CALIBRATION PROCEDURE

PXIe-5111

This document contains the verification and adjustment procedures for the PXIe-5111. Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

Required Software

Calibrating the PXIe-5111 requires you to install the following software on the calibration system:

- Compatible version of the NI-SCOPE instrument driver. NI recommends you use the latest version of NI-SCOPE for external calibration.
- Supported application development environment (ADE): LabVIEW

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:

- *PXIe-5110/5111/5113 Getting Started Guide*
- *NI High-Speed Digitizers Help*
- *PXIe-5111 Specifications*

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

Test Equipment

Refer to the following table for a list of necessary equipment and model recommendations for calibration of the PXIe-5111.

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

Table 1. PXIe-5111 Test Equipment

Equipment	Recommended Model	Where Used	Minimum Requirements
Oscilloscope calibrator	Fluke 9500B/600 with Fluke 9530 Active Head	Verifications: • DC accuracy Adjustment	Square wave generation: • Amplitude: 0.02 V_{pk-pk} to 20 V_{pk-pk} into 1 MΩ symmetrical to ground (0 V) • Frequency: 500 Hz • Aberrations: <2% of peak for the first 500 ns
			DC generation: • Amplitude: ±5.0 V into 50 Ω, ±118.0 V into 1 M Ω • Accuracy: ±(0.025% of output + 25 μV)

Table 1. PXIe-5111 Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
Power sensor	Rohde & Schwarz NRP6A	Test system characterization Verifications: • 50 Ω bandwidth	Power measurement: • Frequency range: 50 kHz to 326 MHz • Power range: -27 dBm to 10 dBm • VSWR: <1.11 • Absolute accuracy: – <0.048 dB for 50 kHz – <0.063 dB for 325.1 MHz • Relative accuracy at -4 dBm: <0.022 dB for 50 kHz to 326 MHz
Signal generator	Rohde & Schwarz SMA100A	Test system characterization Verifications: • 50 Ω bandwidth	Sine wave generation: • Amplitude: -22 dBm to 16 dBm • Frequency: 50 kHz to 326 MHz • Harmonics: <-30 dBc • Frequency accuracy: ±100 ppm
Power splitter	Aeroflex/Weinschel 1593	Test system characterization Verifications: • 50 Ω bandwidth	• Amplitude: -22 dBm to 16 dBm • Frequency: 50 kHz to 326 MHz • VSWR: <1.25
50 Ω BNC terminator (f)	Fairview Microwave ST3B-F	Test system characterization	• Impedance: 50 Ω • Frequency: DC to 326 MHz • VSWR: <1.1

Table 1. PXIe-5111 Test Equipment (Continued)

Equipment	Recommended Model	Where Used	Minimum Requirements
SMA (m)-to-SMA (m) cable	—	Test system characterization Verifications: • 50 Ω bandwidth	• Frequency: DC to 326 MHz • VSWR: <1.1 • Length: ≤1 m
SMA (f)-to-N (m) adapter	Fairview Microwave SM4226	Test system characterization Verifications: • 50 Ω bandwidth	• Frequency: DC to 326 MHz • VSWR: <1.05
BNC (f)-to-N (f) adapter	Fairview Microwave SM3526	Test system characterization Verifications: • 50 Ω bandwidth	• Frequency: DC to 326 MHz • VSWR: <1.1 • Impedance: 50 Ω
SMA (m)-to-BNC (m) adapter (×2)	Fairview Microwave SM4716	Test system characterization Verifications: • 50 Ω bandwidth	• Frequency: DC to 326 MHz • VSWR: <1.1 • Impedance: 50 Ω

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5111 meets published specifications:

- Allow all test instruments a warm-up time of at least the amount of time stated in their specifications documents.
- 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-5111. The warm-up time ensures that the PXIe-5111 and test instrumentation are at a stable operating temperature.
- 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-5111, including front panel connections and screws, are secure.
- Use shielded copper wire for all cable connections to the module. 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 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 standards 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-5111. NI uses these limits to determine whether the PXIe-5111 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-5111, 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.

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 balance of the output ports on your power splitter and amplitude loss through your power splitter.

The results of this step are used as a correction in the following procedures:

- *Verifying 50 Ω Bandwidth*

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 in the nonvolatile memory 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.

Notice 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 Balance and Loss

This procedure characterizes the amplitude balance of the two output ports of the power splitter and amplitude loss through the power splitter over a range of frequencies.

The results of the characterization are later used as a correction in the following procedures:

- *Verifying 50 Ω Bandwidth*

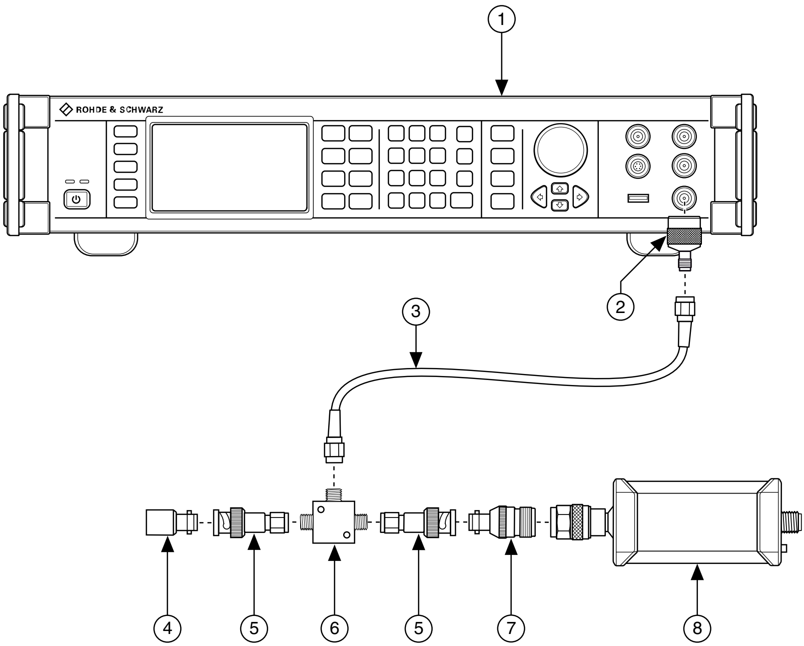
Table 2. Power Splitter Characterization

Config	Test Point: Frequency (MHz)
1	0.05
2	325.1

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.

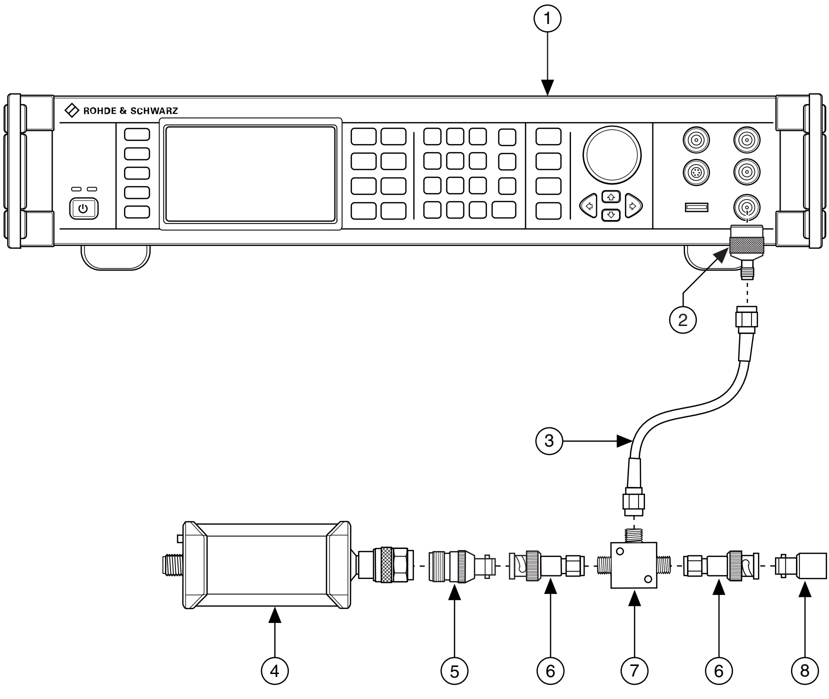


1. Signal generator
2. SMA (f)-to-N (m) adapter
3. SMA (m)-to-SMA (m) cable
4. 50 Ω BNC terminator (f)
5. SMA (m)-to-BNC (m) adapter
6. Power splitter
7. BNC (f)-to-N (f) adapter
8. Power sensor

8. Configure the power sensor with the following settings:
   - Power measurement: continuous average
   - Path selection: automatic
   - Averaging: automatic
   - Averaging resolution: 4 (0.001 dB)
   - Aperture: 20 ms
9. 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: 2.0 dBm

10. Configure the power sensor to correct for the *Test Point Frequency* value using the power sensor frequency correction function.
11. Wait 0.1 second for settling.
12. Use the power sensor to measure the power in dBm.
13. Repeat steps 9 through 12 for each configuration in the *Power Splitter Characterization* table, recording each result as *splitter output 2 power*, where each configuration has a corresponding value.
14. Disconnect the power sensor and 50 Ω BNC terminator (f) from splitter output 2 and splitter output 1.
15. Connect the power sensor to splitter output 1.
16. Connect the 50 Ω BNC terminator (f) to splitter output 2.

    The following figure illustrates the hardware setup.



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)

17. 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: 2.0 dBm
18. Configure the power sensor to correct for the *Test Point Frequency* value using the power sensor frequency correction function.
19. Wait 0.1 second for settling.
20. Use the power sensor to measure the power in dBm.
21. Repeat steps 17 through 20 for each configuration in the *Power Splitter Characterization* table, recording each result as *splitter output 1 power*, where each configuration has a corresponding value.
22. Calculate the splitter balance for each frequency point using the following equation:

    splitter balance = splitter output 2 power - splitter output 1 power
23. Calculate the splitter loss for each frequency point using the following equation:

    splitter loss = signal generator amplitude level - splitter output 2 power
24. Disconnect the 50 Ω BNC terminator (f) from splitter output 2. Refer to the remaining assembly as the *power sensor assembly*.

    Note Do not disassemble the power sensor assembly. The power splitter amplitude balance and loss characterization is invalid if the power sensor assembly has been disassembled.

    The power sensor assembly will be used in the following procedures:
    - *Verifying 50 Ω Bandwidth*

Verification

The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Verification of the PXIe-5111 is complete only after you have successfully completed all tests in this section using the *As-Found Limits*.

Refer to the following for the names, locations, and functions of the PXIe-5111 front panel connectors.

Figure 1. PXIe-5111 Front Panel

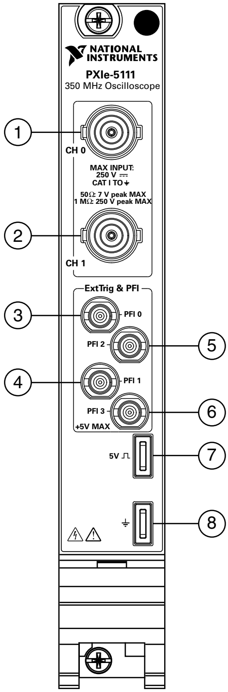


Table 3. Signal Descriptions

	Signal	Connector Type	Description
1	CH 0	BNC female	Analog input connection; digitizes data and triggers acquisitions.
2	CH 1		
3	PFI 0	HD-BNC female	PFI line for digital trigger input/output.
4	PFI 1		
5	PFI 2		
6	PFI 3		
7	5 V square wave	Probe compensation terminal	Generates a 5 V square wave for passive probe compensation.
8	Ground	Probe compensation terminal	Ground reference for passive probe compensation.

Verifying DC Accuracy

This procedure verifies the DC accuracy of the PXIe-5111 by comparing the voltage measured by the device to the value sourced by the voltage standard.

Caution Avoid touching the connections when generating a high voltage from the calibrator.

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

Table 4. DC Accuracy Verification

Config	Input Impedance (Ω)	Vertical Range (V_{pk-pk})	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
1	50	0.1 V	0	1.5	0.0475	±2.15	±1.098
2	50	0.1 V	0	3.0	0.0475	±2.15	±1.10275
3	50	0.1 V	0	1.5	-0.0475	±2.15	±1.098
4	50	0.1 V	0	3.0	-0.0475	±2.15	±1.10275
5	50	0.1 V	4.95	1.5	4.9975	±21.95	±10.008
6	50	0.1 V	4.95	3.0	4.9975	±21.95	±10.01275
7	50	0.1 V	-4.95	1.5	-4.9975	±21.95	±10.008
8	50	0.1 V	-4.95	3.0	-4.9975	±21.95	±10.01275
9	50	0.2 V	0	1.5	0.095	±4.1	±2.1215
10	50	0.2 V	0	3.0	0.095	±4.1	±2.0455
11	50	0.2 V	0	1.5	-0.095	±4.1	±2.1215
12	50	0.2 V	0	3.0	-0.095	±4.1	±2.0455
13	50	0.2 V	4.9	1.5	4.995	±23.7	±10.9415
14	50	0.2 V	4.9	3.0	4.995	±23.7	±10.8655
15	50	0.2 V	-4.9	1.5	-4.995	±23.7	±10.9415
16	50	0.2 V	-4.9	3.0	-4.995	±23.7	±10.8655
17	50	0.4 V	0	1.5	0.19	±8	±4.119
18	50	0.4 V	0	3.0	0.19	±8	±4.043

Table 4. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range ($V_{pk\text{-}pk}$)	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
19	50	0.4 V	0	1.5	-0.19	±8	±4.119
20	50	0.4 V	0	3.0	-0.19	±8	±4.043
21	50	0.4 V	4.8	1.5	4.99	±27.2	±12.759
22	50	0.4 V	4.8	3.0	4.99	±27.2	±12.683
23	50	0.4 V	-4.8	1.5	-4.99	±27.2	±12.759
24	50	0.4 V	-4.8	3.0	-4.99	±27.2	±12.683
25	50	1 V	0	1.5	0.475	±19.7	±9.2525
26	50	1 V	0	3.0	0.475	±19.7	±9.7275
27	50	1 V	0	1.5	-0.475	±19.7	±9.2525
28	50	1 V	0	3.0	-0.475	±19.7	±9.7275
29	50	1 V	4.5	1.5	4.975	±37.7	±17.3525
30	50	1 V	4.5	3.0	4.975	±37.7	±17.8275
31	50	1 V	-4.5	1.5	-4.975	±37.7	±17.3525
32	50	1 V	-4.5	3.0	-4.975	±37.7	±17.8275
33	50	2 V	0	1.5	0.95	±39.2	±19.17
34	50	2 V	0	3.0	0.95	±39.2	±19.835
35	50	2 V	0	1.5	-0.95	±39.2	±19.17
36	50	2 V	0	3.0	-0.95	±39.2	±19.835
37	50	2 V	4	1.5	4.95	±55.2	±26.37
38	50	2 V	4	3.0	4.95	±55.2	±27.035
39	50	2 V	-4	1.5	-4.95	±55.2	±26.37
40	50	2 V	-4	3.0	-4.95	±55.2	±27.035
41	50	4 V	0	1.5	1.9	±78.2	±38.72

Table 4. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (V_{pk-pk})	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
42	50	4 V	0	3.0	1.9	±78.2	±38.15
43	50	4 V	0	1.5	-1.9	±78.2	±38.72
44	50	4 V	0	3.0	-1.9	±78.2	±38.15
45	50	4 V	3	1.5	4.9	±90.2	±44.12
46	50	4 V	3	3.0	4.9	±90.2	±43.55
47	50	4 V	-3	1.5	-4.9	±90.2	±44.12
48	50	4 V	-3	3.0	-4.9	±90.2	±43.55
49	50	10 V	0	1.5	4.75	±195.2	±100.125
50	50	10 V	0	3.0	4.75	±195.2	±95.375
51	50	10 V	0	1.5	-4.75	±195.2	±100.125
52	50	10 V	0	3.0	-4.75	±195.2	±95.375
53	50	10 V	2	1.5	5	±182.2	±98.5
54	50	10 V	2	3.0	5	±182.2	±95.5
55	50	10 V	-2	1.5	-5	±182.2	±98.5
56	50	10 V	-2	3.0	-5	±182.2	±95.5
57	1 M	0.1 V	0	1.5	0.0475	±2.15	±1.2975
58	1 M	0.1 V	0	3.0	0.0475	±2.15	±1.2975
59	1 M	0.1 V	0	1.5	-0.0475	±2.15	±1.2975
60	1 M	0.1 V	0	3.0	-0.0475	±2.15	±1.2975
61	1 M	0.1 V	5	1.5	5.0475	±22.15	±10.2975
62	1 M	0.1 V	5	3.0	5.0475	±22.15	±10.2975
63	1 M	0.1 V	-5	1.5	-5.0475	±22.15	±10.2975
64	1 M	0.1 V	-5	3.0	-5.0475	±22.15	±10.2975

Table 4. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (V_{pk-pk})	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
65	1 M	0.2 V	0	1.5	0.095	±4.1	±2.435
66	1 M	0.2 V	0	3.0	0.095	±4.1	±2.435
67	1 M	0.2 V	0	1.5	-0.095	±4.1	±2.435
68	1 M	0.2 V	0	3.0	-0.095	±4.1	±2.435
69	1 M	0.2 V	5	1.5	5.095	±24.1	±11.435
70	1 M	0.2 V	5	3.0	5.095	±24.1	±11.435
71	1 M	0.2 V	-5	1.5	-5.095	±24.1	±11.435
72	1 M	0.2 V	-5	3.0	-5.095	±24.1	±11.435
73	1 M	0.4 V	0	1.5	0.19	±8	±4.67
74	1 M	0.4 V	0	3.0	0.19	±8	±4.67
75	1 M	0.4 V	0	1.5	-0.19	±8	±4.67
76	1 M	0.4 V	0	3.0	-0.19	±8	±4.67
77	1 M	0.4 V	5	1.5	5.19	±28	±13.67
78	1 M	0.4 V	5	3.0	5.19	±28	±13.67
79	1 M	0.4 V	-5	1.5	-5.19	±28	±13.67
80	1 M	0.4 V	-5	3.0	-5.19	±28	±13.67
81	1 M	1 V	0	1.5	0.475	±19.7	±11.675
82	1 M	1 V	0	3.0	0.475	±19.7	±11.675
83	1 M	1 V	0	1.5	-0.475	±19.7	±11.675
84	1 M	1 V	0	3.0	-0.475	±19.7	±11.675
85	1 M	1 V	20	1.5	20.475	±99.7	±47.675
86	1 M	1 V	20	3.0	20.475	±99.7	±47.675
87	1 M	1 V	-20	1.5	-20.475	±99.7	±47.675

Table 4. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (V_{pk-pk})	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
88	1 M	1 V	-20	3.0	-20.475	±99.7	±47.675
89	1 M	2 V	0	1.5	0.95	±39.2	±23.35
90	1 M	2 V	0	3.0	0.95	±39.2	±23.35
91	1 M	2 V	0	1.5	-0.95	±39.2	±23.35
92	1 M	2 V	0	3.0	-0.95	±39.2	±23.35
93	1 M	2 V	20	1.5	20.95	±119.2	±59.35
94	1 M	2 V	20	3.0	20.95	±119.2	±59.35
95	1 M	2 V	-20	1.5	-20.95	±119.2	±59.35
96	1 M	2 V	-20	3.0	-20.95	±119.2	±59.35
97	1 M	4 V	0	1.5	1.9	±78.2	±46.7
98	1 M	4 V	0	3.0	1.9	±78.2	±46.7
99	1 M	4 V	0	1.5	-1.9	±78.2	±46.7
100	1 M	4 V	0	3.0	-1.9	±78.2	±46.7
101	1 M	4 V	20	1.5	21.9	±158.2	±82.7
102	1 M	4 V	20	3.0	21.9	±158.2	±82.7
103	1 M	4 V	-20	1.5	-21.9	±158.2	±82.7
104	1 M	4 V	-20	3.0	-21.9	±158.2	±82.7
105	1 M	10 V	0	1.5	4.75	±195.2	±116.75
106	1 M	10 V	0	3.0	4.75	±195.2	±116.75
107	1 M	10 V	0	1.5	-4.75	±195.2	±116.75
108	1 M	10 V	0	3.0	-4.75	±195.2	±116.75
109	1 M	10 V	100	1.5	104.75	±595.2	±296.75
110	1 M	10 V	100	3.0	104.75	±595.2	±296.75

Table 4. DC Accuracy Verification (Continued)

Config	Input Impedance (Ω)	Vertical Range (V_{pk-pk})	Vertical Offset (V)	Sample Rate (GS/s)	Test Points (V)	As-Found Limits (mV)	As-Left Limits (mV)
111	1 M	10 V	-100	1.5	-104.75	±595.2	±296.75
112	1 M	10 V	-100	3.0	-104.75	±595.2	±296.75
113	1 M	20 V	0	1.5	9.5	±390.2	±233.5
114	1 M	20 V	0	3.0	9.5	±390.2	±233.5
115	1 M	20 V	0	1.5	-9.5	±390.2	±233.5
116	1 M	20 V	0	3.0	-9.5	±390.2	±233.5
117	1 M	20 V	100	1.5	109.5	±790.2	±413.5
118	1 M	20 V	100	3.0	109.5	±790.2	±413.5
119	1 M	20 V	-100	1.5	-109.5	±790.2	±413.5
120	1 M	20 V	-100	3.0	-109.5	±790.2	±413.5
121	1 M	40 V	0	1.5	19	±780.2	±467
122	1 M	40 V	0	3.0	19	±780.2	±467
123	1 M	40 V	0	1.5	-19	±780.2	±467
124	1 M	40 V	0	3.0	-19	±780.2	±467
125	1 M	40 V	100	1.5	119	±1880.2	±917
126	1 M	40 V	100	3.0	119	±1880.2	±917
127	1 M	40 V	-100	1.5	-119	±1880.2	±917
128	1 M	40 V	-100	3.0	-119	±1880.2	±917

1. Connect the calibrator test head to channel 0 of the PXIe-5111.
2. Configure the PXIe-5111 with the following settings:
   - Input impedance: the Input Impedance value from the *DC Accuracy Verification* table.
   - Maximum input frequency: 350 MHz
   - Vertical coupling: DC coupling
   - 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: the Sample Rate value from the *DC Accuracy Verification* table.

- Minimum number of points: 8,500,000 samples
- NI-SCOPE scalar measurement: **Voltage Average**

3. Configure the calibrator output impedance to match the impedance of the PXIe-5111.
4. Configure the calibrator to output the Test Point value from the *DC Accuracy Verification* table.
5. Enable the calibrator output.
6. Wait the required amount of time for settling and then record the measured voltage.
   - For the first configuration from step 2 with 1 MΩ input impedance, wait two seconds for settling.
   - For all other configurations, wait one second for settling.
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. Repeat steps 2 through 8 for each configuration listed in the *DC Accuracy Verification* table.
10. Disable the calibrator output.
11. Connect the calibrator test head to channel 1 of the PXIe-5111 and repeat steps 2 through 9 for each configuration listed in the *DC Accuracy Verification* table.
12. Disable the calibrator output.

Verifying 50 Ω Bandwidth

Follow this procedure to verify the 50 Ω analog bandwidth accuracy of the PXIe-5111 by generating a sine wave and comparing the amplitude measured by the PXIe-5111 to the amplitude measured by the power sensor.

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

Table 5. 50 Ω Bandwidth Verification

Config	Sample Rate (S/s)	Vertical Range (V_{pk-pk})	Test Point		As-Found Limits (dB)	As-Left Limits (dB)
			Frequency (MHz)	Amplitude (dBm)		
1	1.5 G	0.04 V	0.05	-26.98	REF	REF
2	1.5 G	0.04 V	325.1	-26.98	-3.0 to 1.3	-2.6 to 1.3
3	3 G	0.04 V	0.05	-26.98	REF	REF
4	3 G	0.04 V	325.1	-26.98	-3.0 to 1.3	-2.6 to 1.3
5	1.5 G	0.1 V	0.05	-19.02	REF	REF

Table 5. 50 Ω Bandwidth Verification (Continued)

Config	Sample Rate (S/s)	Vertical Range ($V_{pk\text{-}pk}$)	Test Point		As-Found Limits (dB)	As-Left Limits (dB)
			Frequency (MHz)	Amplitude (dBm)		
6	1.5 G	0.1 V	325.1	-19.02	-3.0 to 1.3	-2.6 to 1.3
7	3 G	0.1 V	0.05	-19.02	REF	REF
8	3 G	0.1 V	325.1	-19.02	-3.0 to 1.3	-2.6 to 1.3
9	1.5 G	0.2 V	0.05	-13.00	REF	REF
10	1.5 G	0.2 V	325.1	-13.00	-3.0 to 1.3	-2.6 to 1.3
11	3 G	0.2 V	0.05	-13.00	REF	REF
12	3 G	0.2 V	325.1	-13.00	-3.0 to 1.3	-2.6 to 1.3
13	1.5 G	0.4 V	0.05	-6.98	REF	REF
14	1.5 G	0.4 V	325.1	-6.98	-3.0 to 1.3	-2.6 to 1.3
15	3 G	0.4 V	0.05	-6.98	REF	REF
16	3 G	0.4 V	325.1	-6.98	-3.0 to 1.3	-2.6 to 1.3
17	1.5 G	1 V	0.05	-0.98	REF	REF
18	1.5 G	1 V	325.1	-0.98	-3.0 to 1.3	-2.6 to 1.3
19	3 G	1 V	0.05	-0.98	REF	REF
20	3 G	1 V	325.1	-0.98	-3.0 to 1.3	-2.6 to 1.3
21	1.5 G	2 V	0.05	7.0	REF	REF
22	1.5 G	2 V	325.1	7.0	-3.0 to 1.3	-2.6 to 1.3
23	3 G	2 V	0.05	7.0	REF	REF
24	3 G	2 V	325.1	7.0	-3.0 to 1.3	-2.6 to 1.3
25	1.5 G	4 V	0.05	9.0	REF	REF
26	1.5 G	4 V	325.1	9.0	-3.0 to 1.3	-2.6 to 1.3
27	3 G	4 V	0.05	9.0	REF	REF
28	3 G	4 V	325.1	9.0	-3.0 to 1.3	-2.6 to 1.3
29	1.5 G	10 V	0.05	9.0	REF	REF

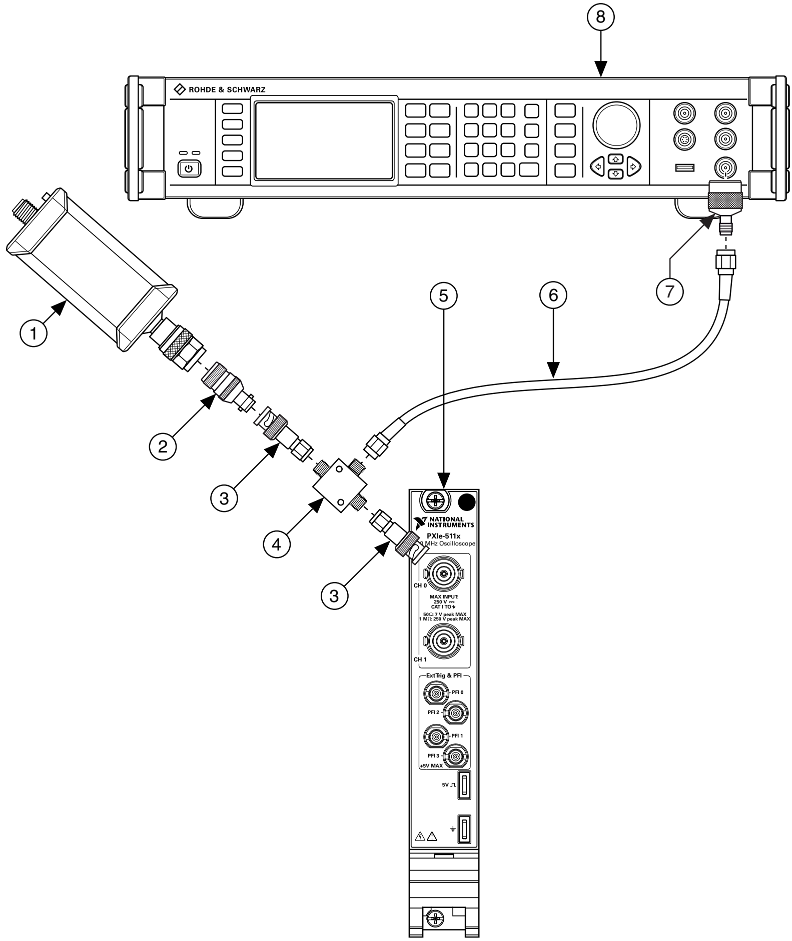
Table 5. 50 Ω Bandwidth Verification (Continued)

Config	Sample Rate (S/s)	Vertical Range (V_{pk-pk})	Test Point		As-Found Limits (dB)	As-Left Limits (dB)
			Frequency (MHz)	Amplitude (dBm)		
30	1.5 G	10 V	325.1	9.0	-3.0 to 1.3	-2.6 to 1.3
31	3 G	10 V	0.05	9.0	REF	REF
32	3 G	10 V	325.1	9.0	-3.0 to 1.3	-2.6 to 1.3

1. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to channel 0 of the PXIe-5111.

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.



1. Power sensor
2. BNC (f)-to-N (f) adapter
3. SMA (m)-to-BNC (m) adapter
4. Power splitter
5. PXIe-5111
6. SMA (m)-to-SMA (m) cable
7. SMA (f)-to-N (m) adapter
8. Signal generator

2. Configure the power sensor with the following settings:
   - Power measurement: continuous average
   - Path selection: automatic
   - Averaging: automatic
   - Averaging resolution: 4 (0.001 dB)
   - Aperture: 20 ms

3. Configure the PXIe-5111 with the following settings:
   - Input impedance: 50 Ω
   - Maximum input frequency: 350 MHz
   - Vertical offset: 0 V
   - Vertical coupling: DC coupling
   - Vertical range: the Vertical Range value from the *50 Ω Bandwidth Verification* table
   - Sample rate: the Sample Rate from the *50 Ω Bandwidth Verification* table
   - Minimum number of points: 1,048,576 samples
4. Configure the signal generator to generate a sine waveform with the following characteristics into a 50 Ω load:
   - Frequency: the Test Point Frequency value from the *50 Ω Bandwidth Verification* table
   - Amplitude: the Test Point Amplitude value from the *50 Ω Bandwidth Verification* table

   Note Select the *splitter loss* value from the list of test points from the *Test System Characterization* section for the current Test Point Frequency.
5. Configure the power sensor to correct for the Test Point Frequency using the power sensor frequency correction function.
6. Wait 0.1 second for settling.
7. Use the power sensor to measure the power in dBm. Record the result as *measured input power*.
8. Calculate the corrected input power using the following equation:

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

   Note Select the *splitter balance* value from the list of test points from the *Test System Characterization* section for the current Test Point Frequency.
9. Use the PXIe-5111 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*.
10. 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 13.
11. Calculate the *power reference* using the following equation:

    power reference = *device input power* - *corrected input power*
12. Go to step 15. The power error is not calculated for this configuration.
13. Calculate the *power error* using the following equation:

    power error = *device input power* - *corrected input power* - *power reference*
14. Compare the power error to the appropriate Limit from the *50 Ω Bandwidth Verification* table.
15. Repeat steps 2 through 14 for each configuration in the *50 Ω Bandwidth Verification* table.

16. Connect splitter output 2 of the power sensor assembly to channel 1 of the PXIe-5111 and repeat steps 2 through 14 for each configuration listed in the *50 Ω Bandwidth Verification* table.
17. Disable the signal generator output.

Adjustment

This section describes the steps needed to adjust the PXIe-5111 to meet published specifications.

Adjusting the PXIe-5111

Before performing this procedure, complete the following:

- Complete the *Test System Characterization* procedures;
- Calculate the splitter loss of your power splitter; and
- Ensure the channels of the PXIe-5111 are not connected.

Complete the following steps to adjust the PXIe-5111.

1. Call the ni5110 Ext Cal API.lvlib:Open Ext Cal Session VI to obtain an external calibration session.

   To perform an adjustment, you must specify the **calibration password**. The default calibration password is `NI`.
2. Complete the *Adjusting 1 MΩ Compensation Attenuator* procedure on channel 0.
3. Complete the *Adjusting 1 MΩ DC Reference* procedure on channel 0.
4. Complete the *Adjusting 50 Ω DC Reference* procedure on channel 0.
5. Complete the *Adjusting 1 MΩ Compensation Attenuator* procedure on channel 1.
6. Complete the *Adjusting 1 MΩ DC Reference* procedure on channel 1.
7. Complete the *Adjusting 50 Ω DC Reference* procedure on channel 1.
8. Call the ni5110 Ext Cal API.lvlib:Close Ext Cal Session VI with the following settings to close the external calibration session:

   action: Set this parameter to **Commit** to store the new calibration constants, adjustment time, adjustment date, and adjustment temperature to the nonvolatile memory of the oscilloscope. If any errors occurred that were not corrected during any of the external adjustment steps, or if you want to abort the operation, set this parameter to **Cancel** to discard the new calibration constants without changing any of the calibration data stored in the nonvolatile memory of the oscilloscope.
9. Call the NI-SCOPE Initialize VI to obtain an NI-SCOPE session.
10. Use the Self Calibrate VI to self-calibrate the PXIe-5111.
11. Call the Close VI to close the NI-SCOPE session.

Adjusting 1 MΩ Compensation Attenuator

Follow this procedure to adjust the 1 MΩ compensation attenuator of the PXIe-5111.

1. Connect the calibrator test head to the specified channel of the PXIe-5111.

2. Call the ni5110 Ext Cal API.lvlib:Compensated Attenuator Cal Initialize VI with the following settings:
   - **channel**: the specified channel
   - **input impedance**: 1 MΩ
3. Call the ni5110 Ext Cal API.lvlib:Compensated Attenuator Configure VI to obtain the amplitude and frequency of the square waveform to generate, and configure the calibrator with the following settings:
   - Output: square waveform with symmetrical polarity about ground
   - Amplitude: the specified value
   - Frequency: the specified value
   - Load impedance: 1 MΩ
4. Enable the calibrator output if it is not already enabled.
5. Wait 1 second for settling.
6. Call the ni5110 Ext Cal API.lvlib:Compensated Attenuator Cal Adjust VI with the following settings:
   - **frequency generated (Hz)**: the frequency of the square waveform present on the specified channel of the PXIe-5111
   - **amplitude generated (Vpk-pk)**: the amplitude of the square waveform present on the specified channel of the PXIe-5111
7. Repeat steps 3 through 6 until the **compensated attenuator cal complete** indicator of the ni5110 Ext Cal API.lvlib:Compensated Attenuator Cal Adjust VI returns `TRUE`.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5111* task.

Adjusting 1 MΩ DC Reference

Follow this procedure to adjust the DC gain and offset of the 1 MΩ DC reference of the PXIe-5111.

Caution Avoid touching the connections when generating a high voltage from the calibrator.

1. Connect the calibrator test head to the specified channel of the PXIe-5111.
2. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Initialize VI with the following settings:
   - **channel**: the specified channel
   - **input impedance**: 1 MΩ
3. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Configure VI to obtain the DC voltage to generate, and configure the calibrator with the following settings:
   - Output: the specified DC voltage
   - Load impedance: 1 MΩ
4. Enable the calibrator output if it is not already enabled.
5. Wait 1 second for settling.

6. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Adjust VI with the following settings:
   - **actual voltage generated (V)**: the DC voltage present on the specified channel of the PXIe-5111
7. Repeat steps 3 through 6 until the **dc reference cal complete** indicator of the ni5110 Ext Cal API.lvlib:DC Reference Cal Adjust VI returns `TRUE`.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5111* task.

Adjusting 50 Ω DC Reference

Follow this procedure to adjust the DC gain and offset of the 50 Ω DC reference of the PXIe-5111.

1. Connect the calibrator test head to the specified channel of the PXIe-5111.
2. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Initialize VI with the following settings:
   - **channel**: the specified channel
   - **input impedance**: 50 Ω
3. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Configure VI to obtain the DC voltage to generate, and configure the calibrator with the following settings:
   - Output: the specified DC voltage
   - Load impedance: 50 Ω
4. Enable the calibrator output if it is not already enabled.
5. Wait 1 second for settling.
6. Call the ni5110 Ext Cal API.lvlib:DC Reference Cal Adjust VI with the following settings:
   - **actual voltage generated (V)**: the DC voltage present on the specified channel of the PXIe-5111
7. Repeat steps 3 through 6 until the **dc reference cal complete** indicator of the ni5110 Ext Cal API.lvlib:DC Reference Cal Adjust VI returns `TRUE`.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5111* task.

Reverification

Repeat the *Verification* section to determine the as-left status of the PXIe-5111.

Note If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your PXIe-5111 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 PXIe-5111 verification.

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

Call the ni5110 Ext Cal Utilities.lvlib:Set External Cal Verification Date 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`.

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.

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.

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit *ni.com/product-certifications*, search by model number, and click the appropriate link.

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