COPPER MOUNTAIN
TECHNOLOGIES

TR7530

Network Analyzer
Performance Test Manual

September, 2014

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1 SAFETY INSTRUCTIONS

Carefully read through the following safety instructions before starting the performance test of the Analyzer. The Analyzer must be used only by skilled and specialized staff or 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). 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 the environment containing inflammable gases 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 when connected or disconnected from the DUT (Device Under Test). Static charge can build up on the operator's body and damage the sensitive circuits of internal components of both the Analyzer and the DUT. To avoid damage from electric discharge, do 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.
- 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

The list of performance tests is specified 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
Output power level accuracy test	6.3.2
Harmonic distortion test	6.3.3
Non-harmonic spurious test	6.3.4
Transmission coefficient magnitude and phaseaccuracy test	6.3.5
Reflection coefficient magnitude and phase accuracy test	6.3.6
Receiver noise floor test (IF bandwidth 10 Hz)	6.3.7
Trace noise test	6.3.8

3 TEST EQUIPMENT

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

Table 2

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.
75 Ω 3GHz TEST CABLE CC-7030106002-NM/NM
Type N 75 Ω Attenuator 40 dB, male - female: DC frequency range up to 3 GHz
Type N 75 Ω Attenuator 20 dB, male - female: DC frequency range up to 3 GHz
Agilent 85036B 75 Ω type N calibration kit: DC frequency range up to 3 GHz (or RPC-N, 75 Ω Calibration Kit P5CK10A-170: DC frequency range up to 4 GHz)
Maury 8882F12, Adapter N, 75 Ω-female - N, 50 Ω-male: DC frequency range up to 2 GHz.
Maury 8882F21, Adapter N, 75 Ω-male - N, 50 Ω-female: DC frequency range up to 2 GHz.
Agilent 11852B Option 004 Adapter N, 75 Ω-female - N, 50 Ω-male: 5.7 dB, DC frequency range up to 3 GHz.
Agilent 11852B Adapter N, 75 Ω-male - N, 50 Ω-female: 5.7 dB, DC frequency range up to 3 GHz.
RPC-N, 75 Ω Load P5S150-C10S3(1 pcs): N, 75 Ω -male, DC frequency range up to 4 GHz, VSWR max 1.03.
RPC-N Air Line male-female, length xx mm (length of the line defined by the user).
05W00K-000 Gage female incl. block: measurement range ±500 µm, scale gradation 1 µm, accuracy ±5 µm.
Torque wrench: torque range 1.1 to 1.7 Nm.

All test equipment shall be verified and have valid verification or calibration certificates. Equipment similar to the listed above can be used provided it follows the specifications indicated in Table 2.

4 AMBIENT CONDITIONS

Perform the performance tests under the following ambient conditions:

- Ambient temperature 23±5 ^{0}C;
- Relative air humidity 30 to 80 % at 25 ^{0}C;
- Atmospheric pressure 630 to 795 mm Hg.

When performing transmission coefficient magnitude and phase accuracy test (section 6.3.5) and reflection coefficient magnitude and phase accuracy test (section 6.3.6), make sure that the ambient temperature is within ±1 °C of the calibration temperature.

5 PREPARATION FOR TEST

Verification Officer should thoroughly read and understand the manuals of the verified Analyzer and the test equipment.
The verified 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 in the Analyzer software. To do this, open the [System, Performance Test] menu and select [Type – Periodic], then start the test by selecting [Create Report]and follow the program instructions.
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 against the list of accessories in the Operating Manual.

Do not perform further performance tests with analyzers that have defects such as mechanical damage or are missing components or accessories. Such instruments should be discarded or sent for repair.

6.2 Gaging Connectors

To perform connector gaging of the Analyzer, use the 05W00K-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 of the gage set being used.

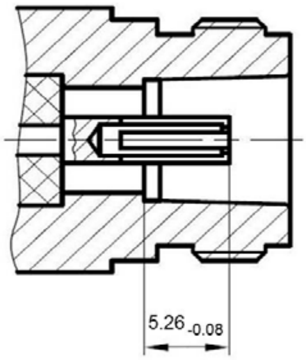

Figure 1 – Connecting dimensions of connector.

Note that gages are commonly 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 connectors of the network analyzer. To reduce the random errors and achieve maximum accuracy, take the average of several measurements made with different gage orientations to the connector.

6.3 Performance Verification

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

6.3.1 CW Frequency Accuracy Test

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

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

6.3.1.3 Switch the Analyzer to 300 kHz CW generation mode [Stimulus, Center 300 kHz, Span 0 MHz] and for measurements in single-sweep mode [Stimulus, Trigger, Single].

6.3.1.4 Connect the frequency counter to the analyzer using an adapter 8882F21.

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

6.3.1.6 Calculate the relative frequency error of the signal source using the following formula(1):

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

Where f is the measured frequency (Hz) and f_0 is the frequency setting (Hz).

6.3.1.7 Repeat the frequency measurement at the output frequency of 3 GHz [Stimulus, Center 3 GHz], [Stimulus, Trigger, Single].

The test is considered to be passed if the relative frequency error is within the specification indicated in Table 3.

Table 3

Port	Frequency [MHz]	Measured Frequency[Hz]	Rel Frequency Error [ppm]	Specification [ppm]
1	0.3			±5
	3000			

6.3.2 Output Power Level Accuracy Test

6.3.2.1 Prepare the power sensor for operation. and connect it to. Connect the adapter 8882F21 to the power sensor. Connect the power sensor to port 1 of the Analyzer under test.

6.3.2.2 Initialize the Analyzer under test [System, Preset, Apply]. Switch the Analyzer to the absolute measurement mode [Response, Measurement, Abs R].

6.3.2.3 Switch the Analyzer to 0 dBm CW generation mode [Stimulus, Span 0 MHz, Power 0 dBm] and for measurements in single-sweep mode [Stimulus, Trigger, Single].

6.3.2.4 Set the output frequency to 20 kHz [Stimulus, Center 20 kHz], [Stimulus, Trigger, Single]. Calculate the value of the Output Power using the following formula (2):

$$P = Pmeas + S21 \qquad (2)$$

Where: Pmeas – value measured with a power sensor (dBm),
S21 – insertion loss of the adapter 8882F21, (dB)

6.3.2.5 Enter the derived from the formula (2) the values in Table 4.

6.3.2.6 Repeat the measurements as described in section 6.3.2.4 for other frequency values specified in Table 4.

6.3.2.7 Set the Analyzer frequency range from 20 kHz to 3.0 GHz. Set the IF bandwidth to 100 Hz. Perform measurement normalization [Trace, Memorize Data Trace, Data Math, Data/Mem].

6.3.2.8 Enable markers at 20 and 300 kHz, 10, 50, 100, 200, 500, 1000, 2000 and 3000 MHz.

6.3.2.9 Set the output power level to 5 dBm. Enter the marker values in Table 4.

6.3.2.10 Repeat the measurements as described in section 6.3.2.8 for -10 and -50 dBm level values.

6.3.2.11 Determine the power errors at the specified levels of +5 dBm, -10 dBm and

-50 dBm by adding values in the 0 dBm line and the respective line of Table 4.

The test is considered to be passed if the power errors, measured in the -50 to 5 dBm level range, are within ±1.0 dB.

Table 4

Port	RF Output Level[dBm]	Measured RF Output Level [dBm]										Power Error[dB]	Specifica-tion [dB]
		Frequency [MHz]											
		0.02	0.3	10	50	100	200	500	1000	2000	3000		
1	0												±1.0
	5												
	-10												
	-50												

6.3.3 Harmonic Distortion Test

6.3.3.1 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 spectrum analyzer to 5 dBm. Connect the spectrum analyzer to port 1 of the Analyzer under test using an adapter 8882F21.

6.3.3.2 Initialize the Analyzer under test [System, Preset, Apply]. Set the output power level to 0 dBm [Stimulus, Power 0 dBm]and for measurements in single-sweep mode [Stimulus, Trigger, Single].

6.3.3.3 Measure the maximum harmonic distortion (up to third order harmonic) at output frequencies of 300 kHz, 10, 20, 50, 100, 200, 500, 1000, 2000 and 3000 MHz. Enter the measured values in Table 5.

Table 5

Port	Harmonic Distortion [dBc]										Upper Specifica-tion [dBc]
	Frequency [MHz]										
	0.3	10	20	50	100	200	500	1000	2000	3000	
1											-20

The test is considered to be passed if the output harmonic distortion is less than -20 dBc.

6.3.4 Non-Harmonic Spurious Test

6.3.4.1 The non-harmonic spurious level is measured using a spectrum analyzer. Prepare the spectrum analyzer for operation in accordance with its operating manual. Set the reference level of the spectrum analyzer to 5 dBm. Set the stimulus start frequency to 10 kHz, stimulus stop frequency to 6 GHz, and IF bandwidth to 300 kHz.

6.3.4.2 Switch the Analyzer under test to slow sweep mode over a 300 kHz to 3 GHz span. Initialize the Analyzer [System, Preset, Apply]. Set the output power level to 0 dBm [Stimulus, Power 0 dBm], and the IF bandwidth to 10 Hz [Response, IF Bandwidth 10 Hz]. Connect the spectrum analyzer to port 1 of the Analyzer under test using an adapter 8882F21.

6.3.4.3 During the sweep, measure the minimum difference between the levels of useful signal and spurious signal. Enter the measured value in Table 6.

Table 6

Port	Non-Harmonic Spurious [dBc]	Upper Specification[dBc]
1		-30

The test is considered to be passed if the measured difference is less than -30 dBc at output frequencies up to 3 GHz.

6.3.5 Transmission Coefficient Magnitude and Phase Accuracy Test

6.3.5.1 Transmission coefficient magnitude and phase accuracy test is performed by comparing the measured and actual values of transmission magnitude and phase of the 20 dB and 40 dB attenuators.

6.3.5.2 Initialize the Analyzer under test [System, Preset, Apply]. Arrange traces in different windows [Trace, Allocate Traces, x2 •]. Assign the S_{21} Log Mag measured parameter to Trace 1, S_{21} Phase to Trace 2. See allocation of traces in Figure 2.

S21 LOG MAG
S21 PHASE

Figure 2 – Allocation of traces in different window.

6.3.5.3 Enable the segment sweep mode. The frequencies of the segments should correspond to the characterized frequencies of the attenuators. The recommended points are 20 kHz, 1.0 GHz and 3.0 GHz. Set same start and stop frequencies in each segment and set the number of measurement points in each segment to 1.

6.3.5.4 Enable the markers for the segment frequencies on each trace.

6.3.5.5 Set the output power level to -5 dBm [Stimulus, Power -5 dBm], and IF bandwidth to 10 Hz [Response, IF Bandwidth 10 Hz].

6.3.5.6 Connect up the measurement setup as shown in Figure 3. Do not connect the attenuators. Use the torque wrench to tighten the RF cable connectors and adapter. The RF cable should be a phase and amplitude stable, test-grade cable.

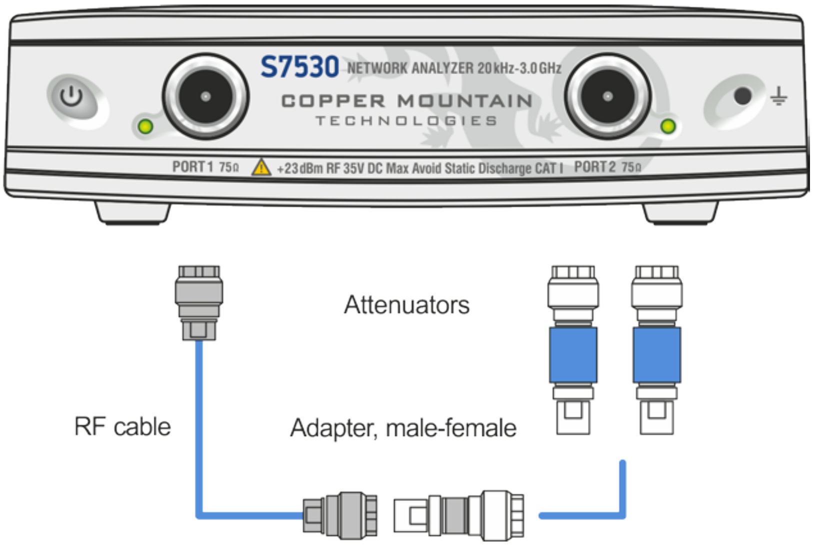

Figure 3 – Transmission coefficient accuracy measurement setup.

6.3.5.7 Perform one-path two-port calibration using the calibration kit. Use the torque wrench to tighten the connectors.

6.3.5.8 Transmission coefficient magnitude and phase accuracy at -20 dB is verified using the 20 dB attenuator. Connect the attenuator as shown above. Determine the measured magnitude and phase values using markers and enter them in Table 7 and Table 8 for the 20 dB attenuator. Deviation from the actual value is considered to be a measurement error. The test is considered to be passed if the measured magnitude error is less than 0.1 dB and the measured phase error is less than 1°. When comparing attenuator parameters, pay attention to their orientation. If necessary, check the attenuator calibration certificate to properly determine the orientation.

6.3.5.9 Transmission coefficient magnitude and phase accuracy at -40 dB is verified using the 40 dB attenuator. Connect the attenuator as shown above. Determine the measured values using markers and enter them in Table 7 and Table 8 for the 40 dB attenuator. Deviation from the characterized value is considered to be a measurement error. The test is considered to be passed if the measured magnitude error is less than 0.1 dB and the measured phase error is less than 1°. When comparing attenuator parameters, pay attention to its orientation. If necessary, check the attenuator calibration certificate to properly determine the orientation.

Table 7 – Transmission coefficient magnitude accuracy.

Frequency [MHz]	Actual Magnitude Value [dB]	$\|S_{21}\|$		Specification [dB]
	$\|S_{21}\|$	Measured Value [dB]	Magnitude Error [dB]	
0.02				±0.55
1000				±0.55
3000				±0.55

Table 8– Transmissioncoefficientphaseaccuracy.

Frequency [MHz]	Actual Phase Value [°]	$\arg(S_{21})$		Specification [°]
	$\arg(S_{21})$	Measured Value [°]	Phase Error [°]	
0.02				±3
1000				±3
3000				±3

The test is considered to be passed if the measured magnitude and phase errors are within the specification indicated in Table 7 and Table 8for both 20 dB and 40 dB attenuators.

6.3.6 Reflection Coefficient Magnitude and Phase Accuracy Test

6.3.6.1 The reflection coefficient magnitude and phase accuracy test is performed by comparing the measured and actual values of reflection magnitude and phase of the stepped line, shown in the Fig. 4

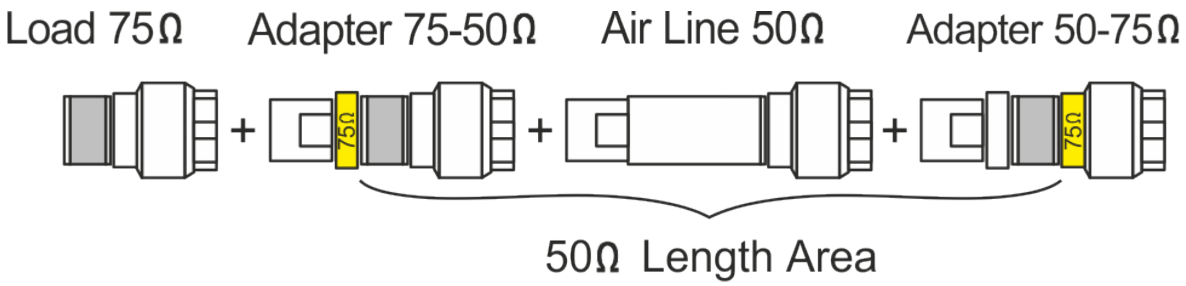

Figure 4 – Stepped line for verification of the Reflection Coefficient Magnitude and Phase Accuracy.

The total length of the Air Line 50 Ω and the 50 Ohm sections of the adapters should not exceed 75 mm. Stepped line should be characterized with a connected Load 75 Ω.

6.3.6.2 Adjust the following settings on the Analyzer under test: set the frequency range from 20 kHz to 3.0 GHz; IF bandwidth to 10 Hz; number of traces displayed to 2 [Trace, Add trace]; and measured parameters to S_{11} (to traces 1). Set the Trace 1 format to S_{11} Phase [Response, Format, Phase]; set trace 2 format to S_{11} Log Mag [Response, Format, Log Mag]. Enable the segment sweep mode. The frequencies of the segments should correspond to the characterized frequencies of the air line. Set the number of measurement points in each segment to 1. Enable the markers for segmented frequencies.

6.3.6.3 Enter the actual magnitude values A_{nomi} and the actual phase values $A_{nom\,j}$ in Table 9 and Table 10 respectively.

6.3.6.4 Determine the values for measured magnitude and phase with markers.

6.3.6.5 Enter the measured magnitude values A_{measi} in Table 9, and enter the measured phase values $A_{meas\,j}$ in Table 10.

6.3.6.6 Determine magnitude error using formula (4):

$$\Delta A_i = A_{measi} - A_{nomi}. \qquad (2)$$

6.3.6.7 Enter the magnitude error ΔA_i in Table 9.

Table 9 – Reflection coefficient magnitude accuracy.

Frequency [MHz]	Actual S-parameters Air Line		S11 Magnitude measurement [dB]	Magnitude Error [dB]	Specification [dB]
	Mag [dB]	Phase [°]			

Table 10 – Reflection coefficient phase accuracy.

Frequency [MHz]	Actual S-parameters Air Line		S11 Phase measurement [°]	Phase Error [°]	Specification [°]
	Mag [dB]	Phase [°]			

6.3.6.8 Determine phase error using the following formula (5):

$$\Delta A_j = A_{meas\ j} - A_{nomj}. \quad (3)$$

6.3.6.9 Enter the phase error ΔA_j in Table 10.

6.3.6.10 Enter the accuracy of the reflection coefficient measurement in the Specification columnsof Table 9 and Table 10.

If the actual mean magnitude value of the air line is:
- from 0 to -15 dB, enter ±0.4 dB in Table 9 and ±3° in Table 10;
- from -15 to -25 dB, enter ±1 dB in Table 9 and ±6° in Table 10;
- from -25 to -35 dB, enter ±3 dB in Table 9 and ±20° in Table 10.

The test is considered to be passed if magnitude and phase errors are within the specification indicated in Table 9 and Table 10 for air line.

6.3.7 Receiver Noise Floor Test (IF bandwidth 10 Hz)

6.3.7.1 Connect the loads to all measurement ports of the Analyzer under test.

6.3.7.2 Adjust the following settings on the Analyzer: frequency range from 20 kHz to 300 kHz; 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]. Determine the mean trace parameter (using the Mean marker).

6.3.7.3 Determine the mean trace parameter (using the Mean marker). Enter the measured value in Table 11 for the frequency range from 20 kHz to 300 kHz.

Table 11

Frequency	Receiver Noise Floor [dBm]	Max Measured Value[dBm]	Upper Specification[dBm]

20 kHz to 300 kHz	S_{21}			-90
300 kHz to 3.0 GHz	S_{21}			-115

6.3.7.4 Setthe Analyzer frequency range from 300 kHz to 3.0 GHz. Determine the mean trace parameter. Enter the measured value in Table 11.

The test is considered to be passed if the measured noise floor is within the specification indicated in Table 11.

6.3.8 Trace Noise Test

6.3.8.1 Initialize the Analyzer under test [System, Preset, Ok].

6.3.8.2 Connect OPEN to measurement port 1.

6.3.8.3 Set the frequency range from 20 kHz to 300 kHz, IF bandwidth to 3 kHz, the number of measurement points to 5000, and output power level to 0 dBm.

6.3.8.4 Perform normalization of measurement of S11 [Display, Data -> Memory, Data Math, Data / Mem].

6.3.8.5 Enable the statistical analysis marker [Markers, Marker Math, Statistics - ON]. Determine the mean square deviation value. Enter the measured value in Table 12.

6.3.8.6 Setthe Analyzer frequency range from 300 kHz to 3.0 GHz. Perform normalization of measurement. Determine the mean square deviation value. Enter the measured value in Table 12.

Table 12

Frequency	Trace Noise Magnitude [dB]		Max Measured Value[dB]	Upper Specification[dB]
20 kHz to 300 kHz	S_{11}			0.015
	S_{21}			
300 kHz to 3.0 GHz	S_{11}			0.002
	S_{21}			

6.3.8.7 Connect measurement ports 1 and 2 using measurement cable. Enable measurement of S_{21} [Measurement, S_{21}].Repeat the measurements as described in sections 6.3.8.3-6.3.8.6.

The test is considered to be passed if the mean square deviation values are within the specification indicated inTable 12.

7 PERFORMANCE TEST REPORTS

Performance test reports are filled in during the test procedure.

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.

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.