Reference Guide

Agilent Technologies
Electronic Calibration Modules

RF Two-Port
85091C 85092C 85093C
85096C 85098C 85099C

RF Four-Port
N4431A

Microwave Two-Port
85060B 85062B 85064B

Agilent Part Number: 85091-90009
Printed in USA
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Notice

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Certification

Agilent Technologies certifies that this product met its published specification at the time of shipment from the factory. Agilent further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (NIST, formerly NBS), to the extent allowed by the institutes calibration facility, and to the calibration facilities of other International Standards Organization members.

Assistance

Product maintenance agreements and other customer assistance agreements are available for Agilent products.

For any assistance, contact Agilent. See “Contacting Agilent” on page 1-9.

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1 General Information

ECal Module Overview

Agilent Electronic Calibration (ECal) modules provide a precision, single-connection, one to four-port calibration technique for your network analyzer. ECal modules use 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 chapter provides the following information:

Inspecting ECal Module Kit

ECal modules are shipped with accessories in a foam-lined storage case. The case protects the items and provides a container to store them when not in use. Verify the case and its contents are not damaged and that all parts are included. For part number information, refer to Chapter 5, "Replaceable Parts."

If the case or any device appears damaged, or if the shipment is incomplete, contact Agilent. See "Contacting Agilent" on page 1-9. Agilent will arrange for repair or replacement of incomplete or damaged shipments without waiting for settlement from the transportation company. Refer to "Returning Devices to Agilent" on page 1-8 for shipping instructions.

NOTE Protect against electrostatic discharge (ESD) when handling and operating ECal modules. See "Preventing Electrostatic Discharge" on page 3-2.

Record the Device Serial Numbers

ECal modules are individually serialized. The following table allows you to record each serial number and the date of initial use. This information provides a reminder for annual recertification. See "Recertification" on page 4-3.

Table 1-1 ECal Module Serial Numbers

Model Number	Serial Number	Date

NOTE Microwave modules with serial numbers below 800 need to be retrofitted for operation with the 85097B VNA interface kit. The retrofitting must be done by a qualified Agilent Technologies service office. See "Contacting Agilent" on page 1-9.

Compatible Network Analyzers

ECal modules are designed to work with a variety of Agilent network analyzers. Table 1-2 lists the network analyzers compatible with each ECal module series. Not all ECal module and network analyzer combinations have the same features or capabilities. For complete information on equipment setups and the operation of ECal modules with your network analyzer, refer to your PNA/ENA on-line help or your VNA user's guide.

Table 1-2 Compatible Network Analyzers

Network Analyzers	ECal Modules			Interface Required
	8509x series[a]	N4431A series[b]	8506x series	
VNA[c]				
8719D/ES/ET	Yes	Yes	Yes	85097B
8720D/ES/ET	Yes	Yes	Yes	85097B
8722D/ES/ET	Yes	Yes	Yes	85097B
8753ES/ET	Yes	Yes	Yes	85097B
PNA				
E8356/7/8A	Yes	Yes	No	USB
E8801/2/3A	Yes	Yes	No	USB
N3381/2/3A	Yes	All ports[d]	No	USB
E8364A	Yes	Yes	No	USB
ENA				
E5070/1A	Yes	All ports	No	USB

a. PNA network analyzers are compatible with 8509xB and 8509xC only.
b. Available using ECal module Ports A and B unless specified otherwise.
c. Firmware revision 7.68 or higher required.
d. Available with PNA firmware upgrade Rev. 2.5 (released mid-2002).

NOTE For 8753 network analyzers, ECal modules may be used below 300 kHz. However, calibration accuracy is *not* specified. The display trace connecting the two points on either side of the 300 kHz boundary may misrepresent actual performance.

Before Connecting ECal Module

Use the following guidelines before connecting the ECal module to the network analyzer test ports.

Prerequisite Knowledge

Connector Care: This manual assumes you are trained in proper connector care. Connector care is critical for accurate calibrations and measurements. In addition, you will preserve the precision and extend the life of your connectors, saving both time and money.

Any damaged ECal module connector will invalidate the calibration achieved with that ECal module. Connector care includes inspecting, cleaning and gaging connectors on the ECal module as well as the device under test. For more detailed information about connector care, see "Preventive Maintenance" on page 3-3.

Protection from ESD Damage: Always use a grounded antistatic mat in front of your test equipment and wear a grounded wrist strap attached to it when handling or operating the ECal module or device under test. Also, avoid touching the center conductor of the ECal module test ports.

For more information about preventing ESD, see "Preventing Electrostatic Discharge" on page 3-2.

TIP Use the connector end caps (supplied with the ECal module) when the module is not being used.

Input Power Limits

Observe the input power levels to the ECal module as shown in Table 1-3.

Table 1-3 Input Power Characteristics for all ECal Modules

Input Power Limits	
Maximum Input Power	+20.0 dBm
Minimum Input Power[a]	–65.0 dBm

a. This is the typical power required at the port of the module used. The typical power is –45 dBm when used with a VNA series network analyzer.

Setting Up and Operating ECal Module

This section shows the basic setup for connecting the ECal module to the VNA, PNA and ENA network analyzers. The firmware for each analyzer provides the calibration functions and features available for the ECal module.

Warm-Up Time Before Use

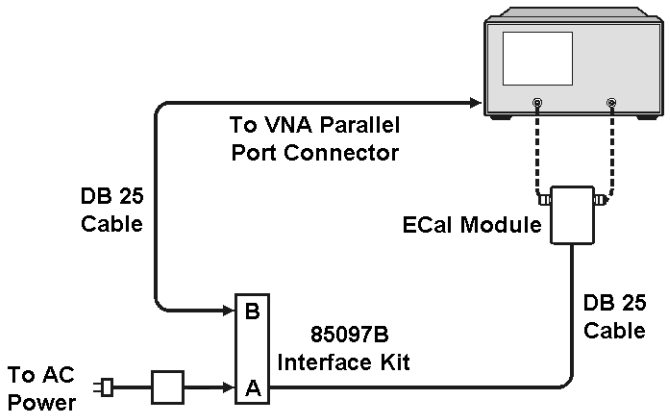
The average warm-up time is 10 minutes for a two-port ECal module and 20 minutes for a four-port module. A green indicator LED will light when it is OK to proceed with the calibration.

Connecting to VNA Network Analyzers

ECal modules connect to VNA series network analyzers using the 85097B VNA interface kit (see Figure 1-1). The interface kit functions as the digital interface and power source for the ECal module and can connect to one or two modules. The DB25 cables connect the interface unit to the parallel port on the rear panel of the VNA and to the parallel port connector on the ECal module.

The ECal module is ready for calibration after the recommended warm-up period.

Figure 1-1 Connecting ECal Module to VNA Network Analyzer



NOTE The 85097B VNA interface kit must be ordered separately. To order kit, see "Contacting Agilent" on page 1-9. For information on kit contents, see "85097B ECal VNA Interface Kit" on page 5-12.

For more information about the operation of the VNA Interface Kit, refer to the *VNA Interface Kit Reference Guide* (part number 85091-90010)

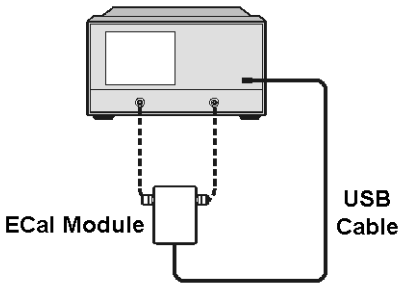
Connecting to PNA/ENA Network Analyzers

Ecal modules connect directly to the USB port, located on the front panel of the PNA or ENA network analyzer (see Figure 1-2). USB cables are provided with the ECal modules.

The USB cable supplies power and data from the analyzer. When the ECal module is plugged in, the analyzer automatically recognizes the type of module and makes it available as a standard for calibration.

The ECal module is ready for calibration after the recommended warm-up period.

Figure 1-2 Connecting ECal Module to PNA/ENA Network Analyzer



Returning Devices to Agilent

WARNING **No operator serviceable parts inside. Refer servicing to qualified personnel.**

If an ECal module requires service, contact Agilent for information on where to send it. See "Contacting Agilent" on page 1-9. When transporting the module, use original or comparable packaging. Please include the following information with your returned module.

- 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)

Contacting Agilent

Using the following table, contact Agilent by internet, telephone, or fax, to get assistance with your test and measurement needs.

Table 1-4 Contacting Agilent

Online assistance: `http://www.agilent.com/find/assist`

United States *(tel)* 1 800 452 4844	**Latin America** *(tel)* (305) 269 7500 *(fax)* (305) 269 7599	**Canada** *(tel)* 1 877 894 4414 *(fax)* (905) 282-6495	**Europe** *(tel)* (+31) 20 547 2323 *(fax)* (+31) 20 547 2390
New Zealand *(tel)* 0 800 738 378 *(fax)* (+64) 4 495 8950	**Japan** *(tel)* (+81) 426 56 7832 *(fax)* (+81) 426 56 7840	**Australia** *(tel)* 1 800 629 485 *(fax)* (+61) 3 9210 5947	**Singapore** *(tel)* 1 800 375 8100 *(fax)* (65) 836 0252
Malaysia *(tel)* 1 800 828 848 *(fax)* 1 800 801 664	**Philippines** *(tel)* (632) 8426802 *(tel) (PLDT subscriber only):* 1 800 16510170 *(fax)* (632) 8426809 *(fax) (PLDT subscriber only):* 1 800 16510288	**Thailand** *(tel) outside Bangkok:* (088) 226 008 *(tel) within Bangkok:* (662) 661 3999 *(fax)* (66) 1 661 3714	**Hong Kong** *(tel)* 800 930 871 *(fax)* (852) 2506 9233
Taiwan *(tel)* 0800-047-866 *(fax)* (886) 2 25456723	**People's Republic of China** *(tel) (preferred):* 800-810-0189 *(tel) (alternate):* 10800-650-0021 *(fax)* 10800-650-0121	**India** *(tel)* 1-600-11-2929 *(fax)* 000-800-650-1101	

Ordering ECal Modules and Options

This section provides the operating characteristics and connector options available with the three series of Agilent ECal modules.

- 8509x Modules
- N4431A Modules
- 8506x Modules

8509x Modules

8509x series ECal modules are available with the connector types and frequency ranges shown in Table 1-5 on page 1-11. Mixed connector options (shown in Table 1-6 on page 1-11) allow you to configure the module with different connector types for Ports A and B. ECal modules are ordered by the model number followed by the desired options.

Figure 1-3 Model 85092C Option M0F

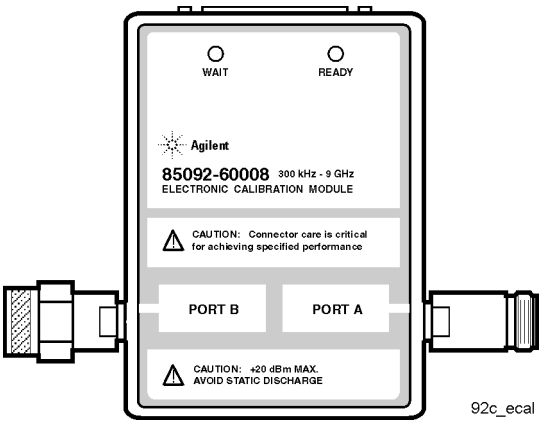


Figure 1-4 Model 85092C Option 104 201

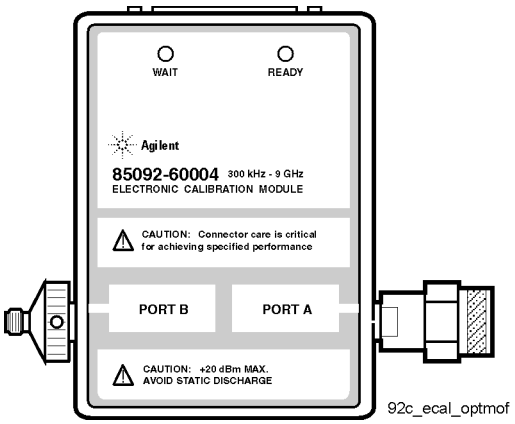


Table 1-5 8509x Modules

Model Number	Connector Type	Operating Frequency	Port A and B Option		
			(m) and (f)	(m) and (m)	(f) and (f)
85091C	7 mm (APC-7)	300 kHz to 9 GHz	No Option		
85092C	Type-N 50 ohm	300 kHz to 9 GHz	MOF	00M	00F
85093C	3.5 mm	300 kHz to 9 GHz	MOF	00M	00F
85096C	Type-N 75 ohm	300 kHz to 3 GHz	MOF	00M	00F
85098C	7-16	300 kHz to 7.5 GHz	MOF	00M	00F
85099C	Type-F	300 kHz to 3 GHz	MOF	00M	00F

Table 1-6 8509x Mixed Connector Options

Model Number	Port A Option			Port B Option					
	Type	(f)	(m)	Type	(f)	(m)	Type	(f)	(m)
85092C	Type-N 50Ω	103	104	3.5 mm	201	202	7-16[a]	205	206
85093C	3.5 mm	101	102	Type-N 50Ω	203	204	7-16[a]	205	206
85098C	7-16[a]	105	106	3.5 mm	201	202	Type-N 50Ω	203	204

a. Limits ECal module high frequency to 7.5 GHz

Other Options	Description
00A	Adds one (m)-(m) and one (f)-(f) adapter. 85093C includes an additional 5/16 in torque wrench.
UK6	Adds commercial calibration certificate with measured data.

N4431A Modules

N4431A series ECal modules are available with the connector types and frequency ranges shown in Table 1-7. Mixed connector options (shown in Table 1-8) allow you to configure the module with different connector types for each port. ECal modules are ordered by the model number followed by the desired options.

Figure 1-5 Model N4431A Option 010

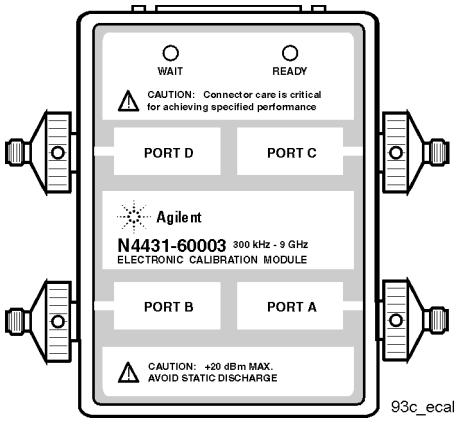


Table 1-7 N4431A Modules

Model Number	Connector Type-Port A,B,C,D	Operating Frequency	Option
N4431A	3.5 mm (f)	300 kHz to 9 GHz	010
N4431A	Type-N 50Ω (f)	300 kHz to 9 GHz	020

Table 1-8 N4431A 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

a. Limits ECal module high frequency to 7.5 GHz

Other Options	Description
UK6	Adds commercial calibration certificate with measured data.

8506x Modules

8506x series ECal modules are available with the connector types and frequency ranges shown in Table 1-9. ECal modules are ordered by the model number followed by the desired options.

Figure 1-6 Model 85062B

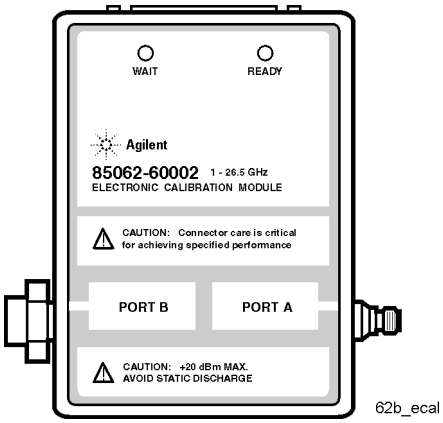


Table 1-9 8506x Modules

Model Number	Connector Type	Operating Frequency	Port A and B Option		
			(m) and (f)	(m) and (m)	(f) and (f)
85060B	7 mm (APC-7)	1 to 18 GHz	No Option		
85062B	3.5 mm	1 to 26.5 GHz	MOF[a]	00M	00F
85064B	Type-N 50Ω	1 to 18 GHz	MOF[b]	00M	00F

a. 85062B Option MOF replaces 85062B after June 1, 2002.
b. 85064B Option MOF replaces 85064B after June 1, 2002.

Other Options	Description
001	Adds an 8509x RF ECal module with same connector types.
00A	Adds one (m)-(m) and one (f)-(f) adapter. 85062B includes an additional 5/16 in. torque wrench.
UK6	Adds commercial calibration certificate with measured data.

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

WARNING **To prevent electrical shock, disconnect from instrument before cleaning. Use a dry cloth or one slightly dampened with water to clean the external case parts. Do not attempt to clean internally.**

WARNING **If this product is not used as specified, the protection provided by the equipment could be impaired. This product must be used in a normal condition (in which all means for protection are intact) only.**

Installation Notices

CAUTION This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2, per IEC 1010 and 664 respectively.

CAUTION When installing the product in a cabinet, the convection in and out of the product must not be restricted. The ambient temperature (outside the cabinet) must be less than the maximum operating temperature of the system by 4 °C for every 100 watts dissipated in the cabinet. If the total power dissipated in the cabinet is greater than 800 watts, then forced convection must be used.

Instrument Markings

	When you see this symbol on your instrument, you should refer to the instrument's instruction manual for important information.
	This symbol indicates hazardous voltages.
	The laser radiation symbol is marked on products that have a laser output.
	This symbol indicates that the instrument requires alternating current (ac) input.
	The CE mark is a registered trademark of the European Community. If it is accompanied by a year, it indicates the year the design was proven.
	The CSA mark is a registered trademark of the Canadian Standards Association.
1SM1-A	This text indicates that the instrument is an Industrial Scientific and Medical Group 1 Class A product (CISPER 11, Clause 4).
	This symbol indicates that the power line switch is ON.
	This symbol indicates that the power line switch is OFF or in STANDBY position.
 jc84a	The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.

Compliance Notices

This product has been designated and tested in accordance with the standards listed on the "Declaration of Conformity" on page 1-16, 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 conditions.

Compliance IEC 61000-4-4: 1995 (electrical transients) and IEC 61000-4-3: 1995 (electrostatic discharge): Passes using Criterion B.

Calibration cycle may be interrupted by power line transients applied to external power supply or by electrostatic discharge applied to module. Normal function is restored by restarting the calibration process.

Compliance with Canadian EMC Requirements

This ISM device complies with Canadian ICES-001.

Cet appareil ISM est conforme a la norme NMB du Canada.

Declaration of Conformity

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DECLARATION OF CONFORMITY

According to ISO/IEC Guide 22 and CEN/CENELEC EN 45014

Manufacturer's Name:	Agilent Technologies, Inc.
Manufacturer's Address:	1400 Fountaingrove Parkway Santa Rosa, CA 95403-1799 USA

Declares that the products

Product Name:	Electronic Calibration Modules
Model Number:	85092C, 85093C, 85098C, 85060B, 85062B, 85064B, N4431A
Product Options:	This declaration covers all options of the above products.

Conform to the following product specifications:

EMC: IEC 61326-1:1997+A1:1998 / EN 61326-1:1997+A1:1998

Standard	Limit
CISPR 11:1990 / EN 55011-1991	Group 1, Class A
IEC 61000-4-2:1995+A1998 / EN 61000-4-2:1995	4 kV CD, 8 kV AD
IEC 61000-4-3:1995 / EN 61000-4-3:1995	3 V/m, 80 - 1000 MHz
IEC 61000-4-4:1995 / EN 61000-4-4:1995	0.5 kV sig., 1 kV power
IEC 61000-4-5:1995 / EN 61000-4-5:1996	0.5 kV L-L, 1 kV L-G
IEC 61000-4-6:1996 / EN 61000-4-6:1998	3 V, 0.15 – 80 MHz
IEC 61000-4-11:1994 / EN 61000-4-11:1998	1 cycle, 100%

Safety: IEC 61010-1:1990 + A1:1992 + A2:1995 / EN 61010-1:1993 +A2:1995
CAN/CSA-C22.2 No. 1010.1-92

Supplementary Information:
The products herewith comply with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC and carry the CE-marking accordingly.

These modules were tested with Agilent Technologies Network Analyzers.

Santa Rosa, CA, USA 8 Feb. 2002

Greg Pfeiffer/Quality Engineering Manager

For further information, please contact your local Agilent Technologies sales office, agent, or distributor.

Rev. C

2 Specifications and Characteristics

Specifications: Terminology and Definitions

The following terms and definitions are for Agilent 8509x series, N4431A series RF ECal modules and 8506x series microwave ECal modules. The definitions are intended to help clarify terms used in the specifications. The definitions are specific to these modules and are not necessarily valid definitions for other Agilent Technologies products.

Table 2-1 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. Refer to Figure 2-1 on page 2-4 for an explanation of the measured areas, and "Pin Depth Characteristics" on page 2-6 for actual measurement values.
Specification (spec)	Warranted performance. Specifications include guard bands to account for the expected statistical distribution, measurement uncertainties, and changes in performance due to environmental conditions.
Characteristic	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

Table 2-2 Environmental Specifications for ECal Modules

Specifications	Limits
Temperature	
Operating	+20 °C to +30 °C
Storage	–40 °C to +70 °C
Error-corrected range	±1 °C of measurement calibration temperature
Altitude	
Operation[a]	< 4,500 meters (15,000 feet)
Storage	< 15,000 meters (50,000 feet)
Relative Humidity	Always Non-Condensing
Operation	0% to 80% (at 26 °C maximum dry bulb)
Storage	0% to 95% (at 26 °C maximum dry bulb)
EMI	
Conducted Susceptibility	CETM 765
Radiated Susceptibility	EN 50082-1/IEC 801-3
Radiated Emissions	CISPR11
Magnetic Emissions	CETM 765

a. The 85097B VNA interface unit is not warranted for use above 3,000 meters (10,000 feet).

Operating Temperature and Accuracy Enhancement

Because the dimensions of components can 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 unnecessary handling of the module connectors, cable connectors, and adapters because your fingers are a heat source that may increase the temperature of your device.

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.

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. Agilent 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 3-8 explains how to use gages to determine if the devices have maintained their mechanical integrity. Refer to "Pin Depth Characteristics" on page 2-6 for typical and observed pin depth limits.

Pin Depth Information

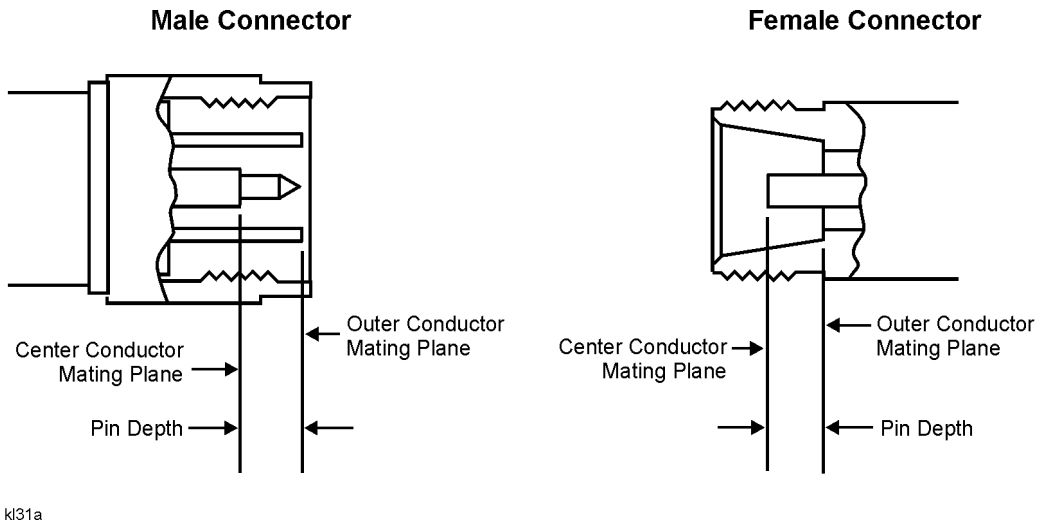
Pin depth is the distance the center conductor mating plane differs from being flush with the outer connector mating plane (see Figure 2-1). The pin depth of a connector can be in one of two states: either protruding or recessed.

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 2-1 Type-N Connector Pin Depth



Type-N Mechanical Characteristics

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 2-1). 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.

In type-N connectors, 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.

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 Agilent 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. Agilent 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.

Pin Depth Characteristics

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 2-1 for a visual representation of proper pin depth (slightly recessed).

NOTE Agilent Technologies does not supply pin depth gages for 7-16 connectors. The 7-16 module adapter pin depth is set at 0 to –38.1 micrometers recessed from the nominal 1.77 mm offset between inner conductor and outer conductor mating planes.

Table 2-3 Type-N 50 Ω Connector Pin Depth Characteristics

Device	Typical Pin Depth[a] in Micrometers (10^{-4} inches)	Measurement Uncertainty[b] in Micrometers (10^{-4} inches)	Observed Pin Depth Limits in Micrometers (10^{-4} inches)
Type-N 50 Ω ECal Module	–25.4 to –50.8 (–10.0 to –20.0)	+3.8 to –3.8 (+1.5 to –1.5)	–21.6 to –54.6 (–8.5 to –21.5)
Type-N 50 Ω Adapter	0 to –12.7 (0 to –5.0)	+3.8 to –3.8 (+1.5 to –1.5)	+3.8 to –16.5 (+1.5 to –6.5)

a. Measured from a 5.258 mm (0.207 inches) nominal offset.
b. Approximately +2 sigma to –2 sigma of gage uncertainty based on studies performed at the factory using analog gages according to recommended procedures.

Table 2-4 3.5 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Micrometers (10^{-4} inches)	Measurement Uncertainty[a] in Micrometers (10^{-4} inches)	Observed Pin Depth Limits in Micrometers (10^{-4} inches)
3.5 mm ECal Module	–25.4 to –50.8 (–10.0 to –20.0)	+1.3 to –1.3 (+0.5 to –0.5)	–24.1 to –52.1 (–9.5 to –20.5)
3.5 mm Adapter	–2.5 to –13.0 (–1.0 to –5.0)	+1.3 to –1.3 (+0.5 to –0.5)	–1.2 to –14.3 (–0.5 to –5.5)

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

Table 2-5 7 mm Connector Pin Depth Characteristics

Device	Typical Pin Depth in Micrometers (10^{-4} inches)	Measurement Uncertainty[a] in Micrometers (10^{-4} inches)	Observed Pin Depth Limits in Micrometers (10^{-4} inches)
7 mm ECal Module	–25.4 to –50.8 (–10.0 to –20.0)	+1.3 to –1.3 (+0.5 to –0.5)	–24.1 to –52.1 (–9.5 to –20.5)

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

Supplemental Mechanical Characteristics

Table 2-6 8509x, N4431A RF ECal Mechanical Characteristics

Characteristic	Limits
Net weight with case 8509x (two-port) N4431A (four-port)	 2.7 kilograms (5.9 lbs) 2.9 kilograms (6.3 lbs)
Shipping weight 8509x (two-port) N4431A (four-port)	 4.3 kilograms (9.5 lbs) 4.5 kilograms (9.9 lbs.)
Shipping dimensions Length Width Height	 55.2 cm (21.75 inches) 36.8 cm (14.50 inches) 27.3 cm (10.75 inches)

Table 2-7 8506x Microwave ECal Mechanical Characteristics

Characteristic	Limits
Net weight with case Standard Option 001	 2.7 kilograms (5.9 lbs) 3.3 kilograms (7.3 lbs)
Shipping weight Standard Option 001	 4.3 kilograms (9.5 lbs) 4.9 kilograms (10.8 lbs)
Shipping dimensions Length Width Height	 55.2 cm (21.75 inches) 36.8 cm (14.50 inches) 27.3 cm (10.75 inches)

Typical Corrected Performance

The following tables display the typical corrected performance for all ECal modules. These values describe non-warranted performance that most units will exhibit.

8509x Modules

Typical Corrected Performance for 85091C (7 mm)

Parameter	Frequency Range			
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 9.0 GHz
Directivity (dB)	52.0	56.0	55.0	45.0
Source Match (dB)	45.0	44.0	41.0	34.0
Reflection Tracking (dB)	±0.04	±0.04	±0.07	±0.1
Transmission Tracking (dB)	±0.06	±0.06	±0.13	±0.23
Load Match (dB)	47.0	47.0	46.0	39.0

Typical Corrected Performance for 85092C (Type-N 50Ω)

Parameter	Frequency Range			
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 9.0 GHz
Directivity (dB)	52.0	54.0	52.0	47.0
Source Match (dB)	45.0	44.0	41.0	36.0
Reflection Tracking (dB)	±0.04	±0.04	±0.06	±0.07
Transmission Tracking (dB)	±0.04	±0.04	±0.07	±0.14
Load Match (dB)	47.0	47.0	44.0	39.0

Typical Corrected Performance for 85093C (3.5 mm)

Parameter	Frequency Range			
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 9.0 GHz
Directivity (dB)	52.0	52.0	50.5	47.0
Source Match (dB)	44.0	44.0	39.0	34.0
Reflection Tracking (dB)	±0.03	±0.03	±0.05	±0.07
Transmission Tracking (dB)	±0.04	±0.05	±0.07	±0.12
Load Match (dB)	47.0	47.0	44.0	40.0

Typical Corrected Performance for 85096C (Type-N 75Ω)

Parameter	Frequency Range		
	300 kHz to 300 MHz	300 MHz to 1.3 GHz	1.3 to 3.0 GHz
Directivity (dB)	50.0	48.0	43.0
Source Match (dB)	48.0	45.0	38.0
Reflection Tracking (dB)	±0.03	±0.06	±0.1
Transmission Tracking (dB)	±0.08	±0.09	±0.16
Load Match (dB)	43.0	41.0	39.0

Typical Corrected Performance for 85098C (7-16)

Parameter	Frequency Range			
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 7.5 GHz
Directivity (dB)	47.0	50.0	46.0	45.0
Source Match (dB)	43.0	43.0	38.0	37.0
Reflection Tracking (dB)	±0.03	±0.03	±0.05	±0.06
Transmission Tracking (dB)	±0.05	±0.06	±0.08	±0.10
Load Match (dB)	42.0	43.0	41.0	38.0

Typical Corrected Performance[a] for 85099C (Type-F)

Parameter	Frequency Range		
	300 kHz to 300 MHz	300 MHz to 1.3 GHz	1.3 to 3.0 GHz
Directivity (dB)	50.0	48.0	43.0
Source Match (dB)	48.0	45.0	38.0
Reflection Tracking (dB)	±0.03	±0.07	±0.15
Transmission Tracking (dB)	±0.08	±0.10	±0.17
Load Match (dB)	43.0	41.0	39.0

a. When mated with male connectors with a 0.77 mm (.030 in) to 0.86 (0.34) pin diameter

N4431A Modules

The following table displays the typical corrected performance for N4431A Option 010 (3.5 mm (f) on all ports) when measuring "thru path" A-B, C-D, A-D and B-C.

Typical Corrected Performance for N4431A Option 010 (3.5 mm)

Parameter	Frequency Range				
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 8.0 GHz	8.0 to 9.0 GHz
Directivity (dB)	57	55	52	50	47
Source Match (dB)	50	47	45	44	43
Reflection Tracking (dB)	±0.03	±0.03	±0.04	±0.04	±0.05
Transmission Tracking (dB)	±0.06	±0.09	±0.12	±0.14	±0.2
Load Match (dB)	47	46	45	44	42

The following table displays the typical corrected performance for N4431A Option 010 (3.5 mm (f) on all ports) when measuring "thru path" A-C and B-D.

Typical Corrected Performance for N4431A Option 010 (3.5 mm)

Parameter	Frequency Range				
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 8.0 GHz	8.0 to 9.0 GHz
Directivity (dB)	57	55	52	50	47
Source Match (dB)	50	47	45	44	43
Reflection Tracking (dB)	±0.03	±0.03	±0.04	±0.04	±0.05
Transmission Tracking (dB)	±0.06	±0.08	±0.1	±0.12	±0.14
Load Match (dB)	47	46	45	45	43

N4431A Modules

The following table displays the typical corrected performance for N4431A Option 020 (Type-N (f) on all ports) when measuring “thru path” A-B, C-D, A-D and B-C.

Typical Corrected Performance for N4431A Option 020 (Type-N 50Ω)

Parameter	Frequency Range				
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 8.0 GHz	8.0 to 9.0 GHz
Directivity (dB)	55	52	47	44	42
Source Match (dB)	47	43	42	40	39
Reflection Tracking (dB)	±0.03	±0.04	±0.04	±0.05	±0.06
Transmission Tracking (dB)	±0.07	±0.1	±0.14	±0.2	±0.22
Load Match (dB)	47	45	40	38	35

The following table displays the typical corrected performance for N4431A Option 020 (Type-N (f) on all ports) when measuring “thru path” A-C and B-D.

Typical Corrected Performance for N4431A Option 020 (Type-N 50Ω)

Parameter	Frequency Range				
	300 kHz to 1.0 GHz	1.0 to 3.0 GHz	3.0 to 6.0 GHz	6.0 to 8.0 GHz	8.0 to 9.0 GHz
Directivity (dB)	55	52	47	44	42
Source Match (dB)	47	43	42	40	39
Reflection Tracking (dB)	±0.03	±0.04	±0.04	±0.05	±0.06
Transmission Tracking (dB)	±0.07	±0.09	±0.13	±0.15	±0.16
Load Match (dB)	47	45	40	38	36

8506x Modules

Typical Corrected Performance for 85060B (7 mm)

Parameter	Frequency Range		
	1 to 2 GHz	2 to 8 GHz	8 to 18 GHz
Directivity (dB)	50.0	49.0	46.0
Source Match (dB)	46.0	45.0	40.0
Reflection Tracking (dB)	±0.032	±0.046	±0.065
Transmission Tracking (dB)	±0.043	±0.050	±0.140
Load Match (dB)	46.0	44.0	40.0

Typical Corrected Performance for 85062B (3.5 mm)

Parameter	Frequency Range			
	1 to 2 GHz	2 to 8 GHz	8 to 20 GHz	20 to 26.5 GHz
Directivity (dB)	48.0	49.0	46.0	44.0
Source Match (dB)	45.0	43.0	40.0	37.0
Reflection Tracking (dB)	±0.041	±0.041	±0.064	±0.088
Transmission Tracking (dB)	±0.048	±0.068	±0.130	±0.170
Load Match (dB)	45.0	43.0	40.0	38.0

Typical Corrected Performance for 85064B (Type-N 50 Ω)

Parameter	Frequency Range		
	1 to 2 GHz	2 to 8 GHz	8 to 18 GHz
Directivity (dB)	50.0	49.0	46.0
Source Match (dB)	46.0	45.0	40.0
Reflection Tracking (dB)	±0.034	±0.046	±0.065
Transmission Tracking (dB)	±0.043	±0.050	±0.140
Load Match (dB)	46.0	44.0	40.0

Electrical Specifications

The following tables display the specifications for all 8509x series RF ECal modules. For detailed descriptions about these specifications go to `http://www.agilent.com/find/ecal` and download the white paper "ECal Specifications."

85092C Option M0F, (Type-N 50 Ω)

The 85092C option M0F has a type-N female connector on Port A and type-N male connector on Port B. Due to the mechanical characteristics of the type-N mating plane of male and female connectors (see "Type-N Mechanical Characteristics" on page 2-5), the short and open phase specifications for this option are listed by port designation.

Specifications for 85092C Option M0F

Frequency	Load	Open			Short		
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Port A Maximum Phase[a]	Port B Maximum Phase[a]	Maximum Magnitude (dB)	Port A Maximum Phase[a]	Port B Maximum Phase[a]
300 kHz to 1.0 GHz	23.0	6.4	–219°	–243°	4.0	–396°	–420°
1.0 to 3.0 GHz	19.0	4.0	–645°	–713°	3.9	–833°	–901°
3.0 to 6.0 GHz	14.0	7.0	–1297°	–1431°	3.2	–1474°	–1608°
6.0 to 9.0 GHz	12.0	5.9	–1923°	–2123°	6.9	–2126°	–2326°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for 85092C Option M0F

Frequency	Mismatch	S_{11} and S_{22}	S_{21} and S_{12}	
	Minimum Return Loss (dB)	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	8.3	12.0	3.4	–283°
1.0 to 3.0 GHz	3.7	19.0	4.6	–843°
3.0 to 6.0 GHz	9.4	14.0	5.7	–1675°
6.0 to 9.0 GHz	7.4	11.0	7.4	–2520°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

85092C Option 00F, (Type-N 50 Ω)

The following tables display the specifications for 85092C ECal module Option 00F. Option 00F has two female connectors.

Specifications for 85092C Option 00F

Frequency	Load	Open		Short	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	23.0	6.4	–219°	4.0	–396°
1.0 to 3.0 GHz	19.0	4.0	–645°	3.9	–833°
3.0 to 6.0 GHz	14.0	7.0	–1297°	3.2	–1474°
6.0 to 9.0 GHz	12.0	5.9	–1923°	6.9	–2126°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for 85092C Option 00F

Frequency	Mismatch	S_{11} and S_{22}	S_{21} and S_{12}	
	Minimum Return Loss (dB)	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	8.3	12.0	3.4	–271°
1.0 to 3.0 GHz	3.7	19.0	4.6	–807°
3.0 to 6.0 GHz	9.4	14.0	5.7	–1606°
6.0 to 9.0 GHz	7.4	11.0	7.4	–2416°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

85092C Option 00M, (Type-N 50 Ω)

The following tables display the specifications for 85092C ECal module option 00M. Option 00M has two male connectors.

Specifications for 85092C Option 00M

Frequency	Load	Open		Short	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	23.0	6.4	–243°	4.0	–420°
1.0 to 3.0 GHz	19.0	4.0	–713°	3.9	–901°
3.0 to 6.0 GHz	14.0	7.0	–1431°	3.2	–1608°
6.0 to 9.0 GHz	12.0	5.9	–2123°	6.9	–2326°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for 85092C Option 00M

Frequency	Mismatch	S_{11} and S_{22}	S_{21} and S_{12}	
	Minimum Return Loss (dB)	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	8.3	12.0	3.4	–295°
1.0 to 3.0 GHz	3.7	19.0	4.6	–875°
3.0 to 6.0 GHz	9.4	14.0	5.7	–1742°
6.0 to 9.0 GHz	7.4	11.0	7.4	–2624°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

85093C Options M0F/00F/00M, (3.5 mm)

The following tables display the specifications for 85093C ECal module options M0F (male and female connectors), 00F (two female connectors), and 00M (two male connectors).

Specifications for 85093C Options M0F/00F/00M

Frequency	Load	Open		Short	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase
300 kHz to 1.0 GHz	23.0	6.5	–220°	4.8	–382°
1.0 to 3.0 GHz	19.0	4.7	–648°	4.1	–903°
3.0 to 6.0 GHz	14.0	7.7	–1301°	3.6	–1626°
6.0 to 9.0 GHz	13.0	6.5	–1923°	7.2	–2340°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for 85093C Options M0F/00F/00M

Frequency	Mismatch	S_{11} and S_{22}	S_{21} and S_{12}	
	Minimum Return Loss (dB)	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	7.9	12.0	3.5	–542°
1.0 to 3.0 GHz	3.9	19.0	5.0	–895°
3.0 to 6.0 GHz	9.2	14.0	6.1	–1624°
6.0 to 9.0 GHz	7.6	12.0	8.0	–2648°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

85098C Options M0F/00F/00M, (7-16)

The following tables display the specifications for 85098C ECal module options M0F (male and female connectors), 00F (two female connectors), and 00M (two male connectors).

Specifications for 85098C Option M0F/00F/00M

Frequency	Load	Open		Short	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	23.0	6.5	–220°	4.1	–430°
1.0 to 3.0 GHz	18.0	3.9	–645°	4.1	–900°
3.0 to 6.0 GHz	14.0	6.6	–1297°	3.4	–1613°
6.0 to 7.5 GHz	14.0	5.1	–1616°	8.1	–1993°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for 85098C Option M0F/00F/00M

Frequency	Mismatch	S_{11} and S_{22}	S_{21} and S_{12}	
	Minimum Return Loss (dB)	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]
300 kHz to 1.0 GHz	7.9	12.0	3.5	–306°
1.0 to 3.0 GHz	3.9	19.0	4.8	–894°
3.0 to 6.0 GHz	9.4	14.0	5.7	–1612°
6.0 to 7.5 GHz	7.3	12.0	6.6	–2268°

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

N4431A Option 010, (3.5 mm)

The following tables display the specifications for N4431A ECal module option 010 (female connectors on all 4 ports).

Specifications for N4431A Option 010

Frequency	Load	Open		Short		Mismatch
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase	Minimum Return Loss (dB)
300 kHz to 1.0 GHz	21	0.7	–160	2.0	–339	9
1.0 to 3.0 GHz	18	1.8	–477	2.2	–651	10
3.0 to 6.0 GHz	14	3.2	–951	2.9	–1121	8
6.0 to 8.0 GHz	11	3.4	–1264	3.3	–1428	5
8.0 to 9.0 GHz	11	3.5	–1418	3.6	–1584	4

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for N4431A Option 010

Frequency	Reflection[a]	Transmission[a]		Reflection[b]	Transmission[b]	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[c]	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase
300 kHz to 1.0 GHz	18	5.0	–304	17	3.7	–260
1.0 to 3.0 GHz	16	6.0	–904	23	4.2	–773
3.0 to 6.0 GHz	10	7.3	–1808	12	5.2	–1544
6.0 to 8.0 GHz	10	7.9	–2419	14	5.4	–2063
8.0 to 9.0 GHz	8	8.9	–2723	11	5.8	–2325

a. When measuring “thru path” A-B, C-D, A-D, C-B.
b. When measuring “thru path” AC, BD.
c. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

N4431A Option 020, (Type-N)

The following tables display the specifications for N4431A ECal module Option 020 (female connectors on all 4 ports).

Specifications for N4431A Option 020

Frequency	Load	Open		Short		Mismatch
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[a]	Maximum Magnitude (dB)	Maximum Phase	Minimum Return Loss (dB)
300 kHz to 1.0 GHz	21	0.6	–174	2.0	–354	9
1.0 to 3.0 GHz	17	1.6	–521	2.1	–692	11
3.0 to 6.0 GHz	13	2.5	–1039	2.5	–1200	8
6.0 to 8.0 GHz	11	2.6	–1375	3.2	–1546	5
8.0 to 9.0 GHz	11	3.2	–1549	3.3	–1710	4

a. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Specifications for N4431A Option 020

Frequency	Reflection[a]	Transmission[a]		Reflection[b]	Transmission[b]	
	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase[c]	Minimum Return Loss (dB)	Maximum Magnitude (dB)	Maximum Phase
300 kHz to 1.0 GHz	18	5.1	–319	17	3.7	–275
1.0 to 3.0 GHz	16	6.1	–950	23	4.2	–818
3.0 to 6.0 GHz	10	7.4	–1900	12	5.4	–1633
6.0 to 8.0 GHz	10	7.9	–2540	13	5.5	–2181
8.0 to 9.0 GHz	9	8.8	–2861	14	6.0	–2458

a. When measuring “thru path” A-B, C-D, A-D, C-B.
b. When measuring “thru path” AC, BD.
c. The phase data is measured as unwrapped phase. Unwrapped phase is the continuous total phase shift at the frequency point of interest.

Operating Characteristics

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

Download the Vector Network Uncertainty Calculator

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

The program uses your Agilent 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®[1] Windows®[2] based and uses a Microsoft Excel spreadsheet to calculate, graph, and display uncertainty curves.

1. Microsoft® is a U.S. registered trademark of Microsoft Corporation.
2. Windows® is a U.S. registered trademark of Microsoft Corporation.

3 Use, Maintenance, and Care of ECal Modules

Preventing Electrostatic Discharge

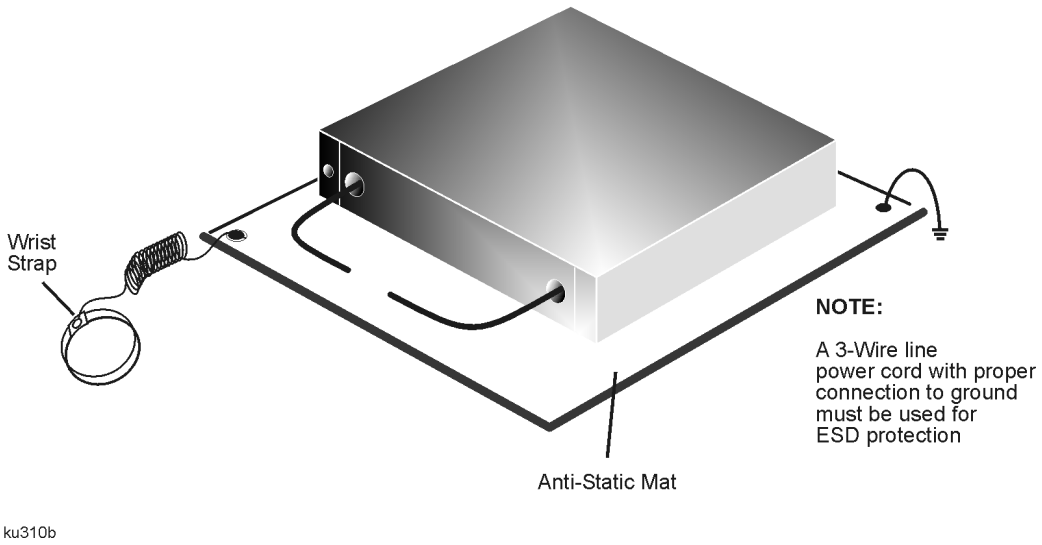
Protection against electrostatic discharge (ESD) is essential while connecting, inspecting, or cleaning devices attached to a static-sensitive circuit (such as those found in network analyzers and ECal modules).

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 network analyzers.
- *always* have a grounded antistatic mat in front of your test equipment.
- *always* wear a heel strap when working in an area with a conductive floor.

For parts numbers for ESD protection supplies, refer to "Other Accessories" on page 5-12.

Figure 3-1 ESD Protection Using Mat, Wrist Strap, and Grounded Power Cord



Preventive Maintenance

The best way to ensure that ECal modules provide accurate calibrations is to practice proper RF connector care. Failure to detect and remove dirt or metallic particles on a mating plane surface can degrade repeatability and accuracy and can damage any connector mated to it. Improper connections, resulting from pin depth values being out of observed limits, or from poor connection techniques, can also damage these devices.

Techniques for maintaining the integrity of modules are described in following sections:

Inspecting RF Connector Interfaces Visually

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.

In some cases, magnification is necessary to see damage on a connector. Not all defects that are visible only under magnification will affect the electrical performance of the connector. Use the following guidelines when evaluating the integrity of a connector.

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?

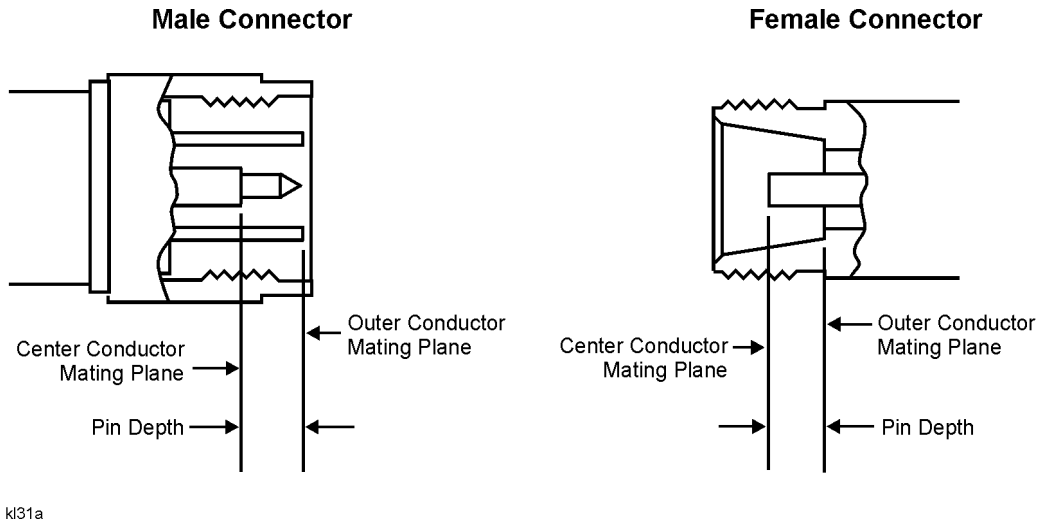
Connector wear is caused by connecting and disconnecting the devices. The more use the device gets, the faster it wears and degrades. The wear is greatly accelerated when connectors are not kept clean, or are not properly connected. This is especially true with electrically characterized devices such 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 3-2 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 3-2 Type-N Connector Pin Depth and Mating Surfaces



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 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 connectors are essential for ensuring the integrity of RF and microwave coaxial connections.

NOTE The following cleaning procedure can be used for all of the connectors except the 7 mm connector. Refer to "Cleaning Precision 7 mm Connectors" on page 3-7.

WARNING **Always use protective eyewear when using compressed air or nitrogen.**

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 "Preventing Electrostatic Discharge" on page 3-2 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**

   Use a lint-free swab or cleaning cloth moistened with isopropyl alcohol to remove any dirt or stubborn contaminants on a connector that cannot be removed with compressed air or nitrogen. Refer to "Other Accessories" on page 5-12 for cleaning swabs and isopropyl alcohol part numbers.

a. Apply a small amount of isopropyl alcohol to a lint-free cleaning 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 3-2 on page 3-5. 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 Precision 7 mm Connectors

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

With the Center Collet in Place

1. Dispense a small amount of isopropyl alcohol on the lint free cloth.
2. Retract the connector sleeve threads to expose the connector interface.
3. Gently press the contact end of the connector into the moistened cloth and rotate the connector. The cloth scrubs away dirt and contaminants on the connector interface without damaging it.
4. Blow the connector dry with a gentle stream of compressed air or nitrogen.

NOTE 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 (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 "Cleaning Connectors" on page 3-6.

Gaging Connectors

The gages available from Agilent 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 devices under test (DUTs), test accessories, and the ECal modules. Do not use the gages for precise pin depth measurements.

Clarifying the Terminology of a Connector Interface

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

- A male connector gage has a female connector on the gage so that it can measure male devices.
- A female connector gage has a male connector on the gage so that it can measure female devices.

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. Only the factory—through special gaging processes and electrical testing—can accurately verify the mechanical characteristics of the devices.

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 "Pin Depth Characteristics" on page 2-6 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) is not the true value. Always compare the measured value with the observed pin depth limits with the observed pin depth limits in the tables located in "Pin Depth Characteristics" on page 2-6 for each type of connector.

When to Gage Connectors

Gage a connector at the following times:

- Prior to using a 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 module, you must remove the 7 mm collet before gaging the pin depth of the connectors. Use the collet extraction tool provided in your 7 mm module to remove the collet.

Recognizing Gage Types

Each type of connector uses a different connector gage.

- See Figure 3-3 on page 3-10 for an illustration of a typical 3.5 mm gage.
- See Figure 3-4 on page 3-11 for an illustration of a typical type-N gage.
- See Figure 3-5 on page 3-12 for an illustration of a typical 7 mm gage.

The gages for all of the modules are screw-on type gages. Every connector gage requires a gage master to zero the gage. 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.

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). See Figure 3-4 on page 3-11. 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 "Pin Depth Information" on page 2-4 for definitions of protrusion and recession.

Figure 3-3 Typical 3.5 mm Connector Gage

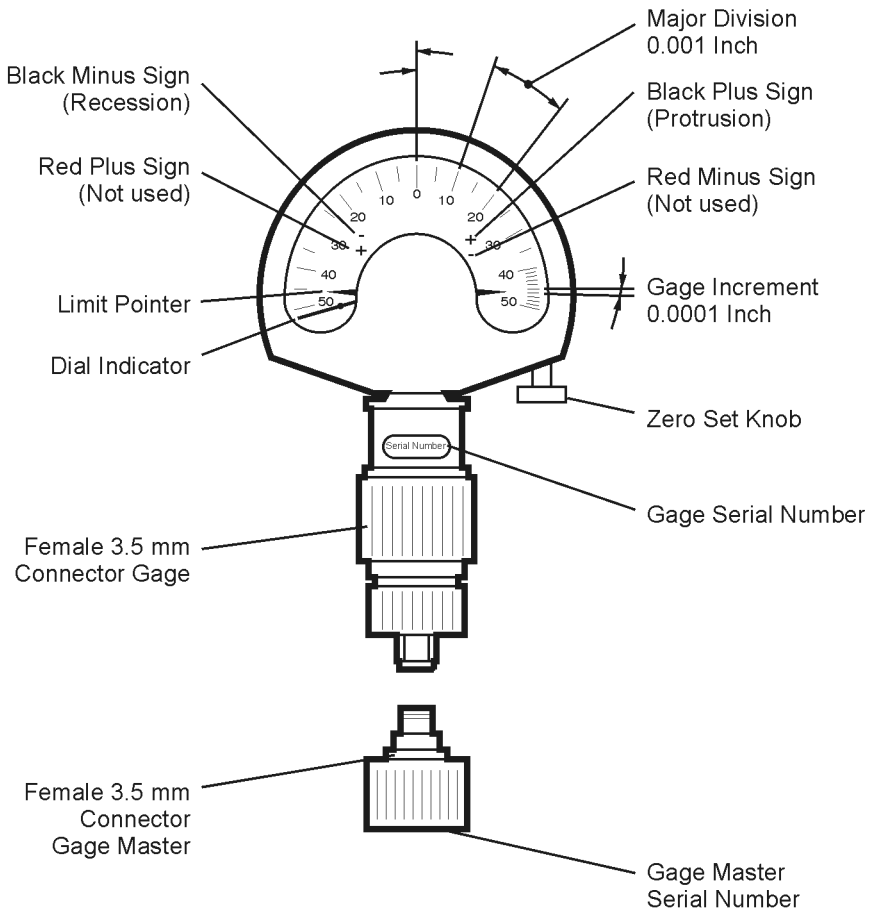


Figure 3-4 Typical Type-N Connector Gage

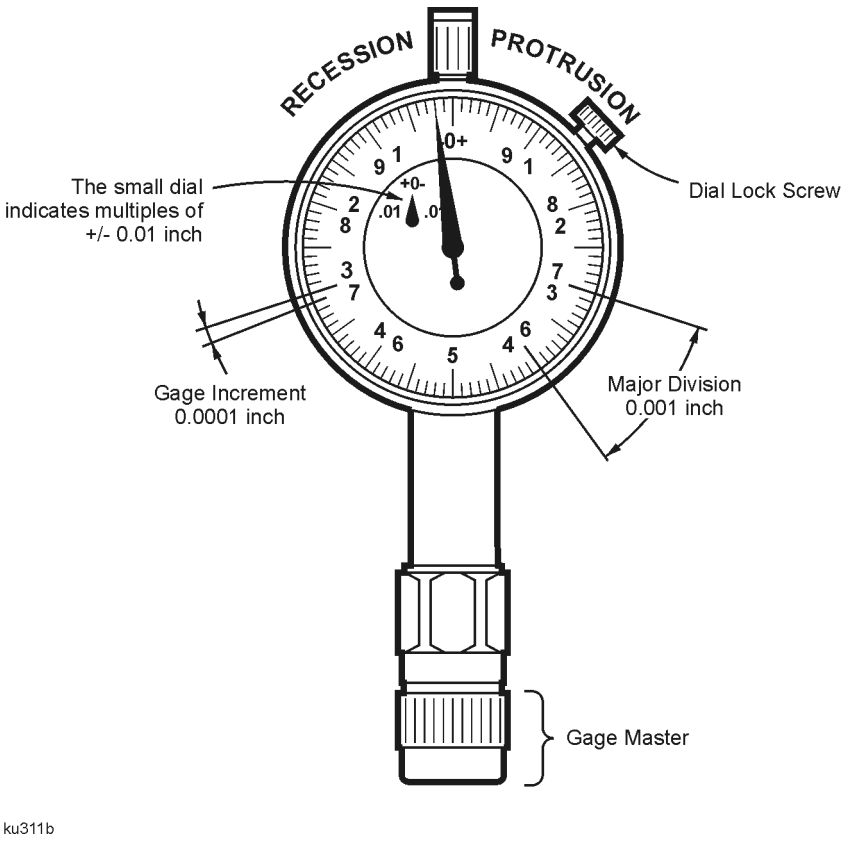
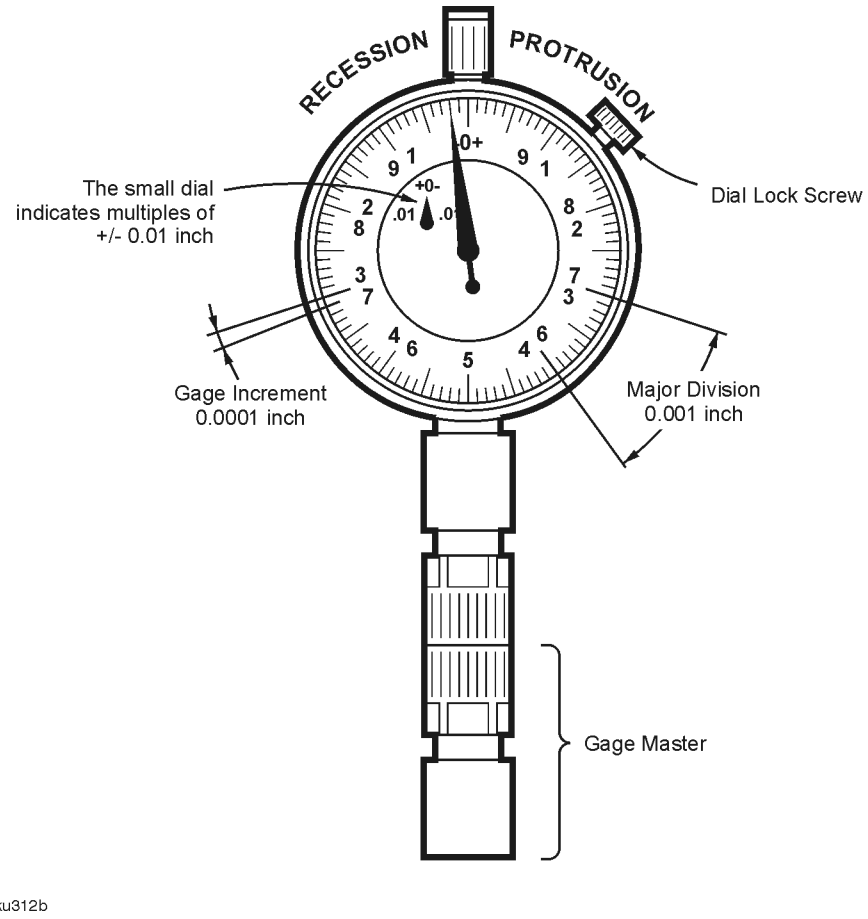


Figure 3-5 Typical 7 mm Connector Gage



Gaging Procedures

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 3.5 mm and 7 mm pin depth gages are different than the type-N gage design. The 3.5 and 7 mm gages do not require any offsetting 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.
2. Inspect and clean the gage, gage master, and device to be gaged. Refer to "Inspecting RF Connector Interfaces Visually" on page 3-4 and "Cleaning Connectors" on page 3-6.

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 3-15.

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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 3-1 on page 3-18.
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.

   3.5 and 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

CAUTION Remove the collet when gaging 7 mm connectors.

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 7mm: 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.

   3.5 mm: Read the gage indicator dial. Read only the black ± signs; not the red ± 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 "Pin Depth Characteristics" on page 2-6 for each type of connector.

Making Connections

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

CAUTION These procedures assume that you have taken the necessary ESD precautions, and that you have already cleaned, inspected (visually and mechanically), and gaged the connectors.

3.5 mm, Type-N, 7-16 and Type-F Devices

1. 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.

2. 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
3. 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.
4. Make sure the connectors are properly supported. Relieve any side pressure on the connection from long or heavy devices or cables.
5. Torque the connection according to the procedures described in "Final Connection Using a Torque Wrench" on page 3-16.

7 mm Devices

1. Fully extend the connector sleeve on one of the connectors. Spin its knurled connector nut to make sure the threads are fully extended. Fully retract the sleeve on the other connector. The extended sleeve creates a cylinder into which the other connector fits.

   If one of the connectors is fixed (such as on a test port), fully extend that connector sleeve and fully retract the sleeve on the moveable connector.
2. Carefully align the connectors. As you make the actual connection, be sure the connectors align perfectly.
3. Push the connectors straight together. Do *not* twist or screw the connectors together.
4. Engage the connector nut (of the connector with the retracted sleeve) over the threads of the other connector (the connector with the extended sleeve). Turn only the connector nut. Let the connector nut pull the two connectors straight together.

5. 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.
6. Make sure the connectors are properly supported. Relieve any side pressure on the connection from long or heavy devices or cables.
7. Torque the connection according to the procedures described in the following section.

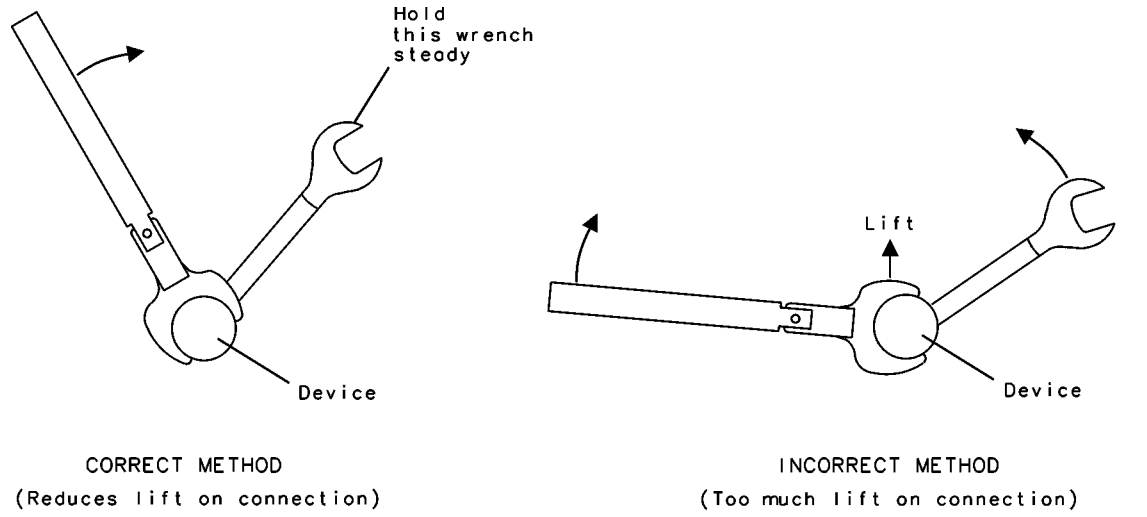
Final Connection Using a Torque Wrench

NOTE Using a torque wrench guarantees that 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 3-1 on page 3-18 provides information on the torque wrench recommended for use with each connector type.

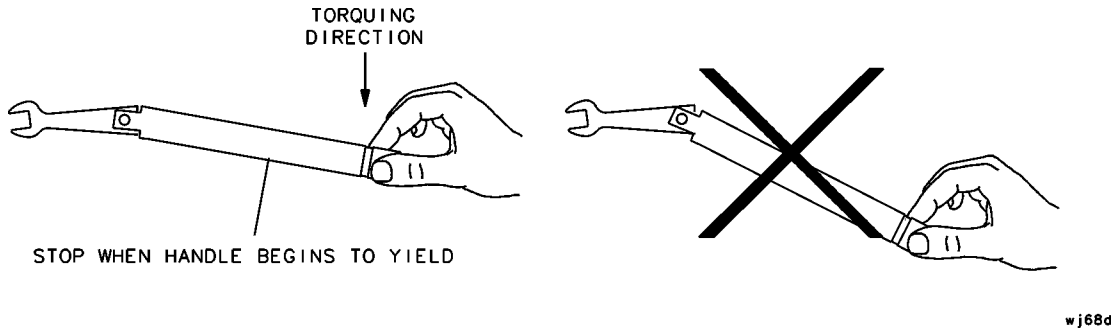
1. Turn the connector nut. This may be possible to do by hand if one of the connectors is fixed (as on a test port). However, it is recommended that you use an open-end wrench to keep the body of the device from turning.
2. Position both wrenches within 90 degrees of each other before applying force. 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 3-6.

Figure 3-6 Wrench Positions



3. Hold the torque wrench lightly, at the end of the handle only (beyond the groove). See Figure 3-7.

Figure 3-7 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. Tighten the connection just to the torque wrench break point. The wrench handle gives way at its internal pivot point. Do not tighten the connection further. See Figure 3-7.

Table 3-1 ECal Module Torque Wrench Information

Connector Type	Torque Wrench Part Number	Wrench Opening	Torque Setting	Torque Tolerance[a]
3.5 mm (test port)	8710-1764	20 mm	90 N-cm (8 in-lb)	±9 N-cm (±0.8 in-lb)
3.5 mm (standard)	8710-1765	5/16 in	90 N-cm (8 in-lb)	±9 N-cm (±0.8 in-lb)
Type-N 50, 75 Ω	8710-1766	3/4 in	135 N-cm (12 in-lb)	±13.5 N-cm (±1.2 in-lb)
7 mm (APC-7)	8710-1766	3/4 in	135 N-cm (12 in-lb)	±13.5 N-cm (±1.2 in-lb)
7-16	8710-2174	1 1/16 in	226 N-cm (20 in-lb)	±22.6 N-cm (±2 in-lb)

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

How to Separate 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 to prevent the device body from turning.
2. Use another open-end 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.
- 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.

4 Verification and Recertification of ECal Modules

Verification and Recertification of ECal Modules

The performance of your ECal module can only be verified by returning the module to Agilent Technologies for recertification. The equipment and calibration standards required to certify the specification limits of the module have been specially manufactured and are not commercially available.

How Agilent Verifies Your ECal Module

Agilent 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 2, “Specifications and Characteristics.”

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

Recertification

The following will be provided with a recertified ECal module:

- 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

Agilent Technologies offers different types of calibration for the recertification of the module. For more information, contact Agilent. See "Contacting Agilent" on page 1-9.

How Often to Recertify

The suggested initial interval for recertification is 12 months or sooner. The actual need for recertification depends on the use of the module. After reviewing the results of the initial recertification, you may establish a different recertification interval that reflects the usage and wear of the module.

NOTE The recertification interval should begin on the date the module is *first used* after the recertification date.

Where to Send a Kit for Recertification

Contact the sales or service office nearest you for information on where to send your kit for recertification. See "Contacting Agilent" on page 1-9 for a list of offices. Refer to "Returning Devices to Agilent" on page 1-8 for instructions on the preparation of returning the device.

5 Replaceable Parts

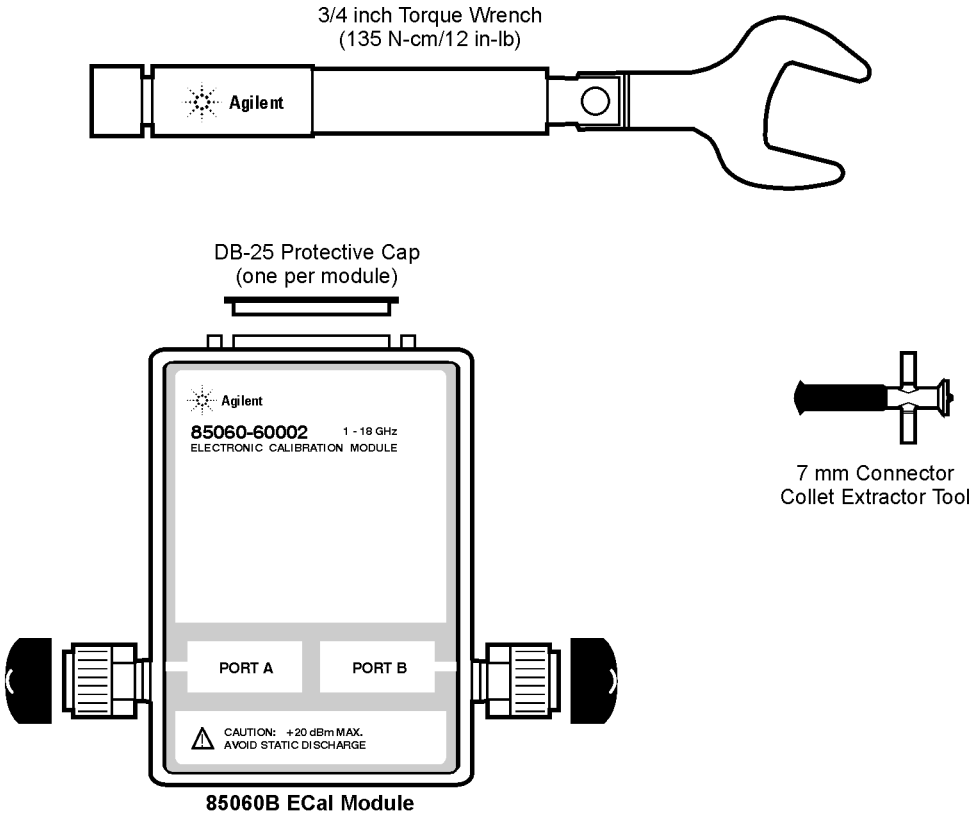
Description of This Chapter

The following tables list the replaceable part numbers for ECal modules and their accessories. To order a part, note the description, Agilent part number, and the quantity desired. Telephone or send your order to the Agilent. See "Contacting Agilent" on page 1-9.

7 mm (APC-7) ECal Modules

Description	Qty	Part Number
85060B Microwave Module		
Module with 7 mm connectors	1	85060-60002
85091C RF Module		
Module with 7 mm connectors	1	85091-60004
Protective End Caps		
DB-25 multi-pin connector cap 7 mm connector cap	1 2	1252-4690 1401-0249
Other		
3/4 inch, 135 N-cm (12 in-lb) torque wrench (standard) 7 mm collet extractor tool (standard) Electronic calibration module reference manual Connector care quick reference card (part of reference manual) USB cable, 1.8 meter Storage case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1 1 1	8710-1766 5060-0370 85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85060-80018
Accessories Not Included		
Screw-on 7 mm pin depth gage 7 mm repair kit (includes collet extractor tool) 1/2 in to 9/16 in open-end wrench		85050-80012 11591A 8710-1770

Figure 5-1 7 mm Module and Accessories



Not Shown:

- ECal module reference guide
- Storage box
- USB cable

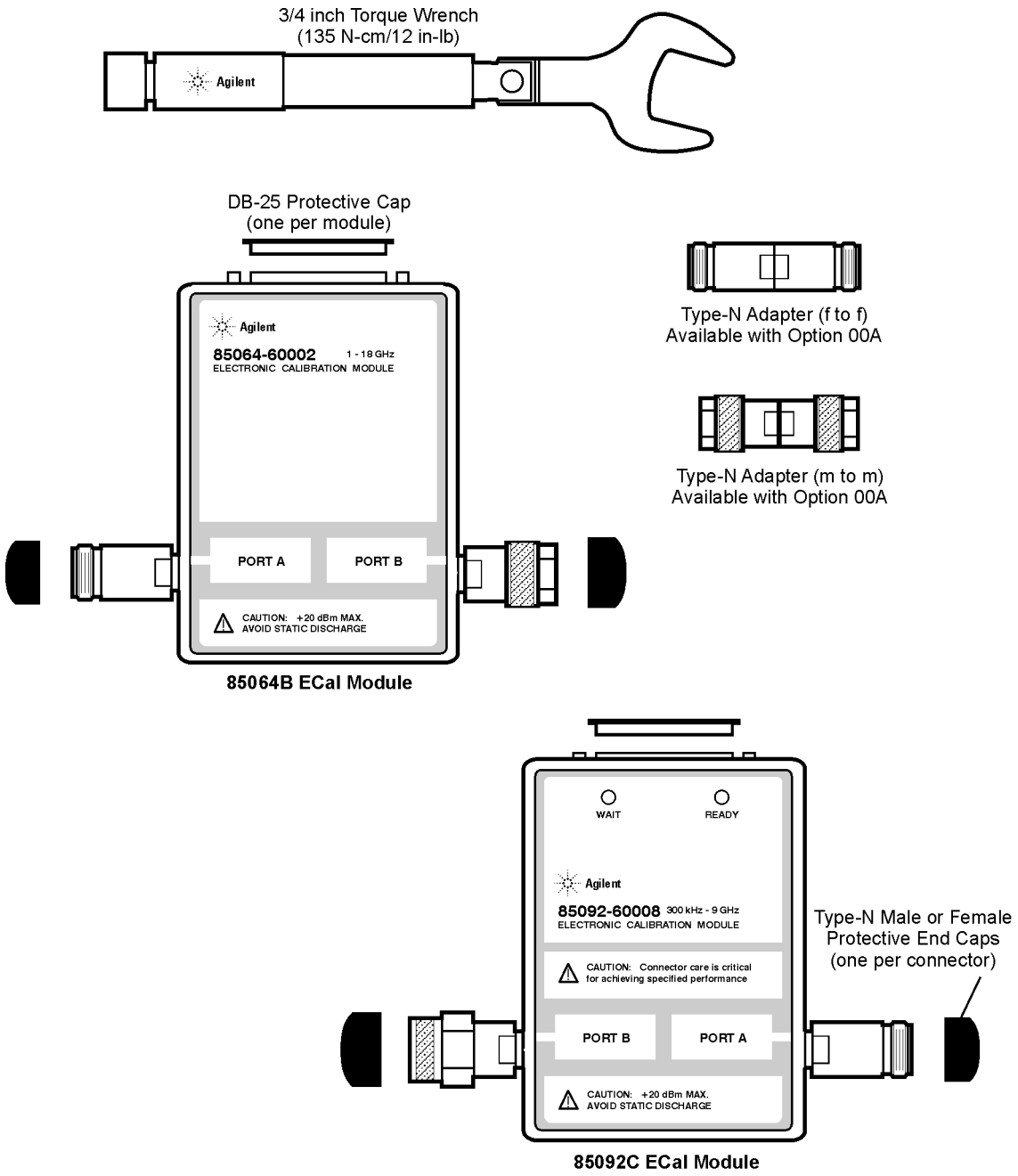
ku307c

Type-N (50 ohm) ECal Modules

Description	Qty	Part Number
85092C RF Modules		
Module with male/female connectors (Option M0F) Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85092-60008 85092-60009 85092-60010
N4431A RF Module (four-port)		
Module with four female connectors (Option 020)	1	N4431-60004
85064B Microwave Modules		
Module with male/female connectors (Option M0F)[a] Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85064-60002 85064-60004 85064-60006
Adapters (added with Option 00A)		
Type-N (50 Ω) female to female adapter Type-N (50 Ω) male to male adapter	1 1	85054-60037 85054-60038
Protective End Caps		
DB-25 multi-pin connector cap Type-N female connector cap Type-N male connector cap	1 1 1	1252-4690 1401-0247 1401-0248
Other		
3/4 in, 135 N-cm (12 in-lb) torque wrench (standard) Specification/Verification program disk (only with 8506x series) Electronic calibration module reference manual Connector care quick reference card (part of reference manual) USB cable A to B 1.8 meter (only 85064B Option 001, or 85092C) Storage Case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1 1 1	8710-1766 08510-10033 85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85060-80018
Items Not Included		
Screw-on type-N pin depth gage 1/2 in to 9/16 in open-ended wrench Type-N slotless contact repair kit Type-N slotless contacts (pkg. of 10) Type-N slotless contact (1 only)		85054-60049 8710-1770 85054-60056 85054-60057 85054-60058

a. Option M0F replaces standard module after June 1, 2002

Figure 5-2 Type-N (50 ohm) Modules and Accessories



Not Shown:

- ECal module reference guide
- Storage box
- Option 00F (female-to-female)
- Option 00M (male-to-male)
- USB cable

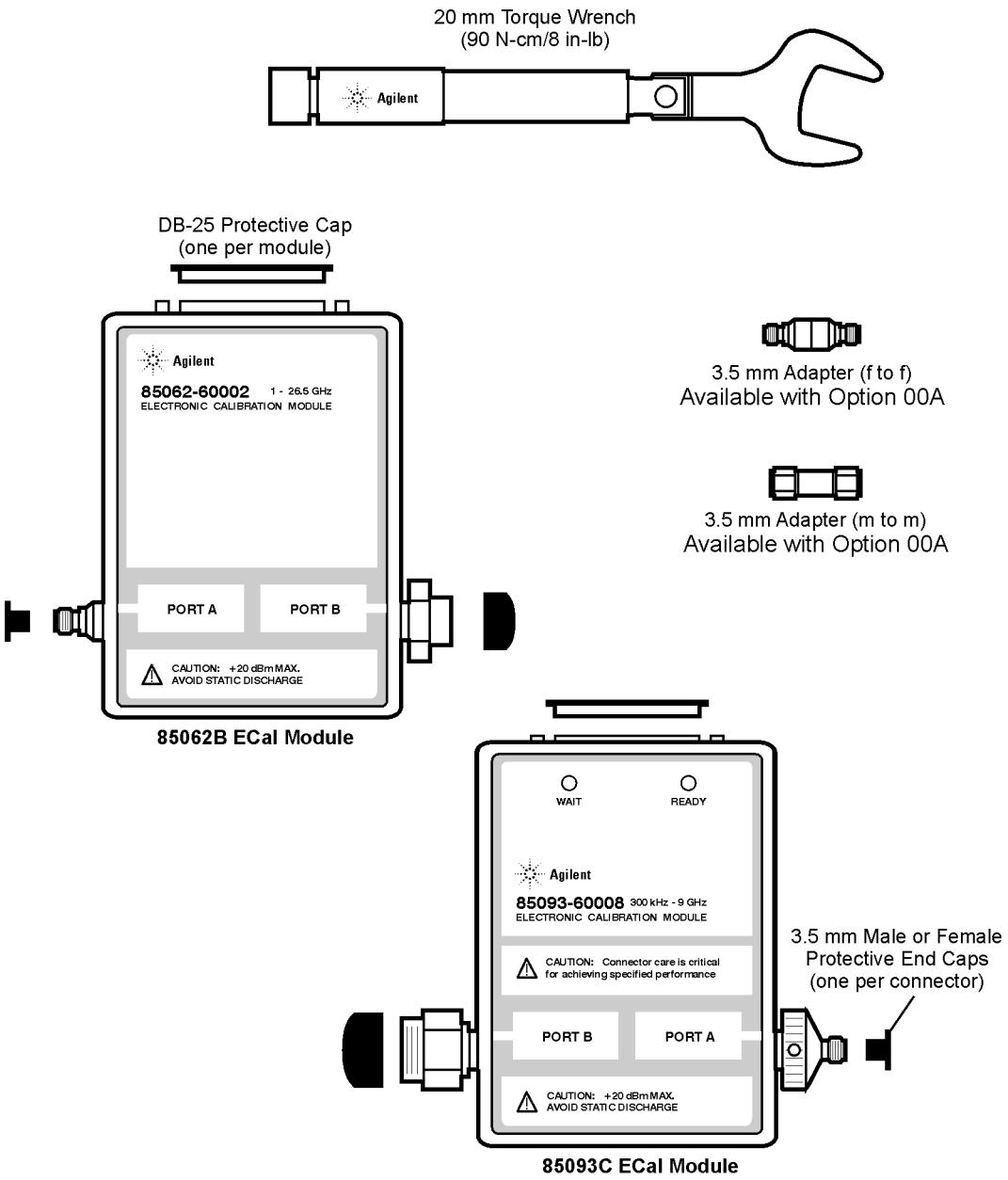
ku302c

3.5 mm ECal Modules

Description	Qty	Part Number
85093C RF Modules		
Module with male/female connectors (Option M0F) Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85093-60008 85093-60009 85093-60010
N4431A RF Module (four-port)		
Module with four female connectors (Option 010)	1	N4431-60003
85062B Microwave Modules		
Module with male/female connectors (Option M0F)[a] Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85062-60002 85062-60004 85062-60006
Adapters (added with Option 00A)		
3.5 mm female to female adapter 3.5 mm male to male adapter	1 1	85052-60012 85052-60014
Protective End Caps		
DB-25 multi-pin connector cap 3.5 mm female connector cap (for module and adapter) 3.5 mm male connector cap (for adapter) 3.5mm male connector cap (for module)	1 1 1 1	1252-4690 1401-0245 1401-0246 1401-0248
Other		
20 mm, 90 N-cm (8 in-lb) torque wrench (standard) 5/16 in, 90 N-cm (8 in-lb) torque wrench (added with Option 00A) Specification/Verification program disk (only with 8506x series) Electronic calibration module reference guide Connector care quick reference card (part of reference manual) USB cable, 1.8 meter Storage Case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1 1 1 1	8710-1764 8710-1765 08510-10033 85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85060-80018
Items Not Included		
Spanner wrench 3.5 mm repair kit with 10 contacts 3.5 mm slotless contacts (pkg. of 10) 3.5 mm slotless contact (1 only)		08513-20014 85052-60049 85052-60050 85052-60051

a. Option M0F replaces standard module after June 1, 2002

Figure 5-3 3.5 mm Modules and Accessories



Not Shown:

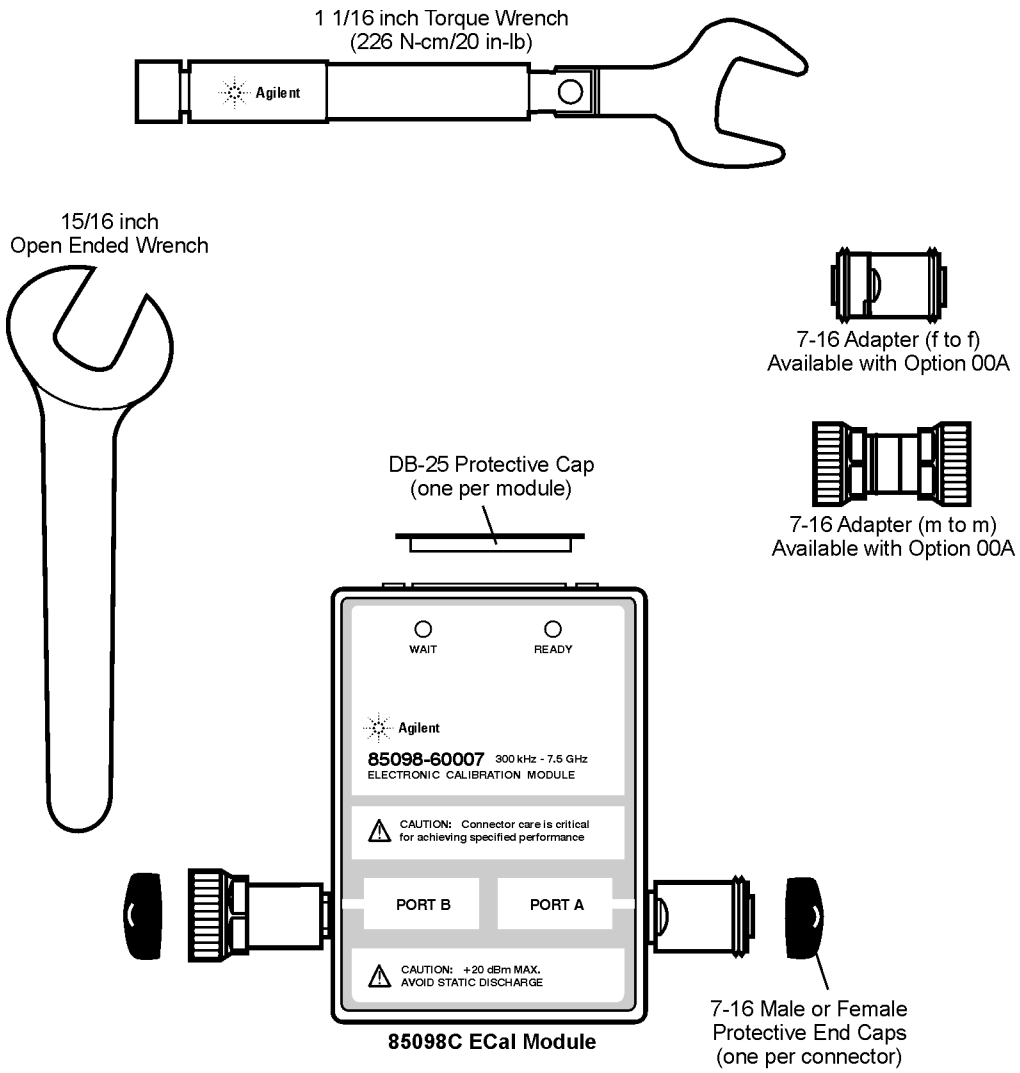
- ECal module reference guide
- Storage box
- Option 00F (female-to-female)
- Option 00M (male-to-male)
- USB cable

ku304c

7-16 ECal Modules

Description	Qty	Part Number
85098C RF Modules		
Module with male/female connectors (Option M0F) Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85098-60007 85098-60008 85098-60009
Adapters (added with Option 00A)		
7-16 female to female adapter 7-16 male to male adapter	1 1	11906-80016 11906-80015
Protective End Caps		
DB-25 multi-pin connector cap 7-16 male connector cap 7-16 female connector cap	1 1 1	1252-4690 1401-0417 1401-0418
Other		
1-1/16 in, 226 N-cm (20 in-lb) torque wrench (standard) 15/16 in open-ended wrench (standard) Electronic calibration module reference manual Connector care quick reference card (part of reference manual) USB Cable, 1.8 meter Storage Case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1 1 1	8710-2175 8710-2174 85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85091-80006

Figure 5-4 7-16 Module and Accessories



Not Shown:

- ECal module reference guide
- Storage box
- Option 00F (female-to-female)
- Option 00M (male-to-male)
- USB cable

ku306c

Type-N (75 ohm) ECal Modules

Description	Qty	Part Number
85096C RF Modules		
Module with male/female connectors (Option M0F) Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85096-60007 85096-60008 85096-60009
Adapters (added with Option 00A)		
Type-N (75 Ω) female to female adapter Type-N (75 Ω) male to male adapter	1 1	85036-60014 85036-60013
Protective End Caps		
DB-25 multi-pin connector cap Type-N male connector cap Type-N female connector cap	1 1 1	1252-4690 1401-0248 1401-0247
Other		
Electronic calibration module reference manual Connector care quick reference card (part of reference manual) USB cable, 1.8 meters Storage Case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1	85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85091-80006

Type-F ECal Modules

Description	Qty	Part Number
85099C RF Modules		
Module with male/female connectors (Option M0F) Module with male/male connectors (Option 00M) Module with female/female connectors (Option 00F)	1 1 1	85099-60009 85099-60010 85099-60011
Adapters (added with Option 00A)		
Type-F female to female adapter Type-F male to male adapter	1 1	85039-60002 85039-60006
Protective End Caps		
DB-25 multi-pin connector cap Type-F male connector cap Type-F female connector cap	1 1 1	1252-4690 1401-0297 1401-0296
Other		
Type-F wrench (standard) Electronic calibration module reference manual Connector care quick reference card (part of reference manual) USB cable, 1.8 meters Storage Case Protective foam (top) Protective foam (bottom)	1 1 1 1 1 1 1	8710-1841 85091-90009 08510-90360 8121-0506 5181-5771 85091-80005 85091-80007

Other Accessories

Description	Qty	Part Number
85097B ECal VNA Interface Kit		
Interface Unit Shielded DB25 Cables Power Supply Reference Guide Quick Reference Card	1 3 1 1 1	85097-60002 8120-8710 0950-3331 85091-90010 85091-90011
Cleaning Supplies		
Compressed air (235 ml)	1	8500-6659
99.5% isopropyl alcohol (8 oz)	1	8500-0559
99.5% isopropyl alcohol (30 ml)	1	8500-5344
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	9300-1126

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