PLANAR TR1300/1 Network Analyzer

Performance Test

2016

TABLE OF CONTENTS

PLANAR TR1300/1 Network Analyzer (Analyzer) is designed for S-parameters measurement of RF and microwave devices in coaxial transmission lines with N-type connectors.

The recommended test interval is one year.

1. SAFETY REQUIREMENTS

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 I as well as POLLUTION DEGREE 2 in IEC61010–1.

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

- Never operate the Analyzer in the environment containing inflammable gases or fumes.
- Operators must not remove the cover or 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.
- 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 Analyzer to avoid the danger of additional hazards, do not install replacement parts or perform unauthorized modifications to the Analyzer.
- Do not connect the measuring terminals to mains.

Electrostatic discharge can damage your Analyzer when connected or disconnected from the DUT. Static charge can build up on your body and damage the sensitive circuits of internal components of both the Analyzer 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.
- Connect the Analyzer and the body of the DUT to protective grounding before you start operation.

2. PERFORMANCE TESTS

List of the performance tests is specified in Table 1.

Table 1

Test Description	**Section**
Visual inspection	6.1
Test run	6.2
Gaging connectors	6.3
Performance verification tests	6.4
CW frequency accuracy test	6.4.1
Output power level accuracy test	6.4.2
Uncorrected source match and load match tests	6.4.3
Uncorrected directivity test	6.4.4
S_{21} transmission coefficient magnitude accuracy test (at -20 dB, -40 dB and -60 dB)	6.4.5
S_{21} transmission coefficient phase accuracy test	6.4.6
S_{11} reflection coefficient magnitude and phase accuracy test	6.4.7
Receiver noise floor test (IF bandwidth 10 Hz)	6.4.8
Trace noise test	6.4.9

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 from 10 Hz to 20 GHz, accuracy ± 5×10^{-7}
E5071C Network Analyzer: reflection measurement accuracy ± (1.1 ÷ 1.9) %, frequency range from 300 kHz to 8.5 GHz
NRP-Z51 Thermal Power Sensor: DC frequency range up to 18 GHz, power level measurement range -30 to +20 dBm, power level measurement accuracy ± 0.2 dB.
Maury 2561A Load, VSWR=1.05±0.05
Maury 2561A Load, VSWR=2.00±0.12
Agilent 85032E Calibration Kit, Type-N, 50 ohm: DC frequency range up to 6 GHz
Rosenberger RPC-N Verification Kit 05CK200-150: DC frequency range up to 18 GHz, attenuation measurement accuracy ±0.06 dB.
RPC-N adapter 05 S 121-K00S3: male-female, DC frequency range up to 18 GHz, VSWR max 1.1
05 W 00K-000 Gage female incl. block. Measurement range ±500 µm, scale gradation 1 µm, accuracy ± 5 µm
Planar C50NMNM.1 Test Cable

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 ^{0}C
- relative air humidity 30 to 80 % at 25 ^{0}C
- atmospheric pressure 630 to 795 mm Hg.

When performing S_{21} transmission coefficient magnitude accuracy test (section 6.4.5) and S_{11} 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

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

6.1. Visual Inspection

During visual inspection check the Analyzer for:

- damaged seals;
- 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.

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

6.3. Gaging Connectors

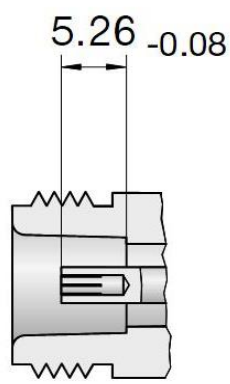

Fig 1. Connecting dimensions of connector

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 the 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 1 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, Power, Output Power, 0 dBm, Trigger, Single].

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 1.3 GHz.

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

1 Hereinafter the brackets […] show the procedure of setting the required mode of the Analyzer operation as a sequence of selected menu items, softkeys and sets of values.

Table 3

Set frequency value, MHz	Lower limit, Hz	Measured frequency value, Hz	Upper limit, Hz
0.3	299,998.50		300,001.50
1300	1,299,993,500		1,300,006,500

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, Apply]. Set the trace parameter to S_{21} [Response, Measurement, S21]. Enable frequency offset mode [Stimulus, Freq. Offset, ON].

6.4.2.3. Switch the Analyzer to -10 dBm CW generation mode [Stimulus, Span, 0 MHz, Power, Output Power, -10 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. Disconnect the thermal power sensor from the port 1. Set the Analyzer frequency range from 300 kHz to 1.3 GHz [Stimulus, Start, 300 kHz, Stop, 1.3 GHz]. Set the IF bandwidth to 100 Hz [Response, IF Bandwidth, 100 Hz]. Connect C50NMNM.1 test cable between the port 1 and port 2. Perform calibration by the THRU standard [Calibration, Response (Thru), Thru, Apply].

Table 4

Port	Specified RF Output Level [dBm]	Measured RF Output Level [dBm]									
		Frequency [MHz]									
		0.3	1.0	5.0	20	100	200	500	800	1100	1300
1	-10										
	+3										
	-20										
	-40										
	-55										

6.4.2.7. Enable markers at 300 kHz, 1, 5, 20, 100, 200, 500, 800, 1100 and 1300 MHz.

6.4.2.8. Set the power level to 3 dBm [Stimulus, Power, Output Power, 3 dBm]. Enter the marker values in Table 4.

6.4.2.9. Repeat the measurements as described in section 6.4.2.8 for -20, -40 and -55 dBm level values.

6.4.2.10. Determine the power values at the specified levels of +3 dBm, -20 dBm, -40 dBm and -55 dBm by adding the values from the -10 dBm line of Table 4 to the measured values at the respective level.

The test is considered to be passed if the power level values, measured in -55 to +3 dBm level range, are within ±1.5 dB.

6.4.3. Uncorrected Source Match and Load Match Tests

6.4.3.1. Uncorrected source match and load match tests are performed using E5071C Network Analyzer in accordance with its operating manual.

6.4.3.2. Initialize the Analyzer [System, Preset, Apply].

6.4.3.3. Connect E5071C to the measurement port 1 of the Analyzer and measure the uncorrected source match within the frequency range from 300 kHz to 1.3 GHz.

6.4.3.4. Connect E5071C to the measurement port 2 of the Analyzer and measure the load match within the frequency range from 300 kHz to 1.3 GHz.

The test is considered to be passed if the measured values of uncorrected source match in the whole operating frequency range are less than -18 dB for port 1 and the measured values of load match is less than -28 dB for port 2.

6.4.4. Uncorrected Directivity Test

6.4.4.1. Initialize the Analyzer [System, Preset, Apply]. Disable the system correction [System, System Correction, OFF].

6.4.4.2. Connect OPEN calibration standard to the measurement port 1. Perform normalization of OPEN measurement of S_{11} [Calibration, Response (Open), Open, Apply].

6.4.4.3. Connect LOAD calibration standard to the measurement port 1. Measure the maximum trace value on the graph or using a marker.

The test is considered to be passed if the measured value is less than -18 dB.

6.4.5. S_{21} 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 05CK200-150 verification kit. Enter the characterized attenuation values in the *Corresponding* column of the Table 5. Attenuation of 60 dB is achieved by adding attenuation of 20 dB and 40 dB attenuators.

6.4.5.2. Initialize the Analyzer [System, Preset, Apply]. Set the power level to -10 dBm [Stimulus, Power, -10 dBm], and IF bandwidth to 10 Hz [Response, IF Bandwidth, 10 Hz]. Set the trace parameter to S_{21} [Response, Measurement, S21]. Set Log Mag format to the trace [Response, Measurement, Log Mag]. Enable the segment sweep mode [Stimulus, Sweep Type, Segment]. Create a table of segments [Stimulus, Segment Table]. The first frequency point is set to 0.3 MHz by default. To continue the table, click [Add] and enter the next required frequency value. The frequencies of the segments should correspond to the characterized frequencies of the attenuators. The recommended points are 300 kHz, 600 MHz and 1.3 GHz. Repeat the above procedure until you fill in the table. Set the number of measurement points in each segment to 1. Add markers according to the number of characterization points [Markers, Add Marker].

6.4.5.3. Connect test cable with 05 S 121-K00S3 adapter attached between port 1 and port 2. Male connector side of the adapter should be connected to port 1. Perform one path 2-port calibration.

6.4.5.4. Transmission coefficient magnitude accuracy at -20 dB is verified using 20 dB 05AS122-K20S3 attenuator. Connect attenuator (male connector side) to Port 1. Connect test cable with 05 S 121-K00S3 adapter attached to the free connector of the attenuator. Determine the measured S_{21} values using markers and enter them into the *Measured Value* column of Table 5. Calculate the deviation of the measured values from the characterized attenuation values. Enter these calculated values into the *Measurement Error* column of Table 5.

6.4.5.5. The test is considered to be passed if the measured error is less than 0.1 dB.

6.4.5.6. Transmission coefficient magnitude accuracy at -40 dB is verified using 40 dB 05AS122-K40S3 attenuator. Connect attenuator (male connector side) to Port 1. Connect test cable with 05 S 121-K00S3 adapter attached to the free connector of the attenuator. Determine the measured S_{21} values using markers and enter them into the *Measured Value* column of Table 6. Calculate the deviation of the measured values from the characterized attenuation values. Enter these calculated values into the *Measurement Error* column of Table 5.

6.4.5.7. The test is considered to be passed if the measured error does not exceed 0.1 dB.

6.4.5.8. Transmission coefficient magnitude accuracy at -60 dB is verified using daisy chain connected 20 dB 05AS122-K20S3 and 40 dB 05AS122-K40S3 attenuators. Connect attenuators (male connector side) to Port 1. Connect test cable with 05 S 121-K00S3 adapter attached to the free connector of the attenuator. Determine the measured S_{21} values using markers and enter them into the *Measured Value* column of Table 6. Calculate the deviation of the measured values from the characterized attenuation values. Enter these calculated values into the *Measurement Error* column of Table 5.

The test is considered to be passed if the measured error is less than 0.2 dB.

Table 5

Frequency	Rated Attenuation Value [dB]	Characterized Attenuation Value [dB]	$\lvert S_{21} \rvert$ Measured Value [dB]	$\lvert S_{21} \rvert$ Measurement Error [dB]	Accuracy [dB]
300 kHz	20				±0.1
	40				±0.1
	60				±0.2
600 MHz	20				±0.1
	40				±0.1
	60				±0.2
1.3 GHz	20				±0.1
	40				±0.1
	60				±0.2

6.4.6. S_{21} Transmission Coefficient Phase Accuracy Test

6.4.6.1. S_{21} transmission coefficient phase accuracy test is performed by using 05S101-K100 Airline from the 05СК200-150 Verification.

6.4.6.2. Preset the Analyzer [System, Preset].

6.4.6.3. Initialize the Analyzer [System, Preset, Apply]. Set the power level to -10 dBm [Stimulus, Power, -10 dBm], and IF bandwidth to 10 Hz [Response, IF Bandwidth, 10 Hz]. Set the trace parameter to S_{21} [Response, Measurement, S21]. Set Log Mag format to the trace [Response, Measurement, Expand Phase]. Enable the segment sweep mode [Stimulus, Sweep Type, Segment]. Create a table of segments [Stimulus, Segment Table]. The first frequency point is set to 300 kHz by default. To continue the table, click [Add] and enter the next required frequency value. The frequencies of the segments should be 300 kHz, 600 MHz, 1.3 GHz. Repeat the above procedure until you fill in the table. Set the number of measurement points in each segment to 1. Add markers according to the frequencies of the segments [Markers, Add Marker]. Connect test cable with 05 S 121-K00S3 adapter attached between port 1 and port 2. Male connector side of the adapter should be connected to port 1.

6.4.6.4. Perform one-path 2-port calibration. Connect 05S101-K100 Airline (male connector side) to Port 1 in the following manner: insert the inner conductor of the Airline into Port 1 connector, put on the outer conductor and tighten the screw nut using the calibrated wrench. Connect test cable with 05 S 121-K00S3 adapter attached to the free connector of the Airline. Determine the measured S_{21} values using markers and enter them into column 4 of Table 6 for the Rated Attenuation Value 0 dB.

6.4.6.5. Disconnect test cable from the 05S101-K100 Airline. Connect the 05AS122-K40S3 attenuator 40 dB to the Airline, then connect test cable to the attenuator. Determine the measured S_{21} values using markers and enter them into column 4 of Table 6 for the Rated Attenuation Value 40 dB.

6.4.6.6. Disconnect the 05S101-K100 Airline, and connect the 40 dB 05AS122-K40S3 attenuator directly to port 1. Determine the measured S_{21} values using markers and enter them into column 3 of Table 6 for the Rated Attenuation Value 40 dB.

6.4.6.7. Determine the phase difference $\Delta = \varphi_2 - \varphi_1$ and enter the value into the column 5 of Table 6.

6.4.6.8. Determine S_{21} phase measurement error as difference between the values in columns 6 and 5 of Table 6, and enter the calculated values into column 7.

The test is considered to be passed if the measurement error values of S_{21} transmission coefficient phase measurement (column 7) are within the range specified in column 8 of Table 6.

Table 6

Airline Transmission Coefficient Phase

Frequency	Rated Attenuation Value [dB]	S_{21} Measured Phase φ2 without Airline [degree]	S_{21} Measured Phase φ2 with Airline [degree]	Phase Difference φ2-φ1 [degree]	Characterized Phase Shift [degree]	Measurement Error [degree]	Accuracy [degree]
1	2	3	4	5	6	7	8
300 kHz	0	0			0.04		± 1
	40						± 1
600 MHz	0	0			72.07		± 1
	40						± 1
1.3 GHz	0	0			156.16		± 1
	40						± 1

6.4.7. S_{11} Reflection Coefficient Magnitude And Phase Accuracy Test

6.4.7.1. Reflection coefficient magnitude and phase accuracy test is performed by comparing the measured and real values of reflection magnitude and phase of 2561A and 2561G LOADs, which are coaxial loads with VSWR = 1.05 and VSWR = 2.00 respectively, and which are characterized by reflection coefficient magnitude and phase. Recommended characterization frequencies are 0.3 MHz, 600 MHz, 1.0 GHz, 1.3 GHz. The characterization accuracy of the reflection coefficient of the LOAD with VSWR = 1.05 should be less than 1% for magnitude and less than 9° for phase. The characterization accuracy of the reflection coefficient of the LOAD with VSWR = 2.00 should be less than 1.5 % for magnitude and less than 2° for phase.

6.4.7.2. Initialize the Analyzer under test [System, Preset]. Set the IF bandwidth value to 10 Hz [Response, IF Bandwidth, 10 Hz]. Set the number of traces to 2 [Trace, Add Trace] and measured parameter to S_{11} [Response, Measurement, S11]. Set Log Mag format to the first trace [Response, Measurement, Log Mag], and Phase format to the second trace [Response, Measurement, Phase]. Enable the segment sweep mode [Stimulus, Sweep Type, Segment]. Create a table of segments [Stimulus, Segment Table]. The first frequency point is set to 300 kHz by default. To continue the table, click [Add] and enter the next required frequency value. The frequencies of the segments should correspond to the characterized frequencies of the 2561A and 2561G LOADs. Repeat the above procedure until you fill in the table. Set the number measurement points in each segment to 1. Add markers according to the number of characterization points [Markers, Add Marker].

6.4.7.3. Perform full one-port calibration of the Analyzer with Agilent 85032E Calibration Kit. Connect the LOAD with VSWR = 1.05 to the Analyzer (port 1).

6.4.7.4. Use markers to determine the LOAD reflection phase and magnitude during three connections, each time turning the LOAD by approximately 120° about its axis.

6.4.7.5. Enter the measured values into *Measurement 1*, *Measurement 2* and *Measurement 3* columns of Table 7 individually for reflection magnitude and reflection phase.

6.4.7.6. Determine the mean values for magnitude and phase using formula (1):

$$A_{mean\ i(j)} = (A_{meas1\ i(j)}+A_{meas2\ i(j)} + A_{meas3\ i(j)})/3, \qquad (1)$$

where

$A_{meas1\ i(j)}$ - magnitude (i) or phase (j) values of reflection coefficient from *Measurement 1* column

A_{meas2} - magnitude (i) or phase (j) values of reflection coefficient from *Measurement 2* column

A_{meas3} - magnitude (i) or phase (j) values of reflection coefficient from *Measurement 3* column

Enter the A_{mean} values into *Mean Value* columns for reflection magnitude and reflection phase in Table 7.

6.4.7.7. Determine S_{11} magnitude measurement error using formula (2):

$$\Delta A_i = A_{mean\ i} - A_{xi}\ , \qquad (2)$$

where $A_{mean\ i}$ – mean value of S_{11} magnitude, dB

A_{xi} – characterized value of S_{11} magnitude, dB

Table 7

Load Reflection Coefficient Magnitude and Phase at VSWR =1.05

Frequency	Reflection coefficient magnitude, dB							Reflection coefficient phase, degree						
	Charac-terized value	Measu-rement 1	Measu-rement 2	Measu-rement 3	Mean Value	Measu-rement Error	Accu-racy	Charac-terized value	Measu-rement 1	Measu-rement 2	Measu-rement 3	Mean Value	Measu-rement Error	Accu-racy
0.3 MHz							±3.0							±8
600 MHz							±3.0							±8
1.0 GHz							±3.0							±8
1.3 GHz							±3.0							±8

Table 8

Load Reflection Coefficient Magnitude and Phase at VSWR =2.00

Frequency	Reflection coefficient magnitude, dB							Reflection coefficient phase, degree						
	Charac-terized value	Measu-rement 1	Measu-rement 2	Measu-rement 3	Mean Value	Measu-rement Error	Accu-racy	Charac-terized value	Measu-rement 1	Measu-rement 2	Measu-rement 3	Mean Value	Measu-rement Error	Accu-racy
0.3 MHz							±0.4							±4
600 MHz							±0.4							±4
1.0 GHz							±0.4							±4
1.3 GHz							±0.4							±4

Enter the ΔA_i values into *Measurement Error* column for reflection magnitude in Table 7.

6.4.7.8. Determine S_{11} phase measurement error using the following formula (3):

$$\Delta A_j = A_{mean\ j} - A_{xj}, \qquad (3)$$

where $A_{mean\ j}$ – mean value of S_{11} phase, degrees

A_{xj}– characterized value of S_{11} phase, degrees

Enter the ΔA_j values into *Measurement Error* column for reflection phase in Table 7.

Connect the LOAD with VSWR = 2.0 to the Analyzer, repeat the procedure described in sections 6.4.4.3-6.4.4.7, and enter the values in Table 8.

The test is considered to be passed if:

- measured error values of magnitude reflection coefficient are within values specified in *Accuracy* columns of Tables 7 and 8;
- measured error values of phase reflection coefficient are within values specified in *Accuracy* columns of Tables 7 and 8.

6.4.8. Receiver Noise Floor Test (IF bandwidth 10 Hz)

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

6.4.8.2. Initialize the Analyzer [System, Preset, Apply].

6.4.8.3. Perform the following settings on the Analyzer: output power level to 0 dBm [Stimulus, Power, Output Power, 0 dBm]; IF bandwidth to 10 Hz [Response, IF Bandwidth, 10 Hz]; number of measurement points to 1001 [Stimulus, Points, 1001]; and measured parameter to S_{21} [Response, Measurement, S_{21}]. 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).

The test is considered to be passed if the measured noise floor is less than -127 dB.

6.4.9. Trace Noise Test

Initialize the Analyzer under test [System, Preset]. Set the IF bandwidth to 3 kHz [Response, IF Bandwidth, 3 kHz], the number of measurement points to 1601 [Stimulus, Points, 1601].

6.4.8.1 Connect OPEN calibration standard to the measurement port 1. Perform normalization of OPEN measurement of S_{11} [Calibration, Response (Open), Open, Apply].

6.4.8.2 Enable the statistical analysis marker [Markers, Marker Math, Statistics, ON]. Determine the mean square deviation value.

The test is considered to be passed if the mean square deviation value is less than 0.002 dB.

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.