CALIBRATION PROCEDURE

# PXIe-5163

This document contains the verification and adjustment procedures for the PXIe-5163. Refer to *ni.com/calibration* for more information about calibration solutions.

Please review and become familiar with the entire procedure before beginning the calibration process.

## Contents

# Required Software

Calibrating the PXIe-5163 requires you to install the following software on the calibration system:

- NI-SCOPE. The PXIe-5163 was first supported in NI-SCOPE 18.7.
- LabVIEW Instrument Design Libraries for Reconfigurable Oscilloscopes. The PXIe-5163 was first supported in LabVIEW Instrument Design Libraries for Reconfigurable Oscilloscopes 18.0.
- 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-5163 Getting Started Guide*
- *NI High-Speed Digitizers Help*
- *NI Reconfigurable Oscilloscopes Help*
- *PXIe-5163 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-5163.

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-5163 Test Equipment

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| Oscilloscope calibrator | Fluke 9500B/600 with Fluke 9530 Active Head | Verifications:<br>• Timebase accuracy<br>• DC accuracy<br>Adjustment | Sine wave generation:<br>• Amplitude: 0.9 V pk-pk into 50 Ω<br>• Frequency: 11 MHz and 99 MHz<br>• Frequency accuracy: ±0.25 ppm |
| | | | Square wave generation:<br>• Amplitude: 0.5 V pk-pk to 45 V pk-pk into 1 MΩ symmetrical to ground (0 V)<br>• Frequency: 500 Hz<br>• Abberations: <2% of peak for the first 500 ns |
| | | | DC generation:<br>• Amplitude: ±2.5 V into 50 Ω, ±200 V into 1 MΩ<br>• Accuracy: ±(0.025% of output + 25 μV) |

**Table 1.** PXIe-5163 Test Equipment (Continued)

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| DMM | NI PXI-4071 or PXIe-4081 | Verifications:<br>• AC amplitude accuracy | AC voltage measurement:<br>• Range: 0.125 V pk-pk to 20 V pk-pk<br>• Input impedance: ≥10 MΩ<br>• Bandwidth: ≥50 kHz<br>• Accuracy at 50 kHz<br>– ±(0.07% of reading + 14 µV) for 0.125 V pk-pk test point<br>– ±(0.06% of reading + 71 µV) for 0.25 V pk-pk to 1.25 V pk-pk test points<br>– ±(0.06% of reading + 707 µV) for 2.5 V pk-pk to 12.5 V pk-pk test points<br>– ±(0.12% of reading + 35 mV) for 20.0 V pk-pk test point |
| Function generator | NI PXI-5402/5406 or Agilent 33220A | Verifications:<br>• AC amplitude accuracy | Sine wave generation:<br>• Amplitude:<br>– 0.125 V pk-pk to 2.5 V pk-pk into 50 Ω<br>– 0.125 V pk-pk to 20 V pk-pk into 1 MΩ<br>• Frequency: 50 kHz |
| BNC tee (m-f-f) | Pasternack PE9174 | Verifications:<br>• AC amplitude accuracy | Impedance: 50 Ω |
| Double banana plug to BNC (f) | Pasternack PE9008 | Verifications:<br>• AC amplitude accuracy | Impedance: 50 Ω |

**Table 1.** PXIe-5163 Test Equipment (Continued)

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| BNC (m)-to-BNC (m) cable (×2) | Pasternack PE308 | Verifications:<br>• AC amplitude accuracy | Length: ≤1 meter |
| Power sensor | Rohde & Schwarz NRP-Z91 or NRP18A(N) | Test system characterization<br><br>Adjustment<br><br>Verifications:<br>• Passband amplitude flatness and bandwidth | Power measurement:<br>• Frequency range: 50 kHz to 495.1 MHz<br>• Power range: -16 dBm to 10 dBm<br>• VSWR: ≤1.11:1<br>• Absolute accuracy<br>  – <0.048 dB for 50 kHz to <100 MHz<br>  – <0.063 dB for 100 MHz to 495.1 MHz<br>• Relative accuracy at -4 dBm<br>  – <0.022 dB for 50 kHz to <100 MHz<br>  – <0.022 dB for 100 MHz to 495.1 MHz |
| Signal generator | Rohde & Schwarz SMA100A | Test system characterization<br><br>Adjustment<br><br>Verifications:<br>• Passband amplitude flatness and bandwidth | Sine wave generation:<br>• Amplitude: -10 dBm to 16 dBm<br>• Frequency: 50 kHz to 495.1 MHz<br>• Harmonics: <-30 dBc<br>• Frequency accuracy: ±100.0 ppm |

**Table 1.** PXIe-5163 Test Equipment (Continued)

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| Power splitter[1] | Keysight 11667A or Aeroflex/ Weinschel 1593 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Amplitude: -16 dBm to 16 dBm<br>• Frequency: 50 kHz to 495.1 MHz<br>• VSWR: ≤1.10:1 |
| 50 Ω BNC (f) terminator | Fairview Microwave ST3B-F | Test system characterization | • Amplitude: 10 dBm<br>• Frequency: DC to 495.1 MHz<br>• VSWR: ≤1.25:1 |
| 50 Ω BNC (m) terminator | Fairview Microwave ST2B | Verifications:<br>• RMS noise | • Frequency: DC to 495.1 MHz<br>• VSWR: ≤1.15:1 |
| Type N (m)-to-Type N (m) cable[2] | Maury Microwave SP-N-MM-24 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency: DC to 495.1 MHz<br>• VSWR: ≤1.10:1<br>• Length: ≤1 meter |

[1] The Aeroflex/Weinschel 1593 must be verified to VSWR ≤1.10:1 from 50 kHz to 495.1 MHz. This calibration procedure is written for the Keysight 11667A. If using the Aeroflex/ Weinschel 1593, use the prescribed connectors and adapters in an analogous manner.

[2] Required if using the Keysight 11667A.

[3] Required if using the Aeroflex/Weinschel 1593.

**Table 1.** PXIe-5163 Test Equipment (Continued)

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| SMA (m)-to-SMA (m) cable[3] | — | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency: DC to 495.1 MHz<br>• VSWR: ≤1.10:1<br>• Length: ≤1 meter |
| Type N (m)-to-BNC (m) adapter (×2)[2] | Maury Microwave 8821D1 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency range: DC to 495.1 MHz<br>• VSWR: ≤1.08:1 |
| SMA (f)-to-N (m) adapter[3] | Fairview Microwave SM4226 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency range: DC to 495.1 MHz<br>• VSWR: ≤1.05:1 |

**Table 1.** PXIe-5163 Test Equipment (Continued)

| Equipment | Recommended Model | Where Used | Minimum Requirements |
|---|---|---|---|
| BNC (f)-to-N (f) adapter | Fairview Microwave SM3526 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency range: DC to 495.1 MHz<br>• VSWR: ≤1.10:1<br>• Impedance: 50 Ω |
| SMA (m)-to-BNC (m) adapter (×2)[3] | Fairview Microwave SM4716 | Test system characterization<br>Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Frequency range: DC to 495.1 MHz<br>• VSWR: ≤1.10:1<br>• Impedance: 50 Ω |
| BNC feed-thru terminator[2] | Pomona 4119-50 | Adjustment<br>Verifications:<br>• Bandwidth | • Amplitude: 10 dBm<br>• Frequency: 50 kHz to 301 MHz<br>• VSWR:<br>– ≤1.10:1 at ≤250 MHz<br>– ≤1.20:1 at >250 MHz, ≤301 MHz<br>• Impedance: 50 Ω |
| SMA feed-thru terminator[3] | Pasternack PE6026 | Adjustment<br>Verifications:<br>• Passband amplitude flatness and bandwidth | • Amplitude: 10 dBm<br>• Frequency: 50 kHz to 301 MHz<br>• VSWR: ≤1.25:1 at ≤301 MHz<br>• Impedance: 50 Ω |

# Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-5163 meets published specifications:

- Allow a warm-up time of at least 15 minutes after the chassis is powered on. The warm-up time ensures that the PXIe-5163 is at a stable operating temperature.
- Allow all test instruments a warm-up time of at least the stated amount of time in their specification document. The warm-up time ensures that the test instruments 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-5163, 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 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-5163. NI uses these limits to determine whether the PXIe-5163 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-5163, 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 Passband Amplitude Flatness and Bandwidth*
   - *Verifying 1 MΩ Bandwidth*
   - *Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth*
   - *Adjusting 1 MΩ 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 Passband Amplitude Flatness and Bandwidth*
- *Verifying 1 MΩ Bandwidth*
- *Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth*
- *Adjusting 1 MΩ Bandwidth*

**Table 2.** Power Splitter Characterization

| Config | Test Point: Frequency (MHz) |
|---|---|
| 1 | 0.05 |
| 2 | 1.1 |
| 3 | 6.1 |
| 4 | 10.1 |
| 5 | 30.1 |
| 6 | 45.1 |
| 7 | 60.1 |
| 8 | 75.1 |
| 9 | 90.1 |
| 10 | 100.1 |
| 11 | 120.1 |
| 12 | 150.1 |
| 13 | 170.1 |
| 14 | 190.1 |
| 15 | 200.1 |
| 16 | 210.1 |
| 17 | 230.1 |
| 18 | 245.1 |

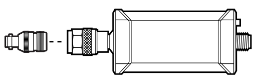
**Table 2.** Power Splitter Characterization (Continued)

| Config | Test Point: Frequency (MHz) |
|---|---|
| 19 | 250.1 |
| 20 | 270.1 |
| 21 | 285.1 |
| 22 | 290.1 |
| 23 | 330.1 |
| 24 | 350.1 |
| 25 | 370.1 |
| 26 | 390.1 |
| 27 | 400.1 |
| 28 | 420.1 |
| 29 | 450.1 |
| 30 | 460.1 |
| 31 | 470.1 |
| 32 | 480.1 |
| 33 | 485.1 |
| 34 | 490.1 |
| 35 | 495.1 |

1. Connect the BNC (f)-to-Type N (f) adapter to the power sensor.

   Refer to this assembly as the *power sensor*.

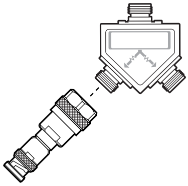
**Figure 1.** Power Sensor



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 a Type N (m)-to-Type N (m) cable.
4. Connect a Type N (m)-to-BNC (m) adapter to one of the power splitter output ports.

Refer to this assembly as *splitter output 1*.

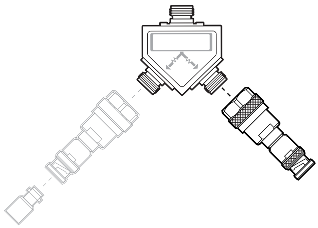
**Figure 2.** Splitter Output 1



5. Connector the 50 Ω BNC (f) terminator to splitter output 1.
6. Connect the other Type N (m)-to-BNC (m) adapter to the other output port of the power splitter.

   Refer to this assembly as *splitter output 2*.

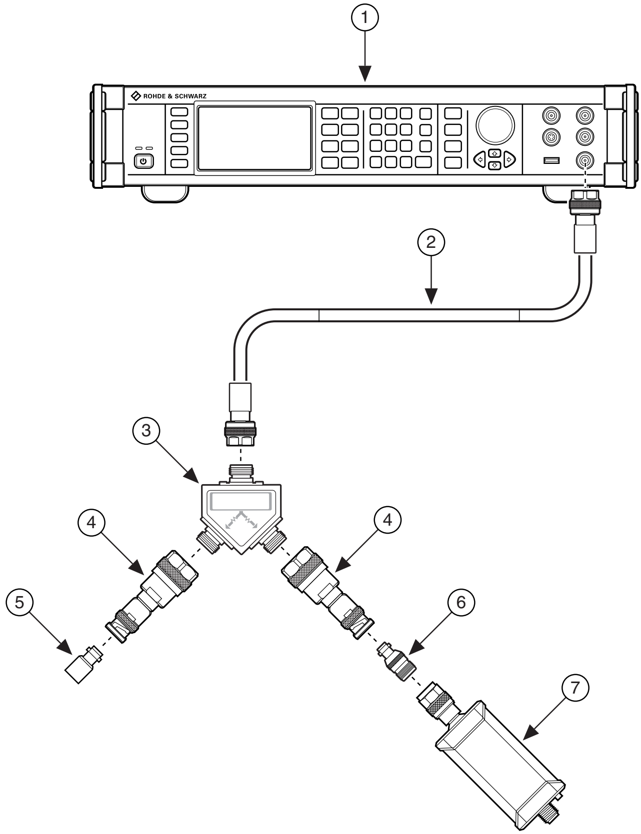
**Figure 3.** Splitter Output 2



7. Connect the power sensor to splitter output 2.

   The following figure illustrates the hardware setup.

**Figure 4.** Connection Diagram for Measuring at Splitter Output 2




1. Signal generator
2. Type N (m)-to-Type N (m) cable
3. Keysight 11667A power splitter
4. Type N (m)-to-BNC (m) adapter
5. 50 Ω BNC (f) terminator
6. Type N (f)-to-BNC (f) adapter
7. Power sensor

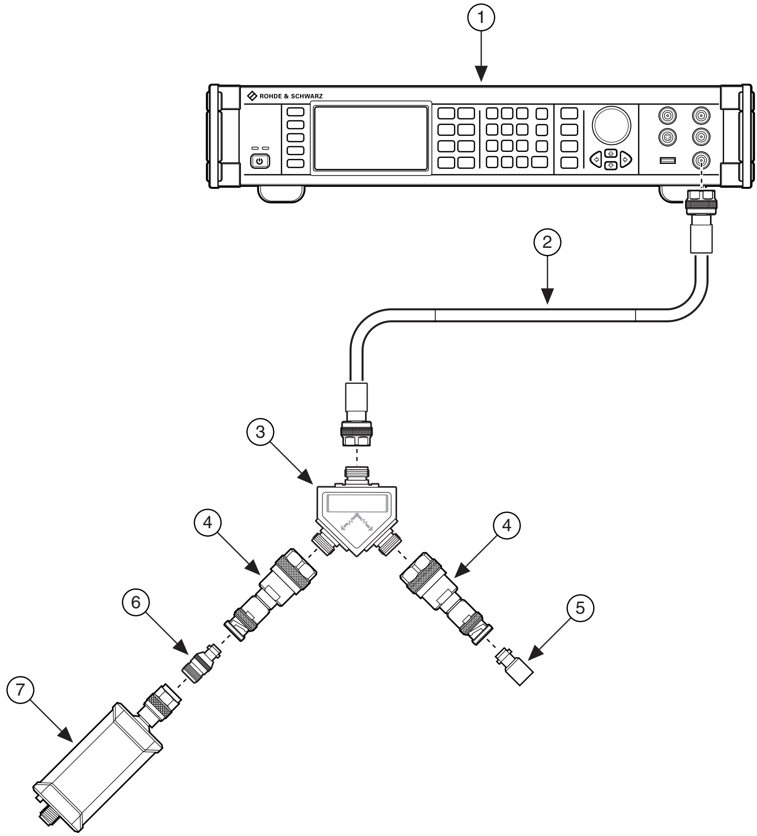
8. Configure the power sensor with the following settings:
   - Power measurement: continuous average
   - Path selection: automatic
   - Averaging: automatic
   - Averaging resolution: 4 (0.001 dB)
   - Aperture: 20 ms
9. Configure the signal generator to generate a sine waveform with the following 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 seconds for settling.
12. Use the power sensor to measure the power in dBm.
13. Repeat steps *9* on page 14 through *12* on page 15 for each configuration in the *Power Splitter Characterization* table.

    Record each result as *Splitter Output 2 Power*, where each configuration has a corresponding value.
14. Disconnect the power sensor and 50 Ω BNC (f) terminator from splitter output 2 and splitter output 1.
15. Connect the power sensor to splitter output 1.
16. Connect the 50 Ω BNC (f) terminator to splitter output 2.

    The following figure illustrates the hardware setup.

**Figure 5.** Connection Diagram for Measuring at Splitter Output 1




1. Signal generator
2. Type N (m)-to-Type N (m) cable
3. Keysight 11667A power splitter
4. Type N (m)-to-BNC (m) adapter
5. 50 Ω BNC (f) terminator
6. Type N (f)-to-BNC (f) adapter
7. Power sensor

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 seconds for settling.
20. Use the power sensor to measure the power in dBm.
21. Repeat steps *17* on page 16 through *20* on page 16 for each configuration in the *Power Splitter Characterization* table.

Record 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:

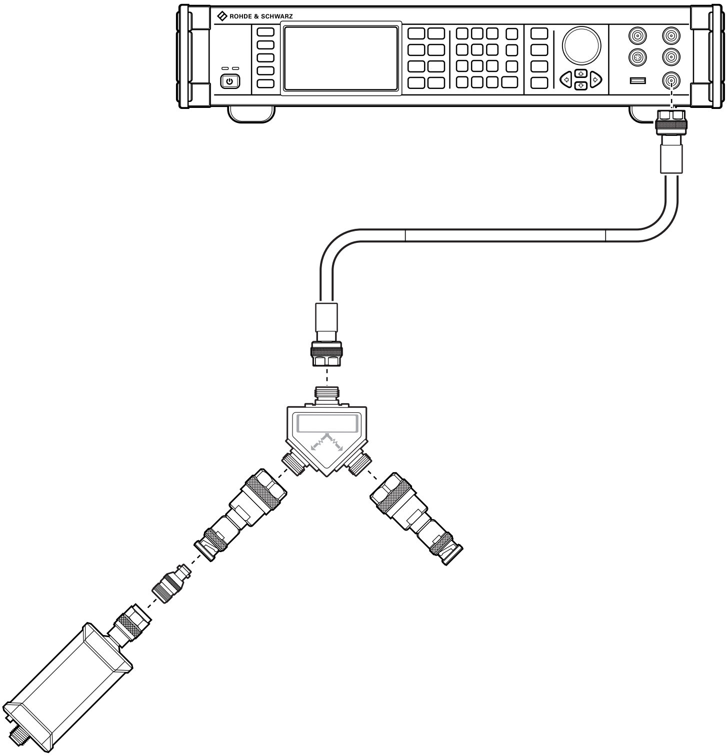
    *Splitter Loss = Signal Generator Amplitude Level - Splitter Output 2 Power*

24. Disconnect the 50 Ω BNC (f) terminator 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.

**Figure 6.** Power Sensor Assembly




The power sensor or power sensor assembly will be used in the following procedures:

- *Verifying 50 Ω Passband Amplitude Flatness and Bandwidth*
- *Verifying 1 MΩ Bandwidth*

- *Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth*
- *Adjusting 1 MΩ Bandwidth*

# Verification

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

Verification of the PXIe-5163 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, locations, and functions of the PXIe-5163 front panel connectors and LED indicators.

**Figure 7.** PXIe-5163 Front Panel

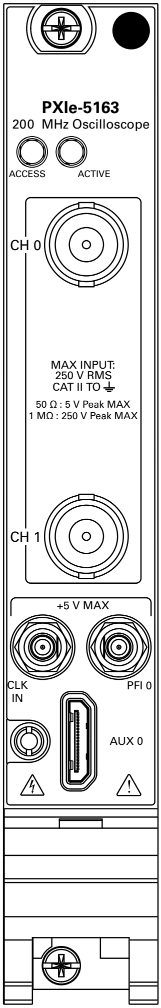



**Table 3.** Connectors

| Signal | Connector Type | Description |
|---|---|---|
| CH 0 and CH 1 | BNC female | Analog input connection; digitizes data and triggers acquisitions. |
| CLK IN | SMB | Imports an external reference clock or sample clock to the oscilloscope. |

**Table 3.** Connectors (Continued)

| Signal | Connector Type | Description |
|---|---|---|
| PFI 0 | SMB | PFI line for digital trigger input/output, probe compensation. |
| AUX 0 | MHDMR | Reference clock input, reference clock output, bidirectional digital PFI, and 3.3 V power output. |

**Table 4.** Access LED

| Color | Indications |
|---|---|
| Off | The module is not yet functional or the module has detected a problem with a power rail. |
| Amber | The module is being accessed. |
| Green | The module is ready to be programmed. |

**Table 5.** Active LED

| Color | Indications |
|---|---|
| Off | Module is not armed, triggered, or acquiring a waveform. |
| Amber | The module is armed and waiting for a Reference (Stop) Trigger. |
| Green | The module has received a Reference (Stop) Trigger. Also indicates that the module is acquiring a waveform. |
| Red | The module has detected an error. The LED remains red until the error condition is removed. The following scenarios are examples of potential errors:<br>• Detected an unlocked condition on a previously locked PLL. A PLL that is unlocked while in reset does not show an error.<br>• Unable to detect the external sample clock.<br>• Detected an overheating or overpowering error.<br>**Note** Certain driver interactions may cause the Active LED to flash red. An error condition does not exist unless the Active LED remains red. |

## Verifying DC Accuracy

This procedure verifies the DC accuracy of the PXIe-5163 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 6.** DC Accuracy Verification

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Vertical Offset (V) | Test Points (V) | As-Found Limits (mV) | As-Left Limits (mV) |
|---|---|---|---|---|---|---|
| 1 | 50 | 0.25 V | 0 | 0.113 | ±1.06 | ±0.87 |
| 2 | 50 | 0.25 V | 0 | -0.113 | ±1.06 | ±0.87 |
| 3 | 50 | 0.5 V | 0 | 0.225 | ±2.13 | ±1.72 |
| 4 | 50 | 0.5 V | 0 | -0.225 | ±2.13 | ±1.72 |
| 5 | 50 | 1 V | 0 | 0.450 | ±4.25 | ±3.38 |
| 6 | 50 | 1 V | 0 | -0.450 | ±4.25 | ±3.38 |
| 7 | 50 | 2.5 V | 0 | 1.125 | ±10.6 | ±8.34 |
| 8 | 50 | 2.5 V | 0 | -1.125 | ±10.6 | ±8.34 |
| 9 | 50 | 5 V | 0 | 2.250 | ±21.3 | ±16.5 |
| 10 | 50 | 5 V | 0 | -2.250 | ±21.3 | ±16.5 |
| 11 | 1 M | 0.25 V | 0 | 0.113 | ±1.38 | ±0.83 |
| 12 | 1 M | 0.25 V | 0 | -0.113 | ±1.38 | ±0.83 |
| 13 | 1 M | 0.25 V | 5 | 5.113 | ±21.4 | ±13.0 |
| 14 | 1 M | 0.25 V | -5 | -5.113 | ±21.4 | ±13.0 |
| 15 | 1 M | 0.5 V | 0 | 0.225 | ±2.61 | ±1.75 |
| 16 | 1 M | 0.5 V | 0 | -0.225 | ±2.61 | ±1.75 |
| 17 | 1 M | 0.5 V | 5 | 5.225 | ±22.6 | ±13.9 |
| 18 | 1 M | 0.5 V | -5 | -5.225 | ±22.6 | ±13.9 |
| 19 | 1 M | 1 V | 0 | 0.450 | ±5.08 | ±3.65 |

**Table 6.** DC Accuracy Verification (Continued)

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Vertical Offset (V) | Test Points (V) | As-Found Limits (mV) | As-Left Limits (mV) |
|---|---|---|---|---|---|---|
| 20 | 1 M | 1 V | 0 | -0.450 | ±5.08 | ±3.65 |
| 21 | 1 M | 1 V | 5 | 5.450 | ±25.1 | ±15.7 |
| 22 | 1 M | 1 V | -5 | -5.450 | ±25.1 | ±15.7 |
| 23 | 1 M | 2.5 V | 0 | 1.125 | ±12.5 | ±8.99 |
| 24 | 1 M | 2.5 V | 0 | -1.125 | ±12.5 | ±8.99 |
| 25 | 1 M | 2.5 V | 10 | 11.13 | ±52.5 | ±33.3 |
| 26 | 1 M | 2.5 V | -10 | -11.13 | ±52.5 | ±33.3 |
| 27 | 1 M | 5 V | 0 | 2.250 | ±24.8 | ±17.8 |
| 28 | 1 M | 5 V | 0 | -2.250 | ±24.8 | ±17.8 |
| 29 | 1 M | 5 V | 10 | 12.25 | ±64.8 | ±42.1 |
| 30 | 1 M | 5 V | -10 | -12.25 | ±64.8 | ±42.1 |
| 31 | 1 M | 10 V | 0 | 4.500 | ±49.4 | ±36.2 |
| 32 | 1 M | 10 V | 0 | -4.500 | ±49.4 | ±36.2 |
| 33 | 1 M | 10 V | 10 | 14.50 | ±89.4 | ±60.2 |
| 34 | 1 M | 10 V | -10 | -14.50 | ±89.4 | ±60.2 |
| 35 | 1 M | 25 V | 0 | 11.25 | ±123 | ±96.4 |
| 36 | 1 M | 25 V | 0 | -11.25 | ±123 | ±96.4 |
| 37 | 1 M | 25 V | 50 | 61.25 | ±323 | ±225 |
| 38 | 1 M | 25 V | -50 | -61.25 | ±323 | ±225 |
| 39 | 1 M | 50 V | 0 | 22.50 | ±246 | ±188 |
| 40 | 1 M | 50 V | 0 | -22.50 | ±246 | ±188 |
| 41 | 1 M | 50 V | 50 | 72.50 | ±446 | ±310 |
| 42 | 1 M | 50 V | -50 | -72.50 | ±446 | ±310 |
| 43 | 1 M | 100 V | 0 | 45.00 | ±493 | ±392 |

**Table 6.** DC Accuracy Verification (Continued)

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Vertical Offset (V) | Test Points (V) | As-Found Limits (mV) | As-Left Limits (mV) |
|---|---|---|---|---|---|---|
| 44 | 1 M | 100 V | 0 | -45.00 | ±493 | ±392 |
| 45 | 1 M | 100 V | 50 | 95.00 | ±693 | ±502 |
| 46 | 1 M | 100 V | -50 | -95.00 | ±693 | ±502 |
| 47 | 1 M | 100 V | -155.0 | -200.0 | ±1113 | ±802 |
| 48 | 1 M | 50 V | -177.5 | -200.0 | ±956 | ±658 |
| 49 | 1 M | 25 V | -188.8 | -200.0 | ±878 | ±597 |
| 50 | 1 M | 10 V | -195.5 | -200.0 | ±831 | ±552 |
| 51 | 1 M | 5 V | -197.8 | -200.0 | ±816 | ±540 |
| 52 | 1 M | 2.5 V | -198.9 | -200.0 | ±808 | ±534 |
| 53 | 1 M | 100 V | 155.0 | 200.0 | ±1113 | ±802 |
| 54 | 1 M | 50 V | 177.5 | 200.0 | ±956 | ±658 |
| 55 | 1 M | 25 V | 188.8 | 200.0 | ±878 | ±597 |
| 56 | 1 M | 10 V | 195.5 | 200.0 | ±831 | ±552 |
| 57 | 1 M | 5 V | 197.8 | 200.0 | ±816 | ±540 |
| 58 | 1 M | 2.5 V | 198.9 | 200.0 | ±808 | ±534 |

1. Connect the calibrator test head to channel 0 of the PXIe-5163.
2. Configure the PXIe-5163 with the following settings:
   - Input impedance: the Input Impedance value from the *DC Accuracy Verification* table
   - Maximum input frequency: 200 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: 1 GS/s
   - 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-5163.
4. Configure the calibrator to output the Test Point value from the *DC Accuracy Verification* table.
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. Repeat steps *2* on page 23 through *8* on page 24 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-5163 and repeat steps *2* on page 23 through *8* on page 24 for each configuration listed in the *DC Accuracy Verification* table.
12. Disable the calibrator output.

## Verifying AC Amplitude Accuracy

Follow this procedure to verify the AC amplitude accuracy of the PXIe-5163 by comparing the voltage measured by the PXIe-5163 to the voltage measured by the DMM.

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

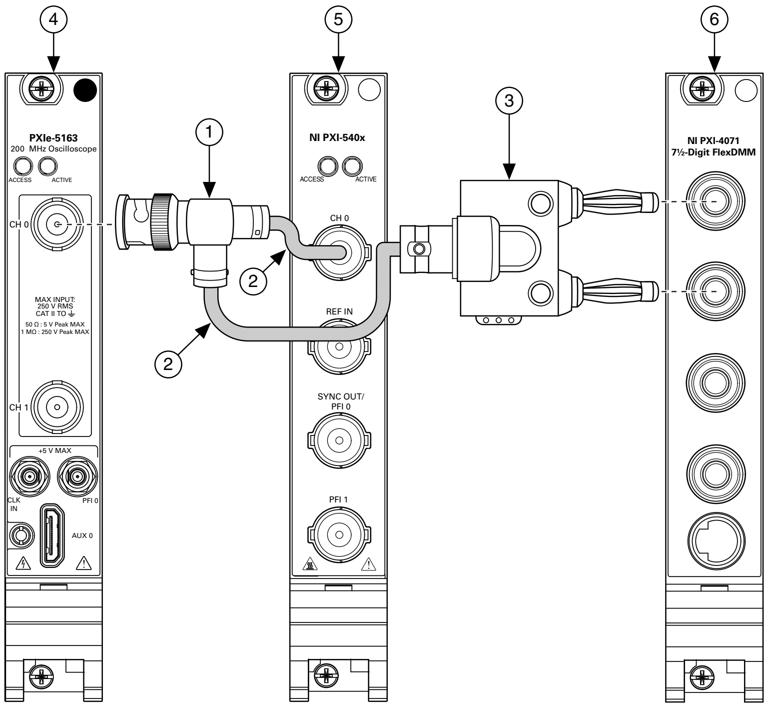
**Table 7.** AC Amplitude Accuracy Verification

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Test Point (V pk-pk) | DMM Range (V RMS) | As-Found Limits (dB) | As-Left Limits (dB) |
|---|---|---|---|---|---|---|
| 1 | 50 | 0.25 V | 0.125 | 0.05 | 0.225 | 0.186 |
| 2 | 50 | 0.5 V | 0.25 | 0.5 | 0.225 | 0.186 |
| 3 | 50 | 1 V | 0.5 | 0.5 | 0.225 | 0.186 |
| 4 | 50 | 2.5 V | 1.25 | 0.5 | 0.225 | 0.186 |
| 5 | 50 | 5 V | 2.5 | 5.0 | 0.225 | 0.186 |
| 6 | 1 M | 0.25 V | 0.125 | 0.05 | 0.225 | 0.150 |
| 7 | 1 M | 0.5 V | 0.25 | 0.5 | 0.225 | 0.150 |
| 8 | 1 M | 1 V | 0.5 | 0.5 | 0.225 | 0.150 |
| 9 | 1 M | 2.5 V | 1.25 | 0.5 | 0.225 | 0.150 |
| 10 | 1 M | 5 V | 2.5 | 5.0 | 0.225 | 0.150 |
| 11 | 1 M | 10 V | 5 | 5.0 | 0.225 | 0.150 |
| 12 | 1 M | 25 V | 12.5 | 5.0 | 0.225 | 0.120 |

Table 7. AC Amplitude Accuracy Verification (Continued)

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Test Point (V pk-pk) | DMM Range (V RMS) | As-Found Limits (dB) | As-Left Limits (dB) |
|---|---|---|---|---|---|---|
| 13 | 1 M | 50 V | 20 | 50.0 | 0.225 | 0.120 |
| 14 | 1 M | 100 V | 20 | 50.0 | 0.225 | 0.120 |

**Figure 8.** AC Verification Test Connections




1. BNC tee (m-f-f)
2. BNC (m)-to-BNC (m) cable
3. BNC (f) to Double Banana Plug
4. PXIe-5163
5. Function Generator
6. DMM

1. Connect the DMM and function generator to channel 0 of the PXIe-5163 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
- Aperture: 0.02 second
- Range: the DMM Range value from the *AC Amplitude Accuracy Verification* table

3. Configure the PXIe-5163 with the following settings:
   - Input impedance: the Input Impedance value from the *AC Amplitude Accuracy Verification* table
   - Maximum input frequency: 200 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *AC Amplitude Accuracy Verification* table
   - Sample rate: 125 MS/s
   - Minimum number of points: 1,048,576 samples
4. Configure the function generator and generate a waveform with the following characteristics:
   - Waveform: Sine wave
   - Amplitude: the Test Point value from the *AC Amplitude Accuracy Verification* table
   - Frequency: 50 kHz
   - Load impedance: the Input Impedance value from the *AC Amplitude Accuracy Verification* table

   **Note** These values assume you are using a PXI-5402/5406 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 0.1 seconds for the output of the function generator to settle.
6. Acquire and measure the amplitude of the sine wave using the PXIe-5163 and the Extract Single Tone Information VI. Convert the result from V peak to V RMS.

   Record the result as $V_{\text{PXIe-5163 Measured}}$.
7. Measure the amplitude of the sine wave in V RMS using the DMM.

   Record the result as $V_{\text{DMM Measured}}$.
8. Calculate the amplitude error using the following formula:

   $$AC\ Voltage\ Error = 20 \times \log_{10}(V_{\text{PXIe-5163 Measured}} / V_{\text{DMM Measured}})$$
9. Compare the amplitude error to the appropriate Limit from the *AC Amplitude Accuracy Verification* table.
10. Repeat steps *2* on page 25 through *9* on page 26 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
11. Disable the function generator output.
12. Connect the DMM and function generator to channel 1 of the PXIe-5163 as shown in the *AC Verification Test Connections* figure and repeat steps *2* on page 25 through *9* on page 26 for each configuration listed in the *AC Amplitude Accuracy Verification* table.
13. Disable the function generator output.

# Verifying 50 Ω Passband Amplitude Flatness and Bandwidth

Follow this procedure to verify the 50 Ω analog passband amplitude flatness and bandwidth accuracy of the PXIe-5163 by generating a sine wave and comparing the amplitude measured by the PXIe-5163 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 8.** 50 Ω Passband Amplitude Flatness and 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 | 125 M | 0.25 V | 0.05 | -11 | REF | REF |
| 2 | 1 G | 0.25 V | 1.1 | -11 | ±0.5 | ±0.38 |
| 3 | 1 G | 0.25 V | 10.1 | -11 | ±0.5 | ±0.38 |
| 4 | 1 G | 0.25 V | 30.1 | -11 | ±0.5 | ±0.37 |
| 5 | 1 G | 0.25 V | 60.1 | -11 | ±0.5 | ±0.35 |
| 6 | 1 G | 0.25 V | 90.1 | -11 | ±0.5 | ±0.33 |
| 7 | 1 G | 0.25 V | 100.1 | -11 | ±0.5 | ±0.32 |
| 8 | 1 G | 0.25 V | 150.1 | -11 | ±0.5 | ±0.31 |
| 9 | 1 G | 0.25 V | 200.1 | -11 | -3.0 to 1.0 | -1.27 to 0.28 |
| 10 | 125 M | 0.5 V | 0.05 | -5 | REF | REF |
| 11 | 1 G | 0.5 V | 1.1 | -5 | ±0.5 | ±0.38 |
| 12 | 1 G | 0.5 V | 10.1 | -5 | ±0.5 | ±0.38 |
| 13 | 1 G | 0.5 V | 30.1 | -5 | ±0.5 | ±0.37 |
| 14 | 1 G | 0.5 V | 60.1 | -5 | ±0.5 | ±0.35 |
| 15 | 1 G | 0.5 V | 90.1 | -5 | ±0.5 | ±0.33 |
| 16 | 1 G | 0.5 V | 100.1 | -5 | ±0.5 | ±0.32 |
| 17 | 1 G | 0.5 V | 150.1 | -5 | ±0.5 | ±0.31 |

**Table 8.** 50 Ω Passband Amplitude Flatness and 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) | | |
| 18 | 1 G | 0.5 V | 200.1 | -5 | -3.0 to 1.0 | -1.27 to 0.28 |
| 19 | 125 M | 1 V | 0.05 | 1 | REF | REF |
| 20 | 1 G | 1 V | 1.1 | 1 | ±0.5 | ±0.38 |
| 21 | 1 G | 1 V | 10.1 | 1 | ±0.5 | ±0.38 |
| 22 | 1 G | 1 V | 30.1 | 1 | ±0.5 | ±0.37 |
| 23 | 1 G | 1 V | 60.1 | 1 | ±0.5 | ±0.35 |
| 24 | 1 G | 1 V | 90.1 | 1 | ±0.5 | ±0.33 |
| 25 | 1 G | 1 V | 100.1 | 1 | ±0.5 | ±0.32 |
| 26 | 1 G | 1 V | 150.1 | 1 | ±0.5 | ±0.31 |
| 27 | 1 G | 1 V | 200.1 | 1 | -3.0 to 1.0 | -1.27 to 0.28 |
| 28 | 125 M | 2.5 V | 0.05 | 9 | REF | REF |
| 29 | 1 G | 2.5 V | 1.1 | 9 | ±0.5 | ±0.38 |
| 30 | 1 G | 2.5 V | 10.1 | 9 | ±0.5 | ±0.38 |
| 31 | 1 G | 2.5 V | 30.1 | 9 | ±0.5 | ±0.37 |
| 32 | 1 G | 2.5 V | 60.1 | 9 | ±0.5 | ±0.35 |
| 33 | 1 G | 2.5 V | 90.1 | 9 | ±0.5 | ±0.33 |
| 34 | 1 G | 2.5 V | 100.1 | 9 | ±0.5 | ±0.32 |
| 35 | 1 G | 2.5 V | 150.1 | 9 | ±0.5 | ±0.31 |
| 36 | 1 G | 2.5 V | 200.1 | 9 | -3.0 to 1.0 | -1.27 to 0.28 |
| 37 | 125 M | 5 V | 0.05 | 9 | REF | REF |
| 38 | 1 G | 5 V | 1.1 | 9 | ±0.5 | ±0.38 |
| 39 | 1 G | 5 V | 10.1 | 9 | ±0.5 | ±0.38 |

**Table 8.** 50 Ω Passband Amplitude Flatness and 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) | | |
| 40 | 1 G | 5 V | 30.1 | 9 | ±0.5 | ±0.37 |
| 41 | 1 G | 5 V | 60.1 | 9 | ±0.5 | ±0.35 |
| 42 | 1 G | 5 V | 90.1 | 9 | ±0.5 | ±0.33 |
| 43 | 1 G | 5 V | 100.1 | 9 | ±0.5 | ±0.32 |
| 44 | 1 G | 5 V | 150.1 | 9 | ±0.5 | ±0.31 |
| 45 | 1 G | 5 V | 200.1 | 9 | -3.0 to 1.0 | -1.27 to 0.28 |

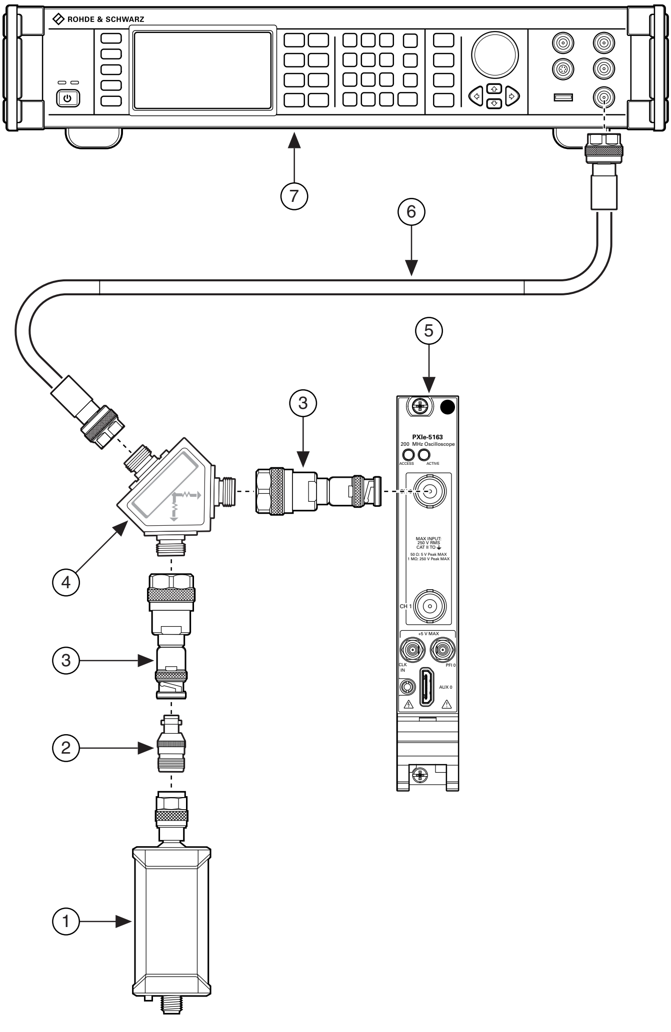
1. Connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to channel 0 of the PXIe-5163.

   **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 9.** 50 Ω Passband Amplitude Flatness and Bandwidth Verification Cabling Diagram

**Notice** Provide strain relief for connectors on the DUT in order to prevent damage to the instrument.




1. Power sensor
2. BNC (f)-to-N (f) Adapter
3. Type N (m)-to-BNC (m) adapter
4. Keysight 11667A power splitter
5. PXIe-5163
6. Type N (m)-to-Type N (m) cable
7. 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-5163 with the following settings:
   - Input impedance: 50 Ω
   - Maximum input frequency: 200 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *50 Ω Passband Amplitude Flatness and Bandwidth Verification* table
   - Sample rate: the Sample Rate value from the *50 Ω Passband Amplitude Flatness and 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 Passband Amplitude Flatness and Bandwidth Verification* table
   - Amplitude: the Test Point Amplitude value from the *50 Ω Passband Amplitude Flatness and 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 seconds 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:

   $$\text{Corrected Input Power} = \text{Measured Input Power} + \text{Splitter Balance}$$

   **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-5163 to acquire and measure the power using the Extract Single Tone Information VI, converting the result from V peak to dBm.

   Record the result as *Device Input Power*.
10. If the Test Point Frequency value from the *50 Ω Passband Amplitude Flatness and 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:

   $$\text{Power Reference} = \text{Device Input Power} - \text{Corrected Input Power}$$

12. Go to step 14. 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 Passband Amplitude Flatness and Bandwidth Verification* table.
15. Repeat steps 2 through 14 for each configuration in the *50 Ω Passband Amplitude Flatness and Bandwidth Verification* table.
16. Connect splitter output 2 of the power sensor assembly to channel 1 of the PXIe-5163 and repeat steps 2 through 14 for each configuration listed in the *50 Ω Passband Amplitude Flatness and Bandwidth Verification* table.
17. Disable the signal generator output.

## Verifying 1 MΩ Bandwidth

Follow this procedure to verify the 1 MΩ analog bandwidth accuracy of the PXIe-5163 by generating a sine wave and comparing the amplitude measured by the PXIe-5163 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 9.** 1 MΩ 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 | 125 M | 0.25 V | 0.05 | -11 | REF | REF |
| 2 | 1 G | 0.25 V | 200.1 | -11 | -3.0 to 1.0 | -1.77 to 0.69 |
| 3 | 125 M | 0.5 V | 0.05 | -5 | REF | REF |
| 4 | 1 G | 0.5 V | 200.1 | -5 | -3.0 to 1.0 | -1.77 to 0.69 |
| 5 | 125 M | 1 V | 0.05 | 1 | REF | REF |
| 6 | 1 G | 1 V | 200.1 | 1 | -3.0 to 1.0 | -1.77 to 0.69 |
| 7 | 125 M | 2.5 V | 0.05 | 9 | REF | REF |
| 8 | 1 G | 2.5 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |
| 9 | 125 M | 5 V | 0.05 | 9 | REF | REF |

**Table 9.** 1 MΩ 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) | | |
| 10 | 1 G | 5 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |
| 11 | 125 M | 10 V | 0.05 | 9 | REF | REF |
| 12 | 1 G | 10 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |
| 13 | 125 M | 25 V | 0.05 | 9 | REF | REF |
| 14 | 1 G | 25 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |
| 15 | 125 M | 50 V | 0.05 | 9 | REF | REF |
| 16 | 1 G | 50 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |
| 17 | 125 M | 100 V | 0.05 | 9 | REF | REF |
| 18 | 1 G | 100 V | 200.1 | 9 | -3.0 to 1.0 | -1.77 to 0.69 |

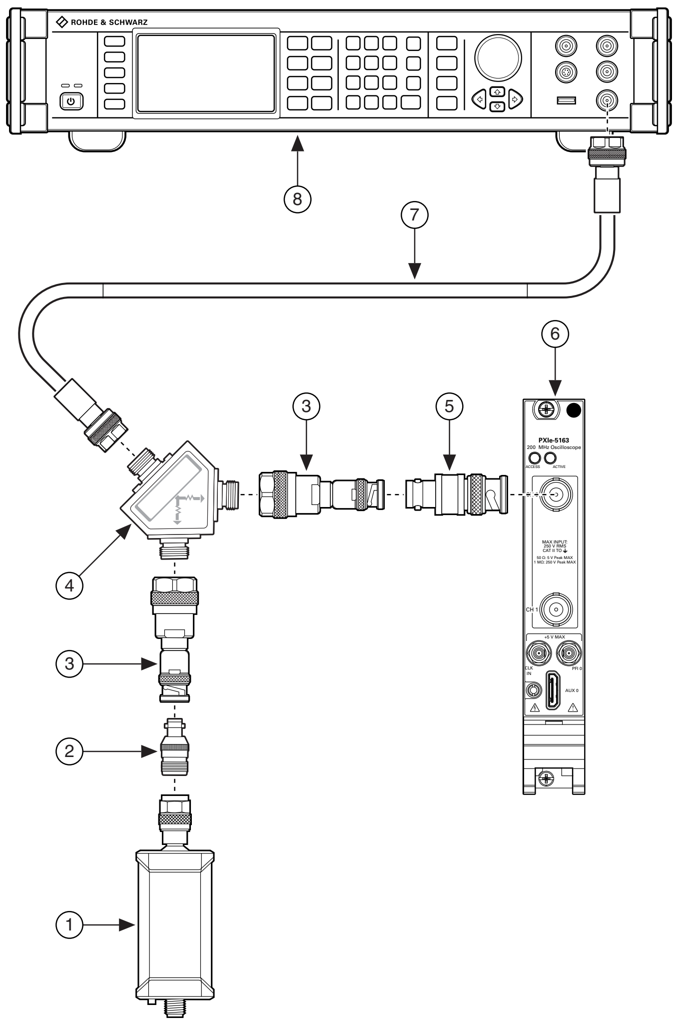
1. Place the 50 Ω BNC feed-thru terminator on the Type N (m)-to-BNC (m) adapter connected to splitter output 2, and connect splitter output 2 of the power sensor assembly, as described in the *Test System Characterization* section, to channel 0 of the PXIe-5163.

   **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 10.** 1 MΩ Bandwidth Verification Cabling Diagram

> **Notice** Provide strain relief for connectors on the DUT in order to prevent damage to the instrument.




1. Power sensor
2. BNC (f)-to-N (f) Adapter
3. Type N (m)-to-BNC (m) adapter
4. Keysight 11667A power splitter
5. 50 Ω BNC feed-thru terminator
6. PXIe-5163
7. Type N (m)-to-Type N (m) cable
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-5163 with the following settings:
   - Input impedance: 1 MΩ
   - Maximum input frequency: 200 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 rate: the Sample Rate value from the *1 MΩ Bandwidth Verification* table
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 *1 MΩ Bandwidth Verification* table
   - Amplitude: the Test Point Amplitude value from the *1 MΩ Bandwidth Verification* table plus splitter loss

   **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 seconds 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-5163 to acquire and measure the power using the Extract Single Tone Information VI, converting the result from V peak to dBm.

   Record the result as *Device Input Power*.
10. 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 13.
11. Calculate the *Power Reference* using the following equation:

    *Power Reference* = *Device Input Power* - *Corrected Input Power*
12. Go to step 14. 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 *1 MΩ Bandwidth Verification* table.
15. Repeat steps 2 through 14 for each configuration in the *1 MΩ Bandwidth Verification* table.
16. Connect the splitter output 2 of the power sensor assembly from the *Test System Characterization* section to channel 1 of the PXIe-5163. Repeat steps 2 through 14 for each configuration in the *1 MΩ Bandwidth Verification* table.
17. Disable the signal generator output.

# Verifying Timebase Accuracy

Follow this procedure to verify the frequency accuracy of the PXIe-5163 onboard timebase using an oscilloscope calibrator.

**Table 10.** Timebase Accuracy Verification

| As-Found Limits | As-Left Limits |
|---|---|
| ±5.0 ppm (±495 Hz) | ±1.0 ppm (±99 Hz) |

1. Connect the calibrator test head to channel 0 of the PXIe-5163.
2. Configure the PXIe-5163 with the following settings:
   - Input impedance: 50 Ω
   - Maximum input frequency: 200 MHz
   - Vertical range: 1 V pk-pk
   - Sample rate: 1 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-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.

   Record the result as $F_{Measured}$.
6. Calculate the timebase error using the following formula:

   $Timebase\ Error = (F_{Measured} - (99 \times 10^6)) / 99$ [ppm]
7. Compare the timebase error to the appropriate limit from the *Timebase Accuracy Verification* table.

   **Note** Timebase verification is required on only one channel.
8. Disable the calibrator output.

# Verifying RMS Noise

Follow this procedure to verify the RMS noise of the PXIe-5163 using a 50 Ω terminator.

**Table 11.** RMS Noise Verification

| Config | Input Impedance (Ω) | Vertical Range (V pk-pk) | Test Limit (% of FS) |
|---|---|---|---|
| 1 | 50 | 0.25 V | 0.045 |
| 2 | 50 | 0.5 V | 0.040 |
| 3 | 50 | 1 V | 0.035 |
| 4 | 50 | 2.5 V | 0.030 |
| 5 | 50 | 5 V | 0.030 |
| 6 | 1 M | 0.25 V | 0.110 |
| 7 | 1 M | 5 V | 0.060 |
| 8 | 1 M | 1 V | 0.050 |
| 9 | 1 M | 2.5 V | 0.100 |
| 10 | 1 M | 5 V | 0.060 |
| 11 | 1 M | 10 V | 0.050 |
| 12 | 1 M | 25 V | 0.080 |
| 13 | 1 M | 50 V | 0.060 |
| 14 | 1 M | 100 V | 0.050 |

1. Connect the 50 Ω BNC terminator (m) to channel 0 of the PXIe-5163.
2. Configure the PXIe-5163 with the following settings:
   - Input impedance: the Input Impedance value from the *RMS Noise Verification* table
   - Maximum input frequency: 200 MHz
   - Vertical offset: 0 V
   - Vertical range: the Vertical Range value from the *RMS Noise Verification* table
   - Sample rate: 1 GS/s
   - Minimum number of points: 1,048,576 samples
3. Use the PXIe-5163 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 $\sigma$ 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-5163 and repeat steps 2 through 4 for each configuration listed in the *RMS Noise Verification* table.

# Adjustment

This section describes the steps needed to adjust the PXIe-5163 to meet published specifications.

## Adjusting the PXIe-5163

Before performing this procedure, complete the *Test System Characterization* procedures and calculate the splitter balance and splitter loss of your power splitter. Ensure the channels of the PXIe-5163 are not connected.

1. Call the niHsai Group B External Cal API v1 Host.lvclass:Open Ext Cal Session VI to obtain an external calibration session.

   To perform an adjustment, you must specify the **calibration password**. By default, the **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 Timebase* procedure on channel 0. This procedure only needs to run on one channel.
6. Complete the *Adjusting 1 MΩ Compensation Attenuator* procedure on channel 1.
7. Complete the *Adjusting 1 MΩ DC Reference* procedure on channel 1.
8. Complete the *Adjusting 50 Ω DC Reference* procedure on channel 1.
9. Complete the *Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth* procedure on channel 0.
10. Complete the *Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth* procedure on channel 1.
11. Complete the *Adjusting 1 MΩ Bandwidth* on page 44 procedure on channel 0.
12. Complete the *Adjusting 1 MΩ Bandwidth* on page 44 procedure on channel 1.
13. Call the niHsai Group B External Cal API v1 Host.lvclass:Close Ext Cal Session VI with the following settings to close the external calibration session:

    **action**: Set this control to Commit to store the new calibration constants, adjustment time, adjustment date, and adjustment temperature to 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 control to Cancel to discard the new calibration constants without changing any of the calibration data stored in the nonvolatile memory of the oscilloscope.
14. Call the niScope Initialize VI to obtain an NI-SCOPE session.
15. Self-calibrate the PXIe-5163 using the niScope Cal Self Calibrate VI.

16. Call the niScope 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-5163.

1. Connect the calibrator test head to the specified channel of the PXIe-5163.
2. Call the niHsai Group B External Cal API v1 Host.lvclass:Compensated Attenuator Cal Initialize VI with the following settings:
   - **channel**: the specified channel
   - **input impedance**: 1 MΩ
3. Call the niHsai Group B External Cal API v1 Host.lvclass:Compensated Attenuator Cal Configure VI to obtain the amplitude and frequency of the square waveform to generate. Configure the calibrator to output a square waveform with symmetrical polarity and with the specified amplitude and frequency into 1 MΩ.
4. Enable the calibrator output if not already enabled.
5. Wait 1 second for settling.
6. Call the niHsai Group B External Cal API v1 Host.lvclass: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-5163
   - **amplitude generated (Vpk-pk)**: The amplitude of the square waveform present on the specified channel of the PXIe-5163
7. Repeat steps *3* on page 39 through *6* on page 39 until the **compensated attenuator cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:Compensated Attenuator Cal Adjust VI returns TRUE.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5163* 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-5163.

**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-5163.
2. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Initialize VI with the following settings:
   - **channel**: The specified channel
   - **input impedance**: 1 MΩ
3. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Configure VI to obtain the DC voltage to generate and configure the calibrator to output the specified DC voltage into 1 MΩ.
4. Enable the calibrator output if not already enabled.
5. Wait 1 second for settling.

6. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Adjust VI with the following settings:
   - **actual voltage generated (V)**: The DC voltage present on the specified channel of the PXIe-5163
7. Repeat steps *3* on page 39 through *6* on page 40 until the **DC cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Adjust VI returns TRUE.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5163* 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-5163.

1. Connect the calibrator test head to the specified channel of the PXIe-5163.
2. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Initialize VI with the following settings:
   - **channel**: The specified channel
   - **input impedance**: 50 Ω
3. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Configure VI to obtain the DC voltage to generate and configure the calibrator to output the specified DC voltage into 50 Ω.
4. Enable the calibrator output if not already enabled.
5. Wait 1 second for settling.
6. Call the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Adjust VI with the following settings:
   - **actual voltage generated (V)**: The DC voltage present on the specified channel of the PXIe-5163
7. Repeat steps *3* on page 40 through *6* on page 40 until the **DC cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:DC Reference Cal Adjust VI returns TRUE.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5163* task.

# Adjusting Timebase

Follow this procedure to adjust the internal timebase reference of the PXIe-5163.

1. Connect the calibrator test head to the specified channel of the PXIe-5163.
2. Call the niHsai Group B External Cal API v1 Host.lvclass:Timebase Cal Initialize VI with the following settings:
   - **channel**: The specified channel
3. Call the niHsai Group B External Cal API v1 Host.lvclass:Timebase Cal Configure VI to obtain the frequency to generate and configure the calibrator to output a 0.9 V pk-pk sine wave at the specified frequency into 50 Ω.

4. Enable the calibrator output if not already enabled.
5. Wait 1 second for settling.
6. Call the niHsai Group B External Cal API v1 Host.lvclass:Timebase Cal Adjust VI with the following settings:
   - **actual frequency generated (Hz)**: The frequency of the sine wave present on channel 0 of the PXIe-5163
7. Repeat steps *3* on page 40 through *6* on page 41 until the **Timebase cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:Timebase Cal Adjust VI returns TRUE.
8. Disable the calibrator output.

Return to the main *Adjusting the PXIe-5163* task.

# Adjusting 50 Ω Passband Amplitude Flatness and Bandwidth

Follow this procedure to adjust the 50 Ω passband amplitude flatness and bandwidth of the PXIe-5163.

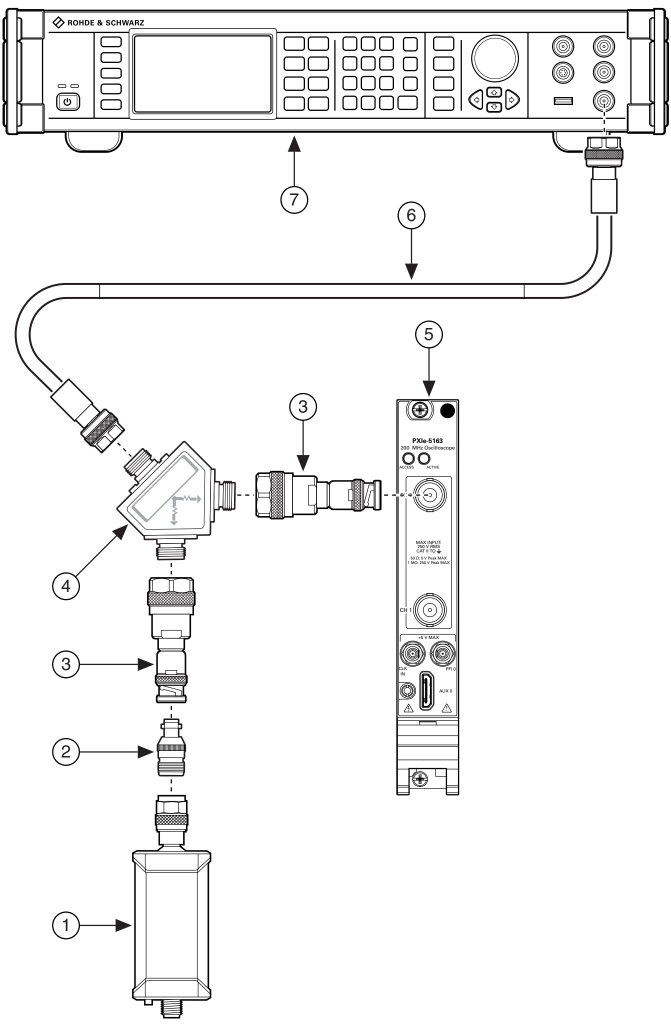
1. Remove the 50 Ω BNC feed-thru terminator from the Type N (m)-to-BNC (m) adapter connected to splitter output 2, and connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to the specified channel of the PXIe-5163.

   **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 11.** 50 Ω Passband Amplitude Flatness and Bandwidth Verification Cabling Diagram

**Notice** Provide strain relief for connectors on the DUT in order to prevent damage to the instrument.




1. Power sensor
2. BNC (f)-to-N (f) Adapter
3. Type N (m)-to-BNC (m) adapter
4. Keysight 11667A power splitter
5. PXIe-5163
6. Type N (m)-to-Type N (m) cable
7. Signal generator

2. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Initialize VI with the following settings:
    - **channel**: The specified channel
    - **input impedance**: 50 Ω
3. 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
4. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Configure VI to obtain the amplitude and frequency of the sine waveform to generate. Configure the signal generator to output a sine waveform with the specified amplitude plus *splitter loss* and frequency into a 50 Ω load.

    **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. Enable the signal generator output if not already enabled.
6. Configure the power sensor to correct for the current sine wave frequency using the power sensor frequency correction function.
7. Wait 0.1 seconds for settling.
8. Use the power sensor to measure the power in dBm.

    Record the result as *Measured Input Power*.
9. 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.
10. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Adjust VI with the following settings:
    - **actual frequency generated (Hz)**: The frequency of the sine waveform present on the specified channel of the PXIe-5163
    - **actual amplitude generated (dBm)**: The corrected input power of the sine waveform present on the specified channel of the PXIe-5163
11. Repeat steps *4* on page 43 through *10* on page 43 until the **passband flatness cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Adjust VI returns TRUE.
12. Disable the signal generator output.

Return to the main *Adjusting the PXIe-5163* task.

# Adjusting 1 MΩ Bandwidth

Follow this procedure to adjust the 1 MΩ bandwidth of the PXIe-5163.

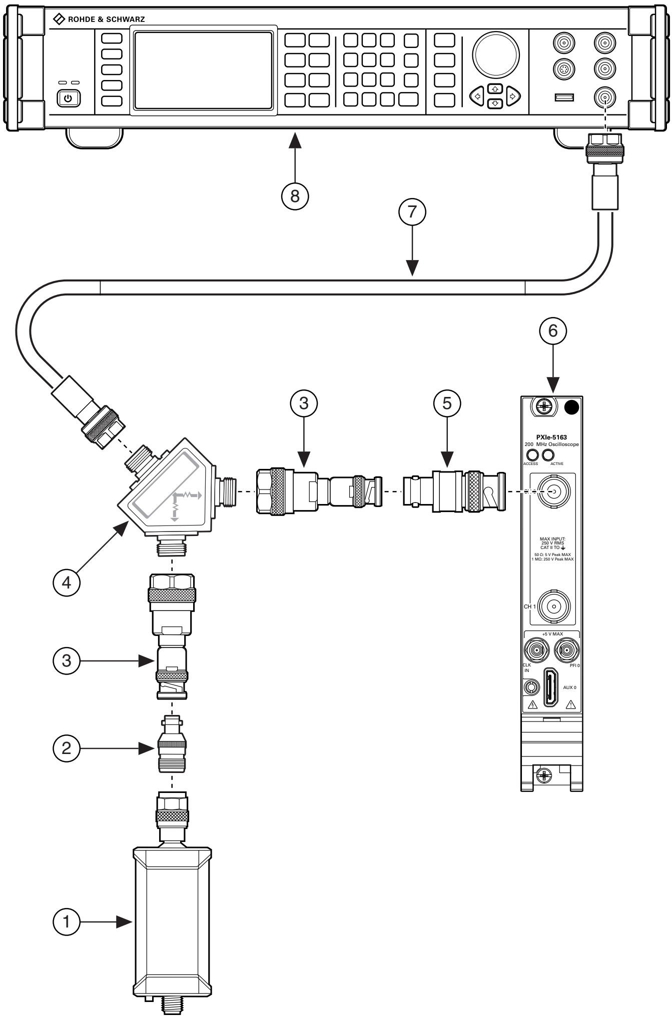
1. Place the 50 Ω BNC feed-thru terminator on the Type N (m)-to-BNC (m) adapter connected to splitter output 2, and connect splitter output 2 of the power sensor assembly from the *Test System Characterization* section to the specified channel of the PXIe-5163.

   **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 12.** 1 MΩ Bandwidth Verification Cabling Diagram

**Notice** Provide strain relief for connectors on the DUT in order to prevent damage to the instrument.




1. Power sensor
2. BNC (f)-to-N (f) Adapter
3. Type N (m)-to-BNC (m) adapter
4. Keysight 11667A power splitter
5. 50 Ω BNC feed-thru terminator
6. PXIe-5163
7. Type N (m)-to-Type N (m) cable
8. Signal generator

2. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Initialize VI with the following settings:
   - **channel**: The specified channel
   - **input impedance**: 1 MΩ
3. 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
4. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Configure VI to obtain the amplitude and frequency of the sine waveform to generate. Configure the signal generator to output a sine waveform with the specified amplitude plus *splitter loss* and frequency into a 50 Ω load.
5. Enable the signal generator output if not already enabled.

   **Note** Select the *splitter loss* value from the list of test points from the *Test System Characterization* section for the current Test Point Frequency.

6. Configure the power sensor to correct for the current sine wave frequency using the power sensor frequency correction function.
7. Wait 0.1 seconds for settling.
8. Use the power sensor to measure the power in dBm.

   Record the result as *Measured Input Power*.
9. 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.

10. Call the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Adjust VI with the following settings:
    - **actual frequency generated (Hz)**: The frequency of the sine waveform present on the specified channel of the PXIe-5163
    - **actual amplitude generated (dBm)**: The corrected input power of the sine waveform present on the specified channel of the PXIe-5163
11. Repeat steps *4* on page 46 through *10* on page 46 until the **passband flatness cal complete** indicator from the niHsai Group B External Cal API v1 Host.lvclass:Passband Flatness Cal Adjust VI returns TRUE.
12. Disable the signal generator output.

Return to the main *Adjusting the PXIe-5163* task.

# Reverification

Repeat the *Verification* section to determine the as-left status of the PXIe-5163.

**Note** If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your PXIe-5163 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-5163 verification.

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

Call the niHSAI Calibration API v1 Host.lvlib:Set Verification Date and Time VI with the following settings:

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

# Revision History

| Revision | Edition Date | Affected Section | Changes |
|---|---|---|---|
| 376611A-01 | September 2020 | — | This is the initial release version of the *PXIe-5163 Calibration Procedure*. |

# 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.

# NI Services

Visit *ni.com/support* to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit *ni.com/services* to learn about NI service offerings such as calibration options, repair, and replacement.

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

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376611A-01 September 29, 2020