CALIBRATION PROCEDURE

NI PXIe-5171R

This document contains the verification and adjustment procedures for the NI PXIe-5171R (NI 5171R). Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

Required Software

Calibrating the NI 5171R requires you to install the following software on the calibration system:

- LabVIEW Instrument Design Libraries for Reconfigurable Oscilloscopes. The NI 5171R was first supported in LabVIEW Instrument Design Libraries for Reconfigurable Oscilloscopes 14.0.

You can download all required software from *ni.com/downloads*.

Related Documentation

You might find the following documents helpful as you perform the calibration procedure:

- *NI PXIe-5171R Getting Started Guide*
- *NI Reconfigurable Oscilloscopes Help*
- *NI PXIe-5171R Specifications*

The latest versions of these documents are available from *ni.com/manuals*.

Test Equipment

This section lists the equipment required to calibrate the NI 5171R.

If you do not have the recommended equipment, select a substitute calibration standard using the specifications listed in the table.

Table 1. NI 5171R Test Equipment

Equipment	Recommended Model	Where Used	Minimum Requirements
Oscilloscope calibrator	Fluke 9500B/600 with Fluke 9530 Active Head	Verifications: • Timebase accuracy • DC accuracy Adjustments: • Timebase • DC	Sine Wave Amplitude: 0.9 V_{pk-pk} at 11 MHz into 50 Ω Sine Wave Frequency Accuracy: 0.25 ppm at 11 MHz DC Output Range: ±40 mV to ±2.5 V into 50 Ω DC Output Accuracy: ±(0.025% of output + 25 µV) into 50 Ω
SMA (m)-to-BNC (f) adapter	Fairview Microwave SM4723	Verifications: • Timebase accuracy • DC accuracy Adjustments: • Timebase • DC	Frequency range: DC to 11 MHz Impedance: 50 Ω

Table 1. NI 5171R Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
DMM	NI PXI-4071	Verifications: • AC amplitude accuracy	AC voltage accuracy: ±0.1% of reading at 50 kHz AC Input Range: 0.1 $V_{pk\text{-}pk}$ to 3.5 $V_{pk\text{-}pk}$ AC Input Impedance: ≥10 MΩ Bandwidth: ≥100 kHz
Function generator	NI PXI-5402 or Agilent 33220A	Verifications: • AC amplitude accuracy	Sine Wave Frequency: 50 kHz Sine Wave Amplitude Range: 0.1 $V_{pk\text{-}pk}$ to 3.5 $V_{pk\text{-}pk}$ into 50 Ω
SMA Tee (f-f-f)	Fairview Microwave SM4942	Verifications: • AC amplitude accuracy	Impedance: 50 Ω
SMA (m)-to-SMA (m) adapter (x2)	Fairview Microwave SM4960	Test system characterization Verifications: • AC amplitude accuracy • Flatness and bandwidth	Frequency range: DC to 275 MHz VSWR: <1.05 Impedance: 50 Ω
Double banana plug to BNC (f)	Pasternak PE9008	Verifications: • AC amplitude accuracy	Impedance: 50 Ω
SMA (m)-to-BNC (m) cable (x2)	—	Verifications: • AC amplitude accuracy	Frequency range: DC to 275 MHz Impedance: 50 Ω Length: <1 meter

Table 1. NI 5171R Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power sensor	Rohde & Schwarz (R&S) NRP-Z91	Test system characterization Verifications: • Flatness and bandwidth	Range: -15 dBm to 5 dBm Frequency range: 50 kHz to 275 MHz Absolute Power Accuracy: <0.048 dB for <100 MHz, <0.063 dB for 100 MHz to 275 MHz Relative Power Accuracy: <0.022 dB for <100 MHz, <0.031 dB for 100 MHz to 275 MHz VSWR: <1.11
Signal generator	Rhode & Schwartz SMA100A	Test system characterization Verifications: • Flatness and bandwidth	Frequency range: 50 kHz to 275 MHz Amplitude range: -7 dBm to 8 dBm Harmonics: <-30 dBc
Power splitter	Aeroflex/Weinschel 1593	Test system characterization Verifications: • Flatness and bandwidth	Frequency range: 50 kHz to 275 MHz VSWR: <1.08 Amplitude tracking: <0.5 dB
50 Ω SMA terminator (f)	Fairview Microwave ST1825F	Test system characterization	Frequency range: DC to 275 MHz VSWR: <1.05 Impedance: 50 Ω

Table 1. NI 5171R Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
SMA (f)-to-N (m) adapter	Fairview Microwave SM4226	Test system characterization Verifications: • Flatness and bandwidth	Frequency range: DC to 275 MHz VSWR: <1.05 Impedance: 50 Ω
SMA (f)-to-N (f) adapter	Fairview Microwave SM4236	Test system characterization Verifications: • Flatness and bandwidth	Frequency range: DC to 275 MHz VSWR: <1.05 Impedance: 50 Ω

Related Information

Verification on page 11

This section provides instructions for verifying the device specifications.

Test Conditions

The following setup and environmental conditions are required to ensure the NI 5171R meets published specifications:

- The NI 5171R is warmed up for 15 minutes at ambient temperature. Warm-up begins after the chassis is powered, the device is recognized by the host, and the ADC clock is configured using either instrument design libraries or the NI-SCOPE device driver.
- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the device, including front panel connections and screws, are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 °C ± 3 °C
- Keep relative humidity between 10% and 90%, noncondensing.
- Ensure that the PXI chassis fan speed is set to HIGH, that the fan filters (if present) are clean, and that the empty slots contain slot blockers and filler panels. For more

information about cooling, refer to the *Maintain Forced-Air Cooling Note to Users* document available at *ni.com/manuals*.

- Plug the chassis and the instrument standard into the same power strip to avoid ground loops.

Password

The default password for password-protected operations is `NI`.

Calibration Interval

Recommended calibration interval	2 years

As-Found and As-Left Limits

The as-found limits are the published specifications for the NI 5171R. NI uses these limits to determine whether the NI 5171R meets the device specifications when it is received for calibration. Use the as-found limits during initial verification.

The as-left calibration limits are equal to the published NI specifications for the NI 5171R, less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to reduce the probability that the instrument will be outside the published specification limits at the end of the calibration cycle. Use the as-left limits when performing verification after adjustment.

Measurement Uncertainty

Measurement uncertainty was calculated in accordance with the method described in ISO GUM (Guide to the Expression of Uncertainty in Measurement), for a confidence level of 95%. The expressed uncertainty is based on the recommended measurement methodology, standards, metrology best practices and environmental conditions of the National Instruments laboratory. It should be considered as a guideline for the level of measurement uncertainty that can be achieved using the recommended method. It is not a replacement for the user uncertainty analysis that takes into consideration the conditions and practices of the individual user.

Calibration Overview

Install the device and configure it in Measurement & Automation Explorer (MAX) before calibrating.

Calibration includes the following steps:

1. Test system characterization—Characterize the amplitude imbalance of the output ports on your power splitter. The results of this step are used as a correction in the flatness and bandwidth verification procedure.
2. Verification—Verify the existing operation of the device. This step confirms whether the device is operating within the published specification prior to adjustment.
3. Adjustment—Perform an external adjustment of the calibration constants of the device. The adjustment procedure automatically stores the calibration date and temperature on the EEPROM to allow traceability.
4. Re-verification—Repeat the Verification procedure to ensure that the device is operating within the published specifications after adjustment.

Refer to the following sections to complete each procedure.

Test System Characterization

The following procedures characterize the test equipment used during verification.

Caution The connectors on the device under test (DUT) and test equipment are fragile. Perform the steps in these procedures with great care to prevent damaging any DUTs or test equipment.

Zeroing the Power Sensor

1. Ensure that the power sensor is not connected to any signals.
2. Zero the power sensor using the built-in function, according to the power sensor documentation.

Characterizing Power Splitter Amplitude Imbalance

This procedure characterizes the amplitude imbalance of the two output ports of the power splitter over a range of frequencies.

The results of the characterization are later used as a correction in the *Verifying Flatness and Bandwidth* procedure.

Table 2. Power Splitter Characterization

Configuration	Test Point	
	Frequency (MHz)	Amplitude (dBm)
1	0.05	-0.5
2	50.1	-0.5
3	100.1	-0.5
4	150.1	-0.5

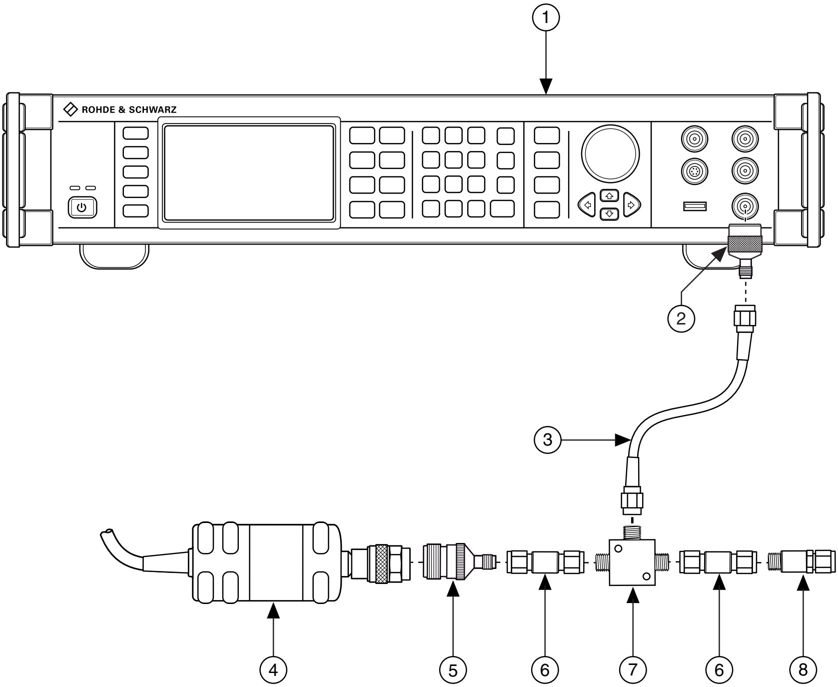
Table 2. Power Splitter Characterization (Continued)

Configuration	Test Point	
	Frequency (MHz)	**Amplitude (dBm)**
5	260.1	-0.5
6	270.1	-0.5

1. Connect an SMA (f)-to-N (f) adapter to the power sensor. Refer to this assembly as the *power sensor*.
2. Zero the power sensor as described in the *Zeroing the Power Sensor* section.
3. Connect the RF OUT connector of the signal generator to the input port of the power splitter using an SMA (f)-to-N (m) adapter and an SMA (m)-to-SMA (m) cable.
4. Connect an SMA (m)-to-SMA (m) adapter to one of the power splitter output ports. Refer to this assembly as *splitter output 1*.
5. Connect the 50 Ω SMA terminator (f) to splitter output 1.
6. Connect the other SMA (m)-to-SMA (m) adapter to the other output port of the power splitter. Refer to this assembly as *splitter output 2*.
7. Connect the power sensor to splitter output 2.

   The following figure illustrates the hardware setup.

Figure 1. Connection Diagram for Measuring at Splitter Output 2



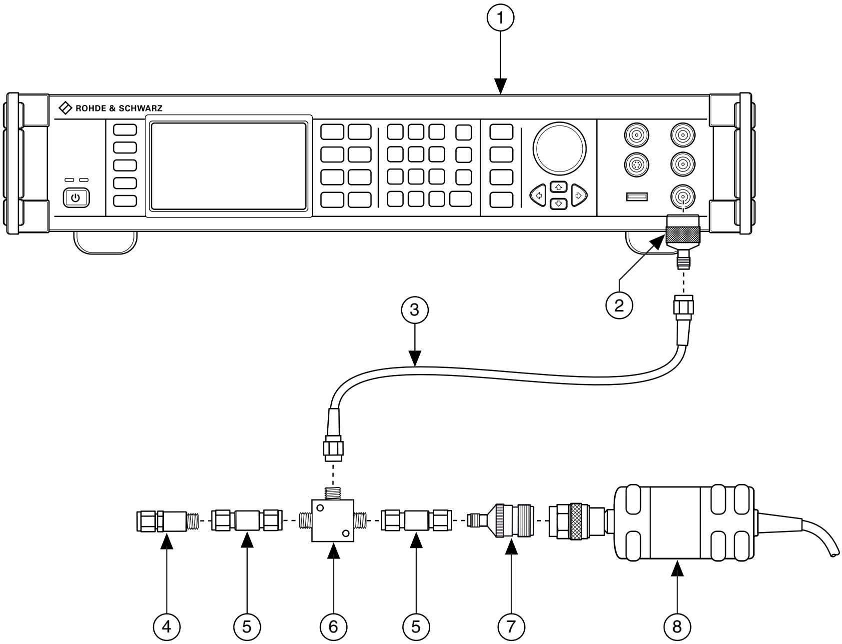
1. Signal Generator
2. SMA (f)-to-N (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. Power Sensor
5. SMA (f)-to-N (f) Adapter
6. SMA (m)-to-SMA (m) Adapter
7. Power Splitter
8. 50 Ω SMA Terminator (f)

8. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the *Test Point Frequency* value from the *Power Splitter Characterization* table
   - Amplitude level: the *Test Point Amplitude* value from the *Power Splitter Characterization* table
9. Configure the power sensor to correct for the *Test Point Frequency* value using the power sensor frequency correction function.
10. Use the power sensor to measure the power in dBm.
11. Repeat steps 8 through 10 for each configuration in the *Power Splitter Characterization* table, recording each result as *splitter output 2 power*, where each configuration has a corresponding value.
12. Disconnect the power sensor and 50 Ω SMA terminator (f) from splitter output 2 and splitter output 1.
13. Connect the power sensor to splitter output 1.

14. Connect the 50 Ω SMA terminator (f) to splitter output 2.

    The following figure illustrates the hardware setup.

Figure 2. Connection Diagram for Measuring at Splitter Output 1



1. Signal Generator
2. SMA (f)-to-N (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 50 Ω SMA Terminator (f)
5. SMA (m)-to-SMA (m) Adapter
6. Power Splitter
7. SMA (f)-to-N (f) Adapter
8. Power Sensor

15. Configure the signal generator to generate a sine waveform with the following characteristics:
    - Frequency: the *Test Point Frequency* value from the *Power Splitter Characterization* table
    - Amplitude level: the *Test Point Amplitude* value from the *Power Splitter Characterization* table
16. Configure the power sensor to correct for the *Test Point Frequency* value using the power sensor frequency correction function.
17. Use the power sensor to measure the power in dBm.
18. Repeat steps 15 through 17 for each configuration in the *Power Splitter Characterization* table, recording each result as *splitter output 1 power*, where each configuration has a corresponding value.
19. Calculate the splitter imbalance for each frequency point using the following equation:

    splitter imbalance = *splitter output 2 power* - *splitter output 1 power*

20. Disconnect the 50 Ω SMA terminator (f) from splitter output 2. Refer to the remaining assembly as the *power sensor assembly*. The power sensor assembly will be used in the *Verifying Flatness and Bandwidth* procedure.

Related Information

Verifying Flatness and Bandwidth on page 19

Follow this procedure to verify the analog flatness and bandwidth accuracy of the NI 5171R by generating a sine wave and comparing the amplitude measured by the NI 5171R to the amplitude measured by the power sensor.

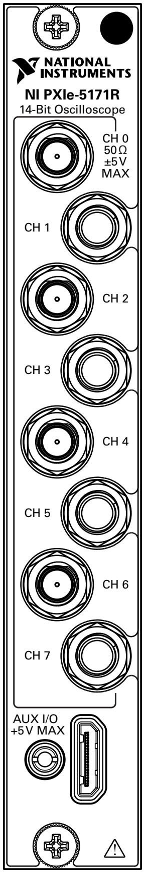
Verification

This section provides instructions for verifying the device specifications.

Verification of the NI 5171R is complete only after you have successfully completed all tests in this section using the *As-Found Limits*.

Refer to the following figure for the names and locations of the NI 5171R front panel connectors. You can find information about the functions of these connectors in the device getting started guide.

Figure 3. NI 5171R Front Panel



Related Information

Test Equipment on page 2

This section lists the equipment required to calibrate the NI 5171R.

Verifying Timebase Accuracy

Follow this procedure to verify the frequency accuracy of the NI 5171R onboard timebase using an oscilloscope calibrator.

Table 3. Timebase Accuracy Verification

As-Found Limit	As-Left Limit	Measurement Uncertainty[1]
25 PPM	1.6 PPM	0.2 PPM

1. Connect the SMA (m)-to-BNC (f) adapter to channel 0 of the NI 5171R.
2. Connect the calibrator test head to the SMA (m)-to-BNC (f) adapter.
3. Configure the NI 5171R with the following settings:
   - Bandwidth: Full Bandwidth
   - Vertical range: 1 $V_{pk\text{-}pk}$
   - Sample rate: 250 MS/s
   - Number of samples: 1,048,576 samples
4. Configure the calibrator and generate a waveform with the following characteristics:
   - Waveform: Sine wave
   - Amplitude: 0.9 $V_{pk\text{-}pk}$
   - Frequency: 11 MHz
   - Load impedance: 50 Ω
5. Enable the calibrator output.
6. Wait 1 second for settling, then measure and record the peak frequency using the Extract Single Tone Information VI.
7. Calculate the timebase error using the following formula:

   $\textit{Timebase error} = (F_{\text{measured}} - (11 \times 10^6))/11$
8. Compare the timebase error to the appropriate limit from the *Timebase Accuracy Verification* table.

   Note Timebase verification is only required on one channel.

Verifying DC Accuracy

Follow this procedure to verify the DC accuracy of the NI 5171R by comparing the voltage measured by the NI 5171R to the value sourced by the voltage standard.

Refer to the following table as you complete the following steps:

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[1] Measurement uncertainty based on Fluke 9500B with Fluke 9530 test head specifications that apply at T_{cal} ±5 °C, where Factory T_{cal} = 23 °C. Uncertainty of the 9500B includes long-term stability of 1 year (5 years for frequency), temperature coefficient, linearity, load, and line regulation and traceability of factory and National Calibration Standard.

[2] Measurement uncertainty based on Fluke 9500B with Fluke 9530 test head specifications that apply at T_{cal} ±5 °C, where Factory T_{cal} = 23 °C. Uncertainty of the 9500B includes long-term stability of 1 year (5 years for frequency), temperature coefficient, linearity, load, and line regulation and traceability of factory and National Calibration Standard.

Table 4. DC Accuracy Verification

Config	Bandwidth	Vertical Range ($V_{pk\text{-}pk}$)	Test Points (V)	As-Found Test Limit (mV)	As-Left Test Limit (mV)	Measurement Uncertainty (mV)[2]
1	Anti-alias Filter	0.2	0.090	±2.8	±1.58	±0.08
2	Full Bandwidth	0.2	0.090	±2.8	±1.58	±0.08
3	Anti-alias Filter	0.2	-0.090	±2.8	±1.58	±0.08
4	Full Bandwidth	0.2	-0.090	±2.8	±1.58	±0.08
5	Anti-alias Filter	0.4	0.180	±3.1	±1.13	±0.15
6	Full Bandwidth	0.4	0.180	±3.1	±1.13	±0.15
7	Anti-alias Filter	0.4	-0.180	±3.1	±1.13	±0.15
8	Full Bandwidth	0.4	-0.180	±3.1	±1.13	±0.15
9	Anti-alias Filter	1	0.450	±6.8	±1.83	±0.19
10	Full Bandwidth	1	0.450	±6.8	±1.83	±0.19
11	Anti-alias Filter	1	-0.450	±6.8	±1.83	±0.19
12	Full Bandwidth	1	-0.450	±6.8	±1.83	±0.19
13	Anti-alias Filter	2	0.900	±11.1	±3.26	±0.57
14	Full Bandwidth	2	0.900	±11.1	±3.26	±0.57
15	Anti-alias Filter	2	-0.900	±11.1	±3.26	±0.57
16	Full Bandwidth	2	-0.900	±11.1	±3.26	±0.57
17	Anti-alias Filter	5	2.250	±25.6	±7.15	±0.61
18	Full Bandwidth	5	2.250	±25.6	±7.15	±0.61
19	Anti-alias Filter	5	-2.250	±25.6	±7.15	±0.61
20	Full Bandwidth	5	-2.250	±25.6	±7.15	±0.61

1. Connect the SMA (m)-to-BNC (f) adapter to channel 0 of the NI 5171R.
2. Connect the calibrator test head to the SMA (m)-to-BNC (f) adapter.
3. Configure the NI 5171R with the following settings:
   - Bandwidth: the Bandwidth value from the *DC Accuracy Verification* table
   - Vertical range: the Vertical Range value from the *DC Accuracy Verification* table

- Sample rate: 250 MS/s
- Number of samples: 1,048,576 samples

4. Configure the calibrator output impedance to 50 Ω.
5. Configure the calibrator to output the Test Point value from the *DC Accuracy Verification* table.
6. Enable the calibrator output.
7. Wait 1 second for settling, then compute the average of the samples acquired and record the measured voltage.
8. Use the following formula to calculate the voltage error:

   DC voltage error = V_{measured} - Test Point
9. Compare the voltage error to the appropriate limit from the *DC Accuracy Verification* table.
10. Repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
11. Connect the calibrator test head to channel 1 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
12. Connect the calibrator test head to channel 2 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
13. Connect the calibrator test head to channel 3 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
14. Connect the calibrator test head to channel 4 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
15. Connect the calibrator test head to channel 5 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
16. Connect the calibrator test head to channel 6 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.
17. Connect the calibrator test head to channel 7 of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 3 through 9 for each configuration listed in the *DC Accuracy Verification* table.

Verifying AC Amplitude Accuracy

Follow this procedure to verify the AC amplitude accuracy of the NI 5171R by comparing the 50 kHz AC voltage measured by the NI 5171R to the 50 kHz AC voltage measured by the DMM.

Refer to the following table as you complete the following steps:

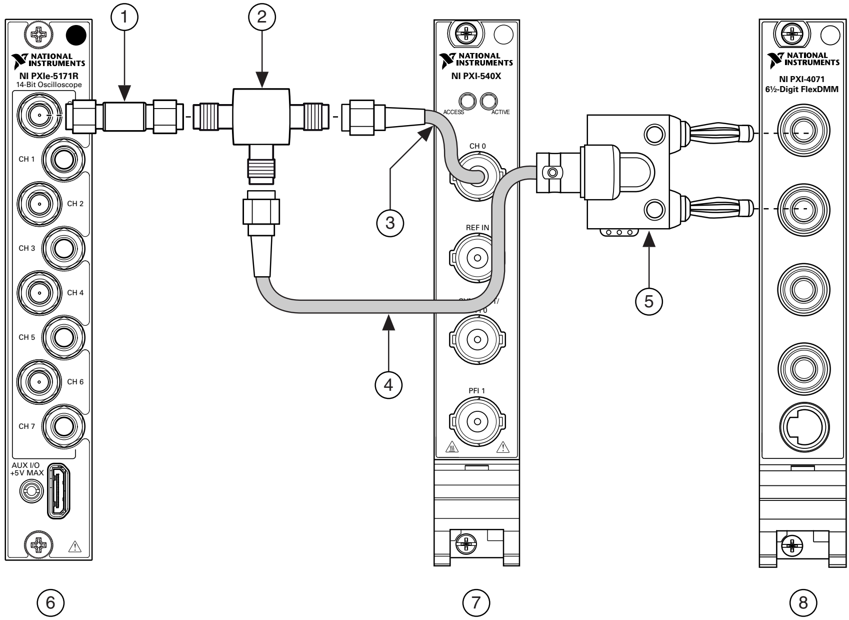
Table 5. AC Amplitude Accuracy Verification

Config	Bandwidth	Vertical Range (V_{pk-pk})	DMM Range (Vrms)	Test Point (V_{pk-pk})	As Found Limit (dB)	As Left Limit (dB)	Measurement Uncertainty (dB)[3]
1	Anti-alias Filter	0.2	0.05	0.14	±0.15	±0.025	±0.006
2	Full Bandwidth	0.2	0.05	0.14	±0.15	±0.025	±0.006
3	Anti-alias Filter	0.4	0.5	0.34	±0.15	±0.025	±0.007
4	Full Bandwidth	0.4	0.5	0.34	±0.15	±0.025	±0.007
5	Anti-alias Filter	1	0.5	0.70	±0.15	±0.025	±0.006
6	Full Bandwidth	1	0.5	0.70	±0.15	±0.025	±0.006
7	Anti-alias Filter	2	0.5	1.40	±0.15	±0.025	±0.005
8	Full Bandwidth	2	0.5	1.40	±0.15	±0.025	±0.005
9	Anti-alias Filter	5	5.0	3.50	±0.15	±0.025	±0.007
10	Full Bandwidth	5	5.0	3.50	±0.15	±0.025	±0.007

[3] *Measurement Uncertainty* is based on the following equipment and conditions:

- NI PXI-4071 specifications apply after self-calibration is performed, in an ambient temperature of 23 °C ± 5 °C, with 6.5 digit resolution, a measurement aperture greater than 80 µs, and Auto Zero enabled
- The cable from the BNC Tee to the DMM must be 1 meter or less
- Pasternack SMA Adapter (M-M) PE9069
- Pasternack SMA Tee PE9246

Figure 4. AC Verification Test Connections



1. SMA (m)-to-SMA (m) adapter
2. SMA Tee (f-f-f)
3. SMA (m)-to-BNC (m) cable
4. SMA (m)-to-BNC (m) cable
5. BNC (f) to Double Banana Plug
6. NI 5171R
7. NI 5402
8. DMM

1. Connect the DMM and function generator to channel 0 of the NI 5171R as shown in the *AC Verification Test Connections* figure.
2. Configure the DMM with the following settings:
   - Function: AC voltage
   - Resolution: 6.5 digits
   - Min frequency: 49 kHz
   - Auto Zero: Enabled
   - Range: the DMM Range value from the *AC Amplitude Accuracy Verification* table
3. Configure the NI 5171R with the following settings:
   - Bandwidth: the Bandwidth value from the *AC Amplitude Accuracy Verification* table
   - Vertical range: the Vertical Range value from the *AC Amplitude Accuracy Verification* table
   - Sample rate: 250 MS/s
   - Number of samples: 1,048,576 samples

4. Configure the function generator and generate a waveform with the following characteristics:
   - Waveform: Sine wave
   - Amplitude: The Test Point value from the *AC Amplitude Accuracy Verification* table
   - Frequency: 50 kHz
   - Load impedance: 50 Ω

   Note These values assume you are using a NI 5402 function generator. For other function generators, the output voltage varies with load output impedance, up to doubling the voltage for a high impedance load.
5. Wait 1 second for the output of the function generator to settle.
6. Measure and record the amplitude using the Extract Single Tone Information VI for the NI 5171R.
7. Measure and record the amplitude for the DMM.

   Note The Extract Single Tone Information VI returns an amplitude result in V_{pk} , but the DMM will return the amplitude as V_{rms}. Convert the results to the same unit before calculating error.
8. Calculate the amplitude error using the following formula:

   $\textit{AC Voltage Error} = 20 \times \log_{10}(V_{NI\ 5171R\ Measured}/V_{DMM\ Measured})$
9. Compare the amplitude error to the appropriate Limit from the *AC Amplitude Accuracy Verification* table.
10. Repeat steps 2 through 8 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
11. Connect the DMM and function generator to channel 1 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
12. Connect the DMM and function generator to channel 2 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
13. Connect the DMM and function generator to channel 3 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
14. Connect the DMM and function generator to channel 4 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
15. Connect the DMM and function generator to channel 5 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
16. Connect the DMM and function generator to channel 6 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
17. Connect the DMM and function generator to channel 7 of the NI 5171R as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 9 for each configuration listed in the *AC Amplitude Accuracy Verification* table.

Verifying Flatness and Bandwidth

Follow this procedure to verify the analog flatness and bandwidth accuracy of the NI 5171R by generating a sine wave and comparing the amplitude measured by the NI 5171R to the amplitude measured by the power sensor.

Before performing this procedure, complete the *Test System Characterization* procedures and calculate the *splitter imbalance* of your power splitter.

Table 6. Flatness and Bandwidth Verification

Config	Bandwidth	Vertical Range (Vpk-pk)	Test Point		As-Found Limit (dB)	As-Left Limit (dB)	Measurement Uncertainty (dB)[4]
			Frequency[5] (MHz)	Amplitude (dBm)			
1	Anti-alias Filter	1	0.05	7.5	—	—	—
2	Anti-alias Filter	1	50.1	7.5	±0.50	±0.32	±0.12
3	Anti-alias Filter	1	90.1	7.5	-1.00 to 0.50	-0.63 to 0.25	±0.14
4	Anti-alias Filter	1	100.1	7.5	-3.00 to 0.50	-2.63 to 0.13	±0.14
5	Full Bandwidth	0.2	0.05	-6.5	—	—	—
6	Full Bandwidth	0.2	50.1	-6.5	±0.50	±0.36	±0.12
7	Full Bandwidth	0.2	100.1	-6.5	-0.75 to 0.50	-0.58 to 0.33	±0.14
8	Full Bandwidth	0.2	150.1	-6.5	-1.00 to 0.50	-0.80 to 0.30	±0.15

[4] Measurement uncertainty is based on the following equipment and conditions:
- Rohde & Schwarz Z91 configured with automatic path selection, a transition setting of 0 dB, a 20 ms aperture, and 32 averages.
- Harmonics from the signal generator are less than -30 dBc
- Aeroflex/Weinschel 1593 Resistive Power Splitter
- Fairview Microwave SMA Adapter (M-M) SM4960
- Cable from power splitter to signal generator is 1 meter or less

[5] The 0.05 MHz test point is used to normalize the remaining test points.

Table 6. Flatness and Bandwidth Verification (Continued)

Config	Bandwidth	Vertical Range (Vpk-pk)	Test Point		As-Found Limit (dB)	As-Left Limit (dB)	Measurement Uncertainty (dB)[4]
			Frequency[5] (MHz)	Amplitude (dBm)			
9	Full Bandwidth	0.2	260.1	-6.5	-3.00 to 0.50	-2.730to 0.230	±0.16
10	Full Bandwidth	1	0.05	7.5	—	—	—
11	Full Bandwidth	1	50.1	7.5	±0.50	±0.36	±0.12
12	Full Bandwidth	1	100.1	7.5	-0.75 to 0.50	-0.58 to 0.33	±0.14
13	Full Bandwidth	1	150.1	7.5	-1.00 to 0.50	-0.800 to 0.300	±0.15
14	Full Bandwidth	1	270.1	7.5	-3.00 to 0.50	-2.730 to 0.230	±0.16

1. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to channel 0 of the NI 5171R.

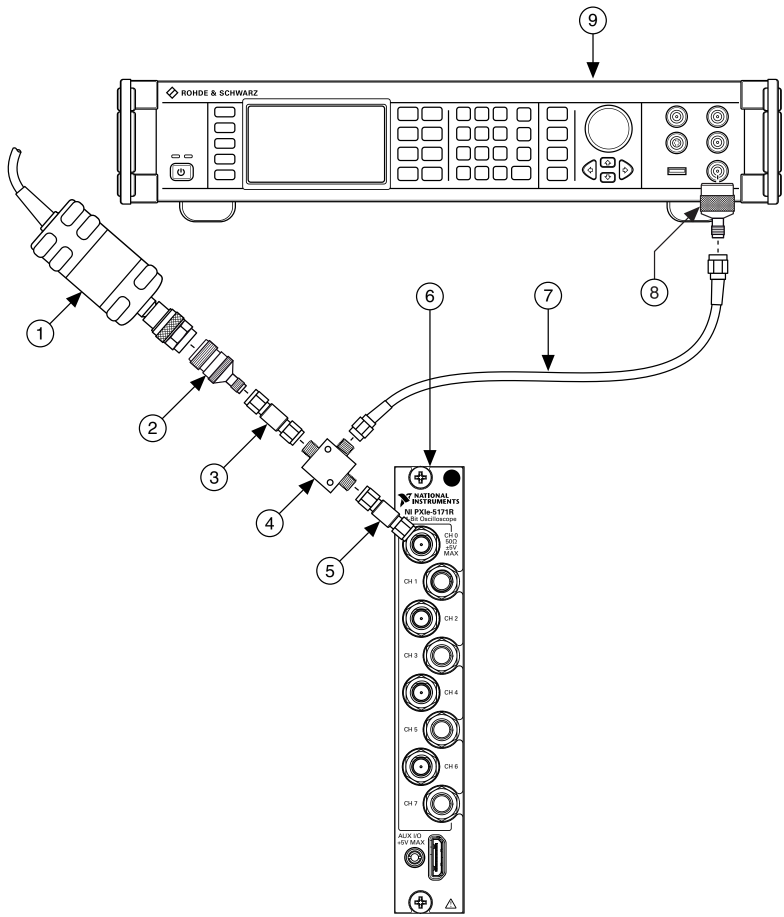
   Note The power sensor assembly must match the configuration used in the *Test System Characterization* section, in which the power sensor is connected to splitter output 1 and the signal generator is connected to the input port of the power splitter.

   The following figure illustrates the hardware setup.

[4] Measurement uncertainty is based on the following equipment and conditions:
- Rohde & Schwarz Z91 configured with automatic path selection, a transition setting of 0 dB, a 20 ms aperture, and 32 averages.
- Harmonics from the signal generator are less than -30 dBc
- Aeroflex/Weinschel 1593 Resistive Power Splitter
- Fairview Microwave SMA Adapter (M-M) SM4960
- Cable from power splitter to signal generator is 1 meter or less

[5] The 0.05 MHz test point is used to normalize the remaining test points.

Figure 5. Flatness and Bandwidth Verification Cabling Diagram



1. Power Sensor
2. SMA (f)-to-N (f) Adapter
3. SMA (m)-to-SMA (m) Adapter
4. Power Splitter
5. SMA (m)-to-SMA (m) Adapter
6. NI 5171R
7. SMA (m)-to-SMA (m) Cable
8. SMA (f)-to-N (m) adapter
9. Signal Generator

2. Configure the NI 5171R with the following settings:
   - Bandwidth: the Bandwidth value from the *Flatness and Bandwidth Verification* table
   - Vertical range: the Vertical Range value from the *Flatness and Bandwidth Verification* table
   - Sample rate: 250 MS/s
   - Number of samples: 1,048,576 samples

3. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the Test Point Frequency value from the *Flatness and Bandwidth Verification* table
   - Amplitude level: the Test Point Amplitude value from the *Flatness and Bandwidth Verification* table
4. Configure the power sensor to correct for the Test Point Frequency using the power sensor frequency correction function.
5. Use the power sensor to measure the power in dBm. Record the result as *measured input power*.
6. Calculate the corrected input power using the following equation:

   corrected input power = *measured input power* + *splitter imbalance*

   Note Select the *splitter imbalance* value from the list of test points from the *Test System Characterization* section for the current Test Point Frequency.
7. Use the NI 5171R to acquire and measure the power using the Extract Single Tone Information VI, converting the result from V_{pk} to dBm. Record the result as *device input power*.
8. If the Test Point Frequency value from the *Flatness and Bandwidth Verification* table is 50 kHz, proceed to step 9. Otherwise, proceed to step 11.
9. Calculate the *power reference* using the following equation:

   power reference = *device input power* - *corrected input power*
10. Proceed to step 13. The power error is not calculated for this configuration.
11. Calculate the *power error* using the following equation:

    power error = *device input power* - *corrected input power* - *power reference*
12. Compare the power error to the appropriate Limit from the *Flatness and Bandwidth Verification* table.
13. Repeat steps 2 through 12 for each configuration in the *Flatness and Bandwidth Verification* table.
14. Connect splitter output 2 of the power sensor assembly to channel 1 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.
15. Connect splitter output 2 of the power sensor assembly to channel 2 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.
16. Connect splitter output 2 of the power sensor assembly to channel 3 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.
17. Connect splitter output 2 of the power sensor assembly to channel 4 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.

18. Connect splitter output 2 of the power sensor assembly to channel 5 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.
19. Connect splitter output 2 of the power sensor assembly to channel 6 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.
20. Connect splitter output 2 of the power sensor assembly to channel 7 of the NI 5171R and repeat steps 2 through 12 for each configuration listed in the *Flatness and Bandwidth Verification* table.

Related Information

Characterizing Power Splitter Amplitude Imbalance on page 7

This procedure characterizes the amplitude imbalance of the two output ports of the power splitter over a range of frequencies.

Adjustment

This section describes the steps needed to adjust the NI 5171R to meet published specifications.

Adjusting DC

Follow this procedure to adjust the DC gain and offset of the NI 5171R.

1. Call the niHSAI Open Ext Cal Session VI to obtain an external calibration session.
2. Connect the SMA (m)-to-BNC (f) adapter to channel 0 of the NI 5171R.
3. Connect the calibrator test head to the SMA (m)-to-BNC (f) adapter.
4. Configure the calibrator output impedance to 50 Ω.
5. Configure the calibrator to a known state by outputting 10 mV of DC voltage.
6. Enable the calibrator output.
7. Call the niHSAI DC Cal Initialize VI with the following settings:
   - **Channel**: 0
8. Call the niHSAI DC Cal Configure VI to obtain the DC voltage to generate and configure the calibrator to output the specified DC voltage.
9. Wait 1 second for settling.
10. Call the niHSAI DC Cal Adjust VI with the following settings:
    - **Actual Voltage Generated**: The DC voltage present on channel 0 of the NI 5171R
11. Repeat steps 8 through 10 until the **DC Cal Complete indicator** from the niHSAI DC Cal Adjust VI returns TRUE.
12. Connect the calibrator test head to the channel 1 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 0 to 1.
13. Connect the calibrator test head to the channel 2 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 1 to 2.

14. Connect the calibrator test head to the channel 3 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 2 to 3.
15. Connect the calibrator test head to the channel 4 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 3 to 4.
16. Connect the calibrator test head to the channel 5 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 4 to 5.
17. Connect the calibrator test head to the channel 6 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 5 to 6.
18. Connect the calibrator test head to the channel 7 input of the NI 5171R using the SMA (m)-to-BNC (f) adapter and repeat steps 5 through 11, changing the value of the **channels** parameter from 6 to 7.
19. Disable the calibrator output.
20. Call the niHSAI Close Ext Cal Session VI with the following settings:
    - **Action**: If the external adjustment procedure completed without any errors, set this control to Commit to store the new calibration constants, adjustment time, adjustment date, and adjustment temperature to the onboard EEPROM. If any errors occurred during the external adjustment procedure, or if you want to abort the operation, set the control to Abort to discard the new calibration constants without changing any of the calibration data stored in the onboard EEPROM.

Adjusting Timebase

Follow this procedure to adjust the internal timebase reference of the NI 5171R.

1. Call the niHSAI Open Ext Cal Session VI to obtain an external calibration session.
2. Connect the calibrator test head to channel 0 of the NI 5171R using the SMA (m)-to-BNC (f) adapter.
3. Configure the calibrator to a known state by outputting an 11 MHz, 0.9 $V_{pk\text{-}pk}$ sine wave.
4. Enable the calibrator output.
5. Call the niHSAI Timebase Cal Initialize VI with the following settings:
    - **Channel**: 0
6. Call the niHSAI Timebase Cal Configure VI to obtain the frequency to generate and configure the calibrator to output a 0.9 $V_{pk\text{-}pk}$ sine wave at the specified frequency.
7. Wait 1 second for settling.
8. Call the niHSAI Timebase Cal Adjust VI with the following settings:
    - **Actual Frequency Generated**: The frequency of the sine wave present on channel 0 of the NI 5171R
9. Repeat steps 6 through 8 until the **Timebase Cal Complete** indicator from the Timebase Cal Adjust VI returns TRUE.
10. Disable the calibrator output.

11. Call the niHSAI Close Ext Cal Session VI with the following settings:
    - **Action**: If the external adjustment procedure completed without any errors, set this control to Commit to store the new calibration constants, adjustment time, adjustment date, and adjustment temperature to the onboard EEPROM. If any errors occurred during the external adjustment procedure, or if you want to abort the operation, set the control to Abort to discard the new calibration constants without changing any of the calibration data stored in the onboard EEPROM.

Reverification

Repeat the *Verification* section to determine the as-left status of the device.

Note If any test fails reverification after performing an adjustment, verify that you have met the *Test Conditions* before returning your device to NI. Refer to the *Worldwide Support and Services* section for information about support resources or service requests.

Updating Verification Date and Time

This procedure updates the date and time of the last NI 5171R verification.

Prior to updating the calibration date and time, you must successfully complete all required verifications or reverifications following adjustment.

Call the niHSAI Set Verification Date and Time VI with the following settings:

- Wire the current date and time to the **verification date** parameter.
- Wire the current calibration password to the **calibration password** parameter. The default password is `NI`.

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