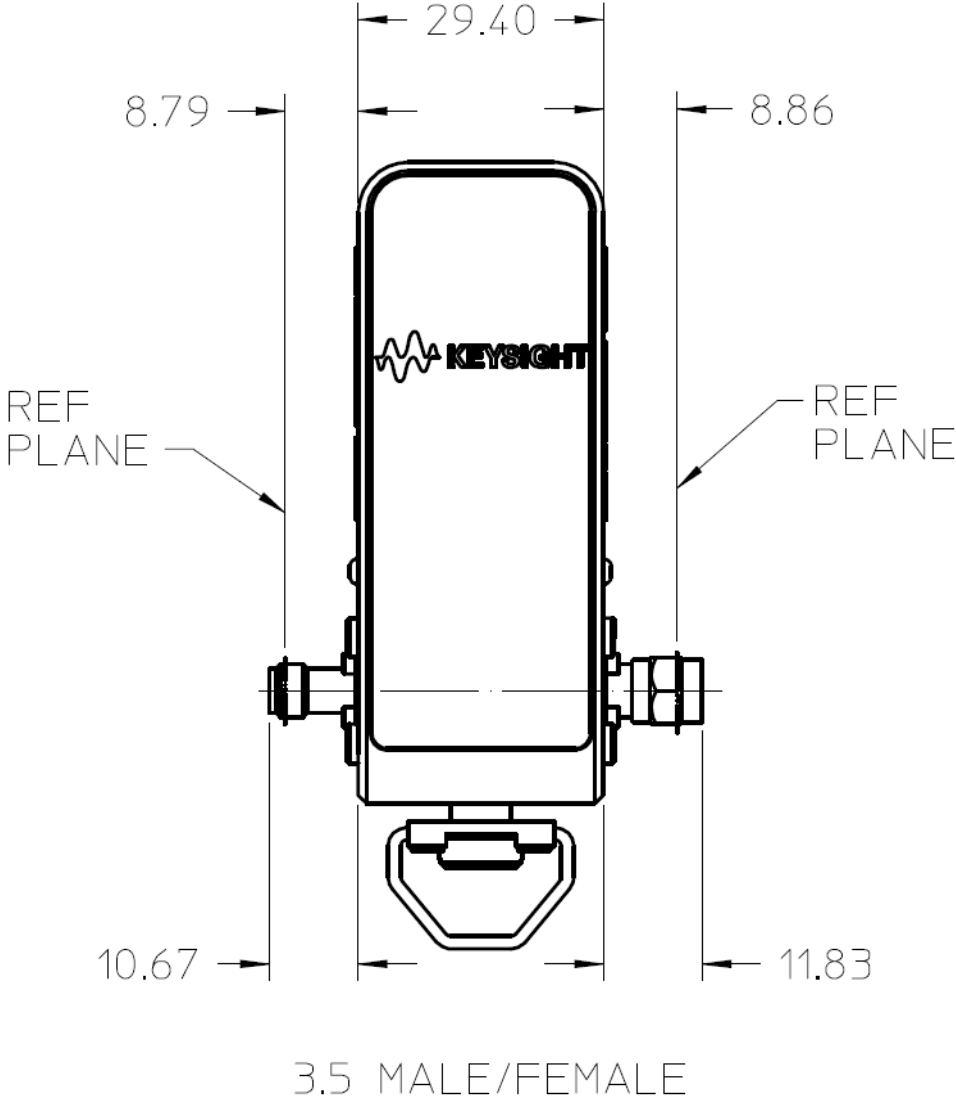
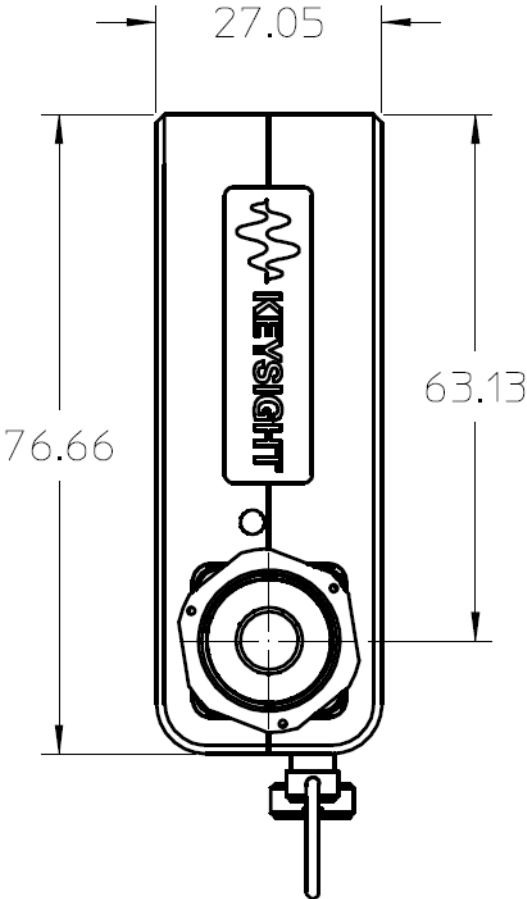
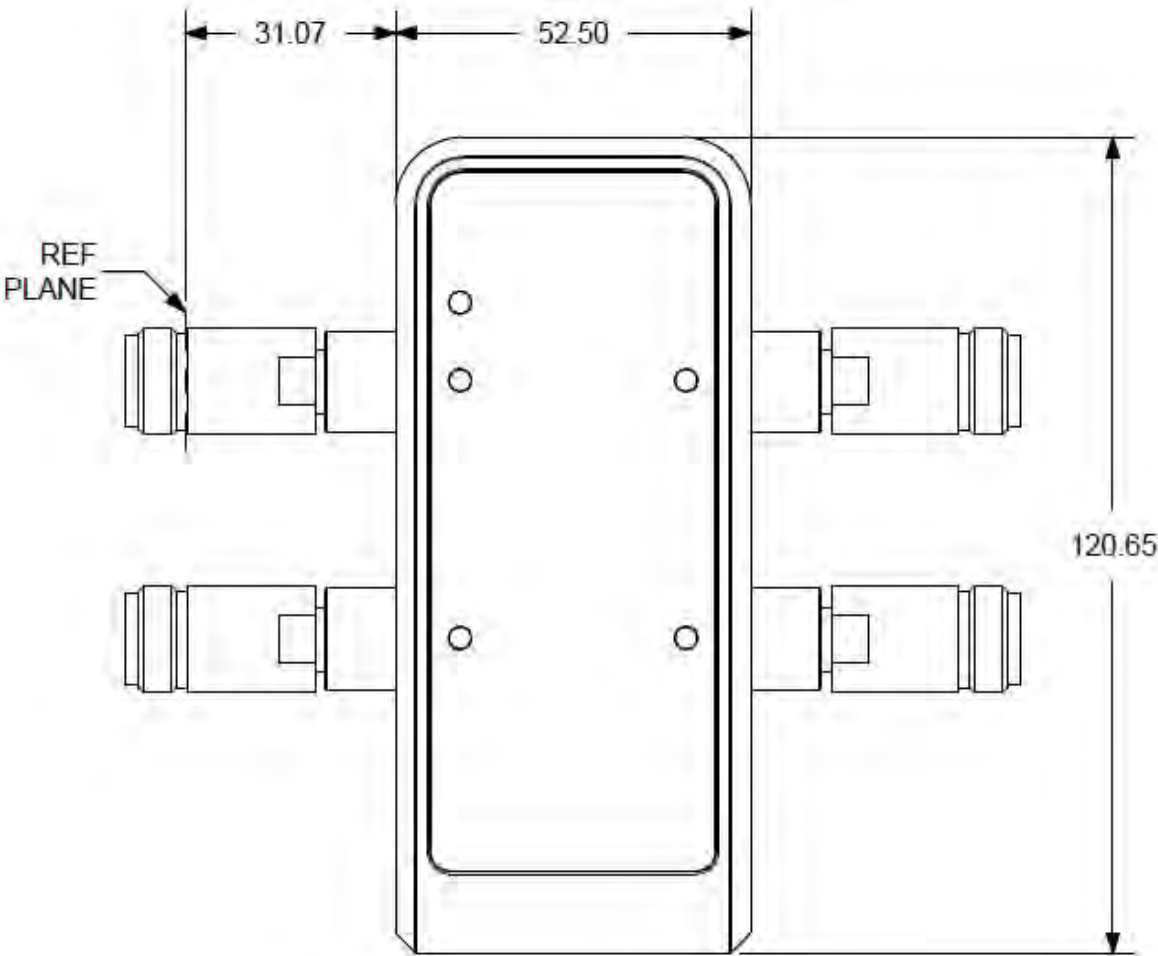


Figure 5-7 N755xA Modules (2-Port) – Side View



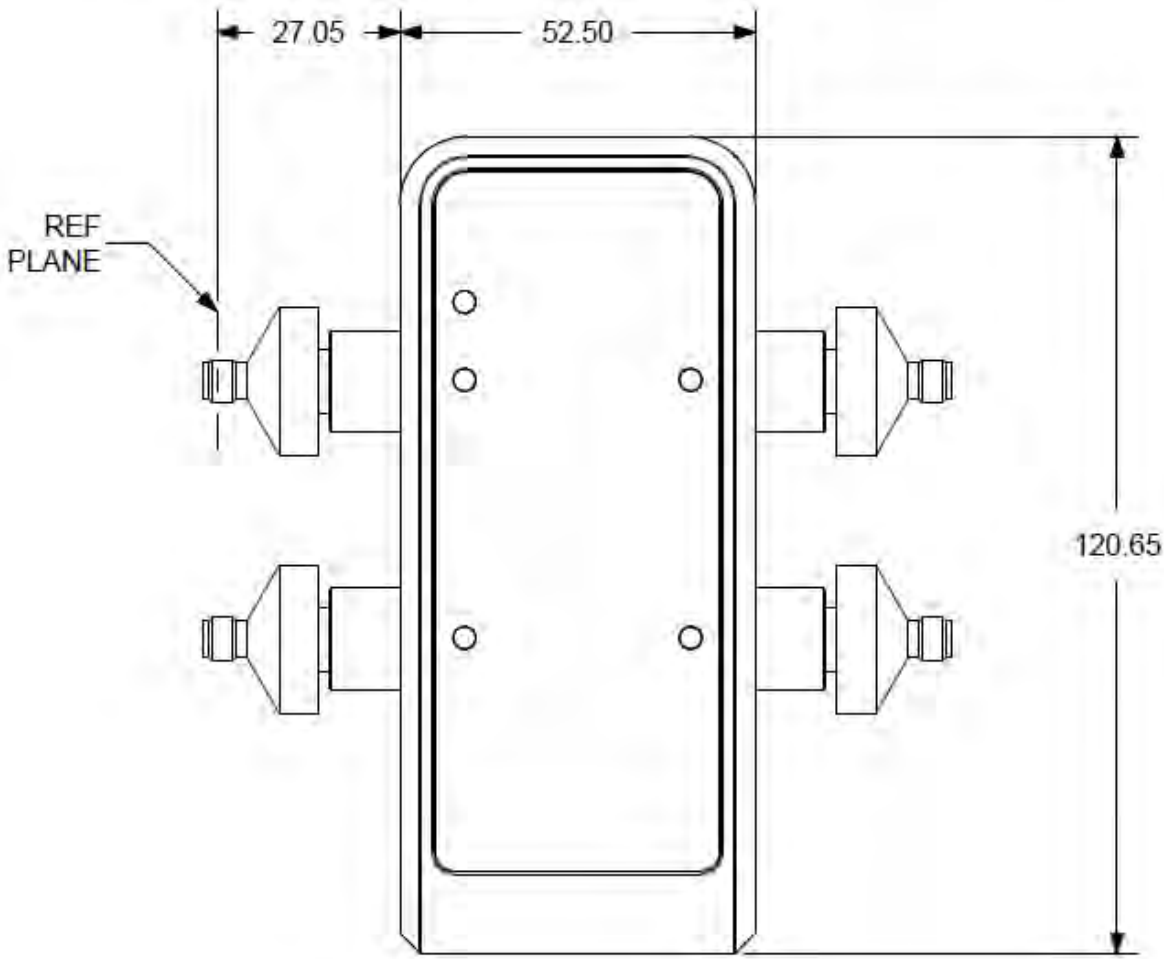
N443xD Mechanical Dimensions (mm)

Figure 5-8 N4431/3D Modules (2-Port) – Type-N Female



Type-N Female/Female

Figure 5-9 N443xD Modules (4-Port) - 3.5 mm Female



3.5 mm Female/Female

Figure 5-10 N443xD Modules (4-Port) – Type-N Side View

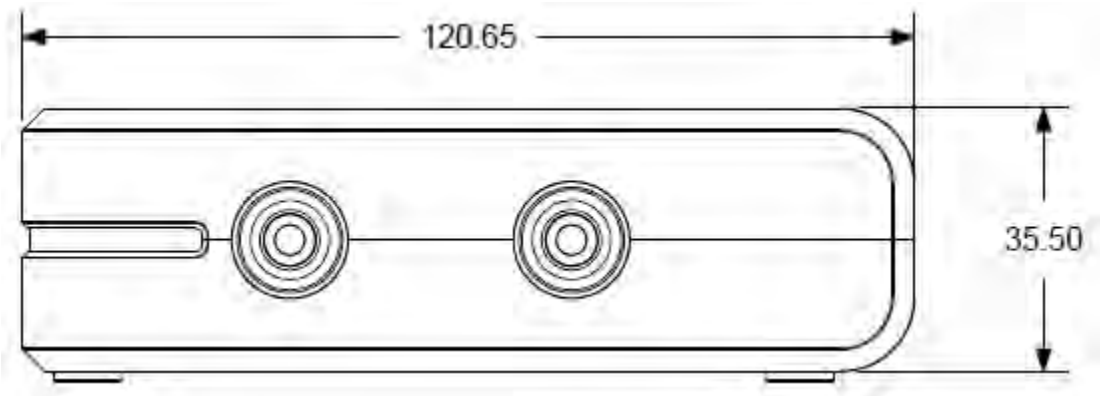


Figure 5-11 N443xD Modules (4-Port) – Type-N Bottom View

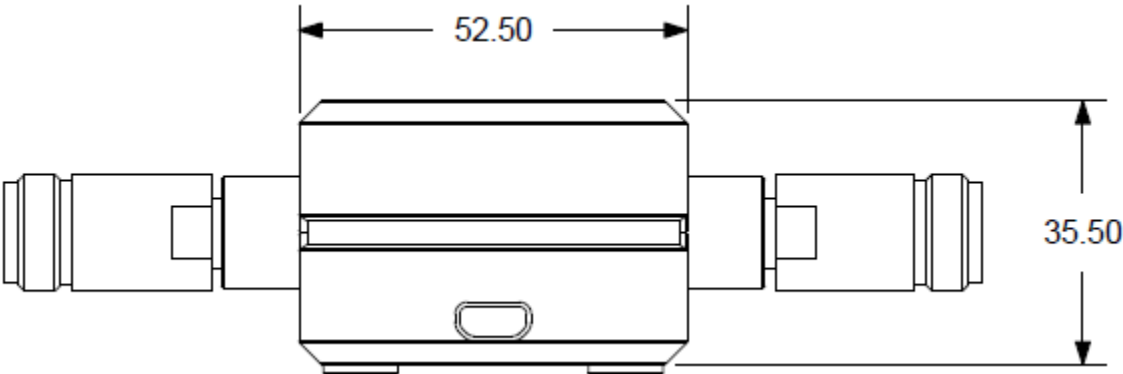


Figure 5-12 N443xD Modules (4-Port) – 3.5 mm Side View

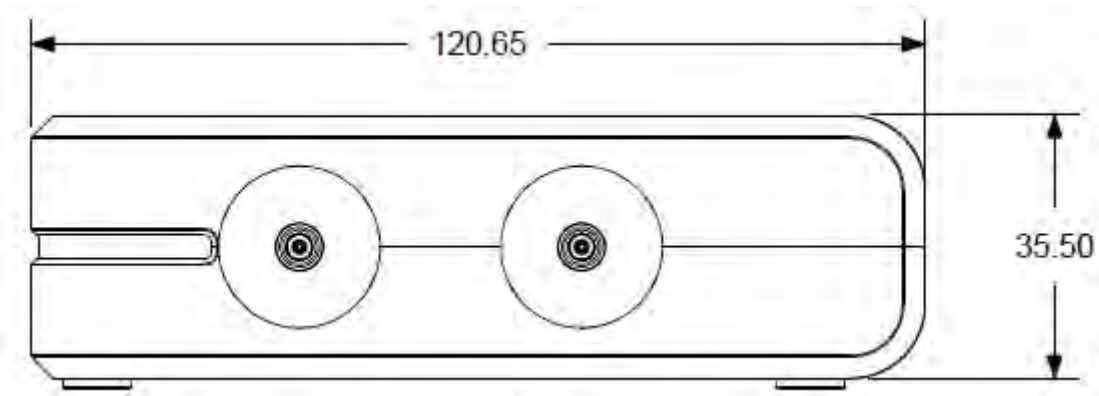
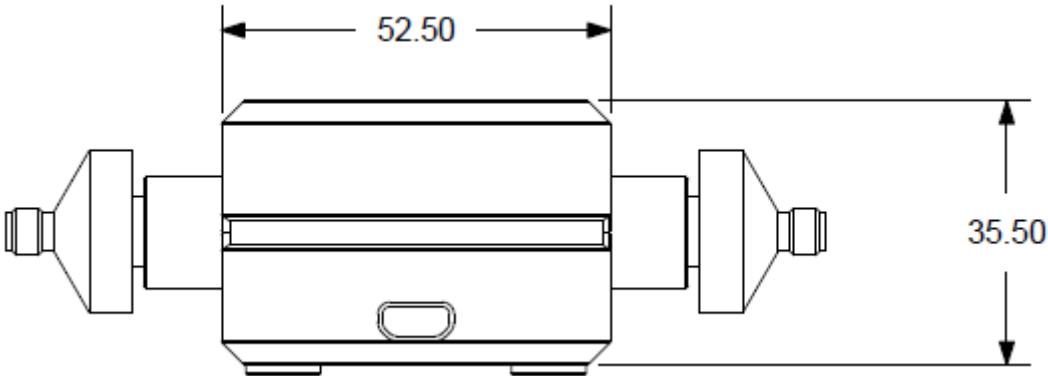


Figure 5-13 N443xD Modules (4-Port) – 3.5 mm Bottom View



N4690D Mechanical Dimensions (mm)

Figure 5-14 N4690D Modules (2-Port) - Type N Male/Female

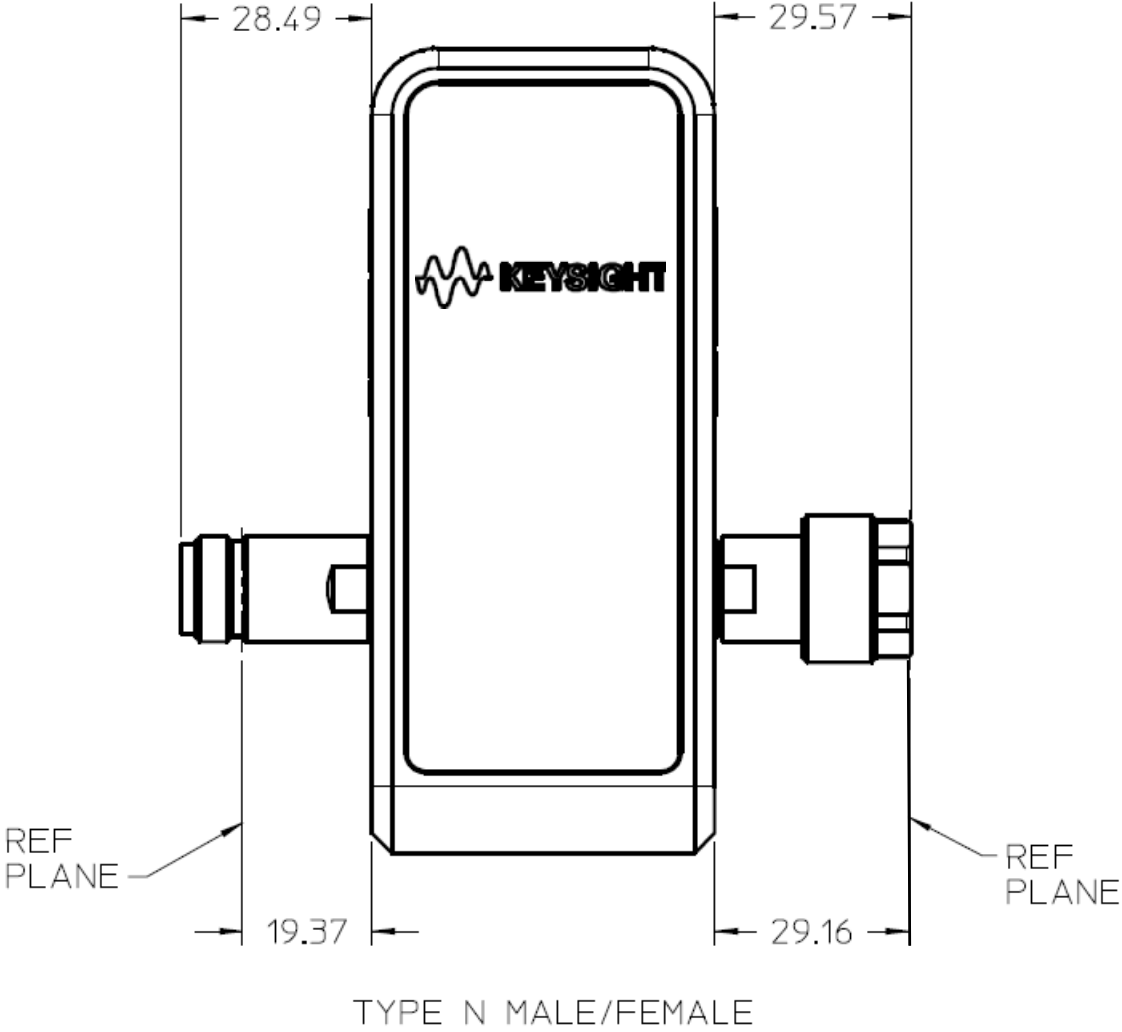


Figure 5-15

N4691D Modules (2-Port) – 3.5 mm Male/Female

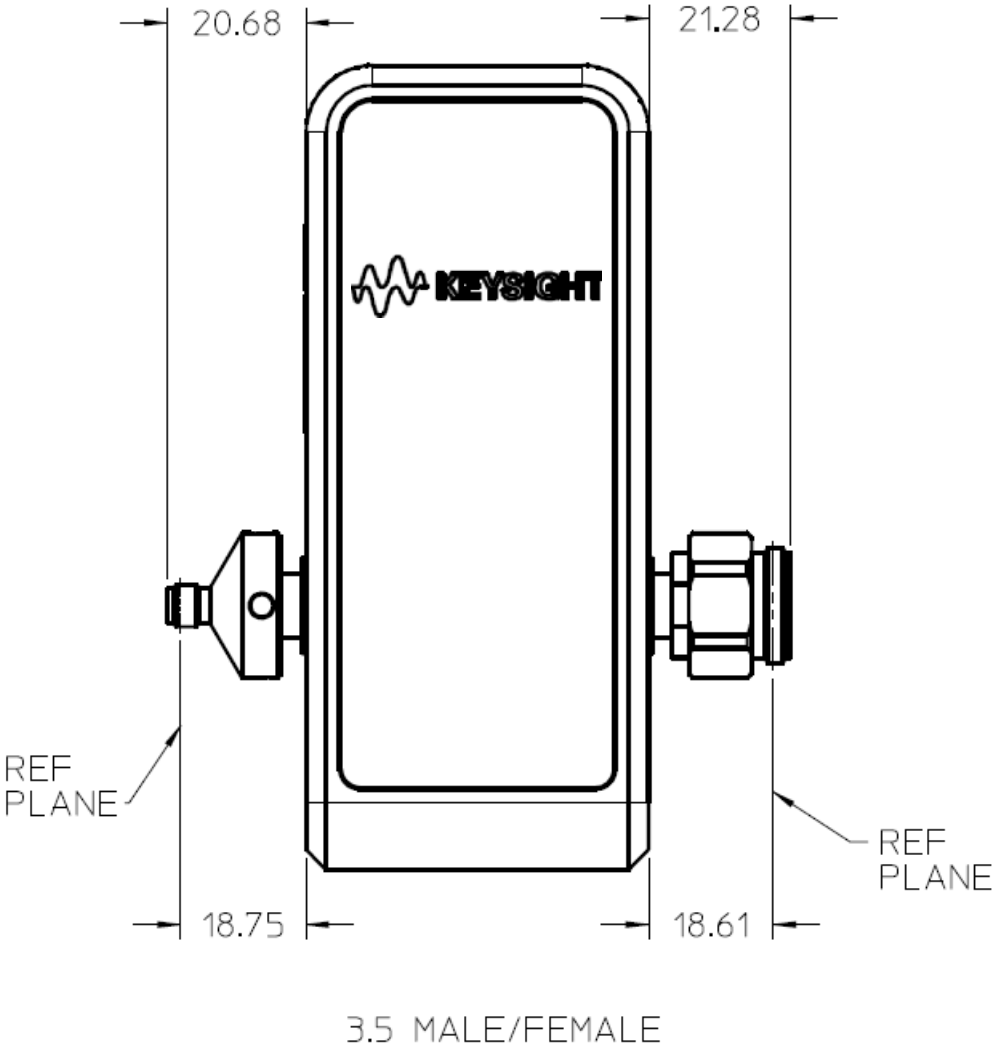


Figure 5-16 N4692D Modules (2-Port) – 2.92 mm Male/Female

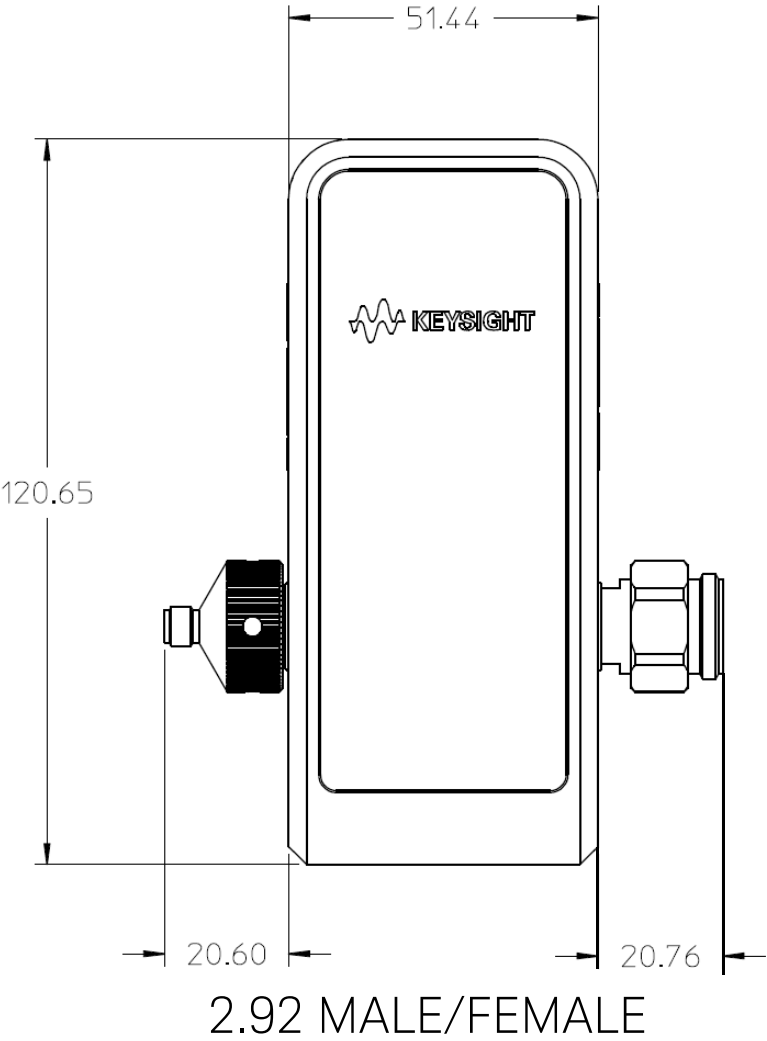


Figure 5-17

N4693D Modules (2-Port) – 2.4 mm Male/Female

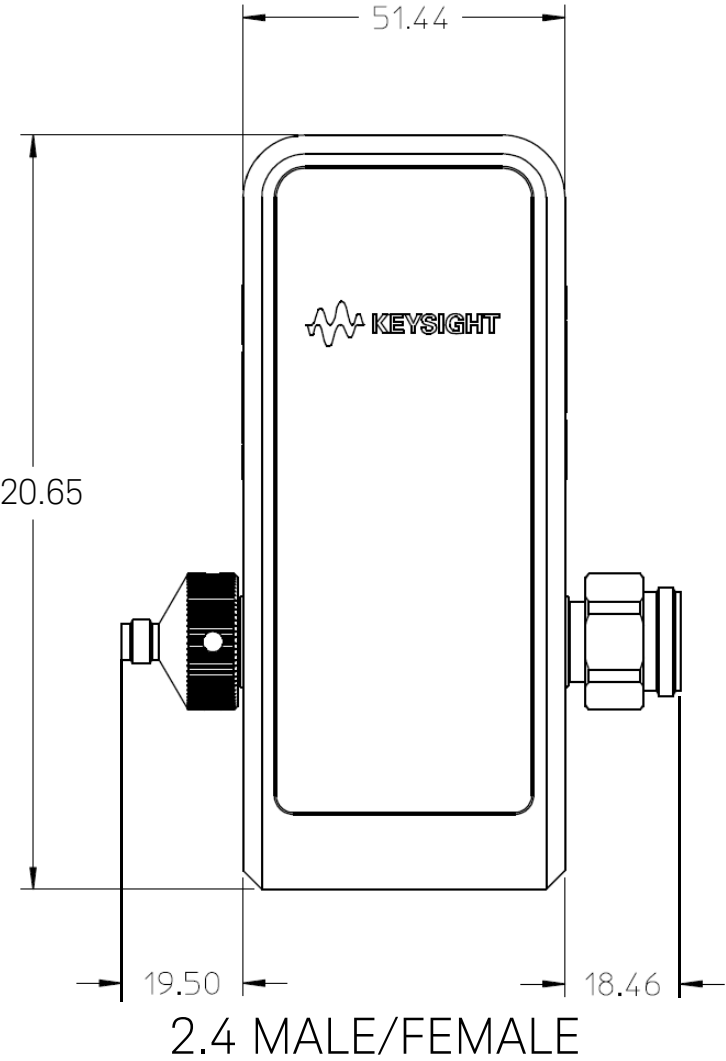
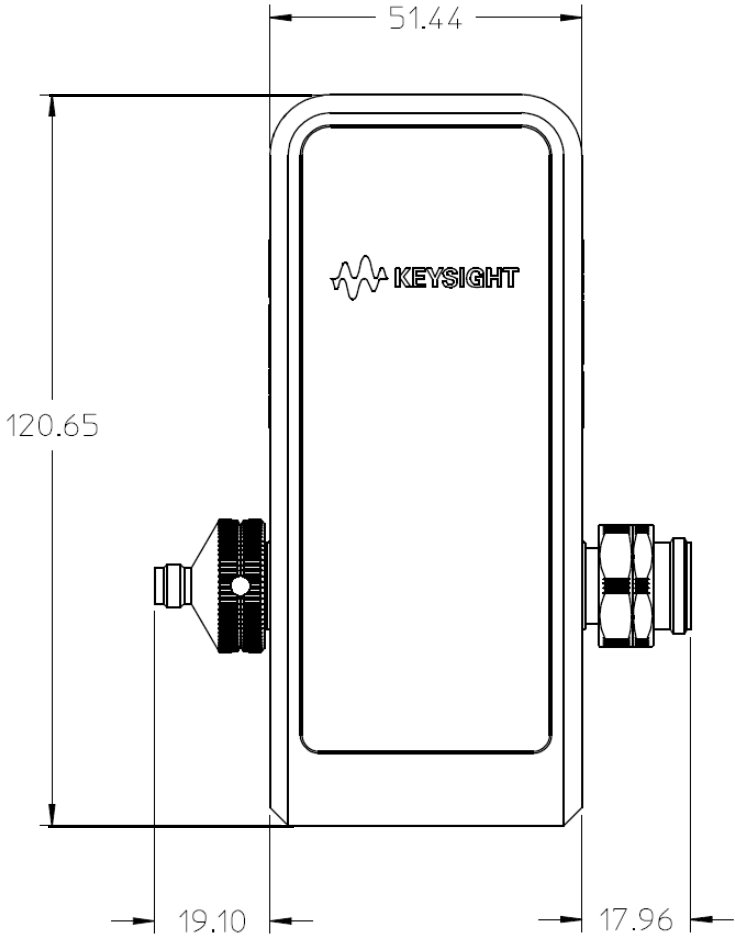


Figure 5-18

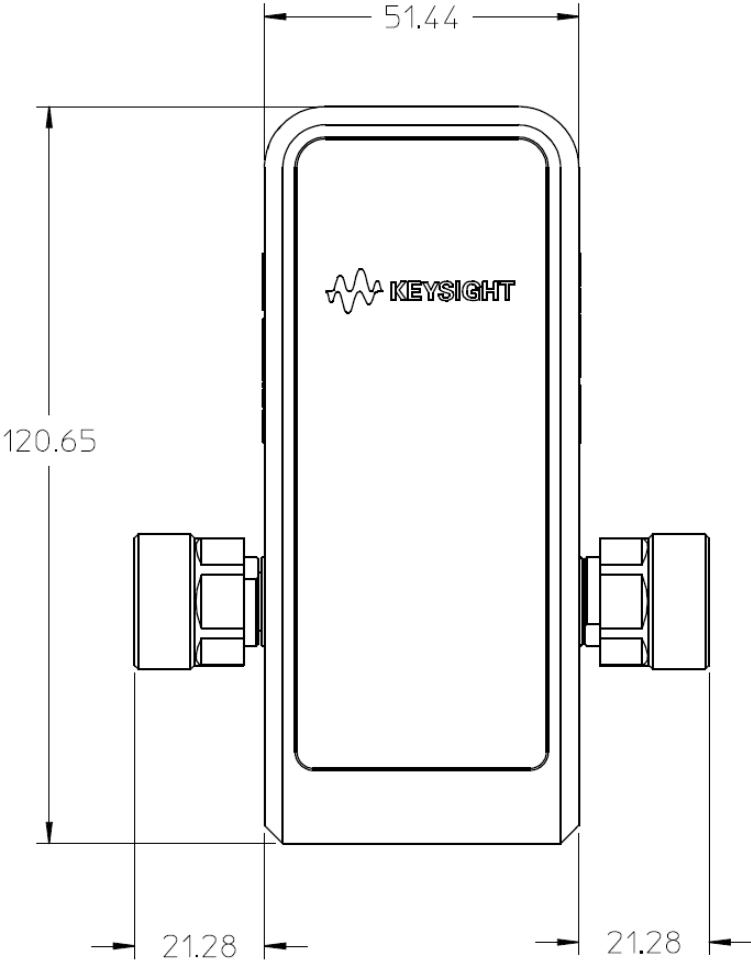
N4694D Modules (2-Port) – 1.85 mm Male/Female



1.85 MALE/FEMALE

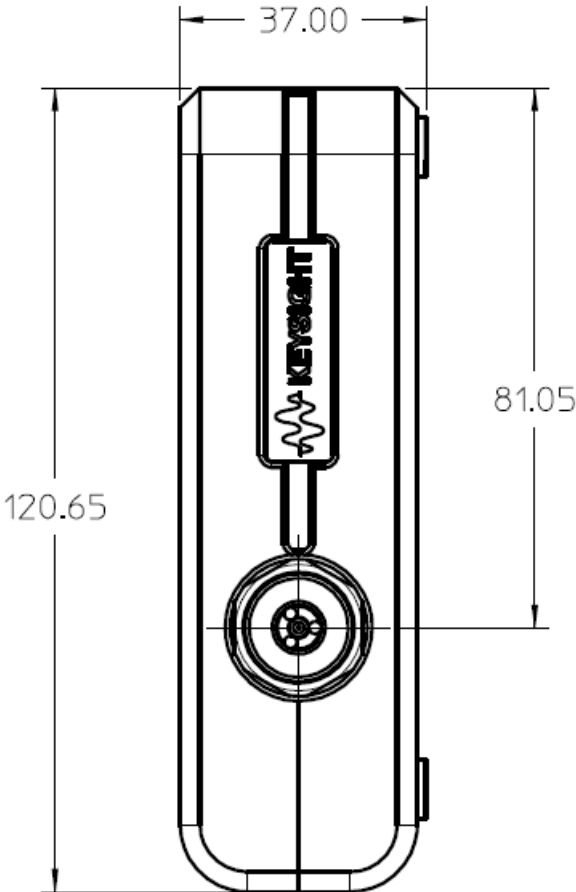
Figure 5-19

N4696D Modules (2-Port) – 7 mm sexless Male/sexless Female



7 SEXLESS MALE/ SEXLESS FEMALE

Figure 5-20 N469xD Modules (2-Port) – Side View



Measurement Uncertainty Calculator

This section provides information about determining the uncertainty of the measurements on your network analyzer.

Download the Vector Network Analyzer Uncertainty Calculator

You can download a program from Keysight that provides the measurement uncertainty associated with your vector network analyzer measurement and ECal module. Go to www.keysight.com/find/na_calculator and follow the instructions on the Web site to download the program.

The program uses your Keysight network analyzer model number, your ECal module model number, and electrical limits to calculate specific uncertainty charts for your network analyzer. The program is Microsoft Windows based and uses a Microsoft Excel spreadsheet to calculate, graph, and display uncertainty curves.

6 Replaceable Parts

Description of This Chapter

NOTE

N7550A/1/2/3/4/5/6A must be returned to factory for service.

N7550A/1/2A are value line products and can be re-certified and serviced. But, because the ECal modules are intricately constructed and because of the resulting cost of re-certification or minor repairs, the re-certification and repairs can cost more than a new device.

Keysight provides a Utility that can be used to verify that your ECal module is performing as expected. Refer to [“ECal Confidence Check – Basic Validation of the Calibration” on page 3-11](#).

The following tables contain the replaceable part numbers for ECal options and accessories. Refer to [“Inspecting the ECal Kit” on page 2-1](#) for the contents of each kit. To order a part, note the description, Keysight part number, and the quantity desired. Telephone or send your order to Keysight Technologies. See [“Contacting Keysight” on page 1-23](#).

Type-N (50 ohm) Modules and Accessories

Table 6-1 Type-N Modules and Accessories

Description ^a	Qty	Part Number
Adapters (added with Option 00A – N469xD only)		
Type-N (50 Ω) -f- to -f- adapter	1	85054-60037
Type-N (50 Ω) -m- to -m- adapter	1	85054-60038
Protective End Caps		
Type-N f-f connector cap (for module) ^b	1	N7550-40004
Type-N m-m connector cap (for module) ^b	1	N7550-40006
Type-N f-m connector cap (for module) ^b	1	N7550-40005
Type N -f-connector cap (for adapter) ^c	1	1401-0225
Type N -m-connector cap (for adapter) ^c	1	1401-0214
Gages^b		
Type-N pin depth gages (-m- and -f- gages and masters)	1 set	85054-60049
Other		
Electronic calibration module reference manual (online)	1	N7550-90002
USB cable A to B 2 meter	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^c	1	8710-1770
3/4 in, 135 N-cm (12 in-lb) torque wrench ^c	1	8710-1766
Ruggedized plastic storage box for the ECal module and accessories (Option 150) ^b	1	N7550-60009 – Refer to Table 4-2, “N755xA Option 150 Storage Box Part Numbers”, on page 4-23.
Replacement ruggedized plastic storage box for the ECal module and accessories ^d	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**

b. Available on the N755xA ECals only.

c. These items are not included, but can be ordered separately.

d. This item is included, but a replacement can be ordered separately.

1.85 mm Modules and Accessories

Table 6-2 1.85 mm Modules and Accessories

Description ^a	Qty	Part Number
Adapters (added with Option 00A - N469xD only)		
1.85 mm -f- to -f- adapter	1	85058-60114
1.85 mm -m- to -m- adapter	1	85058-60113
Protective End Caps		
1.85 mm -f- connector cap (for adapter) ^b	as required	1401-0202
1.85 mm -m- connector cap (for adapter) ^b	as required	1401-0208
Gages^b		
2.4 mm -f- pin-depth gage ^c	1	11752-60607
2.4 mm -m- pin-depth gage	1	11752-60108
Other		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^b	1	8710-1770
20 mm, 90 N-cm (8 in-lb) torque wrench ^b	1	8710-1764
5/16 in, 90 N-cm (8 in-lb) torque wrench ^b	1	8710-1765
Spanner wrench ^b	1	08513-20014
Replacement ruggedized plastic storage box for the ECal module and accessories ^d	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

- a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**
b. These items are not included, but can be ordered separately.
c. A 2.4 mm gage is capable of measuring 2.4 mm and 1.85 mm connectors.
d. This item is included, but a replacement can be ordered separately.

2.4 mm Modules and Accessories

Table 6-3 2.4 mm Modules and Accessories

Description ^a	Qty	Part Number
Adapters (added with Option 00A - N469xD only)		
2.4 mm -f- to -f- adapter	1	85052-60012
2.4 mm -m- to -m- adapter	1	85052-60014
Protective End Caps		
2.4 mm -f-f connector cap (for module) ^b	1	N7550-40001
2.4 mm -m-m connector cap (for module) ^b	1	N7550-40003
2.4 mm -m-f connector cap (for module) ^b	1	N7550-40002
2.4 mm -f- connector cap (for adapter) ^c	as required	1401-0202
2.4 mm -m- connector cap (for adapter) ^c	as required	1401-0208
Gages^c		
2.4 mm -f- pin-depth gage	1	11752-60107
2.4 mm -m- pin-depth gage	1	11752-60108
Other		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^c	1	8710-1770
20 mm, 90 N-cm (8 in-lb) torque wrench ^c	1	8710-1764
5/16 in, 90 N-cm (8 in-lb) torque wrench ^c	1	8710-1765
Spanner wrench ^c	1	08513-20014
Ruggedized plastic storage box for the ECal module and accessories (Option 150) ^c	1	N7550-60009 – Refer to Table 1-1, “N755xA Modules”, on page 1-6.
Replacement ruggedized plastic storage box for the ECal module and accessories ^d	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**

b. Available on the N755xA ECals only.

c. These items are not included, but can be ordered separately.

d. This item is included, but a replacement can be ordered separately.

2.92 mm Modules and Accessories

Table 6-4 2.92 mm Modules and Accessories

Description ^a	Qty	Part Number
Adapters (added with Option 00A – N469xD only)		
2.92 mm female to female adapter	1	N4692-60022
2.92 mm male to male adapter	1	N4692-60021
Protective End Caps		
2.92 mm -f -f connector cap (for module) ^b	1	N7550-40001
2.92 mm -m -m connector cap (for module) ^b	1	N7550-40003
2.92 mm -m -f connector cap (for module) ^b	1	N7550-40002
2.92 mm female connector cap (for adapter) ^d	as required	1401-0202
2.92 mm male connector cap (for adapter) ^d	as required	1401-0208
Gages^d		
2.92 mm female pin-depth gage ^c	1	11752-60105
2.92 mm male pin-depth gage ^c	1	11752-60106
Other		
Electronic calibration module reference manual (online)	1	N7550-90002
USB cable, 2 meters	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^d	1	8710-1770
20 mm, 90 N-cm (8 in-lb) torque wrench ^d	1	8710-1764
5/16 in, 90 N-cm (8 in-lb) torque wrench ^d	1	8710-1765
Spanner wrench ^d	1	08513-20014
Ruggedized plastic storage box for the ECal module and accessories (Option 150) ^d	1	N7550-60009 – Refer to Table 1-1, “N755xA Modules”, on page 1-6.
Replacement ruggedized plastic storage box for the ECal module and accessories ^e	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

- a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**
b. Available on the N755xA ECals only.
c. A 3.5 mm gage is capable of measuring 3.5 mm and 2.92 mm connectors.
d. These items are not included, but can be ordered separately.
e. This item is included, but a replacement can be ordered separately.

3.5 mm Modules and Accessories

Table 6-5 3.5 mm Modules and Accessories

Description ^a	Qty	Part Number
Adapters (added with Option 00A – N469xD only)		
3.5 mm -f- to -f- adapter	1	85052-60012
3.5 mm -m- to -m- adapter	1	85052-60014
Protective End Caps		
3.5 mm -f-f connector cap (for module) ^b	1	N7550-40001
3.5 mm -m-m connector cap (for module) ^b	1	N7550-40003
3.5 mm -m-f connector cap (for module) ^b	1	N7550-40002
3.5 mm -f- connector cap (for adapter) ^c	as required	1401-0202
3.5 mm -m- connector cap (for adapter) ^c	as required	1401-0208
Gages^c		
3.5 mm -f- pin-depth gage ^d	1	11752-60105
3.5 mm -m- pin-depth gage ^d	1	11752-60106
Other		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^c	1	8710-1770
20 mm, 90 N-cm (8 in-lb) torque wrench ^c	1	8710-1764
5/16 in, 90 N-cm (8 in-lb) torque wrench ^c	1	8710-1765
Spanner wrench ^c	1	08513-20014
Ruggedized plastic storage box for the ECal module and accessories (Option 150) ^c	1	N7550-60009 – Refer to Table 1-1, “N755xA Modules”, on page 1-6.
Replacement ruggedized plastic storage box for the ECal module and accessories ^e	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**

b. Available on the N755xA ECal's only.

c. These items are not included, but can be ordered separately.

d. A 3.5 mm gage is capable of measuring 3.5 mm and 2.92 mm connectors.

e. This item is included, but a replacement can be ordered separately.

4.3-10 Modules and Accessories

Table 6-6 4.3-10 Modules and Accessories

Description ^a	Qty	Part Number
Miscellaneous		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
Wrench-Torque 22 mm, 12 in-lb	1	8710-2811
Replacement ruggedized plastic storage box for the ECal module and accessories ^b	1	1540-2355 – Refer to Table 1-2, “N4431D Modules (All connectors are female)” , on page 1-9.

- a. See **“Clarifying the Terminology of a Connector Interface”** on page 1-1.
b. This item is included, but a replacement can be ordered separately.

7 mm Modules and Accessories

Table 6-7 7 mm Modules and Accessories

Description ^a	Qty	Part Number
Protective End Caps		
7 mm connector cap	1	1401-0249
Gages^c		
7 mm pin-depth gage	1	85050-80012
Other		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
1/2 in to 9/16 in open-ended wrench ^c	1	8710-1770
3/4 in, 135 N-cm (12 in-lb) torque wrench ^c	1	8710-1766
Replacement ruggedized plastic storage box for the ECal module and accessories ^b	1	1540-2345 – Refer to Table 1-4, “N469xD Modules”, on page 1-13.

a. See **“Clarifying the Terminology of a Connector Interface” on page 1-1.**

b. This item is included, but a replacement can be ordered separately.

7-16 Modules and Accessories

Table 6-8 7-16 Modules and Accessories

Description ^a	Qty	Part Number
Miscellaneous		
Electronic calibration module reference guide (online)	1	N7550-90002
USB cable A to B, 2 meter	1	8121-2671
Tool-hand and miscellaneous hard chrome-finish	1	8710-2174
Torque-Wrench 2.26 N-m 1-1/16 in hard-chrome finish	1	8710-2175
Replacement ruggedized plastic storage box for the ECal module and accessories ^b	1	1540-2355 – Refer to Table 1-2, “N4431D Modules (All connectors are female)” , on page 1-9.

- a. See **“Clarifying the Terminology of a Connector Interface”** on page 1-1.
b. This item is included, but a replacement can be ordered separately.

Other ECal Accessories

Table 6-9

Description	Qty	Part Number
Cleaning Supplies		
Compressed air (235 ml)	1	8500-6659
Anhydrous isopropyl alcohol (>92% pure) ^a	--	--
Cleaning swabs	100	9301-1243
Lint-free cleaning cloth	150	9310-4242
ESD Supplies		
Grounding wrist strap	1	9300-1367
5 ft Wrist-strap to table-mat grounding cord	1	9300-0980
2 x 4 ft conductive table mat with 15 ft ground wire	1	9300-0797
ESD heel strap	1	9300-1308
Module Accessories		
Rubber foot	1	85060-40001
For Type-N torque wrench accessories, refer to Table 6-1, "Type-N Modules and Accessories" , on page 6-2.		
For 3.5 mm torque wrench accessories, refer to Table 6-5, "3.5 mm Modules and Accessories" , on page 6-6.		
For 2.92 mm torque wrench accessories, refer to Table 6-5, "3.5 mm Modules and Accessories" , on page 6-6.		
Ruggedized plastic storage box for the ECal module and accessories (Option 150)	1	N7550-60009 Refer to Table 1-1, "N755xA Modules" , on page 1-6.
Replacement ruggedized plastic storage box for the ECal module and accessories ^c	1	1540-2345 – Refer to Table 1-4, "N469xD Modules" , on page 1-13.

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



This information is subject to change without notice.

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