

Keysight 346A/B/C Noise Source (Including Options 001 and 004)

Instruments with serial prefixes 4124A and above are supplied with the noise source ENR data preloaded on a diskette - see Chapters 3 and 4.

Instruments with serial prefixes MY5823 and above are supplied with the noise source ENR data preloaded on a CD - see Chapters 3 and 4.

Notices

Copyright Notice

© Keysight Technologies 2001 - 2018

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies as governed by United States and international copyright laws.

Manual Part Number

00346-90148

Edition

Edition 4, July 26, 2018

Printed in:

Printed in Malaysia

Published by:

Keysight Technologies
Bayan Lepas Free Industrial Zone,
11900 Penang, Malaysia

Technology Licenses

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

Declaration of Conformity

Declarations of Conformity for this product and for other Keysight products may be downloaded from the Web. Go to <http://www.keysight.com/go/conformity>. You can then search by product number to find the latest Declaration of Conformity.

U.S. Government Rights

The Software is "commercial computer software," as defined by Federal Acquisition Regulation ("FAR") 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement ("DFARS") 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at <http://www.keysight.com/find/sweula>. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR FOR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT SHALL CONTROL.

Safety Information

CAUTION

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

WARNING

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

Environmental Conditions

The instrument is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental condition	Requirement
Temperature	Operating condition
	– 0 °C to 55 °C
	Storage/shipment condition
	– –55 °C to 75 °C
Humidity	<95% RH
Altitude	Operating condition
	– <4600 m (15000 ft)
	Storage/shipment condition
	– <15300 m (50000 ft)

Safety Symbols

The following symbols on the instrument and in the manual indicate precautions which must be taken to maintain safe operation of the instrument.

 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 supplied documentation.	 This symbol indicates that a device, or part of a device, may be susceptible to electrostatic discharges (ESD) which can result in damage to the product. Observe ESD precautions given on the product, or its user documentation, when handling equipment bearing this mark.
---	--

Regulatory Information

The 346A/B/C Noise Source (including Options 001 and 004) complies with the following Electromagnetic Compatibility (EMC) compliances:

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

In order to preserve the EMC performance of the product, any cable which becomes worn or damaged must be replaced with the same type and specification.

Regulatory markings

 The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.	 ICES/NMB-001 indicates that this ISM product complies with the Canadian ICES-001. Cet appareil ISM est conforme à la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.
 The RCM mark is a registered trademark of the Australian Communications and Media Authority.	 This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
 This instrument is Class A suitable for professional use and is for use in electromagnetic environments outside of the home. A급 기기 (업무용 방송통신기자재) 이 기기는 업무용(A급) 전자파적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정외의 지역에서 사용하는 것을 목적으로 합니다.	 This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

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

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

Product category

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is as shown below.



Do not dispose in domestic household waste.

To return this unwanted instrument, contact your nearest Keysight Service Center, or visit <http://about.keysight.com/en/companyinfo/environment/takeback.shtml> for more information.

Sales and Technical Support

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

- www.keysight.com/find/mta
(product-specific information and support, software and documentation updates)
- www.keysight.com/find/assist
(worldwide contact information for repair and service)

Table of Contents

Environmental Conditions	3
Safety Symbols	4
Regulatory Information	5
Regulatory markings	5
Waste Electrical and Electronic Equipment (WEEE) Directive 2002/96/EC	6
Product category	6
Sales and Technical Support	6
1 Introduction	
Product Overview	16
2 Installation	
Handling Precautions	20
Initial Inspection	20
Service and Recalibration	21
Instruments Covered by this Manual	21
Equipment available but not supplied	22
Options	22
Mating connectors	23
3 Specifications	
General Specifications	26
Specifications	26
Excess Noise Ratio expanded uncertainty (U(Y))	27
Supplemental characteristics	29
Physical specifications	29
4 Operating Guide	
Operating Instructions	32
Recommended test equipment	33

Operator's check	33
Operator's Maintenance	39
Performance Tests	40
Adjustments	40
Replaceable Parts	40
Service	43
Principles of operation	43
Troubleshooting	43
Repair	43
Returning the noise source for calibration	44
5 Manual Changes	
Manual Changes	46
Change A	46
6 Using the ENR Data Diskette or CD	
Introduction	48
Loading ENR Data from Diskette	49
Retrieving ENR Data from CD	50
Saving the ENR Data to the Noise Figure Analyzer's Internal Memory	51
Copying the ENR Data to the Noise Figure Analyzer's Internal Memory	53
7 ENR File Format	
Format Details	56
Comment records	56
Header fields	56
ENR data	58
Examples	61
Example 1	61
Example 2	62
A Caring for Connectors	

Introduction	66
Connector part numbers	66
Handling and storage	66
Visual Inspection	67
Obvious defects and damage	67
Mating plane surfaces	67
Precision 7 mm connectors	68
Sexed connectors	69
Cleaning	70
Compressed air	70
Cleaning alcohol	70
Precision 7 mm connectors	71
Cleaning interior surfaces	71
Drying connectors	72
Mechanical Inspection: Connector Gages	73
Mechanical Specifications	74
Precision 7 mm connectors	74
Sexed connectors	75
50 Ω Type-N connectors	75
75 Ω Type-N connectors	76
Using Connector Gages	77
Inspecting and cleaning the gage	77
Zeroing the gage	77
Measuring connectors	78
Making Connections	80
Align connectors carefully	80
To make a preliminary connection	81
Final connection using a torque wrench	81
Disconnection	83
Adapters	84
Principles of Microwave Connector Care	86

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

List of Figures

Figure 1-1	A partial view of typical calibration label	16
Figure 3-1	Characteristic ENR plot versus cardinal frequency points	28
Figure 4-1	Typical noise figure measurement test setup	32
Figure 4-2	Operator's check test setup 1	34
Figure 4-3	Operator's check test setup 2a	35
Figure 4-4	Operator's check test setup 2b	36
Figure 4-5	Typical example of power reading with Noise Source On	37
Figure 4-6	Typical example of power reading with Noise Source Off	38
Figure 4-7	Preparing for parts removal/replacement	42
Figure 4-8	Simplified diagram of the noise source	43
Figure A-1	Precision 7 mm connector	68
Figure A-2	Precision 3.5 mm connectors	69
Figure A-3	SMA connectors	69
Figure A-4	Cleaning interior surfaces	72
Figure A-5	Type-N connectors	75
Figure A-6	Using the connector gage	78

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

List of Tables

Table 1-1	Model characteristics of individual noise sources	17
Table 2-1	Connectors that can be mated with the noise sources	23
Table 3-1	346A/B/C specifications	26
Table 3-2	Characteristic ENR (U(Y)) specification	28
Table 3-3	Supplemental characteristics	29
Table 3-4	Physical specifications	29
Table 4-1	Recommended test equipment for operator's checks	33
Table 4-2	Replaceable parts list for 346A	41
Table 4-3	Replaceable parts list for 346B and 346C	41
Table 4-4	Replaceable labels list	41
Table 5-1	Manual changes by serial number	46
Table 7-1	Mandatory header fields	57
Table 7-2	Optional header fields	57
Table A-1	Recommended connector gages	73
Table A-2	Recommended torque settings	82
Table A-3	Adapters	85
Table A-4	Principles of microwave connector care	86

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

1 Introduction

Product Overview 16

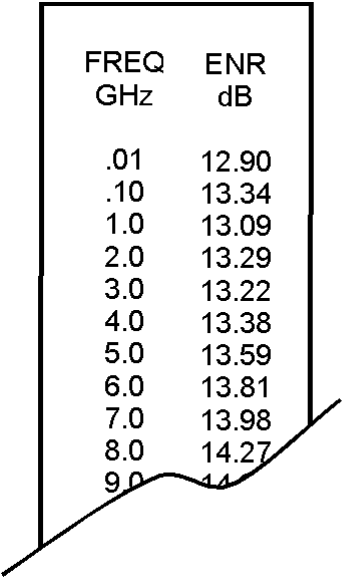
This chapter provides an overview of the Keysight 346A/B/C Noise Source.

Product Overview

The Keysight 346A/B/C noise source produces noise output (power-on) when +28 V is applied. When it is off, there is residual noise due to thermal agitation in the noise source (power-off). These two noise levels are used to measure the gain and added noise of the device under test, and consequently, its noise figure.

The Excess Noise Ratio (ENR) for each noise source has been measured at major frequencies and recorded on a label attached to the noise source (see [Figure 1-1](#)). ENR references power-on to the noise power that exists at 290 Kelvin (17 °C). In addition, a separate calibration sheet showing the complex reflection coefficient in both the on and off states is included with each instrument.

All three models are provided with a BNC female connector for power input. The output connector is a male APC-3.5 on the standard noise sources. Type-N connectors are available as options for the Keysight 346A and 346B noise sources. In addition to these general characteristics, certain characteristics apply to the specific models. These characteristics are listed in [Table 1-1](#).



FREQ GHz	ENR dB
.01	12.90
.10	13.34
1.0	13.09
2.0	13.29
3.0	13.22
4.0	13.38
5.0	13.59
6.0	13.81
7.0	13.98
8.0	14.27
9.0	14.4

Figure 1-1 A partial view of typical calibration label

Table 1-1 Model characteristics of individual noise sources

Keysight 346A	Keysight 346B	Keysight 346C
Reflection coefficient differential between on and off states is specified to be no greater than 0.01.	Reflection coefficient differential between on and off states is not specified, but is less than 0.1 typically.	Reflection coefficient differential between on and off states is not specified, but is less than 0.1 typically.
Specified output noise spectrum from 10 MHz to 18 GHz.	Specified output noise spectrum from 10 MHz to 18 GHz.	Specified output noise spectrum from 10 MHz to 26.5 GHz.
Nominal ENR is 6 dB over the specified frequency range.	Nominal ENR is 15 dB over the specified frequency range.	Nominal ENR is 15 dB over the specified frequency range.
Not directly usable for Keysight 8970A IF attenuator calibration (Special Function 33). 10 dB of gain is required.	Suitable for Keysight 8970A IF attenuator calibration (Special Function 33).	Suitable for Keysight 8970A IF attenuator calibration (Special Function 33).
Not directly usable for Keysight 8970B IF attenuator calibration. Refer to “Calibration, IF Attenuators” in the <i>Keysight 8970B Operating Manual</i> .	Suitable for Keysight 8970B IF attenuator calibration. Refer to “Calibration, IF Attenuators” in the <i>Keysight 8970B Operating Manual</i> .	Suitable for Keysight 8970B IF attenuator calibration. Refer to “Calibration, IF Attenuators” in the <i>Keysight 8970B Operating Manual</i> .

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

2 Installation

Handling Precautions	20
Initial Inspection	20
Service and Recalibration	21
Instruments Covered by this Manual	21

This chapter provides you important information on how to check and prepare your instrument for operation.

Handling Precautions

CAUTION

Do not disassemble the noise source. The diode module is static sensitive and can be damaged or the calibration can be altered.

CAUTION

Do not drop the noise source. Dropping can damage the unit or alter the calibration.

Proper connector care is essential. See “[Operator's Maintenance](#)” on page 39 for more information.

Initial Inspection

- 1 Unpack and inspect the shipping container and its contents thoroughly to ensure that nothing was damaged during shipment. If the shipping container or cushioning material is damaged, the contents should be checked both mechanically and electrically.
 - Check for mechanical damage such as scratches or dents.
 - Procedures for checking electrical performance are given under “[Operator's check](#)” on page 33.
- 2 If the contents are damaged or defective, contact your nearest Keysight Technologies Service and Support Office. Refer to “[Sales and Technical Support](#)” on page 6 of this manual. Keysight Technologies will arrange for repair or replacement of the damaged or defective equipment. Keep the shipping materials for the carrier's inspection.
- 3 If you are returning the instrument under warranty or for service, repackaging the instrument requires original shipping containers and material or their equivalents. Keysight Technologies can provide packaging materials identical to the original materials. Refer to “[Sales and Technical Support](#)” on page 6 of this manual for the Keysight Technologies nearest to you. Attach a tag indicating the type of service required, return address, model number, and serial number. Mark the container **FRAGILE** to insure careful handling. In any correspondence, refer to the instrument by model number and serial number.

Service and Recalibration

If your 346A/B/C requires service or repair, contact the nearest Keysight office for information on where to send it. The performance of the 346A/B/C can only be verified by specially-manufactured equipment and calibration standard from Keysight. The recommended interval for recalibration is 12 months.

Instruments Covered by this Manual

The noise sources covered by this manual have a two-part serial number. The first four digits and letter constitute the serial number prefix. The last five digits form a sequential suffix that is unique to each noise source. The prefix is the same for all noise sources of a particular configuration. It will change when a design modification occurs. The contents of this manual apply directly to those instruments having the same serial number prefixes listed on the title page.

A noise source manufactured after the printing of this manual may have a serial number prefix which is not listed on the title page. This unlisted serial number prefix indicates the noise source is different than those documented in this manual. If manual changes are needed, the manual for this newer noise source is accompanied by a *Manual Changes* supplement. The supplement contains “change information” that explains how to adapt this manual to the newer noise source.

In addition to change information, the supplement may contain information for correcting errors in the manual. The supplement is identified with the manual print date and part number, both of which appear on the manual title page.

For information concerning a serial number prefix that is not listed on the title page in the Manual Change supplement, contact your nearest Keysight Technologies office.

Keysight 346A/B/C Noise Source which was manufactured before the printing of this manual will have a serial number prefix lower than the one listed on the title page. Manual changes for these older models are found in [Chapter 5, “Manual Changes”](#).

NOTE

Keysight Technologies are migrating their existing product serial numbers to a new format. All new products use this new format. The format is the first two letters signify the country of manufacture, for example, US representing the USA, the next four numbers, the serial number prefix, and the last five numbers form a sequential suffix that is unique to each product. For example, US123456789, where 1234 is the prefix and 56789 is the suffix. The two letters MY represent Malaysia.

Equipment available but not supplied

The following equipment is available from Keysight Technologies for use with the noise sources:

- 8710-1766: 3/4" torque wrench (APC-7)
- 5060-0344: 9/16" torque wrench (APC-3.5)

NOTE

Keysight Model 346B Noise Sources with serial prefixes of 2037A and below, have an APC-3.5 connector of a different configuration. The 9/16" torque wrench will not fit these older models.

Options

The Keysight 346A and 346B Noise Sources are available with the following output connector options:

- Option 001, Type-N (male)
- Option 004, Type-N (female)

Since the Type-N connectors do not operate up to 26.5 GHz, no output connector options are available for the Keysight 346C.

Mating connectors

The noise sources can be mated with other instrumentation having the connectors listed in [Table 2-1](#).

Table 2-1 Connectors that can be mated with the noise sources

Configuration	Mating connector
Input: all units	BNC male ^[a]
Output: standard	– APC-3.5 female – SMA female
Opt 001	Type-N female ^[a]
Opt 004	Type-N male ^[a]

[a] Must comply with U.S. Military Standard MII,C-39012.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

3 Specifications

General Specifications 26

This chapter provides the specifications of the 346A/B/C Noise Source.

General Specifications

Specifications

The specifications in [Table 3-1](#) are performance standards or limits against which the noise source may be tested. These specifications for the noise source when used with a Noise Figure Analyzer are ONLY valid if the analyzer has been allowed to meet its specified warm up time of 60 minutes.

ENR expanded uncertainty analysis and supplemental characteristics are not specifications but are typical characteristics included as additional information.

Table 3-1 346A/B/C specifications

Specification	346A	346B	346C
Frequency range	10 MHz to 18 GHz	10 MHz to 18 GHz	10 MHz to 26.5 GHz
Operating temperature	0 °C to 55 °C	0 °C to 55 °C	0 °C to 55 °C
Excess Noise Ratio (ENR) range ^[a]	4.5 to 6.5 dB	14 to 16 dB	12 to 17 dB
Maximum Standing Wave Ratio (SWR) [for source ON/OFF states]	<1.3:1 (0.01 to 0.03 GHz) <1.15:1 (0.03 to 5.0 GHz) <1.25:1 (5.0 to 18.0 GHz)	<1.3:1 (0.01 to 0.03 GHz) <1.15:1 (0.03 to 5.0 GHz) <1.25:1 (5.0 to 18.0 GHz)	<1.25:1 (0.01 to 18.0 GHz) <1.35:1 (18.0 to 26.5 GHz)
Reflection Coefficient (Rho) (r) [for source ON/OFF states] ^[b]	0.13 (0.01 to 0.03 GHz) 0.07 (0.03 to 5.0 GHz) 0.11 (5.0 to 18.0 GHz)	0.13 (0.01 to 0.03 GHz) 0.07 (0.03 to 5.0 GHz) 0.11 (5.0 to 18.0 GHz)	0.11 (0.01 to 18.0 GHz) 0.15 (18.0 to 26.5 GHz)
Impedance	50 Ω nominal	50 Ω nominal	50 Ω nominal
Maximum reverse power	1 watt	1 watt	1 watt
Power required	28 $\pm$ 1 V (60 mA peak, 30 mA average for source ON)	28 $\pm$ 1 V (60 mA peak, 30 mA average for source ON)	28 $\pm$ 1 V (45 mA)
Connectors ^[c]	Output: APC-3.5 (male) standard ^[d] Input: Bias: BNC (f)	Output: APC-3.5 (male) standard ^[d] Input: Bias: BNC (f)	Output: APC-3.5 (male) standard ^[d] Input: Bias: BNC (f)

- [a] ENR values are given at cardinal frequency points over the frequency range of each noise source. Calibrated values at cardinal frequencies printed on each noise source label and on a separate report supplied with each Keysight 346A/B/C Noise Source. Specifications are valid at calibration temperature only.
- [b] Maximum change in complex reflection coefficient between source ON and source OFF at all frequencies for 346A only: 0.01.
- [c] For correct connector usage, refer [Table A-2](#) for the torque settings.
- [d] Also mates with female SMA connectors. See option information for other connector styles.

Excess Noise Ratio expanded uncertainty (U(Y))

ENR values are given at cardinal frequency points over the frequency range of each noise source. These ENR values are printed on the noise source label and on a separate printed report supplied with the 346A/B/C Noise Source. Included in the printed report is the measurement uncertainty for each cardinal frequency point.

A significant proportion of the expanded uncertainty (U(Y)) is based on the uncertainties provided by the United States National Institute of Standards and Technology (NIST) and/or The United Kingdom National Physics Laboratories (NPL). Keysight therefore reserve the right to change the overall expanded uncertainties based on changes in uncertainty values within the National Standards Institutes.

Uncertainties are valid at the ambient temperature of $23\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ (296 K) only.

A typical characteristic plot of ENR (U(Y)) versus each cardinal frequency point is shown in [Figure 3-1](#). The uncertainties given are typical – refer to the printed calibration report for the actual uncertainties for your noise source.

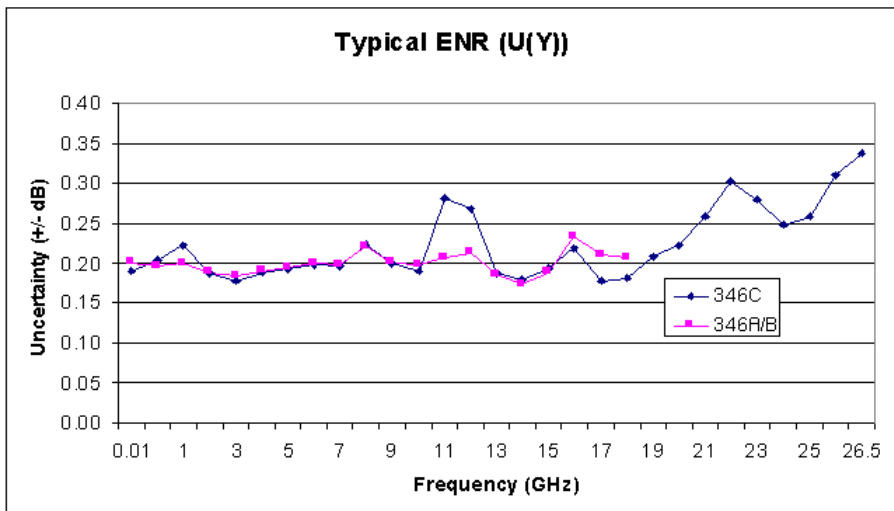


Figure 3-1 Characteristic^[1] ENR plot versus cardinal frequency points

Table 3-2 Characteristic ENR (U(Y)) specification

Specification	346A	346B	346C
ENR uncertainty (±dB) ^[a]	0.21 (0.01 to 1.5 GHz)	0.20 (0.01 to 1.5 GHz)	0.22 (0.01 to 1.5 GHz)
	0.20 (1.5 to 3.0 GHz)	0.19 (1.5 to 3.0 GHz)	0.19 (1.5 to 3.0 GHz)
	0.20 (3.0 to 7.0 GHz)	0.20 (3.0 to 7.0 GHz)	0.20 (3.0 to 7.0 GHz)
	0.23 (7.0 to 18.0 GHz)	0.23 (7.0 to 18.0 GHz)	0.28 (7.0 to 18.0 GHz)
			0.34 (18.0 to 26.5 GHz)

[a] Characteristic values are met or bettered by 90% of instruments with 90% confidence.

[1] Characteristic values are met or bettered by 90% of instruments with 90% confidence.

Supplemental characteristics

Table 3-3 Supplemental characteristics

Characteristic	346A/B/C
ENR variation with temperature	<0.01 dB/°C for 30 MHz to 26.5 GHz
ENR variation with voltage	Internal current regulator for <0.02 dB variation for 28 ±1 V
Switching speed	For repetitive operation (in previous state for less than 5 seconds): – Turn-on: < 20 μs – Turn-off: <80 μs
	For single-shot operation (in previous state more than 5 seconds): – Turn-on: < 3 ms – Turn-off: <80 μs

Physical specifications

Table 3-4 Physical specifications

Specifications	346A/B/C
Net weight	0.1 kg (3.5 oz.)
Dimensions	140 × 21 × 31mm (5.5 × 0.8 × 1.2 in)

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

4 Operating Guide

Operating Instructions	32
Operator's Maintenance	39
Performance Tests	40
Adjustments	40
Replaceable Parts	40
Service	43

This chapter provides simple quick-check instructions to verify the 346A/B/C noise source's functionality prior to usage. It also provides information on service and maintenance of the 346A/B/C.

Operating Instructions

This section refers to operation with noise figure meters. For more detailed operating instructions, refer to the operating manual for the noise figure meter used.

CAUTION

Use a DC blocking capacitor to protect the noise source from damage when connected to any system where a DC voltage is present on the output center conductor.

Noise figure measurements of devices (such as amplifiers, mixers, transistors, and receivers) can be made using the noise source with a noise figure meter.

Figure 4-1 depicts a simple test setup for a noise figure measurement.

NOTE

The noise figure meter must have a $+28 \pm 1$ V switch supply.

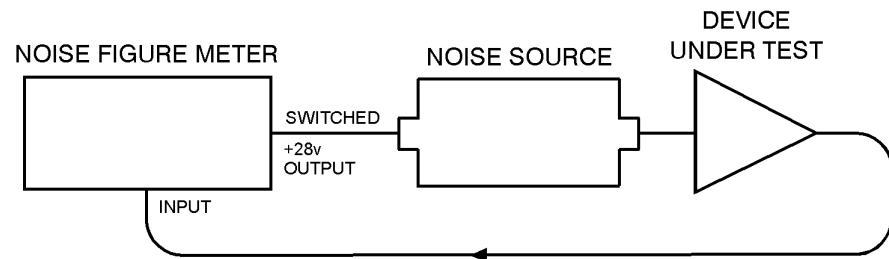


Figure 4-1 Typical noise figure measurement test setup

Recommended test equipment

Table 4-1 is a list of equipment that can be used to perform an operational verification check.

Table 4-1 Recommended test equipment for operator's checks

Check no.	Instrument	Critical specification	Recommended model
1	Power meter and power sensor	– Minimum sensitivity: 0.1 nW – Frequency range: 10 MHz to 18 GHz	Keysight E4418A with Keysight 8481D, or E4412A, or E9300A
	Power supply	– Voltage: 28.0 ± 1.0 V – Current: 100 mA	Keysight 6028A
2	Noise figure meter	– Voltage output: 28.0 ± 1.0 V – Input noise figure: <7.4 FdB at 100 MHz	Keysight 8970B or Keysight N8972/3/4/5A

Operator's check

The operator's checks in this section should be performed if failure of the noise source is suspected. The checks can be used only to verify that the noise sources are producing a broadband noise spectrum. They cannot be used to check the units against specifications. Only one of the checks is necessary to verify operation. **Table 4-1** shows the recommended test equipment used for each check.

Operator's check with power meter (Check 1)

- 1 Connect the equipment as shown in **Figure 4-2**.

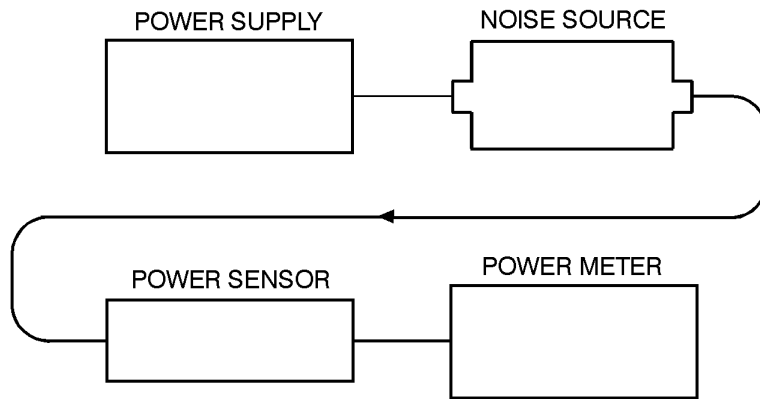


Figure 4-2 Operator's check test setup 1

- 2 Turn the power supply OFF. Zero the power meter.
- 3 Turn the power supply ON (+28 V). Measure the power output with the noise source on.
- 4 Verify that the result of the measurement is within the following limits and hence the noise source is operating correctly:
 - Keysight 346A power output: -66 ± 4 dBm
 - Keysight 346B power output: -56 ± 4 dBm
 - Keysight 346C power output: -56 ± 4 dBm

Operator's check with Keysight 8970B noise figure meter (Check 2a)

- 1 Remove any cables from the noise figure meter input. Press **PRESET**. After 5 seconds, verify that the noise figure display shows **--FdB** and the left display shows **30 MHz**.
- 2 Connect the equipment as shown in [Figure 4-3](#).

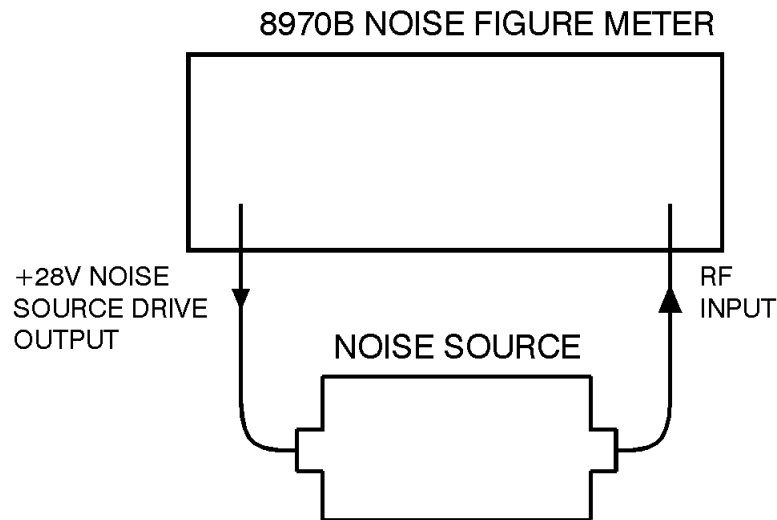


Figure 4-3 Operator's check test setup 2a

- 3** Enter a tuned frequency of 100 MHz. (See "Fixed Frequency Tuning" in the *Keysight 8970B Operating Manual*.)
- 4** Enter special function 5.3 to enable the instrument for spot ENR entry. (See "Special Functions" in the *Keysight 8970B Operating Manual*.)
- 5** Enter the ENR at 100 MHz from the noise source calibration label. (See "Spot ENR, T_{hot} , and T_{Cold} ", in the *Keysight 8970B Operating Manual*.)
- 6** Confirm that the noise source is operating correctly.
The noise figure measurement of the noise figure meter will appear in the noise figure display. If the result of the measurement is less than **7.4 FdB**, the noise source is operating.
- 7** Press **PRESET** to return the instrument to preset conditions.

Operator's check with Keysight N8972/3/4/5AB noise figure analyzer (Check 2b)

- 1 Remove any cables from the NFA input and the noise source drive.
- 2 Press the **Preset** key.
Wait until the preset routine has completed before proceeding.

NOTE

The preset condition used is the NFA default of **Preset (Factory)**.

- 3 Connect the 346A/B/C to the NFA Input port using a BNC cable, as shown in Figure 4-4.



Figure 4-4 Operator's check test setup 2b

- 4 Press the **ENR** key.
- 5 Press the **ENR Table** menu key.
- 6 Press the **Edit Table** menu key.
- 7 Press the **Clear Table** menu key.
- 8 Enter 100 MHz in the Frequency column of the table: Press **1, 0, 0** on the numeric keypad followed by the **MHz** menu key.

- 9 Press the **Tab** key to highlight the ENR Value column of the table.
- 10 Enter the ENR value of the 346A/B/C at 100 MHz (0.1 GHz) using the numeric keypad followed by the **dB** menu key.
- 11 Press the **Frequency/Points** key.
- 12 Press the **Frequency Mode** menu key.
- 13 Press the **Fixed** menu key.
- 14 Press the **Fixed Frequency** menu key.
Enter 100 MHz as a fixed frequency value, by pressing the **1, 0, 0** numeric keys followed by pressing the **MHz** menu key.
- 15 Press the **Sweep** key.
- 16 Press the **Manual Meas** menu key.
- 17 Press the **Manual State** menu key and set it to **Manual State (On)**.
- 18 Press the **Noise Source** menu key and set it to **Noise Source (On)**.
- 19 Press the **IF Att** menu key and set it to **IF Att (Hold)**.
- 20 Monitor the power value which appears in the manual measurement screen.
Figure 4-5 shows a typical example of this.

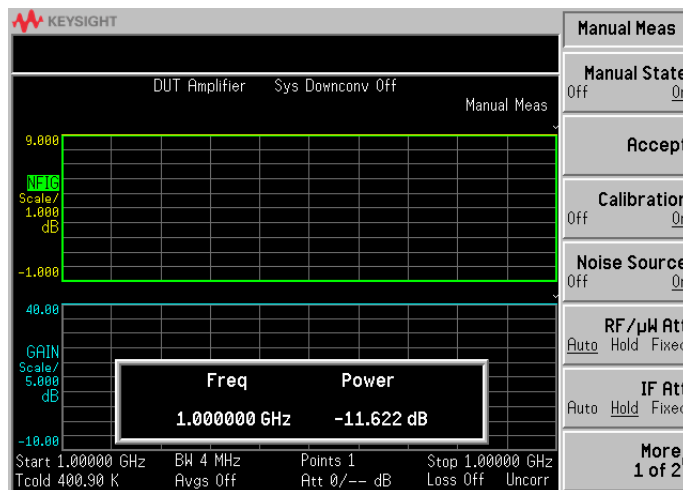


Figure 4-5 Typical example of power reading with Noise Source On

- 21** Press the **Noise Source** menu key and set it to **Noise Source (Off)**.
- 22** Monitor the power value which appears in the manual measurement screen.
Figure 4-6 shows a typical example of this.

NOTE

The monitored value is only to be used to indicate if the 346A/B/C is switching the Excess Noise “On” and “Off” by showing a change in power value.

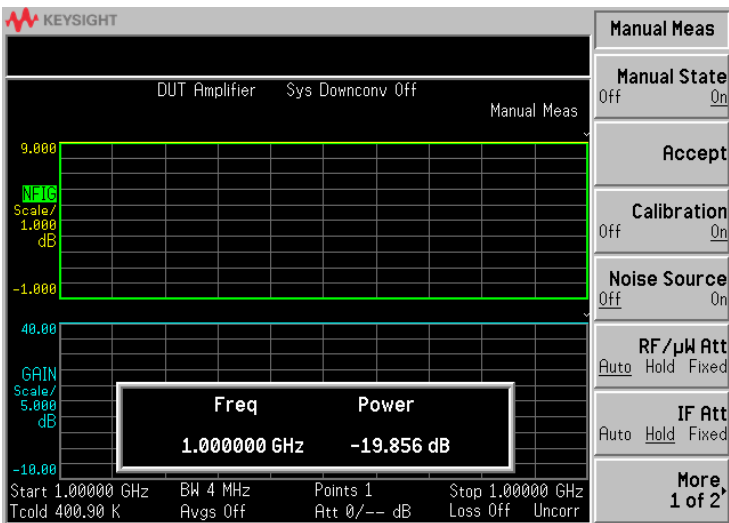


Figure 4-6 Typical example of power reading with Noise Source Off

- 23** If there is no change in value, return the 346A/B/C to Keysight Technologies for repair.

Operator's Maintenance

Proper connector care is a vital part of the maintenance which you should perform. By following the general connector care practices outlined below, the life of the connector can be greatly extended.

- Connectors should be properly torqued as shown below.

Connector type	Torque specifications
N	1.3 N m (12 in.-lb.)
APC-7	1.3 N m (12 in.-lb.)
SMA to APC-3.5	0.9 N m (8 in.-lb.)
APC-3.5 to APC-3.5	0.9 N m (8 in.-lb.)

- Always tighten or loosen a connector by rotating only the nut. Never rotate the noise source body.
- Use isopropyl or ethyl alcohol on a swab to clean connectors. Absorbent, lint-free paper wrapped around the end of tweezers is recommended. Carefully clean the conductive surfaces and avoid wetting the plastic parts inside the connector with alcohol. After cleaning, be sure the connector is blown dry before re-assembly.
- It is good practice to inspect a connector after cleaning. During the inspection, check for contaminants and worn plating. Also check for a misaligned center conductor or spread fingers on the APC-3.5 or Type-N connectors.
- Support the cable or component attached to the connector.
- When using APC-7 connectors, the nut of one connector should always be backed off completely and the nut on the mating connector should be tightened. Never set an APC-7 connector on its mating surface. Before storage, always screw the nut out to protect the surfaces.
- Be sure the connectors are axially aligned before the nut is tightened.
- Use a connector gage periodically to check the center pin depth. The shoulder of the center conductor must never extend beyond the plane of the outer conductor mating surface in an APC-3.5 connector.
- For more information, refer to [“Appendix A: Caring for Connectors”](#) on page 65.

Performance Tests

Due to the complex test equipment involved, there are no recommended performance tests to perform. Return the noise sources to Keysight Technologies when tests are required to verify its performance and for periodic re-calibration. The suggested interval before initial re-calibration is one year.

Adjustments

There are no adjustments that can be made on the noise sources.

Replaceable Parts

Table 4-2 and Table 4-3 list all replaceable parts available for the Keysight 346A/B/C noise source. Figure 4-7 shows a typical noise source being prepared for parts replacement at modular level by removing the four end screws (two at each end).

NOTE

- If the 346A/B/C is opened and parts are replaced, the noise source will require calibration.
- Due to a parts change, adjustment of the bias current may be necessary for the noise source to meet its ENR specifications when parts are replaced in older units. *Installation Note 00346-90137* details the adjustment process for the 346A and 346B. *Installation Note 00346-90140* details the adjustment process for the 346C. Both are supplied with their appropriate replacement parts.

To order parts, contact your local Keysight Sales and Service Office. Refer to “Sales and Technical Support” on page 6 of this manual.

Table 4-2 Replaceable parts list for 346A

Model/Option	Keysight part number				
	Bulkhead RF	Noise cartridge kit (serial prefix ≤ MY/SG/US5322)	Noise cartridge (serial prefix ≥ MY/SG/US5323)	Attenuator kit	PC board
346A Std	00346-60168	00346-60194	00346-60193	00346-60194	00346-60157
– Option 001	00346-60169	00346-60194	00346-60193	00346-60194	00346-60157
– Option 004	00346-60171	00346-60194	00346-60193	00346-60194	00346-60157

Table 4-3 Replaceable parts list for 346B and 346C

Model/Option	Keysight part number			
	Bulkhead RF replacement	Replacement noise cartridge assembly	Replacement attenuator assembly	Replacement PC board assembly
346B Std	00346-60026	00346-60154	00346-60027	00346-60157
– Option 001	00346-60018	00346-60154	00346-60027	00346-60157
– Option 004	00346-60020	00346-60154	00346-60027	00346-60157
346C Std	00346-60021	00346-60155	00346-60027	00346-60158

Table 4-4 Replaceable labels list

Part number	Label description
00346-80006	346A label caution
00346-80007	346B label caution
00346-80008	346C label noise
00346-80012	Label - Blank ENR



Figure 4-7 Preparing for parts removal/replacement

Service

Principles of operation

Figure 4-8 shows a simplified diagram of the noise source. When driven by a +28 V pulse, the 346A/B/C produces an output noise spectrum with an ENR of approximately 5.0 dB for the 346A and approximately 15.0 dB for the 346B and 346C. The noise generator is an avalanche diode positioned into a 50 Ω system. The noise source is divided into a DC section including a voltage converter and a current regulator, and an RF section which includes the noise generator, a matching network and an attenuator.

The +28 V supplies a 5.6 kHz oscillator which is rectified as the supply for the constant current source to produce a controlled noise level output. The current regulator controls through the noise generator diode producing a known level of broadband noise that is constant for a supply voltage of 27 to 29 V.

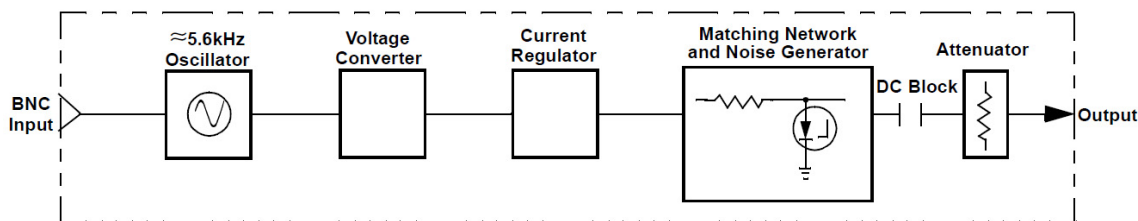


Figure 4-8 Simplified diagram of the noise source

Troubleshooting

Check the connectors. If there is no apparent damage to the connectors, perform one of the operator's checks described in the [Operating Instructions](#) section of this manual. If the noise source's output does not fall within the stated range, or if the connectors are damaged, return the unit to Keysight Technologies for repair.

Repair

Repair by the user is not recommended because of the complex equipment required for test and calibration.

Returning the noise source for calibration

When returning the 346A/B/C to Keysight Technologies for repair or calibration, please specify whether an ENR Data Diskette or CD is needed.

Instruments with serial prefixes MY5823 will only be provided with ENR DATA CD if requested.

When the 346A/B/C is used with a Keysight Noise Figure Analyzer NFA, the ENR Data Diskette is used to automatically load the ENR values into memory.

When the 346A/B/C is used with an 8970A/B Noise Figure Meter, you must enter the ENR values manually, and the ENR Data Diskette is not necessary.

5 Manual Changes

Manual Changes 46

This chapter contains information for adapting this manual to Keysight 346B noise sources with serial number prefixes of 2015A and 1935A.

Manual Changes

To adapt this manual to your instrument, refer to **Table 5-1**. Make all of the manual changes listed opposite your instrument’s serial number prefix. Perform these changes in the sequence listed.

Table 5-1 Manual changes by serial number

Instrument	Serial number prefix	Make manual changes
346B	1935A, 2015A	A

If your instrument (all models) has a serial number prefix which is higher in value than those listed on the title page of this manual, it may be documented in a yellow MANUAL CHANGES supplement. For additional information, refer to “**Instruments Covered by this Manual**” on page 21 in this manual.

Change A

Table 3-3 Supplemental characteristics

Change Switching Speed for both repetitive operation and single shot operation to read: Turn off <140 μ s.

6 Using the ENR Data Diskette or CD

Introduction	48
Loading ENR Data from Diskette	49
Retrieving ENR Data from CD	50
Saving the ENR Data to the Noise Figure Analyzer's Internal Memory	51
Copying the ENR Data to the Noise Figure Analyzer's Internal Memory	53

This chapter provides the information on using the ENR data for the Keysight NFA Series Noise Figure Analyzers.

Introduction

The Keysight 346 and 347 series of noise sources are supplied with the noise source ENR data preloaded on a diskette or CD to allow easy downloading into the Keysight NFA series noise figure analyzers. This eliminates time consuming and error prone manual keying of the ENR values.

Additionally you can easily open the ENR files using a standard text editor, and the files are easy to interpret and create.

This chapter covers the following:

- Loading ENR data from diskette
- Retrieving ENR data from CD
- Saving the ENR data to the noise figure analyzer's internal memory
- Copying the ENR data from the diskette to the noise figure analyzer's internal memory

NOTE

The following procedures do not apply to noise sources used with the Keysight 8970A/B Noise Figure Meter.

You must enter ENR values manually into the 8970A/B.

The following procedures do not apply to noise sources with serial prefixes MY5823

Loading ENR Data from Diskette

To load the ENR data from the diskette and use the data as the current ENR table, proceed as follows:

- 1 Power up the noise figure analyzer and wait for the power-up sequence to complete.
- 2 Insert the diskette into the floppy drive of the noise figure analyzer.

NOTE

Do not insert the diskette into the noise figure analyzer until the power-up sequence is complete.

- 3 On the noise figure analyzer, press the **File** key and press the **Load** menu key to access the file system.
- 4 Press the **ENR** menu key and select whether the ENR table is a **Meas Table** (used for measurements) or a **Cal Table** (used for calibration). If you intend to use the same ENR table for calibration and measurement, then set the ENR table as **Meas Table**.

The noise figure analyzer allows you to use the same or separate ENR tables for calibration and measurement as required. For more details on specifying **Meas Table** and **Cal Table**, see the *Noise Figure Analyzer User's Guide*.

- 5 Press the **Select** menu key and use the arrow keys if necessary to highlight **[-A-]**. If **C:** is the currently selected drive use the **".."** directory to reach the **A:** drive as directed on the screen. Press the **Select** menu key again to read the diskette.
- 6 Use the down arrow key (↓) to highlight the ENR file and press the **Enter** key to load it.

When the file is successfully loaded, a message for example, **A:A0100364.ENR file loaded** appears on the display.

NOTE

ENR files with a large number of frequency points (for example, up to 50 GHz) may take a few seconds to load.

Retrieving ENR Data from CD

Noise Source with serial prefixes MY5823 and above are supplied with the noise source ENR data preloaded on a CD.

The ENR files can be retrieved using computer CD-ROM drive and edited using a standard text editor.

ENR filename format

The ENR filename of the ENR file stored on the diskette or CD, for example **A0100123.enr**, has the following format:

- The first letter shows the noise source type and can be:
 - A = 346A
 - B = 346B
 - C = 346C
 - R = R347A
 - Q = Q347A
- The next four digits, for example **0100**, show the calibration date. For example, **0100** shows a calibration date of January 2000.
- The last three digits, for example **123**, are the last three digits of the serial number of the noise source.
- The file extension is **.enr** to indicate ENR file format.

Once the ENR file is loaded, to verify that the ENR data is correct, press the **ENR** key, then press the **ENR Table>** menu item to display the ENR table.

The noise figure analyzer allows you to use the same or separate ENR tables for calibration and measurement as required. For more details on using ENR tables, see the *Noise Figure Analyzer User's Guide*.

When the ENR table is selected, the **Alpha Editor** is now presented to you, allowing you to specify a name for the file. If required you can use the numeric keypad to enter numbers in the filename. Note that you can also use the default filename which is in the format of **TSTxxxx** where **x** is a sequentially allocated number. For details of the filename format used for the ENR data supplied on the diskette, see "**ENR filename format**" on page 50.

- 4 Input the name of the ENR table using the **Alpha Editor** and numeric keypad. Use the **Tab** key to move to the **". .":** field.
- 5 If the **To: Path:** field is currently **A:**, press the **Select** menu key and use the arrow key to highlight **[-C-]**, then press the **Select** menu key again. With the **To: Path:** field set to **C:**, press **Enter** to save the file with the specified filename.

When the file is successfully saved, a message for example **C:A0100364.ENR file saved**, appears on the status line of the display.

Copying the ENR Data to the Noise Figure Analyzer's Internal Memory

To copy the noise source ENR data from the diskette (**A:** drive) to the noise figure analyzer's internal memory (**C:** drive), proceed as follows:

- 1 Power up the noise figure analyzer and wait for the power-up sequence to complete.
- 2 Insert the diskette into the floppy drive of the noise figure analyzer.

NOTE

Do not insert the diskette into the noise figure analyzer until the power-up sequence is complete.

- 3 Press the **File** key and press the **File Manager** menu key.
- 4 Press the **Copy>** menu key.
The file system is now presented to you.
- 5 Press the **ENR** menu key to set the file type and format to ENR.
- 6 Set the **From: Path:** field to **A:**, use the down arrow key (↓) to highlight the ENR file and the **Select** key to select it for copying.
The filename you are going to copy now appears in the **From: Name:** field.
- 7 Press the **Tab** key to navigate to the **To: Path:** field and ensure it is set to **C:**.
- 8 Press the **Enter** key to copy the selected file from the diskette (**A:**) to the noise figure analyzer's internal memory (**C:**).

When the file is successfully copied, a message for example **A:A0100364.ENR file copied**, appears on the status line of the display.

For details on the ENR filename format, see "[ENR filename format](#)" on page 50.

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

7 ENR File Format

Format Details	56
Examples	61

This chapter explains the format of an ENR file.

Format Details

An ENR file:

- includes all data currently supplied on the printed noise source Calibration Certificate
- can be viewed and edited using a standard text editor (for example Notepad)
- is simple to create and interpret
- is easily printable
- is easily imported into Excel

The ENR file is read line by line. Each line is terminated by either a linefeed character, or a carriage-return, linefeed pair. Each line must be less than 100 characters long, excluding the terminator.

Lines containing only whitespace (tab or space character) are ignored. Each line is interpreted as one of three types of record:

- Comment
- Header Field
- ENR Data

Comment records

A comment record must have either a '#' or '!' as the first character in the line. The entire line is ignored. Comment records can appear at any point within the file.

Header fields

General form

Header fields must have a '[' as the first character in the line. Each header field has the general form:

- **[FieldName OptionalValue]**
- The '[' must be the first character on the line.
- The fieldname and optionalvalue, if present, must be separated by whitespace.
- Whitespace following the ']' is ignored.

- The file must start with one or more header fields (ignoring comments and blank lines).

All header fields must appear at the beginning of the file before the ENR data records. Mixing header fields and ENR data is not permitted.

Mandatory header fields

Certain header fields must be present. These are:

Table 7-1 Mandatory header fields

FieldName	Description	OptionalValue	Description	Example
Filetype	Indicates the type of file	ENR	Only 'ENR' is allowed for ENR data files	[Filetype ENR]
Version	Indicates the version of the file format which applies to this file	versionnumber (formatted as major.minor)	Allows for future changes in the file format.	[Version 1.0]

NOTE

All mandatory fields must appear in the file before any optional header fields.

Optional header fields

The following header fields are also allowed. Note that only the first two, **Serialnumber** and **Model** are currently used by the noise figure analyzer.

Table 7-2 Optional header fields

FieldName	Description	OptionalValue	Description	Example
Serialnumber	The serial number of the noise source	serialtext	A string containing the serial number	[Serialnumber 3318A14223]
Model	Identifies the noise source model number	modelcode	Model code string	[Model 346B]

Table 7-2 Optional header fields (continued)

FieldName	Description	OptionalValue	Description	Example
Option	Identifies any model code option	optioncode	Option code string	[Option 001]
Caldate	Date of calibration of noise source	date&time	Formatted date and optional time	[Caldate 19991202.09:15:30]
Calduedate	Indicates date when next calibration of noise source is due	date&time	Formatted date and optional time	[Calduedate 20001225]
Temperature	Calibration temperature	value	Number followed by unit. Valid units are C, F, K	[Temperature 24C]
Humidity	Calibration relative humidity	value	Number followed by optional '%'	[Humidity 40%]

The format of **date&time** parameters is **YYYYMMDD[.hh:mm:ss]**, i.e. a 4-digit year, 2-digit month, and 2-digit date, optionally followed by a '.' then 2-digit hour ':' 2-digit minutes ':' 2-digit seconds.

Unknown header fields are ignored by the noise figure analyzer. This allows for future expansion.

ENR data

ENR data records must be ordered from the lowest to the highest frequency.

General form

The noise figure analyzer attempts to interpret lines which are not comments or header fields as ENR data. ENR data has the general form:

Freq [Funit] ENR [Eunit] [Euncert [on_mag on_phase off_mag
off_phase [Runcert]]]

NOTE

The square brackets denote optional fields.

Field separator

Each field is separated by whitespace. A single ‘,’ is allowed within or instead of the whitespace.

Numeric fields

With the exception of the two optional unit fields, the other fields are numeric. Numbers are formatted as an optional sign, followed by a sequence of one or more digits (which can include a single decimal point within the sequence), followed by an optional exponent. The exponent consists of the ‘e’ or ‘E’ followed by an optional sign followed by between one and three digits.

Frequency fields

The frequency field (**Freq**) is the frequency at which the ENR amplitude was measured.

The frequency unit field (**Funit**) is optional. The default unit is Hz.

Valid units are Hz, kHz, MHz, GHz, THz. Units are not case sensitive.

ENR fields

The ENR amplitude (**ENR**) is the measured ENR at the specified frequency.

The ENR unit field (**Eunit**) is optional. The default unit is dB. Currently, the only allowed unit is dB. Note that units K, C, F (temperature) are reserved for possible future use, but are not supported by the noise figure analyzer at this time.

The uncertainty field for the ENR amplitude (**Euncert**) is optional. However, this field must be present if reflection coefficient data is supplied.

Reflection coefficient data

The reflection coefficient data is optional and is formatted as four fields (**on_mag**, **on_phase**, **off_mag**, **off_phase**):

- reflection magnitude with noise source on
- reflection angle (in degrees) with noise source on
- reflection angle with noise source off
- reflection angle (degrees) with noise source off

If any reflection coefficient data is supplied, then all four fields must be present. Note that the file format requires that the ENR uncertainty field must be present before any reflection data.

The reflection coefficient uncertainty (**Runcert**) is an optional parameter. Reflection coefficient data must be present if this field is supplied.

Examples

Example 1

This first example shows a simple ENR file where the Frequency and ENR values have been entered manually into the noise figure analyzer:

```
# ENR Data File
# Created by N8973A Keysight NFA Series Noise Figure Analyzer
# Serial Number US00000012 Firmware Revision A.00.01
# 13:37:07 Mar 28, 2000
# Format is: Frequency (Hz), ENR (dB)

[Filetype ENR]
[Version 1.0]
10000000, 15.3500
100000000, 15.4230
1000000000, 15.2280
2000000000, 15.0900
3000000000, 14.9600
4000000000, 14.8400
5000000000, 14.7890
6000000000, 14.7500
7000000000, 14.7720
8000000000, 14.8570
9000000000, 14.9580
10000000000, 15.0600
11000000000, 15.0830
12000000000, 15.1950
13000000000, 15.2710
14000000000, 15.3430
15000000000, 15.4800
16000000000, 15.6750
17000000000, 15.8400
18000000000, 15.8940
```

Example 2

The second example is a typical ENR file supplied on diskette or CD with a noise source:

```
[Filetype ENR]
[Version 1.0]
[Serialnumber 3318A15364]
[Model 346B]
[Caldate 20000110.13:53:54]
[Temperature 24C]
```

[Humidity 40%]

!	Frequency	ENR	Unc	Refl. Coef. On	Refl. Coef. Off		
!	MHz	dB	dB	Mag	Phase Deg	Mag	Phase Deg
	10 MHz	15.281	.193	.0450	-136.0	.0330	-66.0
	100 MHz	15.291	.190	.0358	+168.0	.0110	-24.6
	1000 MHz	15.118	.151	.0398	+39.6	.0107	+164.5
	2000 MHz	14.999	.168	.0377	-85.7	.0266	+ .9
	3000 MHz	14.879	.172	.0267	+150.6	.0390	-129.2
	4000 MHz	14.795	.173	.0130	-18.1	.0313	+106.0
	5000 MHz	14.818	.179	.0359	+169.5	.0104	-99.3
	6000 MHz	14.846	.181	.0556	+63.7	.0451	+104.3
	7000 MHz	14.895	.180	.0430	-37.0	.0579	-2.3
	8000 MHz	15.016	.198	.0232	-160.3	.0491	-123.8
	9000 MHz	15.134	.201	.0122	+71.4	.0407	+107.3
	10000 MHz	15.253	.194	.0080	+116.2	.0248	-15.4
	11000 MHz	15.249	.243	.0241	+65.7	.0259	+144.5
	12000 MHz	15.349	.240	.0196	+8.8	.0457	+32.2
	13000 MHz	15.383	.188	.0217	-5.4	.0362	-61.9
	14000 MHz	15.355	.178	.0228	-66.6	.0075	+151.2
	15000 MHz	15.367	.187	.0141	+141.6	.0136	-13.2
	16000 MHz	15.421	.182	.0251	+6.4	.0030	-127.2
	17000 MHz	15.418	.174	.0242	-100.5	.0148	-29.7
	18000 MHz	15.464	.179	.0183	+124.4	.0198	-149.1

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

A Caring for Connectors

Introduction	66
Visual Inspection	67
Cleaning	70
Mechanical Inspection: Connector Gages	73
Mechanical Specifications	74
Using Connector Gages	77
Making Connections	80
Adapters	84
Principles of Microwave Connector Care	86

The material contained in this appendix may not apply to the connector you are using on the instrument.

Introduction

Recent advances in measurement capabilities have made connectors and connection techniques more important than ever before. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices represent an increasing burden in downtime and expense.

This Appendix will help you get the best performance from all coaxial microwave connectors:

- To know what to look for when cleaning and inspecting them, in order to preserve their precision and extend their life.
- To make the best possible microwave connections, improving the accuracy and repeatability of all of your measurements, saving both time and money.

Connector part numbers

Refer to the latest edition of the Keysight RF & Microwave Test Accessories Catalog for connector part numbers.

Handling and storage

Microwave connectors must be handled carefully, inspected before use and when not in use, stored in a way that gives them maximum protection. Avoid touching the connector mating plane surfaces and avoid setting the connectors contact-end down, especially on a hard surface.

Never store connectors with the contact end exposed. Plastic end caps are provided with all Keysight connectors and these should be retained after unpacking and placed over the ends of the connectors whenever they are not in use. Extend the threads of connectors that have a retractable sleeve or sliding connector nut, then put the plastic end cap over the end of the connector.

Above all, never store any devices loose in a box or in a desk or a bench drawer. Careless handling of this kind is the most common cause of connector damage during storage.

Visual Inspection

Visual inspection and, if necessary, cleaning should be done every time a connection is made.

Metal and metal by-product particles from the connector threads often find their way onto the mating plane surfaces when a connection is disconnected and even one connection made with a dirty or damaged connector can damage both connectors beyond repair.

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.

Obvious defects and damage

Examine the connectors first for obvious defects or damage — badly worn plating, deformed threads or bent, broken, or misaligned center conductors. Connector nuts should move smoothly and be free of burrs, loose metal particles, and rough spots.

Immediately discard, or mark for identification and send away for repair, any connector that has obvious defects like these.

Mating plane surfaces

Flat contact between the connectors at all points on their mating plane surfaces is required for a good connection. Therefore, particular attention should be paid to deep scratches or dents and to dirt and metal or metal by-product particles on the connector mating plane surfaces.

Also look for bent or rounded edges on the mating plane surfaces of the center and outer conductors and for any signs of damage due to excessive or uneven wear or misalignment.

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 it and inspect it again. Damage or defects like dents or scratches, which are deep enough to displace metal on the mating plane surface of the connector, may indicate that the connector itself is damaged and should not be used. Try to determine the cause of the damage before making further connections.

Precision 7 mm connectors

Precision 7 mm connectors, among them APC-7® connectors, should be inspected visually with the center conductor collets in place, and whenever the collet has been removed. See [Figure A-1](#).

The collet itself should be inspected for edge or surface damage and for any signs that the spring contacts are bent or twisted. If they are, replace the collet. When the collet has been re-inserted, verify that it springs back immediately when pressed with a blunt plastic rod or with the rounded plastic handle of the collet removing tool. Never use a pencil or your finger for this purpose.

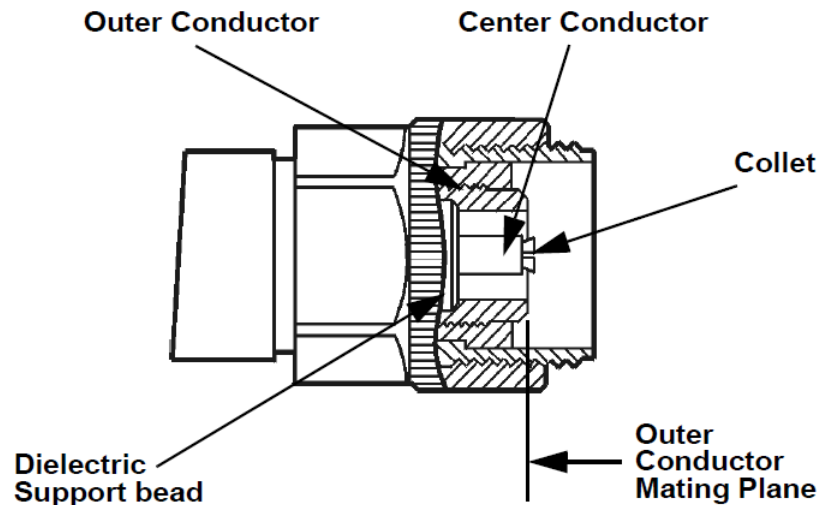


Figure A-1 Precision 7 mm connector

Sexed connectors

On sexed connectors, especially precision 3.5 mm and SMA connectors, pay special attention to the female center conductor contact fingers (Figure A-2 and Figure A-3). These are very easily bent or broken, and damage to them is not always easy to see. Any connector with damaged contact fingers will not make good electrical contact and must be replaced.

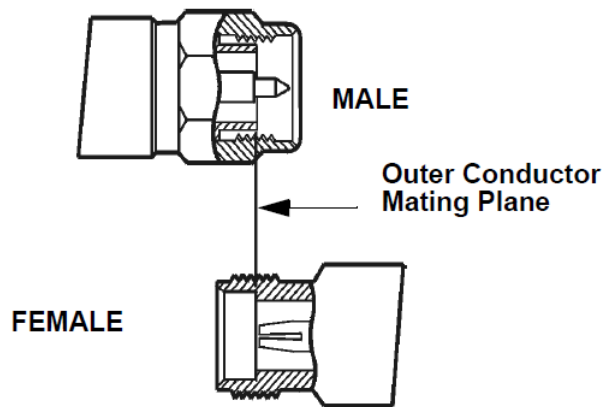


Figure A-2 Precision 3.5 mm connectors

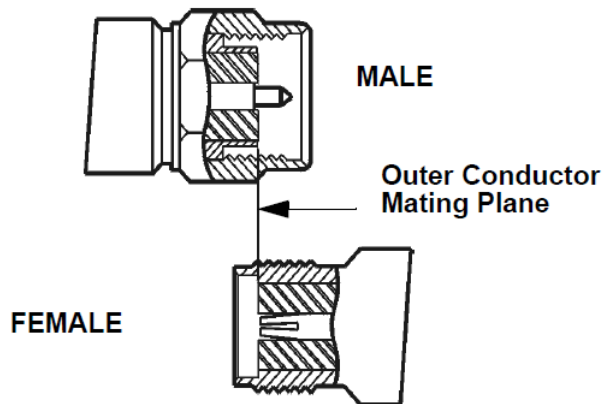


Figure A-3 SMA connectors

Cleaning

Careful cleaning of all connectors is essential to assure long, reliable connector life, to prevent accidental damage to connectors, and to obtain maximum measurement accuracy and repeatability. Yet it is the one step most often neglected or done improperly. Supplies recommended for cleaning microwave connectors are as follows:

- Compressed air
- Alcohol
- Cotton swabs
- Lint-free cleaning cloth

Compressed air

Loose particles on the connector mating plane surfaces can usually be removed with a quick blast of compressed air. This is very easy to do and should always be tried first using compressed air from a small pressurized can. The stream of air can be directed exactly where it is wanted through a plastic (not metal) nozzle. No hoses or other connections are needed. Hold the can upright, to avoid spraying liquid along with the vapor.

Cleaning alcohol

Dirt and stubborn contaminants that cannot be removed with compressed air can often be removed with a cotton swab or lint-free cleaning cloth moistened with alcohol.

NOTE

Use the least amount of alcohol possible, and avoid wetting any plastic parts in the connectors with the alcohol.

Alcohol should be used in liquid rather than spray form. If a spray must be used, always spray the alcohol onto a cloth or swab, never directly into a connector.

Very dirty connectors can be cleaned with pure alcohol. Other solutions that contain additives should not be used.

Carefully avoid wetting the plastic support bead (which is easily damaged by alcohol) inside the connector and blow the connector dry immediately with a gentle stream of compressed air.

Precision 7 mm connectors

When precision 7 mm connectors have been cleaned with the center conductor collet removed, insert the collet and clean the mating plane surfaces again.

When the connector is attached to a small component, or to a cable, calibration, or verification standard, the easiest way to do this is to put a lint-free cleaning cloth flat on a table and put a couple of drops of alcohol in the center of the cloth. It should be noted that it is not necessary to remove the collet to use this cleaning method.

Retract the connector sleeve threads so that the connector interface is exposed. Gently press the contact end of the connector into the cloth moistened with alcohol, then turn the connector.

Dirt on the connector interface will be scrubbed away by the cloth without damaging the connector. Blow the connector dry with a gentle stream of compressed air.

This cleaning method can be adapted even for fixed connectors such as those attached to test ports. Simply fold the cloth into several layers of thickness, moisten it, press it against the connector interface, and turn it to clean the connector. Blow the connector dry with a gentle stream of compressed air.

Cleaning interior surfaces

Interior surfaces, especially on precision 3.5 mm connectors, are very difficult to reach, and it is easy to damage connectors in trying to clean them. The openings are very small, and generally the center conductor is supported only at the inner end, by a plastic dielectric support bead. This makes it very easy to bend or break the center conductor.

One suitable method ([Figure A-4](#)) is to cut off the sharp tip of a round wooden toothpick, or a smaller diameter wooden rod, and then to wrap it with a single layer of lint-free cleaning cloth.



Figure A-4 Cleaning interior surfaces

NOTE

Metal must never be used (it will scratch the plated surfaces), and in cleaning precision 3.5 mm connectors the diameter must not exceed 0.070 in. (1.7 mm). The wooden handle of a cotton swab, for example, is too large for this purpose. Even though the handle can sometimes be inserted into the connector, even when wrapped in lint-free cloth, movement of the handle against the center conductor can exert enough force on the center conductor to damage it severely.

Moisten the cloth with a small amount of alcohol and carefully insert it into the connector to clean the interior surfaces. Use an illuminated magnifying glass or microscope to see clearly the areas you wish to clean.

Drying connectors

When you have cleaned a connector, always be sure that it is completely dry before reassembling or using it. Blow the connector dry with a gentle stream of clean compressed air and inspect it again under a magnifying glass to be sure that no particles or alcohol residues remain.

Mechanical Inspection: Connector Gages

Even a perfectly clean, unused connector can cause problems if it is mechanically out of specification. Since the critical tolerances in microwave connectors are on the order of a few ten-thousandths of an inch, using a connector gage is essential.

Before using any connector for the first time, inspect it mechanically using a connector gage. How often connectors should be gaged after that depends upon usage.

In general, connectors should be gaged whenever visual inspection or electrical performance suggests that the connector interface may be out of specification, for example due to wear or damage. Connectors on calibration and verification devices should also be gaged whenever they have been used by someone else or on another system or piece of equipment.

Precision 3.5 mm and SMA connectors should be gaged relatively more often than other connectors, owing to the ease with which the center pins can be pulled out of specification during disconnection.

Connectors should also be gaged as a matter of routine – after every 100 connections and disconnections initially, more or less often after that as experience suggests.

Connector gage kits containing all of the items required are included in many Keysight calibration kits. They are also available separately. Part numbers are as follows:

Table A-1 Recommended connector gages

Type	Part number/ordering information
Precision 7 mm (APC-7)	85050-80012
Precision 3.5 mm	11752D
Precision 2.4 mm	11752E
Type-N	85054-60047

Mechanical Specifications

The critical dimension to be measured, regardless of connector type, is the position (generally, the recession or setback) of the center conductor relative to the outer conductor mating plane.

Mechanical specifications for connectors specify a maximum distance and a minimum distance that the center conductor can be positioned behind (or, in female Type-N connectors, in front of) the outer conductor mating plane. Nominal specifications for each connector type exist, but the allowable tolerances (and sometimes the dimensions themselves) differ from manufacturer to manufacturer and from device to device. Therefore, before gaging any connector, consult the mechanical specifications provided with the connector or the device itself.

Precision 7 mm connectors

In precision 7 mm connectors, contact between the center conductors is made by spring-loaded contacts called collets. These protrude slightly in front of the outer conductor mating plane when the connectors are apart. When the connection is tightened, the collets are compressed into the same plane as the outer conductors.

For this reason, two mechanical specifications are generally given for precision 7 mm connectors – the maximum recession of the center conductor behind the outer conductor mating plane with the center conductor collet removed; and a minimum and maximum allowable protrusion of the center conductor collet in front of the outer conductor mating plane with the collet in place.

The center conductor collet should also spring back immediately when pressed with a blunt plastic rod or with the rounded plastic handle of the collet removing tool. Never use a pencil or your finger for this purpose.

With the center conductor collet removed, no protrusion of the center conductor in front of the outer conductor mating plane is allowable, and sometimes a minimum recession is required. Consult the mechanical specifications provided with the connector or the device itself.

Sexed connectors

In Type-N and precision 3.5 mm connectors, the position of the center conductor in the male connector is defined as the position of the shoulder of the male contact pin – not the position of the tip. The male contact pin slides into the female contact fingers and electrical contact is made by the inside surfaces of the tip of the female contact fingers on the sides of the male contact pin.

50 Ω Type-N connectors

NOTE

No Type-N connector should ever be used when there is any possibility of interference between the shoulder of the male contact pin and the tip of the female contact fingers when the connectors are mated. In practice this means that no Type-N connector pair should be mated when the separation between the tip of the female contact fingers and the shoulder of the male contact pin could be less than zero when the connectors are mated. Gage Type-N connectors carefully to avoid damage.

Type-N connectors differ from other connector types in that the outer conductor mating plane is offset from the mating plane of the center conductors. The outer conductor sleeve in the male connector extends in front of the shoulder of the male contact pin. When the connection is made, this outer conductor sleeve fits into a recess in the female outer conductor behind the tip of the female contact fingers (Figure A-5).

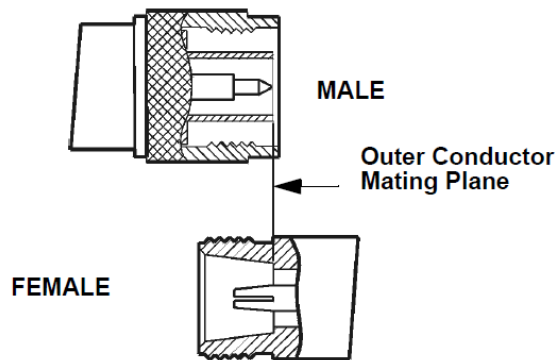


Figure A-5 Type-N connectors

Therefore the mechanical specifications of Type-N connectors give a maximum protrusion of the female contact fingers in front of the outer conductor mating plane and a minimum recession of the shoulder of the male contact pin behind the outer conductor mating plane.

As Type-N connectors wear, the protrusion of the female contact fingers generally increases, due to wear of the outer conductor mating plane inside the female connector. This decreases the total center conductor contact separation and should be monitored carefully.

75 Ω Type-N connectors

75 Ω Type-N connectors differ from 50 Ω Type-N connectors most significantly in that the center conductor, male contact pin, and female contact hole are smaller. Therefore, mating a male 50 Ω Type-N connector with a female 75 Ω Type-N connector will destroy the female 75 Ω connector by spreading the female contact fingers apart permanently or even breaking them.

NOTE

If both 75 Ω and 50 Ω Type-N connectors are among those on the devices you are using, identify the 75 Ω Type-N connectors to be sure that they are never mated with any 50 Ω Type-N connectors.

Using Connector Gages

Before a connector gage is used, it must be inspected, cleaned, and zeroed.

Inspecting and cleaning the gage

Inspect the connector gage and the gage calibration block carefully, exactly as you have inspected the connector itself. Clean or replace the gage or the block if necessary (dirt on the gage or block will make the gage measurements of the connectors inaccurate and can transfer dirt to the connectors themselves, damaging them during gaging or when the connection is made).

Zeroing the gage

Zero the gage by following the steps described below. Be sure that you are using the correct connector gage and correct end of the gage calibration block for the connector being measured.

- Hold the gage by the plunger barrel (not the dial housing or cap) and, for male connectors, slip the protruding end of the calibration block into the circular bushing on the connector gage. For precision 7 mm, female precision 3.5 mm use the flat end of the gage calibration block. For female Type-N connectors, use the recessed end of calibration block.
- Hold the gage by the plunger barrel only (Figure A-6). Doing so will prevent errors in gage readings due to the application of stresses to the gage plunger mechanism through the dial indicator housing.
- Carefully bring the gage and gage block together, applying only enough pressure to the gage and gage block to result in the dial indicator pointer settling at a reading.
- Gently rock the two surfaces together, to make sure that they have come together flatly. The gage pointer should now line up exactly with the zero mark on the gage. If it does not, inspect and clean the gage and gage calibration block again and repeat this process. If the gage pointer still does not line up with the zero mark on the gage, loosen the dial lock screw and turn the graduated dial until the gage pointer exactly lines up with zero. Then re-tighten the lock screw.



Figure A-6 Using the connector gage

NOTE

Gages should be checked often, to make sure that the zero setting has not changed. Generally, when the gage pointer on a gage that has been zeroed recently does not line up exactly with the zero mark, the gage or calibration block needs cleaning. Clean carefully and check the zero setting again.

Measuring connectors

Measuring the recession of the center conductor behind the outer conductor mating plane in a connector is done in exactly the same way as zeroing the gage, except of course that the graduated dial is not re-set when the measurement is made.

If the connector has a retractable sleeve or sliding connector nut – precision 7 mm connectors, for example – extend the sleeve or nut fully. This makes it easier to keep the gage centered in the connector. Hold the gage by the plunger barrel and slip the gage into the connector so that the gage plunger rests against the center conductor. Carefully bring the gage into firm contact with the outer conductor mating plane.

Apply only enough pressure to the gage so that the gage pointer settles at a reading.

Gently rock the connector gage within the connector, to make sure that the gage and the outer conductor have come together flatly. Read the recession (or protrusion) from the gage dial. (For maximum accuracy, measure the connector several times and take an average of the readings.)

Rotate the gage relative to the connector between each measurement. To monitor connector wear, record the readings for each connector over time.

Making Connections

Making good connections is easy if a few simple principles are kept in mind:

- All connectors must be undamaged, clean, and within mechanical specification.
- The connectors must be precisely aligned with one another and in flat physical contact at all points on the mating plane surfaces.
- The connection must not be too tight or too loose.
- Lateral or horizontal (bending) force must not be applied to the connection, nor should any connection ever be twisted.

Align connectors carefully

Careful alignment of the connectors is critical in making a good connection, both to avoid damaging connectors and devices and to assure accurate measurements.

As you bring one connector up to the other and as you make the actual connection, be alert for any sign that the two connectors are not aligned perfectly. If you suspect that misalignment has occurred, stop and begin again.

Alignment is especially important in the case of sexed connectors, such as precision 3.5 mm and SMA connectors, to avoid bending or breaking the contact pins. The center pin on the male connector must slip concentrically into the contact fingers of the female connector. This requires great care in aligning the two connectors before and as they are mated.

When they have been aligned, the center conductors must be pushed straight together, not twisted or screwed together, and only the connector nut (not the device itself) should then be rotated to make the connection. (slight resistance is generally felt as the center conductors mate).

Alignment of precision 7 mm connectors is made easier by the fact that the connector sleeve on one of the connectors must be extended fully (and the sleeve on the other connector retracted fully) in order to make the connection. Extending the sleeve creates a cylinder into which the other connector fits.

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

To make a preliminary connection

Align the two connectors carefully and engage the connector nut over the exposed connector sleeve threads on the other connector.

Gently turn the connector nut until a preliminary connection is made. Let the connector nut pull the two connectors straight together. Do not twist one connector body into the other (as you might drive a screw or insert a light bulb) as this is extremely harmful and can damage the connectors.

When the mating plane surfaces make uniform, light contact, the preliminary connection is tight enough. Do not overtighten this connection.

NOTE

At this stage all you want is a connection in which the outer conductors make gentle contact at all points on both mating surfaces. Very light finger pressure (no more than 2 inch-ounces of torque) is enough.

Final connection using a torque wrench

When the preliminary connection has been made, use a torque wrench to make the final connection. Tighten the connection only until the “break” point of the wrench is reached, when the wrench handle gives way at its internal pivot point. Do not tighten the connection further.

Also make sure that torque actually is being applied to the connection through the torque wrench, not only to the wrench handle or in any way that prevents the break point of the wrench from controlling the torque applied to the connection. Suggestions to ensure that torque is actually being applied are given in [Table A-2](#).

Using a torque wrench guarantees that the connection will not be too tight, thus preventing possible damage to the connectors and impaired electrical performance. It also guarantees that all connections will be made with the same degree of tightness every time they are made.

Torque wrenches pre-set to the correct value for each connector type are included in many Keysight calibration kits, and they are also available separately. Torque settings are detailed in [Table A-2](#).

When using a torque wrench, prevent rotation of anything other than the connector nut that is being tightened with the torque wrench. Generally this is easy to do by hand (all the more so if one of the connectors is fixed) as on a test port. In other situations, an open-end wrench can be used to keep the bodies of the connectors from turning.

Hold the torque wrench lightly by the knurled end of the handle only. Apply force at the end of the torque wrench only, perpendicular to the wrench and always in a plane parallel to the outer conductor mating planes. This will result in torque being applied to the connection through the wrench until the break point of the wrench is reached.

Avoid pivoting the wrench handle on the thumb or other fingers. This results in an unknown amount of torque being applied to the connection when the break point of the wrench is reached. Avoid twisting the head of the wrench relative to the outer conductor mating plane. This results in applying more than the recommended torque.

Table A-2 Recommended torque settings

Type	Description
Precision 7 mm	12 lb-in (136 N-cm)
Precision 3.5 mm	8 lb-in (90 N-cm)
SMA	5 lb-in (56 N-cm)
	Use the SMA wrench to connect male SMA connectors to female precision 3.5 mm connectors. Connections of male precision 3.5 mm connectors to female SMA connectors can be made with the precision 3.5 mm torque wrench (8 lb-in).
Type-N	Type-N connectors may be connected finger tight. If a torque wrench is used, 12 lb-in (136 N-cm) is recommended.

To reiterate the main do's and do not's detailed previously:

- Avoid holding the wrench tightly, in such a way that the handle is not pivoted but simply pushed downward the same amount throughout its length. If this is done, an unlimited amount of torque can be applied.
- Hold the wrench at the same point near the end of the handle every time, and always in the same orientation. Whenever possible, begin tightening the connection with the wrench held horizontally.

Disconnection

Disconnect connectors by first loosening the connector nut that was tightened in order to make the connection. If necessary, use the torque wrench or an open-end wrench to start the process, but leave the connection finger tight. At all times support the devices and the connection to avoid putting lateral (bending) force on the connectors.

Complete the disconnection by disconnecting the connector nut completely.

NOTE

Never disconnect connectors by twisting one connector or device out of the other as one might remove a screw or a light bulb. This is extremely harmful and connector damage can occur whenever the device body rather than the nut alone is being turned.

If the connection is between sexed connectors, pull the connectors straight apart and be especially careful not to twist the body of any device as you do so. Twisting the connection can damage the connector by damaging the center conductors or the interior component parts to which the connectors themselves are attached. It can also scrape the plating from the male contact pin or even (in rare instances) unscrew the male or female contact pin slightly from its interior mounting, bringing it out of specification (this can also occur if the female contact fingers are unusually tight).

Adapters

Adapters are used to connect a device with one connector interface to a device or to test equipment that has another interface, or to reduce wear on connectors that may be difficult or expensive to replace. Reducing wear is possibly the most important use of adapters, especially when devices that have SMA connectors are being used.

SMA connectors are low-cost connectors generally used up to about 23 GHz. They are not precision mechanical devices and are not designed for repeated connections and disconnections as they wear out quickly and are very often found, upon assembly, to be out of specification, even before they have been used. This makes them potentially destructive to any precision 3.5 mm connectors with which they might be mated.

CAUTION

Worn, damaged, or out-of-specification SMA connectors can destroy a precision 3.5 mm connector even on the very first connection. For this reason it is recommended that you use high-quality precision adapters, sometimes called “connector savers”, whenever more than a few connections are to be made between SMA and precision 3.5 mm connectors.

In most applications two adapters will be required, one each at the input and the output of the device. Male-female adapters cause no change in the sex of the interface. The same interface is presented when the adapter is in place as is presented in the original setup.

Same-sex adapters (male-male, female-female) change the sex of the interface. For example, if the original interface presents a male connector, attaching a female-female adapter will result in a female interface to which devices or cables that have male SMA (or male precision 3.5 mm) connectors can be connected.

Adapters are included in many Keysight calibration kits and with many Keysight devices, or they may be ordered separately.

Table A-3 **Adapters**

Type	Description
Precision 7 mm and Type-N	– Precision 7 mm/male 3.5 mm
	– Precision 7 mm/female 3.5 mm
	– Precision 7 mm/male 50 Ω Type-N
	– Precision 7 mm/female 50 Ω Type-N
Precision 3.5 mm and SMA	– Male 3.5 mm/female 3.5 mm
	– Male 3.5 mm/female 3.5 mm
	– Female 3.5 mm/female 3.5 mm
	– Precision 7 mm/male 3.5 mm
	– Precision 7 mm/female 3.5 mm
	– “Connector saver” male 3.5 mm/female 3.5 mm
	– “Connector saver” male 3.5 mm/male 3.5 mm

Principles of Microwave Connector Care

Table A-4 Principles of microwave connector care

Handling and storage	
DO	DO NOT
– Keep connectors clean. – Extend sleeve or connector nut. – Use plastic end caps during storage.	– Touch mating plane surfaces. – Set connectors contact-end down.
Visual inspection	
DO	DO NOT
– Inspect each connector carefully before every connection. – Look for metal particles, scratches, and dents.	– Use a damaged connector – EVER.
Cleaning	
DO	DO NOT
– Try compressed air first. – Clean connector threads.	– Use any abrasives. – Get liquid onto plastic support beads.
Gaging	
DO	DO NOT
– Clean and zero the gage before using. – Use correct gage type. – Use correct end of calibration block. – Gage all connectors before first use.	– Use an out-of-spec connector.
Making connections	
DO	DO NOT
– Align connectors carefully. – Make preliminary connection lightly. – Turn connector nut only to tighten. – Use a torque wrench for final connection.	– Apply bending force to connection. – Overtighten preliminary connection. – Twist or screw in connectors. – Tighten past “break” point of torque wrench.



This information is subject to change without notice. Always refer to the Keysight website for the latest revision.

© Keysight Technologies 2001 - 2018
Edition 4, July 26, 2018

Printed in Malaysia



00346-90148

www.keysight.com