Keysight N4000A, N4001A, and N4002A SNS Series Smart Noise Sources

Operating and Service Manual

KEYSIGHT TECHNOLOGIES

Notices

Copyright Notice

Manual Part Number

N4000-90009

Edition

Edition 4, May 26, 2017

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 OF 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.

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

Electromagnetic compatibility

The N4000A, N4001A, and N4002A SNS Series Smart Noise Sources comply 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.

Radio-frequency electromagnetic field immunity

When a 3 Vm-1 radio-frequency electromagnetic field is applied to the SNS series smart noise source according to IEC 61000-4-3, degradation of performance may be observed. When the frequency of the incident field falls within the bandwidth of a measured noise figure or gain, the values displayed will deviate from those expected. This phenomenon will only affect that specific frequency, and the SNS will continue to perform to specification at all other frequency sample points.

The NFA may be unable to calibrate a chosen frequency sample point, if the frequency matches that of an incident electromagnetic field.

Regulatory Markings

CE	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 ISM GRP 1-A	ICES/NMB-001 indicates that this ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.
RCM	The RCM mark is a registered trademark of the Australian Communications and Media Authority.	40	This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
KC MSIP-REM-Kst-xxxxxxxxxxxxxx	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

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

List of Figures

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

List of Tables

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

1 Introduction

This chapter provides an overview of the Keysight N4000/1/2A SNS Series Smart Noise Sources.

Product Overview

This manual contains operating and service information for the Keysight SNS series smart noise sources, consisting of models; N4000A, N4001A, and N4002A.

The SNS series smart noise source, when commanded “Off” produces RF noise due to thermal agitation of its RF components at a level appropriate to its physical temperature. When commanded “On” it still produces this noise and produces additional noise component, referred to as EXCESS NOISE. 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 SNS has been measured at cardinal frequencies and these frequency/ENR pair values are stored in the SNS’s internal EEPROM. The ENR of the source relates the level of excess noise in dB to the noise level appropriate to the standard temperature; 296 K. ENR does not include the “Off” noise component.

Also included in the EEPROM calibration data is the measurement uncertainty and the complex reflection coefficient in both the “On” and “Off” states for each SNS.

The SNS has a built in thermometer which monitors the ambient temperature. This value can be transferred to the analyzer and control the setting of the T_{cold} value.

All models are provided with a twelve pin connector for power input and data transfer. The output connector is a male APC-3.5 on the standard noise sources. Type-N connectors are available as options for the Keysight SNS models N4000A and N4001A.

Figure 1-1 Keysight SNS series smart noise source

2 Installation

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

Handling Precautions

CAUTION The diode module is static sensitive and can be damaged or the calibration can be altered.

CAUTION Do not rotate the body of the SNS series smart noise source when connecting to the noise figure analyzer, or internal damage may result.

CAUTION Do not drop the SNS series smart noise source. Dropping can damage the unit or alter the calibration.

Proper connector care is essential. See "Operator's Maintenance" on page 41 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 31.
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 N4000/1/2A requires service or repair, contact the nearest Keysight office for information on where to send it. The performance of the N4000/1/2A can only be verified by specially-manufactured equipment and calibration standard from Keysight. The recommended interval for recalibration is 12 months.

Equipment Supplied with the NFA

The following equipment is supplied from Keysight Technologies with the N8974A and the N8975A Noise Figure Analyzer models for use with the Precision APC 3.5 mm smart noise sources:

- 8710-1761: 7.0 mm wrench
- 83059B: Precision 3.5 mm coaxial adapter

Equipment Available but not Supplied

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

- 8710-1764: 20 mm 8 lb-in torque wrench
- 8710-1765: 5/16" 8 lb-in torque wrench
- 8710-1766: 3/4" 12 lb-in torque wrench (for use with Option 001)

Options

The Keysight N4000A and N4001A noise sources are available with Option 001, Type-N (male) output connector option.

Since the Type-N connectors are not suitable for use above 18.0 GHz, no output connector option is available for the Keysight N4002A.

Mating connectors

The SNS series smart 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	Multi-pin connector[a]
Output: standard	APC-3.5 female
Option 001	Type-N female[b]

[a] This is designed to operate with the NFA using the 11730 cable. A 11730A cable is supplied with the NFA.

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

3 Specifications

This chapter provides the specifications of the N4000/1/2A SNS Series Smart Noise Sources.

General Specifications

Specifications

The specifications in Table 3-1 are performance standards or limits against which the SNS series smart noise source may be tested. These specifications for the noise source are ONLY valid if the analyzer has been allowed to meet its specified warm-up time.

The ENR expanded uncertainty analysis for noise source calibration is provided in "Excess Noise Ratio expanded uncertainty (U(Y))" on page 23.

The "Supplemental characteristics" on page 26 are not specifications but are typical characteristics included as additional information.

Table 3-1 N4000/1/2A specifications

Specification	N4000A	N4001A	N4002A
Frequency range	10 MHz to 18 GHz	10 MHz to 18 GHz	10 MHz to 26.5 GHz
Excess Noise Ratio (ENR) range[a]	4.5 to 6.5 dB	14 to 16 dB	12 to 17 dB
Impedance	50 Ω nominal	50 Ω nominal	50 Ω nominal
Operating temperature	0 to 55 °C	0 to 55 °C	0 to 55 °C
Maximum reverse power	1 watt	1 watt	1 watt
Maximum Standing Wave Ratio (SWR) [for source ON/OFF states]	<1.06:1 (0.01 to 1.5 GHz) <1.06:1 (1.5 to 3.0 GHz) <1.13:1 (3.0 to 7.0 GHz) <1.22:1 (7.0 to 18.0 GHz)	<1.15:1 (0.01 to 1.5 GHz) <1.15:1 (1.5 to 3.0 GHz) <1.20:1 (3.0 to 7.0 GHz) <1.25:1 (7.0 to 18.0 GHz)	<1.22:1 (0.01 to 1.5 GHz) <1.22:1 (1.5 to 3.0 GHz) <1.22:1 (3.0 to 7.0 GHz) <1.25:1 (7.0 to 18.0 GHz) <1.35:1 (18.0 to 26.5 GHz)
Reflection Coefficient (Rho) (r) [for source ON/OFF states][b]	0.03 (0.01 to 1.5 GHz) 0.03 (1.5 to 3.0 GHz) 0.06 (3.0 to 7.0 GHz) 0.10 (7.0 to 18.0 GHz)	0.07 (0.01 to 1.5 GHz) 0.07 (1.5 to 3.0 GHz) 0.09 (3.0 to 7.0 GHz) 0.11 (7.0 to 18.0 GHz)	0.10 (0.01 to 1.5 GHz) 0.10 (1.5 to 3.0 GHz) 0.10 (3.0 to 7.0 GHz) 0.11 (7.0 to 18.0 GHz) 0.15 (18.0 to 26.5 GHz)
Connectors[c]	SNS output: APC-3.5 (male) standard or Type-N (male) Option 001[d] SNS input: Interconnect with 11730A/B/C cable		

[a] ENR values are given at cardinal frequency points over the frequency range of each noise source. These values are stored within the noise source's internal EEPROM and documented on the calibration report.

[b] Maximum change in complex reflection coefficient between source ON and source OFF at all frequencies for N4000A only: 0.01.

[c] For correct connector usage, refer Table A-2 for the torque settings.

[d] Type-N connector (Option 001) only available on the N4000A and N4001A models.

Characteristic[1] SWR at 23 °C

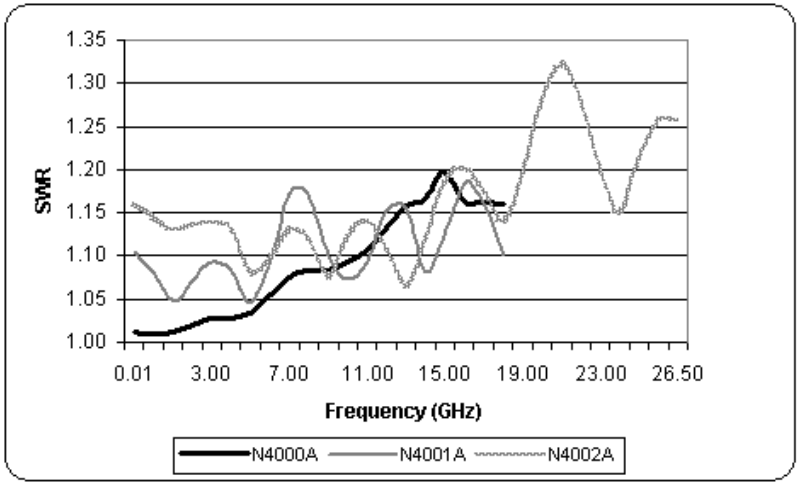

Figure 3-1 Characteristic SWR at 23 °C

Excess Noise Ratio expanded uncertainty (U(Y))

ENR values are given at cardinal frequency points over the frequency range of each SNS series smart noise source. These values are stored within the noise sources internal EEPROM and documented on the calibration report.

The uncertainty analysis for the calibration of the noise sources is in accordance with the ISO/TAG4 Guide. The uncertainty data reported on the calibration report is the expanded uncertainty (U(Y)) with 95% confidence level and a coverage factor of 2. This uncertainty analysis is valid for APC 3.5 mm and Type-N (Option 001) connector types.

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

The uncertainty for each noise source can be unique to that noise source. The uncertainty will typically vary by less than 0.01 dB at any frequency between different noise sources produced in the same year when first produced. Subsequent calibrations must be performed at suitably capable calibration vendors in order to keep the uncertainties similar.

The standard level of calibration for the SNS series is Option A1R (calibration against a 1-level removed reference standard). Another choice is Option APR (calibration against a primary reference standard).

For Option A1R, performance can only be matched with a Standards Lab Calibration, available from the Roseville Standards Lab at Keysight. For Option APR, performance can only be matched by the National Physical Laboratory (NPL) in the UK.

Using the appropriate calibration level should result in similar uncertainties to the original production uncertainties. These will mostly be within 0.01 dB of the original uncertainties, but they will vary with each calibration because they include the repeatability observed on each device. Uncertainties for newly produced devices include population repeatabilities instead of individual device repeatabilities, and thus vary little between devices of the same model and option configuration.

Figure 3-2 and Figure 3-3 show example uncertainties for standard (Option A1R) production noise sources, as of the end of 2013. This time period is after significant changes were made in the uncertainties from better understanding of the error sources and improvements in the references from the National Metrology Institute used, NPL. If NPL performance changes in the future, Keysight uncertainties will follow those changes.

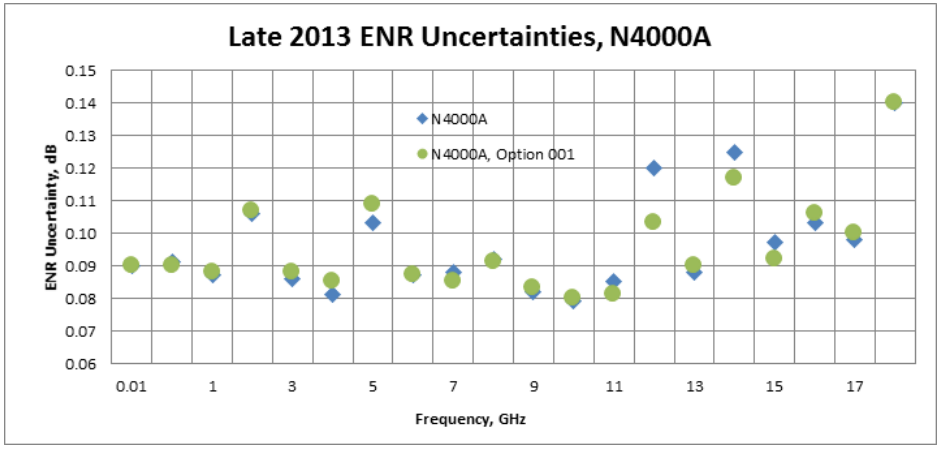

Figure 3-2 Example ENR uncertainty versus frequency for the N4000A model

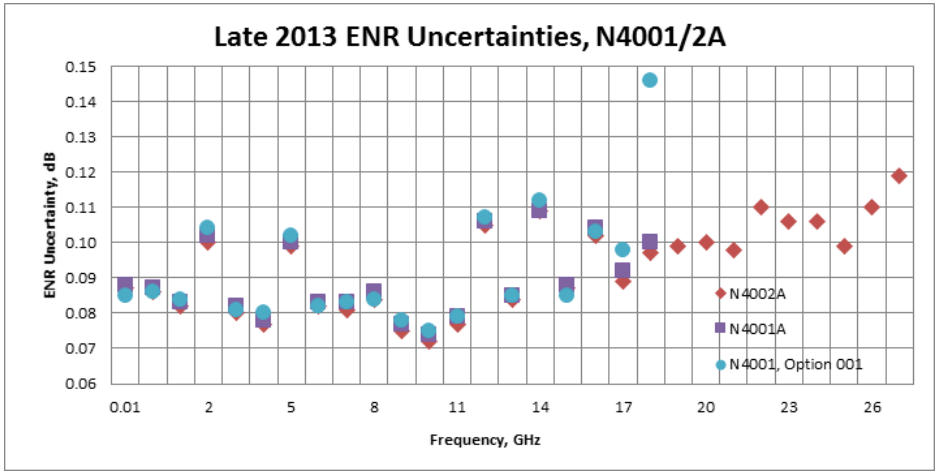

Figure 3-3 Example ENR uncertainty versus frequency for the N4001A and N4002A models

Supplemental characteristics

Table 3-2 Supplemental characteristics

Characteristic	N4000/1/2A	
ENR variation with temperature	<0.01 dB/°C for 30 MHz to 26.5 GHz	
Temperature sensing accuracy	Range	0 to 55 °C
	Resolution	0.25 °C
	Accuracy	– ±1° at 25 °C – ±2° over 0 °C to 55 °C

Physical specifications

Table 3-3 Physical specifications

Specifications	N4000/1/2A
Net weight	0.160 kg (5.64 oz.)
Dimensions	112 × 38 × 30 mm (4.4 × 1.5 × 1.2 in)

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)

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

4 Operating Guide

This chapter provides simple quick-check instructions to verify the N4000/1/2A SNS series smart noise source's functionality prior to usage. It also provides information on service and maintenance of the N4000/1/2A.

Operating Instructions

This section refers to operation with the Keysight NFA Series Noise Figure Analyzers. The Keysight SNS series smart noise sources work with these analyzers as well as other Keysight analyzers. For more detailed operating instructions, refer to the *Keysight NFA Series Noise Figure Analyzers User's Guide*.

CAUTION **Use a DC blocking capacitor to protect the SNS series smart 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 SNS series smart noise source with a noise figure analyzer. Figure 4-1 shows a simple test setup for a noise figure measurement.

Figure 4-1 Typical noise figure measurement test setup

Recommended test equipment

All of the operator's checks are performed using a Keysight Noise Figure Analyzer with firmware version A.01.01 and above. This can be used to perform an operational verification check.

Operator's check

The operator's checks in this section should be performed if failure of the SNS series smart noise source is suspected. The checks can be used only to verify that the SNS series smart noise sources are producing a broadband noise spectrum. They cannot be used to check the units against specifications.

NOTE **The operator's checks are designed to find a fault in the SNS. However, the fault could equally be with the cable and this should also be checked.**

Operator's check for data communication

The following procedure checks that the SNS can transfer the ENR data to the NFA.

1. Remove any cables from the NFA input and SNS drive.
2. Press the **Preset** key. Wait until the preset routine is complete before proceeding.

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

3. Press the **ENR** key.
4. Press the **SNS Setup** menu key.
5. Press the **Preference** menu key and set it to **Preference (SNS)**.
6. Press the **Auto Load ENR** menu key and set it to **Auto Load ENR (Off)**.
7. Connect the SNS to the NFA Port using the multi-pin 11730 cable, as shown in **Figure 4-2** on page 32.

Figure 4-2 Operator's check test setup for data communication

8 Press the **ENR** key.

9 Press the **ENR Mode** menu key and set it to **ENR Mode (Table)**.

10 Press the **Common Table** menu key and set it to **Common Table (On)**.

11 Press the **ENR Table** menu key.

12 Press the **Edit Table** menu key and press the **Clear Table** menu key if there is data in the `ENR Table`.

You are prompted to press this key again. This feature ensures you do not accidentally clear a valid Frequency list table. Press the **Clear Table** menu key again. **Figure 4-3** on page 33 shows a typical cleared ENR table.

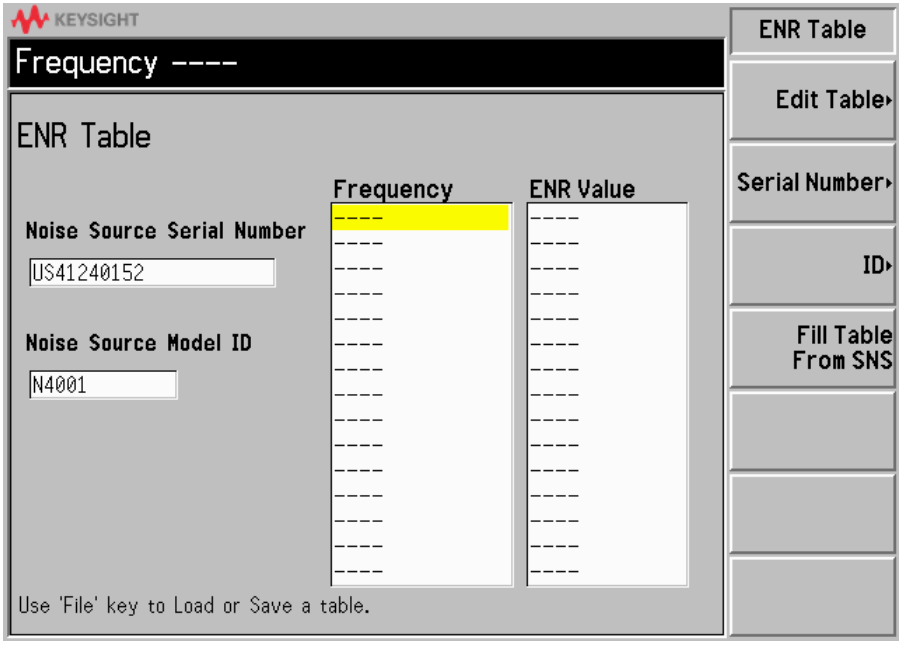

Figure 4-3 A typical cleared ENR table

13 Press the **Prev** key.

14 Press the **Fill Table From SNS** menu key. Wait until the data is uploaded from the SNS before proceeding.

15 Verify the data has been transferred from the SNS to the NFA. The data transfer should be similar to **Figure 4-4** on page 34. If it is not, return the SNS to Keysight Technologies for repair.

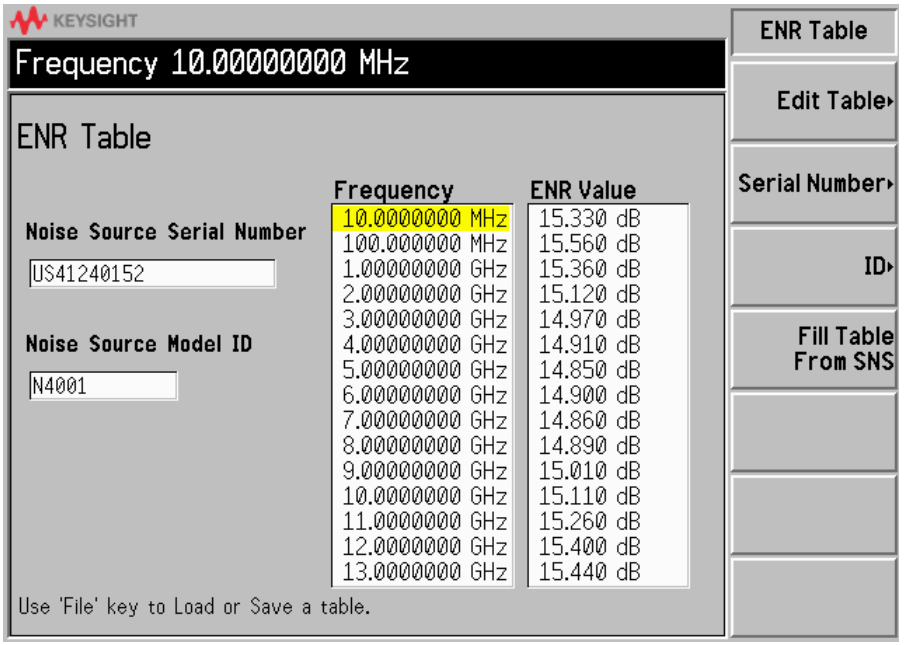

Figure 4-4 A typical ENR table after data entry

Operator's check for T_{cold} communication

The following procedure checks that the SNS can transfer the T_{cold} data to the NFA.

1. Remove any cables from the NFA input and SNS drive.
2. Press the **Preset** key. Wait until the preset routine is complete before proceeding.

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

3. Press the **ENR** key.
4. Press the **Tcold** menu key.

5 Connect the SNS to the NFA Port using the multi-pin 11730 cable, as shown in **Figure 4-5** on page 35.

Figure 4-5 Operator's check test setup for T_{cold} communication

6 Press the **SNS Tcold** menu key and set it to **SNS Tcold (Off)**.

7 Press the **User Tcold** menu key and set it to **User Tcold (On)**.

NOTE The value displayed in the **User Value** menu key, typically 296.50 K. **Figure 4-6** on page 36 shows a typical NFA menu map.

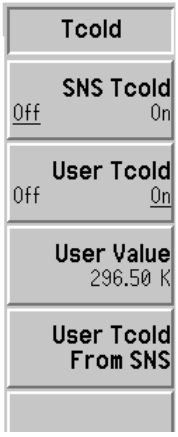

Figure 4-6 Typical user value

8 Press the **User Tcold From SNS** menu key.

In the **User Value** menu key, the new ambient temperature value is displayed. Figure 4-7 shows a typical NFA menu map.

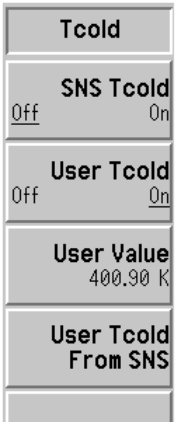

Figure 4-7 Typical user value after uploading SNS value

9 If this value has not changed, warm the SNS by wrapping your hand around its bulkhead as shown in Figure 4-8 for 20 seconds. This gives the SNS thermometer time to change its ambient value. Then press the **User Tcold From SNS** menu key again. The new ambient temperature value is displayed.

Figure 4-8 Operator's check for T_{cold} upload from SNS

10 If the value does not change, return the SNS to Keysight Technologies for repair.

Operator's check for switching noise source off and on

The following procedure checks that the SNS can switch the noise source off and on. This ensures the excess noise switches.

1 Remove any cables from the NFA input and SNS 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 SNS to the NFA Port using the multi-pin 11730 cable, as shown in Figure 4-9.

Figure 4-9 SNS connected to NFA graphic

4 Press the **Frequency/Points** key.

5 Press the **Frequency Mode** menu key.

6 Press the **Fixed** menu key.

7 Press the **Fixed Frequency** menu key. Enter 1.0 GHz as a fixed frequency value, by pressing the **1** numeric key followed by pressing the **GHz** menu key.

8 Press the **Sweep** key.

9 Press the **Manual Meas** menu key.

10 Press the **Manual State** menu key and set it to **Manual State (On)**.

11 Press the **Noise Source** menu key and set it to **Noise Source (On)**.

12 Press the **IF Att** menu key and set it to **IF Att (Hold)**.

13 Monitor the power value which appears in the manual measurement screen. **Figure 4-10** on page 39 shows a typical example of this.

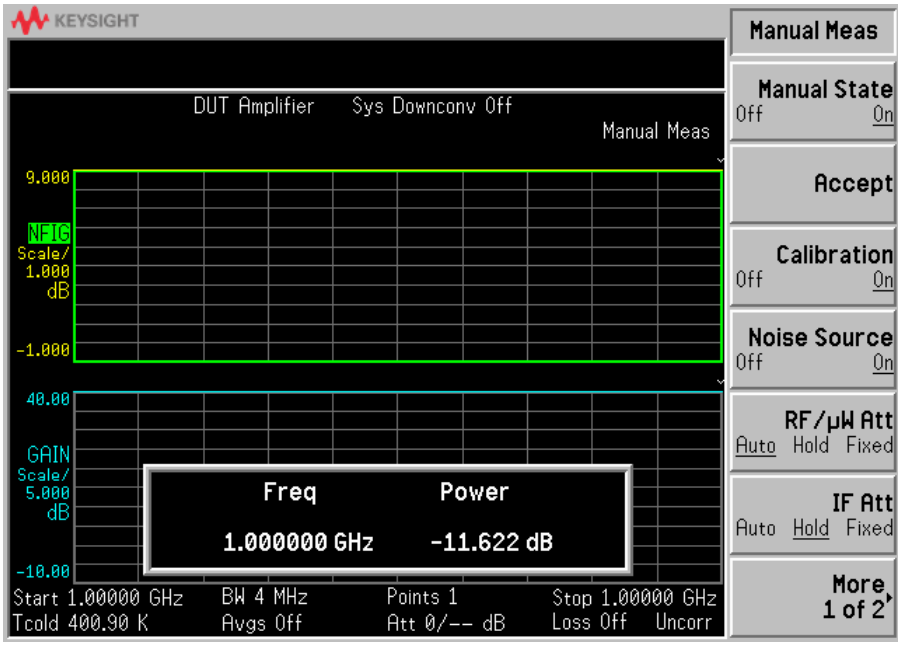

Figure 4-10 Typical example of power reading with Noise Source On

14 Press the **Noise Source** menu key and set it to **Noise Source (Off)**.

15 Monitor the power value which appears in the manual measurement screen. **Figure 4-11** on page 40 shows a typical example of this.

NOTE The monitored value is only to be used to indicate if the SNS is switching the Excess Noise “On” and “Off” by showing a change in power value.

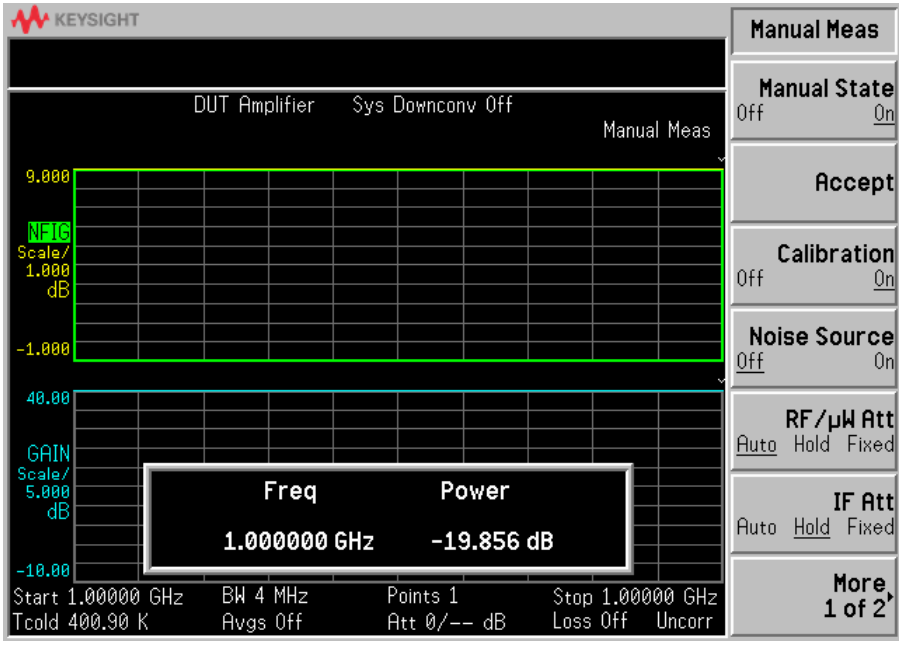

Figure 4-11 Typical example of power reading with Noise Source Off

16 If there is no change in value, return the SNS to Keysight Technologies for repair.

Operator's Maintenance

Proper connector care is a vital part of the maintenance which should be performed by the user. The life of the connector can be greatly extended by following the general connector care practices outlined in "Appendix A: Caring for Connectors" on page 59.

Performance Tests

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

Adjustments

There are no adjustments that can be made to the SNS series smart noise sources.

Replaceable Parts

Table 4-1, Table 4-2, and Table 4-3 list all replaceable parts available for the Keysight N4000/1/2A SNS series smart noise source. Figure 4-12 shows a typical SNS series smart noise source being prepared for parts replacement at the assembly level by removing the four end screws (two at each end).

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

NOTE If the N4000/1/2A is opened and parts replaced, it requires re-calibration.

Table 4-1 Replaceable parts list for N4000A[a]

Model/Option	Keysight part number				
	Bulkhead RF	Noise cartridge kit (serial prefix ≤ MY/SG/US5322)	Noise cartridge (serial prefix ≥ MY/SG5323)	Attenuator kit	PC board
N4000A	N4000-60020	00346-60194	00346-60193	00346-60194	N4000-60016
N4000A Opt 001	N4000-60021	00346-60194	00346-60193	00346-60194	N4000-60016

[a] Only replace these parts if you have calibration facilities to verify the SNS.

Table 4-2 Replaceable parts list for N4001A and N4002A[a]

Model/Option	Keysight part number			
	Replacement bulkhead assembly	Replacement noise cartridge	Attenuator replacement kit	PC board assembly
N4001A	N4001-60003	00346-60154	00346-60027	N4000-60001
N4001A Opt 001	N4001-60004	00346-60154	00346-60027	N4000-60001
N4002A	N4002-60004	00346-60155	00346-60027	N4002-60001

[a] Only replace these parts if you have calibration facilities to verify the SNS.

Table 4-3 Chassis parts

Model	Keysight part number	Reference designator	Description
N4000A, N4001A, N4002A	E9321-20002	MP1, MP2	Machined casting
N4000A, N4001A, N4002A	E9321-00001	MP3, MP4	Shield
N4000A, N4001A, N4002A	E9321-40001	MP5, MP6	Plastic shell
N4000A, N4001A, N4002A	0460-1919	MP7, MP8	Copper roll shielding tape
N4000A, N4001A, N4002A	N4000-80002	MP9	Label - Caution
N4000A, N4001A, N4002A	N4000-80003	MP10, MP11	Label - SNS Series
N4000A	N4000-80001	MP12	Label - N4000A
N4001A	N4001-80001	MP12	Label - N4001A
N4002A	N4002-80001	MP12	Label - N4002A
N4000A, N4001A, N4002A	00346-80011	MP13	Label - Caution

Table 4-4 Documentation

Model	Keysight part number	Description
N4000A, N4001A, N4002A	N4000-90001	Operating and Service Manual

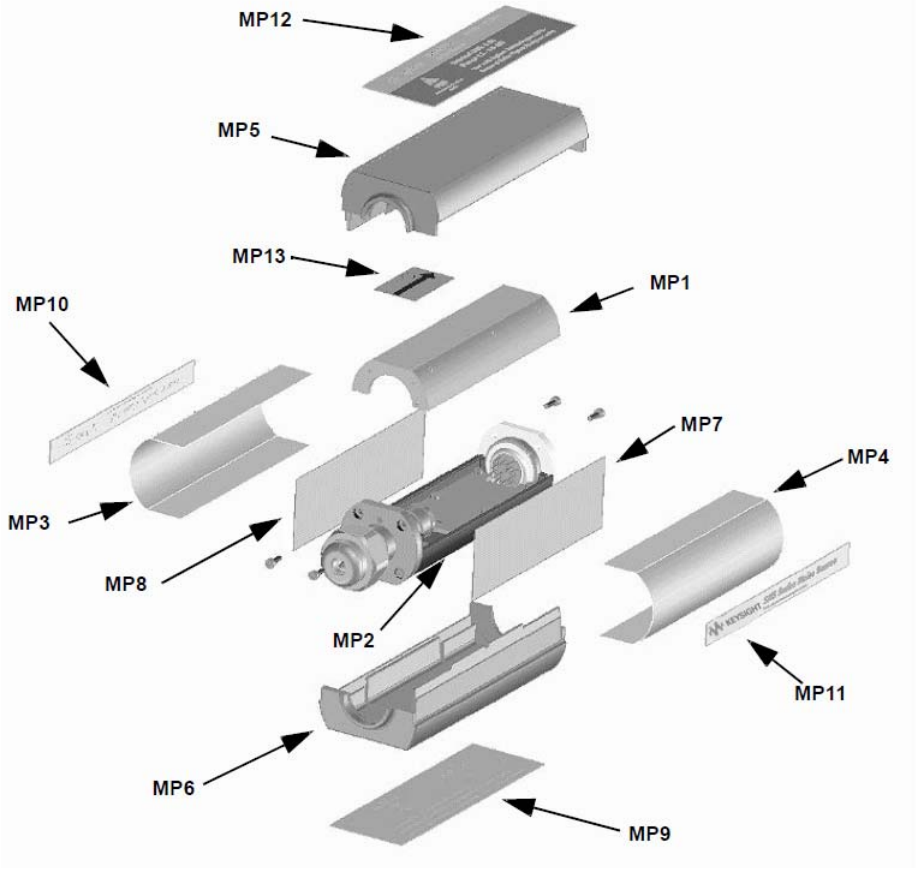

Figure 4-12 Illustrated parts breakdown

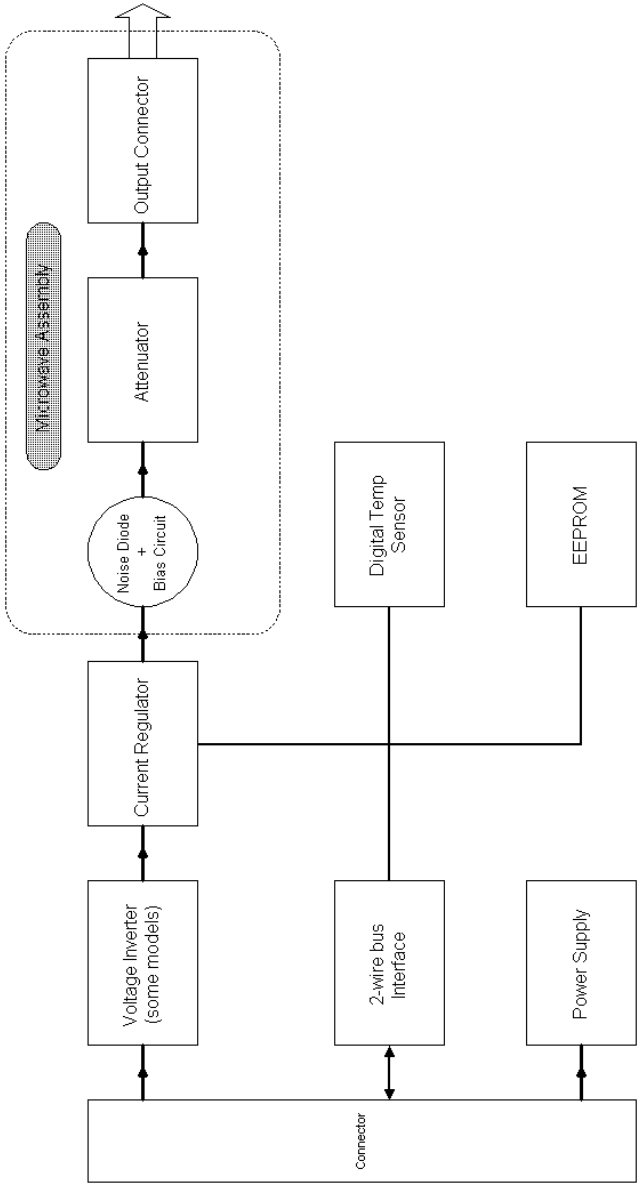

Figure 4-13 SNS series smart noise source block diagram

Service

Principles of operation

Referring to the SNS block diagram in **Figure 4-13** on page 45, a constant +28 V is supplied from the NFA through the multi-pin “Connector” block when the SNS is connected to the noise figure analyzer. A voltage inverter is used in the N4000A and N4001A to input approximately –25 V to the current regulator.

The current regulator applies a negative bias current to the noise diode for the N4000A and N4001A models. The N4002A utilizes a positive bias, so the voltage inverter is not necessary. The current regulator block also provides the switching necessary to produce the noise “On” and “Off” states.

The 2-wire bus interface allows for data transfer to and from the noise source. The data stored in the EEPROM includes model, serial number, diode current setting, and SNS calibration data.

The power supply provides +5 V to the 2-wire bus interface, EEPROM, and digital temperature sensor.

The digital temperature sensor is a digital thermometer, thermally coupled to the microwave assembly.

When the smart noise source is in its “On” state, the noise diode produces broadband noise which is input to the attenuator.

The attenuator sets the final Excess Noise Ratio (ENR) and output impedance of the smart noise source. A 16 dB attenuator is used in the N4000A to provide nominal ENR values of 5 dB. A 6 dB attenuator is used in the N4001A and N4002A models for nominal ENR values of 15 dB.

The standard output connector is a Precision 3.5 mm. A Type-N connector is optional.

Troubleshooting

Check the connectors and perform the operator’s check described in the Operating Instructions section of this manual. If the operator’s check results indicate a problem, or if the connectors are damaged, please contact Keysight Technologies. Our representatives can help isolate the problem and make arrangements for repairs if necessary.

Repair of defective noise source

Repair by the user is not recommended because of the complex equipment required for test and calibration. However, a number of replacement parts are available for customers with repair and calibration capabilities. See “Replaceable Parts” on page 42.

NOTE This manual does not include specific repair procedures covering the replacement of parts listed in “Replaceable Parts” on page 42.

Disassembly procedure

NOTE If the Keysight SNS series smart noise source is opened and parts are replaced, it requires re-calibration.

CAUTION Disassemble the noise source only in a static-free work area. Electrostatic discharge can damage the noise source.

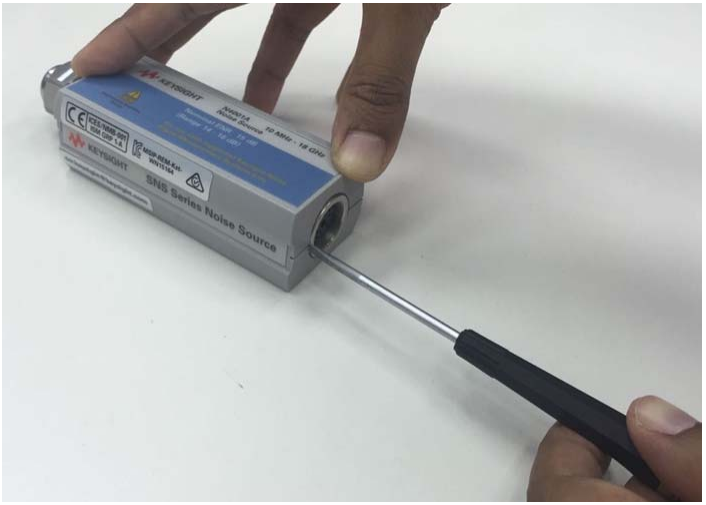

Figure 4-14 Removing the smart noise source plastic shell

Disassemble the SNS series smart noise source by performing the following steps.

1 At the rear of the noise source, insert the blade of a screwdriver between the plastic shells (see **Figure 4-14** on page 47). To prevent damage to the shells, use a screwdriver blade as wide as the slot between the two shells.

2 Pry alternately at both sides of the connector until the plastic shells are apart. Remove the shells and the magnetic shields.

Reassembly procedure

1 Replace the magnetic shields and plastic shells as shown in **Figure 4-12** on page 44.

2 Snap the plastic shells together.

Returning the SNS series smart noise source for calibration

When returning the N4000/1/2A to Keysight Technologies for calibration, send it to your nearest Keysight Sales and Service Office. Refer to "Sales and Technical Support" on page 6 of this manual.

5 ENR File Format

This chapter explains the format of an ENR file.

Format Details

An SNS ENR file:

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

Format

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 5-1 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 Only the first two fields, `Serialnumber` and `Model` are currently used by the noise figure analyzer.

Table 5-2 Optional header fields

FieldName	Description	OptionalValue	Description	Example
Serialnumber	The serial number of the SNS series smart noise source	serialtext	A string containing the serial number	`[Serialnumber 3318A14223]`
Model	Identifies the SNS series smart noise source model number	modelcode	Model code string	`[Model N4000A]`
Option	Identifies any model code option	optioncode	Option code string	`[Option 001]`
Caldate	Date of calibration of SNS series smart noise source	date&time	Formatted date and optional time	`[Caldate 19991202.09:15:30]`
Calduedate	Indicates date when next calibration of SNS series smart 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[a]	`[Temperature 24C]`
Humidity	Calibration relative humidity	value	Number followed by optional '%'	`[Humidity 40%]`
Placeofcal	Name of calibration site	placetext	string containing the place of calibration	`[Placeofcal SouthQueensferry]`
Trackingnum	Tracking number used during manufacture	value	number	`[Trackingnum 100]`
Current	Calibrated value of SNS current DAC value	value	number	`[Current 3000]`

[a] If a unit is not specified, C will be used as the default unit.

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 [on_mag_uncert [on_phase_uncert off_mag_uncert
off_phase_uncert]]]]
```

NOTE Square brackets signify 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, for example, '**10e6**' to represent 10 MHz.

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

If any reflection coefficient data is supplied, then all four fields must be present.

NOTE **The file format requires the ENR uncertainty field to be present before any reflection data.**

The reflection coefficient uncertainty (`on_mag_uncert`) is an optional parameter. Either one or four reflection uncertainties are allowed. If one value is supplied, it is assumed to apply to all reflection parameters. Alternatively, uncertainties can be supplied for all four reflection parameters independently. Reflection coefficient data must be present if this field is supplied.

Viewing the Smart Noise Source ENR Data

To view the ENR data you need a noise figure analyzer and a diskette.

NOTE For an explanation of saving a file to a diskette using the NFA, see the *Noise Figure Analyzer User's Guide*.

1 Connect the SNS to the NFA Port using the multi-pin 11730 cable, as shown in **Figure 4-2** on page 32.

NOTE Ensure the NFA is set to read the SNS data. See "Operator's check for data communication" on page 31 for further information.

2 Press the **File** key.

3 Press the **Save** menu key.

4 Press the **ENR** menu key.

5 Press the **SNS** menu key.

6 Press the **Tab** key to highlight the `Path: C:`

Ensure '`.`' '`^UP^`' is highlighted.

7 Press the **Select** menu key.

Ensure the '`[-A-]`' directory is highlighted.

8 Press the **Select** menu key.

9 Press the **Enter** key. Wait until the data is saved to the diskette.

10 You can now view the data on a PC using, for example, Wordpad as shown in "Examples" on page 56.

The data is presented using Comma Separated Values (CSV). This allows you to view it in a spreadsheet.

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 GB40390000 Firmware Revision A.01.01
# 13:37:07 Mar 28, 2001
# 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 an SNS ENR file saved to a diskette:

```
# ENR Data File
# Created by N8975A NFA Series Noise Figure Analyzer
# Serial Number GB40390000 Firmware Revision A.01.01
# 13:37:07 Mar 28, 2001
# Format is: Frequency (Hz), ENR (dB), ENR Unc (dB),
# On Refl.Mag (lin), On Refl.Phase (deg),
# Off Refl.Mag (lin), Off Refl.Phase (deg),
# On Refl.Mag Unc (lin), On Refl.Phase Unc (deg),
# Off Refl.Mag Unc (lin), Off Refl.Phase Unc (deg)
[Filetype ENR]
[Version 1.1]
[Serialnumber US41240152]
[Model N4001A]
[Option 001]
[Caldate 20000727]
[Calduedate 20010727]
[Placeofcal EPSGQ]
[Trackingnum 10]
[Temperature 296.5K]
[Humidity 65%]
[Current 36272]
10000000,15.281,0.193,0.0450,-136.0,0.0450,-136.0,0.0030,-6.0,0.0070,
+6.0
100000000,15.291,0.190,0.0358,+168.0,0.0358,+168.0,0.0040,+4.6,0.0050,
-4.6
1000000000,15.118,0.151,0.0398,+39.6,0.0398,+39.6,0.0100,+4.5,0.0067,
+1.5
2000000000,14.999,0.168,0.0377,0.168,0.0377,-85.7,0.0056,+0.9,0.0086,
+1.9
3000000000,14.879,0.172,0.0267,+150.6,0.0267,+150.6,0.0080,-9.2,0.0090,
-1.2
4000000000,14.795,0.173,0.0130,-18.1,0.0130,-18.1,0.0013,+16.0,0.0063,
+10.0
5000000000,14.818,0.179,0.0359,+169.5,0.0359,+169.5,0.0024,-9.3,0.0035,
-0.3
6000000000,14.846,0.181,0.0556,+63.7,0.0556,+63.7,0.0041,+10.3,0.0067,
-4.3
```

```
7000000000,14.895,0.180,0.0430,-37.0,0.0430,-27.0,0.0079,-2.3,0.0049,
-2.3
8000000000,15.016,0.198,0.0232,-160.3,0.0232,-160.3,0.0091,-3.8,0.0053,
-1.8
9000000000,15.134,0.201,0.0122,+71.4,0.0122,+71.4,0.0037,+17.3,0.0057,
+7.3
10000000000,15.253,0.194,0.0080,+116.2,0.0080,+116.2,0.0048,-1.4,0.0056
,-5.4
11000000000,15.249,0.243,0.0241,+65.7,0.0241,+65.7,0.0059,+1.5,0.0049,
+44.5
12000000000,15.349,0.240,0.0196,+8.8,0.0196,+8.8,0.0057,+3.2,0.0077,
+2.2
13000000000,15.383,0.188,0.0217,-5.4,0.0217,-5.4,0.0062,-6.9,0.0045,
-1.9
14000000000,15.355,0.178,0.0228,-66.6,0.0228,-66.6,0.0075,+11.2,0.0065,
+1.2
15000000000,15.367,0.187,0.0141,+141.6,0.0141,+141.6,0.0036,-3.2,0.0029
,-1.2
16000000000,15.421,0.182,0.0251,+6.4,0.0251,+6.4,0.0030,+7.2,0.0042,
-1.2
17000000000,15.418,0.174,0.0242,-100.5,0.0242,-100.5,0.0048,-2.7,0.0050
,+9.7
18000000000,15.464,0.179,0.0183,+124.4,0.0183,+124.4,0.0098,-1.1,0.0100
,+9.1
```

NOTE The values shown in Example 2 are representative of their position in the file. Therefore, they may not be numerically accurate.

A Caring for Connectors

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.

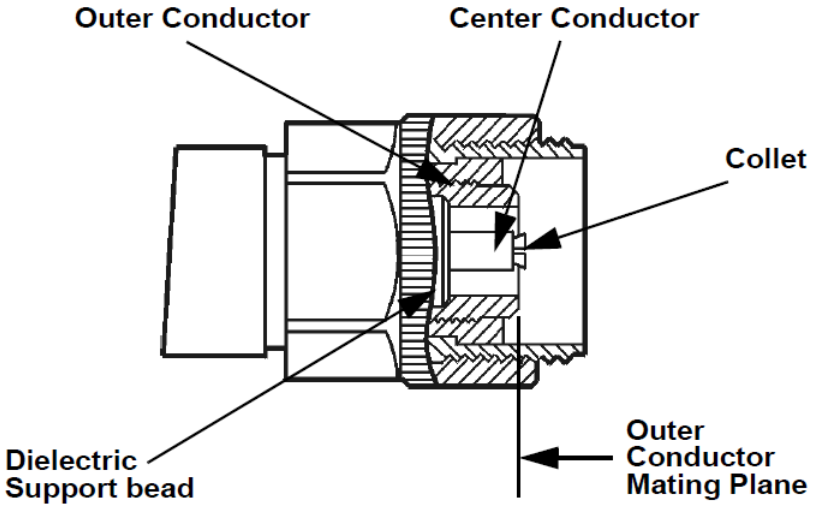

Figure A-1 Precision 7 mm connector

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.

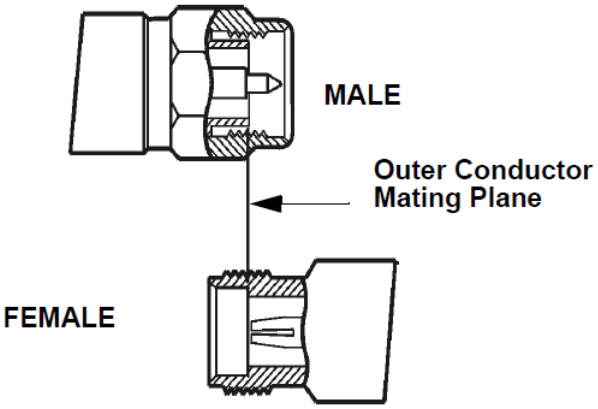

Figure A-2 Precision 3.5 mm connectors

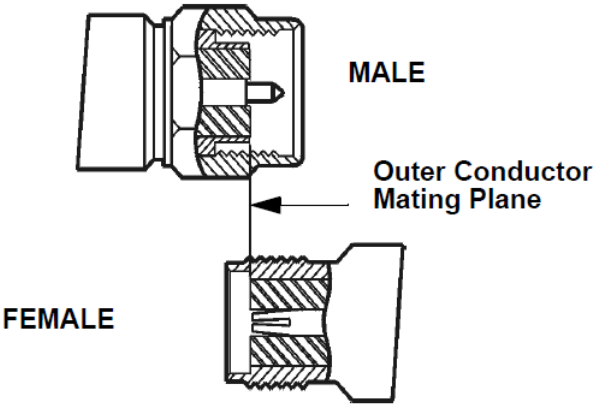

Figure A-3 SMA connectors

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).

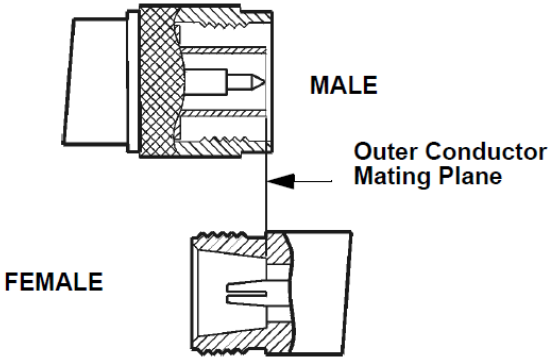

Figure A-5 Type-N connectors

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

Edition 4, May 26, 2017

Printed in Malaysia

N4000-90009
www.keysight.com