CALIBRATION PROCEDURE

PXIe-5160

This document contains the verification and adjustment procedures for the PXIe-5160. Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

Required Software

Calibrating the PXIe-5160 requires you to install the following software on the calibration system:

- NI-SCOPE 4.1
- Supported application development environment (ADE)—LabVIEW or LabWindows™/CVI™

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

Related Documentation

For additional information, refer to the following documents as you perform the calibration procedure:

- *NI PXIe-5160/5162 Getting Started Guide*
- *NI High-Speed Digitizers Help*
- *NI PXIe-5160 Specifications*

Visit *ni.com/manuals* for the latest versions of these documents.

Test Equipment

This section lists the equipment required to calibrate the PXIe-5160.

Table 1. PXIe-5160 Test Equipment

Equipment	Recommended Model	Where Used	Minimum Requirements
Oscilloscope calibrator	Fluke 9500B/600 with Fluke 9530 Active Head	Verifications: • Timebase accuracy • DC accuracy • Input impedance • Input capacitance Adjustment	Sine wave amplitude: 0.9 Vpk-pk at 11 MHz into 50 Ω
			Sine wave frequency accuracy: 0.25 ppm at 11 MHz
			Square wave amplitude range: 0.5 Vpk-pk to 45 Vpk-pk into 1 MΩ, symmetrical to ground (0 V)
			Square wave frequency: 500 Hz
			Square wave aberrations: <2% of peak for the first 500 ns
			DC output range: • ±2.5 V into 50 Ω • ±40 V into 1 MΩ
			DC output accuracy: ±(0.025% of output + 25 µV)
			Impedance measurement: ±0.1% of reading at 50 Ω and 1 MΩ
			Capacitance measurement: ±2% of reading ± 0.25 pF

Table 1. PXIe-5160 Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
DMM	NI PXI-4070	Verifications: • AC amplitude accuracy	AC voltage accuracy at 50 kHz: • ≤(0.09% of reading + 0.04% of range) for test points < 0.15 Vpk-pk • ≤(0.09% of reading + 0.02% of range) for test points ≥ 0.35 Vpk-pk
			AC input range: 0.1 Vpk-pk to 20 Vpk-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 Vpk-pk to 3.5 Vpk-pk into 50 Ω • 0.1 Vpk-pk to 20 Vpk-pk into 1 MΩ
BNC Tee (m-f-f)	Pasternack PE9174	Verifications: • AC amplitude accuracy	Impedance: 50 Ω
Double banana plug to BNC (f)	Pasternack PE9008	Verifications: • AC amplitude accuracy	Impedance: 50 Ω
BNC (m)-to-BNC (m) cable (x2)	Pasternack PE3087	Verifications: • AC amplitude accuracy	Length: ≤1 meter

Table 1. PXIe-5160 Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power sensor	Rohde & Schwarz NRP-Z91	Test system characterization Verifications: • Bandwidth	Range: -26 dBm to 10 dBm
			Frequency range: 50 kHz to 475.1 MHz
			Absolute power accuracy: • <0.048 dB at 50 kHz • <0.063 dB at 475 MHz
			Relative power accuracy: • <0.022 dB at 50 kHz • <0.031 dB at 475.1 MHz
			VSWR: <1.11
Signal generator	Rhode & Schwarz SMA100A	Test system characterization Verifications: • Bandwidth	Frequency range: 50 kHz to 501 MHz
			Amplitude range: -20 dBm to 16 dBm
			Harmonics: <-30 dBc
Power splitter	Aeroflex/Weinschel 1593	Test system characterization Verifications: • Bandwidth	Frequency range: 50 kHz to 501 MHz
			VSWR: <1.1
			Amplitude tracking: <0.5 dB
50 Ω BNC terminator (f)	Fairview Microwave ST3B-F	Test system characterization	Frequency range: DC to 501 MHz
			VSWR: <1.1
			Impedance: 50 Ω

Table 1. PXIe-5160 Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
50 Ω BNC terminator (m)	Fairview Microwave ST2B	Verifications: • RMS noise	Frequency range: DC to 501 MHz
			VSWR: <1.15
			Impedance: 50 Ω
SMA (m)-to-SMA (m) cable	—	Test system characterization Verifications: • Bandwidth	Frequency range: DC to 501 MHz
			VSWR: <1.1
			Length: ≤1 meter
SMA (f)-to-N (m) adapter	Fairview Microwave SM4226	Test system characterization Verifications: • Bandwidth	Frequency range: DC to 501 MHz
			VSWR: <1.05
			Impedance: 50 Ω
BNC (f)-to-N (f) adapter	Fairview Microwave SM3526	Test system characterization Verifications: • Bandwidth	Frequency range: DC to 501 MHz
			VSWR: <1.1
			Impedance: 50 Ω
SMA (m)-to-BNC (m) adapter (x2)	Fairview Microwave SM4716	Test system characterization Verifications: • Bandwidth	Frequency range: DC to 501 MHz
			VSWR: <1.1
			Impedance: 50 Ω
BNC feed-through terminator	Fairview Microwave ST0150	Test system characterization Verifications: • Bandwidth	Frequency range: DC to 301 MHz
			VSWR: • <1.1 at 100 MHz • <1.25 at 301 MHz
			Impedance: 50 Ω

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5160 meets published specifications:

- 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 PXIe-5160, 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. The device temperature will be greater than the ambient temperature.
- Keep relative humidity between 10% and 90%, noncondensing.
- Allow a warm-up time of at least 15 minutes after the chassis is powered on and NI-SCOPE is loaded and recognizes the PXIe-5160. The warm-up time ensures that the PXIe-5160 and test instrumentation are at a stable operating temperature.
- 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 PXIe-5160. NI uses these limits to determine whether the PXIe-5160 meets the 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 PXIe-5160, 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 NI Measurement & Automation Explorer (MAX) before calibrating.

Calibration includes the following steps:

1. Self-calibration—Adjust the self-calibration constants of the device.
2. 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 bandwidth verification procedure.
3. Verification—Verify the existing operation of the device. This step confirms whether the device is operating within the published specification prior to adjustment.
4. 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.
5. Re-verification—Repeat the Verification procedure to ensure that the device is operating within the published specifications after adjustment.

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 50 Ω Bandwidth* procedure and the *Verifying 1 MΩ Bandwidth* procedure.

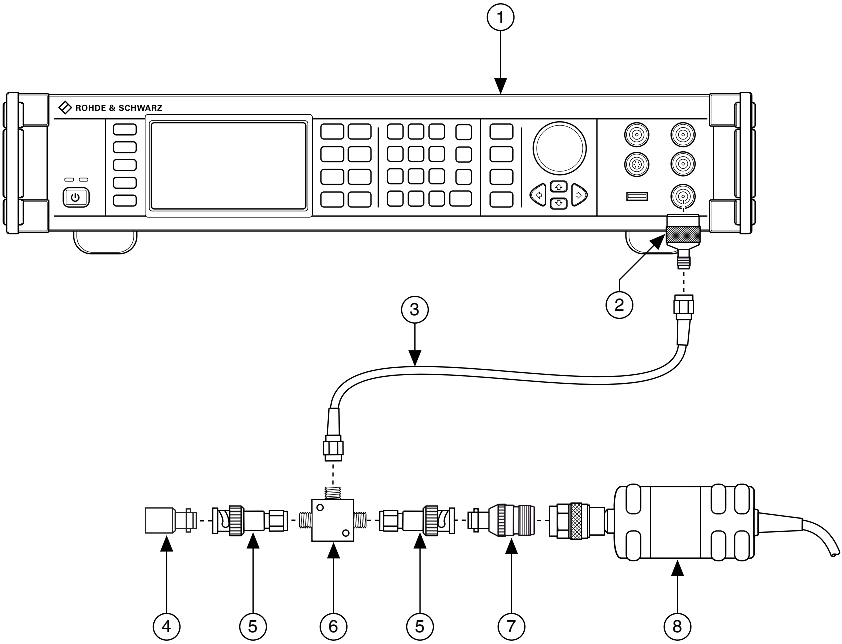
Table 2. Power Splitter Characterization

Config	Test Point	
	Frequency (MHz)	**Amplitude (dBm)**
1	0.05	-0.5
2	250.1	-0.5
3	300.1	-0.5
4	475.1	-0.5

1. Connect the BNC (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-BNC (m) adapter to one of the power splitter output ports. Refer to this assembly as *splitter output 1*.
5. Connect the 50 Ω BNC terminator (f) to splitter output 1.
6. Connect the other SMA (m)-to-BNC (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

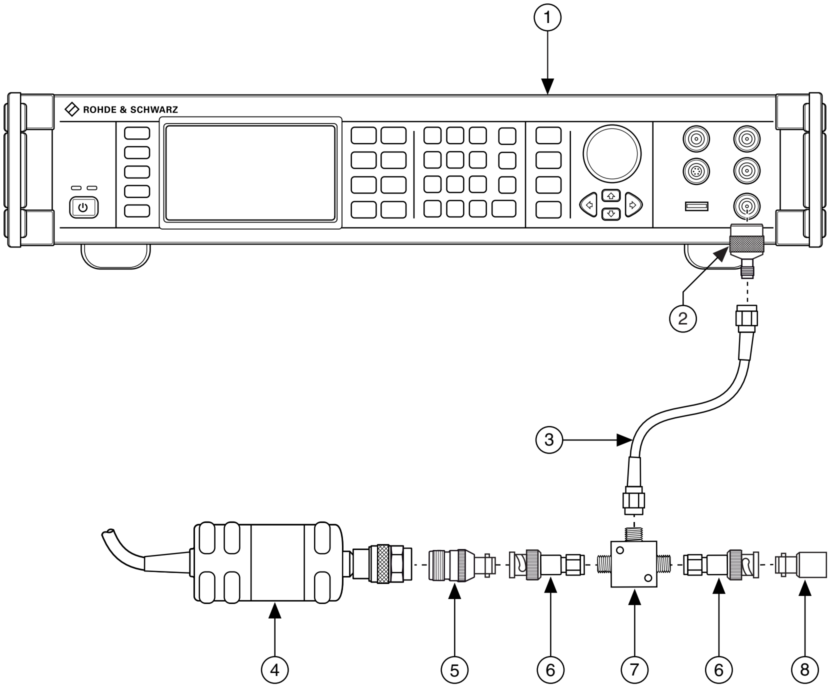


1. Signal Generator
2. SMA (f)-to-N (m) Adapter
3. SMA (m)-to-SMA (m) Cable
4. 50 Ω BNC Terminator (f)
5. SMA (m)-to-BNC (m) Adapter
6. Power Splitter
7. BNC (f)-to-N (f) Adapter
8. Power Sensor

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 BNC terminator (f) from splitter output 2 and splitter output 1.
13. Connect the power sensor to splitter output 1.
14. Connect the 50 Ω BNC 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. Power Sensor
5. BNC (f)-to-N (f) Adapter
6. SMA (m)-to-BNC (m) Adapter
7. Power Splitter
8. 50 Ω BNC Terminator (f)

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 BNC 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 50 Ω Bandwidth* procedure and the *Verifying 1 MΩ Bandwidth* procedure.

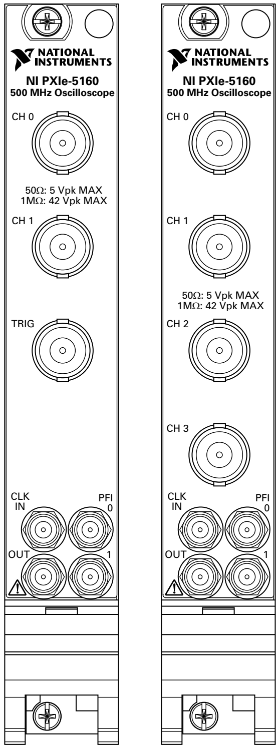
Verification

This section provides instructions for verifying the device specifications.

Verification of the PXIe-5160 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 PXIe-5160 front panel connectors. You can find information about the functions of these connectors in the device getting started guide.

Figure 3. PXIe-5160 (2CH) and PXIe-5160 (4CH) Front Panels



Verifying DC Accuracy

This procedure verifies the DC accuracy of the PXIe-5160 by comparing the voltage measured by the device to the value sourced by the voltage standard.

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

Table 3. DC Accuracy Verification

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Vertical Offset (V)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)	Measurement Uncertainty (mV)[1]
1	50	0.2 V	0	0.090	±3.6	±2.11	±0.05
2	50	0.2 V	0	-0.090	±3.6	±2.11	±0.05
3	50	0.2 V	0.5	0.590	±10.6	±4.16	±0.15
4	50	0.2 V	-0.5	-0.590	±10.6	±4.16	±0.15
5	50	0.5 V	0	0.225	±8.1	±4.39	±0.09
6	50	0.5 V	0	-0.225	±8.1	±4.39	±0.09
7	50	0.5 V	0.5	0.725	±15.1	±6.44	±0.18
8	50	0.5 V	-0.5	-0.725	±15.1	±6.44	±0.18
9	50	1 V	0	0.450	±15.6	±8.57	±0.18
10	50	1 V	0	-0.450	±15.6	±8.57	±0.18
11	50	1 V	0.5	0.950	±22.6	±10.62	±0.26
12	50	1 V	-0.5	-0.950	±22.6	±10.62	±0.26
13	50	2 V	0	0.900	±30.6	±15.20	±0.43
14	50	2 V	0	-0.900	±30.6	±15.20	±0.43
15	50	2 V	1.5	2.400	±51.6	±20.90	±0.48
16	50	2 V	-1.5	-2.400	±51.6	±20.90	±0.48
17	50	5 V	0	2.250	±75.6	±40.35	±0.46

[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.

Table 3. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Vertical Offset (V)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)	Measurement Uncertainty (mV)[1]
18	50	5 V	0	-2.250	±75.6	±40.35	±0.46
19	1 M	0.2 V	0	0.090	±3.6	±2.73	±0.06
20	1 M	0.2 V	0	-0.090	±3.6	±2.73	±0.06
21	1 M	0.2 V	0.5	0.590	±10.6	±8.23	±0.16
22	1 M	0.2 V	-0.5	-0.590	±10.6	±8.23	±0.16
23	1 M	0.5 V	0	0.225	±8.1	±6.08	±0.11
24	1 M	0.5 V	0	-0.225	±8.1	±6.08	±0.11
25	1 M	0.5 V	0.5	0.725	±15.1	±11.58	±0.18
26	1 M	0.5 V	-0.5	-0.725	±15.1	±11.58	±0.18
27	1 M	1 V	0	0.450	±15.6	±12.36	±0.14
28	1 M	1 V	0	-0.450	±15.6	±12.36	±0.14
29	1 M	1 V	0.5	0.950	±22.6	±17.86	±0.24
30	1 M	1 V	-0.5	-0.950	±22.6	±17.86	±0.24
31	1 M	2 V	0	0.900	±30.6	±23.12	±0.38
32	1 M	2 V	0	-0.900	±30.6	±23.12	±0.38
33	1 M	2 V	5	5.900	±100.6	±78.12	±1.16
34	1 M	2 V	-5	-5.900	±100.6	±78.12	±1.16
35	1 M	5 V	0	2.250	±75.6	±57.30	±0.46
36	1 M	5 V	0	-2.250	±75.6	±57.30	±0.46
37	1 M	5 V	5	7.250	±145.6	±112.30	±1.42
38	1 M	5 V	-5	-7.250	±145.6	±112.30	±1.42

[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.

Table 3. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Vertical Offset (V)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)	Measurement Uncertainty (mV)[1]
39	1 M	10 V	0	4.500	±150.6	±119.60	±0.89
40	1 M	10 V	0	-4.500	±150.6	±119.60	±0.89
41	1 M	10 V	5	9.500	±220.6	±174.60	±1.86
42	1 M	10 V	-5	-9.500	±220.6	±174.60	±1.86
43	1 M	20 V	0	9.000	±300.6	±231.20	±1.76
44	1 M	20 V	0	-9.000	±300.6	±231.20	±1.76
45	1 M	20 V	30	39.000	±720.6	±561.20	±7.58
46	1 M	20 V	-30	-39.000	±720.6	±561.20	±7.58
47	1 M	50 V	0	22.500	±750.6	±573.00	±4.38
48	1 M	50 V	0	-22.500	±750.6	±573.00	±4.38
49	1 M	50 V	15	37.500	±960.6	±738.00	±7.29
50	1 M	50 V	-15	-37.500	±960.6	±738.00	±7.29

1. Connect the calibrator test head to channel 0 of the PXIe-5160.
2. Configure the PXIe-5160 with the following settings:
   - Input impedance: the Input Impedance value from the *DC Accuracy Verification* table
   - Maximum input frequency: (1 MΩ) 300 MHz, (50 Ω) 500 MHz
   - Vertical offset: the Vertical Offset value from the *DC Accuracy Verification* table
   - Vertical range: the Vertical Range value from the *DC Accuracy Verification* table
   - Sample rate: 2.5 GS/s
   - Minimum number of points: 50,000 samples
   - NI-SCOPE scalar measurement: Voltage Average
3. Configure the calibrator output impedance to match the impedance of the PXIe-5160.
4. Configure the calibrator to output the Test Point value from the *DC Accuracy Verification* table.

[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.

5. Enable the calibrator output.
6. Wait one second for settling, then record the measured voltage.
7. Use the following formula to calculate the voltage error:

   $DC\ voltage\ error = V_{measured} - Test\ Point$
8. Compare the voltage error to the appropriate limit from the *DC Accuracy Verification* table.
9. Change the maximum input frequency to 175 MHz and repeat steps 6 through 8.
10. Change the maximum input frequency to 20 MHz and repeat steps 6 through 8.
11. Configure the device with the following settings and repeat steps 6 through 10:
    - Maximum input frequency: (1 MΩ) 300 MHz, (50 Ω) 500 MHz
    - Sample rate: 1.25 GS/s
12. Repeat steps 2 through 11 for each configuration listed in the *DC Accuracy Verification* table.
13. Connect the calibrator test head to channel 1 of the PXIe-5160 and repeat steps 2 through 11 for each configuration listed in the *DC Accuracy Verification* table.

    Note If you are verifying the PXIe-5160 (4CH), proceed to the following step. If you are verifying the PXIe-5160 (2CH), DC accuracy verification is complete.
14. Connect the calibrator test head to channel 2 of the PXIe-5160 and repeat steps 2 through 11 for each configuration listed in the *DC Accuracy Verification* table.
15. Connect the calibrator test head to channel 3 of the PXIe-5160 and repeat steps 2 through 11 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 PXIe-5160 by comparing the voltage measured by the PXIe-5160 to the voltage measured by the DMM.

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

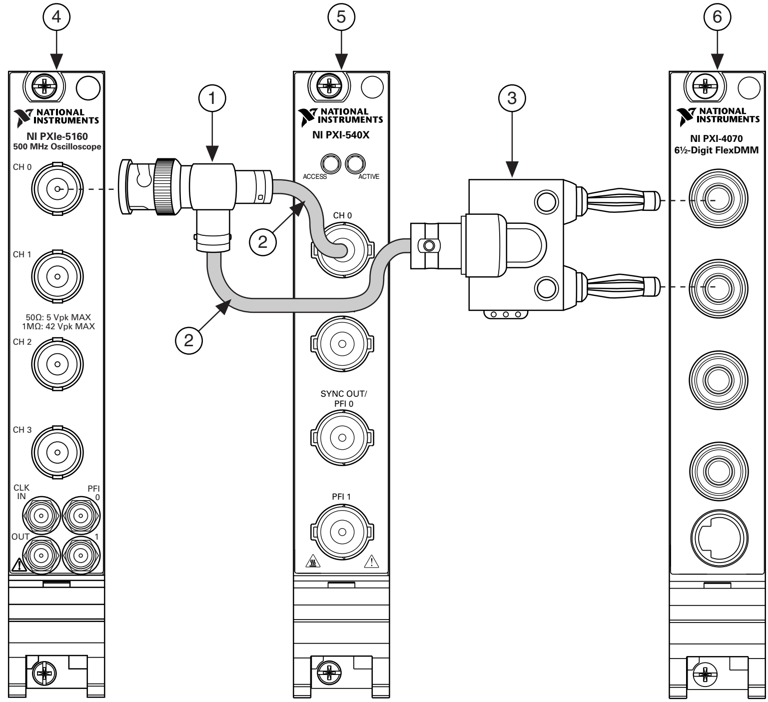
Table 4. AC Amplitude Accuracy Verification

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Test Point (Vpk-pk)	Frequency (kHz)	DMM Range (Vrms)	As-Found Limits (dB)	As-Left Limits (dB)	Measurement Uncertainty (dB)[2]
1	50	0.2 V	0.14	50.0	0.05	±0.50	±0.39	±0.014
2	50	0.5 V	0.35	50.0	0.5	±0.50	±0.39	±0.018
3	50	1 V	0.7	50.0	0.5	±0.50	±0.39	±0.014
4	50	2 V	1.4	50.0	0.5	±0.50	±0.39	±0.012
5	50	5 V	3.5	50.0	5.0	±0.50	±0.39	±0.018
6	1 M	0.2 V	0.14	50.0	0.05	±0.50	±0.41	±0.013
7	1 M	0.5 V	0.35	50.0	0.5	±0.50	±0.41	±0.017
8	1 M	1 V	0.7	50.0	0.5	±0.50	±0.41	±0.013
9	1 M	2 V	1.4	50.0	0.5	±0.50	±0.41	±0.011
10	1 M	5 V	3.5	50.0	5.0	±0.50	±0.41	±0.017
11	1 M	10 V	7	50.0	5.0	±0.50	±0.41	±0.013
12	1 M	20 V	14	50.0	5.0	±0.50	±0.41	±0.011
13	1 M	50 V	20	50.0	50.0	±0.50	±0.41	±0.024

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

- NI PXI-4070 specifications apply after self-calibration is performed, in an ambient temperature of 23 °C ± 10 °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 BNC Tee PE9174

Figure 4. AC Verification Test Connections



1. BNC tee (m-f-f)	4. NI 5160
2. BNC (m)-to-BNC (m) cable	5. Function Generator
3. BNC (f) to Double Banana Plug	6. DMM

1. Connect the DMM and function generator to channel 0 of the PXIe-5160 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 PXIe-5160 with the following settings:
   - Input impedance: the Input Impedance value from the *AC Amplitude Accuracy Verification* table
   - Maximum input frequency: (1 MΩ) 300 MHz, (50 Ω) 500 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *AC Amplitude Accuracy Verification* table

- Sample clock timebase source: VAL_INTERNAL_TIMEBASE
- Sample rate: 2.5 GS/s
- Sample clock timebase multiplier: 2
- Sample clock timebase divisor: 200
- Minimum number of points: 50,000 samples
- NI-SCOPE scalar measurement: AC Estimate

Note The actual sample rate of the PXIe-5160 is calculated by the following formula:
25 MS/s = (*Sample clock timebase rate* × *Sample clock timebase multiplier) /* *Sample clock timebase divisor*

Note Setting the Sample clock timebase attribute keeps the PXIe-5160 in the desired configuration even when data decimation is needed to measure the amplitude of the 50 kHz sine wave.

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: the Input Impedance value from the *AC Amplitude Accuracy Verification* table

   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 the output voltage amplitude using the PXIe-5160 and the DMM.
7. Record the Vrms measurements.
8. Calculate the amplitude error using the following formula:

   $AC\ Voltage\ Error = 20 \times \log_{10}(V_{\text{PXIe-5160 Measured}}/V_{\text{DMM Measured}})$
9. Compare the amplitude error to the appropriate Limit from the *AC Amplitude Accuracy Verification* table
10. Change the maximum input frequency to 175 MHz and repeat steps 5 through 9.
11. Change the maximum input frequency to 20 MHz and repeat steps 5 through 9.
12. Configure the device with the following settings and repeat steps 5 through 11:
    - Maximum input frequency: (1 MΩ) 300 MHz, (50 Ω) 500 MHz
    - Sample clock timebase multiplier: 1
    - Sample clock timebase divisor: 100
13. Repeat steps 2 through 12 for each configuration listed in the *AC Amplitude Accuracy Verification* table.

14. Connect the DMM and function generator to channel 1 of the PXIe-5160 as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 12 for each configuration listed in the *AC Amplitude Accuracy Verification* table.

> **Note** If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), AC amplitude accuracy verification is complete.

15. Connect the DMM and function generator to channel 2 of the PXIe-5160 as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 12 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
16. Connect the DMM and function generator to channel 3 of the PXIe-5160 as shown in the *AC Verification Test Connections* figure and repeat steps 2 through 12 for each configuration listed in the *AC Amplitude Accuracy Verification* table.

Verifying 50 Ω Bandwidth

Follow this procedure to verify the 50 Ω analog bandwidth accuracy of the PXIe-5160 by generating a sine wave and comparing the amplitude measured by the PXIe-5160 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 5. 50 Ω Bandwidth Verification

Config	Vertical Range (Vpk-pk)	Test Point		As-Found Limits (dB)	As-Left Limits (dB)	Measurement Uncertainty (dB)[3]
		Frequency (MHz)	Amplitude (dBm)			
1	0.05 V	0.05	-18.5	—	—	—
2	0.05 V	475.1	-18.5	-3.00 to 1.00	-2.70 to 1.00	±0.13
3	2 V	0.05	13.5	—	—	—
4	2 V	475.1	13.5	-3.00 to 1.00	-2.70 to 1.00	±0.13

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

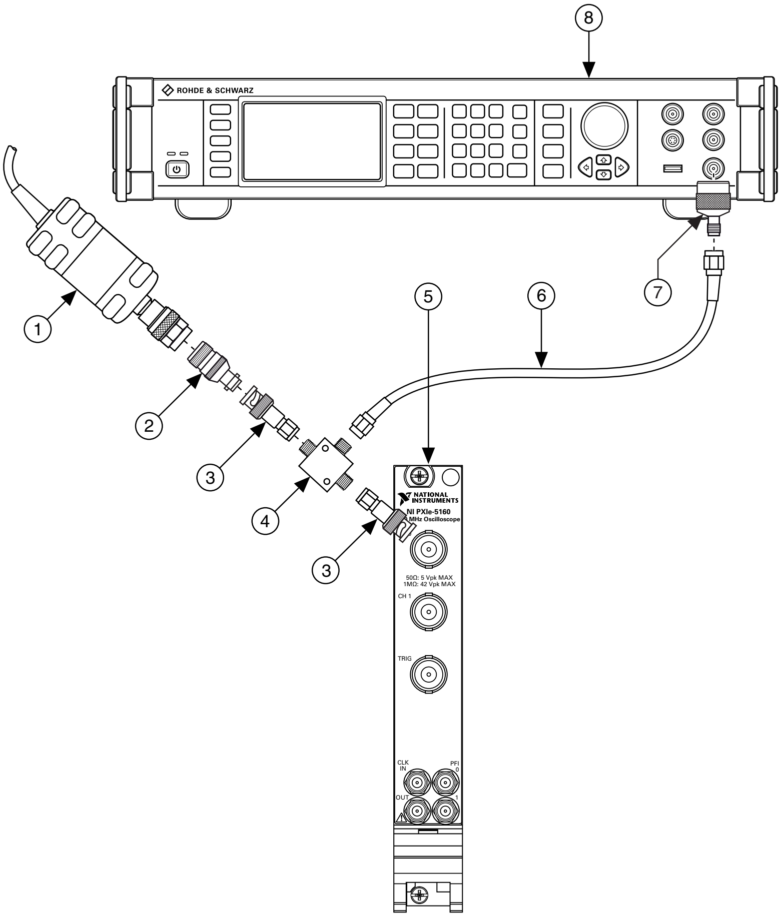
- Rohde & Schwarz Z91 configured with automatic path selection, a transition setting of 0 dB, a 20 ms aperture, and 32 averages.
- Harmonics from the signal generator are less than -30 dBc
- Aeroflex/Weinschel 1593 Resistive Power Splitter
- Cable from power splitter to signal generator is 1 meter or less

1. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to channel 0 of the PXIe-5160.

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.

Figure 5. 50 Ω Bandwidth Verification Cabling Diagram



1. Power Sensor
2. BNC (f)-to-N (f) Adapter
3. SMA (m)-to-BNC (m) Adapter
4. Power Splitter
5. NI 5160
6. SMA (m)-to-SMA (m) Cable
7. SMA (f)-to-N (m) Cable
8. Signal Generator

2. Configure the PXIe-5160 with the following settings:
   - Input impedance: 50 Ω
   - Maximum input frequency: 500 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *50 Ω Bandwidth Verification* table
   - Minimum number of points: 1,048,576 samples
   - Sample clock timebase source: VAL_INTERNAL_TIMEBASE
   - Sample clock timebase rate: 2.5 GS/s
   - Sample clock timebase multiplier: 1
   - Sample clock timebase divisor:
     – If the Test Point Frequency value from the *50 Ω Bandwidth Verification* table is 50 kHz, set this value to 100.
     – For all other Test Point Frequency values, set this value to 2.

   Note The actual sample rate of the PXIe-5160 is calculated by the following formula:
   25 MS/s = (Sample Clock Timebase Rate × Sample Clock Timebase Multiplier)/Sample Clock Timebase Divisor
3. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the Test Point Frequency value from the *50 Ω Bandwidth Verification* table
   - Amplitude level: the Test Point Amplitude value from the *50 Ω 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 PXIe-5160 to acquire and measure the power using the Extract Single Tone Information VI, converting the result from Vpk to dBm. Record the result as *device input power*.
8. If the Test Point Frequency value from the *50 Ω Bandwidth Verification* table is 50 kHz, proceed to the following step. Otherwise, go to step 11.
9. Calculate the *power reference* using the following equation:

   power reference = *device input power* - *corrected input power*
10. Go 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 *50 Ω Bandwidth Verification* table.
13. Repeat steps 2 through 12 for each configuration in the *50 Ω Bandwidth Verification* table.
14. Connect splitter output 2 of the power sensor assembly to channel 1 of the PXIe-5160 and repeat steps 2 through 12 for each configuration listed in the *50 Ω Bandwidth Verification* table.

Note If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), 50 Ω bandwidth verification is complete.

15. Connect splitter output 2 of the power sensor assembly to channel 2 of the PXIe-5160 and repeat steps 2 through 12 for each configuration listed in the *50 Ω Bandwidth Verification* table.
16. Connect splitter output 2 of the power sensor assembly to channel 3 of the PXIe-5160 and repeat steps 2 through 12 for each configuration listed in the *50 Ω Bandwidth Verification* table.

Verifying 1 MΩ Bandwidth

Follow this procedure to verify the 1 MΩ analog bandwidth accuracy of the PXIe-5160 by generating a sine wave and comparing the amplitude measured by the PXIe-5160 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. 1 MΩ Bandwidth Verification

Config	Vertical Range (Vpk-pk)	Test Point		As-Found Limits (dB)	As-Left Limits (dB)	Measurement Uncertainty (dB)[4]
		Frequency (MHz)	Amplitude (dBm)			
1	1 V	0.05	7.5	—	—	—
2	1 V	300.1	7.5	-3.00 to 1.00	-2.55 to 1.00	±0.13
3	2 V	0.05	13.5	—	—	—

[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 BNC Feed-Through Terminator ST0150
- Cable from power splitter to signal generator is 1 meter or less

Table 6. 1 MΩ Bandwidth Verification (Continued)

Config	Vertical Range (Vpk-pk)	Test Point		As-Found Limits (dB)	As-Left Limits (dB)	Measurement Uncertainty (dB)[4]
		Frequency (MHz)	Amplitude (dBm)			
4	2 V	250.1	13.5	-3.00 to 1.00	-2.68 to 1.00	±0.11
5	10 V	0.05	16	—	—	—
6	10 V	250.1	16	-3.00 to 1.00	-2.68 to 1.00	±0.11

1. Connect the 50 Ω BNC feed-through terminator to channel 0 of the PXIe-5160. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to the 50 Ω BNC feed-through terminator.

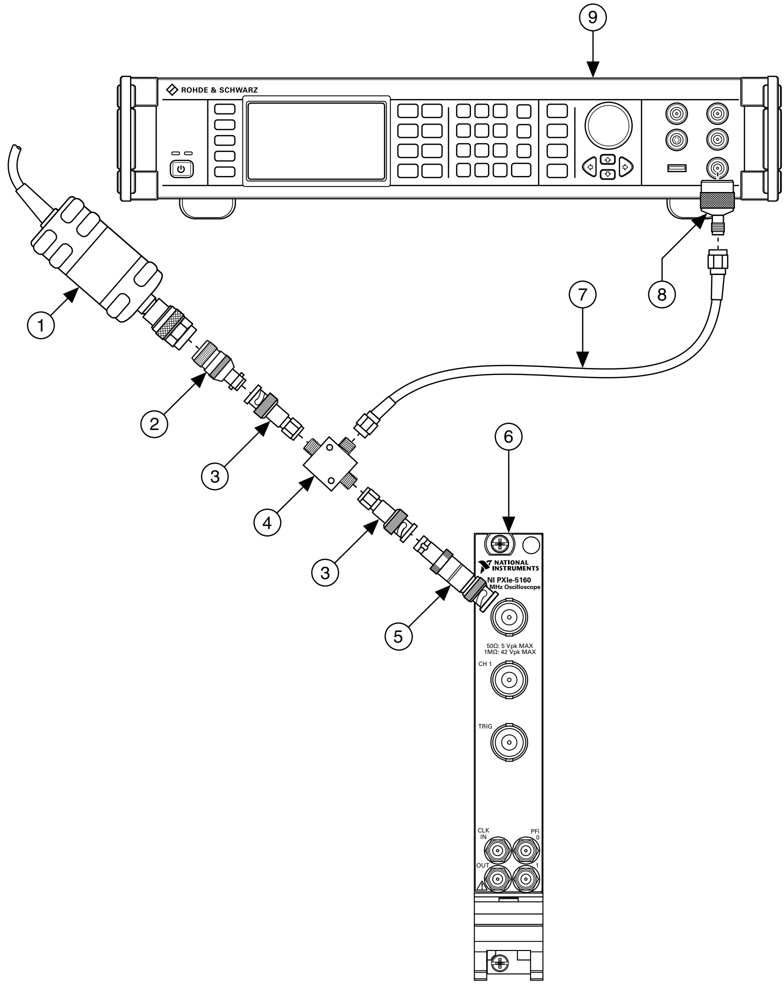
Note The power sensor assembly must match the configuration used in the *Test System Characterization* section, in which the power sensor is connected to splitter output 1 and the signal generator is connected to the input port of the power splitter.

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 BNC Feed-Through Terminator ST0150
- Cable from power splitter to signal generator is 1 meter or less

Figure 6. 1 MΩ Bandwidth Verification Cabling Diagram



1. Power Sensor
2. BNC (f)-to-N (f) Adapter
3. SMA (m)-to-BNC (m) Adapter
4. Power Splitter
5. 50 Ω Feed-Through Terminator
6. NI 5160
7. SMA (m)-to-SMA (m) Cable
8. SMA (f)-to-N (m) Cable
9. Signal Generator

2. Configure the PXIe-5160 with the following settings:
   - Input impedance: 1 MΩ
   - Maximum input frequency: 300 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *1 MΩ Bandwidth Verification* table

- Minimum number of points: 1,048,576 samples
- Sample clock timebase source: VAL_INTERNAL_TIMEBASE
- Sample clock timebase rate: 2.5 GS/s
- Sample clock timebase multiplier: 1
- Sample clock timebase divisor:
  – If the Test Point Frequency value from the *1 MΩ Bandwidth Verification* table is 50 kHz, set this value to 100.
  – For all other Test Point Frequency values, set this value to 2.

Note The actual sample rate of the PXIe-5160 is calculated by the following formula:
25 MS/s = (Sample Clock Timebase Rate × Sample Clock Timebase Multiplier)/Sample Clock Timebase Divisor

3. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the Test Point Frequency value from the *1 MΩ Bandwidth Verification* table
   - Amplitude level: the Test Point Amplitude value from the *1 MΩ 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 PXIe-5160 to acquire and measure the power using the Extract Single Tone Information VI, converting the result from Vpk to dBm. Record the result as *device input power*.
8. If the Test Point Frequency value from the *1 MΩ Bandwidth Verification* table is 50 kHz, proceed to the following step. Otherwise, go to step 11.
9. Calculate the *power reference* using the following equation:

   power reference = *device input power* - *corrected input power*
10. Go 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 *1 MΩ Bandwidth Verification* table.
13. Repeat steps 2 through 12 for each configuration in the *1 MΩ Bandwidth Verification* table.

14. Connect the 50 Ω BNC feed-through terminator to channel 1 of the PXIe-5160. Connect splitter output 2 of the power sensor assembly to the 50 Ω BNC feed-through terminator and repeat steps 2 through 12 for each configuration in the *1 MΩ Bandwidth Verification* table.

Note If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), 1 MΩ bandwidth verification is complete.

15. Connect the 50 Ω BNC feed-through terminator to channel 2 of the PXIe-5160. Connect splitter output 2 of the power sensor assembly to the 50 Ω BNC feed-through terminator and repeat steps 2 through 12 for each configuration in the *1 MΩ Bandwidth Verification* table.
16. Connect the 50 Ω BNC feed-through terminator to channel 3 of the PXIe-5160. Connect splitter output 2 of the power sensor assembly to the 50 Ω BNC feed-through terminator and repeat steps 2 through 12 for each configuration in the *1 MΩ Bandwidth Verification* table.

Verifying Timebase Accuracy

Follow this procedure to verify the frequency accuracy of the PXIe-5160 onboard timebase using an oscilloscope calibrator.

Table 7. Timebase Accuracy Verification

Test Limits	Measurement Uncertainty
±25 PPM (±2,475 Hz)	±0.2 PPM (±19.8 Hz)

1. Connect the calibrator test head to channel 0 of the PXIe-5160.
2. Configure the PXIe-5160 with the following settings:
   - Input impedance: 50 Ω
   - Maximum input frequency: 500 MHz
   - Vertical range: 1 Vpk-pk
   - Sample rate: 1.25 GS/s
   - Minimum number of points: 1,048,576 samples
3. Configure the calibrator and generate a waveform with the following characteristics:
   - Waveform: Sine wave
   - Amplitude ($V_{pk\text{-}pk}$): 0.9 V
   - Frequency: 99 MHz
   - Load impedance: 50 Ω
4. Enable the calibrator output.
5. Wait 1 second for settling, then measure and record the peak frequency using the Extract Single Tone Information VI.

[5] 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.

6. Calculate the timebase error using the following formula:

   Timebase error = (F_{measured} - (99 × 10^6))/99

7. Compare the timebase error to the appropriate limit from the *Timebase Accuracy Verification* table.

   Note Timebase verification is only required on one channel.

8. Disable the calibrator output.

Verifying Input Impedance

Follow this procedure to verify the input impedance of the PXIe-5160 using an oscilloscope calibrator.

Table 8. Input Impedance Verification

Config	Vertical Range (Vpk-pk)	Input Impedance (Ω)	As-Found Test Limits (Ω)	As-Left Test Limits (Ω)	Measurement Uncertainty (Ω)
1	1 V	50	±0.875	±0.48	±0.045
2	2 V	50	±0.875	±0.48	±0.045
3	1 V	1 M	±9000	±7000	±775
4	10 V	1 M	±9000	±7000	±775
5	20 V	1 M	±9000	±7000	±775

1. Connect the calibrator test head to channel 0 of the PXIe-5160.
2. Configure the PXIe-5160 with the following settings:
   - Input impedance: the Input Impedance value from the *Input Impedance Verification* table.
   - Maximum input frequency: (50 Ω) 500 MHz, (1 MΩ), 300 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Rage value from the *Input Impedance Verification* table.
   - Sample rate: 2.5 GS/s
   - Minimum number of points: 50,000 samples
3. Configure the calibrator output impedance to match that of the PXIe-5160.
4. Configure the calibrator to measure impedance.
5. Enable the calibrator.
6. Wait 1 second for settling, then record the measured impedance.
7. Use the following formula to calculate the input impedance error:

   input impedance error = $\text{Impedance}_{\text{Measured}}$ - Input Impedance value from the *Input Impedance Verification* table

8. Compare the input impedance error to the appropriate Limit from the *Input Impedance Verification* table.
9. Repeat steps 2 through 8 for each configuration listed in the *Input Impedance Verification* table.
10. Connect the calibrator test head to channel 1 of the PXIe-5160 and repeat steps 2 through 8 for each configuration listed in the *Input Impedance Verification* table.

Note If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), input impedance verification is complete.

11. Connect the calibrator test head to channel 2 of the PXIe-5160 and repeat steps 2 through 8 for each configuration listed in the *Input Impedance Verification* table.
12. Connect the calibrator test head to channel 3 of the PXIe-5160 and repeat steps 2 through 8 for each configuration listed in the *Input Impedance Verification* table.

Verifying Input Capacitance

Follow this procedure to verify in the input capacitance of the PXIe-5160 using an oscilloscope calibrator.

Table 9. Input Capacitance Verification

Config	Vertical Range (Vpk-pk)	As-Found Test Limits (pF)	As-Left Test Limits (pF)	Measurement Uncertainty (pF)[6]
0	1 V	12.5 to 17.5	12.9 to 17.1	±0.46
1	10 V	12.5 to 17.5	12.9 to 17.1	±0.46
2	20 V	12.5 to 17.5	12.9 to 17.1	±0.46

1. Connect the calibrator test head to channel 0 of the PXIe-5160.
2. Configure the PXIe-5160 with the following settings:
   - Input impedance: 1 MΩ
   - Maximum input frequency: 300 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *Input Capacitance Verification* table
   - Sample rate: 2.5 GS/s
   - Minimum number of points: 50,000 samples
3. Configure the calibrator to measure capacitance.
4. Enable the calibrator.
5. Wait 1 second for settling, then record the measured capacitance.

[6] 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.

6. Compare the input capacitance to the appropriate Limit from the *Input Capacitance Verification* table.
7. Repeat steps 2 through 6 for each configuration listed in the *Input Capacitance Verification* table.
8. Connect the calibrator test head to channel 1 of the PXIe-5160 and repeat steps 2 through 6 for each configuration listed in the *Input Capacitance Verification* table.

Note If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), input capacitance verification is complete.

9. Connect the calibrator test head to channel 2 of the PXIe-5160 and repeat steps 2 through 6 for each configuration listed in the *Input Capacitance Verification* table.
10. Connect the calibrator test head to channel 3 of the PXIe-5160 and repeat steps 2 through 6 for each configuration listed in the *Input Capacitance Verification* table.

Verifying RMS Noise

Follow this procedure to verify the RMS noise of the PXIe-5160 using a 50 Ω terminator.

Table 10. RMS Noise Verification

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Max Input Frequency (MHz)	As-Found Test Limit (% of FS)	As-Left Test Limit (% of FS)	Measurement Uncertainty (% of FS)
1	50	0.05 V	20	0.30	0.26	±0.019
2	50	1 V	20	0.17	0.14	±0.009
3	50	0.05 V	175	0.30	0.26	±0.018
4	50	1 V	175	0.17	0.14	±0.010
5	50	0.05 V	500	0.30	0.26	±0.019
6	50	0.1 V	500	0.19	0.16	±0.012
7	50	0.2 V	500	0.17	0.14	±0.009
8	50	0.5 V	500	0.17	0.14	±0.008
9	50	1 V	500	0.17	0.14	±0.009
10	50	2 V	500	0.17	0.14	±0.008
11	50	5 V	500	0.17	0.14	±0.009
12	1 M	0.05 V	20	0.30	0.26	±0.021
13	1 M	1 V	20	0.17	0.14	±0.009

Table 10. RMS Noise Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Max Input Frequency (MHz)	As-Found Test Limit (% of FS)	As-Left Test Limit (% of FS)	Measurement Uncertainty (% of FS)
14	1 M	0.05 V	175	0.30	0.26	±0.021
15	1 M	1 V	175	0.17	0.14	±0.009
16	1 M	0.05 V	300	0.30	0.26	±0.019
17	1 M	0.1 V	300	0.19	0.16	±0.011
18	1 M	0.2 V	300	0.17	0.14	±0.009
19	1 M	0.5 V	300	0.17	0.14	±0.009
20	1 M	1 V	300	0.17	0.14	±0.010
21	1 M	2 V	300	0.17	0.14	±0.009
22	1 M	5 V	300	0.17	0.14	±0.009
23	1 M	10 V	300	0.17	0.14	±0.009
24	1 M	20 V	300	0.17	0.14	±0.009
25	1 M	50 V	300	0.17	0.14	±0.009

1. Connect the 50 Ω terminator to channel 0 of the PXIe-5160.
2. Configure the PXIe-5160 with the following settings:
   - Input impedance: the Input Impedance value from the *RMS Noise Verification* table
   - Maximum input frequency: the Max Input Frequency value from the *RMS Noise Verification* table
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *RMS Noise Verification* table
   - Sample rate: 2.5 GS/s
   - Minimum number of points: 1,048,576 samples
3. Use the PXIe-5160 to acquire a waveform, then calculate the standard deviation of the acquired waveform. Use the standard deviation to compute the RMS noise using the following formula:

   $RMS\ noise\ (\%\ of\ FS) = (100 \times \sigma)/Vertical\ range$
   where σ is the standard deviation of the acquired waveform.
4. Compare the RMS noise to the appropriate Limit from the *RMS Noise Verification* table.
5. Repeat steps 2 through 4 for each configuration listed in the *RMS Noise Verification* table.

6. Connect the 50 Ω terminator to channel 1 of the PXIe-5160 and repeat steps 2 through 4 for each configuration listed in the *RMS Noise Verification* table.

Note If you are verifying the PXIe-5160 (4CH), proceed to the following steps. If you are verifying the PXIe-5160 (2CH), RMS noise verification is complete.

7. Connect the 50 Ω terminator to channel 2 of the PXIe-5160 and repeat steps 2 through 4 for each configuration listed in the *RMS Noise Verification* table.
8. Connect the 50 Ω terminator to channel 3 of the PXIe-5160 and repeat steps 2 through 4 for each configuration listed in the *RMS Noise Verification* table.

Adjustment

Follow this procedure to externally adjust the PXIe-5160.

Table 11. Vertical Range Adjustment

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Input (V)
1	1 M	50 V	22.500
2	1 M	50 V	-22.500
3	1 M	20 V	9.000
4	1 M	20 V	-9.000
5	1 M	10 V	4.500
6	1 M	10 V	-4.500
7	1 M	5 V	2.250
8	1 M	5 V	-2.250
9	1 M	2 V	0.900
10	1 M	2 V	-0.900
11	1 M	1 V	0.450
12	1 M	1 V	-0.450
13	1 M	0.631 V	0.284
14	1 M	0.631 V	-0.284
15	1 M	0.5 V	0.225
16	1 M	0.5 V	-0.225
17	1 M	0.2 V	0.090

Table 11. Vertical Range Adjustment (Continued)

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Input (V)
18	1 M	0.2 V	-0.090
19	1 M	0.1 V	0.045
20	1 M	0.1 V	-0.045
21	1 M	0.05 V	0.023
22	1 M	0.05 V	-0.023
23	50	0.05 V	0.023
24	50	0.05 V	-0.023
25	50	0.1 V	0.045
26	50	0.1 V	-0.045
27	50	0.2 V	0.090
28	50	0.2 V	-0.090
29	50	0.5 V	0.225
30	50	0.5 V	-0.225
31	50	0.631 V	0.284
32	50	0.631 V	-0.284
33	50	1 V	0.450
34	50	1 V	-0.450
35	50	2 V	0.900
36	50	2 V	-0.900
37	50	5 V	2.250
38	50	5 V	-2.250

Table 12. 1 MΩ Compensation Attenuator Adjustment

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Input (V)
1	1 M	1 V	0.500
2	1 M	1 V	0.900

Table 12. 1 MΩ Compensation Attenuator Adjustment (Continued)

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Input (V)
3	1 M	10 V	5.000
4	1 M	10 V	9.000
5	1 M	50 V	25.000
6	1 M	50 V	45.000

Table 13. External Trigger Range Adjustment

Config	Input Impedance (Ω)	Vertical Range (Vpk-pk)	Input (V)
1	1 M	10 V	4.500
2	1 M	10 V	-4.500
3	1 M	1 V	0.450
4	1 M	1 V	-0.450
5	50	5 V	2.250
6	50	5 V	-2.250

1. Call the niScope Cal Start VI to obtain an NI-SCOPE external calibration session.
2. Connect the calibrator test head to channel 0 of the PXIe-5160.
3. Configure the calibrator output impedance to the Input Impedance value from the *Vertical Range Adjustment* table.
4. Configure the calibrator output voltage to the DC Input value from the *Vertical Range Adjustment* table.
5. Enable the calibrator output.
6. Wait 1 second for settling.
7. Call the niScope Cal Adjust Range VI with the following settings to adjust the vertical range:
   - **range**: the Vertical Range value from the *Vertical Range Adjustment* table
   - **stimulus**: the Input value from the *Vertical Range Adjustment* table
8. Repeat steps 3 through 7 for each configuration listed in the *Vertical Range Adjustment* table.
9. Disable the calibrator output.
10. Configure the calibrator output impedance to the Input Impedance value from the *1 MΩ Compensation Attenuator Adjustment* table.
11. Configure the calibrator to output a 500 Hz symmetrical-to-ground square wave with amplitude equal to the Input value from the *1 MΩ Compensation Attenuator Adjustment* table.

12. Enable the calibrator output.
13. Wait 1 second for settling.
14. Call the niScope Cal Adjust Compensation VI with the following setting to adjust the 1 MΩ compensation attenuator:
    - **range**: the Vertical Range value from the *1 MΩ Compensation Attenuator Adjustment* table
15. Repeat steps 10 through 14 each configuration listed in the *1 MΩ Compensation Attenuator Adjustment* table.
16. Connect the calibrator test head to channel 1 of the PXIe-5160 and repeat steps 3 through 15, changing the value of the **channels** parameter from 0 to 1.

Note If you are adjusting the PXIe-5160 (4CH), proceed to the following steps. If you are adjusting the PXIe-5160 (2CH), go to step 19.

17. Connect the calibrator test head to channel 2 of the PXIe-5160 and repeat steps 3 through 15, changing the value of the **channels** parameter from 0 to 2.
18. Connect the calibrator test head to channel 3 of the PXIe-5160 and repeat steps 3 through 15, changing the value of the **channels** parameter from 0 to 3.

Note If you are adjusting the PXIe-5160 (4CH), go to step 33. If you are adjusting the PXIe-5160 (2CH), proceed to the following steps.

19. Connect the calibrator test head to the external trigger input of the PXIe-5160.
20. Configure the calibrator output impedance to the Input Impedance value from the *External Trigger Range Adjustment* table.
21. Configure the calibrator output voltage to the DC Input value from the *External Trigger Range Adjustment* table.
22. Enable the calibrator output.
23. Wait 1 second for settling.
24. Call the niScope Cal Adjust Range VI with the following settings to adjust the vertical range:
    - **channelName**: `VAL_EXTERNAL`
    - **range**: the Vertical Range value from the *External Trigger Range Adjustment* table
    - **stimulus**: the Input value from the *External Trigger Range Adjustment* table
25. Repeat steps 20 through 24 for each configuration listed in the *External Trigger Range Adjustment* table.
26. Disable the calibrator output.
27. Configure the calibrator output impedance to the Input Impedance value from the *1 MΩ Compensation Attenuator Adjustment* table.
28. Configure the calibrator to output a 500 Hz symmetrical-to-ground square wave with amplitude equal to the Input value from the *1 MΩ Compensation Attenuator Adjustment* table.
29. Enable the calibrator output.
30. Wait 1 second for settling.

31. Call the niScope Cal Adjust Compensation Attenuator VI with the following settings to adjust the 1 MΩ compensation attenuator:
    - **channelName**: `VAL_EXTERNAL`
    - **range**: the Vertical Range value from the *1 MΩ Compensation Attenuator Adjustment* table
32. Repeat steps 27 through 31 for each configuration listed in the *1 MΩ Compensation Attenuator Adjustment* table.
33. Disconnect or disable all inputs to the PXIe-5160.
34. Call the niScope Cal Adjust VI with the following settings to adjust the 1 MΩ offset range:
    - **range**: `0`
    - **stimulus**: `0`
35. Call the niScope Cal End VI to close the external calibration session and save the calibration date and temperature.
36. Call the niScope Initialize VI to obtain an NI-SCOPE session.
37. Self-calibrate the PXIe-5160 using the niScope Cal Self Calibrate VI.

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.

Worldwide Support and Services

The NI website is your complete resource for technical support. At *ni.com/support*, you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit *ni.com/services* for information about the services NI offers.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting *ni.com/certification*. If your product supports calibration, you can obtain the calibration certificate for your product at *ni.com/calibration*.

NI corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. NI also has offices located around the world. For support in the United States, create your service request at *ni.com/support* or dial 1 866 ASK MYNI (275 6964). For support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information.

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