Planar 304/1

Network Analyzer

Performance Test Manual

Revision 16.1
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The Copper Mountain Technologies Planar 304/1 Network Analyzer (Analyzer) is designed for S-parameter measurement of RF and microwave devices with coaxial transmission lines using its N-type connectors.

The recommended performance test interval is one year.

1 SAFETY REQUIREMENTS

Carefully read the following safety instructions before putting the Analyzer into operation. Observe all the precautions and warnings provided in this Manual for all the phases of operation, service, and repair of the Analyzer.

The Analyzer should be used only by skilled and thoroughly trained personnel with the required skills and knowledge of safety precautions.

The Analyzer complies with INSTALLATION CATEGORY II as well as POLLUTION DEGREE 2 as defined in IEC61010−1. The Analyzer is a MEASUREMENT CATEGORY I (CAT I) device. Do not use the Analyzer as a CAT II, III, or IV device.

The Analyzer is for INDOOR USE only.

The Analyzer has been tested as a stand-alone device and in combination with the accessories supplied by Copper Mountain Technologies, in accordance with the requirements of the standards described in the Declaration of Conformity. If the Analyzer is integrated with another system, compliance with related regulations and safety requirements are to be confirmed by the builder of the system.

Never operate the Analyzer in an environment containing flammable gasses or fumes.

Operators must not remove the cover or any other part of the housing. The Analyzer must not be repaired by the operator. Component replacement or internal adjustment must be performed by qualified maintenance personnel only.

Never operate the Analyzer if the power cable is damaged. Never connect the test ports to A/C power mains.

Electrostatic discharge can damage the Analyzer whether connected to or disconnected from the DUT. Static charge can build up on your body and damage sensitive internal components of both the Analyzer and the DUT. To avoid damage from electric discharge, observe the following:

- Always use a desktop anti-static mat under the DUT.
- Always wear a grounding wrist strap connected to the desktop anti-static mat via daisy-chained 1 MΩ resistor.
- Connect the post marked ⏚ on the body of the Analyzer to the body of the DUT before you start operation.

Observe all general safety precautions related to operation of electrically energized equipment.

2 PERFORMANCE TESTS

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

Table 1 – Performance Tests

Test Description	**Section**
Visual inspection	6.1
Test run	6.2
Gaging connectors	6.3
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CW frequency accuracy test	6.4.1
Output power level accuracy test	6.4.2
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3 TEST EQUIPMENT

The required equipment for performance tests is listed below.

Test Equipment and Specifications
Agilent 53150A Frequency Counter: frequency range 10 Hz to 20 GHz, accuracy ±1× 10^{-7}.
Agilent E4408B Spectrum Analyzer: frequency range 9 kHz to 26.5 GHz; power level measurement accuracy ±2 dB.
NRP-Z51 Thermal Power Sensor: DC frequency range up to 18 GHz, power level measurement range -30 to +20 dBm, power level measurement accuracy ± 0.061 dB.
RPC-N Verification Kit 05CK200-150: DC frequency range up to 18 GHz, attenuation measurement accuracy ±0.06 dB.
RPC-N Calibration Kit 05CK10A-150: DC frequency range up to 18 GHz
05 W 00K-000 Gage female incl. block: measurement range ±500 μm, scale gradation 1 μm, accuracy ± 5 μm

All the test equipment shall be verified and have valid verification certificates.

Equipment similar to the listed above can be used provided it ensures the specifications indicated in Table 2.

4 AMBIENT CONDITIONS

Perform the performance tests under the following ambient conditions:

- ambient temperature 23±5 deg. C;
- relative air humidity 30% to 80% at 25 deg. C;
- atmospheric pressure 630 to 795 mm Hg.

When performing S21 and S12 transmission coefficient magnitude accuracy test (section 6.4.5) and S11 and S22 reflection coefficient magnitude and phase accuracy test (section 6.4.6), make sure that the ambient temperature is within ±1 °C of the calibration temperature.

5 PREPARATION FOR TEST

The verification technician should thoroughly read and understand the manuals of both the Analyzer to be verified and the test equipment to be used.

The Analyzer and the employed test equipment should be properly grounded and warmed up during the time specified in the corresponding manuals.

6 PERFORMANCE TEST PROCEDURE

The performance test of the Analyzer can be performed in two ways.

You can perform the performance verification of the Analyzer automatically using the special performance test program provided for the Analyzer software: VNAPT. For more information about VNAPT please contact support@coppermountaintech.com or visit our website: www.coppermountaintech.com.

This section details the performance test procedure in case you are not using the above-mentioned automatic performance test.

6.1 Visual Inspection

During visual inspection check the Analyzer for:

- contaminated and damaged connectors and jacks;
- housing damages and loose components (check by sound when tilting the Analyzer);
- damaged or loose controls;
- missing accessories.

Do not perform further performance tests with the Analyzers having defects (mechanical damage) or missing components or accessories. Such instruments should be discarded or sent for repair.

6.2 Test Run

During the test run perform the following steps in accordance with the instructions in the Operating Manual:

- check the software operation;
- check the display functions (display of windows, channels, and traces);
- check the softkey control panels for proper functioning;
- initialize the Analyzer.

The test run is considered to be passed if no errors are detected.

6.3 Gaging Connectors

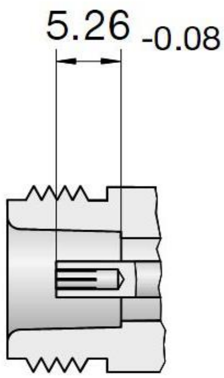

Figure 1 - Connecting dimensions of connector.

To perform connector gaging of the Analyzer, use 05 W 00K-000 Gage female including block (measurement range ±500 µm, scale gradation 1 µm, accuracy ± 5 µm) or another available common gage set designed for gaging N-type connectors of vector network analyzers. Follow the gaging procedures specified in the manual to the gage set you are using.

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

6.4 Performance Verification

Before you start performance verification tests, warm up the Analyzer for 40 minutes.

6.4.1 CW Frequency Accuracy Test

6.4.1.1 Preset the Analyzer [System, Preset][1]. Connect the frequency counter to the port of the Analyzer under test.

6.4.1.2 Switch the Analyzer to 300 kHz CW generation mode [Stimulus, Center 300 kHz, Span 0 MHz].

6.4.1.3 Enter the measured frequency value into the corresponding column of Table 3.

6.4.1.4 Repeat the signal frequency measurement at the operating frequency of 3.2 GHz.

The test is considered to be passed if the measured frequency values are within the limits indicated in Table 3.

Table 3 – CW Frequency Accuracy Test Table.

Set frequency value, MHz	**Lower limit, Hz**	**Measured frequency value, Hz**	**Upper limit, Hz**
0.3	299,998.50		300,001.50
3200	3,199,984,000		3,200,016,000

[1] Hereafter the brackets […] are used to denote the procedure of setting the required mode of the Analyzer operation as a sequence of selected menu items, softkeys and sets of values.

6.4.2 Output Power Level Accuracy Test

6.4.2.1 Prepare the thermal power sensor for operation and connect it to port 1 of the Analyzer under test.

6.4.2.2 Initialize the Analyzer [System, Preset]. Switch the Analyzer to the absolute measurement mode [Measurement, Absolute, Receiver R1 - Source Port1].

6.4.2.3 Switch the Analyzer to 0 dBm CW generation mode [Stimulus, Span 0 MHz, Power 0 dBm].

6.4.2.4 Set the operating frequency to 300 kHz [Stimulus, Center 300 kHz]. Enter the measured level value in Table 4.

6.4.2.5 Repeat the measurements as described in section 6.4.2.4 for other frequency values specified in Table 4.

6.4.2.6 Set the Analyzer frequency range from 300 kHz to 3.2 GHz. Set the IF bandwidth to 100 Hz. Perform measurement normalization [Display, Data -> Memory, Data Math, Data / Mem].

Table 4 – Output Power Level Accuracy Test Table.

Port	**Specified RF Output Level [dBm]**	**Measured RF Output Level [dBm]**									
		Frequency [MHz]									
		0.3	1.0	5.0	20	100	500	1000	1500	2500	3200
1	0										
	10										
	-10										
	-30										
	-45										
2	0										
	10										
	-10										
	-30										
	-45										

6.4.2.7 Enable markers at 300 kHz, 1, 5, 20, 100, 500, 1000, 1500, 2500 and 3200 MHz.

6.4.2.8 Set the power level to 10 dBm. Enter the marker values in Table 4.

6.4.2.9 Repeat the measurements as described in section 6.4.2.8 for -10, -30 and -45 dBm level values.

6.4.2.10 Connect the thermal power sensor to port 2 of the Analyzer under test. Switch the Analyzer to the absolute measurement mode [Measurement, Absolute, Receiver R2 – Source Port2]. Repeat the measurements as described in sections 6.4.2.3 to 6.4.2.9.

6.4.2.11 Determine the power values at the specified levels of +10 dBm, -10 dBm, -30 dBm and -45 dBm by adding values in 0 dBm line and the respective line of Table 4.

The test is considered to be passed if the power level values, measured in -45 to 10 dBm level range, are within ±1 dB.

6.4.3 Harmonic Distortion Test

6.4.3.1 Output harmonic distortion is measured using spectrum analyzer. Prepare the spectrum analyzer for operation in accordance with its operating manual. Set the reference power level of the Analyzer to 10 dBm. Connect the spectrum analyzer to port 1 of the Analyzer under test.

6.4.3.2 Initialize the Analyzer [System, Preset]. Set the output power level to 0 dBm.

6.4.3.3 Measure the maximum harmonic distortion (up to third order harmonic) at output frequencies of 300 kHz, 1, 5, 20, 100, 500, 1000, 1500, 2500 and 3200 MHz. Enter the measured values in Table 5.

6.4.3.4 Connect the spectrum analyzer to port 2 of the Analyzer under test. Enable the S22 measurement mode [Measurement, S22]. Repeat the measurements as described in section 6.4.3.3.

The test is considered to be passed if the output harmonic distortion is less than -30 dBc.

Table 5 – Harmonic Distortion Table.

Port	Harmonic Distortion [dBc]									
	Frequency [MHz]									
	0.3	1.0	5.0	20	100	500	1000	1500	2500	3200
1										
2										

6.4.4 Non-Harmonic Spurious Test

6.4.4.1 Non-harmonic spurious level is measured using spectrum analyzer. Prepare the spectrum analyzer for operation in accordance with its operating manual. Set the reference level of the Analyzer to 10 dBm. Set the stimulus start frequency to 10 Hz, stimulus stop frequency to 10 GHz, and IF bandwidth to 300 kHz.

6.4.4.2 Switch the Analyzer to slow sweep mode over 300 kHz to 3.2 GHz span. Initialize the Analyzer [System, Preset]. Set the power level to 0 dBm, and IF bandwidth to 1 Hz. Connect the spectrum analyzer to port 1 of the Analyzer under test.

6.4.4.3 During the sweep measure the minimum difference between the levels of useful signal and spurious signal.

The test is considered to be passed if the measured difference is less than -30 dBc at operating frequencies up to 3.2 GHz.

6.4.5 S21 and S12 Transmission Coefficient Magnitude Accuracy Test (at -20 dB, -40 dB and -60 dB)

6.4.5.1 The accuracy test is performed using attenuators from 05??200-150 verification kit. Initialize the Analyzer under test. Set the power level to -5 dBm, and IF bandwidth to 1 Hz. Enable two traces [Display, Num of Traces, 2], and assign S21 and S12 parameters to them. Enable the segment frequency sweep mode. Set same start and stop frequencies in each segment. The recommended points are 300 kHz, 2 GHz and 3.2 GHz. Set the number of measurement points to 1 per each segment. Arrange traces in different windows [Display, Allocate Channels, x2]. Enable markers at 300 kHz, 2 GHz and 3.2 GHz frequency values. Connect the measurement cable to port 1 and perform two-port calibration.

6.4.5.2 S21 and S12 transmission coefficient magnitude accuracy at -20 dB is verified using 20 dB 05AS122-K20S3 attenuator. Determine the measured S21 and S12 values using markers and enter them in Table 6. Deviation from the characterized attenuation value is considered to be the measurement error. The test is considered to be passed if the measured error is less than 0.1 dB.

6.4.5.3 S21 and S12 transmission coefficient magnitude accuracy at -40 dB is verified using 40 dB 05AS122-K40S3 attenuator. Determine the measured S21 and S12 values using markers and enter them in Table 6. Deviation from the characterized attenuation value is considered to be the measurement error. The test is considered to be passed if the measured error does not exceed 0.1 dB.

6.4.5.4 S21 and S12 transmission coefficient magnitude accuracy at -60 dB is verified using 20 dB 05AS122-K20S3 and 40 dB 05AS122-K40S3 attenuators. Determine the measured S21 and S12 values using markers and enter them in Table 6. Deviation from the characterized attenuation value is considered to be the measurement error. The test is considered to be passed if the measured error is less than 0.2 dB.

Table 6 – Transmission Coefficient Magnitude Accuracy Test Table.

Frequency	Rated Attenuation Value, dB	Characterized Attenuation Value, dB	$\|S_{21}\|$		$\|S_{12}\|$		Accuracy, dB
			Measured Value, dB	Measurement Error, dB	Measured Value, dB	Measurement Error, dB	
300 kHz	20						±0.1
	40						±0.1
	60						±0.2
2 GHz	20						±0.1
	40						±0.1
	60						±0.2
3 GHz	20						±0.1
	40						±0.1
	60						±0.2

6.4.6 S11 and S22 Reflection Coefficient Magnitude and Phase Accuracy Test

Reflection coefficient magnitude and phase accuracy test is performed by comparing the measured and real values of reflection magnitude and phase of the 05 S 102-K100 stepped Airline from 05 CK 200-150 verification kit.

6.4.6.1 Perform the following settings on the Analyzer: frequency range from 300 kHz to 3.2 GHz; IF bandwidth to 1 Hz; number of traces displayed to 4 [Display, Num of Traces, 4]; and measured parameters to S_{11} (to traces 1 and 2) and S_{22} (to traces 3 and 4). Set trace 1 format to S_{11} Phase [Format, Phase]; set trace 2 format to S_{11} Log Mag [Format, Log Mag]; set trace 3 format to S_{22} Phase [Format, Phase]; and set trace 4 format to S_{22} Log Mag [Format, Log Mag]. Enable the segment sweep mode. The frequencies of the segments should correspond to the characterized frequencies of the 05 S 102-K100 Airline. Set the number measurement points in each segment to 1. Enable the markers for the segment frequencies. Place the Analyzer in vertical position. Connect C50NMNM.1 coaxial Cable with 05 S 121-K00S3 adapter attached to Port 1 of the Analyzer.

6.4.6.2 Perform full two-port calibration of the Analyzer with RPC-N Calibration Kit 05 CK 10A-150. Connect 05 S 102-K100 Airline (male connector side) to Port 2 in the following manner: insert the inner conductor of the Airline into Port 2 connector; put on the outer conductor and tighten the screw nut using the calibrated wrench. Connect C50NMNM.1 coaxial Cable with 05 S 121-K00S3 adapter attached to the free connector of the Airline.

6.4.6.3 Use markers to determine the Airline reflection magnitude and phase. Enter the measured magnitude values into columns 3 and 4 of Table 7, and measured phase values into columns 9 and 10 of Table 7.

6.4.6.4 Determine the mean values for the characterized magnitude and phase of the 05 S 102-K100 Airline using formula (1):

$$A_{nom\ i(j)} = (A_{male\ i(j)} + A_{female\ i(j)})/2, \text{ where} \qquad (1)$$

$A_{male\ i(j)}$ – characterized magnitude (i) or phase (j) values of reflection coefficient on male connector

$A_{female\ i(j)})$ – characterized magnitude (i) or phase (j) values of reflection coefficient on female connector

Enter the $A_{nom\ i}$ magnitude values into column 2 of Table 7, and enter the $A_{nom\ j}$ phase values into column 8 of Table 7.

6.4.6.5 Determine the mean values for measured magnitude and phase using formula (2):

$$A_{mean\ i(j)} = (A_{meas1\ i(j)} + A_{meas2\ i(j)})/2, \text{ where} \qquad (2)$$

$A_{meas1\ i(j)}$ - magnitude (i) or phase (j) values of reflection coefficient from column 3 or 9;

A_{meas2} - magnitude (i) or phase (j) values of reflection coefficient from column 4 or 10.

Enter the A_{mean} magnitude values into column 5 of Table 7, and enter the A_{mean} phase values into column 5 of Table 7.

6.4.6.6 Determine S_{11} magnitude measurement error using formula (3):

$$\Delta A_i = A_{mean\ i} - A_{nom\ i}, \text{ where} \qquad (3)$$

$A_{mean\ i}$ – mean value of S_{11} magnitude (column 5 in Table 7)

$A_{nom\ i}$ – characterized value of S_{11} magnitude (column 2 in Table 7).

Enter the ΔA_i values into column 6 of Table 7.

Table 7 – Airline Reflection Coefficient Magnitude and Phase Table.

Frequency, MHz	**Reflection coefficient magnitude, dB**						**Reflection coefficient phase, degree**					
	Characterized value	**Measurement**		**Mean Value**	**Measurement Error**	**Accuracy**	**Characterized value**	**Measurement**		**Mean Value**	**Measurement Error**	**Accuracy**
		Port 1	**Port 2**					**Port 1**	**Port 2**			
1	2	3	4	5	6	7	8	9	10	11	12	13

6.4.6.7 Determine S_{11} phase measurement error using the following formula (4):

$$\Delta A_j = A_{mean\ j} - A_{nom\ j}, \text{ where} \quad (4)$$

$A_{mean\ j}$ – mean value of S_{11} phase (column 11 in Table 7)
$A_{nom\ j}$ – characterized value of S_{11} phase (column 8 in Table 7).

Enter the ΔA_j values into column 12 of Table 7.

6.4.6.8 Enter the accuracy of the reflection coefficient measurement of the 05S102-K100 Airline into columns 7 and 13 of Table 7.

If the characterized value of the reflection coefficient magnitude of the Airline (column 2 in Table 7) is:

- from 0 to -15 dB, enter ±0.4 dB into column 7 and ±4 degrees into column 13;
- from -15 to -25 dB, enter ±1.5 dB into column 7 and ±7 degrees into column 13;
- from -25 to -35 dB, enter ±4 dB into column 7 and ±22 degrees into column 13.

The test is considered to be passed if:

- measurement error values of reflection coefficient magnitude measurement (column 6 in Table 7) are within the range specified in column 7 of Table 7;

- measurement error of reflection coefficient phase measurement (column 12 in Table 7) are within the range specified in column 13 of Table 7.

6.4.7 Receiver Noise Floor Test (IF bandwidth 10 Hz)

6.4.7.1 Receiver noise floor test of the Analyzer is performed without use of any test equipment.

6.4.7.2 Perform the following settings on the Analyzer: frequency range to 300 kHz to 3.2 GHz; output power level to 0 dBm; IF bandwidth to 10 Hz; number of measurement points to 1000; and measured parameter to S21. Enable the statistical analysis marker [Markers, Marker Math, Statistics - ON]. Connect the LOADs to measurement ports 1 and 2. Determine the mean trace parameter (using Mean marker). Enter the measured value in Table 8.

6.4.7.3 The test is considered to be passed if the measured noise floor is less than -120 dB.

Table 8 – Receiver Noise Floor Test Table.

Frequency	**Receiver Noise Floor [dBm]**		
	S_{21}	**S_{12}**	**Max Value**
300 kHz to 3.2 GHz			

6.4.7.4 Repeat the measurements as described in section 6.4.7.2 for measurement port 2 after assigning S12 parameter to traces.

6.4.8 Trace Noise Test

6.4.8.1 Initialize the Analyzer under test [System, Preset]. Set the IF bandwidth to 3 kHz, the number of measurement points to 5000, and output power level to 0 dBm.

6.4.8.2 Connect OPEN to the measurement port 1. Perform normalization of OPEN measurement of S11 [Calibration, Open, Apply].

6.4.8.3 Enable the statistical analysis marker [Markers, Marker Math, Statistics - ON]. Determine the mean square deviation value. Enter the measured value in Table 9.

Table 9 – Trace Noise Test Table.

Trace Noise Magnitude [dB]				
S_{11}	**S_{22}**	**S_{21}**	**S_{12}**	**Max Value**

6.4.8.4 Connect OPEN to the measurement port 2. Perform normalization of the OPEN measurement of S22. Repeat the measurements as described in section 6.4.8.3.

6.4.8.5 Connect measurement ports 1 and 2 using measurement cable. Perform normalization of frequency response (Thru) for S21 measurement. Repeat the measurements as described in section 6.4.8.3.

6.4.8.6 Perform normalization of frequency response (Thru) for S12 measurement. Repeat the measurements as described in section 6.4.8.3.

6.4.8.7 The test is considered to be passed if the mean square deviation value is less than 0.001 dB.

7 PERFORMANCE TEST PROCEDURE

Performance test reports are filled in during the test procedure.

7.1.1.1 If the test is passed, the performance test certificate is issued, and the performance test sticker is attached to the Analyzer housing or the corresponding stamp is placed in the technical documentation.

7.1.1.2 If the Analyzer failed the performance test, the previous performance test certificate is cancelled, the performance test sticker or stamp is removed and a non-compliance notice stating the reasons of test failure is issued. Such Analyzer should not be operated.