



COPPER MOUNTAIN
TECHNOLOGIES

Planar R54 / R140

Vector Reflectometer

Performance Test Manual



Version December, 2014

TABLE OF CONTENTS

1 SAFETY REQUIREMENTS	3
2 PERFORMANCE TESTS	4
3 TEST EQUIPMENT	5
4 AMBIENT CONDITIONS	6
5 PREPARATION FOR TEST	7
6 PERFORMANCE TEST PROCEDURE.....	8
6.1 Visual Inspection	8
6.2 Gaging Connectors.....	9
6.3 Performance Verification.....	10
6.3.1 CW Frequency Accuracy Test	10
6.3.2 Reflection Coefficient Magnitude and Phase Accuracy Test	12
7 PERFORMANCE TEST REPORTS.....	16

The Planar R54 and Planar R140 vector reflectometers are designed for measuring the complex reflection coefficient (S_{ii} scattering parameter) of RF and microwave devices.

The Planar R140 reflectometer has frequency range of 85 MHz to 14 GHz, whereas the Planar R54 has frequency range of 85 MHz to 5.4 GHz. Except as noted, both models are referred to interchangeably in this document as “the Reflectometer”.

The recommended performance test interval is annual.

1 SAFETY REQUIREMENTS

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

The Reflectometer must be used only by skilled and specialized staff or thoroughly trained personnel with the required skills and knowledge of safety precautions.

The Reflectometer complies with INSTALLATION CATEGORY I as well as POLLUTION DEGREE 2 in IEC61010–1.

The Reflectometer is MEASUREMENT CATEGORY I (CAT I). Do not use for CAT II, III, or IV.

- NEVER OPERATE THE REFLECTOMETER IN AN ENVIRONMENT CONTAINING INFLAMMABLE GASSES OR FUMES.
- OPERATORS MUST NOT REMOVE THE COVER OR ANY PART OF THE HOUSING. THE REFLECTOMETER MUST NOT BE REPAIRED BY THE OPERATOR. COMPONENT REPLACEMENT OR INTERNAL ADJUSTMENT MUST BE PERFORMED BY QUALIFIED MAINTENANCE PERSONNEL ONLY.
- DO NOT REPLACE COMPONENTS OR MODIFY THE REFLECTOMETER TO AVOID THE DANGER OF ADDITIONAL HAZARDS. DO NOT INSTALL REPLACEMENT PARTS OR PERFORM UNAUTHORIZED MODIFICATIONS TO THE REFLECTOMETER.
- DO NOT CONNECT THE MEASURING TERMINALS TO MAINS.

Electrostatic discharge can damage your Reflectometer 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 Reflectometer 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.

2 PERFORMANCE TESTS

A list of the performance tests is contained in Table 1.

Table 1

Test Description	Section
Visual inspection	6.1
Gaging connectors	6.2
Performance verification tests	6.3
CW frequency accuracy test	6.3.1
Reflection coefficient magnitude and phase accuracy test	6.3.2

IF THE REFLECTOMETER FAILS ANY OF THE TESTS LISTED IN TABLE 1, DO NOT CONDUCT FURTHER TESTS. ISSUE A NON-COMPLIANCE NOTICE.

UPON COMPLETION OF THE PERFORMANCE TEST, VISUALLY CHECK THE TEST PORT CONNECTOR OF THE REFLECTOMETER UNDER TEST FOR ANY CONTAMINATION AND DAMAGE. IF FOREIGN PARTICLES ARE OBSERVED, CLEAN THE CONNECTOR.

3 TEST EQUIPMENT

The equipment required for performance testing is listed in Table 2.

Table 2

Test Equipment and Specifications
Agilent 53150A Frequency Counter: frequency range 10 Hz to 20 GHz, accuracy $\pm 1 \times 10^{-7}$.
05CK10A-150 Calibration Kit. The specified effective system data are established after performing a suitable system error calibration of the reflectometer using data-based definitions of the calibration kit standards: <ul style="list-style-type: none"> - directivity> 45 dB in the frequency range DC to 4.8 GHz, > 42 dB in the frequency range 4.8 GHz to 14 GHz; - source match.....> 37 dB in the frequency range DC to 4.8 GHz, > 35 dB in the frequency range 4.8 GHz to 14 GHz; - reflection tracking....< 0.1 dB in the frequency range DC to 4.8 GHz, < 0.2 dB in the frequency range 4.8 GHz to 14 GHz.
ZV-Z270 Calibration Kit. The specified effective system data are established after performing a suitable system error calibration of the reflectometers using data-based definitions of the calibration kit standards in the operating frequency range: <ul style="list-style-type: none"> - directivity > 46 dB; - source match > 43 dB; - reflection tracking < 0.04 dB.
05W00S-000 Gage plug: measurement range $\pm 500 \mu\text{m}$, scale gradation $1 \mu\text{m}$, accuracy $\pm 5 \mu\text{m}$.
03S105-K00S3 coaxial adapter: type N female - 3.5 mm male, frequency range up to 18 GHz.
Torque wrench: torque range 1.1 to 1.7 Nm.
Wrench which fits devices to be connected.
Personal Computer (PC): Windows XP / VISTA/ 7/ 8, processor 1 GHz, memory 1 GB, interface USB 2.0.

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

EQUIPMENT SIMILAR TO THAT LISTED CAN BE USED PROVIDED THE SPECIFICATIONS SHOWN IN TABLE 2 ARE SATISFIED.

4 AMBIENT CONDITIONS

Execute performance test under the following ambient conditions:

- Ambient temperature: 23 ± 5 °C;
- Relative air humidity: ≤ 80 % at 25 °C;
- Atmospheric pressure: 630 to 800 mm Hg.

When performing reflection coefficient magnitude and phase accuracy testing (section 6.3.2), ensure that the ambient temperature remains within $\pm 1^\circ\text{C}$ of the calibration temperature.

5 PREPARATION FOR TEST

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

Confirm the required test environment is available.

Keep the Reflectometer 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 kits standards for contaminated or damaged connectors. If necessary perform gaging of the standards' connectors.

DO NOT USE DEVICES IF ANY DAMAGE OR IMPROPER MATING DIMENSIONS ARE OBSERVED. OTHERWISE, THE REFLECTOMETER CONNECTORS MAY BE DAMAGED.

Test equipment should be properly grounded and warmed up for the times specified in the corresponding manuals.

6 PERFORMANCE TEST PROCEDURE

The Reflectometer performance verification can be automated using “VNA Performance Test” software program (in this document as “performance test program”). To do this, perform the following steps:

Connect the Reflectometer to the PC using the USB cable. The instrument’s READY/STANDBY indicator will be flashing green.

Install the driver, the Reflectometer software, and the performance test program. Start the Reflectometer software. After a few seconds the Reflectometer software status bar will indicate READY, and the instrument’s READY/STANDBY indicator will be green.

Allow for a 30 minute warm-up time before starting performance verification tests.

Click the [System, Performance Test, Execute] softkeys of the Reflectometer software. The performance test program will be started. Follow the performance test program instructions.

For more details please refer to the Reflectometer operating manual.

Note: In the event any error message is displayed on the PC screen or the software status bar indicates NOT READY, close the Reflectometer software and confirm that the USB cable is properly connected and the driver is properly installed. Restart the Reflectometer software.

Proceed with performance test only if the Reflectometer software is installed, the Reflectometer software status bar indicates READY, performance test program is started, and no error messages appear.

6.1 VISUAL INSPECTION

6.1.1 Select **Visual Inspection** in the performance test program. Fill in the table specified in the program after performing the procedures described below.

6.1.2 Check the Reflectometer under test for missing accessories in accordance with the Reflectometer operating manual.

6.1.3 Check the Reflectometer test port connector (PORT 50Ω) for contamination. If necessary, clean the connector as described below:

- Clean the connector surfaces shown by arrows in figure 1 with a lint-free cotton swab dampened with isopropyl alcohol.

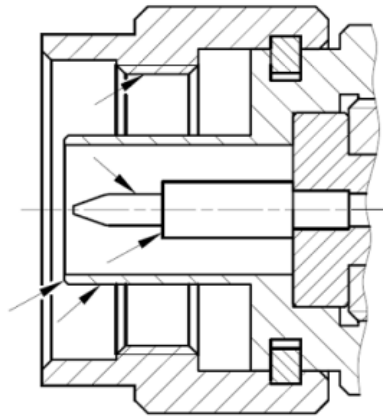


Figure 1. Connector type N, male

- 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.

DO NOT USE ANY METAL OBJECTS TO CLEAN THE CONNECTOR.

6.1.4 Check the Reflectometer test port connector for mechanical damage (dents or irregularities on the inner and outer conductors).

6.1.5 Check the Reflectometer housing for mechanical damage and loose components (check for any sound while rotating the Reflectometer), traces of corrosion on metal parts, damaged coatings, or illegible markings.

6.1.6 Check the USB cable for damage.

THE TEST IS CONSIDERED TO BE PASSED AND THE PROGRAM STATEMENT OF COMPLIANCE IS PASSED IF:

- The reflectometer has all accessories listed in the operation manual.
- The connector does not have any mechanical damage.
- There are no deep scratches or dents in the Reflectometer housing.
- There is no sound in the housing from loose components.
- There is no evidence of metal corrosion.
- The coatings are not damaged.
- The label markings are legible.
- The USB cable is not damaged.

6.2 GAGING CONNECTORS

6.2.1 Select **Gaging Connector** in the performance test program.

6.2.2 To perform the test port connector gaging, use 05W00S-000 Gage plug or another available common gage set designed for gaging type N connectors. Follow the gaging procedures specified in the manual to the gage set you are using.

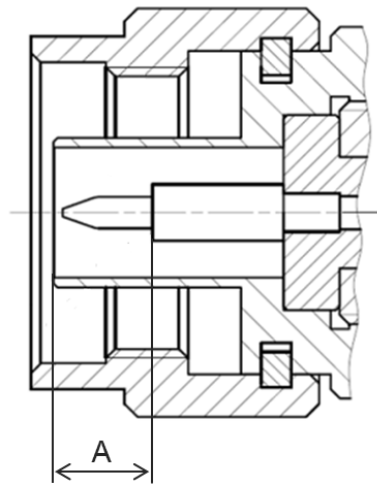


Figure 2. Connector type N, male

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

6.2.4 Enter the measured value in the table specified in the program.

Table 3. Gaging test port connector

Port	Lower limit, [mm]	Measured value, [mm]	Upper limit, [mm]
PORT 50 Ω type N, male	5.28		5.36

THE TEST IS CONSIDERED TO BE PASSED IF THE MEASURED VALUE OF THE REFLECTOMETER'S 50 Ω CONNECTOR PORT IS BETWEEN 5.28 mm AND 5.36 mm AND THE PROGRAM STATEMENT OF COMPLIANCE IS PASSED.

6.3 PERFORMANCE VERIFICATION

6.3.1 CW Frequency Accuracy Test

6.3.1.1 Select **CW Frequency Accuracy Test** in the performance test program.

6.3.1.2 Prepare the frequency counter for operation in accordance with its operating manual.

6.3.1.3 Connect the frequency counter to the Reflectometer test port. If necessary, use the 03S105-K00S3 coaxial adapter. See the measurement setup in Figure 3.

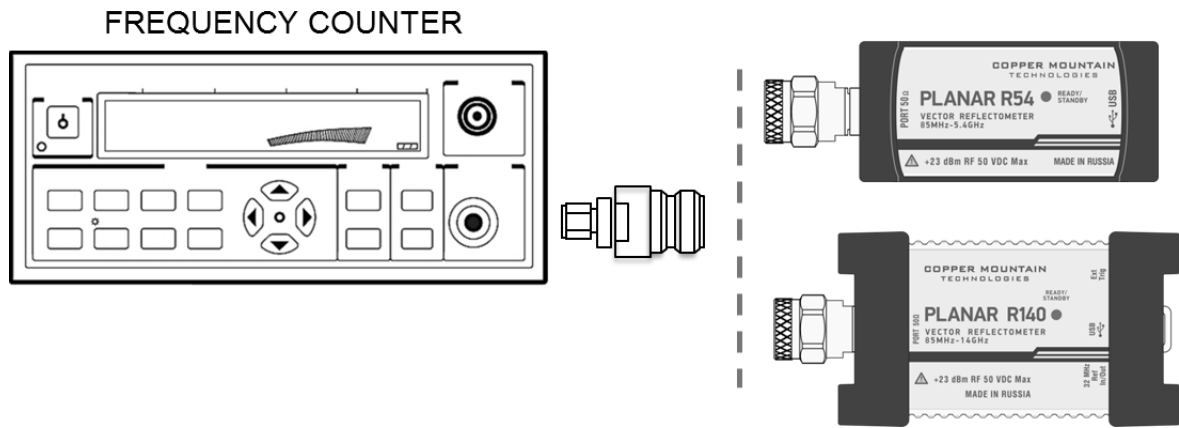


Figure 3. Measurement setup for the CW frequency accuracy test

6.3.1.4 In the table specified in the program, click the **85** softkey to set the signal source frequency to 85 MHz.

6.3.1.5 Measure the frequency f using the frequency counter. Enter the measured frequency value into the corresponding column of the program table.

Table 4. CW Frequency Accuracy Test

Frequency, [MHz]	Measured Frequency, [Hz]	Rel Frequency Error [ppm]	Specification [ppm]
85			
5400 (14000 for R140)			

Note: The performance test program calculates the relative frequency error of the signal source using the following formula (1):

$$\Delta f = (f - f_0) \cdot 10^6 / f_0, \quad (1)$$

where f – measured frequency, Hz;
 f_0 – frequency setting, Hz.

6.3.1.6 Click the **5400** softkey to set the signal source frequency to 5400 MHz for Planar R54, or the **14000** softkey to set the signal source frequency to 14000 MHz for Planar R140.

6.3.1.7 Measure the frequency f using the frequency counter. Enter the measured frequency value into the corresponding columns of the program table.

THE TEST IS CONSIDERED TO BE PASSED IF THE RELATIVE FREQUENCY ERROR IS WITHIN ± 5.0 ppm FOR PLANAR R54 AND WITHIN ± 2.5 ppm FOR PLANAR R 140 AND THE PROGRAM STATEMENT OF COMPLIANCE IS PASS.

6.3.2 Reflection Coefficient Magnitude and Phase Accuracy Test

The verification method is based on the calibration comparison technique. It allows for determining residual errors of reflection coefficient measurements.

The method involves two consecutive calibrations of the same Reflectometer using two different calibration tools and further step-by-step comparison of the measurement results.

The ZV-Z270 calibration kit is used as a benchmark (reference) calibration kit, and the 05CK10A-150 calibration kit is used as a test (user) calibration kit. The test equipment is listed in Table 2.

It is possible to use other measurement methods which ensure the required accuracy of the performance verification of the Reflectometers under test.

6.3.2.1 Select the **Reflection Coefficient Magnitude and Phase Accuracy Test** in the performance test program.

6.3.2.2 Prepare the calibration kits for operation in accordance with their operating manuals. It is recommended to check the calibration kits' definitions (all standards of the kits) in the Reflectometer software against the kits' documentation. Add any definitions which are not available in the Reflectometer software.

6.3.2.3 Click the **User Calibration** softkey of the performance test program and go to the Reflectometer software.

6.3.2.4 Perform full one-port calibration using the test (user) calibration kit in accordance with the Reflectometer's operating manual. Refer to the measurement setup in Figure 4.

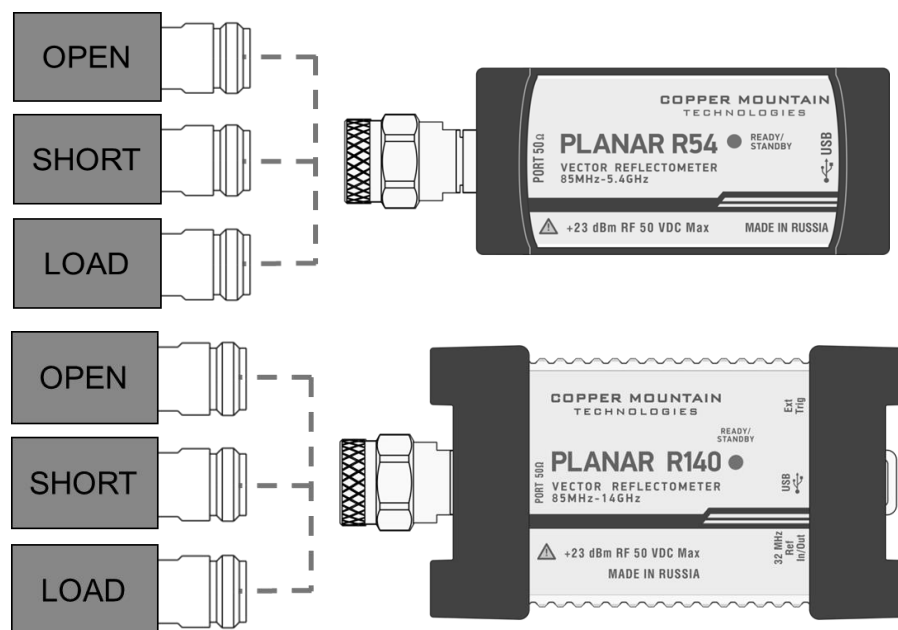


Figure 4. Measurement setup for the reflection coefficient magnitude and phase accuracy test

The standards are connected as follows:

- Carefully align the connectors of the devices.

- While holding the standard being connected, 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 (see figure 5).
- Tighten with light finger pressure avoiding rotation of the mating planes at the same time.

WARNING! ROTATE THE NUT OF THE MALE CONNECTOR ONLY. AVOID ROTATION OF THE DEVICES.

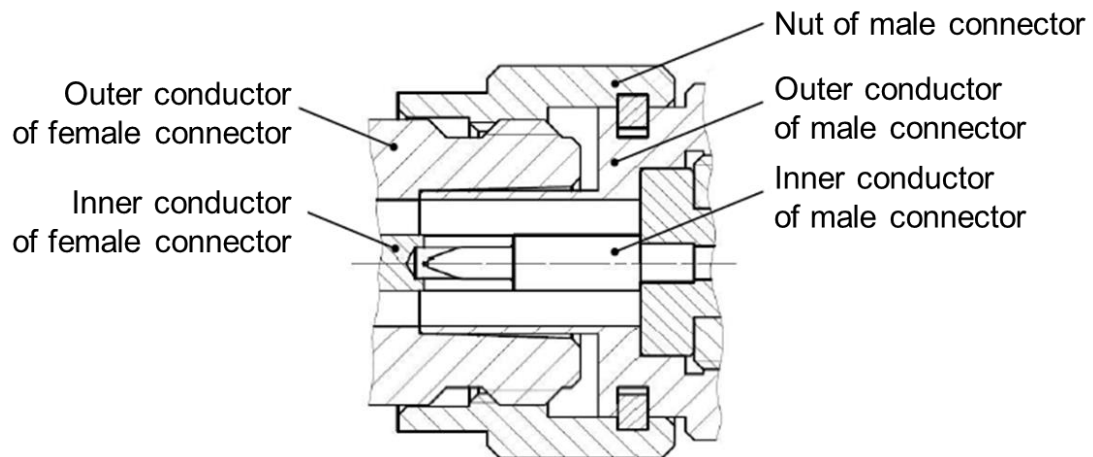


Figure 5. Connection example

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

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

6.3.2.5 After calibration, return to the performance test program and click the **Reference Calibration** softkey.

6.3.2.6 Similarly, perform full one-port calibration using the benchmark (reference) calibration kit.

6.3.2.7 When the user and reference calibrations are complete, check that the measured uncorrected and residual (effective) parameters are within specification limits. See Figures 6 to 8 for examples of measurement reports from the performance test program (bold lines indicate measurement results, thick lines indicate specification limits).

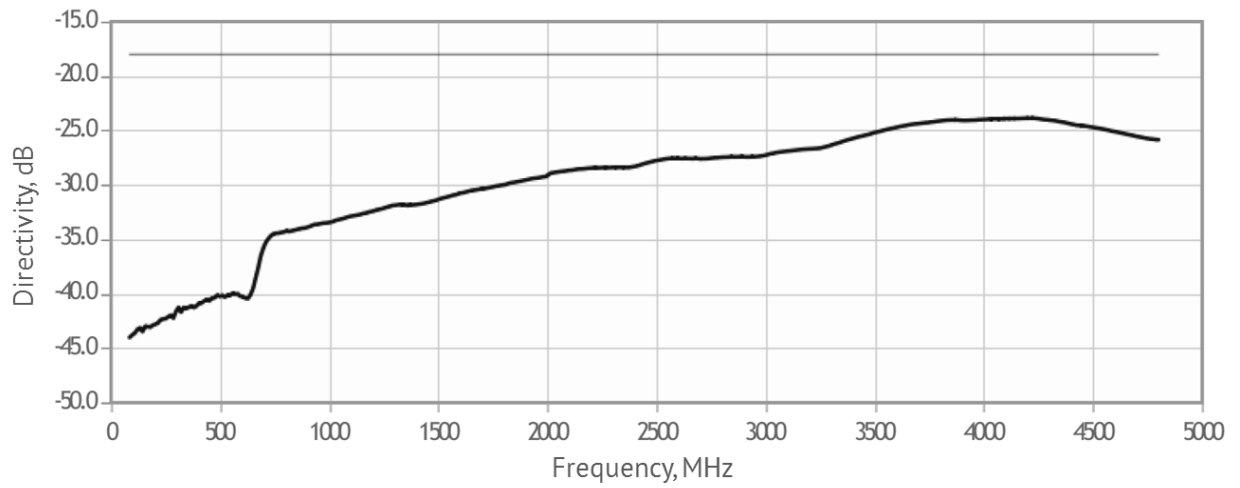


Figure 6. Uncorrected directivity example

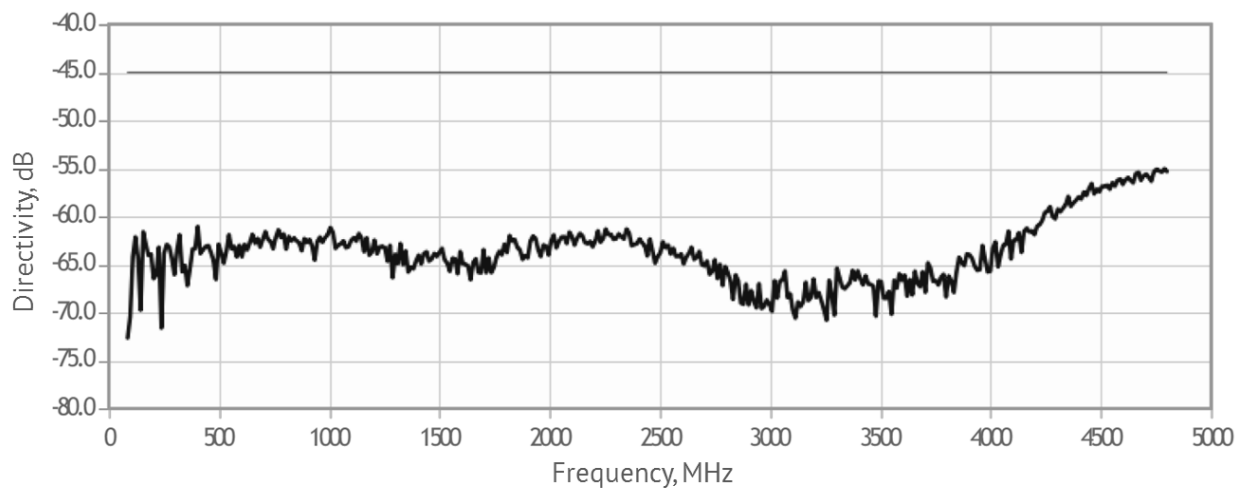


Figure 7. Residual directivity example

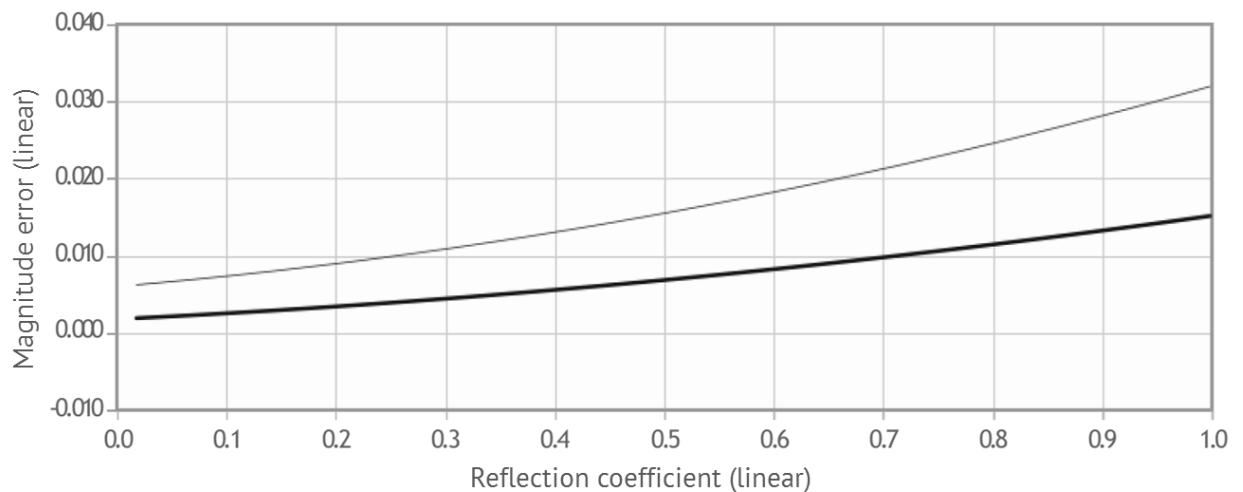


Figure 8. Reflection coefficient magnitude error example

THE TEST IS CONSIDERED TO BE PASSED IF THE MEASURED UNCORRECTED AND RESIDUAL (EFFECTIVE) PARAMETERS ARE WITHIN THE SPECIFICATIONS INDICATED IN TABLE 5 AND THE PROGRAM STATEMENT OF COMPLIANCE IS PASS.

Table 5

Parameter	Specification	
	Planar R54	Planar R140
Uncorrected directivity:		
85 to 4800 MHz	18 dB	10 dB
4800 to 14000 MHz	–	10 dB
Uncorrected source match:		
85 to 4800 MHz	18 dB	10 dB
4800 to 14000 MHz	–	10 dB
Effective directivity:		
85 to 4800 MHz	45 dB	45 dB
4800 to 14000 MHz	–	42 dB
Effective source match:		
85 to 4800 MHz	37 dB	37 dB
4800 to 14000 MHz	–	35 dB
Effective reflection tracking:		
85 to 4800 MHz	± 0.10 dB	± 0.10 dB
4800 to 14000 MHz	–	± 0.20 dB

7 PERFORMANCE TEST REPORTS

Performance test reports are to be filled in during execution of the test procedure.

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

If the Reflectometer has failed the performance test, the previous performance test certificate is cancelled and a non-compliance notice stating the reasons for test failure is issued.