CALIBRATION PROCEDURE

PXIe-5185/5186

This document contains information for calibrating National Instruments PXIe-5185/5186 digitizers. The PXIe-5185/5186 digitizers were developed jointly between Tektronix and National Instruments. The devices use Tektronix, Enabling Technology™ to deliver wide analog bandwidth and high-speed sampling on the National Instruments Synchronization and Memory Core (SMC) technology with TClk synchronization.

For more information on calibration, visit `ni.com/calibration`.

Contents

NATIONAL INSTRUMENTS™

50 Ω and 1 MΩ Devices

Early versions of the PXIe-5185/5186 support only 50 Ω input impedance. Check the part number of your device to see what input impedance is supported by your device:

- PXIe-5185 module part numbers 199363*x*-0*z*L and PXIe-5186 module part numbers 193537*x*-0*z*L (where *x* is any letter and *z* is any number) only support 50 Ω input impedance. These devices require NI-SCOPE 3.8.7 or later.
- PXIe-5185 module part numbers 152962*x*-0*z*L and PXIe-5186 module part numbers 152961*x*-0*z*L (where *x* is any letter and *z* is any number) support both 50 Ω and 1 MΩ input impedance. These devices require NI-SCOPE 3.9.6 or later.

50 Ω devices need to be tested for only 50 Ω input impedance because they have no 1 MΩ input.

Software Requirements

Calibrating the PXIe-5185/5186 requires installing the NI-SCOPE instrument driver on the calibration system. Refer to the *50 Ω and 1 MΩ Devices* section to see which driver version your device requires. You can download the NI-SCOPE instrument driver from the NI website at `ni.com/downloads/drivers`. NI-SCOPE supports programming a self-calibration and an external calibration in multiple application development environments (ADEs). When you install NI-SCOPE, you need to install support for only the ADE that you intend to use.

LabVIEW support is in the `niScope.llb` file, and all calibration functions appear in the NI-SCOPE Calibration palette. For LabWindows™/CVI™ users, the NI-SCOPE function panel, `niScope.fp`, provides access to the available functions.

For the locations of files you may need to calibrate your device, refer to the *NI-SCOPE Readme*, which is available on the NI-SCOPE media.

Related Documentation

For information about NI-SCOPE and the PXIe-5185/5186, consult the following documents:

- *NI High-Speed Digitizers Getting Started Guide*—provides instructions for installing and configuring the PXIe-5185/5186.
- *NI High-Speed Digitizers Help*—includes detailed information about the PXIe-5185/5186 and NI-SCOPE VIs and functions and information about creating applications using NI-SCOPE.
- *PXIe-5185 Specifications*—provides the published specification values for the PXIe-5185.
- *PXIe-5186 Specifications*—provides the published specification values for the PXIe-5186.

These documents are installed with NI-SCOPE. You can also find the latest versions of the documentation at `ni.com/manuals`.

Password

The default calibration password is `NI`.

Calibration Interval

NI recommends a calibration interval of one year to ensure the warranted specifications for the PXIe-5185/5186 are met.

Test Equipment

National Instruments recommends that you use the equipment in Table 1 for calibrating the PXIe-5185/5186. If you do not have the recommended instruments, use these specifications to select a substitute calibration standard.

Table 1. PXIe-5185/5186 Test Equipment

Equipment	Recommended Model	Requirements
Oscilloscope calibrator	Fluke 9500B/3200	DC Output Range: 2 V to -2 V into 50 Ω, 6.5V to -6.5 V into 1 MΩ DC Voltage Accuracy: DC ±0.3% of output into 50 Ω and 1 MΩ Leveled Sine Wave Amplitude Range: 0.9 V_{pk-pk} into 50 Ω Leveled Sine Wave Frequency Accuracy: ±4 ppm Square Wave: 8.0 V_{pk-pk} at 100 kHz into 1 MΩ
3.2 GHz output module	Fluke 9530 Active Head	
Power sensor	Rohde & Schwarz NRP-Z91	Range: -26 dBm to 10 dBm Frequency range: 50 kHz to 5.0 GHz Absolute power accuracy: • <0.048 dB at 50 kHz • <0.063 dB at 5.0 GHz Relative power accuracy: • <0.022 dB at 50 kHz • <0.031 dB for frequencies > 50 kHz and < 5.0 GHz VSWR: <1.11

Table 1. PXIe-5185/5186 Test Equipment (Continued)

Equipment	Recommended Model	Requirements
Signal generator	Rohde & Schwarz SMA100A	Frequency range: 50 kHz to 5.0 GHz Amplitude range: -20 dBm to 16 dBm Harmonics: <-30 dBc
Power splitter	Aeroflex/Weinschel	Frequency range: 50 kHz to 5.0 GHz VSWR: <1.1 Amplitude tracking: <0.5 dB
50 Ω BNC terminator (f)	Fairview Microwave ST3B-F	Frequency range: DC to 0.5 GHz VSWR: <1.2 Impedance: 50 Ω
50 Ω SMA terminator (f)	Fairview Microwave ST1852F	Frequency range: DC to 5.0 GHz VSWR: <1.1 Impedance: 50 Ω
SMA (m)-to-SMA (m) cable	—	Frequency range: DC to 5.0 GHz VSWR: <1.1 Length: ≤1 meter
SMA (m)-to-BNC (f)	Fairview Microwave SM4723	Frequency range: DC to 100 kHz Impedance: 50 Ω
SMA (f)-to-N (m) adapter	Fairview Microwave SM4226	Frequency range: DC to 5.0 GHz VSWR: <1.05 Impedance: 50 Ω
SMA (f)-to-N (f) adapter	Fairview Microwave SM4236	Frequency range: DC to 5.0 GHz VSWR: <1.15 Impedance: 50 Ω
SMA (m)-to-SMA (m) adapter (×2)	Fairview Microwave SM4960	Frequency range: DC to 5.0 GHz VSWR: <1.1 Impedance: 50 Ω

Table 1. PXIe-5185/5186 Test Equipment (Continued)

Equipment	Recommended Model	Requirements
BNC (f)-to-N (f) adapter	Fairview Microwave SM3526	Frequency range: DC to 0.5 GHz VSWR: <1.2 Impedance: 50 Ω
SMA (m)-to-BNC (m) adapter (×2)	Fairview Microwave SM4716	Frequency range: DC to 0.5 GHz VSWR: <1.3 Impedance: 50 Ω
BNC feed-through terminator	Fairview Microwave ST0150	Frequency range: DC to 0.5 GHz VSWR: • <1.1 at 100 MHz • <1.25 at 500 MHz Impedance: 50 Ω
PXI Express Chassis	Any NI PXI Express chassis that meets the requirements	100 MHz reference clock for PXI Express slots with an accuracy of ±25ppm

Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Verify that all connections to the device, including front panel connections, are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pairs wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 ±3 °C. The device temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm up time of at least 25 minutes to ensure that the measurement circuitry is at a stable operating temperature.
- Ensure that the PXI Express chassis fan speed is set to HIGH, that the fan filters are clean if present, and that the empty slots contain PXI chassis slot blockers and filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.
- Plug the chassis/PC and the calibrator into the same power strip to avoid ground loops.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).
2. *Self-Calibration*—Adjust the self-calibration constants of the device.
3. *Verification*—Verify the existing operation of the device. This step confirms whether the device is operating within the published specifications prior to adjustment.
4. *Adjustment*—Perform an external adjustment of the device that adjusts the calibration constants of the device. The adjustment procedure automatically stores the calibration date 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.

These procedures are described in more detail in the following sections.

Initial Setup

Refer to the *NI High-Speed Digitizers Getting Started Guide* for information about how to install the software and hardware and how to configure the device in MAX.

Self-Calibration

The PXIe-5185/5186 includes precise internal circuits and references used during self-calibration to adjust for any errors caused by short-term fluctuations in the environment.

Note Allow a 25 minute warm-up period before you begin self-calibration.

Self-calibration can be initiated from MAX, NI-SCOPE Soft Front Panel (SFP), or NI-SCOPE.

MAX

To initiate self-calibration from MAX, complete the following steps:

1. Launch MAX.
2. Select **My System»Devices and Interfaces**.
3. Select the device that you want to calibrate.
4. Initiate self-calibration in one of the following ways:
   - Click **Self-Calibrate** in the upper right corner of the window.
   - Right-click the device name under Devices and Interfaces, and select **Self-Calibrate** from the drop-down menu.

NI-SCOPE Soft Front Panel

To initiate self-calibration from the NI-SCOPE SFP, complete the following steps:

1. Launch the NI-SCOPE SFP.

2. Select the device you want to calibrate using the Device Configuration dialog box by selecting **Edit»Device Configuration**.
3. Launch the Calibration dialog box by selecting **Utility»Self Calibration**.
4. Click **OK** to begin self-calibration.

NI-SCOPE

To self-calibrate the digitizer programmatically using NI-SCOPE, complete the following steps:

1. Open a session and obtain a session handle using the niScope Initialize VI.
2. Self-calibrate the digitizer using niScope Cal Self Calibrate VI.
3. End the session using the niScope Close VI.

External Calibration

External calibration involves both verification and adjustment. Verification is the process of testing the device to ensure that it is within certain specifications. You can use verification to ensure that the adjustment process was successful.

Adjustment is the process of measuring and compensating for device performance to improve the input accuracy. Performing an adjustment updates the calibration date, resetting the calibration interval. The device is warranted to meet or exceed its published specifications for the duration of the calibration interval.

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 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

These procedures characterize the amplitude imbalance of the two output ports of the power splitter over a range of frequencies. You must perform separate characterizations for the two different connector types used in verification.

SMA Adapters

This procedure characterizes the power splitter imbalance when using SMA adapters. The results of this characterization are later used as a correction in the *Verifying 50 Ω AC Amplitude Accuracy and Bandwidth* procedure.

Table 2. Power Splitter Characterization for SMA Configuration

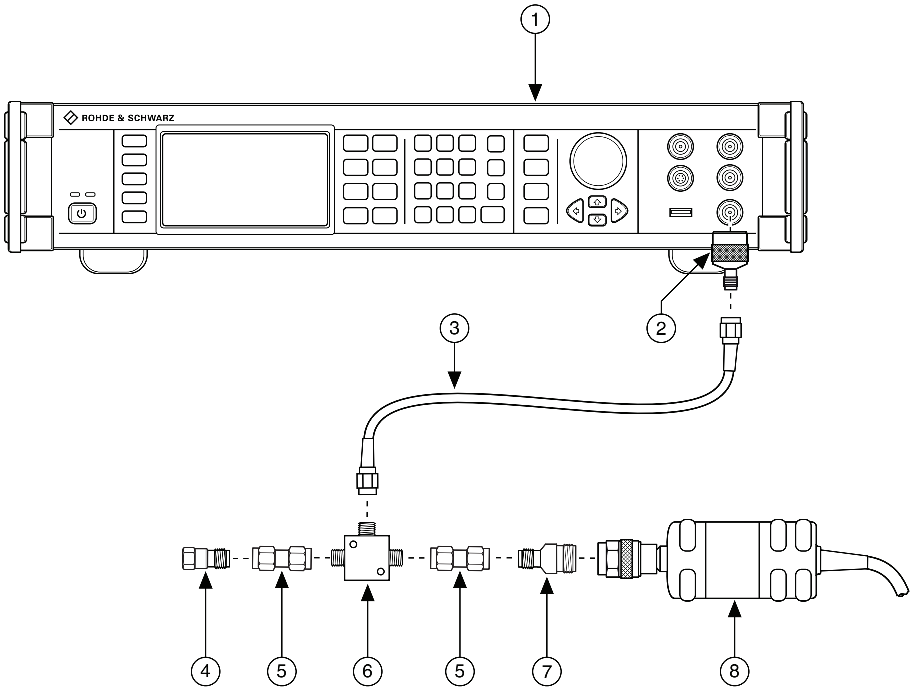
Configuration	Test Point		
	Impedance	**Frequency (MHz)**	**Amplitude (dBm)**
1	50 Ω	0.05	-0.5
2	50 Ω (PXIe-5185 only)	3000	-0.5
3	50 Ω (PXIe-5186 only)	5000	-0.5

1. Connect the 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 (SMA)



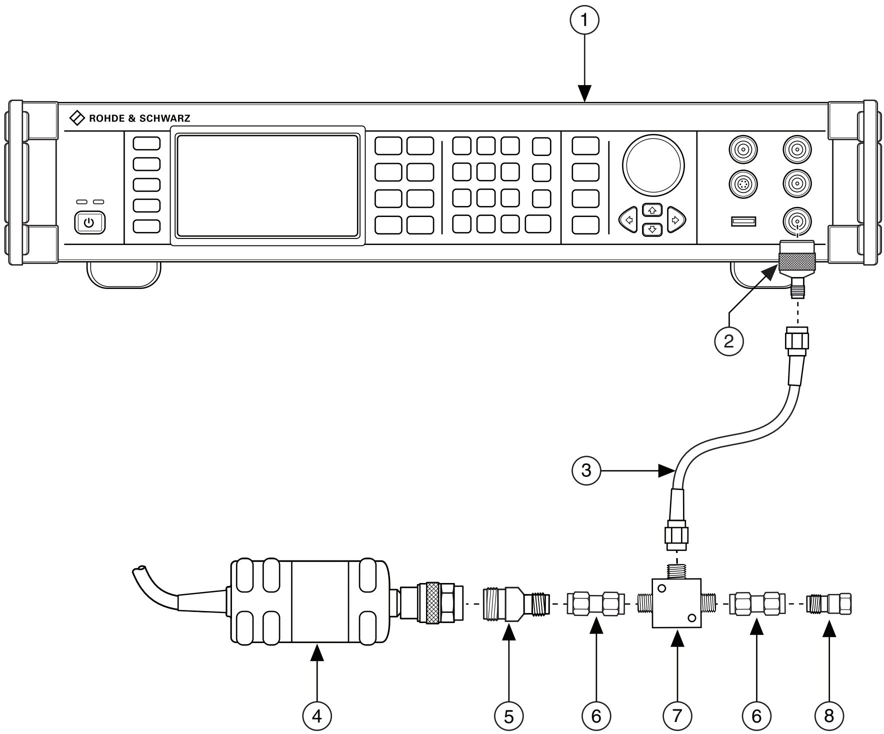
1	Signal Generator	5	SMA (m)-to-SMA (m) Adapter
2	SMA (f)-to-N (m) Adapter	6	Power Splitter
3	SMA (m)-to-SMA (m) Cable	7	SMA (f)-to-N (f) Adapter
4	50 Ω SMA Terminator (f)	8	Power Sensor

8. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the Test Point Frequency value from Table 2
   - Amplitude level: the Test Point Amplitude value from Table 2
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 Table 2, 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 (SMA)



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

15. Configure the signal generator to generate a sine waveform with the following characteristics:
    - Frequency: the *Test Point Frequency* value from Table 2
    - Amplitude level: the *Test Point Amplitude* value from Table 2
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 Table 2, 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 50 Ω AC Amplitude Accuracy and Bandwidth* procedure.

BNC Adapters

This procedure characterizes the power splitter imbalance when using BNC adapters. The results of this characterization are later used as a correction in the *Verifying 1 MΩ AC Amplitude Accuracy and Bandwidth* procedure.

Table 3. Power Splitter Characterization with BNC Configuration

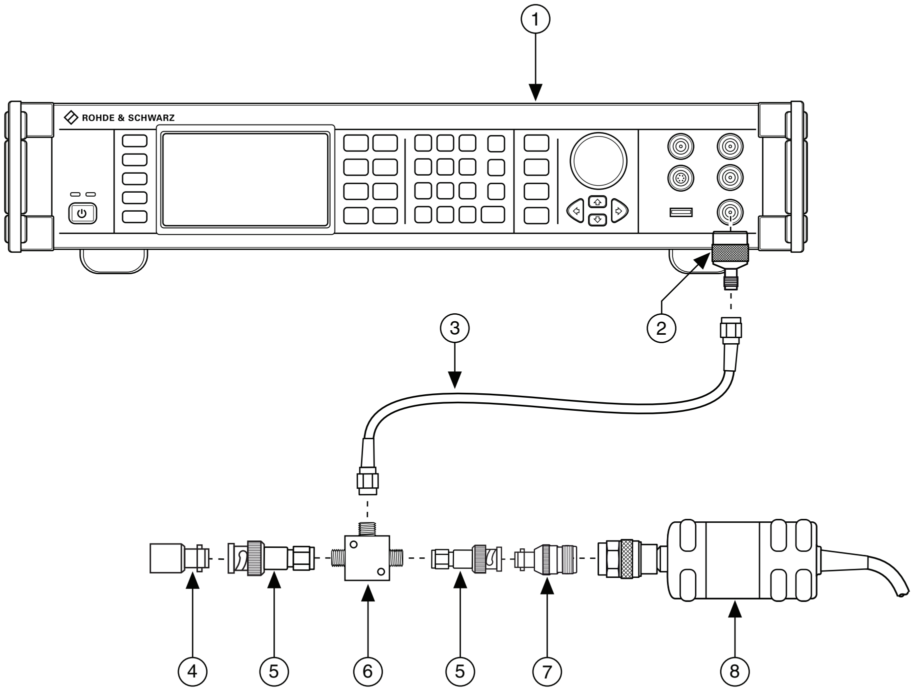
Configuration	Test Point		
	Impedance	**Frequency (MHz)**	**Amplitude (dBm)**
1	1 MΩ	0.05	-0.5
2	1 MΩ	425	-0.5

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 3. Connection Diagram for Measuring at Splitter Output 2 (BNC)



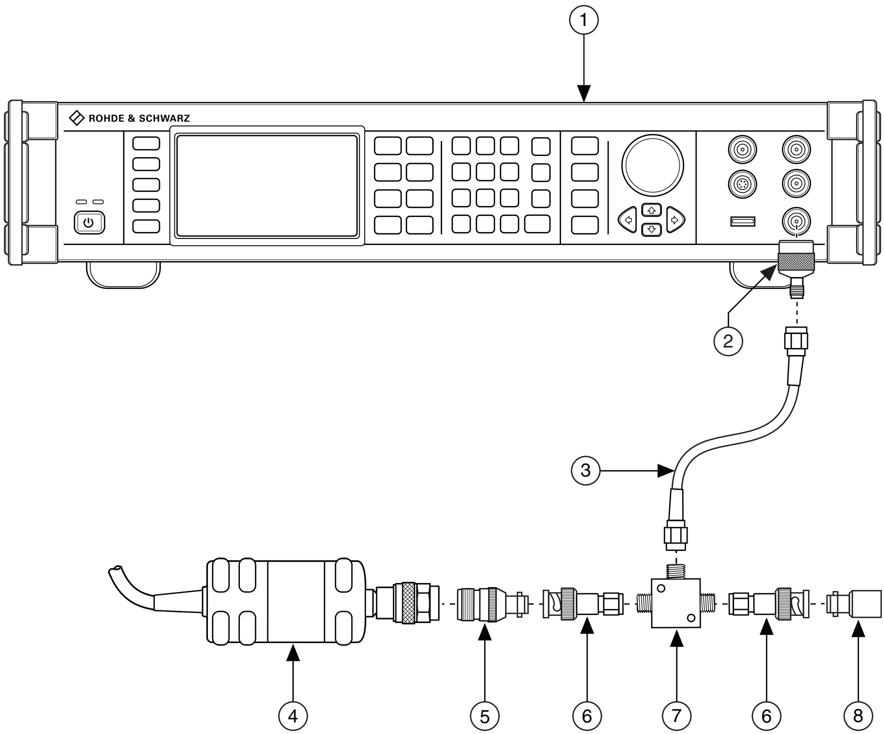
1	Signal Generator	5	SMA (m)-to-BNC (m) Adapter
2	SMA (f)-to-N (m) Adapter	6	Power Splitter
3	SMA (m)-to-SMA (m) Cable	7	BNC (f)-to-N (f) Adapter
4	50 Ω BNC Terminator	8	Power Sensor

8. Configure the signal generator to generate a sine waveform with the following characteristics:
   - Frequency: the Test Point Frequency value from Table 3
   - Amplitude level: the Test Point Amplitude value from Table 3
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 Table 3, 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 4. Connection Diagram for Measuring at Splitter Output 1 (BNC)



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

15. Configure the signal generator to generate a sine waveform with the following characteristics:
    - Frequency: the *Test Point Frequency* value from Table 3
    - Amplitude level: the *Test Point Amplitude* value from Table 3
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 Table 3, 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 1 MΩ AC Amplitude Accuracy and Bandwidth* procedure.

Verification

This section provides instructions for verifying the PXIe-5185/5186 specifications. Refer to Table 4 for a list of the verification tests and the equipment needed for each test.

Table 4. Verification Tests

Test Type	Specification		Recommended Equipment
	50 Ω	1 MΩ*	
DC Accuracy	±(2% of Input + 0.35% FS + 0.7 mV) ±1.2% of Offset Setting	±(2% of Input + 0.9% FS + 1.3 mV) ±1.2% of Offset Setting	Fluke 9500B Fluke 9530
AC Amplitude Accuracy	±0.35 dB	±0.5 dB	Rohde & Schwarz SMA100A Rohde & Schwarz NRP-Z91
Bandwidth (-3 dB)	3 GHz (PXIe-5185) 5 GHz (PXIe-5186)	425 MHz	Rohde & Schwarz SMA100A Rohde & Schwarz NRP-Z91
Timebase Accuracy	±25 ppm		Fluke 9500B Fluke 9530

* 1 MΩ input available on PXIe-5185 module part number 152962*x*-0*z*L and PXIe-5186 module part number 152961*x*-0*z*L, where *x* is any letter and *z* is any number.

Verifying DC and Programmable Vertical Offset Accuracy

To verify the DC and programmable vertical offset accuracy of the PXIe-5185/5186, compare the voltage measured by the device and the value sourced by the voltage standard. Table 5 lists the settings for each channel.

1. Connect the calibrator test head directly to the channel 0, 50 Ω input of the PXIe-5185/5186.
2. Configure the PXIe-5185/5186 with the following settings:
   - **Vertical coupling**: DC

- **Input impedance**: The *Input Impedance* value from Table 5 for the current iteration
- **Max input frequency**: **(PXIe-5185)** 3 GHz, **(PXIe-5186)** 5 GHz
- **Programmable vertical offset**: The *Programmable Vertical Offset* value from Table 4 for the current iteration
- **Range**: The *Vertical Range* value from Table 5 for the current iteration
- **Sample rate**: 12.5 GS/s
- **Minimum number of samples**: 1,048,567

3. Configure the calibrator output impedance to match that of the PXIe-5185/5186 for the current iteration listed in Table 5.
4. Configure the calibrator to output the *Test Point* voltage for the current iteration listed in Table 5.
5. Enable the calibrator output.
6. Wait 2.5 s for settling, then record the measured voltage.
7. Use the following formula to calculate the voltage difference:

$$\textit{error} = \text{V measured} - \textit{Test Point}$$

8. Compare the *error* to the *Test Limit* provided in Table 5.
9. Repeat steps 2-8 for iterations 2 through 16 listed in Table 5.
10. Connect the calibrator test head directly to the channel 1 50 Ω input of the PXIe-5185/5186 and repeat steps 2 through 9.

Note If your module supports 1 MΩ input, follow steps 11 and 12. Otherwise, DC and programmable vertical offset accuracy has been verified. 1 MΩ input is available on PXIe-5185 module part number 152962*x*-0*z*L and PXIe-5186 module part number 152961*x*-0*z*L, where *x* is any letter and *z* is any number.

11. Connect the calibrator test head directly to the channel 0, 1 MΩ input of the PXIe-5185/5186 and repeat steps 2 through 8 for iterations 17 through 44 listed in Table 5.
12. Connect the calibrator test head directly to the channel 1, 1 MΩ input of the PXIe-5185/5186 and repeat steps 2 through 8 for iterations 17 through 44 listed in Table 5.

Table 5. PXIe-5185/5186 DC and Programmable Vertical Offset Accuracy Limits

Iteration	Input Impedance	Vertical Range (V_{pk-pk})	Programmable Vertical Offset (V)	Test Point (V)	Test Limit (V)
1	50 Ω	0.11	0	0.045	±0.0020
2	50 Ω	0.11	0	-0.045	±0.0020
3	50 Ω	0.11	0.25	0.295	±0.0100
4	50 Ω	0.11	-0.25	-0.295	±0.0100

Table 5. PXIe-5185/5186 DC and Programmable Vertical Offset Accuracy Limits

Iteration	Input Impedance	Vertical Range (V_{pk-pk})	Programmable Vertical Offset (V)	Test Point (V)	Test Limit (V)
5	50 Ω	0.2	0	0.08	±0.0030
6	50 Ω	0.2	0	-0.08	±0.0030
7	50 Ω	0.2	0.25	0.33	±0.0110
8	50 Ω	0.2	-0.25	-0.33	±0.0110
9	50 Ω	0.5	0	0.2	±0.0065
10	50 Ω	0.5	0	-0.2	±0.0065
11	50 Ω	0.5	0.25	0.45	±0.0145
12	50 Ω	0.5	-0.25	-0.45	±0.0145
13	50 Ω	1	0	0.4	±0.0122
14	50 Ω	1	0	-0.4	±0.0122
15	50 Ω	1	0.25	0.65	±0.0202
16	50 Ω	1	-0.25	-0.65	±0.0202
17	1 MΩ	0.11	0	0.045	±0.0032
18	1 MΩ	0.11	0	-0.045	±0.0032
19	1 MΩ	0.11	0.25	0.295	±0.0112
20	1 MΩ	0.11	-0.25	-0.295	±0.0112
21	1 MΩ	0.2	0	0.08	±0.0047
22	1 MΩ	0.2	0	-0.08	±0.0047
23	1 MΩ	0.2	0.25	0.33	±0.0127
24	1 MΩ	0.2	-0.25	-0.33	±0.0127
25	1 MΩ	0.5	0	0.2	±0.0098
26	1 MΩ	0.5	0	-0.2	±0.0098
27	1 MΩ	0.5	0.25	0.45	±0.0178
28	1 MΩ	0.5	-0.25	-0.45	±0.0178
29	1 MΩ	1	0	0.4	±0.0183
30	1 MΩ	1	0	-0.4	±0.0183

Table 5. PXIe-5185/5186 DC and Programmable Vertical Offset Accuracy Limits

Iteration	Input Impedance	Vertical Range (V_{pk-pk})	Programmable Vertical Offset (V)	Test Point (V)	Test Limit (V)
31	1 MΩ	1	0.25	0.65	±0.0263
32	1 MΩ	1	-0.25	-0.65	±0.0263
33	1 MΩ	2	0	0.8	±0.0353
34	1 MΩ	2	0	-0.8	±0.0353
35	1 MΩ	2	2.5	3.3	±0.1153
36	1 MΩ	2	-2.5	-3.3	±0.1153
37	1 MΩ	5	0	2	±0.0863
38	1 MΩ	5	0	-2	±0.0863
39	1 MΩ	5	2.5	4.5	±0.1663
40	1 MΩ	5	-2.5	-4.5	±0.1663
41	1 MΩ	10	0	4	±0.1713
42	1 MΩ	10	0	-4	±0.1713
43	1 MΩ	10	2.5	6.5	±0.2513
44	1 MΩ	10	-2.5	-6.5	±0.2513

Verifying 50 Ω AC Amplitude Accuracy and Bandwidth

Follow this procedure to verify the 50 Ω AC amplitude accuracy and analog bandwidth of the PXIe-5185/5186 by generating a sine wave and comparing the amplitude measured by the PXIe-5185/5186 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. 50 Ω AC Amplitude Accuracy and Bandwidth Verification

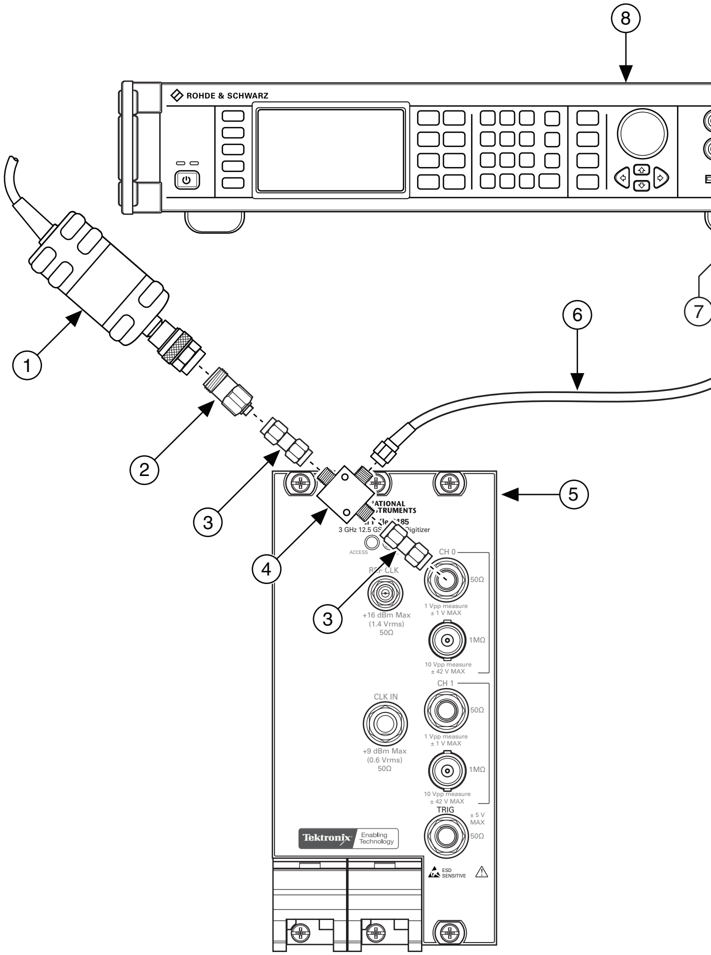
Iteration	Sample Rate	Test Point (dBm)	Test Limit (dB)
1	1.25 GS/s	-12 at 50 kHz	±0.35
2	12.5 GS/s	**(PXIe-5185)** -12 at 3 GHz **(PXIe-5186)** -12 at 5 GHz	-3 to 1

1. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to the channel 0, 50 Ω input of the PXIe-5185/5186.

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 AC Amplitude Accuracy and Bandwidth Verification Cabling Diagram



1	Power Sensor	5	PXIe-5185/5186
2	SMA (f)-to-N(f) Adapter	6	SMA (m)-to-SMA (m) Cable
3	SMA (m)-to-SMA (m) Adapter	7	SMA (f)-to-N (m) Adapter
4	Power Splitter	8	Signal Generator

2. Configure the PXIe-5185/5186 with the following settings:
   - **Vertical coupling**: DC
   - **Input impedance**: 50 Ω
   - **Maximum input frequency**: 3 GHz (PXIe-5185), 5 GHz (PXIe-5186)
   - **Range**: 0.11 $V_{pk\text{-}pk}$
   - **Sample rate**: The *Sample Rate* value from Table 6 for the current iteration
   - **Minimum number of samples**: 1,048,567
3. Configure the signal generator to generate a sine waveform with the following characteristics:
   - **Frequency**: the *Test Point* frequency value from Table 6
   - **Amplitude level**: the *Test Point* amplitude value from Table 6
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:

$$\textit{corrected input power} = \textit{measured input power} + \textit{splitter imbalance}$$

> **Note** Select the *splitter imbalance* value from the list of test points from the *Test System Characterization* section for the current *Test Point* frequency from Table 6.

7. Use the PXIe-5185/5186 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 from Table 6 is 50 kHz, proceed to the following step. Otherwise, go to step 12.
9. Calculate the *power reference* using the following equation:

$$\text{power reference} = \text{device input power} - \text{corrected input power}$$

10. Compare the power reference to the test limit for Iteration 1 in Table 6 to verify the 50 Ω AC amplitude accuracy.
11. Go to step 14. The power error is not calculated for this configuration.
12. Calculate the *power error* using the following equation:

$$\textit{power error} = \textit{device input power} - \textit{corrected input power} - \textit{power reference}$$

13. Compare the power error to the test limit for Iteration 2 in Table 6 to verify the 50 Ω analog bandwidth.
14. Repeat steps 2 through 13 for each *Iteration* in Table 6.
15. Connect splitter output 2 of the power sensor assembly to the channel 1 50 Ω input of the PXIe-5185/5186 and repeat steps 2 through 13 for each *Iteration* listed in Table 6.

Verifying 1 MΩ AC Amplitude Accuracy and Bandwidth

Follow this procedure to verify the 1 MΩ AC amplitude accuracy and analog bandwidth of the PXIe-5185/5186 by generating a sine wave and comparing the amplitude measured by the PXIe-5185/5186 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 7. 1 MΩ AC Amplitude Accuracy and Bandwidth Verification

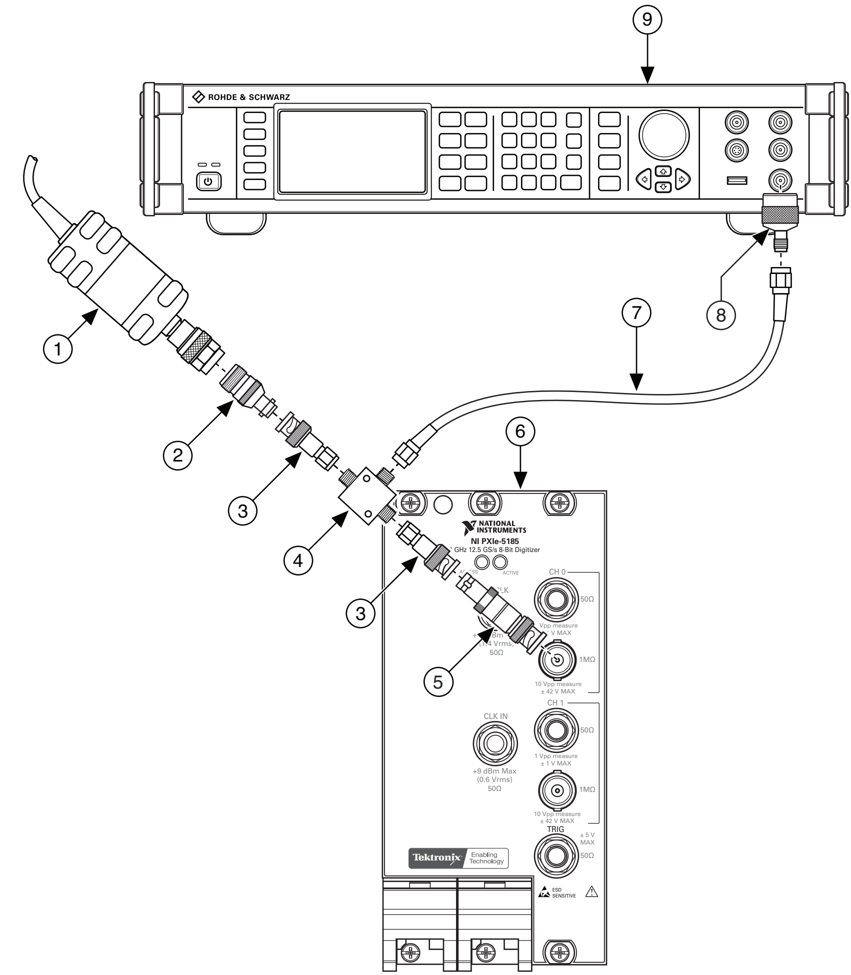
Iteration	Sample Rate	Test Point (dBm)	Test Limit (dB)
1	1.25 GS/s	-12 at 50 kHz	±0.5
2	12.5 GS/s	-12 at 425 MHz	-3 to 1

1. Connect the 50 Ω BNC feed-through terminator to the channel 0 1 MΩ input of the PXIe-5185/5186. 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.

Figure 6. 1 MΩ AC Amplitude Accuracy and Bandwidth Verification Cabling Diagram



1	Power Sensor	6	PXIe-5185/5186
2	BNC (m)-to-N (m) Adapter	7	SMA (f)-to-SMA (f) Cable
3	SMA (f)-to-BNC (f) Adapter	8	SMA (m)-to-N (f) Adapter
4	Power Splitter	9	Signal Generator
5	50 Ω BNC Feed-Through		

2. Configure the PXIe-5185/5186 with the following settings:
   - **Vertical coupling**: DC
   - **Input impedance**: 1 MΩ

- **Maximum input frequency**: 425 MHz
- **Range**: 0.11 $V_{pk\text{-}pk}$
- **Sample rate**: The *Sample Rate* value from Table 7 for the current iteration
- **Minimum number of samples**: 1,048,567

3. Configure the signal generator to generate a sine waveform with the following characteristics:
   - **Frequency**: the *Test Point* frequency from Table 7
   - **Amplitude level**: the *Test Point* amplitude from Table 7
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:

$$\textit{corrected input power} = \textit{measured input power} + \textit{splitter imbalance}$$

> **Note** Select the *splitter imbalance* value from the list of test points from the *Test System Characterization* section for the current *Test Point* frequency from Table 7.

7. Use the PXIe-5185/5186 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 from Table 7 is 50 kHz, proceed to step 9. Otherwise, go to step 12.
9. Calculate the *power reference* using the following equation:

$$\textit{power reference} = \textit{device input power} - \textit{corrected input power}$$

10. Compare the power reference to the test limit for Iteration 1 in Table 7 to verify the 1 MΩ AC amplitude accuracy.
11. Go to step 14. The power error is not calculated for this configuration.
12. Calculate the *power error* using the following equation:

$$\textit{power error} = \textit{device input power} - \textit{corrected input power} - \textit{power reference}$$

13. Compare the power error to the test limit for Interation 2 in Table 7 to verify the 1 MΩ analog bandwidth.
14. Repeat steps 2 through 13 for each *Iteration* in Table 7.
15. Connect the 50 Ω BNC feed-through terminator to the channel 1 1 MΩ input of the PXIe-5185/5186. Connect splitter output 2 of the power sensor assembly to the 50 Ω BNC feed-through terminator and repeat steps 2 through 13 for each *Iteration* in Table 7.

Verifying Timebase Accuracy

To verify the timebase accuracy of the PXIe-5185/5186 compare the peak frequency of a leveled sine wave measured by the PXIe-5185/5186 and the value sourced by the calibrator. Table 8 lists the settings.

Table 8. PXIe-5185/5186 Timebase Accuracy Limits

Channel	Function	Input Impedance	Range ($V_{pk\text{-}pk}$)	Test Point ($V_{pk\text{-}pk}$)	Test Limit
0	Timebase	50 Ω	1.0	0.9 at 1 GHz	±25 ppm (25.0 kHz)

1. Configure the PXIe-5185/5186 with the following settings:
   - **Vertical coupling:** DC
   - **Input impedance**: 50 Ω
   - **Max input frequency**: **(PXIe-5185)** 3 GHz, **(PXIe-5186)** 5 GHz
   - **Range**: 1 $V_{pk\text{-}pk}$
   - **Sample rate**: 12.5 GS/s
   - **Minimum number of samples**: 1,048,567
2. Connect the calibrator test head directly to the channel 0, 50 Ω input of the digitizer.
3. Configure the calibrator output impedance to 50 Ω.
4. Configure the calibrator to output a 1.0 GHz leveled sine wave with peak-to-peak voltage amplitude of 0.90 V.
5. Enable the calibrator output.
6. Wait 2.5 s for settling, then record the measured peak frequency.
7. Use the following formula to calculate the frequency difference:

$$TBerror = (f - 1.0E{+}9)/1.0E{+}3$$

where f = measured frequency

8. Compare the error to the *Test Limit* shown in Table 8.

Note Timebase verification is only required on one channel.

Adjustment

If the PXIe-5185/5186 successfully passed each of the verification procedures within the test limits, then an adjustment is recommended but not required to warrant the published specifications for the next year. If the digitizer was not within the test limits for each of the verification procedures, you can perform the adjustment procedure to improve the accuracy of the digitizer.

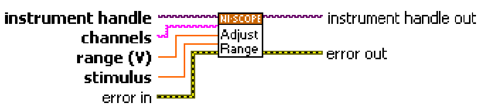
An adjustment is required once a year. Following the adjustment procedure automatically updates the calibration date and temperature in the EEPROM of the digitizer.

Complete the following steps to externally adjust the PXIe-5185/5186.

1. Obtain a calibration session handle using the niScope Cal Start VI.

LabVIEW VI	C/C++ Function Call
	Call `niScope_CalStart` with the following parameters: **resourceName**: The device number assigned by MAX **password**: `"NI"`

2. Connect the calibrator test head directly to the channel 0, 50 Ω input of the digitizer.
3. Configure the calibrator output impedance to 50 Ω.
4. Configure the calibrator to output the voltage listed under *Input (V)* in Table 9 for the current iteration.
5. Enable the calibrator output.
6. Wait 2.5 s for the impedance matching of the calibrator to settle.
7. Adjust the vertical range using the niScope Cal Adjust Range VI.

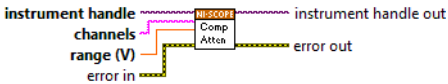
LabVIEW VI	C/C++ Function Call
	Call `niScope_CalAdjustRange` with the following parameters: **vi**: The instrument handle from `niScope_CalStart` **channelName**: `"0"` **range**: `0` **stimulus**: The *Input (V)* value listed in Table 9 for the current iteration

8. Repeat steps 4 through 7 for each iteration in Table 9.
9. Connect the calibrator test head directly to the channel 1, 50 Ω input of the digitizer and repeat steps 3 through 8, changing the value of the **channels** parameter from `"0"` to `"1"`.

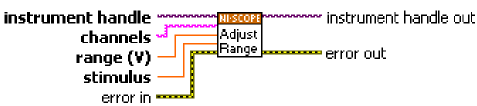
Note If your module supports 1 MΩ input, follow steps 10 through 22. Otherwise, jump to step 23 to complete the adjustment. 1 MΩ input available on PXIe-5185 module part number 152962X-0ZL and PXIe-5186 module part number 152961X-0ZL, where X is any letter and Z is any number.

10. Connect the calibrator test head directly to the channel 0, 1 MΩ input of the digitizer.
11. Configure the calibrator output impedance to 1 MΩ.
12. Configure the calibrator to output a 100 kHz symmetrical square wave with peak-to-peak voltage amplitude of 8.0 V.

13. Enable the calibrator output.
14. Wait 2.5 s for the impedance matching of the calibrator to settle.
15. Adjust the 1 MΩ compensation attenuator using the niScope Cal Adjust Compensation Attenuator VI.

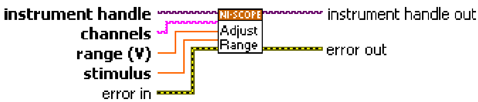
LabVIEW VI	C/C++ Function Call
	Call `niScope_CalAdjustCompensationAttenuator` with the following parameters: **vi**: The instrument handle from `niScope_CalStart` **channelName**: `"0"` **range**: `8.0`

16. Configure the calibrator output impedance to 1 MΩ.
17. Configure the calibrator to output the voltage listed under *Input (V)* in Table 10 for the current iteration.
18. Enable the calibrator output.
19. Wait 2.5 s for the impedance matching of the calibrator to settle.
20. Adjust the vertical range using the niScope Cal Adjust Range VI.

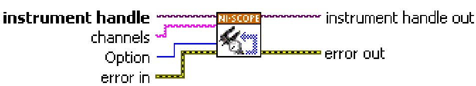
LabVIEW VI	C/C++ Function Call
	Call `niScope_CalAdjustRange` with the following parameters: **vi**: The instrument handle from `niScope_CalStart` **channelName**: `"0"` **range**: `0` **stimulus**: The *Input (V)* value listed in Table 10 for the current iteration

21. Repeat steps 17 through 20 for each iteration in Table 10.
22. Connect the calibrator test head directly to the channel 1, 1 MΩ input of the digitizer and repeat steps 11 through 21, changing the value of the **channels** parameter from `"0"` to `"1"`.
23. Connect the calibrator test head directly to the external trigger channel input on the digitizer.
24. Configure the calibrator output impedance to 50 Ω.
25. Configure the calibrator to output the voltage listed under *Input (V)* in Table 11 for the current iteration. Configure the load impedance of the calibrator to 50 Ω.
26. Enable the calibrator output.

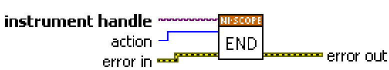
27. Wait 2.5 s for the impedance matching of the calibrator to settle.
28. Adjust the vertical range using the niScope Cal Adjust Range VI.

LabVIEW VI	C/C++ Function Call
	Call `niScope_CalAdjustRange` with the following parameters: **vi**: The instrument handle from `niScope_CalStart` **channelName**: `"NISCOPE_VAL_EXTERNAL"` **range**: 0 **stimulus**: The *Input (V)* value listed in Table 11 for the current iteration

29. Repeat steps 25 through 28 for each iteration in Table 11.
30. Disconnect or disable all inputs to the digitizer.
31. Self-calibrate the digitizer using niScope Cal Self Calibrate VI.

LabVIEW VI	C/C++ Function Call
	Call `niScope_CalSelfCalibrate` with the following parameters: **vi**: The instrument handle from `niScope_CalStart` **channelList**: `VI_NULL` **option**: `VI_NULL`

32. End the calibration session by calling the niScope Cal End VI.

LabVIEW VI	C/C++ Function Call
	Call `niScope_CalEnd` with the following parameters: **sessionHandle**: The instrument handle from `niScope_CalStart` **action**: `NISCOPE_VAL_ACTION_STORE` to save the results of the calibration

You have finished adjusting the PXIe-5185/5186. Repeat the *Verification* section to reverify the performance of the digitizer after adjustments.

Table 9. PXIe-5185/5186 50 Ω Input Parameters for Input Channel External Adjustment

Iteration	Input (V)
1	0.32
2	0.135
3	0.075
4	0.065
5	0.055
6	0.045
7	-0.045
8	-0.055
9	-0.065
10	-0.075
11	-0.135
12	-0.32
13	2.0
14	-2.0

Table 10. PXIe-5185/5186 1 MΩ Input Parameters for Input Channel External Adjustment

Iteration	Input (V)
1	5.0
2	3.0
3	2.0
4	1.0
5	0.75
6	0.5
7	0.32
8	0.135
9	0.075

Table 10. PXIe-5185/5186 1 MΩ Input Parameters for Input Channel External Adjustment (Continued)

Iteration	Input (V)
10	0.065
11	0.055
12	0.045
13	-0.045
14	-0.055
15	-0.065
16	-0.075
17	-0.135
18	-0.32
19	-0.5
20	-0.75
21	-1.0
22	-2.0
23	-3.0
24	-5.0

Table 11. PXIe-5185/5186 Input Parameters for External Trigger Channel External Adjustment

Iteration	Input (V)
1	-5.0
2	0.001
3	5.0

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373258F-01 April 24, 2018