Vector Network Analyzers

Performance Test Manual

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1 DOCUMENT CHANGE RECORD

Revision Date	Brief Description of Changes
24 April 2020	List of analyzers supported are expanded. VNAPT connecting section updated due to Socket server usage transition.

2 CONTENT

3 CALIBRATION LAB

Copper Mountain Technologies' Indianapolis-based calibration laboratory is accredited in accordance with the recognized international standard ISO/IEC 17025:2017 and meets the requirements of ANSI/NCSL Z540-1-1994, ISO 9001:2015. All reference standards and equipment of the laboratory are traceable to International System of Units (SI) via National Institute of Standards and Technology (NIST) or international equivalents that are signatories to the CIPM Mutual Recognition Arrangement.

Our calibration certificate and scope, issued by ANSI National Accreditation Board (ANAB), can be accessed at anab.org using this accreditation number: AC-2060.

Figure 1

Copper Mountain Technologies calibration laboratory is able to verify any instrument presented here at short notice. But if you prefer to perform annual calibration yourself, our experts are always ready to help.

Please feel free to contact our calibration team in case you have any questions:

calibration@coppermountaintech.com

To figure out calibration types and considerations, as well as to achieve more information about calibration process, refer to our company website:

www.coppermountaintech.com

Any laboratory with sufficient RF measurement experience and capability can perform the maintenance needed for annual calibration of instruments.

4 INTRODUCTION

Vector network analyzers (VNA) are designed for measuring S-parameters of RF and microwave devices. They are used in the process of development, adjustment and testing of various electronic devices in industrial and laboratory facilities, including operation as a component of an automated measurement system.

Except as noted, all models are referred to interchangeably in this document as “the analyzer”.

This document contains general information and principles to performing the performance test of the measurement instruments.

NOTE	PERFORMANCE TEST IS USED TO CONFIRM INSTRUMENT PARAMETERS AGAINST SPECIFICATIONS AND TO VERIFY ERROR-CORRECTED UNCERTAINTY LIMITS FOR MEASUREMENTS, EITHER DURING OPERATION OR MAINTENANCE AS WELL AS AFTER REPAIR.

The document can be used by third-party calibration laboratories.

The document is intended to familiarize with:

- All groups of the vector network analyzers provided.
- Purpose and content of the verification procedure.
- All test equipment required.
- Preparation steps.
- Performance test sequence.
- Common recommendations and suggestions to reach more stable results.

NOTE	PERFORMANCE TEST DEPENDS ON THE INSTRUMENT TO BE VERIFIED.

The recommended performance test interval is once each year.

PERFORMANCE TEST IS CARRIED OUT WITH THE SPECIAL DEVELOPED SOFTWARE.

VNA Performance Test (VNAPT) is a software for checking the metrological characteristics of measurement instruments produced by Copper Mountain Technologies. It enables testing the instruments in auto mode, as well as saving and printing the acquired test data.

During any test, the program makes all necessary settings of the instrument, and performs required calculations.

IMPORTANT

The program contains all measurement setups and test descriptions. Due to the embedded instructions, you do not need to refer to the manuals during tests. Accidental actions cannot cause the loss of measurement results or failures.

Data presentation format complies with the recommendations of the international metrological documents.

The software functionality is based on widely spread and simple solutions, such as softkeys, text boxes, tables and graphs. It'll reduce your time to study working with it and performing any measurement.

VNAPT

Supports all instruments produced by Copper Mountain Technologies

Performs testing in auto mode

Measurement mode and read-only mode both are available

Quick connect to devices under test

Built-in instructions &measurement setups

Wizard with test steps

Tables &graphs

Marker system

Save &print reports

Save PDF & PRF files

5 SUPPORTING

Copper Mountain Technologies (CMT) provides a variety of vector network analyzers to accommodate a wide range of test and measurement needs. All instruments are combined into 5 main groups depending on its purpose, specification and functional capabilities: Cobalt series, Full Size VNAs, Compact series, PXIe series as well as 1 Port VNAs (cable and antenna analyzers).

COBALT	The Cobalt series of high-performance vector network analyzers offers an unmatched price-performance combination for S-parameter measurement and incorporates multiple technological innovations.
FULL SIZE	These analyzers are an excellent solution for performing the full range of magnitude and phase measurements of arbitrary electronic devices. The VNAs are flexible, easy to maintain, and are well-suited for lab and production testing. Every instrument is lab-grade quality, with a wide dynamic range, low noise floor, high resolution sweep, and a variety of other advanced features.
COMPACT	Thanks to its unmatched portability, those devices can be shared easily within a team or brought to test sites. The free, lightweight VNA application connects to the devices with a standard USB cable, creating a future-proof solution that significantly enhances ease of use compared with conventional instruments.
PXIe	These analyzers deliver metrology-grade VNA performance and speed to National Instruments PXI system. PXIe VNA fits into one slot of NI chassis.
1-PORT ANALYZERS	Due to their measurement accuracy, ultra-compact size and elimination of a test cable the devices provide a wide variety of analysis capabilities and are ideal for use by specialists working with antennas and antenna feeders in the field, as well as laboratory and production testing.

The product line is divided into 4 types: R, TR, S2 and S4. The R instruments are 1-port VNAs, and the S4 group contains 4-port VNAs. The S2 and TR groups both contain 2-port VNAs. S2 instruments are capable of 2-port, 2-path measurements while TR instruments are capable of 2-port 1-path measurements (S11 and S21 only).

Each product group (R, TR, S2, and S4) is supported by its own VNA software application, named RVNA, TRVNA, S2VNA, and S4VNA respectively. Each of these applications

contains a TCP/IP Socket network protocol that enables other programs to access its functionality. Automation of the VNA requires that the TCP/IP Socket be enable in RVNA, TRVNA, S2VNA, or S4VNA software.

PXIe analyzers are able to perform 2 port, 2-path measurements and are guided by S2VNA PXI software which is adopted to work with NI PXI system.

Table 1 – The analyzers supported by the VNAPT

Model	Software application	Operating frequency range	Connector type	Test equipment
COBALT (9 GHz)				
C1209	S2VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
C1409	S4VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
C2209 (DRA)	S2VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
C2409 (DRA)	S4VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
C4209 (FE)	S2VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
C4409 (FE)	S4VNA	100 kHz to 9 GHz	type N 50 Ohm	Table 4
COBALT (20 GHz)				
C1220	S2VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
C1420	S4VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
C2220 (DRA)	S2VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
C2420 (DRA)	S4VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
C4220 (FE)	S2VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
C4420 (FE)	S4VNA	100 kHz to 20 GHz	NMD 3.5 mm	Table 5
FULL SIZE				
304/1	S2VNA	100 kHz to 3.2 GHz	type N 50 Ohm	Table 6
804/1	S2VNA	100 kHz to 8 GHz	type N 50 Ohm	Table 6
814/1 (DRA)	S2VNA	100 kHz to 8 GHz	type N 50 Ohm	Table 6

Model	Software application	Operating frequency range	Connector type	Test equipment
808/1	S4VNA	100 kHz to 8 GHz	type N 50 Ohm	Table 6
		COMPACT		
TR1300/1	TRVNA	300 kHz to 1.3 GHz	type N 50 Ohm	Table 8
S7530	S2VNA	20 kHz to 3.0 GHz	type N 75 Ohm	Table 9
TR7530	TRVNA	20 kHz to 3.0 GHz	type N 75 Ohm	Table 9
S5048	S2VNA	20 kHz to 4.8 GHz	type N 50 Ohm	Table 7
TR5048	TRVNA	20 kHz to 4.8 GHz	type N 50 Ohm	Table 7
S5065	S2VNA	9 kHz to 6.5 GHz	type N 50 Ohm	Table 7
S5085	S2VNA	9 kHz to 8.5 GHz	type N 50 Ohm	Table 7
S5180	S2VNA	100 kHz to 18 GHz	type N 50 Ohm	Table 8
M5065	S2VNA	300 kHz to 6.5 GHz	type N 50 Ohm	Table 7
M5090	S2VNA	300 kHz to 8.5 GHz	type N 50 Ohm	Table 7
M5180	S2VNA	300 kHz to 18 GHz	type N 50 Ohm	Table 8
SC5065	S2VNA	300 kHz to 6.5 GHz	type N 50 Ohm	Table 7
SC5090	S2VNA	300 kHz to 9 GHz	type N 50 Ohm	Table 7
		PXIe ANALYZERS		
PXIe-S5090	S2VNA PXI	300 kHz to 9 GHz	3.5 mm	Table 10
		1-PORT ANALYZERS		
R54	RVNA	85 MHz to 5.4 GHz	type N 50 Ohm	Table 11
R60	RVNA	1 MHz to 6 GHz	type N 50 Ohm	Table 11
R140	RVNA	85 MHz to 14 GHz	type N 50 Ohm	Table 11
R180	RVNA	1 MHz to 18 GHz	type N 50 Ohm	Table 11

Model	Software application	Operating frequency range	Connector type	Test equipment
R180	RVNA	1 MHz to 18 GHz	3.5 mm	Table 12

NOTE

DRA – direct receiver access.

FE – frequency extension hardware option.

If necessary, study the VNAPT Release Notes to review the history of its version changes.

Detailed information on specifications and software applications for all supported instruments is available at:

www.coppermountaintech.com

6 SAFETY REQUIREMENTS

Carefully read through the following safety instructions before starting performance test.

- The instruments must be used only by skilled and specialized staff or thoroughly trained personnel with the required skills and knowledge of safety precautions.
- The 1-port analyzers comply with INSTALLATION CATEGORY I as well as POLLUTION DEGREE 2 in IEC61010–1.
- The rest analyzers comply with INSTALLATION CATEGORY II as well as POLLUTION DEGREE 2 in IEC61010-1. The Analyzers are INDOOR USE products.
- The instruments are MEASUREMENT CATEGORY I (CAT I). Do not use for CAT II, III, or IV.
- Never operate the instruments in the environment containing inflammable gases or fumes.
- Operators must not remove the cover or part of the housing. The instruments must not be repaired by the operator. Component replacement or internal adjustment must be performed by qualified maintenance personnel only.
- Do not replace components with the power cable connected. To avoid injuries, always disconnect the power and discharge circuits before touching them.
- Do not replace parts or modify the instruments to avoid the danger of additional hazards, do not install replacement parts or perform unauthorized modifications to the instruments.
- Do not connect the measuring terminals to mains.

Electrostatic discharge can damage your instrument when connected or disconnected from the device under test (DUT). Static charge can build up on your body and damage the sensitive circuits of internal components of both the instrument and the DUT.

To avoid damage from electric discharge, observe the following:

- Always use a desktop antistatic mat under the DUT.

- Always wear a grounding wrist strap connected to the desktop antistatic mat via daisy-chained 1 MΩ resistor.

7 PERFORMANCE TEST LIST

A list of the analyzer performance tests is contained in Table 2.

Table 2 - Analyzer performance tests

Test description	COBALT	FULL SIZE	COMPACT up to 9 GHz	COMPACT over 9 GHz, and TR1300/1	PXIe	1-PORT ANALIZERS
Visual inspection	☑	☑	☑	☑	☑	☑
Gaging connectors	☑	☑	☑	☑	☑	☑
Frequency accuracy test	☑	☑	☑	☑	☑	☑
Output power level accuracy test	☑	☑	☑	☑	☑	☒
Harmonic distortion test	☒	☑	☑	☒	☑	☒
Non-harmonic spurious test	☒	☑	☑	☒	☑	☒
Receiver noise floor test	☑	☑	☑	☑	☑	☒
Trace noise magnitude test	☑	☑	☑	☑	☑	☒
Uncorrected parameters test	☑	☑	☑	☑	☑	☑
Transmission coefficient magnitude and phase accuracy test	☑	☑	☑	☑	☑	☒
Reflection coefficient magnitude and phase accuracy test	☑	☑	☑	☑	☑	☑

IF THE ANALYZER FAILS ANY OF THE TESTS LISTED IN TABLE 2 DO NOT CONDUCT FURTHER TESTS. ISSUE A NON-COMPLIANCE NOTICE OR A FAULT REPORT AS PRESCRIBED IN LABORATORY QUALITY SYSTEM.

NOTE — Upon completion of the performance test, visually check each test port connector of the analyzer under test for any contamination and damage. If foreign particles are observed, clean the connector(s).

8 TEST EQUIPMENT

8.1 Summary

Table 3 contains summary list of main test equipment to perform each test across the verification procedure.

Table 3

Test Description	Main test equipment
Visual inspection	–
Gaging connectors	Gauging kit
Frequency accuracy test	Frequency counter or spectrum analyzer
Output power level accuracy test	Power sensor
Harmonic distortion test	Spectrum analyzer
Non-harmonic spurious test	Spectrum analyzer
Receiver noise floor test	Matched loads
Trace noise magnitude test	Open or short standard from user calibration kit Test cable
Uncorrected parameters test	User calibration kit
Transmission coefficient magnitude and phase accuracy test:	
Common verification	Verification kit. Attenuators
Calibration comparison	Reference calibration kit
Reflection coefficient magnitude and phase accuracy test	
Common verification	Verification kit. Stepped airline (mismatched loads for 1-port analyzers)
Calibration comparison	Reference calibration kit

NOTE

Number of the tests depends on the instrument to be verified.

One can choose performing either common verification, or calibration comparison technique in dependence on what type of test equipment is available in a lab.

User calibration kit should be used for calibration of the analyzer under test during transmission and reflection accuracy tests regardless verification method applied.

The recommended equipment required for performance testing of certain instrument is listed in Tables 4-12.

8.2 Cobalt series (type N 50 Ohm)

Table 4 – Equipment for testing the analyzer with type N 50 Ohm connectors

Test equipment and specifications for Cobalt series VNAs with type N 50 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z51 thermal power sensor (Rohde &Schwarz): frequency range DC to 18 GHz, power measurement range -35 dBm to +20 dBm, measurement accuracy ±0.15 dB.
85055A verification kit (Keysight Technologies): frequency range up to 18 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z270 reference calibration kit with data-based standard definitions (Rohde & Schwarz): frequency range up to 18 GHz. The effective system data: - directivity ≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
05CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 18 GHz. The effective system data: DC to 10 GHz - directivity ≥ 46 dB - source match ≥ 40 dB - load match ≥ 46 dB - reflection tracking ≤ 0.05 dB - transmission tracking ≤ 0.05 dB 10 GHz up to 18 GHz - directivity ≥ 42 dB - source match ≥38 dB - load match ≥ 42 dB - reflection tracking ≤ 0.10 dB - transmission tracking ≤ 0.05 dB

Test equipment and specifications for Cobalt series VNAs with type N 50 Ohm connectors
05GK0KS-010 type N gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.
03GK0KS-010 3.5 mm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm. NOTE This gauge kit is used for the analyzers with loops (DRA option).
05S150-C10S3 matched load (Rosenberger): type N, male, frequency range DC to 18 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).
TESTPRO3 phase- and amplitude-stable test cable (Radiall): frequency range DC to 18 GHz, type N connectors. NOTE It's recommended along with this RF cable to use 05S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 18 GHz, VSWR max 1.1, type N, male to type N, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.
CBL RF cable (Mini-Circuits): frequency range DC to 18 GHz. NOTE This cable is general purpose. It can be required for connection during frequency measurement. To connect with input ports of the frequency counter can be needed between series coaxial adapters are not shown in the table.
ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.
ANO TW-001 torque wrench (Anoison): size 8 mm, torque range 0,8 to 1.0 Nm. NOTE This torque wrench is used for the analyzers with loops (DRA option).
Wrench (spanner) which fits devices to be connected.
Personal computer: Windows 7 and above, interface USB 2.0.
RFRHTemp2000A temperature and humidity data logger (Madge Tech).

8.3 Cobalt series (3.5 mm)

Table 5 – Equipment for testing the analyzer with 3.5 mm connectors

Test equipment and specifications for Cobalt series VNAs with 3.5 mm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z52 thermal power sensor (Rohde & Schwarz): frequency range DC to 33 GHz, power level measurement range -35 to +20 dBm, power level measurement accuracy ±0.15 dB. NOTE To connect power sensor to test port of the analyzer should be used 03K121-K20S3 coaxial adapter with metrology grade connectors (Rosenberger): frequency range DC to 26.5 GHz, VSWR max 1.1, 3.5 mm, female to 3.5 mm, female.
85053B verification kit (Keysight Technologies): frequency range up to 26.5 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z235 reference calibration kit with data-based standard definitions (Rohde & Schwarz): frequency range up to 24 GHz. The effective system data: - directivity≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
03CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 26.5 GHz. The effective system data: DC to 10 GHz - directivity ≥ 46 dB - source match ≥ 40 dB 10 GHz up to 20 GHz - directivity ≥ 42 dB - source match ≥38 dB

Test equipment and specifications for Cobalt series VNAs with 3.5 mm connectors	
- load match ≥ 46 dB	- load match ≥ 42 dB
- reflection tracking ≤ 0.05 dB	- reflection tracking ≤ 0.10 dB
- transmission tracking ≤ 0.05 dB	- transmission tracking ≤ 0.05 dB
03GK0KS-010 3.5 mm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.	
03K150-C10S3 matched load (Rosenberger): 3.5 mm, female, frequency range DC to 26.5 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).	
TESTPRO3 phase- and amplitude-stable test cable (Radiall): frequency range DC to 26.5 GHz, 3.5 mm connectors.	
NOTE	It's recommended along with this RF cable to use 03S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 26.5 GHz, VSWR max 1.1, 3.5 mm, male to 3.5 mm, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.
CBL RF cable (Mini-Circuits): frequency range DC to 20 GHz.	
NOTE	This cable is general purpose. It can be required for connection during frequency measurement. To connect with input ports of the frequency counter can be needed between series coaxial adapters are not shown in the table.
ANO TW-001 torque wrench (Anoison): size 8 mm, torque range 0,8 to 1.0 Nm.	
ANO TW-005 torque wrench (Anoison): size 20 mm, torque range 0,8 to 1.0 Nm.	
Wrench (spanner) which fits devices to be connected.	
Personal computer: Windows 7 and above, interface USB 2.0.	
RFRHTemp2000A temperature and humidity data logger (Madge Tech).	

8.4 Full size (type N 50 Ohm)

Table 6 – Equipment for testing the analyzer with type N 50 Ohm connectors

Test equipment and specifications for Full Size VNAs with type N 50 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z51 thermal power sensor (Rohde & Schwarz): frequency range DC to 18 GHz, power measurement range -35 dBm to +20 dBm, measurement accuracy ±0.15 dB.
E4407B spectrum analyzer (Keysight Technologies): frequency range 9 kHz to 26.5 GHz; relative power measurement accuracy ±2 dB.
85055A verification kit (Keysight Technologies): frequency range up to 18 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z270 reference calibration kit with data-based standard definitions(Rohde & Schwarz): frequency range up to 18 GHz. The effective system data: - directivity ≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
05CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 18 GHz. The effective system data: DC to 10 GHz - directivity ≥ 46 dB - source match ≥ 40 dB - load match ≥ 46 dB 10 GHz up to 18 GHz - directivity ≥ 42 dB - source match ≥38 dB - load match ≥ 42 dB

Test equipment and specifications for Full Size VNAs with type N 50 Ohm connectors	
- reflection tracking ≤ 0.05 dB - transmission tracking ≤ 0.05 dB	- reflection tracking ≤ 0.10 dB - transmission tracking ≤ 0.05 dB
05GK0KS-010 type N gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.	
03GK0KS-010 3.5 mm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm. NOTE This gauge kit is used for the analyzers with loops (DRA option).	
05S150-C10S3 matched load (Rosenberger): type N, male, frequency range DC to 18 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).	
TESTPRO3 phase- and amplitude-stable test cable (Radiall):frequency range DC to 18 GHz, type N connectors. NOTE It's recommended along with this RF cable to use 05S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 18 GHz, VSWR max 1.1, type N, male to type N, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.	
CBL RF cable (Mini-Circuits): frequency range DC to 18 GHz. NOTE This cable is general purpose. It can be required for connection during frequency measurement, and harmonic/non-harmonic testing. To connect with input ports of the frequency counter or spectrum analyzer can be needed between series coaxial adapters are not shown in the table.	
ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.	
ANO TW-001 torque wrench (Anoison): size 8 mm, torque range 0,8 to 1.0 Nm. NOTE This torque wrench is used for the analyzers with loops (DRA option).	
Wrench (spanner) which fits devices to be connected.	
Personal computer: Windows 7 and above, interface USB 2.0.	
RFRHTemp2000A temperature and humidity data logger (Madge Tech).	

8.5 Compact series up to 9 GHz (type N 50 Ohm)

Table 7 – Equipment for testing the analyzer with type N 50 Ohm connectors

Test equipment and specifications for Compact series VNAs with type N 50 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z51 thermal power sensor (Rohde & Schwarz): frequency range DC to 18 GHz, power measurement range -35 dBm to +20 dBm, measurement accuracy ±0.15 dB.
E4407B spectrum analyzer (Keysight Technologies): frequency range 9 kHz to 26.5 GHz; relative power measurement accuracy ±2 dB.
85055A verification kit (Keysight Technologies): frequency range up to 18 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z270 reference calibration kit with data-based standard definitions (Rohde & Schwarz): frequency range up to 18 GHz. The effective system data: - directivity ≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
05CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 18 GHz. The effective system data: DC to 10 GHz - directivity≥ 46 dB - source match ≥ 40 dB - load match ≥ 46 dB 10 GHz up to 18 GHz - directivity≥ 42 dB - source match ≥38 dB - load match ≥ 42 dB

Test equipment and specifications for Compact series VNAs with type N 50 Ohm connectors	
- reflection tracking ≤ 0.05 dB - transmission tracking ≤ 0.05 dB	- reflection tracking ≤ 0.10 dB - transmission tracking ≤ 0.05 dB
05GK0KS-010 type N gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.	
05S150-C10S3 matched load (Rosenberger): type N, male, frequency range DC to 18 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).	
TESTPRO3 phase- and amplitude-stable test cable (Radiall): frequency range DC to 18 GHz, type N connectors.	
NOTE	It's recommended along with this RF cable to use 05S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 18 GHz, VSWR max 1.1, type N, male to type N, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.
CBL RF cable (Mini-Circuits): frequency range DC to 18 GHz.	
NOTE	This cable is general purpose. It can be required for connection during frequency measurement, and harmonic/non-harmonic testing. To connect with input ports of the frequency counter or spectrum analyzer can be needed between series coaxial adapters are not shown in the table.
ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.	
Wrench (spanner) which fits devices to be connected.	
Personal computer: Windows 7 and above, interface USB 2.0.	
RFRHTemp2000A temperature and humidity data logger (Madge Tech).	

8.6 Compact series over 9 GHz (type N 50 Ohm) and TR1300/1

Table 8 – Equipment for testing the analyzer with type N 50 Ohm connectors

Test equipment and specifications for Compact series VNAs with type N 50 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z51 thermal power sensor (Rohde & Schwarz): frequency range DC to 18 GHz, power measurement range -35 dBm to +20 dBm, measurement accuracy ±0.15 dB.
85055A verification kit (Keysight Technologies): frequency range up to 18 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z270 reference calibration kit with data-based standard definitions (Rohde & Schwarz): frequency range up to 18 GHz. The effective system data: - directivity ≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
05CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 18 GHz. The effective system data: DC to 10 GHz - directivity≥ 46 dB - source match ≥ 40 dB - load match ≥ 46 dB - reflection tracking ≤ 0.05 dB - transmission tracking ≤ 0.05 dB 10 GHz up to 18 GHz - directivity≥ 42 dB - source match ≥38 dB - load match ≥ 42 dB - reflection tracking ≤ 0.10 dB - transmission tracking ≤ 0.05 dB

Test equipment and specifications for Compact series VNAs with type N 50 Ohm connectors
05GK0KS-010 type N gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.
05S150-C10S3 matched load (Rosenberger): type N, male, frequency range DC to 18 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).
TESTPRO3 phase- and amplitude-stable test cable (Radiall): frequency range DC to 18 GHz, type N connectors. NOTE: It's recommended along with this RF cable to use 05S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 18 GHz, VSWR max 1.1, type N, male to type N, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.
CBL RF cable (Mini-Circuits): frequency range DC to 18 GHz. NOTE: This cable is general purpose. It can be required for connection during frequency measurement, and harmonic/non-harmonic testing. To connect with input ports of the frequency counter or spectrum analyzer can be needed between series coaxial adapters are not shown in the table.
ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.
Wrench (spanner) which fits devices to be connected.
Personal computer: Windows 7 and above, interface USB 2.0.
RFRHTemp2000A temperature and humidity data logger (Madge Tech).

8.7 Compact series (type N 75 Ohm)

Table 9 – Equipment for testing the analyzer with type N 75 Ohm connectors

Test equipment and specifications for Compact series VNAs with type N 75 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z51 thermal power sensor (Rohde & Schwarz): frequency range DC to 18 GHz, power measurement range -35 dBm to +20 dBm, measurement accuracy ±0.15 dB.
NOTE To connect power sensor to test port of the analyzer should be used AP50NF75NM impedance matching pad (Copper Mountain Technologies): frequency range DC to 3.2 GHz, VSWR max 1.1, type N (50 Ohm), female to type N (75 Ohm), male.
E4407B spectrum analyzer (Keysight Technologies): frequency range 9 kHz to 26.5 GHz; relative power measurement accuracy ±2 dB.
Verification kit: frequency range up to 3 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
85036B reference calibration kit with data-based standard definitions (Keysight Technologies): frequency range up to 3 GHz. The effective system data: - directivity≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
P5CK10A-170 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 4 GHz. The effective system data: - directivity≥ 46 dB - source match ≥ 40 dB - reflection tracking ≤ 0.05 dB - transmission tracking ≤ 0.05 dB

Test equipment and specifications
for Compact series VNAs with type N 75 Ohm connectors

- load match ≥ 46 dB

P5GK0KS-000 type N 75 Ohm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.

P5S150-C10S3 matched load (Rosenberger): type N 75 Ohm, male, frequency range DC to 4 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).

C75NMFM.3 test cable (Copper Mountain Technologies): frequency range DC to 3 GHz, type N 75 Ohm connectors.

NOTE To connect with inputs of the analyzer and test equipment can be needed between series coaxial adapters are not shown in the table.

ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.

Wrench (spanner) which fits devices to be connected.

Personal computer: Windows 7 and above, interface USB 2.0.

RFRHTemp2000A temperature and humidity data logger (Madge Tech).

8.8 PXIe series (3.5 mm)

Table 10 – Equipment for testing the analyzer with 3.5 mm connectors

Test equipment and specifications for PXIe series VNAs with 3.5 mm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NRP-Z52 thermal power sensor (Rohde & Schwarz): frequency range DC to 33 GHz, power level measurement range -35 to +20 dBm, power level measurement accuracy ±0.15 dB. NOTE To connect power sensor to test port of the analyzer should be used 03S121-K20S3 coaxial adapter with metrology grade connectors (Rosenberger): frequency range DC to 26.5 GHz, VSWR max 1.1, 3.5 mm, female to 3.5 mm, male.
E4407B spectrum analyzer (Keysight Technologies): frequency range 9 kHz to 26.5 GHz; relative power measurement accuracy ±2 dB.
85053B verification kit (Keysight Technologies): frequency range up to 26.5 GHz. transmission magnitude error of attenuators ±0.1 dB; transmission phase error of attenuators ±1°; reflection magnitude error of stepped air line from ±0,008 to ±0,016; reflection phase error of stepped air line from ±10,0° to ±1,5°. NOTE Verification kit is used during common verification procedure.
ZV-Z235 reference calibration kit with data-based standard definitions (Rohde & Schwarz): frequency range up to 24 GHz. The effective system data: - directivity≥ 46 dB - source match ≥ 43 dB - load match ≥ 46 dB - reflection tracking ≤ 0.04 dB - transmission tracking ≤ 0.04 dB NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
03CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 26.5 GHz. The effective system data: DC to 10 GHz - directivity ≥ 46 dB 10 GHz up to 20 GHz - directivity ≥ 42 dB

Test equipment and specifications for PXIe series VNAs with 3.5 mm connectors	
- source match ≥ 40 dB	- source match ≥38 dB
- load match ≥ 46 dB	- load match ≥ 42 dB
- reflection tracking ≤ 0.05 dB	- reflection tracking ≤ 0.10 dB
- transmission tracking ≤ 0.05 dB	- transmission tracking ≤ 0.05 dB

03GK0KS-010 3.5 mm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.

03S150-C10S3 matched load (Rosenberger): 3.5 mm, male, frequency range DC to 26.5 GHz, VSWR max 1.1 (quantity of the loads is equal to the quantity of test ports of the analyzer under test).

TESTPRO3 phase- and amplitude-stable test cable (Radiall): frequency range DC to 26.5 GHz, 3.5 mm connectors.

NOTE

It's recommended along with this RF cable to use 03S121-K20S3 coaxial adapters with metrology grade connectors (Rosenberger): frequency range DC to 26.5 GHz, VSWR max 1.1, 3.5 mm, male to 3.5 mm, female. It'll allow to reach more stability and repeatability effects during reflection and transmission measurement.

CBL RF cable (Mini-Circuits): frequency range DC to 20 GHz.

NOTE

This cable is general purpose. It can be required for connection during frequency measurement.

To connect with input ports of the frequency counter can be needed between series coaxial adapters are not shown in the table.

ANO TW-001 torque wrench (Anoison): size 8 mm, torque range 0,8 to 1.0 Nm.

ANO TW-005 torque wrench (Anoison): size 20 mm, torque range 0,8 to 1.0 Nm.

Wrench (spanner) which fits devices to be connected.

Personal computer: Windows 7 and above, interface USB 2.0.

RFRHTemp2000A temperature and humidity data logger (Madge Tech).

8.9 1-port analyzers (type N 50 Ohm)

Table 11 – Equipment for testing the 1-port analyzers with type N 50 Ohm connectors

Test equipment and specifications for 1-port analyzers with type N 50 Ohm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy $\pm 1 \times 10^{-7}$.
NOTE To connect with input ports of the frequency counter can be needed between series coaxial adapters are not shown in the table.
ZV-Z270 reference calibration kit with data-based standard definitions (Rohde &Schwarz): frequency range up to 18 GHz. The effective system data: - directivity ≥ 46 dB - reflection tracking ≤ 0.04 dB - source match ≥ 43 dB
NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
05CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 18 GHz. The effective system data: DC to 10 GHz - directivity≥ 46 dB - source match ≥ 40 dB - reflection tracking ≤ 0.05 dB 10 GHz up to 18 GHz - directivity≥ 42 dB - source match ≥38 dB - reflection tracking ≤ 0.10 dB
2561C and 2561G mismatched loads (Maury Microwave): type N, female, frequency range DC to 18 GHz, nominal VSWR 1.2 and 2.0 accordingly. VSWR relative error $1{,}0 \cdot K_U$ % in frequency range up to 10 GHz, and $1{,}5 \cdot K_U$ % - above 10 GHz (K_U– actual VSWR value at the specified frequency).
2562C and 2562G mismatched loads (Maury Microwave): type N, male, frequency range DC to 18 GHz, nominal VSWR 1.2 and 2.0 accordingly. VSWR relative error $1{,}0 \cdot K_U$ % in frequency range up to 10 GHz, and $1{,}5 \cdot K_U$ % - above 10 GHz (K_U– actual VSWR value at the specified frequency).
NOTE These loads are used during common verification procedure. It's considered that VSWR 1.2 is low reflection standard, while VSWR 2.0

is high reflection standard. Also it's not prohibited to use VSWR 1.05 or 1.1 instead VSWR 1.2.
05GK0KS-010 type N gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.
ANO TW-006 torque wrench (Anoison): size 20 mm, torque range 1.1 to 1.7 Nm.
Wrench (spanner) which fits devices to be connected.
Personal computer: Windows 7 and above, interface USB 2.0.
RFRHTemp2000A temperature and humidity data logger (Madge Tech).

8.10 1-port analyzers (3.5 mm)

Table 12 – Equipment for testing the 1-port analyzers with 3.5 mm connectors

Test equipment and specifications for 1-port analyzers with 3.5 mm connectors
53150A frequency counter (Keysight Technologies): frequency range 10 Hz to 20 GHz, accuracy ±1×10^{-7}.
NOTE To connect with input ports of the frequency counter can be needed between series coaxial adapters are not shown in the table.
ZV-Z235 reference calibration kit with data-based standard definitions(Rohde & Schwarz): frequency range up to 24 GHz. The effective system data: - directivity ≥ 46 dB - reflection tracking ≤ 0.04 dB - source match ≥ 43 dB
NOTE This kit is used during calibration comparison test as reference kit with known parameters of standards.
03CK010-150 user calibration kit with data-based standard definitions (Rosenberger): frequency range up to 26.5 GHz. The effective system data: DC to 10 GHz - directivity ≥ 46 dB - source match ≥ 40 dB - reflection tracking ≤ 0.05 dB 10 GHz up to 20 GHz - directivity ≥ 42 dB - source match ≥38 dB - reflection tracking ≤ 0.10 dB
8033A1.20 and 8033A2.00 mismatched loads (Maury Microwave): 3.5 mm, female, frequency range DC to 26.5 GHz, nominal VSWR 1.2 and 2.0 accordingly. VSWR relative error 1,0·K_U % in frequency range up to 10 GHz, and 1,5·K_U % - above 10 GHz (K_U– actual VSWR value at the specified frequency).
8033B1.20 and 8033B2.00 mismatched loads (Maury Microwave): 3.5 mm, male, frequency range DC to 26.5 GHz, nominal VSWR 1.2 and 2.0 accordingly. VSWR relative error 1,0·K_U % in frequency range up to 10 GHz, and 1,5·K_U % - above 10 GHz (K_U– actual VSWR value at the specified frequency).
NOTE These loads are used during common verification procedure. It's considered that VSWR 1.2 is low reflection standard, while VSWR 2.0 is high reflection standard.

Test equipment and specifications for 1-port analyzers with 3.5 mm connectors
Also it's not prohibited to use VSWR 1.05 or 1.1 instead VSWR 1.2.
03GK0KS-010 3.5 mm gauge kit (Rosenberger): scale gradation 1 µm, accuracy ±6 µm.
ANO TW-001 torque wrench (Anoison): size 8 mm, torque range 0,8 to 1.0 Nm.
Wrench (spanner) which fits devices to be connected.
Personal computer: Windows 7 and above, interface USB 2.0.
RFRHTemp2000A temperature and humidity data logger (Madge Tech).

ALL THE TEST EQUIPMENT SHALL BE VERIFIED AND HAVE VALID VERIFICATION OR CALIBRATION CERTIFICATES.

IMPORTANT	PAY ATTENTION: PERFORMANCE TEST PROGRAM ALLOWS CHANGING THE USER CALIBRATION KIT DEFINITION. IF YOU ARE GOING TO USE THE KIT WITH MORE ROUGH PARAMETERS, THEN THE SOFTWARE AUTOMATICALLY RE-CALCULATES REFLECTION AND TRANSMISSION ERROR LIMIT.

IMPORTANT	PAY ATTENTION: THE TOTAL REFLECTION AND TRANSMISSION ERROR LIMITS ARE THE SUM OF THE MEASUREMENT ERRORS FOR THE VERIFICATION STANDARDS AND THE SYSTEMATIC ERRORS ASSOCIATED WITH THE ANALYZER BEING VERIFIED.

NOTE	CUSTOMER MAY ASK CALIBRATION LABORATORY TO VERIFY ONLY A PART OF THE SPECIFICATIONS IF IT'S PLANNED TO USE NOT OF ALL ANALYZER MEASUREMENT CAPABILITIES. HOWEVER, THIS LIMITED TEST CREATES THE POSSIBILITY OF MAKING INACCURATE MEASUREMENTS IF YOU THEN USE THE ANALYZER IN AN APPLICATION REQUIRING ADDITIONAL CAPABILITIES.

9 AMBIENT CONDITIONS

Execute performance test under the following ambient conditions:

- Ambient temperature: 23±5 ^{0}C;
- Relative air humidity: ≤80 % at 25 °C;
- Atmospheric pressure: 630 to 795 mm Hg.

When performing reflection and transmission coefficients magnitude and phase accuracy testing, ensure that the ambient temperature remains within ±1°C of the calibration temperature.

10 PREPARATION

10.1 General information

Verification personnel should thoroughly read and understand the manuals of the analyzer, and test equipment to be used.

Confirm the required test environment is available.

Keep the analyzer in an off state for at least two hours in the test ambient conditions if it was stored in conditions other than those specified.

Visually check the calibration or verification standards to be used for contaminated or damaged connectors. If necessary, perform gaging of the standards' connectors.

CAUTION	DO NOT USE THE DEVICES IN CASES OF ANY DAMAGE OR IMPROPER CONNECTING DIMENSIONS. OTHERWISE, THE ANALYZER CONNECTORS MAY BE DAMAGED.

It is recommended to check the calibration kit definition (all standards of the used kits) in the instrument software against the kit documentation. Add any definitions which are not available in the software. For more details about calibration kit management please refer to the operating manual of the instrument under test.

Prepare all required test equipment for operation in accordance with its operating manuals.

The analyzer and the test equipment should be properly grounded and warmed up for the specified times.

10.2 RF connector care

10.2.1 Description

When working at frequencies above a few tens of megahertz, more attention should be paid to the quality and reliability of connections than at lower frequencies. At radio frequencies (RF), and above, the integrity of the transmission line must be maintained right through the connection, which means that electrical and mechanical considerations are more important.

NOTE

DAMAGED OR DIRTY CONNECTORS CAN SIGNIFICANTLY DEGRADE MEASUREMENTS. TO CONTINUE TO GET THE BEST PERFORMANCE FROM EQUIPMENT, REGULAR INSPECTION AND CLEANING OF RF CONNECTORS IS NEEDED, AND THIS WILL ALSO HELP TO PROLONG THE CONNECTORS' LIFE.

RF connectors are designed to join devices together as seamlessly as possible. To mate properly, the outer conductor mating surfaces must be clean and flat and the inner conductor surfaces should come very close together, but avoid a collision that could damage whatever lies behind the connector.

NOTE

COLLISION AVOIDANCE IS THE REASON WHY IT IS IMPORTANT TO GAUGE THE MECHANICAL TOLERANCES OF A CONNECTOR OF DEVICES TO BE USED.

Gage connectors:

- Before you use a device for the first time.
- If either visual inspection or electrical performance suggests that the connector interfaces may be out of specification.
- If someone else uses the device.

Routinely: initially after every 100 connections, and after that as often as experience suggests.

NOTE

NO DEVICE SHOULD BE USED IF ITS CONNECTORS ARE FOUND TO BE OUT OF SPECIFICATION.

Connectors do have a limited service life and can become defective due to wear with normal use, but regular inspection and cleaning will help to prolong their life. A connector gauge measures the inner conductor pin depth relative to the outer conductor mating plane. A torque wrench is recommended for tightening connections.

Connectors need to be handled carefully. They should be stored in a safe environment – always use a plastic end-cap for protection. Avoid touching the connector mating surfaces. Clean and inspect connectors before use. A magnifying glass is recommended. Check for scratches in the plating or worn mating surfaces, metal particles in the threads or on the mating surfaces, and bent or misaligned center conductors.

NOTE THIS IS VERY IMPORTANT: A DAMAGED OR OUT-OF-SPEC CONNECTOR CAN DESTROY ANOTHER GOOD CONNECTOR IN JUST ONE CONNECTION.

To clean connectors, low-pressure air can be used to remove loose particles from threads and mating surfaces. If further cleaning is required, a lint-free cleaning swab can be moistened with isopropyl alcohol and applied lightly. Avoid too much pressure on the center conductor and be careful of swab fibers that can become tangled in a center female conductor. When the alcohol has evaporated, air can again be used to blow surfaces clean.

NOTE WHEN MAKING AND BREAKING CONNECTIONS, CONNECTOR MATING SURFACES SHOULD NOT ROTATE.

When making and breaking connections, the axes of both connectors should be aligned, so that the male center pin slips concentrically into the center female contact. Make sure that, as they are pushed together, the connectors engage smoothly. Then, keeping the device steady, tighten the connector nut by hand initially and finish the connection with a torque wrench. At all times prevent the devices from turning. A second spanner can be used for this if necessary. When breaking a connection, again avoid any twisting or bending action on the connectors and prevent rotation by holding the device body with a spanner.

Reference:

Blair Hall. Measurement matters. RF connector care.

10.2.2 Handling and storage

- Install protective end caps when connectors of a device are not in use.
- Holding the connector in your hand or cleaning connector with compressed air can significantly change the temperature. Wait for connector temperature to stabilize before using in calibration or measurements.
- Do not touch mating plane surfaces. Natural skin oils and microscopic particles of dirt are difficult to remove from these surfaces.
- Wear a grounded wrist strap and work on a grounded, conductive table mat. This helps protect devices from electrostatic discharge (ESD).

Handling and storing connectors	
Do	Do Not
Keep connectors clean Protect connectors with plastic end caps	Touch mating-plane surfaces

Connector service life:

- All connectors have a limited service life. This means that connectors can become defective due to wear during normal use. For best results, all connectors should be inspected and maintained to maximize their service life.
- Visual inspection should be performed each time a connection is made. Metal particles from connector threads often find their way onto the mating surface when a connection is made or disconnected.

Visual inspection	
Do	Do Not
Inspect connectors with magnifying glass Look for metal debris, deep scratches or dents	Use a connector with a bent or broken center conductor Use a connector with deformed threads

10.2.3 Cleaning

Cleaning the dirt and contamination from the connector mating plane surfaces and threads can extend the service life of the connector and improve the quality of your calibration and measurements.

To clean connectors, low-pressure air can be used to remove loose particles from threads and mating surfaces. If further cleaning is required, a lint-free cleaning swab can be moistened with isopropyl alcohol and applied lightly. Avoid too much pressure on the center conductor and be careful of swab fibers that can become tangled in a center female conductor. When the alcohol has evaporated, air can again be used to blow surfaces clean.

When cleaning connectors:

- Always use protective eyewear when using compressed air or nitrogen.
- Keep isopropyl alcohol away from heat, sparks and flame. Use with adequate ventilation. Avoid contact with eyes, skin and clothing.
- Avoid electrostatic discharge (ESD). Wear a grounded wrist strap (having a 1 MOhm series resistor) when cleaning connectors.

Cleaning connectors with alcohol shall only be done with the measurement instruments power cord removed, and in a well-ventilated area. Allow all residual alcohol moisture to evaporate, and the fumes to dissipate prior to energizing the instrument.

CAUTION DO NOT USE ANY METAL OBJECTS TO CLEAN THE CONNECTORS.

Cleaning connectors	
Do	Do Not
Clean surfaces first with clean, dry compressed air	Use high pressure air (>60 psi)
Use lint-free swab or brush	Use any abrasives
Use minimum amount of alcohol	Allow alcohol into connector support beads
Clean outer conductor mating surface and threads	Apply lateral force to center conductor

10.2.4 Gaging

Gaging connectors not only provides assurance of proper mechanical tolerances, and thus connector performance, but also indicate situations where the potential for damage to another connector may exist.

- Wear a grounded wrist strap having a 1 MOhm series resistor
- Select the proper gage for your connector
- Inspect and clean gage, gage master, and connectors to be gaged
- Zero the connector gage
- Gage connector: while holding gage by the barrel, carefully connect connector under test to gage; read the gage indicator dial for recession or protrusion and compare reading with device specification.

Gaging connectors	
Do	Do Not
Inspect and clean gage, gage master and device tested Use correct torque wrench Zero gage before use Use multiple measurements and keep record of readings	Use an out of specification connector Hold connector gage by the dial

10.2.5 Connecting

To achieve maximum measurement repeatability, connect the devices as follows:

- Carefully align the connectors of the devices.
- Rotate the nut of the male connector allowing the threads to engage so that the inner conductor of the male connector was inside the inner conductor of the female connector.
- Tighten with light finger pressure avoiding rotation of the mating planes at the same time.

CAUTION	ROTATE THE NUT OF THE MALE CONNECTOR ONLY. AVOID ROTATION OF THE DEVICES.

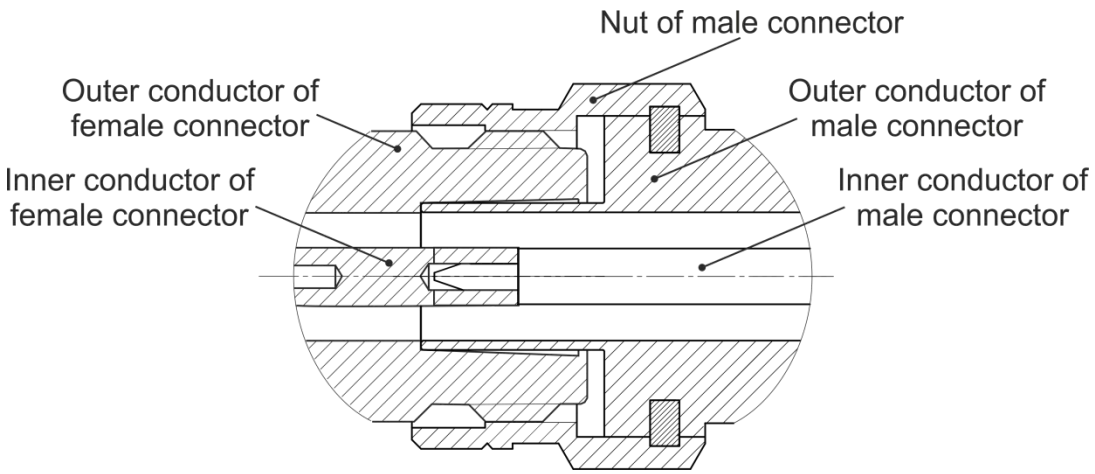


Figure 2 – Connection example (N type)

- Use a torque wrench to tighten the male connector nut. Use a spanner to prevent the connected devices from rotation.

Disconnect the connectors in reverse order. When loosening or disconnecting the male connector nut, hold the device being disconnected to prevent its inner conductor from being damaged.

Making connections	
Do	Do Not
Align connectors first	Cross thread the connection
Rotate only the connector nut	Twist connector body to make connection
Use correct torque wrench	Mate different connector types

11 AUTOMATION

11.1 General information

NOTE PERFORMANCE TEST IS EXECUTING WITH VNAPT SOFTWARE (IN THIS DOCUMENT ALSO AS “PERFORMANCE TEST PROGRAM”).

The VNAPT is used to check instruments by executing a sequence of performance tests and filling in measurement report. It enables testing the instruments in auto mode, as well as saving and printing all acquired test data.

Data presentation format complies with the recommendations of the international metrological documents.

During any test, the VNAPT makes all necessary settings of the instrument, and performs required calculations.

The program contains all measurement setups and test descriptions. Due to the embedded instructions, you do not need to refer to the manuals during tests. Accidental actions cannot cause the loss of measurement results or failures.

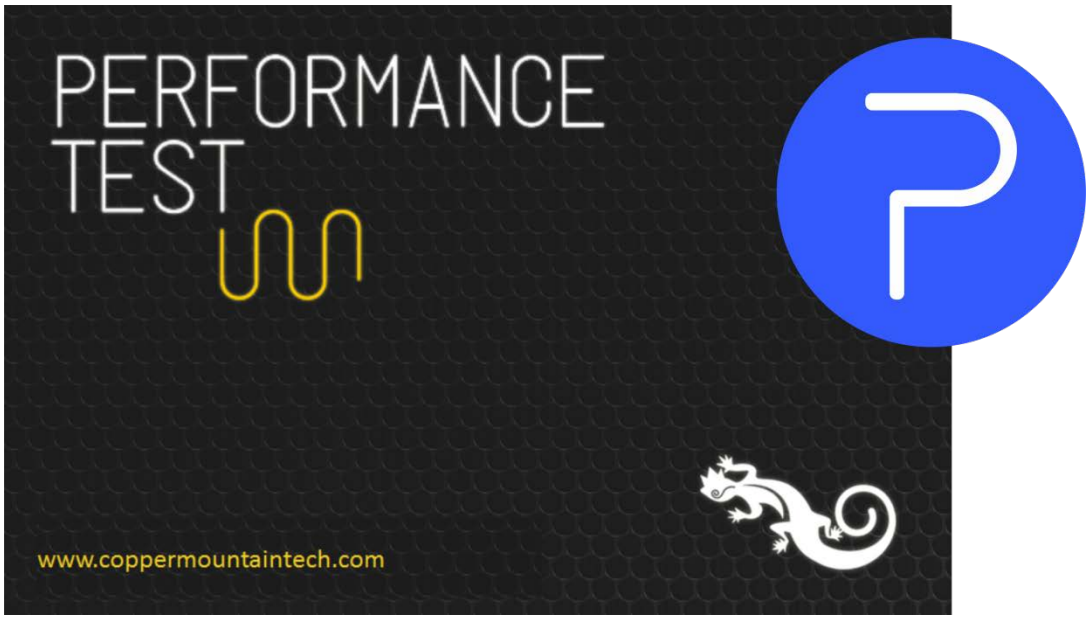


Figure 3 – The performance test program logo

Prior to installation of the performance test program, the software of the instrument must be installed. The software for all supported instruments is available at www.coppermountaintech.com.

NOTE	Copper Mountain Technologies recommend to use newest versions of instrument software as well as newest version of VNAPT

For VNAPT 2.2.270.3997 version and newer (with larger version numbers) the VNAPT controls the software of the instrument under test using TCP/IP protocol via the integrated Socket server.

For SOCKET enabling and Socket port assignment one should use next menu of instrument software:

S2VNA, S4VNA	System → Misc Setup → Network Remote Control Settings
TRVNA	System → Misc Setup → Network Setup
RVNA	System → Network Setup

Inside menu it is requested to set vacant port number (5025 is used by default) and turn SOCKET to ON state.

NOTE	FOR MORE DETAILS OF TCP/IP CONFIGURATIONS AND ADDITIONAL VNAPT ABILITIES, PLEASE REFER TO VNAPT USER MANUAL. IT COULD BE FOUND THROUGH “INSTRUCTION” SOFTKEY ON START PAGE OF VNAPT.

For VNAPT 2.2.262.3848 version and older (with smaller version numbers) the VNAPT controls the software of the instrument under test using COM/DCOM technology via the integrated COM server.

NOTE	TCP/IP PROTOCOL USAGE IS PREFERABLE AND RECOMMENDED INSTEAD OF COM/DCOM TECHNOLOGY

11.2 Installation

Installation of performance test program is performed by executing the file VNAPTInstall.exe.

NOTE	THE USER MUST HAVE ADMINISTRATOR PRIVILEGES FOR INSTALLATION OF THE PERFORMANCE TEST PROGRAM.

- Run the VNAPT setup file and follow instructions of setup wizard;

- Read and accept the license agreement;
- Select the folder in which to install the VNAPT or select the default destination folder;
- Select the *Install* softkey to start components extraction and installation. The installation progress will be indicated in the status line;
- Select the *Run VNA Performance Test* checkbox to start the program after installation, or close the setup wizard without starting the VNAPT.

11.3 Launching program

To start the VNAPT it's needed to click shortcut of installed program. After that the home page window will be appeared on the screen of your PC.

The home page consists of the control elements, the list of the connected devices, the instrument status and more information.

NOTE	IN ORDER TO STARTING VERIFICATION PROCEDURE, JUST NEEDED TO CHOOSE REQUIRED INSTRUMENT CONNECTED TO THE PC AND CLICK THE START SOFTKEY.

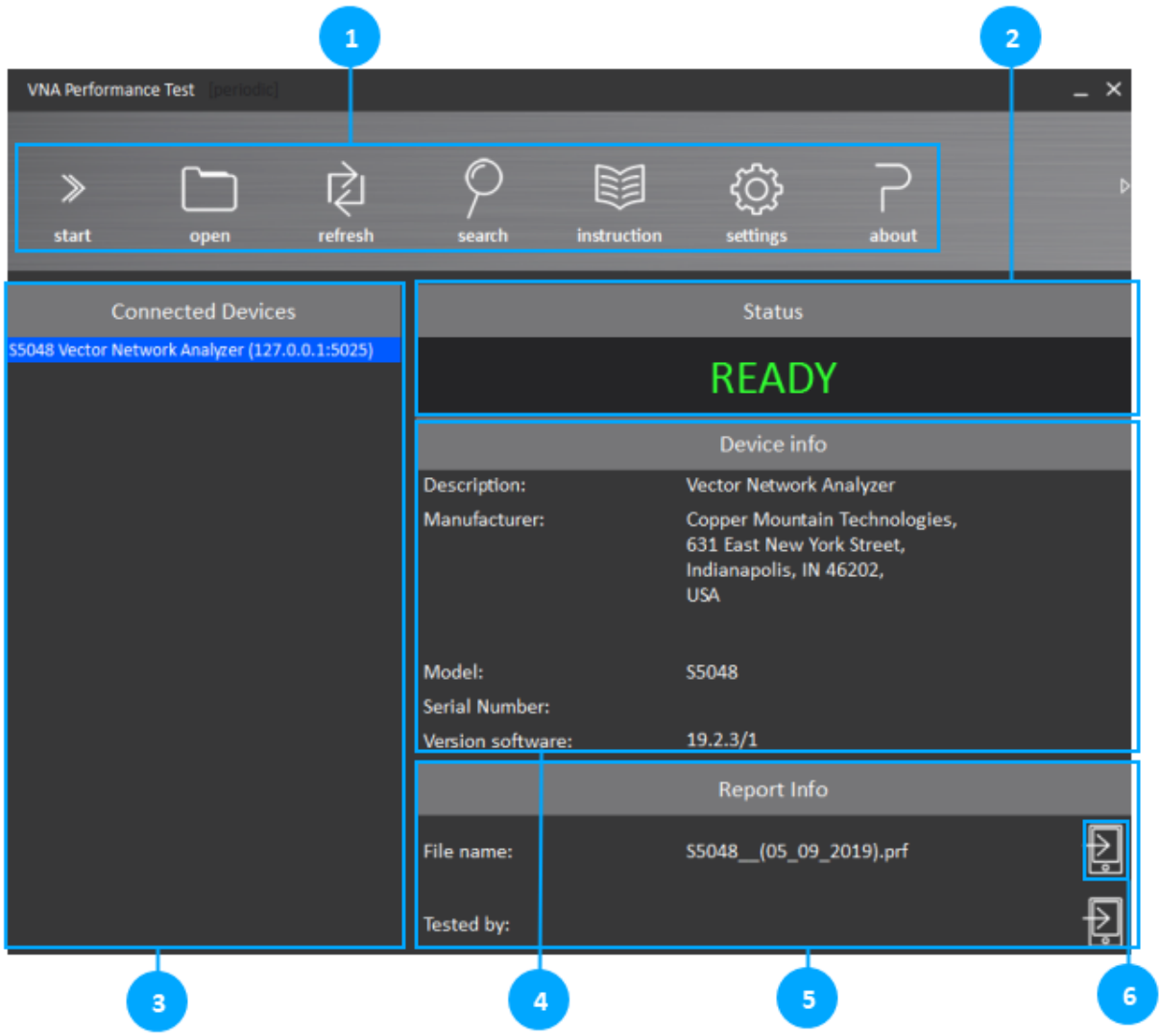


Figure 4 – Home page

An instrument to be tested is selecting from the list of the connected devices. The status and device info fields indicate the current state and identifying data of the selected instrument.

1 **Home page menu**

The menu includes the control elements for working with the report files and searching instruments connected to your PC.

2 **Status**

The instrument status indicates whether the instrument is ready for operation. This status is read from the instrument software. If *Not Ready* status is indicated, check the connection, and if necessary restart the VNAPT and the instrument

software.

3 **List of connected devices**

The list of connected devices displays all instruments connected to the PC. You can select the instrument to be tested or open the report created earlier. The status and the device info fields will be updated, and the current status and identification data of the selected instrument will be displayed.

4 **Device info**

This group displays identification data of the selected instrument (description, manufacturer, etc.) and its software version.

5 **Report info**

The report info can specify the storage folder and the file name in which all test results are saved, as well as information about the specialist. This may be left unchanged. In this case, the file will be saved by default in the report folder Documents\VNAPT\reports. The file name will be generated by default from the model, number and test date, as well as the index number of the file. The index number is assigned if there is at least one file, in which the model and number, as well as the data are similar to the created one.

6 **Edit**

Select this softkey to open a dialog window in which you can enter a new report file name or information about the specialist performing the test.

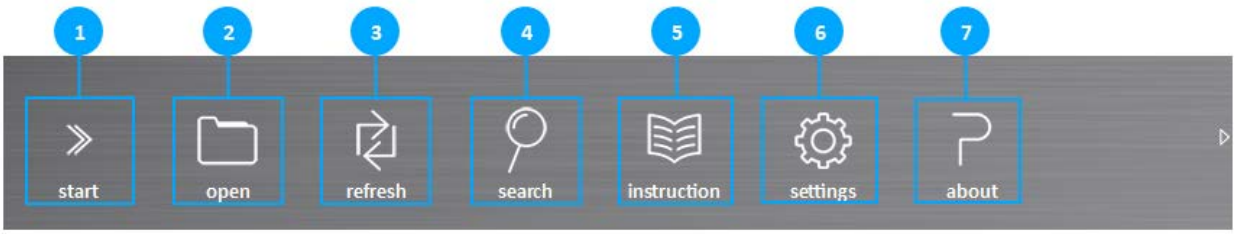


Figure 5 – Home page menu

1 **start**

Select this softkey to open the test record Main Page for the instrument selected from the list. The Home Page will close.

2 **open**

Select this softkey to choose and open a measurement report file created before.

NOTE THE VNAPT ALLOWS VIEWING THE TEST RESULTS EVEN IF THE INSTRUMENT IS NOT CONNECTED TO THE PC.

If the type and the number of the instrument in the test report are different from the instrument connected to the PC and shown in the list of connected devices, the selected file will be opened in the read-only mode.

If the type and the number of the instrument in the test report are the same as the instrument connected to the PC and shown in the list of connected devices, the selected file will be available for editing. In the latter case, the file name and test date will not be updated. To open a report in the editing mode, select the respective instrument in the list of connected devices.

3 **refresh**

Select this softkey to update the instrument status from the program. This softkey is applied if the instrument status in the VNAPT is Not Ready while it is Ready in the software, or vice versa.

4 **search**

Select this softkey to search for the instruments connected to the PC. The status of the first found instrument will be displayed on the screen. And the software for this instrument will start.

5 **instruction**

Select this softkey to open a dialog prompting to print instructions from verification tests for the selected instrument.

6 **settings**

Select this softkey to open a VNAPT settings window.

7 **about**

Select this softkey to open a window containing the VNAPT software data.

Once one pushes the *start* softkey, dialog window for verification method selection appears on your screen. It's required to choose one of the offered methods depending on verification tools you have.

NOTE	TO CHOOSE SUITABLE VERIFICATION METHOD, CAREFULLY READ THROUGH INSTRUCTIONS OF THE REFLECTION AND TRANSMISSION COEFFICIENTS MAGNITUDE AND PHASE ACCURACY TEST GIVEN IN SECTION 10.12 BEFORE STARTING TEST.

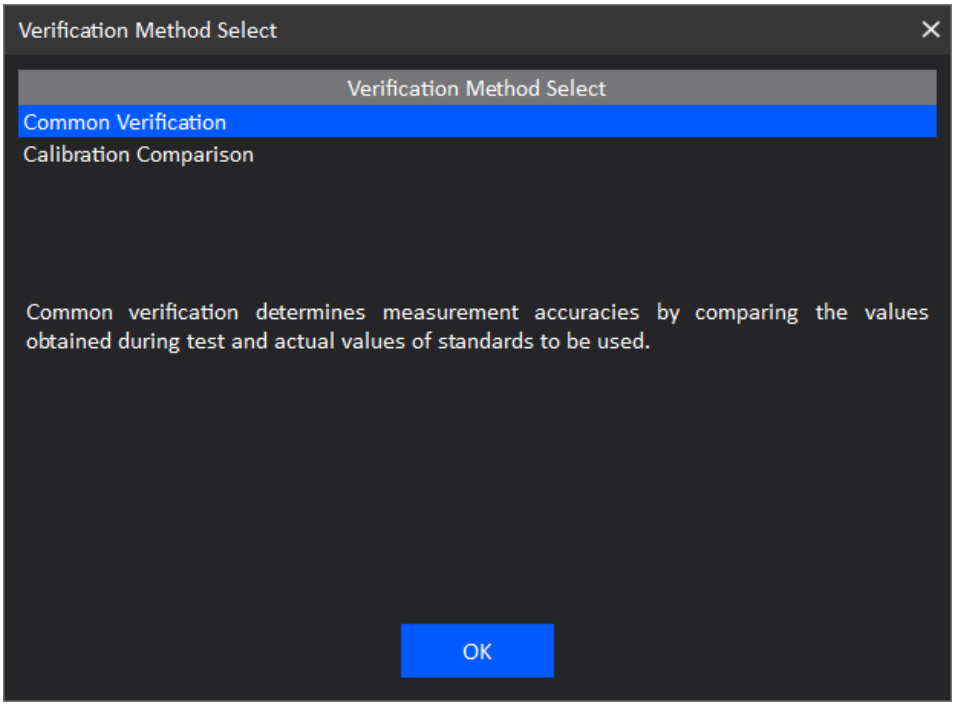


Figure 6 –Dialog window for verification method selection

11.4 Main page

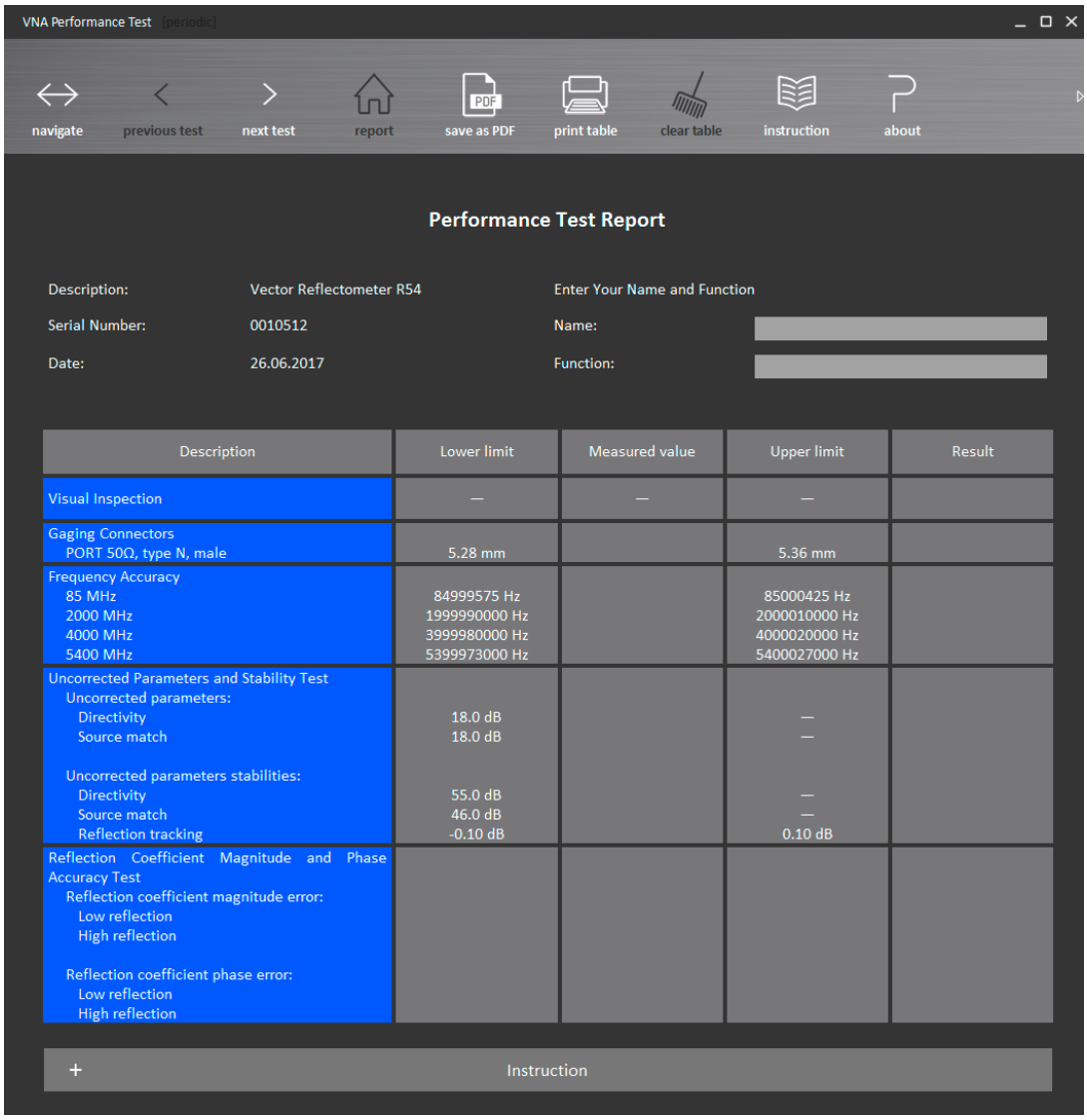


Figure 7 –Main page

The performance tests depend on the instrument to be connected. Measurement set-up and description of the tests are given in the *instruction* area and can also be displayed on a separate screen by selecting the *instruction* softkey.

The main page consists of softkeys, description of instrument, list of tests and information about specialist.

The main menu contains softkeys, which are common for all tests.

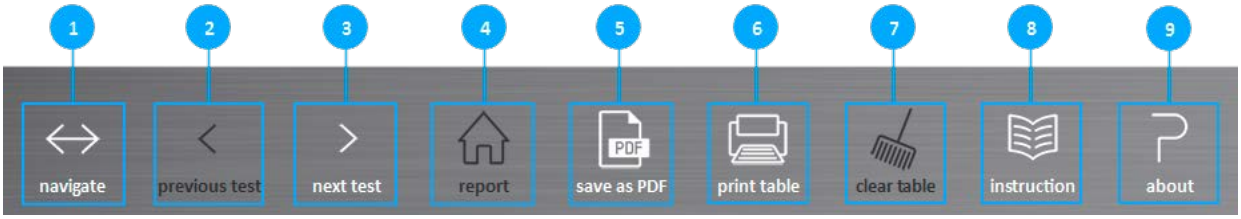


Figure 8 – Main menu

1 **navigate**

Select this softkey to open the Navigation bar with the list of all tests available for the given instrument type. Navigation bar enables quick switching between tests (test record pages). Select this softkey again to close the Navigation bar.

2 **previous test**

Select this softkey to go to the previous test (test record page). This softkey is in Not Active state, if the main page of the test report is open. If you are not on the main page, but the softkey is still Not Active state, it means there is instrument software connection failure. Check connection to the PC.

3 **next test**

Select this softkey to go to the next test (test record page). If the last test is reached, this softkey will be in the Not Active state. If you are not on the last test, but the softkey is still Not Active state, it means there is instrument software connection failure. Check connection to the PC.

4 **report**

Select this softkey to go to the Main Page of the test record. This softkey is in Not Active status, if the Main Page of the test record is open.

5 **save as PDF**

This softkey saves the current test results to the PDF file. A dialog box for choosing folder and file name will be appeared.

6 **print table**

Select this softkey to print out the current test results.

7 **clear table**

Select this softkey to clear all filled-in text boxes, measurement results and calculations on the current page of the test record. If the Main Page of the test record is open or the test report is in the read-only mode, this softkey will be in the Not Active state. It is not possible to delete all data from the Main Page of the test record, because this would result in deleting all data in all text boxes of all test record pages. And this is similar to generating a new test record. In case you need to view an earlier created test record, the text boxes of all pages of which are cleared, you have to go from page to page using the Previous Test and Next Test softkeys, and select Clear table softkey on each of them.

8 **instruction**

Select this softkey to view an instruction window with description of the test and measurement setups (if such setups are available). You can move this window to any part of your screen. It'll be automatically closed once you go to the next test. If the test record is opened in the read-only mode, this softkey is in the Not Active state.

9 **about**

Select this softkey to open a window containing the VNAPT software data.

11.5 Saving results

All test results are automatically saved in the PRF file.

The file is saved by default to the reports folder Documents\VNAPT\reports.

The file path and its name are indicated in the *Report Info* group on the home page. The file name includes the model designation, serial number and date of test, as well as the index number.

12 PERFORMANCE TEST

12.1 Starting procedure

- Install instrument software (if needed). The software for all supported instruments is available at www.coppermountaintech.com.

NOTE	VNAPT REQUIRES THAT THE TCP/IP SOCKET BE ENABLE IN RVNA, TRVNA, S2VNA, OR S4VNA SOFTWARE.

If the TCP/IP socket is not enabled, the performance test program VNAPT will show read-only mode indication. In this case the user should use menu of instrument software and enable socket by using the next

S2VNA, S4VNA	System → Misc Setup → Network Remote Control Settings
TRVNA	System → Misc Setup → Network Setup
RVNA	System → Network Setup

- Install the performance test program VNAPT (if needed). The program is also available at www.coppermountaintech.com.
- Connect device under test to the same PC where already are the installed instrument software and the performance test program.

IMPORTANT	BEFORE YOU START PERFORMANCE VERIFICATION TEST, WARM UP THE 1-PORT ANALYZER FOR 30 MINUTES, AND WARM UP THE OTHER TYPES OF THE ANALYZERS FOR 40 MINUTES.

- Start the performance test program clicking VNAPT shortcut.

Once the performance test program appears, it will search connected devices. If necessary, click the *Refresh* softkey for updating the instrument status.

Select required device under test.

- Choose folder for saving results and fill in identification of specialist, if necessary.

The report info group of the home page shows the storage folder and the file name in which all test results will be saved, as well as information about the specialist. This may be left unchanged.

By default, the file with measurement results will be saved in the report folder Documents\VNAPT\reports. The file name includes the model, number and test date.

- Click the *Start* softkey for starting verification procedure.

Once one pushes the *Start* softkey, dialog window for verification method selection appears on your screen. It's required to choose one of the offered methods depending on verification tools you have.

- Choose one of the verification methods.

NOTE

CAREFULLY READ THROUGH INSTRUCTIONS OF THE REFLECTION AND TRANSMISSION COEFFICIENTS MAGNITUDE AND PHASE ACCURACY TEST GIVEN IN SECTION 12.11.

- Consistently carry out all tests given at the main page of the performance test program.

NOTE

THE TESTS DEPEND ON THE INSTRUMENT TO BE CONNECTED.

MEASUREMENT SETUPS AND DESCRIPTION OF THE TESTS ARE SHOWN IN THE *INSTRUCTION* AREA AND CAN ALSO BE DISPLAYED ON YOUR SCREEN BY SELECTING THE *INSTRUCTION* SOFTKEY.

- Click the *Save as PDF* softkey for saving measurement results to the PDF file.

- After verification procedure completed, close the performance test program. All test results will be saved in the PRF file for further analysis and/or keeping.

12.2 Visual inspection

Analyzer under test
All types of the analyzers

Recommended test standards and equipment
No traceable test standards or equipment are required for this test

Check each test port connector for contamination. If necessary, clean the connector as described below:

- Clean specific connector surfaces with a lint-free cotton swab dampened with isopropyl alcohol.
- Air-blow other inner surfaces of the connector.
- Dry the connector making sure that there is no alcohol inside.
- Check the connector for any contamination again.
- Clean again if necessary.

CAUTION	DO NOT USE ANY METAL OBJECTS TO CLEAN THE CONNECTOR.

Check each test port connector for mechanical damage (dents or irregularities on the inner and outer conductors). For the analyzers with male type connector additionally verify the nut for smoothness of rotation.

Check the analyzer housing for mechanical damage and loose components (check for any sounds while rotating the instrument), or illegible markings.

NOTE	DO NOT PERFORM FURTHER PERFORMANCE TESTS WITH THE ANALYZER THAT HAVE DEFECTS SUCH AS MECHANICAL DAMAGE OR ARE MISSING COMPONENTS. THE INSTRUMENT SHOULD BE DISCARDED OR SENT FOR REPAIR.

12.3 Gaging connectors

Analyzer under test
All types of the analyzers

Recommended test standards and equipment
Gauging kit

To perform connector gaging of the analyzer, use an appropriate gage for the complimentary gender including a block. Follow the gaging procedures specified in the manual of the gage kit you are using.

NOTE	Note that normally, gages are intended for preventive maintenance and troubleshooting purposes only. The connector gages are only capable of performing coarse measurements. However, with proper technique, the gages are useful in detecting gross pin depth errors in connectors of the analyzer. To reduce random errors and achieve maximum accuracy, take the average of several measurements made with different gage orientations to the connector.

Test report table example			
Port	Lower limit [mm]	Measured value [mm]	Upper limit [mm]
Port 1			
...			
Port N			
Loops			
Source/receiver ports			

Connector specification	
Type	Dimensions
Test ports	
type N, female (50 Ohm)	5.18 to 5.26 mm
type N, male (50 Ohm)	5.26 to 5.36 mm
type N, female (75 Ohm)	5.18 to 5.26 mm
3.5 mm, female	-0.08 to 0 mm
3.5 mm, male	-0.08 to 0 mm
Loops for direct receiver access and frequency extension options	
3.5 mm, male	-0.20 to 0 mm
Source/receiver ports for direct receiver access and frequency extension options	
3.5 mm, female	-0.20 to 0 mm
SMA, female	-0.20 to 0 mm

12.4 Frequency accuracy test

This test verifies the frequency accuracy and range of the analyzer's source output.

Analyzer under test
All types of the analyzers

Recommended test standards and equipment
Frequency counter
RF cable

Measurement steps
Connect analyzer under test to frequency counter
In CW generation mode with single sweep, measure 3-5 or more output frequencies by frequency counter
Compare obtained results with device's specification

The measurements are carried out at 3-5 or more arbitrarily frequencies in the beginning, middle and end of the operating frequency range of the analyzer under test.

For instruments with 1 or 2 test ports, the measurements are carried out for 1 port of the analyzer.

For instruments with 4 test ports, the measurements are carried out for 1 and 3 ports of the analyzer.

NOTE	MAKE SURE THAT OUTPUT POWER LEVEL OF THE ANALYZER DOES NOT EXCEED SPECIFIED INPUT LEVEL OF TEST EQUIPMENT USED.

Test report table example				
Port	Frequency [MHz]	Lower limit [Hz]	Measured value [Hz]	Upper limit [Hz]
1	F_{MIN}			
	…			
	F_{MAX}			
3 (for 4 ports analyzers)	F_{MIN}			
	…			
	F_{MAX}			

NOTE

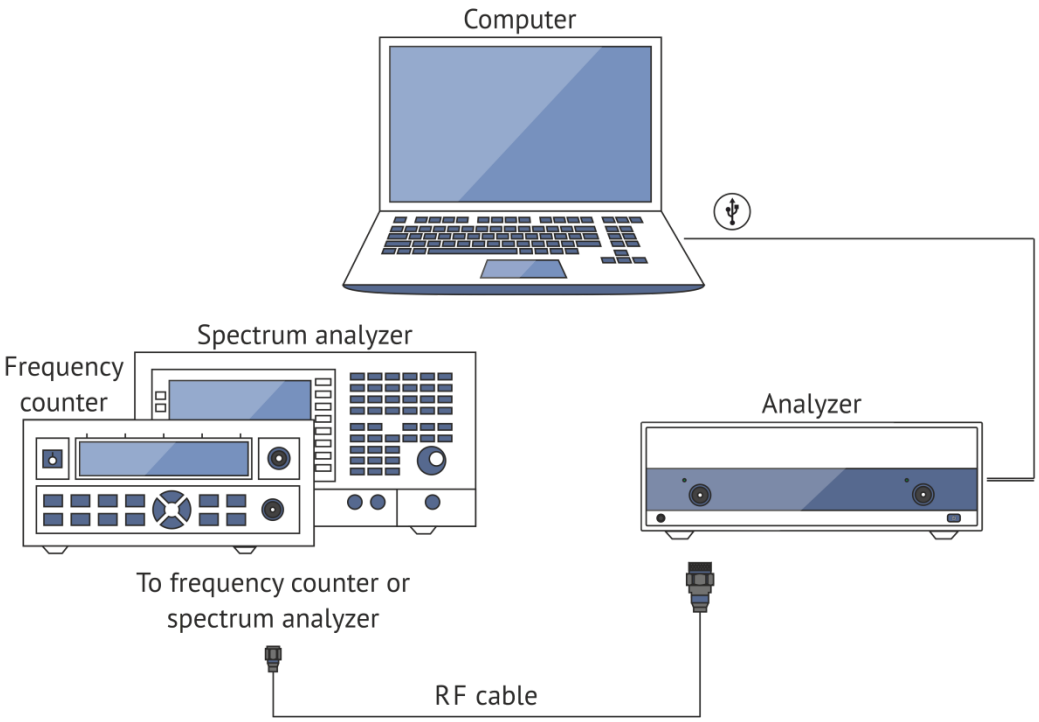
F – frequencies under control.

F_{MIN} and F_{MAX} – min and max frequencies over specified frequency range.

Lower limit is calculated as $F-F\cdot\delta F$ (δF – specified frequency accuracy).

Upper limit is calculated as $F+F\cdot\delta F$ (δF – specified frequency accuracy).

Measurement setup



Frequency measurement

Spectrum analyzer with acceptable time base error can be used instead the frequency counter.

NOTE

To connect with ports of the test equipment can be needed between series coaxial adapters.

Do not connect frequency references of the analyzer and test equipment.

12.5 Output power level accuracy test

This test confirms the accuracy of the source output power of the analyzer over its entire frequency range.

Analyzer under test
COBALT, FULL SIZE, COMPACT, PXI

Recommended test standards and equipment
Thermal power sensor

Measurement steps
Perform power sensor zeroing
Connect power sensor to test port of analyzer
In CW generation mode with single sweep, measure output power level of 0 dBm in at least five frequencies by power sensor
Switch analyzer to absolute measurement mode
Without disconnecting power sensor, in continuous sweep mode over entire frequency range, perform normalization at 0 dBm output power level (data / memory)
Measure different 3-5 or more output power levels at same frequencies by reference receiver
Compare obtained results with device's specification

Output power level should be checked at the output of each test port.

Power measurements are performed at 0 dBm and other 3-5 or more levels in at least five arbitrarily frequencies from operating range. The boundary values of the frequencies and power levels have to be controlled.

Measurement result is the sum of the readings of the reference receivers at each test frequency and the measured values of 0 dBm obtained by the power sensor.

Test report table example					
Port	RF output level [dBm]	Frequency [MHz]	Lower limit [dBm]	Measured value [dBm]	Upper limit [dBm]
N	0	F_{MIN}			
		...			
		F_{MAX}			
	P_{MAX}	F_{MIN}			
		...			
		F_{MAX}			
	...				
	P_{MIN}	F_{MIN}			
		...			
		F_{MAX}			

NOTE

N – number of test port.

P – output power levels under control.

F – test frequencies.

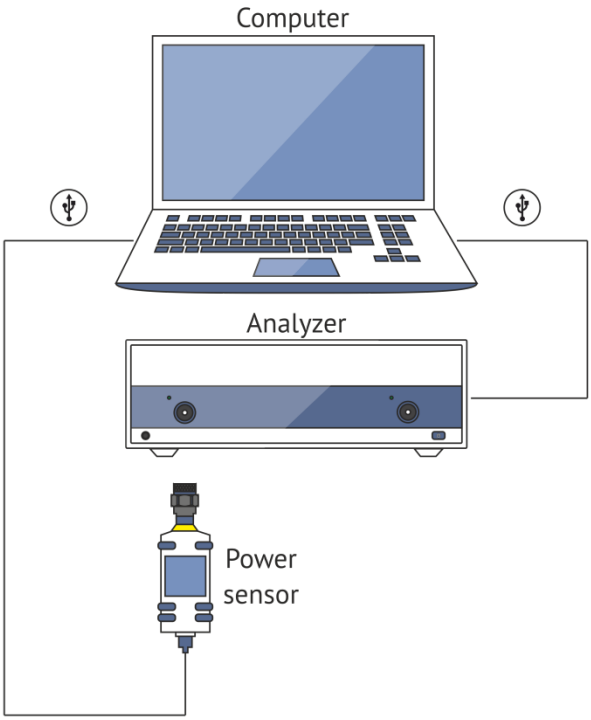
P_{MIN} and P_{MAX} – min and max power levels over specified power range.

F_{MIN} and F_{MAX} – min and max frequencies over specified frequency range.

Lower limit is calculated as $P-\Delta P$ (ΔP in dB – specified power accuracy).

Upper limit is calculated as $P+\Delta P$ (ΔP in dB – specified power accuracy).

Measurement setup



Output power measurement

Power measurement is performed with coaxial adapter connected to power sensor, if the sensor cannot be connected to port of the analyzer directly.

The adapter should have metrology grade connectors.

NOTE

For the analyzer with 75 Ohm test port connectors, power measurement is performed with impedance matching pad connected to power sensor.

When using coaxial adapter or impedance matching pad to connect power sensor to test port of the analyzer, it's needed to take into account the insertion attenuation of this item.

12.6 Harmonic distortion test

Analyzer under test
FULL SIZE, COMPACT up to 9 GHz, PXI

Recommended test standards and equipment
Spectrum analyzer
RF cable

Measurement steps
Reference power level of spectrum analyzer to 10 dBm
Connect spectrum analyzer to test port of analyzer
In CW generation mode with single sweep, measure the maximum harmonic distortions (up to third order harmonic) in at least five frequencies by spectrum analyzer. As an exception it is permitted make measurements up to second order harmonics while frequency is 9 GHz.
Compare obtained results with device's specification

Harmonic distortion measurement is carried out at the output of each test port that is able to work in source mode.

The measurements are performed at the specified output power level in at least five arbitrarily frequencies evenly spaced from each other over the specified frequency range.

As an exception it is permitted make measurements up to second order harmonics while frequency is 9 GHz.

Test report table example				
Port	Frequency [MHz]	Lower limit [dBc]	Measured value [dBc]	Upper limit [dBc]
N	F_1	–		
	…	–		
	F_N	–		

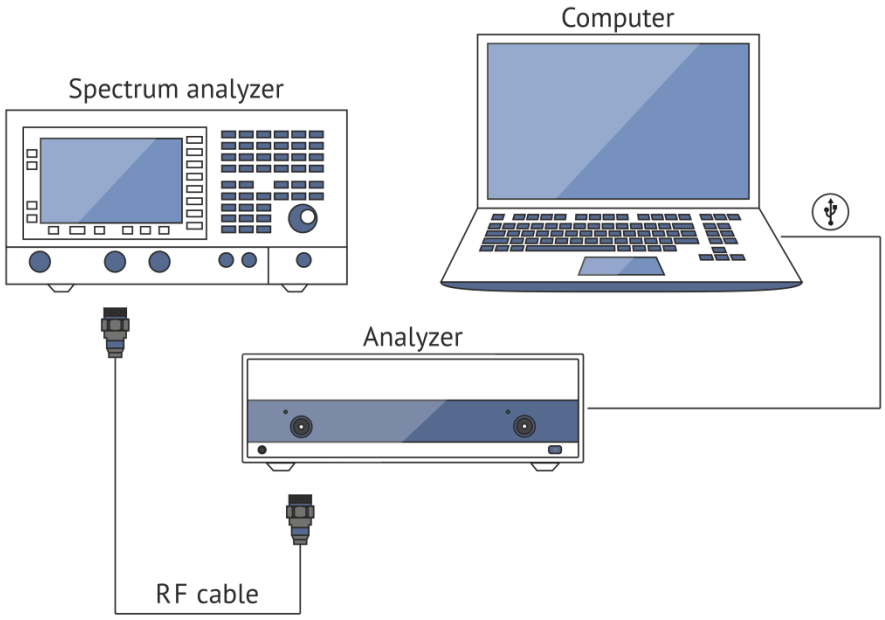
NOTE

N – number of test port.

F_1…F_N – test frequencies over specified range.

Upper limit according with device's specification (at specified output power level, and over specified frequency range).

Measurement setup



Harmonic distortion measurement

12.7 Non-harmonic spurious test

Analyzer under test
FULL SIZE, COMPACT up to 9 GHz, PXI

Recommended test standards and equipment
Spectrum analyzer
RF cable

Measurement steps
Reference power level of spectrum analyzer to 10 dBm
Connect spectrum analyzer to test port of analyzer
At slow continuous sweep (IF bandwidth 1 or 10 Hz), measure minimum difference between levels of useful and spurious signals by spectrum analyzer
Compare obtained results with device's specification

The measurements are performed at the specified output power level over the specified frequency range.

For instruments with 2 test ports, the measurements are performed for 1 port of the analyzer.

For instruments with 4 test ports, the measurements are consistently performed for 1 and 3 ports of the analyzer.

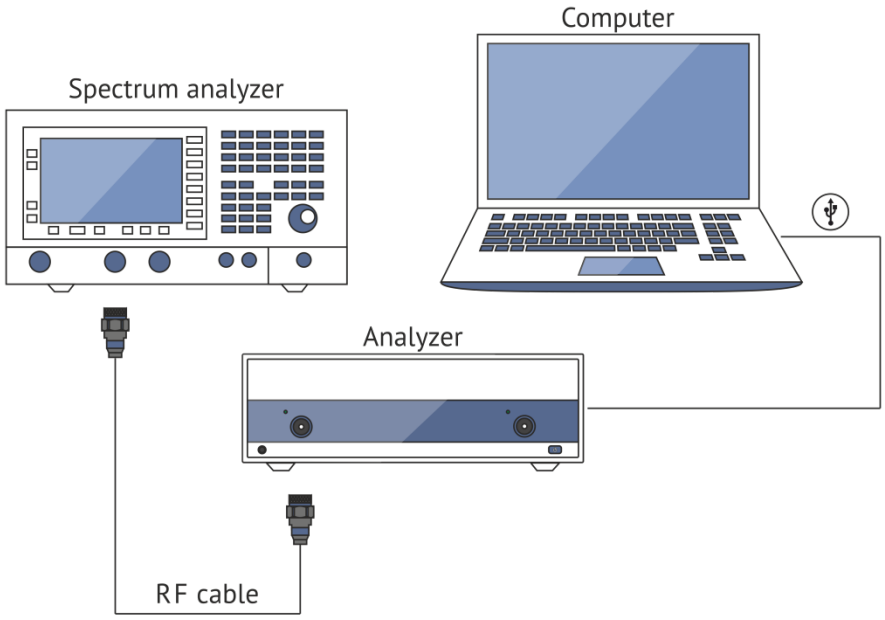
Test report table example			
Port	Lower limit [dBc]	Measured value [dBc]	Upper limit [dBc]
N	–		

NOTE

N – number of test port.

Upper limit according with device's specification (at the specified output power level, and over specified frequency range).

Measurement setup



Non-harmonic spurious measurement

12.8 Receiver noise floor test

This test measures the absolute power level of the noise floor for the analyzer's receivers.

Analyzer under test
COBALT, FULL SIZE, COMPACT, PXI

Test standards and required equipment
Matched loads (quantity of the loads should be equal to the quantity of test ports of the analyzer)

Measurement steps
Connect matched loads to all test ports
Output power level to 0 dBm, IF bandwidth to 100 Hz, points not less than 500 over specified frequency range
Measure mean value for all transmission coefficient traces in linear scale (it's allowed to perform the measurement in log scale directly)
Convert measured values to log scale
Re-calculate measured values to 1 Hz bandwidth
Compare obtained results with device's specification

The measurements are performed for all transmission coefficient traces which can be measured by the analyzer under test.

Measurement result is determined as mean value of certain transmission trace at 1 Hz bandwidth.

Test report table example			
Frequency	Receiver noise floor [dBm]	Max measured value[dBm]	Upper limit [dBm]
ΔF	S21		
	S31		
	S41		
	S12		
	S32		
	S42		
	S13		
	S23		
	S43		
	S14		
	S24		
	S34		

NOTE

ΔF – specified frequency ranges.

Upper limit according with device's specification.

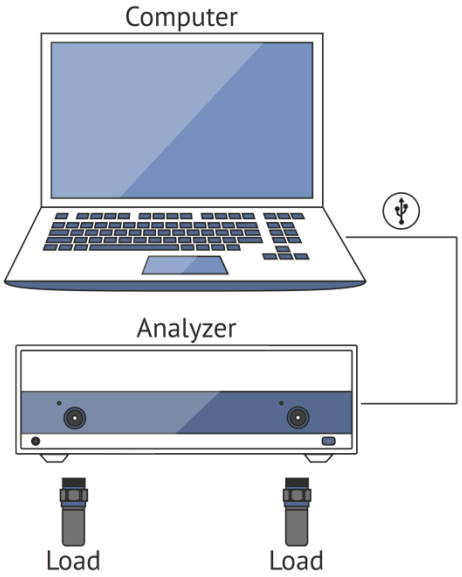
The measurements should be performed for all transmission coefficient traces which can be measured by the analyzer under test:

- S21 and S12 for instruments with 2 test ports and dual directional source;

- S21 for instruments with 2 test ports and one path source;

- S21, S31, S41, S12, S32, S42, S13, S23, S43, S14, S24, S34 for instruments with 4 test ports.

Measurement setup



Receiver noise floor measurement

12.9 Trace noise magnitude test

This test measures the stability of a signal in the internal source and receiver system of the analyzer.

Analyzer under test
COBALT, FULL SIZE, COMPACT, PXI

Test standards and required equipment
Open or short standards (from user calibration kit)
Phase- and amplitude- stable test cable

Measurement steps
Output power level to 0 dBm, IF bandwidth to specified value, points not less than 500 over specified frequency range
Connect open standard to test port
normalize data for reflection trace, measure mean square deviation value
Connect cable between test ports
Normalize data for transmission trace, measure mean square deviation value
Compare obtained results with device's specification

For instruments with 2 test ports and dual directional source, the measurements are performed for S11, S22, S21 and S12.

For instruments with 2 test ports and one path source, the measurements are performed for S11 and S21.

For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer. Parameters are S11, S22, S21, S12, as well as S33, S44, S43, S34.

Measurement result is determined as standard deviation after normalization (data / memory) for certain trace.

Test report table example			
Frequency	Trace noise magnitude [dB]	Max measured value [dB]	Upper limit [dB]
ΔF	S_{11}		
	S_{22}		
	S_{21}		
	S_{12}		
	S_{33}		
	S_{44}		
	S_{43}		
	S_{34}		

NOTE

ΔF– specified frequency ranges.

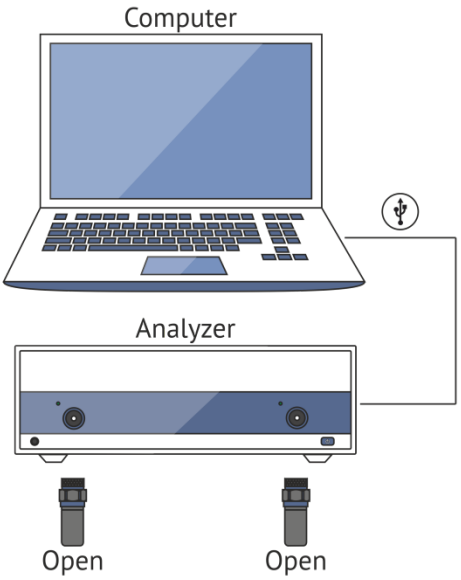
Upper limit according with device's specification.

S11, S22, S21 and S12 for instruments with 2 test ports and dual directional source.

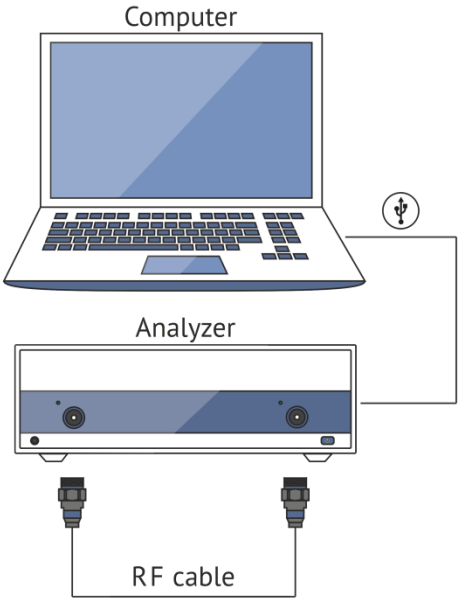
S11 and S21 for instruments with 2 test ports and one path source.

S11, S22, S21, S12, as well as S33, S44, S43, S34 for instruments with 4 test ports.

Measurement setup



OPEN to test port



Cable between test ports

12.10 Uncorrected parameters test

In order to determine the uncorrected parameters, it's necessary to carry out either full one-port calibration for 1-port analyzers, or full two-port calibration for other instruments.

Test verifies the following uncorrected characteristics for each port of the analyzer:

- Directivity.
- Source match.
- Load match (not applicable for 1-port analyzers).

Analyzer under test
All types of the analyzers

Test standards and required equipment	
for 2 and 4 port analyzers	for 1-port analyzers
User calibration kit	User calibration kit
Phase- and amplitude- stable test cable	–

Measurement steps
Verify connectors of calibration standards for contamination and mechanical damage
System correction OFF
Perform calibration & measurement according with setups below
Compare obtained results with device's specification

For calibration kit which will be used it's recommended to check its definition (all standards of the kit) in the analyzer software against the kit documentation. Add any definitions which are not available in the analyzer software. For more details about calibration kit management please refer to the analyzer operating manual.

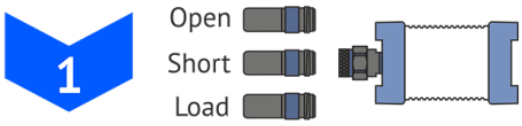
Test report table example			
Uncorrected parameter	Lower limit [dB]	Measured value [dB]	Upper limit [dB]
Directivity			
frequency range ΔF_1		–	
…		–	
frequency range ΔF_N		–	
Source match			
frequency range ΔF_1		–	
…		–	
frequency range ΔF_N		–	
Load match			
frequency range ΔF_1		–	
…		–	
frequency range ΔF_N		–	

NOTE

ΔF_1… ΔF_N – specified frequency ranges.

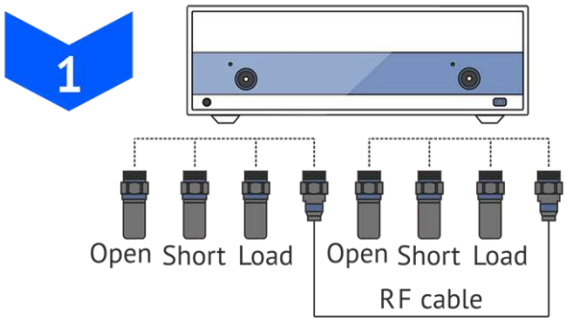
Lower limit according with device's specification.

Measurement setup



Full one-port calibration:
- Directivity
- Source match

Uncorrected parameters measurement sequence
for the 1-port analyzers

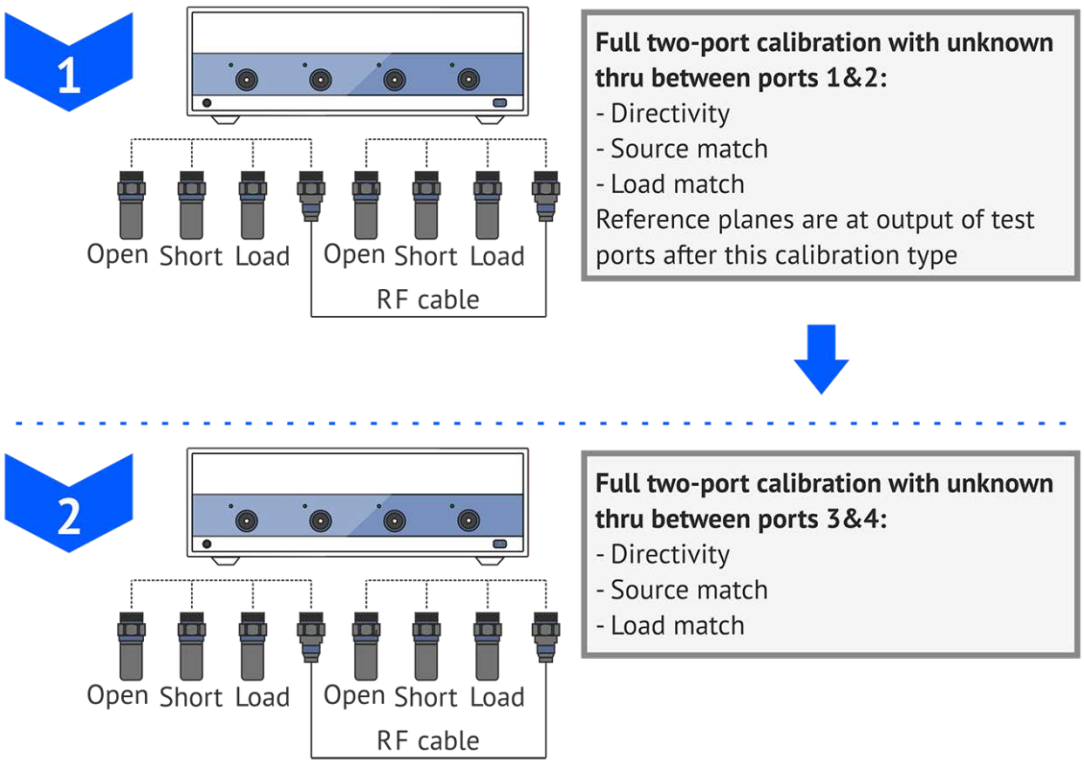


Full two-port calibration with unknown thru:
- Directivity
- Source match
- Load match

Reference planes are at output of test ports after this calibration type

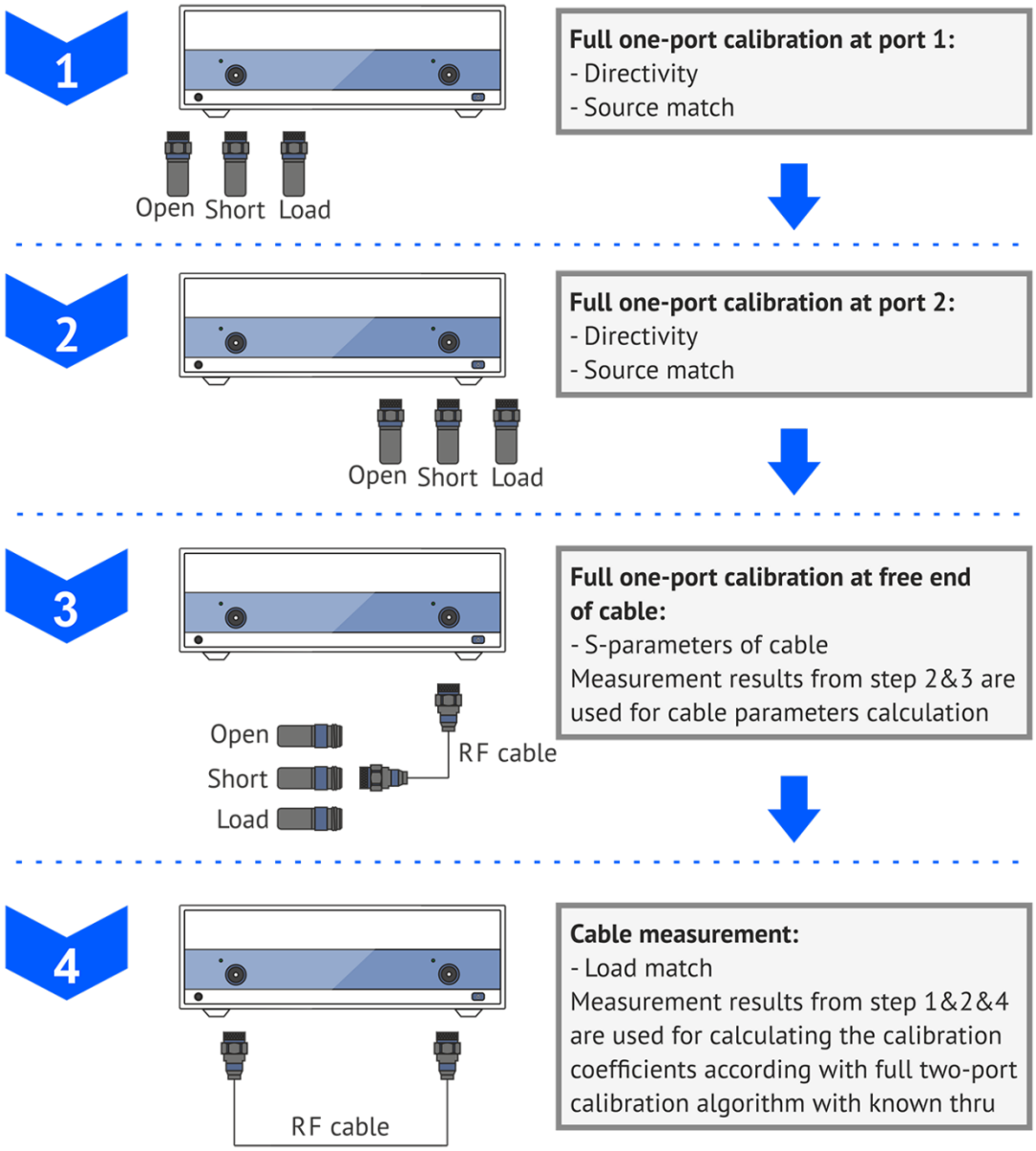
Uncorrected parameters measurement sequence
for the analyzers with 2 test ports and dual directional source
(except 304/1 model)

Measurement setup



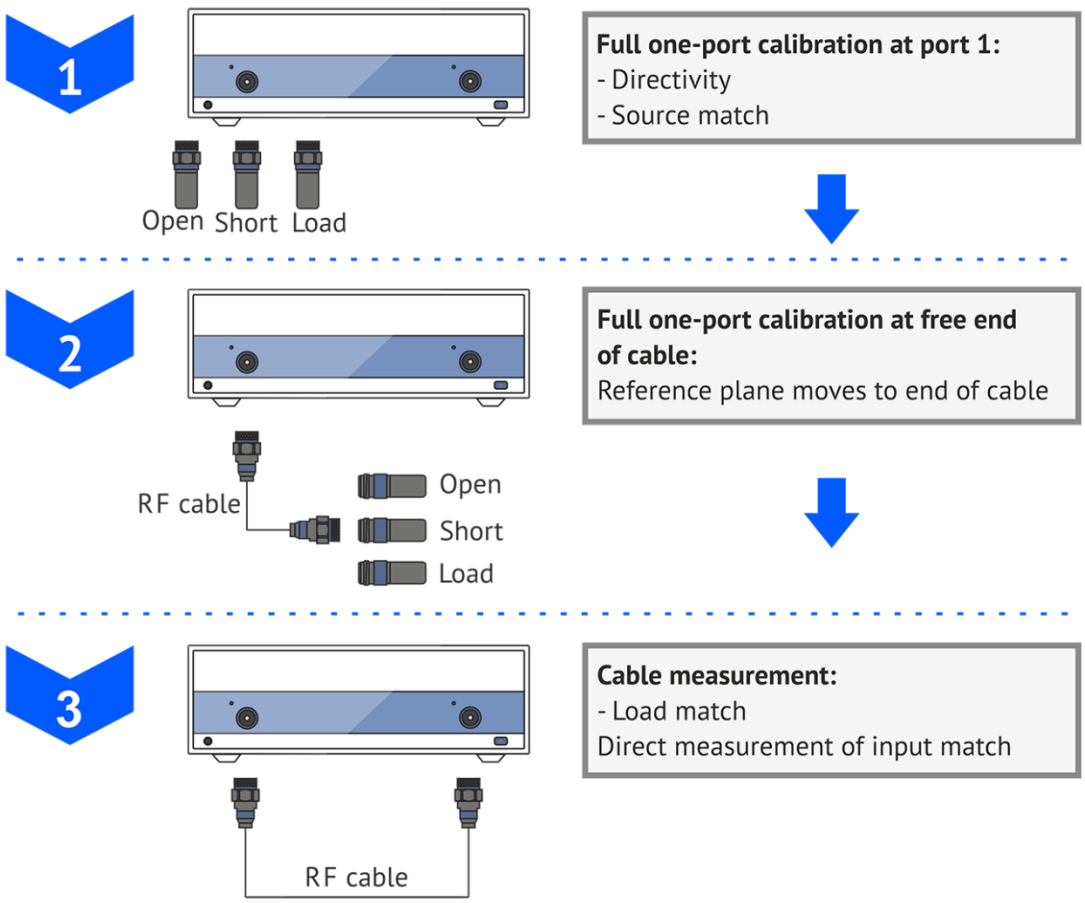
Uncorrected parameters measurement sequence
for the analyzers with 4 test ports

Measurement setup



Uncorrected parameters measurement sequence
for the analyzers with 2 test ports, dual directional source,
and simultaneous employment of three receivers
(for 304/1 model)

Measurement setup



Uncorrected parameters measurement sequence
for the analyzers with 2 test ports and one path source

12.11 Reflection and transmission coefficients magnitude and phase accuracy test

12.11.1 Description

The test can be performed in two ways:

- either using verification kit;
- or using reference calibration kit.

In this document the test with a verification kit will be called as “Common verification”, but with a calibration kit will be defined as “Calibration comparison”.

Common verification	Common verification determines measurement accuracies by comparing the values obtained during test and actual values of standards to be used.
Calibration comparison	Calibration comparison technique allows evaluating effective (residual) errors of the analyzer under test separately from each other to calculate S-parameter accuracies. The method involves two consecutive calibrations of the same analyzer using two different calibration tools and further step-by-step comparison of the measurement results. Additionally it defines uncorrected parameters such as directivity, source and load matches in accordance with conventional error model of vector network analyzers.

A summary of both verification methods is shown in Table 13.

Calibration comparison method has two versions of implementation:

- Calibration comparison:
- Extended calibration comparison.

Extended calibration comparison supports accuracy measurement test prepared for VNAs with arbitrary test port connector (for example, when additional adapter connected to test port). For it accuracy measurement from calibration comparison method consists of two separately tests: uncorrected parameters measurements performing on regular test port connector and accuracy measurements performing on arbitrary test port connectors.

Table 13

	Verification procedure	
	Common verification	Calibration comparison
Basis	Verification kit Mismatched loads (for 1-port analyzers)	Calibration kit
Method	Direct measurements	Calibration comparison technique
Reflection measurement	Stepped air line Mismatched loads	Reference calibration standards
Transmission measurement	20 dB attenuator 40 (50) dB attenuator	Reference calibration standards
Evaluated parameters	Reflection magnitude error Reflection phase error Transmission magnitude error Transmission phase error	Uncorrected directivity Uncorrected source match Uncorrected load match Reflection magnitude error Reflection phase error Receiver noise floor Transmission magnitude error Transmission phase error

NOTE

Reference calibration standards allow getting acceptable level of the effective system data after performing a suitable system error calibration and correction of the instrument under test.

Calibration comparison requires that receiver noise floor test was made before. The noise values are used as isolation limits to calculate transmission errors.

It's allowed to use T-checker device instead of stepped air line during reflection accuracy test.

12.11.2 Reflection measurement. Common verification

Analyzer under test
All types of the analyzers

Test standards and required equipment	
for 2 and 4 port analyzers	for 1-port analyzers
User calibration kit	User calibration kit
Verification kit (stepped air line)	Mismatched loads
Phase- and amplitude-stable test cable	–

Measurement steps
Verify connectors of all standards for contamination and mechanical damage
Check user calibration kit definition
Enter verification standard definition
Perform calibration
Measure S-parameters of verification standard
Compare obtained results with device's specification

NOTE	THE TOTAL ERROR LIMITS ARE THE SUM OF THE MEASUREMENT ERRORS FOR THE REFLECTION STANDARDS AND THE SYSTEMATIC ERRORS ASSOCIATED WITH THE ANALYZER BEING VERIFIED. THE REFLECTION STANDARDS DATA MUST BE GIVEN IN THEIR TRACEABLE CALIBRATION CERTIFICATE.

For 2 and 4 port analyzers, reflection coefficient magnitude and phase accuracy test is performed by comparing the measured and actual values of the stepped 25 Ohm air line from the verification kit.

For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer.

For 1-port analyzers, reflection coefficient magnitude and phase accuracy test is performed by comparing the measured and actual values of mentioned loads.

Test report table example Stepped air line reflection measurement			
Reflection coefficient magnitude error	Lower limit (lin)	Measured value (lin)	Upper limit (lin)
Frequency range ΔF_1			
below -25 dB (below 0,056)			
-25 to -15 dB (0,056 to 0,178)			
-15 to 0 dB (from 0,178 to 1,000)			
…			
Frequency range ΔF_N			
below -25 dB (below 0,056)			
-25 to -15 dB (0,056 to 0,178)			
-15 to 0 dB (from 0,178 to 1,000)			

NOTE

ΔF_1… ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors for air line are taken into account.

Test report table example Stepped air line reflection measurement			
Reflection coefficient phase error	Lower limit [degree]	Measured value [degree]	Upper limit [degree]
Frequency range ΔF_1			
-25 to -15 dB (0,056 to 0,178)			
-15 to 0 dB (from 0,178 to 1,000)			
…			
Frequency range ΔF_N			
-25 to -15 dB (0,056 to 0,178)			
-15 to 0 dB (from 0,178 to 1,000)			

NOTE

ΔF_1… ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors for air line are taken into account.

NOTE	WHEN COMPARING THE AIR LINE PARAMETERS, PAY ATTENTION TO ITS ORIENTATION. IF NECESSARY CHECK THE AIR LINE CALIBRATION CERTIFICATE FOR THE DETERMINATION OF THE PROPER ORIENTATION.

Test report table example Load reflection measurement			
Reflection coefficient magnitude error	Lower limit [lin]	Measured value [lin]	Upper limit [lin]
Frequency range ΔF_1			
…			
Frequency range ΔF_N			

NOTE

ΔF_1... ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors for loads are taken into account.

The table is suitable for both low and high reflection standards.

Test report table example Load reflection measurement			
Reflection coefficient phase error	Lower limit [degree]	Measured value [degree]	Upper limit [degree]
Frequency rangeΔF_1			
…			
Frequency rangeΔF_N			

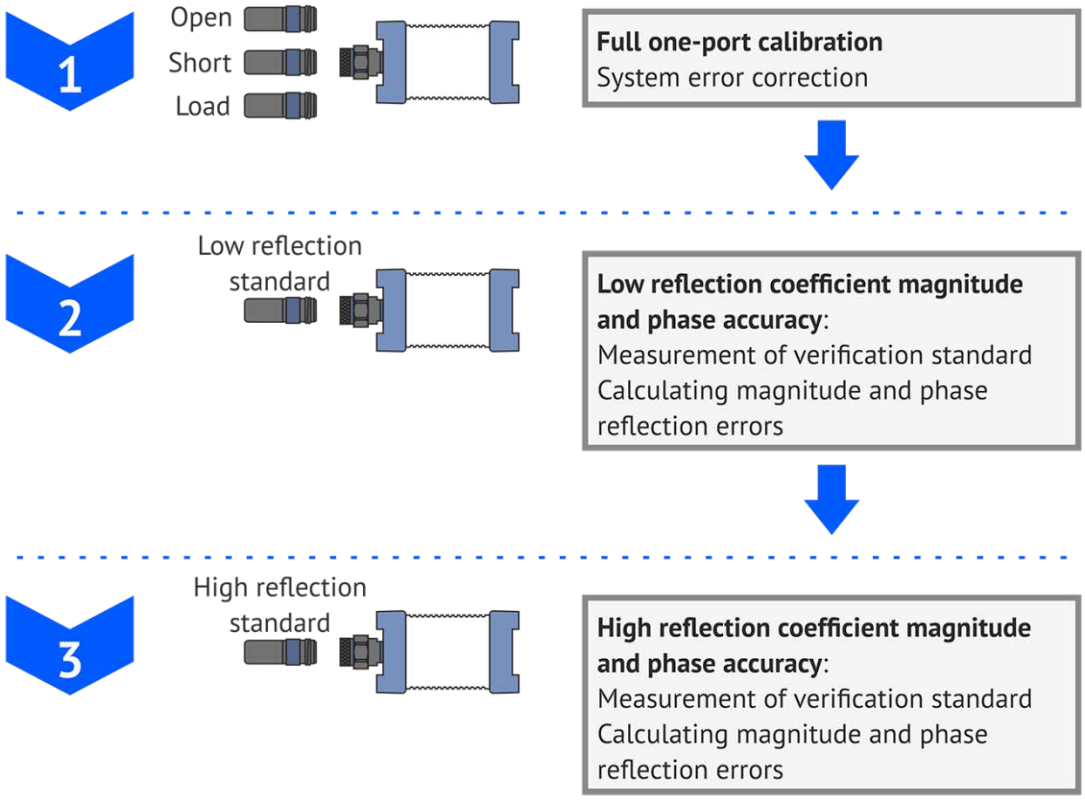
NOTE

ΔF_1... ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors for loads are taken into account.

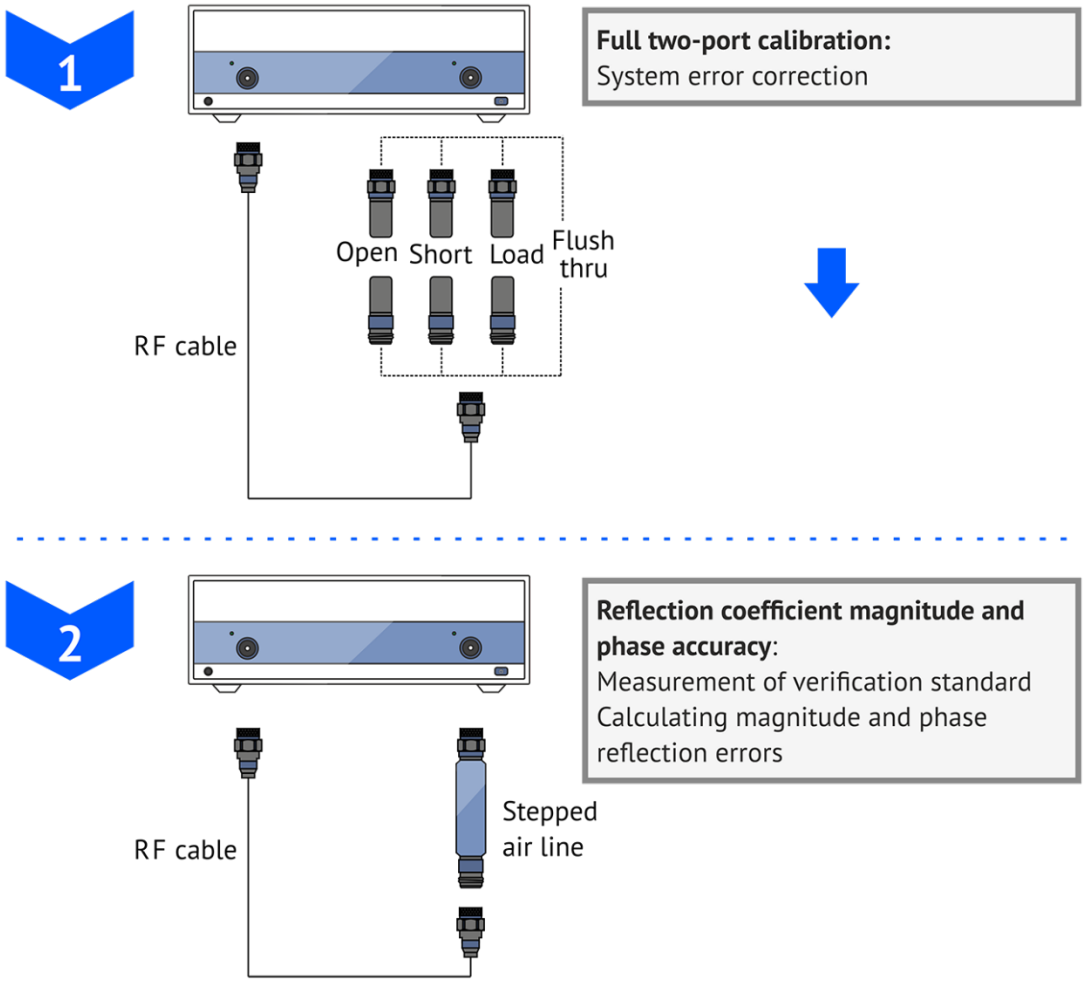
The table is suitable for both low and high reflection standards.

Measurement setup



Reflection accuracy test according with common verification procedure for the 1-port analyzers

Measurement setup



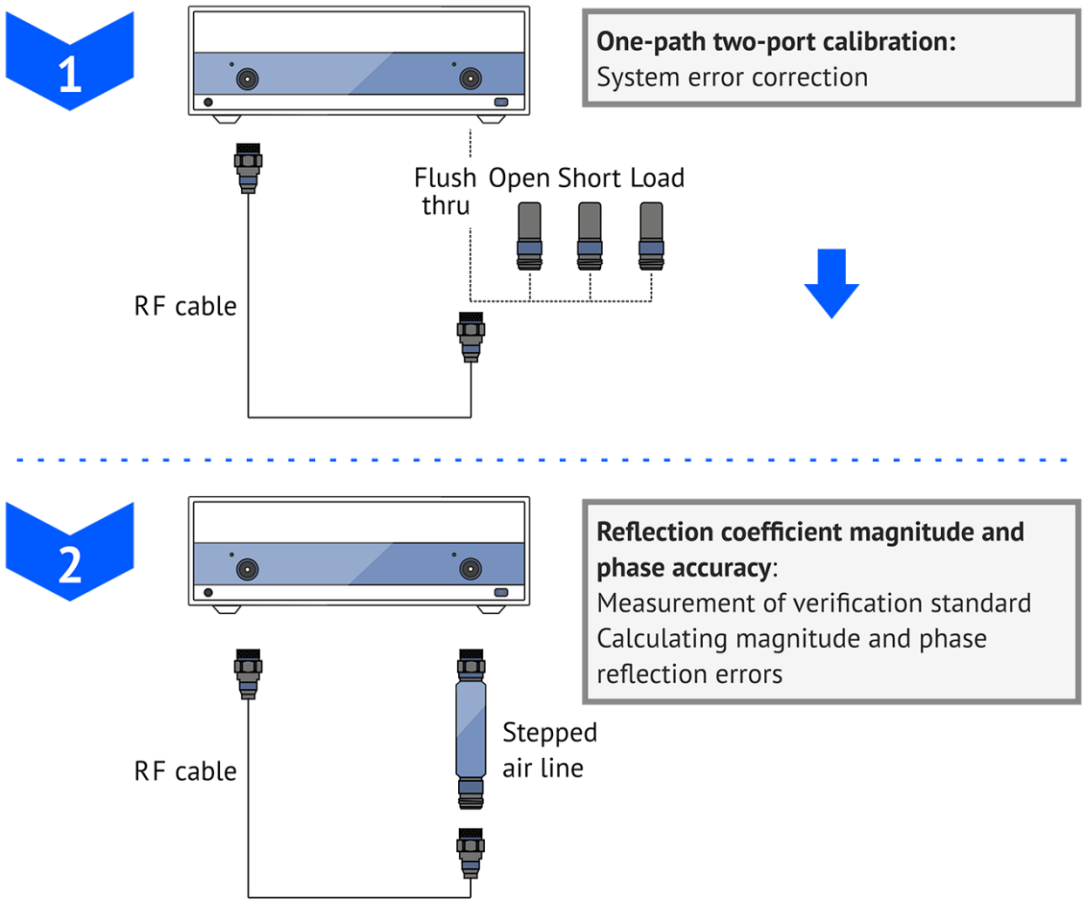
Reflection accuracy test according with common verification procedure for the analyzers with 2 test ports and dual directional source, as well for the analyzers with 4 test ports

NOTE

For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer similarly.

To reach more stability and repeatability effects during the test, it's recommended along with this RF cable to use coaxial adapters with metrology grade connectors.

Measurement setup



Reflection accuracy test according with common verification procedure for the analyzers with 2 test ports and one path source

NOTE To reach more stability and repeatability effects during the test, it's recommended along with this RF cable to use coaxial adapters with metrology grade connectors.

12.11.3 Transmission measurement. Common verification

Analyzer under test
COBALT, FULL SIZE, COMPACT, PXI

Test standards and required equipment
User calibration kit
Verification kit (attenuators)
Phase- and amplitude- stable test cable

Measurement steps
Verify connectors of all standards for contamination and mechanical damage
Check user calibration kit definition
Enter verification standard definition
Perform calibration
Measure S-parameters of verification standard
Compare obtained results with device's specification

NOTE	THE TOTAL ERROR LIMITS ARE THE SUM OF THE MEASUREMENT ERRORS FOR THE TRANSMISSION STANDARDS AND THE SYSTEMATIC ERRORS ASSOCIATED WITH THE ANALYZER BEING VERIFIED. THE TRANSMISSION STANDARDS DATA MUST BE GIVEN INTHEIR TRACEABLE CALIBRATION CERTIFICATE.

For 2 and 4 port analyzers, transmission coefficient magnitude and phase accuracy test is performed by comparing the measured and actual values of the attenuators from the verification kit.

For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer.

Test report table example Attenuator transmission measurement			
Transmission coefficient magnitude error	Lower limit [dB]	Measured value [dB]	Upper limit [dB]
Frequency range ΔF_1			
…			
Frequency range ΔF_N			

NOTE

ΔF_1... ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors of attenuators are taken into account.

The table is suitable for each attenuator to be used.

Test report table example Attenuator transmission measurement			
Transmission coefficient phase error	Lower limit [degree]	Measured value [degree]	Upper limit [degree]
Frequency range ΔF_1			
…			
Frequency range ΔF_N			

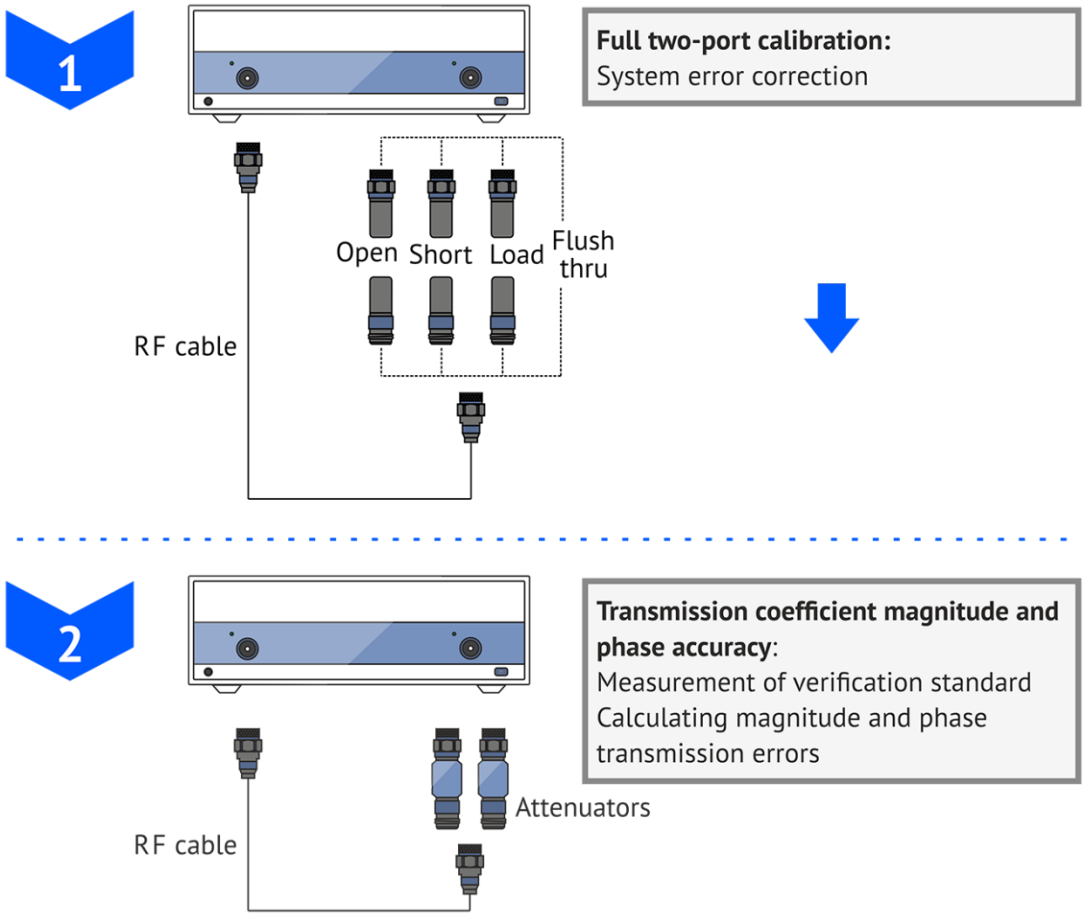
NOTE

ΔF_1... ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification. For limit calculation, measurement errors of attenuators are taken into account.

The table is suitable for each attenuator to be used.

Measurement setup



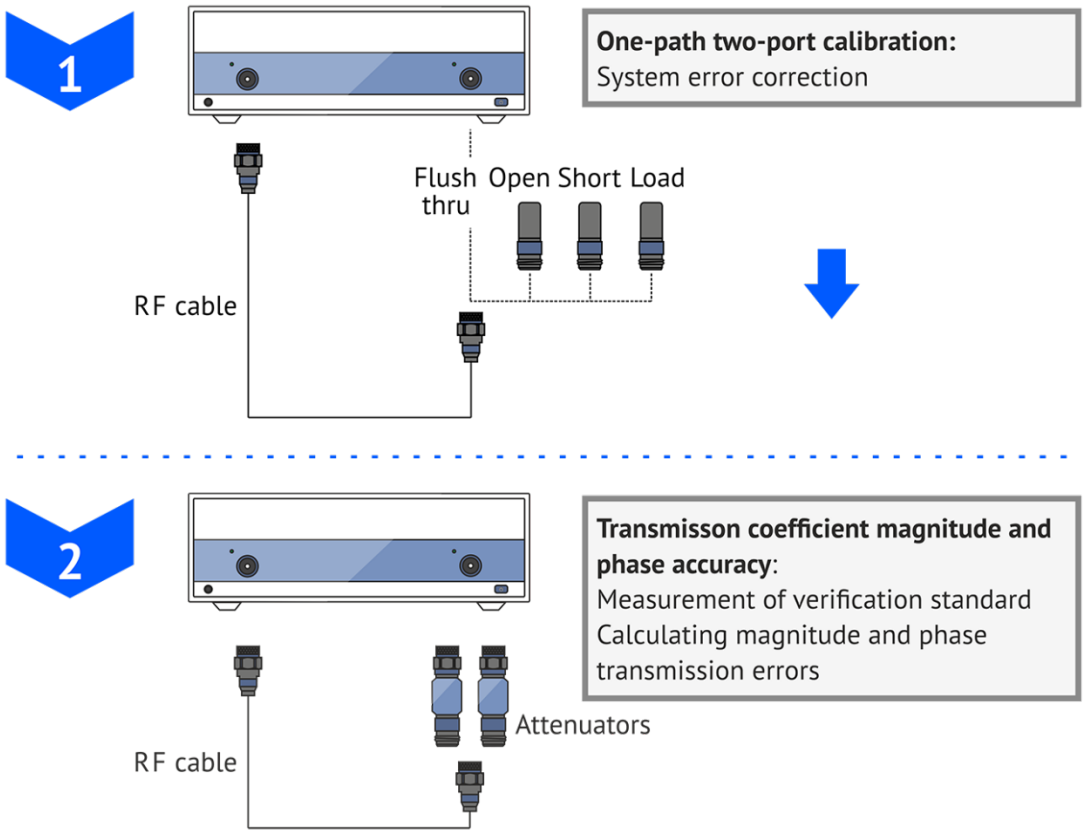
Transmission accuracy test according with common verification procedure for the analyzers with 2 test ports and dual directional source, as well for the analyzers with 4 test ports

NOTE

For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer similarly.

To reach more stability and repeatability effects during the test, it's recommended along with this RF cable to use coaxial adapters with metrology grade connectors.

Measurement setup



Transmission accuracy test according with common verification procedure for the analyzers with 2 test ports and one path source

NOTE To reach more stability and repeatability effects during the test, it's recommended along with this RF cable to use coaxial adapters with metrology grade connectors.

12.11.4 Reflection and transmission measurements. Calibration comparison

Test involves two consecutive calibrations of the same analyzer using two different calibration tools (user and reference calibration kits) and further step-by-step comparison of the measurement results.

It verifies the following characteristics:

- Receiver noise floor (refer to section 12.8).
- Uncorrected parameters for each test port (refer to section 12.10).
- Transmission coefficient magnitude and phase accuracies.
- Reflection coefficient magnitude and phase accuracies.

Analyzer under test
All types of the analyzers

Test standards and required equipment	
for 2 and 4 port analyzers	for 1-port analyzers
User calibration kit	User calibration kit
Reference calibration kit	Reference calibration kit
Matched loads	–
Phase- and amplitude-stable test cable	–

Measurement steps
Verify connectors of all standards for contamination and mechanical damage
Perform receiver noise floor test
Check user calibration kit definition
Enter reference calibration kit definition
Perform calibration with user kit

Measurement steps
Perform calibration with reference kit
Compare obtained results with device's specification

NOTE	THE TOTAL REFLECTION AND TRANSMISSION ERROR LIMITS ARE THE SUM OF THE MEASUREMENT ERRORS FOR THE REFERENCE CALIBRATION KIT STANDARDS (SPECIFIED EFFECTIVE SYSTEM DATA AFTER PERFORMING ERROR CALIBRATION AND CORRECTION) AND THE SYSTEMATIC ERRORS ASSOCIATED WITH THE ANALYZER BEING VERIFIED. THE REFERENCE CALIBRATION KIT DATA MUST BE GIVEN INITS TRACEABLE CALIBRATION CERTIFICATE.

Test report table example			
Residual parameters	Lower limit [dB]	Measured value [dB]	Upper limit [dB]
Directivity			
frequency range ΔF_1		–	
…		–	
frequency range ΔF_N		–	
Source match			
frequency range ΔF_1		–	
…		–	
frequency range ΔF_N		–	
Load match			
frequency range ΔF_1		–	
…		–	

Test report table example			
Residual parameters	Lower limit [dB]	Measured value [dB]	Upper limit [dB]
frequency range ΔF_N		–	
Reflection tracking			
frequency range ΔF_1			
…			
frequency range ΔF_N			
Transmission tracking			
frequency range ΔF_1			
…			
frequency range ΔF_N			

NOTE

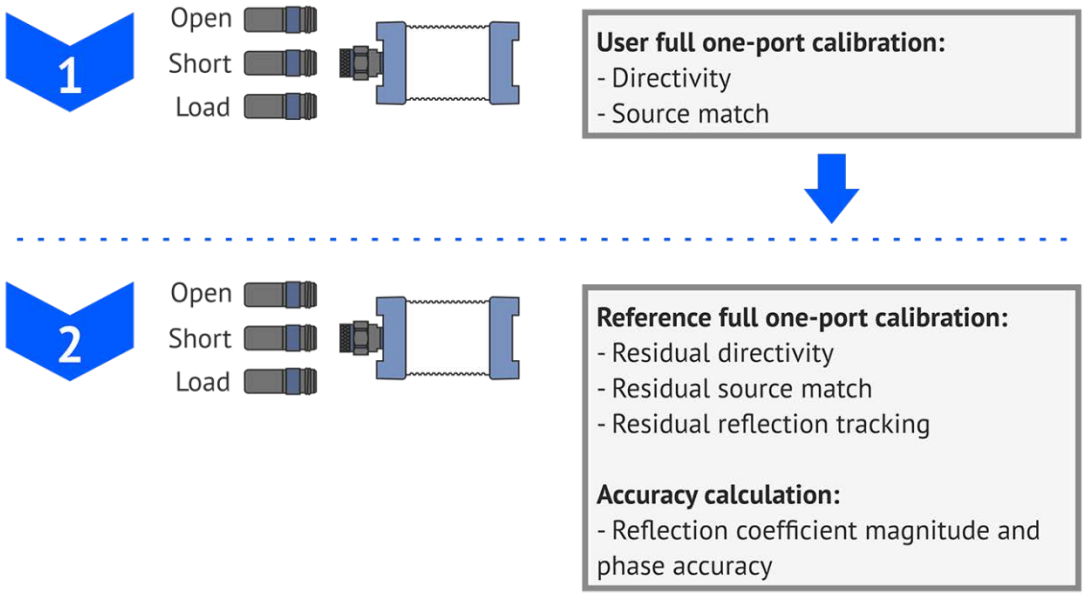
ΔF_1… ΔF_N – specified frequency ranges.

Lower and upper limits according with device's specification.

Test report table for receiver noise floor in accordance with 12.8.

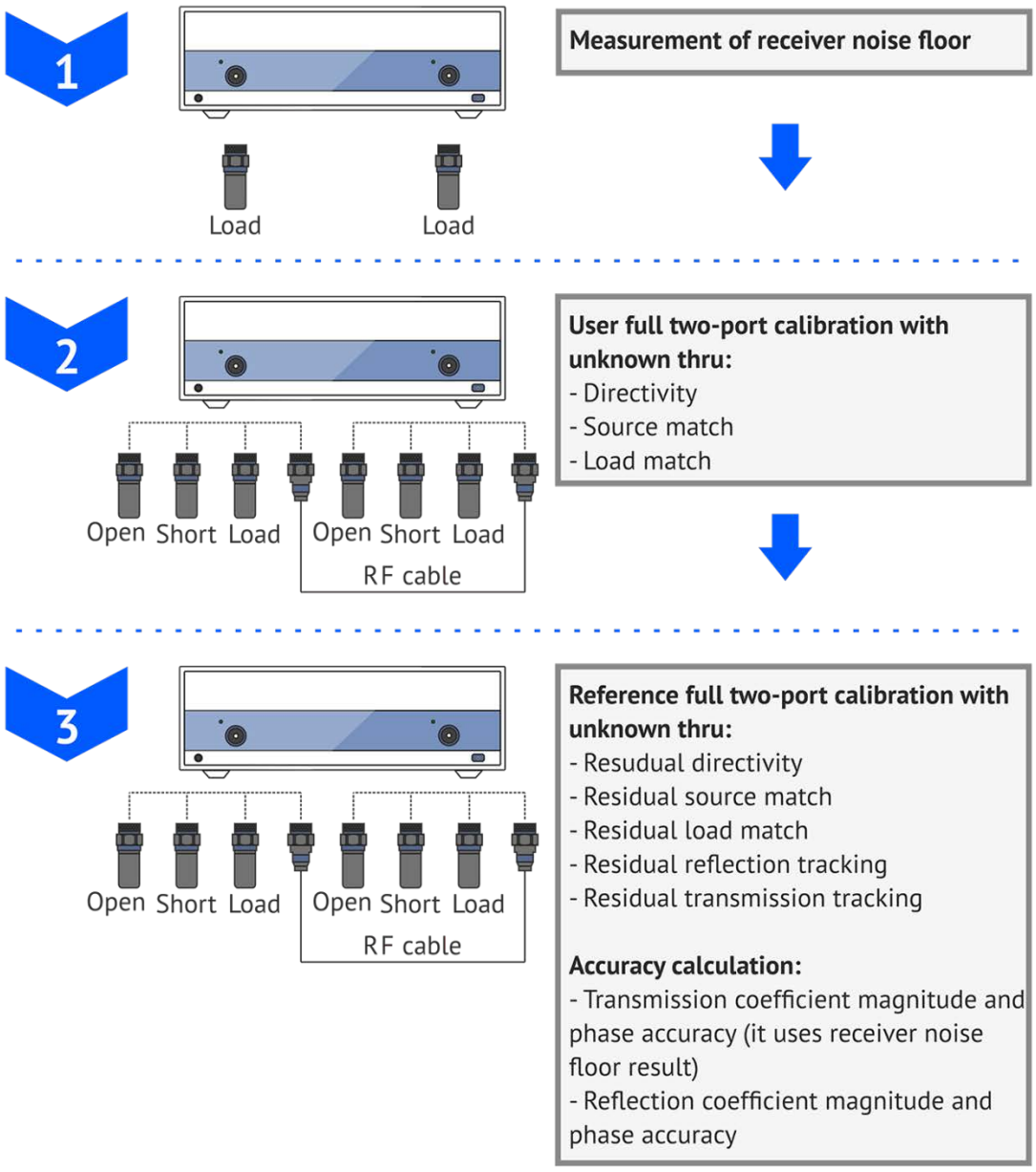
Test report table for uncorrected parameters in accordance with 12.10.

Measurement setup



Reflection accuracy test according with calibration comparison technique for the 1-port analyzers

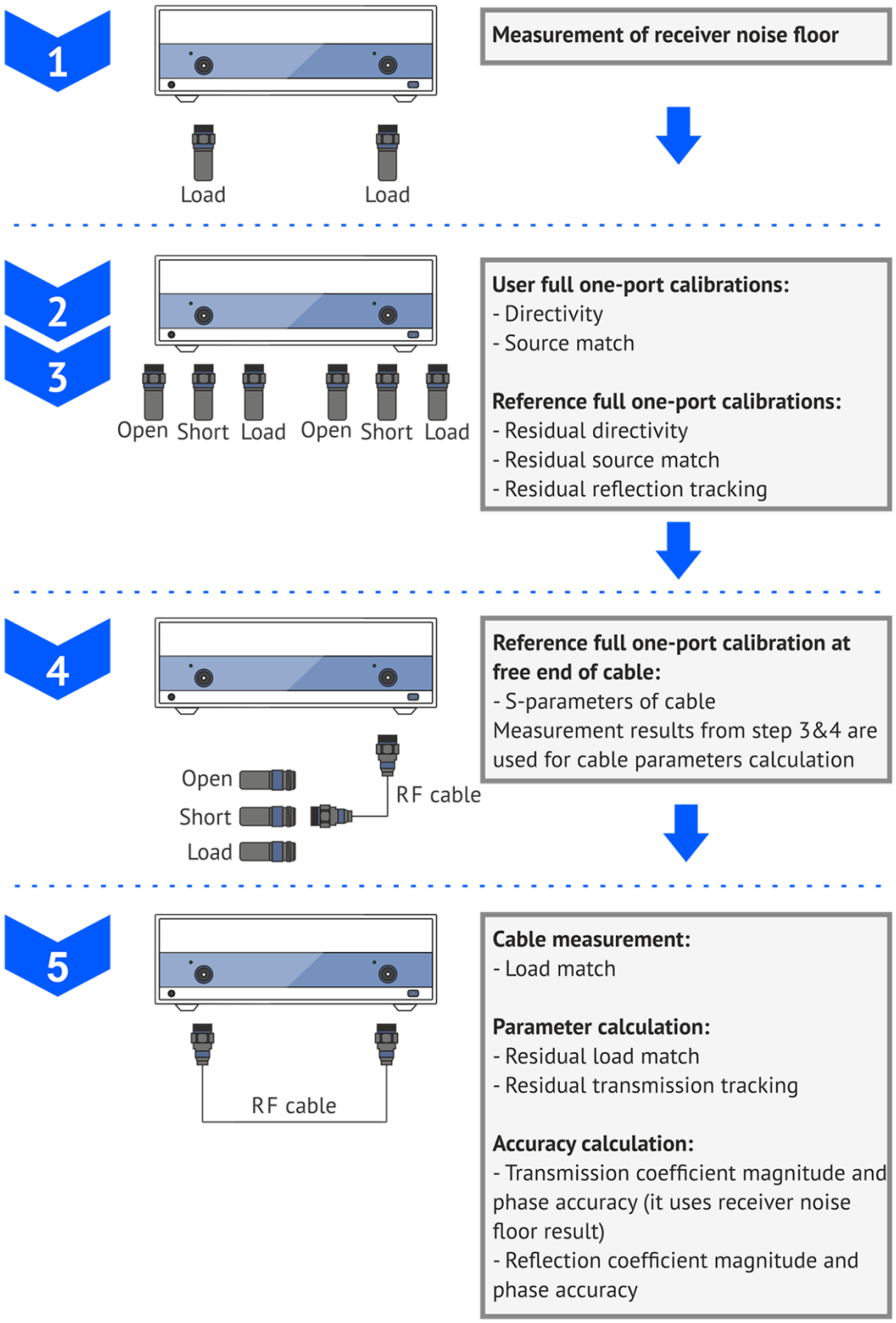
Measurement setup



Reflection and transmission accuracy test according with calibration comparison for the analyzers with 2 test ports and dual directional source (except 304/1 model), as well for the analyzers with 4 test ports

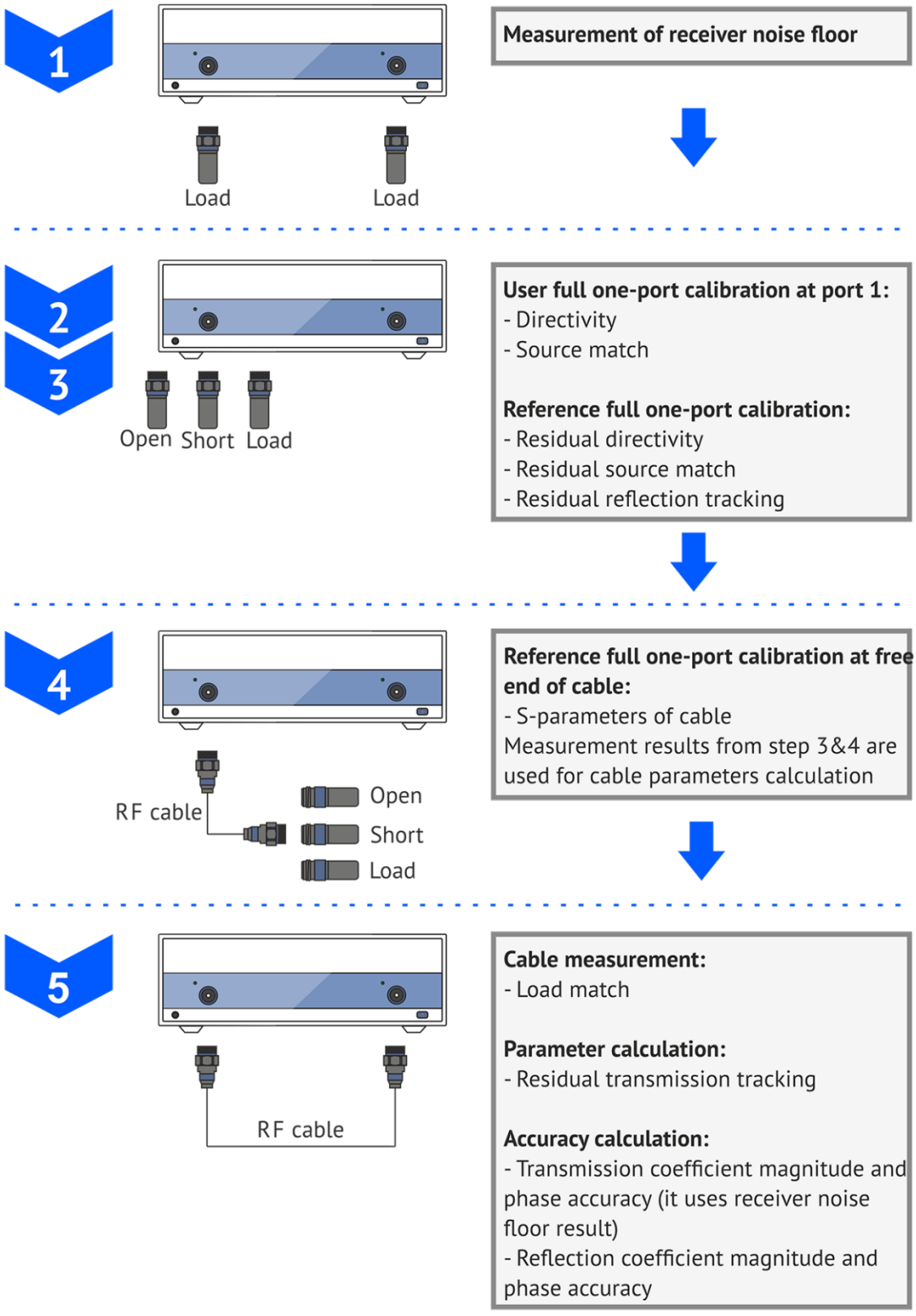
NOTE For instruments with 4 test ports, the measurements are consistently performed between 1-2 ports, and then between 3-4 ports of the analyzer similarly.

Measurement setup



Reflection and transmission accuracy test according with calibration comparison for the analyzers with 2 test ports, dual directional source, and simultaneous employment of three receivers (for 304/1 model)

Measurement setup



Reflection and transmission accuracy test according with calibration comparison for the analyzers with 2 test ports and one path source

13 REPORT

Performance test report is filling in during execution of the test procedure.

If the test is passed, a calibration certificate is issued.

If the analyzer has failed the performance test, the previous certificate is cancelled and a non-compliance notice or a fault report stating the reasons for test failure is issued. Such an instrument should not be used.